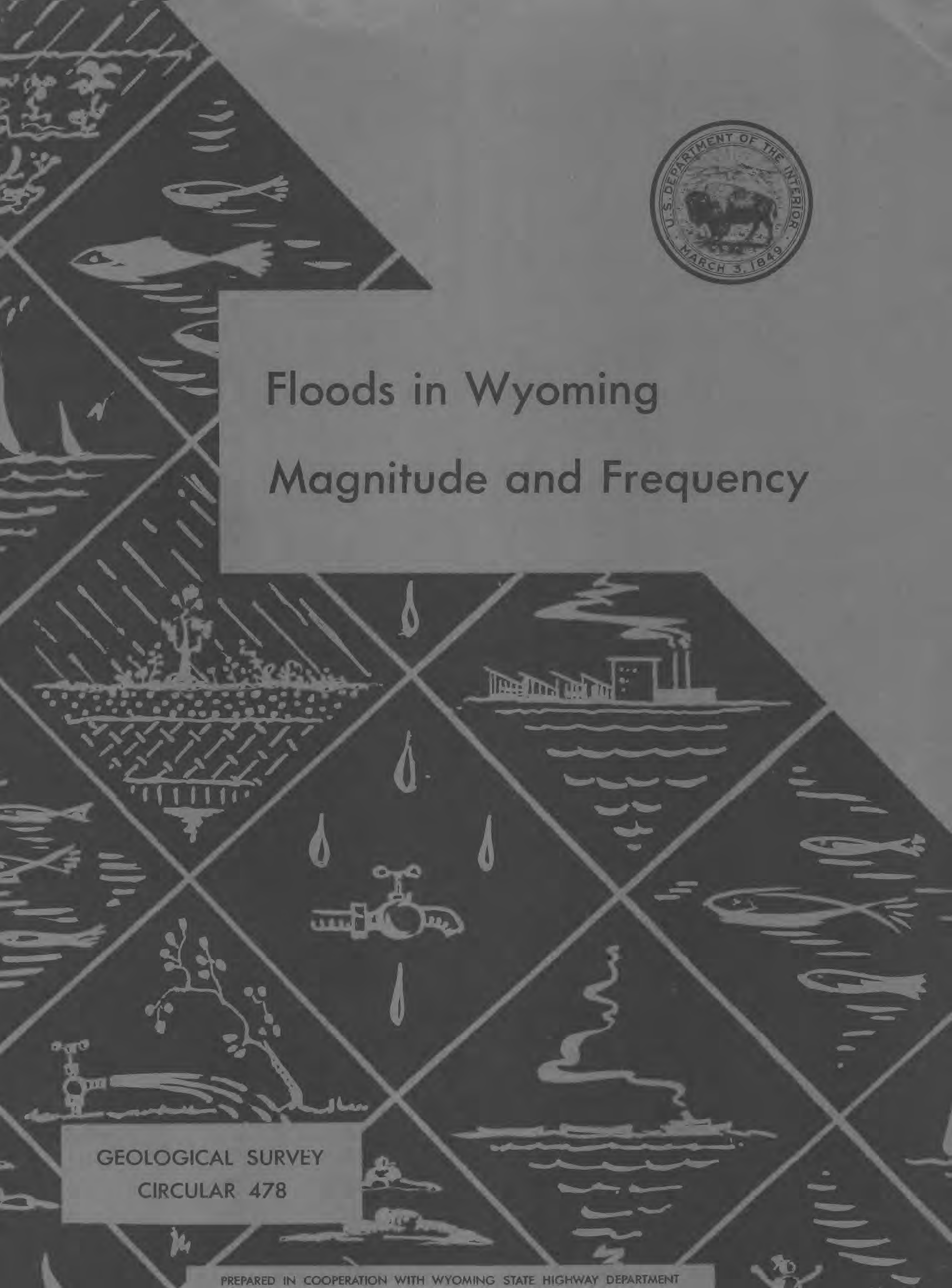

Floods in Wyoming
Magnitude and Frequency

GEOLOGICAL SURVEY
CIRCULAR 478

PREPARED IN COOPERATION WITH WYOMING STATE HIGHWAY DEPARTMENT

Floods in Wyoming Magnitude and Frequency

By J. R. Carter and A. Rice Green

Prepared in cooperation with Wyoming State Highway Department

GEOLOGICAL SURVEY CIRCULAR 478

Washington 1963

United States Department of the Interior
STEWART L. UDALL, SECRETARY

Geological Survey
THOMAS B. NOLAN, DIRECTOR

Free on application to the U.S. Geological Survey, Washington, D. C. 20242

CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

TABLES

Floods in Wyoming, Magnitude and Frequency

By J. R. Carter and A. Rice Green

ABSTRACT

Methods are described in the report for estimating the magnitude of a flood of any frequency between 1.1 and 50 years for any site, gaged or ungaged, on most unregulated streams in Wyoming, within the limits of basin size for which records have been collected. Flood-frequency relations are not defined for a large part of the headwaters of the North Platte River in south-central Wyoming because of the paucity of streamflow data.

Relations of the mean annual flood as the dependent variable to certain basin characteristics as independent variables are defined. Wyoming is in the headwaters of four main river basins; the independent variables used in each basin are as follows:

Missouri River basin: only drainage area for part of the basin; drainage area and mean basin altitude for part of the basin.

Green River basin: drainage area and altitude at site; separate drainage area relation curve for main stem of Green River.

Bear River basin: drainage area and mean basin altitude.

Snake River basin: drainage area, mean annual precipitation, and a geographic factor.

Curves are presented showing the ratio of floods of selected frequencies to the mean annual flood used as an index. A separate ratio curve is shown for the main stem of Green River. The ratio to mean annual flood varies with mean basin altitude for a small part of Snake River basin along the west-central border of the State.

Data are tabulated for the maximum known flood at each gaging station for which records are used in the analysis.

INTRODUCTION

This report contains the results of four separate flood-frequency analyses designated A, B, C, and D. Analysis A is for the portion of Wyoming east of the Continental Divide. Analysis B applies to the portion of Wyoming in Part 9, as designated in streamflow reports entitled "Surface Water Supply of the United Stated" published by the U.S. Geological Survey, and was extracted from an unpublished study by W. P. Somers in 1959. Analysis C applies to Part 10 and was extracted from Circular 457 (Berwick, 1962). Analysis D applies to Part 13 and was extracted from a report by C. A. Thomas, H. C. Broom, and J. E. Cummans (1963).

Methods described in this report can be used to estimate the magnitude of a flood of any selected recurrence interval between 1.1 and 50 years for any unregulated stream in Wyoming, gaged or ungaged, within the scope of the data. Flood-frequency relations are not defined for a large part of the North Platte River basin in south-central Wyoming because of insufficient data.

Similar reports have been prepared for many States, including four that pertain to States contiguous to Wyoming: Nebraska (Furness, 1955; 1962), South Dakota (McCabe and Crosby, 1959), eastern Montana (Berwick, 1958), and Utah (Berwick, 1962).

Analysis A of this report was made by J. R. Carter in 1961 in the Casper subdistrict office of the Denver district under the direction of W. T. Miller, district engineer, as part of a cooperative program with the Wyoming State Highway Department. On October 6, 1961, a surface water district office was established in Cheyenne, Wyo., and since that date, surface water investigations in Wyoming have been under the direction of L. A. Wiard, district engineer. Analyses B, C, and D were prepared by A. Rice Green of the Floods Section, Tate Dalrymple, Chief, Washington, D. C.

The Wyoming State Highway Department is under the direction of J. R. Bromley, Superintendent and Chief Engineer. E. R. Reed is bridge engineer and F. O. Witters is advance plans engineer.

The base data were collected principally by the U.S. Geological Survey in cooperation with various State and Federal agencies.

DESCRIPTION OF THE STATE

TOPOGRAPHY

The topography of Wyoming ranges from vast plains to rugged mountains. The Continental Divide crosses the State from near the northwest corner to a point about midway along the southern border. In the north, it follows the Wind River Range, and in the south the Park Range. Between these ranges is the Great Divide basin, from which no surface drainage flows. The crest between the two mountain ranges is not well defined and, until very recently, the Great Divide basin was believed to be west of the Continental Divide. Recent topographic mapping has shown that it is in the Missouri River basin.

One of the outstanding topographic features of Wyoming is the Great Plains, which constitutes about a third of the area of the State. The Big Horn Mountains in the north and the Laramie Range in the south form the western boundary of the Great Plains that extend eastward into adjoining States.

The mean altitude in Wyoming is about 6,700 feet. Excluding the mountain ranges, the mean altitude in the southern part of the State is greater than 6,000 feet, and in the northern part is about 3,500 feet. The altitude of the lowest point in the State, which is near the northeast corner where the Belle Fourche River crosses into South Dakota, is 3,125 feet. The altitude of the highest point, Gannet Peak in the Wind River Range, is 13,755 feet.

RIVER BASINS

Wyoming is in the headwaters of four major river basins: Parts 6-A and 6-B ("Part" as previously explained), the section of the State east of the Continental Divide, are drained by headwaters of the Missouri River; Part 9, most of the southwest section, is drained by the Green River, which flows south to the Colorado River; Part 10, a small section in the southwest corner, is drained by the Bear River, which flows to Great Salt Lake; and Part 13, the west-central section, is drained by the Snake River and its tributaries, which flow to the Pacific Ocean through the Columbia River.

CLIMATE

Because of the high altitude, Wyoming has a cool climate. For most of the State, mean high temperatures in July range from 85° to 90°F and the low temperatures from 50° to 60°F. Average temperatures decrease quickly as the elevation increases. Rapid and frequent changes between mild and cold periods are characteristic in the winter. In January, mean minimum temperatures generally range from 5° to 15°F, although in the western valleys they may be as low as -5°F.

There is a wide variation in mean annual precipitation. It is generally greater at higher altitudes, although altitude is not the only criterion. For example, in most of the southwest part, where the altitude ranges from about 6,500 to 8,500 feet, mean annual precipitation ranges from 8 to 12 inches, while in the northeast part and along the eastern border, where altitudes mostly range from 4,000 to 5,000 feet, annual averages are generally between 12 and 16 inches.

Snow falls frequently from November through May. There is considerable variation in the annual amount of snow over the State. The mountains receive several times as much snow as regions in the lower altitudes. During the summer, showers are quite frequent and, although they often amount to only a few hundreths of an inch, occasionally there is very heavy rain associated with thunderstorms covering a few square miles. However, the largest floods recorded on the larger streams at low altitudes have resulted from heavy, general rainstorms.

STREAM REGULATION

The degree of regulation of streams in Wyoming ranges from none to practically complete regulation of many of the major streams. The flood-frequency relations defined in this report do not apply to streams where flood peaks are affected appreciably by the operation of diversion and storage projects. As of 1961, the reaches of streams that are affected appreciably by regulation are:

Wind River (Bighorn River) below Wyoming Canal Diversion dam.

Shoshone River from Buffalo Bill Dam to mouth.

Belle Fourche River below Keyhole Reservoir.

North Platte River.

Laramie River from Jelm to mouth.

Green River below gaging station at Warren Bridge, near Daniel, Wyo.

FLOOD-FREQUENCY ANALYSIS A, PARTS 6-A AND 6-B

The methods used in this analysis for computing flood-frequency relationships are discussed in detail by Dalrymple (1960). Briefly, records of annual peak discharges are used to relate a selected index flood to certain significant characteristics of drainage basins and to relate peak discharges, expressed in terms of ratio to the index flood, to recurrence interval.

DATA USED

The base data used in this analysis are the records of annual maximum discharges collected at gaging stations operated by the Geological Survey and other agencies. The annual maximum discharge is defined as the highest momentary peak discharge in a water year. A water year is the 12-month period October 1 through September 30 and is designated by the calendar year in which it ends.

All records of maximum annual discharges collected since 1921 in the Missouri River basin, Wyoming, were used in this analysis if they met the following requirements:

1. The record was 5 or more years in length.
2. Flood peaks were not significantly affected by artificial storage, regulation, or diversions.
3. Records for two stations on the same stream were collected at points where the difference in area of drainage basins is more than 25 percent of the drainage area of the smaller basin. If the records were not concurrent and the areas differed by less than 25 percent, they were combined into one longer record.
4. The records for small drainage basins are typical for the general region in which the gaging stations are located.

The location of each gaging station for which records were used in this report is shown in figure 1. The index number shown is that permanently assigned to the station by the U.S. Geological Survey. Gaging stations for which records do not conform with the criteria given above are not shown in figure 1.

FLOOD SERIES

Investigators of floodflow characteristics of streams have used two types of flood series, the annual flood series and the partial-duration flood series. The annual flood series is a list of annual maximum discharges, and the partial-duration flood series is a list of all flood peaks that exceeded a selected discharge regardless of the number of peaks during the year. The annual series was used in this analysis.

The relative merits of the two series have been discussed by Mitchell (1954, p. 7–8) and many others. There is an important distinction in meaning between the recurrence intervals of annual floods and the recurrence intervals of partial-duration series floods. In the annual flood series, the recurrence interval is the average interval of time within which a given flood will be equaled or exceeded once as an annual maximum. In the partial-duration flood series, the recurrence interval is the average interval of time within which a given flood will be equaled or exceeded once as an event regardless of the relation of the flood to a water year or any other time period. Practically the same results will be obtained by use of either series for recurrence intervals greater than 10 years. Differences are appreciable for floods of more frequent occurrence.

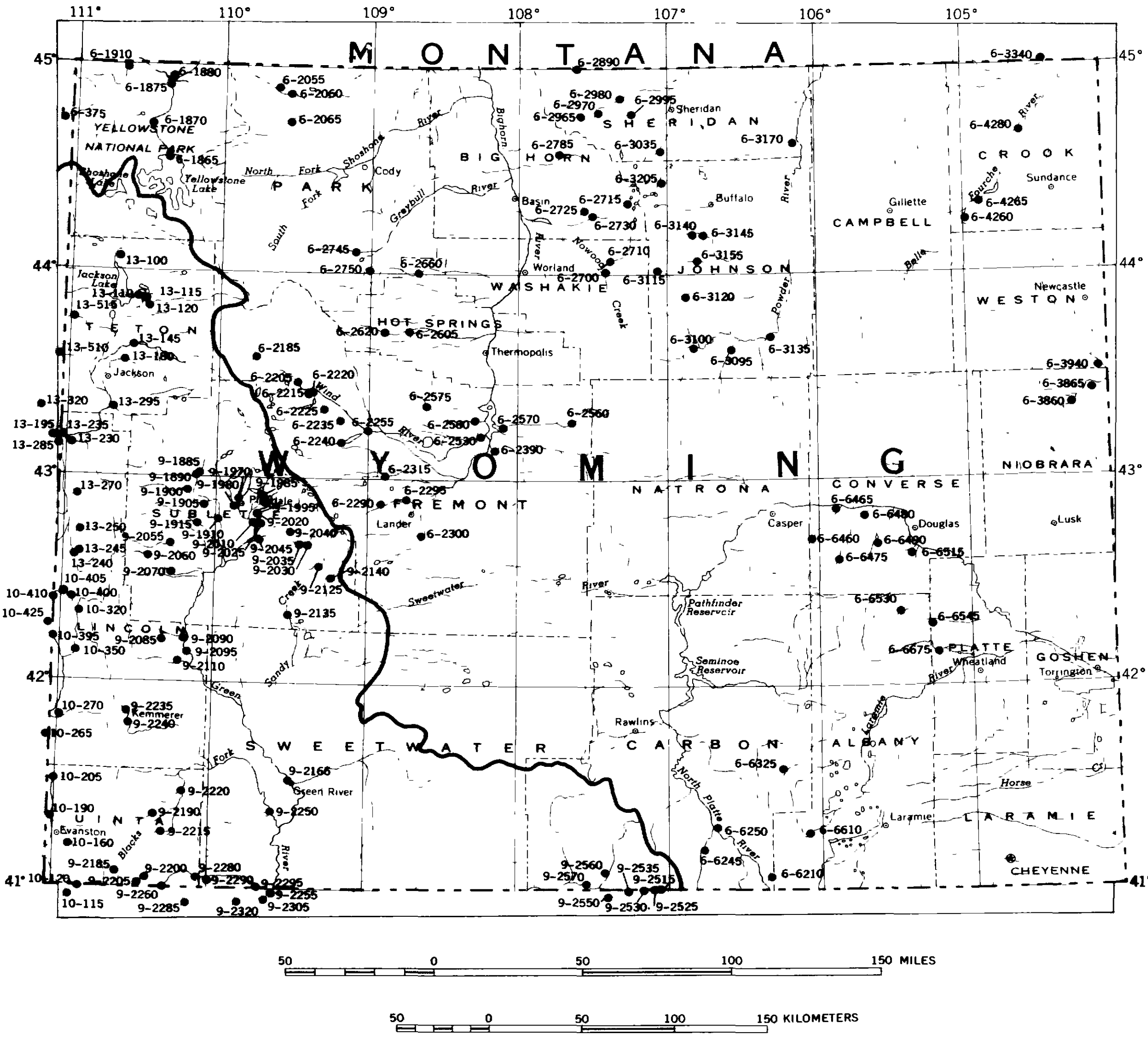

Figure 1—Map of Wyoming showing location of gaging stations for which records were used in the frequency analyses.

There is a definite relationship, shown in the following table, between the recurrence interval of a flood as an event and as an annual maximum (Langbein, 1949).

Recurrence intervals in years

Annual flood series	*Partial-duration series*
1.16	0.5
1.58	1.0
2.00	1.45
2.54	2.0
5.52	5.0
10.5	10
20.5	20
50.5	50
100.5	100

Recurrence intervals are given in this report for floods occurring as annual maxima. Recurrence intervals as events can be computed from the relation shown in the table.

FLOOD FREQUENCY AT GAGING STATIONS

BASE TIME PERIOD

In order that the station frequency curves be comparable, the period of record for each station should represent the same period in time. A 37-year period (water years 1921–57) was selected as the base time period for this study. However, most of the records used did not cover the entire period, and figures for periods of no record were estimated by correlating the flood peaks of the short-term station record with the flood peaks of a long-term record. These estimated figures are not true discharge figures and were not so considered. To avoid estimating an excessive number of working figures, an additional base period, 1941–57, was selected. Curves based on the short-term period were then adjusted to those for the period 1921–57.

FLOOD-FREQUENCY GRAPHS AT GAGING STATIONS

Values of annual peak discharges and estimated figures for periods of no record were listed in chronological order and numbered in order of magnitude, the largest being No. 1, the second largest No. 2, etc. The plotting position for each peak discharge was then computed using the formula $T = \frac{n+1}{m}$, where T is the plotting position in years, n is the number of years in the base period, and m is the relative magnitude of the peak. Plotting positions were not computed for estimated figures, nor were these figures used further in the analysis. Historical data were sometimes used to extend the upper ends of the frequency curves. For example, the highest flood on the Powder River at Arvada during the base period occurred in 1923; however, information from local residents indicates that this flood was the largest for at least 76 years, and the plotting position was computed as 77 instead of 38 years.

In most of the literature, the computed plotting position is also designated as the recurrence interval, the return period, or a similar term. The recurrence interval of a given flood at a given site has only one value, whereas the plotting position of that flood is intimately related to the length of record and will change as additional floods are added to the array. Usage in this report conforms to convention, but it should be recognized that plotting positions of floods and recurrence intervals computed from individual station data are only computation estimates of the true recurrence intervals of the floods. The best estimate of true recurrence intervals will be obtained from regional relations that are the results of the analysis.

The annual floods were plotted on a special form (Powell, 1943) for analysis of flood frequencies by the Gumbel (1941) method. The discharge was plotted as the ordinate and recurrence interval as the abscissa, and curve of visual best fit was drawn through the points.

REGIONAL FREQUENCY ANALYSIS

INDEX FLOOD

The mean annual flood ($Q_{2.33}$) was used as the index flood in this analysis; it is defined as the discharge that has a 2.33-year recurrence interval. The magnitude of the mean annual flood is a measure of certain physiographic and climatological characteristics of the drainage basin. It was estimated for each station graphically from the individual frequency curves.

The factors that were considered to determine the relation of the mean annual flood to the basin characteristics were: size of drainage basin, mean altitude of drainage basin, and slope of the main channel. There are many other factors that probably influence the values of the mean annual floods, but they generally are difficult to measure. However, there are large areas within which the variation from stream to stream of the integrated effect of difficult-to-measure or unknown characteristics is small. Analysis of the relation of mean annual flood to measurable basin characteristics indicates that most of Wyoming can be divided on this basis into 13 subdivisions in 8 groups as shown in figure 2. Each of the groups of subdivisions is called a hydrologic area and is designated by the appropriate number in figure 2.

Divisions between areas were determined primarily on the basis of streamflow records: however, the exact boundaries were usually based on topographic features such as drainage divides.

Base data are insufficient to define flood-frequency relations in a large region of the headwaters of the North Platte River in south-central Wyoming.

In hydrologic area 1, which is mostly mountainous, annual peak discharges are usually caused by snowmelt, and a significant relation was found between mean annual flood and the size and mean altitude of the drainage basin. The relation is shown graphically by the curves in figure 3. The equation of the curves in figure 3 is of the form $Q_{2.33} = CA^xE^y$, where C is a coefficient unique to the area, A is size of drainage basin, and E is mean elevation of drainage basin. The relation is based on 49 station records having a total of 844 station years of record. The drainage areas range from 15.1 to 2,623 square miles, and mean altitudes of drainage basins range from 6,510 to 11,100 feet.

In hydrologic area 2, also a mountainous area, there are only three streamflow

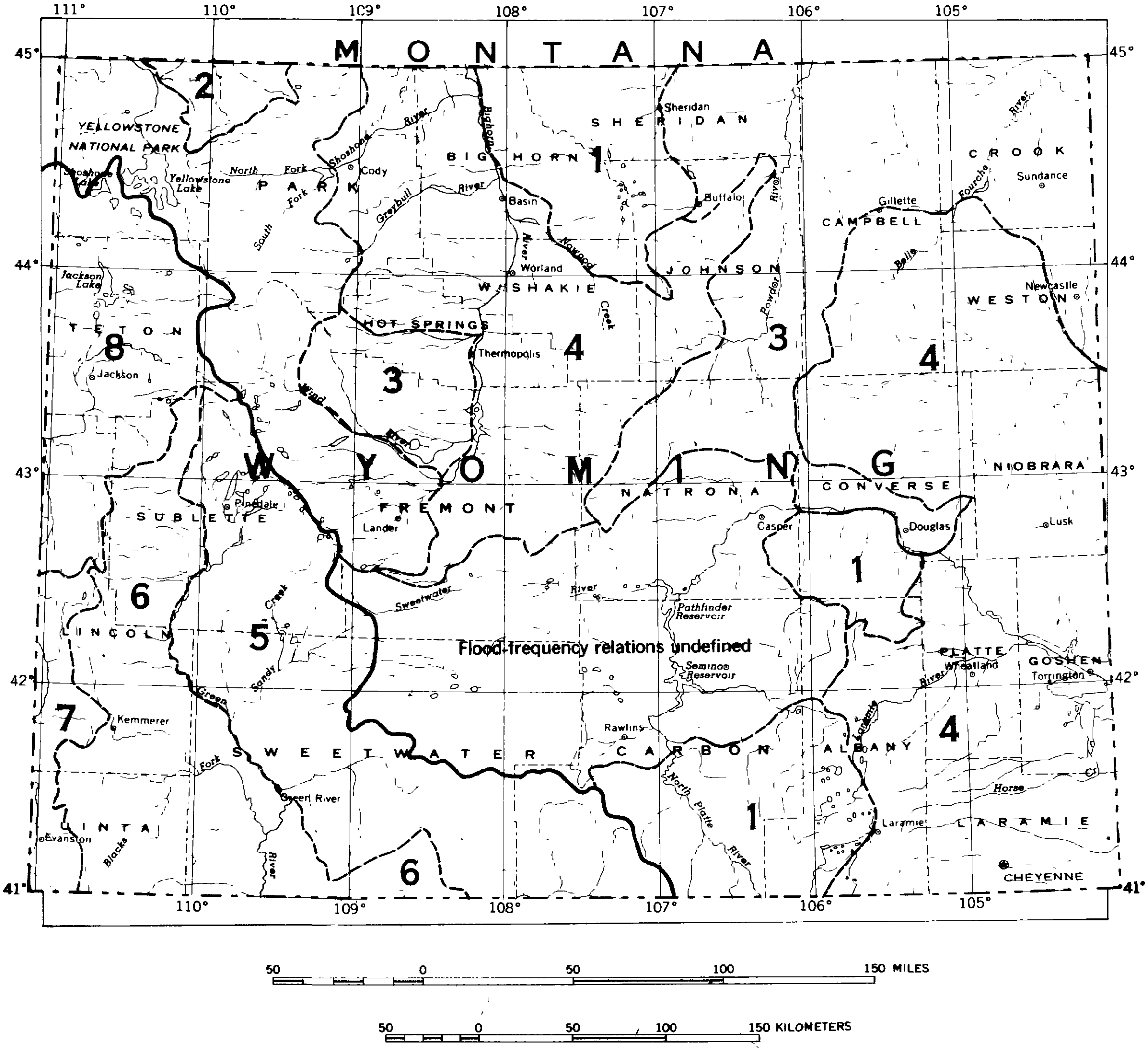

Figure 2.—Map of Wyoming showing hydrologic areas.

records, a number usually considered to be insufficient to define a relation between mean annual floods and basin variables. However, the three records provide rather conclusive evidence that the relation for area 2 is substantially different from that for area 1. This evidence is supported by certain geologic and meteorologic anomalies in the area.

The drainage areas of the three stations range from 194 to 640 square miles, and mean elevations of drainage basins range from 8,690 to 8,970 feet. Correlation of $Q_{2.33}$ with area and mean altitude of the drainage basin indicates that the equation of the relation for area 2 differs from that for the relation for area 1 only in the value of C. Proof of the similarity of the exponent of the altitude terms is not conclusive because of the small differences between the mean altitudes of the three basins considered; however, similarity has been assumed because of the fact that both areas are mountainous and have floods resulting mostly from snowmelt. Values of $Q_{2.33}$ for sites in areas 2 are computed by multiplying values obtained from the curves in figure 3 by 2.07.

Most of hydrologic area 3 is below about 7,000 feet altitude. The terrain is typified by rugged low mountains and hills having sparse vegetation. Flood peaks occur as the result of either snowmelt, rainfall, or a combination of the two. The larger floods usually are the result of intense rainstorms. The only significant relation found was between size of drainage basin and mean annual flood. The relation (fig. 4) is based on 9 station records having a total of 138 station years of record. The drainage areas range from 54.6 to 6,050 square miles.

Hydrologic areas 4 is similar to area 3 in that most of the larger floods are the result of intense rainstorms. The terrain is typified by rolling hills having small relief except in the badlands of the Bighorn Basin. The relation of the mean annual flood to size of drainage basin (fig. 4) is based on 17 station records having a total of 199 station years of record. The drainage areas range from 51.7 to 5,270 square miles.

The ends of the curves in figures 3 and 4 mark the limits of definition by streamflow data. Extrapolation of the curves is not recommended.

COMBINING RECORDS

The record at a gaging station is only a small sample of the actual flood history at the site. A frequency curve based solely on the station data may be considerably different from the true curve and, furthermore, a frequency curve for an individual site cannot be applied directly to an ungaged site where a flood-frequency curve may be desired. The limitation of the individual curves are

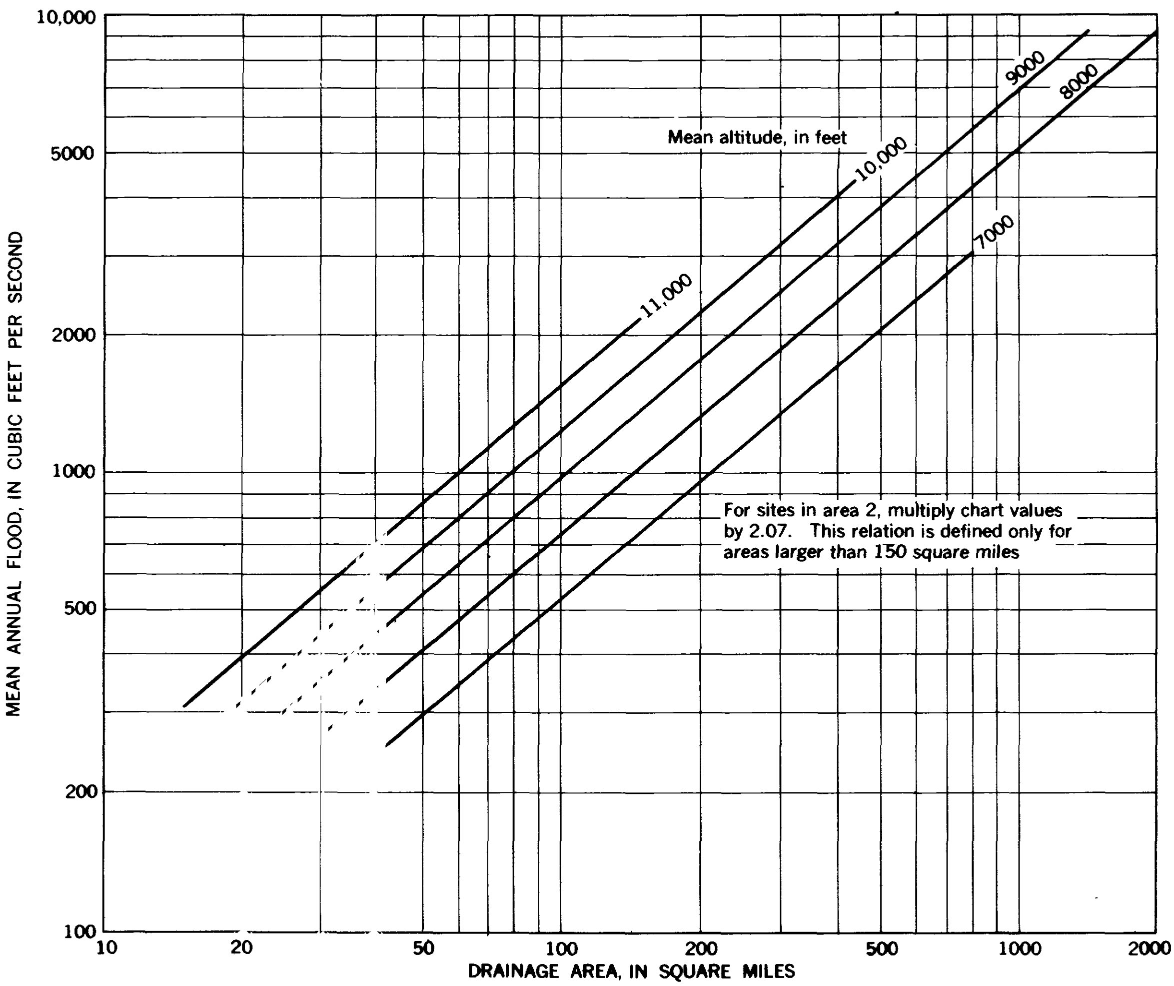

Figure 3.—Variation of mean annual flood with drainage area and mean altitude in hydrologic area 1.

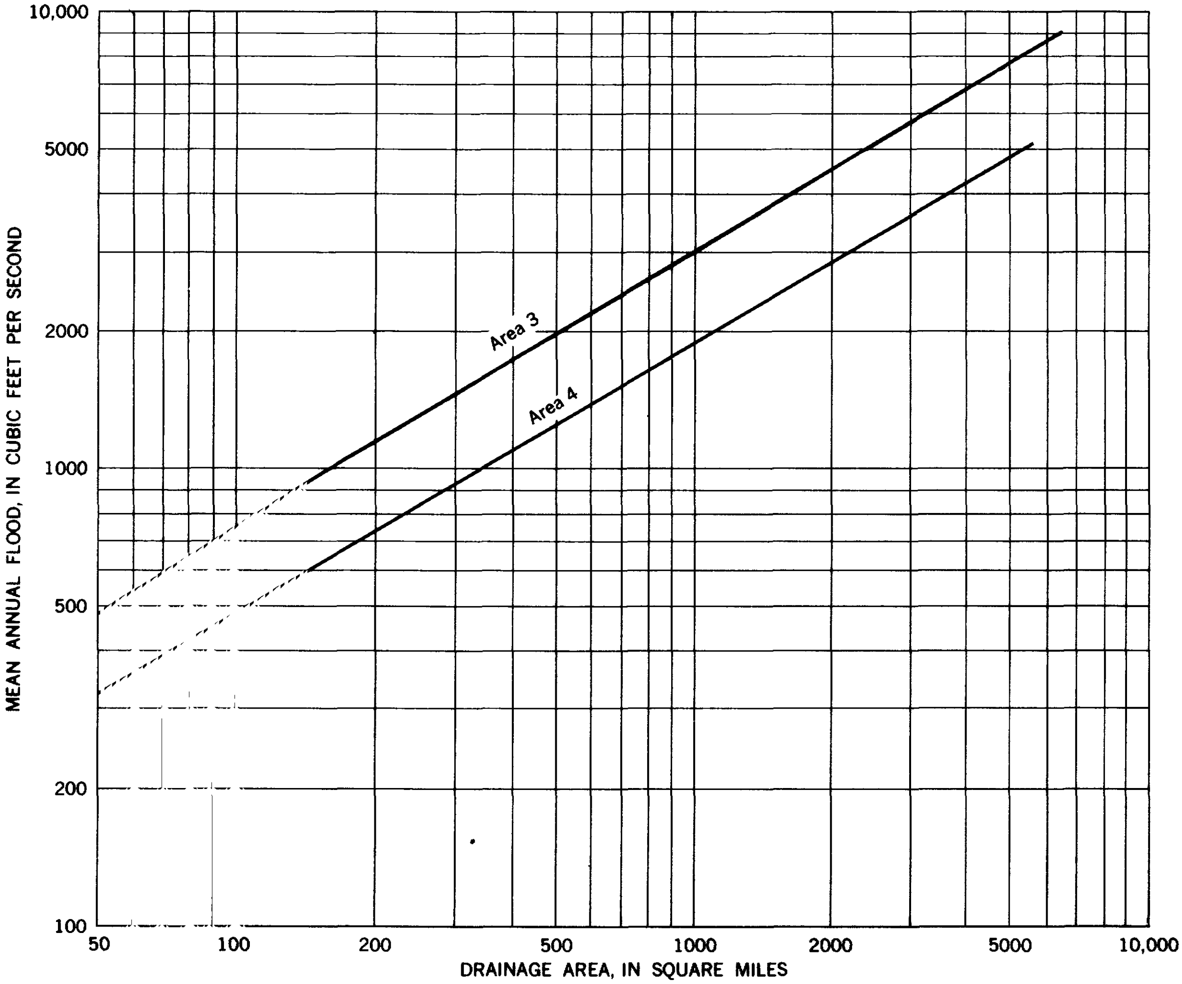

Figure 4.—Variation of mean annual flood with drainage area in hydrologic areas 3 and 4.

overcome by combining records for streams having similar frequency characteristics to produce a dimensionless frequency curve that can be applied to sites, gaged or ungaged, within a large region.

Before a group of individual station records can be combined, it is necessary to determine that all the streams are in a region having uniform flood-frequency characteristics. The test for homogeneity is made by comparing the differences in slopes of the individual frequency curves to the variation in slope that may be attributed to chance in random sampling. The homogeneity test graph used is discussed by Dalrymple (1960).

FLOOD-FREQUENCY REGIONS

Streamflow records indicate that Wyoming can be divided into nine homogeneous regions designated A–I. All except region E are outlined in figure 5. Region E is the main stem of Green River downstream from the gaging station at Warren Bridge, near Daniel, Wyo.

COMPOSITE FREQUENCY CURVES

A composite frequency curve representing the relation of a flood of any selected frequency between 1.1 and 50 years (1.1 and 75 years for region D) to the mean annual flood has been constructed for each region and labeled to correspond to the regions outlined in figure 5. The curves for the section of the State east of the Continental Divide (Parts 6-A and 6-B) are shown in figure 6.

APPLICATION OF FLOOD-FREQUENCY RELATIONS, PARTS 6-A AND 6-B

Within the limits shown, the curves in figure 3, 4, and 6 can be used to determine the flood magnitude for any selected recurrence interval between 1.1 and 50 years on an unregulated stream in the area east of the Continental Divide in Wyoming, except in the area labeled as undefined in figures 2 and 5. The following procedure is used:

1. Determine from figure 2 the number of hydrologic area in which the site is located.

2. Determine the drainage area of the stream above the site. If the site is within areas 1 or 2, determine also the mean altitude of the drainage basin. This can be done by placing a rectangular grid system overlay on a contour map and recording the altitude of the intersections. The grid spacing should be such that a minimum of 50 intersections fall within the basin. The arithmetic average of these altitudes is a sufficiently accurate estimate of the mean altitude of the drainage basin.

3. Determine the mean annual flood from figure 3 or 4.

4. Identify from figure 5 the flood-frequency region in which the site is located.

5. Determine the ratio to the mean annual flood for the flood of the selected recurrence interval (fig. 6).

6. Multiply the ratio to mean annual flood (step 5) by the mean annual flood (step 3) to obtain the flood magnitude.

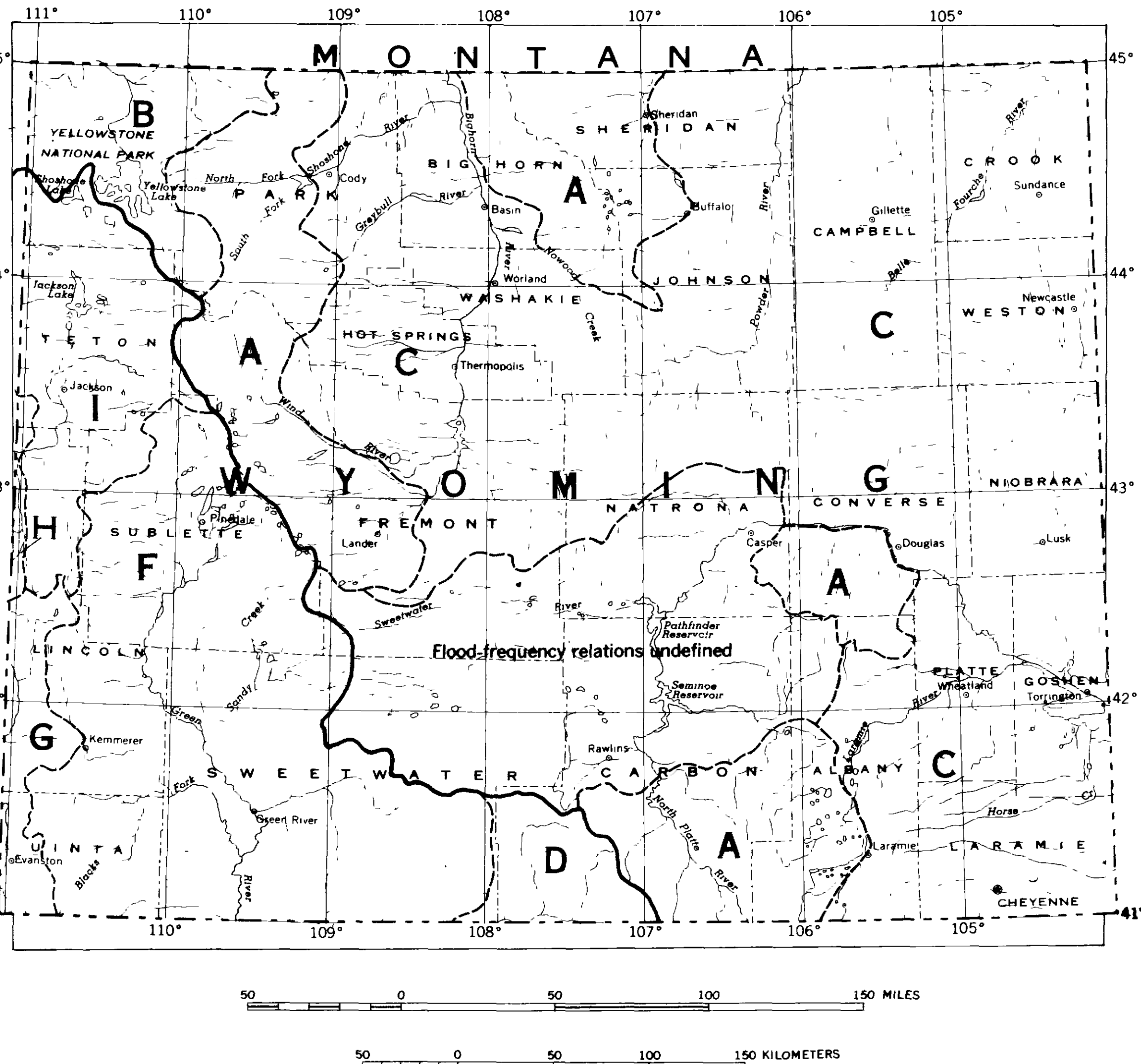

Figure 5. —Map of Wyoming showing flood-frequency regions.

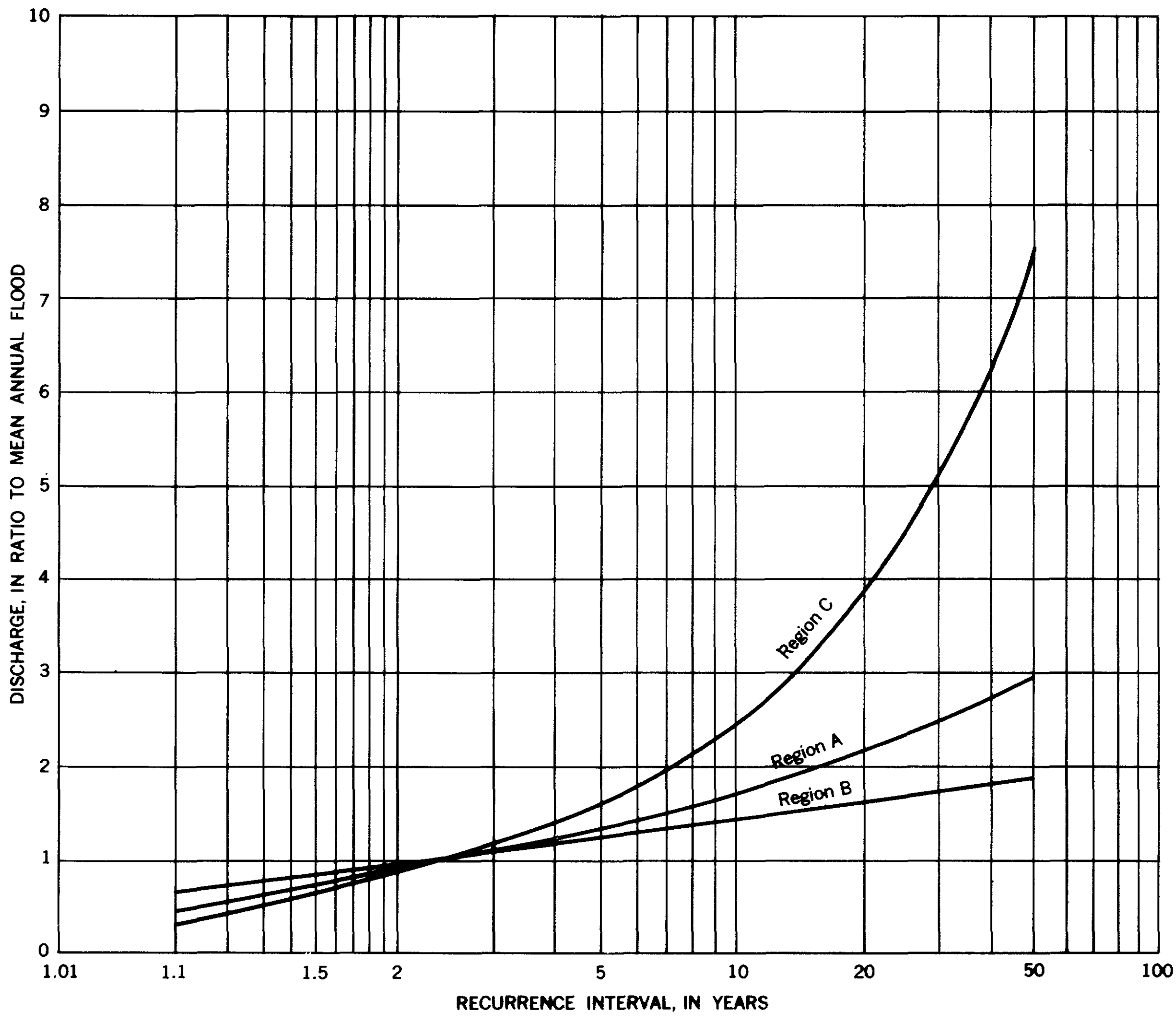

Figure 6.—Composite frequency curves for regions A, B, and C.

To obtain a complete frequency curve for the site, repeat steps 5 and 6 for several selected recurrence intervals.

The above figures also can be used to determine the frequency of a flood of known magnitude.

FLOOD-FREQUENCY ANALYSIS B, PART 9

W. P. Somers, hydraulic engineer, U.S. Geological Survey, made a flood-frequency study (unpublished) for Part 9 in 1959. The curves defined by Somers applicable to that portion of Part 9 in Wyoming were taken from Somers' study and used for this report. In general, the methods and procedures discussed under the foregoing analysis A (Parts 6-A and 6-B, Wyoming) also apply to Part 9, Wyoming. One major difference is in the method used to determine mean annual flood. Drainage area is used as one independent variable, as in analysis A; however, altitude of the selected site, instead of mean altitude of the basin, is used as a second independent variable. See figures 7 and 8.

A separate curve (fig. 9) based on records for only main-stem gaging stations is used to determine mean annual flood along the main stem of Green River below the station at Warren Bridge, near Daniel, Wyo.

Composite frequency curves used to determine the ratio of the flood of the selected frequency to the mean annual flood are shown in figure 10.

APPLICATION OF FLOOD-FREQUENCY RELATIONS, PART 9

The magnitude of a flood of any selected frequency between 1.1 and 50 years (1.1 and

75 years in region D) can be estimated for any site, gaged or ungaged, in Part 9, Wyoming, by the following procedure:

1. If the site is not on the main stem of Green River below the gaging station at Warren Bridge near Daniel, Wyo., determine from figure 2 the hydrologic area in which the site is located.

2. Determine the drainage area of the stream above the site.

3. Determine the altitude of the site above mean sea level.

4. Determine the mean annual flood from figure 7 or 8.

5. Determine from figure 5 the flood-frequency region in which the site is located.

6. Determine the ratio to mean annual flood for the flood of the selected recurrence interval from the appropriate curve in figure 10.

7. Multiply the ratio to mean annual flood (step 6) by the mean annual flood (step 4) to obtain the flood magnitude.

To obtain a complete frequency curve for the site, repeat steps 6 and 7 for several selected recurrence intervals.

The above figures also can be used to determine the frequency of a flood of known magnitude.

If the selected site is on the main stem of Green River below the gaging station at Warren Bridge, near Daniel, Wyo., modify the above procedures as follows:

1. Determine the drainage area above the site.

2. Determine the mean annual flood from figure 9.

3. Determine the ratio to mean annual flood for the flood of the selected recurrence interval from curve E in figure 10.

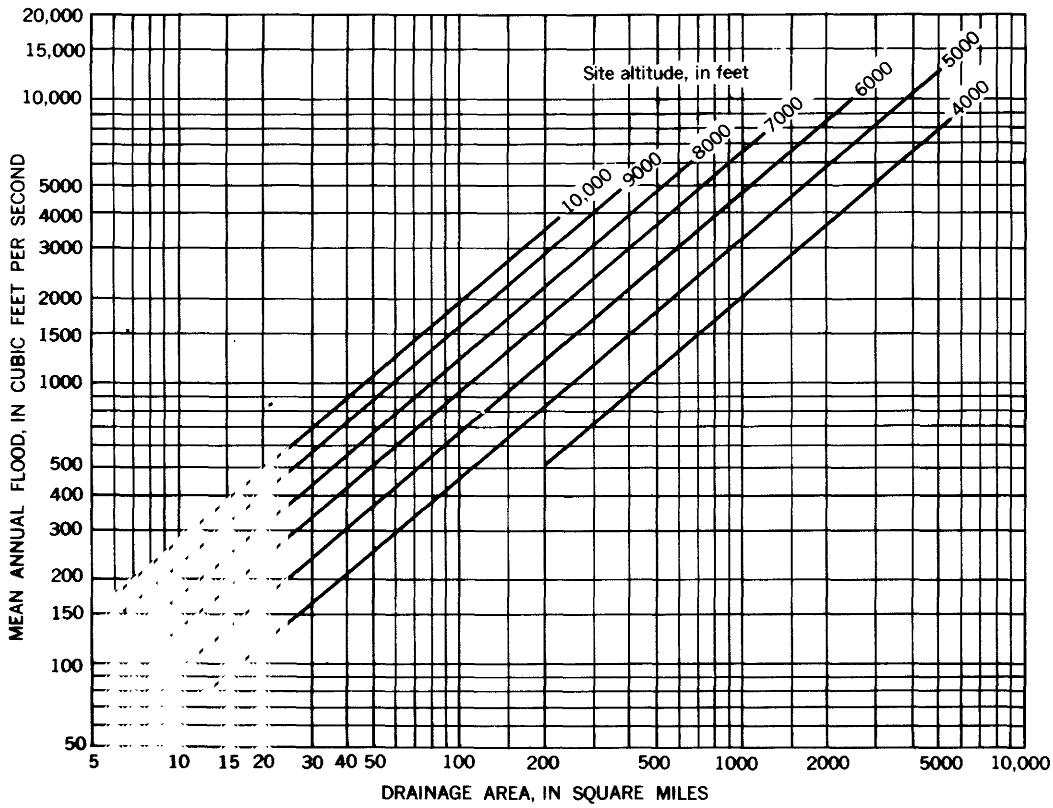

Figure 7.—Variation of mean annual flood with drainage area and altitude at site in hydrologic area 5.

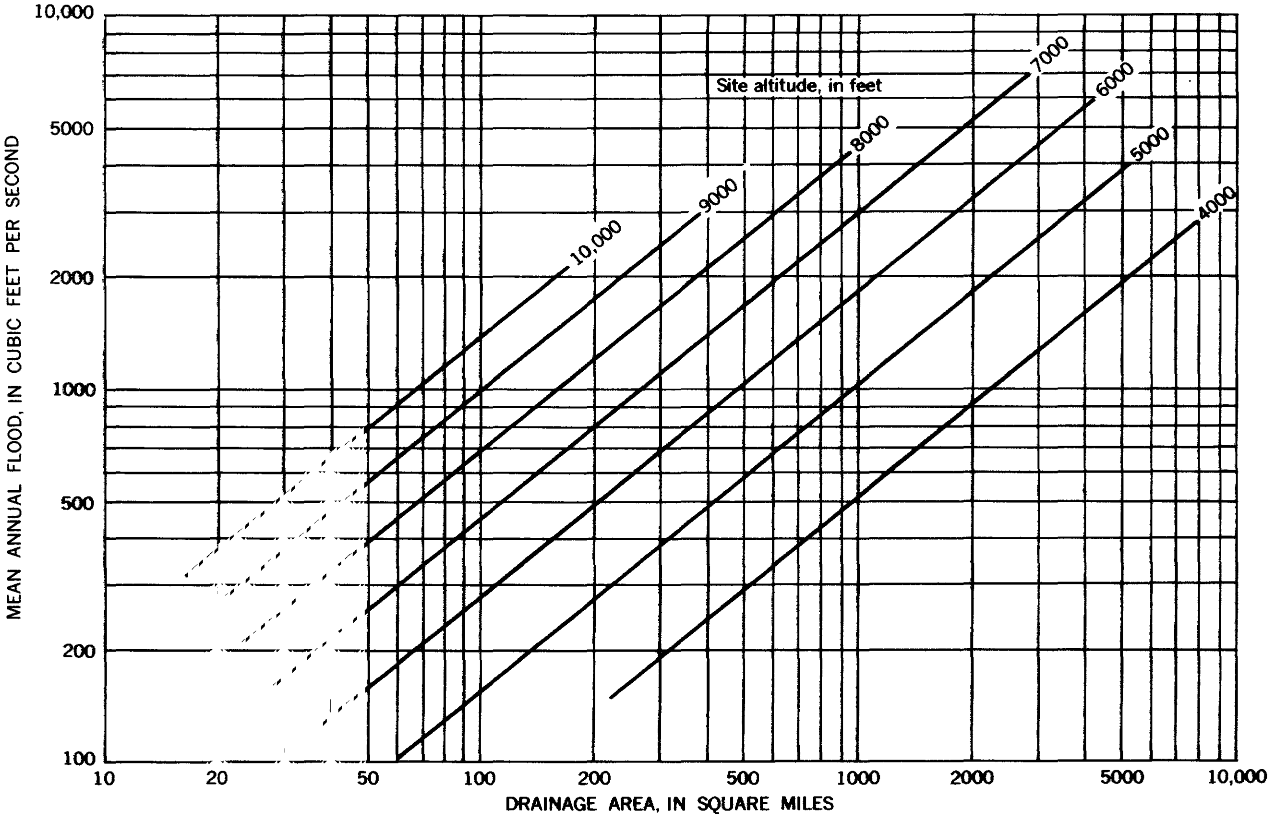

Figure 8.—Variation of mean annual flood with drainage area and altitude at site in hydrologic area 6.

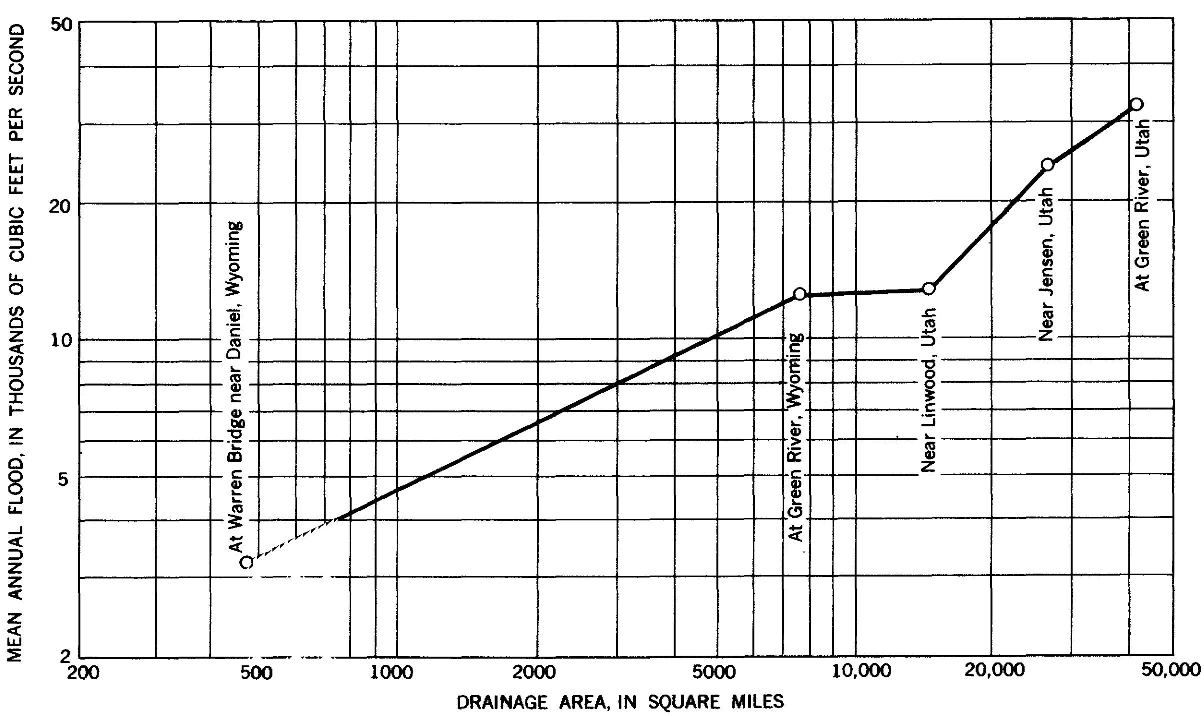

Figure 9.—Variation of mean annual flood with drainage area along main stem of Green River.

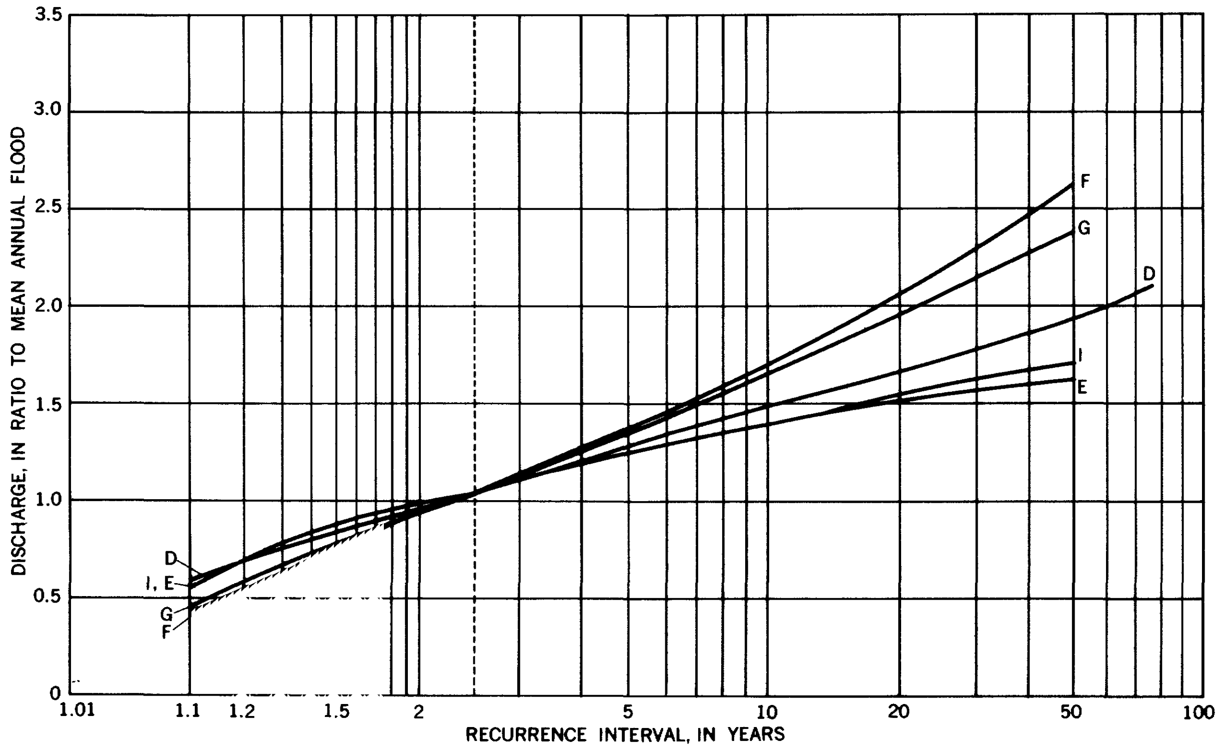

Figure 10.—Composite frequency curves for regions D, E, F, G, and I.

4. Multiply the ratio to mean annual flood (step 3) by the mean annual flood (step 2) to obtain the flood magnitude.

FLOOD-FREQUENCY ANALYSIS C, PART 10

The flood-frequency analysis made by Berwick (1962) for Utah is considered applicable to that portion of Part 10 in Wyoming. The independent variables used to determine mean annual flood are drainage area and mean altitude of the basin as shown in figure 11.

APPLICATION OF FLOOD-FREQUENCY RELATIONS, PART 10

The magnitude of a flood of any selected frequency between 1.1 and 50 years can be estimated for any site, gaged or ungaged, in Part 10, Wyoming, by the following procedure:

1. Determine the drainage area of the stream above the site.

2. Determine the mean altitude of the drainage basin.

3. Determine the mean annual flood from figure 11.

4. Determine the ratio to mean annual flood for the flood of the selected frequency from curve G in figure 10.

5. Multiply the ratio to mean annual flood (step 4) by the mean annual flood (step 3) to obtain the flood magnitude.

To obtain a complete frequency curve for the site, repeat steps 4 and 5 for several selected recurrence intervals.

The above figures also can be used to determine the frequency of a flood of known magnitude.

FLOOD-FREQUENCY ANALYSIS D, PART 13

The analysis for the Snake River basin in Wyoming was made by C. A. Thomas, H. C. Broom, and J. E. Cummans (1963), hydraulic engineers, U.S. Geological Survey, as a part of the analysis for Part 13 in the nationwide series of flood-frequency reports.

Three independent variables—drainage area, mean annual precipitation, and a geographic factor—were used to determine mean annual flood. Mathematical multiple correlation methods were used to evaluate the effect of each independent variable; these methods resulted in the following formula: $Q=0.0006A^{0.88}P^{1.58}G$, where Q is the mean annual flood in cubic feet per second, A is the drainage area in square miles, P is the mean annual precipitation in inches, and G is a geographic factor in percent. The formula as defined by base data is applicable only for drainage areas ranging from 10 to 5,000 square miles.

The mean annual precipitation for the Snake River basin in Wyoming is shown in plate 1, and the geographic factors are shown in plate 2.

The formula for computing the mean annual flood can be solved graphically by use of the nomograph (fig. 12). Procedure is as follows:

1. Plot the geographic factor obtained from plate 2 on the nomograph line G.

2. Plot the drainage area on line A.

3. Draw a straight line between the above plotted points and mark the point of intersection with pivot line 1.

4. Plot the mean annual precipitation obtained from plate 1 on line P.

5. Draw a straight line between the plotted point on line P and the point of intersection on pivot line 1 as determined in step 3. The point of intersection with line Q is the mean annual discharge in cubic feet per second.

The Snake River basin in Wyoming is a part of two homogeneous flood regions, H and I, as shown in figure 5. For region H, the ratio of a flood of a selected frequency to the mean annual flood varies with the mean altitude of the drainage basin as shown in figure 13. The ratio does not vary with altitude for region I.

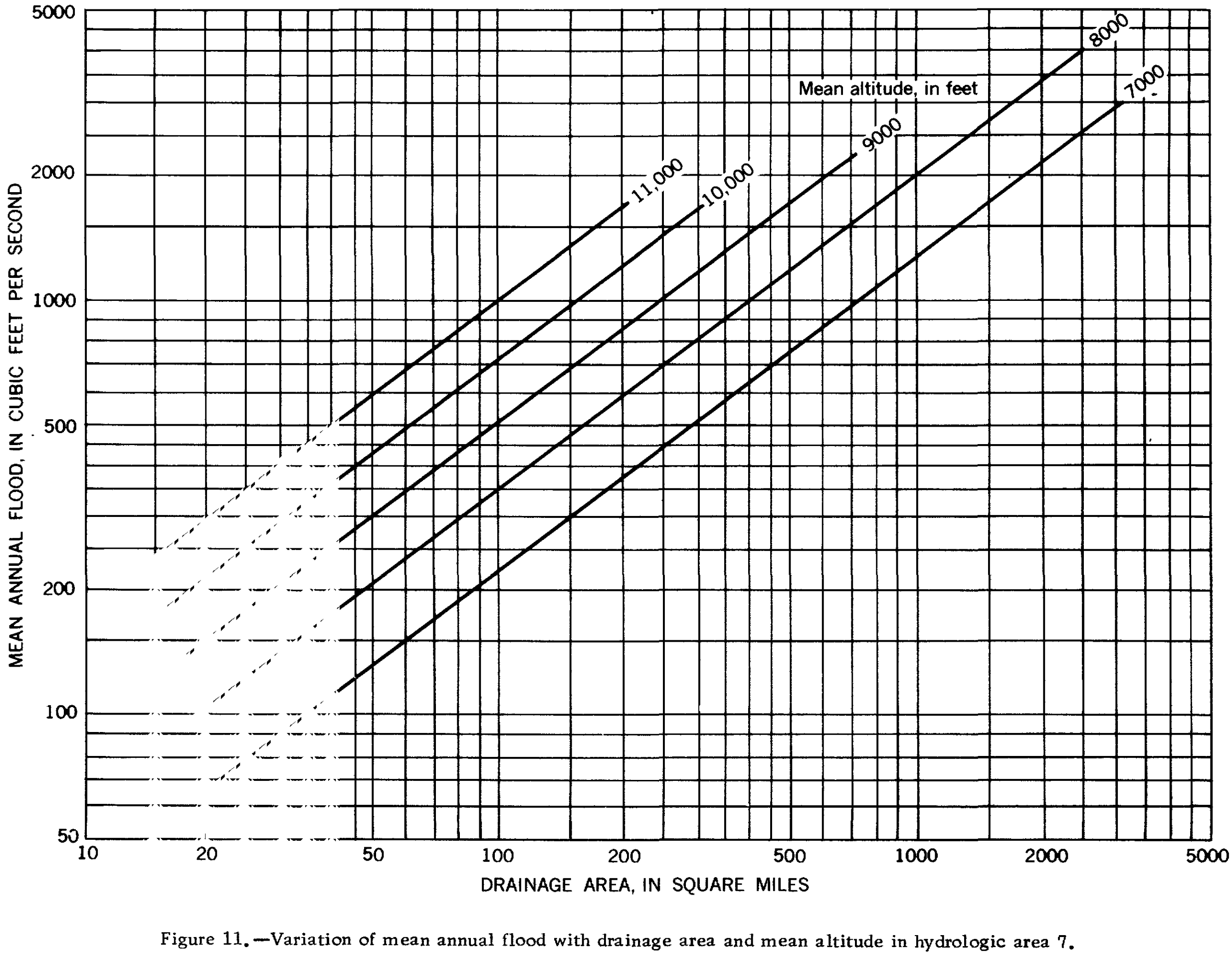

Figure 11.—Variation of mean annual flood with drainage area and mean altitude in hydrologic area 7.

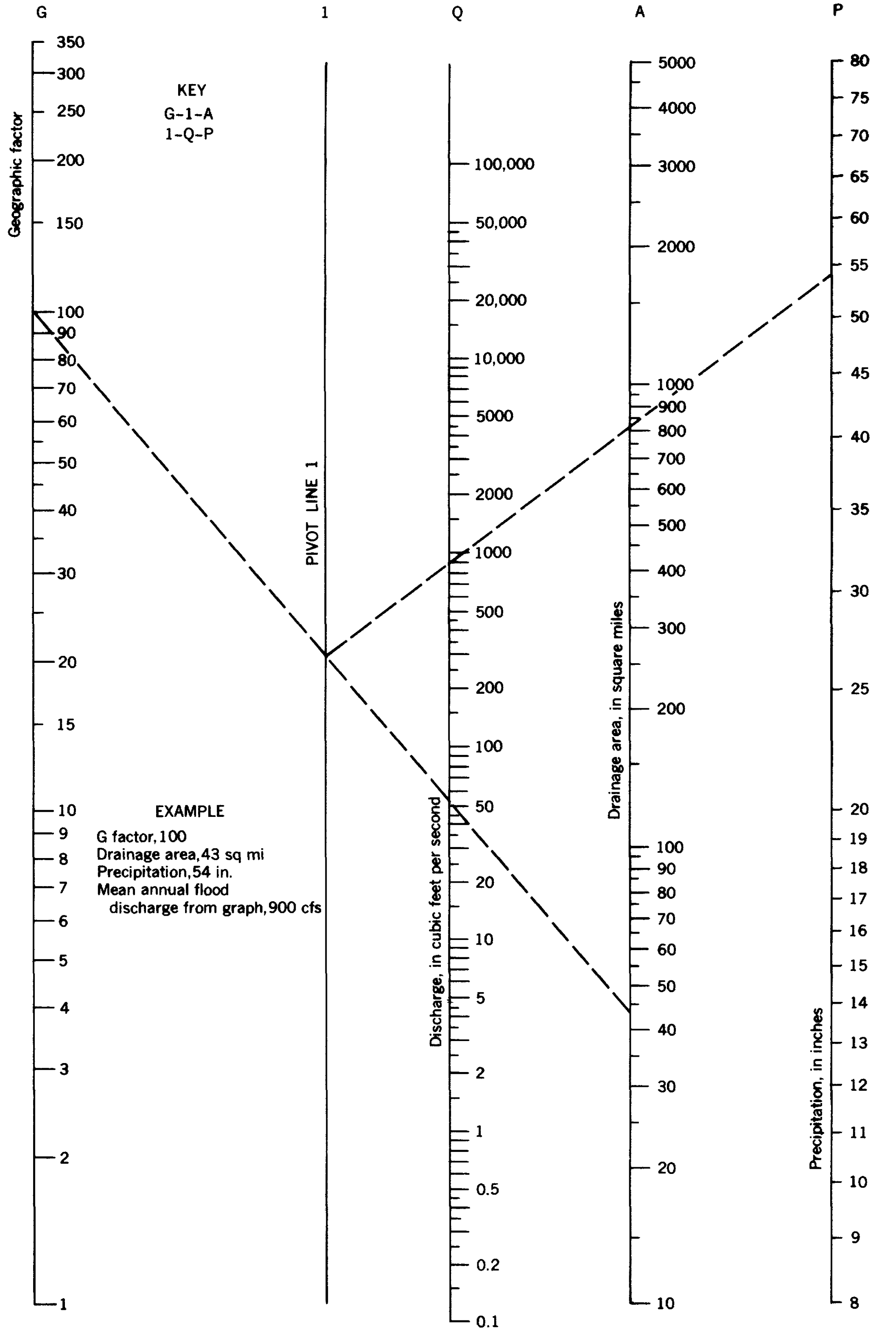

Figure 12.—Nomograph for computing mean annual flood for drainage areas of 10 to 5,000 square miles in Snake River basin.

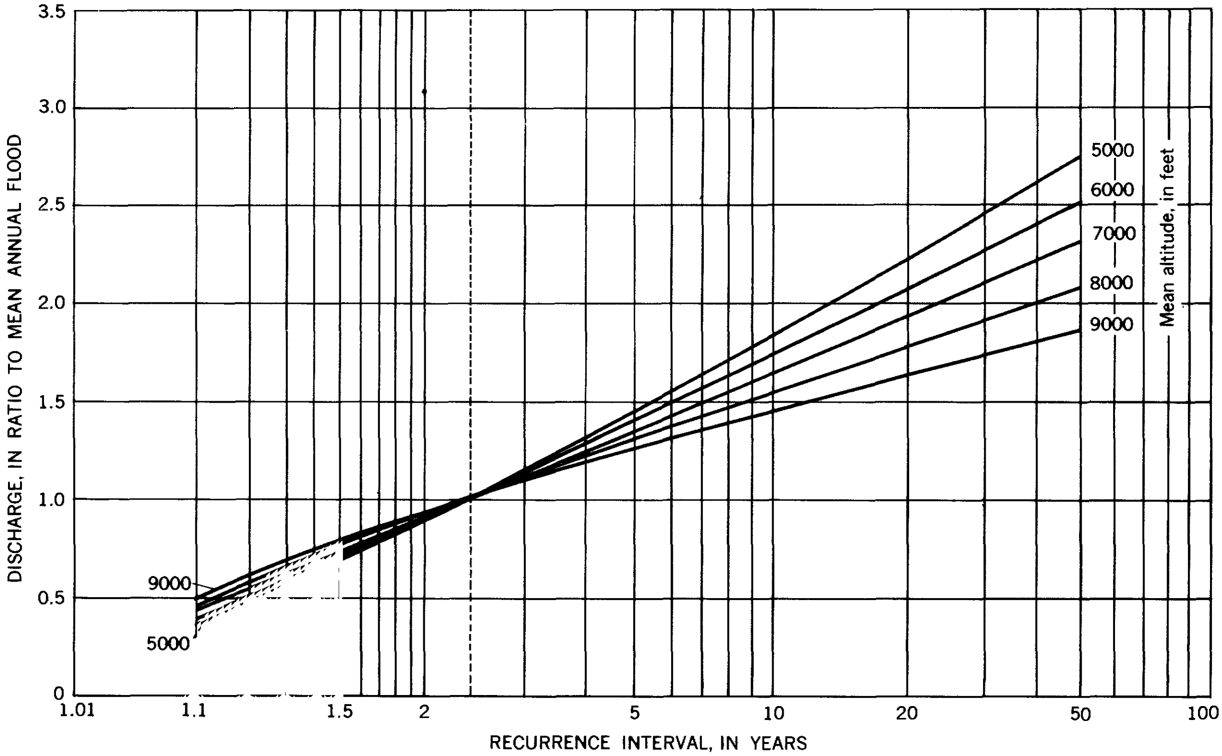

Figure 13. —Composite frequency curves for region H.

APPLICATION OF FLOOD-FREQUENCY RELATIONS, PART 13

The magnitude of a flood of any selected frequency between 1.1 and 50 years can be estimated for any site, gaged or ungaged, in the Snake River basin, Wyoming, by the following procedure:

1. Determine the drainage area of the stream above the selected site.

2. Determine the mean annual precipitation on the basin from plate 1.

3. Determine the geographic factor from plate 2.

4. Compute the mean annual flood from either the formula or the nomograph (fig. 12).

5. Determine from figure 5 the region in which the basin is located.

6. If the basin is in region I, determine the ratio of the selected flood to the mean annual flood from curve I in figure 10. If the basin is in region H, determine the ratio of the selected flood to the mean annual flood from the appropriate curve in figure 13. If the basin is partly in both regions, use a weighted ratio based on the percentage of the basin in each region. (The appropriate curve in figure 13 is the curve for the mean altitude of the part of the basin in region H.)

7. Multiply the ratio to mean annual flood (step 6) by the mean annual flood (step 4) to obtain the flood magnitude.

To obtain a complete frequency curve for the site, repeat steps 6 and 7 for several selected recurrence intervals.

The above figures also can be used to determine the frequency of a flood of known magnitude.

FREQUENCY OF ANNUAL FLOOD STAGES

It is often desirable to estimate the frequency of high stages at a given site. The usual method is to transform the discharge-frequency relation to the stage-frequency relation through the relation of stage to discharge at the site. The reliability of the stage-frequency relation will depend upon the reliability and stability of the stage-discharge relation.

It is not possible to compute the frequency of high stages that are caused by ice jams.

DATA FOR EXTREME FLOODS

Table 1 gives maximum known floods and related data prior to October 1, 1961, at gaging stations used in the frequency analysis.

The gaging station number shown is a number permanently assigned by the Geological Survey. The location is shown by region and area as outlined in figures 5 and 2. Period of known floods means the period during which the listed flood is known to be the maximum and does not necessarily correspond with the period of record as shown in annual streamflow reports. If, for a given period, the maximum stage and discharge was not concurrent, a separate entry is shown for each. For recurrence intervals of 50 years or less, the frequency is shown by listing the recurrence interval, in years. For recurrence intervals of more than 50 years, the frequency is shown by listing the ratio of the flood to the 50-year flood.

LIMITATIONS

The dependability of the results of this analysis is limited to a large extent by the amount of streamflow data presently available. Few or no records have been collected for many parts of the State. There is a statewide deficiency of data in number and length of peak-discharge records for drainage basins of less than 50 square miles, especially at the lower altitudes. Flood-frequency relations were not defined for a large region in the headwaters of North Platte River in south-central Wyoming because of the paucity of streamflow data. The undefined region is indicated in figures 2 and 5.

All curves shown in this report have been drawn to limits warranted by the data. Extension of the curves beyond the limits shown is not recommended.

The Geological Survey and the State Highway Department are engaged in a cooperative program to operate a network of crest-stage gages to collect records of flood flows from small drainage basins in Wyoming. This additional data will in time make possible more nearly accurate delineation of the hydrologic areas and definition of mean annual flood for smaller drainage basins.

SELECTED REFERENCES

Berwick, V. K., 1958, Floods in eastern Montana, magnitude and frequency: U.S. Geol. Survey open-file report.

———1962, Floods in Utah, magnitude and frequency: U.S. Geol. Survey Circ. 457.

Corbett, D. M., and others, 1945, Stream-gaging procedure: U.S. Geol. Survey Water-Supply Paper 888.

Dalrymple, T., 1960, Flood-frequency analyses: U.S. Geol. Survey Water-Supply Paper 1543-A.

Furness, L. W., 1955, Floods in Nebraska, magnitude and frequency: Nebraska Dept. of Roads and Irrigation.

———1962, Floods in Nebraska on small drainage areas, magnitude and frequency: U.S. Geol. Survey Circ. 458.

Gumbel, E. J., 1941, The return period of flood flows: Annals Math. Statistics, v. 12, no. 2, p. 163–190.

Langbein, W. B., 1949, Annual floods and the partial-duration flood series: Am. Geophys. Union Trans., v. 30, p. 879–881.

McCabe, J. A., and Crosby, O. A., 1959, Floods in North and South Dakota, frequency and magnitude: U.S. Geol. Survey open-file report.

Mitchell, W. D., 1954, Floods in Illinois: magnitude and frequency: Illinois Dept. Public Works and Buildings, Div. Waterways.

Powell, R. W., 1943, A simple method of estimating flood frequency: Civil Eng., v. 13, p. 105–106.

Thomas, C. A., Broom, H. C., and Cummans, J. E., 1963, Snake River basin, pt. 13 *of* magnitude and frequency of floods in the United States: U.S. Geol. Survey Water-Supply Paper 1688. (In press.)

Table 1.—*Maximum floods at gaging stations used in the frequency analyses*

No.	Gaging station	Flood region and hydrologic area	Contributing drainage area (sq mi)	Period of known floods	Altitude at site (feet)	Mean basin altitude (feet)	Mean annual precipitation (inches)	Geographic factor	Areal $Q_{2.33}$ (cfs)	Maximum floods				Recurrence interval (years)
										Date	Gage height (feet)	Discharge		
												cfs	cfs per sq mi	
6- 375	Madison River near West Yellowstone, Mont.	B–1	419	1914–61	-------	7,940	-------	------	2,350	May 24, 1956	------	2,150	5.13	2
										Jan. 8, 1937	[1]10.0	------	------	------
430	Taylor Creek near Grayling, Mont.	B–1	98.0	1947–57	-------	8,320	-------	------	800	June 6, 1952	4.32	1,020	10.4	6
435	Gallatin River near Gallatin Gateway, Mont.	B–1	825	1890–94, 1931–61	-------	7,960	-------	------	4,300	June 20, 1892, June 2, 1894	7.70	8,060	9.77	60
1865	Yellowstone River at Yellowstone Outlet, Yellowstone National Park.	B–1	1,006	1927–61	-------	8,670	-------	------	6,600	June 21, 1956	7.55	7,610	7.57	4
1870	Yellowstone River near Canyon Hotel, Yellowstone National Park.	B–1	1,160	1914–50	-------	8,620	-------	------	7,100	June 27, 1918	4.50	8,550	7.36	5
1875	Tower Creek at Tower Falls, Yellowstone National Park.	B–1	51	1923–43	-------	8,340	-------	------	470	May 30, 1925	------	642	12.6	8
										May 28, 1928	6.27	------	------	------
1880	Lamar River near Tower Falls, ranger station, Yellowstone National Park.	B–1	660	1924–61	-------	8,690	-------	------	9,100	May 25, 1928	9.75	13,600	20.6	14
1910	Gardiner River near Mammoth, Yellowstone National Park.	B–1	202	1939–61	-------	7,940	-------	------	1,300	June 4, 1956	4.46	2,080	10.3	20
1915	Yellowstone River at Corwin Springs, Mont.	B–1	2,623	1890–93, 1911–61	-------	8,440	-------	------	13,000	June 14, 1918	11.5	32,000	12.2	[2]1.45
2055	Clarks Fork Yellowstone River above Squaw Creek, near Painter, Wyo.	B–2	194	1946–51	-------	8,970	-------	------	3,500	June 22, 1950	6.75	4,920	25.4	9
2060	Clarks Fork Yellowstone River below Crandall Creek, near Painter, Wyo.	B–2	446	1930–32, 1950–57	-------	8,880	-------	------	7,000	June 4, 1957	9.78	7,850	17.6	4

-2065	Sunlight Creek near Painter, Wyo.	A–1	135	1918–61	-------	8,500	-------	------	1,100	1918	5.8	4,000	29.6	[3]1.25
2185	Wind River near Dubois, Wyo.	A–1	232	1946–61	-------	8,920	-------	------	1,950	June 2, 1956	5.66	1,910	8.23	2
2205	East Fork Wind River near Dubois, Wyo.	A–1	439	1950–57	-------	9,110	-------	------	3,500	June 26, 1954	------	5,700	13.0	9
										June 30, 1957	9.27	------	------	------
2215	Dinwoody Creek near Burris, Wyo.	A–1	100	1909, 1918–30, 1950–58	-------	10,200	-------	------	1,300	July 25, 1923	3.75	1,710	17.1	5
2220	Wind River near Burris, Wyo.	A–1	1,220	1947–53	-------	9,030	-------	------	8,300	June 17, 1951	7.72	------	------	3
										June 14, 1953	------	9,900	8.11	------
2225	Day Creek near Burris, Wyo.	C–3	57	1921–40	-------	10,100	-------	------	520	June 12, 1921	3.9	1,400	24.6	12
2235	Willow Creek near Crowheart, Wyo.	A–1	50	1909, 1921–40	-------	8,720	-------	------	500	May 31, 1939	5.40	1,100	22.0	21
2240	Bull Lake Creek above Bull Lake, Wyo.	A–1	178	1941–53	-------	10,300	-------	------	2,150	June 7, 1952	6.69	3,030	17.0	6
2255	Wind River near Crowheart, Wyo.	A–1	1,891	1927–61	-------	8,320	-------	------	9,900	June 29, 1927	------	[3]13,000	6.88	5
2290	North Fork Little Wind River at Fort Washakie, Wyo.	A–1	127	1921–40	-------	9,620	-------	------	1,400	July 9, 1926	4.85	2,640	20.8	13
2320	North Popo Agie River near Milford, Wyo.	A–1	98.4	1946–61	-------	9,890	-------	------	1,200	June 7, 1952	6.59	2,060	20.9	10
2325	North Popo Agie River near Lander, Wyo.	A–1	140	1938–53	-------	8,970	-------	------	1,300	June 14, 1953	5.54	1,900	13.6	6
2330	Little Popo Agie River near Lander, Wyo.	A–1	125	1946–61	-------	8,020	-------	------	880	June 7, 1952	5.83	1,160	9.29	5
2390	Muskrat Creek near Shoskoni, Wyo.	C–3	733	1923–61	-------	5,850	-------	------	2,500	July 24, 1923	------	6,400	8.74	11
2530	Fivemile Creek near Shoshoni, Wyo.	C–3	285	1923–61	-------	6,270	-------	------	1,400	---do------	------	3,500	12.3	10
										Dec. 27, 1954	[1]9.61	------	------	------
6-2560	Badwater Creek near Lyber Ranch, near Lost Cabin, Wyo.	C–4	131	1949–61	-------	7,320	-------	------	570	July 8, 1949	------	445	3.40	2
										Mar. 30, 1952	[1]8.88	------	------	------
2570	Badwater Creek at Booneville, Wyo.	C–4	808	1923–61	-------	6,200	-------	------	1,680	July 24, 1923	------	18,600	23.0	[2]1.48
2575	Muddy Creek near Pavillion, Wyo.	C–3	258	1949–61	-------	6,860	-------	------	1,300	June 5, 1949	9.70	2,300	8.92	6
2580	Muddy Creek near Shoshoni, Wyo.	C–3	332	1923–61	-------	6,490	-------	------	1,520	June 24, 1923	------	16,300	49.2	[2]1.43

See footnotes at end of table.

Table 1.—*Maximum floods at gaging stations used in the frequency analyses*—Continued

No.	Gaging station	Flood region and hydrologic area	Contributing drainage area (sq mi)	Period of known floods	Altitude at site (feet)	Mean basin altitude (feet)	Mean annual precipitation (inches)	Geographic factor	Areal $Q_{2.33}$ (cfs)	Maximum floods: Date	Maximum floods: Gage height (feet)	Maximum floods: Discharge: cfs	Maximum floods: Discharge: cfs per sq mi	Recurrence interval (years)
6-2605	South Fork Owl Creek above Curtis Ranch, near Thermopolis, Wyo.	C-3	144	1944-59	------	8,460	------	------	920	June 24, 1945	4.25	1,520	10.6	5
2620	North Fork Owl Creek near Anchor, Wyo.	C-3	54.8	1941-61	------	8,150	------	------	510	July 23, 1955	8.0	3,200	58.5	40
2660	Gooseberry Creek, near Grass Creek, Wyo.	C-4	155	1946-56	------	6,760	------	------	620	June 22, 1948	3.62	593	3.83	2
2700	Nowood Creek near Tensleep, Wyo.	C-4	805	1938-55	------	5,950	------	------	1,670	Mar. 12, 13, 1942	[1]13.0	------	------	------
										June 16, 1955	------	3,330	4.14	7
2710	Tensleep Creek near Tensleep, Wyo.	A-1	247	1911-12, 1915-24, 1944-61	------	8,190	------	------	1,700	June 15, 1924	7.05	2,890	11.7	10
2715	Paintrock Creek below Lake Solitude, Wyo.	A-1	15.1	1947-53	------	11,100	------	------	320	June 11, 1953	6.0	543	35.9	10
2725	Paintrock Creek near Hyattville, Wyo.	A-1	164	1921-26, 1941-54	------	9,120	------	------	1,550	June 24, 1945	9.80	8,200	50.0	[2]1.82
2730	Medicine Lodge Creek near Hyattville, Wyo.	A-1	86.8	1943-61	------	8,070	------	------	660	----do------	4.10	1,160	13.4	11
2745	Greybull River near Pitchfork, Wyo.	A-1	282	1946-61	------	9,740	------	------	2,800	June 5, 1957	6.98	5,700	20.2	17
2750	Wood River at Sunshine, Wyo.	A-1	194	1946-61	------	9,100	------	------	1,750	June 5, 1952	------	2,260	11.6	4
										June 6, 1957	5.95	------	------	------
2785	Shell Creek near Shell, Wyo.	A-1	145	1941-61	------	8,810	------	------	1,250	June 24, 1945	7.49	3,020	20.8	28
2890	Little Bighorn River at State line, near Wyola, Mont.	A-1	193	1940-61	------	7,980	------	------	1,250	June 3, 1944	------	2,730	14.1	20
										June 9, 1944	[4]5.93	------	------	------
2965	North Fork Tongue River near Dayton, Wyo.	A-1	32.4	1946-57	------	9,270	------	------	400	May 21, 1948	2.55	560	17.3	6
2970	South Fork Tongue River near Dayton, Wyo.	A-1	85.0	1946-61	------	8,920	------	------	830	May 23, 1956	5.62	1,120	13.2	5
											[5]6.36	------	------	------
2980	Tongue River near Dayton, Wyo.	A-1	204	1919-29, 1941-61	------	8,330	------	------	1,500	June 3, 1944	6.45	3,400	16.7	23

2995	Wolf Creek at Wolf, Wyo.	A–1	37.8	1944–61	-------	7,700	-------	------	300	May 18, 1944	5.0	1,100	29.1	[2]1.26
3035	Little Goose Creek in canyon, near Big Horn, Wyo.	A–1	55	1941–61	-------	7,480	-------	------	380	June 24, 1946	6.13	1,080	19.6	48
3095	South Fork Powder River near Kaycee, Wyo.	C–3	1,150	1938–40, 1950–61	-------	5,830	-------	------	3,200	May 22, 1952	9.00	14,400	12.5	25
3100	Middle Fork Powder River above Kaycee, Wyo.	C–4	450	1949–61	-------	6,930	-------	------	1,180	May 18, 1950	5.68	1,020	2.27	2
											[6]11.7	------	------	------
3115	North Fork Powder River near Hazelton, Wyo.	A–1	25.0	1947–61	-------	8,990	-------	------	300	June 15, 1953	4.34	886	35.4	53
3120	North Fork Powder River near Mayoworth, Wyo.	C–4	106	1941–61	-------	7,890	-------	------	500	Aug. 11, 1941	7.64	1,270	12.0	11
3135	Powder River at Sussex, Wyo.	C–3	3,090	1938–40,	-------	5,940	-------	------	5,900	May 23, 1952	12.6	32,500	10.5	34
				1950–57	-------	-------	-------	------	------	------------	------	------	------	------
				1923–57	-------	-------	-------	------	------	Sept. 30, 1923	13.6	------	------	------
3140	North Fork Crazy Woman Creek near Buffalo, Wyo.	C–4	44.9	1943–49	-------	-------	-------	------	310	June 6, 1949	5.56	611	13.6	7
3145	North Fork Crazy Woman Creek below Spring Draw, near Buffalo, Wyo.	C–4	51.7	1949–61	-------	8,070	-------	------	330	----do------	5.42	610	11.8	6
3155	Middle Fork Crazy Woman Creek near Greub, Wyo.	C–4	82.7	1942–61	-------	8,200	-------	------	430	May 2, 1947	5.77	4,520	54.7	[3]1.40
3170	Powder River at Arvada, Wyo.	C–3	6,050	1919–61	-------	5,460	-------	------	8,800	Sept. 29, 1923	23.7	100,000	16.5	[3]1.51
3205	South Piney Creek at Willow Park, Wyo.	A–1	33.6	1946–57, 1960–61	-------	10,100	-------	------	500	June 10, 1957	4.79	649	19.3	5
3340	Little Missouri River near Alzeda, Mont.	C–3	904	1912–61	-------	-------	-------	------	2,800	Apr. 4, 1944	-----	[7]6,000	6.64	8
3860	Lance Creek at Spencer, Wyo.	C–4	2,070	1948–54, 1957–61	-------	4,670	-------	------	2,900	June 28, 1952	8.3	5,250	2.54	6
3865	Cheyenne River near Spencer, Wyo.	C–4	5,270	1949–61	-------	4,750	-------	------	5,100	----do------	8.6	9,840	1.87	7
3940	Beaver Creek near Newcastle, Wyo.	C–4	1,320	1943, 1945–61	-------	4,650	-------	------	2,250	May 27, 1943	14.0	1,840	1.39	2

See footnotes at end of table.

Table 1.—*Maximum floods at gaging stations used in the frequency analyses*—Continued

No.	Gaging station	Flood region and hydrologic area	Contributing drainage area (sq mi)	Period of known floods	Altitude at site (feet)	Mean basin altitude (feet)	Mean annual precipitation (inches)	Geographic factor	Areal $Q_{2.33}$ (cfs)	Maximum floods: Date	Maximum floods: Gage height (feet)	Maximum floods: Discharge: cfs	Maximum floods: Discharge: cfs per sq mi	Recurrence interval (years)
6-4260	Belle Fourche River near Moorcraft, Wyo.	C–4	1,380	1924–32	------	------	------	------	2,300	Apr. 7, 1924	------	12,500	9.06	33
				1908–61	------	------	------	------	------	June 1908	15.0	------	------	------
4265	Belle Fourche River below Moorcraft, Wyo.	C–4	1,670	1924–61	------	4,740	------	------	2,550	Apr. 7, 1924	12.6	12,500	7.48	28
				1908–61	------	------	------	------	------	June 1908	15.1	------	------	------
4280	Belle Fourche River at Hulett, Wyo.	C–3	2,800	1929–32, 1940–51	------	4,700	------	------	5,500	Mar. 26, 1943	------	6,320	2.26	3
										May 31, 1929	8.9	------	------	------
				1882–1961						Apr. 8, 1924	18.7	------	------	------
6210	Douglas Creek near Foxpark, Wyo.	A–1	120	1947–61	------	9,190	------	------	1,200	June 7, 1957	4.66	1,630	13.6	5
6245	Encampment River at Encampment, Wyo.	A–1	219	1900, 1911–24, 1929–32	------	------	------	------	1,900	May 29, 1900	3.20	4,680	21.4	30
6250	Encampment River at mouth near Encampment, Wyo.	A–1	265	1940–61	------	8,900	------	------	2,200	June 1, 1943	------	4,510	17.0	17
										June 4, 1952	8.33	------	------	------
6325	Rock Creek at Arlington, Wyo.	A–1	64.5	1911–18, 1940–61	------	9,680	------	------	800	June 19, 1953	4.96	1,720	26.7	20
6460	Deer Creek in canyon, near Glenrock, Wyo.	A–1	120	1946–51	------	7,510	------	------	740	Apr. 7, 1950	8.76	855	7.12	3
6465	Deer Creek at Glenrock, Wyo.	A–1	212	1916–24, 1928–61	------	6,790	------	------	950	Apr. 15, 1924	6.5	2,840	13.4	55
6475	Box Elden Creek at Box Elden, Wyo.	A–1	63.2	1946–51	------	7,960	------	------	480	May 4, 1947	4.78	------	------	------
										May 21, 1949	------	496	7.85	2
6480	Box Elden Creek near Careyhurst, Wyo.	A–1	202	1928–61	------	6,800	------	------	900	May 23, 1933	9.04	2,360	11.7	37
6490	La Prele Creek near Douglas, Wyo.	A–1	135	1920–61	------	7,200	------	------	740	May 11, 1920	11.4	1,220	9.04	9
6515	La Bonte Creek near La Bonte, Wyo.	A–1	287	1917–61	------	6,510	------	------	1,100	May 22, 1923	7.5	2,750	9.58	32
6530	Horseshoe Creek near Esterbrook, Wyo.	A–1	45	1947–51	------	7,550	------	------	330	June 21, 1947	4.47	195	4.34	1
6545	Cottonwood Creek near Fletcher Park, Wyo.	A–1	48.1	1947–51	------	6,670	------	------	260	June 22, 1947	5.01	236	4.90	2

6610	Little Laramie River near Filmore, Wyo.	A–1	156	1911–61	------	9,110	------	------	1,450	June 1, 1914	5.9	2,400	15.4	9
6675	North Laramie River near Wheatland, Wyo.	C–4	370	1915–61	------	------	------	------	1,050	July 27, 1951	11.6	9,260	25.0	[2]1.18
9-1885	Green River at Warren Bridge, near Daniel, Wyo.	E	468	1932–61	7,468	------	------	------	3,230	June 29, 1954	------	4,460	9.54	9
										June 17, 1959	5.56	------	------	------
1890	Beaver Creek near Daniel, Wyo.	F–6	141	1939–54	7,440	------	------	------	741	May 16, 1950	8.34	1,540	10.9	20
1900	Horse Creek near Daniel, Wyo.	F–6	124	1932–54	7,350	------	------	------	631	May 31, 1936	3.53	1,670	13.5	52
1905	Horse Creek at Daniel, Wyo.	F–6	173	1913–18	7,185	------	------	------	780	June 16, 1918	5.7	1,530	8.85	16
1910	Green River near Daniel, Wyo.	E	932	1913–22	7,040	------	------	------	4,500	----do.----	7.0	8,750	9.39	[2]1.20
1915	Cottonwood Creek near Daniel, Wyo.	F–6	202	1939–54	7,230	------	------	------	912	June 19, 1946	6.75	------	------	------
										May 30, 1951	------	954	4.72	2
1970	Pine Creek at Fremont Lake Outlet, Wyo.	F–5	114	1911–18	7,450	------	------	------	1,170	June 17, 1918	------	2,330	20.4	17
1980	Pine Creek at Pinedale, Wyo.	F–5	118	1915–54	7,160	------	------	------	1,130	June 18, 1918	4.8	2,170	18.4	15
1985	Pale Creek below Little Half Moon Lake, near Pinedale, Wyo.	F–5	87.5	1939–61	7,350	------	------	------	918	June 17, 1959	6.74	1,300	14.9	5
1995	Fall Creek near Pinedale, Wyo.	F–5	37.2	1939–61	7,300	------	------	------	438	June 15, 1953	8.56	707	19.0	8
2010	New Fork River near Boulder, Wyo.	F–5	552	1915–61	6,900	------	------	------	3,860	June 17, 1918	8.7	12,300	22.3	[2]1.21
2020	Boulder Creek below Boulder Lake, near Boulder, Wyo.	F–5	130	1939–61	7,200	------	------	------	1,230	June 15, 1953	6.12	2,810	21.6	29
2025	Boulder Creek near Boulder, Wyo.	F–5	------	1904–06, 1915–24, 1931–32	7,030	------	------	------	------	June 14, 1918	6.8	3,240	------	------
2030	East Fork near Big Sandy, Wyo.	F–5	79.2	1939–61	7,800	------	------	------	961	June 14, 1953	7.05	1,720	21.7	12
2035	East Fork at East Fork Canal, Wyo.	F–5	106	1916–17, 1921–23	7,460	------	------	------	1,100	June 23, 25, 1917	4.6	1,400	13.2	4
2040	Silver Creek near Big Sandy, Wyo.	F–5	45.4	1939–61	7,500	------	------	------	555	May 28, 1951	7.53	1,030	22.7	14
2045	East Fork at Newfork, Wyo.	F–5	348	1905–06, 1915–24, 1931–32	6,900	------	------	------	2,600	June 19, 1917	6.7	2,940	8.45	3

See footnotes at end of table.

Table 1.—*Maximum floods at gaging stations used in the frequency analyses*—Continued

No.	Gaging station	Flood region and hydrologic area	Contributing drainage area (sq mi)	Period of known floods	Altitude at site (feet)	Mean basin altitude (feet)	Mean annual precipitation (inches)	Geographic factor	Areal $Q_{2.33}$ (cfs)	Maximum floods: Date	Gage height (feet)	Discharge: cfs	Discharge: cfs per sq mi	Recurrence interval (years)
9-2055	North Piney Creek near Mason, Wyo.	F–6	58	1916, 1932–61	7,520	------	------	------	363	June 2, 1956	4.38	619	10.7	10
2060	Middle Piney Creek below South Fork, near Big Piney, Wyo.	F–6	34.3	1940–54	7,980	------	------	------	288	June 29, 1943	-----	254	7.40	2
										May 28, 1951	6.41	------	------	------
2070	Middle Piney Creek near Big Piney, Wyo.	F–6	46	1915–18, 1931–32	7,500	------	------	------	300	June 16, 1918	2.79	282	6.14	2
2085	La Barge Creek near Viola, Wyo.	F–6	172	1913–16, 1941–49	6,890	------	------	------	650	May 25, 1914	8.35	682	3.97	2
2090	La Barge Creek near La Barge, Wyo.	F–6	193	1932–39	6,590	------	------	------	660	May 16, 1936	3.57	442	2.29	1
2095	Green River near Fontenelle, Wyo.	E	3,970	1947–61	6,490	------	------	------	8,900	June 6, 1956	8.33	13,300	3.35	18
2110	Fontenelle Creek near Fontenelle, Wyo.	F–6	224	1916–19, 1932–53	6,580	------	------	------	724	Apr. 19, 1938	4.00	922	4.12	4
2125	Big Sandy Creek at Leckie Ranch, near Big Sandy, Wyo.	F–5	94	1940–61	7,800	------	------	------	1,100	June 17, 1950	6.85	------	------	------
										June 14, 1953	-----	1,310	13.9	3
2135	Big Sandy Creek near Farson, Wyo.	F–5	322	1915–17, 1921–24, 1927–34, 1954–61	6,800	------	------	------	2,350	Aug. 14, 1930	5.96	1,330	4.13	1
2140	Little Sandy Creek near Elkhorn, Wyo.	F–5	20.9	1940–61	8,000	------	------	------	326	Apr. 29, 1955	4.66	------	------	------
										June 30, 1957	-----	298	14.2	2
2165	Green River at Green River, Wyo.	E	7,670	1895–1906, 1915–45	6,070	------	------	------	12,300	June 19, 1918	12.3	22,200	2.90	[2]1.11
2185	Blacks Fork near Millburne, Wyo.	F–6	156	1940–61	8,380	------	------	------	1,150	June 7, 1957	6.00	2,530	16.2	25
2190	Blacks Fork near Urie, Wyo.	F–6	261	1914–24, 1938–55	6,560	------	------	------	832	June 19, 1917	4.72	2,680	10.3	[2]1.22
2200	East Fork of Smith Fork near Robertson, Wyo.	F–6	53.0	1940–61	8,490	------	------	------	510	June 13, 1953	7.94	1,200	22.6	33

2205	West Fork of Smith Fork near Robertson, Wyo.	F–6	37.2	1940–61	8,650	------	------	------	398	May 30, 1950	3.08	920	24.7	30
2215	Smith Fork at Mountainview, Wyo.	F–6	192	1942–57	6,830	------	------	------	724	June 13, 1953	4.56	1,100	5.73	7
2220	Blacks Fork near Lyman, Wyo.	F–6	821	1940–57	6,380	------	------	------	1,950	----do------	7.94	1,200	1.46	1
2235	Hams Fork near Frontier, Wyo.	F–6	298	1946–61	6,970	------	------	------	1,100	May 19, 1950	6.74	2,450	8.22	25
2240	Hams Fork at Diamondville, Wyo.	F–6	386	1919–32, 1946–49	6,870	------	------	------	1,250	May 11, 1923	-----	3,250	8.42	47
										May 20, 1948	5.60	------	------	------
2250	Blacks Fork near Green River, Wyo.	F–6	3,670	1948–61	6,000	------	------	------	5,370	Feb. 28, 1950	[1]13.66	------	------	------
										May 7, 1952	-----	5,500	1.50	2
2255	Green River near Linwood, Utah.	E	14,300	1929–61	5,840	------	------	------	12,600	Mar. 1, 1950	[1]13.47	------	------	------
										June 12, 1957	-----	18,000	1.26	12
2260	Henrys Fork near Lonetree, Wyo.	F–6	55.2	1943–61	8,400	------	------	------	502	June 13, 1953	6.28	1,860	33.7	[2]1.40
2280	Henrys Fork near Burntfork, Wyo.	F–6	242	1943–54	7,120	------	------	------	1,000	June 14, 1953	5.29	1,830	7.57	13
2285	Burnt Fork near Burntfork, Wyo.	F–6	52.8	1944–61	8,300	------	------	------	467	June 6, 1952	8.13	599	11.3	4
2290	Burnt Fork at Burntfork, Wyo.	F–6	73	1930–42	7,100	------	------	------	370	Aug. 2, 1936	9.60	4,360	59.8	[2]4.49
2295	Henrys Fork at Linwood, Utah.	F–6	531	1929–60	6,000	------	------	------	1,120	July 15, 1959	9.42	>6,750	>12.7	>[2]2.29
2305	Green River at Flaming Gorge, near Linwood, Utah.	E	14,900	1924–38	5,840	------	------	------	12,600	July 1, 1927	-----	[7]15,400	1.03	5
2320	Sheep Creek near Manila, Utah.	F–6	42	1943–61	8,680	------	------	------	430	May 19, 1948	6.05	1,020	24.3	33
2515	Middle Fork Little Snake River near Battle Creek, Colo.	D–5	120	1913–22	7,000	------	------	------	1,080	May 25, 1920	7.70	4,400	36.7	[2]2.10
2525	South Fork Little Snake River near Battle Creek, Colo.	D–5	46	1912–20	7,060	------	------	------	500	May 9, 1920	-----	[7]760	16.5	12
2530	Little Snake River near Slater, Colo.	D–5	285	1943–47, 1951–61	6,830	------	------	------	2,150	June 7, 1957	8.27	3,230	11.3	11
2535	Battle Creek near Slater, Colo.	D–5	85.3	1943–51	6,700	------	------	------	740	May 21, 1948	3.43	1,160	13.6	14
2550	Slater Fork near Slater, Colo.	D–5	161	1912, 1932–61	6,600	------	------	------	1,240	May 19, 1912	5.00	1,700	10.6	7

See footnotes at end of table.

Table 1.—*Maximum floods at gaging stations used in the frequency analyses*—Continued

No.	Gaging station	Flood region and hydrologic area	Contributing drainage area (sq mi)	Period of known floods	Altitude at site (feet)	Mean basin altitude (feet)	Mean annual precipitation (inches)	Geographic factor	Areal $Q_{2.33}$ (cfs)	Maximum floods: Date	Gage height (feet)	Discharge: cfs	Discharge: cfs per sq mi	Recurrence interval (years)
9-2560	Savery Creek near Savery, Wyo.	D–5	330	1942–61	6,680	-------	-------	-------	2,350	May 4, 1952	7.30	2,670	8.09	3
2570	Little Snake River near Dixon, Wyo.	D–5	988	1911–23, 1939–61	6,330	-------	-------	-------	5,350	May 26, 1920	8.6	9,600	9.72	30
10- 115	Bear River near Utah-Wyoming State line.	G–7	176	1942–61	-------	9,770	-------	-------	1,060	June 6, 1957	4.27	2,800	15.9	[2]1.11
120	Mill Creek at Utah-Wyoming State line.	G–7	59	1942–61	-------	9,320	-------	-------	390	June 7, 1957	4.39	690	11.7	13
160	Sulphur Creek near Evanston, Wyo.	G–7	80.5	1942–59	-------	7,930	-------	-------	291	Apr. 21, 1948	6.01	------	------	------
										Apr. 23, 1952	-----	1,220	15.2	[2]1.77
190	Bear River near Evanston, Wyo.	G–7	715	1913–56	-------	8,130	-------	-------	1,680	June 14, 1921	6.35	3,690	5.16	34
205	Bear River near Woodruff, Utah.	G–7	870	1942–61	-------	7,930	-------	-------	1,790	Apr. 28, 1952	5.32	3,010	3.46	11
265	Bear River near Randolph, Utah.	G–7	1,640	1943–61	-------	7,470	-------	-------	2,380	May 8, 1952	8.80	2,660	1.62	3
270	Twin Creek at Sage, Wyo.	G–7	246	1943–61	-------	7,180	-------	-------	490	Mar. 18, 1947	6.08	649	2.64	5
320	Smiths Fork near Border, Wyo.	G–7	165	1942–61	-------	8,270	-------	-------	579	June 7, 1957	4.56	1,500	9.10	[2]1.09
350	Smiths Fork at Cokeville, Wyo.	G–7	275	1942–52	-------	7,810	-------	-------	706	May 29, 1951	5.77	------	------	------
										May 4, 1952	-----	1,320	4.80	16
395	Bear River at Border, Wyo.	G–7	2,490	1937–61	-------	7,390	-------	-------	3,160	May 11, 1952	8.89	3,680	1.48	3
400	Thomas Fork near Geneva, Idaho.	G–7	45.3	1939–51	-------	7,170	-------	-------	134	May 18, 1950	4.25	418	9.22	[2]1.32
405	Salt Creek near Geneva, Idaho.	G–7	37.6	1939–51	-------	7,390	-------	-------	128	----do------	5.02	382	10.2	[2]1.26
410	Thomas Fork near Wyoming-Idaho State line.	G–7	113	1949–61	-------	7,290	-------	-------	284	----do------	5.55	869	7.69	[2]1.29
425	Thomas Fork near Raymond, Idaho.	G–7	202	1942–52	-------	7,090	-------	-------	404	May 19, 1950	7.62	1,070	5.30	[2]1.12
13- 100	Snake River at south boundary of Yellowstone National Park.	I–8	485	1914–25	-------	8,220	47	99	6,010	June 20, 1925	7.24	6,450	13.3	3

110	Snake River at Moran, Wyo.	I–8	824	1894–1961	-------	8,040	43	113	9,510	June 1894	-----	(8)	------	------
				1904–61						June 12, 1918	10.41	15,100	18.3	27
115	Pacific Creek near Moran, Wyo.	I–8	160	1918, 1945–61	-------	8,160	40	130	2,310	May 28, 1951	5.60	------	------	------
										May 21, 1954	-----	3,470	21.7	17
120	Buffalo Fork near Moran, Wyo.	I–8	378	1918, 1945–60	-------	8,850	45	90	4,100	June 27, 1954	6.71	5,960	15.8	13
145	Gros Ventre River at Kelly, Wyo.	I–8	622	1900–58	-------	8,850	27	90	2,830	May 18, 1927	-----	(9)	------	------
										June 16, 1918	9.95	6,220	10.0	[2]1.29
180	Flat Creek near Jackson, Wyo.	I–8	40.7	1933–41	-------	8,980	30	90	304	June 15, 1935	3.48	438	10.8	12
195	Hoback River near Jackson, Wyo.	I–8	564	1918, 1945–58	-------	8,000	32	90	3,410	June 16, 1918	13.46	6,160	10.9	[2]1.06
230	Greys River above Reservoir, near Alpine, Wyo.	I–8	451	1918, 1937–38, 1953–61	-------	8,080	34	90	3,070	June 14, 1918	4.85	5,200	11.5	46
235	Snake River below Greys River, at Alpine, Idaho.	MS	3,940	1945–54	-------	8,140	35	94	29,500	June 28, 1954	9.69	28,200	7.16	1
240	Salt River near Smoot, Wyo.	I–8	47.8	1933–51	-------	8,050	33	64	289	June 7, 1957	3.83	460	9.62	27
245	Cottonwood Creek near Smoot, Wyo.	I–8	26.3	1933–57	-------	8,560	41	74	279	June 2, 1956	-----	438	16.7	25
										June 10, 1957	4.12	------	------	------
250	Swift Creek near Afton, Wyo.	I–8	27.4	1943–61	-------	8,400	59	70	486	June 30, 1957	3.52	775	28.3	27
270	Strawberry Creek near Bedford, Wyo.	I–8	21.3	1932–43	-------	8,470	58	57	308	June 27, 1943	4.51	396	18.6	6
285	Salt River at Wyoming-Idaho State line.	H–8	890	1934–55	-------	7,190	25	53	2,030	May 6, 1936	4.64	3,520	3.96	11
295	McCoy Creek above reservoir, near Alpine, Idaho.	H–8	108	1917–18, 1934, 1953–61	-------	6,960	29	100	755	Apr. 21, 1956	5.72	1,130	10.5	7
320	Bear Creek above reservoir, near Irwin, Idaho.	H–8	77.1	1936, 1953–61	-------	7,130	31	83	518	May 5, 1936	3.70	784	10.2	7
510	Teton River near Victor, Idaho.	I–8	47.6	1947–52	-------	8,240	48	44	358	June 7, 1952	3.64	445	9.35	5
515	Teton Creek near Driggs, Idaho.	I–8	33.8	1946–52	-------	8,870	50	140	900	June 6, 1952	3.94	1,030	30.5	3

[1]Ice jam.
[2]Ratio of maximum discharge to that of 50-year flood.
[3]Discharge measurement by Bureau of Reclamation at site 1 mile downstream.
[4]Log jam.
[5]From floodmark, date unknown.
[6]Maximum stage known; date unknown.
[7]Maximum daily discharge
[8]Flood in early June 1894 probably was considerably higher than that of June 12, 1918.
[9]Considerably higher than flood of June 16, 1918; caused by washout of landslide 2 miles upstream releasing 60,000 acre-ft of impounded water.

36972