COLORADO WATER CONSERVATION BOARD
COLORADO DEPARTMENT OF NATURAL RESOURCES

TECHNICAL MANUAL NO. 1

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COLORADO DEPARTMENT OF NATURAL RESOURCES

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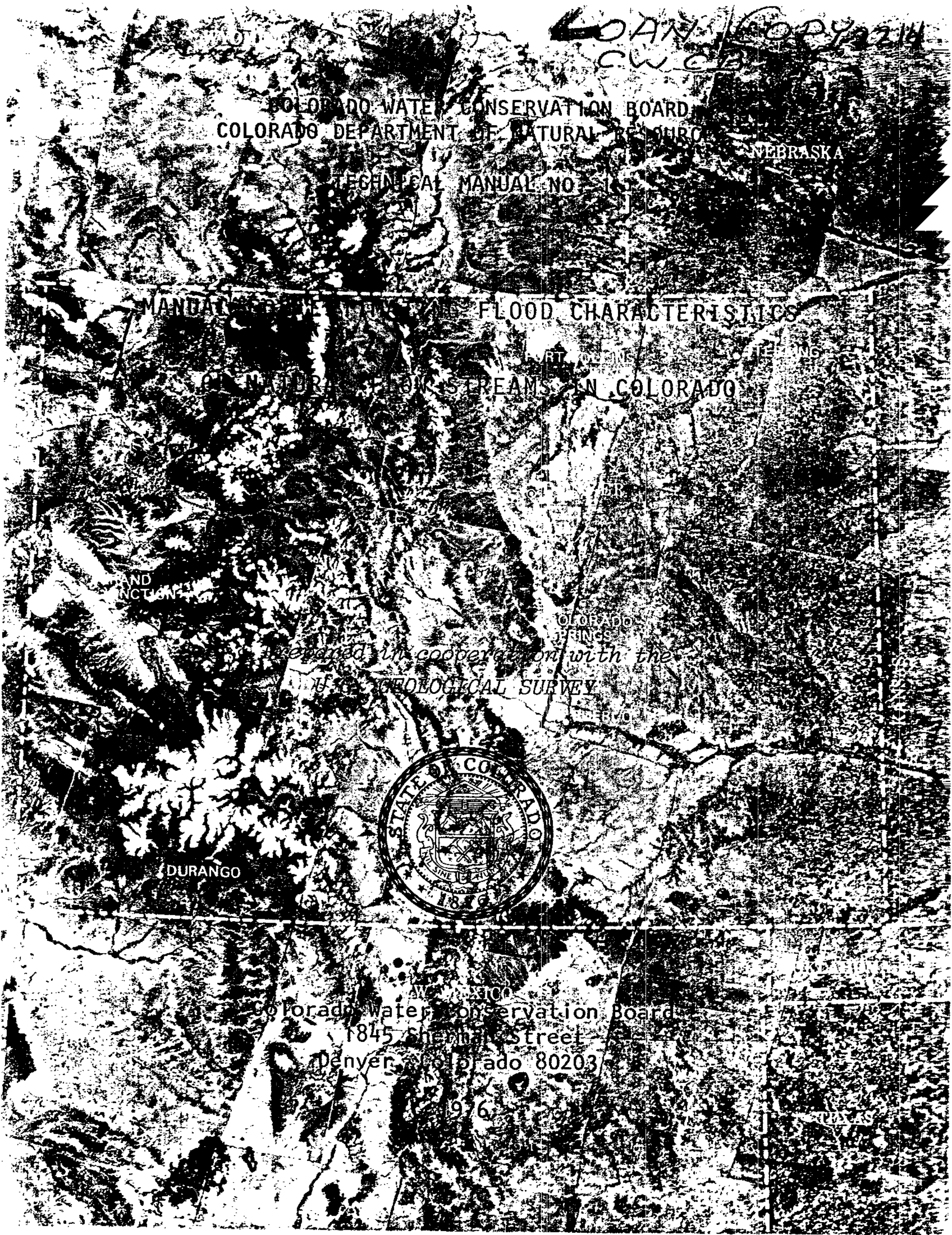
MANUAL FOR ESTIMATING FLOOD CHARACTERISTICS OF NATURAL-FLOW STREAMS IN COLORADO

Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY



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1976

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U.S. GEOLOGICAL SURVEY
James E. Biesecker, District Chief

MISSION OF THE COLORADO WATER CONSERVATION BOARD

The Colorado Water Conservation Board was legislatively created in 1937 for the expressed general purpose "* * * to promote the conservation of the waters of the State of Colorado in order to secure the greatest utilization of such waters and the utmost prevention of floods* * *"

SPECIFIC LEGISLATIVE CHARGES REGARDING THE FLOODPLAIN INFORMATION AND MANAGEMENT PROGRAM ARE:

"To devise and formulate methods, means, and plans for bringing about the greater utilization of the waters of the State and the prevention of flood damages therefrom."

"To designate and approve storm or floodway runoff channels or basins."

"To make such designations available to legislative bodies of cities and incorporated towns; to county planning commissions and to boards of adjustment of cities; and counties of the State."

"To promulgate a model floodplain regulation."

"To identify in general terms floodplain hazard areas by June 30, 1976."

"To assist local governments on a continuing basis in the specific identification of floodplain hazard areas."

"To assist local governments on a continuing basis in determining what use and occupation may be permitted in designated floodplain hazard areas."

COLORADO WATER CONSERVATION BOARD
COLORADO DEPARTMENT OF NATURAL RESOURCES

TECHNICAL MANUAL NO. 1

MANUAL FOR ESTIMATING FLOOD CHARACTERISTICS OF NATURAL-FLOW STREAMS IN COLORADO

By Jerald F. McCain *and* Robert D. Jarrett

U.S. Geological Survey

Prepared in cooperation with the

U.S. GEOLOGICAL SURVEY

Colorado Water Conservation Board
1845 Sherman Street
Denver, Colorado 80203

1976

PREFACE

This manual was prepared by the U.S. Geological Survey in cooperation with the Colorado Water Conservation Board. It was developed to provide a simplified method for calculating approximate limits of flood-prone areas along streams in Colorado. The manual contains methods for calculating 10-, 50-, 100-, and 500-year peak discharges and flood depths for natural-flow streams. The manual is intended to aid planners, engineers, and officials of local governments in identifying flood-prone areas to fulfill the intent of the Colorado General Assembly's "Local Government Land Use Control Enabling Act of 1974," commonly known as House Bill 1041.

Copies of the manual and guidance on its use are available from either agency. The U.S. Geological Survey also can provide other related flood data and technical assistance upon request.

The peak discharge figures for gaging stations have been coordinated with other Federal agencies involved in flood studies in Colorado.

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CONVERSION TABLE

English units in this report may be expressed as metric units by use of the following conversion factors:

To convert English units	*Multiply by*	*To obtain metric units*
Length, in feet (ft)	0.305	metres (m)
Length, in miles (mi)	1.609	kilometres (km)
Area, in square miles (mi^2)	2.590	square kilometres (km^2)
Slope, in feet per mile (ft/mi)	.189	metres per kilometre (m/km)
Runoff rate, in cubic feet per second (ft^3/s)	.0283	cubic metres per second (m^3/s)

GLOSSARY

bankfull stage.--The stage or depth at which a stream overflows its natural banks.

ephemeral stream.--A stream or reach of stream that flows briefly only in direct response to precipitation in the immediate locality and whose channel is at all times above the water table.

equivalent years of record.--The number of years of observed record required to provide an estimate of equal accuracy of that provided by a regression equation.

flood depth.--A term used herein to represent a vertical distance above a line connecting points of zero flow along a reach of channel.

flood-frequency relation.--A graph showing the number of times per year on the average that a flood of a given magnitude is exceeded.

flood plain.--The part of a stream valley, adjacent to the stream channel, that is built of sediments during the present regimen of the stream and which is covered with water when the stream overflows its banks at flood stages.

foothill streams.--A term used herein to denote streams which flow from a high mountain area to a much flatter plain or plateau area. The stream is subjected to floods resulting from rainfall, snowmelt, or a combination of both. As defined herein, foothill streams occur in mixed-population flood areas throughout Colorado except the southwestern part south of the Gunnison River.

gage height.--The elevation of a water surface above or below a datum corresponding to the zero of the gage.

gaging station.--A particular site on a stream or other body of water where systematic observations of gage height, discharge, or water quality parameters (or any combination of these) are obtained.

log-Pearson Type III distribution.--A statistical distribution used in flood-frequency analysis, which is described by three parameters; mean, standard deviation, and coefficient of skewness of the logarithms of the sample observations.

mixed-population flood area.--The transition zone between a high mountain area and a much flatter plain or plateau area where floods are caused by rainfall, snowmelt, or a combination of both.

multiple-regression analysis.--A statistical technique by which a relation between a dependent variable and two or more independent variables can be derived. The result is usually expressed as a regression equation.

natural-flow stream.--A term used in this report to denote a stream on which diversions and regulation have insignificant effect on annual peak discharges.

orographic effect.--The lifting of moisture-laden air over a high barrier such as a mountain range with consequent release of precipitation.

outliers.--Those observations in a statistical sample which plot extremely high or low on the relation defined by all other observations.

peak discharge.--The largest value of streamflow attained by a flood, reported in cubic feet per second.

permeable.--Pertaining to a rock or soil having a texture that permits passage of liquids or gases under the pressure ordinarily found in earth materials.

point of zero flow.-A term used herein to denote the elevation at a cross-section on a stream at which the stream ceases to flow. The elevation represents an average streambed at the section; thus, small crevices and cracks in the streambed can be ignored.

recurrence interval.--The average interval of time, in years, within which a given flood will be exceeded once.

residuals.--The difference between the measured value of an observation and the value computed from a relation based on all observations in the sample.

skewness.--A numerical measure or index of asymmetry of a frequency distribution. From a practical standpoint, the term indicates positive or negative curvature of a flood-frequency relation.

stage.--The height of a water surface above an established datum plane; also gage height.

stage-discharge relation.--A graph showing the relation between the gage height and the volume of water flowing in a channel.

standard error of estimate.--A measure of how well observed data agrees with a regression relation which is computed from the differences (residuals) between observed data and the regression equation.

stream.--Any body of water from a large river to a small rill moving under gravity flow to progressively lower levels in a relatively narrow but clearly defined channel on the surface of the ground.

weighted flood discharge.--A flood discharge for a selected recurrence interval computed as the weighted average of the station value and the regression value. The weighted average is based on length of record of the station data and equivalent years of record for the regression value.

MANUAL FOR ESTIMATING FLOOD CHARACTERISTICS OF NATURAL-FLOW STREAMS IN COLORADO

By Jerald F. McCain and Robert D. Jarrett
U.S. Geological Survey

INTRODUCTION

This manual contains methods for obtaining flood information for the 10-, 50-, 100-, and 500-year floods at sites on natural-flow streams in Colorado. This flood information should be useful in land-use planning, flood insurance studies, and other studies requiring flood-frequency information. The peak-discharge information is applicable to a wide variety of studies ranging from rapid approximation of flood-prone areas to detailed flood-plain studies based on precise hydraulic field measurements. Conversely, the flood-depth information is applicable only for rapid approximation of flood-prone areas or as a general guide to flood depths for comparative purposes. This limited usage of the flood-depth information results from the difficulty in evaluating field conditions, such as channel width, and size of structures, such as bridges and culverts, from existing topographic maps.

The limitations of the methods are discussed first to caution the user of their range of applicability. Next, the methods are described and a step-by-step procedure for applying the methods is presented with several examples. Procedures for transferring the depth information to topographic maps are also described. Other sections contain a discussion of accuracy, analytical development of the methods, and a list of flood data for gaging stations.

Four previous reports have defined the flood frequency of streams in Colorado. These previous reports cover the four major river basins in Colorado as follows: South Platte River basin (Matthai, 1968), Arkansas River basin (Patterson, 1964), Rio Grande basin (Patterson, 1965), and Colorado River basin (Patterson and Somers, 1966). This report is based on 11 to 15 years of additional data and includes many additional gaging-station records. The flood-frequency analyses for the previous reports are based on the index-flood method described by Dalrymple (1960). This report uses the log-Pearson Type III method for fitting a frequency curve to gaging-station data and multiple-regression techniques for regionalization or transferring the results to ungaged basins. More reliable estimates should result from use of information in this report since more basic data and more generally accepted analytical techniques were used.

LIMITATIONS OF METHODS

The following limitations need to be observed when using the methods presented in this manual.

1. They are not applicable to urban areas unless the effects of urbanization on flood characteristics are insignificant. An example of this condition would be a large stream flowing through an urban area.

2. They are not applicable to streams where manmade works, such as improved channels, flood-detention structures, storage reservoirs, and major diversion structures, have a significant effect on flood discharges or depths. For those conditions, open-channel hydraulic studies or stream-system studies will be required to evaluate flood characteristics.

3. Estimating techniques are least reliable for sites on streams in mixed-population flood areas. Flood-estimating techniques for these streams need to be studied in more detail, but an interim estimating technique is presented.

4. The applicability of regression equations for computing flood characteristics at ungaged sites having basin and climatic parameters outside of the ranges listed in the tables at the back of the report, is untested and, therefore, unknown.

5. The flood-depth estimating equations should not be used in reaches of streams affected by backwater from downstream structures.

DESCRIPTION OF METHODS

The three methods described below can be used for obtaining flood information at sites on natural-flow streams in Colorado.

FLOOD INFORMATION AT GAGED SITES

Flood information at gaged sites is listed in the tables at the back of this report. Listed in the first line for each gaging station are the 10-, 50-, 100-, and 500-year flood discharges and the 100-year flood depth based on the period of observed record. Gaging station locations are given as latitude and longitude in degrees, minutes, and seconds under each gaging station name.

Because of the possibility of the observed period of record falling within a high or low climatic cycle, the data may not represent the best estimate for future periods of time. This possibility of error, called time-sampling error, is usually small for long periods of record but may be extremely large for short periods. A procedure described by Sauer (1974) reduces the effects of time-sampling errors by providing a weighted average of discharge from the station value and the regression value which is discussed on pages 5 and 6. The weighted average is computed from the equation

$$Q_{T(W)} = \frac{\left(Q_{T(S)} \times N\right) + \left(Q_{T(R)} \times E\right)}{N + E}$$

where

$Q_{T(W)}$ = the weighted discharge for recurrence interval T,

$Q_{T(S)}$ = the station value of the flood for recurrence interval T,

$Q_{T(R)}$ = the regression value of the flood for recurrence interval T,

N = the number of years of station data used to compute $Q_{T(S)}$, and

E = the equivalent years of record for $Q_{T(R)}$. A value of 10 years as recommended by the U.S. Water Resources Council (1975) should be used in the weighting procedure for all gaged sites throughout Colorado.

A weighted average was computed for each recurrence interval flood at all gaged sites and is listed below the station value in the tables. The weighted averages are the best estimates of future flood discharges of specified frequencies at gaged sites.

FLOOD INFORMATION NEAR GAGED SITES ON THE SAME STREAM

Peak discharges at sites near gaging stations on the same stream can be computed by the following equation:

$$Q_{T(U)} = \left(\frac{A_U}{A_G}\right)^X Q_{T(G)}$$

where

$Q_{T(U)}$ = peak discharge at ungaged site for recurrence interval T,

$Q_{T(G)}$ = weighted average discharge at gaged site for recurrence interval T,

A_U = drainage area at ungaged site,

A_G = drainage area at gaged site, and

X = exponent for each flood region as follows:

Flood Region	Exponent, X
Plains	0.48
Mountains	.79
Northern Plateau	.50
Southern Plateau	.71

The above procedure is applicable for ungaged sites where the drainage area ratio lies between 0.5 and 2.0.

FLOOD INFORMATION AT UNGAGED SITES

This method consists of a series of regression equations which relate flood characteristics to measurable basin and climatic parameters. The resulting equations are of the form:

$$Y_t = a x_1^{b_1} x_2^{b_2}$$

where

Y_t = a flood characteristic, either peak discharge or peak flood depth, for recurrence interval t;
x_1, x_2 = basin and climatic parameters as defined in a later section;
a = regression constant; and
b_1, b_2 = regression coefficients.

The basin and climatic parameters used in this study were selected based on the results of trial regressions using gaging stations with 25 or more years of record. The basin and climatic parameters are defined below with a brief explanation of computation procedures.

Drainage area, A.--The total area of a basin contributing to flood discharges, in square miles, as measured from U.S. Geological Survey topographic maps, usually by planimetering. Simpler but less reliable indexes of drainage-area size might be obtained from smaller scale maps or by overlaying a grid of known square sizes on the outlined catchment and counting the number of squares.

In mixed-population flood areas, the basin needs to be outlined and divided according to the elevation criteria given on page 9, and an area computed for each subbasin.

Mean annual precipitation, P.--The 1931-60 mean annual precipitation for a basin, in inches, as computed from a U.S. Weather Bureau map (1967). The value is computed by a grid-overlay method. The basin is outlined on the maps and the grid is selected so that at least 20 points fall inside the basin. A precipitation value for each grid point is read and recorded. The values are then summed and an average precipitation value for the basin is computed. Copies of the maps can be obtained from the Colorado Water Conservation Board.

Streambed slope, S_S.--The slope of the streambed, in feet per mile, at the study site measured from the best available topographic maps or by field surveys.

Streambed slope is computed as the elevation difference of the contours upstream and downstream of the study site divided by the distance along the stream between the contour crossings measured by stepping with draftman's dividers or with a opisometer or map wheel (fig. 1). Some special problems that may arise are:

1. Where contours cross the stream at or just downstream from the study site, a slope needs to be computed for the reaches both upstream and downstream from the site, and the average of the two slopes used as the streambed slope for the site.

2. For study sites at or very near the mouth of a stream, it may be necessary to determine the approximate elevation of the mainstream at the mouth for use as the downstream point in the computations. In other cases, the mainstream slope may best represent the streambed slope at the study site.

3. If a field survey is made, the streambed elevations should be obtained at points approximately equal distances upstream and downstream from the study site. The minimum distance between points is recommended as 500 ft. Extreme care should be exercised to avoid deep pools or potholes when measuring streambed elevations.

Basin (channel) slope, S_B.--The slope, in feet per mile, measured between two points along the main channel, one of which is located at 10 percent of the channel length and the other at 85 percent of the channel length (fig. 1). Channel length is measured upstream along the water course from the site to the basin divide. The channel slope can be measured from the best available topographic maps except for very small basins that may require field surveys.

In mixed-population flood areas, the channel slope needs to be computed for each subbasin in the manner described above.

Regression equations were developed for peak discharges and depths for the 10-, 50-, 100-, and 500-year floods for each of four flood-characteristic regions in Colorado. The four regions as shown on figure 2 are Plains, Mountain, Northern Plateau, and Southern Plateau. Descriptions of the boundaries of the four regions are given in the explanation to figure 2 and on pages 39 to 44. The equations for each of the regions are listed in tables 1-4. The equations for the 100-year flood discharges and depths are depicted graphically in figures 3-10.

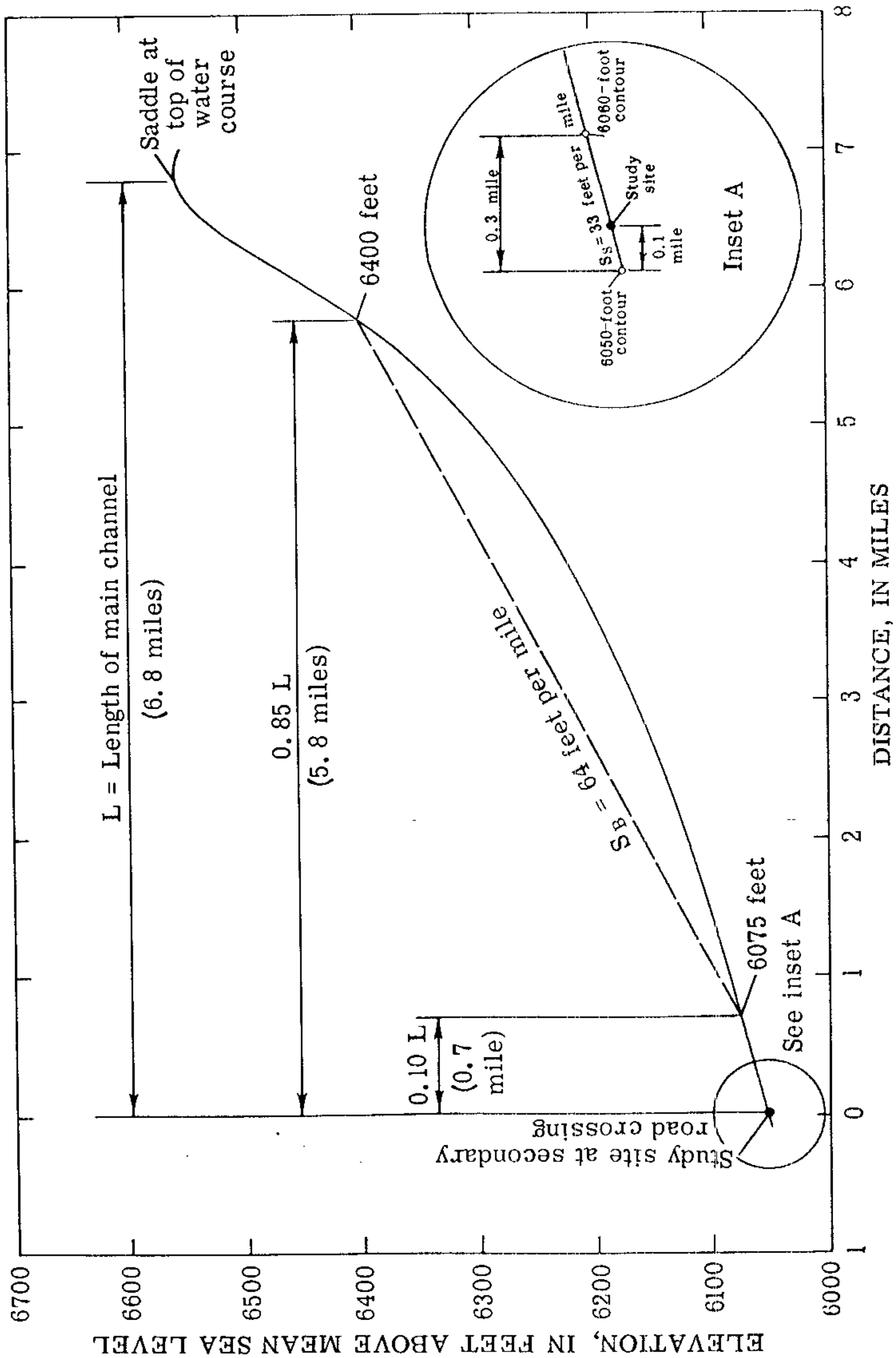


Figure 1.--Profile along Hay Gulch (see example 3) showing required features for computation of basin slope (S_B) and streambed slope (S_S).

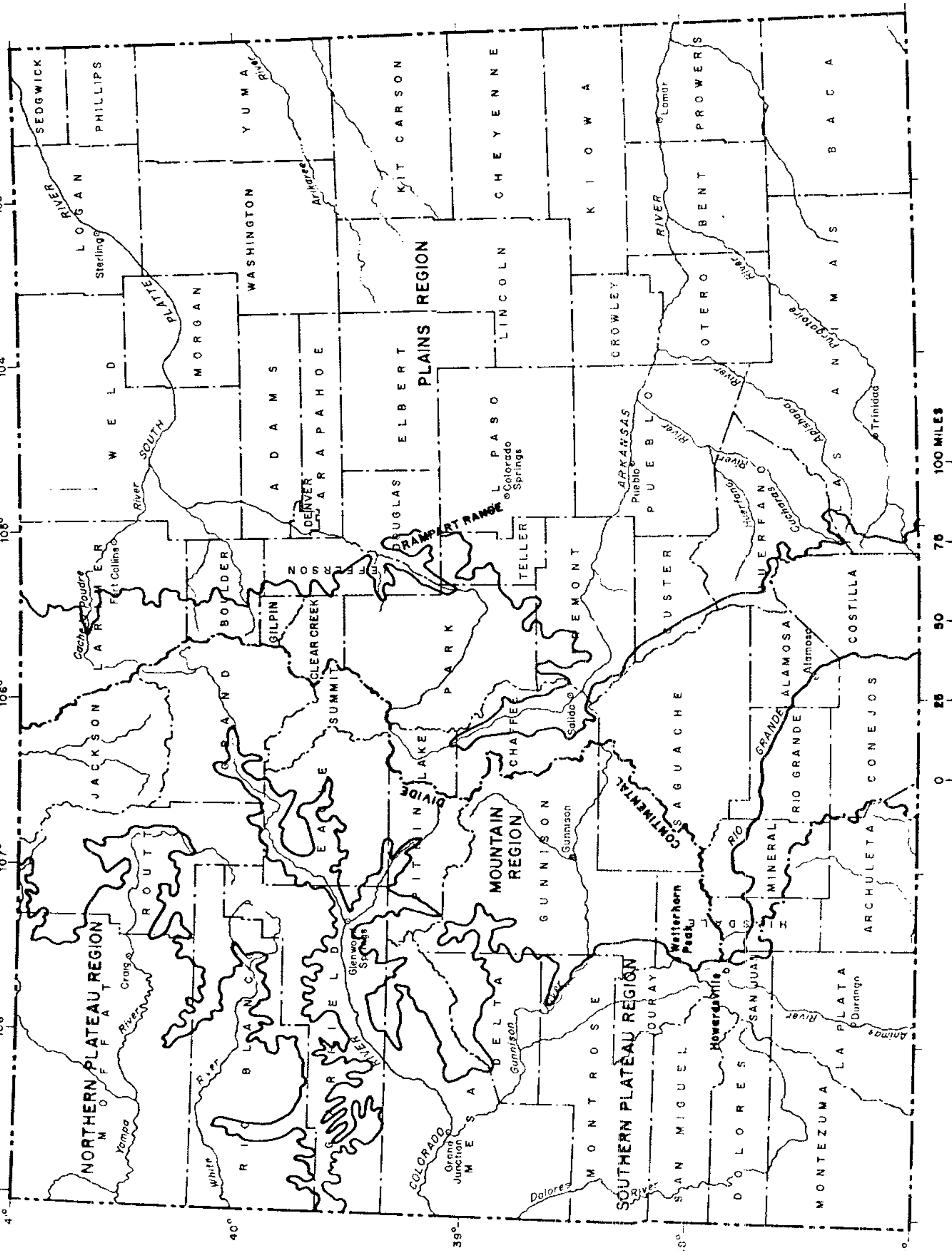


Figure 2.--Flood-characteristic regions in Colorado.

EXPLANATION FOR FIGURE 2
(on facing page)

Plains Region western boundary:

1. Coincides with a line along an elevation of 7,500 feet in the South Platte River basin.

2. Transition zone along Rampart Range crest between the South Platte River and the Arkansas River basins.

3. Coincides with a line along an elevation of 9,000 feet in the Arkansas River basin.

Northern Plateau Region eastern boundary:

1. Coincides with a line along an elevation of 7,500 feet throughout Region.

Southern Plateau Region eastern boundary:

1. North of the Gunnison River, coincides with a line along an elevation of 7,500 feet.

2. South of the Gunnison River, follows the divide between the Cimarron River basin and Big Blue Creek and Lake Fork basins to Wetterhorn Peak.

3. Follows the divide between the Uncompahgre River and the Animas River basins on the west and Lake Fork on the east from Wetterhorn Peak southward to the Continental Divide near Howardsville.

4. Follows the Continental Divide southward to the headwaters of the Rio Grande; then follows the Rio Grande southeastward to the New Mexico State line.

Table 1.--*Plains Region regression equations for peak discharges and depths of selected recurrence-interval floods with corresponding standard error of estimate*

Equation	Standard error of estimate, in percent	
	Average	Range
$Q_{10} = 144A^{0.528}S_B^{0.336}$	31	+36 to -26
$Q_{50} = 891A^{0.482}S_B^{0.154}$	24	+27 to -21
$Q_{100} = 1770A^{0.463}S_B^{0.086}$	28	+32 to -24
$Q_{500} = 5770A^{0.432}$	45	+55 to -35
$D_{10} = 35.5S_S^{-0.462}$	28	+32 to -24
$D_{50} = 52.1S_S^{-0.500}$	23	+26 to -20
$D_{100} = 59.3S_S^{-0.517}$	21	+23 to -19
$D_{500} = 77.3S_S^{-0.553}$	26	+29 to -23

Table 2.--*Mountain Region regression equations for peak discharges and depths of selected recurrence-interval floods with corresponding standard error of estimate*

Equation	Standard error of estimate, in percent	
	Average	Range
$Q_{10} = 0.12A^{0.815}P^{1.592}$	39	+46 to -32
$Q_{50} = 0.91A^{0.795}P^{1.110}$	37	+44 to -30
$Q_{100} = 1.88A^{0.787}P^{0.932}$	38	+45 to -31
$Q_{500} = 8.70A^{0.766}P^{0.560}$	45	+55 to -35
$D_{10} = 0.44A^{0.196}P^{0.347}$	27	+31 to -23
$D_{50} = 1.05A^{0.192}P^{0.133}$	28	+32 to -24
$D_{100} = 1.44A^{0.187}P^{0.059}$	28	+32 to -24
$D_{500} = 1.94A^{0.184}$	31	+36 to -26

Table 3.--*Northern Plateau Region regression equations for peak discharges and depths of selected recurrence-interval floods with corresponding standard error of estimate*

Equation	Standard error of estimate, in percent	
	Average	Range
$Q_{10} = 11.0A^{0.552}P^{0.706}$	28	+32 to -24
$Q_{50} = 70.5A^{0.509}P^{0.289}$	29	+33 to -25
$Q_{100} = 135A^{0.494}P^{0.143}$	30	+34 to -26
$Q_{500} = 293A^{0.469}$	34	+40 to -28
$D_{10} = 13.9S_S^{-0.288}$	24	+27 to -21
$D_{50} = 16.6S_S^{-0.311}$	22	+24 to -20
$D_{100} = 17.2S_S^{-0.310}$	22	+24 to -20
$D_{500} = 19.0S_S^{-0.321}$	21	+23 to -19

Table 4.--*Southern Plateau Region regression equations for peak discharges and depths of selected recurrence-interval floods with corresponding standard error of estimate*

Equation	Standard error of estimate, in percent	
	Average	Range
$Q_{10} = 59.7A^{0.709}$	47	+58 to -36
$Q_{50} = 89.1A^{0.709}$	50	+62 to -38
$Q_{100} = 103A^{0.710}$	53	+66 to -40
$Q_{500} = 137A^{0.713}$	65	+84 to -46
$D_{10} = 1.25A^{0.261}$	25	+28 to -22
$D_{50} = 1.54A^{0.254}$	34	+40 to -28
$D_{100} = 1.64A^{0.254}$	36	+42 to -30
$D_{500} = 1.98A^{0.239}$	44	+53 to -35

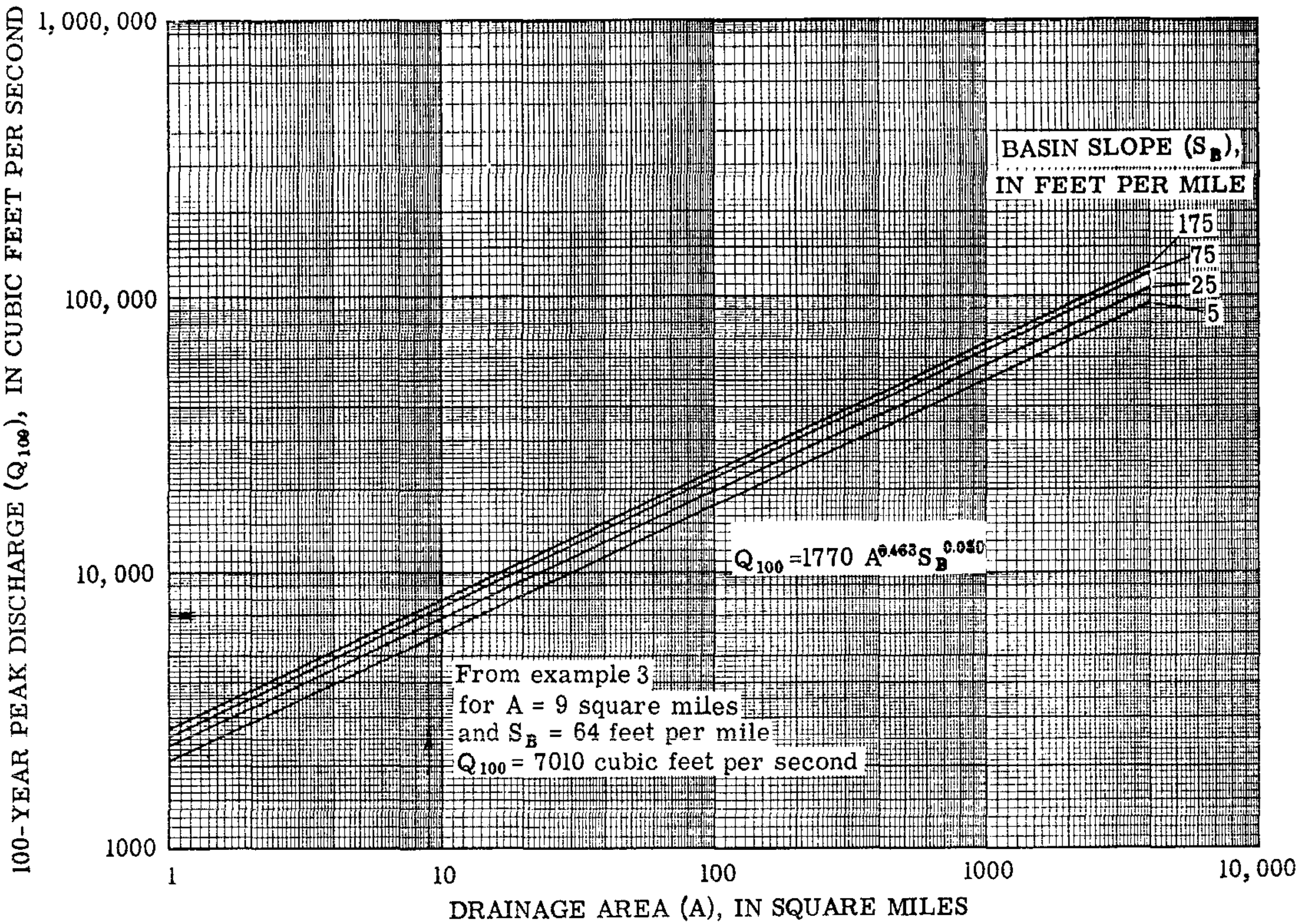


Figure 3.--Relation of 100-year peak discharge to contributing drainage area and basin slope for the Plains Region.

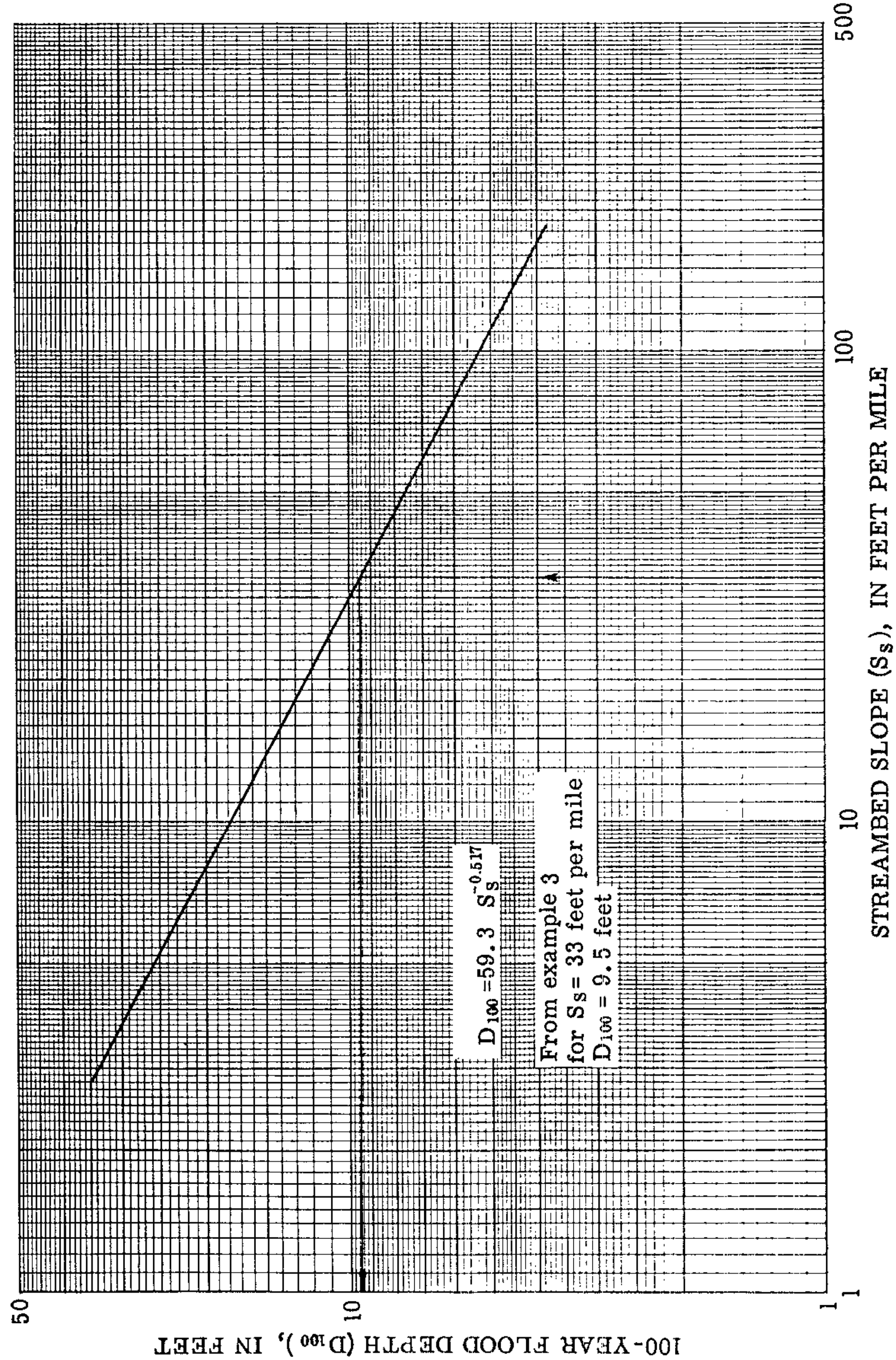


Figure 4.--Relation of 100-year flood depth to streambed slope for the Plains Region.

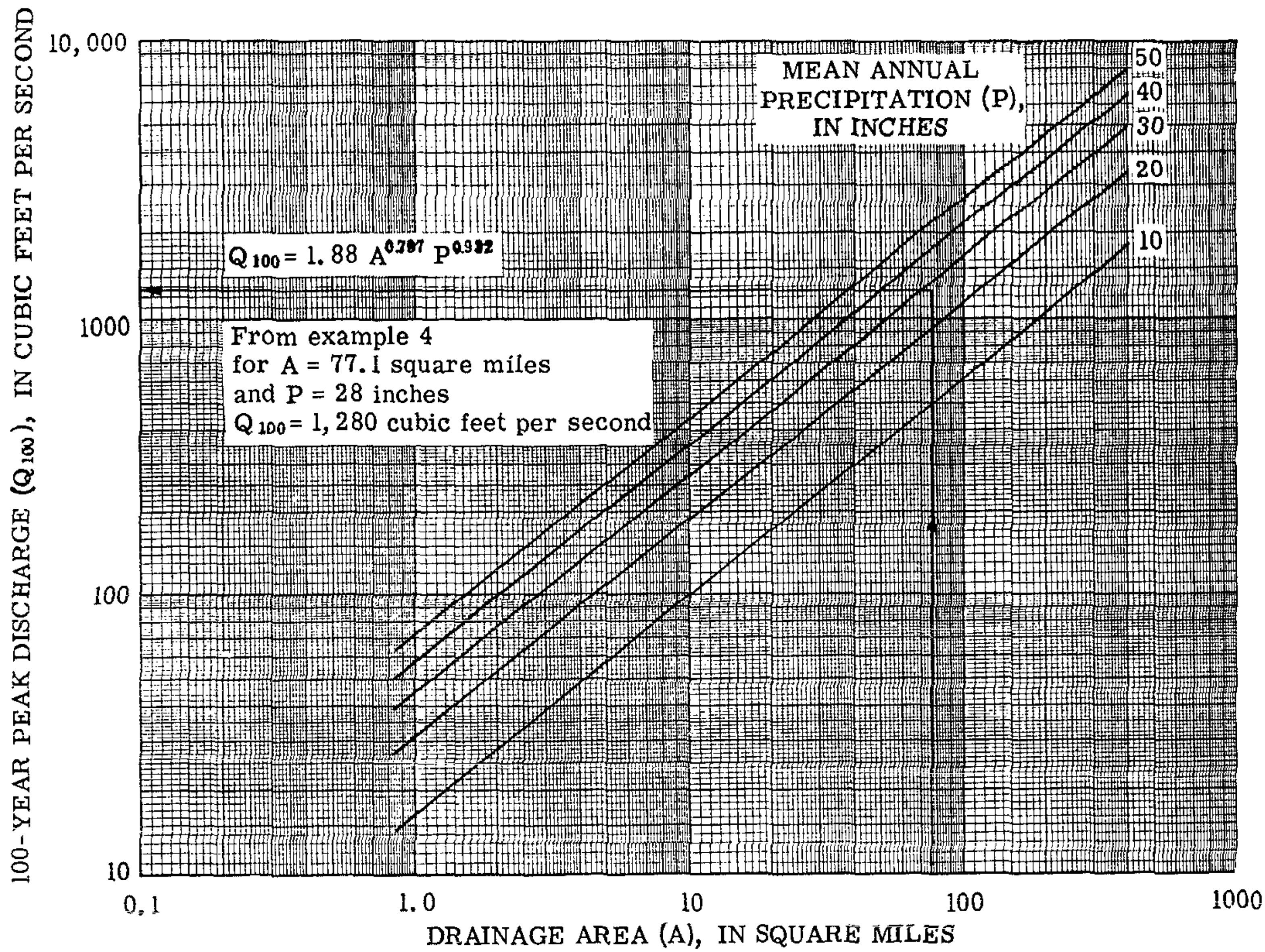


Figure 5.--Relation of 100-year peak discharge to contributing drainage area and mean annual precipitation for the Mountain Region.

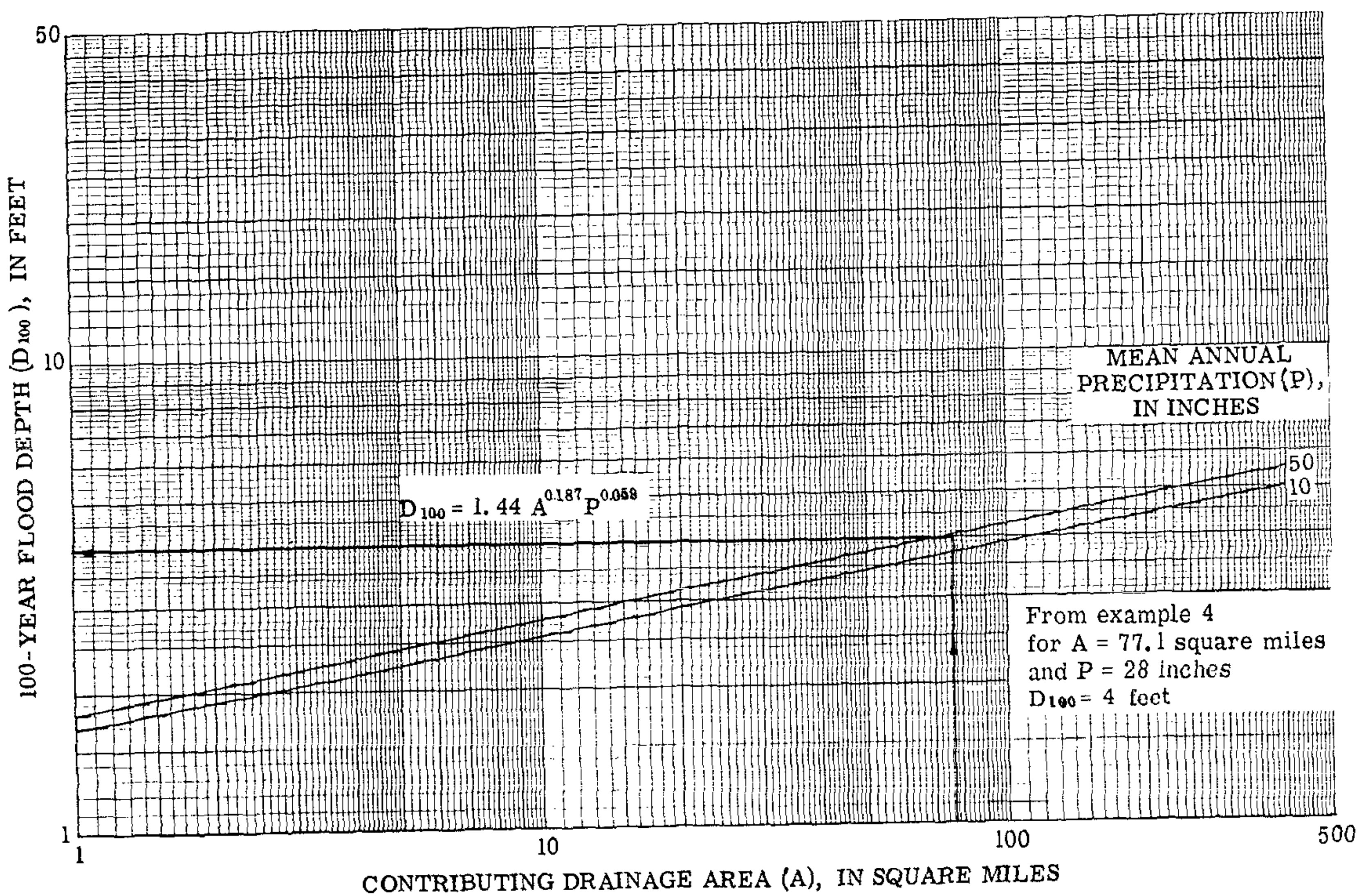


Figure 6.--Relation of 100-year flood depth to contributing drainage area and mean annual precipitation for the Mountain Region.

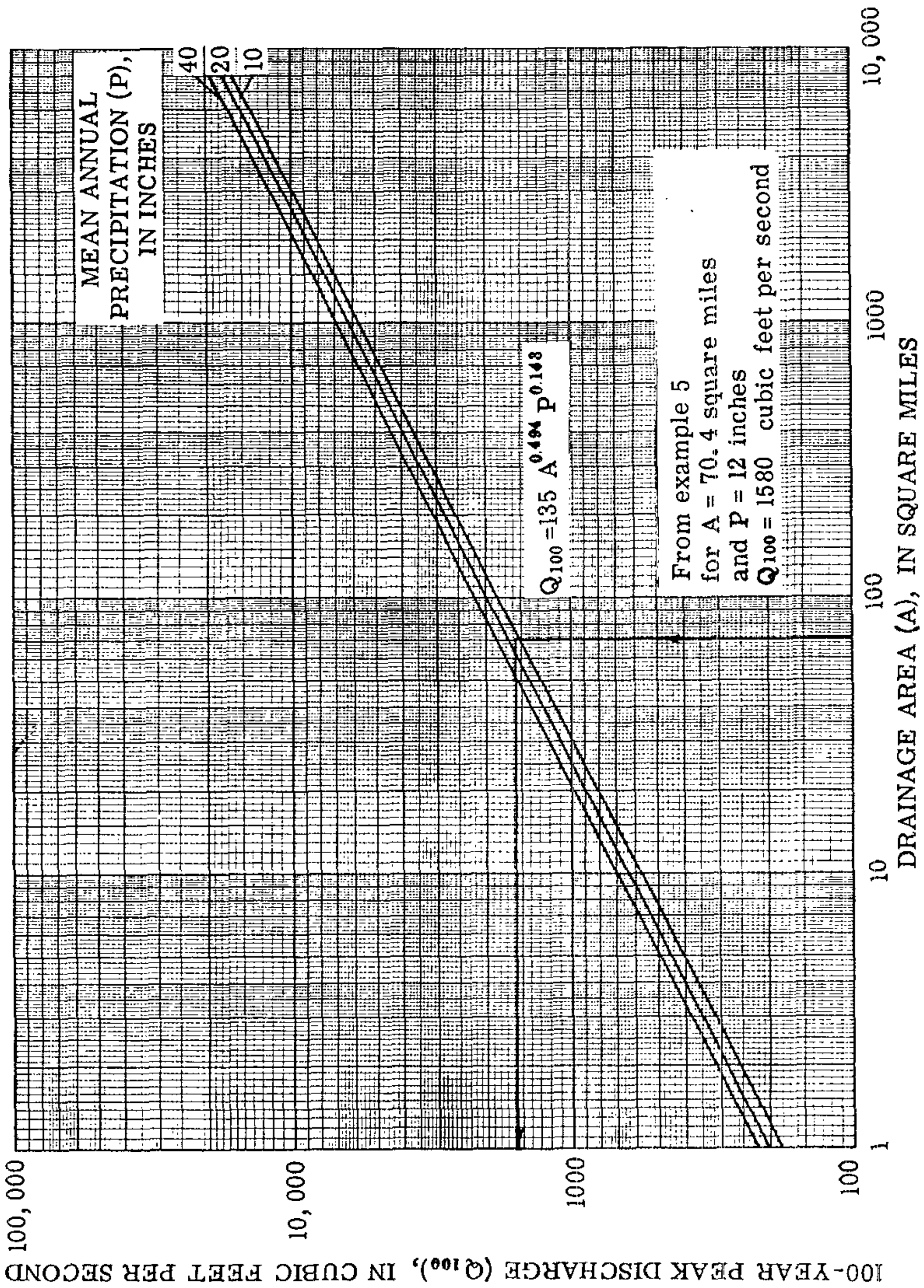
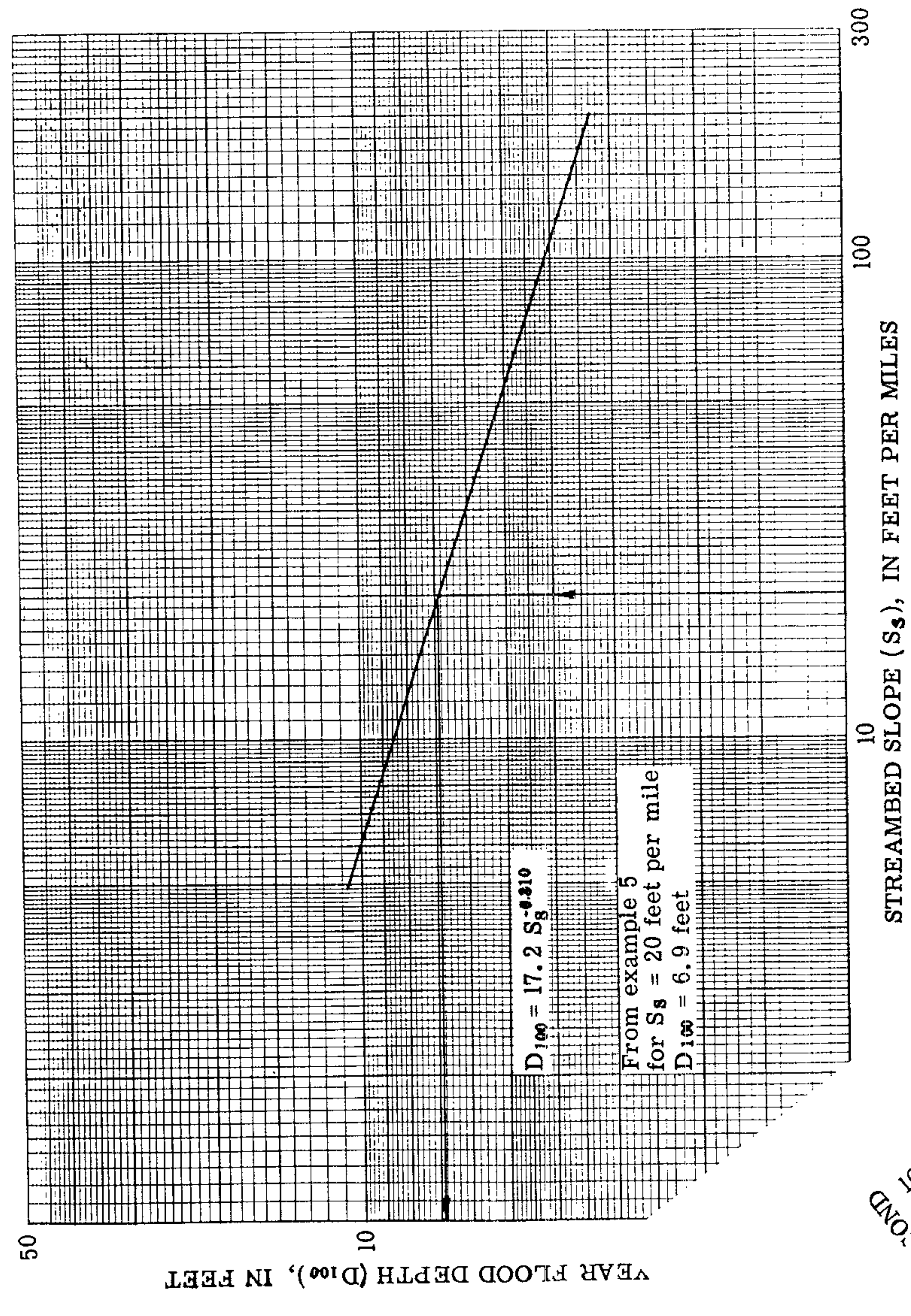


Figure 7.--Relation of 100-year peak discharge to contributing drainage area and mean annual precipitation for the Northern Plateau Region.



f 100-year flood depth to streambed slope for the Northern Plateau Region.

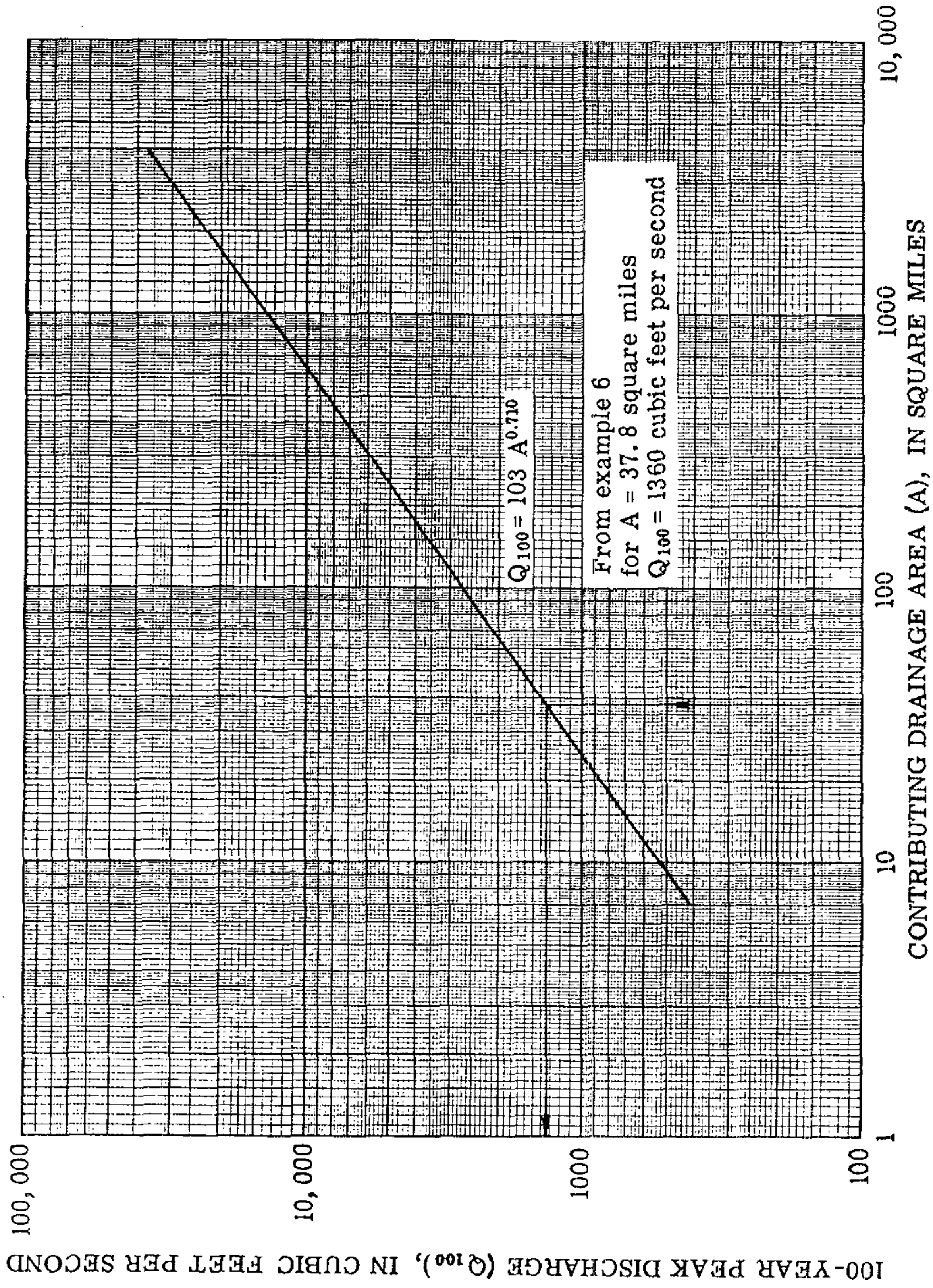


Figure 9.--Relation of 100-year peak discharge to contributing drainage area for the Southern Plateau Region.

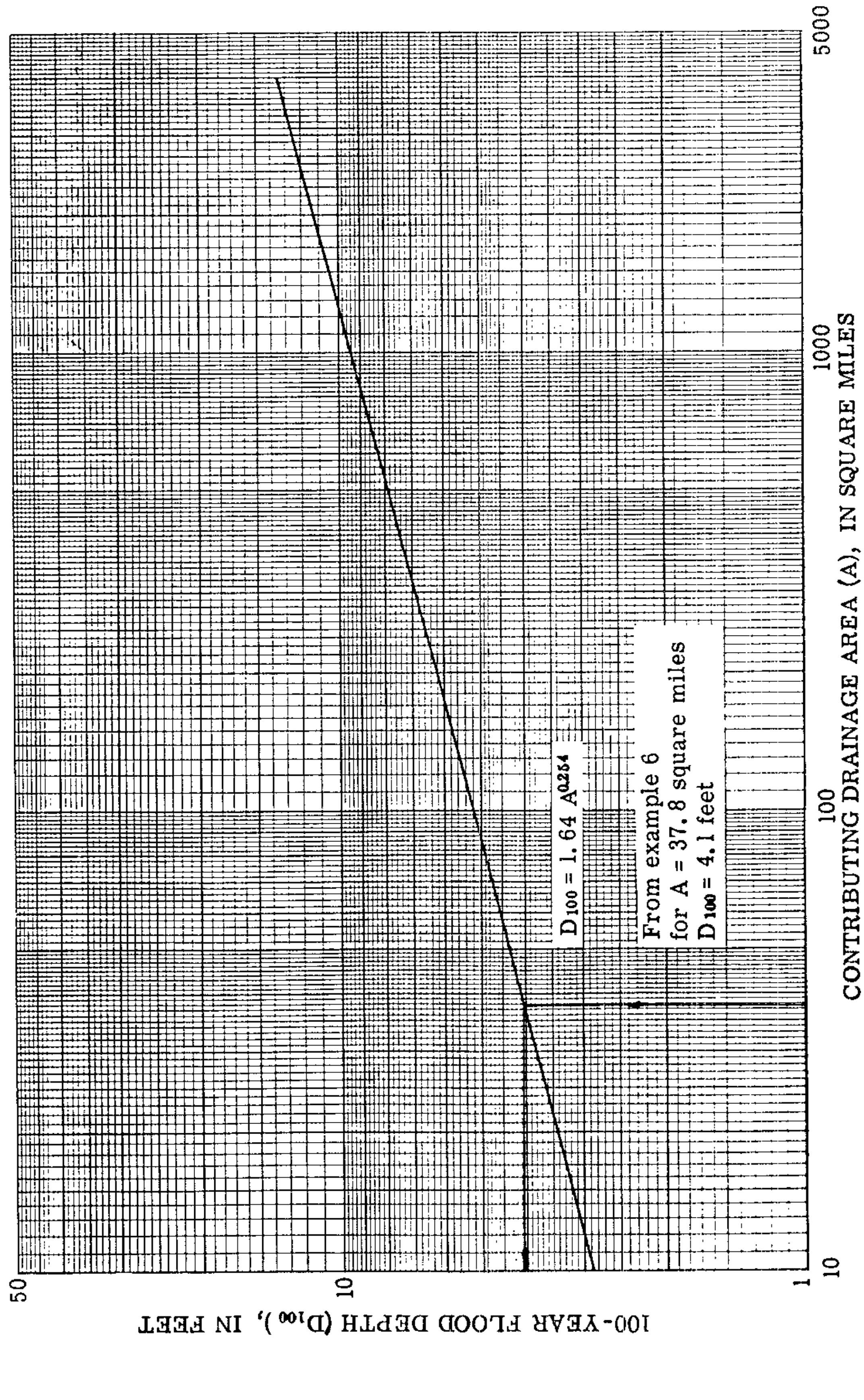


Figure 10.--Relation of 100-year flood depth to contributing drainage area for the Southern Plateau Region.

APPLICATION OF METHODS

The user of this manual needs to follow the steps outlined below for obtaining flood information for sites on natural-flow streams in Colorado.

1. From figure 2, determine flood-characteristic region in which site lies.

2. From tables 5-8, determine if study site is at a gaged site or near a gaged site on the same stream. The latitude and longitude of each gaging station is listed under the station name. For additional information regarding gaging-station locations, consult the U.S. Geological Survey Water-Supply Papers listed on pages 45 to 47.

3. If the study site is located at a gaged site listed in tables 5-8, use described method for "Gaged Sites."

4. If the study site is located near a gaged site on the same stream, use the described method for "Sites on Same Stream near Gaged Sites."

5. If the study site is not located at or near a gaged site, then use the described method for "Ungaged Sites."

GAGED SITES

Peak discharge information for gaged sites can be obtained from tables 5-8. The recommended values for use are the weighted-average discharges listed on the second line for each gaging station. The procedure used for computing the weighted-average discharges is described on page 3. The flood depths for the 100-year flood based on observed gaging-station data are listed in the last column of tables 5-8. This method is illustrated in Example 1.

Example 1.--*Flood Frequency at a Gaged Site*

Determine the best estimate of Q_{10}-, Q_{50}-, Q_{100}-, and Q_{500}-year recurrence-interval floods for station 06712000, Cherry Creek near Franktown, Colo. (lat 39°21'21", long 104°45'46", NE¼ sec. 15, T. 8 S., R. 66 W.).

Map coverage: Castle Rock North quadrangle, scale = 1:24,000
Denver quadrangle, scale = 1:250,000.

Determine the Plains regression flood discharges $Q_{T(R)}$ at the station. Basin parameters required are A and S_B.

$$A=169 \text{ mi}^2 \text{ and } S_B=32 \text{ ft/mi, from table 5.}$$

$$Q_{10(R)}=144A^{0.528}S_B^{0.336}=144(169)^{0.528}(32)^{0.336}=144(15.01)(3.20)= 6,920 \text{ ft}^3/\text{s}$$

$$Q_{50(R)}=891A^{0.482}S_B^{0.154}=891(169)^{0.482}(32)^{0.154}=891(11.85)(1.71)=18,050 \text{ ft}^3/\text{s}$$

$$Q_{100(R)}=1,770A^{0.463}S_B^{0.086}=1,770(169)^{0.463}(32)^{0.086}=1,770(10.75)(1.35)=25,690 \text{ ft}^3/\text{s}$$

$$Q_{500(R)}=5,770A^{0.432}=5,770(169)^{0.432}=5,770(9.17)=52,910 \text{ ft}^3/\text{s}$$

Obtain station flood discharges from table 5:

$$Q_{10(S)} = 4,530 \text{ ft}^3/\text{s}$$

$$Q_{50(S)} = 11,700 \text{ ft}^3/\text{s}$$

$$Q_{100(S)} = 16,300 \text{ ft}^3/\text{s}$$

$$Q_{500(S)} = 31,000 \text{ ft}^3/\text{s}$$

Compute weighted discharges $Q_{T(W)}$ to be used at the gaging station.

$$Q_{T(W)} = \frac{\left(Q_{T(S)} \times N\right) + \left(Q_{T(R)} \times E\right)}{N + E}$$

N = 34 years, from table 5, and
E = 10 years.

$$Q_{10(W)} = \{(4,530)(34) + (6,920)(10)\} \div (34+10) = (154,020 + 69,200) \div 44 = 5,070 \text{ ft}^3/\text{s}$$

$$Q_{50(W)} = \{(11,700)(34) + (18,050)(10)\} \div (34+10) = (397,800 + 180,500) \div 44 = 13,100 \text{ ft}^3/\text{s}$$

$$Q_{100(W)} = \{(16,300)(34) + (25,690)(10)\} \div (34+10) = (554,200 + 256,900) \div 44 = 18,400 \text{ ft}^3/\text{s}$$

$$Q_{500(W)} = \{(31,000)(34) + (52,910)(10)\} \div (34+10) = (1,054,000 + 529,100) \div 44 = 36,000 \text{ ft}^3/\text{s}$$

SITES NEAR GAGED SITES ON THE SAME STREAM

Peak discharge information for study sites near gaged sites on the same stream can be computed using the method described on page 4. The first step is to determine the drainage area ratio of ungaged site to gaged site. If that ratio lies between 0.5 and 2.0, the equation given on page 4 should be used to compute the required peak discharges. If the drainage area ratio lies outside the range, the method for "Ungaged Sites" should be used.

Flood depth information for study sites near gaged sites on the same stream should be computed from the flood depth regression equations for the region in which the study site lies. The method is illustrated in Example 2.

Example 2.--*Flood Frequency near a Gaged Site*

Determine the Q_{10}-, Q_{50}-, Q_{100}-, and Q_{500}-year recurrence-interval floods for Cherry Creek at State Route 83, 4.5 mi south of Franktown, Colo. (lat 39°19'41", long 104°44'02", NW¼ sec. 25, T. 8 S., R. 66 W.).

Map coverage: Russellville Gulch quadrangle, scale = 1:24,000
Denver quadrangle, scale = 1:250,000.

From table 5, note that station 06712000 Cherry Creek near Franktown, Colo. (A_{Gage}=169 mi^2), is located downstream.

Determine the contributing drainage area at the site (A_U=132 mi^2).

Check that A_U is either more than half A_G or less than twice A_G:

$$A_U \div A_G = 132\ mi^2 \div 169\ mi^2 = 0.78.$$

This meets the drainage-area requirement, and the following relation is used:

$$Q_{T(U)} = (A_U \div A_G)^X Q_{T(G)}$$

where X=0.48 for the Plains Region, and $Q_{T(G)}$ is the weighted discharge from table 5.

Obtain the weighted discharges at the gage:

$$Q_{10} = 5{,}070 \text{ ft}^3/\text{s}$$
$$Q_{50} = 13{,}100 \text{ ft}^3/\text{s}$$
$$Q_{100} = 18{,}400 \text{ ft}^3/\text{s}$$
$$Q_{500} = 36{,}000 \text{ ft}^3/\text{s}$$

Compute discharges at ungaged site:

$$Q_{10} = (132 \div 169)^{0.48}(5{,}070 \text{ ft}^3/\text{s}) = 0.89(5{,}070) = 4{,}510 \text{ ft}^3/\text{s}$$
$$Q_{50} = (132 \div 169)^{0.48}(13{,}100 \text{ ft}^3/\text{s}) = 0.89(13{,}100) = 11{,}700 \text{ ft}^3/\text{s}$$
$$Q_{100} = (132 \div 169)^{0.48}(18{,}400 \text{ ft}^3/\text{s}) = 0.89(18{,}400) = 16{,}400 \text{ ft}^3/\text{s}$$
$$Q_{500} = (132 \div 169)^{0.48}(36{,}000 \text{ ft}^3/\text{s}) = 0.89(36{,}000) = 32{,}000 \text{ ft}^3/\text{s}$$

UNGAGED SITES

Peak discharges and depths for selected recurrence-interval floods at ungaged sites on natural-flow streams in Colorado can be computed by one of the following procedures, depending on the location of the basin and the elevation of the basin divide. If the basin lies entirely in a single region, then Procedure 1 is used. If the basin lies partly in the Mountain Region and partly in one of the other regions, then Procedure 2 is used.

Procedure 1.--Computation of flood characteristics of streams which lie entirely in one flood-characteristic region.

1. Identify the flood region of the drainage basin on figure 2 and select the appropriate equations for the basin from tables 1 through 4.

2. Compute the required basin and climatic parameters using the definitions and instructions given on pages 5 and 6.

3. Solve the equations for the desired flood characteristics. Figures 3 to 10 provide graphical solutions for 100-year flood characteristics.

Examples 3 to 6 illustrate the use of the equations and graphs contained in this report.

Example 3.--*Plains Region*

Flood discharges and depths for the 10-, 50-, 100-, and 500-year recurrence-interval floods are required at secondary road crossing of Hay Gulch, 11.6 mi east of Parker (lat 39°30'46", long 104°32'32", NE¼ sec. 22, T. 6 S., R. 64 W.).

The basin is shown on U.S. Geological Survey 7½-minute topographic maps (scale = 1:24,000) as follows:

Watkins SE quadrangle
Cabin Gulch quadrangle.

Using figure 2 and the topographic maps, Hay Gulch lies in the Plains Region and the basin divide is less than 7,500 ft in elevation.

The equations for flood discharges and depths for the Plains Region are listed in table 1.

The equations require that the following basin parameters be computed:

A =drainage area, in square miles,
S_B=basin slope, in feet per mile, and
S_S=streambed slope, in feet per mile.

Using the procedures described on pages 5 and 6, the following values for the required parameters were obtained:

Drainage area (A)=9.0 mi^2
The drainage basin was outlined on the topographic map and the enclosed area was planimetered.

Basin slope (S_B)=64 ft/mi (see fig. 1).
Length of main channel (L) from site to basin divide along longest channel was measured to be 6.8 mi.

$$0.85L=6.8(0.85)=5.8 \text{ mi}$$
$$0.10L=6.8(0.10)=0.68 \text{ mi}$$
Elevation at 5.8 mi upstream=6,400 ft
Elevation at 0.68 mi upstream=6,075 ft
$$S_B=(6,400-6,075)\div(5.8-0.68)=64 \text{ ft/mi}$$

Streambed slope (S_S) = 33 ft/mi (see fig. 1).

Contour downstream from site=6,050 ft
Contour upstream from site=6,060 ft
Distance between contours=0.3 mi
$$S_S=(6,060-6,050)\div 0.3=33 \text{ ft/mi}$$

The basin parameters are inserted in the appropriate equations which are solved as follows:

$$Q_{10} = 144A^{0.528}S_B^{0.336} = 144(9.0)^{0.528}(64)^{0.336} = 144(3.19)(4.04) = 1,860 \text{ ft}^3/\text{s}$$
$$Q_{50} = 891A^{0.482}S_B^{0.154} = 891(9.0)^{0.482}(64)^{0.154} = 891(2.88)(1.90) = 4,880 \text{ ft}^3/\text{s}$$
$$Q_{100}=1,770A^{0.463}S_B^{0.086}=1,770(9.0)^{0.463}(64)^{0.086} =1,770(2.77)(1.43) = 7,010 \text{ ft}^3/\text{s}$$
$$Q_{500} =5,770A^{0.432}=5,770(9.0)^{0.432}=5,770(2.58)=14,900 \text{ ft}^3/\text{s}$$

$$D_{10} =35.5S_S^{-0.462}=35.5(33)^{-0.462}=35.5(0.20)= 7.0 \text{ ft}$$
$$D_{50} =52.1S_S^{-0.500}=52.1(33)^{-0.500}=52.1(0.17)= 8.9 \text{ ft}$$
$$D_{100}=59.3S_S^{-0.517}=59.3(33)^{-0.517}=59.3(0.16)= 9.5 \text{ ft}$$
$$D_{500}=77.3S_S^{-0.553}=77.3(33)^{-0.553}=77.3(0.14)=10.8 \text{ ft}$$

If desired, use a graphical solution for Q_{100} and D_{100}:

Q_{100}--refer to figure 3.

For A=9 mi^2 and S_B=64 ft/mi. From figure 3, Q_{100}=7,010 ft^3/s.

D_{100}--refer to figure 4.

For S_S=33 ft/mi. From figure 4, D_{100}=9.5 ft.

Example 4.--*Mountain Region*

Flood information is required for Geneva Creek at U.S. Highway 285 crossing (lat 39°27'35", long 105°39'47", NE¼NE¼ sec. 9, T. 7 S., R. 74 W.).

Map coverage: Mount Logan quadrangle, scale = 1:24,000
Denver quadrangle, scale = 1:250,000.

Parameters

Q=discharge, in cubic feet per second,
A=drainage area, in square miles,
P=mean annual precipitation, in inches, and
D=depth, in feet.

$A=77.1\ mi^2$.
P=28 inches (From U.S. Weather Bureau (1967) isohyetal map. Use grid method to obtain P at 20 points in basin and average.).

$Q_{10}=0.12A^{0.815}P^{1.592}=0.12(77.1)^{0.815}(28)^{1.592}=0.12(34.51)(201.31)=\ 834\ ft^3/s$

$Q_{50}=0.91A^{0.795}P^{1.110}=0.91(77.1)^{0.795}(28)^{1.110}=0.91(31.64)(\ 40.40)=1,160\ ft^3/s$

$Q_{100}=1.88A^{0.787}P^{0.932}=1.88(77.1)^{0.787}(28)^{0.932}=1.88(30.56)(\ 22.32)=1,280\ ft^3/s$

$Q_{500}=8.70A^{0.766}P^{0.560}=8.70(77.1)^{0.766}(28)^{0.560}=8.70(27.90)(\ 6.50)=1,580\ ft^3/s$

$D_{10}=0.44A^{0.196}P^{0.347}=0.44(77.1)^{0.196}(28)^{0.347}=0.44(2.34)(3.18)=3.3\ ft$

$D_{50}=1.05A^{0.192}P^{0.133}=1.05(77.1)^{0.192}(28)^{0.133}=1.05(2.30)(1.56)=3.8\ ft$

$D_{100}=1.44A^{0.187}P^{0.059}=1.44(77.1)^{0.187}(28)^{0.059}=1.44(2.25)(1.22)=4.0\ ft$

$D_{500}=1.94A^{0.184}=1.94(77.1)^{0.184}=1.94(2.22)=4.3\ ft$

If desired, use a graphical solution for Q_{100} and D_{100}:

Q_{100}--Refer to figure 5.

For $A=77.1\ mi^2$ and P=28 inches.

From figure 5, $Q_{100}=1,280\ ft^3/s$.

D_{100}--Refer to figure 6.

For $A=77.1\ mi^2$ and P=28 inches.

From figure 6, $D_{100}=4.0$ ft.

Example 5.--*Northern Plateau Region*

Flood information is required at North Sand Wash secondary road crossing (lat 40°44'34", long 108°26'13", NW¼NW¼ sec. 17, T. 9 N., R. 98 W.).

Map coverage: Lone Mountain quadrangle, scale = 1:62,500
Craig quadrangle, scale = 1:250,000.

Parameters

Q =discharge, in cubic feet per second,
A =drainage area, in square miles,
P =mean annual precipitation, in inches,
D =depth, in feet, and
S_S=streambed slope, in feet per mile.

A =70.4 mi^2.
P =12 inches (From U.S. Weather Bureau (1967) isohyetal map. Use grid method to obtain P at 20 points in basin and average.)

Contour downstream from point=6,080 ft
Contour upstream from point=6,120 ft
Distance between contours=2.0 mi
$S_S=(6,120-6,080)\div 2.0=20$ ft/mi

$$Q_{10}=11.0A^{0.552}P^{0.706}=11.0(70.4)^{0.552}(12)^{0.706}=11.0(10.5)(5.78)=668 \text{ ft}^3/\text{s}$$
$$Q_{50}=70.5A^{0.509}P^{0.289}=70.5(70.4)^{0.509}(12)^{0.289}=70.5(8.72)(2.05)=1,260 \text{ ft}^3/\text{s}$$
$$Q_{100}=135A^{0.494}P^{0.143}=135(70.4)^{0.494}(12)^{0.143}=135(8.18)(1.43)=1,580 \text{ ft}^3/\text{s}$$
$$Q_{500}=293A^{0.469}=293(70.4)^{0.469}=293(7.35)=1,980 \text{ ft}^3/\text{s}$$

$$D_{10}=13.9S_S^{-0.288}=13.9(20)^{-0.288}=13.9(0.42)=5.9 \text{ ft}$$
$$D_{50}=16.6S_S^{-0.311}=16.6(20)^{-0.311}=16.6(0.39)=6.5 \text{ ft}$$
$$D_{100}=17.2S_S^{-0.310}=17.2(20)^{-0.310}=17.2(0.40)=6.9 \text{ ft}$$
$$D_{500}=19.0S_S^{-0.321}=19.0(20)^{-0.321}=19.0(0.38)=7.2 \text{ ft}$$

If desired, use a graphical solution for Q_{100} and D_{100}:

Q_{100}--Refer to figure 7.

For A=70.4 mi^2 and P=12 inches.

From figure 7, Q_{100}=1,580 ft^3/s.

D_{100}--Refer to figure 8.

For S_S=20 ft.

From figure 8, D_{100}=6.9 ft.

Example 6.--*Southern Plateau Region*

Flood information is required for Hermosa Creek at lower end of Hermosa Park, 3/4 mi downstream from forks, Hermosa Park (lat 37°36'55", long 107° 55'30", sec. 26, T. 39 N., R. 10 W.).

Map coverage: Elk Creek, Hermosa Peak, Engineer Mountain, Electra Lake quadrangles, scale = 1:24,000.

Parameters

A=drainage area, in square miles.
$A=37.8\ mi^2$.

$$Q_{10}=59.7A^{0.709}=59.7(37.8)^{0.709}=59.7(13.1)=\ 784\ ft^3/s$$
$$Q_{50}=89.1A^{0.709}=89.1(37.8)^{0.709}=89.1(13.1)=1{,}170\ ft^3/s$$
$$Q_{100}=103A^{0.710}=103(37.8)^{0.710}=103(13.2)=1{,}360\ ft^3/s$$
$$Q_{500}=137A^{0.713}=137(37.8)^{0.713}=137(13.3)=1{,}820\ ft^3/s$$

$$D_{10}=1.25A^{0.261}=1.25(37.8)^{0.261}=1.25(2.58)=3.2\ ft$$
$$D_{50}=1.54A^{0.254}=1.54(37.8)^{0.254}=1.54(2.52)=3.9\ ft$$
$$D_{100}=1.64A^{0.254}=1.64(37.8)^{0.254}=1.64(2.52)=4.1\ ft$$
$$D_{500}=1.98A^{0.239}=1.98(37.8)^{0.239}=1.98(2.38)=4.7\ ft$$

If desired, use a graphical solution for Q_{100} and D_{100}:

Q_{100}--Refer to figure 9.

For $A=37.8\ mi^2$.

From figure 9, $Q_{100}=1{,}360\ ft^3/s$.

D_{100}--Refer to figure 10.

For $A=37.8\ mi^2$.

From figure 10, $D_{100}=4.1$ ft.

Procedure 2.--Computation of flood characteristics of streams in mixed-population flood areas (see pages 43 and 44).

1. Compute basin and climatic parameters separately for parts of drainage area lying in Mountain and lower flood regions.

2. Compute flood characteristics for Mountain Region using regression equations in table 2.

3. Compute flood characteristics for lower region using regression equations in tables 1, 3, or 4. If study site is above 6,500 ft in elevation, (8,000 ft in Arkansas River basin), reduce flood discharges by factor obtained from figure 11.

4. From 2 and 3 above, select larger of two flood discharges for each recurrence interval for use as design flood values.

5. As a general rule, select larger depth for each recurrence interval from 2 and 3. At points near the region boundary, an averaging or smoothing process may be required.

Application of this procedure is illustrated in Example 7.

Example 7.--*Mixed-Population Flood Area*

Flood discharges and depths for the 10-, 50-, 100-, and 500-year recurrence-interval floods are required for Troublesome Creek at confluence with Bear Creek in Kittredge (lat 39°38'45", long 105°18'19", SW¼ sec. 35, T. 4 S., R. 71 W.).

Map coverage: Evergreen and Squaw Pass quadrangles, scale = 1:24,000
Denver quadrangle, scale = 1:250,000.

Using figure 2 and the topographic maps, Troublesome Creek lies in the Plains and Mountain Regions. Procedure 2 described above should be used for computing flood characteristics for this site.

The equations for flood discharges and depths for the Plains and Mountain Regions are obtained from tables 1 and 2, respectively.

The equations require that the following basin parameters be computed:

A =drainage area, in square miles,

S_B=basin slope, in feet per mile,

S_S=streambed slope, in feet per mile,

P =mean annual precipitation, in inches, and

R =reduction factor for site elevation from figure 11.

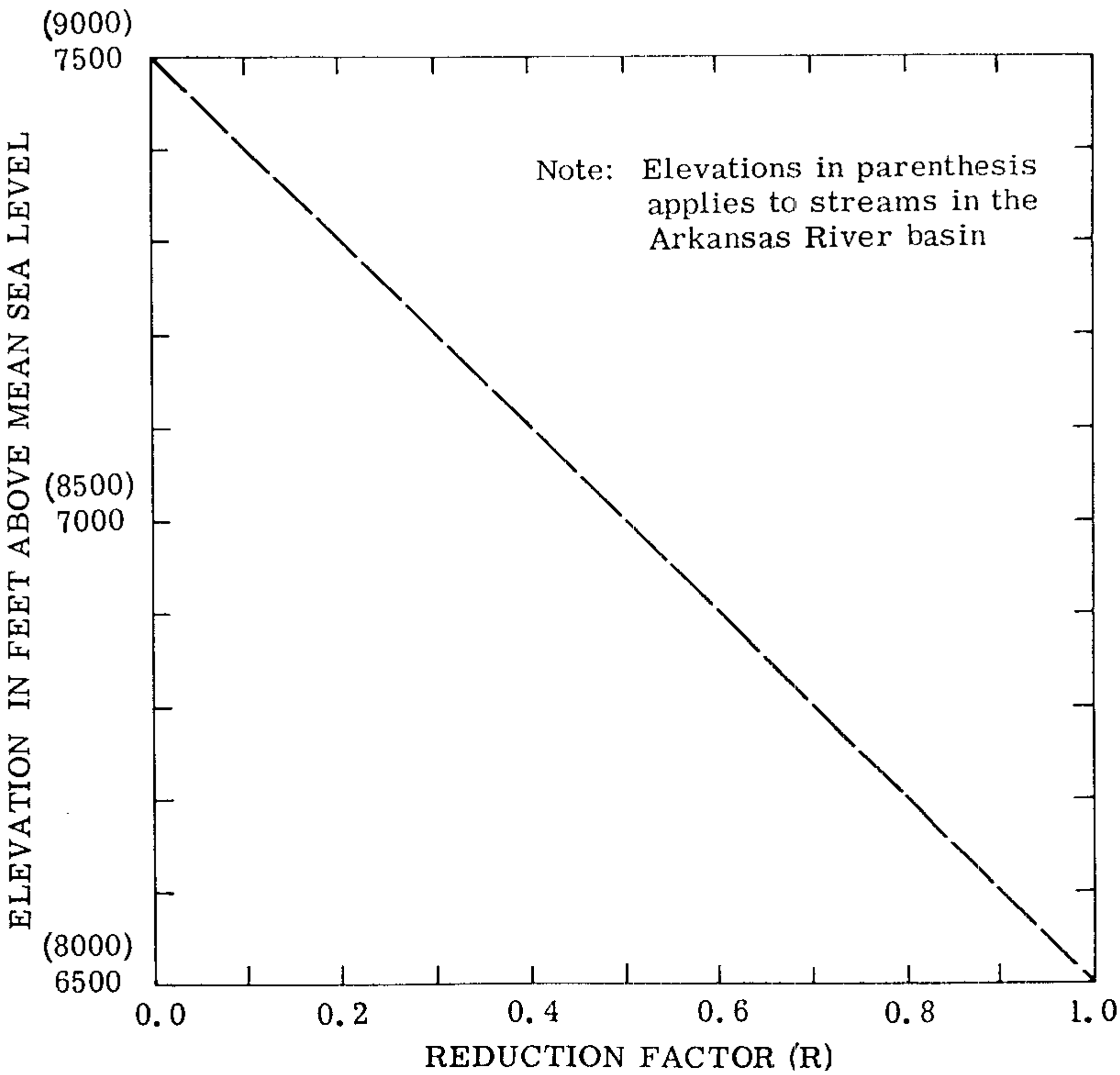


Figure 11.--Regression equation reduction factor above specified elevation for foothill streams.

Using the procedures outlined on pages 5 and 6, the following values for the required parameters were obtained:

Drainage area (A)

$A=9.3\ mi^2$.

Area below 7,500 ft=3.0 mi^2 Plains Region
Area above 7,500 ft=6.3 mi^2 Mountain Region

Basin slope (S_B)

Determine basin slope (S_B) for area between site and 7,500 ft.
Length of main channel (L) from site to 7,500-ft contour=3.4 mi.

0.85 L=0.85(3.4 mi)=2.9 mi
0.10 L=0.10(3.4 mi)=0.3 mi
Elevation at 0.85 L=7,420 ft
Elevation at 0.10 L=6,900 ft

$S_B=(7,420-6,900)/(2.9-0.3)=520/2.6=200$ ft/mi.

Streambed slope (S_S)

Contour upstream from site=6,880 ft
Estimated elevation at confluence=6,850 ft
Distance between points=0.27 mi

$S_S=(6,880-6,850)\div 0.27=30\div 0.27=111$ ft/mi.

Mean annual precipitation (P)

P=19 inches (for that part of basin above 7,500 ft in elevation).

Reduction factor (R)

Site elevation=6,850 ft.
From figure 11, R=0.64.

This factor is applied to the Plains Region discharges.

Compute Q_{10}, Q_{50}, Q_{100}, and Q_{500} for Plains Region for area below 7,500 ft.

$$Q_{10} = 144(A)^{0.528}(S_B)^{0.336} = 144(3)^{0.528}(200)^{0.336} = 144(1.79)(5.93)=1,530\ ft^3/s$$

$$Q_{50} = 891(A)^{0.482}(S_B)^{0.154} = 891(3)^{0.482}(200)^{0.154} = 891(1.70)(2.26)=3,420\ ft^3/s$$

$$Q_{100}=1,770(A)^{0.463}(S_B)^{0.086}=1,770(3)^{0.463}(200)^{0.086} =1,770(1.66)(1.58)=4,640\ ft^3/s$$

$$Q_{500}=5,770(A)^{0.432}=5,770(3)^{0.432}=5,770(1.61)=9,290\ ft^3/s$$

Multiply Plains Region discharges by the reduction factor (R) to obtain the discharges to be used for the Plains Region.

$$Q_{10} = 0.64(1{,}530\ ft^3/s) = 980\ ft^3/s$$
$$Q_{50} = 0.64(3{,}420\ ft^3/s) = 2{,}190\ ft^3/s$$
$$Q_{100} = 0.64(4{,}640\ ft^3/s) = 2{,}970\ ft^3/s$$
$$Q_{500} = 0.64(9{,}290\ ft^3/s) = 5{,}950\ ft^3/s$$

Compute Q_{10}, Q_{50}, Q_{100}, and Q_{500} for the Mountain Region for area above 7,500 ft.

$$Q_{10} = 0.12A^{0.815}P^{1.592} = 0.12(6.3)^{0.815}(19)^{1.592} = 0.12(4.48)(108.59) = 58\ ft^3/s$$
$$Q_{50} = 0.91A^{0.795}P^{1.110} = 0.91(6.3)^{0.795}(19)^{1.110} = 0.91(4.32)(26.27) = 103\ ft^3/s$$
$$Q_{100} = 1.88A^{0.787}P^{0.932} = 1.88(6.3)^{0.787}(19)^{0.932} = 1.88(4.26)(15.55) = 125\ ft^3/s$$
$$Q_{500} = 8.70A^{0.766}P^{0.560} = 8.70(6.3)^{0.766}(19)^{0.560} = 8.70(4.10)(5.20) = 186\ ft^3/s$$

Select the highest discharge for each recurrence interval. In this case the reduced discharges for the Plains Region are used.

Compute the flood depths from depth equations for both regions and use the greatest depth for each recurrence interval.

Flood depths--Plains Region

$$D_{10} = 35.5S_S^{-0.462} = 35.5(111)^{-0.462} = 35.5(0.11) = 3.9\ ft$$
$$D_{50} = 52.1S_S^{-0.500} = 52.1(111)^{-0.500} = 52.1(0.09) = 4.7\ ft$$
$$D_{100} = 59.3S_S^{-0.517} = 59.3(111)^{-0.517} = 59.3(0.09) = 5.3\ ft$$
$$D_{500} = 77.3S_S^{-0.553} = 77.3(111)^{-0.553} = 77.3(0.07) = 5.4\ ft$$

Flood depths--Mountain Region

$$D_{10} = 0.44A^{0.196}P^{0.347} = 0.44(6.3)^{0.196}(19)^{0.347} = 0.44(1.43)(2.78) = 1.8\ ft$$
$$D_{50} = 1.05A^{0.192}P^{0.133} = 1.05(6.3)^{0.192}(19)^{0.133} = 1.05(1.42)(1.48) = 2.2\ ft$$
$$D_{100} = 1.44A^{0.187}P^{0.059} = 1.44(6.3)^{0.187}(19)^{0.059} = 1.44(1.41)(1.19) = 2.4\ ft$$
$$D_{500} = 1.94A^{0.184} = 1.94(6.3)^{0.184} = 1.94(1.40) = 2.7\ ft$$

Use the flood depths computed from the Plains Region relations.

DELINEATION OF FLOOD-PRONE AREAS

The following procedures can be used for outlining flood-prone areas.

Direct field measurement:

1. Compute flood-depth information for selected sites along streams.

2. Visit selected sites and locate points of zero flow in channel near site for base reference points (see fig. 12).

3. Add computed flood depths to points on streambed profile and use surveying techniques to locate points on each side of stream which represent limits of flood plains for the selected recurrence-interval flood.

4. Repeat above steps at enough sites to enable interpolation of flood-plain boundary for study reach.

5. Flood-plain boundary points may be transferred onto topographic map.

Office measurement:

1. Using the methods described in this manual, compute discharges and depths at several locations along each stream. Computations always need to be made just downstream from each major tributary.

2. Plot profile of streambed based upon measurements on topographic map of distance between contour crossings.

3. Plot depths computed in 1 as vertical distances above streambed profile.

4. Draw flood profile using depths from 3.

5. From map study, locate where flood profile intersects land-surface contours and mark locations on map. Some subjective judgment often is required.

6. Draw flood-plain boundary between marked locations, being guided by contour shape. Again, subjective judgment is required in many instances. Accuracy of flood-prone area maps prepared by this method is closely related to the contour interval of the map used. Large errors can result when maps with large contour intervals are used.

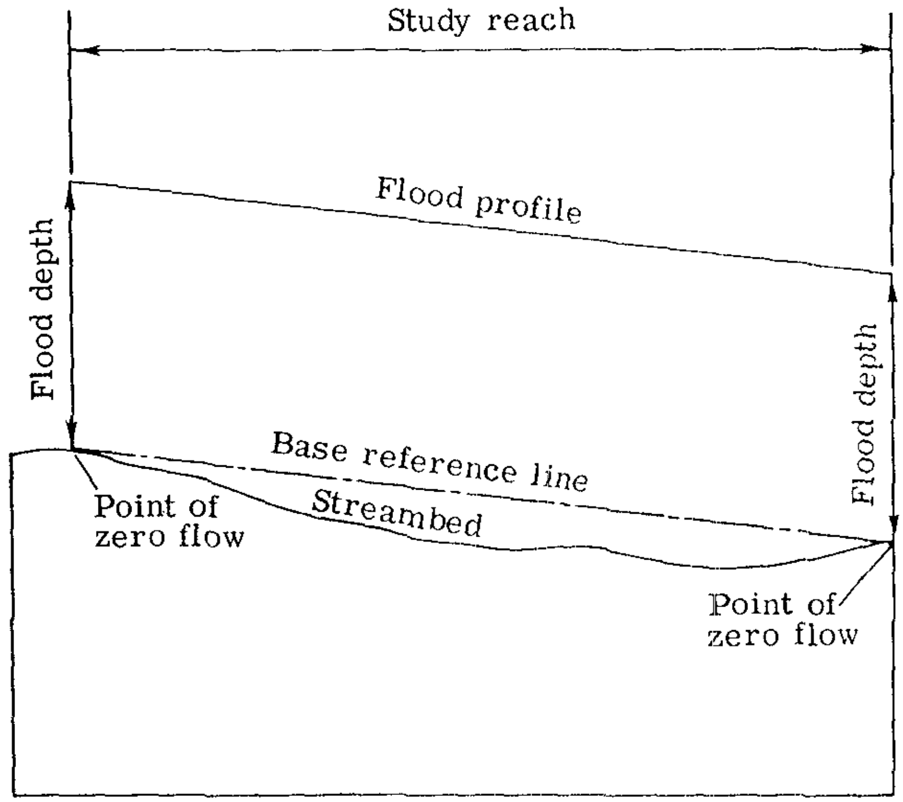


Figure 12.--Hypothetical study reach showing points of zero flow and related flood-depth features.

ACCURACY OF RESULTS

The accuracy of a regression equation is usually expressed as the standard error of estimate. It is a measure of how well the observed data agree with estimates from the regression equations. The standard error of estimate, in percent, is the range of error found at about two-thirds of the sample sites. Stated another way, two out of every three observations for a large sample of data would fall within the specified percentage. The standard error of estimate for each equation is listed in tables 1-4.

Accuracy can also be expressed as equivalent years of record (Hardison, 1971) that represent the number of actual years of streamflow record needed to provide an estimate of equal accuracy as that of the regression estimate. Values of equivalent years of record were computed for each peak discharge regression equation listed in tables 1-4, but the computed values for the Plains Region were extremely large and the values for the Mountain Region and Southern Plateau Region were abnormally small. The U.S. Water Resources Council (1975) recommends that a value of 10 years be assumed for equivalent years of record. For consistency, a value of 10 years was used for equivalent years of records for all peak discharge regression equations in the four flood regions.

ANALYTICAL DEVELOPMENT OF METHODS

The methods described in this manual were developed from a flood-frequency analysis of gaging-station data and a multiple-regression analysis of flood characteristics and basin and climatic parameters of 258 gaged basins in Colorado and adjacent States. These flood data are given in tables 5-8. The length of record at all gaging stations used was at least 10 years, with 99 stations having records equal to or greater than 25 years in length.

Each station record was screened for significant effects of diversion or regulation. Several of the stations which are now regulated have natural-flow parts of record of 10 years or more. These unregulated parts of record were used to develop natural-flow flood-frequency characteristics for the streams. This information, although useful in defining regional flood characteristics, is not applicable for the gaged sites under present-day conditions. A footnote is provided in tables 5-8 for each gaging station in this category.

FLOOD-FREQUENCY RELATIONS

For a stream where gaging-station records are available, a flood-frequency relation can be defined by fitting the array of annual maximum discharges to a theoretical statistical distribution. The U.S. Water Resources Council (1967) recommended a uniform technique for determining flood-flow frequencies by fitting the logarithms of the annual maximum discharges to a log-Pearson Type III distribution. This procedure, generally accepted by most Federal and State agencies, is referred to as a log-Pearson Type III frequency analysis.

Annual peak discharges through September 30, 1973, for each gaging station used in this study were fitted to the log-Pearson Type III distribution. A subjective appraisal of high and low outliers was made based on the reasonableness of the computed flood-frequency curves. High outliers cause frequency curves to estimate extremely large flood discharges, especially for the larger recurrence intervals, through an increased standard deviation and large positive skewness. Low outliers cause large negative skewness but increase the standard deviation of the frequency distribution. To some degree, these characteristics are compensating, but extreme negative skewness can produce flood-frequency relations which estimate little or no increase in discharges with increases in recurrence intervals. The outliers were eliminated, where warranted, and the flood characteristics were recomputed based on the remaining annual peak discharges. The gaging stations where outliers were eliminated are footnoted in tables 5-8.

The computed peak discharges for the 10-, 50-, 100-, and 500-year recurrence-interval floods for each gaging station used in this analysis are listed in tables 5-8.

COMPUTATION OF FLOOD DEPTHS

Depths for the 10-, 50-, 100-, and 500-year floods were computed for 223 gaging stations in Colorado and adjacent States. Some of the stations used in the discharge analysis were not used in the depth analysis because of difficulties in obtaining stage-discharge relations or because of suspected inaccuracies in extending some stage-discharge relations to cover extremely large flood discharges.

The most recent stage-discharge relation for each station (usually through September 30, 1973) was used as the base relation, with previous relations being used where applicable to extend the base relation both upward and downward. Many of the relations required long extensions in order to cover the range in discharge. Straight-line extensions on log-log graph paper were made except where other information, such as bankfull stage, indicated curvature.

The depth computations consisted of picking a stage for the 10-, 50-, 100-, and 500-year discharges from the stage-discharge relation. Next, the stage of the point of zero flow was obtained from the relation and subtracted from the stage of the flood discharge. Selection of the point of zero flow is illustrated in figure 12. The computed depths for the 100-year flood are listed in tables 5-8.

REGRESSION ANALYSIS

Standard multiple regression techniques were used to develop equations by relating flood characteristics at gaged sites to basin and climatic parameters. Initial regression equations were obtained for each flood characteristic using all four basin variables and then redefining the relations by successively eliminating the least significant basin or climatic parameter until only one parameter remained. The final regression equations are based on basin and climatic parameters for which all coefficients were significant at the 5 percent level.

The first regression trial was made using gaging-station records for all natural-flow streams in Colorado and selected streams in adjoining States. The accuracy of the results was extremely poor and no significant trends could be identified from plots of residuals from the regression equations. The poor result was attributed to the extremely varied topography of the State and the several sources and forms of precipitation which produce floods. Additional regression runs were made using numerous combinations of areas to obtain reasonable regional subdivisions.

The final regression results indicate that the flood characteristics of natural-flow streams in Colorado can best be defined by dividing the State into four regions. The regions as shown in figure 2 are Plains, Mountain, Northern Plateau, and Southern Plateau. A brief description of each region is given in the following paragraphs and the flood-characteristic equations for each region are listed in tables 1-4. The equations for the 100-year flood discharges and depths can be solved graphically by using figures 3-10.

Plains Region

The Plains Region, comprising almost one-half of the total area of Colorado. consists of the eastern foothills of the Rocky Mountains and the adjoining High Plains to the east (fig. 2). The western edge of the region corresponds to the approximate upper limit of floods resulting from widespread, high-intensity rainfall. In the South Platte River basin, the boundary corresponds to a line drawn along an elevation of 7,500 ft. The boundary in the Arkansas River basin corresponds to an elevation of 9,000 ft. The transition between the two elevations was made along the Rampart Range west of Palmer Ridge which forms the boundary between the two river basins. The western boundary was based on an interpretation of flood-discharge data for gaging stations in the foothill areas of both basins.

The flood-producing rainfalls occur from April through September each year during which period about two-thirds of the mean annual precipitation falls. Because of the absence of snow accumulation, snowmelt floods do not occur on streams which originate in the Plains Region. Streams in general are ephemeral but respond quickly to intense rainfall resulting in short-duration, small-volume floods.

Records for 83 gaging stations were initially used in the regression for Plains streams. Preliminary results indicated that most gaging stations in northeast Colorado and areas to the north and east plotted highly negative on the regression relations. This area, commonly referred to as the Sand Hills, is characterized by numerous permeable closed depressions and discontinuous stream channels. The major difficulty appears to be the inability to accurately define the contributing drainage area of basins within the area. Because of this problem, the gaging stations in the Sand Hills area were eliminated from later regression trials. The final regression equations for the Plains Region are applicable to the contributing parts of drainage basins within the Sand Hills area.

The equations relating flood characteristics to basin parameters and the standard error of estimate for each equation are listed in table 1. The equations for the 100-year flood discharge and depth are depicted graphically in figures 3 and 4, respectively.

Mountain Region

The Mountain Region comprises all areas in Colorado in which flooding is predominantly caused by spring snowmelt runoff (fig. 2). The eastern boundary coincides with the western boundary of the Plains Region. The western boundary north of the Gunnison River corresponds to an elevation of 7,500 ft. South of the Gunnison River, the boundary follows the divide between the Little Cimarron River and Big Blue Creek to the Continental Divide at Wetterhorn Peak. Southward, the boundary follows the Continental Divide to the Rio Grande; then it follows the Rio Grande to the Colorado-New Mexico border. The region includes both the steep mountain terrain and the high, relatively level, mountain park areas within its boundaries.

The principal form of precipitation during the winter is snow derived from moisture moving eastward from the Pacific Ocean. The orographic effect of the high mountains generally produces more snowfall on the western slopes. Separate regressions were attempted for eastern and western mountain streams but the two areas were combined because results did not warrant the division. Infrequently, severe floods are caused by rainfall during optimum conditions of snowpack depth and rate of temperature rise. During the summer rainfall occurs throughout the region but, because of the elevation, the moisture supply is insufficient to produce significant floods.

The regression equations relating flood characteristics to basin parameters for the Mountain Region are listed in table 2 with the standard error of estimate for each equation. The equations for the 100-year flood discharge and depth are depicted graphically in figures 5 and 6, respectively.

Northern Plateau Region

The Northern Plateau Region comprises the area of northwestern Colorado within the White River and Yampa River basins below an elevation of 7,500 ft (fig. 2). Much of the area is dissected by virtually parallel streams with narrow uncut plateaus between. The annual precipitation ranges from about 10 inches at lower elevations to about 20 inches at an elevation of 7,500 ft, of which approximately 60 percent occurs as snowfall from October through April. Summer thunderstorms produce high-intensity rainfall in the region, but are usually limited in areal extent. Floods are primarily caused by snowmelt runoff from April through June.

Records for 21 gaging stations were used to derive the regression equations for the Northern Plateau Region. Most of the gaging stations are located at higher elevations along the eastern and southern edge of the region or on larger streams at lower elevations. The smaller drainage basins at lower elevations have not been adequately measured to provide reliable estimates of flood characteristics; thus, the applicability of the regression equations to these sites is untested and unknown. Supplemental flood information, where available, needs to be used for deriving flood characteristics for these streams.

The regression equations relating flood characteristics to basin parameters for the Northern Plateau Region are listed in table 3 with the standard error of estimate for each equation. The equations for the 100-year flood discharge and depth are depicted graphically in figures 7 and 8, respectively.

Southern Plateau Region

The Southern Plateau Region comprises the southwestern part of Colorado west of the Mountain Region (fig. 2). North of the Gunnison River the boundary coincides with a line along an elevation of 7,500 ft, including the mainstem tributaries of the Colorado River westward to the Utah State line. The boundary south of the Gunnison River follows drainage divides to the Rio Grande, then it follows the Rio Grande to the State line. The part of the region south of the Gunnison River includes both the Plateau section of extreme western Colorado and the high, rugged terrain of the San Juan Mountains.

Annual precipitation ranges from 8 inches in some areas along the western border to 50 inches in the San Juan Mountains. High-intensity rainfall occurs during the summer months with infrequent rain storms during September and October producing large floods on streams in the highest parts of the region. Most annual floods result from snowmelt runoff during the spring months, but these floods are usually much smaller than the infrequent floods during September and October.

The regression equations relating flood characteristics to basin parameters for the Southern Plateau Region are listed in table 4 with the corresponding standard error of estimate for each equation. The equations for the 100-year flood discharge and depth are depicted graphically in figures 9 and 10, respectively.

Mixed-Population Flood Areas

Many streams in Colorado originate in high mountain areas and flow out of the mountains to much flatter plain or plateau areas. Floods on these streams at higher elevations are caused by snowmelt runoff but at lower elevations, floods can result from snowmelt, rainfall, or a combination of rain on snow. Reaches of streams that receive annual maximum floods from both phenomena are herein referred to as foothill streams and the part of a drainage basin affected is called a mixed-population flood area. The existence of the problem of mixed-population floods in Colorado was implied by Jenkins (1960, p. 6).

During the early phases of this study it was noted that the flood records for foothill streams did not adequately fit the log-Pearson Type III statistical distribution. In general, flood-frequency relations for gaging stations on foothill streams exhibit large positive skewness; that is, the relations are concave upward in shape. Another characteristic feature of these relations is that several of the highest floods, which usually occur during summer months, plot extremely high in spite of the large positive skewness of the relations. This lack of a satisfactory fit of the higher floods results in low estimates for the larger recurrence-interval floods. These features were noted for flood records of gaging stations throughout Colorado but were more pronounced for streams along the eastern foothills of the Rocky Mountains. This report contains the assumption that mixed-population flood areas form the transition zone between the Mountain Region and each of the other three flood regions, except for that part of the Southern Plateau Region south of the Gunnison River. Flood records for this part of the State did not provide sufficient evidence to define separate flood regions for snowmelt and rainfall floods.

The gaging-station records for foothill streams were separated from other records and an investigation was started to separate the flood-frequency relations into snowmelt and rainfall components. Flood records for several gaging stations along the Front Range provided useful and interesting information but a satisfactory procedure for computing flood discharges of foothill streams could not be derived in the limited time available for this study. An interim procedure discussed in the following paragraphs was developed based on preliminary results of the foothill streams investigation and a review of literature relating to rainfall-produced floods in Colorado and Utah.

The primary consideration in developing an interim procedure for foothill streams was to establish a transition zone between the rainfall flood zone (lower region) and the snowmelt flood zone (Mountain Region). Because of the lack of homogeneous flood-frequency data on small streams in the foothill areas, an arbitrary division was required. The principal sources of information utilized in establishing the transition zone were: 1. Published reports by Woolley (1946), Follansbee and Sawyer (1948), Matthai (1969), Farmer and Fletcher (1971), Butler and Marsell (1972), and Snipes and others (1974); 2. Streamflow data collected by various State and Federal agencies; and 3. Field observations and measurements of stream channel characteristics.

Based on information from the above-listed sources, several methods were tested for technical soundness and simplicity of application. The method selected for use is based on the assumption that areal extent and intensity of floods resulting from thunderstorms decrease as elevation increases in the foothill areas of Colorado. This assumption is supported by information contained in the references and, to some degree, by field observations of channel characteristics. This reduction is depicted in figure 11 as a reduction factor versus elevation graph. The reduction factor is selected based on elevation of the study site and is applied to the peak discharge regression equations for the lower flood regions. Although highly subjective, the method does provide a smooth transition between the lower and upper flood regions. It is also easy to apply and provides seemingly realistic peak discharges from rainfall at higher elevations. Strict interpretation of figure 11 indicates that floods produced by thunderstorms do not occur in the Mountain Region. The assumption used herein was that thunderstorms can occur at high elevations but, owing to the small areal coverage and reduced intensities, the resulting floods are smaller than snowmelt floods. This assumption needs to be checked when studying small areas at high elevations. The interim procedure is described in the section entitled "Application of Methods."

SELECTED REFERENCES

Butler, Elmer, and Marsell, R. E., 1972, Developing a state water plan--Cloudburst floods in Utah, 1939-69: Utah Dept. Nat. Resources, Water Resources Div., Coop. Inv. Rept. 11, 103 p.

Dalrymple, Tate, 1960, Flood-frequency analyses: U.S. Geol. Survey Water-Supply Paper 1543-A, 80 p.

Farmer, E. E., and Fletcher, J. E., 1971, Precipitation characteristics of summer storms at high-elevation stations in Utah: U.S. Dept. Agriculture, Forest Serv., Intermountain Forest and Range Expt. Sta. Research Paper INT-110, 24 p.

Fenneman, N. M., 1931, Physiography of Western United States: New York, McGraw-Hill Book Co., Inc., 534 p.

Follansbee, Robert, and Sawyer, L. R., 1948, Floods in Colorado: U.S. Geol. Survey Water-Supply Paper 997, 151 p.

Hardison, C. H., 1971, Prediction error of regression estimates of streamflow characteristics at ungaged sites, *in* Geological Survey Research 1971: U.S. Geol. Survey Prof. Paper 750-C, p. C228-C236.

Jenkins, Clifford T., 1960, Preliminary report on frequency and extent of flood inundation on Boulder Creek at Boulder, Colo.: U.S. Geol. Survey open-file report, 28 p.

Matthai, H. F., 1968, Magnitude and frequency of floods in the United States, Part 6-B, Missouri River basin below Sioux City, Iowa: U.S. Geol. Survey Water-Supply Paper 1680, 491 p.

_____1969, Floods of June 1965 in South Platte River basin, Colorado: U.S. Geol. Survey Water-Supply Paper 1850-B, 64 p.

Patterson, J. L., 1964, Magnitude and frequency of floods in the United States, Part 7, Lower Mississippi River basin: U.S. Geol. Survey Water-Supply Paper 1681, 636 p.

_____1965, Magnitude and frequency of floods in the United States, Part 8, Western Gulf of Mexico basins: U.S. Geol. Survey Water-Supply Paper 1682, 506 p.

Patterson, J. L., and Somers, W. P., 1966, Magnitude and frequency of floods in the United States, Part 9, Colorado River basin: U.S. Geol. Survey Water-Supply Paper 1683, 475 p.

Sauer, V. B., 1974, Flood characteristics of Oklahoma streams: U.S. Geol. Survey Water Resources Inv. 52-73.

Snipes, R. J., and others, 1974, Floods of June 1965 in Arkansas River basin, Colorado, Kansas, and New Mexico: U.S. Geol. Survey Water-Supply Paper 1850-D, 97 p.

Thomas, D. M., and Benson, M. A., 1970, Generalization of streamflow characteristics from drainage-basin characteristics: U.S. Geol. Survey Water-Supply Paper 1975, 55 p.

U.S. Geol. Survey, 1954, Compilation of records of surface waters of the United States through September 1950--Part 9, Colorado River basin: U.S. Geol. Survey Water-Supply Paper 1313, 749 p. [1955.]

_____1955, Compilation of records of surface waters of the United States through September 1950--Part 7, Lower Mississippi River basin: U.S. Geol. Survey Water-Supply Paper 1311, 606 p.

_____1958, Compilation of records of surface waters of the United States through September 1950--Part 6-B, Missouri River basin below Sioux City, Iowa: U.S. Geol. Survey Water-Supply Paper 1310, 619 p.

_____1960, Compilation of records of surface waters of the United States through September 1950--Part 8, Western Gulf of Mexico basins: U.S. Geol. Survey Water-Supply Paper 1312, 633 p.

_____1964, Compilation of records of surface waters of the United States, October 1950 to September 1960--Part 6-B, Missouri River basin below Sioux City, Iowa: U.S. Geol. Survey Water-Supply Paper 1730, 514 p.

_____1964, Compilation of records of surface waters of the United States, October 1950 to September 1960--Part 7, Lower Mississippi River basin: U.S. Geol. Survey Water-Supply Paper 1731, 552 p.

_____1964, Compilation of records of surface waters of the United States, October 1950 to September 1960--Part 8, Western Gulf of Mexico basins: U.S. Geol. Survey Water-Supply Paper 1732, 574 p.

_____1964, Compilation of records of surface waters of the United States, October 1950 to September 1960--Part 9, Colorado River basin: U.S. Geol. Survey Water-Supply Paper 1733, 586 p.

_____1969, Surface water supply of the United States, 1961-65--Part 6, Missouri River basin--Volume 3, Missouri River basin from Sioux City, Iowa, to Nebraska City, Nebraska: U.S. Geo. Survey Water-Supply Paper 1918, 751 p.

_____1969, Surface water supply of the United States, 1961-65--Part 6, Missouri River basin--Volume 4, Missouri River basin below Nebraska City, Nebraska: U.S. Geol. Survey Water-Supply Paper 1919, 805 p.

_____1969, Surface water supply of the United States, 1961-65--Part 7, Lower Mississippi River basin--Volume 2, Arkansas River basin: U.S. Geol. Survey Water-Supply Paper 1921, 878 p.

_____1970, Surface water supply of the United States, 1961-65--Part 8, Western Gulf of Mexico basins--Volume 2, Basins from Lavaca River to Rio Grande: U.S. Geol. Survey Water-Supply Paper 1923, 786 p.

_____1970, Surface water supply of the United States, 1961-65--Part 9, Colorado River basin--Volume 1, Colorado River basin above Green River: U.S. Geol. Survey Water-Supply Paper 1924, 488 p.

_____1970, Surface water supply of the United States, 1961-65--Part 9, Colorado River basin--Volume 2, Colorado River basin from Green River to Compact Point: U.S. Geol. Survey Water-Supply Paper 1925, 618 p.

U.S. Water Resources Council, 1967, A uniform technique for determining flood flow frequencies: Washington, D.C., U.S. Water Resources Council Bull. 15, 5 p.

_____1975, A uniform technique for determining flood flow frequencies: Washington, D.C., U.S. Water Resources Council Bull. [In press.]

U.S. Weather Bureau, 1967, Normal annual precipitation, normal May-September precipitation 1931-1960, Colorado: U.S. Weather Bur. map. (Available from Colorado Water Conserv. Board.)

Wooley, R. R., 1946, Cloudburst floods in Utah, 1850-1938: U.S. Geol. Survey Water-Supply Paper 994, 128 p. [1947.]

Table 5.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Plains Region*

[Flood discharges for each gaging station are: (first line) values used in multiple regression analysis, (second line) weighted averages. Numbers below station name are latitude and longitude in degrees, minutes, and seconds]

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
SOUTH PLATTE RIVER BASIN												
06712000	CHERRY CREEK NEAR FRANKTOWN, COLO. LAT 39 21 21 LONG 104 45 46	34	169	6150	32	26	16	4530 5070	11700 13100	16300 18400	31000 36000	10.7
06712500	CHERRY CREEK NEAR MELVIN, COLO. LAT 39 35 42 LONG 104 48 44	x29	336	5626	34	17	16	11800 11400	29700 28600	41100 39600	78700 76800	13.2
06821500	ARIKAREE RIVER AT HAIGLER, NEBR. LAT 40 01 45 LONG 101 58 10	42	980	3251	18	9	16	13500 13700	30700 32200	40000 42900	66100 75100	22.4
06825000	SOUTH FORK REPUBLICAN RIVER NEAR IDALIA, COLO. LAT 39 26 59 LONG 102 14 32	22	1300	3690	19	19	16	21000 19800	41900 42700	51100 54800	72100 89500	8.4
06858500	NORTH FORK SMOKY HILL RIVER NEAR MCALLASTER, KANS. LAT 39 01 01 LONG 101 20 51	+18	650	3070	12	13	18	6790 7990	34400 32700	64800 57400	257000 199000	-
06858700	NORTH FORK SMOKY HILL RIVER TRIBUTARY NEAR WINONA, KANS. LAT 39 01 51 LONG 101 17 07	12	1.1	3260	82	56	18	985 844	1840 1850	2330 2520	3770 4820	-
06859500	LADDER CREEK BELOW CHALK CREEK, NEAR SCOTT CITY, KANS. LAT 38 47 20 LONG 100 52 10	x24	1460	2640	11	8	18	7760 9920	37000 38800	66300 65500	228000 200000	19.3
06860000	SMOKY HILL RIVER AT ELKADER, KANS. LAT 38 47 33 LONG 100 51 19	35	3555	2625	14	14	17	18600 20300	57500 60000	83900 87000	175000 180000	12.6
06860300	SOUTH BRANCH HACKBERRY CREEK NEAR ORION, KANSAS LAT 38 56 31 LONG 100 42 10	11	49.6	2850	15	14	19	2380 2590	8100 8470	12900 13200	34400 32900	-
06860500	HACKBERRY CREEK NEAR GOVE, KANS. LAT 38 57 15 LONG 100 29 05	+18	426	2593	12	16	19	7480 7710	29500 27600	48200 43900	131000 112000	-
06871000	NORTH FORK SOLOMON RIVER AT GLADE, KANS. LAT 39 40 41 LONG 99 18 30	21	849	1754	9	10	21	11200 11000	21400 24900	26200 33400	38000 60000	-
06871500	BOW CREEK NEAR STOCKTON, KANS. LAT 39 33 44 LONG 99 17 04	23	337	1802	9	9	21	5740 5970	19400 19800	31200 31300	88500 83300	-
06871800	NORTH FORK SOLOMON RIVER AT KIRWIN, KANS. LAT 39 39 34 LONG 99 06 55	•25	1367	1660	9	9	21	14200 14000	34500 36200	47700 51400	94400 105000	24.5
06872100	MIDDLE CREEK AT KENSINGTON, KANS. LAT 39 45 21 LONG 99 02 04	17	58.9	1760	18	17	24	3650 3510	12900 11800	20800 18600	58600 49300	-

Table 5.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Plains Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
ARKANSAS RIVER BASIN												
07106000	FOUNTAIN CREEK NEAR FOUNTAIN, COLO. LAT 38 36 08 LONG 104 40 13	15	676	5342	86	20	17	13900 16400	24000 30800	29200 38700	43100 54400	8.2
07106500	FOUNTAIN CREEK AT PUEBLO, COLO. LAT 38 18 27 LONG 104 36 09	+30	920	4725	51	25	15	21700 21200	49100 47800	66800 64700	128000 124000	12.3
07108500	ST. CHARLES RIVER NEAR PUEBLO, COLO. LAT 38 12 39 LONG 104 31 57	13	468	4690	117	22	18	15500 16700	26700 30700	32700 38500	50000 64000	8.3
07106800	ST. CHARLES RIVER NEAR VINELAND, COLO. LAT 38 13 37 LONG 104 29 54	22	476	4619	106	14	18	23100 21500	46100 42800	58100 54300	91000 88400	17.7
07119500	APISHAPA RIVER NEAR FOWLER, COLO. LAT 38 05 28 LONG 103 58 52	+38	1125	4318	36	12	15	16500 17100	39100 40500	54000 55700	107000 110000	19.[illegible]
07121000	TIMPAS CREEK NEAR ROCKY FORD, COLO. LAT 37 57 10 LONG 103 43 26	14	451	4220	31	10	12	16200 14200	33900 31800	43900 42400	73700 76700	20.6
07121500	TIMPAS CREEK AT MOUTH, NEAR SWINK, COLO. LAT 38 00 10 LONG 103 39 18	24	496	4113	28	9	12	15200 14200	34200 32900	45000 44000	76700 78900	20.0
07124500	PURGATOIRE RIVER AT TRINIDAD, COLO. LAT 37 10 15 LONG 104 30 31	+61	795	5977	80	27	19	19600 19800	36200 37300	44900 46600	59100 73900	13.2
07125000	PURGATOIRE RIVER NEAR HOEHNE, COLO. LAT 37 14 54 LONG 104 24 11	14	857	5705	60	19	18	21600 21000	48000 46100	63600 61000	112000 110000	13.9
07125100	FRIJOLE CREEK NEAR ALFALFA, COLO. LAT 37 12 00 LONG 104 11 37	12	80.0	5400	90	23	15	6370 6480	17400 16200	25700 23000	50100 50200	15.7
07125500	SAN FRANCISCO CREEK NEAR ALFALFA, COLO. LAT 37 10 06 LONG 104 08 40	14	160	5320	160	23	17	10900 11200	23600 23100	31000 30000	53700 52900	14.6
07126000	PURGATOIRE RIVER NEAR ALFALFA, COLO. LAT 37 11 18 LONG 104 07 56	22	1320	5280	45	28	18	24700 24200	54500 53400	73400 71800	138000 135000	-
07126500	PURGATOIRE RIVER AT NINEMILE DAM, NEAR HIGBEE, COLO. LAT 37 44 06 LONG 103 29 45	47	2900	4241	26	11	16	35600 34400	80000 78000	108000 106000	204000 200000	17.6
07128000	PURGATOIRE RIVER AT HIGHLAND DAM, NEAR LAS ANIMAS, COLO. LAT 37 53 57 LONG 103 18 11	24	3376	3980	19	8	15	38600 35600	89000 83500	122000 115000	243000 228000	21.0

Table 5.--Selected basin and climatic parameters and flood characteristics for gaging stations in the Plains Region--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
ARKANSAS RIVER BASIN - CONTINUED												
07128500	PURGATOIRE RIVER NEAR LAS ANIMAS, COLO. LAT 38 02 02 LONG 103 12 00	35	3503	3875	19	9	15	36500 34800	78700 77100	105000 104000	190000 191000	18.5
07129500	RULE CREEK NEAR CADDOA, COLO. LAT 37 59 58 LONG 103 04 34	10	435	3890	20	5	13	8650 9200	23300 24900	33500 35800	71200 75400	21.8
07153500	DRY CIMARRON RIVER NEAR GUY, N. MEX. LAT 36 59 15 LONG 103 25 25	32	545	4900	99	11	20	10700 12600	29800 31700	44000 45100	102000 98600	-
07154400	CARRIZOZO CREEK NEAR KENTON, OKLA. LAT 36 52 55 LONG 103 01 05	+17	111	4380	4	17	16	10500 7630	23500 18800	31300 26200	56200 51700	-
07154500	CIMARRON RIVER NEAR KENTON, OKLA. LAT 36 55 36 LONG 102 57 31	21	1038	4267	26	10	16	22000 20300	47200 45500	62900 61400	116000 116000	-
07155000	CIMARRON RIVER ABOVE UTE CREEK, NEAR BOISE CITY, OKLA. LAT 36 54 46 LONG 102 37 08	14	1879	3933	21	12	16	31700 27400	75600 66600	105000 92700	208000 184000	-
07199000	CANADIAN RIVER NEAR HEBRON, N. MEX. LAT 36 47 14 LONG 104 27 42	27	229	6248	54	25	18	10800 10500	33000 30200	51500 45900	137000 116000	-
07201000	RATON CREEK, AT RATON, N. MEX. LAT 36 54 LONG 104 26	19	14.4	6640	143	105	18	1830 2280	5140 5750	7470 8110	16300 17000	-

X ONE OR MORE HIGH OUTLIERS ELIMINATED.
\+ ONE OR MORE LOW OUTLIERS ELIMINATED.
* UNREGULATED PERIOD OF RECORD.

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*

[Flood discharges for each gaging station are: (first line) values used in multiple regression analysis, (second line) weighted averages. Numbers below station name are latitude and longitude in degrees, minutes, and seconds]

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
SOUTH PLATTE RIVER BASIN												
06616000	NORTH FORK MICHIGAN RIVER NEAR GOULD, COLO. LAT 40 33 10 LONG 106 00 36	•21	21.2	8793	140	74	26	267 266	308 319	322 339	350 380	3.1
06617100	MICHIGAN RIVER AT WALDEN, COLO. LAT 40 44 28 LONG 106 16 44	•24	185	8045	-	17	18	855 854	1130 1170	1240 1300	1490 1610	4.1
06618500	ILLINOIS CREEK AT WALDEN, COLO. LAT 40 43 35 LONG 106 17 24	•24	259	8039	18	8	19	1150 1150	2350 2300	3070 2970	5450 5160	6.9
06620400	DOUGLAS CREEK ABOVE KEYSTONE, WYO. LAT 41 11 00 LONG 106 16 10	10	22.1	9300	67	211	30	804 730	1050 902	1170 993	1460 1240	5.8
06621000	DOUGLAS CREEK NEAR FOXPARK, WYO. LAT 41 04 52 LONG 106 18 25	26	120	8200	77	53	27	1470 1450	1750 1730	1840 1830	1990 2010	4.1
06622000	BIG CREEK AT BIG CREEK RANGER STATION, WYO LAT 41 03 00 LONG 106 31 30	*12	106	7770	-	45	23	1200 1140	1480 1420	1590 1540	1790 1790	-
06622500	FRENCH CREEK NEAR FRENCH, WYO. LAT 41 12 30 LONG 106 31 30	X14	59.6	7500	158	106	24	1560 1440	1900 1690	2020 1790	2260 2040	3.0
06622700	NORTH BRUSH CREEK NEAR SARATOGA, WYO. LAT 41 22 10 LONG 106 31 22	13	37.4	8020	-	70	20	932 848	1210 1050	1340 1160	1640 1450	4.3
06706000	NORTH FORK SOUTH PLATTE RIVER BELOW GENEVA CREEK, AT GRANT, COLO. LAT 39 27 26 LONG 105 39 29	•X30	127	8561	220	69	26	757 778	1040 1100	1170 1240	1470 1550	2.6
06716500	CLEAR CREEK NEAR LAWSON, COLO. LAT 39 45 57 LONG 105 37 32	•25	145	8080	170	327	26	1750 1710	2280 2220	2490 2420	2950 2890	6.2
06722500	SOUTH ST. VRAIN CREEK NEAR WARD, COLO. LAT 40 05 27 LONG 105 30 50	•23	14.4	9372	220	232	33	351 345	453 442	498 484	610 592	2.3
06725500	MIDDLE BOULDER CREEK AT NEDERLAND, COLO. LAT 39 57 42 LONG 105 30 14	28	36.2	8186	240	100	27	713 695	894 864	967 934	1130 1100	4.9
06729000	SOUTH BOULDER CREEK NEAR ROLLINSVILLE, COLO. LAT 39 54 53 LONG 105 30 05	•12	42.7	8380	-	69	24	624 594	796 756	872 831	1060 1030	2.3
06732000	GLACIER CREEK NEAR ESTES PARK, COLO. LAT 40 20 41 LONG 105 35 00	•17	24.2	7980	350	32	30	340 342	406 422	431 452	486 518	3.2

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
SOUTH PLATTE RIVER BASIN - CONTINUED												
06748200	FALL CREEK NEAR RUSTIC, COLO. LAT 40 33 05 LONG 105 37 35	13	3.6	9765	-	69	28	91 82	131 119	151 136	204 181	3.1
06748510	LITTLE BEAVER CREEK NEAR IDYLWILDE, COLO. LAT 40 38 19 LONG 105 39 40	+11	0.9	10000	-	586	25	24 21	31 30	34 34	41 44	2.1
06748530	LITTLE BEAVER CREEK NEAR RUSTIC, COLO. LAT 40 37 23 LONG 105 33 52	13	12.3	8350	-	232	23	145 141	205 210	231 240	292 315	2.0
06748600	SOUTH FORK CACHE LA POUDRE RIVER NEAR RUSTIC, COLO. LAT 40 38 49 LONG 105 29 35	17	90.3	7597	220	74	24	924 857	1400 1290	1630 1490	2250 2020	4.5
ARKANSAS RIVER BASIN												
07079500	EAST FORK ARKANSAS RIVER NEAR LEADVILLE, COLO. LAT 39 15 35 LONG 106 20 24	+12	50.0	9700	-	63	26	697 617	962 870	1080 976	1380 1240	2.9
07081000	TENNESSEE CREEK NEAR LEADVILLE, COLO. LAT 39 15 51 LONG 106 20 25	15	48.0	9760	-	75	27	476 499	546 634	566 681	601 788	2.5
07083000	HALFMOON CREEK NEAR MALTA, COLO. LAT 39 10 20 LONG 106 23 19	27	23.6	9830	300	89	25	392 358	463 446	487 478	532 549	2.6
07086500	CLEAR CREEK ABOVE CLEAR CREEK RESERVOIR, COLO. LAT 39 01 05 LONG 106 16 38	28	67.1	8885	160	48	25	979 885	1300 1200	1440 1330	1760 1650	3.4
07089000	COTTONWOOD CREEK BELOW HOT SPRINGS, NEAR BUENA VISTA, COLO. LAT 38 48 46 LONG 106 13 18	35	65.0	8532	240	296	26	551 572	790 822	904 936	1210 1230	3.3
07095000	GRAPE CREEK NEAR WESTCLIFFE, COLO. LAT 38 11 10 LONG 105 28 59	46	320	7690	52	29	20	1410 1440	3490 3310	4900 4540	9990 8900	6.8
07114000	CUCHARAS RIVER AT BOYD RANCH, NEAR LA VETA, COLO. LAT 37 25 12 LONG 105 03 08	38	56.0	7781	230	111	26	365 408	587 638	681 733	896 955	3.7
RIO GRANDE RIVER BASIN												
08224500	KERBER CREEK AT ASHLEY RANCH, NEAR VILLA GROVE, COLO. LAT 38 14 28 LONG 106 06 57	41	38.0	8900	220	96	28	225 273	382 437	461 515	677 723	1.5

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
	GRANDE RIVER BASIN - CONTINUED											
27500	NORTH CRESTONE CREEK NEAR CRESTONE, COLO. LAT 38 00 49 LONG 105 41 32	38	10.7	8360	600	352	24	239 216	523 457	711 612	1390 1170	3.2
230500	CARNERO CREEK NEAR LA GARITA, COLO. LAT 37 51 35 LONG 106 19 08	50	117	8150	150	66	22	550 591	1140 1160	1460 1450	2420 2330	4.7
3231000	LA GARITA CREEK NEAR LA GARITA, COLO. LAT 37 48 48 LONG 106 19 04	53	61.0	8030	160	66	23	412 427	633 656	725 751	935 973	2.3
08240500	TRINCHERA CREEK ABOVE TURNERS RANCH, NEAR FORT GARLAND, COLO. LAT 37 22 29 LONG 105 17 40	51	45.0	8520	320	66	23	324 335	594 597	736 730	1140 1110	3.7
08241000	TRINCHERA CREEK ABOVE MOUNTAIN HOME RESERVOIR, NEAR FORT GARLAND, COLO. LAT 37 23 41 LONG 105 22 07	32	61.0	8150	210	56	21	315 344	522 565	614 662	832 900	3.0
08241500	SANGRE DE CRISTO CREEK NEAR FORT GARLAND, COLO. LAT 37 25 30 LONG 105 24 52	51	190	7900	76	29	14	602 598	1270 1240	1660 1610	2880 2760	11.1
08242500	UTE CREEK NEAR FORT GARLAND, COLO. LAT 37 26 50 LONG 105 25 30	*50	32.0	8045	230	81	20	282 275	416 413	478 477	637 641	3.7
08252500	COSTILLA CREEK ABOVE COSTILLA DAM, N. MEX. LAT 36 53 52 LONG 105 15 16	*22	25.1	9429	227	96	26	192 225	320 357	380 416	534 566	-
08253000	CASIAS CREEK NEAR COSTILLA, N. MEX. LAT 36 53 48 LONG 105 15 35	*35	16.6	9404	461	100	25	133 148	190 215	213 242	264 306	-
08253500	SANTISTEVAN CREEK NEAR COSTILLA, N. MEX. LAT 36 53 03 LONG 105 16 50	36	2.1	9487	862	422	25	16 21	22 30	24 34	29 43	-
08263000	LATIR CREEK NEAR CERRO, N. MEX. LAT 36 49 45 LONG 105 32 50	32	10.5	8280	704	384	25	100 109	161 173	191 203	271 283	-
08264000	RED RIVER NEAR RED RIVER, N. MEX. LAT 36 37 20 LONG 105 23 20	24	19.1	9394	477	211	27	206 220	297 318	335 358	426 456	-
08267500	RIO HONDO NEAR VALDEZ, N. MEX. LAT 36 32 30 LONG 105 33 21	38	36.2	7650	336	176	25	356 360	576 573	682 673	958 930	-
08271000	RIO LUCERO NEAR ARROYO SECO, N. MEX. LAT 36 30 30 LONG 105 31 49	*42	16.6	8051	406	264	27	223 223	300 306	330 338	395 410	-

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN												
09012500	NORTH INLET AT GRAND LAKE, COLO. LAT 40 15 12 LONG 105 48 39	•10	45.9	8434	-	84	32	992 834	1220 1060	1320 1140	1570 1350	5.7
09016500	ARAPAHO CREEK AT MONARCH LAKE OUTLET, COLO. LAT 40 06 45 LONG 105 44 57	27	46.9	8310	310	24	31	1130 1000	1310 1190	1360 1250	1460 1370	4.1
09017000	ARAPAHO CREEK BELOW MONARCH LAKE, COLO. LAT 40 07 50 LONG 105 46 30	10	59.0	8244	-	31	31	1250 1020	1740 1400	1980 1560	2600 1980	5.4
09020000	WILLOW CREEK NEAR GRANBY, COLO. LAT 40 10 50 LONG 106 00 31	19	109	8234	58	38	28	806 909	941 1150	983 1230	1060 1400	4.7
09024000	FRASER RIVER NEAR WINTER PARK, COLO. LAT 39 54 00 LONG 105 46 34	•22	27.6	8906	-	48	28	536 481	748 675	845 759	1090 972	3.3
09026500	ST. LOUIS CREEK NEAR FRASER, COLO. LAT 39 54 36 LONG 105 52 40	•24	32.9	8980	-	153	34	390 442	448 532	466 560	496 618	2.5
[illegible]32000	RANCH CREEK NEAR FRASER, COLO. LAT 39 57 00 LONG 105 45 54	•15	19.9	8685	-	264	28	272 274	323 352	342 382	380 450	3.0
09032500	RANCH CREEK NEAR TABERNASH, COLO. LAT 39 59 51 LONG 105 49 23	•25	51.3	8340	-	30	26	551 545	659 692	695 745	762 859	3.5
09033000	MEADOW CREEK NEAR TABERNASH, COLO. LAT 40 03 03 LONG 105 46 37	21	8.0	9780	203	56	29	262 222	321 282	345 306	397 360	3.2
09033500	STRAWBERRY CREEK NEAR GRANBY, COLO. LAT 40 05 12 LONG 105 47 39	10	11.6	8650	-	248	27	116 142	166 207	190 235	254 307	2.7
09035500	WILLIAMS FORK BELOW STEELMAN CREEK, COLO. LAT 39 46 44 LONG 105 55 40	•15	16.3	9800	-	164	31	383 340	432 411	447 434	470 484	3.4
09036000	WILLIAMS FORK NEAR LEAL, COLO. LAT 39 49 53 LONG 106 03 15	••28	89.3	8790	160	35	32	1470 1390	1710 1660	1790 1750	1940 1930	4.3
09036500	KEYSER CREEK NEAR LEAL, COLO. LAT 39 54 27 LONG 106 01 00	10	13.8	9080	340	330	26	185 184	217 245	231 270	263 333	2.5
09037500	WILLIAMS FORK NEAR PARSHALL, COLO. LAT 40 00 01 LONG 106 10 45	••48	184	7809	-	26	25	1550 1530	1960 1980	2120 2150	2470 2540	4.3

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09040000	EAST FORK TROUBLESOME CREEK NEAR TROUBLESOME, COLO. LAT 40 09 27 LONG 106 16 58	27	76.0	7670	83	127	30	579 671	960 1040	1150 1210	1690 1670	3.5
09041000	MUDDY CREEK NEAR KREMMLING, COLO. LAT 40 17 37 LONG 106 28 59	22	87.4	7856	-	21	35	775 944	1010 1210	1120 1320	1400 1570	4.7
09041100	ANTELOPE CREEK NEAR KREMMLING, COLO. LAT 40 14 26 LONG 106 22 23	x12	11.5	7933	360	169	26	63 106	177 234	271 270	713 548	2.5
09046600	BLUE RIVER NEAR DILLON, COLO. LAT 39 32 55 LONG 106 02 19	16	119	9120	-	67	28	889 1000	1340 1450	1530 1540	2010 2080	3.9
09047000	BLUE RIVER AT DILLON, COLO. LAT 39 36 50 LONG 106 03 05	•50	128	8821	140	39	27	1020 1050	1170 1250	1220 1330	1290 1450	4.0
09047500	SNAKE RIVER NEAR MONTEZUMA, COLO. LAT 39 36 20 LONG 105 56 33	26	57.7	9320	230	65	33	933 911	1150 1140	1230 1220	1360 1370	4.3
09047700	KEYSTONE GULCH NEAR DILLON, COLO. LAT 39 35 40 LONG 105 58 19	16	9.1	9350	360	192	28	78 104	119 155	138 177	185 231	1.8
09048000	SNAKE RIVER AT DILLON, COLO. LAT 39 36 45 LONG 106 02 30	42	90.9	8870	-	39	30	1000 1010	1230 1270	1310 1360	1470 1540	3.5
09050100	TENMILE CREEK BELOW NORTH TENMILE CREEK, AT FRISCO, COLO. LAT 39 34 37 LONG 106 06 33	16	93.3	9090	150	68	30	1480 1330	1760 1650	1850 1750	2010 1960	4.3
09050500	TENMILE CREEK AT DILLON, COLO. LAT 39 36 45 LONG 106 03 15	40	111	8818	120	62	30	1540 1480	1870 1830	1990 1960	2240 2220	4.0
09052000	ROCK CREEK NEAR DILLON, COLO. LAT 39 43 23 LONG 106 07 41	21	15.8	8503	400	248	30	265 262	308 324	323 346	352 395	2.6
09053000	SLATE CREEK NEAR DILLON, COLO. LAT 39 46 54 LONG 106 10 02	•11	16.6	8228	410	211	37	263 315	320 390	343 416	394 476	2.2
09053500	BLUE RIVER ABOVE GREEN MOUNTAIN RESERVOIR, COLO. LAT 39 49 55 LONG 106 13 20	•19	511	7947	-	22	30	4540 4470	5230 5370	5430 5650	5780 6180	4.7
09054000	BLACK CREEK BELOW BLACK LAKE, NEAR DILLON, COLO. LAT 39 47 59 LONG 106 16 04	14	15.0	8750	-	88	42	355 382	423 454	451 478	514 534	2.5

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09054500	BLACK CREEK ABOVE GREEN MOUNTAIN RESERVOIR, COLO. LAT 39 51 21 LONG 106 15 07	10	18.5	7960	--	264	40	379 419	506 531	565 573	718 680	2.8
09055000	OTTER CREEK ABOVE GREEN MOUNTAIN RESERVOIR, COLO. LAT 39 51 10 LONG 106 16 02	10	8.4	7980	--	98	27	90 110	119 155	131 174	157 219	1.4
09055500	CATARACT CREEK ABOVE GREEN MOUNTAIN RESERVOIR, COLO. LAT 39 51 00 LONG 106 17 27	10	13.6	8320	--	176	35	368 329	455 415	493 448	583 527	2.5
09058500	PINEY RIVER BELOW PINEY LAKE, NEAR MINTURN, COLO. LAT 39 42 29 LONG 106 25 38	17	13.0	9145	240	222	43	347 362	398 419	412 434	442 467	2.7
09060500	ROCK CREEK NEAR TOPONAS, COLO. LAT 40 02 28 LONG 106 39 19	*20	47.6	8544	140	38	24	434 436	482 544	495 583	518 677	3.3
09063000	EAGLE RIVER AT RED CLIFF, COLO. LAT 39 30 34 LONG 106 22 00	45	70.0	8648	-	62	26	748 737	1010 1010	1110 1110	1310 1330	3.4
09063400	TURKEY CREEK NEAR RED CLIFF, COLO. LAT 39 31 22 LONG 106 23 15	10	23.9	8885	--	148	34	478 458	711 640	813 712	1050 881	2.9
09063500	TURKEY CREEK AT RED CLIFF, COLO. LAT 39 30 50 LONG 106 22 00	*18	29.6	8642	290	96	32	473 473	663 651	759 732	1020 946	3.2
09064500	HOMESTAKE CREEK NEAR RED CLIFF, COLO. LAT 39 28 24 LONG 106 22 02	*34	58.3	8783	150	38	37	1100 1090	1250 1250	1300 1310	1370 1400	3.0
09065100	CROSS CREEK NEAR MINTURN, COLO. LAT 39 34 05 LONG 106 24 45	13	33.5	7990	-	88	36	719 681	783 787	802 819	832 885	3.7
09065500	GORE CREEK AT UPPER STATION, NEAR MINTURN, COLO. LAT 39 37 40 LONG 106 16 24	19	14.3	8620	380	422	37	497 439	625 553	675 594	783 687	3.8
09066000	BLACK GORE CREEK NEAR MINTURN, COLO. LAT 39 35 47 LONG 106 15 52	19	11.8	9180	270	169	33	309 283	362 345	380 367	415 413	3.0
09066400	RED SANDSTONE CREEK NEAR MINTURN, COLO. LAT 39 40 58 LONG 106 24 03	10	7.3	9150	--	185	38	172 185	235 243	262 264	324 315	2.6
09066500	GORE CREEK NEAR MINTURN, COLO. LAT 39 36 53 LONG 106 26 22	12	100	7756	190	96	32	1640 1470	1850 1760	1910 1850	2010 2030	4.9

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09069500	GYPSUM CREEK NEAR GYPSUM, COLO. LAT 39 32 44 LONG 106 56 03	*12	63.4	7600	-	176	30	300 524	451 735	523 818	711 1030	2.9
09073500	ROARING FORK RIVER AT ASPEN, COLO. LAT 39 11 22 LONG 106 48 50	13	109	7885	-	148	30	2630 2020	3480 2690	3830 2950	4630 3540	6.6
09074000	HUNTER CREEK NEAR ASPEN, COLO. LAT 39 12 21 LONG 106 47 49	11	40.0	8610	-	234	34	954 816	1120 994	1170 1050	1280 1170	3.5
09078000	FRYINGPAN RIVER AT NORRIE, COLO. LAT 39 19 51 LONG 106 39 27	*29	90.6	8410	-	92	30	1440 1340	1780 1690	1910 1820	2190 2100	5.8
09078100	NORTH FORK FRYINGPAN RIVER ABOVE CUNNINGHAM CREEK, NEAR NORRIE, COLO. LAT 39 21 32 LONG 106 34 04	10	12.0	9410	-	127	37	310 298	362 362	379 382	411 426	3.5
09078200	CUNNINGHAM CREEK NEAR NORRIE, COLO. LAT 39 20 03 LONG 106 34 29	10	7.1	9600	-	201	30	213 173	266 227	285 247	327 295	2.1
09078500	NORTH FORK FRYINGPAN RIVER NEAR NORRIE, COLO. LAT 39 20 34 LONG 106 39 55	31	42.0	8400	280	264	29	917 824	1200 1090	1320 1230	1580 1440	3.9
09082800	NORTH THOMPSON CREEK NEAR CARBONDALE, COLO. LAT 39 19 47 LONG 107 19 58	10	26.8	8120	-	162	29	376 374	489 505	532 554	624 668	3.1
09084000	CATTLE CREEK NEAR CARBONDALE, COLO. LAT 39 28 00 LONG 107 03 06	+13	31.1	7640	300	117	27	273 318	358 438	391 425	445 596	2.7
09096000	PLATEAU CREEK AT UPPER STATION, NEAR COLLBRAN, COLO. LAT 39 13 25 LONG 107 48 05	13	24.1	7885	-	70	31	391 386	602 565	773 643	967 843	4.8
09096800	BUZZARD CREEK BELOW OWENS CREEK, NEAR HEIBERGER, COLO. LAT 39 14 10 LONG 107 38 00	15	49.7	8206	-	48	33	624 677	838 897	924 978	1120 1160	5.1
09097600	BRUSH CREEK NEAR COLLBRAN, COLO. LAT 39 19 30 LONG 107 50 30	12	9.6	8183	460	352	27	217 184	419 325	537 472	911 639	2.8
09099500	BIG CREEK AT UPPER STATION, NEAR COLLBRAN, COLO. LAT 39 07 55 LONG 107 55 05	11	20.2	8590	-	354	36	438 428	647 591	749 661	1020 842	3.6
09110500	EAST RIVER NEAR CRESTED BUTTE, COLO. LAT 38 52 05 LONG 106 54 38	+11	90.3	8880	100	22	33	1190 1210	1350 1460	1420 1550	1580 1750	4.1

Table 6.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Mountain Region*--Continued

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COLORADO RIVER BASIN - CONTINUED												
09111500	SLATE RIVER NEAR CRESTED BUTTE, COLO. LAT 38 52 00 LONG 106 49 38	*11	70.1	8827	100	10	35	1220 1160	1290 1330	1320 1390	1370 1500	3.4
09112000	CEMENT CREEK NEAR CRESTED BUTTE, COLO. LAT 38 50 05 LONG 106 49 38	12	26.1	9050	190	422	32	311 364	396 475	431 517	512 614	2.8
09112500	EAST RIVER AT ALMONT, COLO. LAT 38 39 57 LONG 106 50 50	45	289	8006	52	42	32	3800 3660	5650 5320	6590 6140	9200 8370	8.0
09113300	OHIO CREEK AT BALDWIN, COLO. LAT 38 45 56 LONG 107 03 28	12	47.2	8600	-	95	31	627 641	842 860	930 943	1130 1140	3.6
09113500	OHIO CREEK NEAR BALDWIN, COLO. LAT 38 42 08 LONG 106 59 52	24	121	8180	110	59	29	1100 1150	1350 1460	1440 1570	1610 1800	5.6
09115500	TOMICHI CREEK AT SARGENTS, COLO. LAT 38 23 45 LONG 106 25 20	41	149	8415	120	43	24	666 754	902 1050	991 1160	1190 1420	3.7
09118000	QUARTZ CREEK NEAR OHIO, COLO. LAT 38 33 35 LONG 106 38 09	24	106	8430	150	73	25	583 677	728 902	780 987	886 1180	2.8
09122000	CEBOLLA CREEK AT POWDERHORN, COLO. LAT 38 17 38 LONG 107 06 51	18	340	8000	82	35	22	1550 1680	2590 2700	3110 3180	4500 4420	3.1
09122500	SOAP CREEK NEAR SAPINERO, COLO. LAT 38 33 39 LONG 107 19 29	11	57.4	7790	160	89	28	735 697	1080 1000	1270 1150	1780 1530	4.6
09123500	LAKE FORK AT LAKE CITY, COLO. LAT 38 01 30 LONG 107 18 28	14	115	8665	100	43	29	1260 1240	1580 1610	1710 1750	2010 2080	4.5
09124500	LAKE FORK AT GATEVIEW, COLO. LAT 38 17 56 LONG 107 13 46	36	334	7828	67	50	27	2490 2510	3160 3250	3440 3550	4070 4210	4.9
09125000	CURECANTI CREEK NEAR SAPINERO, COLO. LAT 38 29 15 LONG 107 24 51	27	35.0	7867	130	88	29	405 421	510 547	548 592	628 694	2.7
09130600	WEST MUDDY CREEK NEAR RAGGED MOUNTAIN, COLO. LAT 39 07 51 LONG 107 34 29	10	7.5	8658	270	106	38	218 210	383 320	467 370	699 506	5.1
09132900	WEST HUBBARD CREEK NEAR PAONIA, COLO. LAT 39 01 56 LONG 107 36 47	13	2.4	9640	-	327	34	72 70	97 94	109 105	139 131	2.6

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Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09244500	ELKHEAD CREEK NEAR CLARK, COLO. LAT 40 43 59 LONG 107 10 18	16	45.4	7800	65	31	28	1000 824	1220 1040	1300 1130	1440 1290	5.7

^x ONE OR MORE HIGH OUTLIERS ELIMINATED.

^+ ONE OR MORE LOW OUTLIERS ELIMINATED.

^* UNREGULATED PERIOD OF RECORD.

Table 7.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Northern Plateau Region*

[Flood discharges for each gaging station are: (first line) values used in multiple regression analysis, (second line) weighted averages. Numbers below station name are latitude and longitude in degrees, minutes, and seconds]

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN												
09239500	YAMPA RIVER AT STEAMBOAT SPRINGS, COLO. LAT 40 29 01 LONG 106 49 54	67	604	6695	54	26	30	5130 5000	6060 5910	6700 6500	7070 6920	6.5
09241000	ELK RIVER AT CLARK, COLO. LAT 40 43 03 LONG 106 54 55	47	206	7268	98	50	38	3610 3450	4310 4090	4580 4330	5160 4880	5.8
09242500	ELK RIVER NEAR TRULL, COLO. LAT 40 30 53 LONG 106 57 12	12	415	6590	-	20	34	5200 4520	5940 5150	6230 5390	6840 5980	6.3
09245000	ELKHEAD CREEK NEAR ELKHEAD, COLO. LAT 40 40 15 LONG 107 17 10	21	64.2	6830	150	70	27	1300 1240	1560 1550	1650 1660	1850 1920	5.0
09245500	NORTH FORK ELKHEAD CREEK NEAR ELKHEAD, COLO. LAT 40 40 50 LONG 107 17 10	15	21.0	6990	-	62	23	837 718	1290 1100	1500 1280	2040 1710	3.4
09248600	EAST FORK OF WILLIAMS FORK ABOVE WILLOW CREEK, COLO. LAT 40 15 40 LONG 107 17 35	16	108	7100	230	68	30	1450 1510	1750 1860	1860 2000	2100 2310	4.9
09249000	EAST FORK OF WILLIAMS FORK NEAR PAGODA, COLO. LAT 40 18 45 LONG 107 19 10	16	150	6830	170	59	28	1450 1590	1920 2080	2130 2290	2620 2780	3.3
09253000	LITTLE SNAKE RIVER NEAR SLATER, COLO. LAT 40 59 58 LONG 107 08 34	28	285	6831	26	29	28	3110 2980	3710 3600	3930 3830	4360 4310	6.2
09254500	SLATER FORK AT BAXTER RANCH, NEAR SLATER, COLO. LAT 40 53 22 LONG 107 19 49	10	80.0	7070	-	132	25	922 1060	1230 1450	1370 1620	1720 2000	4.1
09255000	SLATER FORK NEAR SLATER, COLO. LAT 40 58 54 LONG 107 22 58	+42	161	6600	-	15	22	1320 1380	1740 1850	1920 2050	2340 2500	11.1
09256000	SAVERY CREEK NEAR SAVERY, WYO. LAT 41 05 52 LONG 107 22 53	30	330	6680	42	34	25	1950 2120	2370 2630	2510 2820	2740 3170	6.3
09257000	LITTLE SNAKE RIVER NEAR DIXON, WYO. LAT 41 01 42 LONG 107 32 55	41	988	6331	58	15	26	7050 6640	9000 8420	9790 9140	11600 10800	10.4
09260000	LITTLE SNAKE RIVER NEAR LILY, COLO. LAT 40 32 50 LONG 108 25 25	50	3730	5685	-	6	14	8960 8570	11600 11300	12600 12400	14600 14500	9.2
09302800	NORTH FORK WHITE RIVER NEAR BUFORD, COLO. LAT 40 02 08 LONG 107 31 13	17	223	7340	120	47	36	1790 2140	2060 2450	2150 2560	2330 2840	4.4

Table 7.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Northern Plateau Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09303000	NORTH FORK WHITE RIVER AT BUFORD, COLO. LAT 39 59 15 LONG 107 36 50	25	254	7010	47	53	35	2240 2420	3000 3090	3330 3370	4110 4060	6.[illegible]
09303500	SOUTH FORK WHITE RIVER NEAR BUFORD, COLO. LAT 39 55 19 LONG 107 33 03	15	157	7460	150	10	35	25[illegible]0 23[illegible]	3180 2940	3480 3180	4210 3780	6.9
09304000	SOUTH FORK WHITE RIVER AT BUFORD, COLO. LAT 39 58 28 LONG 107 37 30	23	170	6970	81	56	34	2420 2370	2880 2820	3060 2990	3500 3430	6.1
09304200	WHITE RIVER ABOVE COAL CREEK, NEAR MEEKER, COLO. LAT 40 00 18 LONG 107 49 29	12	660	6400	-	31	31	37[illegible]0 41[illegible]0	4110 4600	4210 4770	4380 5190	5.[illegible]
09304500	WHITE RIVER NEAR MEEKER, COLO. LAT 40 02 01 LONG 107 51 42	65	762	6300	44	32	29	46[illegible]0 46[illegible]0	5540 5530	5890 5880	6620 6620	6.1
09304800	WHITE RIVER BELOW MEEKER, COLO. LAT 40 00 26 LONG 108 06 02	12	1040	5928	-	21	26	4[illegible]50 4520	4400 5220	4490 5470	4640 5990	6.[illegible]
09306000	WILLOW CREEK NEAR OURAY, UTAH LAT 39 56 30 LONG 109 39 00	X*15	890	4830	-	18	14	2340 2610	5020 4930	6650 6250	11900 9970	5.6

[X]ONE OR MORE HIGH OUTLIERS ELIMINATED.

[+]ONE OR MORE LOW OUTLIERS ELIMINATED.

[*]UNREGULATED PERIOD OF RECORD.

Table 8.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Southern Plateau Region*

[Flood discharges for each gaging station are: (first line) values used in multiple regression analysis, (second line) weighted averages. Numbers below station name are latitude and longitude in degrees, minutes, and seconds]

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
RIO GRANDE RIVER BASIN												
08216500	WILLOW CREEK AT CREEDE, COLO. LAT 37 51 22 LONG 106 55 37	23	35.3	8880	350	143	27	387 496	539 714	599 809	732 1040	3.3
08218000	GOOSE CREEK NEAR WAGONWHEEL GAP, COLO. LAT 37 41 15 LONG 106 53 19	15	53.6	8800	200	103	28	921 954	1500 1500	1780 1760	2530 2460	2.7
08218500	GOOSE CREEK AT WAGONWHEEL GAP, COLO. LAT 37 45 07 LONG 106 49 46	19	90.0	8460	160	57	24	677 944	1020 1420	1180 1640	1610 2220	2.8
08219500	SOUTH FORK RIO GRANDE AT SOUTH FORK, COLO. LAT 37 39 25 LONG 106 38 55	50	216	8222	120	48	36	3020 2970	5100 4920	6230 5970	9550 9010	8.3
08220500	PINOS CREEK NEAR DEL NORTE, COLO. LAT 37 35 30 LONG 106 26 56	X40	53.0	8480	250	88	28	466 572	753 900	886 1050	1220 1440	5.5
08223500	ROCK CREEK NEAR MONTE VISTA, COLO. LAT 37 29 25 LONG 106 15 32	25	32.9	8230	260	111	32	185 335	256 486	282 553	332 710	3.3
36000	ALAMOSA CREEK ABOVE TERRACE RESERVOIR, COLO. LAT 37 22 29 LONG 106 20 03	46	107	8600	99	38	36	1940 1890	3220 3080	3910 3720	5950 5570	4.2
08245500	CONEJOS RIVER AT PLATORO, COLO. LAT 37 21 14 LONG 106 31 28	*14	44.4	9800	72	55	38	1330 1140	1540 1450	1620 1580	1800 1900	3.4
08246500	CONEJOS RIVER NEAR MOGOTE, COLO. LAT 37 03 14 LONG 106 11 13	*43	282	8272	43	33	29	4420 4200	6480 6180	7510 7160	10300 9800	7.9
08247500	SAN ANTONIO RIVER AT ORTIZ, COLO. LAT 36 59 35 LONG 106 02 17	+48	110	7970	64	31	25	1100 1200	1700 1840	1980 2140	2670 2880	5.3
08248000	LOS PINOS RIVER NEAR ORTIZ, COLO. LAT 36 58 56 LONG 106 04 23	55	167	8040	80	31	25	2310 2300	3070 3110	3360 3440	3990 4190	6.6
08248500	SAN ANTONIO RIVER AT MOUTH, NEAR MANASSA, COLO. LAT 37 10 37 LONG 105 52 39	50	348	7650	-	6	20	1800 2130	2440 2980	2660 3310	3060 4030	8.1
08281200	WOLF CREEK NEAR CHAMA, N. MEX. LAT 36 57 20 LONG 106 32 10	13	27.7	8310	296	141	25	1230 969	2260 1690	2860 2090	4770 3330	-
08283500	RIO CHAMA AT PARK VIEW, N. MEX. LAT 36 44 15 LONG 106 34 40	33	405	7280	80	42	27	6980 6340	9760 8950	11000 10100	14000 13000	-

Table 8.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Southern Plateau Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
RIO GRANDE RIVER BASIN - CONTINUED												
08284000	RITO DE TIERRA AMARILLA AT TIERRA AMARILLA, N. MEX. LAT 36 41 55 LONG 106 33 25	12	49.7	7520	138	77	21	733 833	1130 1260	1320 1470	1810 2000	-
08284500	WILLOW CREEK NEAR PARK VIEW, N. MEX. LAT 36 40 05 LONG 106 42 15	+33	193	6945	48	38	18	2460 2470	4070 3990	4900 4770	7260 6930	-
COLORADO RIVER BASIN												
09059500	PINEY RIVER NEAR STATE BRIDGE, COLO. LAT 38 48 00 LONG 106 35 00	29	86.2	7272	210	87	28	944 1060	1130 1380	1190 1510	1300 1810	4.4
09067500	EAGLE RIVER AT EAGLE, COLO. LAT 39 39 24 LONG 106 49 29	14	628	6560	-	36	29	6630 6260	7940 8210	8420 9070	9450 11200	6.2
09068000	BRUSH CREEK NEAR EAGLE, COLO. LAT 39 33 26 LONG 106 45 45	22	69.7	7450	350	101	28	551 757	842 1140	984 1330	1370 1830	3.7
09070000	EAGLE RIVER BELOW GYPSUM, COLO. LAT 39 38 58 LONG 106 57 11	*24	944	6275	64	24	27	5930 6440	7360 8570	7880 9490	8960 11700	7.6
09081550	CRYSTAL RIVER AT PLACITA, COLO. LAT 39 08 34 LONG 107 15 26	+13	107	7372	-	63	34	1900 1790	2060 2230	2120 2430	2230 2930	4.7
09081600	CRYSTAL RIVER ABOVE AVALANCHE CREEK NEAR REDSTONE, COLO. LAT 39 13 56 LONG 107 13 36	18	167	6905	140	59	33	3170 2840	3780 3630	4000 3960	4470 4750	5.3
09082500	CRYSTAL RIVER NEAR REDSTONE, COLO. LAT 39 17 55 LONG 107 12 49	29	229	6484	-	70	34	3880 3610	4540 4450	4770 4800	5220 5570	6.6
09083000	THOMPSON CREEK NEAR CARBONDALE, COLO. LAT 39 19 50 LONG 107 13 26	14	75.7	6450	220	132	34	823 1020	1170 1480	1310 1690	1640 2210	3.3
09085000	ROARING FORK RIVER AT GLENWOOD SPRINGS, COLO. LAT 39 32 37 LONG 107 19 44	*59	1451	5721	-	26	28	13900 13400	17400 17100	18700 18600	21500 22000	8.4
09096500	PLATEAU CREEK NEAR COLLBRAN, COLO. LAT 39 15 02 LONG 107 50 24	*+35	80.4	7130	170	176	30	1820 1710	2440 2340	2740 2650	3540 3450	5.9
09097500	BUZZARD CREEK NEAR COLLBRAN, COLO. LAT 39 16 20 LONG 107 51 00	52	143	6955	-	46	28	1140 1280	1670 1890	1890 2150	2390 2770	7.2

Table 8.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Southern Plateau Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09126000	CIMARRON RIVER NEAR CIMARRON, COLO. LAT 38 15 45 LONG 107 32 39	*16	66.6	8650	190	108	32	1420 1330	2110 1970	2450 2290	3380 3130	4.7
09128500	SMITH FORK NEAR CRAWFORD, COLO. LAT 38 43 40 LONG 107 30 22	38	43.7	7091	250	76	28	623 674	831 928	912 1040	1090 1290	3.4
09130500	EAST MUDDY CREEK NEAR BARDINE, COLO. LAT 39 00 46 LONG 107 21 28	19	132	6655	130	25	29	1600 1710	2380 2540	2760 2950	3780 4010	4.8
09132500	NORTH FORK GUNNISON RIVER NEAR SOMERSET, COLO. LAT 38 55 45 LONG 107 26 53	40	531	6039	150	48	29	5550 5460	7160 7250	7790 8010	9150 9720	5.6
09134500	LEROUX CREEK NEAR CEDAREDGE, COLO. LAT 38 55 35 LONG 107 47 35	*28	35.1	7255	270	176	33	1070 984	1390 1320	1530 1470	1850 1820	5.5
09145000	UNCOMPAHGRE RIVER AT OURAY, COLO. LAT 38 01 09 LONG 107 40 32	14	42.0	7800	320	141	30	1670 1330	2550 2010	3010 2370	4310 3330	9.9
46000	UNCOMPAHGRE RIVER BELOW OURAY, COLO. LAT 38 01 52 LONG 107 40 28	16	76.0	7670	220	96	32	2210 1860	2800 2460	3030 2720	3540 3330	5.3
09146200	UNCOMPAHGRE RIVER NEAR RIDGWAY, COLO. LAT 38 11 02 LONG 107 44 43	15	149	6878	-	39	26	1690 1840	2060 2470	2200 2760	2490 3440	5.0
09146400	WEST FORK DALLAS CREEK NEAR RIDGWAY, COLO. LAT 38 04 25 LONG 107 51 02	15	13.1	8400	680	192	36	160 244	250 371	295 433	413 591	1.5
09146500	EAST FORK DALLAS CREEK NEAR RIDGWAY, COLO. LAT 38 05 36 LONG 107 48 47	16	16.8	7980	500	325	35	262 331	317 448	337 501	376 625	2.2
09146600	PLEASANT VALLEY CREEK NEAR NOEL, COLO. LAT 38 08 44 LONG 107 55 09	12	8.0	8680	220	354	21	381 326	620 515	728 602	991 815	3.2
09147100	COW CREEK NEAR RIDGWAY, COLO. LAT 38 08 58 LONG 107 38 39	18	45.4	7620	370	151	32	1080 1010	1530 1460	1740 1670	2280 2210	5.2
09147500	UNCOMPAHGRE RIVER AT COLONA, COLO. LAT 38 19 53 LONG 107 46 44	56	443	6319	-	50	22	2860 3110	3810 4250	4210 4750	5130 5950	5.5
09150500	ROUBIDEAU CREEK AT MOUTH, NEAR DELTA, COLO. LAT 38 44 15 LONG 108 09 40	16	242	4864	-	275	14	2260 2520	3530 3850	4140 4500	5730 6170	8.8

Table 8.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Southern Plateau Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09152000	KANNAH CREEK NEAR WHITEWATER, COLO. LAT 38 57 42 LONG 108 13 47	45	61.9	6060	350	248	28	1000 1020	1380 1430	1550 1620	1940 2060	3.5
09165000	DOLORES RIVER BELOW RICO, COLO. LAT 37 38 20 LONG 108 03 33	22	105	8422	120	62	36	1880 1800	2460 2450	2690 2730	3250 3420	5.4
09166500	DOLORES RIVER AT DOLORES, COLO. LAT 37 28 16 LONG 108 30 15	59	556	6919	-	24	30	6300 6150	9200 9310	10500 10300	13700 13500	9.0
09167000	LOST CANYON CREEK AT DOLORES, COLO. LAT 37 27 41 LONG 108 30 03	13	81.0	6920	-	25	22	1080 1200	1570 1740	1790 2030	2310 2670	6.2
09167500	DOLORES RIVER NEAR MCPHEE, COLO. LAT 37 34 37 LONG 108 34 19	14	793	6666	-	18	25	8830 7980	14000 12400	16400 14500	22700 19900	9.8
09168100	DISAPPOINTMENT CREEK NEAR DOVE CREEK, COLO. LAT 37 52 36 LONG 108 34 57	*15	145	6420	84	53	23	3370 2840	5510 5120	6280 6380	13600 10100	14.9
09172000	FALL CREEK NEAR FALL CREEK, COLO. LAT 37 57 30 LONG 108 00 19	X17	33.5	7929	270	151	31	420 531	702 840	844 993	1230 1400	4.0
09172500	SAN MIGUEL RIVER NEAR PLACERVILLE, COLO. LAT 38 02 05 LONG 108 07 15	38	308	7056	84	44	30	2310 2550	3230 3640	3630 4130	4620 5360	4.9
09175000	NATURITA CREEK NEAR NORWOOD, COLO. LAT 37 58 32 LONG 108 19 38	*11	27.7	7601	-	59	30	768 702	1170 1040	1300 1200	1730 1600	6.0
09175500	SAN MIGUEL RIVER AT NATURITA, COLO. LAT 38 13 04 LONG 108 33 57	45	1080	5393	59	32	24	5800 6230	8830 9520	10200 11000	13400 14600	9.7
09177500	TAYLOR CREEK NEAR GATEWAY, COLO. LAT 38 31 08 LONG 109 06 33	*20	12.0	8120	180	86	23	416 387	766 684	958 839	1510 1280	4.0
09181000	ONION CREEK NEAR MOAB, UTAH LAT 38 43 30 LONG 109 20 40	*11	18.8	4120	-	121	12	1630 1060	2240 1510	2510 1710	3150 2180	4.7
09185500	HATCH WASH NEAR LA SAL, UTAH LAT 38 14 36 LONG 109 26 22	22	378	5500	-	53	13	1980 2620	4690 5230	6790 6840	13400 12200	7.4
09186500	INDIAN CREEK ABOVE COTTONWOOD CREEK, NEAR MONTICELLO, UTAH LAT 37 58 30 LONG 109 31 05	*21	31.2	6290	-	141	25	491 553	1270 1190	1810 1610	3810 3100	8.8

Table 8.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Southern Plateau Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09187000	COTTONWOOD CREEK NEAR MONTICELLO, UTAH LAT 38 03 45 LONG 109 34 25	16	115	5340	-	77	18	2090 1950	6060 4720	8800 6570	18700 13100	15.8
09339900	EAST FORK SAN JUAN RIVER ABOVE SAND CREEK, NEAR PAGOSA SPRINGS, COLO LAT 37 23 25 LONG 110 50 25	.X16	64.1	7950	280	63	45	1010 1060	1500 1580	1730 1820	2370 2480	5.0
09340000	EAST FORK SAN JUAN RIVER NEAR PAGOSA SPRINGS, COLO. LAT 37 22 10 LONG 106 53 30	39	86.9	7598	210	103	44	1670 1620	2390 2330	2720 2670	3510 3470	4.6
09340500	WEST FORK SAN JUAN RIVER ABOVE BORNS LAKE, NEAR PAGOSA SPRINGS, COLO LAT 37 29 10 LONG 106 53 30	. 17	41.2	8400	490	249	47	1150 1030	1540 1430	1710 1610	2140 2070	3.0
09341500	WEST FORK SAN JUAN RIVER NEAR PAGOSA SPRINGS, COLO. LAT 37 22 43 LONG 106 53 56	26	87.9	7614	260	44	44	2150 1950	3010 2770	3400 3140	4370 4080	4.5
09342500	SAN JUAN RIVER AT PAGOSA SPRINGS, COLO. LAT 37 15 58 LONG 107 00 37	44	298	7052	170	36	38	6350 5800	15400 13500	22200 19200	51600 43500	13.2
09343000	RIO BLANCO NEAR PAGOSA SPRINGS, COLO. LAT 37 12 46 LONG 106 47 38	37	58.0	7950	190	53	40	1460 1380	2090 1980	2380 2270	3150 3010	2.6
09344000	NAVAJO RIVER AT BANDED PEAK RANCH, NEAR CHROMO, COLO. LAT 37 05 07 LONG 106 41 20	37	69.8	7941	200	67	36	1060 1090	1450 1530	1620 1720	2040 2210	3.3
09344300	NAVAJO RIVER ABOVE CHROMO, COLO. LAT 37 01 55 LONG 106 43 56	14	96.4	7700	120	58	33	1180 1320	1720 1950	1990 2260	2720 3070	3.2
09346000	NAVAJO RIVER AT EDITH, COLO. LAT 37 00 10 LONG 106 54 25	*36	172	7033	83	50	31	1670 1810	2710 2870	3250 3410	4800 4930	4.6
09346200	RIO AMARGO AT DULCE, N. MEX. LAT 36 56 00 LONG 107 00 00	15	168	6720	-	14	19	2000 2100	3170 3250	3770 3830	5420 5370	-
09346400	SAN JUAN RIVER NEAR CARRACAS, COLO. LAT 37 00 49 LONG 107 18 42	11	1230	6090	-	23	29	7120 8140	11100 12400	13000 14500	18200 19900	-
09349500	PIEDRA RIVER NEAR PIEDRA, COLO. LAT 37 13 20 LONG 107 20 32	34	371	6510	90	52	32	4690 4520	8670 8040	11000 10100	18500 16400	9.0
09350500	SAN JUAN RIVER AT ROSA, N. MEX. LAT 37 00 20 LONG 107 24 10	42	1990	5980	40	13	30	13800 13700	23000 22300	28000 27000	42200 40000	-

Table 8.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Southern Plateau Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09350800	VAQUEROS CANYON NEAR GOBERNADOR, N. MEX. LAT 36 43 20 LONG 107 16 50	+16	60.0	6640	-	81	14	1260 1190	3200 2590	4520 3510	9380 6750	-
09352500	LOS PINOS RIVER BELOW SNOWSLIDE CANYON, NEAR WEMINUCHE PASS, COLO LAT 37 38 20 LONG 107 20 00	13	25.3	10120	-	60	37	653 626	963 927	1100 1070	1420 1400	6.7
09352900	VALLECITO CREEK NEAR BAYFIELD, COLO. LAT 37 28 39 LONG 107 32 35	x10	72.1	7906	-	141	41	1560 1400	1790 1820	1870 2010	2020 2460	3.7
09353500	LOS PINOS RIVER NEAR BAYFIELD, COLO. LAT 37 22 58 LONG 107 34 37	12	270	7583	-	244	40	3840 3530	4840 4780	5230 5350	6060 6680	6.8
09354000	LOS PINOS RIVER AT IGNACIO, COLO. LAT 37 07 45 LONG 107 37 50	*17	448	6469	-	33	32	5130 4910	7670 7330	8780 8440	11400 11100	-
09355700	GOBERNADOR CANYON NEAR GOBERNADOR, N. MEX. LAT 36 41 05 LONG 107 25 10	+14	19.8	6410	-	37	14	1270 947	1630 1260	1770 1390	2090 1700	-
09356500	SAN JUAN RIVER NEAR BLANCO, N. MEX. LAT 36 43 50 LONG 107 48 50	27	3560	5540	17	12	25	19300 19400	30300 30000	35500 35200	49100 48400	-
09357500	ANIMAS RIVER AT HOWARDSVILLE, COLO. LAT 37 49 59 LONG 107 35 56	38	55.9	9617	240	88	29	1480 1390	1960 1870	2180 2100	2720 2660	4.2
09359000	MINERAL CREEK NEAR SILVERTON, COLO. LAT 37 48 50 LONG 107 41 40	14	43.9	9399	230	51	37	1310 1130	1900 1650	2200 1910	3030 2610	5.3
09359500	ANIMAS RIVER ABOVE TACOMA, COLO. LAT 37 34 13 LONG 107 46 48	11	348	7520	87	68	37	8460 6230	10700 8290	11600 9200	13500 11300	7.9
09361000	SALT CREEK NEAR OXFORD, COLO. LAT 37 25 19 LONG 107 50 40	43	172	6706	110	124	33	2240 2250	3710 3660	4440 4350	6360 6180	6.7
09361500	ANIMAS RIVER AT DURANGO, COLO. LAT 37 16 45 LONG 107 52 47	53	692	6501	64	18	34	10200 9560	18400 16900	23300 21300	39500 35500	9.2
09362000	LIGHTNER CREEK NEAR DURANGO, COLO. LAT 37 16 12 LONG 107 53 38	22	56.0	6534	170	64	29	1420 1340	2820 2480	3620 3120	6080 5030	6.2
09363000	FLORIDA RIVER NEAR DURANGO, COLO. LAT 37 19 31 LONG 107 44 54	46	96.0	7302	180	81	38	1840 1780	2820 2720	3300 3180	4620 4430	5.6

Table 8.--*Selected basin and climatic parameters and flood characteristics for gaging stations in the Southern Plateau Region*--Continued

Station number	Station name	Period of record, in years	Drainage area, in square miles	Gage datum, in feet above mean sea level	Basin slope, in feet per mile	Streambed slope, in feet per mile	Mean annual precipitation, in inches	10-Year flood discharge, in cubic ft per second	50-Year flood discharge, in cubic ft per second	100-Year flood discharge, in cubic ft per second	500-Year flood discharge, in cubic ft per second	100-Year flood depth, in feet
COLORADO RIVER BASIN - CONTINUED												
09363100	SALT CREEK NEAR OXFORD, COLO. LAT 37 08 23 LONG 107 45 10	+12	16.7	6470	-	53	16	678 570	1110 904	1320 1070	1860 1480	5.4
09363200	FLORIDA RIVER AT BONDAD, COLO. LAT 37 03 24 LONG 107 52 09	12	221	6000	-	30	31	1250 1930	2150 3030	2600 3580	3850 5020	5.1
09363500	ANIMAS RIVER NEAR CEDAR HILL, N. MEX. LAT 37 02 17 LONG 107 52 25	*28	1090	5950	53	22	31	10300 9830	14500 14000	16500 16000	21600 21200	-
09364500	ANIMAS RIVER AT FARMINGTON, N. MEX. LAT 36 43 12 LONG 108 12 08	*57	1360	5278	41	26	28	11500 11300	16700 16400	19100 18800	24900 24700	-
09369000	EAST MANCOS RIVER NEAR MANCOS, COLO. LAT 37 22 14 LONG 108 13 53	x14	11.1	7450	-	201	28	157 229	202 322	220 365	259 469	1.8
09372000	MCELMO CREEK NEAR COLORADO-UTAH STATE LINE LAT 37 19 27 LONG 109 00 54	23	350	4890	-	30	15	2100 2620	3330 4040	3950 4750	5640 6640	5.9
09382000	PARIA RIVER AT LEES FERRY, ARIZ. LAT 36 52 20 LONG 111 35 38	+48	1410	3123	31	24	14	10200 10200	16800 16500	20100 19700	28700 27900	17.5

[x] ONE OR MORE HIGH OUTLIERS ELIMINATED.

[+] ONE OR MORE LOW OUTLIERS ELIMINATED.

[*] UNREGULATED PERIOD OF RECORD.