science for a changing world

In cooperation with the
BUREAU OF INDIAN AFFAIRS, BUREAU OF LAND MANAGEMENT,
CONFEDERATED SALISH AND KOOTENAI TRIBES,
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION,
MONTANA DEPARTMENT OF TRANSPORTATION, and the
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998

Water-Resources Investigations Report 03-4308

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
U.S. Geological Survey

Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998

By Charles Parrett and D.R. Johnson

Water-Resources Investigations Report 03-4308

Helena, Montana
February 2004

In cooperation with the
BUREAU OF INDIAN AFFAIRS
BUREAU OF LAND MANAGEMENT
CONFEDERATED SALISH AND KOOTENAI TRIBES
MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
MONTANA DEPARTMENT OF TRANSPORTATION and the
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

Front cover photograph:

Looking upstream at Carter Bridge on the Yellowstone River near Livingston, Mont., during flood of June 1996. (Photograph by Stephen V. Lynn, U.S. Geological Survey.)

U.S. Department of the Interior

Gale A. Norton, Secretary

U.S. Geological Survey

Charles G. Groat, Director

U.S. Geological Survey, Reston, Virginia: 2004
For sale by U.S. Geological Survey, Information Services
Box 25286, Denver Federal Center
Denver, CO 80225

For more information about the USGS and its products:
Telephone: 1-888-ASK-USGS
World Wide Web: http//www.usgs.gov/

Any use of trade, product, or firm name in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted materials contained within this report.

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS--Continued

TABLES

CONVERSION FACTORS, DATUM, AND ACRONYMS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter/kilometer
inch (in.)	2.54	centimeter
square mile (mi^2)	2.59	square kilometer

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Water year: The 12-month period October 1 through September 30. It is designated by the calendar year in which it ends.

Acronyms:

BIA	Bureau of Indian Affairs, U.S. Department of the Interior
BLM	Bureau of Land Management, U.S. Department of the Interior
CSKT	Confederated Salish and Kootenai Tribes
MDNRC	Montana Department of Natural Resources and Conservation
MDT	Montana Department of Transportation
NRCS	Natural Resources Conservation Service, U.S. Department of Agriculture
USDA	Forest Service U.S. Department of Agriculture Forest Service
USGS	U.S. Geological Survey

METHODS FOR ESTIMATING FLOOD FREQUENCY IN MONTANA BASED ON DATA THROUGH WATER YEAR 1998

By Charles Parrett and D.R. Johnson

Abstract

Annual peak discharges having recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years (*T*-year floods) were determined for 660 gaged sites in Montana and in adjacent areas of Idaho, Wyoming, and Canada, based on data through water year 1998. The updated flood-frequency information was subsequently used in regression analyses, either ordinary or generalized least squares, to develop equations relating *T*-year floods to various basin and climatic characteristics, equations relating *T*-year floods to active-channel width, and equations relating *T*-year floods to bankfull width. The equations can be used to estimate flood frequency at ungaged sites. Montana was divided into eight regions, within which flood characteristics were considered to be reasonably homogeneous, and the three sets of regression equations were developed for each region.

A measure of the overall reliability of the regression equations is the average standard error of prediction. The average standard errors of prediction for the equations based on basin and climatic characteristics ranged from 37.4 percent to 134.1 percent. Average standard errors of prediction for the equations based on active-channel width ranged from 57.2 percent to 141.3 percent. Average standard errors of prediction for the equations based on bankfull width ranged from 63.1 percent to 155.5 percent. In most regions, the equations based on basin and climatic characteristics generally had smaller average standard errors of prediction than equations based on active-channel or bankfull width. An exception was the Southeast Plains Region, where all equations based on active-channel width had smaller average standard errors of prediction than equations based on basin and climatic characteristics or bankfull width.

Methods for weighting estimates derived from the basin- and climatic-characteristic equations and the channel-width equations also were developed. The weights were based on the cross correlation of residuals from the different methods and the average standard errors of prediction. When all three methods were combined, the average standard errors of prediction ranged from 37.4 percent to 120.2 percent. Weighting of estimates reduced the standard errors of prediction for all *T*-year flood estimates in four regions, reduced the standard errors of prediction for some *T*-year flood estimates in two regions, and provided no reduction in average standard error of prediction in two regions. A computer program for solving the regression equations, weighting estimates, and determining reliability of individual estimates was developed and placed on the USGS Montana District World Wide Web page. A new regression method, termed Region of Influence regression, also was tested. Test results indicated that the Region of Influence method was not as reliable as the regional equations based on generalized least squares regression.

Two additional methods for estimating flood frequency at ungaged sites located on the same streams as gaged sites also are described. The first method, based on a drainage-area-ratio adjustment, is intended for use on streams where the ungaged site of interest is located near a gaged site. The second method, based on interpolation between gaged sites, is intended for use on streams that have two or more streamflow-gaging stations.

INTRODUCTION

Reliable information about the magnitude and exceedance frequency of annual peak flows, generally referred to as flood-frequency information, is required for the economical design of water conveyance and storage structures such as culverts, bridges, storm sewers, dams, and levees. In addition, reliable flood-frequency information is crucial for effective planning and management of water resources, to protect lives and property in flood-prone areas, and for the determination of actuarial flood-insurance rates.

Several previous studies have provided flood-frequency information at long-term streamflow-gaging stations and presented methods for calculating flood-frequency data at ungaged sites in Montana based on drainage-basin and climatic characteristics, herein referred to as basin characteristics (Parrett and Omang, 1981; Omang and others, 1986; and Omang, 1992). A previous study by Parrett and others (1987) also presented a method for estimating flood-frequency information at ungaged sites in Montana using channel-geometry characteristics. All previous studies were based on flood-frequency data at gaged sites having at least 10 years of peak-flow record at the time of analysis. Because of a need to have up-to-date flood-frequency information in order to estimate flood discharges at ungaged sites, the U.S. Geological Survey (USGS) conducted a flood-frequency study in cooperation with the Bureau of Indian Affairs (BIA), the Bureau of Land Management (BLM), the Confederated Salish and Kootenai Tribes (CSKT), Montana Department of Natural Resources and Conservation (MDNRC), Montana Department of Transportation (MDT), and the U.S. Department of Agriculture Forest Service (USDA Forest Service).

Purpose and Scope

The purpose of this report is to describe the methods and results of the analysis of flood frequency at 634 gaged sites in Montana and 26 gaged sites in adjacent areas of Idaho, Wyoming, and Canada and present methods for estimating flood-frequency data at ungaged sites. Updated flood-frequency information at gaged sites in Montana through water year 1998 is provided and includes 10 more years of peak-flow record at stations used by Omang (1992) in a previous flood-frequency study, along with new stations with at least 10 years of peak flow record. Based on previous flood-frequency studies (Omang and others, 1986; Parrett and Omang, 1987; Omang, 1992), the State was divided into eight regions for flood-frequency analysis (fig. 1 on pl. 1); the boundaries of these regions are generally based on the hydrologic flood conditions described in the section “General flood conditions.” Five of the regions (West Region, Northwest Region, Northwest Foothills Region, Southwest Region, and Upper Yellowstone-Central Mountain Region) are located in the western one-half of Montana and three regions (Northeast Plains Region, East-Central Plains Region, and Southeast Plains Region) are located in the eastern one-half of Montana.

Regression analysis was used to develop a set of equations for estimating flood frequency at ungaged sites based on flood-frequency data and basin characteristics at gaged sites. A combination of Ordinary Least Squares (OLS) regression analysis and Generalized Least Squares (GLS) regression analysis (Tasker and Stedinger, 1989), a regression method that accounts for differing number of years of record and annual peak-discharge variability at gaged sites, was used to develop a set of equations for ungaged sites within 7 of the 8 hydrologic regions in Montana. OLS regression analysis was used to develop equations for ungaged sites within the remaining geographic region, which has unique flood-frequency characteristics. Similarly, GLS regression analysis was used to develop two sets of equations for estimating flood frequency at ungaged sites based on channel geometry (active-channel and bankfull width) measured at gaged sites within seven regions and OLS regression was used to develop equations based on channel geometry for the one region having unique flood-frequency characteristics. Methods for weighting estimates from the basin-characteristics and the channel-geometry equations also were developed.

An alternative regression method called the Region of Influence (ROI) method (Tasker and Slade, 1994) based on basin characteristics at gaged sites also was tested. This method, which does not require the delineation of fixed regional boundaries, results in a unique equation for each use at an ungaged site.

Two methods for estimating flood frequency at ungaged sites located on the same streams as gaged sites also are described. One method, based on a drainage-area-ratio adjustment, is intended for use on streams where the ungaged site of interest is located close to a gaged site. The other method, based on interpolation between gaged sites, is intended for use on streams having several gaged sites. A method also is presented for weighting flood-frequency estimates based on recorded data at gaged sites with estimates based on regional regression equations.

Maximum recorded floods in each hydrologic region are compared to the maximum known floods in the conterminous United States through the use of envelope curves. Plots relating maximum recorded floods to drainage areas provide a means for assessing the reasonableness of flood-frequency estimates.

Acknowledgments

Special thanks are given to Timothy J. Morgan (USGS) who provided timely assistance with the regional skew analysis and flood-frequency analyses at gaged sites. Special thanks also are given to Gary Tasker (USGS retired), who helped with the GLS and ROI regression analyses and wrote the computer program for calculating flood frequency at ungaged sites. Mr. Tasker provided much of his assistance on a voluntary basis after his retirement.

General Flood Conditions

Montana is a large (approximately 147,000 mi^2) state with widely varying topographic and climatic conditions. The western half of Montana is generally composed of rugged, north-south trending mountain ranges separated by large, intermontane valleys, whereas the eastern half of Montana is characterized by rolling or generally flat plains, interspersed with areas of deeply incised streams and rugged relief generally termed badlands or breaks. Most of the mountainous, western half of Montana is in the Northern and Middle Rocky Mountain physiographic provinces, while most of the non-mountainous, eastern half is in the Great Plains province (Fenneman, 1946).

Flooding in Montana is affected by topography and the source and timing of precipitation events and snowmelt (table 1). In western Montana, most of the annual precipitation falls mainly as snow in the winter and comes from

Table 1. Hydrologic regions and flood characteristics in Montana

Hydrologic region	General description and extent	Flood characteristics
West	Mountains and valleys west of Continental Divide; parts of Flathead and Blackfoot River basins	Most floods caused by snowmelt or snowmelt mixed with rain. Annual peak discharges less variable than in other regions.
Northwest	Eastern parts of Flathead and Blackfoot River basins; mountains and foothills east of the Continental Divide and northeast of Missoula	Largest floods caused by runoff from rain associated with moist air masses from the Gulf of Mexico. Most annual peak discharges are from snowmelt or snowmelt mixed with rain.
Northwest Foothills	Foothills and prairies of the Marias, Teton, Sun, and Dearborn River basins near Great Falls	Floods caused by snowmelt, large amounts of rain, or thunderstorms. Annual peak discharges are more variable than those from similar-sized streams in the mountainous regions.
Northeast Plains	Rolling prairies of the Milk River basin upstream from Glasgow; foothills and plains part of the Judith River basin	Floods on larger streams caused by prairie snowmelt or snowmelt mixed with rain. Most floods on smaller streams caused by thunderstorms. Annual peak discharges are more variable than those from streams in the Northwest Foothills region.
East-Central Plains	Plains and badlands of the lower parts of Musselshell, Missouri, Milk, and Poplar River basins; northern part of Yellowstone River basin east of Billings	Floods on larger streams caused by prairie snowmelt or snowmelt mixed with rain. Most floods on smaller streams caused by thunderstorms. Thunderstorms are more prevalent and intense than in any other region. Annual peak discharges are more variable than in any other region.
Southeast Plains	Rolling plains of southern part of Yellowstone River basin east of Billings	Floods on larger streams caused by prairie snowmelt or snowmelt mixed with rain. Most floods on smaller streams caused by thunderstorms. Annual peak discharges somewhat less variable and smaller than those from similar-sized streams in the East-Central Plains region.
Upper Yellowstone-Central Mountain	Mountains and valleys of the upper Yellowstone River basin; mountains and valleys of the Smith River basin; parts of the Judith and Musselshell River basins.	Floods caused by snowmelt or snowmelt mixed with rain on larger streams and snowmelt or thunderstorms on smaller streams. Annual peak discharges similar to, though more variable than, those in the West region.
Southwest	Mountains and valleys of the Missouri River basin upstream from the Dearborn River	Floods caused by snowmelt or snowmelt mixed with rain on larger streams and snowmelt or thunderstorms on smaller streams. Annual peak discharges generally are smaller and more variable than those from similar-sized streams in other mountainous regions.

moist air masses that originate over the Pacific Ocean. Thus, flooding generally is the result of mountain snowmelt runoff, frequently combined with rainfall runoff, in May and June. Winter rains or rain on melting snow in western Montana valleys occasionally cause significant flooding, and intense summer thunderstorms occasionally cause flooding on small streams. On the eastern slopes of the Continental Divide, severe flooding sometimes results from large May or June rains that originate from moist air masses from the Gulf of Mexico. Although these rains generally are dissipated as the moist air is uplifted over the crest of the Continental Divide, the largest storms have crossed the Divide and caused severe flooding on the western slopes as well as the eastern slopes (Boner and Stermitz, 1967).

In eastern Montana, large storms that result in flooding may come from either the Pacific Ocean or Gulf of Mexico. Flooding in this area may result from snowmelt runoff in the spring, or snowmelt combined with rain over the plains. Intense summer thunderstorms frequently cause flooding on small streams on the plains. Flooding in eastern Montana tends to be more variable, both spatially and temporally, than in western Montana because precipitation from large storms is more variable. Thunderstorms are more prevalent in eastern Montana than in western Montana, and thunderstorms are highly variable in terms of extent, location, and precipitation amounts and intensities. The variability in the monthly occurrence of annual peak discharge for each Region is illustrated by box plots on figure 2. As indicated by the box plots, the distribution of the month of occurrence of annual peak discharge is more variable in the plains of eastern Montana than in the mountainous regions of western Montana. However, only in the West and Northwest Regions did any annual flood peaks occur as late in the year as December.

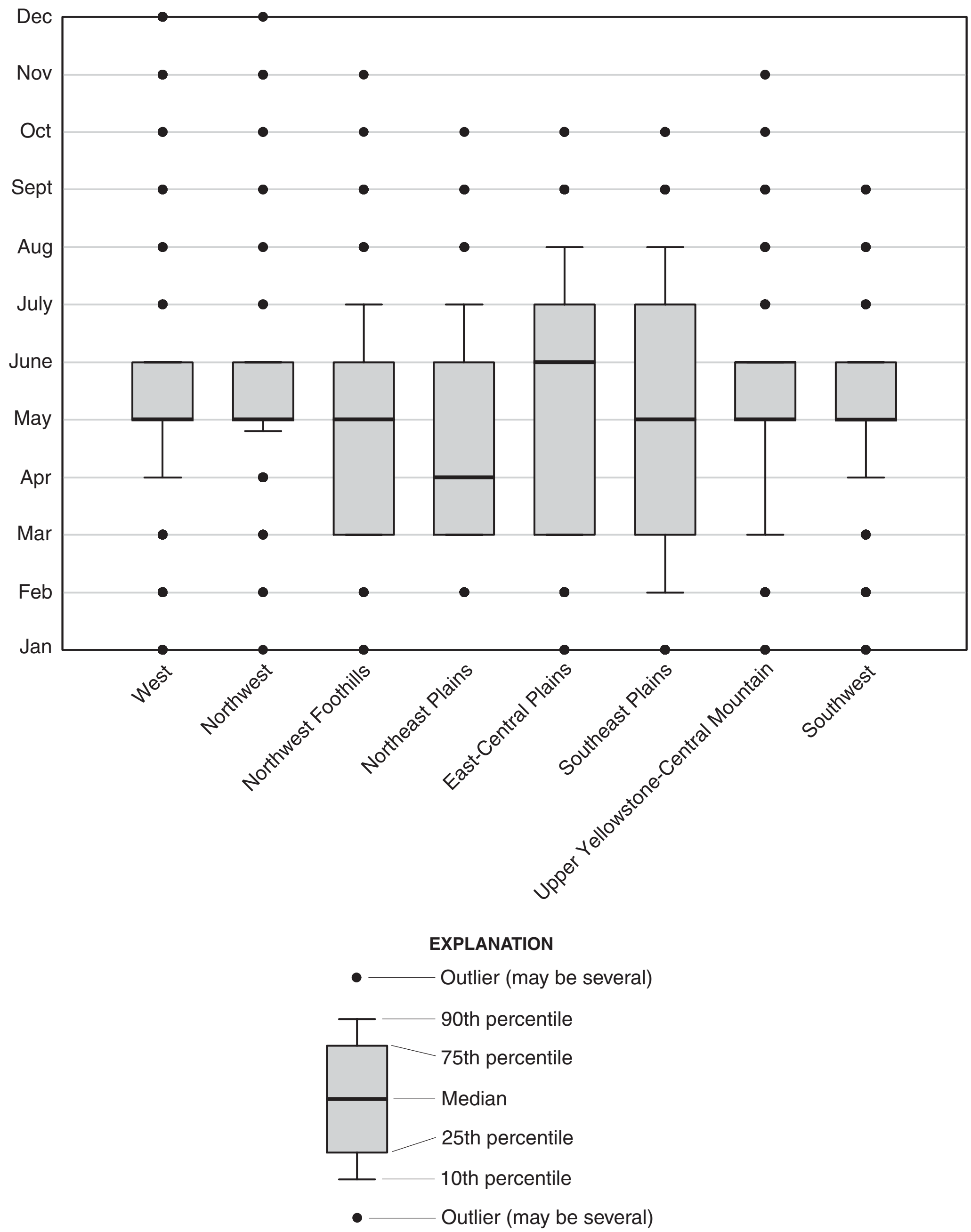
METHODS FOR ESTIMATING FLOOD FREQUENCY

Flood-Frequency Analysis

Flood-Frequency Data

Flood-frequency data (annual peak discharges having recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years) were determined for 634 USGS gaged sites in Montana, 16 sites near the Montana border in Canada whose streamflow records are published by the USGS, Montana District, 9 USGS sites near the Montana border in Wyoming, and 1 USGS site near the Montana border in Idaho (fig. 1). Recurrence interval, which is the reciprocal of annual exceedance frequency, represents the average length of time between exceedances of a particular annual peak discharge. For example, an annual peak discharge with a recurrence interval of 100 years is a rare flood that, on average, is exceeded once every 100 years and has a 0.01 chance of exceedance in any year. An annual peak discharge with a recurrence interval of *T* years commonly is referred to as a *T*-year flood and expressed as Q_T. All gaged sites for which flood-frequency data were determined had at least 10 years of recorded annual peak-discharge data through 1998. Included were 158 sites where peak-flow data are not considered to be representative of the prevailing, regional flood conditions. Some of these non-representative sites are on large streams whose flood-frequency characteristics may be different from those on smaller streams, some are on streams whose annual peak discharges are regulated by reservoir storage, and some are affected by unique flood runoff conditions, such as glacier-melt runoff. Data from these 158 non-representative sites provide important at-site flood-frequency information, but were not used to develop regional relations for the estimation of flood frequency at ungaged sites. Regional relations were based on data from 502 gaged sites. Basin-characteristics, channel-width, and flood-frequency data for all sites are presented in table 2 (back of the report). Basin-characteristics data, channel-geometry data, and flood-frequency data for all Montana sites also are available on the USGS Montana District homepage (http://montana.usgs.gov/freq).

Flood-frequency data at most gaged sites were determined by fitting a log-Pearson Type III probability distribution to the recorded annual peak discharges using methods described by the Interagency Advisory Committee on Water Data (Bulletin 17B, 1982) herein referred to as Bulletin 17B. The log-Pearson Type III probability distribution is a three-parameter distribution that uses the mean, standard deviation, and skew of the base 10 logarithms of recorded annual peak discharge (sample data) as parameter estimates for all annual peak discharges (population data). The fitted log-Pearson Type III probability distribution plots as a curve, termed a flood-frequency curve, on log-probability



(75th and 90th percentile are the same for West, Northwest, Upper Yellowstone-Central Mountain, and Southwest Regions. 25th and 10th percentile are the same for Northwest Foothills, Northeast Plains, and East-Central Plains Regions)

Figure 2. Variability in monthly occurrence of annual peak discharge by region, Montana.

paper as shown by the example in figure 3. Ninety-five percent confidence limits for the fitted curves also were calculated (Bulletin 17B, 1982) as shown on figure 3, but the results are not included in table 2 for brevity.

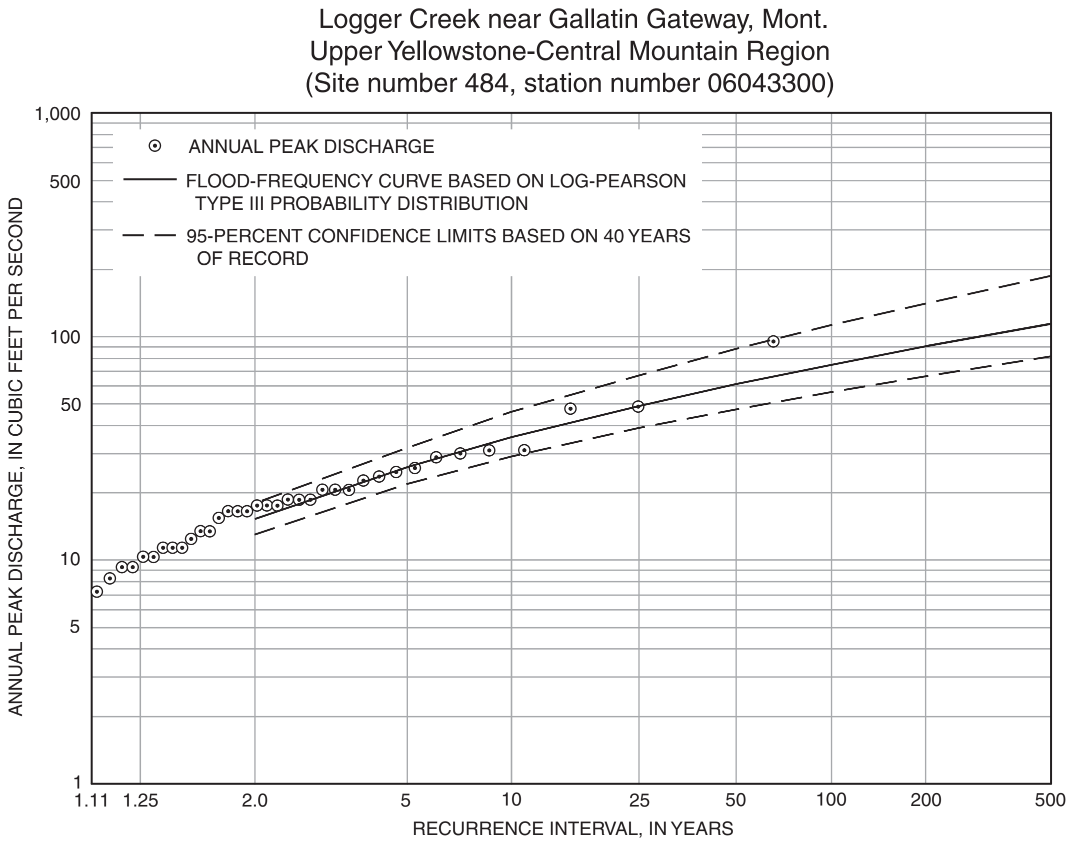


Figure 3. Example flood-frequency curve based on log-Pearson Type III probability distribution.

Procedures for fitting the log-Pearson Type III probability distribution, described in Bulletin 17B, include high and low outlier tests for determining whether recorded flood peaks are high outliers that require some adjustment to the historical period of record or low outliers that should be excluded. For this report, an historical period of record was applied if a recorded peak discharge was known to be the largest since some previous flood before the beginning of systematic data collection. The low-outlier criterion described in Bulletin 17B was relaxed for some stations in this study where one or more flood peaks were notably smaller than all other recorded flood peaks, even though none met the strict criterion for exclusion. Generally, small flood peaks were excluded from the log-Pearson Type III analysis if their exclusion resulted in a flood-frequency curve with a significantly different shape from the curve with the peaks included.

For sites on streams whose annual peak discharges are affected by reservoir regulation, the sample skew coefficient was used to fit the log-Pearson Type III probability distribution to the recorded flood peaks. For sites whose periods of record include periods before reservoir construction as well as periods after reservoir construction, the log-Pearson Type III distribution was fitted only to the period of record after reservoir construction.

For sites where recorded annual peak discharges are not affected by reservoir regulation, Bulletin 17B indicates that flood frequency curves are more reliable if sample skew is weighted with regional skew. The following section describes the methods used for determining regional skew for Montana.

Regional Skew Map

Values of skew calculated from small samples commonly do not provide reliable estimates of population skew. Accordingly, a national map with regional skew values that could be used to weight station skew to improve flood-frequency estimates at individual sites was presented in Bulletin 17B. The national skew map was based on data from sites on unregulated streams with 25 or more years of record. Because only a small number of Montana sites were used in the development of the national skew map, Omang (1992) used a regional skew map developed specifically for Montana by the Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service; S.M. Hamilton, written commun., 1982). Many more gaged sites on unregulated streams in Montana now (through 1998) have 25 or more years of annual peak discharge record than when previous regional skew maps were developed. Consequently, a new regional skew map based on data from 201 sites on unregulated streams having 25 or more years of record was developed for this study using methods described in Bulletin 17B. A statewide average skew also was calculated from station skew values for the 201 unregulated sites. The new regional skew map, the regional skew map developed by the NRCS, the regional skew map in Bulletin 17B, and the statewide average skew were used to determine a skew value (map skew) for each of the 201 sites having 25 or more years of annual peak discharge data. The difference between the station skew at each long-term site and the map skew was used as the measure of map skew error at each site. An overall measure of map skew error (weighted by number of years of record) for the entire state (State Map Error) for each method was determined from the following equation:

$$\text{State Map Error} = \left[\frac{\sum_{i=1}^{201} N_i \, Diff_i^2}{\sum_{i=1}^{201} N_i}\right]^{0.5}, \qquad (1)$$

where

N_i is the number of years of record at site i, and

$Diff_i$ is the difference between station skew and map skew at site i.

The State Map Error for each method of determination of regional skew is shown in table 3.

Table 3. State Map Errors for various methods of determining regional skew

Source of Regional Skew Data	State Map Error
Map developed for this study	0.62
National map from Bulletin 17B[1]	.64
Montana regional map developed by NRCS[2]	.65
Statewide average	.76

[1]Interagency Advisory Committee on Water Data (1982).
[2]S.M. Hamilton, Natural Resources Conservation Service, written commun., 1982.

Although the results presented in table 3 indicate that the skew map developed for this study is slightly better (smaller State Map Error) than either the national map or the Montana regional skew map developed by the NRCS, the differences are small and probably not significant. All skew maps were significantly better than the statewide average skew. Because of the small differences among the various skew maps and because the national map is widely used by other states and is consistent from state to state, that portion of the national map applicable to Montana (fig. 4) was used in this study for determination of regional skew. Regional skew determined by interpolation from the national skew map was used together with station skew in a weighting procedure described in Bulletin 17B to determine final at-site flood-frequency data for most gaged sites. Exceptions included sites on streams whose annual peak discharges are affected by reservoir regulations, where station skew only was used, and sites primarily in the Northwest Region where annual peak discharges result from independent causes (mixed-population floods). A method for determining flood frequency at sites having mixed-population floods is described in the next section.

Mixed-Population Flood-Frequency Analysis

As described in previous flood-frequency studies for Montana (Parrett and Omang, 1981; Omang and others, 1986; and Omang, 1992), flood-frequency analysis at gaged sites in the Northwest Region was complicated by the presence of a few, usually very large, rain-caused floods during the period of record with all other floods caused by snowmelt or snowmelt mixed with rain. At most sites in the Northwest Region, the log-Pearson Type III probability distribution did not provide a good fit to annual peak discharges when all flood data were combined. As described in Bulletin 17B, annual peak discharges that result from two independent causes generally need to be separated by cause and analyzed using mixed-population methods. Accordingly, annual peak discharges for 26 sites in the Northwest Region were separated into two categories—those caused by rain and those caused by snowmelt or snowmelt mixed with rain—and separate analyses were made for each category. Seven sites in the West Region and one in the Northwest Foothills Region also were determined to have one or more very large floods caused by winter rainfall during the period of record with all other floods caused by snowmelt or snowmelt mixed with rain. The mixed-population analysis described in the following paragraphs also was applied to these sites in the West and Northwest Foothills Regions.

The small number (2-5) of extreme rain-caused floods at each site complicated determination of the exceedance probabilities for these events. The exceedance probability for the largest of the rain-caused floods at each site was somewhat arbitrarily estimated. In some instances, the largest floods were the result of a regional storm that lasted 24 to 36 hours, and the calculated exceedance probability for the 24-hour duration precipitation amount at a nearby rain gage (Parrett, 1997) was used as a guide in assigning exceedance probability to the flood peak. In other instances, general information about extensive erosion and deposition in a regional flood report (Boner and Stermitz, 1967) was used to estimate exceedance probabilities for the flood peaks. Although the exceedance probabilities associated with the largest flood discharges at sites with mixed-population floods are imprecise, the authors believe they better represent the relative rareness of the recorded floods than do the small amounts of historical and recorded data. The exceedance probability for the smallest of the extreme rain-caused floods at each site usually was estimated based on the ratio of the number of extreme rain-caused floods to the number of total annual peak discharges. For example, if a site had 60 years of total annual peak-discharge record and three extreme rain-caused floods, the exceedance probability associated with the smallest of the three extreme rain-caused floods would be 3 divided by 60, or 0.05. The recurrence interval associated with this exceedance probability is 1 divided by 0.05, or 20 years. The flood-frequency curve for the limited number of rain-caused floods at each site then was estimated by drawing a straight line on a log-probability (extreme-value) graph between the smallest and largest extreme rain-caused floods. The flood-frequency curve for the more numerous annual peak discharges caused by snowmelt or snowmelt mixed with rain was determined at each site by fitting a log-Pearson Type III probability distribution to just those annual peak discharges with no adjustment for regional skew. Finally, the combined flood-frequency curve for each site was determined by calculating exceedance probability for various flood magnitudes using the following equation developed by the U.S. Army Corps of Engineers (1958):

$$Pt = Pr + Ps - Pr\,Ps, \qquad (2)$$

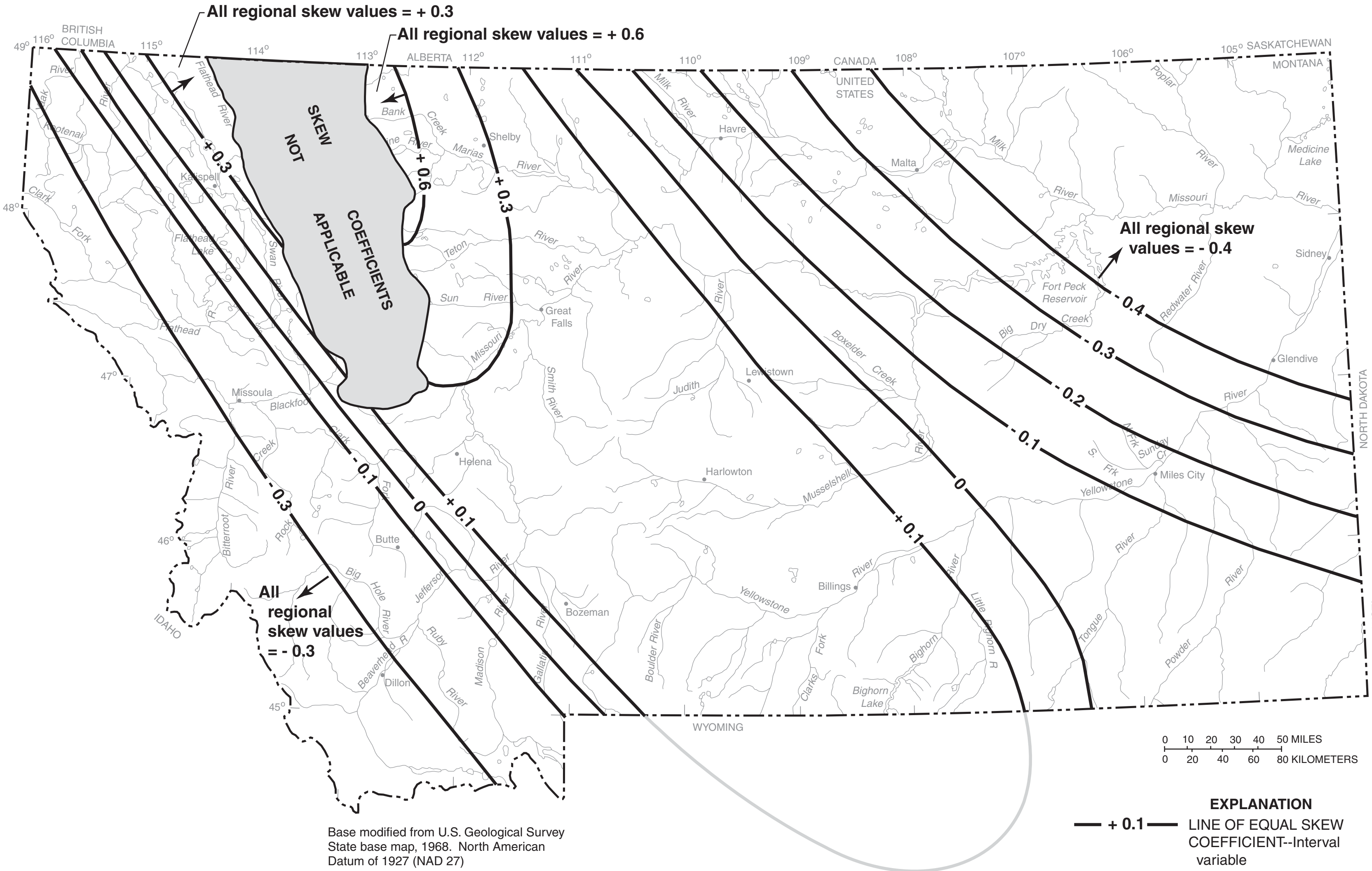


Figure 4. Regional skew coefficients for Montana (modified from Interagency Advisory Committee on Water Data,1982).

where

Pt is the exceedance probability for a given flood magnitude regardless of cause,

Pr is the exceedance probability for the same flood magnitude given that it is a flood caused by rainfall, and

Ps is the exceedance probability for the same flood magnitude given that it is a flood caused by snowmelt or snowmelt mixed with rainfall runoff.

An example of a flood-frequency curve based on mixed-population analysis for a site in the Northwest Region is shown on figure 5. No methods are currently available for determining confidence intervals for flood-frequency data based on the mixed-population analysis described in this report; consequently, confidence intervals are not shown on figure 5.

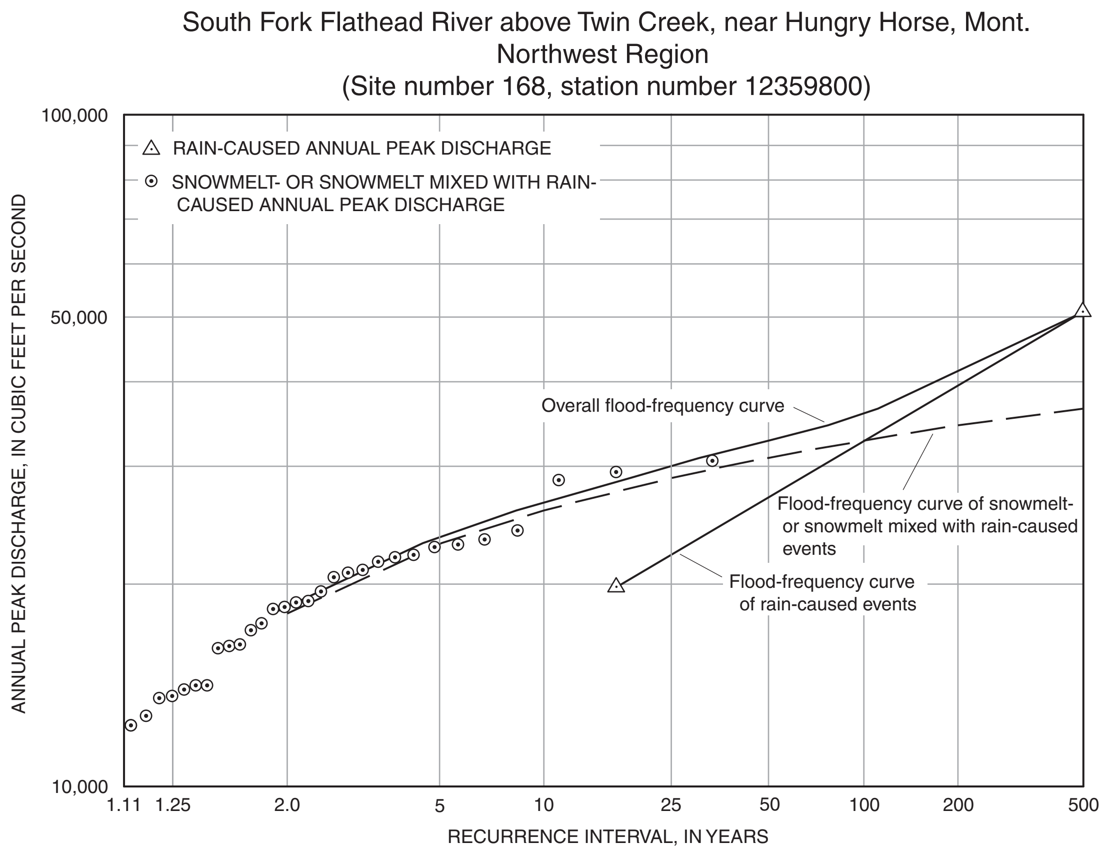


Figure 5. Example flood-frequency curve based on mixed-population analysis.

Regional Flood-Frequency Relations

Regional equations expressing flood frequency as a function of various explanatory variables were developed using regression methods. First, Ordinary Least Squares (OLS) regression was used to develop preliminary equations relating the annual peak discharge with a recurrence interval of T years (Q_T) within each of the eight hydrologic regions (table 1) to the best combination of basin characteristics (explanatory variables). All possible combinations of explanatory variables were used in the regression analysis, and the combination producing the maximum coefficient of determination (R^2) (Helsel and Hirsch, 1992, p. 227) was considered to be the best. In most regions, the best combination of explanatory variables varied from one Q_T to the next. To ensure that the equations within a region would be reasonable and consistent over the range of Q_T, the same combination of explanatory variables was selected for each Q_T. The combination that was selected was that providing the best overall fit, especially for those Q_T with recurrence intervals greater than 50 years.

Once the best combinations of explanatory variables were determined from the OLS regression analysis, those same variables were then used in an alternative regression procedure called Generalized Least Squares (GLS) regression (Tasker and Stedinger, 1989). GLS regression, unlike OLS regression, considers the time-sampling error and the interstation correlation of the dependent variable (Q_T). On this basis, GLS regression generally results in equations that are more reliable than those developed by OLS regression. GLS regression estimates the time-sampling error for all Q_T at each station based on statistics for the log-Pearson Type III probability distribution. As previously described, flood-frequency characteristics for stations in the Northwest Region were based on a mixed-population analysis and do not fit the log-Pearson Type III distribution. Consequently, GLS regression was not used for the Northwest Region, and all regression results for that region are based only on OLS regression. Although several gaged sites in the West Region and one in the Northwest Foothills Region also were analyzed using the mixed-population analysis, more than 110 sites in these two regions were analyzed using the log-Pearson Type III distribution, and use of the GLS regression method was considered appropriate for the regions as a whole.

After best-fit equations relating Q_T to various basin characteristics within each region were determined, OLS regression was used to relate Q_T to active-channel width and to bankfull width within the Northwest Region; GLS regression was used to relate Q_T to active-channel width and bankfull width within each of the other regions.

The regression methods based on basin characteristics were compared with regression methods based on active-channel and bankfull width. Then, methods for weighting the different regression estimates in order to provide more reliable estimates were developed. Finally, a relatively new linear regression method—the Region of Influence (ROI) method that uses basin characteristics as explanatory variables but is not based on fixed geographical regions of applicability—also was tested for use in Montana.

To help ensure that relations between Q_T and the explanatory variables (basin characteristics) would be linear, all variables were converted to base 10 logarithms (log), and the equations were of the following linear form:

$$\log Q_T = \log K + a_1 \log x_1 + a_2 \log x_2 + \ldots a_p \log x_p, \quad (3)$$

where

Q_T	is an annual peak discharge, in cubic feet per second, with a recurrence interval of T years,
K	is a regression constant,
a_1 through a_p	are regression coefficients, and
x_1 through x_p	are basin characteristics.

Regression equations based on either active-channel width or bankfull width as the only explanatory variable had the following simpler form:

$$\log Q_T = \log K + a \log x, \quad (3a)$$

where x is either active-channel width or bankfull width, in feet, a is the regression coefficient, and all other terms are as previously described.

Equation 3 can be expressed in terms of the actual variable values rather than logarithms as:

$$Q_T = K' x_1^{a_1} x_2^{a_2} \ldots x_p^{a_p}, \quad (4)$$

where K' is the antilog (10^K) of the linear regression constant and all other terms are as previously described.

Similarly, equation 3a can be expressed in terms of actual variable values as:

$$Q_T = K' x^a, \tag{4a}$$

where all terms are as previously described.

The solution to the general regression equations (3 and 3a) can be obtained using matrix algebra for both OLS and GLS regression methods. Because intermediate matrices in the solution are required for determination of measures of regression reliability and confidence limits, the matrices required to solve equations 3 and 3a are described in the Appendix (back of the report). Also described in the Appendix are the intermediate solution matrices and how they are used to calculate regression reliability and confidence limits.

Basin-Characteristics Regression Analysis

Basin characteristics that previously had been measured for gaged sites in Montana (Omang, 1992) and that were considered as possible explanatory variables in multiple regression equations in this study were:

A	drainage area, in mi^2;
L	main channel length, in mi;
S	main channel slope, in ft/mi;
P	mean annual precipitation, in in.;
F	percentage of basin covered by forest;
E	mean basin elevation, in ft;
E_{6000}	percentage of basin above 6,000 ft elevation; and
JANMIN	average mean January minimum temperature in the basin, in degrees F.

Basin characteristics that were found to be significant in any of the regional regression equations were drainage area (*A*), mean annual precipitation (*P*), mean basin elevation (*E*), percentage of the basin above 6,000 ft elevation (E_{6000}), and percentage of basin covered by forest (*F*). For gaged sites, drainage area was determined by planimetry of the basin boundary on a suitable-scale USGS quadrangle map. For small basins with drainage areas smaller than about 100 square miles, 1:24,000 quadrangle maps were used. For larger basins, the map scale ranged from 1:48,000 to 1:250,000. Mean annual precipitation for gaged basins was determined by first overlaying a transparent grid on a map showing basin boundary and contours of mean annual precipitation developed by the NRCS, formerly U.S. Soil Conservation Service (U.S. Soil Conservation Service, 1981). The grid size varied depending upon the basin size. In general, the grid size was selected to ensure that at least 10 grid intersections were within the basin boundary. The mean annual precipitation value at each grid intersection within the basin boundary was summed and then divided by the total number of grid intersections to produce a basin average value for mean annual precipitation. Mean basin elevation at gaged sites was determined in a similar manner by overlaying a variable-sized transparent grid on a USGS quadrangle map showing the basin boundary, summing the elevation found at each grid intersection, and dividing by the total number of grid intersections. Percentage of basin above 6,000 ft in elevation was determined by planimetry (on a suitable-scale USGS quadrangle map) of the area of the gaged basin above the 6,000-ft contour line and dividing by the total drainage area. A suitable map scale was determined on the basis of basin size in the same manner as for drainage area. In a similar manner, percentage of basin covered by forest was determined by planimetry (on a suitable-scale USGS quadrangle map) of the green-colored area of the gaged basin and dividing by the total drainage area.

To ensure that all values of the basin characteristics would be greater than zero before transformation to base 10 logarithms (logarithm of 0 is undefined), 1.0 was added to all values of E_{6000} and *F* prior to the regression analysis. In addition, to ensure that the regression coefficient for mean basin elevation would be reasonably large, all values of *E* were divided by 1,000 prior to the regression analysis.

The use of computerized Geographic Information Systems (GIS) enables rapid computation of basin and climatic characteristics at ungaged sites. However, depending on map scale and the relative coarseness of the digital elevation maps used to determine elevation-based characteristics, GIS measurements may not be comparable to characteristics measured from maps at the gaged sites. Likewise, various maps of mean annual precipitation based on data more recent than the NRCS map used in this report are now generally available for GIS determination of mean annual precipitation. However, these maps generally do not have the detailed precipitation data for mountainous areas that were used to develop the maps used for this report. Thus, GIS-measured characteristics, including mean annual precipitation values from other sources, should be compared at several gaged sites to those shown in this report before using GIS-measured characteristics at ungaged sites to estimate flood frequency from the regression equations. For convenience, the maps of mean annual precipitation developed by the NRCS using data from 1941-70 (U.S. Soil Conservation Service, 1981) are reproduced in this report (fig. 6 on pl. 1) for the regions where mean annual precipitation was a significant explanatory variable.

The hydrologic flood regions used for the regression analyses (fig. 1) are based largely on previous flood-frequency analyses for Montana (Omang and others, 1986; Omang, 1992). Some slight modifications to those previously determined regional boundaries were made for this report primarily to ensure that physiographic and climatic conditions were similar within each region. Regions whose boundaries are slightly different from those shown in Omang (1992) are the West, Southeast, Upper Yellowstone-Central Mountain, and Southwest Regions.

Results of the regression analyses based on basin characteristics for all regions are presented in table 4 (back of the report). Measures of the overall reliability of the regression equations included in table 4 are the average sampling error variance, the model error variance, the average standard error of prediction (*SEP*), and the estimated equivalent years of record (*EYR*). The average sampling error variance provides an indication of the error associated with the *T*-year flood as a result of the variability of annual peak discharges at the gaged sites. The model error variance provides a measure of the error associated with the regression model. The average *SEP* (in base 10 log units) is the square root of the sum of the model error variance and average sampling error variance (both in log units) and indicates the overall average prediction error for any estimated Q_T in each region based on the data used to develop the regression equation. Overall, smaller values of average *SEP* indicate better reliability of the regression equations than do larger values of average *SEP*. The average *SEP*, which is commonly expressed in percent rather than log units, can be converted from log units to percent using the following equation:

$$SEP\text{ (percent)} = \left[100\left(e^{(5.3018\, SEP(\log)^2)} - 1\right)\right]^{0.5}, \quad (5)$$

where

e	is the natural logarithmic base (approximately 2.71828), and
SEP (log)	is the *SEP* in base 10 log units.

The *EYR* indicates the number of years of record that would be needed at a gaged site in the region to provide the same reliability for Q_T as the regression estimate. Regions with highly variable annual peak discharges and resultant large time-sampling errors at the gaged sites will tend to have larger average *SEP* than regions where annual peak discharges are less variable. For this reason, *EYR* probably is a better indicator of overall regression reliability among regions. However, calculation of *EYR* also is based on the assumption that the annual peak discharges at a site can be described by the log-Pearson Type III probability distribution. As previously described, the log-Pearson Type III distribution is not generally applicable in the Northwest Region because annual floods result from two different causes (mixed populations). Accordingly, values of *EYR* are not shown in table 4 for the Northwest Region, and, therefore, values of average *SEP* are used to make most comparisons among regions.

Although the average *SEP* provides an indication of the average reliability of a regression equation within a region, the reliability of a particular estimate rather than the average reliability of all estimates is more useful. Calculation of the standard error of prediction for a particular estimate (SEP_i) is described in the Appendix.

Once the SEP_i has been calculated for a particular estimate, the SEP_i can further be used to calculate a confidence interval for the estimate using the following equation:

$$CI_{i,a} = \pm\, t_{(a/2,n-p)}\,(SEP_i), \quad (6)$$

where

$CI_{i,a}$ is the confidence interval, in log units, for an estimate at site *i* for a confidence level of *a*,

$t_{(a/2,n-p)}$ is the Student's *t* value for a confidence level of *100*(*1-a*) percent and (*n-p+ 1*) degrees of freedom, and

n and *p* are the number of sites used in the regression equation and the number of independent variables used in the regression equation, respectively.

If the discharge estimate at site *i*, $Q_{T,i}$ is converted to a logarithm, log $Q_{T,i}$, the confidence interval can be expressed in units of discharge using the following equation:

$$10^{(\log Q_{T,i} - CI_{cl,i})} \leq \text{true} Q_{T,i} \leq 10^{(\log Q_{T,i} + CI_{cl,i})}, \quad (7)$$

where true $Q_{T,i}$ is the true or actual value of the *T*-year flood at site *i*.

For example, assume an estimated Q_T at site *i* of 200 cubic feet per second has an $SEP_i = 0.225$ log units. Further assume that the estimate is in a region where the number of sites used in the regression analysis is 40 and the number of independent variables in the regression equation is 2. The 90-percent confidence interval for this estimate would be computed as follows:

First, from a table in any statistics textbook, the value of Student's *t* for $a/2 = 0.05$ and $(n\text{-}p) + 1 = 39$ is determined to be 1.68.

Then, from equation 6,

$CI_{i,ca} = \pm 1.68\ (0.225),$
$= \pm\ 0.378.$

Then, from equation 7,

$10^{\log 200 - 0.378} \leq \text{true } Q_{T,i} \leq 10^{\log 200 + 0.378},$

$10^{2.301 - 0.378} \leq \text{true } Q_{T,i} \leq 10^{2.301 + 0.378},$

$10^{1.923} \leq \text{true } Q_{T,i} \leq 10^{2.679},$

84 cubic feet per second ≤ true $Q_{T,i}$ ≤ 480 cubic feet per second.

Table 5 shows the range of (*n-p*) among the three regression methods (basin characteristics, active-channel width, and bankfull width) in each region. This small variation in (*n-p*) among methods results in no change to the Student's *t* value for a confidence interval of 90 percent. Thus, values of Student's *t* for a confidence interval of 90 percent within any region can be determined from table 5 and used for any of the different regression methods.

Table 5. Student's *t* for a confidence interval of 90 percent for different regions

[Abbreviations: *n*, number of stations used in the regression analysis; *p*, number of explanatory (independent) variables used in the regression analysis]

Region	Range of (*n-p*)	Student's *t* for 90-percent confidence interval
West	89-93	1.66
Northwest	28-33	1.69
Northwest Foothills	21-23	1.73
Northeast Plains	38-55	1.68
East-Central Plains	76-83	1.66
Southeast Plains	59-67	1.67
Upper Yellowstone-Central Mountain	81-90	1.66
Southwest	41-42	1.68

Within each region, the average *SEP* values (in percent) generally decrease with increasing recurrence interval (T) from $T = 2$ years to about $T = 25$ years (table 4). From $T = 25$ years to $T = 500$ years, the average *SEP* values increase. For all regions, the highest *SEP* is for the extreme recurrence intervals ($T = 2$ or $T = 500$ years), and the lowest *SEP* is for the mid-range recurrence intervals ($T = 5$, 10, 25, or 50 years). The West Region had average *SEP* values that generally were smaller than those for all other regions except the Northwest Region. The Northwest Region had the smallest values of *SEP* for all recurrence intervals. The smallest value of average *SEP* for any Q_T in any region was 37.4 percent for estimation of Q_{50} in the Northwest Region, and the largest value of average *SEP* for any Q_T in any region was 134.1 percent for estimation of Q_2 in the Southeast Plains Region.

The *EYR* increased with increasing recurrence interval to $T = 100$ years in all regions except the Northwest Regions where *EYR* was indeterminate. For the Northwest Foothills and East-Central Plains Regions, the maximum *EYR* was for a recurrence interval of $T = 50$ years or $T = 100$ years. For all other regions, the maximum *EYR* was for a recurrence interval of $T = 200$ or $T = 500$ years. Among regions, the Northwest Foothills and Upper Yellowstone-Central Mountain Regions had the largest *EYR* for recurrence intervals greater than about 5 years and the West Region had the smallest *EYR* for all recurrence intervals. Overall, the EYR ranged from 0.9 year for the equations for estimation of Q_2 in the West and Southwest Regions to 23.8 years for the equations for estimation of Q_{50} and Q_{100} in the Northwest Foothills Region.

Multiple regression equations may not be reliable if the values of any explanatory variables are outside the range of values used to develop the equations. The range of values for each basin characteristic (explanatory variable) can be used as a guide for deciding when the equations may not be applicable (table 6). Regression estimates also may not be reliable for some combinations of values of explanatory variables that define a location far from the center of the joint distribution of all values of the explanatory variables even though each value is within the ranges shown in table 6. The $\mathbf{x_i}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\mathbf{X})^{-1}\mathbf{x_i}$ matrix for OLS regression and the $\mathbf{x_i}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\Lambda^{-1}\mathbf{X})^{-1}\mathbf{x_i}$ matrix for GLS regression, terms that are described in the Appendix and used for the calculation of SEP_i, provide a measure of how far a set of particular explanatory variables are from the center of the joint distribution of all values of the explanatory variables. If values of these matrices are greater than about $2p/n$, where p and n are the number of explanatory variables and number of data points in the regression, respectively, the regression result may not be reliable.

Table 6. Range of values of basin characteristics used to develop regression equations

[Abbreviations: *A*, drainage area, in square miles; *E*, mean basin elevation, in feet; E_{6000}, percentage of basin above 6,000 feet in elevation; *F*, percentage of basin covered by forest; *P*, mean annual precipitation, in inches; Min, minimum value; Max, maximum value. Symbol: --, not applicable]

Region	*A*		*E*		E_{6000}		*F*		*P*	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
West	0.86	2,378	--	--	--	--	15	100	12	79
Northwest	.14	1,548	--	--	--	--	--	--	15	95
Northwest Foothills	.25	1,041	--	--	--	--	--	--	--	--
Northeast Plains	.11	1,208	2,060	4,860	--	--	--	--	--	--
East-Central Plains	.22	2,447	2,090	4,250	--	--	--	--	--	--
Southeast Plains	.14	1,974	--	--	--	--	0	67	--	--
Upper Yellowstone-Central Mountain	.47	2,032	--	--	0	100	--	--	--	--
Southwest	.39	2,476	--	--	--	--	0	100	--	--

Channel-Width Regression Analysis

Previous studies in Montana (Parrett and others, 1983; Parrett and others, 1987) have shown that active-channel width and bankfull width are correlated with annual peak discharges (Q_T) and that regression equations based on these measures of channel width are comparable in reliability to regression equations based on basin characteristics.

Channel width generally reflects the prevailing streamflow and sediment-transport conditions at a site. Thus, a peak-flow magnitude estimated using a channel-width equation may be more reliable than a peak-flow magnitude estimated using a basin-characteristics equation, regardless of the average *SEP* values, if the basin characteristics do not include variables that may uniquely affect flooding at a particular site.

Channel widths, which are formed by the flood regimen at a site, are unlike basin characteristics which, acting together in a complex fashion, result in the flood regimen at a site. Thus, basin characteristics and channel widths can both help to explain, through regression analysis, the variation in Q_T throughout Montana, but basin characteristics can be considered causative factors of flooding, whereas channel widths typically are resultant effects of flooding.

The active-channel width used in this report has been described by Osterkamp and Hedman (1977, p. 256) as the channel width formed by prevailing discharges. It is a short-term geomorphic feature whose upper limit is defined by a break in the relatively steep bank of the active channel to a more gently sloping surface beyond the channel edge. The break in slope normally coincides with the lower limit of permanent vegetation.

The bankfull width used in this report has been described by Riggs (1974) as the horizontal distance between the tops of the banks of the main channel. The top of the banks is defined as the place where the flood plain and the channel intersect and is usually distinguished by an abrupt change in slope from near-vertical to horizontal. The reference level at bankfull width is almost the same as the bankfull stage for perennial streams described by Wolman (1955) as the stage at which overbank flooding occurs.

A schematic sketch of a typical stream cross section with the locations of the active-channel and bankfull widths identified is shown in figure 7. A sketch of a plan view of a typical alluvial stream indicating the best location for measuring either active-channel or bankfull width is shown in figure 8.

At most gaged sites used in this report, suitable channel reaches for measuring both active-channel and bankfull width were found at or near the gaging stations. Each width was measured at 2-3 locations separated by at least one

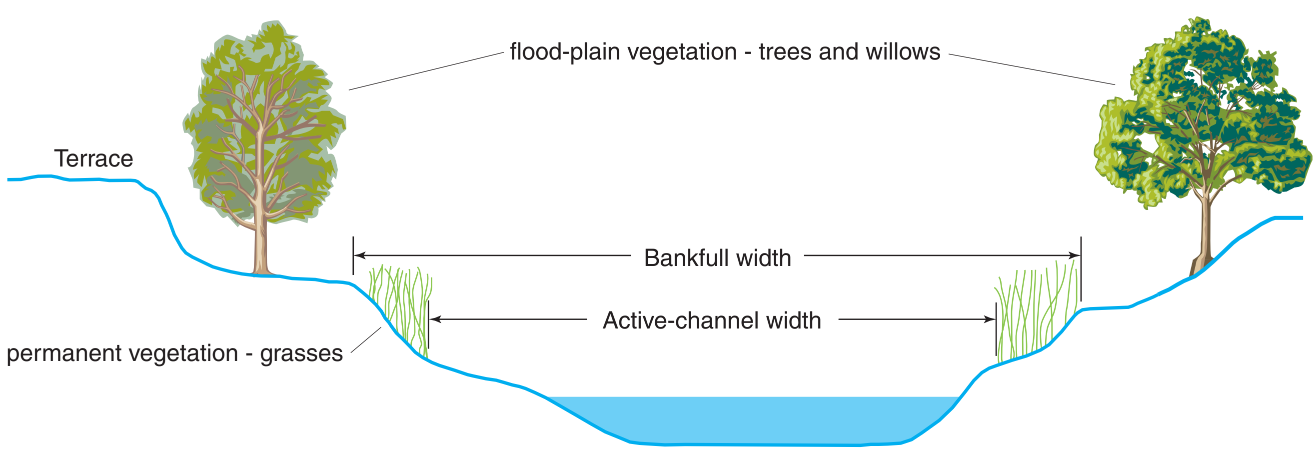


Figure 7. Typical stream cross section showing active-channel and bankfull widths.

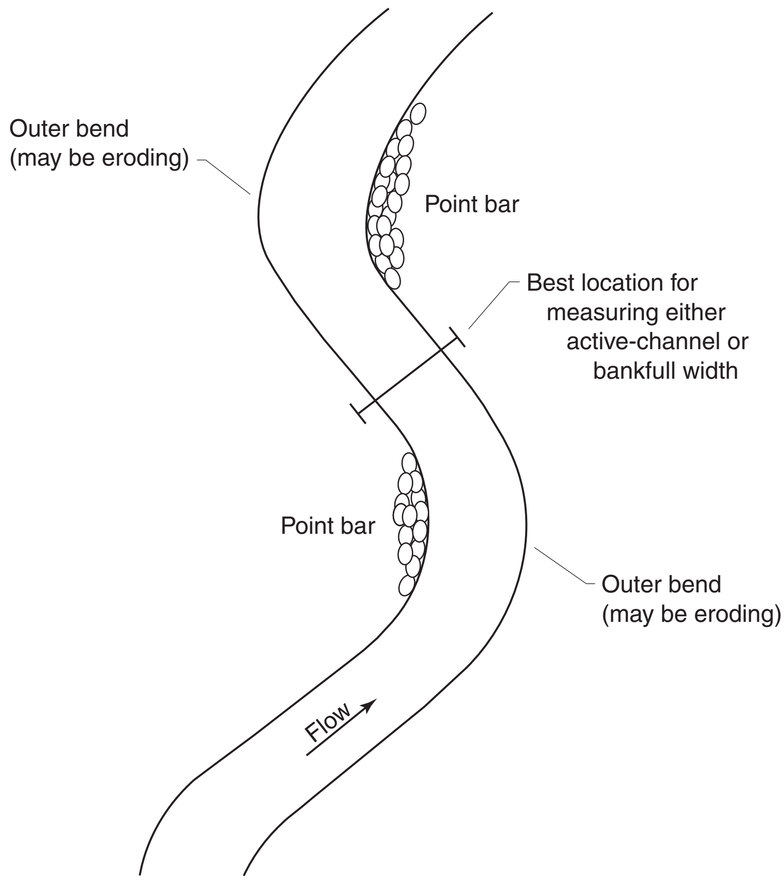


Figure 8. Typical alluvial stream (plan view) showing best location for measuring channel width.

channel width, and the separate measurements were averaged to yield a single value for each channel feature. At some locations, one or both of the features could not be identified. On most perennial streams, active-channel width commonly was an easier feature to define than bankfull width. Conversely, on many ephemeral stream channels, bankfull width was easier to define than active-channel width. Thus, the number of sites used in each channel-width regression analysis varied slightly from each other and from the number used in the basin- characteristics regression analysis.

As previously described, simple linear regression equations relating logarithms of Q_T to logarithms of active-channel and bankfull widths were developed for each of the eight regions in Montana. For the Northwest Region, OLS regression was used because a mixed-population flood-frequency analysis was required for this region. For all other regions, GLS regression was used. The results of the regression analysis using active-channel width are shown in table 7 at the back of the report, and the results of the regression analysis using bankfull width are shown in table 8 at the back of the report.

Tables 7 and 8 include data for measurement error variance (due to width measurement error) not presented for the regression equations based on basin characteristics. Because basin characteristics are all measured from maps, the error associated with the measurements are considered to be generally small and insignificant so long as the same scale maps are used. However, measurement of channel width requires a field visit to the site, selection of a proper channel reach for width measurement, and identification and measurement of the width feature. Thus, measurements of channel width by different observers are likely to have significantly larger errors than measurements of basin characteristics. Wahl (1977) determined that the measurement error variance in the logarithm of estimated discharge resulting from width measurement error alone could be related to the regression coefficient as shown in the following equations for active-channel width (8) and bankfull width (9):

$$\text{Measurement error variance due to active-channel width } (W_{ac}) \text{ measurement error} = 0.00744\, a^2, \tag{8}$$

$$\text{Measurement error variance due to bankfull-width } (W_{bf}) \text{ measurement error} = 0.0097\, a^2, \tag{9}$$

where a is the regression coefficient in the regression equation relating Q_T to channel width.

The channel-width measurement errors determined by Wahl (1977) are considered to be reasonably representative of measurement errors likely to be found from application of the regression equations in tables 7 and 8 to ungaged sites in Montana. Accordingly, equations 8 and 9 were used to estimate the measurement error variance due to width measurement errors shown in tables 7 and 8, and the average *SEP* was calculated as the square root of the sums of the model error variance, the sampling error variance, and the measurement error variance due to width measurement error.

The SEP_i for a particular estimate based on active-channel or bankfull width is calculated the same way as the SEP_i based on basin characteristics (appendix). Likewise, equation 6, previously derived for calculation of confidence intervals for particular estimates, is applicable to particular estimates made from the regression equations based on channel width. The regression equations based on channel width may not be reliable when the measured widths are outside the ranges shown in table 9.

The values of average *SEP* for both active-channel width and bankfull-width regression equations (tables 7 and 8) in each region generally decreased with increasing recurrence intervals up to about T = 10 or 25 years, then increased with increasing recurrence intervals. The smallest average *SEP* for equations based on active-channel width was 57.2 percent for estimation of Q_5 in the Southwest Region, and the largest value of average *SEP* for active-channel width equations was 141.3 percent for estimation of Q_{500} in the Northwest Foothills Region. For equations based on bankfull width, the smallest average *SEP* was 63.1 percent for estimation of Q_5 in the Southwest Region, and the largest value of average *SEP* was 155.5 percent for estimation of Q_{500} in the Northeast Plains Region. In most regions, values of *EYR* increased with increasing recurrence intervals up to T = 500 years. In the Southeast and Southwest Regions, *EYR* generally increased with increasing recurrence interval up to about T = 50 or 100 years, then decreased slightly. *EYR* could not be determined for the Northwest Region for any of the estimation equations because of the mixed-population flood-frequency analysis required for that region.

Table 9. Range of channel widths used to develop regression equations

[Abbreviations: W_{ac}, width of active channel, in feet; W_{bf}, width of bankfull channel, in feet; min, minimum value; max, maximum value]

Region	W_{ac}		W_{bf}	
	min	**max**	**min**	**max**
West	3.0	165	5.0	190
Northwest	2.5	225	4.5	270
Northwest Foothills	1.0	88	3.5	108
Northeast Plains	1.5	51	2.8	59
East-Central Plains	2.0	52	3.5	85
Southeast Plains	1.5	119	3.8	131
Upper Yellowstone-Central Mountain	1.0	150	2.5	170
Southwest	1.8	223	3.5	260

To compare the overall reliability of the different estimation equations among the regions, the average *SEP* values were used. For most recurrence intervals in most regions (tables 4, 7, and 8), the smallest average *SEP* values were provided by the basin-characteristics equations, followed by the active-channel width equations and then the bankfull-width equations. However, in the Southeast Plains Region, the smallest average *SEP* values were provided by the active-channel width equations, followed by the bankfull-width equations and then the basin-characteristics equations. In the Upper Yellowstone-Central Mountain and Southwest Regions, the average *SEP* values were smaller for both sets of channel-width equations than for the basin-characteristics equations for some recurrence intervals and larger for other recurrence intervals.

Limitations of Regression Equations

As previously described, regression equations based on basin characteristics may not be reliable if the values of the characteristics at a particular ungaged site define a location that is far removed from the center of the joint distribution of all values of the explanatory variables. Similarly, a regression equation based on channel width may not be reliable if the measured channel width at a particular ungaged site is outside the range of widths used to define the regression equations (table 9).

The regression equations also may not be reliable if an ungaged site of interest is located in a different region from the region where the stream originates. For streams that cross regional boundaries, the regression equation for each region can be applied separately, using basin characteristics or channel-width data at the site. The separate results then can be weighted in accordance with the proportion of drainage area in each region. For example, if 40 percent of the drainage area at an ungaged site is in the upstream region and 60 percent is in the downstream region, the estimate based on the equation for the upstream region can be multiplied by 40 percent and added to 60 percent of the estimate based on the equation for the downstream region. The standard error of prediction for such a weighted estimate also can be approximated by using the same weighting procedure based on drainage area. When the upstream part of a drainage basin is in the Northwest Region and the downstream part of the drainage basin is in the Northwest Foothills Region, weighting the separately calculated flood discharges in proportion to drainage area in each region is appropriate only for floods having recurrence intervals of 25 years or less. Flood records on some streams in the Northwest Foothills Region that originate in the Northwest Region indicate that large flood discharges (recurrence intervals greater than about 25 years) may actually decrease in the downstream direction as a result of valley (flood plain) storage effects. Determining whether large flood discharges from drainage areas in the Northwest Region increase, decrease, or stay the same with increasing drainage area in the Northwest Foothills Region requires careful study of the individual stream in question.

Regression equations also may not be valid where unique, local geohydrologic or climatic features affect floods. As previously described, channel-width equations may be more reliable for these sites than equations based on basin characteristics. On the other hand, channel-width equations for flood estimation may not be reliable for unique geologic conditions such as bedrock channels or streams where the channel has recently changed as a result of large floods. Designers and hydrologists required to make flood estimates at ungaged sites need to be aware of unique or recently changed conditions. In some instances, additional study or site-specific knowledge gleaned from site visits or conversations with long-time residents may help to determine which flood-estimation methods are applicable.

Comparison of Regional Relations with those from Previous Study

The equations presented in this report are considered to be an improvement over equations in the previous regional flood-frequency study by the USGS (Omang, 1992) primarily because of the additional peak-flow record available for the current study. Nevertheless, the standard errors of prediction and equivalent years of record reported by Omang (1992) generally were better than those shown for the basin-characteristics equations in this report. Accordingly, a comparison between the equations previously developed by Omang (1992) and those in this report was made. The comparison was made by using each set of equations to calculate the 100-year flood for all gaging-station sites used in the current study for the development of regional equations and then computing differences (residuals) between logs of calculated values and logs of values from the flood-frequency curves based on recorded flood data. The standard deviation of the residuals, a measure of reliability analogous to the calculated average standard error of prediction based on regression diagnostics, was calculated for each set of equations for each region. The results, shown in table 10 and displayed graphically in figure 9, indicate that the basin-characteristics equations in this report were slightly better (smaller standard deviation of residuals) than the equations previously developed by Omang (1992) in 5 of 8 regions. The two sets of equations were about equal in one region (East-Central Plains), and the equations developed by Omang were slightly better in the West Region and the Upper Yellowstone-Central Mountain Region. Given the small difference between the two sets of equations, future regional flood-frequency studies are not expected to offer significant improvement to the basin-characteristics equations in this report unless new basin characteristics are determined for gaged sites or new and more reliable regression methods become available.

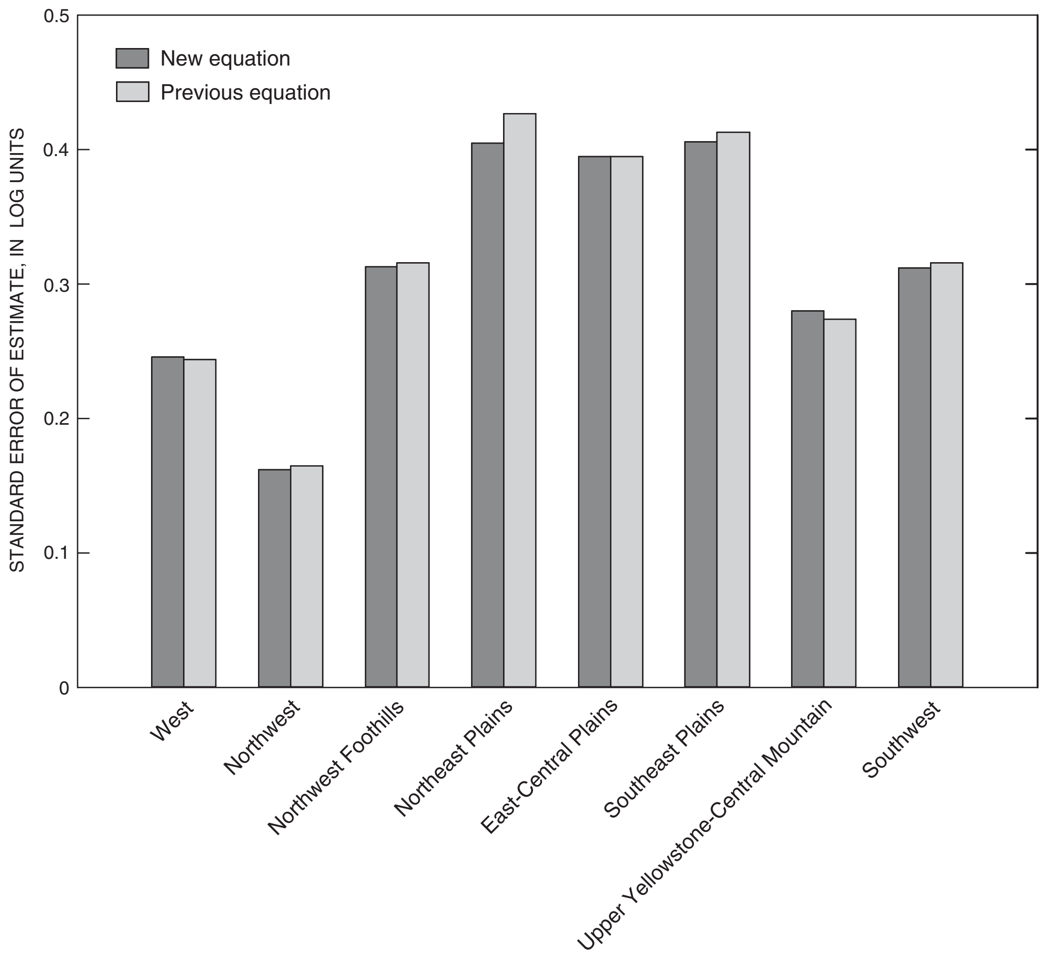


Figure 9. Comparison of new basin-characteristics equations with equations in previous U.S. Geological Survey report (Omang, 1992).

Table 10. Comparison of results for estimation of 100-year flood from new basin-characteristics equations with those from previous equations (Omang, 1992)

[Standard deviation refers to the differences (residuals) between 100-year floods based on recorded data and 100-year floods estimated from basin-characteristics equation]

Region	Standard deviation, in log units	
	New Equations	Previous Equations
West	0.246	0.244
Northwest	.162	.165
Northwest Foothills	.313	.316
Northeast Plains	.405	.427
East-Central Plains	.395	.395
Southeast Plains	.406	.413
Upper Yellowstone-Central Mountain	.280	.274
Southwest	.312	.316

Despite the relatively small differences in the two sets of basin-characteristics regression equations, the methods based on channel-width and for weighting results from basin-characteristics equations with results from channel-width equations (described in the “Weighted Regression Estimates” section of this report) offer significant improvement to methods previously reported (Omang, 1992). In addition, the methods for estimating the reliability of a particular estimate at an ungaged site are a significant improvement to previously reported measures of estimation reliability.

Maximum Recorded Floods and Envelope Lines

Maximum recorded floods and the corresponding drainage areas for each gaging station used for regression analyses within each region are displayed in figures 10 and 11. Envelope lines encompassing the maximum known floods in the conterminous United States (Crippen and Bue, 1977) and the maximum recorded floods in each region also are shown on figures 10 and 11. Regression lines relating the 100-year flood to drainage area also are shown on figures 10 and 11. The envelope lines indicate how the maximum floods experienced in each region compare to the maximum known floods in the Nation. The differences between the regional envelope lines and the 100-year flood regression line indicate the relative size of the largest recorded floods.

For example, the regional envelope line that plots closest to the national envelope line for drainage areas greater than about 50 mi^2 is that for the Northwest Region. Large general storms have produced large floods in this region, as described earlier. The regional envelope line for the Northwest Region also is farthest from the regional regression line for drainage areas of about 100 mi^2, indicating that the recorded maximum floods have been the largest, on a relative basis, for basins of that size.

Similarly, figures 10 and 11 indicate that the regional envelope line for smaller drainage areas (less than about 10 mi^2) that plots closest to the National envelope line is that for the Southeast Plains Region. The regional envelope line is farthest from the regional regression line for a drainage area of about 2 mi^2 indicating that the recorded maximum floods have been the largest, on a relative basis, for small basins. The Southeast Plains Region is subject to intense thunderstorms, which generally produce large flooding from small basins.

Figures 10 and 11 can be used to assess the reasonableness of flood estimates based on the methods described in this report or other methods. For example, a 100-year flood estimate that plots well above or well below the general trend of the data indicated by the regional maximum recorded floods and the regional regression line might be unreasonable. Alternative methods for flood estimation may need to be considered in those instances.

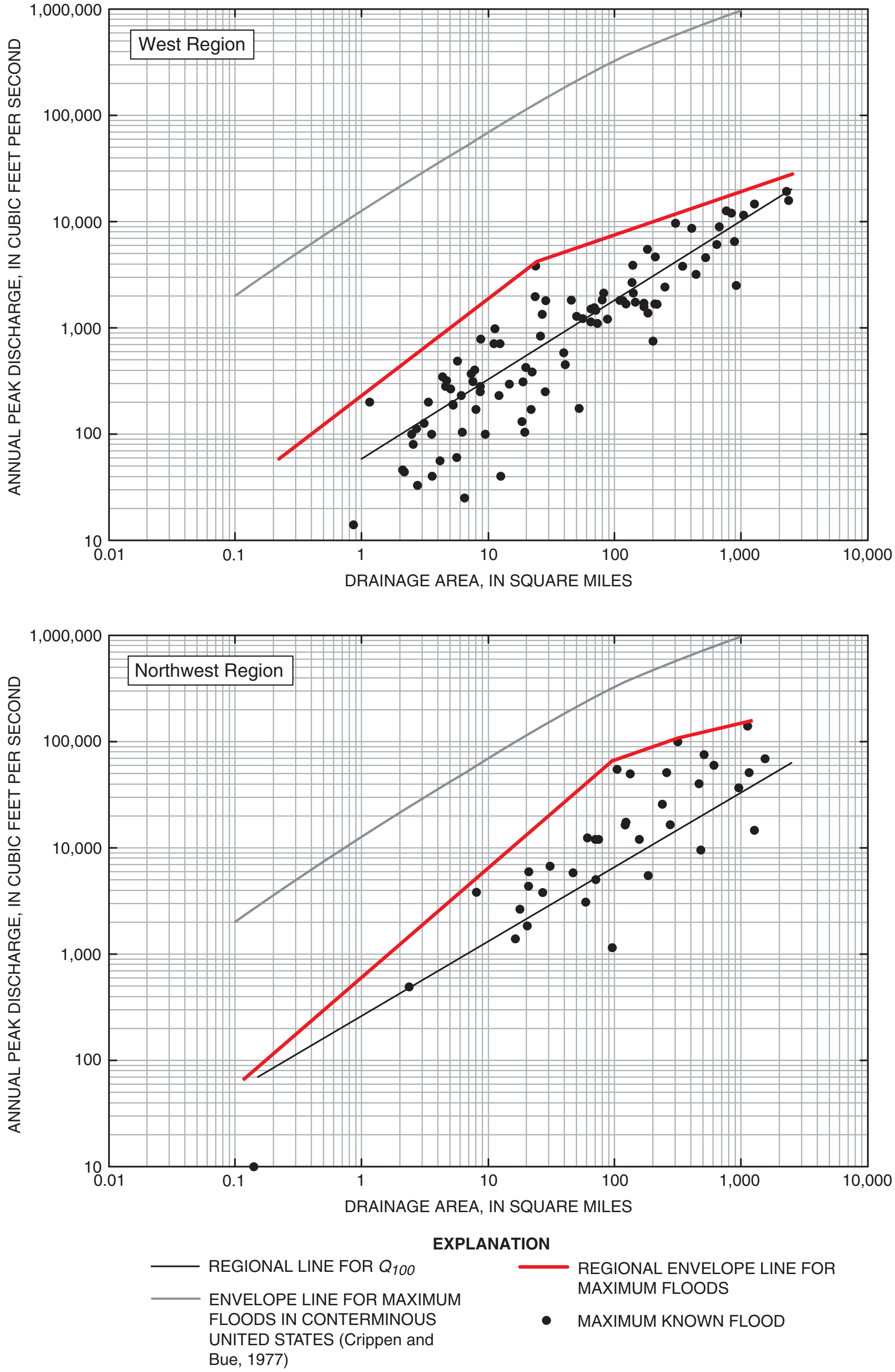


Figure 10. Maximum known floods, regional and national envelope lines, and regression lines relating 100-year flood (Q_{100}) to drainage area, West, Northwest, Northwest Foothills, and Northeast Plains Regions, Montana.

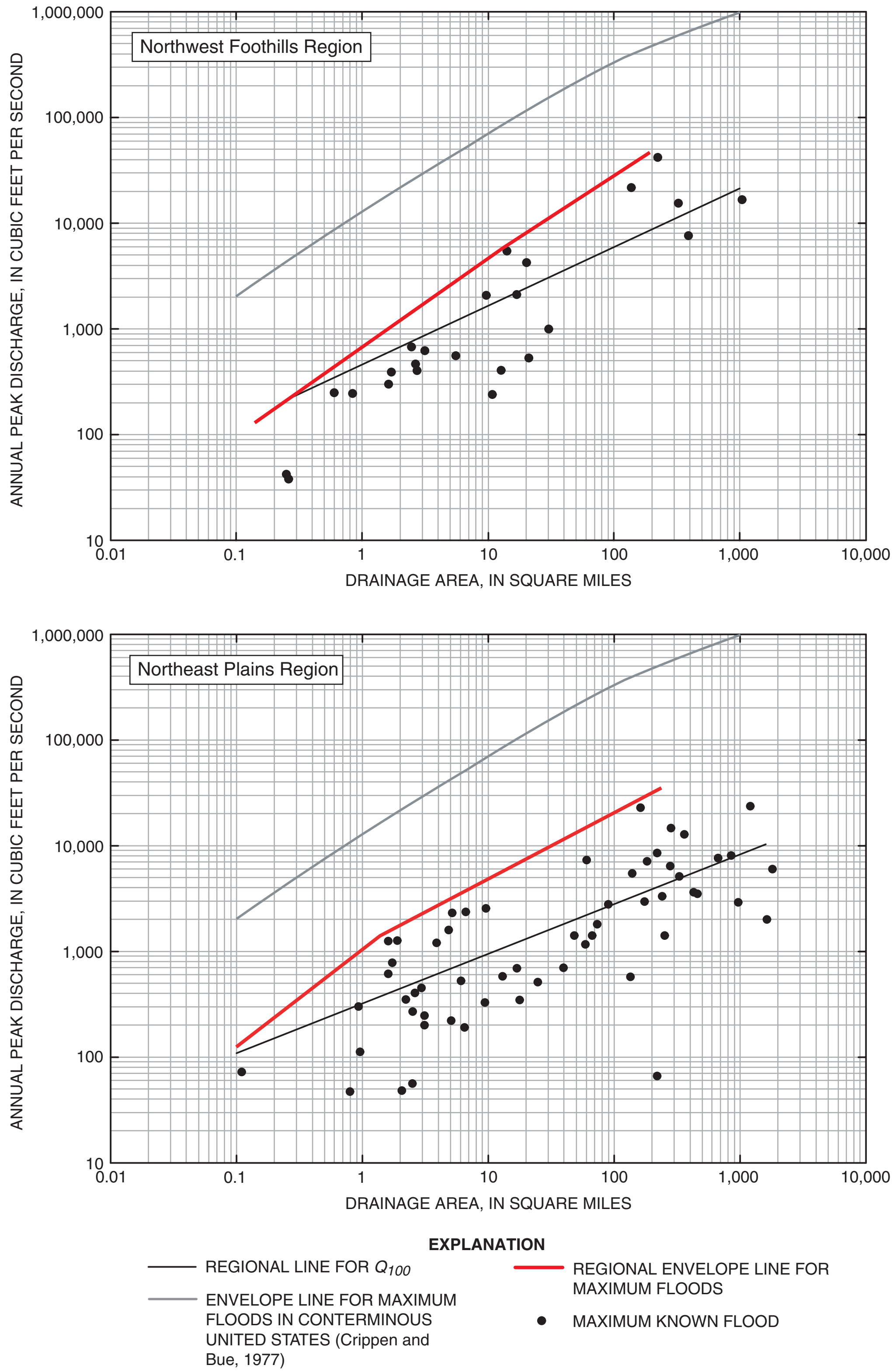


Figure 10. Maximum known floods, regional and national envelope lines, and regression lines relating 100-year flood (Q_{100}) to drainage area, West, Northwest, Northwest Foothills, and Northeast Plains Regions, Montana (Continued).

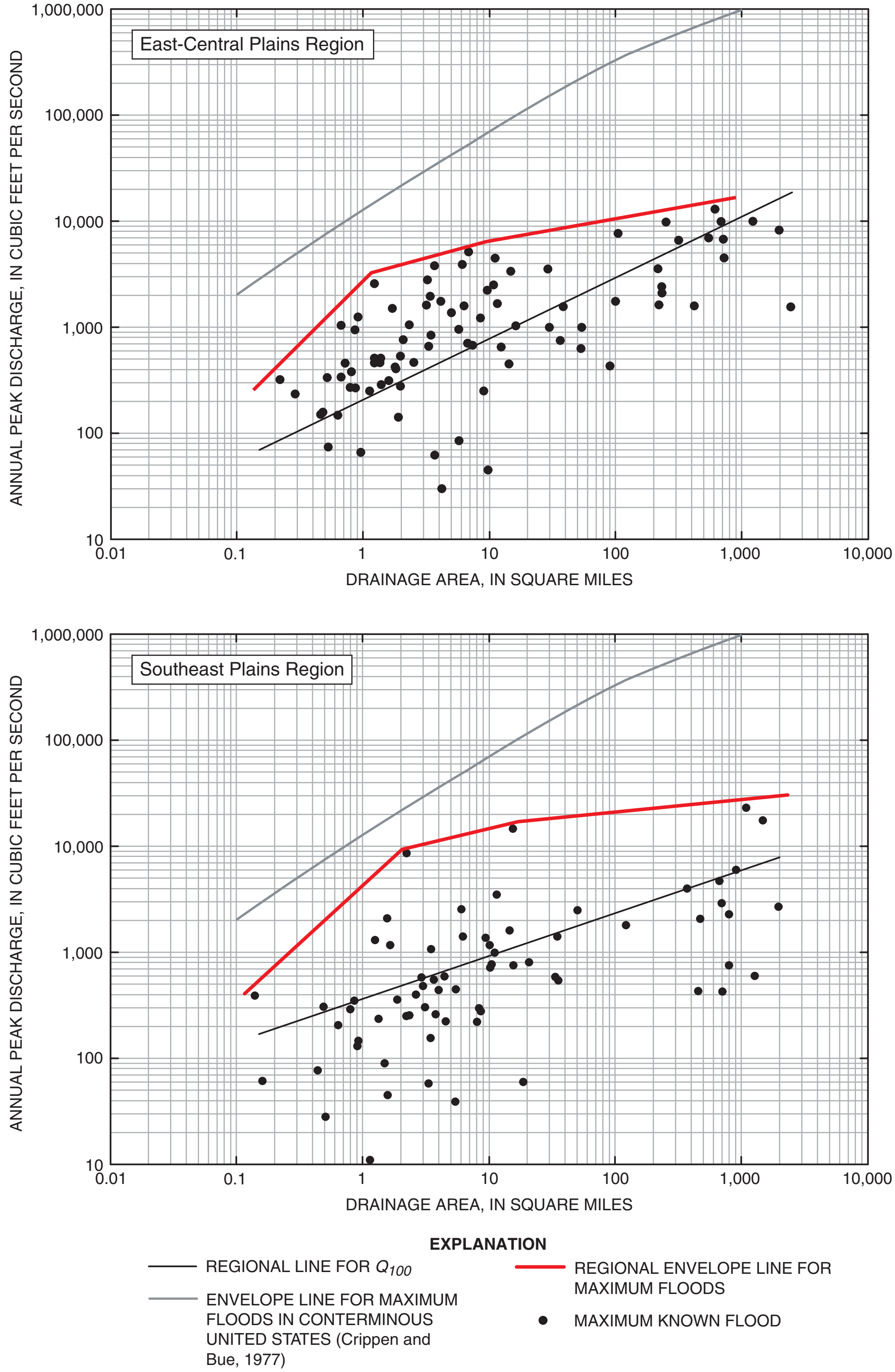


Figure 11. Maximum known floods, regional and national envelope lines, and regression lines relating 100-year flood (Q_{100}) to drainage area, East-Central Plains, Southeast Plains, Upper Yellowstone-Central Mountain, and Southwest Regions, Montana.

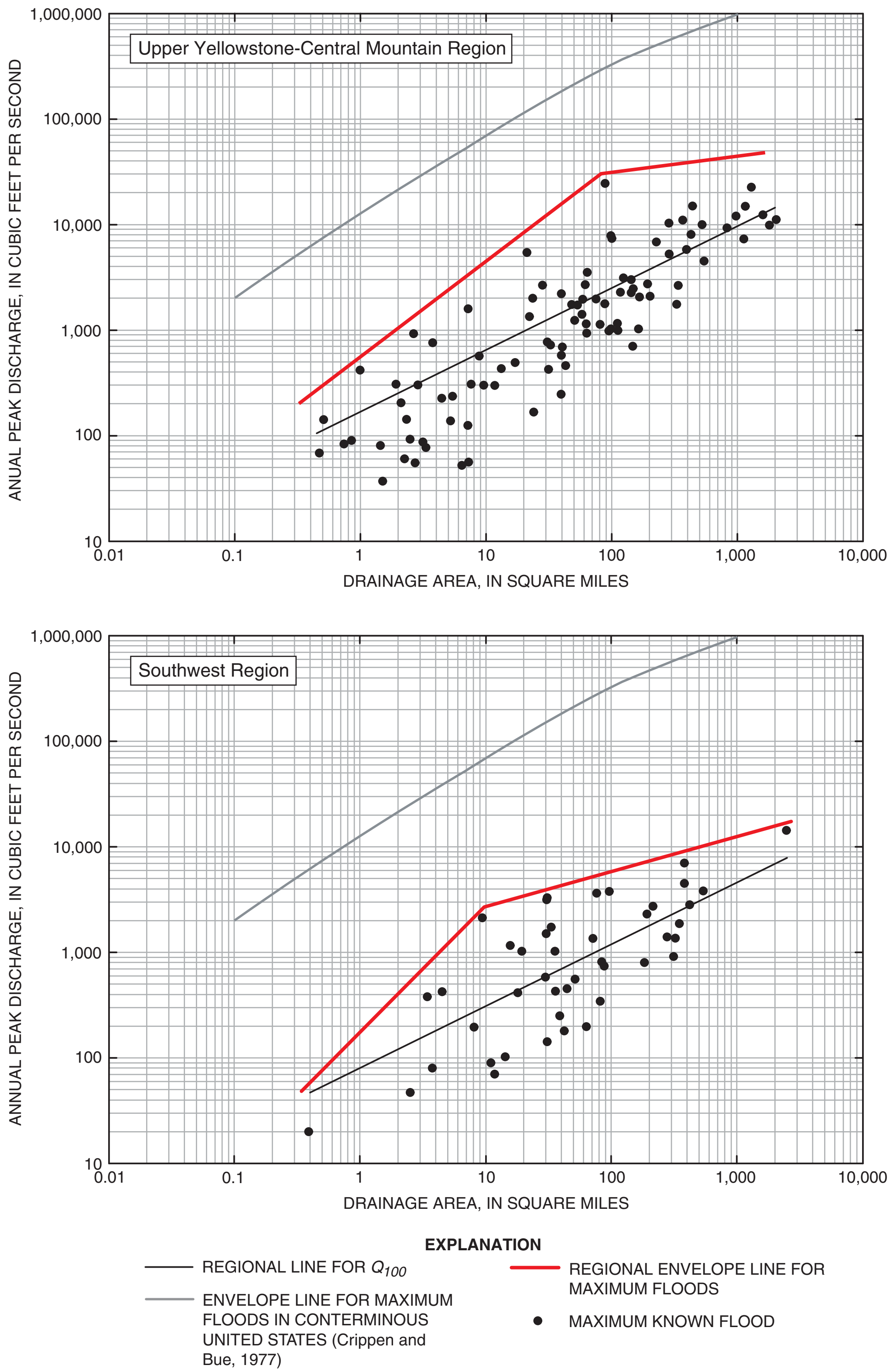


Figure 11. Maximum known floods, regional and national envelope lines, and regression lines relating 100-year flood (Q_{100}) to drainage area, East-Central Plains, Southeast Plains, Upper Yellowstone-Central Mountain, and Southwest Regions, Montana (Continued).

Weighted Regression Estimates

Regression equations based on basin characteristics and regression equations based on channel width provide different methods for estimating *T*-year floods. When different methods for flow estimation are independent, results from each method can be weighted inversely proportional to their error variances and averaged to produce weighted estimates that are more reliable than the results from the individual methods. Even when estimates from different methods are not independent, the following equations (E.J. Gilroy, formerly with the U.S. Geological Survey, written commun., 1987) can be used to determine a weighted estimate with a minimum error variance that is at least as small as that from any of the individual methods:

$$Z = a1 \cdot x1 + a2 \cdot x2 + a3 \cdot x3\,, \qquad (10)$$

where

- Z is the logarithm of an unbiased, weighted estimate of some *T*-year flood;
- $a1$, $a2$, and $a3$ are weights that result in a minimum-variance, unbiased linear combination of $x1$, $x2$, and $x3$; and
- $x1$, $x2$, and $x3$ are logarithms of estimates of the *T*-year flood from three different methods.

Equations for the weights are as follows:

$$a1 = [C\,(SEP_3^{\,2} - S_{1,3}) - B\,(SEP_3^{\,2} - S_{2,3})]/(A\,C - B^2), \qquad (11)$$

$$a2 = [A\,(SEP_3^{\,2} - S_{2,3}) - B\,(SEP_3^{\,2} - S_{1,3})]/(A\,C - B^2), \qquad (12)$$

$$a3 = 1 - a1 - a2, \qquad (13)$$

where

SEP_1, SEP_2, and SEP_3 are the standard errors of prediction of the three different estimation methods,

- C = $SEP_2^{\,2} + SEP_3^{\,2} - 2\,S_{2,3}$,
- $S_{1,2}$ = $r_{1,2}\,(SEP_1 \cdot SEP_2)$ and is the covariance of methods 1 and 2,
- $S_{1,3}$ = $r_{1,3}\,(SEP_1 \cdot SEP_3)$ and is the covariance of methods 1 and 3,
- $S_{2,3}$ = $r_{2,3}\,(SEP_2 \cdot SEP_3)$ and is the covariance of methods 2 and 3,
- $r_{x,y}$ = the cross-correlation coefficient between estimates from methods *x* and *y*,
- A = $SEP_1^{\,2} + SEP_3^{\,2} - 2\,S_{1,3}$, and
- B = $SEP_3^{\,2} + S_{1,2} - S_{1,3} - S_{2,3}$.

The cross-correlation coefficient ($r_{x,y}$)is computed from the following equation:

$$r_{x,y} = \frac{\sum_{i=1}^{N} x_i y_i - N\overline{xy}}{(N-1)S_x S_y}\,, \qquad (14)$$

where

$r_{x,y}$	is the correlation coefficient, ranging from –1.0 to 1.0, between the residuals (differences between Q_T from the regression equation and Q_T from the gaged record at all gaged sites in a region) from method *x* and method *y*,
N	is the total number of sample residuals (total number of gaged sites used in the analysis),
x_i and y_i	are the *i*th residuals from methods *x* and *y*,
$\bar{x}$ and $\bar{y}$	are the mean values of the residuals from methods *x* and *y*, and
S_x and S_y	are the standard deviations of the residuals from methods *x* and *y*.

The cross-correlation coefficient calculated from equation 14 provides a measure of the independence of two methods for flow estimation. A value of $r_{x,y}$ equal to 0.0 indicates that the two estimates are totally independent. Conversely, a value of $r_{x,y}$ equal to $\pm$ 1.0 indicates that the two estimates are not independent. Table 11 shows the cross-correlation coefficients in each region for all three methods of flow estimation. As indicated by table 11, estimates made from basin-characteristics equations are somewhat more independent from estimates made from either active-channel width or bankfull-width equations than estimates from either of the two width equations are from each other.

The estimated standard error of prediction of the weighted estimate, SEP_z, is calculated as follows:

$$SEP_z = [(a1 \cdot SEP_1)^2 + (a2 \cdot SEP_2)^2 + (1 - a1 - a2)^2\, SEP_3^2 + 2\, a1 \cdot a2 \cdot S_{1,2} + 2\, a1\, (1 - a1 - a2)\, S_{1,3} + 2\, a2\, (1 - a1 - a2)\, S_{2,3}]^{0.5}, \qquad (15)$$

where all terms have been previously defined.

If only two of the estimating methods are used, the following two equations for computing weights and standard error of prediction are applicable:

$$Z = a1 \cdot x1 + a2 \cdot x2, \qquad (16)$$

where $a1 = (SEP_2^2 - S_{1,2})/(SEP_1^2 + SEP_2^2 - 2\, S_{1,2})$, and

$a2 = (SEP_1^2 - S_{1,2})/(SEP_1^2 + SEP_2^2 - 2\, S_{1,2})$; and

$$SEP_z = \sqrt{(SEP_1^2\, SEP_2^2 - S_{1,2}^2)/(SEP_1^2 + SEP_2^2 - 2\, S_{1,2})}\,. \qquad (17)$$

The above equations were used to calculate weights and average standard errors of prediction for all combinations of the three estimation methods based on regression equations. The results of those calculations are listed in table 12 at the back of the report and graphically displayed on figures 12 and 13. The weights for the equations based on basin characteristics generally were larger than the weights for either set of channel-width equations. In the Southeast Plains Region, weights for the equations based on active-channel width were larger than those for the equations based on basin characteristics or the equations based on bankfull width. Weighting of estimates from basin-characteristics equations with estimates from either active-channel width equations or bankfull-width equations reduces the average *SEP* for all recurrence intervals in the West Region, the Southeast Plains Region, and the Southwest Region. Weighting estimates in the Northeast Plains Region, the East-Central Plains Region, and the Upper Yellowstone-Central Mountain Region reduces the average *SEP* for most, but not all, recurrence intervals. Weighting estimates provides little or no reduction in average *SEP* over average *SEP* from basin-characteristics equations alone in the Northwest Region and in the Northwest Foothills Region. Only in the Upper Yellowstone-Central Mountain Region for recurrence intervals up to $T = 25$ years did weighting all three methods provide a significant improvement in *SEP* over weighting either one of the channel-width equations with the basin-characteristics equations.

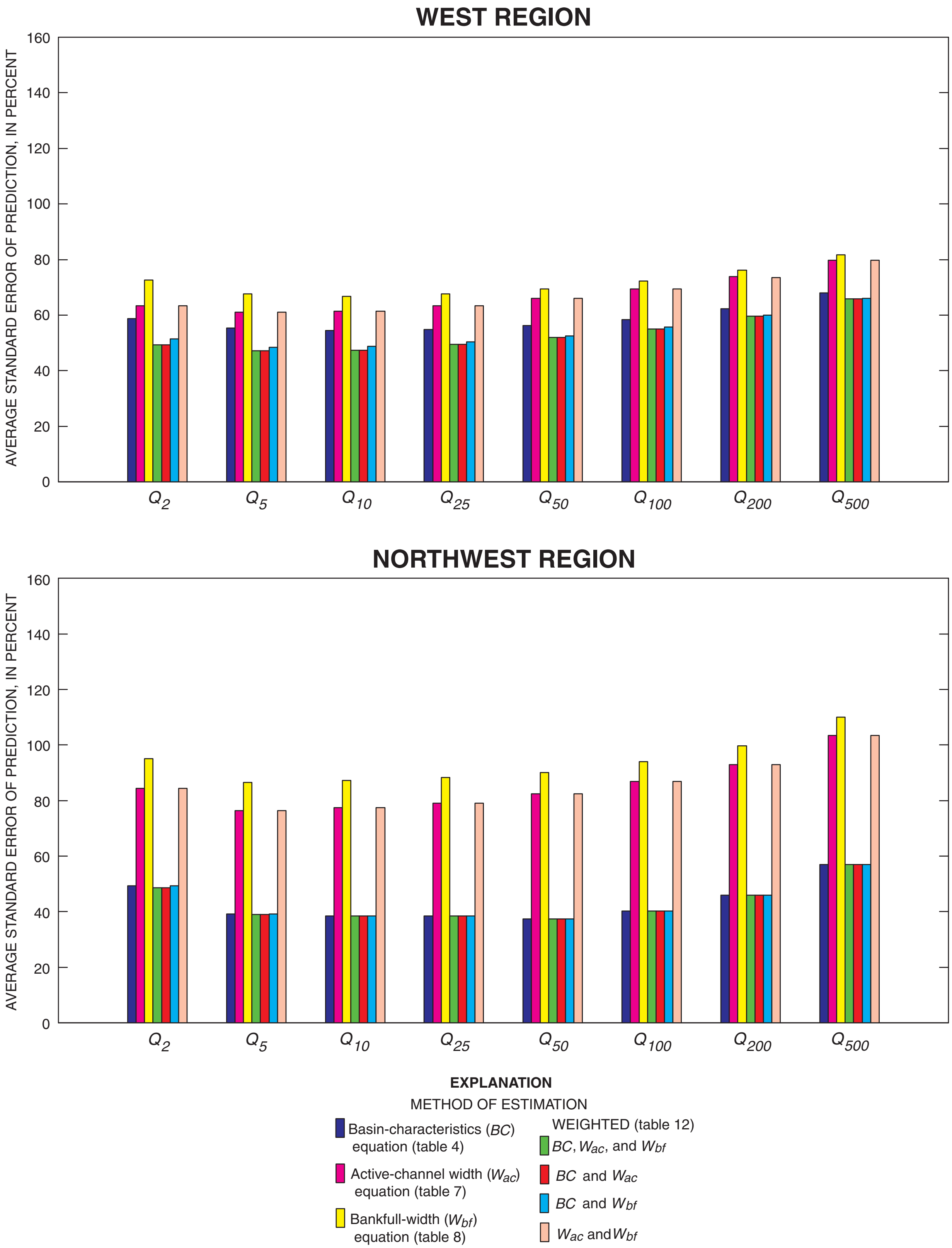


Figure 12. Average standard errors of prediction (*SEP*) for various combinations of estimation methods in West, Northwest, Northwest Foothills, and Northeast Plains Regions, Montana.

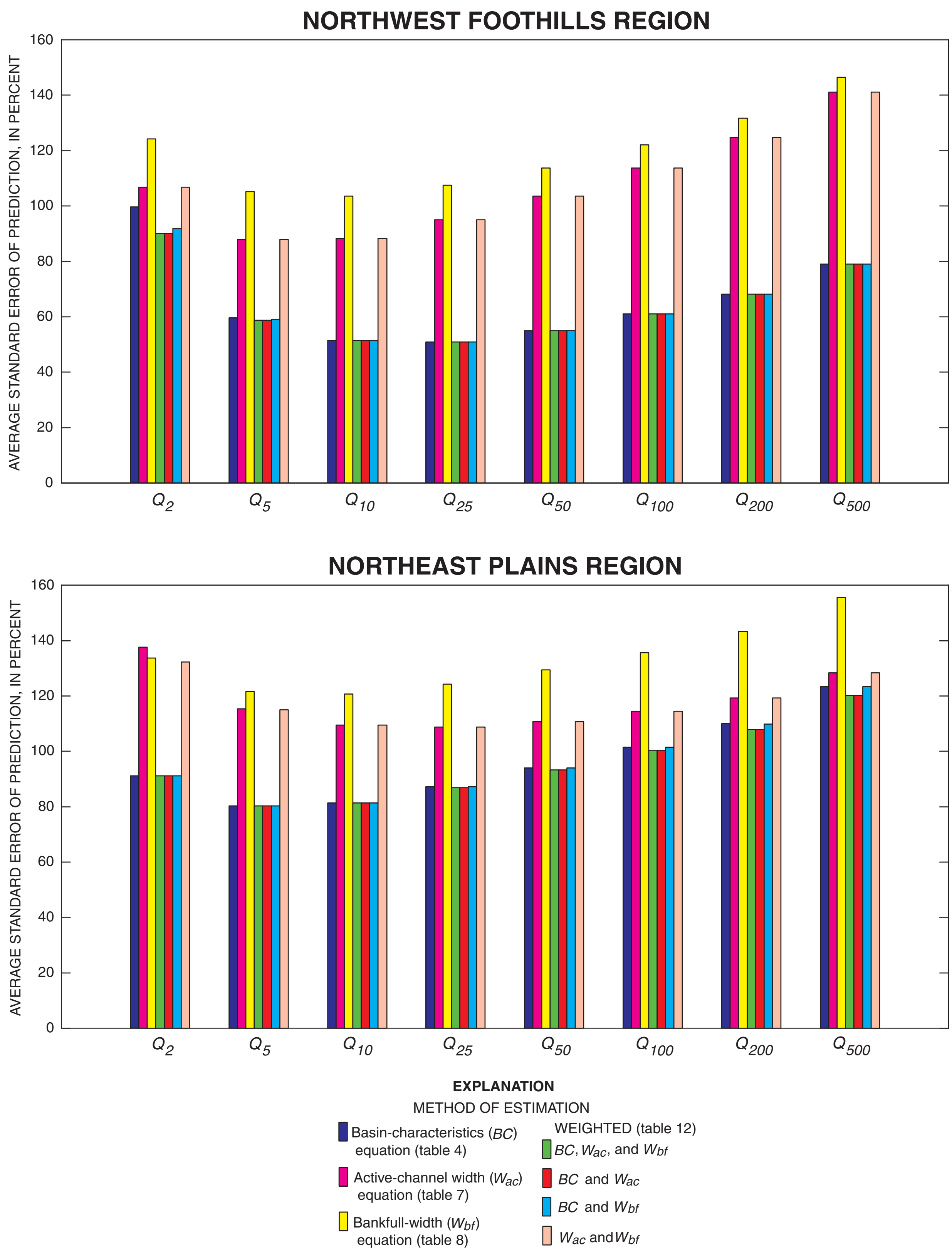


Figure 12. Average standard errors of prediction (*SEP*) for various combinations of estimation methods in West, Northwest, Northwest Foothills, and Northeast Plains Regions, Montana (Continued).

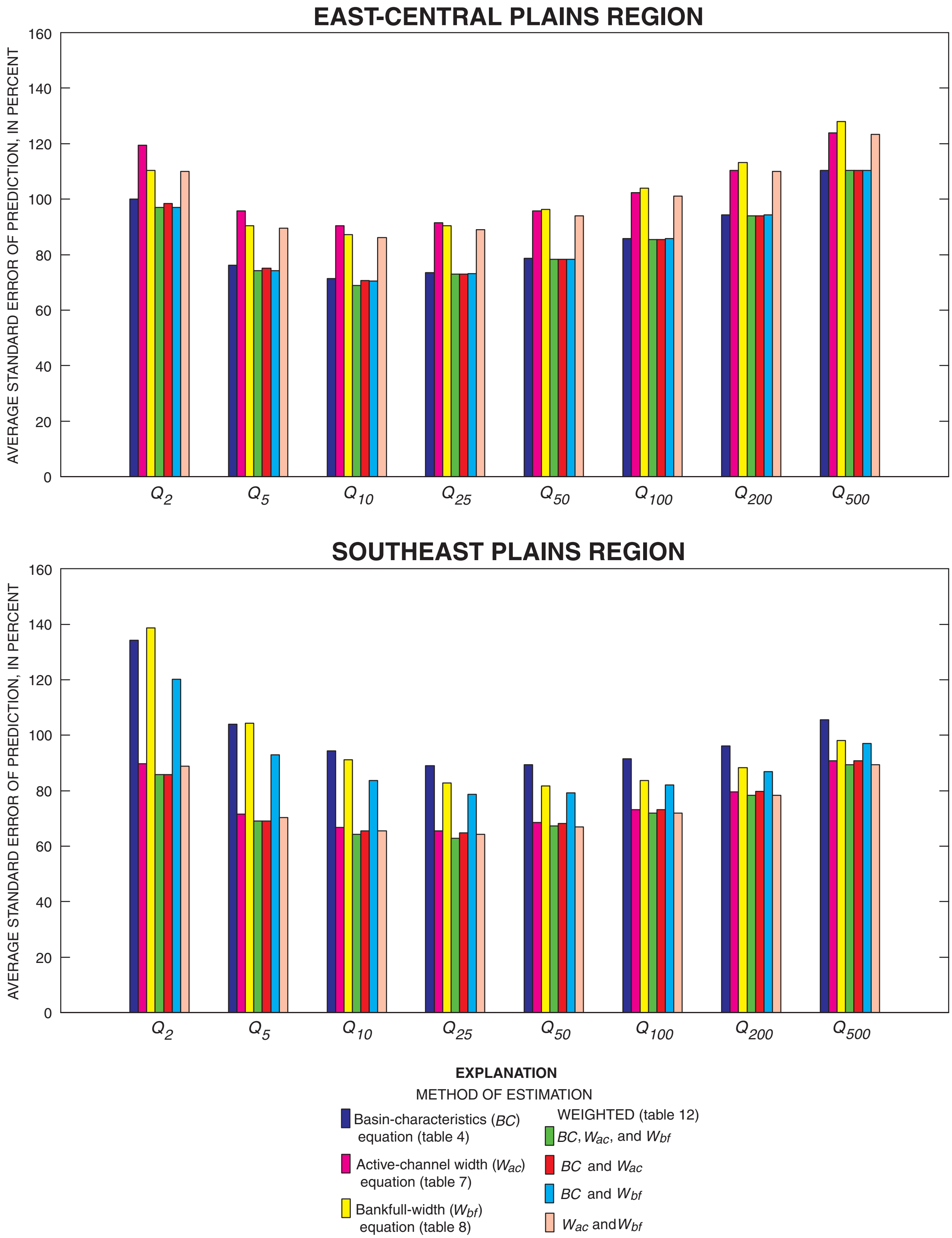


Figure 13. Average standard errors of prediction (*SEP*) for various combinations of estimation methods in East-Central Plains, Southeast Plains, Upper Yellowstone-Central Mountain, and Southwest Regions, Montana.

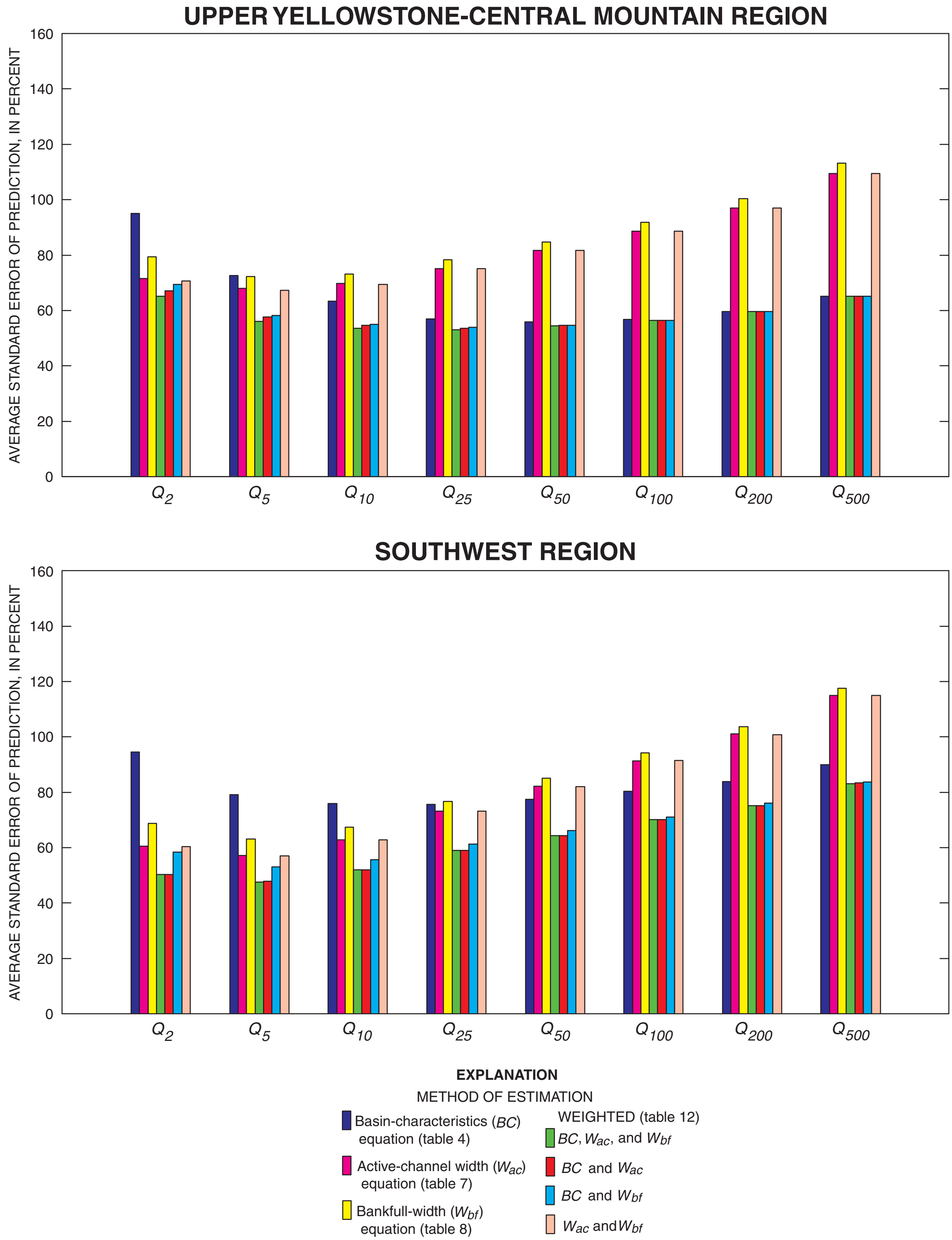


Figure 13. Average standard errors of prediction (*SEP*) for various combinations of estimation methods in East-Central Plains, Southeast Plains, Upper Yellowstone-Central Mountain, and Southwest Regions, Montana (Continued).

Table 11. Cross-correlation coefficients between residuals for combinations of different estimation methods

[Abbreviations: Q_T, annual peak discharge with recurrence interval *T*, in years; basin-W_{ac}, cross correlation between residuals from regression estimates based on basin characteristics and active-channel width; basin-W_{bf}, cross correlation between residuals from regression estimates based on basin characteristics and bankfull width; W_{ac}-W_{bf}, cross correlation between residuals from regression estimates based on active-channel width and bankfull width]

Annual peak discharge	West Region			Northwest Region			Northwest Foothills Region			Northeast Plains Region		
	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}
Q_2	0.372	0.363	0.889	0.523	0.542	0.952	0.644	0.561	0.922	0.806	0.790	0.947
Q_5	.381	.365	.900	.485	.519	.957	.602	.532	.934	.782	.781	.948
Q_{10}	.424	.407	.914	.528	.55	.965	.662	.598	.946	.788	.799	.952
Q_{25}	.491	.475	.932	.560	.584	.972	.741	.678	.958	.808	.829	.959
Q_{50}	.548	.531	.943	.628	.642	.976	.782	.722	.964	.828	.852	.964
Q_{100}	.603	.588	.952	.693	.701	.979	.812	.755	.969	.847	.873	.968
Q_{200}	.655	.644	.959	.744	.747	.982	.834	.780	.973	.865	.890	.971
Q_{500}	.712	.704	.967	.808	.807	.986	.855	.806	.977	.886	.911	.975

Annual peak discharge	East-Central Plains Region			Southeast Region			Upper Yellowstone-Central Mountain Region			Southwest Region		
	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}	Basin-W_{ac}	Basin-W_{bf}	W_{ac}-W_{bf}
Q_2	0.800	0.801	0.929	0.539	0.706	0.663	0.510	0.429	0.846	0.088	0.228	0.911
Q_5	.735	.738	.916	.555	.693	.622	.435	.385	.900	.162	.259	.939
Q_{10}	.739	.747	.919	.616	.715	.639	.445	.406	.932	.254	.317	.962
Q_{25}	.775	.789	.931	.705	.762	.693	.509	.481	.957	.356	.391	.978
Q_{50}	.809	.824	.941	.765	.800	.743	.569	.547	.969	.415	.437	.984
Q_{100}	.840	.855	.950	.814	.834	.789	.621	.606	.977	.462	.475	.989
Q_{200}	.867	.881	.957	.852	.863	.828	.666	.656	.983	.499	.507	.992
Q_{500}	.896	.909	.965	.890	.894	.869	.713	.708	.988	.538	.541	.994

Region of Influence Regression

With Region of Influence (ROI) regression, unique equations are developed for each ungaged site and *T*-year flood of interest. The method uses a search routine to select stations with basin characteristics that are similar to those at the ungaged site and performs an OLS regression using data only from the selected stations. The unique region composing the stations selected for a site-specific regression is termed the region of influence (Burn, 1990). The unique set of stations that make up the region of influence for each estimate is made up of the *N* nearest neighbors, where the nearness is measured by the overall dimensionless difference of the values of the basin characteristics. This overall dimensionless difference in basin characteristics at any two sites, *i* and *j*, is determined by the following equation:

$$d_{i,j} = \left(\sum_{k=1}^{p} \left(\frac{x_{i,k} - x_{j,k}}{sd(X_k)} \right)^2 \right)^{0.5} , \tag{18}$$

where

$d_{i,j}$	is the overall dimensionless difference in basin characteristic at sites *i* and *j*,
p	is the number of characteristics used to calculate $d_{i,j}$,
X_k	is the *k*th characteristic,
$sd(X_k)$	is the sample standard deviation of X_k, and
$x_{i,k}$ and $x_{j,k}$	are values of X_k at the *i*th and *j*th sites, respectively.

Because of the widely varying topography and climate across Montana, ROI regression was not considered applicable to Montana as a whole. Rather, the State was divided into three super-regions that were thought to be reasonably homogeneous with regard to topography and climate. One super-region included all the mountainous parts of Montana (West Region, Upper Yellowstone-Central Mountain Region, and the Southwest Region), except the unique Northwest Region. The second super-region included only the Northwest Region, and the third super-region included the remaining generally plains regions of Montana (Northwest Foothills Region, Northeast Plains Region, East-Central Plains Region, and Southeast Plains Region).

Within the super-regions, various trial applications of ROI regression were made with varying numbers of nearest neighbors (*N*) and trial selections of basin and climatic variables. The prediction error sum of squares (PRESS statistic) (Helsel and Hirsch, 1992, p. 247) was calculated for each trial ROI regression and used to determine the best combination of *N* and basin and climatic variables. For the mountainous super-region, the best *N* was 40 stations, and the best set of basin and climatic variables included drainage area, mean annual precipitation, and percent of forest cover. Because only 39 stations were available for use in the Northwest Region, ROI was considered to provide no advantage over GLS regression and was not tested in this region. For the plains super-region, the best *N* was 45 stations, and the best combination of basin and climatic variables was drainage area, mean basin elevation, and percentage of basin above 6,000 ft in elevation.

To compare ROI regression to GLS regression for fixed regions, the PRESS statistic was calculated for GLS regression results for the 100-year flood within each region (except the Northwest Region) and summed over the three regions composing the mountainous super-region and over the four regions composing the plains super-region. These summed values were compared to the PRESS statistics computed for the best ROI regression trials in the two super-regions. For the mountainous super-region, the PRESS statistic for ROI regression was the same as the summed PRESS statistic for GLS regressions in the individual regions. For the plains super-region, the summed PRESS statistic for the GLS regressions in the individual regions was markedly better (smaller) than the PRESS statistic for ROI regression. On this basis, ROI regression could be considered a reasonable alternative estimation procedure to GLS regression within the mountainous super-region, but not within the plains super-region. However, even within the mountainous super-region GLS regression is considered to be the best approach for flood estimation for the following reasons: (1) use of the ROI regression procedure requires use of a computer program or access to the USGS Montana District home page for calculation (http://montana.usgs.gov/freq), neither of which may be readily available for in-the-field application, and (2) ROI regression may provide flood discharge estimates for different recurrence intervals that are inconsistent because the equations may be based on different basin variables. Consequently, the ROI regression procedure was not further developed for use in Montana.

Estimating Flood Frequency on Gaged Streams

Ungaged Sites on Gaged Streams

If an ungaged site of interest is near a gaged site on the same stream, flood-frequency data for the gaged site can be used to estimate flood frequency for the ungaged site using a drainage-area ratio adjustment. The *T*-year flood at the ungaged site ($Q_{T,U}$) is calculated using the following equation:

$$Q_{T,U} = Q_{T,G}\left(\frac{DA_U}{DA_G}\right)^{\exp_T}, \qquad (19)$$

where

$Q_{T,G}$ is the *T*-year flood at the gaged site, in cubic feet per second,
DA_U is the drainage area at the ungaged site, in square miles,
DA_G is the drainage area at the gaged site, in square miles, and
$\exp_T$ is the regression coefficient for a simple OLS regression relating the log of *T*-year flood to log of drainage area within each region (table 13).

Table 13. Regression coefficients for ordinary least squares (OLS) regressions relating *T*-year flood (Q_T) to drainage area

***T*-year flood**	**Regression coefficient relating *T*-year flood to drainage area for indicated region**							
	West Region	**Northwest Region**	**Northwest Foothills Region**	**Northeast Plains Region**	**East-Central Plains Region**	**Southeast Plains Region**	**Upper Yellowstone-Central Mountain Region**	**Southwest Region**
Q_2	0.851	0.884	0.609	0.620	0.464	0.516	0.877	0.894
Q_5	.818	.822	.587	.564	.459	.478	.768	.776
Q_{10}	.798	.789	.577	.536	.454	.458	.712	.720
Q_{25}	.776	.747	.566	.506	.446	.433	.656	.661
Q_{50}	.761	.722	.560	.486	.439	.418	.618	.622
Q_{100}	.747	.700	.555	.469	.432	.403	.587	.585
Q_{200}	.734	.685	.551	.453	.426	.389	.557	.550
Q_{500}	.717	.665	.547	.433	.417	.371	.523	.510

Equation 19 can be used to estimate flood-frequency characteristics at ungaged sites on large streams, where the regression equations are not applicable because their large drainage areas fall outside the range of values used to develop the equations. However, equation 19 is likely to be unreliable if the value of DA_U/DA_G is less than 0.5 or greater than 1.5. For ungaged sites where the values are beyond those limits, the regression equations in table 4 generally are considered to provide more reliable estimates of $Q_{T,U}$ than equation 19.

Estimates for *T*-year floods at ungaged sites on gaged streams also can be made using channel-width ratio adjustments in a manner similar to the use of drainage-area ratio adjustments. The *T*-year flood at the ungaged site ($Q_{T,U}$) is calculated using an equation similar to equation 19:

$$Q_{T,U} = Q_{T,G}\left(\frac{W_U}{W_G}\right)^{\exp_T}, \qquad (20)$$

where

W_U is the channel width (either W_{ac} or W_{bf}) at the ungaged site, in feet,

W_G is the channel width (either W_{ac} or W_{bf}) at the gaged site, in feet, and,

$\exp_T$ is the regression coefficient for either W_{ac} or W_{bf} for the *T*-year flood found in table 7 or table 8.

Use of the drainage-area ratio adjustment or the channel-width ratio adjustment to estimate *T*-year floods at an ungaged site on a nearby stream might be appropriate in some instances. For example, an ungaged site might be located on a stream that is known to have flood characteristics similar to those on a nearby gaged stream. If the flood characteristics at the gaged site are not generally similar to those at other gaged sites in the region, use of the drainage-area ratio adjustment or the channel-width adjustment might provide a more reliable estimate than use of the regional regression equations. Without some additional knowledge about flood characteristics in a specific area of application, however, use of regional regression equations is considered to provide more reliable estimates of *T*-year floods at sites on ungaged streams.

If an ungaged site of interest is between two gaged sites on the same stream, the logarithms of flood-frequency characteristics at the ungaged site can be linearly interpolated between logarithms of flood-frequency characteristics at the two gaged sites using logarithms of drainage area as the basis for interpolation as follows:

$$\log Q_{T,U} = \log Q_{T,G1} + [(\log Q_{T,G2} - \log Q_{T,G1}) / (\log DA_{G2} - \log DA_{G1})] (\log DA_U - \log DA_{G1}), \qquad (21)$$

where

log is the base 10 logarithm,

$Q_{T,U}$ is the *T*-year flood at the ungaged site, in cubic feet per second,

$Q_{T,G1}$ is the *T*-year flood at the upstream gaged site, in cubic feet per second,

$Q_{T,G2}$ is the *T*-year flood at the downstream gaged site, in cubic feet per second,

DA_{G2} is the drainage area at the downstream gaged site, in square miles,

DA_{G1} is the drainage area at the upstream gaged site, in square miles, and

DA_U is the drainage area, at the ungaged site, in square miles.

Equation 21 also can be used to estimate flood-frequency characteristics at ungaged sites on large streams where the use of regression equations is not applicable because their drainage areas fall outside the range of values used to develop the equations. The obvious limitation on the use of equation 21 is the need to have a gaged site both upstream and downstream from the ungaged site. Application of equation 21 may provide unreliable estimates if the two gaged sites have different periods of record with insufficient overlap.

Weighted Estimates at Gaged Sites

Flood-frequency data for gaged sites may have large errors due to large variability in annual peak discharges (time-sampling errors), particularly if annual peak-discharge records are short. To improve flood-frequency data for gaged sites, Bulletin 17B indicates that at-station flood-frequency data can be weighted with estimated flood-frequency data from regional regression equations. Because time-sampling error is associated with record length, the length of record at the gaged site and the equivalent years of record for the regional regression equation can be used as weighting factors as shown below:

$$\log Q_{T,W} = \frac{(\log Q_{T,E} \times EYR) + (\log Q_{T,R} \times LR)}{(EYR + LR)}, \qquad (22)$$

where

$\log Q_{T,W}$	is the weighted estimate for the *T*-year flood, in log units,
$\log Q_{T,E}$	is the estimated *T*-year flood based on a regional regression equation, in log units,
EYR	is the equivalent years of record for the regional regression equation,
$\log Q_{T,R}$	is the estimated *T*-year flood based on gaged record, in log units, and
LR	is the number of years of gaged record.

A weighted estimate at a gaged site can be determined using a regional regression equation based on basin characteristics or channel width. Estimates from both sets of equations cannot be weighted together with an estimate based on gaged record, because regression estimates from basin-characteristics equations are correlated with estimates from channel-width equations.

EXAMPLE APPLICATIONS

The general procedures for estimation of flood frequency at ungaged sites using the methods developed in this report are illustrated in the following examples. The examples describe solutions solved manually for typical applications and may not reflect the actual problems associated with any specific application. Although the equations for estimation of *T*-year floods generally are straightforward and relatively easy to solve manually, the equations for calculation of standard errors of prediction for particular estimates require matrix algebra and are difficult to solve manually. The weighting equations also are complex and difficult to solve manually. Accordingly, a web-based program for solving all appropriate equations for calculation of *T*-year floods and weighted *T*-year floods and associated standard errors of prediction and confidence limits has been incorporated on the USGS Montana District homepage (http://montana.usgs.gov/freq/, accessed December 2003). A thorough understanding of the complex solution steps described in the example problems will enable users of the web-based program to better understand the program output. The program indicates required input data and outputs results in a user-friendly format.

Example 1.

Problem: Flood frequency at ungaged sites based on weighted estimates from basin characteristics and channel-width regression equations.

An estimate of the 100-year flood (Q_{100}) is required for a small stream in the West Region. The drainage area and percent forest cover were measured from a USGS 7.5-minute quadrangle map and found to be 12.5 mi^2 and 38 percent, respectively. The mean annual precipitation was determined (fig. 6, plate 1) to be 31 in. The site was visited, and the active-channel width and bankfull width were measured as 12 ft and 18 ft, respectively.

Solution:

Using the equation for Q_{100} for the West Region (table 4, back of report), the 100-year flood was estimated using basin characteristics as follows:

$$\begin{aligned} Q_{100} &= 18.7\,A^{0.812}\,P^{1.06}\,(F+1)^{-0.664}, \\ &= 18.7\,(12.5)^{0.812}\,(31)^{1.06}\,(39)^{-0.664}, \\ &= 18.7\,(7.77)\,(38)\,(0.088), \\ &= 487\ \text{ft}^3/\text{s}. \end{aligned}$$

The standard error of prediction for this estimate (example 1, estimate 1) is calculated from matrix equation 28 as follows:

$$SEP_1 = [\text{Model error variance} + \mathbf{x_1}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\Lambda^{-1}\mathbf{X})^{-1}\,\mathbf{x_1}]^{0.5}.$$

The Model error variance for a 100-year flood estimate (Q_{100}) in the West Region is found in table 4 (0.052), and the $(\mathbf{X}^{\mathbf{T}}\,\Lambda^{-1}\mathbf{X})^{-1}$ matrix for the 100-year flood equation in the West Region is found in table 14 (back of the report). The $\mathbf{x_1}$ column matrix is based on the at-site values of the logarithms of the pertinent basin characteristics as follows:

$$\mathbf{x_1} = \begin{vmatrix} 1 \\ \log 12.5 \\ \log 31 \\ \log 39 \end{vmatrix}, \text{ or } \begin{vmatrix} 1 \\ 1.097 \\ 1.491 \\ 1.591 \end{vmatrix}$$

The transpose of the $\mathbf{x_1}$ matrix ($\mathbf{x_1}^{\mathbf{T}}$) is the following row matrix:

$$\mathbf{x_1^T} = |1 \quad 1.097 \quad 1.491 \quad 1.591|$$

Substituting these values into equation 28 and solving by matrix algebra leads to the following:

$$SEP_1 = \left[0.0521 + |1 \quad 1.097 \quad 1.491 \quad 1.591| \cdot \begin{vmatrix} 0.19951 & -0.00094 & -0.02182 & -0.08441 \\ -0.00094 & 0.00116 & 0.00156 & -0.00187 \\ -0.02182 & 0.00156 & 0.02447 & -0.01024 \\ -0.08441 & -0.00187 & -0.01024 & 0.05411 \end{vmatrix} \cdot \begin{vmatrix} 1 \\ 1.097 \\ 1.491 \\ 1.591 \end{vmatrix} \right]^{0.5}$$

$SEP_1 = [0.052 + 0.00654]^{0.5}$,

$SEP_1 = [0.0585]^{0.5}$,

$SEP_1 = 0.242$.

As previously described, a regression estimate may not be reliable if the combination of values of explanatory variables define a location far from the center of the joint distribution of all values of explanatory variables. To test whether the location defined by the combination of values of explanatory variables is far from the center, the value of the matrix $\mathbf{x_1}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\,\Lambda^{-1}\mathbf{X})^{-1}\mathbf{x_1}$ is compared to $2p/n$. The value of this matrix, 0.00654, is considerably smaller than $2p/n$ for the West Region (2 · (3 variables)/(96 sites), or 0.0625), so the location defined by the combination of values of explanatory variables is close to the center of all the joint distribution of all values of explanatory variables in the West Region. On this basis, the regression estimate for this example is considered reliable.

Data in table 12 indicate that, on average, a weighted 100-year flood estimate in the West Region based on use of all three regression equations (basin characteristics, active-channel width, and bankfull width) will be more reliable (smaller standard error of prediction) than an estimate based on just basin and climatic characteristics. Further, a weighted estimate based on just the basin-characteristics equation and the active-channel width equation would be as reliable, on average, as an estimate based on all three regression equations. However, because the bankfull width was measured at this site and because the weights and standard errors of prediction for a particular estimate may vary somewhat from the average values presented in table 12, a weighted estimate based on all three regression equations was used.

Using the equation for Q_{100} for the West Region (table 7), the 100-year flood was estimated using active-channel width as follows:

$$
\begin{aligned}
Q_{100} &= 9.57\, W_{ac}^{\,1.45}, \\
&= 9.57\,(12)^{1.45}, \\
&= 9.57\,(36.7), \\
&= 351\ \text{ft}^3/\text{s}.
\end{aligned}
$$

Because the measured active-channel width at the site was well within the range of widths used to develop the estimation equations in the West Region (table 9), the estimate was considered to be reliable. The standard error of prediction for this estimate (example 1, estimate 2) is calculated from matrix equation 28 as follows:

$$SEP_2 = [(\text{Model error variance} + \text{measurement error variance}) + \mathbf{x_2}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\Lambda^{-1}\mathbf{X})^{-1}\,\mathbf{x_2}]^{0.5}.$$

As previously described, using channel-width as a dependent variable in regression requires the use of an additional error term to account for the relatively large error in measured width. The Model error variance and measurement error variance for a 100-year flood estimate in the West Region based on active-channel width are found in table 7 (0.056 and 0.016, respectively), and the $(\mathbf{X}^{\mathbf{T}}\Lambda^{-1}\mathbf{X})^{-1}$ matrix for the 100-year flood equation in the West Region is found in table 15 (back of the report). The $\mathbf{x_2}$ column matrix is based on the at-site value of the logarithm of active-channel width as follows:

$$\mathbf{x_2} = \begin{vmatrix} 1 \\ \log 12 \end{vmatrix}, \text{or} \begin{vmatrix} 1 \\ 1.079 \end{vmatrix} .$$

The $\mathbf{x_2}^{\mathbf{T}}$ row matrix thus becomes the following:

$$\mathbf{x_2}^{\mathbf{T}} = \begin{vmatrix} 1 & 1.079 \end{vmatrix} .$$

Substituting the appropriate values into equation 28 leads to the following:

$$SEP_2 = \left[(0.056 + 0.016) + \begin{vmatrix} 1 & 1.079 \end{vmatrix} \cdot \begin{vmatrix} 0.01018 & -0.00600 \\ -0.00600 & 0.00405 \end{vmatrix} \cdot \begin{vmatrix} 1 \\ 1.079 \end{vmatrix}\right]^{0.5},$$

$$
\begin{aligned}
&= [0.072 + 0.001947]^{0.5}, \\
&= [0.0739]^{0.5}, \\
&= 0.272.
\end{aligned}
$$

Finally, the 100-year flood was estimated using the bankfull-width equation (table 8) for the West Region as follows:

Q_{100} = $2.99\ W_{bf}^{\ 1.66}$,
= $2.99\ (18)^{\ 1.66}$,
= 2.99 (121),
= 362 ft^3/s.

Because the measured bankfull width at the site was well within the range of widths used to develop the estimation equations in the West Region, the estimate was considered to be reliable. The standard error of prediction for this estimate (example 1, estimate 3) is calculated from matrix equation 28 as follows:

$$SEP_3 = [(\text{Model error variance} + \text{measurement error variance}) + \mathbf{x_3}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\Lambda^{-1}\mathbf{X})^{-1}\mathbf{x_3}]^{0.5}\ .$$

Substituting appropriate values from tables 8 and 16 and solving as before provides the following:

SEP_3 = $[(0.050 + 0.027) + (0.00183)]^{0.5}$,
= $[0.0788]^{0.5}$,
= 0.281.

The weights for the three estimates of Q_{100} at this site are calculated from equations 11 through 13. First, solutions to equations 11 through 13 require values of cross-correlation coefficients for the three methods from table 11 as follows:

$r_{1,2}$ the cross-correlation coefficient between residuals from the basin and climatic characteristics equation and the active-channel width equation, = 0.603;

$r_{1,3}$ the cross-correlation coefficient between residuals from the basin and climatic characteristics equation and the bankfull-width equation, = 0.588; and

$r_{2,3}$ the cross-correlation coefficient between residuals from the active-channel width equation and the bankfull-width equation, = 0.952.

Then, equations for the covariances for the different methods can be solved as follows:

$S_{1,2} = r_{1,2}\ (SEP_1 \cdot SEP_2) = 0.603\ (0.242 \cdot 0.272) = 0.0397$,
$S_{1,3} = r_{1,3}\ (SEP_1 \cdot SEP_3) = 0.588\ (0.242 \cdot 0.281) = 0.0400$,
$S_{2,3} = r_{2,3}\ (SEP_2 \cdot SEP_3) = 0.952\ (0.272 \cdot 0.281) = 0.0728$.

Then, equations for intermediate terms for computation of weights (A, B, and C) can be solved as follows:

$A = SEP_1^2 + SEP_3^2 - 2\ S_{1,3} = (0.242)^2 + (0.281)^2 - 2\ (0.0400) = 0.0575$,
$B = SEP_3^2 + S_{1,2} - S_{1,3} - S_{2,3} = (0.281)^2 + (0.0397) - (0.0400) - (0.0728) = 0.00586$,
$C = SEP_2^2 + SEP_3^2 - 2\ S_{2,3} = (0.272)^2 + (0.281)^2 - 2\ (0.0728) = 0.00734$.

The weight for the estimate based on basin and climatic characteristics (*a*1) is calculated from equation 11 as follows:

$a1 = [C\ (SEP_3^2 - S_{1,3}) - B\ (SEP_3^2 - S_{2,3})]/(A\ C - B^2)$,
$= [0.00734\ (0.281^2 - 0.0400) - 0.00586\ (0.281^2 - 0.0728)]/[(0.0575)(0.00734) - (0.00586)^2]$,
$= [0.000286 - 0.0000361]/[0.000422 - 0.0000343]$,
$= 0.000250/0.000388$,
$= 0.64$.

Similarly, the weight for the estimate based on active-channel width (*a*2) is calculated from equation 12 as follows:

$$
\begin{aligned}
a2 &= [A\,(SEP_3{}^2 - S_{2,3}) - B\,(SEP_3{}^2 - S_{1,3})]/(A\,C - B^2), \\
&= [0.0575\,(0.281^2 - 0.0728) - 0.00586\,(0.281^2 - 0.0400)]/0.000388, \\
&= [0.000354 - 0.000228]/0.000388, \\
&= 0.32.
\end{aligned}
$$

Finally, the weight for the estimate based on bankfull width ($a3$) is calculated from equation 13 as follows:

$$
\begin{aligned}
a3 &= 1 - a1 - a2, \\
&= 1 - 0.64 - 0.32, \\
&= 0.04.
\end{aligned}
$$

The weighted estimate based on all three regression equations is calculated from equation 10 as follows:

$$
\begin{aligned}
Z &= a1 \cdot x1 + a2 \cdot x2 + a3 \cdot x3, \\
&= (0.64)\log 490 + (0.32)\log 351 + (0.04)\log 362, \\
&= (0.64)(2.6902) + (0.32)(2.5453) + (0.04)(2.5587), \\
&= 1.7217 + 0.8145 + 0.1023, \\
&= 2.639.
\end{aligned}
$$

The weighted estimate for Q_{100} is determined from the antilog of Z to be 436 ft^3/s. The standard error of prediction for this estimate based on weighting three individual estimates is calculated from equation 15 as follows:

$$
\begin{aligned}
SEP_z &= [(a1 \cdot SEP_1)^2 + (a2 \cdot SEP_2)^2 + (1 - a1 - a2)^2\, SEP_3{}^2 \\
&+ 2\,a1 \cdot a2 \cdot S_{1,2} + 2\,a1\,(1 - a1 - a2)\,S_{1,3} \\
&+ 2\,a2\,(1 - a1 - a2)\,S_{2,3}]^{0.5}, \\
&= [(0.64 \cdot 0.242)^2 + (0.32 \cdot 0.272)^2 + (0.04)^2(0.281)^2 + 2(0.64)\cdot(0.32)\cdot(0.0397) + 2(0.64)(0.04)(0.0400) \\
&\quad + 2(0.32)(0.04)(0.0728)]^{0.5}, \\
&= [0.02399 + 0.007576 + 0.000126 + 0.01626 + 0.00205 + 0.00186]^{0.5}, \\
&= (0.0524)^{0.5}, \\
&= 0.229.
\end{aligned}
$$

Equations 16 and 17, together with the appropriate value for Student's t (table 5), can be applied to determine a 90-percent confidence interval for the weighted estimate in the same manner as for an estimate from the individual regression equations. Thus, the Student's t value (table 5) for the West Region is 1.66, the weighted estimate of *SEP* is 0.229, and application of equation 6 provides the following:

$$
\begin{aligned}
CI_{i,90\%} &= \pm 1.66\,(0.229), \\
&= \pm 0.380.
\end{aligned}
$$

Then, application of equation 7 provides the following:

$$
\begin{aligned}
&10^{(\log 436 - 0.380)} \le \text{true } Q_{100,i} \le 10^{(\log 436 + 0.380)}, \\
&10^{2.2595} \le \text{true } Q_{100,i} \le 10^{3.0195}, \\
&182 \text{ ft}^3/\text{s} \le \text{true } Q_{100,i} \le 1{,}050 \text{ ft}^3/\text{s}.
\end{aligned}
$$

The standard error of estimate for the weighted estimate is significantly smaller than for the estimate based on basin characteristics only. The calculated weights and standard error of prediction for this estimate are about the same as the average *SEP* and weights shown in table 12. Values shown in table 12 can help determine if a field visit to measure channel widths is justified. If the average weights given to estimates based on channel width are very small compared to the weight given for an estimate based only on basin characteristics, a site visit may not be warranted. On the other hand, if the weights for estimates based on channel width are close to the weight given for an estimate based on basin characteristics, a site visit to measure channel width may substantially improve the flood estimate. Hydrologic judgment and knowledge about the particular area will be required to decide whether all estimation equations are applicable and can be weighted, or whether one or more are not applicable and need not be used.

Discussion:

This example problem showed how the various equations can be solved to yield a weighted estimate of Q_{100} and its associated standard error of prediction and 90-percent confidence interval. Results from the USGS web-based computer program differ slightly from results shown for this example problem because mathematical results for intermediate steps in the solution were rounded to 3 or 4 significant figures for clarity. Only the final answers are rounded to three significant figures in the computer solutions.

Example 2.

Problem: Flood frequency at ungaged sites on streams that cross regional boundaries.

An estimate of 50-year flood (Q_{50}) is required for a site on a small stream in the East-Central Plains Region. The drainage area at the site is 14.6 mi^2. The stream originates in the Upper Yellowstone-Central Mountain Region, and the drainage area (A) at the site where the stream crosses the regional boundary is 5.85 mi^2. The basin characteristic required to calculate Q_{50} in the East-Central Plains Region is mean basin elevation divided by 1,000 ($E/1000$) (table 4) and has a value of 3.95. The bankfull width (W_{bf}) was identified and measured as 12 ft. The other basin characteristic required to calculate Q_{50} in the Upper Yellowstone-Central Mountain Region is the percentage of basin above an elevation of 6,000 ft plus 1.0 ($E_{6000} + 1$) (table 4) and has a value at the ungaged site of 2.0.

Solution:

Using the equation for the Upper Yellowstone-Central Mountain Region (table 4, back of report), Q_{50} was estimated using basin characteristics as follows:

$$Q_{50} = 126\,A^{0.716}\,(E_{6000} + 1)^{-0.182},$$
$$Q_{50} = 126\,(14.6)^{0.716}\,(2.0)^{-0.182},$$
$$Q_{50} = 126\,(6.818)\,(0.881),$$
$$Q_{50} = 757\ \text{ft}^3/\text{s}.$$

The standard error of prediction for this first estimate is calculated from matrix equation 28 (example 2, estimate 1):

$$SEP_1 = [\text{Model error variance } + \mathbf{x_1}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}\mathbf{x_1}]^{0.5}.$$

As in the previous example, the model error variance for a 50-year flood estimate (Q_{50}) in the Upper Yellowstone-Central Mountain Region is found in table 4 (0.047) and the $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrix for the 50-year flood equation is found in table 14. The $\mathbf{x_1}$ **and** $\mathbf{x_1}^{\mathbf{T}}$ matrices are composed of the values 1.0, log(14.6), and log(2.0), and SEP_1 is calculated by solution of equation 28 to be 0.228.

Using the equation for the Upper Yellowstone-Central Mountain Region (table 8, back of report), Q_{50} was estimated using bankfull width as follows:

$$Q_{50} = 27.5\,W_{bf}^{\ 1.17},$$
$$Q_{50} = 27.5\,(12)^{1.17},$$
$$Q_{50} = 27.5\,(18.31),$$
$$Q_{50} = 503\ \text{ft}^3/\text{s}.$$

The model error variance plus measurement error variance for estimation of Q_{50} based on bankfull width in the Upper Yellowstone-Central Mountain Region is found in table 8 (0.084 + 0.013) and the appropriate $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrix is found in table 16 (back of the report). The $\mathbf{x_1}$ and $\mathbf{x_1}^{\mathbf{T}}$ matrices are composed of the values 1.0 and log(12), and SEP_2 (example 2, estimate 2) is found by solution of equation 28 to be 0.319.

From table 11, the cross-correlation ($r_{1,2}$) between residuals from the basin characteristics method and the bankfull-width method for estimation of Q_{50} in the Upper Yellowstone-Central Mountain Region is 0.547. Using this value and the calculated SEP_1 and SEP_2 , a weighted estimate for Q_{50} and the *SEP* for the weighted estimate can be calculated using equations 16 and 17. First, the covariance between the two methods, $S_{1,2}$, is calculated from $S_{1,2} = r_{1,2}$ $(SEP_1 \cdot SEP_2)$ as follows:

$$S_{1,2} = 0.547\ (0.228 \cdot 0.319),$$
$$S_{1,2} = 0.0398.$$

Then, from equation 16, the weight for the basin characteristic method, $a1$, is calculated as follows:

$$a1 = (SEP_2^{\ 2} - S_{1,2})/(SEP_1^{\ 2} + SEP_2^{\ 2} - 2S_{1,2}),$$
$$a1 = (0.319^2 - 0.0398)/[0.228^2 + 0.319^2 - 2\ (0.0398)],$$
$$a1 = (0.102\ - 0.0398)/[0.0520 + 0.102\ - 0.0796],$$
$$a1 = (0.0622)/[0.0744],$$
$$a1 = 0.84.$$

Similarly, the weight for the bankfull-width method, $a2$, is calculated to be 0.16. The weighted estimate for the logarithm of Q_{50} is calculated from equation 16 as follows:

$$Z = a1 \cdot x1 + a2 \cdot x2,$$
$$Z = 0.84 \log 757 + 0.16 \log 503,$$
$$Z = 0.84(2.8791) + 0.16(2.7016),$$
$$Z = 2.4184 + 0.4322,$$
$$Z = 2.8506.$$

Finally, the weighted estimate of Q_{50}, based on equations for the Upper Yellowstone-Central Mountain Region is determined from the antilogarithm of Z to be 709 ft^3/s. Solving equation 17 for the weighted *SEP* yields a value of 0.224.

Using the equation for Q_{50} based on basin characteristics in the East-Central Plains Region yields the following:

$$Q_{50} = 3{,}240\ A^{0.462}\ \ (E/1000)^{\ -1.96},$$
$$Q_{50} = 3{,}240\ (14.6)^{\ 0.462}\ \ (3.95)^{\ -1.96},$$
$$Q_{50} = 3{,}240\ (3.45)\ \ (0.0677),$$
$$Q_{50} = 757\ ft^3/s.$$

Using the appropriate values of model error variance (table 4, 0.082), $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrix (table 14), and logarithms of the values for A and (E/1000), the *SEP* for this estimate of Q_{50} is calculated to be 0.316.

Examination of the average weights and *SEP* values for various combinations of estimation methods (table 12, fig. 13) indicates that use of channel-width equations does not substantially improve estimates of Q_{50} in the East-Central Plains Region. Nevertheless, the measured bankfull width is available, and an individual estimate might have somewhat different *SEP* and weights from the average regional values. Thus, the bankfull-width equation was applied and a weighted estimate was obtained. Using the equation for Q_{50} based on bankfull width in the East-Central Plains Region yields the following:

$$Q_{50} = 59.4\ W_{bf}^{\ 1.23},$$
$$Q_{50} = 59.4\ (12)^{\ 1.23},$$

Q_{50} = 59.4 (21.25),
Q_{50} = 1,260 ft^3/s.

As before, using the appropriate values of model error variance plus measurement error variance from table 8 (0.102 + 0.015), the $(\mathbf{X}^{\mathbf{T}}\Lambda^{-1}\mathbf{X})^{-1}$ matrix (table 16), and logarithm of the value for W_{bf}, the *SEP* for this estimate of Q_{50} is calculated to be 0.349.

From table 11, the cross-correlation ($r_{1,2}$) between the basin characteristics method and the bankfull-width method for estimation of Q_{50} in the East-Central Plains Region is 0.824. Using this value and the calculated *SEP*s for the two methods (SEP_1 and SEP_2), a weighted estimate for Q_{50} and the *SEP* for the weighted estimate can be calculated using equations 16 and 17. As before, the covariance between the two methods, $S_{1,2}$, first is calculated from $S_{1,2} = r_{1,2}\,(SEP_1\,SEP_2)$ as follows:

$S_{1,2}$ = 0.824 (0.316) (0.349),
$S_{1,2}$ = 0.0909.

Then, from equation 16, the weight for the basin and climatic characteristic method, $a1$, is calculated as follows:

$a1 = (SEP_2 - S_{1,2})/(SEP_1^{\,2} + SEP_2^{\,2} - 2S_{1,2})$,
$a1 = (0.349^{\,2} - 0.0909)/[0.316^{\,2} + 0.349^2 - 2\,(0.0909)]$,
$a1 = (0.122 - 0.0909)/[0.0999 + 0.122 - 0.182]$,
$a1 = (0.0311)/[0.0399]$,
$a1 = 0.78$.

The weight for bankfull-width method, $a2$, is similarly calculated to be 0.22. The weighted estimate for the logarithm of Q_{50} is calculated from equation 16 as follows:

$Z = a1 \cdot x1 + a2 \cdot x2$,
$Z = 0.78 \log 757 + 0.22 \log 1{,}260$,
$= 0.78\,(2.8791) + 0.22\,(3.1004)$,
$= 2.2457 + 0.6821$,
$= 2.9278$.

The weighted estimate for Q_{50} is found from the antilogarithm of Z to be 847 ft^3/s. The weighted *SEP* for this value is found from application of equation 17 to be 0.313.

Finally, the weighted estimate of Q_{50} from the application of both the basin characteristics equation and the bankfull-width equation for the Upper Yellowstone-Central Mountain Region is multiplied by the ratio of that part of the drainage area in the Upper Yellowstone-Central Mountain Region to the total drainage area as follows:

Upper Yellowstone-Central Mountain Region Q_{50} = 709 (5.85/14.6),
Upper Yellowstone-Central Mountain Region Q_{50} = 709 (0.401) = 284 ft^3/s.

Similarly, the weighted estimate for Q_{50} from the application of the basin characteristics equation and the bankfull-width equation for the East-Central Plains Region is multiplied by the ratio of the drainage area in just the East-Central Plains Region to the total drainage area as follows:

East-Central Plains Region Q_{50} = 847 (14.6 – 5.85)/14.6,
East-Central Plains Region Q_{50} = 847 (8.75)/14.6,
East-Central Plains Region Q_{50} = 847 (0.599) = 507 ft^3/s.

Finally, the estimate for Q_{50} at the site is the sum of the weighted estimates for each region, or 284 + 507 = 791 ft^3/s. The *SEP* for this combined estimate also can be approximated by weighting each regional estimate of *SEP* in accordance with the proportion of drainage area within each region as follows:

$$SEP_{\text{combined}} = 0.224\,(5.85/14.6) + 0.313\,(14.6\text{-}5.85)/14.6,$$
$$SEP_{\text{combined}} = 0.224\,(0.401) + 0.313\,(0.599),$$
$$SEP_{\text{combined}} = 0.277.$$

To estimate a 90-percent confidence interval for this combined estimate, this value of *SEP* can be used together with the Student's *t* value (table 5) for the East-Central Plains Region (1.66) in equations 6 and 7 as follows:

$$10^{\log 791\ -\ 0.4598} \leq \text{true } Q_{50} \leq 10^{\log 791\ +0.4598},$$
$$10^{2.8982\ -\ 0.4598} \leq \text{true } Q_{50} \leq 10^{2.8982\ +0.4598},$$
$$10^{2.4384} \leq \text{true } Q_{50} \leq 10^{3.3580},$$
$$274 \text{ ft}^3/\text{s} \leq \text{true } Q_{50} \leq 2{,}280 \text{ ft}^3/\text{s}.$$

Discussion:

The above solution to example 2 represents one way to address the problem of estimating a Q_T for a site on a stream that crosses regional boundaries. However, the regional boundaries are imprecise and a rigorous attempt to apportion the estimated Q_T between regions may not be warranted for a reconnaissance-level application or an application for design purposes where a conservatively large estimate may be desirable. In these instances, estimates can be made using equations for both regions and selecting the largest value rather than weighting individual estimates according to drainage area. The solutions illustrated in the previous example may differ slightly from solutions from the USGS web-based computer program because of rounding.

Example 3.

Problem: Flood frequency at ungaged sites on gaged streams.

An estimate of the 50-year flood (Q_{50}) is required for a site on Sunday Creek near Miles City. The site is located upstream from streamflow-gaging station 06309075 (site number 389, table 2), has a drainage area (*A*) of 428 mi^2, and a mean basin elevation (*E*) of 3,010 ft.

Solution:

The drainage area and Q_{50} at streamflow-gaging station 06309075 are 714 mi^2 and 8,280 ft^3/s, respectively (table 2). From table 13, the regression coefficient relating drainage area to Q_{50} in the East-Central Plains Region where Sunday Creek is located is determined to be 0.439. The estimated Q_{50} for the ungaged site on Sunday Creek is calculated from equation 19 as follows:

$$Q_{50,U} = Q_{50,G}\ (DA_U/DA_G)^{\exp_{50}},$$
$$= 8{,}280\ (428/714)^{0.439},$$
$$= 8{,}280\ (0.599)^{0.439},$$
$$= 8{,}280\ (0.799),$$
$$= 6{,}620 \text{ ft}^3/\text{s}.$$

The drainage-area ratio (428/714 = 0.6) is slightly larger than the suggested limiting value of 0.5. For comparison, the regression equation based on basin characteristics also may be used to estimate a value of Q_{50}. Accordingly, the equation for Q_{50} for the East-Central Plains Region (table 4) is used to calculate a second estimate as follows:

$$Q_{50} = 3{,}240\, A^{0.462}\ (E/1000)^{-1.96},$$
$$Q_{50} = 3{,}240\ (428)^{0.462}\ (3.01)^{-1.96},$$

$$Q_{50} = 3{,}240\ (428)^{0.462}\ (3.01)^{-1.96},$$

$$Q_{50} = 3{,}240\ (16.4)\ (0.115),$$

$$Q_{50} = 6{,}110\ \text{ft}^3/\text{s}.$$

Discussion:

Example 3 illustrates use of the drainage-area ratio adjustment method for a site with a drainage area ratio near the suggested limit of applicability. In this example, use of the basin-characteristics regression equation is probably just as appropriate as use of the drainage-area ratio adjustment method. Both methods produce estimates of Q_{50} that are reasonably similar and probably of equal reliability. For design purposes, the more conservative (larger) value of Q_{50} might be used, whereas for other planning or regulatory purposes the smaller value of Q_{50} might be used.

SUMMARY

This report describes methods used and analysis of flood frequency at gaged sites and presents methods for determining flood-frequency data at ungaged sites. Flood-frequency information was updated at 660 gaged sites having 10 or more years of peak-flow record through water year 1998. Flood-frequency data are presented in tabular format as annual peak discharges (*Q*) having recurrence intervals (*T*) of 2, 5, 10, 25, 50, 100, 200, and 500 years. Flood-frequency data at most gaged sites were determined by fitting a log-Pearson Type III probability distribution to the recorded annual peak discharge data using methods described in Bulletin 17B.

In the analysis, station skew was weighted with a regional skew value, determined from the national map in Bulletin 17B, to improve flood-frequency characteristics at individual sites. The Bulletin 17B map was used because it was found to differ only slightly from a new skew map developed for this report, an existing skew map developed by the NRCS, and use of a state-wide average skew value and because it provides consistent results at State borders.

Based on previous flood-frequency studies, the State of Montana was divided into eight regions for flood-frequency analysis; five of the regions (West Region, Northwest Region, Northwest Foothills Region Southwest Region, and Upper Yellowstone-Central Mountain Region) are located in the western one-half of Montana and three regions (Northeast Region, East-Central Plains Region, and Southeast Plains Region) are located in the eastern one-half of Montana.

At 26 sites in the Northwest Region, 7 sites in the West Region, and 1 site in the Northwest Foothills Region, the log-Pearson Type III probability distribution did not provide a good fit to flood-frequency data when all the flood data were combined. Accordingly, annual peak discharge data at these sites were separated into two categories—those caused by extreme rainfall and those caused by snowmelt or snowmelt mixed with rain—and separate, or mixed-population, flood-frequency analyses were made for each category. The two individual flood-frequency curves were combined to produce the final flood-frequency curves at these sites.

To estimate flood-frequency characteristics at ungaged sites, equations expressing *T*-year floods (Q_T) as a function of various explanatory variables were developed using regression methods. Within every region but the Northwest Region, a combination of OLS and GLS regression was used to obtain final equations relating Q_T to various basin characteristics. In the Northwest Region, OLS regression was used to obtain final equations. Measures of the overall reliability for the regression equations include the average sampling error variance, the model error variance, the average standard error of prediction (*SEP*), and the estimated equivalent years of record (*EYR*).

On a State-wide basis, the average *SEP* values ranged from 37.4 percent for the equation for estimation of Q_{50} in the Northwest Region to 134.1 percent for the equation for estimation of Q_2 in the Southeast Plains Region. The *EYR* ranged from 0.9 year for the equations for estimation of Q_2 in the West and Southwest Regions to 23.8 years for the equations for estimation of Q_{50} and Q_{100} in the Northwest Foothills Region.

Simple linear regression equations relating logarithms of Q_T to logarithms of active-channel and bankfull widths were developed for each of the eight regions in Montana. For the Northwest Region, OLS regression was used and for all other regions GLS regression was used.

An additional error term (width measurement error) was included in the regression equations based on channel width. For most recurrence intervals in most regions except the Southeast Plains and Southwest Regions, the average *SEP* values for the basin-characteristics equation generally were smaller than the average *SEP* values for both sets of channel-width equations. In addition, the average *SEP* values for the active-channel width equations were slightly smaller than the average *SEP* values for the bankfull-width equations. On a State-wide basis, the average *SEP* values for the active-channel width equations ranged from 57.2 percent for the equation for estimation of Q_5 in the Southwest Region to 141.3 percent for the equation for estimation of Q_{500} in the Northwest Foothills Region. Similarly, the average *SEP* values for the bankfull-width equations ranged from 63.1 percent for the equation for estimation of Q_5 in the Southwest Region to 155.5 percent for the equation for estimation of Q_{500} in the Northeast Plains Region.

The regression methods based on basin characteristics were compared with regression estimates based on channel width. Weights and average standard errors of prediction for all combinations of the three estimation methods based on regression equations were calculated. Weighting of estimates from basin-characteristics equations with estimates from either active-channel width equations or bankfull-width equations reduces the average *SEP* for all recurrence intervals in the West Region, the Southeast Plains Region, and the Southwest Region. Weighting estimates provides little or no reduction in average *SEP* over average *SEP* from basin-characteristics equations alone in the Northwest Region and in the Northwest Foothills Region. Weighting estimates in the Northeast Plains Region, the East-Central Plains Region, and the Upper Yellowstone-Central Mountain Region, reduces the average *SEP* for most, but not all, recurrence intervals. Only in the Upper Yellowstone-Central Mountain Region for recurrence intervals up to $T = 25$ years did weighting all three methods provide a significant improvement in *SEP* over weighting either one of the channel-width equations with the basin-characteristics equations.

The Region of Influence (ROI) regression method was tested for use in Montana. The method uses a search routine to select nearby stations with basin characteristics that are similar to those at the estimation site and performs an OLS regression using data only from the selected stations. The unique set of stations that make up the region of influence for each estimate is made up of the *N* nearest neighbors, where the nearness is measured by an overall dimensionless difference in the values of the basin characteristics.

As part of the ROI analysis, the State was divided into three super-regions that were thought to be reasonably homogeneous with regard to topography and climate. Within the super-regions, various trial applications of ROI regression and comparison tests with GLS regression results within the eight regions were made. Based on those comparisons, the ROI regression was not considered to be a reasonable alternative estimation procedure to GLS regression.

The regional regression equations developed in this report may not be reliable if an ungaged site of interest is located in a different region from the region where the stream originates. For streams that cross regional boundaries, the regression equation for each region can be applied separately, using basin or channel-width data at the site. The separate results then can be weighted in accordance with the proportion of drainage area in each region. When the upstream part of a drainage basin is in the Northwest Region and the downstream part of the drainage basin is in the Northwest Foothills Region, weighting the separately calculated flood discharges in proportion to drainage area in each region is appropriate only for floods having recurrence intervals of 25 years or less. Flood records on some streams in the Northwest Foothills Region that originate in the Northwest Region indicate that large flood discharges (recurrence intervals greater than about 25 years) may actually decrease in the downstream direction as a result of valley (flood plain) storage effects. Determining whether large flood discharges from drainage areas in the Northwest Region increase, decrease, or stay the same with increasing drainage area in the Northwest Foothills Region requires careful study of the individual stream in question.

If an ungaged site of interest is near a gaged site on the same stream, flood-frequency data at the gaged site can be used to estimate flood frequency at the ungaged site using a drainage-area ratio adjustment. The drainage-area ratio adjustment is calculated by taking the ratio of drainage areas at the two sites to a power that is based on the regression coefficient from an OLS regression relating Q_T to drainage area as the only independent variable. If an ungaged site of interest is between two gaged sites on the same stream, the logarithms of flood-frequency characteristics at the ungaged site can be linearly interpolated between logarithms of flood-frequency characteristics at the two gaged sites using logarithms of drainage area as the basis for interpolation.

REFERENCES CITED

Boner, F.C., and Stermitz, Frank, 1967, Floods of June 1964 in northwestern Montana: U.S. Geological Survey Water-Supply Paper 1840-B, 242 p.

Burn, D.H., 1990, Evaluation of regional flood frequency analysis with a region of influence approach: Water Resources Research, v. 26, no. 10, p. 149-165.

Crippen, J.R., and Bue, C.D., 1977, Maximum floodflows in the conterminous United States: U.S. Geological Survey Water-Supply Paper 1887, 52 p.

Fenneman, N.M., 1946, Physical divisions of the United States: Washington, D.C., U.S. Geological Survey special map, scale 1:7,000,000.

Helsel, D.R., and Hirsch, R.M., 1992, Statistical methods in water resources: Amsterdam; New York, Elsevier, 522 p.

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency—Bulletin 17B of the Hydrology Subcommittee: U.S. Geological Survey, Office of Water Data Coordination, 183 p.

Omang, R.J., 1992, Analysis of the magnitude and frequency of floods and the peak-flow gaging network in Montana: U.S. Geological Survey Water-Resources Investigations Report 92-4048, 70 p.

Omang, R.J., Parrett, Charles, and Hull, J.A., 1986, Methods for estimating magnitude and frequency of floods in Montana based on data through 1983: U.S. Geological Survey Water-Resources Investigations Report 86-4027, 85 p.

Osterkamp, W.R., and Hedman, E.R., 1977, Variation of width and discharge for natural high-gradient stream channels: Water Resources Research, v. 13, no. 2, p. 256-258.

Parrett, Charles, 1997, Regional analysis of annual precipitation maxima in Montana: U.S. Geological Survey Water-Resources Investigations Report 97-4004, 51 p.

Parrett, Charles, Hull, J.A., and Omang, R.J., 1987, Revised techniques for estimating peak discharges from channel width in Montana: U.S. Geological Survey Water-Resources Investigations Report 87-4121, 34 p.

Parrett, Charles, and Omang, R.J., 1981, Revised techniques for estimating magnitude and frequency of floods in Montana: U.S. Geological Survey Open-File Report 81-917, 66 p.

Parrett, Charles, Omang, R.J., and Hull, J.A., 1983, Mean annual runoff and peak flow estimates based on channel geometry of streams in northeastern and western Montana: U.S. Geological Survey Water-Resources Investigations Report 83-4046, 53 p.

Riggs, H.C., 1974, Flash flood potential from channel measurements, *in* Flash Floods Symposium, Paris, 1974: International Association of Hydrological Sciences Proceedings, no. 112, p. 52-56.

Tasker, G.D., and Slade, R.M. Jr., 1994, An interactive regional regression approach to estimating flood quantiles, *in* Fontane, D.G., and Tuvel, H.N., eds., Water Policy and Management—Solving the Problems, Proceedings of the 21st Annual Conference of the Water Resources Planning and Management Division: American Society of Civil Engineers, p. 782-785.

Tasker, G.D., and Stedinger, J.R., 1989, An operational GLS model for hydrologic regression: Journal of Hydrology, v. 111, p. 361-375.

U.S. Army Corps of Engineers, 1958, Frequency of New England floods: Sacramento, California, Civil Works Investigations Project CW-151, Flood Volume Studies—West Coast, Research Note 1, 4 p.

U.S. Soil Conservation Service, 1981, Average annual precipitation, Montana, based on 1941-1970 base period: Bozeman, Mont., U.S. Department of Agriculture, Soil Conservation Service, 13 p.

Wahl, K.L., 1977, Accuracy of channel measurements and implications in estimating streamflow characteristics: U.S. Geological Survey Journal of Research, v. 5, no. 6, p. 811-814.

Wolman, M.G., 1955, The natural channel of Brandywine Creek, Pennsylvania: U.S Geological Survey Professional Paper 271, 56 p.

APPENDIX

Matrices and matrix algebra provide a convenient way to describe and analyze regression equations. Accordingly, important matrices for regression analysis and determinations of regression reliability are described in this appendix. Methods for solving the matrix algebra equations shown are beyond the scope of this report and can be found in standard mathematical textbooks.

To determine the values for the regression constants and coefficients for any Q_T in any region, the basic linear regression equation shown in equation (3) or (3a) is first expressed in matrix form as:

$$\mathbf{Q_T} = \mathbf{A}\ \mathbf{X}. \tag{23}$$

The $\mathbf{Q_T}$, **A**, and **X** matrices for a region having n gaged sites and p explanatory variables are as follows:

$$\mathbf{Q_T} = \begin{vmatrix} \log Q_{T1} \\ \log Q_{T2} \\ \text{—} \\ \log Q_{Tn} \end{vmatrix}, \mathbf{A} = \begin{vmatrix} K \\ a_2 \\ \text{—} \\ a_p \end{vmatrix}, \mathbf{X} = \begin{vmatrix} 1 & \log x_{11} & \log x_{21} \text{—} & \log x_{p1} \\ 1 & \log x_{12} & \log x_{22} \text{—} & \log x_{p2} \\ & & \text{—} & \\ 1 & \log x_{1n} & \log x_{2n} \text{—} & \log x_{pn} \end{vmatrix} . \tag{24}$$

The least-squares solution matrix for **A** for OLS regression can be expressed as:

$$\mathbf{A} = (\mathbf{X^T X})^{-1}\ \mathbf{X^T Q_T}, \tag{25}$$

where

$\mathbf{X^T}$	is the transpose of matrix **X**, and
$(\mathbf{X^T X})^{-1}$	is the inverse of matrix $(\mathbf{X^T X})$.

The least-squares solution matrix for GLS regression can similarly be expressed as:

$$\Lambda = (\mathbf{X^T} \Lambda^{-1} \mathbf{X})^{-1}\ \mathbf{X^T}\ \Lambda^{-1} \mathbf{Q_T}, \tag{26}$$

where

Λ	is the covariance matrix that must be estimated as described by Tasker and Stedinger (1989).

The estimated covariance matrix (Λ) is based on the variance of annual peak discharges at each site, the assumption that the annual peak discharges can be described by a log-Pearson Type III probability distribution, and the cross correlation of annual peak discharges at each pair of sites. Use of the covariance matrix in the GLS regression procedure usually results in improved regression equations over the OLS regression procedure (Tasker and Stedinger, 1989).

Both the $(\mathbf{X^T X})^{-1}$ matrix and the $(\mathbf{X^T}\ \Lambda^{-1} \mathbf{X})^{-1}$ matrix are p+1 by p+1 matrices, where p is the number of explanatory variables used in the regression analysis. For the regressions based on basin characteristics, the sizes of these matrices vary from region to region. For the regressions based only on channel width, the sizes of these matrices are always 2 by 2. The $(\mathbf{X^T X})^{-1}$ matrix is a function of only the independent variables used in the regression, whereas the $(\mathbf{X^T} \Lambda^{-1} \mathbf{X})^{-1}$ matrix is a function of the independent variables used and the recurrence interval T. Thus, a single $(\mathbf{X^T X})^{-1}$ matrix is applicable for all eight OLS regression equations based on basin and climatic variables in the Northwest Region. Likewise, a single $(\mathbf{X^T X})^{-1}$ matrix is applicable for all eight OLS regression equations based on active-channel width, and a single $(\mathbf{X^T X})^{-1}$ matrix is applicable for all eight OLS regression equations based on bankfull width in the Northwest Region. In each of the other regions, the $(\mathbf{X^T} \Lambda^{-1} \mathbf{X})^{-1}$ matrix varies with $\mathbf{Q_T}$ and eight different matrices are used for the eight different GLS regression equations based on basin and climatic variables in each region. Similarly, eight different $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrices are used for the eight different GLS regression equations based on active-channel width and eight different $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrices for the GLS regression equations based on bankfull width.

The $(\mathbf{X}^{\mathbf{T}}\mathbf{X})^{\mathbf{-1}}$ and the $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrices are required to calculate the standard error of prediction for any particular regression estimate (SEP_i). The standard error of prediction for a particular estimate based on basin characteristics for any Q_T in the Northwest Region can be determined from the values of the explanatory variables at the particular site, *i*, using the following equation:

$$SEP_i = [\text{Model error variance } (1 + \mathbf{x_i}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\mathbf{X})^{\mathbf{-1}}\mathbf{x_i})]^{0.5}, \quad (27)$$

where

SEP_i is the standard error of prediction for an estimate of Q_T at site *i*;

Model error variance, in log units, is obtained from table 4 for the Q_T of interest;

$\mathbf{x_i}^{\mathbf{T}}$ is the row vector comprised of the value 1.0 and the log values of basin characteristics at site *i*;

$\mathbf{x_i}$ is the column vector comprised of the value 1.0 and the log values of basin characteristics at site *i*; and

$(\mathbf{X}^{\mathbf{T}}\mathbf{X})^{\mathbf{-1}}$ the OLS matrix applicable in the Northwest Region (table 14).

Similarly, the reliability of a particular estimate based on basin characteristics for any other region where GLS regression equations were developed can be determined using the following equation:

$$SEP_i = [\text{Model error variance} + \mathbf{x_i}^{\mathbf{T}}(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}\,\mathbf{x_i}]^{0.5}, \quad (28)$$

where all terms are as previously defined. The SEP_i for an estimate of Q_T at site *i* using channel width instead of basin characteristics also can be calculated using equation 27 for the Northwest Region and equation 28 for all other regions. Application of equations 27 and 28 for channel-width equations, however, requires the following changes: (1) the term “Model error variance” in both equations needs to be replaced by “Model error variance plus measurement error variance”, and (2) the $\mathbf{x_i}^{\mathbf{T}}$ and $\mathbf{x_i}$ vectors are comprised of the value 1.0 and the log value of either active-channel or bankfull width. The $(\mathbf{X}^{\mathbf{T}}\mathbf{X})^{\mathbf{-1}}$ and the $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrices for the regression equations based on basin characteristics are shown in table 14 (back of the report), and the $(\mathbf{X}^{\mathbf{T}}\mathbf{X})^{\mathbf{-1}}$ and the $(\mathbf{X}^{\mathbf{T}}\Lambda^{\mathbf{-1}}\mathbf{X})^{\mathbf{-1}}$ matrices for the regression equations based on active-channel width and bankfull width are shown in tables 15 and 16, respectively (back of the report).

DATA

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada

[Site number refers to number shown on location map, figure 1 on plate 1. Station number is U.S. Geological Survey number, wherein first two digits indicate the major river basin (05 is the Hudson Bay basin, 06 is the Missouri River basin, and 12 is the Columbia River basin) and the remaining 6 digits indicate a downstream station order. Sites with * after the last digit were not used in the regression analyses. All sites are in Montana, except as indicated. Type of flood data and frequency analysis: LP, indicates a log-Pearson Type III frequency analysis; R, indicates a regulated site; M, indicates a mixed-population frequency analysis; C, XXXXXXXX, indicates that record for this station was combined with record for station XXXXXXXX. Vertical coordinate system is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). Horizontal coordinate system referenced to the North American Datum of 1927 (NAD 27). Abbreviations: *A*, drainage area, in square miles; *E*, mean basin elevation, in feet; E_{6000}, percentage of basin above 6,000 feet in elevation; *F*, percentage of basin covered by forest; *P*, mean annual precipitation, in inches; W_{ac}, width of active channel, in feet; W_{bf}, width of bankfull channel, in feet. Symbol: --, not available]

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bankfull width (W_{bf})
		West Region									
1	12300000*	Kootenay River at Newgate, British Columbia	LP	41	7,660	--	--	--	--	--	--
2	12300400	Cayuse Creek near Trego	LP	13	5.29	4,700	0	95	28	11	--
3	12300500	Fortine Creek near Trego	LP	23	110	4,550	1	98	28	22	29
4	12300800	Deep Creek near Fortine	LP	33	18.9	5,010	30	92	50	16	18
5	12301300	Tobacco River near Eureka	LP	41	440	4,170	5	97.8	32	48	58
6	12301700	Kootenai River Tributary near Rexford	LP	12	.86	4,330	0	99	30	4.0	6.0
7	12301800	Gold Creek near Rexford	LP	11	6.12	4,700	5	100	31	9.0	14
8	12301810	Big Creek near Rexford	LP	10	137	4,930	0	100	37	42	55
9	12301933*	Kootenai River below Libby Dam, near Libby	LP, R	26	8,985	--	--	--	--	--	--
10	12301993	Wolf Creek tributary near Libby	LP	11	2.76	4,550	0	90	25	5.7	8.8
11	12301997	Richards Creek near Libby	LP	19	9.50	4,460	0	90	29	6.8	11
12	12301999	Wolf Creek near Libby	LP	11	216	4,100	0	100	27	40	47
13	12302055	Fisher River near Libby	M	49	838	4,100	0	92	32	111	130
14	12302400	Shaughnessy Creek near Libby	LP	33	1.16	3,760	0	97	60	7.0	11
15	12302500	Granite Creek near Libby	M	23	23.6	5,260	31	87.8	67	32	43
16	12303000*	Kootenai River at Libby	LP, R	20	10,240	--	--	--	--	--	--
17	12303100	Flower Creek near Libby	M	33	11.1	5,240	43.9	96.2	67	17	24
18	12303400	Ross Creek near Troy	LP	20	23.8	4,650	6	84	79	38	47
19	12303440	Camp Creek near Troy	LP	20	11.3	5,110	37	77	63	19	--
20	12303500	Lake Creek at Troy	M	28	210	4,080	9	95.8	67	70	78
21	12304060	Blacktail Creek near Yaak	LP	14	8.66	4,820	7	93	35	12	16
22	12304120	Zulu Creek near Yaak	LP	13	5.27	5,000	12	94	34	8.5	13
23	12304250	Whitetail Creek near Yaak	LP	15	2.48	4,220	0	96.7	35	9.0	17
24	12304300	Cyclone Creek near Yaak	LP	32	5.73	4,610	0	95	67	9.0	22
25	12304400	Fourth of July Creek near Yaak	LP	15	7.84	4,520	0	89	64	13	21
26	12304500	Yaak River near Troy	LP	45	766	5,050	22	97	43	136	176
27	12305000*	Kootenai River at Leonia, Idaho	LP, R	24	11,740	--	--	--	--	--	--

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years: *2*	*5*	*10*	*25*	*50*	*100*	*200*	*500*	Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
					West Region						
1	57,700	72,800	81,600	91,600	98,400	105,000	111,000	118,000	98,200	49.014	115.173
2	51	89	120	162	197	235	276	334	187	48.609	115.028
3	768	1,100	1,330	1,640	1,880	2,120	2,380	2,740	1,810	48.650	114.917
4	130	169	197	233	261	291	321	365	310	48.767	114.883
5	1,510	2,110	2,490	2,940	3,270	3,580	3,890	4,290	3,180	48.894	115.087
6	6	10	14	18	21	24	27	31	14	48.800	115.300
7	64	111	150	209	261	320	386	488	230	48.783	115.317
8	1,320	2,360	3,100	4,070	4,810	5,530	6,260	7,220	2,680	48.748	115.353
9	27,900	34,100	38,300	43,600	47,500	51,500	55,500	61,000	47,200	48.401	115.320
10	13	21	26	33	39	45	52	62	33	48.398	114.918
11	24	50	71	100	123	148	173	207	100	48.259	115.199
12	617	1,270	1,750	2,390	2,860	3,320	3,780	4,350	1,660	48.234	115.284
13	3,400	4,800	5,600	7,000	8,600	10,900	14,000	18,600	12,000	48.356	115.314
14	11	30	52	94	141	203	287	439	200	48.300	115.600
15	250	1,100	1,320	1,800	2,120	2,660	3,500	5,070	1,960	48.302	115.591
16	29,600	35,900	39,700	44,300	47,600	50,800	53,900	58,000	42,700	48.401	115.552
17	250	320	390	490	610	840	1,200	1,730	709	48.345	115.606
18	918	1,570	2,130	3,020	3,820	4,760	5,870	7,630	3,820	48.207	115.869
19	226	340	431	564	677	804	945	1,160	980	48.313	115.843
20	2,100	2,900	3,500	4,900	6,300	8,500	12,000	16,000	4,650	48.447	115.876
21	73	128	169	227	275	325	378	454	280	48.951	115.541
22	42	72	98	137	173	214	262	337	190	48.730	115.642
23	28	45	58	77	93	110	128	155	100	48.833	115.817
24	128	186	231	298	355	418	489	597	485	48.750	115.900
25	179	229	264	311	348	386	426	482	400	48.700	115.867
26	6,780	8,980	10,300	12,000	13,200	14,300	15,400	16,900	12,600	48.562	115.969
27	33,700	43,900	50,700	59,300	65,900	72,500	79,300	88,400	123,000	48.618	116.046

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		West Region--Continued									
28	12323240*	Blacktail Creek at Butte	LP	10	95.4	--	--	--	--	--	--
29	12323250*	Silver Bow Creek below Blacktail Creek, at Butte	LP	15	103	--	--	--	--	--	--
30	12323300	Smith Gulch near Silver Bow	LP	40	4.36	6,060	55	24.1	12	3.0	5.5
31	12323500	German Gulch Creek near Ramsay	LP	16	40.6	6,930	88	88.3	18	22	27
32	12323600*	Silver Bow Creek at Opportunity	LP	10	284	--	--	--	--	--	--
33	12323750	Silver Bow Creek at Warm Springs	LP	15	394	6,330	66	41	17	33	42
34	12323770*	Warm Springs Creek at Warm Springs	LP	15	163	--	--	--	--	--	--
35	12324100	Racetrack Creek below Granite Creek, near Anaconda	LP	17	39.5	7,600	93	94.7	35	22	28
36	12324200	Clark Fork at Deer Lodge	LP	20	916	6,400	62	46	22	--	--
37	12324250	Cottonwood Creek at Deer Lodge	LP	18	45.4	6,480	69	58	20	22	27
38	12324590	Little Blackfoot River near Garrison	LP	26	407	5,940	50	65	20	62	73
39	12324680*	Clark Fork at Goldcreek	LP	21	1,704	--	--	--	--	--	--
40	12324700	Clark Fork tributary near Drummond	LP	38	4.61	4,820	6	15	15	4.0	10
41	12324800	Morris Creek near Drummond	LP	16	12.6	5,430	19	60	18	3.0	5.0
42	12325500	Flint Creek near Southern Cross	LP	58	52.6	6,800	100	84	24	12	17.5
43	12329500	Flint Creek at Maxville	LP	57	208	6,220	59	68	20	28	35
44	12330000	Boulder Creek at Maxville	LP	59	71.3	6,980	83	98	31	28	32
45	12331600	Clark Fork at Drummond	C, 12331800, LP	18	2,378	6,040	51	52	20	103	120
46	12331700	Edwards Gulch at Drummond	LP	24	4.69	5,090	13	35	16	3.0	7.0
47	12331900*	Clark Fork near Clinton	LP	14	2,629	--	--	--	--	--	--
48	12332000	Middle Fork Rock Creek near Philipsburg	LP	61	123	7,180	89	93.3	35	56	71
49	12334510	Rock Creek near Clinton	LP	27	885	6,510	70	85	27	116	140
50	12334550*	Clark Fork at Turah Bridge, near Bonner	LP	13	3641	--	--	--	--	--	--
51	12335500	Nevada Creek above Reservoir, near Finn	LP	59	116	5,880	36	74.4	23	28	36
52	12338500	Blackfoot River near Ovando	M	25	1,274	5,760	37	83.4	29	150	180
53	12338540	Monture Creek above Dunham Creek, near Ovando	LP	14	64.7	6,380	59	78	41	52	68
54	12338550*	Dunham Creek at mouth, near Ovando	LP	14	31.7	--	--	--	--	--	--
55	12338600*	Monture Creek at Forest Service Boundary, near Ovando	LP	19	105	6,160	63	75	41	--	--
56	12338690	Monture Creek near Ovando	LP	10	140	5,910	54	75	35	52	68
57	12339300	Deer Creek near Seeley Lake	LP	18	19.8	5,150	14	82	39	22	29
58	12339450	Clearwater River near Clearwater	LP	19	345	5,280	26	81	37	70	110
59	12339900	West Twin Creek near Bonner	LP	33	7.33	5,430	27	62	25	15	22
60	12340000	Blackfoot River near Bonner	LP	65	2,290	5,710	35	87.5	29	150	190
61	12340200	Marshall Creek near Missoula	LP	16	5.63	4,870	14	84	23	6.0	9.0
62	12340500*	Clark Fork above Missoula	LP	70	5,999	5,690	46	75.8	30	--	--
63	12341000	Rattlesnake Creek at Missoula	LP	10	79.7	5,730	52.6	88.1	34	39	48
64	12342500*	West Fork Bitterroot River near Conner	LP	58	317	6,610	90	95	36	60	78
65	12342950	Trapper Creek near Conner	LP	18	28.5	6,830	67	67	66	22	31
66	12344000	Bitterroot River near Darby	LP	61	1,049	6,490	61	95.4	22	148	184
67	12344300	Burke Gulch near Darby	LP	25	6.50	5,490	23	80	22	3.0	5.5
68	12345800	Camas Creek near Hamilton	LP	16	5.05	7,090	79	76	62	15	20
69	12345850	Sleeping Child Creek near Hamilton	LP	20	65.2	6,230	64	77	31	33	37
70	12346500	Skalkaho Creek near Hamilton	LP	30	87.8	6,800	82	99	36	34	44
71	12347500	Blodgett Creek near Corvallis	LP	24	25.9	6,730	67	92.3	64	30	38

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
					West Region--Continued						
28	139	224	283	361	419	478	538	618	303	45.911	112.527
29	235	306	352	408	450	490	531	584	447	45.997	112.562
30	16	45	77	138	203	289	401	598	345	45.950	112.667
31	181	275	345	442	520	604	693	822	450	46.014	112.792
32	391	663	884	1,210	1,490	1,810	2,160	2,690	1,300	46.108	112.805
33	533	853	1,090	1,410	1,660	1,930	2,210	2,600	1,320	46.185	112.768
34	260	389	475	581	658	734	808	906	494	46.181	112.785
35	366	485	556	637	693	745	794	855	580	46.279	112.919
36	984	1,640	2,130	2,790	3,320	3,860	4,440	5,240	2,500	46.398	112.742
37	243	518	745	1,070	1,340	1,630	1,930	2,360	1,820	46.400	112.717
38	1,250	2,540	3,620	5,230	6,600	8,100	9,740	12,100	8,650	46.520	112.793
39	2,500	4,600	6,250	8,610	10,500	12,600	14,800	18,000	12,000	46.591	112.928
40	47	100	147	221	287	361	446	574	280	46.617	113.033
41	9	16	21	30	37	45	54	67	40	46.667	113.100
42	83	136	174	222	259	296	333	382	174	46.233	113.299
43	451	691	862	1,090	1,270	1,450	1,650	1,910	1,680	46.464	113.239
44	372	570	726	953	1,150	1,360	1,600	1,950	1,460	46.472	113.233
45	3,760	6,700	8,850	11,700	13,900	16,200	18,400	21,500	15,800	46.663	113.149
46	20	63	113	209	311	443	610	897	318	46.674	113.142
47	2,790	5,380	7,600	11,000	14,000	17,400	21,200	27,000	16,000	46.718	113.588
48	906	1,240	1,430	1,640	1,790	1,920	2,040	2,190	1,680	46.195	113.500
49	3,220	4,480	5,250	6,170	6,800	7,410	7,990	8,720	6,500	46.723	113.682
50	5,070	8,440	10,800	13,900	16,300	18,600	21,000	24,100	12,400	46.826	113.813
51	504	937	1,270	1,720	2,080	2,440	2,830	3,350	1,800	46.778	112.767
52	5,400	6,800	7,800	10,500	14,000	17,500	22,000	31,000	14,600	47.019	113.228
53	869	988	1,060	1,150	1,210	1,270	1,320	1,400	1,140	47.119	113.146
54	507	634	720	832	918	1,010	1,100	1,220	900	47.123	113.164
55	1,350	1,650	1,820	2,020	2,160	2,290	2,410	2,560	2,400	47.094	113.153
56	1,550	1,920	2,130	2,370	2,540	2,690	2,830	3,000	2,120	47.046	113.190
57	244	321	372	438	487	537	588	657	425	47.210	113.541
58	1,600	2,200	2,630	3,210	3,670	4,160	4,680	5,410	3,800	47.019	113.387
59	97	167	223	304	372	446	527	646	370	46.917	113.717
60	8,890	12,600	14,900	17,500	19,300	21,000	22,600	24,500	19,200	46.900	113.756
61	17	27	35	48	59	71	85	106	60	46.883	113.917
62	14,900	21,600	25,900	31,200	35,000	38,600	42,200	46,800	32,300	46.877	113.931
63	1,270	1,660	1,910	2,210	2,430	2,650	2,860	3,140	1,830	46.872	113.983
64	1,870	2,730	3,250	3,840	4,240	4,600	4,940	5,360	4,060	45.725	114.281
65	450	589	688	824	931	1,050	1,170	1,340	1,800	45.895	114.181
66	5,890	8,310	9,790	11,500	12,700	13,900	15,000	16,300	11,500	45.972	114.141
67	9	15	19	24	28	31	35	40	25	46.033	114.150
68	148	209	248	296	330	364	397	439	265	46.150	114.217
69	455	702	872	1,090	1,250	1,410	1,570	1,790	1,500	46.133	114.057
70	672	872	986	1,120	1,200	1,280	1,350	1,440	1,210	46.161	113.948
71	633	775	863	970	1,050	1,120	1,190	1,290	836	46.269	114.236

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		West Region--Continued									
72	12348500	Willow Creek near Corvallis	LP	19	21.9	6,620	72	78	29	16.5	21
73	12350000	Bear Creek near Victor	LP	19	26.8	6,430	68	99	63	41	47
74	12350200	Gash Creek near Victor	LP	16	3.37	6,770	79	86.1	60	10.5	15.5
75	12350250*	Bitterroot River at Bell Crossing, near Victor	LP	12	1,963	--	--	--	--	--	--
76	12350500	Kootenai Creek near Stevensville	LP	22	28.9	6,350	65	69	64	38	46
77	12351000	Burnt Fork Bitterroot River near Stevensville	LP	40	73.2	6,570	70	82.8	32	20	28
78	12351200*	Bitterroot River near Florence	LP	12	2,354	5,920	47	78	36	260	300
79	12351400	Eightmile Creek near Florence	LP	16	19.5	5,590	35	86.5	21	10	16
80	12352000	Lolo Creek above Sleeman Creek, near Lolo	LP	12	250	5,430	33.3	97.8	52	51	60
81	12352200	Hays Creek near Missoula	LP	16	4.16	4,540	3	79	33	4.0	7.5
82	12352500*	Bitterroot River near Missoula	LP	14	2,814	--	--	--	--	--	--
83	12353000*	Clark Fork below Missoula	LP	69	9,003	5,710	44	78.5	17	--	--
84	12353250	Ninemile Creek near Alberton	LP	10	50.2	5,190	23	77	42	40	--
85	12353280	Ninemile Creek near Huson	LP	10	170	4,920	24	86	38	48	60
86	12353400	Negro Gulch near Alberton	LP	23	8.02	4,760	8	81.6	33	8.0	13
87	12353800	Thompson Creek near Superior	LP	20	12.2	4,720	13	86.8	43	9.0	14
88	12353820*	Dry Creek near Superior	LP	10	46.3	--	--	--	--	--	--
89	12353850	East Fork Timber Creek near Haugan	LP	16	2.72	4,320	0	89	58	8.0	12
90	12354000	St. Regis River near St. Regis	M	27	303	4,520	1	99	52	130	136
91	12354100	North Fork Little Joe Creek near St. Regis	LP	15	14.7	4,870	2	89	56	16	21
92	12354500*	Clark Fork at St. Regis	LP	83	10,709	5,460	38	80.1	18	--	--
93	12355000*	Flathead River at Flathead, British Columbia	LP	66	427	--	--	--	--	--	--
94	12355350	Big Creek at Big Creek Ranger Station, near Columbia Falls	LP	20	82.1	5,340	20	74	48	43	50
95	12363000*	Flathead River at Columbia Falls	LP, R	47	4,464	--	--	--	--	--	--
96	12363900	Rock Creek near Olney	LP	15	3.61	4,470	17	88	35	6.0	8.0
97	12363920	Stillwater River at Olney	LP	10	146	4,820	13	85	40	54	67
98	12364000	Logan Creek at Tally Lake, near Whitefish	LP	10	183	4,910	6	100	28	47	67
99	12365000	Stillwater River near Whitefish	LP	47	524	4,320	3	97.5	31	70	85
100	12366000	Whitefish River near Kalispell	LP	49	170	4,170	11	86.8	37	64	82
101	12367500	Ashley Creek near Kalispell	LP	20	201	4,670	0	78	24	26	38
102	12369200	Swan River near Condon	LP	20	69.1	5,830	39	61	54	72	84
103	12369250	Holland Creek near Condon	LP	18	22.3	5,250	26	79	44	22	33
104	12369650*	North Fork Lost Creek near Swan Lake	LP	10	13.0	--	--	--	--	--	--
105	12370000	Swan River near Bigfork	LP	77	671	5,020	26	89.8	23	165	185
106	12370500	Dayton Creek near Proctor	LP	33	18.5	4,370	0	94	20	11	14
107	12370900	Teepee Creek near Polson	LP	21	2.18	5,460	45	89	51	6.0	10
108	12371100	Hell Roaring Creek near Polson	LP	27	6.22	5,210	37	90	48	9.0	14
109	12372000*	Flathead River near Polson	LP, R	61	7,096	--	--	--	--	--	--
110	12374250*	Mill Creek above Bassoo Creek, near Niarada	LP	16	19.6	--	--	--	--	--	--
111	12374300	Mill Creek near Niarada	LP	15	28.2	4,510	7	91	27	13	21
112	12375700	Garden Creek near Hot Springs	LP	15	3.57	4,180	0	94	19	8.0	12
113	12375900	South Crow Creek near Ronan	LP	16	7.57	6,350	76	48	67	--	--

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
West Region--Continued											
72	106	137	155	174	187	198	209	222	170	46.294	113.994
73	686	889	1,020	1,190	1,320	1,440	1,570	1,740	1,340	46.383	114.217
74	109	159	191	231	260	288	315	351	200	46.400	114.267
75	9,330	13,100	15,500	18,700	21,000	23,300	25,700	28,800	18,700	46.443	114.123
76	814	1,060	1,200	1,360	1,470	1,570	1,660	1,770	1,300	46.537	114.159
77	338	506	622	769	880	992	1,110	1,260	1,100	46.464	113.944
78	15,200	18,600	20,800	23,600	25,700	27,700	29,800	32,500	20,300	46.633	114.050
79	50	73	89	110	126	142	159	181	104	46.653	113.958
80	1,460	1,760	1,960	2,210	2,410	2,610	2,810	3,090	2,430	46.750	114.150
81	11	26	40	62	82	104	129	166	56	46.817	114.100
82	14,500	20,000	23,400	27,300	30,000	32,500	35,000	38,000	3,300	46.832	114.053
83	28,100	38,900	45,200	52,400	57,300	61,700	65,900	70,900	55,100	46.869	114.126
84	519	774	964	1,230	1,440	1,670	1,920	2,270	1,280	47.186	114.587
85	1,120	1,450	1,640	1,870	2,020	2,170	2,310	2,480	1,700	47.063	114.413
86	28	55	81	124	165	215	276	375	170	47.017	114.533
87	67	117	154	204	244	284	326	383	230	47.200	114.917
88	386	462	508	561	599	635	670	714	560	47.221	114.972
89	39	60	74	91	104	117	130	147	112	47.417	115.417
90	4,300	6,000	7,100	8,250	10,100	13,100	17,900	27,500	9,640	47.297	115.122
91	184	239	268	300	319	337	352	370	295	47.267	115.150
92	36,300	49,500	57,000	65,300	70,700	75,600	80,000	85,200	68,900	47.302	115.086
93	7,210	9,390	10,900	12,900	14,500	16,200	17,900	20,300	16,300	49.001	114.476
94	1,140	1,440	1,650	1,940	2,160	2,390	2,640	2,980	2,130	48.602	114.165
95	43,900	55,800	63,200	71,900	78,200	84,200	90,100	97,800	176,000	48.362	114.184
96	15	25	32	41	49	57	66	78	40	48.617	114.650
97	649	986	1,240	1,590	1,870	2,180	2,510	2,980	1,740	48.536	114.571
98	465	878	1,200	1,650	2,020	2,400	2,800	3,360	1,380	48.453	114.569
99	1,590	2,510	3,130	3,900	4,470	5,030	5,580	6,290	4,570	48.319	114.386
100	809	1,050	1,200	1,370	1,500	1,620	1,740	1,890	1,580	48.320	114.278
101	95	213	332	542	751	1,010	1,340	1,900	749	48.166	114.429
102	828	1,050	1,180	1,360	1,480	1,600	1,730	1,890	1,540	47.423	113.670
103	277	338	371	407	430	451	470	493	385	47.439	113.670
104	260	310	344	386	417	448	480	523	380	47.885	113.798
105	5,080	6,300	7,070	8,000	8,670	9,330	9,980	10,800	8,890	48.024	113.979
106	36	62	82	110	132	156	181	216	131	47.917	114.333
107	10	20	30	47	65	88	117	168	44	47.817	114.017
108	30	62	89	130	165	203	245	306	104	47.700	114.050
109	45,100	60,600	68,600	76,600	81,500	85,500	88,900	92,700	73,200	47.680	114.246
110	43	82	116	170	220	279	348	458	173	47.830	114.696
111	93	167	220	291	344	398	451	522	250	47.833	114.683
112	26	49	67	94	116	139	165	200	100	47.650	114.717
113	168	251	303	367	413	456	498	552	312	47.492	114.026

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (*A*)	Mean basin elevation (*E*)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (*F*)	Mean annual precipitation (*P*)	Active-channel width (W_{ac})	Bankfull width (W_{bf})
		West Region--Continued									
114	12376000*	Crow Creek near Ronan	LP	10	46.1	--	--	--	--	--	--
115	12377150	Mission Creek above Reservoir, near St. Ignatius	LP	16	12.4	7,120	82	33	74	--	--
116	12381400*	South Fork Jocko River near Arlee	LP	16	56.0	--	--	--	--	--	--
117	12383500*	Big Knife Creek near Arlee	LP	17	6.88	--	--	--	--	--	--
118	12387450*	Valley Creek near Arlee	LP	16	15.3	--	--	--	--	--	--
119	12388400*	Revais Creek below West Fork, near Dixon	LP	16	23.4	--	--	--	--	--	--
120	12388700*	Flathead River at Perma	LP, R	15	8,795	--	--	--	--	--	--
121	12389000*	Clark Fork near Plains	LP, R	47	19,958	--	--	--	--	--	--
122	12389150	McGregor Creek tributary near Marion	LP	11	2.55	5,020	5	100	30	5.2	9.2
123	12389500	Thompson River near Thompson Falls	LP	44	642	4,710	5	99	41	68	85
124	12390700	Prospect Creek at Thompson Falls	M	43	182	4,410	3	98.2	54	44	67
125	12391100	White Pine Creek near Trout Creek	LP	11	8.75	4,960	6	86	58	23	30
126	12391200	Canyon Creek near Trout Creek	LP	19	8.64	4,500	0	73	62	17	22
127	12391400*	Clark Fork below Noxon Rapids Dam, near Noxon	LP, R	39	21,833	--	--	--	--	--	--
128	12391430	Skelton Creek near Noxon	LP	12	2.10	4,970	0	83	59	7.5	13
129	12391525	Snake Creek near Noxon	LP	13	3.11	4,080	0	90	57	11	15
130	12391550	Bull River near Noxon	LP	10	139	4,470	9	85	65	64	70
		Northwest Region									
131	05010000	Belly River at International Boundary	M	17	74.8	6,180	58	51.3	79	--	--
132	05011000	Belly River near Mountain View, Alberta	M	68	121	5,920	46	59.8	65	105	135
133	05011500	Waterton River near International Boundary	M	17	61.0	6,060	56	53.9	84	--	--
134	05012500	Boundary Creek at International Boundary	M	17	21.0	5,610	33	70.6	75	--	--
135	05013000	Waterton River near Waterton Park, Alberta	M	55	238	5,910	48	58.6	68	--	--
136	05013900*	Grinnell Creek at Grinnell Glacier, near Many Glacier	LP	10	1.10	--	--	--	--	--	--
137	05014000*	Grinnell Creek near Many Glacier	LP	29	3.32	6,530	72	47.4	95	25	35
138	05014500	Swiftcurrent Creek at Many Glacier	M	86	30.9	6,460	64	58.1	95	45	62
139	05016000*	Swiftcurrent Creek at Sherburne	LP, R	80	64.6	6,390	62	63	85	54	64
140	05017500	St. Mary River near Babb	LP	64	276	6,170	53	66	71	165	180
141	05020500	St. Mary River at International Boundary	LP	94	465	5,790	39	57	59	160	170
142	06073000	Dearborn River near Clemons	M	30	123	6,230	76	91.3	37	54	83
143	06078500	North Fork Sun River near Augusta	M	30	258	6,150	61	87.8	42	86	93
144	06079600	Beaver Creek at Gibson Dam, near Augusta	LP	15	20.8	6,030	50	89	29	16.5	24
145	06080000	Sun River near Augusta	M	27	609	6,330	70	85.5	42	160	193
146	06081500	Willow Creek near Augusta	LP	20	96.1	5,080	16.4	24.1	21	20	35
147	06084500	Elk Creek at Augusta	M	22	157	5,170	20.5	37.6	21	46	50
148	06091700*	Two Medicine River below South Fork, near Browning	M	22	250	--	--	--	--	--	--
149	06092000	Two Medicine River near Browning	M	43	317	5,600	36.9	42	36	164	185
150	06092500	Badger Creek near Browning	C, 06093200, M	23	133	6,020	51	59.3	39	--	--
151	06097100	Blacktail Creek near Heart Butte	LP	17	16.4	4,880	0	56	25	14	21
152	06098500*	Cut Bank Creek near Browning	LP	14	123	--	--	--	--	--	--

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
					West Region--Continued						
114	449	580	675	805	910	1,020	1,140	1,310	1,400	47.486	114.094
115	420	531	598	675	729	780	828	890	706	47.323	113.979
116	399	612	773	999	1,180	1,380	1,600	1,910	1,220	47.196	113.850
117	38	55	67	82	94	106	118	135	100	47.148	113.973
118	57	79	93	112	127	142	157	177	116	47.170	114.230
119	156	224	272	336	386	439	493	570	382	47.266	114.406
120	37,400	44,500	48,500	53,200	56,400	59,400	62,200	65,700	54,700	47.368	114.584
121	77,400	94,800	105,000	117,000	125,000	132,000	139,000	148,000	134,000	47.430	114.855
122	16	29	41	61	78	99	123	162	80	48.029	114.932
123	2,320	3,660	4,570	5,720	6,580	7,420	8,270	9,380	6,080	47.592	115.229
124	1,680	2,400	2,880	3,430	5,210	6,940	8,950	11,800	5,490	47.586	115.354
125	212	340	442	591	717	858	1,010	1,250	781	47.739	115.674
126	136	187	218	256	283	309	335	367	250	47.854	115.499
127	73,200	100,000	115,000	131,000	142,000	151,000	159,000	169,000	124,900	47.961	115.733
128	24	34	40	48	53	59	65	72	46	47.963	115.888
129	44	83	113	155	189	225	262	315	126	48.123	115.753
130	2,100	2,900	3,430	4,120	4,630	5,160	5,690	6,400	3,890	48.047	115.834
					Northwest Region						
131	1,500	1,800	1,900	2,450	3,800	6,000	9,000	17,500	12,000	48.997	113.681
132	2,100	2,800	3,200	4,600	6,500	9,100	13,000	21,000	16,400	49.100	113.697
133	2,120	2,450	2,700	3,000	4,000	6,200	9,600	18,000	12,400	48.956	113.900
134	530	650	720	910	1,600	2,500	4,300	8,600	5,930	48.997	113.906
135	4,500	5,500	6,300	7,600	10,500	15,000	21,000	33,000	25,700	49.113	113.838
136	68	84	95	108	117	127	137	150	100	48.761	113.721
137	176	255	321	421	510	613	732	918	540	48.771	113.698
138	1,050	1,300	1,400	1,700	2,600	3,800	5,400	8,700	6,700	48.799	113.656
139	1,140	1,610	1,950	2,420	2,790	3,190	3,620	4,240	2,510	48.830	113.516
140	3,550	5,020	6,180	7,860	9,290	10,900	12,700	15,400	16,500	48.833	113.419
141	3,710	6,380	8,910	13,200	17,400	22,700	29,300	40,600	40,000	49.003	113.313
142	1,200	1,800	2,300	3,300	5,000	7,100	10,500	17,400	17,400	47.292	112.450
143	3,000	4,000	4,700	6,000	7,600	12,000	19,000	33,000	51,100	47.641	112.859
144	94	222	379	719	1,130	1,740	2,650	4,520	4,360	47.600	112.750
145	6,300	10,000	13,500	18,000	24,000	32,000	42,000	60,000	59,700	47.621	112.706
146	163	434	737	1,320	1,930	2,730	3,780	5,620	1,150	47.550	112.467
147	950	1,600	2,400	3,200	4,100	5,300	7,500	12,000	12,000	47.483	112.383
148	3,000	5,000	7,000	11,000	17,000	23,000	35,000	64,000	11,700	48.427	112.989
149	3,400	5,000	6,500	9,200	13,000	20,000	32,000	60,000	100,000	48.474	112.802
150	1,800	2,400	3,000	4,600	7,000	11,000	18,000	32,000	49,700	48.351	112.841
151	136	297	478	834	1,230	1,780	2,540	4,000	1,390	48.249	112.789
152	1,050	1,920	2,790	4,380	6,010	8,140	10,900	15,900	5,480	48.617	113.035

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Northwest Region--Continued									
153	06102500	Teton River below South Fork, near Choteau	C, 06103000, M	28	105	6,550	88.9	55.6	35	41	70
154	06132200	South Fork Milk River near Babb	M	38	70.4	5,470	11.7	43.9	36	22	27
155	06132400	Dry Fork Milk River near Babb	LP	30	17.9	5,130	0	22	28	9.5	11.5
156	06133500	North Fork Milk River above St. Mary Canal, near Browning	LP	59	59.0	4,850	0	0	21	23	31
157	06134000*	North Milk River near International Boundary	LP, R	81	91.8	--	--	--	--	--	--
158	12335000	Blackfoot River near Helmville	M	16	481	5,890	47	94.6	15	100	120
159	12355500	North Fork Flathead River near Columbia Falls	M	77	1,548	5,120	29	87.3	26	225	270
160	12356000	Skyland Creek near Essex	M	25	8.09	6,000	48	93	47	19	28
161	12356500	Bear Creek near Essex	M	25	20.4	5,770	32.2	74.4	47	25	36
162	12357000	Middle Fork Flathead River at Essex	M	24	510	5,900	46	87	52	172	192
163	12357300	Moccasin Creek near West Glacier	LP	17	2.38	5,620	41	81	57	16	22
164	12357400	Middle Fork Flathead River tributary at West Glacier	LP	15	.14	3,580	0	76	39	2.5	4.5
165	12358500	Middle Fork Flathead River near West Glacier	M	55	1,128	5,800	44	84.7	59	185	220
166	12359000	South Fork Flathead River at Spotted Bear Ranger Station, near Hungry Horse	M	18	958	6,130	57	88.8	52	178	200
167	12359500	Spotted Bear River near Hungry Horse	M	10	184	6,000	55.5	91.9	56	65	105
168	12359800	South Fork Flathead River above Twin Creek, near Hungry Horse	M	31	1,160	6,090	56.9	89.2	52	--	--
169	12360000	Twin Creek near Hungry Horse	M	11	47.0	5,300	57	83.3	53	41	59
170	12361000	Sullivan Creek near Hungry Horse	M	24	71.3	5,510	38	80	35	63	78
171	12361500	Graves Creek near Hungry Horse	LP	13	27.0	5,430	42	94.4	67	40	60
		Northwest Foothills Region									
172	12362500*	South Fork Flathead River near Columbia Falls	LP, R	47	1,663	5,780	53	85.7	37	290	325
173	06073500	Dearborn River near Craig	LP	26	325	5,330	31	55	28	69	85
174	06073600	Black Rock Creek near Augusta	LP	25	5.54	4,380	0	0	16	4.0	7.2
175	06078200*	Missouri River near Ulm	LP,R	42	20,941	--	--	--	--	--	--
176	06086000*	Sun River at Fort Shaw	C, 06085800; 06087500, M	39	,417	--	--	--	--	--	--
177	06087900	Muddy Creek tributary near Power	LP	17	3.15	3,840	0	1	13	3.0	5.5
178	06088300*	Muddy Creek near Vaughn	LP	23	282	--	--	--	--	--	--
179	06088500	Muddy Creek at Vaughn	LP	62	391	3,840	0	3.9	12	45	60
180	06089000*	Sun River near Vaughn	LP	65	1,854	4,960	27	35	24	200	255
181	06089300	Sun River tributary near Great Falls	LP	21	21.1	3,510	0	0	13	10	18
182	06090800*	Missouri River at Fort Benton	LP, R	46	24,749	--	--	--	--	--	--
183	06090810	Ninemile Coulee near Fort Benton	LP	18	16.9	3,460	0	0	14	9.8	18
184	06098000	Dupuyer Creek near Valier	M	25	137	5,040	16	27.5	25	22	33
185	06098700	Powell Coulee near Browning	LP	25	12.7	4,380	0	0	16	5.5	11
186	06099000	Cut Bank Creek at Cut Bank	LP	57	1,041	4,460	5.6	10.2	19	88	108
187	06099500*	Marias River near Shelby	LP	93	3,242	4,620	13.5	19	24	--	--
188	06099700	Middle Fork Dry Fork Marias River near Dupuyer	LP	16	20.2	4,590	0	5.9	19	9.0	24
189	06100200	Heines Coulee tributary near Valier	LP	17	.6	3,910	0	0	13	1.0	4.0
190	06100300	Lone Man Coulee near Valier	LP	39	14.1	3,890	0	0	13	6.5	14

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
					Northwest Region--Continued						
153	810	1,500	2,000	3,500	5,900	10,000	17,000	32,000	54,600	47.833	112.607
154	1,500	1,800	1,900	2,450	3,800	6,000	9,000	17,500	12,000	48.754	113.167
155	158	539	1,060	2,250	3,720	5,900	9,080	15,500	2,640	48.833	113.200
156	266	721	1,250	2,320	3,490	5,090	7,250	11,200	3,090	48.963	113.062
157	837	1,260	1,630	2,230	2,790	3,460	4,280	5,610	3,670	49.022	112.971
158	2,000	2,800	3,400	4,500	6,400	9,500	14,000	22,000	9,500	46.936	112.942
159	20,000	25,000	28,000	33,000	43,000	54,000	69,000	98,000	69,100	48.496	114.127
160	160	230	280	450	750	1,300	2,000	3,800	3,820	48.292	113.386
161	400	630	830	1,250	1,700	2,400	3,400	5,600	1,840	48.281	113.425
162	9,500	13,000	15,000	19,500	24,000	30,000	36,000	49,000	75,300	48.275	113.603
163	113	201	280	409	530	675	850	1,130	490	48.483	113.850
164	2	5	8	14	19	26	34	48	10	48.500	113.967
165	20,000	26,000	30,000	35,000	41,000	49,000	61,000	85,000	140,000	48.495	114.009
166	15,000	18,000	20,200	23,000	25,000	28,000	32,000	37,000	36,700	47.922	113.524
167	3,600	4,500	5,200	6,400	7,900	10,000	13,000	20,000	5,480	47.928	113.519
168	19,000	24,000	26,200	30,000	32,000	36,000	41,000	50,000	50,900	47.979	113.560
169	1,400	1,950	2,400	3,300	4,000	5,000	6,000	8,000	5,830	47.986	113.558
170	1,900	2,400	2,700	3,100	3,500	4,100	5,000	7,000	5,020	48.029	113.703
171	1,140	1,580	1,930	2,470	2,950	3,490	4,120	5,090	3,780	48.131	113.810
					Northwest Foothills Region						
172	12,100	15,700	18,600	22,600	25,900	29,600	33,600	39,600	46,200	48.357	114.037
173	1,690	2,820	3,860	5,590	7,240	9,270	11,800	15,900	15,400	47.199	112.096
174	168	321	447	631	786	955	1,140	1,410	555	47.291	112.163
175	16,500	23,900	28,400	33,700	37,400	40,800	44,000	48,100	35,000	47.435	111.385
176	7,200	10,000	13,500	18,000	22,500	29,500	37,000	50,000	20,000	47.519	111.814
177	136	323	495	768	1,010	1,290	1,590	2,050	620	47.750	111.717
178	766	1,330	1,850	2,730	3,590	4,640	5,940	8,140	3,560	47.625	111.635
179	645	1,210	1,790	2,870	4,000	5,510	7,500	11,200	7,600	47.561	111.538
180	5,460	9,300	12,900	19,200	25,300	32,900	42,500	59,000	53,500	47.527	111.485
181	82	287	529	986	1,450	2,030	2,740	3,900	530	47.533	111.400
182	23,100	35,500	44,800	57,600	68,100	79,300	91,300	109,000	78,700	47.818	110.666
183	82	362	802	1,910	3,370	5,660	9,150	16,500	2,110	47.700	110.703
184	850	1,500	2,400	4,000	6,000	9,000	13,000	21,000	21,600	48.236	112.397
185	36	154	321	688	1,120	1,710	2,520	3,980	405	48.750	112.756
186	1,690	3,340	4,940	7,720	10,500	13,900	18,300	25,600	16,600	48.633	112.346
187	5,910	12,100	19,000	32,800	48,500	70,500	101,000	162,000	241,000	48.427	111.889
188	88	344	737	1,730	3,060	5,180	8,510	15,800	4,240	48.150	112.467
189	6	19	38	87	153	260	433	827	249	48.250	112.233
190	61	326	758	1,810	3,150	5,120	7,920	13,300	5,440	48.233	112.233

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Northwest Foothills Region--Continued									
191	06100500*	Dry Fork Marias River at Fowler	LP	12	314	--	0	--	12	--	--
192	06101500*	Marias River near Chester	LP	43	4,927	--	--	--	--	--	--
193	06101560*	Pondera Coulee near Chester	LP	11	598	--	--	--	--	--	--
194	06101600	Marias River tributary no. 3 near Chester	LP	16	.26	2,990	0	0	11	2.3	4.3
195	06101700	Fey Coulee tributary near Chester	LP	29	2.47	3,260	0	0	11	--	--
196	06101800	Sixmile Coulee near Chester	LP	17	30.3	3,110	0	0	11	4.0	7.0
197	06101900	Dead Indian Coulee near Fort Benton	LP	16	2.73	3,340	0	0	11	4.8	8.5
198	06102000*	Marias River near Brinkman	LP	38	6,425	4,040	6.8	10.2	17	--	--
199	06102100	Dry Fork Coulee tributary near Loma	LP	15	.84	2,770	0	0	12	3.5	6.5
200	06102200	Marias River tributary at Loma	LP	17	1.62	2,830	0	0	12	5.0	14
201	06102300	Marias River tributary no. 2 at Loma	LP	17	.25	2,750	0	0	12	2.7	5.1
202	06105800	Bruce Coulee tributary near Choteau	LP	36	1.7	4,170	0	0	14	3.3	13
203	06106000	Deep Creek near Choteau	LP	15	223	4,910	18	13.6	21	49	60
204	06108000*	Teton River near Dutton	LP	44	1,307	4,470	14.2	11.1	18	72	84
205	06108200	Kinley Coulee near Dutton	LP	16	9.67	3,700	0	0	13	2.0	3.5
206	06108300	Kinley Coulee tributary near Dutton	LP	16	2.65	3,760	0	0	13	--	--
207	06132700*	Milk River near Del Bonita	LP	21	325	5,000	5	19.4	24	48	64
208	06133000*	Milk River at Western Crossing of International Boundary	LP	67	401	4,870	5	14.8	22	--	--
209	06134500*	Milk River at Milk River, Alberta	LP, R	81	1,050	4,010	2.9	6.7	18	--	--
210	06134700*	Verdigris Coulee near the mouth, Milk River, Alberta	LP	14	137	--	--	--	--	--	--
211	06134800	Van Cleeve Coulee tributary near Sunburst	LP	29	10.8	3,600	0	0	12	3.0	5.5
		Northeast Plains Region									
212	06090300*	Missouri River near Great Falls	LP, R	47	23,292	--	--	--	--	--	--
213	06109500*	Missouri River at Virgelle	LP, R	46	34,379	--	--	--	--	--	--
214	06109530	Little Sandy Creek tributary near Virgelle	LP	26	.80	3,530	0	0	16	2.2	4.2
215	06109560	Alkali Coulee tributary near Virgelle	LP	25	.96	2,940	0	0	14	3.4	6.4
216	06114550	Wolf Creek tributary near Coffee Creek	LP	25	1.73	4,020	0	0	15	2.3	2.8
217	06114900	Taffy Creek tributary near Winifred	LP	25	2.95	3,290	0	0	14	4.6	10
218	06135000*	Milk River at Eastern Crossing of International Boundary	LP, R	80	2,525	--	--	--	--	--	--
219	06135500	Sage Creek at Q Ranch, near Wild Horse, Alberta	LP	45	175	3,200	0	0	13	9.0	22
220	06136000	Sage Creek at International Boundary	LP	38	220	3,150	0	0	13	15	32
221	06136400	Spring Coulee tributary near Simpson	LP	26	2.49	2,830	0	0	11	--	--
222	06137400	Big Sandy Creek at Reservation Boundary, near Rocky Boy	LP	17	24.7	4,860	0	54	21	--	--
223	06137570	Boxelder Creek near Rocky Boy	LP	22	48.2	4,070	0	23	21	--	--
224	06137580*	Sage Creek near Whitlash	LP	12	7.26	--	--	--	--	--	--
225	06137600	Sage Creek tributary no. 2 near Joplin	LP	25	2.21	3,220	0	0	12	--	--
226	06137900	England Coulee at Hingham	LP	15	.93	3,090	0	0	11	--	--
227	06138500	Big Sandy Creek near Box Elder	LP	10	1,629	3,230	0	2.2	12	--	--
228	06138700	South Fork Spring Coulee near Havre	LP	39	6.47	3,100	0	0	13	8.0	--
229	06138800	Spring Coulee near Havre	LP	15	17.8	3,090	0	0	13	11	20
230	06139500	Big Sandy Creek near Havre	LP	38	1,805	3,200	0	2	12	51	--
231	06140000*	Beaver Creek near Havre	LP	24	87.4	--	--	--	--	--	--

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
					Northwest Foothills Region--Continued						
191	275	657	1,070	1,840	2,650	3,720	5,100	7,570	1,450	48.317	111.783
192	2,360	3,820	4,880	6,290	7,390	8,530	9,700	11,300	10,400	48.306	111.080
193	116	491	1,140	3,030	5,910	11,100	20,100	42,800	3,580	48.271	111.145
194	8	18	28	45	61	80	103	140	38	48.233	110.883
195	35	128	246	485	746	1,090	1,540	2,310	675	48.450	111.083
196	20	116	277	687	1,220	2,020	3,190	5,490	1,000	48.333	110.950
197	15	70	157	369	640	1,050	1,640	2,820	403	48.083	110.833
198	5,520	12,200	20,000	36,000	54,600	81,400	120,000	196,000	70,000	48.267	110.700
199	18	63	122	244	383	573	828	1,290	244	47.950	110.550
200	16	54	104	217	355	560	856	1,450	300	47.950	110.517
201	3	11	21	43	69	106	157	257	42	47.950	110.500
202	48	116	184	303	421	566	743	1,040	390	47.733	112.250
203	543	1,280	2,060	3,500	4,980	6,900	9,360	13,700	41,800	47.750	112.233
204	1,200	2,200	4,000	7,000	11,000	18,000	28,000	50,000	71,300	47.930	111.552
205	19	165	494	1,560	3,240	6,210	11,200	22,700	2,070	47.850	111.600
206	11	66	168	451	845	1,480	2,470	4,550	465	47.850	111.550
207	1,240	2,540	3,870	6,260	8,710	11,900	16,000	23,100	17,300	48.950	112.750
208	1,070	2,500	3,860	6,110	8,200	10,700	13,500	18,000	7,930	49.008	112.545
209	1,930	3,620	5,160	7,700	10,100	12,900	16,400	21,900	9,850	49.144	112.079
210	39	74	108	168	227	301	394	554	280	49.111	111.759
211	26	75	125	214	298	399	518	705	239	48.883	111.817
					Northeast Plains Region						
212	19,400	37,400	49,700	64,700	75,100	84,800	93,800	105,000	72,000	47.568	111.060
213	24,400	39,200	51,500	70,000	86,200	105,000	126,000	158,000	122,000	48.005	110.257
214	4	8	11	17	22	29	38	52	47	48.088	109.943
215	10	26	45	80	118	166	229	340	112	48.055	110.089
216	13	50	111	282	538	993	1,780	3,750	780	47.299	110.133
217	38	112	188	319	442	586	752	1,010	449	47.652	109.259
218	2,720	5,100	7,190	10,500	13,400	16,900	20,900	27,100	12,000	48.984	110.469
219	484	1,160	1,720	2,530	3,170	3,830	4,510	5,410	2,950	49.108	110.223
220	32	44	52	60	65	70	75	80	66	49.004	110.189
221	5	18	33	61	88	120	156	211	56	48.943	110.214
222	68	176	295	520	757	1,070	1,470	2,180	510	48.173	109.825
223	99	314	595	1,210	1,950	3,030	4,580	7,630	1,400	48.302	109.844
224	32	63	88	125	155	188	224	275	100	48.891	111.030
225	5	31	73	178	310	502	773	1,280	350	48.911	110.772
226	11	43	77	134	183	236	292	367	299	48.559	110.419
227	121	485	993	2,120	3,450	5,340	7,950	12,800	2,000	48.367	109.983
228	18	62	113	206	297	409	543	754	190	48.417	109.833
229	29	173	395	890	1,450	2,190	3,130	4,710	345	48.417	109.867
230	215	953	1,970	4,120	6,490	9,640	13,700	20,700	6,000	48.527	109.841
231	226	521	815	1,320	1,810	2,410	3,140	4,340	1,500	48.483	109.783

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Northeast Plains Region--Continued									
232	06140400	Bullhook Creek near Havre	LP	16	39.6	3,220	0	4	15	11	17
233	06140500*	Milk River at Havre	LP, R	46	5,785	--	--	--	--	--	--
234	06141600*	Little Box Elder Creek at mouth, near Havre	LP	10	95.9	--	--	--	--	--	--
235	06141900	Milk River tributary near Lohman	LP	15	.11	2,500	0	0	12	--	--
236	06142400	Clear Creek near Chinook	LP	15	135	3,950	0	16	19	--	--
237	06144100*	Walburger Coulee below diversion, near Govenlock, Sask.	LP	16	32.6	--	--	--	--	--	--
238	06144350*	Middle Creek near Saskatchewan Boundary (Sask.)	LP	37	118	3,970	0	0	13	17	24
239	06144500*	Lodge Creek at International Boundary	LP, R	16	753	3,480	0	14	13	23	36
240	06145000*	McRae Creek at International Boundary	LP	22	59	2,900	0	0	12	5.3	13
241	06145500	Lodge Creek below McRae Creek, at International Boundary	LP, R	47	825	3,490	0	0	13	24	37
242	06148000*	Battle Creek above CLWIC, near West Plains, Sask.	LP	28	270	4,070	0	39	16	20	28
243	06149500*	Battle Creek at International Boundary	LP, R	82	997	3,460	0	11	13	23	34
244	06150000	Woodpile Coulee near International Boundary	LP	47	60.2	2,950	0	0	12	11	16
245	06150500	East Fork Battle Creek near International Boundary	LP	47	89.5	3,000	0	0	12	15	32
246	06151000	Lyons Creek at International Boundary	LP	62	66.7	3,000	0	0	12	17	23
247	06151500*	Battle Creek near Chinook	LP	31	1,623	--	--	--	--	--	--
248	06153400	Fifteenmile Creek tributary near Zurich	LP	25	1.60	2,670	0	0	12	3.0	6.3
249	06154100*	Milk River near Harlem	LP	28	9,822	--	--	--	--	--	--
250	06154350	Peoples Creek tributary near Lloyd	LP	25	2.51	4,620	0	10	18	3.8	10
251	06154400	Peoples Creek near Hays	LP	32	220	3,570	0	0	16	28	53
252	06154410	Little Peoples Creek near Hays	LP	26	13.0	4,640	0	71	17	10	19
253	06154430*	Lodge Pole Creek at Lodge Pole	LP	12	19.5	--	--	--	--	--	--
254	06154490	Willow Coulee near Dodson	LP	10	5.16	2,550	0	0	12	--	--
255	06154500	Peoples Creek near Dodson	C, 06154550, LP	38	670	3,500	0	2.7	15	22	--
256	06154510*	Kuhr Coulee tributary near Dodson	LP	16	1.25	--	--	--	--	--	--
257	06154550*	Peoples Creek below Kuhr Coulee near Dodson	LP	10	675	--	--	--	--	--	--
258	06155030*	Milk River near Dodson	LP	16	11,192	--	--	--	--	--	--
259	06155100	Black Coulee near Malta	LP	13	6.64	2,550	0	0	13	5.0	9.0
260	06155200	Alkali Creek near Malta	LP	18	162	2,470	0	0	13	25	27
261	06155300	Disjardin Coulee near Malta	LP	43	4.84	2,470	0	0	13	4.0	8.5
262	06155400	South Fork Taylor Coulee near Malta	LP	19	5.08	2,530	0	0	12	4.0	10
263	06155500*	Milk River at Malta	LP, R	19	11,762	--	--	--	--	--	--
264	06155600	Murphy Coulee tributary near Hogeland	LP	25	2.62	3,330	0	0	12	7.3	13
265	06156000	Whitewater Creek near International Boundary	LP	52	458	2,820	0	0	12	17	28
266	06156100	Lush Coulee near Whitewater	LP	26	9.58	2,670	0	0	12	8.5	14
267	06158000*	Frenchman River above Eastend Reservoir, near Ravenscrag, Sask.	LP, R	34	601	3,670	0	11	12	--	--
268	06159500*	Frenchman River below Eastend Reservoir, near Eastend, Sask.	LP, R	72	619	--	--	--	--	--	--

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
Northeast Plains Region--Continued											
232	110	317	526	873	1,190	1,550	1,960	2,570	700	48.517	109.633
233	1,880	3,230	4,480	6,550	8,530	11,000	14,000	18,900	11,400	48.564	109.695
234	113	330	581	1,060	1,580	2,250	3,110	4,620	960	48.562	109.531
235	1	8	20	53	98	165	262	452	72	48.583	109.433
236	70	180	276	417	531	650	772	936	571	48.579	109.391
237	24	100	193	366	535	737	970	1,320	212	49.292	110.022
238	242	740	1,230	2,000	2,650	3,360	4,120	5,160	4,980	49.425	110.052
239	1,590	3,150	4,400	6,180	7,620	9,160	10,800	13,000	5,110	49.017	109.750
240	270	644	945	1,360	1,670	1,970	2,280	2,660	1,160	49.017	109.719
241	542	2,100	4,030	7,710	11,500	16,100	21,800	30,800	9,890	49.005	109.717
242	550	1,110	1,560	2,230	2,770	3,360	3,990	4,880	3,020	49.433	109.683
243	589	1,540	2,470	4,010	5,440	7,090	8,990	11,900	9,780	49.002	109.422
244	368	1,220	2,110	3,600	4,940	6,450	8,100	10,500	7,280	48.983	109.531
245	307	845	1,360	2,180	2,900	3,690	4,550	5,800	2,780	48.972	109.129
246	142	466	791	1,300	1,730	2,190	2,670	3,330	1,400	49.005	109.230
247	700	4,170	9,320	18,900	27,800	37,500	47,600	61,000	19,400	48.651	109.230
248	13	56	119	266	448	715	1,100	1,850	1,250	48.643	109.047
249	1,920	4,410	7,020	11,800	16,800	23,100	31,300	45,600	19,000	48.489	108.758
250	7	26	54	119	199	316	485	818	270	48.193	109.307
251	183	764	1,600	3,480	5,740	8,990	13,500	22,100	8,460	48.224	108.713
252	51	136	222	367	504	665	853	1,150	576	47.966	108.660
253	62	127	182	263	330	403	482	596	306	48.031	108.532
254	48	357	928	2,410	4,310	7,090	11,000	18,300	2,310	48.325	108.414
255	647	1,850	3,100	5,210	7,190	9,510	12,200	16,300	7,590	48.343	108.359
256	38	143	269	501	731	1,010	1,330	1,840	436	48.388	108.388
257	433	1,230	2,030	3,340	4,540	5,920	7,460	9,770	1,800	48.364	108.356
258	1,470	3,490	5,390	8,420	11,200	14,300	17,800	23,200	13,200	48.403	108.293
259	73	181	305	555	833	1,220	1,750	2,760	2,350	48.217	108.033
260	149	695	1,500	3,330	5,480	8,520	12,700	20,300	22,900	48.267	107.967
261	28	86	166	351	587	953	1,510	2,690	1,580	48.276	107.964
262	14	63	121	219	305	400	500	635	220	48.317	107.917
263	6,790	11,500	14,600	18,400	21,200	23,800	26,400	29,600	24,000	48.367	107.867
264	37	120	221	420	637	923	1,300	1,950	403	48.788	108.747
265	175	947	2,050	4,290	6,620	9,540	13,000	18,500	3,500	48.953	107.861
266	27	121	261	583	972	1,530	2,320	3,800	2,530	48.686	107.690
267	1,470	2,600	3,450	4,620	5,540	6,490	7,480	8,840	12,600	49.483	109.000
268	1,300	2,620	3,610	4,950	5,970	6,990	8,010	9,350	11,500	49.515	108.838

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Northeast Plains Region--Continued									
269	06160600*	Frenchman River below Eastern Irrigation Project, near Eastend, Sask.	LP, R	28	835	--	--	--	--	--	--
270	06161000*	Frenchman River at 50-Mile, near Bracken, Sask.	LP, R	34	1,248	--	--	--	--	--	--
271	06163400	Denniel Creek near Val Marie, Sask.	LP	14	251	2,940	0	0	12	--	--
272	06163500*	Frenchman River below Val Marie, Sask.	LP, R	29	1,725	--	--	--	--	--	--
273	06164000*	Frenchman River at International Boundary	LP, R	82	2,120	--	--	--	--	--	--
274	06164510*	Milk River at Juneberg Bridge, near Saco	LP, R	21	17,670	--	--	--	--	--	--
275	06164600	Beaver Creek tributary near Zortman	LP	25	3.89	3,260	0	8	12	3.3	6.2
276	06164623*	Little Warm Creek tributary near Lodge Pole	LP	16	2.42	--	--	--	--	--	--
277	06165200	Guston Coulee near Malta	LP	25	2.06	2,500	0	0	12	2.7	4.3
278	06166000	Beaver Creek below Guston Coulee, near Saco	LP	16	1,208	2,670	0	0	12	--	--
279	06168500	Rock Creek at International Boundary	LP	35	241	2,910	0	0	13	--	--
280	06169000	Horse Creek at International Boundary	LP	46	73.5	2,810	0	0	13	4.0	11
281	06169500	Rock Creek below Horse Creek, near International Boundary	LP	52	328	2,870	0	0	13	26	41
282	06170000	McEachern Creek at International Boundary	LP	53	182	2,830	0	0	13	21	36
283	06170200	Willow Creek near Hinsdale	LP	10	283	2,710	0	0	12	37	56
284	06171000*	Rock Creek near Hinsdale	LP	11	1,313	--	--	--	--	--	--
285	06174600	Snow Coulee at Opheim	LP	26	3.11	3,250	0	0	12	2.8	7.0
286	06178000	Poplar River at International Boundary	LP	67	362	2,950	0	0	14	19	32
287	06178500*	East Poplar River at International Boundary	LP, R	42	534	2,800	0	0	16	22	59
288	06179100	Butte Creek tributary near Four Buttes	LP	26	1.60	2,610	0	0	13	3.3	6.3
289	06179500	West Fork Poplar River at International Boundary	LP	20	139	3,000	0	0	13	30	--
290	06180000	West Fork Poplar River near Richland	LP	17	428	2,900	0	0	12	21	31
291	06181995*	Beaver Creek at International Boundary	LP	17	149	--	0	0	14	--	--
292	06182500	Big Muddy Creek at Daleview	LP	26	279	2,510	0	0	15	16	33
293	06182700	Middle Fork Big Muddy Creek near Flaxville	LP	11	3.12	2,730	0	0	14	1.5	3.5
294	06183000	Big Muddy Creek at Plentywood	LP	19	850	2,460	0	0	14	24	--
295	06183100	Box Elder Creek near Plentywood	LP	19	9.40	2,380	0	0	14	6.0	11
296	06183300	Marron Creek tributary near Plentywood	LP	44	6.08	2,440	0	0	14	4.0	9.5
297	06183400	Spring Creek at Highway, near Plentywood	LP	19	16.9	2,330	0	0	14	8.5	14
298	06183450	Big Muddy Creek near Antelope	LP	27	967	2,380	0	0	14	--	--
299	06184200	Lost Creek tributary near Homestead	LP	26	1.90	2,060	0	0	14	4.5	8.0
		East-Central Plains Region									
300	06115100	Missouri River tributary near Landusky	LP	17	3.39	2,690	0	91	12	8.0	16.5
301	06115200*	Missouri River near Landusky	LP, R	46	40,987	--	--	--	--	--	--
302	06115300	Duval Creek near Landusky	LP	36	3.31	3,110	0	0	13	8.0	14
303	06123500*	Musselshell River near Ryegate	LP, R	33	1,979	5,210	24.8	22.5	16	--	--
304	06125680	Big Coulee Creek tributary near Cushman	LP	25	1.23	3,790	0	0	14	2.3	5.3
305	06125700	Big Coulee near Lavina	LP	15	232	4,230	0	4.8	14	16	26
306	06126300	Currant Creek near Roundup	LP	15	220	4,250	5	8	13	26	28

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
Northeast Plains Region--Continued											
269	633	1,700	2,810	4,750	6,630	8,900	11,600	16,000	12,000	49.409	108.600
270	1,500	2,770	3,680	4,830	5,680	6,500	7,300	8,320	14,000	49.417	108.017
271	461	1,320	2,080	3,180	4,040	4,910	5,770	6,880	1,410	49.307	107.703
272	1,220	2,570	3,680	5,250	6,510	7,830	9,210	11,100	17,700	49.198	107.689
273	1,190	2,620	3,820	5,540	6,960	8,460	10,000	12,200	22,700	49.000	107.302
274	2,410	6,850	11,500	19,500	27,100	36,200	46,900	63,600	12,400	48.509	107.217
275	59	187	341	649	983	1,430	2,010	3,050	1,200	47.927	108.352
276	80	310	608	1,220	1,880	2,760	3,880	5,830	1,270	47.995	108.319
277	4	17	36	71	106	148	196	267	48	48.243	107.549
278	456	1,160	1,960	3,570	5,340	7,790	11,100	17,300	23,500	48.357	107.580
279	590	1,360	2,010	2,950	3,710	4,500	5,330	6,460	3,310	48.989	106.792
280	298	729	1,100	1,620	2,040	2,470	2,910	3,490	1,800	48.989	106.836
281	846	1,980	2,870	4,070	4,960	5,830	6,680	7,740	5,110	48.969	106.839
282	698	1,960	3,020	4,460	5,540	6,570	7,550	8,740	7,080	48.992	106.928
283	1,860	4,330	6,700	10,600	14,300	18,700	23,800	31,800	14,600	48.565	106.980
284	3,870	5,060	5,870	6,920	7,720	8,540	9,380	10,500	12,900	48.467	107.033
285	34	91	143	221	285	352	422	516	245	48.841	106.413
286	689	1,920	3,360	6,200	9,320	13,500	19,100	29,400	12,700	48.990	105.696
287	808	1,610	2,260	3,180	3,920	4,710	5,540	6,690	4,020	48.999	105.409
288	15	86	184	378	569	794	1,050	1,430	609	48.809	105.586
289	197	816	1,620	3,220	4,900	7,050	9,700	14,100	5,450	49.000	106.367
290	581	1,500	2,380	3,800	5,070	6,510	8,120	10,500	3,600	48.800	106.017
291	361	828	1,230	1,810	2,300	2,810	3,350	4,100	1,680	49.000	105.035
292	1,110	2,470	3,800	6,100	8,320	11,100	14,400	19,900	6,360	48.911	104.945
293	36	111	188	317	434	567	714	931	200	48.802	105.113
294	1,040	2,510	4,020	6,670	9,280	12,500	16,500	23,100	8,000	48.767	104.583
295	93	189	265	369	451	535	621	736	328	48.833	104.500
296	27	78	134	232	326	441	576	790	524	48.817	104.450
297	82	364	751	1,560	2,440	3,600	5,070	7,570	690	48.767	104.517
298	939	1,970	2,830	4,110	5,170	6,330	7,570	9,350	2,890	48.673	104.512
299	14	88	220	563	1,010	1,690	2,670	4,580	1,260	48.403	104.497
East-Central Plains Region											
300	58	433	1,190	3,380	6,510	11,600	19,500	36,200	1,950	47.633	108.700
301	28,000	47,800	64,300	89,300	111,000	136,000	165,000	208,000	137,000	47.631	108.687
302	67	192	332	592	856	1,190	1,610	2,310	660	47.750	108.700
303	1,400	3,130	4,740	7,350	9,720	12,500	15,700	20,600	9,500	46.301	109.206
304	9	50	118	286	501	819	1,280	2,160	460	46.247	109.033
305	92	281	513	989	1,520	2,260	3,260	5,120	2,400	46.265	108.947
306	130	429	820	1,670	2,660	4,080	6,060	9,870	1,620	46.367	108.650

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (*A*)	Mean basin elevation (*E*)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (*F*)	Mean annual precipitation (*P*)	Active-channel width (W_{ac})	Bankfull width (W_{bf})
		East-Central Plains Region--Continued									
307	06126470	Halfbreed Creek near Klein	LP	14	53.2	3,870	0	82	14	3.9	6.7
308	06126500*	Musselshell River near Roundup	LP, R	52	4,023	4,750	15.8	21.4	14	88	108
309	06127100	South Willow Creek tributary near Roundup	LP	15	1.38	3,590	0	10.5	11	3.0	6.7
310	06127200	Musselshell River tributary near Musselshell	LP	16	10.8	3,300	0	21	11	2.8	7.0
311	06127500*	Musselshell River at Musselshell	LP, R	53	4,568	4,640	14	25.2	14	--	--
312	06127520	Home Creek near Sumatra	LP	26	1.98	3,190	0	0	12	2.7	5.5
313	06127570	Butts Coulee near Melstone	LP	36	6.71	3,000	0	0	11	4.6	8.7
314	06127585	Little Wall Creek tributary near Flatwillow	LP	25	9.77	3,890	0	0	14	6.7	14
315	06127900*	Flatwillow Creek near Flatwillow	LP, R	44	188	5,170	19	42	25	24	30
316	06128200*	Flatwillow Creek near Winnett	LP	13	642	--	--	--	--	--	--
317	06128900	Box Elder Creek tributary near Winnett	LP	19	16.2	2,900	0	0	13	9.0	14
318	06129000	Box Elder Creek near Winnett	LP	21	684	3,470	2	3.9	14	38	59
319	06129500	McDonald Creek at Winnett	LP	36	421	4,140	0	7	18	26	44
320	06129700	Gorman Coulee near Cat Creek	LP	26	2.32	2,910	0	0	13	7.0	7.5
321	06129800	Gorman Coulee tributary near Cat Creek	LP	44	.81	2,900	0	0	13	2.5	5.0
322	06130500*	Musselshell River at Mosby	LP	67	7,846	4,130	8	23	14	98	170
323	06130600	Cat Creek near Cat Creek	LP	18	36.5	2,870	0	0	13	4.0	11
324	06130610	Bair Coulee near Mosby	LP	25	1.79	3,130	0	0	12	3.0	10
325	06130620	Blood Creek tributary near Valentine	LP	25	1.97	3,100	0	0	13	4.3	6.3
326	06130700	Sand Creek near Jordan	LP	11	317	3,050	0	0	11	11	--
327	06130800	Second Creek tributary near Jordan	LP	17	.52	2,830	0	0	11	--	--
328	06130850	Second Creek tributary no. 2 near Jordan	LP	33	2.08	2,830	0	0	11	3.0	8.0
329	06130900	Second Creek tributary no. 3 near Jordan	LP	15	.72	2,780	0	0	11	--	--
330	06130915	Russian Coulee near Jordan	LP	25	3.45	2,660	0	0	12	3.3	6.3
331	06130925	Thompson Creek tributary near Cohagen	LP	22	1.23	2,830	0	0	12	--	9.0
332	06130940	Spring Creek tributary near Van Norman	LP	25	1.39	2,570	0	0	12	4.0	7.3
333	06130950	Little Dry Creek near Van Norman	LP	20	1,224	2,860	0	0	11	24	38
334	06131000*	Big Dry Creek near Van Norman	LP	58	2,554	2,870	0	0	11	91	220
335	06131100	Terry Coulee near Van Norman	LP	25	.48	2,540	0	0	12	3.0	6.3
336	06131200	Nelson Creek near Van Norman	LP	11	100	2,620	0	0	14	11	25
337	06131300	McGuire Creek tributary near Van Norman	LP	25	.79	2,460	0	0	12	3.0	4.2
338	06132000*	Missouri River below Fort Peck Dam, at Fort Peck	LP, R	60	57,556	--	--	--	--	--	--
339	06172000*	Milk River near Vandalia	LP, R	31	20,926	--	--	--	--	--	--
340	06172200	Buggy Creek near Tampico	LP	12	105	2,770	0	0	12	20	36
341	06172300	Unger Creek near Vandalia	LP	41	11.1	2,560	0	0	12	6.8	11
342	06172350	Mooney Coulee near Tampico	LP	16	14.3	2,410	0	0	13	4.0	8.0
343	06173300	Willow Creek tributary near Fort Peck	LP	19	.86	2,360	0	0	12	2.3	7.8
344	06174300	Milk River tributary no. 3, near Glasgow	LP	25	1.82	2,320	0	0	12	2.5	6.0
345	06174500*	Milk River at Nashua	LP, R	59	22,332	--	--	--	--	--	--
346	06175000	Porcupine Creek at Nashua	LP	26	725	2,800	0	0	12	27	34
347	06175550	East Fork Sand Creek near Vida	LP	15	8.51	2,440	0	1	16	9.0	17
348	06175700	East Fork Wolf Creek near Lustre	LP	43	9.61	2,850	0	0	11	4.0	8.0

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
East-Central Plains Region--Continued											
307	20	80	179	445	831	1,490	2,590	5,200	630	46.387	108.541
308	1,650	3,370	4,850	7,090	9,030	11,200	13,600	17,100	9,610	46.428	108.572
309	67	180	309	558	824	1,180	1,640	2,460	510	46.517	108.583
310	48	159	309	649	1,070	1,700	2,620	4,500	2,500	46.500	108.250
311	1,440	3,060	4,480	6,700	8,660	10,900	13,400	17,100	9,850	46.523	108.108
312	32	99	166	275	371	478	594	759	278	46.637	107.620
313	83	196	304	483	650	846	1,080	1,440	705	46.650	107.817
314	8	21	36	61	85	115	150	207	45	46.760	108.607
315	154	317	451	645	803	973	1,150	1,410	954	46.800	108.617
316	438	1,340	2,440	4,670	7,150	10,500	15,100	23,300	3,770	46.933	108.200
317	124	279	425	663	882	1,140	1,440	1,900	1,030	47.017	108.167
318	1,330	2,820	4,160	6,310	8,250	10,500	13,100	17,100	9,910	47.013	108.158
319	339	722	1,040	1,510	1,890	2,310	2,750	3,360	1,590	47.000	108.350
320	99	344	628	1,150	1,680	2,310	3,080	4,290	1,050	47.017	108.100
321	25	96	191	401	647	994	1,470	2,370	380	47.013	108.093
322	3,590	8,670	12,700	18,200	22,300	26,200	30,100	34,900	18,000	46.995	107.888
323	93	214	330	519	695	900	1,140	1,520	748	47.050	108.017
324	18	93	219	535	945	1,570	2,480	4,300	420	47.054	107.612
325	8	37	80	187	325	538	856	1,510	533	47.336	108.459
326	645	1,690	2,860	5,050	7,340	10,300	14,200	20,900	6,600	47.250	106.850
327	19	59	111	224	361	561	852	1,430	334	47.200	106.800
328	24	86	166	331	512	755	1,070	1,630	760	47.200	106.817
329	16	46	83	161	253	385	573	940	458	47.217	106.833
330	30	97	179	346	531	779	1,110	1,700	840	47.333	106.711
331	35	103	185	351	534	784	1,120	1,730	510	46.951	106.461
332	32	90	153	270	387	535	717	1,020	287	47.249	106.306
333	2,130	4,110	5,740	8,170	10,200	12,500	15,000	18,600	10,000	47.339	106.363
334	2,310	7,000	11,600	18,900	25,200	32,100	39,500	49,800	24,600	47.349	106.357
335	26	61	96	153	206	270	344	462	158	47.386	106.170
336	653	1,250	1,680	2,220	2,620	3,010	3,390	3,860	1,750	47.537	106.153
337	65	177	282	442	577	723	878	1,100	270	47.606	106.153
338	16,900	23,900	28,700	34,800	39,500	44,300	49,200	56,000	51,000	48.044	106.356
339	7,340	16,900	24,300	33,900	41,000	47,800	54,400	62,500	27,200	48.373	106.974
340	439	2,130	4,160	7,630	10,700	14,000	17,400	22,000	7,660	48.367	106.783
341	57	281	629	1,450	2,450	3,900	5,930	9,750	4,460	48.367	106.800
342	39	178	344	632	893	1,180	1,490	1,930	450	48.283	106.700
343	47	155	277	496	709	966	1,270	1,750	940	47.893	106.889
344	27	108	199	355	496	651	818	1,050	405	48.205	106.551
345	5,750	12,200	17,200	23,700	28,600	33,400	38,100	44,100	45,300	48.130	106.364
346	661	1,580	2,460	3,910	5,270	6,860	8,720	11,600	4,500	48.136	106.337
347	178	450	733	1,240	1,740	2,370	3,150	4,400	1,220	47.800	105.617
348	83	220	380	704	1,070	1,570	2,270	3,580	2,230	48.400	105.800

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bankfull width (W_{bf})
		East-Central Plains Region--Continued									
349	06175900	Wolf Creek tributary no. 2, near Wolf Point	LP	30	6.10	2,470	0	0	12	4.0	9.0
350	06176500	Wolf Creek near Wolf Point	LP	37	251	2,570	0	0	11	21	30
351	06176950	Missouri River tributary no. 6 near Wolf Point	LP	19	.53	2,140	0	0	14	2.7	4.8
352	06177000*	Missouri River near Wolf Point	LP	62	82,290	--	--	--	--	--	--
353	06177020	Tule Creek tributary near Wolf Point	LP	25	1.91	2,450	0	0	12	3.0	7.0
354	06177050	East Fork Duck Creek near Brockway	LP	44	12.4	2,910	0	0	14	4.0	12
355	06177100	Duck Creek near Brockway	LP	17	54.0	2,910	0	0	13	9.5	34
356	06177150	Redwater River at Brockway	LP	18	216	2,810	0	0	13	14	54
357	06177200	Tusler Creek near Brockway	LP	16	90.2	2,980	0	0	14	12	35
358	06177250	Tusler Creek tributary near Brockway	LP	18	3.17	2,700	0	0	12	4.5	12
359	06177300	Redwater River tributary near Brockway	LP	17	.29	2,620	0	0	13	--	--
360	06177350	South Fork Dry Ash Creek near Circle	LP	18	5.74	2,840	0	0	13	7.0	16
361	06177400	McCune Creek near Circle	LP	23	29.9	2,810	0	0	14	12.5	22
362	06177500	Redwater River at Circle	LP	66	547	2,810	0	0	13	15	27
363	06177700	Cow Creek tributary near Vida	LP	36	1.71	2,490	0	0	16	3.0	10
364	06177720	West Fork Sullivan Creek near Richey	LP	20	14.8	2,740	0	0	14	4.3	10
365	06177800	Gady Coulee near Vida	LP	30	.91	2,450	0	0	15	3.0	9.0
366	06177820	Horse Creek tributary near Richey	LP	25	.63	2,640	0	0	14	2.3	6.0
367	06177825	Redwater River near Vida	LP	10	1,974	2,560	0	0	14	52	85
368	06180500*	Poplar River near Bredette	LP	14	2,940	--	--	--	--	--	--
369	06181000*	Poplar River near Poplar	LP	48	3,174	2,730	0	0	12	56	--
370	06181200	Missouri River tributary no. 2 near Brockton	LP	15	1.60	2,170	0	0	13	3.0	5.8
371	06185000	Big Muddy Creek near Culbertson	LP	12	2,447	2,370	0	0	12	--	--
372	06185100	Big Muddy Creek tributary near Culbertson	LP	15	7.38	2,110	0	0	13	5.0	10
373	06185110*	Big Muddy Creek near mouth, near Culbertson	LP	11	2,684	--	--	--	--	--	--
374	06185200	Missouri River tributary no. 3 near Culbertson	LP	15	1.23	2,090	0	0	13	5.3	8.2
375	06185300	Missouri River tributary no. 4 near Bainville	LP	15	11.6	2,170	0	0	14	4.0	8.0
376	06185400	Missouri River tributary no. 5 at Culbertson	LP	36	3.67	2,210	0	0	14	4.0	8.0
377	06185500*	Missouri River near Culbertson	LP, R	50	91,557	--	--	--	--	--	--
378	06217300	Twelvemile Creek near Shepherd	LP	26	9.05	3,490	0	0	14	6.3	15
379	06217700	North Fork Crooked Creek tributary near Shepherd	LP	37	6.85	3,660	0	24	14	8.0	12
380	06294900	Middle Fork Froze to Death Creek tributary near Ingomar	LP	15	1.36	3,220	0	0	12	4.5	8.0
381	06294960	Anderson Creek at Vananda	LP	13	5.71	2,870	0	0	12	2.0	5.5
382	06295020	Short Creek near Forsyth	LP	37	3.23	2,820	0	27	12	3.0	6.5
383	06295050	Little Porcupine Creek near Forsyth	LP	20	614	2,910	0	0	13	44	65
384	06296115	Reservation Creek near Miles City	LP	26	6.29	2,620	0	0	12	5.8	12
385	06309000*	Yellowstone River at Miles City	LP	34	48,253	--	--	--	--	--	--
386	06309020	Rock Springs Creek tributary at Rock Springs	LP	17	.96	3,000	0	0	12	--	--
387	06309040	Dry House Creek near Angela	LP	16	38.6	2,940	0	0	12	17	25

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
East-Central Plains Region--Continued											
349	77	380	791	1,610	2,460	3,520	4,780	6,770	3,900	48.200	105.750
350	290	1,770	4,150	9,620	16,000	24,700	36,000	55,500	9,780	48.096	105.678
351	14	33	48	67	81	95	108	124	74	48.056	105.556
352	19,800	27,800	33,600	41,600	48,000	54,800	62,000	72,400	66,800	48.067	105.532
353	41	71	93	124	147	172	198	233	141	48.244	105.492
354	84	217	339	526	685	857	1,040	1,300	650	47.200	105.783
355	164	591	1,050	1,820	2,510	3,270	4,090	5,250	1,000	47.250	105.817
356	558	1,470	2,260	3,410	4,330	5,280	6,240	7,500	3,550	47.317	105.750
357	140	340	503	726	896	1,060	1,230	1,440	430	47.300	105.650
358	8	80	239	700	1,330	2,310	3,720	6,400	1,610	47.300	105.683
359	9	32	65	142	237	378	583	994	234	47.350	105.683
360	31	78	120	183	235	291	351	434	85	47.300	105.583
361	63	308	701	1,680	2,940	4,860	7,690	13,400	1,000	47.350	105.583
362	763	2,270	3,760	6,190	8,330	10,700	13,400	17,100	6,960	47.414	105.575
363	87	274	489	892	1,300	1,830	2,470	3,550	1,500	47.717	105.483
364	30	134	309	783	1,460	2,600	4,470	8,760	3,370	47.532	105.235
365	122	375	643	1,110	1,540	2,060	2,660	3,570	1,250	47.917	105.500
366	35	68	96	140	180	225	276	355	148	47.877	104.935
367	845	4,080	8,530	17,600	27,200	39,400	54,400	78,700	8,230	47.902	105.215
368	3,080	7,870	13,200	23,300	33,900	48,000	66,300	98,900	40,000	48.417	105.200
369	2,560	8,860	16,500	31,100	46,500	66,100	90,700	132,000	40,000	48.171	105.178
370	51	116	177	276	366	472	595	786	313	48.150	104.900
371	878	1,310	1,570	1,860	2,060	2,240	2,400	2,600	1,550	48.267	104.717
372	44	168	333	686	1,090	1,640	2,380	3,720	676	48.200	104.700
373	93	396	840	1,860	3,100	4,890	7,400	12,200	1,860	48.164	104.629
374	14	106	305	949	1,980	3,850	7,090	14,900	2,570	48.100	104.517
375	320	626	874	1,230	1,520	1,840	2,170	2,640	1,670	48.133	104.350
376	38	200	457	1,070	1,830	2,940	4,480	7,410	3,790	48.167	104.517
377	20,600	29,700	36,700	46,900	55,500	64,900	75,400	91,000	78,200	48.122	104.475
378	26	99	184	335	480	651	847	1,140	250	45.921	108.462
379	69	326	756	1,890	3,460	6,010	10,000	18,800	5,120	46.067	108.500
380	69	140	210	333	456	613	810	1,150	463	46.583	107.400
381	57	165	294	550	831	1,210	1,720	2,630	950	46.393	107.008
382	105	464	914	1,760	2,580	3,570	4,700	6,420	2,790	46.300	106.667
383	1,770	3,650	5,400	8,290	11,000	14,300	18,100	24,300	13,000	46.300	106.567
384	167	598	1,070	1,860	2,580	3,390	4,270	5,540	1,590	46.377	105.973
385	48,700	64,600	74,700	87,100	96,000	105,000	113,000	125,000	102,000	46.422	105.861
386	10	27	43	73	101	136	177	244	66	46.817	106.250
387	144	517	986	1,930	2,950	4,290	6,010	9,000	1,560	46.683	106.167

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bankfull width (W_{bf})
		East-Central Plains Region--Continued									
388	06309060	North Fork Sunday Creek tributary no. 2 near Angela	LP	30	.22	2,710	0	0	12	2.0	4.0
389	06309075	Sunday Creek near Miles City	LP	10	714	2,890	0	0	12	45	67
390	06309078	Tree Coulee near Kinsey	LP	26	4.13	2,560	0	0	12	2.3	9.0
391	06326550	Cherry Creek tributary near Terry	LP	19	2.52	2,520	0	10	12	3.5	8.0
392	06326900	Yellowstone River tributary no. 4 near Fallon	LP	15	.67	2,410	0	13	12	13	19
393	06326950	Yellowstone River tributary no. 5 near Marsh	LP	37	.87	2,440	0	0	12	2.5	5.0
394	06326960	Timber Fork Upper Sevenmile Creek tributary near Lindsay	LP	25	1.13	2,810	0	0	14	--	--
395	06328400	Thirteenmile Creek tributary near Bloomfield	LP	19	.67	2,640	0	0	13	--	--
396	06328700	Linden Creek at Intake	LP	17	4.02	2,320	0	0	13	5.0	10
397	06328900	Indian Creek at Intake	LP	16	.46	2,130	0	0	13	2.2	3.5
398	06328900	War Dance Creek near Intake	LP	17	3.69	2,320	0	0	13	3.0	6.5
399	06329200	Burns Creek near Savage	LP	21	233	2,600	0	0	13	15	50
400	06329500*	Yellowstone River near Sidney	LP	34	69,103	--	--	--	--	--	--
401	06329510	Fox Creek tributary near Lambert	LP	24	5.01	2,580	0	6	13	5.0	9.5
402	06329570	First Hay Creek near Sidney	LP	36	29.1	2,360	0	0	14	11	18
		Southeast Plains Region									
403	06294400	Andresen Coulee near Custer	LP	36	2.35	2,850	0	31	12	2.5	5.0
404	06294500*	Bighorn River above Tullock Creek, near Bighorn	C, 06294700, LP, R	17	22,414	--	--	--	--	--	--
405	06294600	East Cabin Creek tributary near Hardin	LP	26	8.63	3,450	0	24	14	3.5	6.5
406	06294800	Unknown Creek near Bighorn	LP	17	14.6	3,060	0	10	13	6.5	14
407	06294850	Buckingham Coulee near Myers	LP	17	2.63	3,120	0	29	13	3.5	7.0
408	06294930	Sarpy Creek tributary near Colstrip	LP	27	4.44	3,340	0	13	14	3.0	6.0
409	06294940	Sarpy Creek near Hysham	LP	11	453	3,420	0	35	14	13	24
410	06294985	East Fork Armells Creek tributary near Colstrip	LP	26	1.87	3,110	0	9	14	3.8	6.5
411	06294995	Armells Creek near Forsyth	LP	18	370	3,280	0	21	14	19	24
412	06295000*	Yellowstone River at Forsyth	LP	24	40,339	--	--	--	--	--	--
413	06295100	Rosebud Creek near Kirby	LP	32	35.5	4,650	0	12	16	5.5	10
414	06295113*	Rosebud Creek at Reservation Boundary, near Kirby	LP	19	123	--	--	--	--	--	--
415	06295130	Rosebud Creek tributary near Busby	LP	15	1.14	3,480	0	32	14	2.5	3.8
416	06295200	Whitedirt Creek near Lame Deer	LP	15	1.58	3,560	0	63	14	2.3	4.5
417	06295250	Rosebud Creek near Colstrip	LP	24	799	3,920	0	48	15	18	23
418	06296000	Rosebud Creek near Forsyth	C, 06296003, LP	19	1,279	3,610	0	41	15	21	28
419	06296100	Snell Creek near Hathaway	LP	33	10.5	2,840	0	11	13	3.5	6.5
420	06306100	Squirrel Creek near Decker	LP	10	33.6	4,460	0	13	15	6.0	12
421	06306300	Tongue River at State Line, near Decker	LP	38	1,477	5,800	37	37	16	119	131
422	06306900	Spring Creek near Decker	LP	29	34.7	4,010	0	5	14	13	20
423	06306950	South Fork Leaf Rock Creek near Kirby	LP	38	4.53	4,240	0	10	15	4.0	8.0
424	06307500*	Tongue River at Tongue River Dam, near Decker	LP, R	60	1,770	--	--	--	--	--	--
425	06307520	Canyon Creek near Birney	LP	20	50.2	4,010	0	51	15	19	30
426	06307600	Hanging Woman Creek near Birney	LP	21	470	3,880	0	17	14	14	26

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
East-Central Plains Region--Continued											
388	43	99	147	219	279	345	415	514	320	46.567	106.067
389	1,460	3,180	4,600	6,630	8,280	10,000	11,800	14,300	6,760	46.473	105.843
390	108	471	1,050	2,520	4,490	7,620	12,500	22,800	1,750	46.555	105.797
391	64	148	224	342	446	563	692	883	466	46.855	105.341
392	79	156	224	332	429	541	671	873	338	46.867	105.100
393	5	40	105	258	431	658	938	1,380	267	46.950	104.900
394	8	40	90	217	385	643	1,030	1,830	250	47.183	105.172
395	34	92	161	301	459	679	982	1,550	1,040	47.413	104.833
396	9	21	35	62	91	129	179	270	30	47.300	104.517
397	13	45	84	165	255	377	540	832	150	47.289	104.527
398	10	36	68	129	192	273	373	540	62	47.333	104.483
399	311	1,040	1,830	3,200	4,480	5,980	7,690	10,300	2,100	47.372	104.429
400	63,000	89,200	106,000	125,000	139,000	152,000	165,000	182,000	159,000	47.678	104.156
401	8	52	143	432	892	1,730	3,190	6,770	1,370	47.649	104.614
402	36	207	500	1,250	2,240	3,750	5,960	10,400	3,530	47.833	104.267
Southeast Plains Region											
403	5	16	30	62	99	153	230	381	255	46.067	107.550
404	7,710	11,400	14,100	17,700	20,600	23,600	26,700	31,200	16,100	46.125	107.468
405	26	75	126	218	307	416	546	754	277	45.798	107.261
406	149	546	1,040	2,040	3,090	4,470	6,230	9,210	1600	46.200	107.417
407	29	90	163	305	458	660	922	1,380	398	46.233	107.283
408	11	48	112	291	561	1,040	1,860	3,880	590	45.915	107.133
409	94	271	467	826	1,190	1,640	2,200	3,140	428	46.239	107.137
410	18	86	191	438	741	1,180	1,800	2,980	357	46.067	106.711
411	125	635	1,440	3,370	5,780	9,300	14,300	23,800	3,990	46.250	106.806
412	45,700	62,300	74,100	89,700	102,000	115,000	128,000	147,000	109,800	46.266	106.690
413	70	157	234	349	447	555	671	838	540	45.246	106.967
414	55	97	133	187	236	291	355	453	219	45.361	106.990
415	5	8	10	13	15	17	19	21	11	45.583	106.867
416	9	25	42	72	102	138	181	250	45	45.600	106.733
417	121	272	423	684	938	1,250	1,640	2,270	754	45.768	106.569
418	349	754	1,160	1,890	2,620	3,550	4,720	6,730	3,000	46.197	106.474
419	51	223	438	840	1,230	1,700	2,240	3,060	767	46.300	106.150
420	48	124	214	397	605	895	1,300	2,060	584	45.051	106.927
421	3,210	5,030	6,280	7,860	9,040	10,200	11,400	12,900	17,500	45.009	106.836
422	70	262	531	1,150	1,910	3,030	4,650	7,870	1,400	45.086	106.837
423	15	74	156	324	503	733	1,020	1,490	222	45.183	106.917
424	2,270	3,740	4,760	6,060	7,020	7,970	8,910	10,200	10,800	45.141	106.771
425	34	194	479	1,240	2,280	3,930	6,460	11,700	2,490	45.241	106.676
426	287	738	1,180	1,900	2,560	3,330	4,210	5,550	2,060	45.299	106.508

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (*A*)	Mean basin elevation (*E*)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (*F*)	Mean annual precipitation (*P*)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Southeast Plains Region--Continued									
427	06307620	Tie Creek near Birney	LP	13	18.7	4,040	0	59	16	2.3	5.5
428	06307640	Spring Creek near Ashland	LP	15	1.56	3,160	0	14	12	--	14
429	06307660	Walking Horse Creek near Ashland	LP	16	3.33	3,170	0	15	12	--	--
430	06307700	Cow Creek near Fort Howes Ranger Station, near Otter	LP	27	8.37	3,860	0	67	15	3.5	7.5
431	06307720	Brian Creek near Ashland	LP	26	8.03	3,520	0	42	14	--	--
432	06307740	Otter Creek at Ashland	LP	21	707	3,730	0	43	15	16	26
433	06307760	Stebbins Creek near Ashland	LP	15	5.41	3,960	0	64	15	2.0	5.5
434	06307780	Stebbins Creek at mouth, near Ashland	LP	29	20.8	3,480	0	37	14	8.0	14
435	06307830*	Tongue River below Brandenberg Bridge, near Ashland	C, 06307800, LP, R	17	4,062	4,500	13	34	15	120	145
436	06307930	Jack Creek near Volborg	LP	26	5.47	2,840	0	8	14	7.3	14
437	06308100	Sixmile Creek tributary near Epsie	LP	20	.80	3,600	0	0	15	2.8	5.5
438	06308200	Basin Creek tributary near Volborg	LP	44	.14	2,980	0	5	14	1.8	4.0
439	06308300	Basin Creek near Volborg	LP	19	11.1	3,060	0	17	14	7.0	13
440	06308330	Deer Creek tributary near Volborg	LP	26	1.65	2,950	0	0	14	5.5	10
441	06308340	LaGrange Creek near Volborg	LP	26	3.66	2,820	0	5	14	3.8	7.0
442	06308400	Pumpkin Creek near Miles City	LP	12	697	3,290	0	16	15	23	60
443	06308500*	Tongue River at Miles City	LP, R	57	5,379	4,170	9.8	30	15	147	180
444	06309080	Deep Creek near Kinsey	LP	37	11.5	2,610	0	0	12	15	28
445	06309090	Ash Creek near Locate	LP	15	6.23	3,150	0	17	14	--	39
446	06324500*	Powder River at Moorhead	LP	69	8,088	5,260	19.5	11	12	170	215
447	06324700	Sand Creek near Broadus	LP	30	10.2	3,330	0	17	14	--	--
448	06324710*	Powder River at Broadus	LP	17	8,748	5,140	18	11.4	13	208	212
449	06324995	Badger Creek at Biddle	LP	27	6.06	3,590	0	5	13	4.5	10
450	06325400	East Fork Little Powder River tributary near Hammond	LP	11	3.45	3,400	0	0	14	3.0	6.0
451	06325500	Little Powder River near Broadus	LP	25	1,974	3,930	0	7.4	15	42	65
452	06325700	Deep Creek near Powderville	LP	26	3.00	3,000	0	0	14	4.0	7.5
453	06325950	Cut Coulee near Mizpah	LP	26	2.23	2,800	0	0	14	7.0	13
454	06326300	Mizpah Creek near Mizpah	LP	12	797	3,210	0	4.3	14	35	58
455	06326400	Meyers Creek near Locate	LP	16	9.42	2,860	0	17	12	9.0	21
456	06326500*	Powder River near Locate	LP	61	13,189	4,600	11.9	10.3	13	225	280
457	06326510	Locate Creek tributary near Locate	LP	19	.91	2,810	0	11	14	2.0	5.5
458	06326580	Lame Jones Creek tributary near Willard	LP	25	.51	3,160	0	0	14	--	--
459	06326600	O'Fallon Creek near Ismay	LP	31	669	3,080	0	2.3	14	25	37
460	06326650	O'Fallon Creek tributary near Ismay	LP	15	.16	2,780	0	0	13	--	--
461	06326700	Deep Creek near Baker	LP	16	3.79	3,180	0	0	14	4.5	10
462	06326800	Pennel Creek tributary near Baker	LP	30	.86	3,170	0	0	14	2.5	5.5
463	06326940	Spring Creek tributary near Fallon	LP	27	3.10	2,540	0	0	12	2.3	5.0
464	06327550	South Fork Horse Creek tributary near Wibaux	LP	26	1.34	2,940	0	0	14	3.0	6.5
465	06327700	Griffith Creek near Glendive	LP	12	15.5	2,490	0	5	13	10	19
466	06327720	Griffith Creek tributary near Glendive	LP	26	3.48	2,430	0	4	14	2.3	6.0
467	06327790	Krug Creek tributary no. 2 near Wibaux	LP	25	.44	2,870	0	0	14	1.5	4.5
468	06328100	Yellowstone River tributary no. 6 near Glendive	LP	25	2.93	2,330	0	13	14	4.0	9.5
469	06329350	Alkali Creek near Sidney	LP	25	.49	2,350	0	5	13	2.5	4.5

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
Southeast Plains Region--Continued											
427	9	23	39	67	95	130	174	247	60	45.473	106.526
428	107	198	288	447	608	815	1,080	1,540	2,080	45.550	106.283
429	4	30	76	186	319	503	745	1,170	58	45.600	106.283
430	22	73	136	261	396	576	812	1,230	296	45.289	106.154
431	7	37	83	187	311	482	713	1,130	220	45.410	106.152
432	49	142	244	424	602	818	1,080	1,500	425	45.588	106.255
433	3	8	16	35	58	95	151	268	39	45.617	106.417
434	89	275	476	825	1,160	1,550	2,010	2,710	806	45.633	106.300
435	2,800	4,250	5,300	6,720	7,840	9,020	10,300	12,000	8,340	45.872	106.187
436	213	321	385	456	503	544	582	625	448	46.082	105.852
437	13	66	160	413	766	1,340	2,240	4,200	290	45.524	105.753
438	7	26	51	108	178	279	422	703	390	45.883	105.667
439	164	520	936	1,730	2,560	3,620	4,950	7,210	990	45.883	105.650
440	31	107	208	420	662	998	1,450	2,300	1,170	46.034	105.521
441	42	119	209	384	573	825	1,160	1,750	550	46.105	105.556
442	438	1,310	2,250	3,950	5,620	7,660	10,100	14,100	2,890	46.228	105.690
443	3,540	6,290	8,510	11,800	14,500	17,600	20,900	25,900	13,300	46.346	105.803
444	397	1,080	1,680	2,530	3,210	3,890	4,560	5,440	3,490	46.550	105.633
445	17	78	181	462	868	1,550	2,680	5,290	1,400	46.367	105.500
446	6,100	11,500	16,400	24,400	32,000	41,000	51,800	69,400	33,000	45.068	105.869
447	18	76	157	334	536	814	1,180	1,850	715	45.433	105.433
448	4,120	8,550	12,800	19,900	26,700	34,900	44,900	61,400	30,000	45.427	105.401
449	23	107	251	647	1,220	2,170	3,740	7,340	2,530	45.079	105.362
450	33	93	150	241	321	409	505	643	155	45.300	105.099
451	1,150	1,840	2,330	2,970	3,460	3,960	4,470	5,160	2,700	45.390	105.304
452	28	100	188	363	548	788	1,090	1,600	480	45.814	105.065
453	107	401	846	1,950	3,430	5,780	9,450	17,400	8,600	46.144	105.168
454	700	1,450	2,080	3,000	3,770	4,590	5,480	6,750	2,270	46.261	105.293
455	263	591	925	1,520	2,110	2,870	3,810	5,420	1,370	46.383	105.283
456	7,320	14,600	20,500	29,000	35,900	43,200	50,900	61,800	31,000	46.449	105.312
457	11	38	72	136	203	287	391	564	130	46.431	105.181
458	2	6	11	22	33	49	71	110	28	46.194	104.551
459	763	2,090	3,340	5,300	6,990	8,840	10,800	13,700	4,700	46.421	104.761
460	31	52	67	87	102	118	134	155	61	46.417	104.733
461	114	168	207	260	302	346	393	458	260	46.300	104.300
462	33	68	103	166	229	308	408	580	350	46.483	104.233
463	12	62	131	268	409	580	783	1,100	303	46.802	104.990
464	29	64	99	156	209	273	349	469	235	46.802	104.381
465	150	707	1,660	4,270	7,990	14,200	24,400	47,500	14,600	47.100	104.567
466	34	176	411	1,000	1,780	2,960	4,700	8,200	1,070	47.106	104.597
467	18	35	48	67	81	96	112	133	77	47.008	104.306
468	78	233	369	562	709	854	993	1,170	576	47.157	104.654
469	14	36	60	108	159	229	323	496	305	47.509	104.118

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bankfull width (W_{bf})
		Southeast Plains Region--Continued									
470	06333850	North Creek near Alzada	LP	24	1.25	3,550	0	0	15	--	--
471	06334000	Little Missouri River near Alzada	LP	53	904	3,910	0	8	16	40	--
472	06334100	Wolf Creek near Hammond	LP	44	10.1	3,710	0	0	15	12	31
473	06334200	Willow Creek near Alzada	LP	16	122	3,690	0	0	15	18	46
474	06334330	Little Missouri River tributary near Albion	LP	27	1.49	3,360	0	0	14	--	--
475	06334610	Hawksnest Creek tributary near Albion	LP	26	.92	3,530	0	0	14	2.8	6.5
476	06334625	Coal Creek tributary near Mill Iron	LP	25	.64	3,450	0	5	16	2.0	5.5
477	06334630	Box Elder Creek at Webster	LP	15	1,092	3,440	0	4.2	14	59	116
478	06334640	North Fork Coal Bank Creek near Mill Iron	LP	15	15.6	3,170	0	0	14	8.0	15
479	06334720	Soda Creek tributary near Webster	LP	30	2.22	3,200	0	0	14	2.0	5.5
480	06336450	Spring Creek near Wibaux	LP	18	4.00	2,900	0	0	14	4.0	8.5
481	06336500*	Beaver Creek at Wibaux	LP	40	351	3,020	0	0	14	31	43
		Upper Yellowstone-Central Mountain Region									
482	06043000	Taylor Creek near Grayling	LP	11	98	8,320	99	60.5	40	39	44
483	06043200	Squaw Creek near Gallatin Gateway	LP	17	40.4	7,440	98	95	35	25	30
484	06043300	Logger Creek near Gallatin Gateway	LP	40	2.48	7,120	87	99	30	8.0	12
485	06043500	Gallatin River near Gallatin Gateway	C, 06044000, LP	85	825	7,960	95	83.3	37	102	120
486	06046500	Rocky Creek near Bozeman	LP	35	50.5	6,110	55	62.4	27	27	37
487	06046700	Pitcher Creek near Bozeman	LP	17	2.33	5,680	15	50	21	5.0	10
488	06047000	Bear Canyon Creek, near Bozeman	LP	19	17.0	6,690	92	88.5	28	13	18
489	06048000	East Gallatin River at Bozeman	LP	23	148	6,210	51	65	26	35	46
490	06048500	Bridger Creek near Bozeman	LP	28	62.5	6,540	62	73.9	33	22	27
491	06050000*	Hyalite Creek at Hyalite Ranger Station, near Bozeman	LP, R	45	48.2	7,710	97	87.8	36	33	42
492	06052500	Gallatin River at Logan	LP	79	1,795	6,820	64	60.3	27	150	170
493	06053050	Lost Creek near Ringling	LP	25	9.59	5,750	19	0	13	9.0	--
494	06074500	Smith River near White Sulphur Springs	LP	12	30.7	6,770	81	74	25	16	20
495	06075600	Fivemile Creek near White Sulphur Springs	LP	15	6.42	5,980	45	33	19	4.0	8.5
496	06076000	Newlan Creek near White Sulphur Springs	LP	22	7.27	6,380	81	97	25	7.0	12
497	06076690*	Smith River near Ft. Logan	LP	18	846	--	--	--	--	--	--
498	06076700	Sheep Creek near Neihart	LP	32	5.22	7,210	99	82	29	12	25
499	06076800	Nugget Creek near Neihart	LP	15	1.50	7,190	99	93	29	3.0	9.0
500	06077000	Sheep Creek near White Sulphur Springs	LP	33	42.8	6,910	94	95.5	30	26	33
501	06077300	Trout Creek near Eden	LP	11	13.2	5,410	22	4	18	6.0	9.0
502	06077500	Smith River near Eden	LP	21	1,594	5,840	35.6	43.3	23	76	98
503	06077700	Smith River tributary near Eden	LP	15	1.44	3,840	0	0	15	1.0	2.5
504	06077800	Goodman Coulee near Eden	LP	24	22.1	4,020	0	2	15	5.5	11
505	06090500	Belt Creek near Monarch	LP	31	368	6,190	56	88.3	25	62	--
506	06090550	Little Otter Creek near Raynesford	LP	25	39.5	5,210	7	29	18	7.0	9.5
507	06109800	South Fork Judith River near Utica	LP	21	58.7	6,640	94	93.4	21	21	25
508	06109900	Judith River tributary near Utica	LP	15	7.15	5,420	9	23	15	--	--
509	06110000	Judith River near Utica	LP	55	328	6,540	71	81	24	37	42
510	06111000	Ross Fork Creek near Hobson	LP	16	337	4,640	2	5.3	17	24	35

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years: *2*	*5*	*10*	*25*	*50*	*100*	*200*	*500*	Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
Southeast Plains Region--Continued											
470	253	570	846	1,260	1,610	1,990	2,400	2,990	1,300	45.067	104.517
471	1,880	3,270	4,250	5,530	6,490	7,450	8,410	9,670	6,000	45.083	104.400
472	167	424	648	973	1,240	1,510	1,790	2,170	1,170	45.167	104.750
473	630	1,160	1,580	2,190	2,680	3,220	3,790	4,620	1,800	45.100	104.583
474	3	13	28	65	115	192	311	566	90	45.211	104.261
475	40	74	99	131	155	178	200	229	146	45.387	104.477
476	4	22	53	133	239	401	642	1,130	205	45.904	104.363
477	1,840	4,300	6,680	10,700	14,400	18,800	24,000	32,300	23,000	45.907	104.058
478	157	379	557	798	980	1,160	1,330	1,550	750	46.943	104.091
479	6	27	58	135	233	380	595	1,030	250	46.009	104.092
480	61	149	231	360	476	605	750	966	438	46.884	104.201
481	894	2,440	3,920	6,270	8,330	10,600	13,200	16,800	3,780	46.990	104.183
Upper Yellowstone-Central Mountain Region											
482	783	928	1,010	1,110	1,160	1,210	1,260	1,320	1,020	45.071	111.204
483	260	394	496	643	764	897	1,040	1,260	690	45.433	111.217
484	15	26	35	49	61	75	90	114	92	45.450	111.233
485	5,340	6,960	7,930	9,080	9,880	10,700	11,400	12,300	9,270	45.498	111.270
486	384	588	748	982	1,180	1,400	1,650	2,020	1,230	45.643	110.926
487	15	31	48	78	109	149	200	290	142	45.650	110.933
488	154	245	309	393	458	524	591	682	489	45.626	110.929
489	549	860	1,100	1,450	1,740	2,050	2,400	2,910	2,460	45.700	111.029
490	299	488	637	855	1,040	1,240	1,470	1,800	1,140	45.706	110.961
491	417	574	682	823	933	1,050	1,160	1,320	948	45.562	111.070
492	5,050	6,780	7,830	9,090	9,970	10,800	11,600	12,700	9,840	45.885	111.438
493	40	139	254	471	689	959	1,290	1,820	300	46.261	110.786
494	119	264	410	671	933	1,260	1,680	2,400	770	46.667	110.733
495	13	24	34	50	65	82	103	136	52	46.617	110.750
496	13	26	39	60	79	103	131	176	56	46.733	110.833
497	759	1,540	2,290	3,570	4,820	6,360	8,250	11,400	4,600	46.796	111.178
498	58	87	107	133	153	173	193	221	138	46.800	110.700
499	9	15	21	30	39	48	59	75	37	46.783	110.700
500	211	306	376	471	547	627	713	835	460	46.768	110.809
501	43	118	211	412	648	991	1,480	2,460	430	47.119	111.372
502	1,880	3,360	4,730	7,010	9,210	11,900	15,200	20,700	12,300	47.190	111.387
503	3	11	23	55	99	171	287	551	80	47.300	111.433
504	90	223	370	653	958	1,370	1,900	2,880	1,340	47.333	111.417
505	1,570	2,790	3,880	5,650	7,320	9,320	11,700	15,600	11,000	47.208	110.926
506	23	73	137	271	425	639	933	1,480	245	47.251	110.731
507	275	641	1,020	1,710	2,420	3,320	4,460	6,420	1,950	46.754	110.323
508	15	55	106	209	321	469	659	989	125	46.883	110.267
509	485	805	1,020	1,280	1,470	1,650	1,820	2,040	1,750	46.892	110.232
510	384	1,090	1,740	2,700	3,480	4,290	5,120	6,230	2,640	46.983	109.800

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (*A*)	Mean basin elevation (*E*)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (*F*)	Mean annual precipitation (*P*)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Upper Yellowstone-Central Mountain Region									
511	06111700	Mill Creek near Lewistown	LP	32	3.14	4,630	0	74	22	3.0	5.0
512	06112100	Cottonwood Creek near Moore	LP	18	47.9	5,840	45	62	29	26	30
513	06112800	Bull Creek tributary near Hilger	LP	25	.99	4,150	0	0	16	2.7	3.5
514	06114500	Wolf Creek near Stanford	LP	13	112	6,190	56.6	67.7	25	13	--
515	06115500	North Fork Musselshell River near Delpine	LP	39	31.4	6,120	77	52.4	21	15	19
516	06117000	Checkerboard Creek at Delpine	LP	10	23.9	6,340	77	50	21	9.3	12
517	06117800	Big Coulee near Martinsdale	LP	26	2.86	5,230	0	5	15	2.0	6.0
518	06118500	South Fork Musselshell River above Martinsdale	LP	38	287	6,110	60	46.6	20	45	56
519	06120500	Musselshell River at Harlowton	LP	90	1,125	5,650	38.8	34.4	18	61	78
520	06120600	Antelope Creek tributary near Harlowton	LP	18	.47	5,400	0	0	15	--	--
521	06120700	Antelope Creek tributary near mouth, near Harlowton	LP	18	1.92	5,200	0	0	15	2.5	5.0
522	06120800	Alkali Creek near Harlowton	LP	36	21.2	4,570	0	0	13	7.5	18
523	06120900	Antelope Creek at Harlowton	LP	24	88.7	4,930	8	7	14	15	23
524	06121000	American Fork near Harlowton	LP	13	94.6	5,820	34	25	20	--	--
525	06121500*	Lebo Creek near Harlowton	LP, R	11	59.1	4,920	0	0	14	16	21
526	06122000	American Fork below Lebo Creek, near Harlowton	LP	22	166	5,480	24.8	10.5	19	24	32
527	06123200	Sadie Creek near Harlowton	LP	27	2.10	5,090	0	0	14	2.0	6.0
528	06124600	East Fork Roberts Creek tributary near Judith Gap	LP	25	.74	4,850	0	0	16	3.0	6.0
529	06128400	South Fork Bear Creek near Roy	LP	15	39.6	3,570	0	2.6	16	13.5	21
530	06128500	South Fork Bear Creek tributary near Roy	LP	37	5.40	3,430	0	0	15	8.0	12
531	06129100	North Fork McDonald Creek tributary near Heath	LP	16	2.24	4,750	0	0	20	2.5	8.0
532	06129200	Alkali Creek near Heath	LP	15	3.76	4,570	0	29.6	18	5.0	9.0
533	06129400	South Fork McDonald Creek tributary near Grassrange	LP	15	.51	3,850	0	12.1	17	--	--
534	06186500*	Yellowstone River at Yellowstone Lake Outlet, Yellowstone National Park, Wyo.	LP	73	1,006	--	--	--	--	--	--
535	06187000*	Yellowstone River near Canyon Hotel, Yellowstone National Park, Wyo.	LP	37	1,157	--	--	--	--	--	--
536	06187500*	Tower Creek at Tower Falls, Yellowstone National Park, Wyo.	LP	21	50.4	--	--	--	--	--	--
537	06187950*	Soda Butte Creek near Lamar Ranger Station, Yellowstone National Park, Wyo.	LP	10	99.0	--	--	--	--	--	--
538	06188000*	Lamar River near Tower Falls Ranger Station, Yellowstone National Park, Wyo.	LP	59	660	--	--	--	--	--	--
539	06189000*	Blacktail Deer Creek near Mammoth, Yellowstone National Park, Wyo.	LP	13	15.0	--	--	--	--	--	--
540	06191000	Gardner River near Mammoth, Yellowstone National Park, Wyo.	C, 06190500, LP	65	202	7,940	98	79.2	30	44	55
541	06191500*	Yellowstone River at Corwin Springs	LP	92	2,623	8,440	96	78.2	33	240	260
542	06192500*	Yellowstone River near Livingston	LP	74	3,551	8,350	89	72.8	28	270	300
543	06193000	Shields River near Wilsall	LP	22	87.8	7,040	97	83.5	28	38	47
544	06193500	Shields River at Clyde Park	LP	41	543	6,090	44.1	30.6	20	68	75
545	06194000	Brackett Creek near Clyde Park	LP	27	57.9	6,140	60	60.8	26	23	31
546	06195600*	Shields River near Livingston	LP	20	852	--	--	--	--	--	--

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	***5***	***10***	***25***	***50***	***100***	***200***	***500***			
Upper Yellowstone-Central Mountain Region											
511	11	29	49	85	123	170	230	330	87	47.000	109.433
512	361	863	1,360	2,210	3,030	4,020	5,200	7,120	1,740	46.983	109.483
513	11	39	78	166	273	429	652	1090	415	47.253	109.364
514	16	53	111	265	490	881	1,550	3,200	990	47.115	110.290
515	89	160	215	291	353	417	485	581	423	46.610	110.575
516	50	104	152	225	288	360	441	562	167	46.567	110.567
517	68	150	250	390	590	760	1,000	1,300	301	46.550	110.314
518	740	1,340	1,900	2,870	3,820	5,000	6,470	8,980	5,240	46.453	110.381
519	1,060	2,040	2,810	3,860	4,700	5,560	6,460	7,690	7,270	46.430	109.840
520	1	5	11	25	46	81	140	279	68	46.650	109.967
521	38	128	230	418	602	827	1,090	1,520	307	46.617	109.950
522	92	417	935	2,240	3,960	6,640	10,700	19,200	5,390	46.467	109.817
523	103	585	1,520	4,370	8,820	16,800	30,600	64,400	24,400	46.433	109.817
524	241	459	652	962	1,240	1,580	1,960	2,570	980	46.367	109.800
525	51	114	182	314	456	647	902	1,370	417	46.383	109.800
526	353	709	1,010	1,470	1,870	2,310	2,800	3,530	2,050	46.400	109.767
527	5	34	88	240	458	816	1,380	2,590	204	46.193	109.903
528	21	50	78	127	173	229	296	402	83	46.681	109.673
529	222	560	924	1,600	2,290	3,170	4,290	6,230	2,200	47.200	108.800
530	42	97	147	224	292	367	450	571	235	47.233	108.800
531	11	27	41	63	83	106	131	169	60	47.067	109.217
532	24	101	215	486	825	1,330	2,060	3,520	757	47.083	109.150
533	14	36	59	99	139	187	246	341	141	47.000	108.783
534	4,800	6,360	7,320	8,450	9,250	10,000	10,800	11,700	9,950	44.568	110.380
535	4,720	6,140	7,050	8,170	8,980	9,780	10,600	11,600	8,550	44.710	110.502
536	319	470	567	687	773	856	938	1,040	642	44.900	110.383
537	1,540	2,010	2,320	2,700	2,970	3,240	3,510	3,870	2,450	44.868	110.165
538	8,670	11,200	12,800	14,800	16,300	17,800	19,400	21,400	19,500	44.928	110.393
539	77	128	167	224	272	323	380	464	198	44.950	110.586
540	1,150	1,550	1,790	2,070	2,270	2,450	2,630	2,850	2,080	44.993	110.691
541	17,500	22,300	25,000	28,100	30,200	32,100	33,900	36,200	32,200	45.112	110.794
542	20,300	25,400	28,700	32,600	35,500	38,300	41,100	44,800	38,000	45.597	110.565
543	552	851	1,080	1,400	1,670	1,960	2,270	2,720	1,770	46.150	110.583
544	1,070	1,750	2,310	3,160	3,900	4,730	5,680	7,130	4,500	45.886	110.618
545	204	385	557	849	1,130	1,480	1,910	2,630	1,400	45.867	110.669
546	2,000	3,120	3,970	5,150	6,110	7,140	8,250	9,850	5,600	45.738	110.479

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bankfull width (W_{bf})
Upper Yellowstone-Central Mountain Region--Continued											
547	06197000	Big Timber Creek near Big Timber	LP	13	74.9	6,680	59	42.9	25	42	65
548	06197500	Boulder River near Contact	LP	34	226	8,510	91	65.3	37	80	95
549	06200000	Boulder River at Big Timber	LP	51	523	7,570	75	57.9	30	120	140
550	06200500	Sweet Grass Creek above Melville	LP	46	63.8	7,630	75	48.7	33	47	56
551	06201000	Sweet Grass Creek below Melville	LP	30	143	6,110	32.8	26.7	15	50	57
552	06201550	Yellowstone River tributary near Greycliff	LP	15	2.72	4,290	0	23	15	--	--
553	06201600	Bridger Creek near Greycliff	LP	16	61.5	5,320	12	45	19	24	32
554	06201650	Work Creek near Reed Point	LP	16	32.5	4,630	0	13	16	20	31
555	06201700	Hump Creek near Reed Point	LP	39	7.61	4,420	0	23	15	4.0	8.0
556	06201750	Berry Creek near Columbus	LP	17	23.5	4,270	0	28	13	9.0	18
557	06202510*	Stillwater River above Nye Creek, near Nye	LP	12	193	--	--	--	--	--	--
558	06204050*	West Rosebud Creek near Roscoe	LP, R	33	52.1	9,560	100	16	55	47	60
559	06204500	Rosebud Creek near Absarokee	LP	35	394	7,890	66.1	29	32	105	130
560	06205000	Stillwater River near Absarokee	LP	68	975	7,220	53	54.6	32	140	163
561	06205100	Allen Creek near Park City	LP	38	7.17	3,960	0	47	13	7.0	28
562	06207500	Clarks Fork Yellowstone River near Belfry	LP	77	1,154	7,430	80	60.9	17	150	170
563	06207600	Jack Creek tributary near Belfry	LP	17	.85	4,380	0	0	11	3.5	6.7
564	06207800	Bluewater Creek near Bridger	LP	12	28.1	4,860	0	14	15	10	23
565	06208500	Clarks Fork Yellowstone River at Edgar	C, 06208800, LP	76	2,032	6,130	45	34.6	14	--	--
566	06209500	Rock Creek near Red Lodge	LP	52	124	9,540	99	40	40	65	80
567	06210000	West Fork Rock Creek below Basin Creek, near Red Lodge	LP	19	63.1	9,050	100	63.5	38	40	48
568	06211000	Red Lodge Creek above Cooney Reservoir, near Boyd	LP	62	143	5,710	23.6	30	22	30	46
569	06211500	Willow Creek near Boyd	LP	62	53.3	4,730	8.1	15.3	20	26	38
570	06212500*	Red Lodge Creek below Cooney Reservoir, near Boyd	LP, R	61	210	5,380	18	24	21	38	55
571	06214150	Mills Creek at Rapelje	LP	25	3.32	4,120	0	0	14	--	--
572	06214500*	Yellowstone River at Billings	LP	73	11,795	--	--	--	--	--	--
573	06215000	Pryor Creek above Pryor	LP	12	39.6	6,000	48.4	27.3	17	10	15
574	06216000	Pryor Creek at Pryor	LP	35	117	5,280	41	23	16	18	27
575	06216200	West Wets Creek near Billings	LP	44	8.80	3,980	0	0	14	4.0	9.0
576	06216300	West Buckeye Creek near Billings	LP	20	2.64	3,780	0	0	14	8.0	16
577	06216500	Pryor Creek near Billings	LP	49	440	4,550	12	13.5	15	50	60
578	06216900*	Pryor Creek near Huntley	LP	21	582	--	--	--	--	--	--
579	06217750	Fly Creek at Pompeys Pillar	LP	13	285	3,470	0	5.5	13	15	25
580	06287000*	Bighorn River near St. Xavier	LP, R	34	19,667	--	--	--	--	--	--
581	06287500	Soap Creek near St. Xavier	LP	22	98.3	4,240	5	2.8	18	20	23
582	06288000	Rotten Grass Creek near St. Xavier	LP	10	147	4,390	11	11	16	21	24
583	06288200	Beauvais Creek near St. Xavier	LP	11	100	4,210	0	0	15	14	20
584	06288500*	Bighorn River near Hardin	LP	26	20,722	--	--	--	--	--	--
585	06289000	Little Bighorn River at State Line, near Wyola	LP	60	193	7,830	93	87	20	39	48
586	06290000	Pass Creek near Wyola	LP	38	111	5,570	15	26.8	22	28	37
587	06290200	Little Bighorn River tributary near Wyola	LP	14	4.43	4,060	0	19	16	4.0	7.3

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	***5***	***10***	***25***	***50***	***100***	***200***	***500***			
				Upper Yellowstone-Central Mountain Region--Continued							
547	676	1,270	1,830	2,810	3,770	4,970	6,470	9,020	1,960	45.954	110.029
548	3,720	4,550	5,120	5,850	6,410	6,980	7,570	8,380	6,800	45.555	110.200
549	5,600	7,000	7,930	9,120	10,000	10,900	11,900	13,200	9,940	45.834	109.938
550	937	1,360	1,680	2,150	2,530	2,950	3,410	4,090	3,510	46.154	110.088
551	941	1,540	2,020	2,750	3,380	4,080	4,880	6,090	3,000	46.067	109.850
552	9	25	43	76	110	152	205	294	55	45.733	109.717
553	135	469	890	1,740	2,680	3,930	5,560	8,440	2,680	45.683	109.717
554	95	396	799	1,630	2,550	3,750	5,290	7,940	720	45.700	109.633
555	29	110	207	390	571	793	1,060	1,470	307	45.700	109.583
556	70	140	320	700	1,300	2,200	4,000	8,300	2,000	45.700	109.383
557	4,430	5,100	5,520	6,050	6,440	6,820	7,200	7,710	6,400	45.396	109.871
558	696	1,070	1,310	1,610	1,820	2,020	2,220	2,470	1,630	45.243	109.731
559	2,310	3,250	3,910	4,780	5,470	6,180	6,920	7,950	5,790	45.487	109.455
560	6,580	8,350	9,440	10,700	11,700	12,600	13,400	14,600	12,000	45.551	109.387
561	53	195	360	660	951	1,300	1,700	2,330	1,580	45.600	109.050
562	7,590	9,340	10,400	11,700	12,700	13,600	14,500	15,700	14,800	45.010	109.065
563	15	39	61	98	132	172	218	288	90	45.162	108.823
564	86	206	355	678	1,070	1,650	2,510	4,300	2,650	45.332	108.801
565	7,710	9,510	10,600	11,900	12,800	13,600	14,400	15,500	11,100	45.466	108.843
566	1,220	1,690	2,000	2,390	2,680	2,960	3,250	3,630	3,110	45.121	109.296
567	508	670	777	913	1,010	1,120	1,220	1,360	933	45.150	109.325
568	616	1,200	1,680	2,380	2,950	3,570	4,240	5,190	2,260	45.438	109.253
569	257	542	824	1,320	1,800	2,410	3,160	4,450	1,720	45.422	109.230
570	459	834	1,200	1,820	2,440	3,230	4,210	5,910	3,470	45.450	109.185
571	3	13	28	61	96	144	207	314	77	45.968	109.255
572	40,100	51,600	58,900	67,700	74,100	80,400	86,700	94,900	82,000	45.797	108.470
573	132	276	414	647	872	1,150	1,480	2,030	575	45.341	108.569
574	143	329	541	964	1,440	2,100	3,020	4,770	2,280	45.435	108.534
575	59	194	332	556	751	965	1,190	1,520	565	45.633	108.400
576	80	197	322	551	788	1,090	1,480	2,150	924	45.650	108.400
577	646	1,250	1,830	2,800	3,740	4,890	6,310	8,680	14,900	45.717	108.317
578	798	1,470	2,070	3,040	3,920	4,970	6,210	8,180	17,500	45.822	108.290
579	400	1,300	2,540	5,360	8,860	14,100	21,900	37,800	10,300	45.993	107.952
580	8,030	12,800	16,400	21,500	25,700	30,200	35,100	42,200	26,400	45.317	107.918
581	405	952	1,580	2,820	4,220	6,160	8,840	14,000	7,810	45.327	107.769
582	415	748	1,030	1,470	1,850	2,290	2,790	3,570	700	45.412	107.683
583	580	1,260	1,940	3,130	4,320	5,810	7,670	10,800	7,350	45.478	108.009
584	27,800	35,100	39,100	43,500	46,300	48,900	51,200	54,000	45,900	45.729	107.581
585	1,040	1,490	1,790	2,170	2,450	2,730	3,010	3,390	2,730	45.007	107.614
586	293	590	896	1,460	2,050	2,820	3,830	5,640	1,150	45.056	107.355
587	13	65	145	339	580	937	1,450	2,430	226	45.138	107.386

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Upper Yellowstone-Central Mountain Region--Continued									
588	06290500	Little Bighorn River below Pass Creek, near Wyola	LP	58	428	6,140	47	45.9	20	51	64
589	06291000	Owl Creek near Lodge Grass	LP	19	163	4,280	0	9.3	15	15	23
590	06291500	Lodge Grass Creek above Willow Creek Diversion, near Wyola	LP	53	80.7	6,360	52	33.3	22	24	39
591	06293300	Long Otter Creek near Lodge Grass	LP	26	11.7	3,490	0	6	14	50	90
592	06293500*	Little Bighorn River near Crow Agency	LP	39	1,181	--	--	--	--	--	--
593	06294000	Little Bighorn River near Hardin	LP	46	1,294	4,770	19.8	21.6	16	85	110
		Southwest Region									
594	06011000	Red Rock River at Kennedy Ranch, near Lakeview	LP	29	323	7,330	100	29.2	22	77	87
595	06012500*	Red Rock River below Lima Reservoir, near Monida	LP, R	74	570	7,180	100	21.8	21	60	--
596	06013400	Muddy Creek near Dell	LP	16	63.4	7,840	99	24	16	5.5	10
597	06013500	Big Sheep Creek below Muddy Creek, near Dell	LP	40	278	8,010	99	31	19	27	33
598	06014000*	Red Rock River near Dell	LP	25	1,421	--	--	--	--	--	--
599	06015400*	Beaverhead River near Grant	LP	19	2,322	--	--	--	--	--	--
600	06015430	Clark Canyon near Dillon	LP	26	18	7,010	90	34	14	9.0	14
601	06015500	Grasshopper Creek near Dillon	LP	39	348	7,050	94	30	19	31	40
602	06016000*	Beaverhead River at Barretts	LP, R	34	2,737	--	--	--	--	--	--
603	06017000*	Beaverhead River at Dillon	LP, R	10	2,895	--	--	--	--	--	--
604	06017500	Blacktail Deer Creek near Dillon	LP	21	312	7,210	96	18.8	12	21	37
605	06018000*	Beaverhead River near Dillon	LP, R	19	3,484	--	--	--	--	--	--
606	06018500*	Beaverhead River near Twin Bridges	LP, R	34	3,619	--	--	--	--	--	--
607	06019400	Sweetwater Creek near Alder	LP	18	81.5	6,870	100	12	15	9.0	13
608	06019500	Ruby River above Reservoir, near Alder	LP	60	538	7,280	91	28.8	18	53	--
609	06019800	Idaho Creek near Alder	LP	26	11.0	7,010	83	52	19	5.5	9.0
610	06020600*	Ruby River below Reservoir, near Alder	LP, R	36	596	--	--	--	--	--	--
611	06021000*	Ruby River near Alder	LP, R	24	614	--	--	--	--	--	--
612	06021500*	Ruby River at Laurin	LP, R	14	650	--	--	--	--	--	--
613	06023000*	Ruby River near Twin Bridges	LP, R	23	935	7,060	83	32	19	48	59
614	06024450*	Big Hole River below Big Lake Creek, at Wisdom	LP	11	575	--	--	--	--	--	--
615	06024500	Trail Creek near Wisdom	LP	12	71.4	7,110	100	97	30	39	48
616	06024590	Wise River near Wise River	LP	13	214	8,090	100	96	31	52	68
617	06025100	Quartz Hill Gulch near Wise River	LP	25	14.3	7,370	95	90	23	1.8	4.0
618	06025300	Moose Creek near Divide	LP	15	42.3	7,050	97	73	18	13	19
619	06025500	Big Hole River near Melrose	LP	74	2,476	7,140	91	65.3	23	223	260
620	06026000	Birch Creek near Glen	LP	30	36.0	7,690	97	86.8	12	22	28
621	06027000*	Jefferson River near Silver Star	C, 06026500, LP	47	7,683	--	--	--	--	--	--
622	06027700	Fish Creek near Silver Star	LP	33	38.9	7,030	80	77	19	17	23
623	06029000	Whitetail Creek near Whitehall	LP	19	30.8	7,330	97.2	85.6	21	17	21
624	06030300	Jefferson River tributary no. 2 near Whitehall	LP	41	4.50	5,440	31	17	12	6.0	11
625	06030500	Boulder River above Rock Creek, near Basin	LP	12	19.4	6,930	100	92.4	20	15	19

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	*5*	*10*	*25*	*50*	*100*	*200*	*500*			
					Upper Yellowstone-Central Mountain Region--Continued						
588	1,180	1,940	2,600	3,650	4,620	5,780	7,150	9,370	8,010	45.177	107.393
589	217	418	593	866	1,110	1,390	1,700	2,190	1,020	45.268	107.301
590	408	600	729	893	1,020	1,140	1,260	1,430	1,130	45.128	107.600
591	29	87	146	239	321	410	507	644	298	45.438	107.395
592	1,790	3,180	4,280	5,850	7,150	8,550	10,100	12,200	6,200	45.567	107.450
593	1,710	2,970	4,060	5,780	7,330	9,150	11,300	14,600	22,600	45.736	107.557
					Southwest Region						
594	719	923	1,030	1,150	1,230	1,290	1,350	1,420	1,360	44.650	112.050
595	612	823	982	1,200	1,390	1,580	1,800	2,110	2,500	44.656	112.371
596	58	101	132	172	202	232	262	301	197	44.633	112.800
597	330	516	649	827	964	1,110	1,250	1,460	1,400	44.655	112.778
598	317	531	704	962	1,180	1,430	1,710	2,130	1,480	44.783	112.733
599	991	1,080	1,130	1,170	1,190	1,210	1,220	1,240	1,100	45.003	112.853
600	46	93	138	219	299	400	526	744	415	45.016	112.836
601	393	681	889	1,160	1,370	1,590	1,800	2,090	1,870	45.111	112.800
602	1,200	1,500	1,720	2,010	2,240	2,480	2,730	3,090	3,000	45.116	112.750
603	974	1,310	1,520	1,770	1,940	2,100	2,260	2,460	1,740	45.218	112.654
604	194	302	386	507	608	719	842	1,030	910	45.046	112.549
605	840	1,010	1,100	1,210	1,280	1,350	1,410	1,490	1,310	45.305	112.563
606	856	1,210	1,430	1,710	1,920	2,120	2,320	2,590	2,200	45.384	112.452
607	62	167	280	487	697	965	1,300	1,870	344	45.078	112.226
608	962	1,360	1,640	2,050	2,370	2,720	3,100	3,640	3,810	45.193	112.142
609	24	43	59	81	99	118	140	170	90	45.200	112.133
610	1,030	1,450	1,740	2,100	2,360	2,630	2,900	3,270	3,010	45.242	112.110
611	495	766	954	1,200	1,380	1,560	1,750	2,000	1,380	45.292	112.100
612	364	594	757	972	1,140	1,310	1,480	1,710	980	45.350	112.117
613	673	1,030	1,260	1,560	1,790	2,000	2,220	2,510	1,500	45.508	112.330
614	1,680	3,120	4,290	6,010	7,450	9,020	10,700	13,300	4,300	45.619	113.457
615	852	1,020	1,130	1,250	1,350	1,440	1,530	1,650	1,350	45.657	113.716
616	1,700	2,170	2,430	2,720	2,900	3,060	3,210	3,380	2,730	45.714	113.024
617	6	16	26	45	64	87	117	167	102	45.776	112.861
618	103	143	168	196	215	232	249	270	180	45.717	112.700
619	7,160	10,400	12,300	14,500	15,900	17,200	18,400	19,900	14,300	45.527	112.701
620	207	283	329	384	422	459	494	539	427	45.379	112.797
621	8,720	12,400	14,600	17,000	18,600	20,100	21,400	23,000	17,100	45.650	112.300
622	126	176	208	246	273	299	325	358	250	45.767	112.250
623	69	101	123	149	168	187	206	231	142	46.023	112.208
624	12	59	137	331	579	955	1,500	2,590	425	45.883	111.983
625	171	323	463	692	909	1,170	1,480	1,990	1,020	46.253	112.500

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Station number	Station name	Type of flood data and frequency analysis	Years of record	Drainage area (A)	Mean basin elevation (E)	Percent basin above 6,000 feet elevation (E_{6000})	Percent basin covered by forest (F)	Mean annual precipitation (P)	Active-channel width (W_{ac})	Bank-full width (W_{bf})
		Southwest Region--Continued									
626	06031950	Cataract Creek near Basin	LP	26	30.6	7,300	94	83	26	29	37
627	06033000	Boulder River near Boulder	LP	59	381	6,640	80	89.1	19	45	60
628	06034700	Sand Creek at Sappington	LP	15	9.41	4,770	0	0	11	6.0	8.0
629	06035000	Willow Creek near Harrison	LP	61	83.8	6,930	70.7	52.5	27	26	28
630	06036650*	Jefferson River at Sappington	C, 06034500, LP	62	9,532	--	--	--	--	--	--
631	06036905*	Firehole River near West Yellowstone (Wyo.)	LP	13	282	--	--	--	--	--	--
632	06037000*	Gibbon River near West Yellowstone (Wyo.)	LP	13	118	--	--	--	--	--	--
633	06037500	Madison River near West Yellowstone	LP	72	420	7,920	99	93.8	20	85	94
634	06038500*	Madison River below Hebgen Lake, near Grayling	LP, R	58	905	7,650	100	90	38	105	120
635	06038550	Cabin Creek near West Yellowstone	LP	25	30.3	8,400	100	73	46	34	46
636	06038800*	Madison River at Kirby Ranch, near Cameron	LP	17	1,065	--	--	--	--	--	--
637	06040000*	Madison River near Cameron	LP	14	1,669	--	--	--	--	--	--
638	06040300	Jack Creek near Ennis	LP	15	51.5	7,490	94	83	33	26	32
639	06041000*	Madison River below Ennis Lake, near McAllister	LP, R	56	2,186	--	--	--	--	--	--
640	06042500*	Madison River near Three Forks	LP	13	2,511	--	--	--	--	--	--
641	06054500*	Missouri River at Toston	LP	66	14,669	--	--	--	--	--	--
642	06055500	Crow Creek near Radersburg	LP	22	76.6	6,980	86	89.5	25	30	38
643	06056200	Castle Creek tributary near Ringling	LP	18	2.51	6,380	80	0	22	5.5	8.0
644	06056300	Cabin Creek near Townsend	LP	39	11.8	6,990	44	76	26	7.0	12
645	06056600	Deep Creek below North Fork Deep Creek, near Townsend	LP	19	87.7	6,170	61	75	24	21	29
646	06058700	Mitchell Gulch near East Helena	LP	40	8.09	5,000	12	45	15	5.0	8.5
647	06061500	Prickly Pear Creek near Clancy	LP	61	192	5,660	34	83.5	19	27	31
648	06061700	Jackson Creek near East Helena	LP	18	3.44	6,290	59.3	100	19	7.0	11
649	06061800	Crystal Creek near East Helena	LP	18	3.77	5,830	38.9	100	19	7.0	10
650	06061900	McClellan Creek near East Helena	LP	19	33.2	5,980	47	96	19	20	28
651	06062500	Tenmile Creek near Rimini	LP	82	30.9	6,580	86.2	97.3	24	16	25
652	06062700	Little Porcupine Creek tributary near Helena	LP	17	.39	6,280	76.5	96.9	20	2.3	3.5
653	06063000	Tenmile Creek near Helena	LP	50	96.5	5,600	39.5	75.4	20	26	33
654	06066500*	Missouri River below Holter Dam, near Wolf Creek	LP, R	46	17,149	--	--	--	--	--	--
655	06068500	Little Prickly Pear Creek near Marysville	LP	20	44.4	5,900	55	97.1	12	14	24
656	06071000	Little Prickly Pear Creek near Canyon Creek	LP	15	183	5,840	43	70	23	24	37
657	06071200	Lyons Creek near Wolf Creek	LP	16	29.9	5,270	13	77	27	11	16
658	06071300	Little Prickly Pear Creek at Wolf Creek	LP	13	381	5,430	32	63	21	--	--
659	06071400	Dog Creek near Craig	LP	16	15.7	4,090	0	4	13	11	15
660	06071600	Wegner Creek at Craig	LP	32	35.7	4,610	3	68	17	13.5	18

Table 2. Basin-characteristics, channel-width, and flood-frequency data for selected streamflow-gaging stations, Montana and adjacent areas in Idaho, Wyoming, and Canada (Continued)

Site number (fig. 1)	Annual peak discharge (*Q*), in cubic feet per second, for indicated recurrence interval (*T*), in years								Largest known annual peak discharge (cubic feet per second)	Latitude of gage (in decimal degrees)	Longitude of gage (in decimal degrees)
	2	***5***	***10***	***25***	***50***	***100***	***200***	***500***			
					Southwest Region--Continued						
626	259	414	557	798	1,030	1,320	1,670	2,270	3,150	46.286	112.243
627	1,080	1,740	2,280	3,080	3,780	4,570	5,450	6,800	7,000	46.211	112.091
628	21	128	305	732	1,250	2,000	3,020	4,890	2,130	45.783	111.750
629	223	344	434	560	663	773	891	1,060	813	45.723	111.740
630	8,940	13,100	15,700	18,700	20,900	22,900	24,900	27,300	17,000	45.898	111.596
631	901	1,250	1,500	1,840	2,110	2,390	2,690	3,120	2,050	44.620	110.862
632	699	1,150	1,460	1,880	2,190	2,510	2,830	3,260	1,500	44.649	110.784
633	1,360	1,740	1,980	2,280	2,510	2,730	2,950	3,250	2,820	44.657	111.068
634	2,510	3,160	3,600	4,160	4,580	5,010	5,450	6,050	10,200	44.867	111.338
635	419	618	773	998	1,190	1,400	1,630	1,980	1,500	44.872	111.341
636	2,910	4,270	5,180	6,320	7,170	8,020	8,870	10,000	5,030	44.889	111.579
637	4,680	6,090	7,020	8,180	9,040	9,890	10,800	11,900	8,830	45.233	111.750
638	345	455	524	605	663	718	772	841	555	45.356	111.581
639	4,900	6,530	7,520	8,700	9,520	10,300	11,100	12,000	9,550	45.490	111.633
640	4,180	5,970	7,150	8,630	9,730	10,800	11,900	13,300	8,175	45.824	111.497
641	18,700	25,000	28,700	32,900	35,700	38,300	40,700	43,600	34,000	46.146	111.420
642	485	715	914	1,230	1,520	1,860	2,260	2,910	3,640	46.268	111.692
643	19	30	37	48	56	65	75	88	47	46.367	111.100
644	10	25	38	58	75	95	116	147	70	46.333	111.217
645	226	332	406	504	579	657	737	846	740	46.333	111.283
646	16	65	127	249	375	532	723	1,030	195	46.567	111.817
647	257	428	577	813	1,030	1,280	1,580	2,060	2,300	46.519	111.946
648	13	30	49	87	131	194	282	454	380	46.472	111.853
649	13	27	41	61	79	100	123	158	80	46.483	111.861
650	152	290	419	635	841	1,090	1,400	1,910	1,730	46.533	111.878
651	205	359	501	737	963	1,240	1,580	2,140	3,290	46.524	112.256
652	2	6	9	14	19	26	35	49	20	46.583	112.267
653	261	511	730	1,070	1,380	1,730	2,130	2,740	3,770	46.606	112.089
654	13,500	20,000	24,200	29,300	33,000	36,600	40,000	44,400	27,100	46.995	112.010
655	159	236	295	378	446	521	602	721	454	46.783	112.400
656	321	504	637	817	958	1,110	1,260	1,480	800	46.817	112.250
657	98	233	371	612	848	1,140	1,500	2,090	580	46.933	112.133
658	791	1,870	2,950	4,810	6,600	8,790	11,400	15,700	4,500	47.006	112.069
659	68	237	466	971	1,570	2,440	3,670	6,040	1,160	47.083	112.000
660	91	233	393	705	1,040	1,490	2,090	3,170	1,020	47.083	111.950

Table 4. Regression equations based on basin characteristics

[Abbreviations: n, number of stations used in the regression analysis; Q_T, annual peak discharge, in cubic feet per second, for recurrence interval *T*, in years; *A*, drainage area, in square miles; *P*, mean annual precipitation, in inches; *F*, percentage of basin covered by forest; *E*, mean basin elevation, in feet; E_{6000}, percentage of basin above 6,000 feet in elevation; *SEP*, standard error of prediction; *EYR*, equivalent years of record. Symbol: --, not applicable]

Regression equation	Error variance, log units		Average *SEP*, in log units	Average *SEP*, in percent	*EYR*
	Average sampling	Model			
West Region (n = 96)					
$Q_2 = 0.268 A^{0.927} P^{1.60} (F+1)^{-0.508}$	0.003	0.056	0.242	60.5	0.9
$Q_5 = 1.54 A^{0.884} P^{1.36} (F+1)^{-0.577}$	.003	.048	.224	55.4	1.4
$Q_{10} = 3.63 A^{0.86} P^{1.25} (F+1)^{-0.605}$	.003	.046	.221	54.3	1.9
$Q_{25} = 8.50 A^{0.835} P^{1.14} (F+1)^{-0.639}$	.003	.046	.222	54.6	2.7
$Q_{50} = 13.2 A^{0.823} P^{1.09} (F+1)^{-0.652}$	.003	.048	.227	56.0	3.1
$Q_{100} = 18.7 A^{0.812} P^{1.06} (F+1)^{-0.664}$	.004	.052	.235	58.5	3.4
$Q_{200} = 24.7 A^{0.804} P^{1.04} (F+1)^{-0.674}$	.004	.058	.248	62.2	3.6
$Q_{500} = 35.4 A^{0.792} P^{1.02} (F+1)^{-0.69}$	.005	.067	.267	67.9	3.7
Northwest Region (n = 35)					
$Q_2 = 0.128 A^{0.918} P^{1.33}$	.003	.038	.202	49.2	--
$Q_5 = 1.19 A^{0.846} P^{0.954}$	.002	.025	.164	39.2	--
$Q_{10} = 4.10 A^{0.807} P^{0.72}$	.002	.024	.161	38.4	--
$Q_{25} = 15.8 A^{0.76} P^{0.51}$	.002	.024	.161	38.4	--
$Q_{50} = 31.2 A^{0.733} P^{0.445}$	.002	.023	.157	37.4	--
$Q_{100} = 56.4 A^{0.71} P^{0.403}$	.002	.026	.168	40.2	--
$Q_{200} = 97.0 A^{0.694} P^{0.364}$	.003	.033	.190	46.0	--
$Q_{500} = 175 A^{0.674} P^{0.347}$	.004	.049	.230	56.9	--
Northwest Foothills Region (n = 24)					
$Q_2 = 14.2 A^{0.598}$	.016	.114	.360	99.5	2.7
$Q_5 = 53.6 A^{0.546}$	.010	.047	.239	59.6	8.7
$Q_{10} = 105 A^{0.546}$	.010	.034	.210	51.3	15.5
$Q_{25} = 208 A^{0.538}$	.012	.032	.208	50.8	22.2
$Q_{50} = 318 A^{0.536}$	.014	.036	.223	55.0	23.8
$Q_{100} = 462 A^{0.537}$	.016	.044	.244	61.0	23.8
$Q_{200} = 649 A^{0.54}$	.019	.053	.268	68.2	23.1
$Q_{500} = 977 A^{0.544}$	.023	.068	.302	79.0	21.8
Northeast Plains Region (n = 57)					
$Q_2 = 30.5 A^{0.601} (E/1000)^{-0.913}$	.008	.106	.337	91.0	3.0
$Q_5 = 143 A^{0.547} (E/1000)^{-1.12}$	.007	.087	.306	80.3	4.3
$Q_{10} = 293 A^{0.52} (E/1000)^{-1.19}$	.007	.088	.309	81.3	5.5
$Q_{25} = 579 A^{0.493} (E/1000)^{-1.21}$	.009	.098	.326	87.2	6.6
$Q_{50} = 860 A^{0.477} (E/1000)^{-1.21}$	.010	.109	.345	93.9	7.2
$Q_{100} = 1,190 A^{0.462} (E/1000)^{-1.20}$	.011	.122	.365	101.4	7.5
$Q_{200} = 1,570 A^{0.45} (E/1000)^{-1.17}$	.013	.137	.386	109.9	7.7
$Q_{500} = 2,130 A^{0.435} (E/1000)^{-1.13}$	.015	.159	.417	123.2	7.7

Table 4. Regression equations based on basin characteristics (Continued)

Regression equation	Error variance, log units		Average *SEP*, in log units	Average *SEP*, in percent	*EYR*
	Average sampling	Model			
East-Central Plains Region (n = 85)					
$Q_2 = 141\ A^{0.495}\ (E/1000)^{-1.85}$	.008	.123	.361	99.9	3.1
$Q_5 = 661\ A^{0.49}\ (E/1000)^{-2.09}$	.006	.080	.293	76.0	5.7
$Q_{10} = 1{,}300\ A^{0.482}\ (E/1000)^{-2.11}$	.006	.071	.278	71.4	8.3
$Q_{25} = 2{,}360\ A^{0.47}\ (E/1000)^{-2.05}$	.007	.074	.285	73.4	10.7
$Q_{50} = 3{,}240\ A^{0.462}\ (E/1000)^{-1.96}$	.008	.082	.301	78.6	11.6
$Q_{100} = 4{,}120\ A^{0.454}\ (E/1000)^{-1.84}$	.009	.094	.322	85.7	12.0
$Q_{200} = 4{,}950\ A^{0.446}\ (E/1000)^{-1.72}$	.011	.109	.346	94.3	11.9
$Q_{500} = 5{,}940\ A^{0.435}\ (E/1000)^{-1.53}$	.012	.133	.381	107.8	11.6
Southeast Plains Region (n = 69)					
$Q_2 = 29.0\ A^{0.60}\ (F+1)^{-0.424}$	.010	.183	.440	134.1	1.5
$Q_5 = 83.1\ A^{0.547}\ (F+1)^{-0.352}$	.008	.130	.371	103.9	2.6
$Q_{10} = 142\ A^{0.517}\ (F+1)^{-0.309}$	.007	.112	.346	94.3	4.0
$Q_{25} = 249\ A^{0.483}\ (F+1)^{-0.264}$	.008	.102	.331	88.9	6.0
$Q_{50} = 355\ A^{0.461}\ (F+1)^{-0.236}$	.008	.102	.332	89.1	7.3
$Q_{100} = 486\ A^{0.441}\ (F+1)^{-0.212}$	.009	.106	.338	91.6	8.3
$Q_{200} = 645\ A^{0.422}\ (F+1)^{-0.19}$	.009	.114	.351	96.1	9.0
$Q_{500} = 905\ A^{0.401}\ (F+1)^{-0.166}$	.011	.130	.375	105.5	9.3
Upper Yellowstone-Central Mountain Region (n = 92)					
$Q_2 = 5.84\ A^{0.832}\ (E_{6000}+1)^{0.098}$	.005	.115	.348	94.9	1.5
$Q_5 = 21.7\ A^{0.782}\ (E_{6000}+1)^{-0.0295}$	.004	.076	.282	72.7	3.2
$Q_{10} = 42.3\ A^{0.758}\ (E_{6000}+1)^{\ 0.0915}$	.004	.060	.252	63.4	5.6
$Q_{25} = 82.6\ A^{0.733}\ (E_{6000}+1)^{-0.148}$	.004	.049	.230	57.1	9.5
$Q_{50} = 126\ A^{0.716}\ (E_{6000}+1)^{-0.182}$	.004	.047	.226	55.9	12.2
$Q_{100} = 181\ A^{0.702}\ (E_{6000}+1)^{-0.211}$	.005	.048	.229	56.8	14.2
$Q_{200} = 252\ A^{0.689}\ (E_{6000}+1)^{-0.238}$	.005	.052	.239	59.5	15.4
$Q_{500} = 375\ A^{0.674}\ (E_{6000}+1)^{-0.271}$	.006	.061	.258	65.2	15.9
Southwest Region (n = 44)					
$Q_2 = 3.02\ A^{0.881}\ (E_{6000}+1)^{0.0981}$	.010	.110	.346	94.4	.9
$Q_5 = 17.1\ A^{0.80}\ (E_{6000}+1)^{-0.104}$	.008	.083	.302	79.0	1.7
$Q_{10} = 41.9\ A^{0.765}\ (E_{6000}+1)^{-0.214}$	.009	.077	.292	75.9	2.4
$Q_{25} = 109\ A^{0.728}\ (E_{6000}+1)^{-0.332}$	.010	.076	.292	75.6	3.4
$Q_{50} = 201\ A^{0.704}\ (E_{6000}+1)^{-0.408}$	.010	.078	.297	77.4	4.0
$Q_{100} = 351\ A^{0.682}\ (E_{6000}+1)^{-0.476}$	.012	.082	.306	80.3	4.5
$Q_{200} = 582\ A^{0.66}\ (E_{6000}+1)^{-0.537}$	.013	.088	.316	83.8	4.9
$Q_{500} = 1{,}060\ A^{0.636}\ (E_{6000}+1)^{-0.611}$	.014	.097	.334	89.9	5.3

Table 7. Regression equations based on active-channel width (W_{ac})

[Abbreviations: n, number of stations used in the regression analysis; Q_T, annual peak discharge, in cubic feet per second, for recurrence interval *T*, in years; W_{ac}, width of active channel, in feet; *SEP*, standard error of prediction; *EYR*, equivalent years of record. Symbol: --, not applicable]

Regression Equation	Error Variance, log units			Average *SEP*, in log units	Average *SEP*, in percent	EYR
	Average sampling	Model	Measurement			
West Region (n = 93)						
$Q_2 = 1.11\ W_{ac}^{1.74}$	0.0013	0.040	0.023	0.252	63.5	1.3
$Q_5 = 2.46\ W_{ac}^{1.63}$	.0013	.038	.020	.244	61.1	1.8
$Q_{10} = 3.75\ W_{ac}^{1.58}$	.0015	.040	.018	.245	61.4	2.2
$Q_{25} = 5.81\ W_{ac}^{1.51}$	.0017	.045	.017	.252	63.4	2.8
$Q_{50} = 7.61\ W_{ac}^{1.48}$	.0019	.050	.016	.261	66.2	3.0
$Q_{100} = 9.57\ W_{ac}^{1.45}$	.0022	.056	.016	.272	69.6	3.2
$Q_{200} = 11.8\ W_{ac}^{1.43}$	.0024	.064	.015	.286	73.8	3.3
$Q_{500} = 15.0\ W_{ac}^{1.41}$	.0028	.075	.015	.304	79.8	3.3
Northwest Region (n = 29)						
$Q_2 = 1.57\ W_{ac}^{1.67}$	.004	.076	.021	.318	84.3	--
$Q_5 = 5.04\ W_{ac}^{1.50}$	.004	.066	.017	.294	76.4	--
$Q_{10} = 9.68\ W_{ac}^{1.40}$	.004	.069	.015	.297	77.3	--
$Q_{25} = 21.3\ W_{ac}^{1.30}$	.004	.075	.012	.302	79.1	--
$Q_{50} = 36.1\ W_{ac}^{1.24}$	.005	.081	.011	.312	82.3	--
$Q_{100} = 60.0\ W_{ac}^{1.19}$	.005	.089	.011	.325	86.7	--
$Q_{200} = 92.7\ W_{ac}^{1.16}$	.006	.100	.010	.342	92.9	--
$Q_{500} = 164\ W_{ac}^{1.12}$	.007	.120	.009	.370	103.4	--
Northwest Foothills Region (n = 22)						
$Q_2 = 5.79\ W_{ac}^{1.23}$	.017	.115	.011	.378	106.6	2.7
$Q_5 = 25.6\ W_{ac}^{1.09}$	.015	.084	.009	.328	87.8	5.1
$Q_{10} = 54.6\ W_{ac}^{1.03}$	.016	.085	.008	.329	88.3	6.8
$Q_{25} = 119\ W_{ac}^{0.969}$	.019	.095	.007	.349	95.3	8.4
$Q_{50} = 194\ W_{ac}^{0.94}$	.022	.108	.007	.371	103.7	9.2
$Q_{100} = 297\ W_{ac}^{0.919}$	.026	.124	.006	.395	113.6	9.6
$Q_{200} = 434\ W_{ac}^{0.905}$	.029	.141	.006	.420	124.9	9.9
$Q_{500} = 682\ W_{ac}^{0.892}$	.035	.166	.006	.454	141.3	10.1
Northeast Plains Region (n = 44)						
$Q_2 = 4.71\ W_{ac}^{1.36}$	.009	.177	.014	.447	137.5	1.8
$Q_5 = 16.2\ W_{ac}^{1.32}$	.008	.139	.013	.399	115.4	2.7
$Q_{10} = 30.3\ W_{ac}^{1.29}$	.008	.128	.012	.385	109.7	3.8
$Q_{25} = 57.1\ W_{ac}^{1.26}$	.008	.126	.012	.383	108.6	5.1
$Q_{50} = 83.8\ W_{ac}^{1.24}$	.009	.130	.012	.388	110.9	6.0
$Q_{100} = 116\ W_{ac}^{1.23}$	.010	.137	.011	.397	114.6	6.7
$Q_{200} = 156\ W_{ac}^{1.22}$	.011	.145	.011	.409	119.6	7.2
$Q_{500} = 217\ W_{ac}^{1.20}$	.012	.161	.011	.428	128.6	7.6

Table 7. Regression equations based on active-channel width (W_{ac}) (Continued)

Regression Equation	Error Variance, log units			Average *SEP*, in log units	Average *SEP*, in percent	EYR
	Average sampling	Model	Measurement			
East-Central Plains Region (n = 77)						
$Q_2 = 8.26\ W_{ac}^{1.17}$	.007	.149	.010	.408	119.3	2.6
$Q_5 = 31.4\ W_{ac}^{1.14}$	.006	.106	.010	.349	95.4	4.3
$Q_{10} = 61.4\ W_{ac}^{1.12}$	.006	.097	.009	.335	90.2	6.1
$Q_{25} = 120\ W_{ac}^{1.10}$	.006	.099	.009	.338	91.4	8.1
$Q_{50} = 181\ W_{ac}^{1.09}$	.007	.107	.009	.350	95.8	9.0
$Q_{100} = 259\ W_{ac}^{1.08}$	.008	.118	.009	.367	102.3	9.6
$Q_{200} = 355\ W_{ac}^{1.07}$	.008	.133	.009	.387	110.5	9.8
$Q_{500} = 515\ W_{ac}^{1.06}$	.010	.157	.008	.418	123.7	9.8
Southeast Plains Region (n = 60)						
$Q_2 = 4.24\ W_{ac}^{1.47}$	.004	.090	.016	.333	90.9	2.8
$Q_5 = 15.4\ W_{ac}^{1.34}$	.004	.061	.013	.279	72.7	5.3
$Q_{10} = 30.2\ W_{ac}^{1.26}$	.004	.054	.012	.263	67.5	8.0
$Q_{25} = 60.5\ W_{ac}^{1.18}$	.004	.053	.010	.260	66.5	11.0
$Q_{50} = 93.2\ W_{ac}^{1.14}$	.004	.058	.010	.269	69.4	12.2
$Q_{100} = 136\ W_{ac}^{1.09}$	.005	.067	.009	.284	74.3	12.6
$Q_{200} = 192\ W_{ac}^{1.05}$	.006	.079	.008	.304	80.8	12.5
$Q_{500} = 291\ W_{ac}^{1.00}$	.007	.099	.007	.336	92.2	11.8
Upper Yellowstone-Central Mountain Region (n = 85)						
$Q_2 = 2.44\ W_{ac}^{1.52}$	.003	.058	.017	.279	71.6	2.7
$Q_5 = 10.1\ W_{ac}^{1.29}$	.003	.056	.012	.267	67.8	4.1
$Q_{10} = 21.3\ W_{ac}^{1.18}$	.003	.061	.010	.273	69.7	5.1
$Q_{25} = 45.9\ W_{ac}^{1.06}$	.004	.073	.008	.291	75.3	6.2
$Q_{50} = 75.1\ W_{ac}^{0.979}$	.004	.085	.007	.310	81.6	6.6
$Q_{100} = 115\ W_{ac}^{0.914}$	.005	.098	.006	.330	88.7	6.8
$Q_{200} = 170\ W_{ac}^{0.855}$	.006	.114	.005	.353	97.1	7.0
$Q_{500} = 271\ W_{ac}^{0.787}$	.007	.137	.005	.385	109.5	7.0
Southwest Region (n = 43)						
$Q_2 = 1.21\ W_{ac}^{1.67}$	.003	.035	.021	.242	60.5	2.5
$Q_5 = 4.62\ W_{ac}^{141}$	.003	.036	.015	.231	57.2	3.5
$Q_{10} = 8.94\ W_{ac}^{1.29}$	.004	.047	.012	.250	62.8	3.6
$Q_{25} = 17.9\ W_{ac}^{1.17}$	.005	.066	.010	.284	73.2	3.6
$Q_{50} = 27.9\ W_{ac}^{1.09}$	.006	.082	.009	.311	82.1	3.6
$Q_{100} = 41.8\ W_{ac}^{1.02}$	.007	.099	.008	.338	91.3	3.6
$Q_{200} = 60.3\ W_{ac}^{0.951}$	.008	.117	.007	.364	101.0	3.5
$Q_{500} = 93.2\ W_{ac}^{0.875}$	.010	.143	.006	.398	114.9	3.5

Table 8. Regression equations based on bankfull width (W_{bf})

[Abbreviations: n, number of stations used in the regression analysis; Q_T, annual peak discharge, in cubic feet per second, for recurrence interval *T*, in years; W_{bf}, width of bankfull channel, in feet; *SEP*, standard error of prediction; *EYR*, equivalent years of record. Symbol: --, not applicable]

Regression Equation	Error Variance, log units			Average *SEP*, in log units	Average *SEP*, in percent	EYR
	Average sampling	Model	Measurement			
		West Region (n = 90)				
$Q_2 = 0.281\ W_{bf}^{1.98}$	0.001	0.040	0.038	0.281	72.3	1.3
$Q_5 = 0.678\ W_{bf}^{1.86}$	.001	.036	.033	.266	67.5	1.9
$Q_{10} = 1.08\ W_{bf}^{1.79}$	.001	.037	.031	.263	66.6	2.4
$Q_{25} = 1.75\ W_{bf}^{1.72}$	.002	.040	.029	.266	67.5	3.1
$Q_{50} = 2.34\ W_{bf}^{1.69}$	.002	.045	.028	.272	69.5	3.4
$Q_{100} = 2.99\ W_{bf}^{1.66}$	.002	.050	.027	.281	72.3	3.5
$Q_{200} = 3.72\ W_{bf}^{1.64}$	.002	.058	.026	.293	76.1	3.6
$Q_{500} = 4.82\ W_{bf}^{1.61}$	.003	.068	.025	.310	81.7	3.6
		Northwest Region (n = 29)				
$Q_2 = 0.527\ W_{bf}^{1.82}$	.005	.084	.032	.348	95.1	--
$Q_5 = 1.93\ W_{bf}^{1.63}$	.004	.075	.026	.324	86.6	--
$Q_{10} = 4.00\ W_{bf}^{1.52}$	.005	.080	.022	.326	87.3	--
$Q_{25} = 9.46\ W_{bf}^{1.40}$	.005	.084	.019	.329	88.0	--
$Q_{50} = 16.6\ W_{bf}^{1.34}$	.005	.089	.018	.334	90.1	--
$Q_{100} = 28.4\ W_{bf}^{1.29}$	.006	.097	.016	.345	94.1	--
$Q_{200} = 45.0\ W_{bf}^{1.26}$	.006	.108	.015	.360	99.6	--
$Q_{500} = 81.6\ W_{bf}^{1.21}$	.007	.127	.014	.386	109.9	--
		Northwest Foothills Region (n = 22)				
$Q_2 = 1.68\ W_{bf}^{1.38}$	.019	.138	.019	.419	124.3	2.2
$Q_5 = 8.91\ W_{bf}^{1.21}$	.017	.109	.014	.374	105.2	4.0
$Q_{10} = 20.4\ W_{bf}^{1.14}$	.019	.106	.013	.370	103.6	5.5
$Q_{25} = 47.5\ W_{bf}^{1.08}$	.021	.112	.011	.380	107.4	7.3
$Q_{50} = 79.4\ W_{bf}^{1.04}$	.024	.122	.011	.395	113.6	8.2
$Q_{100} = 124\ W_{bf}^{1.02}$	.027	.134	.010	.414	121.9	8.9
$Q_{200} = 183\ W_{bf}^{1.01}$	.030	.149	.010	.435	131.6	9.4
$Q_{500} = 288\ W_{bf}^{1.00}$	.035	.170	.010	.464	146.1	9.8
		Northeast Plains Region (n = 39)				
$Q_2 = 1.07\ W_{bf}^{1.62}$	.009	.158	.026	.439	133.8	2.0
$Q_5 = 4.31\ W_{bf}^{1.52}$	.009	.139	.022	.413	121.4	2.6
$Q_{10} = 8.91\ W_{bf}^{1.46}$	.009	.139	.021	.411	120.5	3.4
$Q_{25} = 18.9\ W_{bf}^{1.38}$	.010	.147	.019	.419	124.1	4.4
$Q_{50} = 30.3\ W_{bf}^{1.34}$	.011	.157	.017	.430	129.3	4.9
$Q_{100} = 45.6\ W_{bf}^{1.30}$	.012	.168	.016	.443	135.6	5.4
$Q_{200} = 65.8\ W_{bf}^{1.26}$	.013	.181	.015	.458	143.0	5.7
$Q_{500} = 101\ W_{bf}^{1.21}$	.015	.202	.014	.481	155.5	6.0

Table 8. Regression equations based on bankfull width (W_{bf}) (Continued)

Regression Equation	Error Variance, log units			Average *SEP*, in log units	Average *SEP*, in percent	EYR
	Average sampling	Model	Measurement			
East-Central Plains Region (n = 77)						
$Q_2 = 2.19\ W_{bf}^{1.37}$	.006	.126	.018	.387	110.4	3.1
$Q_5 = 8.91\ W_{bf}^{1.32}$	.005	.090	.017	.335	90.2	5.1
$Q_{10} = 18.3\ W_{bf}^{1.29}$	.005	.085	.016	.326	87.2	7.0
$Q_{25} = 37.9\ W_{bf}^{1.25}$	.006	.091	.015	.335	90.5	8.7
$Q_{50} = 59.4\ W_{bf}^{1.23}$	.007	.102	.015	.351	96.3	9.4
$Q_{100} = 88.3\ W_{bf}^{1.20}$	.008	.116	.014	.371	104.0	9.8
$Q_{200} = 126\ W_{bf}^{1.18}$	.008	.133	.014	.394	113.3	9.8
$Q_{500} = 191\ W_{bf}^{1.15}$	.010	.160	.013	.427	127.8	9.6
Southeast-Plains Region (n = 61)						
$Q_2 = 1.97\ W_{bf}^{1.38}$	.007	.176	.018	.449	138.6	1.5
$Q_5 = 6.42\ W_{bf}^{1.32}$	.006	.116	.017	.372	104.2	2.9
$Q_{10} = 11.8\ W_{bf}^{1.29}$	.005	.093	.016	.337	91.2	4.8
$Q_{25} = 22.9\ W_{bf}^{1.25}$	.005	.078	.015	.313	82.7	7.7
$Q_{50} = 35.3\ W_{bf}^{1.22}$	.005	.077	.014	.310	81.6	9.6
$Q_{100} = 52.2\ W_{bf}^{1.18}$	.006	.081	.014	.316	83.6	10.8
$Q_{200} = 74.7\ W_{bf}^{1.15}$	.006	.089	.013	.329	88.2	11.3
$Q_{500} = 115\ W_{bf}^{1.10}$	.007	.107	.012	.356	97.9	11.1
Upper Yellowstone-Central Mountain Region (n = 82)						
$Q_2 = 0.610\ W_{bf}^{1.78}$	.003	.059	.031	.303	79.4	2.5
$Q_5 = 2.97\ W_{bf}^{1.52}$	.003	.054	.022	.281	72.3	4.0
$Q_{10} = 6.78\ W_{bf}^{1.39}$	.003	.059	.019	.284	73.1	5.0
$Q_{25} = 15.8\ W_{bf}^{1.25}$	.004	.071	.015	.300	78.4	5.9
$Q_{50} = 27.5\ W_{bf}^{1.17}$	.004	.084	.013	.319	84.7	6.2
$Q_{100} = 44.4\ W_{bf}^{1.09}$	.005	.099	.012	.340	92.0	6.4
$Q_{200} = 68.7\ W_{bf}^{1.03}$	.006	.116	.010	.362	100.5	6.4
$Q_{500} = 115\ W_{bf}^{0.949}$	.007	.140	.009	.394	113.4	6.4
Southwest Region (n = 42)						
$Q_2 = 0.343\ W_{bf}^{1.89}$	.003	.036	.035	.270	68.8	2.5
$Q_5 = 1.58\ W_{bf}^{1.60}$	.003	.035	.025	.251	63.1	3.5
$Q_{10} = 3.36\ W_{bf}^{1.46}$	.004	.046	.021	.265	67.4	3.7
$Q_{25} = 7.39\ W_{bf}^{1.32}$	.005	.065	.017	.295	76.7	3.7
$Q_{50} = 12.2\ W_{bf}^{1.23}$	.006	.082	.015	.320	85.1	3.6
$Q_{100} = 19.3\ W_{bf}^{1.15}$	.007	.099	.013	.345	94.1	3.6
$Q_{200} = 29.3\ W_{bf}^{1.08}$	.008	.118	.011	.370	103.6	3.5
$Q_{500} = 48.1\ W_{bf}^{0.988}$	.010	.144	.009	.404	117.5	3.5

Table 12. Weights and average standard errors of prediction for various combinations of estimation methods

[Abbreviations: *SEP*, standard error of prediction; Q_T, annual peak discharges with recurrence interval *T*, in years; W_{ac}, width of active channel, in feet; W_{bf}, width of bankfull channel, in feet]

Combinations of methods of estimation	Weights and weighted *SEP* for specified annual peak discharge and region							
	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}
West Region								
Basin-characteristics method	0.55	0.57	0.59	0.62	0.65	0.68	0.70	0.72
Active-channel width (W_{ac}) method	.45	.43	.41	.37	.32	.29	.27	.28
Bankfull-width (W_{bf}) method	0	0	0	0	.02	.03	.03	0
Average weighted *SEP* (log units)	.202	.194	.195	.203	.212	.223	.239	.260
Average weighted *SEP* (percent)	49.2	47.1	47.3	49.5	52.0	55.0	59.6	65.8
Basin-characteristics method	.55	.57	.59	.62	.65	.68	.70	.72
Active-channel width (W_{ac}) method	.45	.43	.41	.38	.35	.32	.30	.28
Average weighted *SEP* (log units)	.202	.194	.195	.203	.212	.223	.239	.26
Average weighted *SEP* (percent)	49.2	47.1	47.3	49.5	52.0	55.0	59.6	65.8
Basin-characteristics method	.64	.63	.64	.67	.69	.71	.73	.74
Bankfull-width (W_{bf}) method	.36	.37	.36	.33	.31	.29	.27	.26
Average weighted *SEP* (log units)	.210	.199	.200	.206	.214	.225	.240	.261
Average weighted *SEP* (percent)	51.4	48.4	48.7	50.3	52.5	55.6	59.9	66.1
Active-channel width (W_{ac}) method	.98	.92	.9	.89	.86	.84	.79	.79
Bankfull-width (W_{bf}) method	.02	.08	.10	.11	.14	.16	.21	.21
Average weighted *SEP* (log units)	.252	.244	.245	.252	.261	.272	.285	.304
Average weighted *SEP* (percent)	63.4	61.0	61.3	63.4	66.1	69.4	73.5	79.7
Northwest Region								
Basin-characteristics method	.90	.95	.99	1	1	1	1	1
Active-channel width (W_{ac}) method	.10	.05	.01	0	0	0	0	0
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.200	.163	.161	.161	.157	.168	.190	.230
Average weighted *SEP* (percent)	48.7	39.0	38.4	38.4	37.4	40.2	46.0	57.0
Basin-characteristics method	.90	.95	.99	1	1	1	1	1
Active-channel width (W_{ac}) method	.10	.05	.01	0	0	0	0	0
Average weighted *SEP* (log units)	.200	.163	.161	.161	.157	.168	.190	.230
Average weighted *SEP* (percent)	48.7	39.0	38.4	38.4	37.4	40.2	46.0	57.0
Basin-characteristics method	.97	1	1	1	1	1	1	1
Bankfull-width (W_{bf}) method	.03	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.202	.164	.161	.161	.157	.168	.190	.230
Average weighted *SEP* (percent)	49.2	39.2	38.4	38.4	37.4	40.2	46.0	57.0
Active-channel width (W_{ac}) method	1	1	1	1	1	1	1	1
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.318	.294	.297	.302	.312	.325	.342	.370
Average weighted *SEP* (percent)	84.4	76.4	77.4	79.0	82.3	86.8	92.9	103.5

Table 12. Weights and average standard errors of prediction for various combinations of estimation methods (Continued)

Combinations of methods of estimation	Weights and weighted *SEP* for specified annual peak discharge and region							
	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}
Northwest Foothills Region								
Basin-characteristics method	.57	.86	1	1	1	1	1	1
Active-channel width (W_{ac}) method	.43	.14	0	0	0	0	0	0
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.334	.236	.210	.208	.223	.244	.268	.302
Average weighted *SEP* (percent)	90.0	58.7	51.4	50.9	55.0	61.0	68.2	79.0
Basin-characteristics method	.57	.86	1	1	1	1	1	1
Active-channel width (W_{ac}) method	.43	.14	0	0	0	0	0	0
Average weighted *SEP*	.334	.236	.210	.208	.223	.244	.268	.302
Average weighted *SEP* (percent)	90.0	58.7	51.4	50.9	55.0	61.0	68.2	79.0
Basin-characteristics method	.67	.91	1	1	1	1	1	1
Bankfull-width (W_{bf}) method	.33	.09	0	0	0	0	0	0
Average weighted *SEP* (log units)	.339	.237	.210	.208	.223	.244	.268	.302
Average weighted *SEP* (percent)	91.8	59.0	51.4	50.9	55.0	61.0	68.2	79.0
Active-channel width (W_{ac}) method	1	1	1	1	1	1	1	1
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.378	.328	.329	.348	.370	.395	.420	.454
Average weighted *SEP* (percent)	106.7	87.9	88.2	95.1	103.5	113.7	124.7	141.2
Northeast Plains Region								
Basin-characteristics method	1	1	.97	.89	.83	.77	.70	.61
Active-channel width (W_{ac}) method	0	0	.03	.11	.17	.23	.30	.39
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.337	.306	.309	.325	.343	.362	.381	.410
Average weighted *SEP* (percent)	91.1	80.3	81.3	86.8	93.2	100.4	107.9	120.2
Basin-characteristics method	1	1	.97	.89	.83	.77	.7	.61
Active-channel width (W_{ac}) method	0	0	.03	.11	.17	.23	.30	.39
Average weighted *SEP* (log units)	.337	.306	.309	.325	.343	.362	.381	.410
Average weighted *SEP* (percent)	91.1	80.3	81.3	86.8	93.2	100.4	107.9	120.2
Basin-characteristics method	1	1	1	1	1	1	1	1
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.337	.306	.309	.326	.345	.365	.386	.417
Average weighted *SEP* (percent)	91.1	80.3	81.3	87.2	94.0	101.5	109.9	123.3
Active-channel width (W_{ac}) method	.33	.83	1	1	1	1	1	1
Bankfull-width (W_{bf}) method	.67	.17	0	0	0	0	0	0
Average weighted *SEP* (log units)	.436	.398	.385	.383	.388	.397	.408	.428
Average weighted *SEP* (percent)	132.2	115.0	109.5	108.7	110.8	114.5	119.3	128.4

Table 12. Weights and average standard errors of prediction for various combinations of estimation methods (Continued)

Combinations of methods of estimation	Weights and weighted *SEP* for specified annual peak discharge and region							
	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}
East-Central Plains Region								
Basin-characteristics method	.67	.75	.80	.85	.87	.89	.90	.93
Active-channel width (W_{ac}) method	0	0	.02	.10	.13	.11	.10	.07
Bankfull-width (W_{bf}) method	.33	.25	.18	.05	0	0	0	0
Average weighted *SEP* (log units)	.353	.287	.270	.283	.300	.321	.345	.381
Average weighted *SEP* (percent)	97.0	74.1	68.8	72.9	78.3	85.4	94.0	107.8
Basin-characteristics method	.80	.82	.84	.86	.87	.89	.90	.93
Active-channel width (W_{ac}) method	.20	.18	.16	.14	.13	.11	.10	.07
Average weighted *SEP* (log units)	.357	.290	.276	.283	.300	.321	.345	.381
Average weighted *SEP* (percent)	98.5	75.1	70.7	72.9	78.3	85.4	94.0	107.8
Basin-characteristics method	.67	.75	.80	.86	.91	.96	1	1
Bankfull-width (W_{bf}) method	.33	.25	.20	.14	.09	.04	0	0
Average weighted *SEP* (log units)	.353	.287	.275	.284	.300	.322	.346	.381
Average weighted *SEP* (percent)	97.0	74.1	70.4	73.2	78.3	85.8	94.3	107.8
Active-channel width (W_{ac}) method	.13	.24	.33	.44	.52	.61	.71	.80
Bankfull-width (W_{bf}) method	.87	.76	.67	.56	.48	.39	.29	.20
Average weighted *SEP* (log units)	.386	.333	.323	.331	.345	.364	.386	.417
Average weighted *SEP* (percent)	109.9	89.6	86.1	88.9	94.0	101.1	109.9	123.3
Southeast Plains Region								
Basin-characteristics method	.21	.18	.11	.01	0	0	0	0
Active-channel width (W_{ac}) method	.79	.77	.77	.79	.77	.75	.73	.72
Bankfull-width (W_{bf}) method	0	.05	.12	.20	.23	.25	.27	.28
Average weighted *SEP* (log units)	.322	.271	.255	.250	.264	.28	.300	.332
Average weighted *SEP* (percent)	85.8	69.1	64.3	62.8	67.0	71.9	78.3	89.3
Basin-characteristics method	.22	.20	.17	.12	.09	.07	.04	.03
Active-channel width (W_{ac}) method	.78	.80	.83	.88	.91	.93	.96	.97
Average weighted *SEP* (log units)	.322	.271	.259	.257	.268	.284	.304	.336
Average weighted *SEP* (percent)	85.8	69.1	65.5	64.9	68.2	73.2	79.7	90.7
Basin-characteristics method	.53	.50	.45	.38	.33	.30	.27	.26
Bankfull-width (W_{bf}) method	.47	.50	.55	.62	.67	.70	.73	.74
Average weighted *SEP* (log units)	.410	.342	.316	.301	.303	.311	.325	.353
Average weighted *SEP* (percent)	120.2	92.9	83.7	78.7	79.3	82.0	86.8	97.0
Active-channel width (W_{ac}) method	.9	.85	.82	.79	.77	.75	.73	.72
Bankfull-width (W_{bf}) method	.10	.15	.18	.21	.23	.25	.27	.28
Average weighted *SEP* (log units)	.331	.275	.259	.255	.264	.280	.300	.332
Average weighted *SEP* (percent)	88.9	70.4	65.5	64.3	67.0	71.9	78.3	89.3

Table 12. Weights and average standard errors of prediction for various combinations of estimation methods (Continued)

Combinations of methods of estimation	Weights and weighted *SEP* for specified annual peak discharge and region							
	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}
Upper Yellowstone-Central Mountain Region								
Basin-characteristics method	.28	.45	.57	.73	.83	.92	.98	1
Active-channel width (W_{ac}) method	.50	.35	.26	.17	.10	.08	.02	0
Bankfull-width (W_{bf}) method	.22	.20	.170	.10	.06	0	0	0
Average weighted *SEP* (log units)	.258	.227	.218	.216	.221	.228	.239	.258
Average weighted *SEP* (percent)	65.2	56.1	53.6	53.1	54.5	56.4	59.6	65.2
Basin-characteristics method	.28	.45	.57	.73	.83	.92	.98	1
Active-channel width (W_{ac}) method	.72	.55	.43	.27	.17	.08	.02	0
Average weighted *SEP* (log units)	.264	.232	.222	.218	.222	.228	.239	.258
Average weighted *SEP* (percent)	67.0	57.6	54.7	53.6	54.7	56.4	59.6	65.2
Basin-characteristics method	.38	.50	.60	.74	.84	.93	1	1
Bankfull-width (W_{bf}) method	.62	.50	.40	.26	.16	.07	0	0
Average weighted *SEP* (log units)	.272	.234	.223	.219	.222	.228	.239	.258
Average weighted *SEP* (percent)	69.4	58.1	55.0	53.9	54.7	56.4	59.6	65.2
Active-channel width (W_{ac}) method	.76	.75	.79	.89	.96	1	1	1
Bankfull-width (W_{bf}) method	.24	.25	.21	.11	.04	0	0	0
Average weighted *SEP* (log units)	.276	.265	.272	.290	.310	.330	.353	.385
Average weighted *SEP* (percent)	70.7	67.3	69.4	75.1	81.7	88.6	97.0	109.5
Southwest Region								
Basin-characteristics method	.31	.34	.40	.48	.54	.59	.64	.68
Active-channel width (W_{ac}) method	.69	.66	.60	.52	.46	.41	.36	.32
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.206	.196	.212	.237	.255	.274	.290	.314
Average weighted *SEP* (percent)	50.3	47.6	52.0	59.0	64.3	70.1	75.1	83.0
Basin-characteristics method	.31	.34	.40	.48	.54	.59	.64	.68
Active-channel width (W_{ac}) method	.69	.66	.60	.52	.46	.41	.36	.32
Average weighted *SEP* (log units)	.206	.197	.212	.237	.255	.274	.290	.314
Average weighted *SEP* (percent)	50.3	47.9	52.0	59.0	64.3	70.1	75.1	83.0
Basin-characteristics method	.34	.38	.43	.51	.57	.61	.66	.7
Bankfull-width (W_{bf}) method	.66	.62	.57	.49	.43	.39	.34	.3
Average weighted *SEP* (log units)	.235	.216	.225	.245	.261	.277	.293	.316
Average weighted *SEP* (percent)	58.4	53.1	55.6	61.3	66.1	71.0	76.1	83.7
Active-channel width (W_{ac}) method	1	1	1	1	1	1	1	1
Bankfull-width (W_{bf}) method	0	0	0	0	0	0	0	0
Average weighted *SEP* (log units)	.242	.230	.250	.284	.311	.338	.363	.398
Average weighted *SEP* (percent)	60.4	57.0	62.8	73.2	82.0	91.4	100.8	115.0

Table 14. $(X^TX)^{-1}$ and $(X^T\Lambda^{-1}X)^{-1}$ matrices for regression equations based on basin characteristics

[All matrices are $(X^T\Lambda^{-1}X)^{-1}$ matrices, except those for the Northwest Region, which are all $(X^TX)^{-1}$ matrices with the same values. Abbreviation: Q_T, flood magnitude, in cubic feet per second, for recurrence interval *T*, in years]

T-year flood	West Region				Northwest Region			Northwest Foothills Region		Northeast Plains Region		
Q_2	0.16207	-0.00105	-0.01607	-0.06996	2.06281	-0.11031	-1.12493	0.01640	-0.00759	0.06930	-0.00318	-0.12511
	-0.00105	0.00103	0.00126	-0.00138	-0.11031	0.04120	0.01711	-0.00759	0.00800	-0.00318	0.00186	0.00009
	-0.01607	0.00126	0.02164	-0.01052	-1.12493	0.01711	0.67567			-0.12511	0.00009	0.25768
	-0.06996	-0.00138	-0.01052	0.04637								
Q_5	0.14811	-0.00091	-0.01505	-0.06358	2.06281	-0.11031	-1.12493	0.01170	-0.00481	0.06220	-0.00268	-0.11322
	-0.00091	0.00092	0.00117	-0.00131	-0.11031	0.04120	0.01711	-0.00481	0.00429	-0.00268	0.00166	-0.00040
	-0.01505	0.00117	0.01931	-0.00910	-1.12493	0.01711	0.67567			-0.11322	-0.00040	0.23591
	-0.06358	-0.00131	-0.00910	0.04181								
Q_{10}	0.15233	-0.00087	-0.01582	-0.06510	2.06281	-0.11031	-1.12493	0.01190	-0.00469	0.06790	-0.00280	-0.12422
	-0.00087	0.00093	0.00121	-0.00138	-0.11031	0.04120	0.01711	-0.00469	0.00391	-0.00280	0.00179	-0.00066
	-0.01582	0.00121	0.01946	-0.00887	-1.12493	0.01711	0.67567			-0.12422	-0.00066	0.25995
	-0.06510	-0.00138	-0.00887	0.04248								
Q_{25}	0.16521	-0.00086	-0.01762	-0.07024	2.06281	-0.11031	-1.12493	0.01390	-0.00546	0.08060	-0.00319	-0.14823
	-0.00086	0.00099	0.00130	-0.00153	-0.11031	0.04120	0.01711	-0.00546	0.00449	-0.00319	0.00209	-0.00098
	-0.01762	0.00130	0.02064	-0.00902	-1.12493	0.01711	0.67567			-0.14823	-0.00098	0.31106
	-0.07024	-0.00153	-0.00902	0.04541								
Q_{50}	0.17994	-0.00088	-0.01948	-0.07627	2.06281	-0.11031	-1.12493	0.01620	-0.00650	0.09260	-0.00358	-0.17079
	-0.00088	0.00106	0.00141	-0.00168	-0.11031	0.04120	0.01711	-0.00650	0.00541	-0.00358	0.00238	-0.00123
	-0.01948	0.00141	0.02222	-0.00946	-1.12493	0.01711	0.67567			-0.17079	-0.00123	0.35884
	-0.07627	-0.00168	-0.00946	0.04906								
Q_{100}	0.19951	-0.00094	-0.02182	-0.08441	2.06281	-0.11031	-1.12493	0.01900	-0.00779	0.10558	-0.00400	-0.19521
	-0.00094	0.00116	0.00156	-0.00187	-0.11031	0.04120	0.01711	-0.00779	0.00659	-0.00400	0.00270	-0.00148
	-0.02182	0.00156	0.02447	-0.01024	-1.12493	0.01711	0.67567			-0.19521	-0.00148	0.41050
	-0.08441	-0.00187	-0.01024	0.05411								
Q_{200}	0.22430	-0.00104	-0.02467	-0.09483	2.06281	-0.11031	-1.12493	0.02220	-0.00926	0.11951	-0.00447	-0.22148
	-0.00104	0.00130	0.00174	-0.00210	-0.11031	0.04120	0.01711	-0.00926	0.00797	-0.00447	0.00305	-0.00173
	-0.02467	0.00174	0.02746	-0.01138	-1.12493	0.01711	0.67567			-0.22148	-0.00173	0.46605
	-0.09483	-0.00210	-0.01138	0.06068								
Q_{500}	0.26154	-0.00119	-0.02888	-0.11055	2.06281	-0.11031	-1.12493	0.02670	-0.01140	0.13971	-0.00515	-0.25961
	-0.00119	0.00151	0.00202	-0.00244	-0.11031	0.04120	0.01711	-0.01140	0.01000	-0.00515	0.00355	-0.00207
	-0.02888	0.00202	0.03203	-0.01319	-1.12493	0.01711	0.67567			-0.25961	-0.00207	0.54664
	-0.11055	-0.00244	-0.01319	0.07068								

Table 14. $(X^TX)^{-1}$ and $(X^T\Lambda^{-1}X)^{-1}$ matrices for regression equations based on basin characteristics (Continued)

T-year flood	East-Central Plains Region			Southeast Plains Region			Upper Yellowstone-Central Mountain Region			Southwest Region		
Q_2	0.10270	0.00235	-0.22639	0.00989	-0.00167	-0.00512	0.01040	-0.00295	-0.00221	0.06750	-0.00643	-0.02920
	0.00235	0.00210	-0.00954	-0.00167	0.00285	-0.00174	-0.00295	0.00258	-0.00131	-0.00643	0.00542	-0.00170
	-0.22639	-0.00954	0.52713	-0.00512	-0.00174	0.00868	-0.00221	-0.00131	0.00337	-0.02920	-0.00170	0.01770
Q_5	0.08220	0.00173	-0.18112	0.00766	-0.00131	-0.00380	0.00892	-0.00226	-0.00207	0.06200	-0.00540	-0.02710
	0.00173	0.00153	-0.00716	-0.00131	0.00214	-0.00135	-0.00226	0.00186	-0.00090	-0.00540	0.00432	-0.00129
	-0.18112	-0.00716	0.42285	-0.00380	-0.00135	0.00668	-0.00207	-0.00090	0.00260	-0.02710	-0.00129	0.01600
Q_{10}	0.08570	0.00174	-0.18930	0.00719	-0.00123	-0.00350	0.00867	-0.00205	-0.00211	0.06640	-0.00533	-0.02930
	0.00174	0.00151	-0.00722	-0.00123	0.00197	-0.00127	-0.00205	0.00162	-0.00077	-0.00533	0.00421	-0.00126
	-0.18930	-0.00722	0.44235	-0.00350	-0.00127	0.00628	-0.00211	-0.00077	0.00239	-0.02930	-0.00126	0.01710
Q_{25}	0.10068	0.00200	-0.22313	0.00722	-0.00124	-0.00346	0.00897	-0.00199	-0.00227	0.07550	-0.00556	-0.03370
	0.00200	0.00171	-0.00827	-0.00124	0.00193	-0.00127	-0.00199	0.00152	-0.00071	-0.00556	0.00438	-0.00136
	-0.22313	-0.00827	0.52167	-0.00346	-0.00127	0.00635	-0.00227	-0.00071	0.00237	-0.03370	-0.00136	0.01950
Q_{50}	0.11661	0.00230	-0.25900	0.00762	-0.00132	-0.00365	0.00958	-0.00206	-0.00247	0.08410	-0.00589	-0.03780
	0.00230	0.00196	-0.00950	-0.00132	0.00203	-0.00135	-0.00206	0.00156	-0.00073	-0.00589	0.00466	-0.00150
	-0.25900	-0.00950	0.60574	-0.00365	-0.00135	0.00675	-0.00247	-0.00073	0.00251	-0.03780	-0.00150	0.02180
Q_{100}	0.13508	0.00266	-0.30059	0.00821	-0.00142	-0.00395	0.01040	-0.00222	-0.00271	0.09350	-0.00631	-0.04220
	0.00266	0.00227	-0.01100	-0.00142	0.00218	-0.00146	-0.00222	0.00168	-0.00080	-0.00631	0.00504	-0.00168
	-0.30059	-0.01100	0.70326	-0.00395	-0.00146	0.00734	-0.00271	-0.00080	0.00273	-0.04220	-0.00168	0.02440
Q_{200}	0.15565	0.00305	-0.34692	0.00899	-0.00156	-0.00435	0.01150	-0.00245	-0.00300	0.10370	-0.00679	-0.04700
	0.00305	0.00262	-0.01260	-0.00156	0.00239	-0.00161	-0.00245	0.00186	-0.00089	-0.00679	0.00548	-0.00188
	-0.34692	-0.01260	0.81197	-0.00435	-0.00161	0.00808	-0.00300	-0.00089	0.00305	-0.04700	-0.00188	0.02710
Q_{500}	0.18546	0.00363	-0.41411	0.01030	-0.00180	-0.00505	0.01330	-0.00285	-0.00344	0.11841	-0.00754	-0.05390
	0.00363	0.00315	-0.01500	-0.00180	0.00275	-0.00185	-0.00285	0.00219	-0.00107	-0.00754	0.00618	-0.00220
	-0.41411	-0.01500	0.96976	-0.00505	-0.00185	0.00935	-0.00344	-0.00107	0.00357	-0.05390	-0.00220	0.03120

Table 15. $(\mathbf{X^TX})^{-1}$ **and** $(\mathbf{X^T\Lambda^{-1}X})^{-1}$ **matrices for regression equations based on active-channel width**

[All matrices are $(\mathbf{X^T\Lambda^{-1}X})^{-1}$ matrices, except those for the Northwest Region, which are all $(\mathbf{X^TX})^{-1}$ matrices. Abbreviation: Q_T, flood magnitude, in cubic feet per second, for recurrence interval *T*, in years]

T-year flood	West Region		Northwest Region		Northwest Foothills Region		Northeast Plains Region	
Q_2	0.00612	-0.00369	0.45988	-0.25297	0.03231	-0.02797	0.02816	-0.02440
	-0.00369	0.00255	-0.25297	0.14896	-0.02797	0.03468	-0.02440	0.02602
Q_5	0.00628	-0.00374	0.45988	-0.25297	0.02876	-0.02369	0.02398	-0.02050
	-0.00374	0.00256	-0.25297	0.14896	-0.02369	0.02805	-0.02050	0.02162
Q_{10}	0.00686	-0.00406	0.45988	-0.25297	0.03178	-0.02582	0.02391	-0.02026
	-0.00406	0.00276	-0.25297	0.14896	-0.02582	0.03010	-0.02026	0.02121
Q_{25}	0.00794	-0.00468	0.45988	-0.25297	0.03833	-0.03105	0.02552	-0.02146
	-0.00468	0.00316	-0.25297	0.14896	-0.03105	0.03596	-0.02146	0.02231
Q_{50}	0.00900	-0.00531	0.45988	-0.25297	0.04455	-0.03622	0.02754	-0.02309
	-0.00531	0.00358	-0.25297	0.14896	-0.03622	0.04198	-0.02309	0.02392
Q_{100}	0.01018	-0.00600	0.45988	-0.25297	0.05148	-0.04207	0.02990	-0.02502
	-0.00600	0.00405	-0.25297	0.14896	-0.04207	0.04888	-0.02502	0.02586
Q_{200}	0.01155	-0.00683	0.45988	-0.25297	0.05893	-0.04841	0.03256	-0.02722
	-0.00683	0.00461	-0.25297	0.14896	-0.04841	0.05644	-0.02722	0.02809
Q_{500}	0.01347	-0.00798	0.45988	-0.25297	0.06929	-0.05731	0.03665	-0.03066
	-0.00798	0.00540	-0.25297	0.14896	-0.05731	0.06710	-0.03066	0.03161

Table 15. $(\mathbf{X^TX})^{-1}$ and $(\mathbf{X^T\Lambda^{-1}X})^{-1}$ matrices for regression equations based on active-channel width (Continued)

T-year flood	East-Central Plains Region		Southeast Plains Region		Upper Yellowstone-Central Mountain Region		Southwest Region	
Q_2	0.01578	-0.01473	0.00932	-0.00761	0.01011	-0.00619	0.01279	-0.00853
	-0.01473	0.01906	-0.00761	0.00863	-0.00619	0.00433	-0.00853	0.00635
Q_5	0.01267	-0.01144	0.00752	-0.00590	0.01078	-0.00650	0.01374	-0.00907
	-0.01144	0.01468	-0.00590	0.00648	-0.00650	0.00448	-0.00907	0.00669
Q_{10}	0.01262	-0.01128	0.00747	-0.00577	0.01228	-0.00738	0.01761	-0.01171
	-0.01128	0.01444	-0.00577	0.00622	-0.00738	0.00506	-0.01171	0.00869
Q_{25}	0.01385	-0.01237	0.00824	-0.00634	0.01489	-0.00895	0.02414	-0.01618
	-0.01237	0.01584	-0.00634	0.00676	-0.00895	0.00614	-0.01618	0.01211
Q_{50}	0.01535	-0.01378	0.00930	-0.00720	0.01733	-0.01045	0.02960	-0.01993
	-0.01378	0.01766	-0.00720	0.00767	-0.01045	0.00718	-0.01993	0.01498
Q_{100}	0.01718	-0.01551	0.01066	-0.00832	0.01996	-0.01206	0.03532	-0.02386
	-0.01551	0.01990	-0.00832	0.00889	-0.01206	0.00831	-0.02386	0.01800
Q_{200}	0.01927	-0.01753	0.01226	-0.00966	0.02287	-0.01386	0.04127	-0.02796
	-0.01753	0.02251	-0.00966	0.01038	-0.01386	0.00957	-0.02796	0.02114
Q_{500}	0.02236	-0.02053	0.01480	-0.01182	0.02702	-0.01643	0.04960	-0.03370
	-0.02053	0.02640	-0.01182	0.01280	-0.01643	0.01140	-0.03370	0.02556

Table 16. $(X^TX)^{-1}$ and $(X^T\Lambda^{-1}X)^{-1}$ matrices for regression equations based on bankfull width

[All matrices are $(X^T\Lambda^{-1}X)^{-1}$ matrices, except those for the Northwest Region, which are all $(X^TX)^{-1}$ matrices. Abbreviation: Q_T, flood magnitude, in cubic feet per second, for recurrence interval *T*, in years]

T-year flood	West Region		Northwest Region		Northwest Foothills Region		Northeast Plains Region	
Q_2	0.00894	-0.00518	0.62160	-0.32516	0.07698	-0.06033	0.05335	-0.04129
	-0.00518	0.00329	-0.32516	0.17881	-0.06033	0.05518	-0.04129	0.03540
Q_5	0.00864	-0.00494	0.62160	-0.32516	0.06811	-0.05195	0.05037	-0.03871
	-0.00494	0.00310	-0.32516	0.17881	-0.05195	0.04659	-0.03871	0.03289
Q_{10}	0.00925	-0.00525	0.62160	-0.32516	0.07206	-0.05425	0.05332	-0.04081
	-0.00525	0.00327	-0.32516	0.17881	-0.05425	0.04815	-0.04081	0.03448
Q_{25}	0.01059	-0.00597	0.62160	-0.32516	0.08224	-0.06136	0.05996	-0.04573
	-0.00597	0.00371	-0.32516	0.17881	-0.06136	0.05404	-0.04573	0.03843
Q_{50}	0.01195	-0.00674	0.62160	-0.32516	0.09273	-0.06906	0.06627	-0.05046
	-0.00674	0.00417	-0.32516	0.17881	-0.06906	0.06069	-0.05046	0.04230
Q_{100}	0.01354	-0.00764	0.62160	-0.32516	0.10483	-0.07808	0.07310	-0.05561
	-0.00764	0.00474	-0.32516	0.17881	-0.07808	0.06860	-0.05561	0.04652
Q_{200}	0.01546	-0.00875	0.62160	-0.32516	0.11812	-0.08810	0.08043	-0.06115
	-0.00875	0.00543	-0.32516	0.17881	-0.08810	0.07746	-0.06115	0.05109
Q_{500}	0.01818	-0.01032	0.62160	-0.32516	0.13686	-0.10233	0.09128	-0.06941
	-0.01032	0.00642	-0.32516	0.17881	-0.10233	0.09013	-0.06941	0.05793

Table 16. $(\mathbf{X^TX})^{-1}$ and $(\mathbf{X^T}\Lambda^{-1}\mathbf{X})^{-1}$ matrices for regression equations based on bankfull width (Continued)

T-year flood	East-Central Plains Region		Southeast Plains Region		Upper Yellowstone-Central Mountain Region		Southwest Region	
Q_2	0.02799	-0.02222	0.02681	-0.02051	0.01628	-0.00961	0.01947	-0.01237
	-0.02222	0.02065	-0.02051	0.01856	-0.00961	0.00616	-0.01237	0.00846
Q_5	0.02254	-0.01752	0.02004	-0.01499	0.01672	-0.00972	0.02064	-0.01299
	-0.01752	0.01613	-0.01499	0.01334	-0.00972	0.00614	-0.01299	0.00881
Q_{10}	0.02307	-0.01786	0.01817	-0.01339	0.01904	-0.01104	0.02643	-0.01673
	-0.01786	0.01641	-0.01339	0.01177	-0.01104	0.00694	-0.01673	0.01139
Q_{25}	0.02634	-0.02047	0.01785	-0.01300	0.02343	-0.01359	0.03638	-0.02319
	-0.02047	0.01881	-0.01300	0.01129	-0.01359	0.00855	-0.02319	0.01590
Q_{50}	0.02992	-0.02336	0.01893	-0.01375	0.02753	-0.01601	0.04480	-0.02867
	-0.02336	0.02149	-0.01375	0.01189	-0.01601	0.01009	-0.02867	0.01973
Q_{100}	0.03410	-0.02675	0.02083	-0.01515	0.03203	-0.01866	0.05368	-0.03445
	-0.02675	0.02463	-0.01515	0.01307	-0.01866	0.01180	-0.03445	0.02378
Q_{200}	0.03881	-0.03057	0.02341	-0.01708	0.03699	-0.02161	0.06294	-0.04049
	-0.03057	0.02817	-0.01708	0.01474	-0.02161	0.01370	-0.04049	0.02800
Q_{500}	0.04568	-0.03618	0.02782	-0.02042	0.04405	-0.02583	0.07593	-0.04898
	-0.03618	0.03336	-0.02042	0.01766	-0.02583	0.01643	-0.04898	0.03396

Prepared in cooperation with the
BUREAU OF INDIAN AFFAIRS, BUREAU OF LAND MANAGEMENT, CONFEDERATED SALISH AND KOOTENAI TRIBES, MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION, MONTANA DEPARTMENT OF TRANSPORTATION, and the U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

Parrett, Charles, and Johnson, D.R., 2003. Methods for estimating flood frequency in Montana based on data through water year 1998

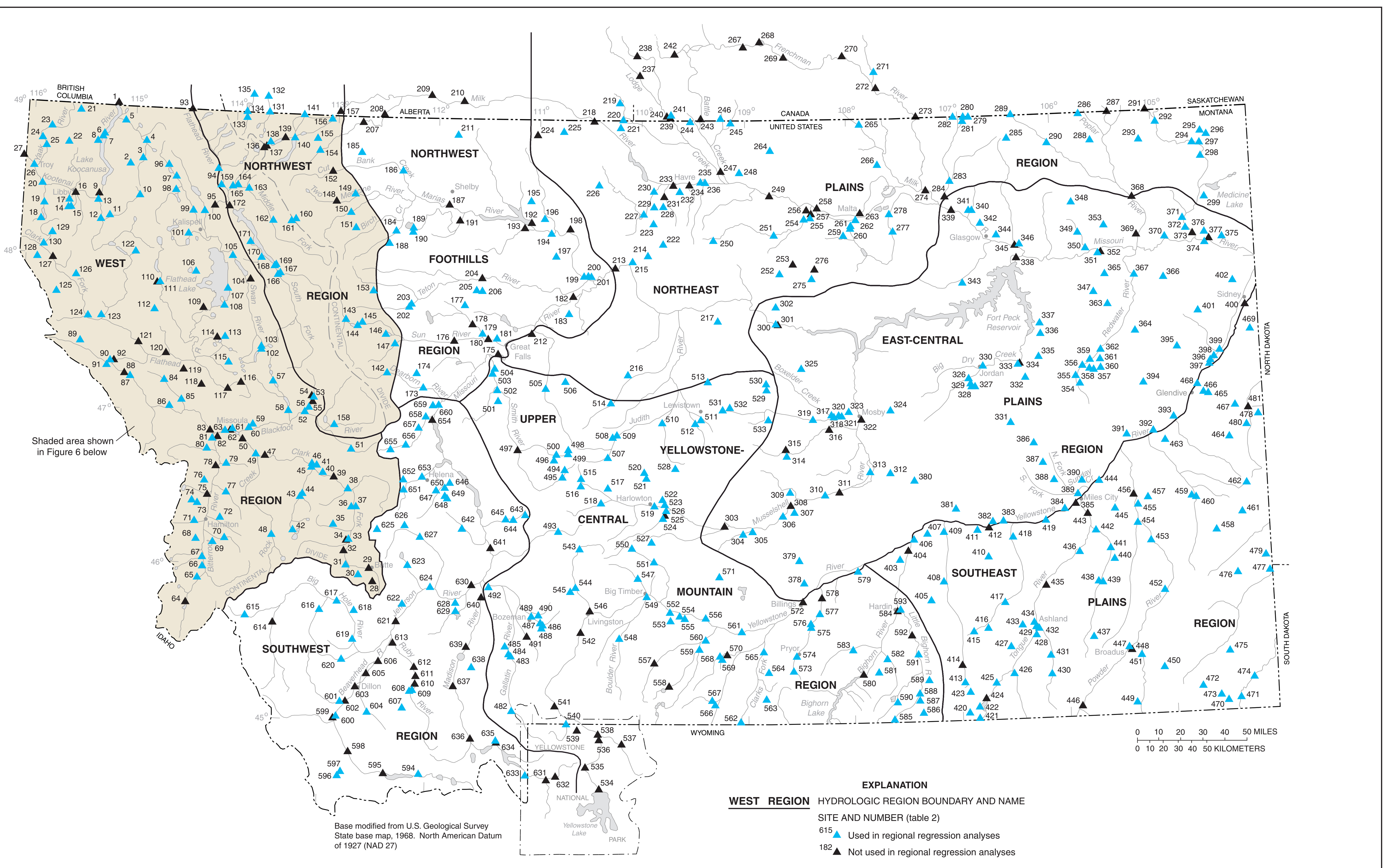


Figure 1. Hydrologic regions and streamflow-gaging stations having compiled flood-frequency characteristics, Montana and adjacent areas in Idaho, Wyoming, and Canada.

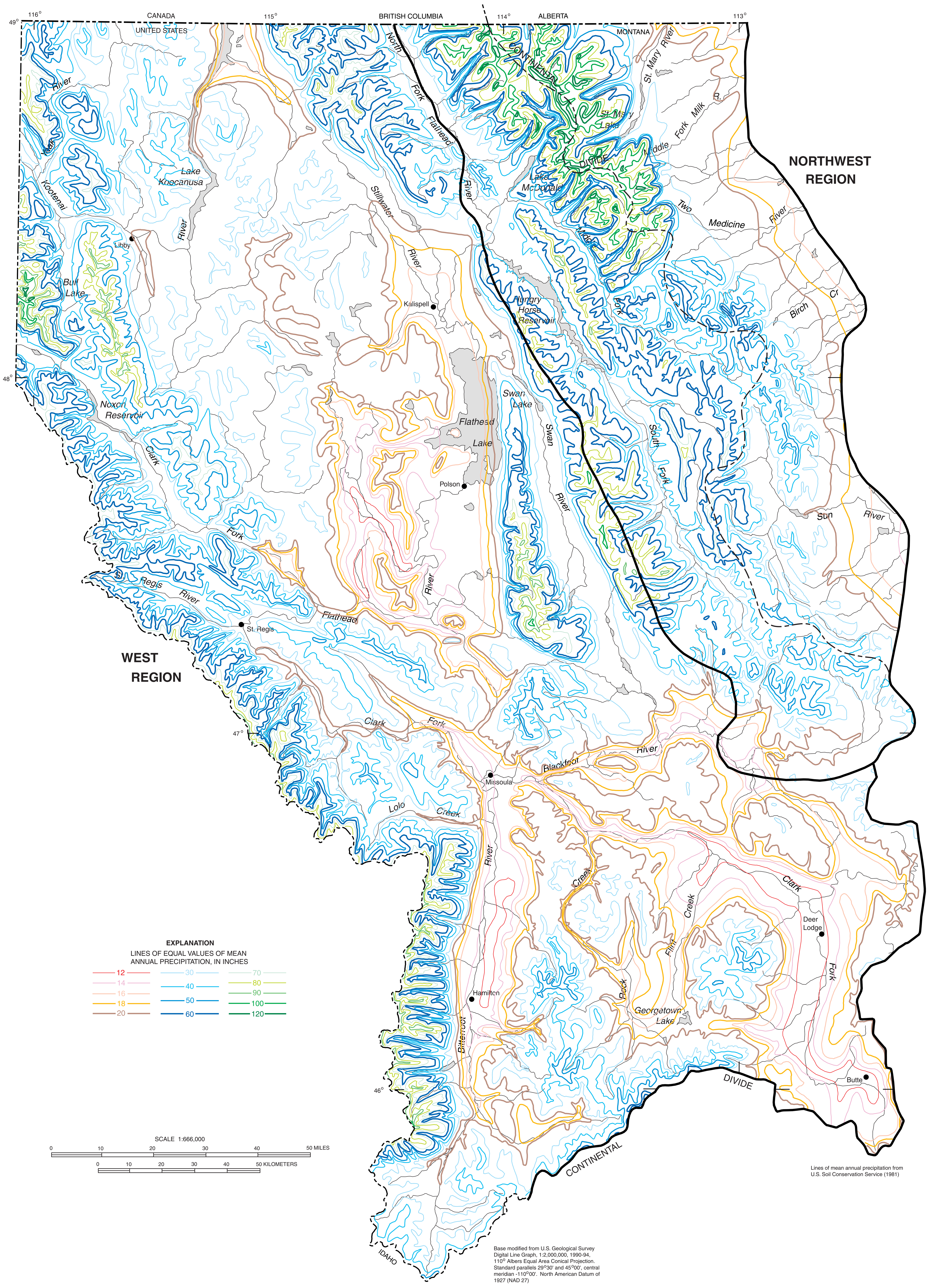


Figure 6. Mean annual precipitation for the West and Northwest Regions, Montana, base period 1941-70.