MAGNITUDE AND FREQUENCY OF FLOODS IN ARKANSAS

By Braxtel L. Neely, Jr.

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CONVERSION FACTORS

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

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallon per day (Mgal/d)	0.0439	cubic meter per second (m^3/s)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre/foot (acre-ft)	1,233	cubic meter (m^3)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United State and Canada, formerly called "Mean Sea Level of 1929."

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ABSTRACT

Techniques are presented for estimating the magnitude and frequency of peak discharges on streams in Arkansas. Comprehensive regression analyses were made in which physical characteristics of streams were related to flood characteristics at gaging stations. Equations derived from the regression analyses provide estimates of peak discharges with selected recurrence intervals from 2 to 100 years on streams that have drainage areas less than 3,000 square miles. The regression analyses indicate that size of drainage area, slope of the main channel, length of the main channel, elevation of the basin, and mean annual precipitation were the most significant basin and climatic characteristics that affect the magnitude and frequency of floods.

A technique is presented for estimating a stage-discharge relation at ungaged sites based on a cross-section determined from topographic maps. This cross-section and stage-discharge relation are used to determine the hydraulic radius for the discharges for each recurrence interval. Techniques are presented for estimating the magnitude and frequency of peak discharges using the hydraulic radius with other physical characteristics of the basin. The techniques that use the hydraulic radius give standard errors of estimate from 5 to 16 percent lower than techniques that do not use hydraulic radius.

Data from 200 gaging stations with drainage areas less than 3,000 square miles and with at least 10 years of record were used in the analyses.

Large rivers such as the Red, Arkansas, White, Black, St. Francis, Mississippi, and Ouachita Rivers have floodflow characteristics that differ from those of smaller tributary streams and were treated individually. Regional regression equations are not applicable to these large rivers. The magnitude and frequency of floods along these rivers are based on station data.

A method is described for estimating the magnitude and frequency of peak discharges on streams for urban areas in Arkansas. The method is from a nationwide U.S. Geological Survey flood-frequency report which uses urban characteristics to adjust rural discharges to estimate urban discharges.

Annual peak discharges at all gaging stations, which are the basic data that support this analysis, are not published in the report. These data are published in a companion report entitled, "Annual peak discharges and stages through 1984 for gaging stations in Arkansas".

INTRODUCTION

The magnitude and frequency of floods are primary factors in the design of bridges, culverts, streets, embankments, dams, levees, and other structures near streams. Information on flood magnitude and frequency is used in managing flood plains, planning subdivisions, and in establishing flood insurance rates.

The Arkansas State Highway and Transportation Department is fully aware of the need for adequate flood peak data to more efficiently design drainage structures in Arkansas. Because of this need, the Arkansas State Highway and Transporation Department entered into a cooperative agreement with the U.S. Geological Survey to update a previous flood-frequency report based on data collected through 1984. This flood-frequency report supersedes the first two reports for Arkansas prepared by Patterson (1961, 1971) because of additional available data and new analysis techniques.

The purpose of this report is to provide a method of estimating the magnitude of floods with selected recurrence intervals from 2 to 100 years for streams in Arkansas. Equations for streams that have drainage areas less than 3,000 square miles (mi^2) were developed by the multiple regression technique. Equations for urban areas are from the report by Sauer and others (1983). For larger streams, individual station analysis is provided.

The study area is Arkansas, however data collected outside the State on streams that drain into and from Arkansas are considered. Figure 1 is a general location map of the study area.

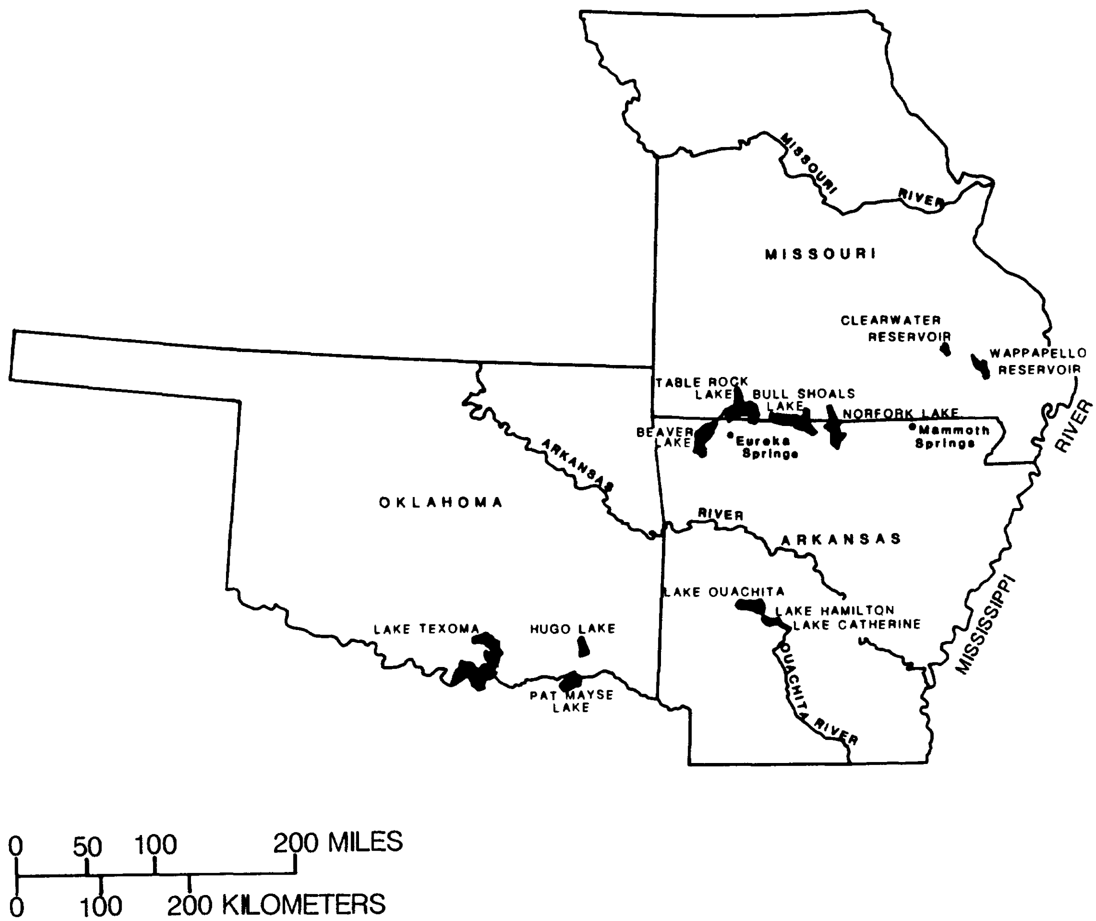


Figure 1.--Location of study area.

GENERAL SETTING

Arkansas has a diverse topography. The State is located in the Ozark Plateaus, Ouachita, and Coastal Plain physiographic provinces (Fenneman, 1938) (fig. 2). The Ozark and Ouachita Mountain ranges have an elevation as high as 2,700 feet (ft) above sea level. Streams in the Ozark Plateaus and the southern half of the Ouachita Mountains tend to have sustained flows during dry seasons, whereas, streams in the Arkansas Valley (fig. 2) and the northern half of the Ouachita Mountains generally go dry (Hunrichs, 1983). The Mississippi Alluvial Plain and the West Gulf Coastal Plain (fig. 2) compose the southeastern part of the State; this is primarily an agricultural area and is relatively flat, with elevations that range from 55 to 500 ft above sea level. The higher parts of the State are used mainly for raising cattle and poultry.

Arkansas has many springs, especially in the foothills of the Ouachita and Ozark Mountains. Thousands of people bath in the water from Arkansas springs each year for therapeutic reasons. The Eureka Springs area in the Ozarks contains approximately 65 springs. Mammoth Spring in the Ozarks is one of the largest springs in Arkansas, with an average discharge of 203 million gallons per day (Mgal/d). In the Hot Springs area in the Ouachitas, 51 springs yield about 1 Mgal/d.

Arkansas' climate is mild and moderately humid. Average annual precipitation ranges from about 40 to 58 inches (in.) (fig. 3). Monthly precipitation exhibits a pronounced seasonal pattern; May usually has the most precipitation and January and October the least. Runoff ranges from about 12 to 32 in. per year, depending on the precipitation pattern (Freiwald, 1985).

Average annual evaporation from shallow lakes ranges from about 36 in. in the northeast to about 44 in. in the southwest (Farnsworth and others, 1982).

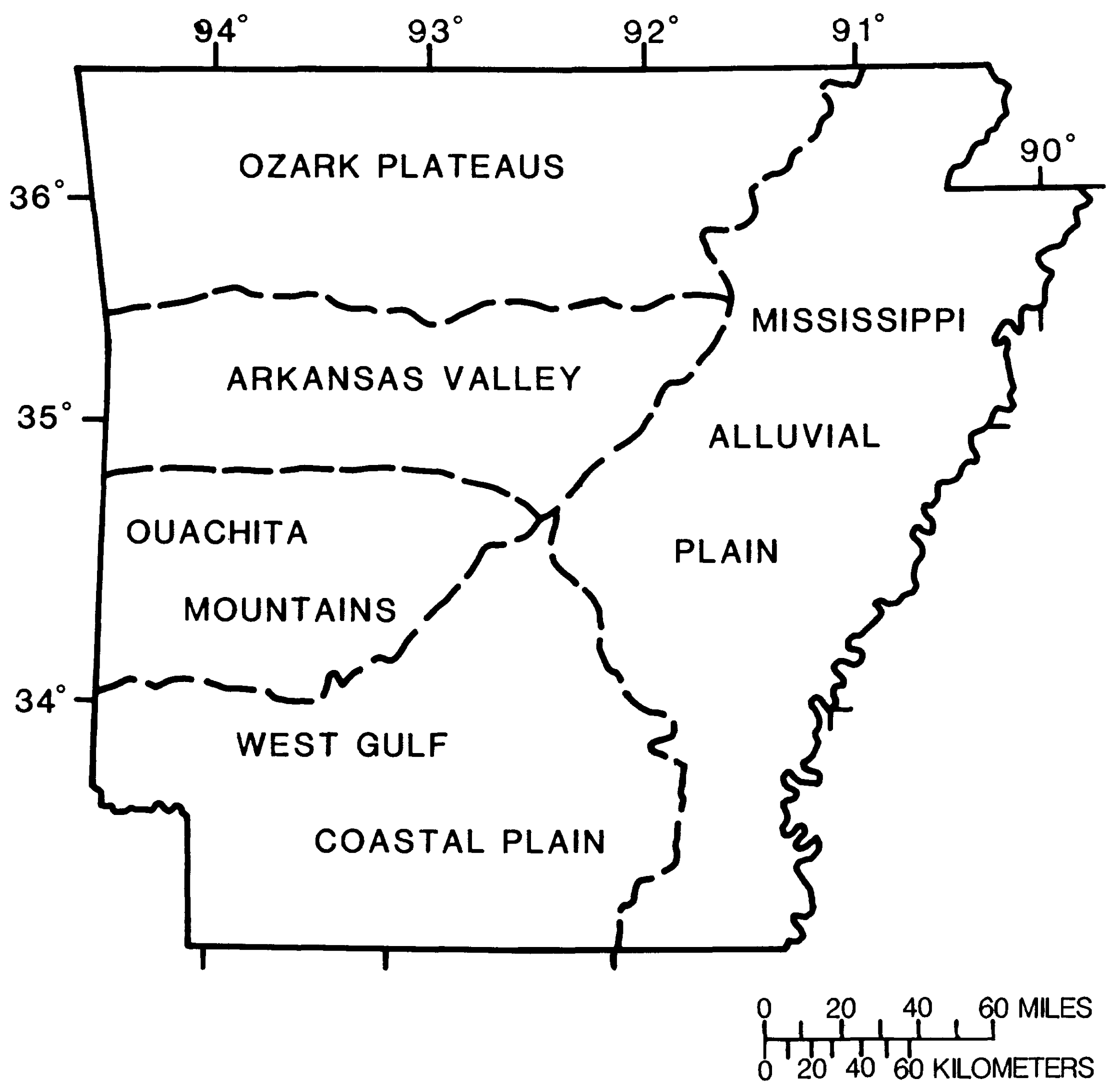


Figure 2.--Physiographic provinces in Arkansas.

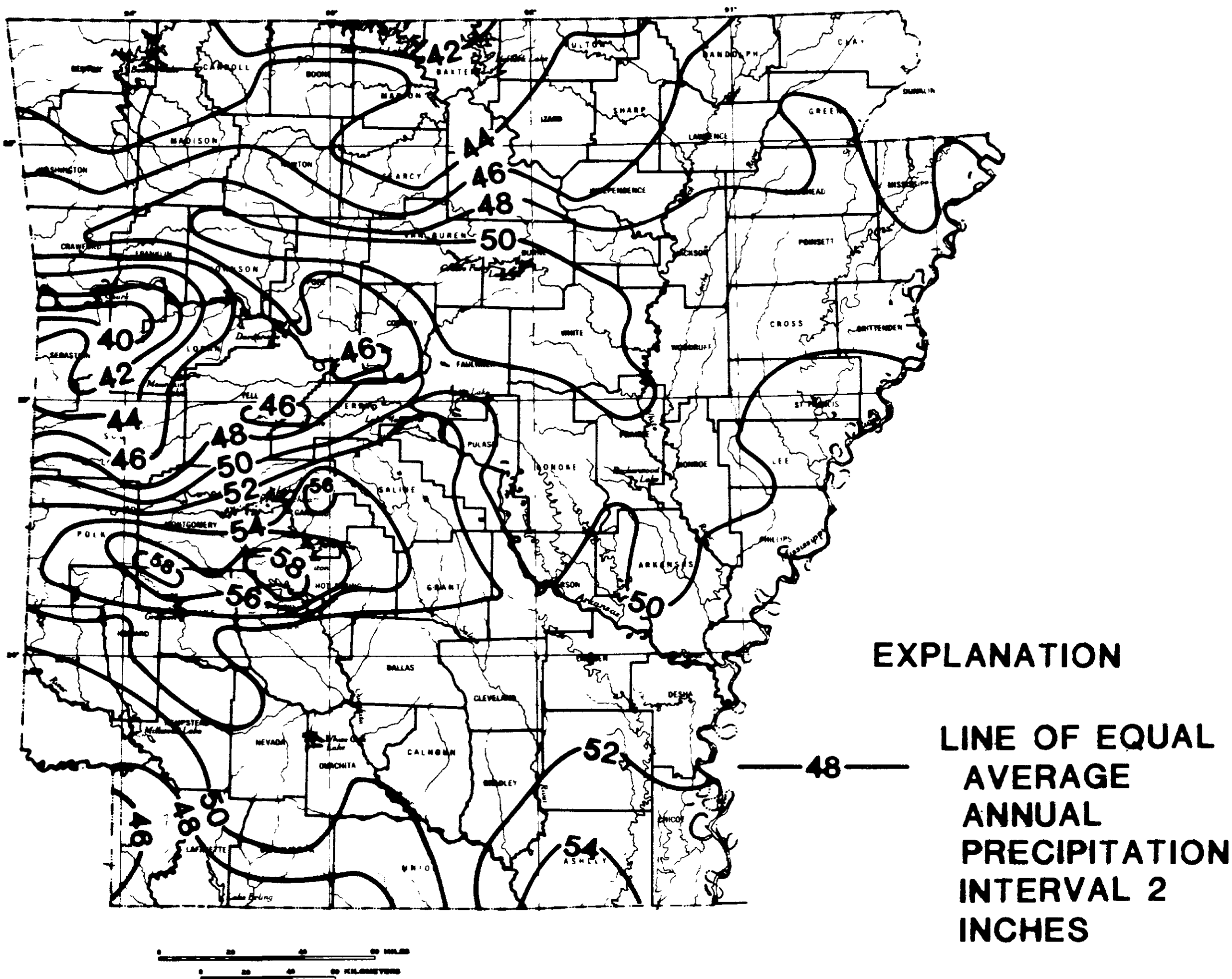


Figure 3.--Mean annual precipitation for Arkansas for the base period 1951-80 (from Freiwald, 1985).

FLOOD DATA

Peak data for 254 gaging stations that have 10 or more years of record were used in preparing this report. Of these stations, 3 are in Missouri, 3 in Oklahoma, and 12 in Louisiana.

The flood data used in this report were, for the most part, collected by the U.S. Geological Survey and the U.S. Army Corps of Engineers. The flood data have been collected at two types of gaging stations: (1) regular gaging stations where records of daily stage and discharge are collected, and (2) crest-stage gaging stations where only the maximum peak stage and discharge for each year are determined. Of the 254 gaging stations used, 160 are regular gaging stations and 94 are crest-stage gaging stations. Generally, the regular gaging stations are on large streams and have been operated for relatively long periods. Only a small percentage of the drainage areas upstream from these gaging stations are less than 100 mi^2. The crest-stage gaging program was begun in 1960 to fill the need for flood data on small areas. The drainage areas upstream from these sites range from less than 0.1 mi^2 to about 50 mi^2.

The flood-frequency analysis presented in this report for streams with drainage areas of less than 3,000 mi^2 is based on 200 sites with at least 10 years of peak discharge data collected through 1984 and free of significant regulation. Sixty-five gaging stations are on regulated streams or on streams with drainage areas greater than 3,000 mi^2. At 11 of the 65 stations, data that were collected prior to regulation were used in the flood-frequency analysis. Figure 4 is a map of Arkansas showing the location of all gaging stations used.

A summary of the distribution of data and average length of record for each station is as follows:

Drainage area, in square miles	Number of stations	Average length of record, in years
Less than 1	37	22
1 to 5	39	22
5 to 10	13	21
10 to 50	21	23
50 to 100	9	29
100 to 500	51	32
500 to 1,000	11	39
1,000 to 2,000	16	36
2,000 to 3,000	3	51

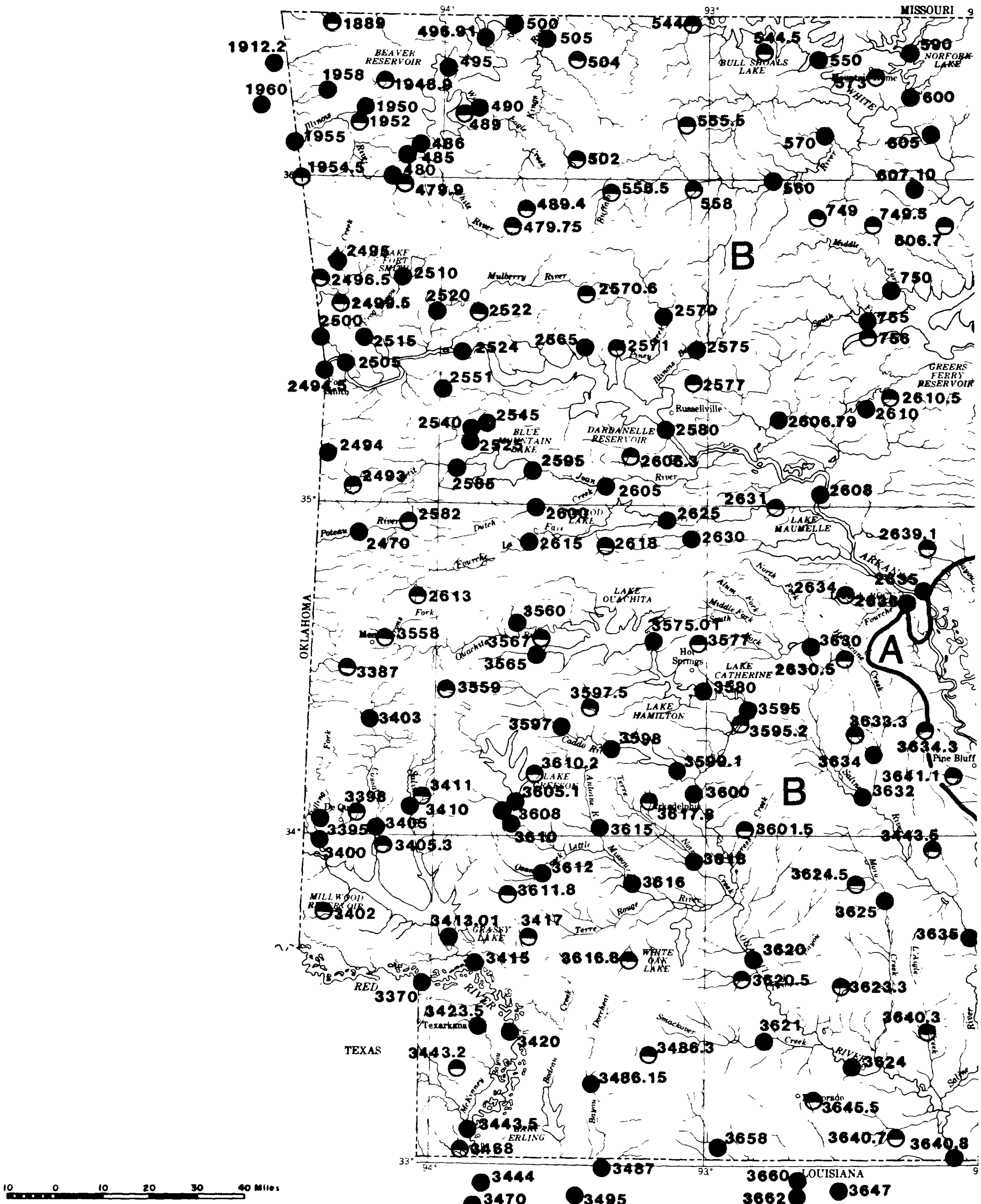
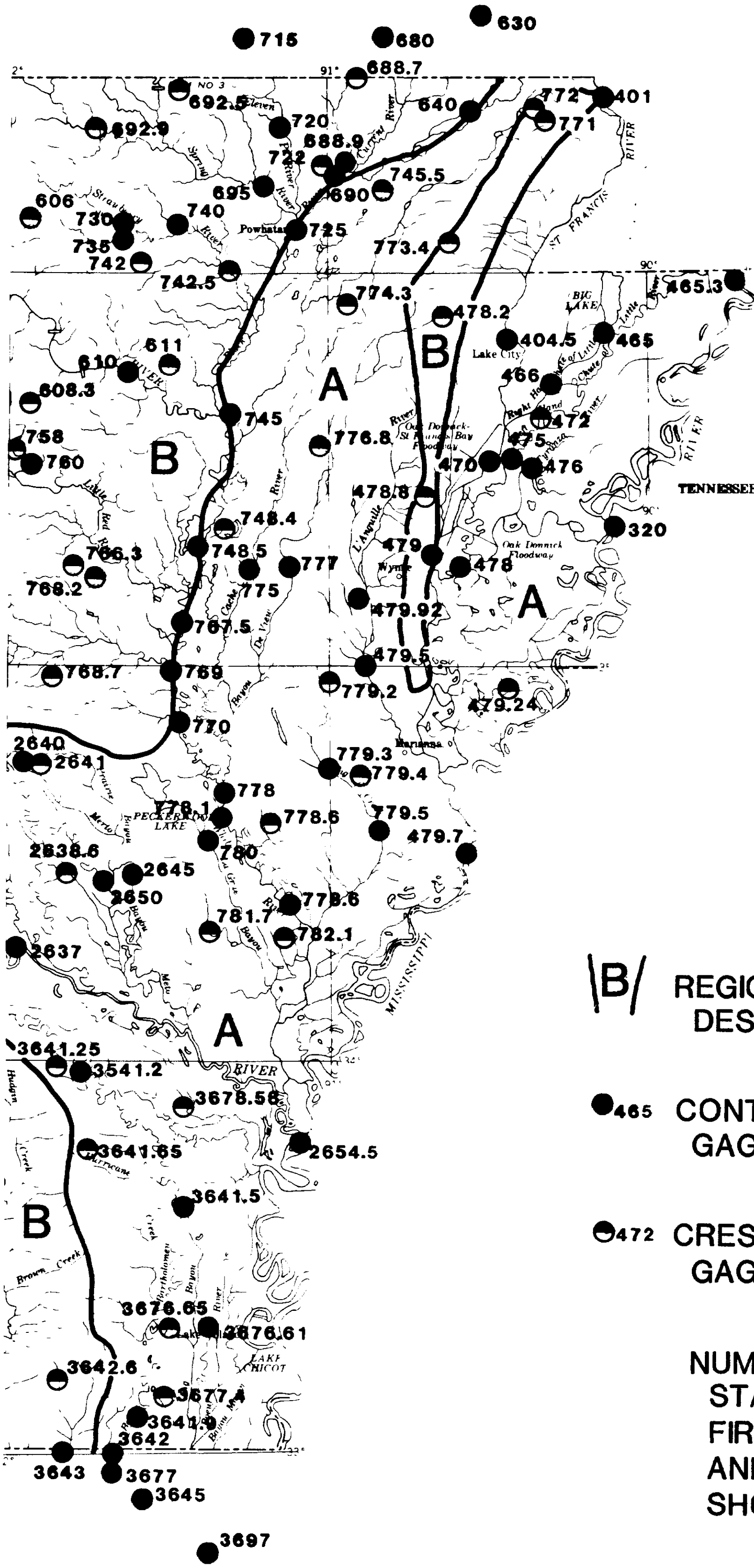


Figure 4.--Regional boundaries and



locations of gaging stations.

EXPLANATION

\B/ REGIONAL BOUNDARY AND DESIGNATION

●465 CONTINUOUS–RECORD GAGING STATION

◓472 CREST–STAGE GAGING STATION

NUMBERS ARE 8 DIGIT STATION NUMBERS WITH FIRST 2 DIGITS OMITTED AND LAST 2 DIGITS BEING SHOWN AS A DECIMAL

FLOOD MAGNITUDE AND FREQUENCY AT GAGING STATIONS

A flood-frequency curve is the relation of flood-peak magnitude to probability of exceedance or recurrence interval. Probability of exceedance is the chance of a given flood magnitude being exceeded in any one year. A 5-year flood for example has the probability of 0.2 (or 20 percent chance) of being exceeded in any given year. Recurrence interval is the reciprocal of probability of exceedance times 100 and is the average number of years between exceedances for a long period of record. A 5-year flood may be expected to be exceeded on the average of once in 5 years or, 20 times in 100 years. This does not mean floods occur at uniformly spaced intervals. In fact, a flood of this magnitude can be exceeded more than once in the same year, or can occur in consecutive years.

The flood-frequency relation for a stream where gaging-station data are available can be defined by fitting the array of annual peak discharges (largest instantaneous discharge for each year) to a theoretical distribution. The Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (1982) has recommended a uniform technique for determining floodflow frequencies by fitting the logarithms of the annual peak discharges to a Pearson Type III distribution and has described these calculations in detail. This procedure is now generally accepted by most Federal and State agencies and is referred to as the log-Pearson Type III frequency distribution. Annual peak discharges for each gaging station used in this study were fitted to the log-Pearson Type III distribution. Peak discharges for recurrence intervals of 2, 5, 10, 25, 50 and 100 years were computed for each station and are listed in tables 1, 2, and 3. For those stations where regulation began during the data collection period, discharge values are presented for both the unregulated and the regulated period.

FLOOD MAGNITUDE AND FREQUENCY AT UNGAGED SITES ON STREAMS DRAINING LESS THAN 3,000 SQUARE MILES

Flood-frequency relations can be estimated for ungaged sites up to 3,000 mi^2 through the use of the equations presented in this section. The equations were developed by relating the 2-, 5-, 10-, 25-, 50-, and 100-year floods to basin and climatic characteristics. Although numerous basin and climatic characteristics were investigated, the ones that were most significant for this study were drainage area, main channel slope, main channel length, mean annual precipitation, and mean basin elevation. The basin and climatic characteristic, equation development, and accuracy and limitations of the results are described in the following paragraphs.

Table 1.—Discharge, for selected recurrence interval, at gaging stations affecting Region A

[A, drainage area; S, slope; L, length; YRS, years of record. Numbers on line with station name are based on station data. Numbers on line below station name are values computed by weighting the regression discharge with station discharge.]

Station identification number	Station name	A	S	L	YRS	Discharge (cubic feet per second), for recurrence interval (years) 2	5	10	25	50	100
7047200	Ditch no. 45 near Lepanto, Ark.	2.16	1.2	3.3	23	170	198	213	230	240	250
						167	197	216	237	250	263
7047600	Tyronza River near Tyronza, Ark.	290	0.7	55.0	36	4,170	5,030	5,530	6,100	6,480	6,850
						4,170	4,910	5,420	6,030	6,440	6,830
7047924	Crooked Bayou tributary at State	.48	4.2	1.2	20	110	204	281	395	492	599
	Highway 149, at Hughes, Ark.					106	190	255	353	436	526
7047942	L'Anguille River near Colt, Ark.	535	0.9	58.7	14	5,900	9,320	11,600	14,400	16,400	18,400
						5,730	8,800	10,800	13,300	15,200	16,900
7063000[a]	Black River at Poplar Bluff, Mo.	1,245	6.2	115.0	25	16,100	34,300	49,800	73,000	92,700	114,000
						15,900	32,700	46,500	67,600	85,400	105,000
7064000[a]	Black River near Corning, Ark.	1,749	3.6	181.0	32	12,200	21,300	28,100	37,300	44,500	51,900
						12,300	21,300	28,000	37,100	44,100	51,400
7074550	Village Creek near O'Kean, Ark.	6.24	1.8	4.8	21	219	498	764	1,200	1,610	2,090
						235	498	732	1,110	1,460	1,860
7074855	Cypress Creek tributary near	5.54	3.3	6.0	20	316	484	604	764	888	1,020
	Augusta, Ark.					320	488	608	766	887	1,010
7077380	Cache River at Egypt, Ark.	701	1.0	72.9	35	4,390	5,870	6,870	8,160	9,140	10,100
						4,510	6,130	7,300	8,710	9,770	10,800
7077430	Willow Ditch near Egypt, Ark.	.48	4.0	1.2	22	36	67	95	139	179	225
						41	75	104	147	184	226
7077500	Cache River at Patterson, Ark.	1,037	0.8	138.0	52	6,540	9,520	11,600	14,300	16,500	18,700
						6,530	9,460	11,500	14,200	16,300	18,400
7077680	Threemile Creek near Amagon, Ark.	7.93	1.3	7.4	20	295	394	448	506	542	574
						300	405	467	535	578	617
7077700	Bayou DeView at Morton, Ark.	421	2.3	70.4	43	3,210	4,270	4,920	5,670	6,200	6,700
						3,330	4,550	5,400	6,330	6,990	7,630
7077860	Boat Gunwale Slash tributary near	10.0	1.9	7.2	22	340	471	545	625	677	723
	Holly Grove, Ark.					353	498	589	686	751	810
7077920	Big Creek at Goodwin, Ark.	31.1	0.9	17.4	24	563	758	869	992	1,070	1,140
						579	785	913	1,050	1,140	1,220
7077940	Spring Creek near Aubrey, Ark.	38.0	1.5	11.0	20	1,360	1,840	2,110	2,400	2,590	2,760
						1,330	1,800	2,080	2,400	2,610	2,810
7077950	Big Creek at Poplar Grove, Ark.	448	0.7	67.3	14	3,010	4,700	5,760	7,010	7,880	8,690
						3,160	4,830	5,910	7,160	8,030	8,830
7078000	LaGrue Bayou near Stuttgart, Ark.	175	0.8	44.8	19	2,400	3,990	5,070	6,440	7,440	8,420
						2,360	3,790	4,730	5,950	6,830	7,700
7078170	Little LaGrue Bayou tributary near	1.51	3.3	4.3	20	184	221	239	258	269	279
	DeWitt, Ark.					177	215	236	260	276	291
7078210	Tarleton Creek tributary at	.20	18.3	1.0	22	70	117	156	215	267	326
	Ethel, Ark.					69	115	152	208	256	311
7263860	Mile Branch near Tomberlin, Ark.	2.75	3.5	3.1	17	363	502	580	665	720	770
						345	476	550	641	702	758
7264000	Bayou Meto near Lonoke, Ark.	207	1.3	52.4	38	2,140	3,010	3,580	4,310	4,860	5,400
						2,180	3,080	3,690	4,450	5,020	5,580
7264100	White Oak Branch near Lonoke,	8.41	5.2	4.4	24	864	1,270	1,520	1,790	1,970	2,130
	Ark.					836	1,230	1,470	1,760	1,950	2,130
7364110	Nevins Creek tributary near	.75	36.6	1.3	24	142	264	364	512	638	776
	Pine Bluff, Ark.					150	280	388	544	675	819
7364120	Bayou Bartholomew near Star	215	0.6	81.7	32	1,720	2,420	2,840	3,320	3,650	3,950
	City, Ark.					1,730	2,420	2,840	3,310	3,640	3,940
7364125	Cane Creek at Star City, Ark.	4.91	40.8	3.0	22	1,030	1,540	1,860	2,240	2,490	2,730
						1,000	1,530	1,890	2,360	2,690	3,030
7364150	Bayou Bartholomew near	576	0.5	167.0	47	3,180	4,360	5,060	5,860	6,390	6,890
	McGehee, Ark.					3,180	4,340	5,040	5,840	6,370	6,860
7364165	Upper Cutoff Creek near	18.0	11.0	7.7	21	899	1,610	2,220	3,160	4,000	4,960
	Monticello, Ark.					933	1,670	2,300	3,230	4,040	4,950
7364190	Bayou Bartholomew at	1,170	0.4	269.0	48	4,750	5,980	6,700	7,530	8,110	8,650
	Wilmot, Ark.					4,750	5,970	6,720	7,570	8,160	8,710
7364200	Bayou Bartholomew near	1,187	0.4	283.0	27	4,370	5,920	6,800	7,760	8,390	8,960
	Jones, La.					4,400	5,910	6,800	7,780	8,420	9,000
7364500	Bayou Bartholomew near	1,645	0.4	318.0	53	7,040	9,040	10,300	11,700	12,700	13,700
	Beekman, La.					6,970	8,920	10,100	11,500	12,500	13,500
7367658	Cypress Creek Canal No. 19	.94	3.6	1.6	24	155	206	239	280	310	340
	near Dumas, Ark.					152	203	237	281	312	344
7367740	Camp Bayou near Parkdale, Ark.	1.86	4.6	2.6	22	230	296	335	379	409	436
						226	297	342	395	433	468

[a] Before regulation; regulated values are shown in table 3.

Table 2.—Discharge, for selected recurrence intervals, at gaging stations affecting Region B

[A, drainage area; S, slope; P, precipitation; E, elevation, YRS, years of record. Numbers on line with station name are based on station data. Numbers on line below station name are values computed by weighting the regression discharge with the station discharge.]

Station identification number	Station name	A	S	P	E	YRS	Discharge (cubic feet per second), for recurrence interval (years) 2	5	10	25	50	100
7047820	Murray Creek near Jonesboro,	1.38	33.2	48	320	24	503	802	1,020	1,300	1,520	1,750
	Ark.						465	728	926	1,180	1,420	1,670
7047880	Pope Creek tributary at	.08	200.0	49	370	22	52	93	129	185	236	296
	Birdeye, Ark.						48	84	115	157	199	248
7047975	Dog Branch at St. Paul, Ark.	1.23	271.0	48	1,990	21	204	395	545	755	924	1,100
							220	441	638	892	1,120	1,350
7047990	West Fork White River tribu-	.67	290.0	44	1,520	25	172	400	605	919	1,190	1,490
	tary near Greenland, Ark.						171	383	567	821	1,060	1,310
7048000	West Fork White River at	83.1	27.5	45	1,710	38	8,740	16,500	22,900	32,000	39,600	47,800
	Greenland, Ark.						8,590	16,100	22,300	31,000	38,500	46,600
7048600	White River near	400	14.4	45	1,600	21	21,900	38,300	50,500	66,900	79,700	92,800
	Fayetteville, Ark.						21,400	37,300	50,000	67,600	82,400	97,400
7048900	Whitener Branch tributary	1.07	105.0	43	1,380	23	155	312	460	706	940	1,220
	near Spring Valley, Ark.						165	344	521	774	1,020	1,290
7048940	War Eagle Creek near	22.4	42.6	48	1,920	22	3,020	5,990	8,460	12,100	15,200	18,600
	Witter, Ark.						3,010	5,890	8,330	11,700	14,700	18,000
7049000	War Eagle Creek near	262	8.5	45	1,590	25	12,600	22,400	29,600	39,100	46,300	53,600
	Hindsville, Ark.						12,300	21,700	28,800	38,400	46,300	54,300
7049500	White River near Rogers,	1,020	5.6	44	1,500	13	24,200	45,000	60,400	80,900	96,500	112,000
	Ark.						24,400	44,700	60,700	83,200	101,000	120,000
7050000	White River at Beaver,	1,238	3.8	44	1,450	39	30,200	49,100	63,500	83,500	99,700	117,000
	Ark.						29,700	48,100	62,500	83,000	99,800	118,000
7050200	Maxwell Creek at Kingston,	2.75	141.0	45	1,627	21	612	1,310	1,900	2,800	3,570	4,410
	Ark.						596	1,230	1,760	2,490	3,160	3,880
7050400	Freeman Branch at	.73	129.0	43	1,361	20	194	324	419	547	646	749
	Berryville, Ark.						189	326	443	592	731	868
7050500	Kings River near	527	6.8	43	1,540	46	18,100	32,400	42,800	56,700	67,300	78,100
	Berryville, Ark.						17,900	31,800	42,200	56,300	67,600	79,100
7054400	Charley Creek near Omaha,	3.41	112.0	42	1,040	21	1,160	2,000	2,690	3,710	4,590	5,560
	Ark.						1,060	1,770	2,330	3,130	3,880	4,710
7054450	East Sugarloaf Creek tribu-	.85	216.0	42	1,060	23	256	500	720	1,070	1,400	1,780
	tary near Lead Hill, Ark.						245	468	664	946	1,230	1,540
7055550	Crooked Creek tributary near	4.36	56.1	45	1,278	24	616	1,130	1,570	2,240	2,830	3,500
	Dogpatch, Ark.						633	1,200	1,720	2,450	3,130	3,840
7055650	Smith Creek near Boxley, Ark.	8.35	137.0	47	1,905	21	1,450	3,330	5,000	7,550	9,730	12,100
							1,430	3,130	4,560	6,560	8,370	10,300
7055800	Dry Branch near Vendor, Ark.	6.15	233.0	45	1,511	21	1,100	2,290	3,300	4,830	6,140	7,580
							1,080	2,290	3,120	4,410	5,600	6,880
7056000	Buffalo River near St. Joe,	829	10.4	45	1,490	46	36,000	66,700	90,000	122,000	147,000	173,000
	Ark.						35,400	64,700	87,000	118,000	143,000	169,000
7057000	Buffalo River near Rush,	1,096	7.1	44	1380	45	39,600	73,800	101,000	139,000	171,000	205,000
	Ark.						38,700	70,900	95,900	131,000	161,000	193,000
7057300	Dodd Creek tributary near	.76	118.0	43	850	24	261	425	540	687	798	909
	Mountain Home, Ark.						248	407	530	685	828	969
7059000	North Fork River near	1,612	6.4	40	1300	15	24,800	42,100	53,900	68,700	79,400	89,900
	Henderson, Ark.						26,100	47,100	65,100	92,200	112,000	133,000
7060600	Band Mill Creek near	1.25	85.3	44	737	24	238	428	595	861	1,100	1,390
	Brockwell, Ark.						242	450	646	923	1,190	1,480
7060670	Hughes Creek near Mountain	3.20	209.0	47	850	21	857	1,310	1,650	2,100	2,460	2,830
	View, Ark.						819	1,280	1,670	2,190	2,660	3,130
7060710	North Sylamore Creek near	58.1	15.4	45	650	19	4,180	10,800	16,900	26,600	34,900	44,200
	Fifty Six, Ark.						4,190	10,000	14,900	22,100	28,400	35,500
7060830	Wolf Bayou near Drasco,	.27	97.8	49	1050	21	58	123	176	251	312	375
	Ark.						64	137	203	285	360	434
7061100	Gibbs Creek at Sulphur	3.90	46.2	47	460	23	840	1,490	1,990	2,680	3,230	3,800
	Rock, Ark.						816	1,450	1,970	2,650	3,260	3,890
7068000	Current River at Doniphan,	2,038	4.7	44	1000	66	26,000	48,300	65,800	90,200	110,000	131,000
	Mo.						26,800	50,300	69,800	97,500	120,000	143,000
7068870	Fourche River tributary	.19	161.0	46	455	21	140	202	245	302	346	392
	at Middlebrook, Ark.						127	181	222	275	326	380
7068890	Fourche River above	229	10.8	46	510	15	15,600	28,800	38,800	52,400	63,000	73,800
	Pocahontas, Ark.						14,600	26,000	34,500	46,100	56,000	66,300
7069250	Brush Creek near Mammoth	.48	156.0	44	685	24	296	525	705	963	1,170	1,400
	Spring, Ark.						271	462	604	795	969	1,160
7069290	Miller Creek near Salem,	2.28	77.5	44	787	21	544	985	1,330	1,830	2,240	2,680
	Ark.						525	949	1,300	1,770	2,200	2,650
7069500	Spring River at Imboden,	1,183	8.4	44	740	48	26,500	51,100	72,000	104,000	132,000	163,000
	Ark.						27,000	52,200	74,100	107,000	136,000	166,000
7071500	Eleven Point River near	793	10.1	44	1000	63	9200	20,200	29,100	41,800	51,900	62,500
	Bardley, Mo.						10,200	23,000	34,400	51,000	64,200	77,400
7072000	Eleven Point River near	1,134	10.2	43	850	53	12,000	23,200	33,600	50,600	66,500	85,600
	Ravenden Springs, Ark.						13,500	27,700	42,200	65,100	85,300	107,000
7072200	Hubble Creek near	1.33	50.6	47	470	24	616	840	980	1,150	1,270	1,380
	Pocahontas, Ark.						570	780	938	1,140	1,330	1,510
7073000	Strawberry River near	217	6.1	44	740	41	9,130	14,800	19,000	24,600	29,000	33,600
	Evening Shade, Ark.						9,000	14,600	19,000	25,000	29,900	35,000
7073500	Piney Fork at Evening	99.2	7.6	45	670	46	4,770	9,000	12,600	18,100	22,800	28,200
	Shade, Ark.						4,770	8,940	12,500	17,700	22,200	27,300
7074000	Strawberry River near	473	6.0	45	680	48	14,800	27,800	38,900	55,800	70,700	87,600
	Poughkeepsie, Ark.						14,800	27,500	38,300	54,400	68,500	84,200
7074200	Dry Branch tributary near	1.22	61.5	45	649	22	586	1,020	1,300	1,640	1,880	2,110
	Sidney, Ark.						538	902	1,140	1,420	1,670	1,920

Table 2.—Discharge, for selected recurrence intervals, at gaging stations affecting Region B—Continued

Station identification number	Station name	A	S	P	E	YRS	Discharge (cubic feet per second), for recurrence interval (years) 2	5	10	25	50	100
7074250	Reeds Creek near Strawberry, Ark.	34.9	17.1	46	440	21	2,980	5,770	8,180	11,900	15,100	18,800
							2,950	5,640	7,980	11,226	14,400	17,700
7074900	Trace Creek tributary near Marshall, Ark.	.26	609.0	44	1,240	24	90	163	216	285	338	391
							88	161	218	292	355	419
7074950	Tick Creek near Leslie, Ark.	1.58	116.0	45	1,519	23	307	652	937	1,350	1,680	2,040
							311	651	940	1,324	1,660	2,020
7075000	Middle Fork Little Red River at Shirley, Ark.	302	13.9	45	1,160	46	22,600	43,700	61,700	89,100	113,000	140,000
							22,000	41,500	57,600	80,746	102,000	126,000
7075300	South Fork Little Red River at Clinton, Ark.	148	21.1	50	1,150	23	10,900	21,900	30,900	43,900	54,600	66,200
							11,000	21,800	30,800	42,544	54,000	65,300
7075500	South Fork Little Red River near Clinton, Ark.	316	16.6	50	1,150	23	22,200	34,800	43,200	53,800	61,400	69,000
							21,700	34,800	44,900	58,800	70,100	81,300
7075600	Choctaw Creek tributary near Choctaw, Ark.	1.36	103.0	50	683	21	239	448	633	927	1,200	1,510
							256	499	732	1,050	1,330	1,670
7075800	Dill Branch tributary near Ida, Ark.	.26	198.0	50	828	21	58	124	180	264	335	412
							64	138	205	292	369	453
7076000[a]	Little Red River near Heber Springs, Ark.	1,153	10.0	48	1,040	34	54,500	74,400	86,400	100,000	110,000	11,9000
							53,000	73,800	89,300	111,000	123,215	144,000
7076630	Key Branch near Searcy, Ark.	.66	84.8	50	332	22	286	393	458	534	587	637
							264	367	446	546	636	735
7076820	Gum Springs Creek near Higginson, Ark.	5.00	32.4	50	305	21	796	1,140	1,370	1,650	1,850	2,040
							775	1,180	1,550	2,050	2,439	2,920
7076850	Cypress Bayou near Beebe, Ark.	166	2.6	50	330	15	6,260	10,900	14,200	18,600	21,800	25,100
							5,760	9,540	12,100	15,700	17,975	21,600
7076870	Pigeon Roost creek at Butlerville, Ark.	23.0	6.9	50	259	24	1,980	3,650	5,010	7,010	8,700	10,500
							1,850	3,260	4,340	5,880	7,156	8,750
7077100	Big Creek near Boydsville, Ark.	12.8	20.5	47	423	20	2,960	4,300	5,100	6,010	6,630	7,190
							2,700	3,870	4,660	5,690	6,479	7,530
7077200	Big Creek tributary near Boydsville, Ark.	1.58	40.5	47	451	23	376	555	673	820	928	1,030
							369	575	752	979	1,166	1,380
7077340	Sugar Creek tributary near Walcott, Ark.	.68	91.3	48	458	22	286	468	594	753	871	987
							269	438	564	720	853	1,000
7188900	Butler Creek tributary near Gravette, Ark.	.96	109.0	43	1,165	21	104	297	482	772	1,020	1,290
							120	326	522	791	1,022	1,290
7191220	Spavinaw Creek near Sycamore, Okla.	133	20.0	43	1,204	25	3,010	8,880	15,300	26,700	38,000	51,800
							3,740	10,400	17,600	28,700	38,168	51,400
7194890	Osage Creek at Cave Springs, Ark.	40.4	19.5	43	1,300	21	1,230	3,180	5,090	8,260	11,200	14,600
							1,550	3,950	6,360	9,910	12,710	16,500
7195000	Osage Creek near Elm Springs, Ark.	130	16.9	43	1,270	30	5,010	10,500	15,000	21,400	26,600	32,100
							5,310	11,300	16,500	23,800	29,096	36,300
7195200	Brush Creek tributary near Tontitown, Ark.	.37	107.0	43	1,279	21	65	165	259	409	543	694
							70	173	268	400	521	659
7195450	Ballard Creek at Summers, Ark.	14.6	41.0	45	1,360	22	1,640	3,800	5,550	7,960	9,840	11,700
							1,680	3,770	5,490	7,750	9,491	11,600
7195500	Illinois River near Watts, Okla.	635	8.5	44	1,386	29	17,200	33,000	45,100	61,600	74,600	88,000
							17,600	33,900	47,100	65,400	77,645	95,500
7195800	Flint Creek at Springtown, Ark.	14.2	22.7	43	1,340	24	607	1,880	3,450	6,670	10,300	15,200
							738	2,130	3,710	6,420	9,159	13,000
7196000	Flint Creek near Kansas, Okla.	110	19.4	43	1,190	27	3,400	9,990	17,300	30,800	44,500	61,800
							3,900	10,800	18,100	30,000	41,600	55,600
7196900	Barren Fork at Dutch Mills, Ark.	46.0	40.2	46	1,315	27	6,160	13,000	18,300	25,300	30,600	35,900
							5,990	12,200	17,000	23,200	28,300	33,600
7247000[a]	Poteau River at Cauthron, Ark.	203	9.8	45	830	47	11,500	19,900	26,100	34,300	40,700	47,100
							11,300	19,500	25,700	34,000	40,800	47,600
7249300	James Fork near Midland, Ark.	44.0	46.5	42	1,010	20	5,280	11,100	16,200	24,100	31,000	38,800
							5,060	10,300	14,700	21,100	27,000	33,500
7249400	James Fork near Hackett, Ark.	147	14.2	43	770	27	6,040	11,100	15,300	21,600	27,000	33,100
							6,260	11,800	16,900	24,200	30,500	37,200
7249500	Cove Creek near Lee Creek, Ark.	35.3	37.0	46	1,400	35	4,930	9,450	13,300	19,300	24,600	30,500
							4,830	9,130	12,800	18,200	23,100	28,500
7249650	Mountain Fork Creek near Evansville, Ark.	8.15	72.8	46	1,420	20	1,300	2,470	3,370	4,600	5,570	6,570
							1,290	2,450	3,410	4,670	5,790	6,910
7249950	Webber Creek tributary near Cedarville, Ark.	.34	188.0	46	1,000	21	30	101	188	357	537	771
							41	126	221	368	520	703
7250000	Lee Creek near Van Buren, Ark.	426	17.4	45	1,070	42	24,300	43,200	57,700	77,700	93,700	111,000
							24,000	42,700	57,500	78,200	95,500	114,000
7252000	Mulberry River near Mulberry, Ark.	373	18.1	48	1,430	46	18,700	34,400	45,600	60,100	70,700	81,200
							18,900	35,000	47,400	64,000	77,000	89,800
7252200	North Fork White Oak Creek tributary near Watalula, Ark.	.46	318.0	46	920	24	151	257	341	462	563	673
							148	256	349	472	587	706
7252500	Sixmile Creek subwatershed No. 6 near Chismville, Ark.	4.23	55.8	41	720	16	850	1,480	1,910	2,470	2,890	3,290
							801	1,400	1,870	2,490	3,060	3,610
7254000	Sixmile Creek subwatershed No. 5 near Chismville, Ark.	2.76	60.3	40	640	18	374	786	1,110	1,570	1,930	2,300
							381	802	1,160	1,640	2,070	2,510
7254500	Sixmile Creek subwatershed No. 2 near Caulksville, Ark.	5.81	19.8	41	720	16	870	1,450	1,860	2,400	2,820	3,240
							827	1,400	1,870	2,490	3,060	3,620
7255100	Sixmile Creek subwatershed No. 23 near Branch, Ark.	4.49	7.8	40	460	15	787	1,530	2,080	2,800	3,340	3,880
							689	1,240	1,600	2,060	2,460	2,890
7256000	Hurricane Creek near Caulksville, Ark.	53.0	23.8	40	510	16	3,130	5,050	6,360	8,040	9,280	10,500
							3,260	5,820	8,220	11,500	14,500	17,300
7256500	Spadra Creek at Clarksville, Ark.	61.1	49.3	49	870	34	5,170	10,400	14,600	20,500	25,400	30,500
							5,320	10,800	15,400	21,700	27,200	32,700
7257000	Big Piney Creek near Dover, Ark.	274	17.0	49	1,410	34	19,400	37,000	51,500	72,800	90,800	111,000
							19,100	35,900	49,600	69,300	86,300	105,000

Table 2.—Discharge, for selected recurrence intervals, at gaging stations affecting Region B—Continued

Station identification number	Station name	A	S	P	E	YRS	Discharge (cubic feet per second), for recurrence interval (years) 2	5	10	25	50	100
7257060	Mikes Creek tributary near	0.19	371.0	50	1,750	20	49	87	116	159	194	231
	Ozone, Ark.						53	101	144	200	251	301
7257100	Minnow Creek tributary near	.19	311.0	49	540	23	51	101	141	199	246	297
	Hagarville, Ark.						54	109	158	220	277	335
7257500	Illinois Bayou near	241	28.0	49	1,320	37	18,100	34,300	48,000	68,700	86,500	106,000
	Scottsville, Ark.						18,200	34,400	48,500	69,200	87,300	107,000
7257700	McCoy Creek near Dover,	7.05	82.5	49	880	24	744	1,820	2,830	4,430	5,860	7,480
	Ark.						812	1,930	2,980	4,460	5,810	7,270
7258200	Pack Saddle Creek tributary	.92	58.6	43	810	24	172	294	390	529	646	773
	near Waldron, Ark.						176	318	448	622	785	947
7258500	Petit Jean River near	241	9.8	44	670	46	11,300	19,400	25,300	33,300	39,500	45,800
	Booneville, Ark.						11,200	19,300	25,500	34,100	41,000	48,100
7260000	Dutch Creek at Waltreak,	81.4	19.4	47	930	40	6,660	11,100	14,400	18,800	22,200	25,700
	Ark.						6,640	11,200	15,000	20,000	24,200	28,400
7260500[a]	Petit Jean River at	764	3.2	46	720	31	15,100	29,400	41,400	59,400	74,800	91,900
	Danville, Ark.						15,300	29,200	40,800	57,500	71,700	87,200
7260630	Jake Creek near Chickalah,	1.85	38.8	47	535	21	452	849	1,150	1,570	1,900	2,240
	Ark.						444	831	1,140	1,550	1,910	2,280
7260679	East Point Fork Remove	.09	188.0	47	370	18	35	55	70	90	106	122
	Creek tributary near St.						34	56	76	101	126	149
	Vincent, Ark.											
7261000	Cadron Creek near Guy,	169	7.4	50	720	30	8,820	14,300	17,900	22,200	25,300	28,300
	Ark.						8,770	14,300	18,400	23,600	27,800	31,800
7261050	Pine Mountain Creek tributary near Damascus, Ark.	.29	88.2	50	700	22	100	180	246	343	425	516
							100	183	257	352	440	534
7261300	Tan-a-hill Creek near Boles,	2.33	288.0	47	1,360	22	411	997	1,590	2,630	3,650	4,910
	Ark.						422	981	1,510	2,330	3,130	4,090
7261500	Fourche LaFave River near	410	11.0	46	1,040	46	22,900	42,200	57,700	80,300	99,100	120,000
	Gravelly, Ark.						22,500	40,800	55,300	76,300	94,100	114,000
7261800	Brogan Creek near Rover,	1.04	168.0	46	890	22	218	450	663	1,010	1,320	1,690
	Ark.						223	458	674	983	1,270	1,600
7263000	South Fourche LaFave River	210	12.1	48	830	43	20,600	33,400	42,400	54,200	63,100	72,000
	near Hollis, Ark.						19,800	31,600	39,900	50,900	59,800	69,000
7263100	Fourche LaFave River tributary near Perryville, Ark.	1.47	134.0	49	495	23	293	512	676	899	1,080	1,260
							302	550	766	1,040	1,290	1,540
7263400	Little Maumelle River at	15.0	35.5	53	590	22	2,540	5,040	7,020	9,810	12,000	14,400
	Ferndale, Ark.						2,530	4,920	6,840	9,400	11,600	13,900
7263910	Cypress Branch near	2.38	33.2	50	325	24	604	837	991	1,190	1,330	1,480
	Jacksonville, Ark.						573	821	1,030	1,320	1,570	1,830
7338700	Twomile Creek near	16.1	48.9	53	1,240	21	2,010	3,550	4,810	6,670	8,250	10,000
	Hatfield, Ark.						2,100	3,860	5,460	7,640	9,590	11,600
7339500[a]	Rolling Fork near DeQueen,	182	18.6	52	840	25	15,800	31,300	45,100	67,200	87,300	111,000
	Ark.						15,500	29,900	42,200	60,600	77,400	96,900
7339800	Pepper Creek near DeQueen,	6.41	47.7	51	550	24	931	2,240	3,420	5,250	6,830	8,580
	Ark.						969	2,240	3,360	4,920	6,320	7,840
7340000[a]	Little River near Horatio,	2,662	4.2	52	820	39	46,400	71,300	89,000	113,000	132,000	152,000
	Ark.						47,600	75,400	97,800	130,000	155,000	180,000
7340200	West Flat Creek near	10.6	12.0	49	415	21	1,590	2,660	3,390	4,300	4,970	5,610
	Foreman, Ark.						1,500	2,450	3,130	398	4,720	5,460
7340300	Cossatot River near	89.6	29.9	53	1,250	17	15,300	29,300	39,800	54,000	64,800	75,800
	Vandervoort, Ark.						14,300	26,100	34,700	46,100	55,800	66,000
7340500[a]	Cossatot River near	360	15.5	54	890	37	28,200	46,800	61,200	81,600	98,400	116,000
	DeQueen, Ark.						27,700	45,700	60,100	80,300	97,500	115,000
7340530	Mill Slough tributary near	.64	60.5	50	395	22	199	367	492	657	784	912
	Lockesburg, Ark.						193	354	480	638	780	923
7341000[a]	Saline River near Dierks,	121	21.5	55	760	34	9,870	19,000	26,800	38,400	48,500	59,800
	Ark.						10,000	19,200	27,200	38,600	48,500	59,400
7341100	Rock Creek near Dierks,	9.48	50.0	52	580	23	2,090	4,520	6,510	9,330	11,600	14,000
	Ark.						2,030	4,190	5,880	8,120	10,100	12,100
7341200[a]	Saline River near	256	14.3	53	610	21	16,200	34,500	51,200	77,700	102,000	129,000
	Lockesburg, Ark.						16,200	33,100	47,700	69,100	88,600	110,000
7341700	Caney Creek near Hope,	12.9	17.5	51	355	20	2,110	3,590	4,770	6,510	7,970	9,580
	Ark.						1,970	3,280	4,330	5,800	7,130	8,600
7342350	McKinney Bayou near	169	1.8	47	325	41	2,830	4,410	5,470	6,810	7,800	8,770
	Texarkana, Ark.						2,850	4,520	5,770	7,470	8,780	10,100
7344320	Mill Creek tributary near	1.43	36.3	46	295	23	272	491	641	828	962	1,090
	Fouke, Ark.						263	479	646	858	1,050	1,230
7346800	East Fork Kelly Bayou tributary at Kiblah, Ark.	.13	109.0	46	260	20	18	39	57	84	108	134
							20	45	69	101	132	164
7347000	Kelly Bayou near Hosston,	116	4.2	47	240	25	1,420	2,030	2,460	3,010	3,440	3,880
	La.						1,580	2,630	3,690	5,230	6,470	7,670
7348615	Bayou Dorcheat near Bussey,	229	2.9	50	306	12	4,240	8,840	12,800	18,800	24,000	29,800
	Ark.						4,420	8,740	12,300	17,400	21,700	26,500
7348630	Barlow Branch tributary	.05	104.0	50	325	22	24	44	61	87	109	134
	near McNeil, Ark.						23	42	59	81	103	126
7348700	Bayou Dorcheat near	605	3.5	50	290	27	5,950	12,400	18,200	27,200	35,300	44,500
	Springhill, La.						6,600	13,800	20,500	30,400	39,800	48,000
7349430	Bodcau Creek at Stamps,	234	3.6	50	320	24	3,270	6,550	9,230	13,100	16,400	19,800
	Ark.						3,610	7,290	10,500	15,000	18,800	22,600
7349500	Bodcau Bayou near Sarepta,	546	1.8	49	226	48	4,280	7,620	10,100	13,300	15,800	18,300
	La.						4,430	8,020	10,900	14,900	18,000	21,100
7355800	Lewis Creek tributary near	.65	159.0	51	1,140	24	193	304	385	493	578	667
	Mena, Ark.						194	320	430	568	694	819
7355900	Big Fork tributary at Big	.16	184.0	56	1,200	19	40	68	93	130	162	199
	Fork, Ark.						46	86	128	179	226	274

Tabla 2.—Discharge, for selected recurrence intervals, at gaging stations affecting Region B—Continued

Station identification number	Station name	A	S	P	E	YRS	Discharge (cubic feet per second), for recurrence interval (years) 2	5	10	25	50	100
7356000	Ouachita River near Mount	414	7.8	52	1,160	43	22,200	38,200	50,400	67,600	81,500	96,400
	Ida, Ark.						21,900	37,200	48,900	65,300	78,900	93,500
7356500	South Fork Ouachita River	64.0	15.4	53	830	29	6,760	11,600	15,200	19,900	23,500	27,200
	at Mount Ida, Ark.						6,640	11,300	15,000	19,700	23,600	27,700
7356700	Barnes Branch near Mount	1.85	82.2	53	760	22	428	862	1,230	1,790	2,270	2,810
	Ida, Ark.						435	867	1,240	1,740	2,200	2,700
7357501[a]	Ouachita River at Blakely	1,100	5.2	52	880	16	42,100	67,300	85,900	111,000	131,000	152,00
	Mountain Dam, near Hot						40,200	63,500	81,400	107,000	127,000	149,001
	Springs, Ark.											
7357700	Glazypeau Creek at Mountain	3.84	72.1	56	810	24	629	1,230	1,720	2,420	2,980	3,590
	Valley, Ark.						668	1,320	1,900	2,660	3,310	3,980
7359500[a]	Ouachita River near	1,585	4.4	56	810	30	54,200	90,100	115,000	145,000	168,000	190,000
	Malvern, Ark.						53,100	86,800	110,000	141,000	165,000	189,000
7359520	Jackson Creek near	3.00	72.1	55	530	20	283	684	1,080	1,770	2,420	3,210
	Malvern, Ark.						357	853	1,350	2,060	2,720	3,450
7359700	Caddo River at Glenwood,	192	18.7	55	970	36	21,100	38,000	50,900	68,600	82,700	97,400
	Ark.						20,500	36,300	48,100	64,300	77,700	91,900
7359750	Little Sugarloaf Creek	2.34	86.7	58	740	22	807	1,650	2,340	3,310	4,100	4,940
	near Bonnerdale, Ark.						781	1,530	2,120	2,880	3,550	4,270
7359800	Caddo River near Alpine,	312	12.3	56	870	28	25,900	39,500	48,600	60,000	68,400	76,700
	Ark.						25,100	38,200	47,900	60,700	71,100	81,500
7360150	Pearson Creek tributary	.40	52.1	52	340	21	75	169	266	440	615	837
	near Dalark, Ark.						79	178	276	424	572	750
7360800	Muddy Fork Creek near	121	19.2	53	560	41	10,900	18,700	24,800	33,400	40,400	48,000
	Murfreesboro, Ark.						10,900	18,700	25,100	33,400	41,500	49,400
7361020	Prairie Creek tributary	.16	217.0	54	635	22	69	138	198	291	375	471
	near Kirby, Ark.						69	136	195	273	348	431
7361180	South Fork Ozan Creek near	17.7	16.1	52	400	22	4,200	5,860	6,880	8,090	8,940	9,740
	Ozan, Ark.						3,830	5,230	6,170	7,410	8,510	9,630
7361200	Ozan Creek near McCaskill	148	9.3	52	420	41	7,330	12,700	16,800	22,500	27,100	32,100
	Ark.						7,360	12,800	17,200	23,300	28,300	33,600
7361500	Antoine River at Antoine,	178	8.4	52	520	35	12,000	18,800	23,600	30,100	35,100	40,300
	Ark.						11,800	18,400	23,400	30,300	35,900	41,700
7361680	Middle Caney Creek tribu-	1.48	47.9	51	357	24	225	463	663	958	1,210	1,480
	tary near Rosston, Ark.						237	488	714	1,020	1,300	1,590
7361780	Bradshaw Creek near	3.46	21.9	52	320	20	473	730	917	1,170	1,370	1,580
	Hollywood, Ark.						473	777	1,050	1,420	1,750	2,080
7361800	Terre Noire Creek east of	250	7.4	52	296	41	16,900	24,000	28,800	34,900	39,500	44,000
	Gurdon, Ark.						16,100	22,600	27,200	33,400	38,500	43,700
7362050	Ross Creek near Camden,	10.4	17.5	50	202	21	386	903	1,380	2,140	2,810	3,580
	Ark.						434	1,020	1,600	2,430	3,180	3,990
7362100	Smackover Creek near	385	4.0	50	230	46	5,860	11,800	17,000	24,900	31,800	39,600
	Smackover, Ark.						5,940	11,900	17,100	24,800	31,500	39,000
7362330	Dunn Creek near Hampton,	13.6	11.2	50	187	23	743	1,740	2,680	4,210	5,620	7,260
	Ark.						731	1,640	2,450	3,670	4,800	6,130
7362450	Cooks Creek near Fordyce,	4.99	20.0	51	315	20	665	1,290	1,780	2,440	2,960	3,490
	Ark.						652	1,250	1,730	2,360	2,910	3,480
7362500	Moro Creek near Fordyce,	240	5.6	51	270	34	4,520	9,090	12,700	17,700	21,700	25,800
	Ark.						4,710	9,480	13,400	19,000	23,500	28,100
7363000	Saline Rivar at Benton,	550	12.4	54	650	47	29,600	49,400	63,500	81,700	95,400	109,000
	Ark.						29,500	49,500	64,500	84,600	100,000	116,000
7363050	Holly Creek tributary near	1.44	47.0	53	345	23	184	406	634	1,040	1,460	1,980
	Benton, Ark.						201	445	694	1,070	1,450	1,890
7363200	Saline River near Sheridan,	1,129	4.5	54	460	47	25,300	40,800	51,600	65,600	76,000	86,500
	Ark.						25,700	42,100	54,600	71,700	84,600	97,500
7363300	Hurricane Creek near	204	6.9	53	375	24	7,760	15,700	21,900	30,500	37,200	44,000
	Sheridan, Ark.						7,820	15,400	21,200	29,200	35,700	42,400
7363330	West Fork Big Creek at	4.86	22.2	53	290	22	446	959	1,390	2,040	2,580	3,160
	Sheridan, Ark.						469	1,000	1,480	2,130	2,710	3,310
7363430	East Fork Derrieusseaux	.64	64.5	51	350	21	118	260	393	609	807	1,040
	Creek near Pine Bluff,						123	269	405	597	779	984
	Ark.											
7363450	Varnell Creek near Rison,	.28	63.3	51	243	21	47	111	168	252	323	400
	Ark.						49	114	172	250	321	398
7363500	Saline River near Rye,	2,102	2.4	52	360	47	23,700	41,800	55,000	72,700	86,300	100,000
	Ark.						24,300	43,000	57,400	77,400	92,700	108,000
7364030	L'Aigle Creek tributary near	.36	48.3	52	170	22	36	77	109	151	183	214
	Hermitage, Ark.						39	87	132	189	240	291
7364070	Bear Creek near Strong,	5.62	15.2	52	165	21	337	541	680	855	985	1,110
	Ark.						341	589	810	1,110	1,380	1,640
7364260	Hanks Creek near Hamburg,	20.9	6.5	54	170	22	686	1,270	1,700	2,260	2,690	3,120
	Ark.						697	1,310	1,810	2,490	3,050	3,630
7364300	Chemin-a-Haut Bayou near	271	3.3	54	142	24	4,860	10,400	15,000	21,800	27,500	33,500
	Beekman, La.						4,690	9,590	13,400	19,000	23,700	28,900
7364550	Caney Creek tributary near	.13	222.0	49	235	23	72	132	186	274	354	450
	El Dorado, Ark.						65	115	158	221	283	357
7364700	Bayou de Loutre near	141	3.6	49	203	22	2,490	5,580	8,770	14,500	20,400	28,000
	Laran, La.						2,510	5,410	8,180	12,700	17,200	22,800
7365800	Cornie Bayou near Three	180	5.1	48	250	29	4,030	9,790	15,700	26,300	36,900	50,200
	Creeks, Ark.						4,050	9,390	14,500	22,900	31,200	41,500
7365900	Three Creeks near Three	50.3	6.2	48	245	23	2,110	4,790	7,430	11,900	16,300	21,600
	Creeks, Ark.						2,040	4,400	6,520	9,840	13,100	17,000
7366000	Corney Bayou near Lillie,	462	3.5	48	185	43	5,930	11,500	16,500	24,300	31,500	39,700
	La.						5,930	11,500	16,400	23,900	30,800	38,500
7366200	Little Corney Bayou near	208	3.7	48	201	29	3,210	6,870	10,100	15,200	19,700	24,800
	Lillie, La.						3,240	6,790	9,870	14,500	18,600	23,200

a Before regulation; regulated values are shown in table 3.

Table 3.—Discharge, for selected recurrence intervals, on large streams and regulated streams

[A, drainage area; YRS, years of record. Numbers on line with station name are based on station data.]

Station identification number	Station name	A	YRS	Discharge (cubic feet per second), for recurrence interval (years) 2	5	10	25	50	100
7032000[a]	Mississippi River at Memphis, Tenn.	932,800	52	1,170	1,410	1,540	1,680	1,770	1,840
7040100	St. Francis River at St. Francis, Ark.	1,772	39	10,600	15,300	18,600	22,800	26,000	29,300
7040450	St. Francis River at Lake City, Ark.	2,374	39	14,100	20,500	24,900	30,700	35,100	39,700
7046600	Right hand chute of Little River at Rivervale, Ark.	2,106	36	14,900	24,500	30,900	38,800	44,600	50,100
7047000	St. Francis River floodway near Marked Tree, Ark.	0	36	19,200	32,000	40,500	51,000	58,500	65,700
7047500	St. Francis River at Marked Tree, Ark.	0	39	3,530	4,320	4,820	5,420	5,850	6,270
7047501[b]	St. Francis River and St. Francis River floodway near Marked Tree, Ark.	5,148	36	22,000	35,400	44,300	55,100	62,800	70,200
7047950	L'Anguille River at Palestine, Ark.	786	32	8,570	12,700	15,100	18,000	20,000	21,800
7047800	St. Francis River at Parkin, Ark.	0	49	10,000	13,500	15,700	18,400	20,400	22,200
7047900	St. Francis Bay at Riverfront, Ark.	0	46	21,100	33,000	40,900	50,500	57,400	64,100
7047902[c]	St. Francis River at Parkin and St. Francies Bay at Riverfront combined	6,475	42	26,700	39,500	47,700	57,600	64,700	71,500
7047970[a]	Mississippi River at Helena, Ark.	941,700	54	1,200	1,450	1,580	1,730	1,830	1,920
7049691	White River at Beaver Dam near Eureka Springs, Ark.	1,192	19	6,320	9,720	12,400	16,100	19,200	22,600
7055000	White River near Flippin, Ark.	6,067	33	25,200	29,400	31,300	33,100	34,200	35,000
7060000	North Fork River at Norfork Dam, near Norfork, Ark.	1,806	40	5,540	8,310	10,300	13,100	15,400	17,700
7060500	White River at Calico Rock, Ark.	9,978	42	62,900	115,000	158,000	224,000	282,000	348,000
7061000	White River at Batesville, Ark.	11,062	14	64,900	114,000	153,000	211,000	260,000	314,000
7064000	Black River near Corning, Ark.	1,749	36	11,800	20,000	25,900	33,700	39,600	45,500
7069000	Black River at Pocahontas, Ark.	4,845	48	23,400	39,200	51,500	69,400	84,200	100,000
7072500	Black River at Black Rock, Ark.	7,369	36	44,700	76,200	101,000	136,000	164,000	195,000
7074500	White River at Newport, Ark.	19,860	41	82,900	143,000	191,000	262,000	323,000	389,000
7076000	Little Red River near Heber Springs, Ark.	1,146	23	8,400	8,960	9,290	9,670	9,930	10,200
7077000	White River at DeValls Bluff, Ark.	23,483	41	875,00	125,000	149,000	177,000	198,000	217,000
7077800	White River at Clarendon, Ark.	25,555	28	81,600	118,000	143,000	174,000	197,000	221,000
7247000	Poteau River at Cauthron Ark.	203	12	8,510	12,000	14,400	17,400	19,600	21,800
7250550	Arkansas River at Dam No. 13 near Van Buren, Ark.	150,547	15	144,000	189,000	218,000	251,000	275,000	298,000
7250550[d]	Arkansas River at Dam No. 13 near Van Buren, Ark.	150,547	45	155,000	218,000	264,000	324,000	372,000	420,000
7251000	Frog Bayou near Mountainburg, Ark.	74.2	25	4,530	8,620	11,500	15,200	17,800	20,400
7251500	Frog Bayou at Rudy, Ark.	216	36	11,100	20,400	26,900	35,200	41,300	47,200
7253000	Sixmile Creek at Chismville, Ark.	24.1	16	1,090	2,130	2,900	3,910	4,680	5,440
7253500	Sixmile Creek near Branch, Ark.	36.7	16	2,150	3,800	4,980	6,520	7,660	8,810
7255000	Sixmile Creek at Caulksville, Ark.	104	16	4,940	7,830	9,810	12,300	14,200	16,100
7255500	Hurricane Creek near Branch, Ark.	17.2	16	748	1,440	1,970	2,700	3,270	3,850
7258000	Arkansas River at Dardanelle, Ark.	153,670	45	201,000	320,000	405,000	518,000	605,000	696,000
7259500	Petit Jean River near Waveland, Ark.	516	37	3,500	5,260	6,510	8,200	9,520	10,900
7260500	Petit Jean River at Danville, Ark.	764	37	8,650	15,900	21,900	30,700	38,300	46,700
7262500	Fourche LaFave River near Nimrod, Ark.	684	42	5,750	7,450	8,660	10,300	11,600	12,900
7263450	Arkansas River at Murray Dam at Little Rock, Ark.	158,030	45	203,000	306,000	373,000	458,000	521,000	582,000
7264500	Bayou Meto near Stuttgart, Ark.	574	45	1,930	2,790	3,410	4,250	4,900	5,600
7265000	Crooked Creek near Humphrey, Ark.	79.2	40	1,380	1,930	2,230	2,560	2,780	2,960

Table 3.--Discharge, for selected recurrence intervals, on large streams and regulated streams--Continued

Station identification number	Station name	A	YRS	Discharge (cubic feet per second), for recurrence interval (years) 2	5	10	25	50	100
7265001	Bayou Meto and Crooked Creek near Stuttgart, Ark.	653	45	3,330	4,750	5,640	6,700	7,460	8,190
7265450[a]	Mississippi River near Arkansas City, Ark.	1,130,600	54	1,320	1,620	1,800	2,010	2,150	2,290
7337000	Red River at Index, Ark.	48,030	42	76,000	109,000	130,000	156,000	174,000	192,000
7339500	Rolling Fork near DeQueen, Ark.	182	11	3,460	5,440	6,830	8,640	10,000	11,400
7340000	Little River near Horatio, Ark.	2,674	16	27,700	41,900	51,500	63,700	72,800	81,800
7340500	Cossatot River near DeQueen, Ark.	361	10	8,020	14,000	18,600	24,800	29,800	35,000
7341000	Saline River near Dierks Ark.	124	12	2,690	5,450	7,880	11,700	15,100	19,000
7341200	Saline River near Lockesburg, Ark.	260	11	10,000	19,300	27,400	40,200	51,800	65,200
7341301	Little River at Millwood Dam near Ashdown, Ark.	4,119	18	33,500	50,100	61,300	75,600	86,200	96,900
7341500	Red River at Fulton, Ark.	52,380	31	90,100	131,000	159,000	195,000	223,000	251,000
7348500	Red River at Shreveport, La.	60,613	37	114,000	164,000	196,000	237,000	267,000	297,000
7357501	Ouachita River at Blakely Mountain Dam near Hot Springs, Ark.	1,105	31	6,590	8,610	9,730	11,000	11,800	12,500
7359500	Ouachita River near Malvern, Ark.	1,585	32	28,200	51,200	71,300	103,000	131,000	164,000
7359910	Caddo River at DeGray regulating dam near Arkadelphia, Ark.								
7360000	Ouachita River at Arkadelphia, Ark.	2,311	33	39,300	68,000	90,000	121,000	146,000	172,000
7360501	Little Missouri River at Narrows Dam near Murfressboro, Ark.	237	34	2,600	3,740	4,530	5,560	6,360	7,170
7361000	Little Missouri River near Murfreesboro, Ark.	380	28	12,600	20,000	25,100	31,500	36,200	40,800
7361600	Little Missouri River near Boughton, Ark.	1,068	32	26,800	41,800	51,600	63,600	72,100	80,400
7362000	Ouachita River at Camden, Ark.	5,357	32	58,300	101,000	134,000	178,000	213,000	250,000
7364000	Saline River near Warren, Ark.	2,476	13	19,400	34,800	46,600	62,900	75,900	89,600
7367661	Boeuf River near Lake Village, Ark.	355[e]	35	4,530	6,940	8,590	10,700	12,300	13,900
7367670	Wards Bayou tributary at Montrose, Ark.	3.24	23	262	383	464	567	643	719
7367680	Boeuf River near Eudora, Ark.	640[e]	42	9,260	12,700	15,000	17,700	19,700	21,600
7367700	Boeuf River near Ark.-La. State line	785[e]	35	11,700	15,300	17,400	19,800	21,400	22,800
7369680	Bayou Macon at Eudora, Ark.	485[e]	44	2,840	3,770	4,330	4,980	5,420	5,830
7369700	Bayou Macon near Kilbourne, Ark.	504[e]	11	2,800	4,120	4,930	5,880	6,530	7,140

[a] Discharge in thousands of cubic feet per second.
[b] St. Francis floodway near Marked Tree (07047000) and St. Francis River at Marked Tree (07047500) combined.
[c] St. Francis River at Parkin (07047800) and St. Francis Bay at Riverfront (07047900) combined.
[d] Adjusted to 45-year period based on data at stations 07258000 and 07263450.
[e] Interchange of flow at high stages.

Basin and Climatic Characteristics

The following are defined for use in this report:

1. Drainage area, A.--The contributing drainage area of the basin, in mi^2.
2. Channel slope, S.--The slope, in feet per mile (ft/mi), computed between two points along the main channel--one point at 10 percent of the channel length, and the other point at 85 percent of the channel length. Both points are measured from the gaged site (or point of intersection when computing discharges for ungaged sites).
3. Main channel length, L.--The channel length, in miles, between the gaged site and the basin divide.
4. Mean basin elevation, E.--The average ground elevation, in ft above sea level, of several equal-area subdivisions of the basin. The drainage basin was overlain with an appropriate sized grid to provide a minimum of 25 subdivisions.
5. Mean annual precipitation, P.--The mean annual precipitation for the basin, in in., during the period 1951-81 (see fig. 3) (Freiwald, 1985).

Regression Analysis

After the discharge-frequency relations were defined and basin and climatic parameters determined for gaging stations used in the analysis, the peak discharge for each recurrence interval was related to the basin and climatic parameters using the linear multiple-regression techniques. The equation has the form:

$$Y = aA^{b1} S^{b2} P^{b3} ----, \qquad (1)$$

where,

Y is the peak-discharge characteristic,
A, S, and P are basin and climatic characteristics, and
a, b1, b2, and b3 are constants and coefficients obtained by regression analysis.

Initially all basin and climatic parameters were used in each regression. The final regression used only those that were statistically significant at the 5-percent level. Only stations with drainage basins less than 3,000 mi^2 having predominantly natural flow and at least 10 years of record were used in the regression analysis. On regulated streams, the data collected prior to regulation were used if that period was of sufficient length.

Initially, data for all stations in the State were used in one regression analysis and the residuals were plotted on a State map. The residual is the actual discharge from station data divided by the computed discharge using the regression equation. The residual from the regression analysis was plotted on a State map. The distribution of residuals showed that the State should be divided into two regions to improve the accuracy of the regression equations because residuals were generally positive in one region and negative in the other. These regions are the same as those defined by Patterson (1971) in the previous flood-frequency report. Region A (fig. 4) includes most of the Mississippi Alluvial Plain in Arkansas, with the exception of Crowleys Ridge. Region B includes the rest of the State. Equations were developed separately for Regions A and for B.

Each basin characteristic was checked by residual analysis to see if it was biased. Biased values did occur for slopes greater than 30 ft/mi and for mean basin elevations greater than 500 ft. To remove this bias, all slopes greater than 30 ft/mi were used as 30 ft/mi and all elevations higher than 500 ft were used as 500 ft.

Peak Discharge Equations for Region A

The regression analysis indicated that, drainage area, channel slope, and channel length are significant characteristics for estimating flood magnitudes in Region A. The following equations were developed for rural streams by the multiple regression technique using data from 33 gaging stations in Region A (fig. 4) in Arkansas. Data for these stations are listed in table 1.

Equation	Average standard error of regression, in percent	Equivalent years of record	
$Q_2 = 107\ A^{0.83}\ S^{0.28}\ L^{-0.33}$	± 30	3	(2)
$Q_5 = 149\ A^{0.88}\ S^{0.36}\ L^{-0.40}$	± 28	4	(3)
$Q_{10} = 175\ A^{0.90}\ S^{0.40}\ L^{-0.42}$	± 29	5	(4)
$Q_{25} = 205\ A^{0.92}\ S^{0.45}\ L^{-0.44}$	± 33	5	(5)
$Q_{50} = 226\ A^{0.93}\ S^{0.48}\ L^{-0.45}$	± 36	5	(6)
$Q_{100} = 245\ A^{0.94}\ S^{0.51}\ L^{-0.46}$	± 40	5	(7)

where,

Q_x = the estimated discharge, in ft^3/s for the indicated recurrence interval x,
A = drainage area, in mi^2,
S = channel slope, in ft/mi. If S is greater than 30, use 30 for S, and
L = channel length, in miles.

Channel length, L, is used in the equations as an index to shape and has a negative exponent. Two basins of equal area will have a lower discharge in the longer basin because of the longer travel time.

Landers (1985) developed equations for the alluvial plain of the lower Mississippi River which includes Region A in Arkansas. Computed discharges using Lander's equations compare favorably with computed discharges using equations shown above.

Peak Discharge Equations for Region B

The regression analysis indicated that drainage area, channel slope, annual precipitation, and mean basin elevation are significant parameters for estimating flood magnitudes in Region B. The following equations were developed using data from 167 gaging stations and are recommended for estimating flood magnitudes for rural streams in Region B (fig. 4). Data for these stations are listed in table 2.

	Average standard error of regression, in percent	Equivalent years of record	
$Q_2 = 0.120\ A^{0.78}\ S^{0.42}\ (P-30)^{0.55}\ E^{0.75}$	±42	4	(8)
$Q_5 = 0.521\ A^{0.78}\ S^{0.48}\ (P-30)^{0.43}\ E^{0.64}$	±34	7	(9)
$Q_{10} = 1.07\ A^{0.78}\ S^{0.51}\ (P-30)^{0.38}\ E^{0.59}$	±33	10	(10)
$Q_{25} = 2.23\ A^{0.79}\ S^{0.53}\ (P-30)^{0.33}\ E^{0.53}$	±33	13	(11)
$Q_{50} = 3.58\ A^{0.79}\ S^{0.55}\ (P-30)^{0.29}\ E^{0.50}$	±35	14	(12)
$Q_{100} = 5.35\ A^{0.79}\ S^{0.56}\ (P-30)^{0.27}\ E^{0.47}$	±38	14	(13)

where,

Q_x = the estimated discharge, in ft^3/s for the indicated recurrence interval x,
A = the drainage area, in mi^2,
S = channel slope, in ft/mi. If S is greater than 30, use 30 for S.
P = mean annual precipitation, in in., and
E = mean basin elevation, in ft. If E is greater than 500, use 500 for E.

Accuracy of Estimating Equations

Accuracy of estimating equations is computed from the difference between station data and the regression equations. The accuracy, in percent, referred to as standard error, is the range of error to be expected about two-thirds of the time. The actual error associated with the use of the equations to estimate flood magnitudes at a given ungaged site is unknown. The error is assumed to equal the standard error of the regression equation.

The accuracy of estimating equations can also be evaluated by the equivalent years of record. The equivalent years of record are an estimate of the number of actual years of streamflow record required at a site to achieve an accuracy equivalent to the regional flood estimate from regression equations (Hardison, 1969). It is used in this report to weight the station log-Pearson Type III data with the regression flood-frequency estimate. This weighting procedure is intended to produce a flood-frequency relation at each site that is more realistic of the long-term relation than the station data or the regression data alone. This procedure for weighting the data is described in a later section of this report.

Sensitivity analyses were performed to measure the sensitivity of the regression equation to measurement errors of the regression parameters. All parameters were assumed to be constant except the one being tested for sensitivity; that parameter was assumed to contain an error ranging from +50 percent to -50 percent. For example, assume that drainage area, A, contains an error of +30 percent in Region A. Then the effect on computed 2-year peak discharge would be 24 percent. The sensitivity of the estimating equations for the 2- and 100-year flood magnitudes to error in basin and climatic parameters is shown below.

Percent error in computed discharge for Region A

Percent error in independent variable	2-year discharge independent variable			100-year discharge independent variable		
	A	S	L	A	S	L
50	40	12	-13	46	23	-18
30	24	8	- 8	28	14	-12
10	8	3	-3	9	5	-4
-10	-8	-3	4	-9	-5	5
-30	-26	-10	12	-28	-17	18
-50	-44	-18	26	-48	-30	39

Percent error in computed discharge for Region B

Percent error in independent variable	2-year discharge independent variable				100-year discharge independent variable			
	A	S	P	E	A	S	P	E
50	37	19	25	36	38	25	12	21
30	22	12	16	22	23	16	7	13
10	8	4	5	7	8	5	3	5
-10	-8	-4	-6	-8	-8	-6	-3	-5
-30	-24	-14	-18	-23	-25	-18	-9	-15
-50	-41	-25	-32	-41	-42	-32	-17	-28

It is very important to accurately measure the parameters that are used in the regression equation. The percent error tables for Regions A and B show that the equations are most sensitive to errors in drainage area, A.

Limitations

The following limitations should be observed when using the regression equations.

1. They should be used for rural areas of Arkansas and should not be used in urban areas unless the effects of urbanization are insignificant.

2. They should not be used where dams, flood-detention structures, and other manmade works have a significant effect on peak discharges. Under such conditions, stream-system studies beyond the scope of this report involving reservoir and open-channel routing may be required to evaluate flood frequency.

3. They should be used on streams with drainage areas less than 3,000 mi^2.

FLOOD MAGNITUDE AND FREQUENCY AT OR NEAR GAGED SITES ON STREAMS DRAINING LESS THAN 3,000 SQUARE MILES

Flood frequency at gaged sites less than 3,000 mi^2 can be determined by a combined use of the regression equations and the gaging station frequency curve. The recommended procedure is to compute the discharge for the desired recurrence interval as a weighted average of the station value and the regression value. The weighted average is based on the length of record of the station data and equivalent years of record for the regression value as determined in a previous section. The weighted values are considered the best estimates for design purposes at a site. The equation used to compute the weighted average is

$$Qx(w) = \frac{Qx(s)(N)+Qx(r)(EQ)}{N+EQ}, \tag{14}$$

where,

Qx(w) = the weighted discharge for recurrence interval x,
Qx(s) = the station discharge for recurrence interval x,
Qx(r) = the regression discharge for recurrence interval x,
N = the number of years of station data used to compute Qx(s), and
EQ = the equivalent years of record for Qx(r) shown previously.

An example of the computations is illustrated in the following table by using station 07073000, Strawberry River near Evening Shade.

Recurrence interval x, in years	Qx(s), in ft^3/s	N, in years	Qx(r), in ft^3/s	E, in years	Qx(w),[1] in ft^3/s
2	9,130	41	7,670	4	9,000
5	14,800	41	13,700	7	14,600
10	19,000	41	19,000	10	19,000
25	24,600	41	26,100	13	25,000
50	29,000	41	32,500	14	29,900
100	33,600	41	38,900	14	35,000

[1] Qx(w) values are shown in tables 1 and 2 for all gaging stations used to define the regression equations.

Flood frequency at sites less than 3,000 mi^2 that are relatively near a gaging station and on the same stream can be calculated by a combined use of the regression equations and the nearby station data. The following procedure is suggested for use if the site has a drainage area within 50 percent of the drainage area of the gaging station. The weighted value, Qx(w), and the regression value, Qx(r), for the gaged site should be computed as described in the preceding paragraphs.

The ratio,

$$R = \frac{Qx(w)}{Qx(r)}, \tag{15}$$

is then calculated for the gaged site. This ratio represents the correction needed to adjust the regression value, Qx(r), to the weighted value, Qx(w), at the gaged site. The calculations for determining the correction factor, R', for an ungaged site that is near a gaged site on the same stream have been reduced to the equation

$$R' = R - \frac{\Delta A(R-1.00)}{0.5Ag} \tag{16}$$

where,

R' = correction factor that is multiplied by the regression value, Qx(r), for the ungaged site,
ΔA = the difference between the drainage areas of the gaged and ungaged sites, and
Ag = drainage area of the gaged site.

If the drainage area of the ungaged site is 50 percent more than or less than the gaged site, that is, ΔA/Ag is greater than 0.5, equation 16 should not be used and the results of the regression equations should be used without adjustment.

The site for which flood-frequency calculations are desired may sometimes be between two gaged sites on the same stream. The 50-percent rule should be applied to determine which gage, if any, should be used to make the adjustment. If the ungaged site is within 50 percent of both gaged sites, correction factors should be computed using each gaged site. If both correction factors are greater than unity, the larger should be used. If both correction factors are less than unity, the smaller should be used. If one is greater than unity and one is less than unity, an average of both correction factors should be used.

The following example illustrates the calculations for determining a 100-year flood for an ungaged site that is between two gaging stations on the same stream. For this example the gaged sites are station 07073000, Strawberry River near Evening Shade, Arkansas, and station 07074000, Strawberry River near Poughkeepsie, Arkansas; and the ungaged site is where the drainage area equals 300 mi^2. Following are data and calculations needed for the gaged and ungaged sites, which are used to compute Q_{100} at the ungaged site. The drainage area of the ungaged site (300 mi^2) is within 50 percent of the drainage areas at both gaged sites. Therefore, the station data for both gaged sites are used in the computations.

(1) Gaged site, 07073000, Strawberry River near Evening Shade:

$Ag = 217\ mi^2$,
$S = 6.06$ ft/mi,
$P = 44$ in.,
$E = 740$ ft,
$N = 41$ years,
$EQ = 14$ years,
$Q_{100}(s) = 33{,}600\ ft^3/s$, from station data,
$Q_{100}(r) = 38{,}900\ ft^3/s$, from regression equation 13,
$Q_{100}(w) = 35{,}000\ ft^3/s$, from equation 14, and
$R = Q_{100}(w)/Q_{100}(r) = 35{,}000/38{,}900 = 0.90$ from equation 15.

(2) Gaged site, 07074000, Strawberry River near Poughkeepsie:

$Ag = 473\ mi^2$,
$S = 5.96$ ft/mi,
$P = 45$ in.,
$E = 680$ ft,
$N = 48$ years,
$EQ = 14$ years,
$Q_{100}(s) = 87{,}600\ ft^3/s$, from station data,
$Q_{100}(r) = 72{,}800\ ft^3/s$, from regression equation 13,
$Q_{100}(w) = 84{,}200\ ft^3/s$, from equation 14,
$R = Q_{100}(w)/Q_{100}(r) = 84{,}200/72{,}800 = 1.16$ from equation 15.

(3) Ungaged site:

$A = 300\ mi^2$,
$S = 6.00$ ft/mi,
$P = 45$ in.,
$E = 710$ ft,
$Q_{100}(r) = 51{,}000\ ft^3/s$, from regression equation 13
$\Delta A = 300 - 217 = 83\ mi^2$ using Evening Shade
$R' = 0.90 - \frac{83}{0.5*217}(0.90-1.00) = 0.98$ using Evening Shade
$\Delta A = 473-300=173\ mi^2$ using Poughkeepsie
$R' = 1.16 - \frac{173}{0.5*473}(1.16-1.00) = 1.04$ using Poughkeepsie.

Since R' using Evening Shade is less than unity and R' using Poughkeepsie is greater than unity, the average is used.

$$R' = (0.98 + 1.04)/2 = 1.01$$
$$Q_{100} = Q_{100}(r)\ (R') = 51{,}000\ (1.01) = 51{,}500\ ft^3/s.$$

This is considered the best estimate for the 100-year peak discharge at the ungaged site on Strawberry River.

FLOOD MAGNITUDE AND FREQUENCY AT UNGAGED SITES ON STREAMS DRAINING LESS THAN 3,000 SQUARE MILES USING THE HYDRAULIC RADIUS

An alternate procedure for computing flood frequency which uses the hydraulic radius as one of the basin characteristics is described in this section. The hydraulic radius in conjunction with the channel slope probably is a better index to the velocity of the flood wave than channel slope alone. Hydraulic radius has not been used in flood-frequency reports in the past because it is difficult to determine at ungaged sites. In order to determine the hydraulic radius at an ungaged site, a cross section of the stream valley and a stage-discharge relation must be known. This part of the report describes a way to estimate a cross section from topographic maps and to compute a stage-discharge relation for that section. The hydraulic radius and the corresponding discharge can be determined at several stages to develop a hydraulic radius-discharge relation. The hydraulic radius can then be determined for any discharge for use in equations 17-28.

Using this procedure a preliminary discharge for any selected recurrence interval can be determined using equations 2-13. This preliminary discharge is used to determine the hydraulic radius at the ungaged site. The hydraulic radius and other basin and climatic characteristics are used in equations 17-28 to determine the final discharge. Calculations of the hydraulic radius are not recomputed using the results of equations 17-28.

The peak discharge equations for Region A using the hydraulic radius procedure are shown below. The hydraulic radius and N data for these stations are listed in table 4.

Equation	Average standard error of regression, in percent	
$Q_2 = 133\ A^{0.57}\ S^{0.16}\ L^{-0.23}\ R^{1.02}\ N^{-1.38}$	± 22	(17)
$Q_5 = 163\ A^{0.67}\ S^{0.23}\ L^{-0.32}\ R^{0.84}\ N^{-1.22}$	± 19	(18)
$Q_{10} = 227\ A^{0.69}\ S^{0.21}\ L^{-0.36}\ R^{0.87}\ N^{-1.53}$	± 19	(19)
$Q_{25} = 287\ A^{0.69}\ S^{0.20}\ L^{-0.36}\ R^{0.92}\ N^{-1.82}$	± 20	(20)
$Q_{50} = 330\ A^{0.67}\ S^{0.18}\ L^{-0.36}\ R^{0.97}\ N^{-2.03}$	± 21	(21)
$Q_{100} = 397\ A^{0.66}\ S^{0.15}\ L^{-0.37}\ R^{1.03}\ N^{-2.28}$	± 23	(22)

The peak discharge equations for Region B using the hydraulic radius procedure are shown below. The hydraulic radius and N data for these stations are listed in table 5.

Equation	Standard error	
$Q_2 = 5.24\ A^{0.45}\ S^{0.23}\ (P-30)^{0.20}\ E^{0.36}\ R^{1.21}\ N^{-1.12}$	± 30	(23)
$Q_5 = 7.20\ A^{0.51}\ S^{0.29}\ (P-30)^{0.24}\ E^{0.32}\ R^{0.99}\ N^{-0.90}$	± 28	(24)
$Q_{10} = 10.9\ A^{0.53}\ S^{0.32}\ (P-30)^{0.24}\ E^{0.28}\ R^{0.92}\ N^{-0.84}$	± 27	(25)
$Q_{25} = 20.7\ A^{0.54}\ S^{0.34}\ (P-30)^{0.21}\ E^{0.20}\ R^{0.93}\ N^{-0.83}$	± 28	(26)
$Q_{50} = 34.5\ A^{0.53}\ S^{0.34}\ (P-30)^{0.19}\ E^{0.14}\ R^{0.97}\ N^{-0.86}$	± 28	(27)
$Q_{100} = 53.3\ A^{0.52}\ S^{0.34}\ (P-30)^{0.17}\ E^{0.09}\ R^{1.01}\ N^{-0.89}$	± 30	(28)

Table 4.--Hydraulic radius and N, for selected recurrence interval, at gaging stations affectiong Region A

Station identification number	Mean weighted hydraulic radius for recurrence interval (years)						N for recurrence interval (years)					
	2	5	10	25	50	100	2	5	10	25	50	100
7047600	6.95	7.32	7.52	7.74	7.89	8.02	2.00	2.00	2.00	2.00	2.00	2.00
7047942	6.10	6.77	7.06	7.34	7.52	7.75	1.89	1.79	1.73	1.67	1.63	1.61
7063000	11.85	14.91	16.90	19.75	22.01	24.29	1.90	1.75	1.67	1.60	1.56	1.54
7064000	6.56	7.04	7.49	8.17	8.71	9.27	1.71	1.55	1.49	1.43	1.40	1.37
7074550	2.14	2.36	2.55	2.82	2.98	2.65	1.68	1.46	1.37	1.30	1.26	1.24
7074855	2.37	2.98	3.34	3.77	4.04	4.30	1.99	1.99	1.98	1.97	1.96	1.96
7077380	6.67	7.70	8.32	9.05	9.55	9.92	2.00	2.00	2.00	2.00	1.99	1.98
7077430	0.60	0.69	0.75	0.83	0.92	1.05	1.23	1.16	1.13	1.11	1.09	1.08
7077500	5.58	6.13	6.42	6.74	6.97	7.17	1.85	1.77	1.72	1.68	1.65	1.62
7077680	2.04	2.13	2.14	2.15	2.16	2.16	1.77	1.70	1.66	1.62	1.60	1.59
7077700	3.51	3.47	3.46	3.56	3.64	3.70	1.57	1.48	1.44	1.41	1.39	1.37
7077860	2.92	3.33	3.52	3.72	3.83	3.93	1.91	1.87	1.85	1.83	1.82	1.81
7077920	3.03	3.57	3.76	3.94	4.04	4.13	2.00	2.00	1.99	1.97	1.96	1.95
7077940	4.54	5.31	5.70	6.08	6.32	6.53	2.00	2.00	2.00	2.00	2.00	2.00
7077950	6.40	7.43	7.89	8.38	8.70	8.99	2.00	1.93	1.88	1.84	1.82	1.80
7078000	5.65	7.41	8.35	9.13	9.52	9.81	2.00	2.00	1.99	1.96	1.94	1.91
7078210	0.80	1.01	1.14	1.32	1.46	1.58	1.07	1.07	1.06	1.06	1.06	1.05
7263860	2.00	2.21	2.32	2.42	2.49	2.54	1.36	1.31	1.30	1.28	1.27	1.26
7264000	4.60	5.36	5.78	6.26	6.59	6.90	2.00	2.00	2.00	2.00	2.00	2.00
7264100	2.79	3.09	3.26	3.43	3.54	3.63	1.40	1.33	1.31	1.28	1.27	1.26
7364110	1.60	2.08	2.37	2.73	2.98	3.23	1.25	1.22	1.20	1.18	1.17	1.16
7364120	4.38	5.29	5.77	6.27	6.60	6.89	1.97	1.97	1.96	1.96	1.96	1.96
7364125	3.81	3.89	3.99	4.11	4.20	4.28	1.74	1.59	1.53	1.47	1.44	1.42
7364150	6.77	8.04	8.69	9.37	9.79	10.16	2.00	2.00	1.99	1.99	1.98	1.98
7364165	4.04	3.64	3.66	3.75	3.95	4.18	1.91	1.64	1.52	1.42	1.37	1.32
7364190	6.05	6.58	6.85	7.14	7.33	7.49	2.00	2.00	2.00	2.00	2.00	2.00
7364200	5.80	6.87	7.42	7.98	8.33	8.64	2.00	2.00	2.00	2.00	2.00	2.00
7364500	8.90	10.03	10.79	11.58	12.11	12.62	2.00	2.00	2.00	2.00	2.00	2.00
7367658	1.79	1.98	1.36	1.34	1.33	1.31	1.32	1.29	1.36	1.32	1.29	1.27
7367740	1.27	1.24	1.22	1.21	1.20	1.19	1.41	1.34	1.31	1.28	1.26	1.25

Table 5.--Hydraulic radius and N, for selected recurrence interval, at gaging stations affecting Region B

Station identification number	Mean weighted hydraulic radius for recurrence interval (years)						N for recurrence interval (years)					
	2	5	10	25	50	100	2	5	10	25	50	100
7047820	2.22	2.13	2.12	2.21	2.27	2.33	1.65	1.45	1.38	1.31	1.27	1.24
7047880	1.11	1.45	1.71	2.06	2.37	2.72	1.57	1.41	1.33	1.27	1.23	1.20
7047975	2.13	2.55	2.83	3.20	3.47	3.75	1.86	1.67	1.59	1.50	1.45	1.42
7047990	1.71	2.56	3.17	3.93	4.48	5.01	1.53	1.36	1.30	1.25	1.22	1.20
7048000	5.81	7.61	9.08	10.72	11.82	12.83	2.00	2.00	1.99	1.98	1.96	1.94
7048600	10.47	12.08	12.83	13.64	14.19	14.71	1.91	1.83	1.78	1.73	1.70	1.68
7048900	1.92	2.47	2.84	3.33	3.79	4.31	1.56	1.45	1.39	1.33	1.29	1.26
7048940	6.37	8.39	9.59	10.98	11.97	12.92	1.70	1.62	1.58	1.53	1.50	1.47
7049000	10.65	14.18	16.25	18.60	20.16	21.60	1.96	1.93	1.92	1.90	1.89	1.88
7049500	13.39	18.37	21.23	24.41	26.53	28.44	1.98	1.95	1.94	1.92	1.91	1.90
7050000	10.46	12.92	14.41	16.15	17.37	18.54	2.00	2.00	2.00	2.00	2.00	2.00
7050200	3.30	4.26	4.98	5.94	6.65	7.34	1.82	1.62	1.54	1.46	1.41	1.38
7050400	1.84	2.12	2.31	2.55	2.72	2.88	1.64	1.50	1.44	1.39	1.36	1.33
7050500	8.19	11.36	13.29	15.57	17.16	18.64	2.00	2.00	2.00	2.00	2.00	1.99
7054400	3.81	4.49	5.10	5.95	6.62	7.29	1.70	1.53	1.46	1.39	1.35	1.32
7054450	1.80	2.28	2.60	3.01	3.33	3.70	1.38	1.30	1.26	1.22	1.19	1.17
7055550	3.43	3.72	3.95	4.28	4.56	4.85	1.90	1.71	1.61	1.51	1.45	1.40
7055650	3.29	4.51	5.24	6.10	6.75	7.37	2.00	2.00	2.00	2.00	2.00	2.00
7055800	4.50	6.05	6.94	7.99	8.74	9.49	1.90	1.84	1.80	1.75	1.71	1.67
7056000	14.45	19.57	22.49	25.98	28.32	30.65	2.00	1.98	1.95	1.93	1.91	1.90
7057000	13.93	17.46	19.34	21.54	23.14	24.62	2.00	2.00	2.00	2.00	2.00	2.00
7057300	1.76	2.13	2.34	2.57	2.72	2.86	1.24	1.20	1.18	1.17	1.16	1.15
7060600	2.24	2.39	2.58	2.88	3.12	3.39	1.89	1.68	1.57	1.47	1.41	1.36
7060670	3.98	4.59	5.00	5.48	5.83	6.16	1.54	1.44	1.40	1.35	1.33	1.30
7060710	4.84	7.71	9.72	12.40	14.39	16.36	2.00	2.00	2.00	2.00	2.00	2.00
7060830	1.44	1.82	2.02	2.25	2.43	2.60	1.99	1.87	1.78	1.69	1.63	1.58
7061100	3.86	4.45	4.56	4.60	4.68	4.83	1.79	1.63	1.58	1.51	1.45	1.41
7068000	10.42	14.62	16.59	18.44	19.76	21.08	2.00	1.99	1.96	1.90	1.87	1.84
7068870	1.36	1.57	1.69	1.84	1.95	2.05	1.30	1.24	1.21	1.19	1.17	1.16
7068890	12.80	12.17	12.42	13.07	13.66	14.31	1.89	1.63	1.54	1.46	1.41	1.38
7069250	2.00	2.50	2.83	3.24	3.56	3.88	1.41	1.30	1.25	1.21	1.18	1.16
7069290	2.48	3.08	3.53	4.11	4.53	4.95	1.55	1.40	1.34	1.29	1.26	1.24
7069500	12.16	16.92	19.41	22.08	23.88	25.43	2.00	1.97	1.93	1.87	1.83	1.79
7071500	8.59	12.44	13.92	15.71	17.04	18.37	2.00	1.95	1.88	1.81	1.77	1.73
7072000	10.03	14.26	16.37	18.25	19.30	20.53	1.99	1.98	1.93	1.85	1.77	1.71
7072200	2.15	2.45	2.61	2.78	2.90	3.00	1.13	1.10	1.09	1.08	1.08	1.07
7073000	8.39	10.86	12.42	14.14	15.27	16.31	2.00	2.00	2.00	1.99	1.98	1.97
7073500	5.79	8.15	9.73	11.75	13.26	14.86	2.00	2.00	2.00	2.00	2.00	2.00
7074000	9.95	13.24	15.75	18.61	20.49	22.36	2.00	2.00	1.99	1.96	1.94	1.91
7074200	2.96	2.67	2.74	2.90	3.02	3.13	1.49	1.38	1.32	1.27	1.25	1.22
7074250	6.11	7.55	8.08	8.56	8.88	9.22	1.76	1.67	1.61	1.53	1.47	1.42
7074900	1.29	1.55	1.73	1.94	2.09	2.23	1.62	1.43	1.36	1.30	1.27	1.24
7074950	2.04	2.68	3.20	3.86	4.30	4.69	1.69	1.44	1.36	1.29	1.26	1.23
7075000	11.54	15.77	17.99	20.34	21.86	23.20	2.00	1.96	1.92	1.86	1.81	1.76
7075300	14.21	16.98	18.41	19.95	20.96	21.92	1.89	1.83	1.80	1.77	1.74	1.72
7075500	11.62	14.18	15.66	17.34	18.45	19.50	1.93	1.88	1.86	1.84	1.82	1.81
7075600	2.32	2.76	3.08	3.53	3.91	4.36	1.82	1.65	1.57	1.48	1.42	1.37
7075800	1.19	1.40	1.60	1.88	2.09	2.30	1.90	1.62	1.49	1.39	1.33	1.29
7076000	16.46	18.78	19.67	20.61	21.26	21.81	2.00	2.00	2.00	2.00	2.00	2.00
7076630	2.00	2.28	2.43	2.59	2.69	2.79	1.26	1.23	1.21	1.20	1.19	1.18
7076820	3.03	3.01	3.00	3.00	3.00	3.00	1.85	1.72	1.66	1.60	1.57	1.54
7076850	6.23	6.50	6.72	7.04	7.28	7.51	1.69	1.54	1.47	1.41	1.38	1.36
7076870	3.36	3.94	4.34	4.76	4.90	5.06	1.41	1.31	1.27	1.23	1.22	1.20
7077100	5.36	6.54	7.16	7.78	8.15	8.36	2.00	2.00	2.00	2.00	1.99	1.98
7077200	2.10	2.59	2.87	3.19	3.41	3.61	2.00	2.00	2.00	2.00	2.00	2.00
7077340	1.78	1.95	2.08	2.29	2.43	2.55	1.61	1.43	1.36	1.30	1.27	1.25
7188900	0.66	1.12	1.42	1.79	2.04	2.05	2.00	2.00	2.00	2.00	2.00	2.00
7191220	5.90	9.25	11.39	13.95	15.76	17.43	1.78	1.67	1.60	1.52	1.47	1.43
7194890	3.44	5.72	7.30	9.31	10.81	12.33	2.00	2.00	2.00	2.00	2.00	2.00
7195000	7.23	10.43	12.03	13.60	14.54	15.35	1.99	1.96	1.93	1.87	1.83	1.80
7195200	1.34	1.77	2.08	2.49	2.80	3.10	1.77	1.53	1.43	1.34	1.30	1.26
7195450	3.91	6.13	7.46	8.74	9.47	10.07	2.00	2.00	1.99	1.97	1.94	1.91
7195500	10.67	14.59	16.84	19.41	21.12	22.69	2.00	2.00	2.00	2.00	2.00	2.00
7195800	2.29	4.27	5.90	8.26	9.76	11.10	2.00	2.00	2.00	1.99	1.94	1.87
7196000	5.56	9.79	12.96	16.48	18.34	19.57	2.00	2.00	1.99	1.94	1.88	1.80
7196900	9.04	11.85	12.99	14.06	14.72	15.30	1.99	1.89	1.82	1.75	1.70	1.66
7247000	9.27	12.02	13.33	14.60	15.39	16.05	2.00	1.97	1.93	1.89	1.86	1.83
7249300	6.19	9.20	11.16	13.08	14.16	15.03	2.00	2.00	1.99	1.95	1.91	1.86
7249400	7.11	9.50	11.01	12.84	14.16	15.75	2.00	2.00	2.00	2.00	2.00	2.00
7249500	6.24	8.81	10.49	12.40	13.66	14.78	2.00	2.00	1.99	1.97	1.94	1.91
7249650	3.79	5.27	6.15	7.12	7.62	8.02	2.00	2.00	2.00	1.99	1.97	1.94
7249950	1.08	1.55	2.02	2.72	3.30	3.92	1.94	1.61	1.44	1.31	1.25	1.20
7250000	12.37	16.08	18.20	20.54	22.10	23.57	1.96	1.91	1.89	1.85	1.83	1.80
7252000	9.23	12.88	14.99	17.35	18.89	20.31	1.99	1.98	1.98	1.97	1.97	1.97
7252200	1.66	1.92	2.14	2.43	2.65	2.87	1.78	1.59	1.50	1.42	1.37	1.33
7252500	2.42	3.08	3.44	3.84	4.11	4.34	1.25	1.20	1.19	1.17	1.16	1.15
7254000	2.71	3.53	3.99	4.52	4.88	5.21	1.64	1.53	1.47	1.42	1.39	1.36
7254500	3.56	3.91	4.12	4.38	4.56	4.74	1.78	1.63	1.57	1.51	1.47	1.44
7255100	2.87	3.78	4.29	4.84	5.20	5.53	1.32	1.26	1.23	1.20	1.19	1.18
7256000	5.99	7.54	8.30	9.07	9.55	9.96	2.00	1.97	1.95	1.92	1.90	1.88

Table 5.--Hydraulic radius and N, for selected recurrence interval, at gaging stations affecting Region B--Continued

Station identification number	Mean weighted hydraulic radius for recurrence interval (years)						N for recurrence interval (years)					
	2	5	10	25	50	100	2	5	10	25	50	100
7256500	6.31	8.90	10.07	11.14	11.78	12.32	2.00	1.97	1.93	1.86	1.82	1.78
7257000	9.09	12.77	15.13	18.01	20.07	22.02	1.95	1.93	1.92	1.90	1.89	1.88
7257060	1.26	1.56	1.74	1.97	2.13	2.29	1.59	1.50	1.45	1.40	1.37	1.34
7257100	1.09	1.23	1.34	1.58	1.77	1.95	1.86	1.56	1.44	1.35	1.30	1.26
7257500	8.66	11.84	13.84	16.24	17.93	19.53	1.97	1.93	1.91	1.87	1.85	1.83
7257700	3.74	4.54	5.00	5.63	6.27	6.96	1.94	1.72	1.60	1.49	1.42	1.37
7258200	1.64	1.97	2.18	2.43	2.61	2.79	1.40	1.33	1.30	1.27	1.25	1.23
7258500	8.34	10.88	12.10	13.33	14.08	14.73	2.00	1.97	1.94	1.90	1.87	1.84
7260000	6.39	8.13	9.04	9.99	10.59	11.13	1.99	1.96	1.93	1.89	1.87	1.84
7260630	2.35	2.67	2.94	3.27	3.51	3.74	1.59	1.40	1.33	1.27	1.24	1.22
7260679	0.61	0.74	0.81	0.90	0.96	1.02	1.11	1.09	1.09	1.08	1.08	1.07
7261000	7.09	9.23	10.42	11.72	12.59	13.38	2.00	2.00	2.00	2.00	2.00	2.00
7261050	1.47	1.85	2.12	2.46	2.70	2.95	1.51	1.36	1.29	1.24	1.21	1.18
7261300	2.73	3.59	4.26	5.22	5.99	6.84	1.78	1.56	1.46	1.36	1.31	1.26
7261500	11.92	15.81	16.91	17.59	17.84	18.24	2.00	1.96	1.89	1.79	1.72	1.66
7261800	2.12	2.57	2.90	3.36	3.71	4.09	1.72	1.53	1.45	1.36	1.32	1.28
7263000	11.26	14.13	15.80	17.73	19.04	20.25	1.95	1.91	1.89	1.87	1.86	1.85
7263100	2.04	2.33	2.53	2.77	2.95	3.11	1.59	1.45	1.39	1.34	1.31	1.28
7263400	4.06	5.71	6.69	7.83	8.69	9.54	2.00	2.00	2.00	2.00	2.00	1.99
7263910	2.33	2.60	2.76	2.94	3.06	3.18	1.30	1.26	1.25	1.23	1.22	1.21
7338700	4.78	5.90	6.59	7.42	8.02	8.61	1.66	1.57	1.53	1.48	1.45	1.42
7339500	8.90	11.91	14.01	15.36	15.88	16.22	2.00	2.00	1.97	1.88	1.81	1.73
7339800	3.97	4.66	5.06	5.62	6.04	6.63	1.63	1.48	1.39	1.31	1.27	1.23
7340000	16.98	17.44	17.43	17.68	18.02	18.46	1.99	1.85	1.76	1.68	1.63	1.59
7340200	3.56	3.69	3.80	3.97	4.09	4.21	1.56	1.41	1.36	1.31	1.29	1.27
7340300	11.14	15.28	17.60	20.17	21.85	23.37	1.93	1.90	1.88	1.86	1.84	1.83
7340500	10.78	12.75	13.32	13.74	14.17	14.67	1.99	1.91	1.84	1.75	1.69	1.65
7340530	2.12	2.79	2.98	3.07	3.19	3.33	1.34	1.29	1.28	1.26	1.24	1.23
7341000	7.86	10.84	12.85	15.39	16.66	17.04	1.93	1.89	1.86	1.83	1.79	1.73
7341100	3.88	4.67	5.20	5.90	6.53	7.18	1.47	1.32	1.27	1.22	1.20	1.18
7341200	7.49	8.12	9.08	10.67	12.02	13.40	1.54	1.36	1.28	1.23	1.20	1.18
7341700	3.95	4.45	4.82	5.29	5.62	5.94	1.48	1.36	1.31	1.27	1.24	1.22
7342350	5.46	4.83	4.52	4.37	4.35	4.34	1.90	1.68	1.58	1.50	1.46	1.42
7344320	2.38	2.44	2.55	2.71	2.83	2.95	1.83	1.58	1.48	1.41	1.37	1.34
7346800	0.81	1.03	1.20	1.41	1.57	1.72	1.64	1.44	1.36	1.29	1.25	1.22
7347000	4.08	4.87	5.34	5.88	6.27	6.63	2.00	2.00	2.00	2.00	2.00	2.00
7348630	0.66	0.82	0.92	1.05	1.15	1.24	1.26	1.20	1.18	1.15	1.14	1.12
7348700	7.82	10.11	10.49	11.26	12.03	12.91	2.00	1.90	1.77	1.66	1.59	1.54
7349430	2.99	3.85	4.37	4.98	5.41	5.80	1.03	1.02	1.02	1.02	1.01	1.01
7349500	6.58	9.00	10.44	11.67	12.33	12.83	2.00	2.00	2.00	1.97	1.94	1.91
7355800	1.60	1.94	2.15	2.40	2.58	2.76	1.41	1.32	1.29	1.25	1.23	1.22
7355900	1.03	1.24	1.39	1.58	1.72	1.86	1.51	1.43	1.39	1.34	1.31	1.29
7356000	12.33	16.04	18.25	20.84	22.60	24.22	1.95	1.92	1.90	1.88	1.86	1.84
7356500	5.25	6.66	7.67	8.91	9.77	10.60	2.00	2.00	2.00	2.00	2.00	2.00
7356700	2.91	3.74	4.24	4.87	5.32	5.77	1.63	1.52	1.47	1.41	1.38	1.34
7357700	2.68	3.38	3.77	4.22	4.53	4.83	1.43	1.35	1.31	1.27	1.25	1.23
7359500	13.80	18.22	20.78	23.51	25.42	27.12	1.99	1.98	1.98	1.97	1.97	1.97
7359520	2.01	2.14	2.32	2.65	2.99	3.40	1.68	1.42	1.32	1.24	1.20	1.16
7359700	12.58	16.27	18.25	20.35	21.71	22.92	1.98	1.93	1.89	1.85	1.82	1.79
7359750	2.92	3.78	4.44	5.24	5.80	6.33	1.43	1.30	1.25	1.21	1.18	1.17
7359800	12.70	15.75	17.42	19.23	20.42	21.51	1.97	1.96	1.95	1.94	1.93	1.92
7360150	0.78	1.23	1.58	2.09	2.51	2.96	2.00	2.00	2.00	2.00	2.00	2.00
7360800	11.71	15.05	17.09	19.48	21.14	22.73	1.90	1.86	1.84	1.82	1.80	1.78
7361020	1.15	1.55	1.82	2.16	2.41	2.66	1.40	1.26	1.21	1.16	1.14	1.12
7361180	6.57	6.90	6.82	6.83	6.84	6.86	1.62	1.54	1.51	1.47	1.45	1.42
7361200	8.11	8.84	9.14	9.46	9.70	10.00	1.92	1.77	1.69	1.61	1.55	1.51
7361500	11.25	13.90	15.43	17.17	18.23	19.18	1.89	1.86	1.85	1.83	1.84	1.83
7361680	1.68	2.16	2.45	2.80	3.05	3.29	1.27	1.21	1.18	1.15	1.14	1.12
7361780	3.57	3.88	3.94	3.96	3.97	4.00	1.98	1.88	1.81	1.71	1.65	1.60
7361800	9.96	10.46	10.70	10.95	11.12	11.27	1.84	1.74	1.69	1.64	1.61	1.58
7362050	2.84	2.83	2.91	3.21	3.54	3.88	1.90	1.59	1.46	1.35	1.31	1.27
7362100	7.55	9.45	9.91	10.27	10.50	10.75	2.00	1.88	1.78	1.67	1.60	1.55
7362330	2.72	3.41	4.05	4.74	5.16	5.59	1.62	1.41	1.34	1.29	1.26	1.24
7362450	3.42	3.60	3.78	4.02	4.21	4.40	1.80	1.58	1.49	1.41	1.37	1.33
7362500	6.95	7.82	8.00	8.18	8.32	8.46	1.97	1.79	1.68	1.59	1.54	1.49
7363000	14.38	18.78	20.73	22.32	23.13	23.75	1.99	1.98	1.96	1.91	1.88	1.84
7363050	1.50	2.09	2.50	3.05	3.48	3.92	1.24	1.20	1.18	1.16	1.14	1.13
7363200	11.98	12.45	12.64	12.86	13.04	13.29	1.82	1.68	1.61	1.54	1.50	1.47
7363300	5.58	6.48	7.14	8.10	8.81	9.49	1.51	1.39	1.33	1.28	1.26	1.24
7363330	2.15	2.62	2.93	3.34	3.64	3.93	1.47	1.33	1.28	1.23	1.21	1.19
7363430	1.30	1.60	1.89	2.36	2.72	3.09	1.49	1.30	1.23	1.17	1.15	1.13
7363450	1.21	1.66	1.95	2.29	2.53	2.76	1.42	1.30	1.26	1.21	1.19	1.17
7363500	13.99	14.77	14.99	15.33	15.61	15.91	1.99	1.81	1.72	1.64	1.59	1.55
7364030	0.74	0.97	1.09	1.24	1.34	1.43	1.32	1.24	1.21	1.19	1.17	1.16
7364070	2.68	2.87	2.99	3.13	3.23	3.34	1.80	1.66	1.60	1.54	1.50	1.47
7364260	2.22	2.74	3.03	3.28	3.44	3.59	1.39	1.33	1.30	1.28	1.27	1.25
7364300	6.80	8.17	8.48	8.90	9.29	9.70	1.99	1.82	1.71	1.60	1.54	1.50
7364550	0.86	1.08	1.23	1.42	1.57	1.72	1.12	1.09	1.08	1.07	1.06	1.05
7364700	3.66	5.46	6.88	8.60	9.81	10.98	2.00	2.00	1.98	1.93	1.89	1.84
7365800	4.76	5.15	5.81	7.05	8.15	9.35	1.63	1.40	1.31	1.24	1.21	1.18
7365900	4.00	5.53	6.14	6.74	7.16	7.61	2.00	1.90	1.80	1.68	1.61	1.54
7366000	7.51	9.03	8.90	9.06	9.41	9.88	2.00	1.88	1.74	1.61	1.53	1.48
7366200	4.14	5.49	6.01	6.73	7.34	8.00	1.99	1.88	1.79	1.69	1.64	1.60

where,

Q, A, S, L, P, E are as previously defined,

R = mean weighted hydraulic radius. Defined as the summation of the hydraulic radius times the discharge in each subsection divided by the total discharge.

N = discharge in the main channel times 2 plus the flood plain discharge, divided by the total discharge. N ranges from 1 to 2. N = 1 if all water is on flood plain. N = 2 if all water is in main channel.

When most of the discharge is in the main channel, the equations tend to overestimate discharge. For this reason, N was used in the equations to compensate for the overestimation of discharge. The standard error of the equations was reduced about 4 percent when N was included.

The standard error of equations 17-28 using this procedure is about 9 percent less than the standard error of equations 2-13. The user must decide if this increase in accuracy is worth the effort of estimating a cross section and stage-discharge relation.

Estimating the Cross Section

The cross section of the channel and flood plain can be determined using the contour lines on a topographic map. The position of the cross section at the ungaged site is drawn on the map normal to flow. Care should be taken to assure that it is a typical valley cross section. The station (lateral distance from an arbitrary point above high water) where these contours cross the cross section is tabulated and plotted. Additional points for determining the cross section can be transferred from other points, either upstream or downstream to the site by adjusting for the slope and distance. All points in the cross section are important but particular care must be taken in determining elevation of bankful stage, elevation of the bottom of the channel and channel width.

The contour lines that cross the channel represent low water at the time the photographs for mapping were taken. The depth of water during low water conditions should be estimated.

The elevation of the bottom of the channel is determined by interpolating between points where the contours cross the channel and subtracting the depth from this value. The elevation of bankful stage can be determined along the channel where the contour line breaks out of the channel and begins to go into the flood plain. This point can be transferred to the site by adjusting it for slope and distance using slope of the flood plain from contour crossings of the channel and distance from the cross section. The channel width can be estimated by measuring this width at several points near the site and using an average or typical value. The entire cross section can be determined in the field by transit-stadia survey. In determining hydraulic radius for analysis in this report all cross sections were determined from topographic maps using the procedure described above.

An example for determining the cross section from topographic maps is described. A typical cross section is drawn on the topographic map as shown on figure 5. This section does not need to be exactly at the site. It can be moved either upstream or downstream to where the cross section appears typical of the reach. The station (lateral distance) where the contour lines cross the cross section is determined and plotted on figure 5. In this example all points are measured from where the 350-ft contour crosses the cross section.

The bottom of the channel is determined by interpolating between where adjacent contour lines cross the channel. The flood plain distance between where the contour lines cross the channel is 770 ft. The contour interval is 10 ft. Therefore, the flood plain slope is 10 divided by 770 or 0.013 ft/ft. The cross section is 525 ft upstream from where the 320-ft contour line crosses the channel. Multiplying distance by slope (525 x 0.013 = 6.8), the bottom of the channel is 326.8 ft (320 + 6.8) at the cross section. This point was actually the water-surface elevation when the photographs for mapping were made. If the approximate depth of low water is known, it can be subtracted from this point. The distance along the main channel between the contour lines is 850 ft. Therefore, the main channel slope is 10 divided by 850 or 0.0118 ft/ft.

Bankful stage is where the 330-ft contour breaks out of the channel and goes onto the flood plain. This is about 170 ft downstream from the cross section. Multiplying distance by slope (170 x 0.013 = 2.2), bankful stage at the cross section is 332.2 ft (330 + 2.2). The elevation of bankful stage and channel bottom is plotted on figure 5 and the cross section is drawn by connecting points. Judgements are made when connecting points either by a straight line or a curved line.

Stage-Discharge Relation

Stage-discharge relations are usually determined by the slope-conveyance method.

$$Q = \frac{1.486}{n} A_1 (R^{0.67}) S_f^{0.50} \tag{29}$$

where,

Q = discharge in ft^3/s,
n = Manning's roughness coefficient,
A_1 = cross sectional area of stream in ft^2,
R = hydraulic radius in ft, defined as area divided by the wetted perimeter, and
S_f = slope of the energy gradient in ft/ft.

5A

5B

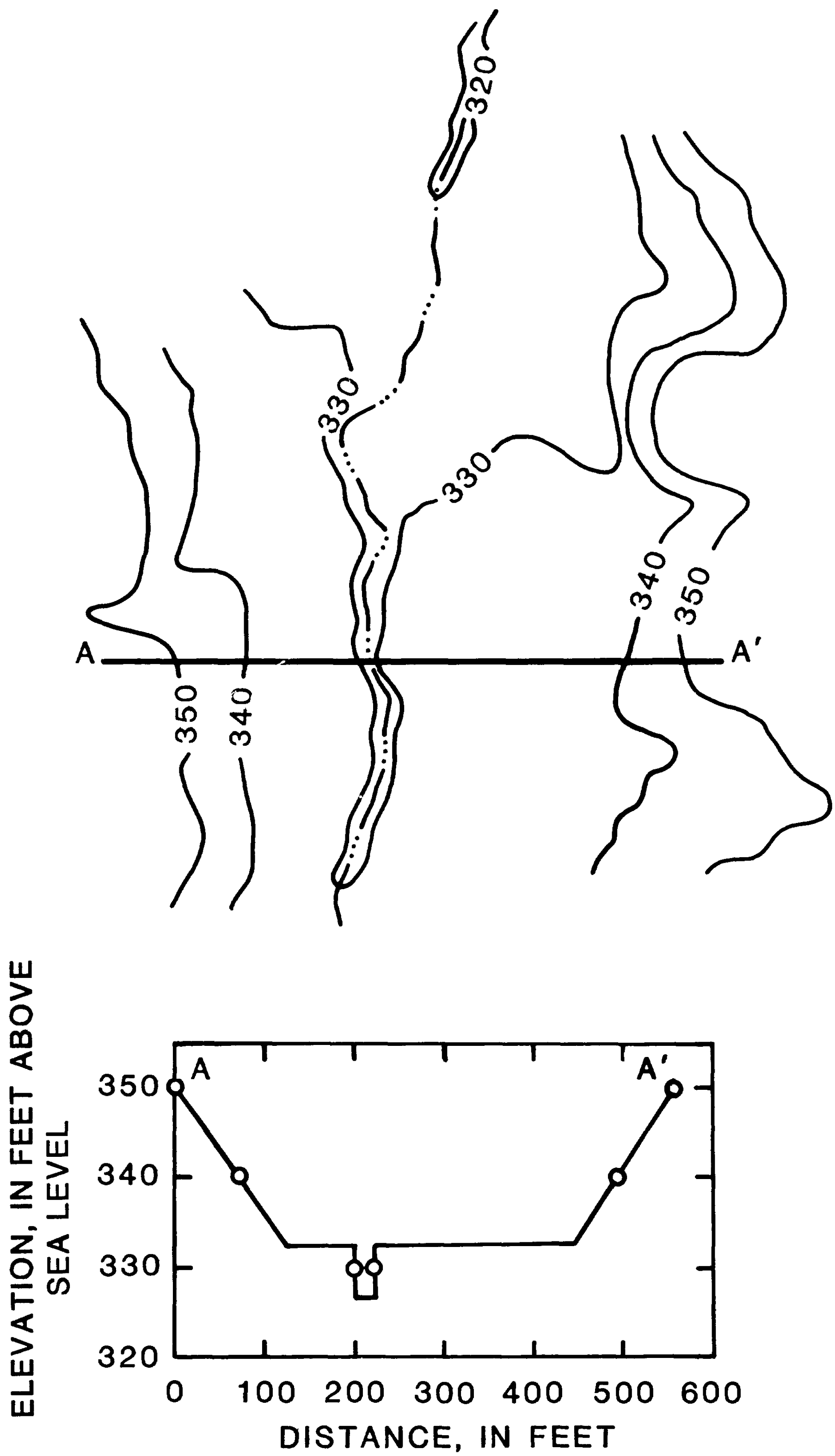


Figure 5.--Cross section of valley from topographic map.

The slope is determined for both the main channel and for the flood plain. The elevations used in determining the slope are picked from the topographic map where the contours cross the main channel. The distance between these points is measured along the main channel when determining the main channel slope and measured along a line parallel to the flood plain flow when determining the flood plain slope. The cross section of the channel and flood plain is used in determining the discharge. The cross section is subdivided so that a discharge can be determined for the main channel and for the flood plain. The cross section on the flood plain is further subdivided if there is a major change in shape.

Manning's roughness coefficient is selected in the field and is difficult at times to determine. Engineering judgement must be used in making the selection. Manning's roughness coefficient, n, which is needed in equation 29 to compute discharge is determined based on the work done by Jarrett (1985) and Riggs (1976). Both Jarrett and Riggs showed that, n, can be related to slope and to elements of the cross section. Jarrett derived the equation

$$n = 0.39\ S_f^{0.38}\ R^{-0.16} \qquad (30)$$

where,

n = Manning's coefficient
S_f = slope of the energy line in ft/ft, and
R = hydraulic radius in ft.

This equation is based on data collected for 75 storm events at 22 stations in Colorado. These are high gradient streams with an average slope of about 62 ft/mi. This equation can be substituted in equation 29 which would eliminate "n" and form the equation

$$Q = 3.81\ A_1\ R^{0.83}\ S_f^{0.12} \qquad (31)$$

Riggs derived the equation

$$Q = 3.39\ A_1^{1.30}\ S^{0.32} \qquad (32)$$

where,

Q = discharge in ft^3/s,
A_1 = cross sectional area in ft^2, and
S = slope of water surface in ft/ft.

This equation is based on data collected at 30 stations throughout the United States. These are low gradient streams with a slope that ranges from 2 to 95 ft/mi with an average of 20.

Both Jarrett and Riggs simplified the computation of discharge by not using Manning's "n" in their equations.

The slope of the 200 Arkansas streams used in the study ranges from 0.41 to 609 ft/mi with a median of 17.5. Both Jarrett's and Riggs' equations which apply to the main channel only are believed to be applicable to Arkansas streams. The slope at 123 stations is applicable to Jarrett's equation for high gradient streams. The slope at 165 stations is applicable to Rigg's equation for low gradient streams. Eighty-eight stations overlap and are applicable to both equations. Rather than use Jarrett's equation for high gradient streams and Rigg's equation for low gradient streams, an attempt was made to combine the data used in deriving both equations and derive an equation that can be used for all streams. Riggs did not use the hydraulic radius in his equation although these data were available for most of his stations. At stations where the hydraulic radius was not available, these data were estimated based on a relation between area and hydraulic radius developed using the other stations. The slope of the water surface, s, and the slope of the energy gradient, S_f, is assumed to be parallel. Data used for both Jarrett's and Riggs' equations were combined and used in a regression analysis to form a single relation for the main channel as shown below:

$$Q = 7.13\ A_1^{0.94}\ R^{0.80}\ S^{0.20} \qquad (33)$$

An equation for computing discharge on the flood plain was developed so that a theoretical rating curve could be developed at each site that would closely parallel the actual rating curve. The theoretical rating curve is determined by adding the discharge computed for the main channel to the discharge computed for the flood plain. The equation for computing discharge on the flood plain was developed by assuming that the exponents on A, R, and S in equation 33 would remain the same and only the constant would change. The constant in the equation was determined for each site so that the difference between the 100-year stage and the 2-year stage was the same for both the theoretical rating curve and the actual rating curve. The median value of these constants was used in the final equation. The equation for computing discharge on the flood plain is

$$Q = 1.30\ A_1^{0.94}\ R^{0.80}\ S^{0.20} \qquad (34)$$

The difference in the constants in equation 33 and 34 means that the "n" value on the flood plain is about five times greater than the "n" in the main channel. Note that the slopes used in equations 33 and 34 are for the main channel and for the flood plain, respectively.

At several selected stages, the discharge is computed for the main channel and for the flood plain. These discharges are added to form the total discharge for that stage. The stage-discharge relation is made by plotting stage against discharge. This relation needs to be developed between the discharges of the 2-year and 100-year floods.

An example for determining the stage-discharge relation, the hydraulic radius, and N is described. The cross section for the site is shown on figure 5. The cross-section properties and discharge are computed for the left flood plain (looking downstream), the main channel, and the right flood plain. The area, wetted perimeter, hydraulic radius, and discharge are computed for each subsection at selected stages. The computations are shown in table 6. Below each selected stage, the area is computed for each subsection. The wetted perimeter is the distance along the ground for each subsection. The wetted perimeter is always equal to or greater than the width. The hydraulic radius is the area divided by the wetted perimeter.

At each selected stage, the discharge is computed for the main channel using equation 33 and for each flood plain using equation 34. The slope of the main channel is used in equation 33 and the slope of the flood plain is used in equation 34. The total discharge for each stage is the summation of the discharges for each subsection. The stage-discharge relation is shown on figure 6.

Discharge-Frequency Curve

An example of computing the discharge-frequency curve for the site shown on figure 5 is described. The basin and climatic characteristics for this site (in Region B) are:

Drainage area = 4.0 mi^2,
Mean annual precipitation = 50.0 inches,
Slope of main channel = 90.0 ft/mi,
Mean basin elevation = 1,490 ft,
Slope of flood plain = 0.0130 ft/ft, and
Slope of main channel = 0.0119 ft/ft.

The preliminary discharges are computed using equation 8-13. The computed discharges are shown below.

$$Q_2 = 0.120\ (4)^{0.78}\ (30)^{0.42}\ (20)^{0.55}\ (500)^{0.75} = 811\ ft^3/s$$
$$Q_5 = 0.521\ (4)^{0.78}\ (30)^{0.48}\ (20)^{0.43}\ (500)^{0.64} = 1{,}520\ ft^3/s$$
$$Q_{10} = 1.07\ (4)^{0.78}\ (30)^{0.51}\ (20)^{0.38}\ (500)^{0.59} = 2{,}180\ ft^3/s$$
$$Q_{25} = 2.23\ (4)^{0.79}\ (30)^{0.53}\ (20)^{0.33}\ (500)^{0.53} = 2{,}930\ ft^3/s$$
$$Q_{50} = 3.58\ (4)^{0.79}\ (30)^{0.55}\ (20)^{0.29}\ (500)^{0.50} = 3{,}700\ ft^3/s$$
$$Q_{100} = 5.35\ (4)^{0.79}\ (30)^{0.56}\ (20)^{0.27}\ (500)^{0.47} = 4{,}480\ ft^3/s$$

The mean weighted hydraulic radius and N are needed in equations 23-28 for computing the discharge for each recurrence interval. The mean weighted hydraulic radius shown in table 6 is computed as the summation of the hydraulic radius times the discharge in each subsection divided by the total discharge. The mean weighted hydraulic radius is plotted against discharge on figure 6.

The N shown in table 6 is computed as the discharge in the main channel times 2 plus the flood plain discharge, divided by the total discharge. The value of N is plotted against discharge on figure 6.

Table 6.--Computation of discharge and cross-sectional properties

	Left flood plain				Main channel				Right flood plain						
Stage (feet)	Area (square feet)	Wetted perimeter (feet)	Hydraulic radius (feet)	Discharge (cubic feet per second)	Area (square feet)	Wetted perimeter (feet)	Hydraulic radius (feet)	Discharge (cubic feet per second)	Area (square feet)	Wetted perimeter (feet)	Hydraulic radius (feet)	Discharge (cubic feet per second)	Total discharge (cubic feet per second)	Mean weighted hydraulic radius (feet)	N
331					92.4	30.4	3.04	503					503	3.04	2.00
332.2	0	70	0	0	118.8	32.8	3.62	732	0	220	0	0	732	3.62	2.00
333	58.3	75.9	0.77	20	136.4	32.8	4.16	932	178.1	225.4	0.79	59	1,011	3.89	1.92
334	137.8	83.3	1.65	83	158.4	32.8	4.83	1,209	406.7	232.1	1.75	242	1,534	4.17	1.79
335	224.6	90.6	2.48	183	180.4	32.8	5.50	1,516	642.0	238.8	2.69	524	2,223	4.59	1.68
336	318.7	98.0	3.25	316	202.4	32.8	6.17	1,852	883.9	245.5	3.60	894	3,062	5.12	1.60
337	420.1	105.4	3.99	482	224.4	32.8	6.84	2,215	1,132	252.2	4.49	1,346	4,043	5.72	1.55
338	528.8	112.8	4.69	682	246.4	32.8	7.51	2,607	1,388	258.9	5.36	1,879	5,168	6.36	1.50

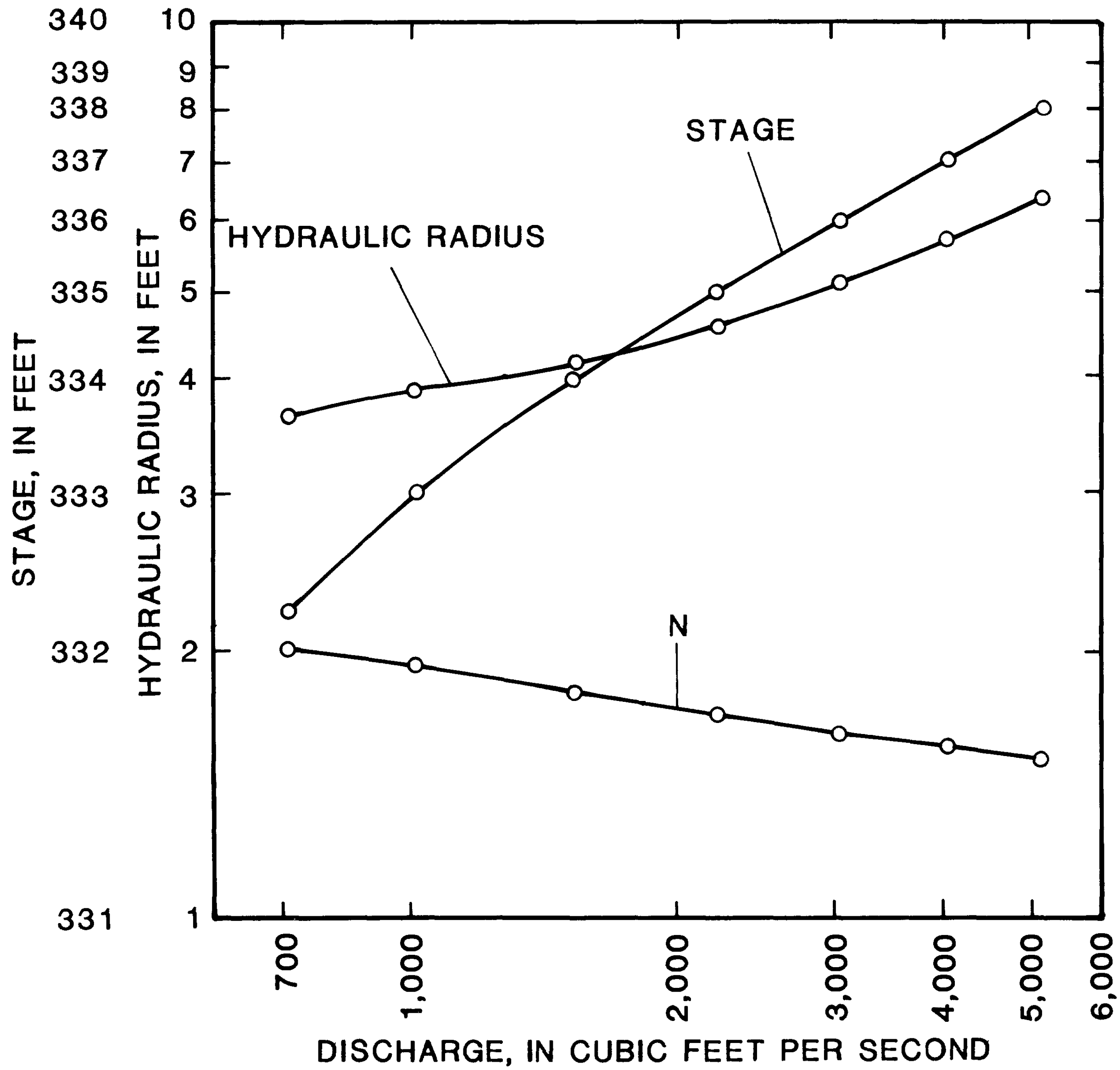


Figure 6.--Stage-discharge, hydraulic radius-discharge, and N-discharge relation.

The preliminary discharge for each recurrence interval computed using equations 8-13 are entered in figure 6 to determine the mean weighted hydraulic radius and N. The mean weighted hydrualic radius and N for each recurrence interval are shown below.

Recurrence interval, in years	Preliminary discharge, cubic feet per second	Mean weighted hydraulic radius, in feet	N
2	811	3.72	1.97
5	1,520	4.14	1.79
10	2,180	4.55	1.69
25	2,930	5.05	1.61
50	3,700	5.54	1.57
100	4,480	5.99	1.53

The discharge using the alternate procedure is computed using equations 23-28 and are shown below.

$$Q_2 = 5.24\ (4)^{0.45}\ (30)^{0.23}\ (20)^{0.20}\ (500)^{0.36}\ (3.72)^{1.21}\ (1.97)^{-1.12} = 836\ ft^3/s$$
$$Q_5 = 7.20\ (4)^{0.51}\ (30)^{0.29}\ (20)^{0.24}\ (500)^{0.32}\ (4.14)^{0.99}\ (1.79)^{-0.90} = 1{,}420\ ft^3/s$$
$$Q_{10} = 10.9\ (4)^{0.53}\ (30)^{0.32}\ (20)^{0.24}\ (500)^{0.28}\ (4.55)^{0.92}\ (1.69)^{-0.84} = 2{,}050\ ft^3/s$$
$$Q_{25} = 20.7\ (4)^{0.54}\ (30)^{0.34}\ (20)^{0.21}\ (500)^{0.20}\ (5.05)^{0.93}\ (1.61)^{-0.83} = 2{,}750\ ft^3/s$$
$$Q_{50} = 34.5\ (4)^{0.53}\ (30)^{0.34}\ (20)^{0.19}\ (500)^{0.14}\ (5.54)^{0.97}\ (1.57)^{-0.86} = 3{,}440\ ft^3/s$$
$$Q_{100} = 53.3\ (4)^{0.52}\ (30)^{0.34}\ (20)^{0.17}\ (500)^{0.09}\ (5.99)^{1.01}\ (1.53)^{-0.89} = 4{,}230\ ft^3/s$$

The values of the mean weighted hydraulic radius and N are not recomputed based on the results of equations 23-28.

The computed discharges using the alternate equations differ slightly from the discharges computed using equations 8-13. The maximum difference is 7 percent. There is no way to know which set of equations give the best answer for any particular site. The average standard error of equations 23-28 is about 9 percent less than the standard error of equations 8-13.

FLOOD MAGNITUDE AND FREQUENCY ON LARGE RIVERS

Large rivers have floodflow characteristics differing from those of smaller tributary streams and were treated individually. The peak discharges for recurrence intervals of 2, 5, 10, 25, 50, and 100 years for all gaging stations on large streams and regulated streams are listed in table 3. The peak discharge for regulated streams reflects the pattern of regulation. If the pattern of regulation changes, the discharges will change.

Mississippi River

The Mississippi River is one of the longest rivers in the world. Its drainage basin extends from New York to Montana and includes about 40 percent of the conterminous United States. A flood-frequency study of such a river is outside the scope of this report. Flood-frequency relations at three gaging stations are shown in table 3 and can be used as a guide to estimate discharges at nearby places along the river. Data for the three gaging stations are plotted on figure 7.

St. Francis River

Regulation began April 1, 1941 by Wappapello Reservoir. The storage capacity of Wappapello Reservoir is 625,000 acre-ft. Downstream from the gaging station at Lake City (07040450) the flow separates into several channels. The flood-frequency curves for St. Francis River, shown in figure 8, include the effect of regulation and is the combined discharge of all channels.

Black River

The regulation by Clearwater Reservoir (storage capacity 413,700 acre-ft) has only a slight effect on flood peaks of Black River. Data collected prior to regulation at the gaging station near Corning (07064000) was used in developing the Region A frequency curves. The flood-frequency curves for Black River are shown on figure 9.

Arkansas River

The flow of Arkansas River is regulated by many locks, dams, and reservoirs. The flood-frequency curves shown on figure 10 include the effect of regulation. The flood-frequency curves for station 07250550 which is based on 15 years of record were adjusted to the 45-year period at the two other stations.

White River

The flow of White River is regulated by Beaver Lake, Table Rock Lake, Bull Shoals Lake, Norfork Lake, and Greers Ferry Lake. Upstream regulation begins at Beaver Lake near Eureka Springs where the drainage area is 1,192 mi^2. The frequency curves on figure 11 show the effects of regulation. Upstream from Beaver lake, the discharge frequency should be computed using the regression equations and the gaging station data shown in table 2.

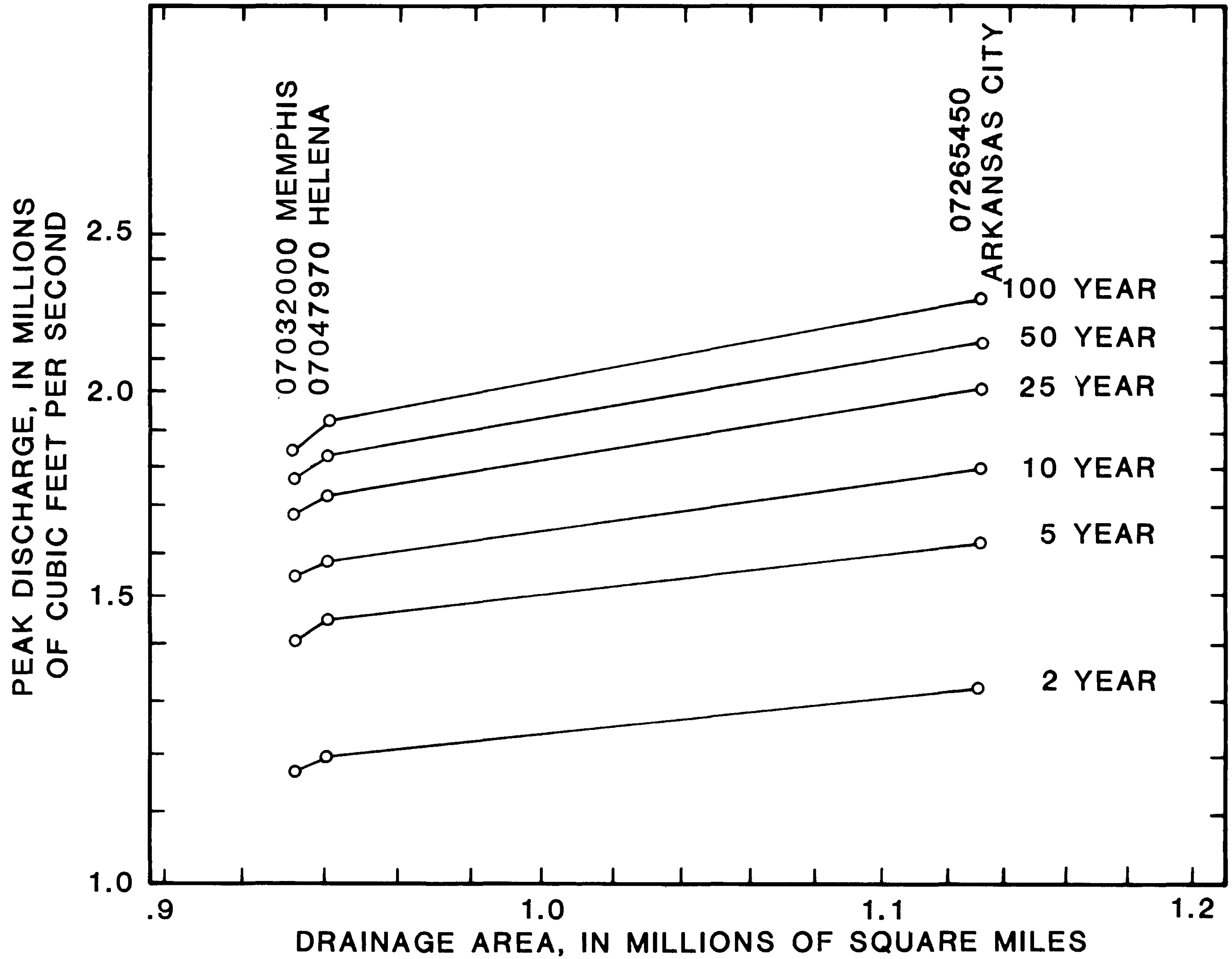


Figure 7.--Flood magnitude and frequency curves for Mississippi River.

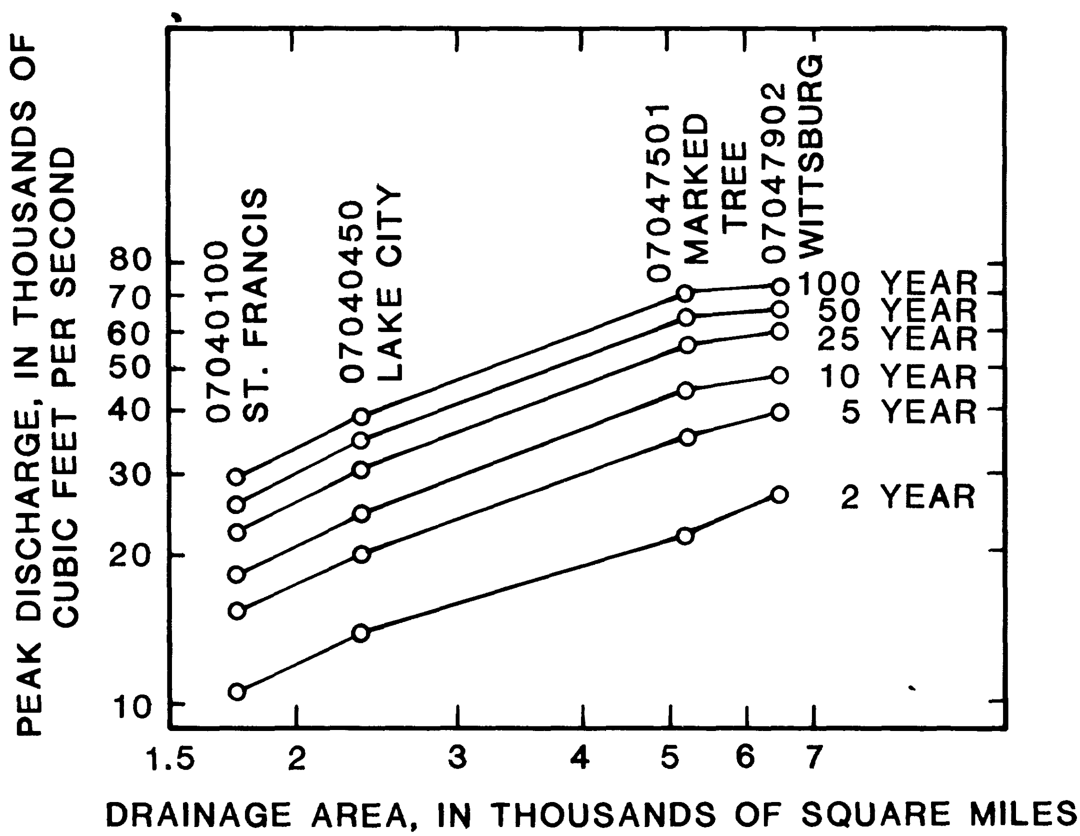


Figure 8.--Flood magnitude and frequency curves for St. Francis River.

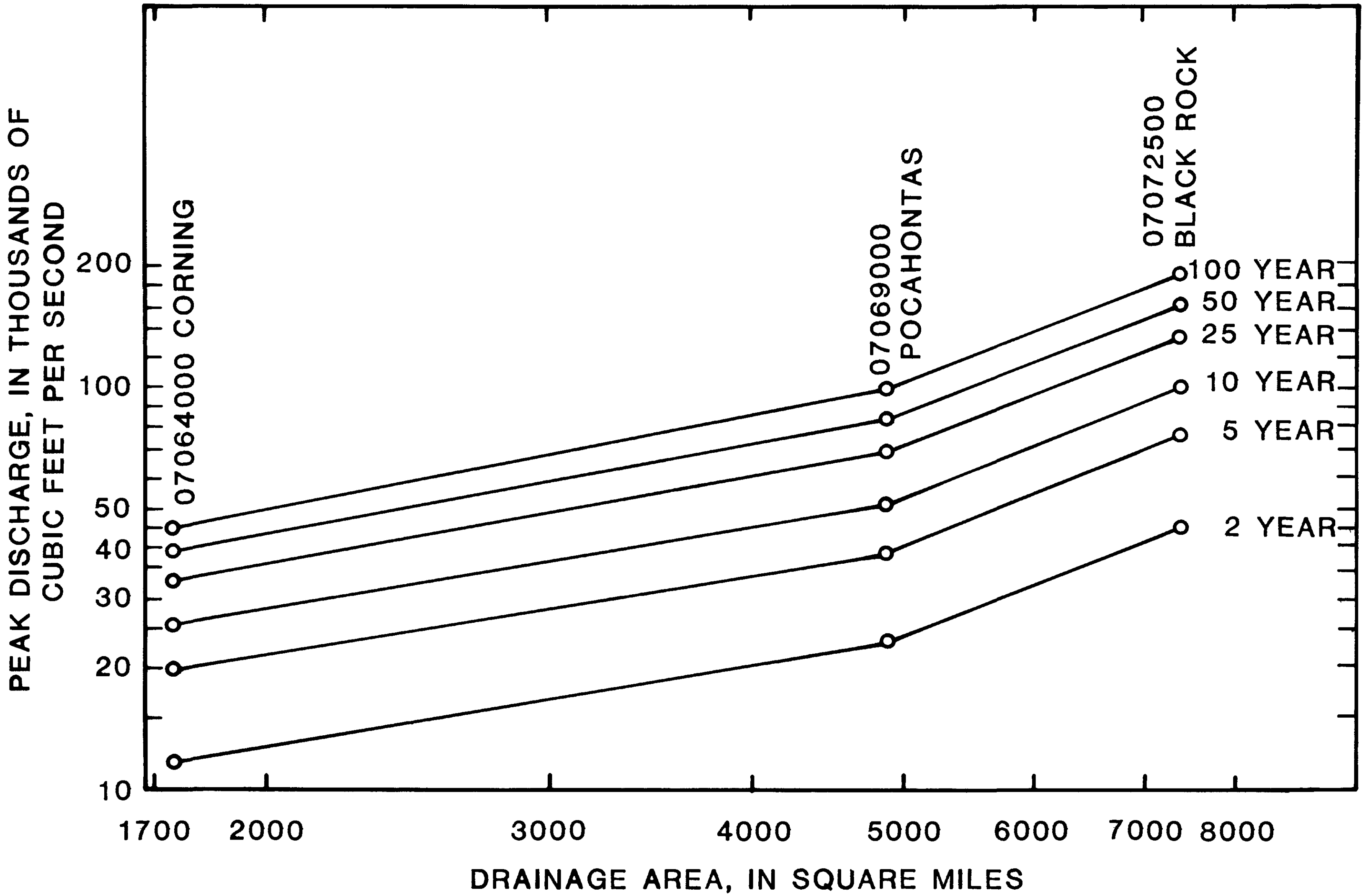


Figure 9.--Flood magnitude and frequency curves for Black River.

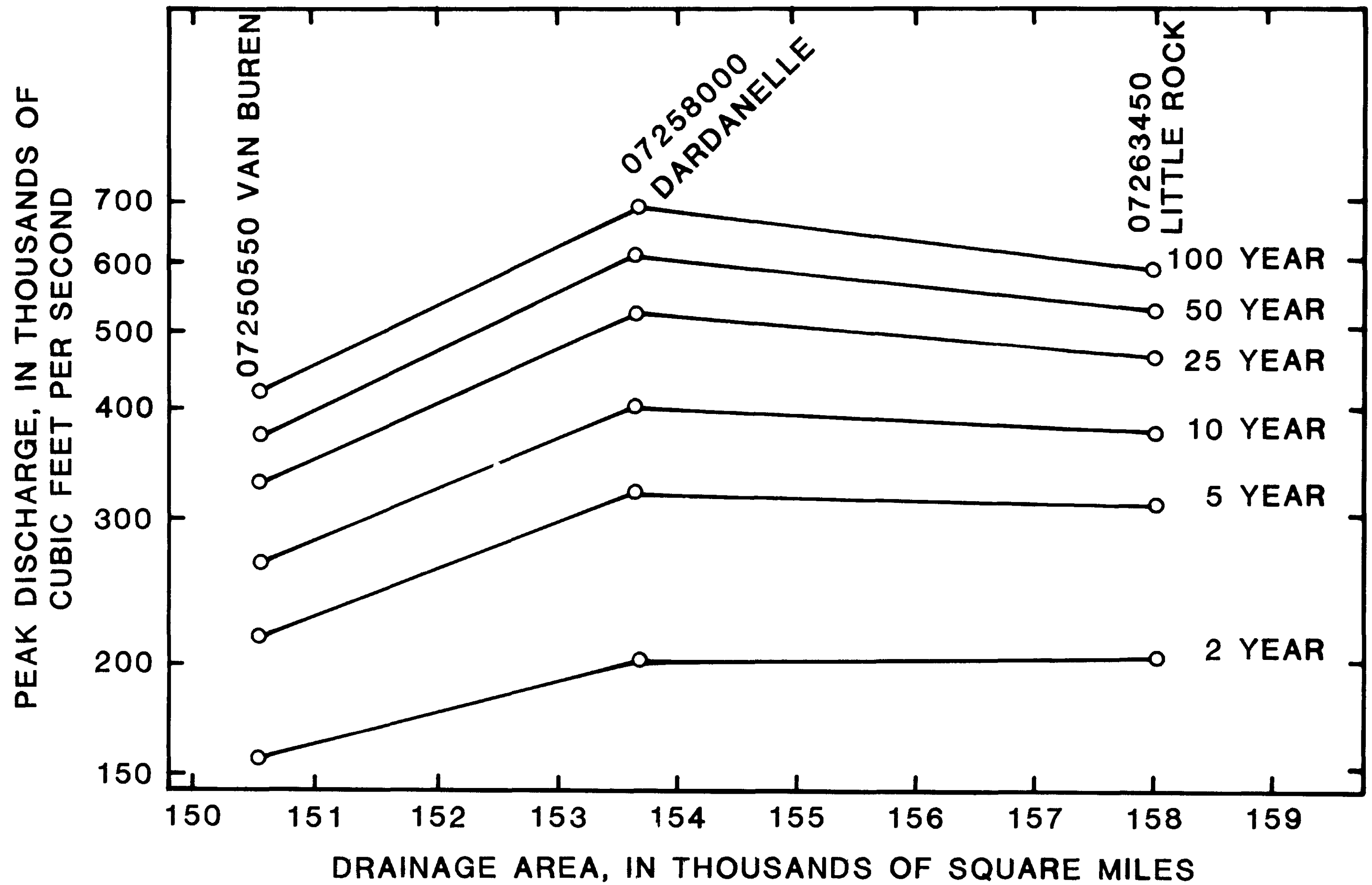


Figure 10.--Flood magnitude and frequency curves for Arkansas River.

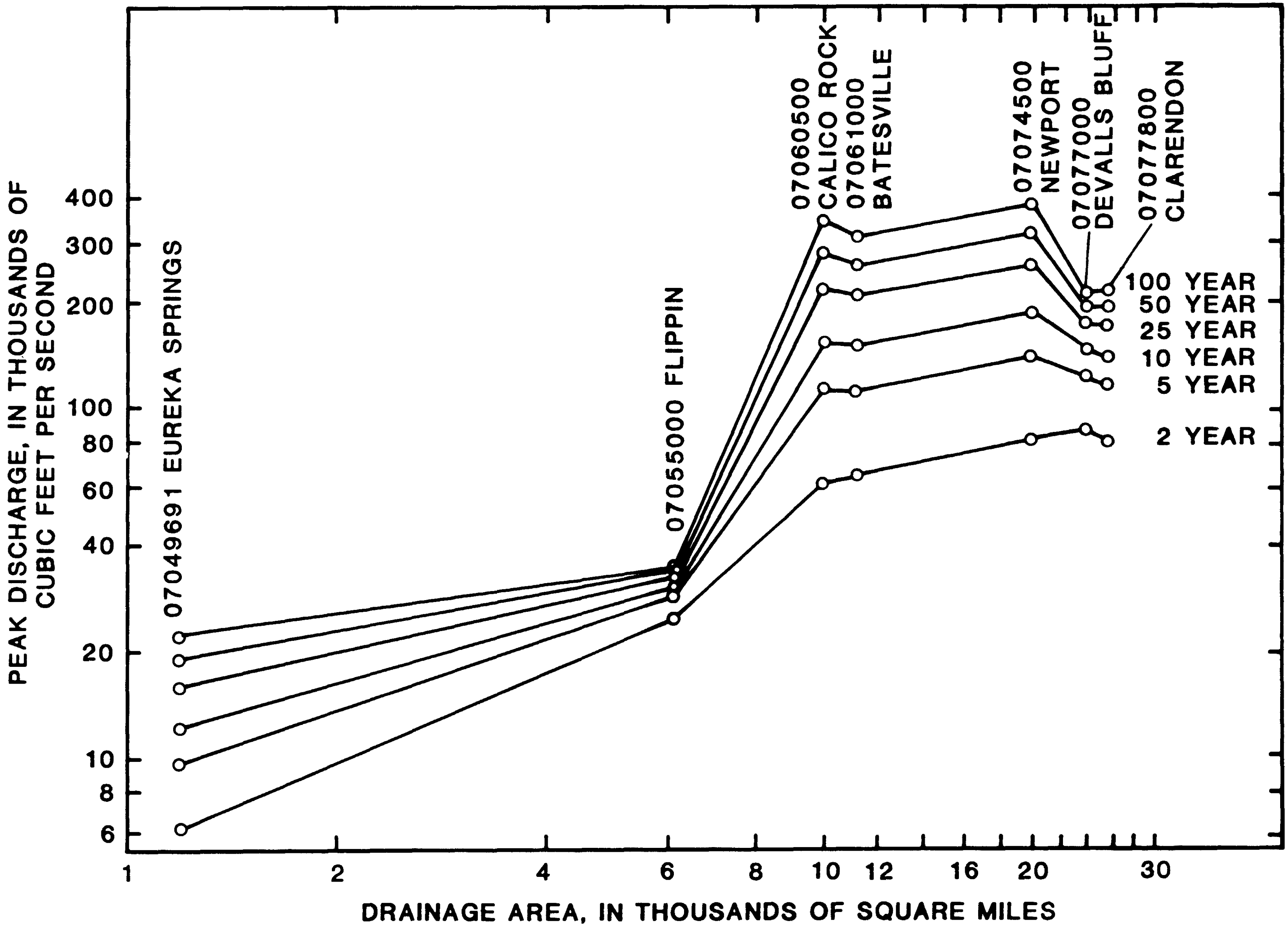


Figure 11.--Flood magnitude and frequency curves for White River.

Red River

The flow of Red River is regulated by Lake Texoma, Pat Mayse Lake, Hugo Lake, Millwood Lake, and Wright Patman Lake. The flood-frequency curves on figure 12 include the effects of regulation.

Ouachita River

The flow of Ouachita River is regulated by Lake Catherine, Lake Hamilton, and Lake Ouachita. Upstream regulation begins with Lake Ouachita at Blakely Mountain Dam which has a drainage area of 1,105 mi^2. The flood-frequency curves on figure 13 include the effects of regulation. Upstream from Lake Ouachita, the discharge frequency should be computed using the regression equations and the gaging station data shown in table 2.

FLOOD FREQUENCY FOR URBAN AREAS

Very little data for urban areas in Arkansas are available. Data has been collected on three urban streams in Little Rock since 1980 and on three streams in Fort Smith since 1978. These data consist of peaks only and are not included in this report.

A nationwide flood-frequency report (Sauer and others, 1983) which uses urban characteristics to adjust rural discharges to estimate urban discharges is available. Equations in that report were developed using all available U.S. Geological Survey urban data throughout the United States along with the respective rural discharge. The equations in that report should be applicable to urban Arkansas streams.

Three sets of equations are shown in that report for computing urban discharges. Two of them uses seven parameters for estimating discharge and the other uses three parameters. Recent studies in the southeastern part of the Nation indicate that the three-parameter equation is biased in certain areas, whereas the seven parameter equation is not biased. The seven parameter equations are probably a good estimate of the urban flood frequency in Arkansas and are shown below. The following equations and definitions are excerpts from Sauer and others (1983):

Equation	Average standard error of regression, in percent	
$UQ_2 = 2.35A^{.41}SL^{.17}(RI2+3)^{2.04}(ST+8)^{-.65}(13-BDF)^{-.32}IA^{.15}RQ_2^{.47}$	± 38	(35)
$UQ_5 = 2.70A^{.35}SL^{.16}(RI2+3)^{1.86}(ST+8)^{-.59}(13-BDF)^{-.31}IA^{.11}RQ_5^{.54}$	± 37	(36)
$UQ_{10} = 2.99A^{.32}SL^{.15}(RI2+3)^{1.75}(ST+8)^{-.57}(13-BDF)^{-.30}IA^{.09}RQ_{10}^{.58}$	± 38	(37)
$UQ_{25} = 2.78A^{.31}SL^{.15}(RI2+3)^{1.76}(ST+8)^{-.55}(13-BDF)^{-.29}IA^{.07}RQ_{25}^{.60}$	± 40	(38)
$UQ_{50} = 2.67A^{.29}SL^{.15}(RI2+3)^{1.74}(ST+8)^{-.53}(13-BDF)^{-.28}IA^{.06}RQ_{50}^{.62}$	± 42	(39)
$UQ_{100} = 2.50A^{.29}SL^{.15}(RI2+3)^{1.76}(ST+8)^{-.52}(13-BDF)^{-.28}IA^{.06}RQ_{100}^{.63}$	± 44	(40)

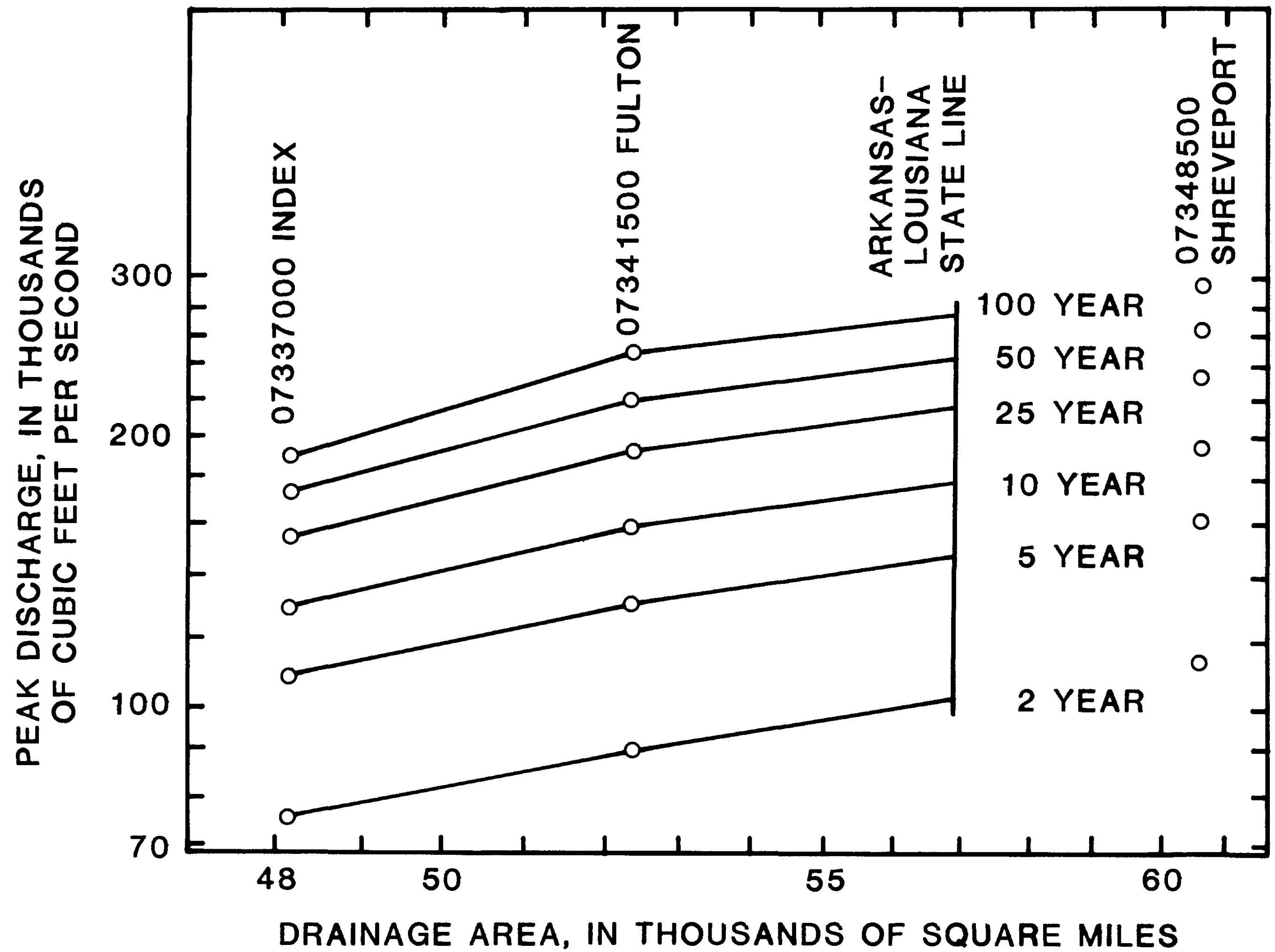


Figure 12.--Flood magnitude and frequency curves for Red River.

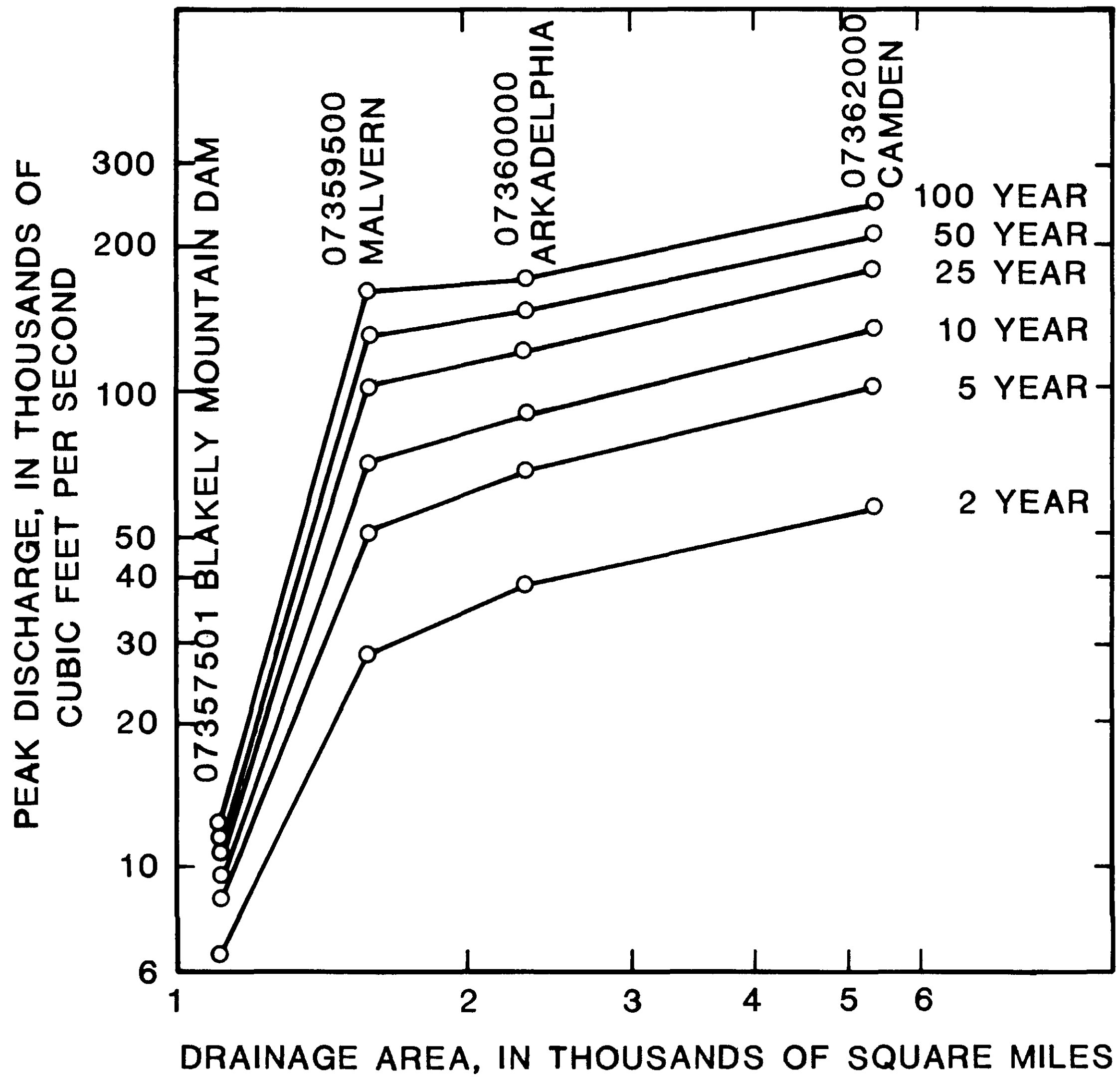


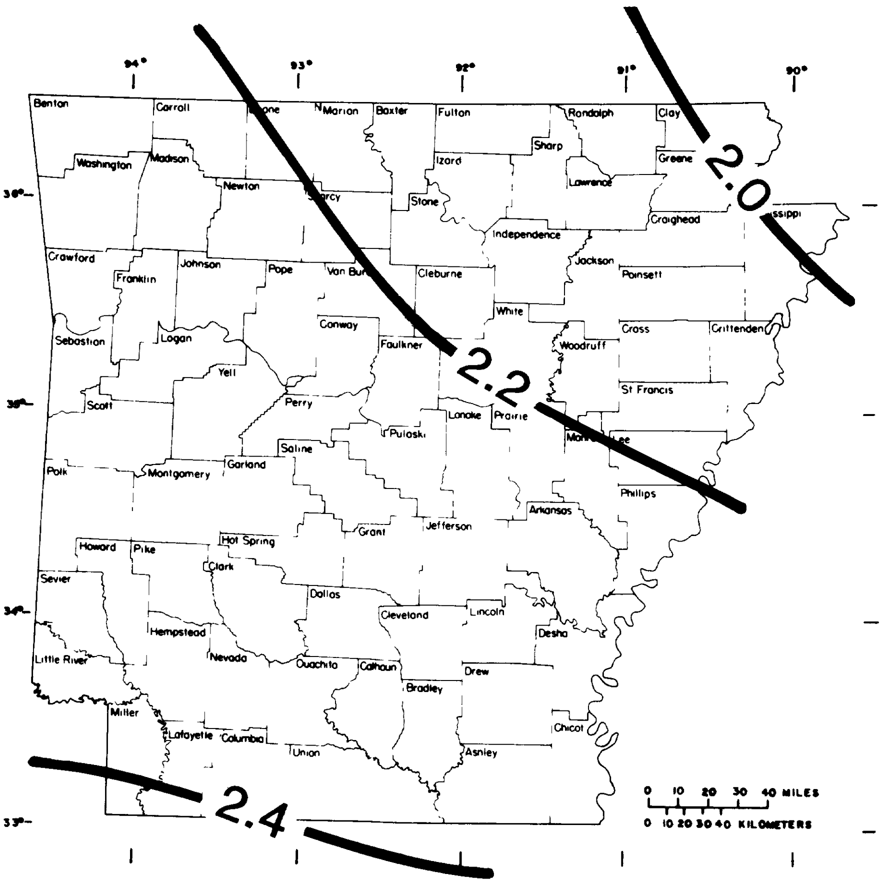
Figure 13.--Flood magnitude and frequency curves for Ouachita River.

where,

UQx = The peak discharge, in ft^3/s, urban discharge for the urban watershed for recurrence interval, x.
A = The contributing drainage area, in mi^2.
SL = The main channel slope, in feet per mile, measured between points which are 10 percent and 85 percent of the main channel length upstream from the study site. For sites where SL is greater than 70, 70 is used in the equations.
RI2 = Rainfall intensity, in in., for the 2-hour 2-year occurrence. The rainfall intensity for the 2-hour, 2-year occurrence is shown on figure 14 (Weather Bureau, 1961).
ST = Basin storage, the percentage of the drainage basin occupied by lakes, reservoirs, swamps, and wetlands. In-channel storage of a temporary nature, resulting from detention ponds or roadway embankments, is not included in the computation of ST.
BDF = The basin development factor.
IA = The percentage of the drainage basin occupied by impervious surfaces, such as houses, buildings, streets, and parking lots.
RQx = The peak discharge, in ft^3/s, for an equivalent rural drainage basin in the same hydrologic area as the urban basin, and for recurrence interval x.

The basin development factor (BDF) describes the conditions of the drainage system. The following description of the BDF and how it is computed is a quotation from Sauer and others (1983).

> The most significant index of urbanization that results from this study is a basin development factor (BDF), which provides a measure of the efficiency of the drainage system. This parameter, which proved to be highly significant in the regression equations, can be easily determined from drainage maps and field inspections of the drainage basin. The basin is first divided into thirds. Then, within each third, four aspects of the drainage system are evaluated and each assigned a code as follows:
>
> 1. Channel improvements.--If channel improvements such as straightening, enlarging, deepening, and clearing are prevalent for the main drainage channels and principal tributaries (those that drain directly into the main channel), then a code of 1 is assigned. Any or all of these improvements would qualify for a code of 1. To be considered prevalent, at least 50 percent of the main drainage channels and principal tributaries must be improved to some degree over natural conditions. If channel improvements are not prevalent, then a code of zero is assigned.
>
> 2. Channel linings.--If more than 50 percent of the length of the main drainage channels and principal tributaries has been lined with an impervious material, such as concrete, then a code of 1 is assigned to this aspect.



EXPLANATION

—2.2— LINE OF EQUAL RAINFALL INTENSITY (INCHES). INTERVAL 0.2 INCH

Figure 14.--Rainfall intensity for the 2-hour, 2-year occurrence (Weather Bureau Technical Paper No. 4).

If less than 50 percent of these channels is lined, then a code of zero is assigned. The presence of channel linings would obviously indicate the presence of channel improvements as well. Therefore, this is an added factor and indicates a more highly developed drainage system.

3. Storm drains, or storm sewers.--Storm drains are defined as enclosed drainage structures (usually pipes), frequently used on the second tributaries where the drainage is received directly from streets or parking lots. Many of these drains empty into open channels; however, in some basins they empty into channels enclosed as box or pipe culverts. When more than 50 percent of the secondary tributaries within a subarea (third) consists of storm drains, then a code of 1 is assigned to this aspect; if less than 50 percent of the secondary tributaries consists of storm drains, then a code of zero is assigned. It should be noted that if 50 percent or more of the main drainage channels and principal tributaries are enclosed, then the aspects of channel improvements and channel linings would also be assigned a code of 1.

4. Curb-and-gutter streets.--If more than 50 percent of a subarea (third) is urbanized (covered by residential, commercial, and/or industrial development), and if more than 50 percent of the streets and highways in the subarea are constructed with curbs and gutters then a code of 1 would be assigned to this aspect. Otherwise, it would receive a code of zero. Drainage from curb-and-gutter streets frequently empties into storm drains.

The above guidelines for determining the various drainage-system codes are not intended to be precise measurements. A certain amount of subjectivity will necessarily be involved. Field checking should be performed to obtain the best estimate. The BDF is the sum of the assigned codes; therefore, with three subareas (thirds) per basin, and four drainage aspects to which codes are assigned in each subarea, the maximum value for a fully developed drainage system would be 12. Conversely, if the drainage system were totally undeveloped, then a BDF of zero would result. Such a condition does not necessarily mean that the basin is unaffected by urbanization. In fact, a basin could be partially urbanized, have some impervious area, have some improvement of secondary tributaries, and still have an assigned BDF of zero.

The BDF is a fairly easy index to estimate for an existing urban basin. The 50-percent guideline will usually not be difficult to evaluate because many urban areas tend to use the same design criteria, and therefore have similar drainage aspects, throughout. Also, the BDF is convenient for projecting future development. Obviously, full development and maximum urban effects on peaks would occur when BDF = 12. Projections of full development or intermediate stages of development can usually be obtained from city engineers.

CONCLUSIONS

Methods are presented for estimating the magnitude and frequency of peak discharges on streams in Arkansas. Flood data from 200 gaging stations were used to develop regression equations to estimate peak discharges with selected recurrence intervals from 2 to 100 years on streams that drain less than 3,000 mi^2. The State was divided into two regions to improve the accuracy of the regression equations. Region A includes most of the Mississippi Alluvial Plain in Arkansas, with the exception of Crowleys Ridge. Region B includes the rest of the State. Equations were developed separately for Regions A and B.

The regression analysis for Region A indicated that size of drainage area, slope of the main channel, and length of the main channel were the most significant basin characteristics that affect the magnitude and frequency of floods. The standard error of these equations ranged from 28 to 40 percent. The regression analysis for Region B indicated that size of drainage area, slope of the main channel, elevation of the basin, and mean annual precipitation were the most significant basin and climatic characteristics that affect the magnitude and frequency of floods. The standard error of these equations ranged from 33 to 42 percent.

An alternate procedure, which uses the hydraulic radius as one of the basin characteristics for computing flood frequency is described. Hydraulic radius has not been used in flood-frequency reports in the past because it is difficult to determine at ungaged sites. In order to determine the hydraulic radius at an ungaged site, a cross section of the stream valley and a stage-discharge relation must be estimated. A method to estimate a cross section from topographic maps and to compute a stage-discharge relation for that section is described.

Large regulated rivers such as the Red, Arkansas, White, Black, St. Francis, Mississippi, and Ouachita Rivers have floodflow characteristics that differ from those of smaller tributary streams and were treated individually. The discharge for the regulated period reflects the pattern of regulation. If the pattern of regulation changes, then the discharges will change.

A method is described for estimating the magnitude and frequency of peak discharges on streams for urban areas in Arkansas. This method is based on a nationwide U.S. Geological Survey flood-frequency report which uses urban characteristics to adjust rural discharge to estimate urban discharges.

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