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A METHOD FOR ESTIMATING MAGNITUDE AND FREQUENCY OF FLOODS IN MONTANA

By M. V. Johnson and R. J. Omang

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ABSTRACT

This report provides methods for estimating flood characteristics at most natural flow sites on rural streams in Montana. It also contains significant flood data and related information for many gaged sites on Montana streams.

Frequency curves are provided for 442 gaged sites as defined by log-Pearson Type III analysis. To allow estimates at ungaged sites, mathematical equations relate the 2-, 5-, 10-, 25-, 50-, and 100-year flood magnitudes to basin characteristics. Drainage area, main channel slope, and mean annual precipitation were found to be the most significant estimating variables. Equations presented are limited to use on streams with drainage areas from about 0.1 to 2,600 square miles (0.3 to 6,700 square kilometres), with slope from about 5 to 1,200 feet per mile (1.5 to 366 metres per kilometre), and with precipitation from 10 to 100 inches (250 to 2,500 millimetres).

Nomographs provide a simple graphical means of solving the estimating relations, and illustrative examples are presented.

INTRODUCTION

Knowledge of flood characteristics is essential for optimum design of bridges, culverts, and drainage systems and to help reduce flood damage. Reliable estimates of flood magnitudes and frequency of occurrence can result in economical designs, realistic flood insurance rates, and equitable land use regulations.

The purpose of this report is to describe methods to estimate the magnitude of floods, having frequencies of occurrence ranging from once each 2 years to once each 100 years, for rural stream sites in Montana. A flood-frequency curve is provided for each site where flood gaging records are of adequate length to justify frequency analysis. Techniques are provided to transfer information from gaged to ungaged sites. These transfer techniques are mathematical equations relating flood-flow magnitudes to characteristics of the drainage basins. The relations were defined from data at the gaged sites but they may be used to estimate flood magnitudes at ungaged sites by solving the equations using data on basin characteristics for the ungaged site. Basin characteristics used in the equations may be evaluated simply from topographic maps and other maps in this report.

To aid in more complete flood assessment, information is presented in the maximum flood flows recorded or observed on Montana streams.

Cooperation

This report was prepared in cooperation with the Montana Department of Highways, the Federal Highway Administration, and the U.S. Forest Service. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the cooperating agencies.

Previous reports

Numerous previous reports (Berwick, 1958; Boner and Omang, 1967; Bodhaine and Thomas, 1964; Patterson, 1966; Boner and Buswell, 1970; and Dodge, 1972) have described techniques for estimating flood-peak magnitude and frequency in Montana. At the time of most of those analyses little information was available from small streams and the techniques were limited to use on relatively large streams. Because the relations given in this report are based upon a larger data base and were defined by a more technically rigorous analysis, they are believed to be more reliable than relations previously suggested.

Hydrologic definitions

Hydrologic terms and concepts used in this report:

1. *Cubic feet per second* (ft^3/s).--One ft^3/s is the rate of discharge of a stream having a cross-sectional area of 1 square foot and an average velocity of 1 foot per second. One ft^3/s equals 0.646 million U.S. gallon per day, 449 gallons per minute, or 0.02832 cubic metre per second.
2. *Continuous-record gaging station.*--A site on a stream where stage and discharge data are obtained continously over a period of time.
3. *Crest-stage partial-record gaging station.*A site on a stream where flood peak data only are collected systematically over a period of years.
4. *Skew coefficient.*--A measure of the non-symmetry of the probability distribution of annual flood peaks and a measure of curvature in the flood-frequency relation.
5. *Recurrence interval.*--The average interval of time, in years, within which the given flood event is expected to be equaled or exceeded once. The reciprocal of the recurrence interval is the probability of occurrence during any year. (A 50-year flood, Q_{50}, has a 2 percent chance of being equaled or exceeded in any given year.) Recurrence intervals imply no regularity of occurrence; a 50-year flood event might be exceeded in consecutive years, or it might not be exceeded in a 100-year period.

6. *Flood-frequency curve.*--A graph showing the relationship between recurrence interval as abscissa and flood-magnitude as ordinate.

7. *Multiple regression.*--A statistical technique for defining the relationship between a dependent variable and two or more independent variables. In this report the dependent variable is the flow characteristic (flood discharge of a given frequency), and the independent variables are drainage basin characteristics, such as main-channel slope and drainage area.

8. *Standard error or estimate* (S_e).--A range of error such that the value estimated by the regression equation is within this range at about two out of three sites and is within twice this range at about 19 out of 20 sites (Thomas and Benson, 1969, p. 20).

Use of metric units of measurement

The analyses and data in this report are based on English units of measurements. The equivalent metric units are given in the text and illustrations where appropriate. English units only are shown in tables where, because of space limitations, the dual system of English and metric units would not be practicable. To convert English units to metric units, the following conversion factors should be used:

English units		Conversion factor		Metric units
Length in inches (in)	X	25.4	=	millimetres (mm)
in feet (ft)	X	.3048	=	metres (m)
in miles (mi)	X	1.609	=	kilometres (km)
Area in square miles (mi^2)	X	2.590	=	square kilometres (km^2)
Runoff rate in cubic feet per second (ft^3/s)	X	.02832	=	cubic metres per second (m^3/s)
Unit runoff in cubic feet per second per square mile [$(ft^3/s)/mi^2$]	X	.01093	=	cubic metres per second per square kilometre [$(m^3/s)/km^2$]

ESTIMATING FLOOD MAGNITUDES

Use of gaging station records

A frequency analysis of gaging stations records is usually the most reliable method for estimating future flood magnitudes at or near gaged sites. Any estimate first should include searching for gage data which may have been collected at or near the desired site. Streamflow characteristics are listed in table 1 (appendix) for sites that are used in this study. The most reliable estimates are obtained for sites where 15 or more years of peak flow record is available. At sites a short distance upstream or downstream, the flow characteristics of a gaged location can be transferred with considerable reliability. The transfer technique requires determination of the drainage areas of the two sites for use in the equation

$$\hat{Q}_t = (A_u/A_g)^{0.6}\, Q_t$$

where $\hat{Q}_t$ is flood magnitude, in ft^3/s, having a t-year recurrence interval at the ungaged sites; A_u is drainage area, in square miles, at ungaged site; A_g is drainage area, in square miles, at gaged site; and Q_t is flood magnitude, in ft^3/s, at the gaged site as listed in table 1. This relation will give reasonably accurate results when the drainage area ratio lies between ½ and 2.

For larger streams that are gaged at several sites, the flood-frequency data for ungaged intermediate sites may be estimated by interpolation. Figures 1 and 2 show frequency relations for Clark Fork and Yellowstone River.

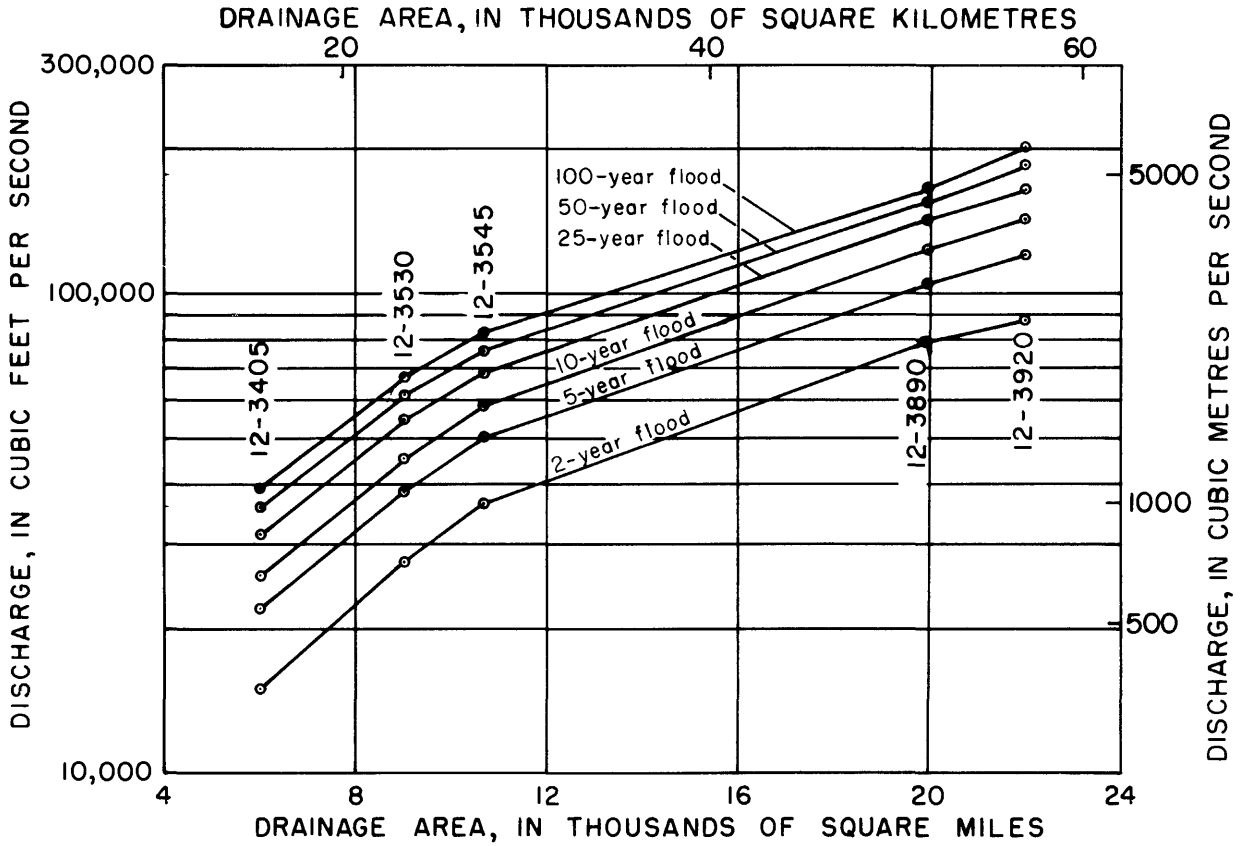

FIGURE 1.-RELATION OF DISCHARGE TO DRAINAGE AREA FOR SELECTED FLOOD FREQUENCIES ALONG MAIN STEM OF CLARK FORK

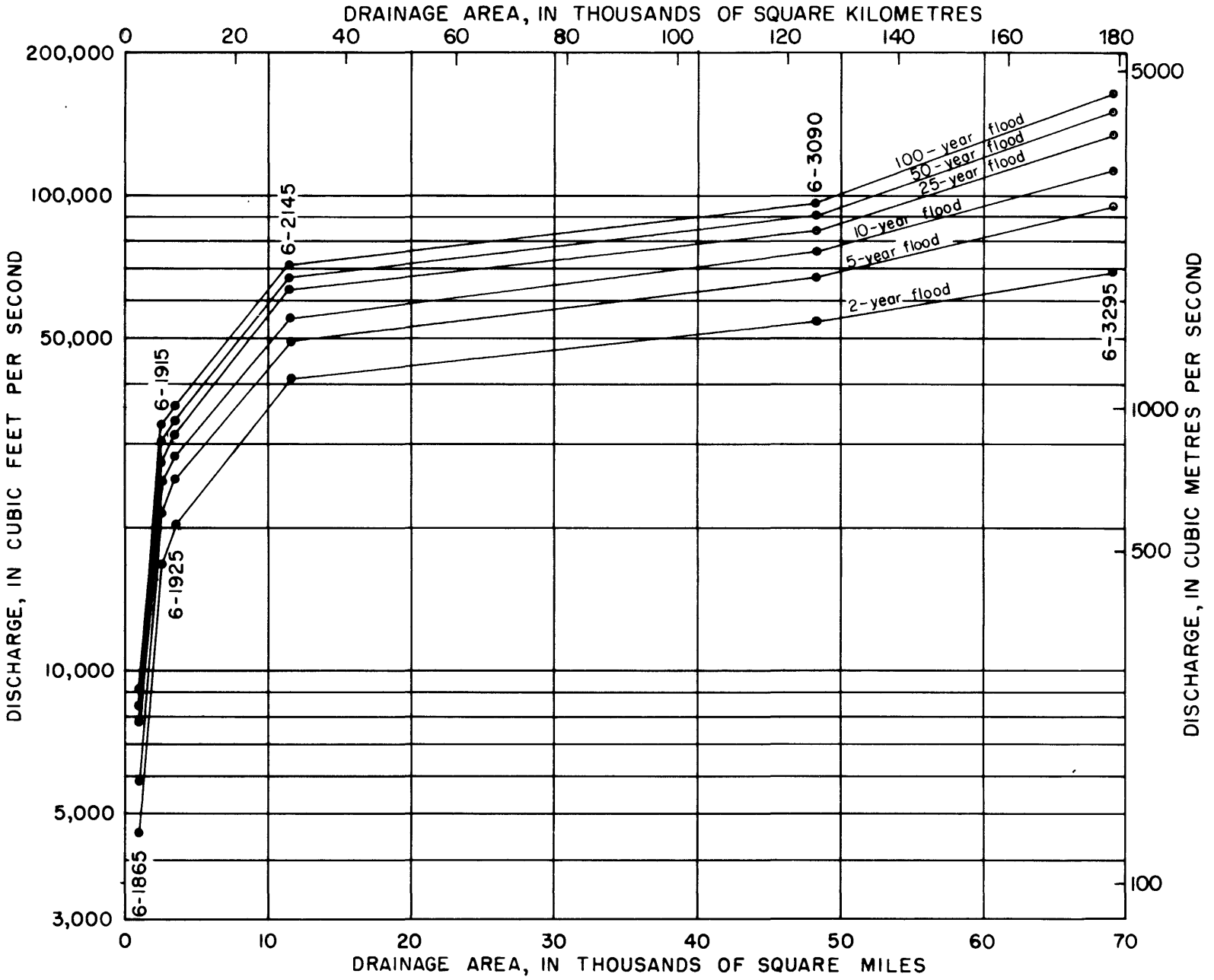

FIGURE 2.—RELATION OF DISCHARGE TO DRAINAGE AREA FOR SELECTED FLOOD FREQUENCIES ALONG MAIN STEM OF YELLOWSTONE RIVER

The reliability of flood magnitude estimates decreases as the frequency curve is extended to recurrence intervals beyond the length of gaging record. To keep the estimates listed in table 1 reasonably accurate, the frequency curves were defined only to these limits:

Years of record	10	15	20	25
Maximum recurrence interval	10	25	50	100

Hardison (1969) showed these limits to produce estimates of about equal reliability.

Use of estimating relations

Following is a method to estimate flood magnitude of ungaged streams where the flood flow is largely unregulated. Streams with short peak flow record, generally less than 10 years, may give unreliable results when frequency relations are based on station data. The proposed method of estimating flood characteristics may give improved results over those determined from short term gage records. The method requires solving the following mathematical equations relating drainage area (A), main channel slope (S), mean annual precipitation (P), and areal factor (F) to flood magnitudes.

$$Q_2 = 2.18 \; A^{0.551} \; S^{-0.520} \; P^{1.58} \; F$$

$$Q_5 = 31.7 \; A^{0.484} \; S^{-0.553} \; P^{1.08} \; F$$

$$Q_{10} = 112 \; A^{0.455} \; S^{-0.576} \; P^{0.860} \; F$$

$$Q_{25} = 388 \; A^{0.429} \; S^{-0.597} \; P^{0.640} \; F$$

$$Q_{50} = 855 \; A^{0.412} \; S^{-0.611} \; P^{0.503} \; F$$

$$Q_{100} = 1,745 \; A^{0.396} \; S^{-0.624} \; P^{0.378} \; F$$

Values for the basin characteristics, A, S, and P, and for the areal factor, F, can be obtained as described below.

Drainage area (A) is the area above the site, in square miles, contributing to surface runoff. At ungaged sites the drainage area can be determined by outlining the drainage basin on the largest scale topographic maps available and planimetering the area within the boundary. Size of area can be approximated by using a transparent grid overlay with squares of a known size and counting the number of squares within the basin boundary. Orthophotographs or aerial photographs of known scale can be used for delineation of drainages where adequate maps are available.

Main channel slope (S), in feet per mile, is the slope of the stream between points that are 10 percent and 85 percent of the distance along the channel from the desired location to the basin divide. Above each junction, the main channel is the one that drains the largest area. The measured main channel length should approximate the meander length and the line on the map indicating the stream must be extended to the basin divide. Channel length can be measured by stepping with dividers set at 0.1 mile.

Altitudes are determined by interpolation between contour lines. The slope is the difference in altitude between the 10 percent and 85 percent points divided by 0.75 of the total main channel length.

Mean annual precipitation (P) is the basin average in inches (1953-67) determined from an isohyetal map compiled from unpublished maps prepared by the Soil Conservation Service and National Weather Service in cooperation with the Montana Department of Natural Resources and Conservation (plates 1 and 2). Mean annual precipitation is determined by weighing the values of precipitation lines within the basin. The grid sampling method can also be used for obtaining average precipitation by determining the precipitation at each grid intersection and averaging the results.

The areal factor (F) is a coefficient to reduce unexplained variance (plate 3). The numerical values of these coefficients are the average of residuals obtained from the statewide multiple regression. When streams cross areal factor boundaries the factor should be areally weighted (See example, page 21).

Flood magnitudes for the selected recurrence interval can be determined directly by entering the basin characteristic values into the equations and solving. Nomographs (figs. 3, 4, and 5) are provided that will solve the equation except for the areal factor (F) which must be applied separately. An example for determining a 25-year magnitude using the nomograph method is shown on figure 3.

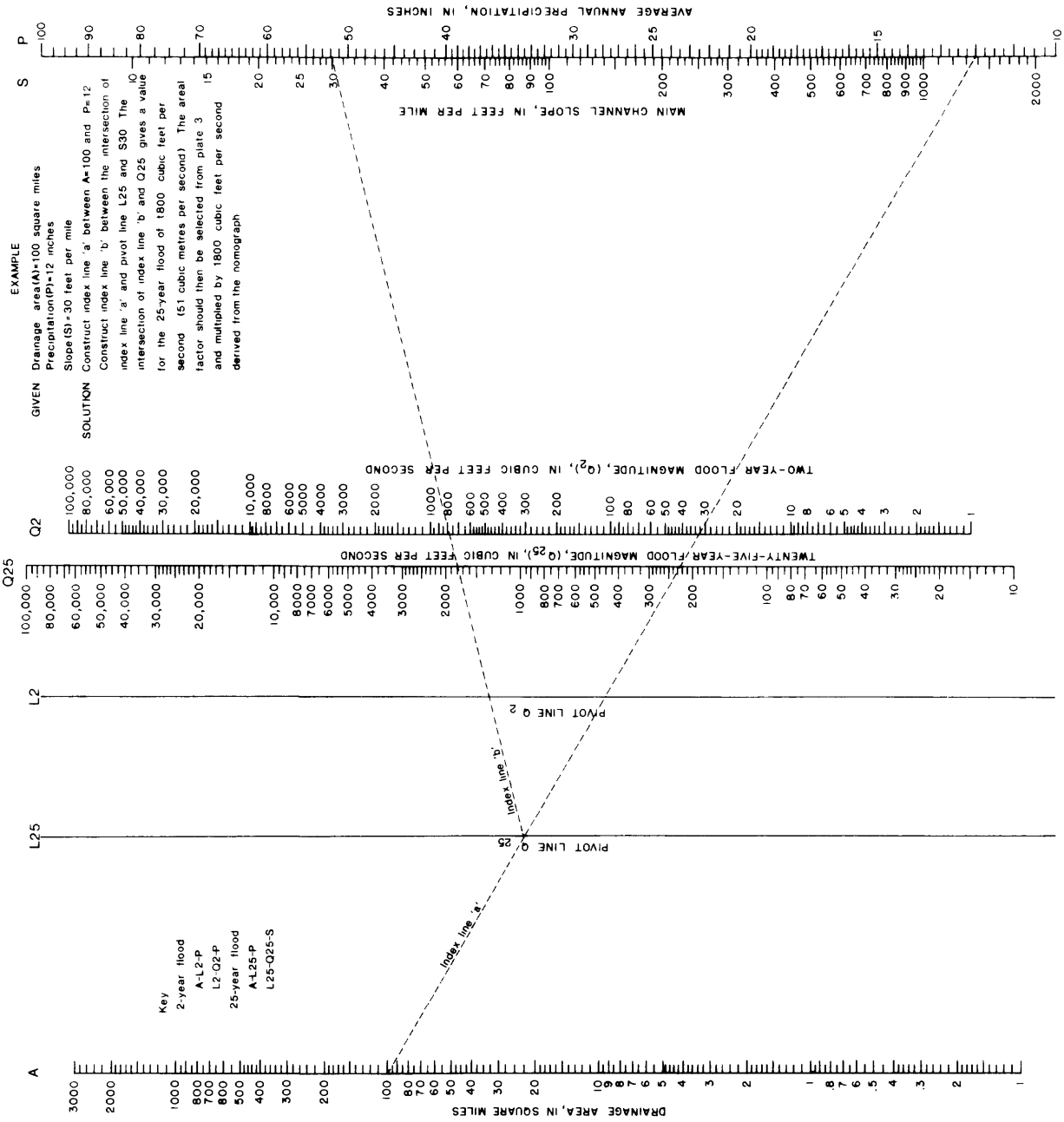

FIGURE 3.-NOMOGRAPHS FOR COMPUTING STATEWIDE FLOOD MAGNITUDES, 2- AND 25-YEAR FLOODS

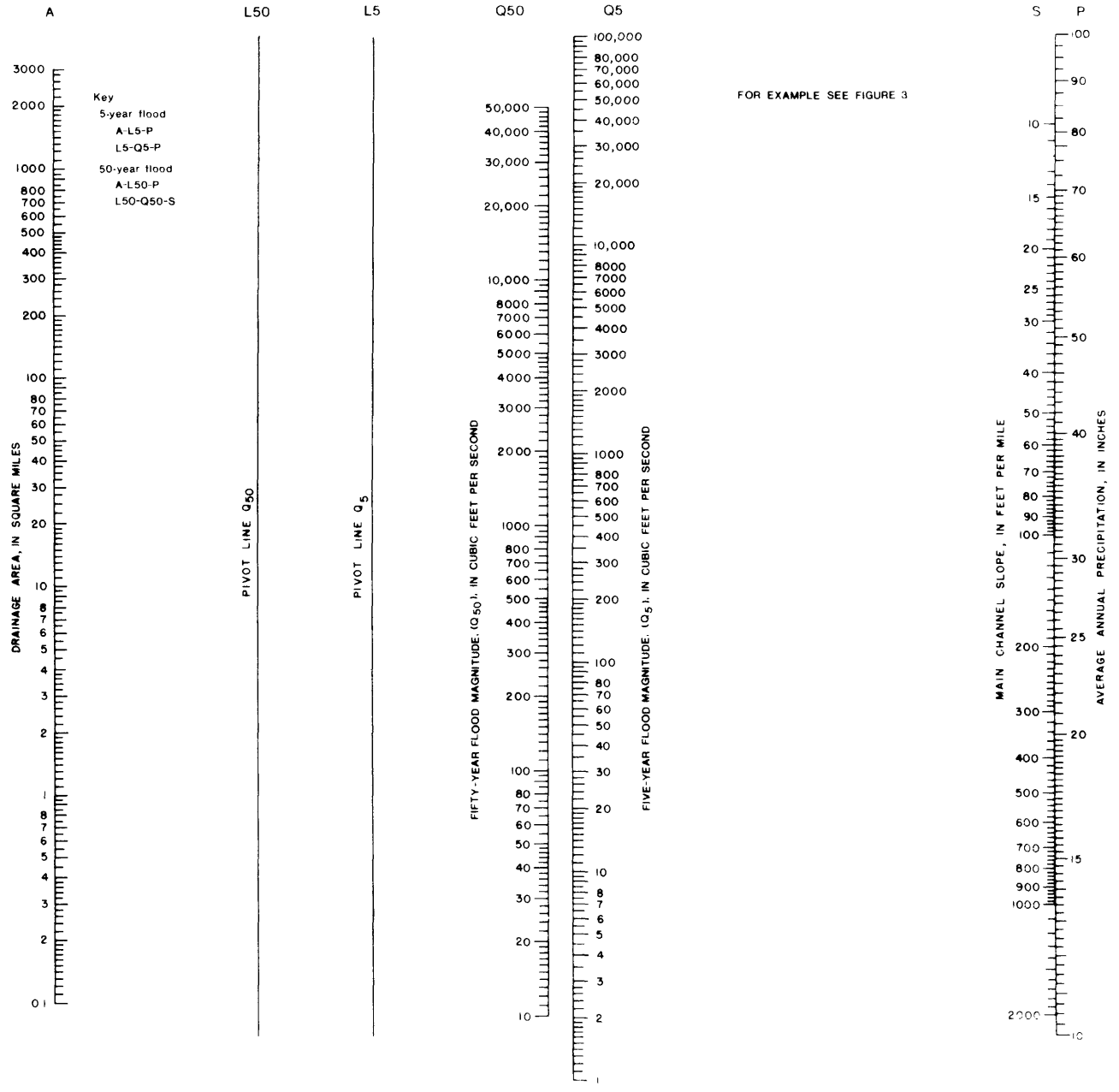

FIGURE 4 -NOMOGRAPHS FOR COMPUTING STATEWIDE FLOOD MAGNITUDES 5- AND 50 YEAR FLOODS

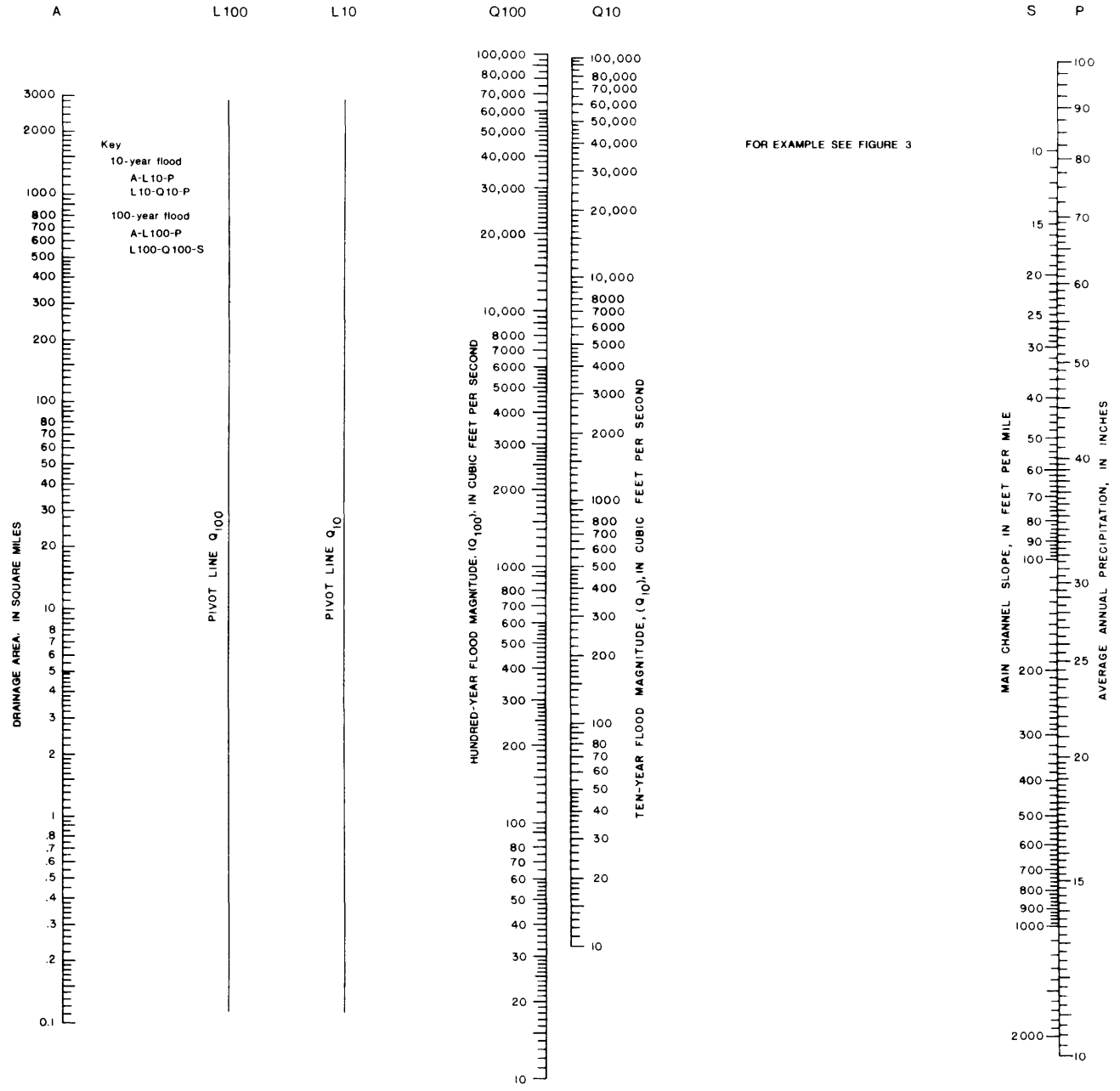

FIGURE 5.-NOMOGRAPHS FOR COMPUTING STATEWIDE FLOOD MAGNITUDES, 10- AND 100-YEAR FLOODS

Substitution of metric values for the variables A, P, and S will give incorrect solutions. The solution in English units can be multiplied by 0.02832 to obtain the metric equivalent in cubic metres per second.

Flood magnitudes for several recurrence intervals can be plotted on a discharge-versus-recurrence-interval graph to develop a full frequency curve. Extensions beyond the 100-year flood are not recommended.

LIMITATIONS AND ACCURACY OF ESTIMATING RELATIONS

Flood-frequency relations are applicable to all sites in Montana where the flood flows are virtually unaffected by urbanization, regulation, or diversion. The estimating relations are known to apply only to the range in variables tested or sampled. The data used to define relations for estimating included drainage areas ranging from 0.1 square mile (0.3 square kilometre) to about 2,600 square miles (6,700 square kilometres). The sample of mean annual precipitation ranged from 10 to 100 inches (250 to 2,500 millimetres). The range in slope was from 5 to 1,200 feet per mile (1.5 to 366 metres per kilometre). Streams that should be excluded are those where a substantial part of the flow originates outside of Montana.

The standard errors of estimate are obtained from equations developed from data at gaged sites and are indices of the reliability of results to be expected at ungaged sites. The standard error, in percent, is the range of error to be expected as the difference between the computed and the actual discharges about two-thirds of the time. The use of logarithms of variables in the analyses causes the standard errors to be larger in the positive direction.

Approximate standard errors of estimate for defined relations are:

Geographic area	Flood relation	Standard error of estimate, in percent		Flood relation	Standard error of estimate, in percent	
		Average	Range		Average	Range
1	Q_2	81	(+109 to -52)	Q_{25}	72	(+95 to -49)
	Q_5	65	(+85 to -45)	Q_{50}	78	(+104 to -52)
	Q_{10}	66	(+86 to -46)	Q_{100}	83	(+113 to -53)
2	Q_2	66	(+86 to -46)	Q_{25}	82	(+111 to -53)
	Q_5	67	(+87 to -47)	Q_{50}	90	(+125 to -55)
	Q_{10}	72	(+95 to -49)	Q_{100}	96	(+135 to -57)
3	Q_2	86	(+117 to -54)	Q_{25}	76	(+101 to -51)
	Q_5	66	(+86 to -46)	Q_{50}	83	(+113 to -53)
	Q_{10}	69	(+90 to -48)	Q_{100}	93	(+130 to -56)
4	Q_2	90	(+125 to -55)	Q_{25}	83	(+113 to -53)
	Q_5	80	(+108 to -52)	Q_{50}	88	(+121 to -55)
	Q_{10}	80	(+108 to -52)	Q_{100}	93	(+130 to -56)
5	Q_2	68	(+89 to -47)	Q_{25}	64	(+83 to -45)
	Q_5	61	(+78 to -44)	Q_{50}	67	(+87 to -47)
	Q_{10}	61	(+78 to -44)	Q_{100}	70	(+92 to -48)
6	Q_2	94	(+132 to -56)	Q_{25}	66	(+86 to -46)
	Q_5	63	(+81 to -45)	Q_{50}	72	(+95 to -49)
	Q_{10}	61	(+78 to -44)	Q_{100}	80	(+108 to -52)
7	Q_2	150	(+230 to -70)	Q_{25}	98	(+138 to -58)
	Q_5	110	(+159 to -61)	Q_{50}	99	(+139 to -59)
	Q_{10}	100	(+142 to -58)	Q_{100}	106	(+152 to -60)

MAXIMUM KNOWN FLOODS

Floods of record at many miscellaneous gaged sites as well as all gaged sites in Montana are shown in figure 6. This figure shows the range of maximum flood discharges that have been experienced on drainage areas from 0.1 square mile to about 15,000 square miles (0.3 to 39,000 square kilometres).

Enveloping lines showing the comparison of maximum floods in Montana with maximum known floods in the United States (Matthai, 1969) are shown on figure 6. The line enveloping maximum floods in Montana was constructed with a 0.5 slope (Jarvis and others, 1936). The line showing expected 100-year flood peaks in Montana was determined from a regression study using drainage area as the only basin characteristic.

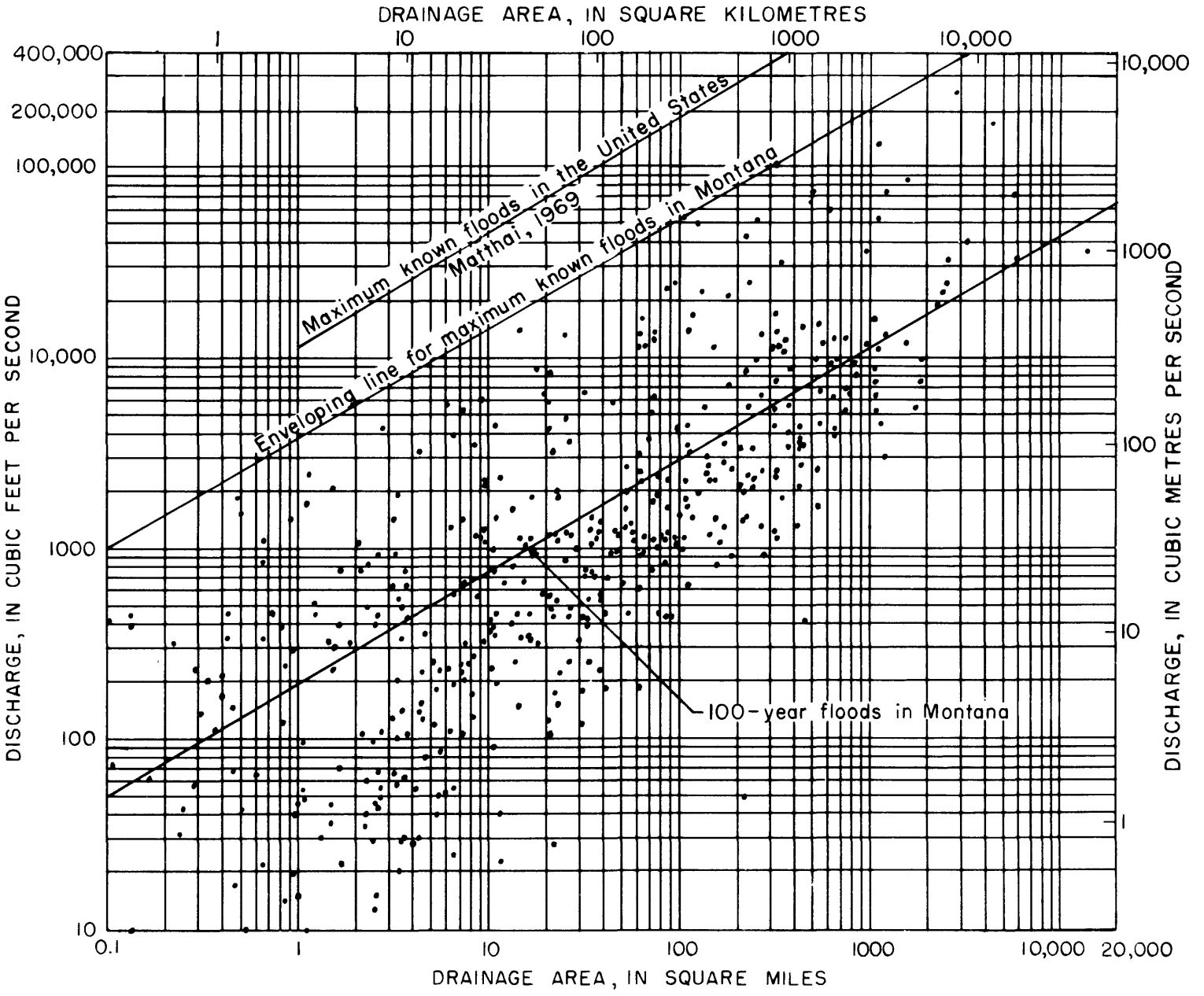

FIGURE 6.-RELATION OF MAXIMUM RECORDED DISCHARGE TO DRAINAGE AREA AT GAGING STATIONS IN MONTANA.

EXAMPLE

The following example illustrates the application of the design equations. When the flood magnitudes are desired in metric units (m^3/s) multiply the answer, in cubic feet per second, by 0.02832.

Determine the 25-year flood magnitude for a hypothetical ungaged site tributary to the Milk River near Nashua. Basin characteristics are assumed as follows:

Drainage area = 100 square miles, of which 30 square miles are in area 3 and 70 square miles are in area 6.

Slope = 30 feet per mile.

Average annual precipitation = 12 inches.

Step 1. Enter the total drainage area, slope, and precipitation values into the 25-year flood nomograph (fig. 3) and solve.

$$\text{Statewide } Q_{25} = 1{,}800 \text{ ft}^3/\text{s}$$

Step 2. From plate 3 the areal coefficient for a 25-year flood is 0.94 for area 3 and 1.94 for area 6. Find the weighted average areal coefficient (F_{avg}).

$$F_{avg} = \frac{(30 \times 0.94) + (70 \times 1.94)}{100} = 1.640$$

$$\text{At the site, } Q_{25} = 1{,}800\ (1.640) = 2{,}950 \text{ ft}^3/\text{s}$$

$$= 2{,}950\ (0.02832) = 83.5 \text{ m}^3/\text{s}$$

FREQUENCY ANALYSIS

Gaging records

Peak-flow data from 422 continuous record and crest-stage partial-record gaging stations were used in this study (table 1). Twenty-nine of these stations have 6 to 9 years of record, 304 stations have 10 to 24 years of record, and 89 stations have 25 or more years of record. Peak-flow data from 36 stations in adjacent states are included in table 1.

Flood characteristics

A flood-frequency curve was defined from each gage record by the log-Pearson Type III method of fitting frequency curves as suggested by the Water Resources Council (1967). The mean and standard deviation as computed from the logarithms of the annual flood peaks were used with a regional average skew coefficient to define station frequency relations listed in table 1.

A graphic plot was prepared for each frequency curve to visually judge the adequacy of the fit of the computed curve to the flood data. Use of regional average skew coefficient greatly reduced the problems frequently encountered with low and high outliers. Frequency curves for sites with zero-flow years were computed on basis of only the years with flow and subsequently adjusted by the Jennings-Benson (1969) method.

Regional skew

The use of regional average skew coefficients (Hardison, 1974; Beard, 1974) has been shown to be the best way to define station frequency curves. Techniques for evaluating regionalized skew coefficients are not yet fixed and are subject to continued investigation. In this study long-term stations (25 or more years of record) were used to develop a regional average skew coefficient for Montana. As a start, a circle of diameter great enough to encompass 40 or more stations was considered a region. The mean skew value was determined for each encircled region. The regions had average skew values ranging from -0.13 to -0.19 and the statewide average is -0.15. This report uses a statewide skew coefficient of -0.15 for determination of all station flood-frequency relations. The computed frequency curves for all stations were examined graphically but no changes from average skew were deemed necessary.

REGRESSION ANALYSIS

The regression analysis used a model of the form

$Q_t = aA^bB^cC^d \ldots N^m$ where:

Q_t is a flow magnitude, in cubic feet per second, having a t-year recurrence interval,

a is a constant defined by regression analysis,

b, c, d, and m are coefficients defined by regression analysis, and

A, B, C,...N are basin characteristics.

Flood magnitudes for selected years of occurrence at each site were used as the dependent variables and basin characteristics were used as the independent parameters. A separate set of equations was defined for each selected recurrence interval by step-backwards computer programs. Numerous computer runs were made to define a consistent set of equations and to test for the practicality of defining different sets of relations for various divisions of the State.

Eight basin characteristics (drainage area, slope of the main channel, area of lakes and ponds, mean basin elevation, area of forest cover, mean annual precipitation, drainage area above 6,000 feet, 1,830 metres, and length of the main channel) were tested for use at the 5 percent level of significance. Of these parameters drainage area proved to be the most significant. The next most significant parameters, slope of the main channel and mean annual precipitation, were nearly equal in correlative value. Other parameters did not greatly improve the estimating ability of the relations.

Various tests indicated that separate relations for various divisions of the State were impractical. From the statewide relations, the differences in log units between observed and computed peak values, herein called residuals, were plotted on a map at their respective station points. Groupings of similar residual values were then used to divide the State into areas where like frequency estimates could be expected. The average of the log residual values for the selected floods in each area was then converted to a natural number and is used as an areal correction factor (F) in the frequency equations. This method simplifies peak computations for the user in that the parameter exponents in the equations remain the same statewide.

The values on page 18 for geographic areas 1-7 show the standard error of estimate for each area after the respective areal coefficients are applied. Tabulated below are statewide values of the standard error of estimate when the regression equations are supplied without consideration for areal divisions.

Geographic area	Flood relation	Standard error of estimate, in percent		Flood relation	Standard error of estimate, in percent	
		Average	Range		Average	Range
Statewide	Q_2	109	(+157 to -61)	Q_{25}	98	(+138 to -58)
	Q_5	90	(+125 to -55)	Q_{50}	104	(+148 to -60)
	Q_{10}	91	(+126 to -56)	Q_{100}	112	(+162 to -62)

Standard errors of estimate obtained from multiple regression methods, using the flood characteristics of stations within each geographic area, are comparable to those obtained from the presented method, which uses the statewide equations times an areal multiplier.

The relatively high standard errors of estimate shown in this report are in some cases misleading. For example, in area 1 there are 102 gaged sites and the 100-year flood shows an average standard error of estimate of 90 percent. If the three stations with the highest residuals were not used the standard error of estimate would be reduced to 69 percent and there would be negligible changes in the formulas.

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APPENDIX

Table 1 .--Drainage-basin and flood-frequency characteristics for selected gaging stations in Montana and adjacent areas.

Station number	Station name	Period of record	Basin characteristics: Drainage area (mi^2)	Basin characteristics: Main channel slope (ft/mi)	Basin characteristics: Mean annual precipitation (in)	Flood characteristics: Discharge, in ft^3/s; Recurrence interval, in years: Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Maximum of record
06011000	Red Rock River	1936-67	323	16.6	22	705	931	1,070	1,240	1,360	1,480	1,360
06011400	Long Creek	1960-67	33.9	65.2	18	165	230	-	-	-	-	265
06011900	Red Rock River tributary	1960-67	1.00	192	17	4	8	-	-	-	-	15
06013200	Traux Creek	1960-73	4.06	592	15	3	19	46	-	-	-	28
06013400	Muddy Creek	1960-73	62.7	95.0	16	62	119	166	-	-	-	187
06013500	Big Sheep Creek	1946-73	280	75.2	19	367	519	619	743	834	-	909
06015500	Grasshopper Creek	1921-73	348	46.0	19	375	657	872	1,170	1,410	1,660	1,870
06016900	Beaverhead River tributary	1960-73	.93	276	11	.1	4	13	-	-	-	19
06017500	Blacktail Deer Creek	1946-64	312	36.5	16	209	292	346	412	-	-	426
06018200	Beaverhead River tributary No. 2	1958-65	.40	78.6	10	2	15	-	-	-	-	170
06019500	Ruby River	1938-73	538	53.3	18	915	1,180	1,340	1,530	1,660	1,790	1,700
06019800	Idaho Creek	1960-73	10.8	263	19	20	36	49	-	-	-	90
06023500	Big Hole River	1948-53	44.0	80.0	31	482	651	-	-	-	-	938
06024000	Miner Creek	1948-53	17.6	145	34	273	316	-	-	-	-	336
06025300	Moose Creek	1960-73	41.4	144	18	99	141	169	-	-	-	180
06025500	Big Hole River	1923-73	2,476	15.4	23	7,110	10,600	13,100	16,100	18,500	20,800	23,000
06027700	Fish Creek	1959-73	39.5	197	19	126	175	207	246	-	-	228
06028500	Little Pipestone Creek	1935-40	30.7	211	16	21	66	-	-	-	-	175
06029000	Whitetail Creek	1949-53, 1955-68	30.8	232	21	66	95	114	140	-	-	126
06030200	Jefferson River tributary	1960-73	1.85	231	12	.5	7	15	-	-	-	22
06030300	Jefferson River tributary No. 2	1958-73	4.50	317	12	13	39	65	107	-	-	169
06030500	Boulder River	1946-57	19.4	85.2	20	161	285	380	-	-	-	582
06033000	Boulder River	1929-72	381	66.0	19	1,090	1,690	2,100	2,640	3,040	3,460	3,490
06034000	South Boulder Creek	1926-33	27.5	310	41	246	335	-	-	-	-	434
06034700	Sand Creek	1960-73	9.41	233	11	29	222	571	-	-	-	2,130
06034800	Jefferson River tributary No. 3	1960-73	1.14	300	12	.6	12	38	-	-	-	96
06035000	Willow Creek	1938-73	83.8	130	27	235	364	454	571	661	752	813
06035500	Norwegian Creek	1938-43, 1946-51	22.4	122	16	22	24	25	-	-	-	28
06036600	Jefferson River tributary No. 4	1960-73	.53	247	12	2	6	9	-	-	-	10
06036700	Jefferson River tributary No. 5	1960-73	3.69	100	12	1	31	77	-	-	-	153
06037500	Madison River	1913-73	420	34.2	24	1,330	1,630	1,810	2,020	2,160	2,290	2,150
06043000	Taylor Creek	1946-67	98.0	138	40	779	927	1,010	-	-	-	1,020
06043200	Squaw Creek	1959-73	40.4	205	35	257	381	466	574	-	-	690
06043300	Logger Creek	1959-73	2.48	970	30	15	23	28	35	-	-	29
06043500	Gallatin River	1930-73	825	16.8	37	5,000	6,630	7,650	8,870	9,740	10,600	9,270
06046500	Rocky Creek	1952-53, 1959-73	49.0	96.0	27	401	594	725	892	-	-	1,230
06046700	Pitcher Creek	1960-73	2.33	245	21	15	26	34	-	-	-	60
06047000	Bear Canyon Creek	1952-53, 1959-73	17.0	256	28	146	234	297	381	-	-	450
06048000	East Gallatin River	1939-61	148	143	26	553	828	1,010	1,250	1,430	-	1,240
06048500	Bridger Creek	1945-69	62.5	91.4	33	295	462	580	735	854	975	902
06050000	Hyalite Creek	1934-73	48.2	70.8	36	402	541	628	734	810	884	956
06052500	Gallatin River	1895-1905, 1928-73	1,795	37.8	27	4,820	6,400	7,390	8,590	9,440	10,300	9,840
06053000	Sixteenmile Creek	1950-55	79.0	43.8	15	109	379	-	-	-	-	545
06055500	Crow Creek	1919-29, 1966-73	78.0	219	25	525	677	770	881	-	-	1,000
06056200	Castle Creek tributary	1960-73	2.59	302	22	21	31	38	-	-	-	47
06056300	Cabin Creek	1960-73	12.6	307	26	18	26	32	-	-	-	40
06056600	Deep Creek	1959-73	87.7	131	24	220	309	367	438	-	-	445
06058700	Mitchell Gulch	1959-73	8.09	302	15	13	61	125	248	-	-	139
06061500	Prickley Pear Creek	1908-16, 1923-33, 1945-71	192	157	19	274	414	509	632	724	817	900
06061700	Jackson Creek	1961-73	3.44	626	19	11	17	21	-	-	-	20
06061800	Crystal Creek	1961-73	3.77	355	19	10	21	31	-	-	-	30
06061900	McClellan Creek	1960-73	33.2	212	19	136	233	305	-	-	-	390
06062500	Tenmile Creek	1914-73	32.7	253	24	225	353	443	562	653	747	781
06062700	Little Porcupine Creek tributary	1959-73	.48	1,100	20	2	5	7	10	-	-	16
06063000	Tenmile Creek	1908-54	102	135	20	262	464	620	837	1,010	1,200	995
06071200	Lyons Creek	1959-73	29.4	144	27	103	200	279	395	-	-	490
06071400	Dog Creek	1960-73	15.9	84.4	13	52	272	600	-	-	-	1,160
06071600	Wegner Creek	1960-73	35.0	119	17	109	263	411	-	-	-	1,020
06073000	Dearborn River	1929-73	123	33.7	37	1,190	2,290	3,190	4,500	5,590	6,780	17,400
06073050	Dearborn River	1945-69	325	50.3	28	2,200	4,130	5,680	7,910	9,750	-	15,400
06075600	Fivemile Creek	1960-73	6.00	121	19	16	27	36	-	-	-	52
06076000	Newland Creek	1946-73	6.74	182	25	13	26	38	54	68	-	56
06076700	Sheep Creek	1960-73	5.22	281	29	59	98	128	-	-	-	138
06076800	Nugget Creek	1959-73	1.48	590	29	9	16	22	29	-	-	37
06077000	Sheep Creek	1941-72	54.4	85.4	30	211	300	359	433	487	541	460
06077500	Smith River	1951-69	1,594	20.0	23	2,170	4,160	5,780	8,150	10,100	-	12,300
06077700	Smith River tributary	1960-73	1.44	255	15	3	8	13	-	-	-	30
06077800	Goodman Coulee	1959-73	21.8	53.7	15	85	185	272	402	-	-	437
06078500	North Fork Sun River	1945-68	258	48.5	42	3,450	5,730	7,420	9,690	11,500	13,300	51,100
06079600	Beaver Creek	1959-73	20.3	145	29	137	395	677	1,180	-	-	4,360
06080000	Sun River	1904-40	609	42.6	42	8,000	14,000	18,600	25,000	30,200	35,600	59,700
06081500	Willow Creek	1905-25	96.1	77.9	21	195	453	693	1,080	1,430	-	1,150
06084000	Smith Creek	1945-52	74.0	89.7	24	544	1,600	2,770	-	-	-	6,140
06084500	Elk Creek	1904-24	157	55.4	21	1,150	2,510	3,740	5,660	7,350	-	12,000
06087900	Muddy Creek tributary	1963-73	3.15	28.9	13	109	259	403	-	-	-	620

Table 1.--Drainage-basin and flood-frequency characteristics for selected gaging stations in Montana and adjacent areas--continued

Station number	Station name	Period of record	Basin characteristics: Drainage area (mi^2)	Basin characteristics: Main channel slope (ft/mi)	Basin characteristics: Mean annual precipitation (in)	Flood characteristics: Discharge, in ft^3/s, Recurrence interval, in years: Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Maximum of record
06088500	Muddy Creek	1934-73	314	15.2	12	638	1,120	1,500	2,020	2,440	2,880	7,600
06089300	Sun River tributary	1956-73	21.1	49.0	13	80	216	357	604	-	-	470
06090500	Belt Creek	1951-73	368	60.2	25	1,600	2,810	3,740	5,030	6,070	-	11,000
06092000	Two Medicine River	1907-24, 1951-73	317	27.6	36	3,660	6,620	8,930	12,200	14,900	17,700	100,000
06092500	Badger Creek	1951-73	133	66.0	39	1,850	3,700	5,260	7,580	9,550	-	49,700
06098000	Dupuyer Creek	1912-37	137	67.3	25	511	1,660	3,000	5,570	8,240	11,700	21,600
06099000	Cut Bank Creek	1905-19, 1951-73	1,065	25.6	19	1,930	3,700	5,140	7,250	9,020	10,900	16,600
06099500	Marias River	1902-06, 1911-73	2,724	15.9	24	6,770	12,800	17,700	24,800	30,800	37,200	241,000
06099700	Middle Fork Dry Fork Marias River	1960-73	20.2	65.1	19	128	417	757	-	-	-	4,240
06100200	Heines Coulee tributary	1960-73	.60	50.0	13	6	17	27	-	-	-	64
06100300	Lone Man Coulee	1960-73	14.1	39.0	13	95	343	657	-	-	-	1,740
06101600	Marias River tributary No. 3	1962-73	.26	62.0	11	8	19	28	-	-	-	32
06101700	Cottonwood Creek tributary	1963-73	2.47	42.0	11	38	68	91	-	-	-	96
06101800	Cottonwood Creek tributary No. 2	1963-73	24.6	11.0	11	11	105	259	-	-	-	220
06101900	Dead Indian Coulee	1963-73	2.85	92.3	11	7	53	-	-	-	-	220
06102000	Marias River	1921-56	5,907	7.30	17	6,510	12,900	18,200	26,000	32,600	39,900	70,100
06102100	Dry Fork Coulee tributary	1959-73	.84	140	12	18	64	119	228	-	-	244
06102200	Marias River tributary	1956-73	1.62	150	12	18	57	100	177	-	-	300
06102300	Marias River tributary No. 2	1956-73	.25	189	12	4	12	21	38	-	-	42
06102500	Teton River	1947-54	105	70.5	35	2,030	6,890	-	-	-	-	54,600
06105800	Bruce Coulee tributary	1963-73	1.70	109	14	69	188	312	-	-	-	390
06106000	Deep Creek	1911-24	223	107	21	912	2,860	5,100	-	-	-	41,800
06107000	Blackleaf Creek	1912-24	61.3	70.6	20	135	270	384	-	-	-	600
06108000	Teton River	1954-73	1,307	20.4	18	1,470	4,120	6,940	12,000	-	-	71,300
06108200	Kinley Coulee	1963-73	9.67	34.0	13	19	224	756	-	-	-	2,070
06108300	Kinley Coulee tributary	1963-73	2.65	56.5	13	12	73	173	-	-	-	465
06109800	South Fork Judith River	1956-73	58.7	126	21	262	561	824	1,230	-	-	1,340
06109900	Judith River tributary	1960-73	7.15	204	15	13	46	81	-	-	-	104
06110000	Judith River	1919-73	328	72.8	24	477	764	971	1,240	1,460	1,670	1,120
06111000	Ross Fork	1946-64	337	40.6	17	564	1,170	1,690	-	-	-	2,640
06111700	Casino Creek tributary	1960-73	3.14	141	22	17	36	52	-	-	-	66
06112100	Cottonwood Creek	1958-73	47.9	85.9	29	307	663	978	1,470	-	-	1,220
06114500	Wolf Creek	1950-62	112	93.6	25	21	62	109	-	-	-	628
06115100	Missouri River tributary	1962-73	3.39	167	12	40	240	580	-	-	-	1,950
06115300	Duval Creek	1963-73	3.31	78.0	13	57	141	222	-	-	-	340
06115500	North Fork Musselshell River	1940-73	31.4	131	21	87	163	223	309	381	458	423
06117000	Checkerboard Creek	1922-32	23.9	122	23	50	104	151	-	-	-	167
06118500	South Fork Musselshell River	1941-73	287	58.7	20	699	1,010	1,210	1,470	1,660	1,850	1,330
06120500	Musselshell River	1905-73	1,125	28.9	18	1,010	1,920	2,670	3,760	4,670	5,660	4,530
06120600	Antelope Creek tributary	1956-73	.47	160	15	2	7	12	21	-	-	68
06120700	Antelope Creek tributary	1956-73	1.92	156	15	58	140	218	347	-	-	307
06120800	Antelope Creek tribuary No. 2	1956-73	21.2	59.4	13	87	329	643	1,290	-	-	3,230
06120900	Antelope Creek	1954-73	88.7	69.3	14	97	524	1,230	3,000	5,270	-	24,400
06122000	American Fork below Lebo Creek	1946-67	166	65.8	19	351	652	893	1,240	1,520	-	1,570
06125500	Careless Creek	1934-42	471	36.1	15	199	289	-	-	-	-	410
06125700	Big Coulee Creek	1957-73	232	24.4	14	115	388	716	1,360	-	-	2,400
06126300	Currant Creek	1958-73	220	43.3	13	140	424	742	1,330	-	-	1,620
06127100	South Willow Creek tributary	1962-73	1.38	93.3	11	107	258	397	-	-	-	510
06127200	Musselshell River tributary	1963-73	10.8	62.5	11	21	160	400	-	-	-	380
06127570	Butts Coulee	1963-73	6.71	34.2	11	106	232	344	-	-	-	488
06128400	South Fork Bear Creek	1962-73	39.6	52.6	16	231	582	928	-	-	-	1,490
06128500	South Fork Bear Creek tributary	1962-73	5.40	57.1	15	57	115	165	-	-	-	185
06128900	Box Elder Creek tributary	1955-73	16.2	25.5	13	125	280	421	642	-	-	1,030
06129000	Box Elder Creek	1930-38, 1958-73	684	12.7	14	1,500	3,170	4,620	6,850	-	-	9,910
06129100	North Fork McDonald Creek trib.	1960-73	2.24	223	20	12	24	33	-	-	-	36
06129200	Alkali Creek	1960-73	3.76	222	18	25	105	218	-	-	-	757
06129400	South Fork McDonald Creek trib.	1963-73	.51	650	17	16	28	-	-	-	-	42
06129500	McDonald Creek	1931-73	421	25.0	18	338	696	1,000	1,470	1,870	2,310	1,440
06129700	Gorman Coulee	1955-73	2.32	29.2	13	75	255	472	898	-	-	810
06129800	Gorman Coulee tributary	1955-73	.81	29.6	13	42	133	237	433	-	-	380
06130600	Cat Creek	1958-73	36.5	31.1	13	94	214	322	496	-	-	748
06130700	Sand Creek	1957-67	317	17.2	11	761	1,810	-	-	-	-	4,410
06130800	Second Creek tributary	1958-73	.52	83.3	11	22	69	119	204	-	-	334
06130850	Second Creek tributary No. 2	1958-73	2.08	62.9	11	33	112	207	393	-	-	760
06130900	Second Creek tributary No. 3	1958-72	.72	254	11	18	49	80	133	-	-	458
06130950	Little Dry Creek	1958-73	1,224	9.40	11	1,780	3,070	4,040	5,370	-	-	5,200
06131000	Big Dry Creek	1939-69	2,554	19.3	11	3,220	8,040	12,800	20,600	28,000	36,600	24,600
06132200	South Fork Milk River	1961-73	68.6	100	36	514	1,410	2,350	-	-	-	12,000
06132250	Livermore Creek	1962-67	25.0	92.7	28	460	1,620	-	-	-	-	4,880
06132400	Dry Fork Milk River	1962-73	17.4	67.0	28	233	684	1,180	-	-	-	1,880
06132700	Milk River	1906-08, 1911, 1913-17, 1919, 1923-24, 1927, 1929-30, 1961-67	325	29.6	24	1,650	3,840	5,890	9,190	12,200	-	17,300

Table 1.--Drainage-basin and flood-frequency characteristics for selected gaging stations in Montana and adjacent areas--continued

Station number	Station name	Period of record	Basin characteristics: Drainage area (mi^2)	Basin characteristics: Main channel slope (ft/mi)	Basin characteristics: Mean annual precipitation (in)	Flood characteristics: Discharge, in ft^3/s; Recurrence interval, in years: Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Maximum of record
06133000	Milk River	1931-73	397	19.7	22	1,070	2,340	3,470	5,230	6,780	8,540	8,800
06133500	North Fork Milk River	1917-73	61.8	34.6	21	370	875	1,350	2,130	2,830	3,650	3,090
06134500	Milk River	1907-73	1,036	14.7	18	2,010	3,520	4,670	6,280	7,570	8,930	8,730
06134800	Van Cleeve Coulee tributary	1963-73	10.8	58.8	12	31	84	138	-	-	-	239
06135500	Sage Creek	1933-73	175	19.2	13	756	1,460	2,030	2,870	3,580	4,350	3,500
06136000	Sage Creek	1946-73	220	15.2	13	30	42	50	59	66	73	49
06137900	England Coulee	1960-73	.93	54.2	11	7	54	144	-	-	-	299
06138700	South Fork Spring Coulee	1960-73	6.47	152	13	15	77	177	-	-	-	190
06138800	Spring Coulee	1959-73	17.8	83.3	13	29	169	385	843	-	-	345
06139500	Big Sandy Creek	1946-67	1,805	17.8	12	503	1,530	2,690	4,830	7,010	-	5,570
06140400	Bullhook Creek	1960-73	39.6	99.0	15	90	300	543	-	-	-	700
06141900	Milk River tributary	1960-73	.11	145	12	8	9	22	-	-	-	72
06144500	Lodge Creek	1911-37	753	13.3	13	1,370	2,670	3,730	5,300	6,610	8,040	5,110
06145000	McRae Coulee	1927-51	59.0	15.4	12	304	629	909	1,330	1,700	-	1,160
06150000	Woodpile Coulee	1927-73	60.2	11.9	12	358	1,160	3,000	3,890	5,750	8,140	3,090
06150500	East Fork Battle Creek	1927-73	89.5	14.0	12	329	886	1,460	2,460	3,420	4,580	2,300
06151000	Lyons Creek	1927-73	66.7	26.3	12	226	612	1,010	1,710	2,390	3,200	1,220
06154400	Peoples Creek	1966-73	220	26.4	16	459	1,660	-	-	-	-	8,460
06154500	Peoples Creek	1918-21, 1951-73	670	20.5	15	862	1,980	3,010	4,660	6,150	-	3,940
06155100	Black Coulee	1956-67	7.03	11.9	13	73	144	203	-	-	-	220
06155200	Alkali Creek	1956-73	162	7.00	13	130	552	1,150	2,460	-	-	800
06155300	Disjardin Coulee	1956-73	4.84	57.5	13	36	102	168	277	-	-	360
06155400	South Fork Taylor Coulee	1956-73	3.89	74.0	13	13	64	138	303	-	-	105
06156000	Whitewater Creek	1927-73	458	18.3	12	141	914	2,350	6,280	11,700	20,300	3,500
06168500	Rock Creek	1927-61	241	13.5	13	597	1,360	2,070	3,200	4,220	5,380	3,310
06169000	Horse Creek	1916-61	73.5	20.8	13	305	725	1,120	1,770	2,360	3,050	1,800
06169500	Rock Creek	1916-26, 1956-73	328	12.3	13	1,120	2,360	3,450	5,120	6,570	8,200	5,110
06170000	McEachern Creek	1924-73	182	20.2	13	675	1,800	2,950	4,950	6,860	9,160	7,080
06170200	Willow Creek	1965-73	283	13.8	12	1,980	4,890	-	-	-	-	14,600
06172200	Buggy Creek	1957-67	105	35.9	12	497	1,910	-	-	-	-	2,220
06172300	Unger Coulee	1958-73	11.1	51.7	12	68	330	720	1,590	-	-	4,460
06172350	Mooney Coulee	1961-73	14.3	33.5	13	27	158	371	-	-	-	400
06174000	Willow Creek	1953-73	538	12.9	12	3,000	6,930	10,600	16,500	-	-	16,000
06175500	East Fork Sand Creek	1963-73	8.51	42.9	16	195	528	861	-	-	-	1,220
06175700	East Fork Wolf Creek	1956-73	9.61	33.3	11	48	247	555	1,270	-	-	2,230
06175900	Wolf Creek tributary No. 2	1955-73	6.54	72.7	12	165	495	862	1,540	-	-	3,900
06176500	Wolf Creek	1910-12, 1950-73	251	26.7	11	371	1,710	3,700	8,270	13,800	-	9,780
06177050	East Fork Duck Creek	1955-73	12.4	53.7	14	105	303	519	908	-	-	650
06177100	Duck Creek	1957-73	54.0	38.5	13	175	686	1,370	2,820	-	-	1,900
06177150	Redwater River	1957-73	216	12.2	13	558	1,330	2,070	3,270	-	-	1,900
06177200	Tusler Creek	1957-73	90.2	37.3	14	147	345	531	831	-	-	430
06177250	Tusler Creek tributary	1957-73	3.17	76.9	12	7	90	252	661	-	-	1,610
06177300	Redwater River tributary	1957-73	.29	80.0	13	9	34	65	121	-	-	234
06177350	South Fork Dry Ash Creek	1955-72	5.74	74.3	13	29	70	109	174	-	-	85
06177400	McCune Creek	1955-73	29.9	33.3	14	87	359	738	1,560	-	-	1,000
06177500	Redwater River	1929-73	547	43.9	13	907	3,340	6,460	12,800	19,800	29,200	6,730
06177700	Cow Creek tributary	1963-73	1.71	88.2	16	62	208	368	-	-	-	750
06177800	Wolf Creek tributary	1962-73	.91	85.7	15	41	371	1,060	-	-	-	1,500
06178000	Middle Fork Poplar River	1931-73	362	15.3	14	706	1,930	3,210	5,460	7,640	10,300	12,700
06178500	East Polar River	1931-73	534	5.90	16	688	1,740	2,790	4,550	6,200	8,150	2,760
06179500	West Fork Polar River	1931-52	139	11.5	13	202	946	2,070	4,670	7,810	-	5,450
06180000	West Fork Poplar River	1935-49	428	5.40	12	560	1,480	2,420	4,030	-	-	3,600
06181000	Polar River	1908-24, 1947-69	3,174	6.43	12	3,580	11,100	19,600	35,600	51,900	72,500	40,000
06181200	Missouri River tributary No. 2	1962-23	1.60	86.9	13	73	140	193	-	-	-	313
06182500	Big Muddy Creek	1947-73	279	11.4	15	1,250	2,610	3,780	5,570	7,110	-	6,360
06183000	Big Muddy Creek	1948-67	850	6.40	14	1,070	2,540	3,910	6,150	-	-	8,000
06183100	Box Elder Creek	1956-73	9.40	38.9	14	97	191	270	387	-	-	328
06183200	Box Elder Creek	1953-63	19.9	36.1	14	703	1,690	-	-	-	-	6,530
06183300	Spring Creek	1955-73	7.05	88.2	14	31	65	96	143	-	-	240
06183400	Spring Creek	1955-73	16.9	51.9	14	68	311	670	1,490	-	-	660
06183500	Big Muddy Creek	1920-24, 1948-51	1,044	7.80	14	1,600	2,820	-	-	-	-	6,300
06185100	Big Muddy Creek tributary	1963-73	7.38	34.5	13	54	198	376	-	-	-	676
06185200	Missouri River tributary No. 3	1963-73	1.23	82.8	13	13	118	335	-	-	-	2,570
06185300	Missouri River tributary No. 4	1963-73	11.6	41.7	14	358	740	1,060	-	-	-	1,670
06185400	Missouri River tributary No. 5	1963-73	3.67	119	14	67	161	251	-	-	-	495
06187500	Tower Creek	1922-45	50.4	165	28	350	468	542	632	-	-	642
06188000	Lamar River	1923-69	660	17.2	34	8,420	10,500	11,700	13,200	14,200	15,100	13,600
06189000	Blacktail Deer Creek	1937-45	15.0	202	20	58	86	-	-	-	-	168
06191000	Gardner River	1938-73	202	176	30	1,250	1,580	1,780	2,020	2,190	2,350	2,080
06191500	Yellowstone River	1910-73	2,623	25.3	33	16,900	21,500	24,300	27,600	29,900	32,100	32,000
06192000	Mill Creek	1951-56	148	150	28	1,590	2,120	-	-	-	-	2,300
06193000	Shields River	1935-57	87.8	87.7	28	569	859	1,060	1,320	1,510	-	1,770
06193500	Shields River	1921-23, 1929-32, 1934-67	543	56.3	20	1,140	1,800	2,270	2,890	3,370	3,850	4,500
06194000	Brackett Creek	1921-23, 1934-57	57.9	111	26	243	412	539	712	850	994	1,400

Table 1.--Drainage-basin and flood-frequency characteristics for selected gaging stations in Montana and adjacent areas--continued

Station number	Station name	Period of record	Basin characteristics: Drainage area (mi^2)	Basin characteristics: Main channel slope (ft/mi)	Basin characteristics: Mean annual precipitation (in)	Flood characteristics: Discharge, in ft^3/s: Recurrence interval, in years: Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Maximum of record
06197000	Big Timber Creek	1912-24	74.9	304	25	697	1,180	1,540	-	-	-	1,960
06197500	Boulder River	1910-16, 1950-73	226	104	37	3,660	4,260	4,600	5,000	5,250	5,490	5,590
06199000	West Fork Boulder River	1907-14	135	107	28	1,620	1,810	-	-	-	-	1,990
06200000	Boulder River	1947-73	523	55.6	30	5,900	7,210	7,980	8,860	9,480	10,100	9,840
06200500	Sweet Grass Creek	1913-24, 1937-73	63.8	106	33	941	1,290	1,500	1,770	1,970	2,160	2,270
06201000	Sweet Grass Creek	1907-24, 1937-42, 1946-52	143	70.4	15	983	1,560	1,970	2,510	2,930	3,360	3,000
06201550	Yellowstone River tributary	1960-73	2.72	173	15	8	23	38	-	-	-	55
06201600	Bridger Creek	1960-73	61.5	103	19	165	514	914	-	-	-	2,680
06201650	Work Creek	1959-73	32.5	111	16	86	350	688	1,340	-	-	720
06201700	Hump Creek	1960-73	7.61	131	15	34	88	141	-	-	-	307
06201750	Berry Creek	1958-73	23.5	80.2	13	6	126	508	1,930	-	-	2,000
06204050	West Rosebud Creek	1965-73	52.1	186	55	701	993	-	-	-	-	1,470
06204500	Rosebud Creek	1935-69	394	123	32	2,360	3,270	3,850	4,580	5,100	5,620	5,790
06205000	Stillwater River	1910-14, 1935-73	975	73.3	32	6,620	8,310	9,330	10,500	11,300	12,100	12,000
06205100	Allen Creek	1961-73	7.17	100	13	72	269	515	990	-	-	1,580
06207500	Clarks Fork Yellowstone River	1921-73	1,154	76.3	17	7,570	9,050	9,900	10,900	11,500	12,200	10,900
06207540	Silver Tip Creek	1967-73	88.0	51.9	8	316	1,010	-	-	-	-	1,100
06209500	Rock Creek	1934-73	124	243	40	1,230	1,720	2,040	2,440	2,720	3,010	3,110
06210000	West Fork Rock Creek	1937-56	63.1	195	38	515	672	886	969	-	-	933
06211000	Red Lodge Creek	1937-73	143	98.0	22	552	1,120	1,610	2,340	-	-	2,260
06211500	Willow Creek	1937-73	53.3	91.1	20	238	496	719	1,060	1,350	1,680	1,720
06215000	Pryor Creek	1921-24, 1966-73	39.6	208	17	135	279	402	-	-	-	575
06216200	Wets Creek	1955-73	8.80	92.5	14	128	223	295	395	-	-	565
06216300	West Buckeye Creek	1955-73	2.64	121	14	80	189	291	457	-	-	924
06216500	Pryor Creek	1912-24, 1938-73	435	42.9	15	671	1,170	1,560	2,090	2,520	2,970	3,720
06217700	Crooked Creek tributary	1962-73	7.21	97.2	14	302	973	1,760	-	-	-	5,120
06217750	Fly Creek	1968-73	285	10.7	13	838	2,380	-	-	-	-	2,680
06217800	Yellowstone River tributary No. 2	1962-73	.66	172	12	.2	4	14	-	-	-	22
06287500	Soap Creek	1939-53, 1967-73	98.3	282	18	467	1,030	1,550	2,350	3,070	-	4,170
06288200	Beauvais Creek	1967-73	100	70.2	15	636	1,210	-	-	-	-	1,600
06289000	Little Bighorn River	1939-73	193	266	20	1,060	1,470	1,730	2,060	2,290	2,520	2,730
06290000	Pass Creek	1935-56	111	127	22	330	574	759	1,020	-	-	1,150
06290500	Little Bighorn River	1939-73	428	157	20	1,330	2,030	2,510	3,140	3,610	4,090	3,630
06291000	Owl Creek	1939-45	161	28.9	15	292	639	-	-	-	-	1,020
06291500	Lodgegrass Creek	1939-73	80.7	238	22	440	620	737	883	990	1,100	1,130
06294000	Little Bighorn River	1912-24, 1928-32, 1938-60	1,294	23.7	16	2,180	3,550	4,540	5,860	6,900	-	4,520
06294400	Andresen Coulee	1963-73	2.35	80.0	12	7	19	31	-	-	-	40
06294800	Unknown Creek	1962-73	14.6	47.3	13	118	422	805	-	-	-	800
06294850	Buckingham Coulee	1962-73	2.63	97.1	13	27	88	157	-	-	-	398
06294900	Middle Fork Froze to Death Creek	1962-73	1.36	107	12	95	180	248	-	-	-	463
06295020	Short Creek	1962-73	3.23	105	12	165	510	903	-	-	-	938
06295050	Little Porcupine Creek	1958-73	614	7.20	13	1,540	3,070	4,350	6,250	-	-	9,350
06295100	Rosebud Creek	1960-73	34.2	20.9	16	113	228	322	-	-	-	540
06295130	Rosebud Creek tributary	1963-73	1.14	120	14	4	8	12	-	-	-	10
06295200	Whitedirt Creek	1959-73	1.58	168	14	8	25	42	72	-	-	45
06296000	Rosebud Creek	1948-69	1,279	13.7	15	404	676	877	1,150	-	-	3,000
06296100	Snell Creek	1963-73	10.5	70.3	13	123	255	369	-	-	-	380
06306900	Spring Creek	1958-73	34.7	45.5	14	116	413	774	1,470	-	-	1,400
06306950	Leaf Rock Creek	1960-73	4.53	125	15	77	176	267	-	-	-	222
06307640	Spring Creek	1962-73	1.56	83.3	12	137	312	472	-	-	-	2,080
06307660	Walking Horse Creek	1963-73	3.33	87.2	12	2	23	54	-	-	-	58
06307760	Stebbins Creek	1963-73	5.41	178	15	4	12	23	-	-	-	39
06307780	Stebbins Creek	1963-73	20.8	76.9	14	111	295	483	-	-	-	570
06308200	Basin Creek tributary	1955-73	.14	71.4	14	22	64	110	190	-	-	390
06308300	Basin Creek	1955-73	10.9	40.0	14	165	521	931	1,700	-	-	990
06309020	North Fork Sunday Creek trib.	1963-73	.96	60.9	12	8	20	31	-	-	-	39
06309040	Dry House Creek	1963-73	35.6	16.0	12	170	625	1,210	-	-	-	1,500
06309060	North Fork Sunday Creek trib. No. 2	1962-73	.22	79.4	12	55	120	178	-	-	-	320
06309080	Deep Creek	1962-73	11.5	40.8	12	796	1,610	2,300	-	-	-	2,430
06309090	Ash Creek	1962-73	6.23	57.0	14	31	124	250	-	-	-	1,400
06324700	Sand Creek	1955-73	10.6	48.0	14	36	125	233	447	-	-	715
06326400	Myers Creek	1962-73	9.42	62.0	12	254	534	778	-	-	-	1,370
06326600	O'Fallon Creek	1962-73	669	8.90	14	1,530	2,530	3,270	-	-	-	4,100
06326650	O'Fallon Creek tributary	1962-73	.17	75.0	13	36	55	67	-	-	-	61
06326700	Deep Creek	1962-73	1.55	34.8	14	115	167	202	-	-	-	225
06326800	Pennel Creek	1962-73	1.00	28.6	14	65	130	184	-	-	-	350
06326900	Yellowstone River trib. No. 4	1962-73	.67	116	12	92	211	322	-	-	-	338
06326950	Yellowstone River trib. No. 5	1962-73	.82	109	12	10	36	65	-	-	-	127
06327700	Griffith Creek	1955-61	15.5	69.8	13	133	641	-	-	-	-	14,600
06327800	Krug Creek tributary	1955-67	1.74	66.7	13	4	34	-	-	-	-	70

Table 1.--Drainage-basin and flood-frequency characteristics for selected gaging stations in Montana and adjacent areas--continued

Station number	Station name	Period of record	Basin characteristics: Drainage area (mi^2)	Basin characteristics: Main channel slope (ft/mi)	Basin characteristics: Mean annual precipitation (in)	Flood characteristics: Discharge, in ft^3/s: Recurrence interval, in years: Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Maximum of record
06328700	Linden Creek	1958-73	4.20	78.1	13	8	17	24	32	-	-	30
06328800	Indian Creek	1958-73	.46	69.7	13	14	47	85	152	-	-	150
06328900	War Dance Creek	1958-73	3.69	62.5	13	6	31	65	128	-	-	62
06329200	Burns Creek	1957-67	233	27.2	13	241	1,320	3,130	-	-	-	2,100
06329570	First Hay Creek	1963-73	30.0	11.3	14	46	129	218	-	-	-	325
06332900	North Creek	1956-73	.68	76.9	15	270	625	956	1,490	-	-	1,100
06334000	Little Missouri River	1911-25, 1928-32, 1935-69	904	9.27	16	1,860	3,280	4,380	5,900	7,140	8,440	6,000
06334100	Wolf Creek	1955-73	9.09	30.8	15	317	605	840	1,180	-	-	1,170
06334200	Willow Creek	1958-73	123	12.8	15	673	1,200	1,620	2,200	-	-	1,800
06334630	Box Elder Creek	1959-73	1,092	6.10	14	1,740	3,840	5,740	-	-	-	7,340
06334640	North Fork Coal Bank Creek	1962-73	15.0	21.6	14	151	378	602	-	-	-	450
06334720	Soda Creek tributary	1962-73	2.22	56.5	14	18	45	71	-	-	-	106
06336450	Spring Creek	1956-73	3.88	57.7	14	64	155	242	385	-	-	438
06336500	Beaver Creek	1938-69	351	5.00	14	891	3,460	6,870	14,000	22,100	33,000	30,000
06298000	Tongue River (Wyo.)	1919-29, 1941-73	204	159	26	1,650	2,220	2,580	3,020	3,330	3,630	3,400
06298500	Little Tongue River (Wyo.)	1951-53, 1955-73	25.1	543	20	129	242	333	464	572	-	850
06299500	Wolf Creek (Wyo.)	1945-73	37.8	350	24	324	509	639	811	943	1,080	1,130
06300500	East Fork Big Goose Creek (Wyo.)	1954-73	20.3	200	27	529	725	850	1,000	1,110	-	1,230
06311000	North Fork Powder River (Wyo.)	1947-73	25.0	103	20	329	458	542	645	720	794	886
06313700	Dead Horse Creek (Wyo.)	1958-73	155	38.0	13	876	1,520	2,020	-	-	-	2,300
06317050	Spotted Horse Creek trib. (Wyo.)	1961-73	4.28	175	12	144	475	867	-	-	-	3,120
06318500	Clear Creek (Wyo.)	1896-99, 1917-27, 1958-73	120	211	16	698	1,080	1,350	1,700	1,960	2,230	3,420
06334500	Little Missouri River (S. Dak.)	1956-73	1,970	3.78	15	2,750	4,260	5,310	6,690	-	-	7,600
06356000	South Fork Grand River (S. Dak.)	1955-73	148	17.8	12	782	1,540	2,170	3,090	-	-	3,780
06358600	S. Fk. Moreau River trib. (S. Dak.)	1958-73	11.3	12.6	13	42	154	288	537	-	-	450
06358620	Sand Creek tributary (S. Dak.)	1958-73	.06	50.0	13	24	35	43	54	-	-	64
06436700	Indian Creek (S. Dak.)	1962-73	315	10.4	14	795	2,190	3,660	-	-	-	2,690
06329700	Painted Woods Creek trib. (N. Dak.)	1955-73	.37	80.0	14	9	33	64	129	-	-	110
06329800	Painted Woods Creek (N. Dak.)	1955-73	17.0	25.0	14	98	268	446	758	-	-	1,200
06329900	Painted Woods Cr. trib.No.2(N. Dak.)	1955-73	8.30	21.0	14	42	118	199	343	-	-	276
06330100	Sand Creek (N. Dak.)	1955-73	38.0	20.0	14	133	486	939	1,860	-	-	1,250
06331000	Little Muddy Creek (N. Dak.)	1954-73	775	8.30	14	1,250	2,810	4,240	6,490	-	-	6,910
06331900	White Earth River trib. (N. Dak.)	1960-73	9.60	29.0	14	79	204	331	-	-	-	1,120
06335000	Little Beaver Creek (N. Dak.)	1938-73	587	11.4	14	3,320	5,990	8,070	11,000	13,400	16,000	12,700
06335700	Deep Creek (N. Dak.)	1955-73	.29	190	14	13	27	39	56	-	-	58
06336100	Sheep Creek tributary (N. Dak.)	1955-65, 1968-73	.32	126	15	25	50	70	-	-	-	147
06336200	Sheep Creek trib. No.2 (N. Dak.)	1955-73	.40	83.0	15	47	154	280	525	-	-	210
06336300	Little Missouri River trib.(N. Dak.)	1955-73	.34	180	15	4	17	34	65	-	-	200
06336400	Jules Creek (N. Dak.)	1955-73	3.80	35.0	15	209	402	559	789	-	-	629
06336980	Little Missouri River trib.(N. Dak.)	1960-73	2.10	59.0	15	245	711	1,220	-	-	-	1,050
06337100	Spring Creek (N. Dak.)	1960-73	23.0	18.0	15	315	777	1,230	-	-	-	1,100
12300500	Fortine Creek	1947-73	112	87.6	29	801	1,120	1,330	1,590	1,780	-	1,810
12300800	Deep Creek	1959-73	18.9	311	49	147	197	228	266	-	-	310
12301300	Tobacco River	1958-73	440	36.4	33	1,630	2,200	2,560	3,000	-	-	2,810
12301700	Kootenai River tributary	1959-70	.86	1,729	30	6	10	14	-	-	-	14
12301800	Gold Creek	1959-69	6.12	776	31	67	112	146	-	-	-	230
12301900	Little Jackson Creek	1961-68	2.60	688	29	6	9	-	-	-	-	13
12301999	Wolf Creek	1967-73	216	33.5	27	649	1,300	-	-	-	-	1,660
12302000	Fisher River	1950-69	780	22.9	32	3,660	4,870	5,630	6,550	7,210	-	6,560
12302050	Peoples Creek	1961-67	2.65	744	28	3	7	-	-	-	-	15
12302400	Shaughnessy Creek	1959-73	1.16	760	60	13	22	30	41	-	-	48
12302500	Granite Creek	1934-41, 1960-69	23.6	254	67	693	1,010	1,230	1,500	1,710	-	1,960
12303100	Flower Creek	1960-73	11.1	636	79	240	293	324	-	-	-	356
12303500	Lake Creek	1945-57	210	31.6	67	2,520	2,980	3,250	-	-	-	3,250
12304250	Whitetail Creek	1960-73	2.48	617	37	26	38	46	-	-	-	49
12304300	Cyclone Creek	1960-73	5.73	506	65	130	165	186	-	-	-	220
12304400	Fourth of July Creek	1960-73	7.84	487	68	181	207	221	-	-	-	258
12304500	Yaak River	1910-16, 1954-73	766	32.9	43	7,820	10,000	11,400	13,000	14,100	-	13,400
12323300	Smith Gulch	1959-73	4.85	136	12	22	44	63	-	-	-	80
12323500	German Gulch	1955-69	40.6	315	18	177	264	323	-	-	-	450
12324100	Racetrack Creek	1957-73	39.5	105	35	351	465	536	622	-	-	537
12324700	Clark Fork tributary	1958-73	4.61	292	15	49	95	132	187	-	-	133
12324800	Morris Creek	1960-73	12.6	237	18	8	14	17	-	-	-	23
12330000	Boulder Creek	1939-73	71.3	89.1	31	367	499	584	687	761	834	764
12332000	Middle Fork Rock Creek	1937-73	123	78.9	36	909	1,230	1,430	1,670	1,840	2,010	1,590
12335500	Nevada Creek	1939-73	116	111	23	508	887	1,180	1,580	1,900	2,240	1,800
12338500	Blackfoot River	1940-63	1,274	13.4	29	5,370	7,290	8,510	10,000	11,100	-	14,600
12339900	West Twin Creek	1959-73	7.33	557	24	100	145	175	213	-	-	200
12340000	Blackfoot River	1903-05, 1939-73	2,290	14.8	29	9,500	13,300	15,700	18,800	21,000	23,200	19,200
12340200	Marshall Creek	1959-73	5.63	441	23	17	26	33	41	-	-	50

Table 1.--Drainage-basin and flood-frequency characteristics for selected gaging stations in Montana and adjacent areas--continued

Station number	Station name	Period of record	Basin characteristics: Drainage area (mi^2)	Basin characteristics: Main channel slope (ft/mi)	Basin characteristics: Mean annual precipitation (in)	Flood characteristics: Discharge, in ft^3/s: Recurrence interval, in years: Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Maximum of record
12340500	Clark Fork	1929-73	5,999	14.7	30	14,600	21,200	25,700	31,300	35,500	39,700	31,700
12341000	Rattlesnake Creek	1908-67	79.7	135	34	1,420	1,940	2,280	-	-	-	2,400
12343400	East Fork Bitterroot River	1956-73	381	67.9	32	2,310	3,250	3,860	4,620	-	-	4,000
12344300	Burke Gulch	1958-73	6.50	423	20	7	12	16	22	-	-	25
12345800	Camas Creek	1958-73	5.05	771	75	147	209	249	300	-	-	265
12346500	Skalkaho Creek	1946-53 1957-73	87.8	186	36	635	821	935	1,070	1,170	-	1,210
12347500	Blodgett Creek	1946-69	26.4	172	73	623	741	808	885	937	-	836
12348500	Willow Creek	1920-23 1958-73	22.4	551	33	104	137	157	181	-	-	170
12350000	Bear Creek	1938-54 1957-59	26.8	278	76	696	893	1,010	-	-	-	1,340
12350200	Gash Creek	1958-73	3.37	1,071	70	108	159	192	235	-	-	200
12350500	Kootenai Creek	1948-53 1958-73	28.9	302	76	804	1,060	1,210	1,440	1,530	-	1,300
12351000	Burnt Fork Bitterroot River	1920-24 1938-73	74.0	171	32	337	506	622	770	881	993	1,100
12351400	Eightmile Creek	1958-73	20.6	302	20	52	75	90	110	-	-	104
12352000	Lolo Creek	1950-60	250	47.4	52	1,520	1,840	2,020	-	-	-	2,430
12352200	Hays Creek	1959-73	4.16	516	33	9	24	37	-	-	-	56
12353400	Nigger Gulch	1959-73	8.02	580	33	34	69	99	143	-	-	170
12353800	Thompson Creek	1961-73	12.2	416	43	68	117	154	-	-	-	190
12353850	East Fork Timber Creek	1961-73	2.72	590	58	37	53	64	-	-	-	66
12354000	St. Regis River	1910-17 1958-73	303	45.0	52	4,070	5,960	7,220	8,820	10,000	-	11,000
12354100	North Fork Little Joe Creek	1960-73	14.7	227	56	180	233	265	-	-	-	262
12355000	Flathead River	1929-73	450	31.7	55	7,570	10,700	12,800	15,400	17,300	19,200	16,300
12356000	Skyland Creek	1946-54 1959-73	8.37	266	47	177	333	457	637	785	-	3,580
12356500	Bear Creek	1946-52	20.7	215	51	627	1,590	-	-	-	-	8,380
12357000	Middle Fork Flathead River	1939-53 1956-64	510	36.7	52	10,100	16,200	20,600	26,500	31,100	-	75,300
12357300	Moccasin Creek	1959-73	2.38	1,610	57	116	201	266	-	-	-	490
12357400	Middle Fork Flathead River trib.	1960-73	.14	356	39	2	5	8	-	-	-	490
12358500	Middle Fork Flathead River	1939-73	1,128	11.7	59	21,800	31,200	37,400	45,100	50,800	56,500	140,000
12359000	South Fork Flathead River	1948-57 1959-67	958	25.3	52	16,300	20,900	23,700	27,100	-	-	36,700
12359500	Spotted Bear River	1948-56	184	64.6	56	4,480	7,160	9,080	-	-	-	20,200
12359800	South Fork Flathead River	1964-73	1,160	21.2	52	21,100	29,200	34,500	-	-	-	50,900
12360000	Twin Creek	1948-56 1964-67	47.0	121	53	1,570	2,440	3,050	-	-	-	5,830
12360500	Lower Twin Creek	1948-66	22.4	128	56	656	865	-	-	-	-	1,200
12361000	Sullivan Creek	1948-56 1959-73	71.3	124	60	1,920	2,570	2,980	3,470	3,820	-	5,020
12361500	Graves Creek	1948-56 1964-67	27.0	328	67	1,310	1,890	2,270	-	-	-	3,780
12363900	Rock Creek	1961-73	3.61	846	35	14	21	26	-	-	-	29
12365000	Stillwater River	1931-50	524	19.8	31	1,600	2,560	3,240	4,150	4,860	-	4,330
12366000	Whitefish Creek	1928-50	170	52.3	37	829	1,090	1,260	1,460	1,600	-	1,400
12370500	Dayton Creek	1959-73	20.9	175	20	36	63	85	114	138	163	131
12370900	Teepee Creek	1960-73	2.55	900	52	10	19	26	-	-	-	44
12370900	Teepee Creek	1960-73	2.55	900	52	10	19	26	-	-	-	44
12371100	Hellroaring Creek	1917-32 1948-67	6.22	748	48	28	58	83	120	153	188	104
12374300	Mill Creek	1959-73	28.2	254	27	97	173	233	317	-	-	250
12375700	Garden Creek	1959-73	3.29	543	19	28	50	66	88	-	-	100
12389500	Thompson River	1911-16 1956-73	642	21.9	41	2,880	4,370	5,400	6,720	-	-	6,190
12390700	Prospect Creek	1956-73	182	118	54	1,760	2,350	2,720	3,160	-	-	2,860
12305500	Boulder Creek (Idaho)	1928-73	53.0	152	40	1,300	1,710	1,950	2,250	2,460	2,670	2,720
12310800	Trail Creek (Idaho)	1961-73	16.1	472	32	175	256	310	-	-	-	341
12316800	Mission Creek (Idaho)	1959-73	23.0	288	25	341	438	497	566	-	-	528
12321000	Smith Creek (Idaho)	1928-60 1962-73	70.0	156	50	1,940	2,520	2,880	3,310	3,620	3,910	3,810
12392100	Trapper Creek (Idaho)	1962-73	1.12	1,590	47	34	44	50	-	-	-	52
12392300	Pack River (Idaho)	1959-73	124	132	47	2,500	3,090	3,440	3,840	-	-	4,370
12411000	Coeur d'Alene River (Idaho)	1951-73	335	37.0	53	6,210	8,200	9,440	10,900	12,000	-	11,900
12413100	Boulder Creek (Idaho)	1961-73	3.13	793	51	96	126	144	-	-	-	144
12413200	Montgomery Creek (Idaho)	1962-73	4.53	548	48	74	122	157	-	-	-	155
05010000	Belly River	1947-64	74.8	42.1	79	1,700	2,750	3,510	4,540	-	-	12,000
05010500	North Fork Belly River	1946-55	10.1	212	75	245	338	-	-	-	-	416
05011000	Belly River	1912-73	121	23.7	65	1,970	2,830	3,400	4,110	4,640	5,160	16,400
05011500	Waterton River	1947-64	61.0	74.7	84	2,360	3,470	4,220	5,160	-	-	12,400
05012000	Street Creek	1948-55	6.00	626	80	253	739	-	-	-	-	5,740
05012500	Boundary Creek	1948-61	21.0	190	75	622	1,050	1,370	1,800	-	-	5,930
05013000	Waterton River	1948-73	238	27.6	68	4,750	6,830	8,200	9,930	11,200	12,500	25,700
05014000	Grinnell Creek	1947-64	3.47	1,560	95	181	244	283	331	365	-	536
05014500	Swiftcurrent Creek	1912-73	31.4	283	95	1,030	1,400	1,640	1,930	2,140	2,340	6,700