Prepared in cooperation with the Oregon Water Resources Department

Estimation of Peak Discharges for Rural, Unregulated Streams in Western Oregon

Scientific Investigations Report 2005–5116

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

Front cover: Flooding in January 1943 at West Salem, Oregon. The photograph was taken on Wallace Road near the Willamette River Bridge. (Photograph courtesy of the Salem, Oregon, Public Library Historic Photograph Collections.)

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Gale A. Norton, Secretary

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
gallon (gal)	3.785	cubic decimeter (dm^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
	Flow Rate	
acre-foot per day (acre-ft/d)	0.01427	cubic meter per second (m^3/s)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm^3/yr)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
million gallons per day per square mile [$(Mgal/d)/mi^2$]	1,461	cubic meter per day per square kilometer [$(m^3/d)/km^2$]
foot per day (ft/d)	0.3048	meter per day (m/d)

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).

Estimation of Peak Discharges for Rural, Unregulated Streams in Western Oregon

By Richard M. Cooper, Oregon Water Resources Department

Abstract

Methods for estimating the magnitudes of peak discharges at various frequencies were developed for rural unregulated streams in western Oregon. Development of these methods had two parts: (1) fitting observed peak discharges to a theoretical probability distribution and (2) developing equations to predict the magnitude of peak discharges at various frequencies. In the first part, logarithms of annual peak discharges were fitted to the Pearson Type III probability distribution for each of 376 gaging stations in the study area. For each gaging station, based on its fitted probability distribution, estimates were made of the magnitudes of the peak discharges for recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years. All annual series of peak discharges used in this analysis were from rural, unregulated streams.

In fitting the probability distributions, estimates of station skew were improved by adjustment with a "generalized" skew value based on the skews for long-term stations in the area. The areal distribution of the generalized logarithmic skew coefficients of annual peak discharge for Oregon was determined using geographic information systems (GIS) techniques. The actual areal distribution is a GIS grid but is represented in this report as an isoline map. In practice, generalized logarithmic skew coefficients are determined from the grid, not the isoline map.

Western Oregon was divided into three "flood regions." For each region, prediction equations were developed for estimating peak discharges at ungaged sites for the selected recurrence intervals. The equations relate peak discharge to physical and climatologic watershed characteristics such as drainage area and precipitation intensity. The equations were derived by generalized least-squares regression using data for the 376 gaged watersheds. Average standard error of prediction for the equations ranged from 25.3 to 39.1 percent. The accuracy of the equations and limitations on their use are discussed. Use of the prediction equations in various circumstances is illustrated with examples.

Use of the prediction equations requires estimates of watershed characteristics. Because of the reliance in this analysis on GIS techniques, making appropriate and reliable estimates of watershed characteristics may be inconvenient for many users. To make the prediction equations as widely available as possible, the Oregon Water Resources Department has developed an interactive Web site utility to facilitate the use of the equations:

http://www.wrd.state.or.us/OWRD/SW/peak_flow.shtml

Introduction

A study of the magnitude and frequency of peak discharges in western Oregon has been completed by the Oregon Water Resources Department with financial assistance from the Federal Emergency Management Agency, the Oregon Department of Transportation, and the Association of Oregon Counties, and with the cooperation of the U.S. Geological Survey. The study was undertaken to provide engineers and land managers with the information needed to make informed decisions about development in or near watercourses in the study area.

Much development takes place near rivers and streams and usually involves a variety of engineered structures. Some structures such as bridges and culverts, dams, levees, and floodways are within the stream banks and generally are exposed to streamflow at all times. Other structures such as homes, businesses, or agricultural buildings are exposed to streamflow only during times of flooding. Safe and economical design of these structures and correct assessment of the hazards of development in flood plains requires knowledge of the magnitude and frequency of the peak discharges of nearby streams.

Peak discharges have the potential to extensively damage any structure exposed to them. The extent to which a structure is designed to withstand the impacts of peak discharges depends on the risk that failure of the structure poses to life and property. In some cases, failure of the structure is unacceptable. For example, a dam upstream of a populated area will be designed to withstand and function properly under the probable maximum flood.

Usually the failure of a structure is more likely to cause property damage than loss of life. In these cases, it may make economic sense to replace the structure periodically rather than build it to withstand any extreme flood. For example, a remote, rarely traveled road may be designed with the expectation that culverts under the road will wash out on average once in 10 to 25 years. As another example, homes on flood plains typically are required to be built above the elevation of the flood likely to occur on average once in 100 years. Because risk assessment is an important part of planning and design, the magnitude of peak discharges at various frequencies is needed.

This report provides techniques for estimating the magnitudes of peak discharges at various frequencies or "return intervals." A return interval is the number of years expected to pass "on average" between peak discharges of a given magnitude. For example, consider the gaging station Umpqua River near Elkton, Oregon (14321000). Annual peak discharges have been observed at this site for 94 years through 2001. A magnitude and frequency analysis, described later, estimates the 2-year peak discharge to be 94,200 cfs (cubic feet per second). The largest peak each year is expected to exceed this value half the time, that is, every 2 years on average. In fact, for the 94 years of record, the annual peak discharge exceeded 94,200 cfs 46 times. Similarly, the 100-year peak discharge is 261,000 cfs and is expected to be exceeded 1 percent of the time or once in 100 years on average. For the 94 years of record, one annual peak discharge exceeded 261,000 cfs.

Purpose and Scope

This report describes the results of an analysis of the peak discharges of rural streams in Oregon west of the crest of the Cascade Range (fig. 1). The results of this study include (1) the magnitude of annual peak discharges for selected frequencies at 376 gaging stations, (2) the areal distribution within Oregon of generalized logarithmic skew coefficients for annual peak discharges, and (3) sets of equations relating the magnitude of peak discharges at selected frequencies to physical and climatological watershed characteristics such as drainage area and mean January precipitation. A set of frequency-specific prediction equations was developed for each of three hydrologically similar regions within western Oregon. The prediction equations may be used at ungaged sites to make estimates of peak discharges.

The selected peak discharge frequencies are described by the recurrence interval at which the peak discharge is likely to recur. The selected recurrence intervals are the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year peak discharges. A 10-year peak discharge has a probability of exceedance in any year of 0.10 or 10 percent, and a 100-year peak discharge, a probability of exceedance of 0.01 or 1 percent.

The study described in this report is based on annual series of peak discharge for 376 gaging stations in western Oregon, southwestern Washington, and northwestern California. Of these stations, 294 are located in western Oregon.

The study had two parts: (1) a magnitude and frequency analysis and (2) a derivation of the prediction equations. In the magnitude and frequency analysis, a frequency distribution was fitted to the annual series of peak discharges at each gaging station. The fitted distribution was used to estimate the magnitude of annual peak discharges at selected frequencies. Determining the areal distribution of the generalized skew coefficients was part of this analysis and is described in the section titled "Generalized Skew." The prediction equations were derived using generalized least-squares regression analysis.

Although the analysis described in this report was based in part on gaging stations located in southwestern Washington and northwestern California, the resulting prediction equations are to be applied only to western Oregon. The out-of-State gaging stations were included to increase the information used in the derivation of the prediction equations, to reduce any edge effects in developing the generalized skew coefficients, and in some cases, because parts of the out-of-State gaging station watersheds lie in Oregon.

The prediction equations may be used to estimate peak flows for any stream. Be aware, however, that the prediction equations do not account for reservoir operations, diversion or urbanization. Many streams are affected by these factors. In these cases, the estimates of peak flow represent a hypothetical condition of the watershed, not the actual condition.

For peak discharges for urban watersheds, it is recommended that the prediction equations developed by Laenen (1980 and 1983) or Sauer and others (1983) be used. Laenen's work is specific to the Portland, Oregon – Vancouver, Washington, area (1980) and to the Willamette Valley (1983). Sauer and others developed prediction equations applicable anywhere in the United States. Sauer and other's equations are included in the National Flood Frequency Program (Sauer, 2002).

The prediction equations require estimates of several physical characteristics of the watershed of interest. Most of these characteristics are estimated from regionalized data. These data are described later in the report and only the versions of the regionalized data described there should be used with the prediction equations. Sources for these data sets are listed elsewhere in the report. The best estimates of watershed characteristics are achieved by analyzing the regionalized data with geographic information systems (GIS) techniques rather than making the estimates manually from plotted isoline maps.

For these reasons, making appropriate and reliable estimates of watershed characteristics may be inconvenient for many users. To make the prediction equations as widely available as possible, the Oregon Water Resources Department has developed an interactive Web site utility to facilitate the use of the equations. The Web site and the options available there are described in a later section of the report.

Acknowledgements

This study was completed in part due to generous financial support from the Federal Emergency Management Agency (from both the National Dam Safety Program and the Federal Insurance and Mitigation Division), the Oregon Department of

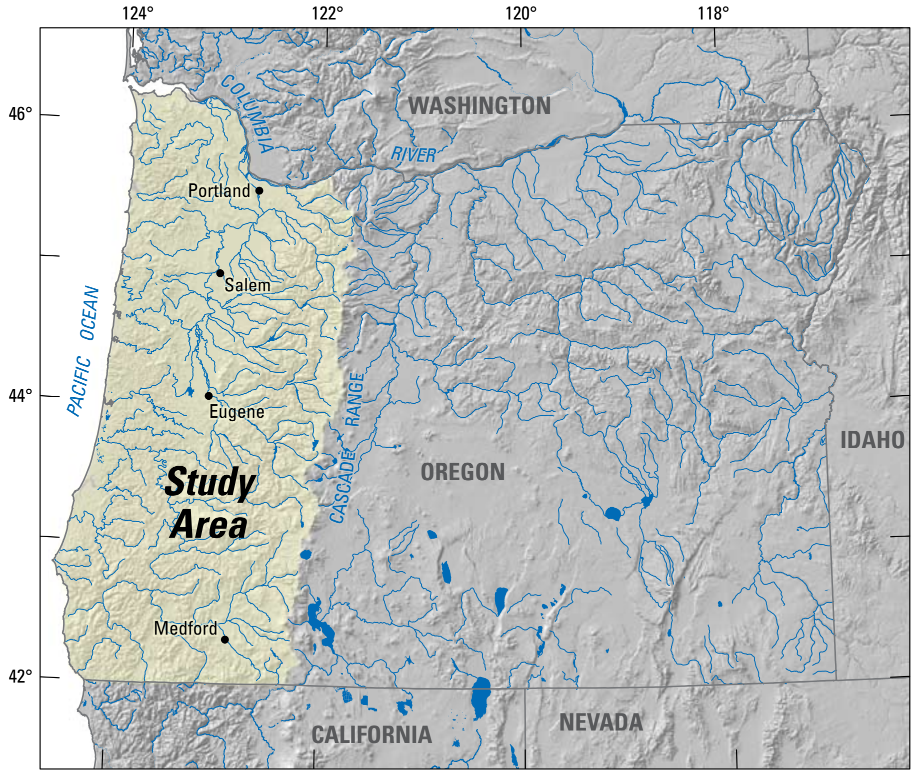

Figure 1. Location of the study area.

Transportation, and the Association of Oregon Counties. Their contributions are gratefully acknowledged.

Many thanks are due Ken Stahr, who made numerous contributions. He has done the bulk of the GIS work. He delineated and digitized most of the watersheds, he managed all the various coverages and grids used to calculate watershed characteristics and calculated those characteristics, and he created several of the figures in this report. He is also largely responsible for developing a method for auto-delineation of watersheds. This method is used in a Web utility available from the Oregon Water Resources Department's Web site for estimating peak discharges at ungaged sites.

Bob Harmon is lead worker for GIS work in the Oregon Water Resources Department. He acquired the watershed characteristic grids and coverages used for this analysis and wrote the computer programs that calculate watershed characteristics.

Rich Marvin and Jonathan La Marche (Oregon Water Resources Department), John Risley (U.S. Geological Survey, Portland Office), Dennis Lettenmaier (University of Washington), Bo Miller (Oregon Department of Transportation), Rob Allerman (Pacific Corps), and Catilino Cecilio (Consulting Engineer) reviewed early drafts of the report and made many valuable observations and criticisms. The report was greatly improved through their efforts.

Previous Studies

Hulsing and Kallio (1964) reported a method for determining the probable magnitude of peak discharges of any return period between 1.1 and 50 years for Pacific slope basins in Oregon and Columbia River tributaries below the Snake River. West of the Cascade crest, the method applies to any watershed greater than 0.5 square miles. East of the crest, watersheds must be greater than 10 square miles.

The peak discharge estimates were based on a correlation of watershed characteristics with mean annual peak discharges. Characteristics used were drainage area, percent area of lakes and ponds, and average annual runoff. Also used was a "geographic factor" based on the residuals resulting from the regression of the mean annual peak discharges on the other three characteristics. Composite frequency curves for nine subregions over the study area gave the relationship between frequency and the ratio of the peak discharge of that frequency to the mean annual peak discharge. Frequency curves for individual stations were fitted visually to the annual peaks plotted on log-probability paper.

The analysis was based on annual peaks for 391 gaging stations. Each site had more than 5 years of record and was unaffected by significant reservoir operations, diversions, or urbanization. The annual peaks and the characteristics for each watershed are included in Hulsing and Kallio's report.

Lystrom (1970) evaluated the streamflow-data program in Oregon. As part of that analysis, Lystrom developed equations for estimating peak discharge magnitudes for recurrence intervals of 2, 5, 10, 25, and 50-years. There are two sets of equations: one for western Oregon and one for eastern Oregon. Lystrom did not explicitly limit the use of the equations, but good practice would limit their application to the range of values exhibited by the characteristics of the watersheds used to develop the equations.

Lystrom's equations were derived by regressing peak discharges of a given frequency on watershed characteristics. Logarithms of annual peaks were fitted to the Pearson Type III distribution to obtain peak discharges of specified frequency. The regressions were developed by ordinary least-squares regression analysis. Standard errors of estimate ranged from 40 to 46 percent. The characteristics considered by Lystrom were drainage area, main-channel slope, percent area of lakes and ponds, mean watershed elevation, percent area of forest cover, mean annual precipitation, 2-year 24-hour precipitation intensity, mean minimum January temperature, and a soils index developed by the Soil Conservation Service. Of these, all but channel slope and percent forest cover appear in the prediction equations Lystrom developed for western Oregon.

Lystrom's analysis was based on annual peaks for 222 gaging stations with more than 10 years of record and unaffected by significant reservoir operations, diversions, or urbanization. The watershed characteristics for each of the gaging stations used in the regressions are included in Lystrom's report.

The Oregon Water Resources Department (1971) developed curves relating mean annual peak discharges to drainage area for 29 hydrologically similar regions in the State. Multipliers related the mean annual peak discharges to peak discharges for recurrence intervals of 1.01, 1.05, 1.25, 2, 5, 20, and 100 years. The analysis applies to all of western Oregon and parts of eastern Oregon. The curves are to be used for watersheds of less than 100 square miles.

The curves were developed from methods described by Hazen (1930). The only watershed characteristic required to use the curves is drainage area. The analysis was based on annual peaks for 120 gaging stations, most of which had more than 20 years of record.

Harris and others (1979) reported a method for estimating peak discharge magnitudes for unregulated streams in western Oregon for recurrence intervals of 2, 5, 10, 25, 50, and 100 years. Four subregions were defined: coast, Willamette, Rogue-Umpqua, and High Cascades. A set of equations was developed for each region. Harris and others did not explicitly limit the use of the equations, but, again, good practice would limit their application to the range of values exhibited by the characteristics of the watersheds used to develop the equations.

The equations were derived by regressing peak discharges of a given frequency on watershed characteristics. Logarithms of annual peaks were fitted to the Pearson Type III probability distribution to obtain peak discharges of specified frequency. The regressions were developed by ordinary least-squares regression analysis. Standard errors of estimate ranged from 32 to 72 percent. The characteristics considered were drainage area, main-channel slope, main-channel length, mean watershed elevation, percent area of lakes, percent forest cover, a soils index developed by the Soil Conservation Service, azimuth, latitude of the gaging station, longitude of the gaging station, mean annual precipitation, 2-year 24-hour precipitation intensity, and mean minimum January temperature. Of these, only drainage area, percent area of lakes, precipitation intensity, and percent forest cover were used in the equations.

The analysis was based on annual peaks for 230 gaging stations with more than 10 years of record and unaffected by significant reservoir operations, diversions, or urbanization. The watershed characteristics for each of the gaging stations used in the regressions are included in Harris and others' report.

Campbell and others (1982) developed a method for predicting peak discharges on small, unregulated watersheds in Oregon for recurrence intervals of 10, 25, 50 and 100 years. Six subregions were defined. The four subregions in western Oregon were the same as those used by Harris and others (1979). In eastern Oregon, one subregion was defined by watersheds in or near the upper Klamath River Basin. A second subregion was defined by watersheds in or near the John Day, Umatilla, Grande Ronde, and Powder River Basins. Watersheds used in the study ranged in size from 0.21 to 10.6 square miles.

In each region, annual peak discharges from gaging stations with more than 20 years of record were fitted to four frequency distributions: Gumbel, two-parameter log-normal, three-parameter log-normal, and log-Pearson Type III. The log-Pearson Type III distribution was determined to be best suited to all regions of the State.

The prediction equations were developed using an ordinary least-squares regression of peak discharges of a given frequency on watershed characteristics. Standard errors of estimate ranged from 21 to 67 percent for western Oregon. The characteristics considered were drainage area, mean watershed elevation, gage datum, main-channel slope, main-channel length, percent forest cover, latitude of the gaging station, longitude of the gaging station, mean annual precipitation, 2-year 24-hour precipitation intensity, and mean minimum January temperature. Of these, only drainage area, mean watershed elevation, mean annual precipitation, latitude of the gaging station, and mean minimum January temperature were used in the equations for western Oregon.

The analysis was based on annual peaks for 80 gaging stations with more than 10 years of record and unaffected by significant reservoir operations, diversions, or urbanization. The watershed characteristics for each of the gaging stations used in the regressions are included in Campbell and others' (1982) report.

Current Study

The current study improves on previous work in several ways. Because of these improvements, the prediction equations developed for this study are considered more reliable than prediction equations previously reported for use in western Oregon and should be used in lieu of equations from previously published reports for western Oregon.

First, more gaging stations were used in this study than in other studies. Most other studies have used only peak discharge record published by the U.S. Geological Survey. This study includes peak discharge record published by the U.S. Geological Survey and the Oregon Water Resources Department.

Second, more than 20 years of streamflow record has been collected since the last comprehensive study for western Oregon (Harris and others, 1979). This new record includes continuation of record at existing stations and addition of record at new stations by both the U.S. Geological Survey and the Oregon Water Resources Department.

Third, generalized logarithmic skew coefficients for Oregon have been developed specifically for this study. The most recent previous study (Harris and others, 1979) used the generalized logarithmic skew coefficients provided by the U.S. Water Resources Council in Bulletin 17A (1977). The new generalized skew coefficients are based on more peak discharge data than the previous analysis of generalized skew. In the 25 years since the previous analysis, new stations have been established and records at many previously existing stations have been extended.

Fourth, more watershed characteristics and better methods to estimate them are now available. Many physical and climatological characteristics of watersheds have been regionalized and put into digital formats in recent years. By using these regionalized characteristics in conjunction with GIS techniques, estimation of watershed characteristics is easier, more precise, more accurate, and more readily reproduced than previously possible.

Finally, other studies in Oregon have used ordinary least-squares regression to develop the prediction equations. This study uses a generalized least-squares analysis that accounts for unequal lengths and variances of streamflow records and cross-correlation between series of streamflow characteristics where ordinary least-squares regression does not.

Description of the Study Area

The study area includes all of Oregon west of the crest of the Cascade Range (fig. 1). Some of the gaging stations used in the analysis lie outside of the study area. These stations are located adjacent to the study area in southwestern Washington and northwestern California. In Washington, gaging stations within about 50 miles of the State line were considered, and in California, gaging stations within about 25 miles of the State line. By physiography and climate, these out-of-State areas are extensions of the adjacent regions of the study area.

Western Oregon has wet winters and dry summers. Annual precipitation varies from less than 20 inches in the interior valleys of southern Oregon to nearly 200 inches at some locations in the coastal mountains. Coastal Oregon is drained by numerous small rivers and streams. Interior parts of western Oregon are drained almost entirely by just three rivers: the Willamette, Umpqua, and Rogue Rivers. Western Oregon is heavily vegetated with thick conifer forests in mountain regions and grasslands and oak woodlands in the valleys.

Physiography

Principal physiographic features of the study area are the Coast and Cascade mountain ranges, the Klamath Mountains, and the Willamette Valley (fig. 2). The Coast Range parallels the coastline from the Olympic Mountains in Washington south to the Klamath Mountains in Oregon. The elevation of the crest line of the Coast Range averages about 1,500 feet with a few peaks near 4,000 feet. Marys Peak, elevation 4,097 feet, is highest. In Oregon, the Coast Range provides a continuous hydrologic divide except where the Umpqua River crosses it. A narrow coastal plain extends to the west of the Coast Range varying in width from less than a mile to around 20 miles. Numerous river valleys extend into the Coast Range from the ocean.

The Cascade Range also parallels the coastline, extending from British Columbia across both Washington and Oregon and into California to the Sierra Nevada. The elevation of the crest line of the Cascades is generally over 4,000 feet with several peaks exceeding 10,000 feet in elevation. In Oregon, Mount Hood is highest at 11,239 feet. Mount Jefferson and the Three Sisters are all over 10,000 feet. In southern Oregon, Mount McLoughlin is the highest peak at 9,495 feet.

In Oregon, the Cascades provide a continuous hydrologic divide along their length. In some areas, the surface water and ground water divides do not coincide. Very permeable volcanic rocks allow movement of ground water across the surface water divides (Gannett and others, 2000). Almost all watersheds draining the west side of the Cascades are tributary to just three rivers: the Willamette, Umpqua and Rogue Rivers.

The Klamath Mountains occupy most of Oregon south of the Umpqua River and west of the Cascade Range. The terrain here is much more rugged and is higher in elevation than other parts of western Oregon. There is not a clear separation between the coastal mountains and the Cascades as there is between the Coast Range and the Cascades to the north. Near the coast, Brandy Peak is the highest peak at 5,316 feet. In the central Klamath Mountains, near the California border, Grayback Mountain has an elevation of 7,048 feet and Mount Ashland an elevation of 7,553 feet. On the divide between the Rogue and Umpqua River Basins, King Mountain reaches 5,265 feet.

The Willamette Valley lies between the Coast and Cascade Ranges. It extends from Eugene in the south to Portland

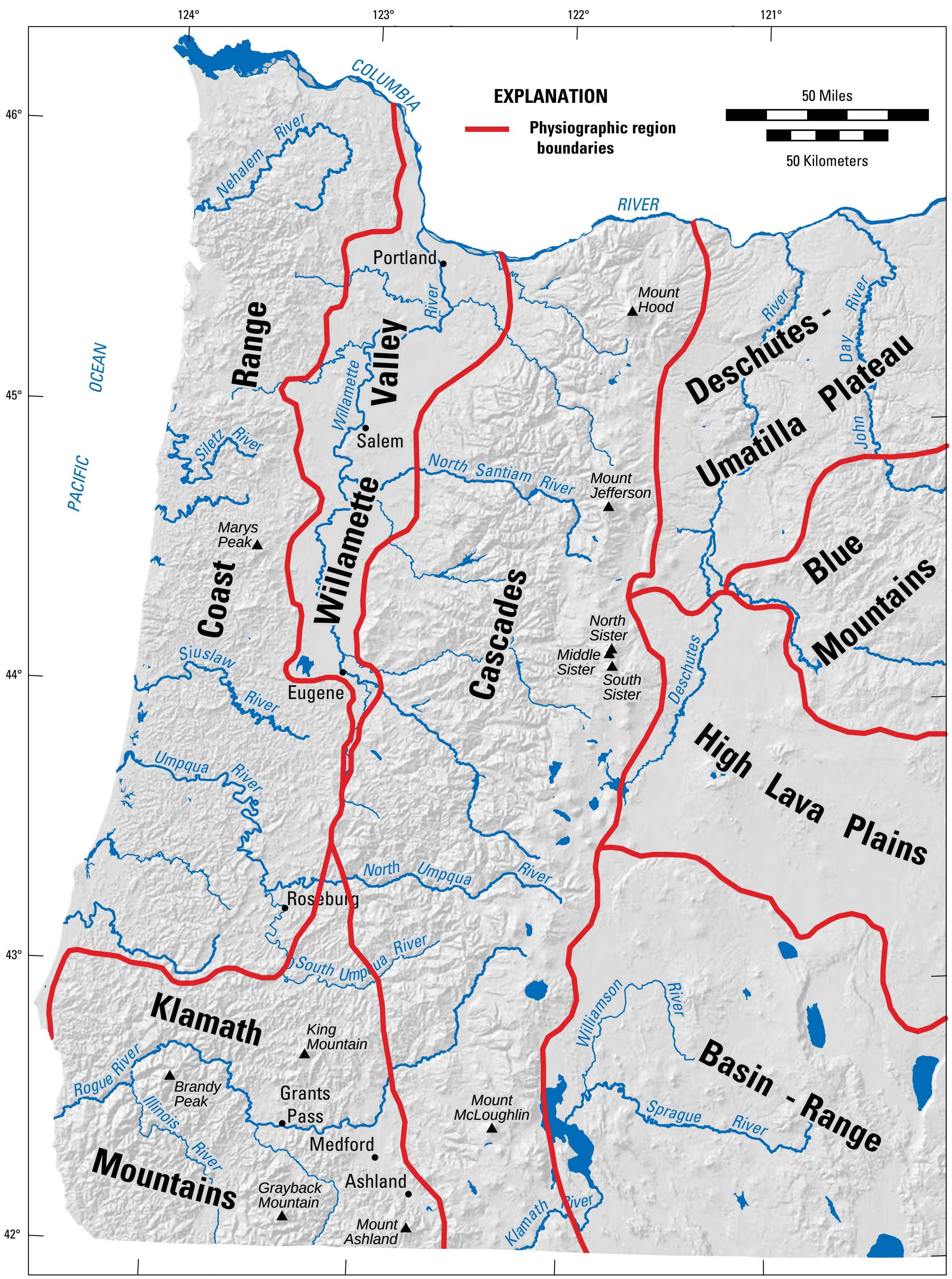

Figure 2. Physiographic features of western Oregon. Physiographic regions are based on Dicken (1965) and Baldwin (1981).

in the north. It varies in width from 10 to 30 miles. Near Eugene, elevations of the valley floor are around 500 feet. The valley slopes gently to the north with elevations at Salem around 130 feet, and at Portland, near sea level. Other features of note are the Umpqua and Rogue River Valleys of southern Oregon. The Umpqua Valley lies directly south of the Willamette Valley. It is less well defined and separates the Coast Range from the Cascades to a lesser extent than does the Willamette Valley. The Umpqua Valley is roughly encompassed by a circle having a radius of 15 to 20 miles centered on the City of Roseburg. It includes the downstream parts of the watersheds draining to Lookingglass, Calapooya and Sutherlin Creeks and the North and South Umpqua Rivers. Elevations on the valley floor average around 500 feet.

The Rogue River Basin has three broad alluvial valleys that are within the Klamath Mountains of southwestern Oregon. The first is along the mainstem of the Rogue River from the town of Shady Cove to the Rogue's confluence with Bear Creek. It includes the lower parts of the watersheds draining to Bear Creek, Little Butte Creek, and Elk Creek. The second is along the mainstem Rogue River from Grants Pass downstream to the Rogue's confluence with Jumpoff Joe Creek. It includes the lower parts of the watersheds draining the Applegate River and Jumpoff Joe Creek. The third is centered near the confluence of the East and West Forks of the Illinois River. The valley extends about 5 miles up each fork and down along the mainstem about five miles. It ranges from about 2 to 5 miles wide. Valley floor elevations among the three valleys range from about 1,000 to 1,500 feet.

Climate

Almost all precipitation in the study area occurs from October to May and is due to frontal storms originating over the Pacific Ocean and moving from west to east over the area. Because these storms originate over the ocean, they are relatively warm, and significant snowfall is confined to higher elevations in the Cascade Range and the Klamath Mountains. Summers, in contrast, are usually dry with only occasional fronts moving across the area. Summertime convective storms (i.e., thunderstorms) occur regularly only in the Cascade and Klamath Mountains and are rare elsewhere.

The mountains receive most of the precipitation because of orographic effects. Annual precipitation in the coastal mountains ranges from about 50 inches to almost 200 inches (G.H. Taylor, Oregon State Climatologist, written commun., 2002). Snowmelt typically is not a significant factor contributing to peak discharges in the Coast Range. Annual precipitation on the west slope of the Cascade Range varies from about 50 inches to over 140 inches. Precipitation amounts are much less in the south Cascades (50 to 60 inches) than in the north (80 to 100 inches). Much of this precipitation falls in winter as snow, and peak discharges are often the result of heavy rain on snow, frozen ground, or both. Annual precipitation in the eastern parts of the Klamath Mountains is less than about 45 inches. Higher elevations in the Klamath Mountains may receive significant snowfall.

The interior valleys lie in the rain shadow of the coastal mountains and receive significantly less precipitation. Annual precipitation ranges from 30 to 50 inches in the Willamette Valley and from 35 to 45 inches in the Umpqua Valley. The valleys of the Rogue River Basin are drier, with 20 to 35 inches of precipitation annually.

Characteristics of Peak Discharges

Peak discharges in the study area result primarily from three hydrological processes: (1) rainfall from frontal storms moving eastward from the Pacific Ocean, (2) snowmelt, and (3) rainfall from convective storms. Very rarely a peak discharge results from a glacial outburst. The most recent of these occurred in September 1998 from the White River Glacier on Mount Hood.

Frontal storms occur mostly in winter and are regional in affect. Precipitation from these storms falls mostly as rain in the Coast Range and interior valleys, but often falls as snow in the Cascades and the Klamath Mountains. Rainfall intensities for these storms tend to be low, but storms may last for several days. Where the precipitation falls as rain, streamflow usually increases rapidly and then, after the front has passed, decreases gradually over several days. Maximum flows are sustained for only a short time—perhaps a few hours. Where the precipitation falls as snow, streamflow is unaffected.

Snowmelt usually occurs in spring and affects watersheds with headwaters at higher elevations in the Cascades and the Klamath Mountains. As the weather warms in the spring, as a general trend, streamflow from snowmelt increases gradually over several weeks or months. Eventually, as the snowpack diminishes, streamflow begins a gradual decline to base flow levels. The maximum streamflows associated with this general trend may be sustained for a week or more. Superimposed on this general trend are numerous short duration peaks due to diurnal temperature variation and to short periods of either rain or high temperatures. Maximum flows associated with these superimposed peaks are sustained only briefly. The overall peak discharge for the period will result from one of these superimposed peaks.

Convective storms usually occur in summer and are most likely to occur in the Cascade Range and the Klamath Mountains. Convective storms tend to be small in area and their effects local. Rainfall intensities for these storms may be high, but their durations are short. Streamflows associated with convective storms rise and then decrease rapidly. Maximum flows are not sustained.

In western Oregon, convective storms may produce no precipitation at all (G.H. Taylor, Oregon State Climatologist, written commun., 2004). These storms result from air masses originating over the Gulfs of Mexico and California. As these air masses move north, they lose much of their moisture over the mountains of Arizona, New Mexico, Nevada, and California. By the time they arrive here, they are relatively dry. They produce lightening over Oregon's mountains, but little rain.

Mixed Processes

Often storms from the subtropical Pacific bring warm temperatures and rain to western Oregon. In these cases, rain may fall on snow and frozen ground at higher elevations and saturated soils at lower elevations. High rainfall amounts, rapidly melting snow, and impervious or saturated soils combine to produce the largest peak events to occur in western Oregon. The floods of December 1964 and February 1996 are examples.

Rain-on-snow events may occur at higher elevations anytime from about November through May. Peaks due only to rainfall usually occur at low elevation, or if at higher elevations, only in the fall or early winter. In western Oregon, annual peaks due only to snowmelt are probably uncommon, occurring only at the highest elevation stations in late spring or early summer.

Whether a peak event is the result of rain only or rain-on snow is a function of elevation. Higher elevation watersheds are more likely to have accumulated snow than low elevation watersheds. Many watersheds, of course, have areas of both high and low elevation. In addition, depending on season or the year, the same watershed may experience both kinds of events.

As will be shown later in the section on flood regions, the relationship between peak discharge and elevation changes abruptly at about 3,000 feet. This observation is best explained by the fact that snow generally does not accumulate at elevations below about 3,000 feet in western Oregon. For purposes of this study, it is assumed that for watersheds with mean elevations below 3,000 feet that most peak events are the result of rain only. For watersheds with mean elevations above 3,000 feet, it is assumed most peak discharges are the result of mixed processes—some combination of rain, rain on snow, and snowmelt.

Relative Importance of Hydrologic Processes

An analysis was done to determine the relative importance of the hydrologic processes contributing to peak discharges. Although it is difficult to classify an individual peak as to the types of hydrologic processes it resulted from, some general conclusions about all peaks can be made. First, we assume that the hydrologic processes associated with a peak discharge are related to its season of occurrence. For example, rain or rain on snow events are most likely in winter, snowmelt in spring, and thunderstorms in summer. Unfortunately, none of these classifications is definitive, only likely. Still, an analysis of this type indicates the relative importance of the hydrologic processes contributing to peak discharges.

In order to see how peak discharges in western Oregon are distributed in time, they were grouped by their month of occurrence (fig. 3). All west side peaks unaffected by regula-

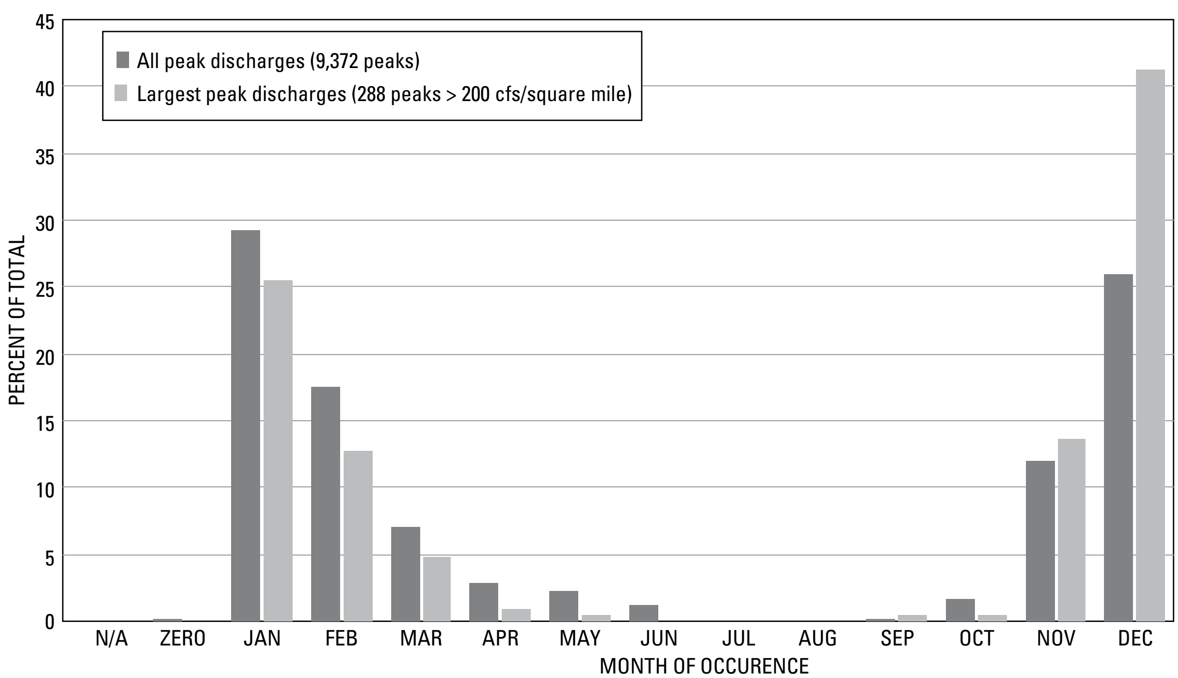

Figure 3. Distribution of the monthly occurrence of 9,372 observed peak discharges for western Oregon. Zero is the percentage of zero peaks (0.10 percent). N/A is the percentage of peaks that are not zero, but for which the date of occurrence is unknown (0.03 percent). Also shown is the distribution of the monthly occurrence of the 288 largest peak discharges, i.e., peak discharges larger than 200 cubic feet per second (cfs) per square mile.

tion or urbanization were included even if the associated gaging station did not qualify for inclusion in the flood frequency analysis. (Gaging stations excluded from the flood frequency analysis included those with fewer than 10 years of record or with too many zero peaks or peaks below the gage threshold.) In all, 9,372 peaks representing 418 gaged sites were identified.

The peak discharges then were grouped by season, with winter defined as October through March, spring as April through June, and summer as July through September. Table 1 shows these summary results. It is clear that most annual peaks occur in the winter, some occur in spring, and a very few in summer. This result suggests that most annual peak discharges in western Oregon are the result of rain or rain-on-snow, a minor part are due to snowmelt, and a negligible number are due to thunderstorms.

A similar analysis was done for the peak discharges with the largest unit discharges (the peak discharge divided by the watershed area). Two hundred eighty-eight peak discharges had unit discharges greater than 200 cfs per square mile. The distribution of these peak discharges is also shown (fig. 3 and table 1). The results are similar to those for all peak discharges, but with an even greater part of the annual peaks occurring in winter.

Historic Floods

The first documented flood in western Oregon occurred in the fall of 1813. For the Willamette River Basin, this flood was on the order of later floods in 1861 and 1890, but its magnitude remains unknown. Information about this flood came from records of the Northwest Fur Company. Other major, but poorly documented, floods are known to have occurred in 1843, 1844, 1849, and 1853 (Brands, 1947).

The largest documented flood on the Willamette River occurred in December 1861. Along the Willamette River, two towns were washed away and all other towns were at least partly submerged. Discharge at Salem on December 4 was 500,000 cfs (Brands, 1947). At Salem, a flood of this magnitude has a recurrence interval of about 100 years. Coastal rivers were also affected. The 1861 flood was also the largest known on the Rogue River (Hubbard, 1991).

The second largest historical flood on the Willamette River peaked at Salem on February 5, 1890, with a discharge of 450,000 cfs (Brands, 1947). At Salem, a flood of this magnitude has a recurrence interval of about 50 years. The third largest known flood on the Willamette River occurred just 9 years earlier, peaking at Salem on January 16, 1881. The discharge was 428,000 cfs (Brands, 1947).

The greatest flood to occur in the Willamette Basin prior to construction of the flood-control reservoirs and for which rainfall and runoff records were generally available occurred in January 1923. Brands (1947) discusses this flood in detail. Discharge at Salem was 348,000 cfs. Hubbard (1991) gives recurrence intervals of from 10 to 100 years for peak discharges for streams in the basin.

Heavy rain and mild temperatures brought flooding to western and northeastern Oregon March 31 to April 1, 1931 (Taylor and Hatton, 1999). The recurrence intervals for flood peaks on the Salmon River at Welches and Willamina Creek near Willamina exceeded 50 years. Recurrence intervals for other streams in the Sandy and Yamhill River Basins were from 10 to 30 years.

A large storm brought heavy rain, wind, and warm temperatures to northwestern Oregon, Washington, Idaho and British Columbia December 21–24, 1933 (Taylor and Hatton, 1999). Recurrence intervals for peak discharges in the Sandy, Clackamas, and Santiam River Basins and along the north coast were from 5 to 20 years.

Heavy rain December 26–30, 1937, caused flooding along the north coast and in the Willamette Valley (Taylor and Hatton, 1999). Generally, recurrence intervals for peak discharges were from 5 to 20 years, but exceeded 40 years for the Pudding River at Aurora and 80 years for the Tualatin River at West Linn.

Rain falling on snow and very warm temperatures caused flooding in northwestern Oregon December 26–29, 1945 (Taylor and Hatton, 1999). Flooding was most severe in the Willamette Valley. Recurrence intervals for many streams were greater than 10 years. The McKenzie River at Vida was about 45 years and the Willamette River at Springfield exceeded 90 years.

Table 1. The seasonal occurrence of 9,372 observed peak discharges for western Oregon. Also shown is the seasonal occurrence of the 288 largest peak discharges, i.e., peak discharges larger than 200 cfs (cubic feet per second) per square mile.

[Spring, April to June; Summer, July to September; Winter; November to March]

	Spring	Summer	Winter	Unknown	Total
Peak discharges	Percent of total				
All 9,372	6.2	0.2	93.5	0.1	100.0
288 largest	1.3	0.4	98.3	0.0	100.0

The floods of October 27–30, 1950, were confined to southwestern Oregon and northwestern California. These floods were almost entirely the result of rainfall, as little snow had accumulated so early in the season. Generally, the floods resulting from this storm were not the greatest known in the area, though peak discharges on the Smith and Umpqua Rivers may have been as great as the flood of 1861 (Paulsen, 1953).

The floods of January 17–21, 1953, affected all of western Oregon, but the most serious flooding occurred in southwestern Oregon and northwestern California. Peak discharges were generally greater than for the floods of October 1950. Snowmelt was not a factor in flooding in the Coast Range, but contributed to flooding on streams heading in the Cascades (Rantz, 1959).

A series of storms from December 1955 to January 1956 caused widespread flooding in most of California, western Nevada, western Oregon and parts of Idaho. In Oregon, the Willamette River and its tributaries and all coastal rivers were affected. Warm temperatures and rain at high elevation melted much of the accumulated snowpack, resulting in record-breaking streamflows for many streams (Hofmann and Rantz, 1963). Recurrence intervals varied from 10 to 50 years, depending on location (Hubbard, 1991).

Heavy rains falling over southwestern Oregon on December 2, 1962, caused severe flooding in some areas of the Rogue Valley (Taylor and Hatton, 1999). Recurrence intervals for peak discharges for the two forks of Ashland Creek exceeded 30 years, for the Rogue River at Raygold, 25 years, and for the South Fork Little Butte Creek, 100 years.

The storm of December 19–23, 1964, was extreme. The recurrence interval for floods in some areas was in excess of 100 years (Hubbard, 1991). All of Oregon, northern California, and parts of Idaho and southern Washington were affected. Peak discharges were substantially increased due to warm rain falling on accumulated snow. Many areas of the State experienced severe flooding. Flooding in the Willamette Valley, however, was significantly reduced because of the flood control reservoirs built in the previous two decades. The peak discharge on the Umpqua River at Elkton of 265,000 cfs exceeded the 1861 peak discharge of 220,000 cfs (Waananen and others, 1971).

The flood of January 1972 affected a limited area in the lower Willamette Valley, the Sandy River, and rivers of the northern Oregon coast. Peak discharges on some coastal streams exceeded those of the December 1964 flood. Recurrence intervals varied from 10 to 100 years for affected streams (Hubbard, 1991).

During January 13–17, 1974, a series of storms with mild temperatures and intense rain followed a period of heavy snow and freezing rain (Taylor and Hatton, 1999). The resulting snowmelt and rapid runoff caused widespread flooding in western Oregon. Recurrence intervals for peak discharges on several steams in the Umpqua and Rogue River Basins exceeded 50 years, with the West Branch of Elk Creek well in excess of 100 years.

Heavy rain fell over much of Oregon February 22–23, 1986. The rain combined with melting snow to bring flooding to many areas (Taylor and Hatton, 1999). In the Sandy River Basin, many streams had peak discharges with recurrence intervals from 10 to 30 years. The recurrence interval for the Middle Santiam River exceeded 80 years.

The storm of January 9–11, 1990, affected coastal streams of northwest Oregon and parts of southwestern Washington. Flooding was exacerbated by high tides and high winds. Recurrence intervals ranged from 25 to 100 years (Hubbard, 1996).

During the period February 5–9, 1996, warm temperatures and intense rain falling on a deep snowpack combined to create severe flooding throughout the northern part of Oregon (Taylor and Hatton, 1999). In many areas, flood magnitudes were generally comparable to or greater than those of the 1964 flood. The peak on the Nehalem River near Foss was the greatest on record, greatly exceeding the 100 year event. In the Willamette Valley, flood control reservoirs minimized flooding.

From November 18–20, 1996, warm, moist air from the tropical Pacific brought record-breaking precipitation to much of Oregon (Taylor and Hatton, 1999). Melting snow exacerbated flooding in some areas. The recurrence interval for the flood peak for the South Fork Coquille River was nearly 50 years and for the Chetco River nearly 70 years. Recurrence intervals for many streams in the interior valleys and the Cascades were on the order of 10 to 30 years.

From December 30, 1996, to January 5, 1997, warm moist air from the subtropical Pacific passed over the entire northwest (Taylor and Hatton, 1999). Heavy rain, warm temperatures, and rapid snowmelt caused flooding over much of the region. In western Oregon, estimated recurrence intervals in a few areas in the south exceeded 15 years. Hard hit was the town of Ashland, which experienced severe flooding. The flood was extreme, but its recurrence interval at Ashland is unknown.

Magnitude and Frequency Analysis

For a site where peak discharges have been systematically measured, the magnitude of peak discharges can be related to frequency by fitting the observed peaks to a theoretical probability distribution. From the probability distribution, the magnitude of the peak discharge for any return interval can be estimated. In practice, however, it is seldom reasonable to make estimates of flood magnitudes for return intervals greater than about 500 years.

For this study, the logarithms of annual series of peak discharges at 376 streamflow gaging stations in western Oregon, southwestern Washington, and northwestern California (Appendix A) were fitted to the Pearson Type III distribution following guidelines established by the Interagency Advisory Committee on Water Data (1982). These guidelines are commonly known as Bulletin 17B. Where the logarithms of the annual peak discharges are used, the fitted Pearson Type III distribution is referred to as the log-Pearson Type III distribution.

The log-Pearson Type III probability distribution requires three parameters: the mean, standard deviation, and skew[1] of the logarithms of the annual series of peak discharges being fitted. The parameters define a smooth trend line through the observed peak discharges when plotted on a log-probability plot (i.e., the logarithm of the magnitude of each annual peak discharge plotted against its probability of occurrence). However, some peak discharges do not fit the general trend of observed peak discharges. Because the data are ranked, these outliers always occur at the high or low ends of the distribution. The log-Pearson Type III distribution usually cannot fit both the general trend of the observed peak discharges and the outliers. This distorted fit typically does a poor job of representing the high end of the distribution and may significantly over- or under-estimate the largest peak discharges.

Following procedures recommended in Bulletin 17B, the parameters of the log-Pearson Type III distribution are adjusted for the effects of high and low outliers as well as for historic peaks, for zero-flow peaks[2], and for peaks below the gage threshold. It is beyond the scope of this report to discuss these adjustments, but for those interested, they are treated in detail in Bulletin 17B.

Even after adjustment for outliers, the station skew value may be poorly defined for short record gaging stations. A better estimate of the skew coefficient is obtained by taking a weighted average of the adjusted station skew and a "generalized" skew based on the skew coefficients for long-term stations in the area.

Although generalized logarithmic skew coefficients for the United States are provided with Bulletin 17B, Bulletin 17B recommends that generalized skew coefficients be developed for each area of concern. If the newly developed generalized skew coefficients have a mean squared error less than that of the generalized skew coefficients provided by Bulletin 17B, the newly developed skew coefficients should be used in lieu of those provided in Bulletin 17B.

Generalized skew coefficients for Oregon were developed as part of this study. These generalized skew coefficients were combined with station skew values to obtain weighted skew estimators for each station. The weighted skew values were used in fitting the Pearson Type III distributions. These topics are discussed in detail later in the report.

In general, fitting the theoretical Pearson Type III distribution to the logarithms of the observed peak discharges was straightforward and produced good results. Of the 376 gaging stations, 181 required adjustment for high or low outliers or historic or zero peak discharges. Peak discharge statistics used in fitting the distribution for the gaging stations are listed in Appendix B. The statistics include length of record; number of historical peaks; user-defined high and low-outlier thresholds; number of high and low outliers; number of zero flow peaks and peaks below the gage threshold; the station, Bulletin 17B, generalized, and weighted skews; and the statistics from the trend analysis. The meaning and significance of these statistics can be found in Bulletin 17B.

A visual check of the "goodness of fit" of the theoretical Pearson Type III distribution to the logarithms of the annual peaks was made for each of the 376 gaging stations. Eight gaging stations originally considered for inclusion in this analysis were rejected based on this visual check. The fitted distributions did not reasonably approximate the actual distribution of observed peak discharges.

To make the check, the theoretical distribution and the observed peaks are plotted on a log-probability plot. (Appendix C discusses how the plotting position was determined for the probability axis.) The log-Pearson Type III distribution generally plots as a curved line. The sense and degree of curvature is determined by the skew coefficient. Curvature is concave upward when the skew coefficient is positive and concave downward when it is negative. When the skew coefficient is zero, the distribution plots as a straight line. An example plot for the gaging station on the Nehalem River is shown in figure 4. Note the low outlier.

Peak discharge magnitudes at selected frequencies are obtained from the log-Pearson Type III distribution by this equation:

$$\log Q = \overline{X} + KS \tag{1}$$

where

$\overline{X}$ = the mean of the logarithms of the peak discharges,
K = a factor that is a function of the skew coefficient of the logarithms of the peak discharges and the selected frequency, and
S = the standard deviation of the logarithms of the peak discharges.

Values of K can be obtained from Appendix 3 of Bulletin 17B. The table requires the skew coefficient and the frequency. The 2-, 5-, 10-, 25-, 50-, 100-, and 500-year peak discharges for the 376 gaging stations are listed in Appendix D.

Peak Discharge Data

The data used in this study are the annual series of peak discharges for the 376 gaging stations. An "annual series" of peaks represents the largest instantaneous peak for each water year of record, reported in cubic feet per second. Peaks were measured at both continuous record sites and at crest-stage gage sites that record only the maximum peak discharge for

[1] The mean is a measure of the central tendency of the distribution, the standard deviation is a measure of the dispersion of the distribution about the mean, and the skew is a measure of the asymmetry of the distribution. A distribution with a skew of zero is symmetrical.

[2] For some watersheds, in some years, there is no streamflow. The annual peak discharge in those years is zero.

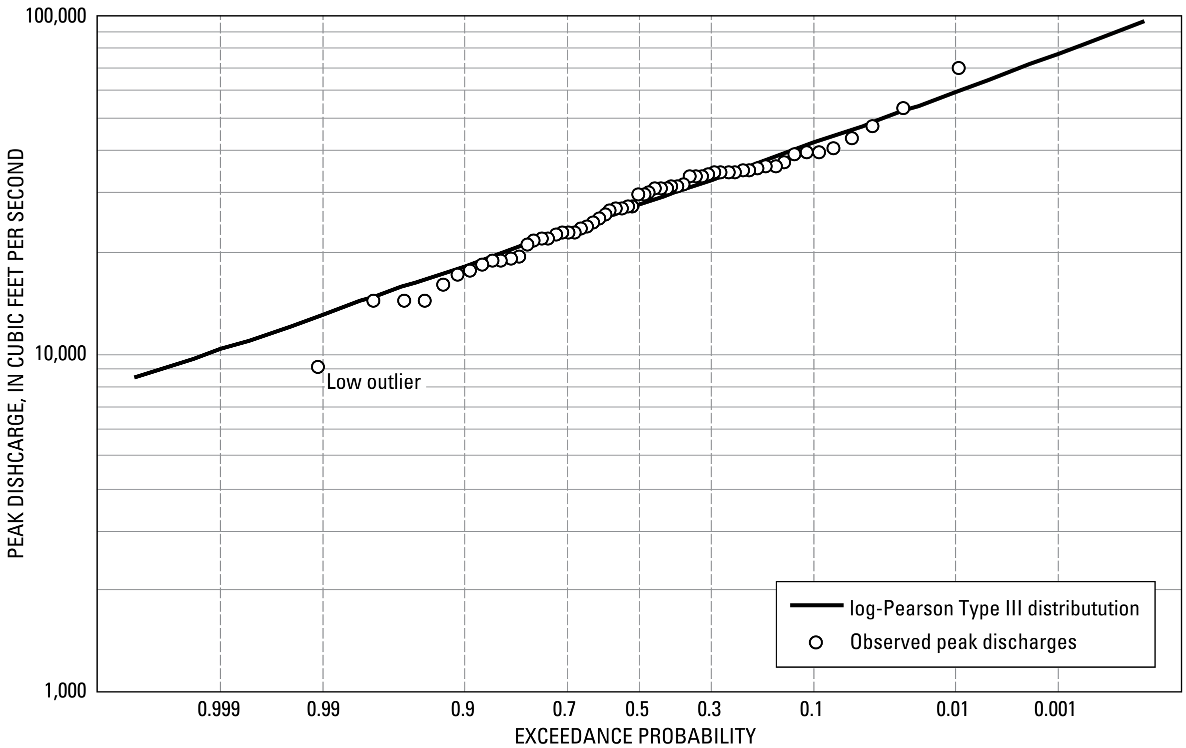

Figure 4. Log-Pearson Type III distribution fitted to the logarithms of peak discharges for the gaging station Nehalem River at Foss, Oregon (14301000).

each year. These measurement sites represent watersheds not significantly affected by reservoir operations, diversions, or urbanization. All sites have 10 or more years of measured peak discharges through water-year 2001. The peak discharges used in this study were measured and reported by the U.S. Geological Survey and the Oregon Water Resources Department. All peak discharge data used in the analysis are available from the Oregon Water Resources Department (*webmaster@wrd.state.or.us*), and all peaks except those originating with the Oregon Water Resources Department are available from the U.S. Geological Survey (*info-or@usgs.gov*).

Quality Assurance

No effort was made to directly check the accuracy of peak discharges reported for the various gaging stations. It was assumed that adequate checks were made by the agency responsible for the peak estimates. However, a few scriveners' errors were discovered during the analysis. Unusual results in fitting the probability distributions or in doing the regression analysis were sometimes the result of erroneous peak values. In the first case, erroneous peaks caused the absolute value of the skew parameter of the distribution to be large. In the second case, erroneous peaks lead to large residuals in forming the prediction equations. In both cases, the observed peaks were examined for errors and corrected as necessary.

Assumptions of the Magnitude and Frequency Analysis

Assumptions of the magnitude and frequency analysis are that the peaks in any systematic series are random, and that they are all derived from the same population. These assumptions mean (1) that the value of one peak does not depend on the value of a preceding peak and (2) that all peaks arise from the same processes, e.g., as the result of rain from a frontal-storm as opposed to rain from a convective storm or as the result of snowmelt. Implicit in the second assumption is that the processes are not changing in time. For example, it is assumed that weather may vary from year to year, but that climate is not steadily getting wetter or drier, or warmer or colder. Other factors are also assumed to remain constant; that land use, for example, does not change substantially over the period the observations are made.

Test for Random Peaks

A usual test for randomness is to check each series of annual peaks for a statistically significant linear serial correlation, i.e., a trend (Thomas and others, 1993; Wiley and others, 2000). A significant trend suggests that systematic, nonrandom changes in peak discharge characteristics are occurring in time. A trend test is not definitive; it is cause for investigation, not necessarily for the elimination of a gaging station from the analysis.

Peak discharges from the 376 gaging stations were tested for linear correlation. The resulting information was analyzed in two ways: (1) to check for regional, climate dependent trends and (2) to check for local trends resulting from significant physical changes to a watershed. Local changes include human caused changes due to land use or water management as well as natural changes such as a volcanic eruption. Local trends that can be attributed to physical changes in the watershed may require all or part of a gaging station's period of record to be removed from consideration.

In the regional analysis, no consistent long-term trend was found, although there is evidence of a regional fluctuation of peak discharges between wet and dry periods. This fluctuation led to a higher than expected number of significant trends in long-term gaging station records. The evidence is too weak, however, to support a strong conclusion as to whether the fluctuation is truly periodic or what its period might be. Locally, no significant trend could be linked to physical changes in the associated watershed.

No gaging stations were eliminated from consideration based on the trend analysis. The details of the trend analysis are found in the Appendix E. It should be noted that watersheds known to be affected by regulation, significant diversion, urbanization, or the eruption of Mount St. Helens were not considered for the analysis.

Test for Mixed Populations

For some watersheds in western Oregon, more than one hydrologic process may generate peak discharges. While it is convenient to think of these processes as giving rise to distinct populations of peak discharges, the processes occur in unpredictable combinations and the populations overlap considerably. For example, rain-on-snow events probably form a continuum from pure rain to pure snowmelt.

For watersheds where more than one hydrologic process generates peak discharges, the log-Pearson Type III distribution may poorly fit the distribution of annual peak discharges. When plotted on a log-probability plot, a mixed population of peak discharges may show a sharp break in slope or a curve that reverses direction. The fitted distribution usually has a large skew coefficient. If the peak discharges are separated into homogeneous populations, log-Pearson Type III distributions fitted to the separate populations may be significantly different from one another. In these cases, the distributions may be combined by the method described by Crippen (1978).

Often, however, the distribution of a mixed population of peak discharges does not exhibit a break in slope or a curve that reverses direction. If the distribution is well approximated by a log-Pearson Type III distribution, and if each of the separate populations is well represented in the mixed population, then there is no benefit to dividing the peak discharges into separate populations. The log-Pearson Type III distribution fitted to the mixed population will be close to the composite distribution calculated from the separate populations (Advisory Committee on Water Information, 2002).

Log-probability plots of observed peaks for the 376 gaging stations used in this study were examined for sharp breaks in slope or a curve that reverses direction. Particular attention was given to high elevation gaging stations, where a mixed population of peak discharges is most likely to occur, and to distributions with large absolute values of skew. Distributions for only four gaging stations showed breaks in slope and none showed a curve that reverses direction. Other distributions had large absolute values of skew, but all had high or low outliers and were corrected to the extent possible by the procedures outlined in Bulletin 17B.

This result suggests that peak discharges for each gaging station may be treated as coming from the same population whether they do or not. A few examples will illustrate the point. Figure 5 shows the monthly distributions for four high elevation watersheds. The watersheds were selected because they have a mix of winter and spring peak discharges: Salmon River near Government Camp, Oregon (14134000), Oak Grove Fork above power plant intake, Oregon (14209000), Clearwater River above Trap Creek near Toketee Falls, Oregon (14314500), and Imnaha Creek near Prospect, Oregon (14331000). Note that the distributions are all bimodal.

Log-probability plots of the peak discharges for the four gaged watersheds are shown in figure 6. The peak discharges are identified as to their season of occurrence. Also shown is the log-Pearson Type III distribution fitted to the peak discharges. The distributions of the peak discharges for the four watersheds do not show breaks in slope or curves that reverse direction. The fitted log-Pearson Type III distributions are all reasonable.

The four distributions with breaks in slope, mentioned earlier, may represent mixed populations of peak discharges, but they were not treated as such. Instead, all peak discharges below the break were treated as low outliers and a conditional probability adjustment was made to the fit of the log-Pearson Type III distribution. This part of the analysis is discussed in detail in the next section.

Low Outliers and Mixed Populations

Bulletin 17B describes a statistical test to identify low outliers. This test usually does a good job of identifying low outliers, and the subsequent conditional probability adjustment satisfactorily improves the fit of the log-Pearson Type III distribution.

Sometimes more than one low peak discharge will fall outside the general trend of all peak discharges. Often in these cases, the statistical test will not identify all the low peak discharges as outliers even though they adversely affect the fit of the log-Pearson Type III distribution. These cases can be identified by a visual inspection of a log-probability plot of the fitted distribution and the observed peak discharges. Because these distributions have large negative skew coefficients, the fitted distributions have strong downward curves. Unless these low outliers are censored, the fit of the log-Pearson Type III

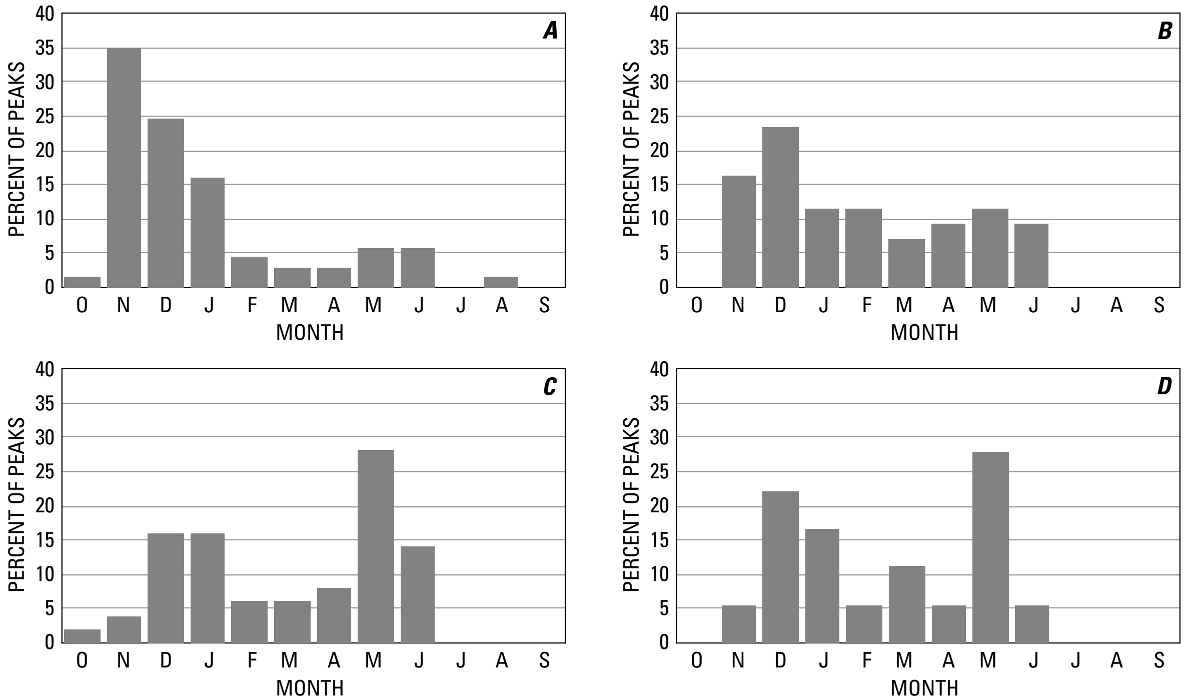

Figure 5. Distributions of the monthly occurrences of annual peak discharges for four gaging stations: (A) Salmon River near Government Camp, Oregon (14134000), (B) Oak Grove Fork above power plant intake, Oregon (14209000), (C) Clearwater River above Trap Creek near Toketee Falls, Oregon (14314500), and (D) Imnaha Creek near Prospect, Oregon (14331000).

distribution is compromised, with the upper end of the distribution poorly defined and often overestimated.

The Advisory Committee on Water Information (2002) offers suggestions on how to determine how many low peak discharges to censor. In general, low peaks are censored one at a time until the conditional probability distribution based on the remaining peaks stops changing significantly.

Not all low outliers are statistical outliers, however. In some cases, especially in drier areas, the low peak discharges may represent a separate population (Thomas and others, 1993). If there are a sufficient number of low peak discharges from this other population, the statistical test may not identify any of them as outliers, but the skew coefficient will have a large negative value, and a log-probability plot of the observed peaks will show a break in slope.

In many cases, it cannot be determined whether the low peaks come from a separate population or are statistical outliers. Even if these low peak discharges represent a separate population, it is not necessary to treat them as such. It is sufficient to treat them as low outliers. They do not provide any information about the *magnitude* of peak discharges at the upper end of the distribution; however, the low peaks do provide information about the *frequency*. The peaks below the low threshold are used with any zero peaks in a conditional probability adjustment as described in Bulletin 17B, Appendix 5.

Figure 7 shows examples of how the fit of the log-Pearson Type III distribution was improved for two gaging stations: (1) Blue River above Quentin Creek near Blue River, Oregon (14161000) and (2) Big Butte Creek near McLeod, Oregon (14337500).

For the Blue River gaging station, the outlier test identified one low outlier. The fitted distribution (dotted line) did not fit the observed peaks well, overestimating peak discharge at the high end. A visual inspection of the log-probability plot suggested that there were two additional low outliers. Increasing the low outlier threshold to 750 cfs censored these two peak discharges. The resulting fitted distribution (solid line) follows the observed peak discharges at the high end of the distribution much better than the distribution based on one outlier.

For the Big Butte Creek gaging station, the outlier test identified no low outliers. A visual inspection of the log-probability plot for the fitted and observed distributions shows a break in slope in the observed distribution, and the station skew has a large negative value (-0.632). The fitted distribution (dotted line) does not fit the observed distribution well, and it overestimates peak discharge at the high end. In this case, the low outlier threshold was increased to 2,000 cfs, sufficient to censor all low peak discharges below the break in slope (Thomas and others, 1993). The resulting fitted distribution (solid line) follows the observed peaks better above the break in slope and does not overestimate at the high end.

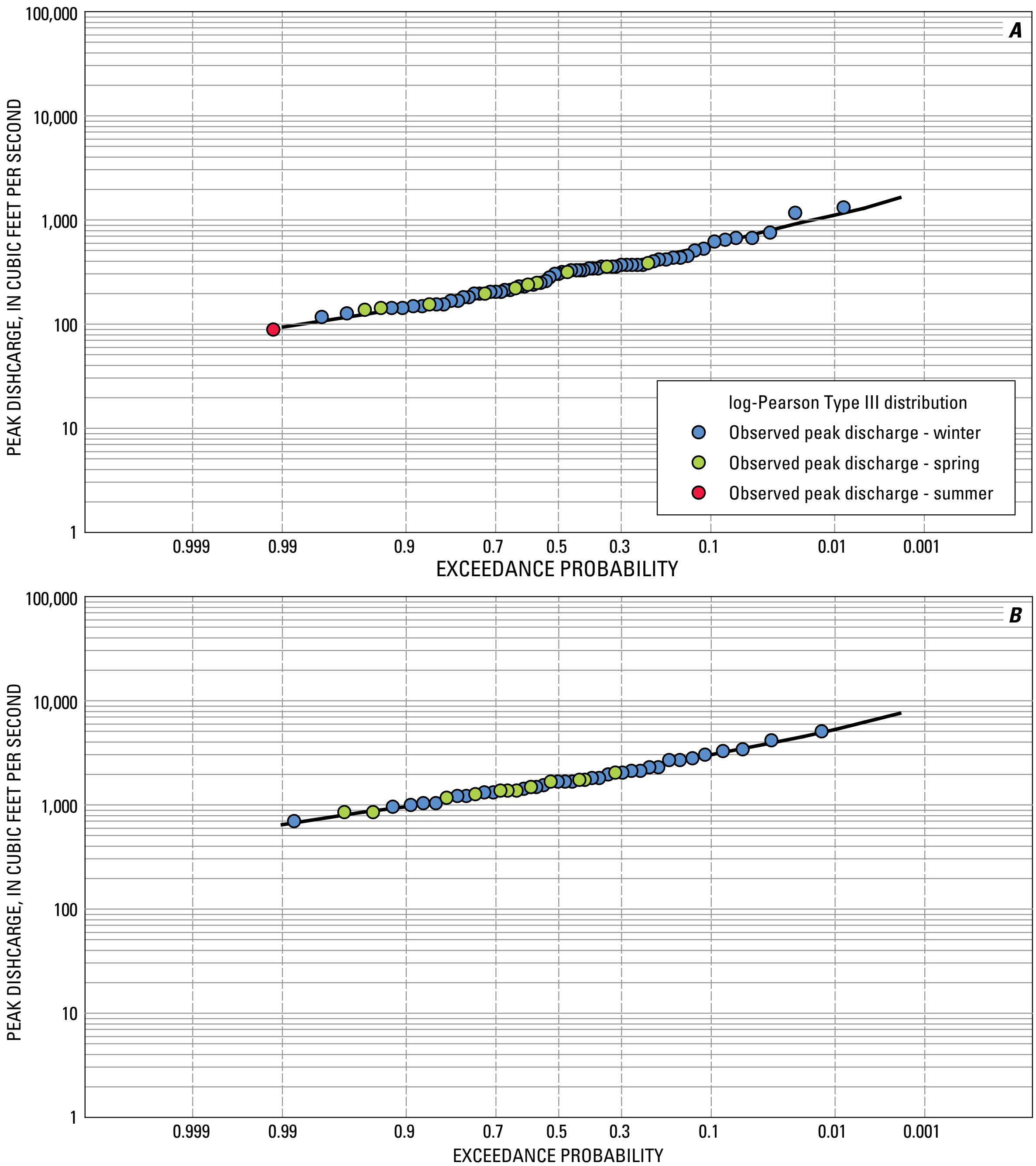

Figure 6. Log-probability plots for annual peak discharges for four gaging stations: (A) Salmon River near Government Camp, Oregon (14134000), (B) Oak Grove Fork above power plant intake, Oregon (14209000), (C) Clearwater River above Trap Creek near Toketee Falls, Oregon (14314500), and (D) Imnaha Creek near Prospect, Oregon (14331000). Peak discharges are identified as to their season of occurrence: winter is November to March, spring is April to June, and summer is July to September. Also shown are the log-Pearson Type III distributions that were fitted to the peaks.

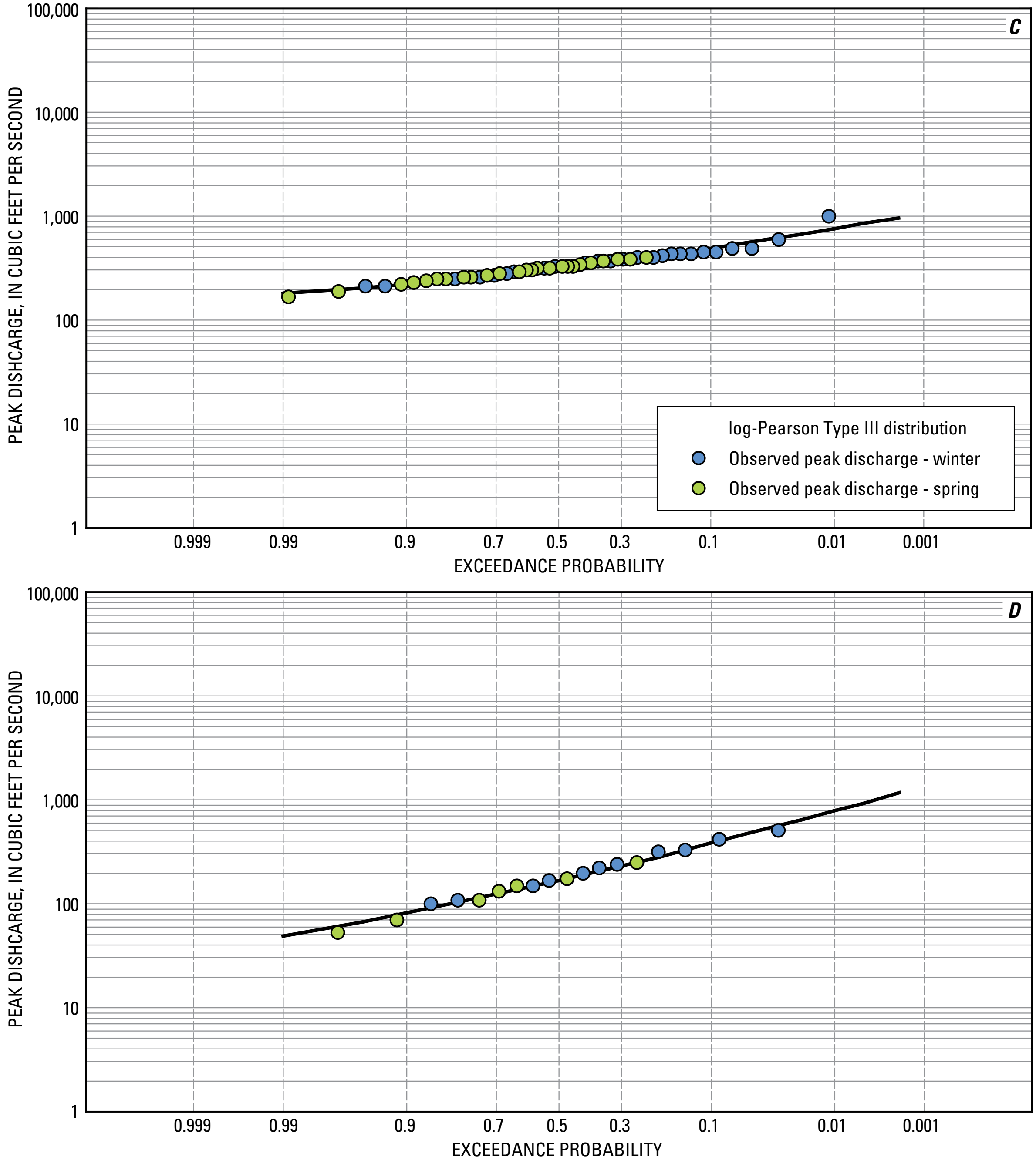

Figure 6. —Continued.

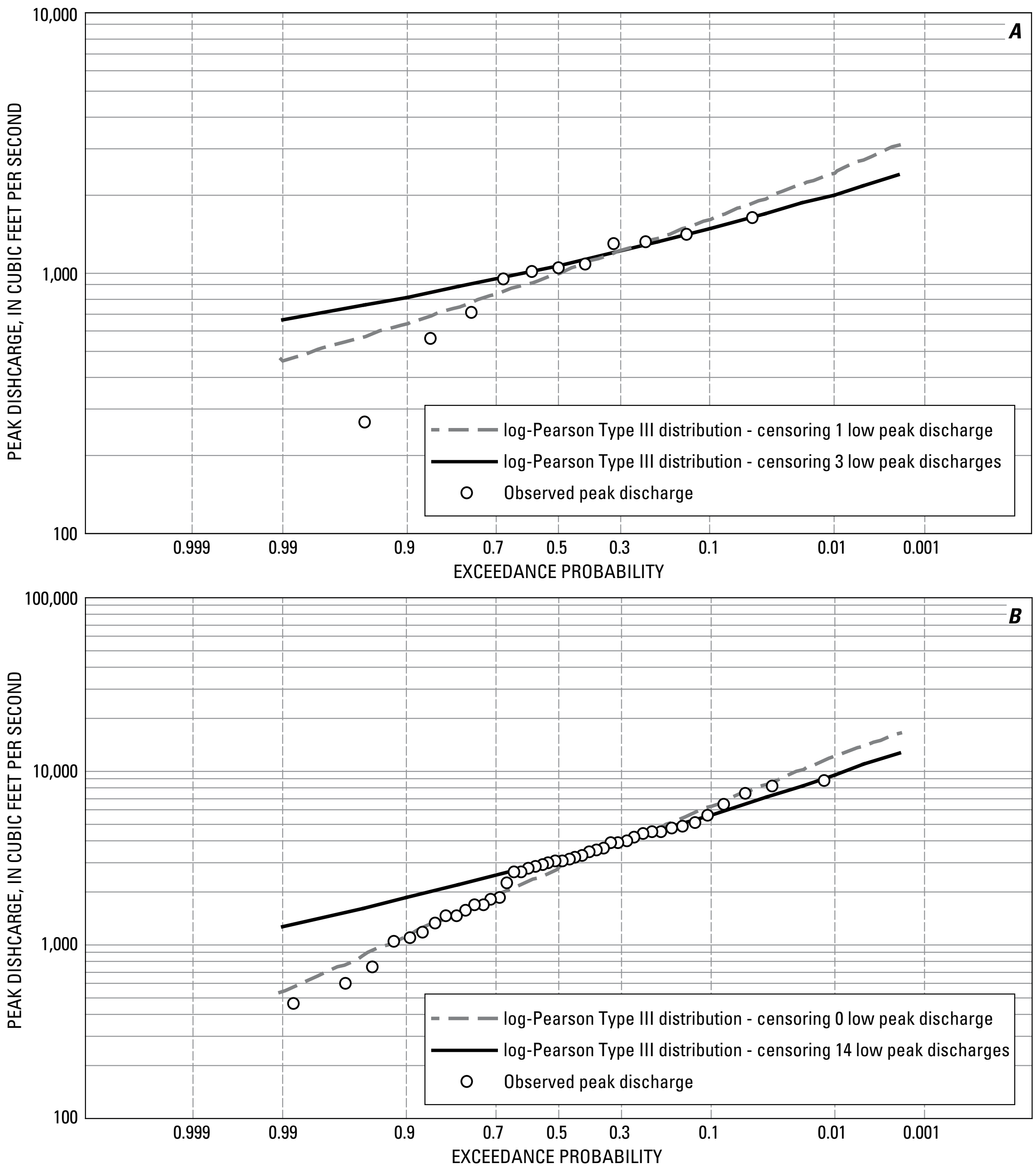

Figure 7. The effect of censoring multiple low peak discharges on the fit of the log-Pearson Type III distribution for two gaging stations: (A) Blue River above Quentin Creek near Blue River, Oregon (14161000) and (B) Big Butte Creek near McLeod, Oregon (14337500).

Generalized Skew

The skew coefficient of an annual series of peaks is sensitive to extreme values, especially when records are short. A more accurate estimate of the skew coefficient is obtained by weighting the station skew with a generalized skew value based on the skew coefficients of nearby long-term gaging stations. The weighting is based on the relative mean-square errors of the station and generalized skew and is given by this equation:

$$G_W = \frac{MSE_{\overline{G}}(G) + MSE_G(\overline{G})}{MSE_{\overline{G}} + MSE_G} \quad (2)$$

where

G_W = weighted skew coefficient,
G = adjusted station skew,
$\overline{G}$ = generalized skew,
$MSE_{\overline{G}}$ = mean-square error of the generalized skew, and
MSE_G = mean-square error of the station skew.

Included with Bulletin 17B is a map of the generalized logarithmic skew coefficients of annual maximum streamflows for the entire United States. Although many peak discharge frequency studies use this map to obtain generalized skew values, Bulletin 17B recommends that users of the guide develop their own generalized skew coefficients for their area of interest using the procedures outlined in the bulletin.

Bulletin 17B outlines three methods for developing generalized skew coefficients: (1) drawing skew isolines on a map, (2) developing skew prediction equations, and (3) using the mean of station skew values. These generalized skews are to be developed using at least 40 stations with 25 or more years of record. The isoline map is drawn by hand from station skews plotted at the centroid of their watersheds. The prediction equations are developed to relate station skews to predictor variables that include the physical or climatological characteristics of the watersheds.

For this analysis, all three methods were tried. For the isoline method, rather than drawing the map by hand as suggested by Bulletin 17B, the map was drawn using GIS techniques, by the method described by Lumia and Baevsky (2000). How this method was adapted for this analysis is described in the next section. For the skew prediction equation method, useful equations could not be developed. There is not a good linear correlation between station skew and any of the available watershed characteristics.

The analyses were done statewide and were based on 267 gaging stations with more than 25 years of record in Oregon, southern Washington, western Idaho, northwestern Nevada, and northern California. The skews used in each analysis were the station skews adjusted for the effects of high and low outliers, zero peak discharges, and peak discharges below the gage threshold (see Bulletin 17B).

The isoline and average skew methods were evaluated based on a comparison of their mean-square errors to that of the generalized skew map provided with Bulletin 17B, the method with the smallest mean-square error being preferred. Mean-square errors for the isoline method and for the generalized skew map of Bulletin 17B were calculated by estimating the skew at each of the long-term stations by each method, squaring the difference between the station skew and the generalized skew, and taking the mean of the squared differences:

$$MSE = \frac{\sum_{i=1}^{n} (G_i - \overline{G_i})^2}{n} \quad (3)$$

where

MSE = mean-square error,
G_i = station skew for gaging station i,
$\overline{G_i}$ = generalized skew for gaging station i,
n = number of stations.

For the method where the generalized skew is estimated as the mean of all station skews, the mean-square error is simply the variance of the station skews.

The mean-square error for the isoline method (MSE = 0.112) was significantly smaller than for either the mean of all stations skews (MSE = 0.222) or the generalized skew from Bulletin 17B (MSE = 0.302 for all of the United States or MSE = 0.227 for the area of the generalized skew analysis).

Developing Generalized Skew Isolines

Lumia and Baevsky's (2000) method assigns skew values to cells of a grid overlaid on the area of interest. The isolines are drawn from this grid. The grid values are estimated by a weighted average of the skews of nearby long-term gaging stations. The station skews, plotted at the centroids of their watersheds, are weighted by their distance from the grid cell and by their length of record. The closer the centroid of the watershed and the longer the station record, the more weight the station skew is given in the calculation. Lumia and Baevsky used the ARC/Info (Environmental Systems Research Institute, Inc., Redlands, California) routine GRID IDW to determine the skew value at each cell (Y.H. Baevsky, U.S. Geological Survey, written commun., 2001), and used that routine's default values for grid spacing, 10,000 meters, and number of stations, 12 (R. Lumia, U.S. Geological Survey, written commun., 2001). LATTICECONTOUR was used to determine the isolines.

This study also used these routines, however, the grid spacing and number of stations were varied to see the effect on the resulting skew isoline map. As the grid spacing decreases, the isolines become increasingly angular and blocky. As the number of stations decreases, the number of isolines increases and peaks and valleys appear around some stations. The gradients near these stations become increasingly steep.

The generalized skew map selected for this study was based on a grid spacing of 20,000 meters and 12 stations. The part of the map for western Oregon is shown in figure 8. This map was selected because it had the smallest mean square error while having skew isolines that are smooth and with no peaks or valleys. This map offers considerable improvement in mean-square error over either the generalized skew map provided by Bulletin 17B or the average of the skews of the 267 stations.

Figure 8 is provided for illustration only. A GIS (ARC/INFO) grid of the generalized skew coefficients may be obtained from the Oregon Water Resources Department (*webmaster@wrd.state.or.us*). It is recommended that generalized skew for a watershed be determined from this grid (using a GIS overlay analysis) rather than from a plotted map of generalized skew isolines.

Estimation of Magnitude and Frequency of Peak Discharges at Ungaged Sites

Peak discharges for an ungaged watershed may be estimated from prediction equations that relate peak discharge to climatologic and physical characteristics of the watershed (Thomas and Benson, 1969; Riggs, 1973). The predition equations are derived using multiple linear-regression techniques. This generalization or regionalization of peak discharges from gaged to ungaged watersheds is known as a "regional regression analysis."

For this study, a combination of regression techniques was used to derive the prediction equations. A preliminary analysis using ordinary least-squares regression was done to define flood regions of homogeneous hydrology and to determine which climatological and physical characteristics of the watersheds would be most useful in the prediction equations. The final prediction equations were derived using generalized least-squares regression (Tasker and others, 1986; Tasker and Stedinger, 1989). The computer model, GLSNET (version 2.5), developed by the U.S. Geological Survey (2000) was used for the generalized least-squares analysis.

Flood Regions

When using regression techniques to derive prediction equations, the accuracy of the equations may be improved by doing the derivations for regions of relatively uniform hydrology called, herein, flood regions. Three flood regions were defined for this study. In order to define these regions, a simple cluster analysis was used (Wiley and others, 2000). First, an ordinary least-squares regression was done using 100-year peak discharges as the response variable and drainage area as the only predictor variable. Then, the residuals from the regression were plotted at the centroids of their respective watersheds on a map of the study area. Clusters of residuals of similar sign and magnitude were presumed to indicate areas of similar hydrology and were defined as flood regions. This procedure was repeated for each flood region as it was defined until no clusters of residuals were apparent,

Immediately apparent from the plot of residuals was a line of large negative residuals along the crest of the Cascade Range (fig. 9). Assuming these large negative residuals to be related to elevation, all the residuals were plotted against the mean elevation of their corresponding watersheds.

Figure 10 shows that the relationships between residuals and mean watershed elevation above and below 3,000 feet are remarkably different. Below 3,000 feet, the residuals increase slightly with elevation. Above 3,000 feet, the trend reverses, and the residuals rapidly decrease with elevation. The model greatly over predicts at the highest elevations. The behavior of the residuals relative to elevation demonstrates the earlier observation that the hydrologic processes generating peak discharges above and below 3,000 feet are different.

The gaging stations for western Oregon were divided into two groups based on elevation, those above 3,000 feet and those below. In each group, the 100-year peak discharges were regressed on area and the residuals plotted. For the gaging stations above 3,000 feet, no clear groupings of residuals occurred. The gaging stations above 3,000 feet, then, represent one flood region.

The plot of residuals for gaging stations with mean watershed elevations below 3,000 feet showed large positive to slightly negative residuals west of the crest of the coastal mountains and large negative to slightly positive residuals in the remaining area. Based on this distribution of residuals, the gaging stations were divided into two groups, east and west of the crest of coastal mountains. For the gaging stations in each group, the 100-year peak discharges were regressed on drainage area and the residuals were plotted. As no clear grouping of residuals occurred in either group, the area associated with each group of stations was defined as a flood region and no further divisions were made.

The three flood regions in western Oregon are shown on figure 11. It is not possible, however, to show a boundary between watersheds with mean elevations above and below 3,000 feet. The 3,000-foot elevation contour is *not* the boundary. Consider a large watershed with mean elevation above 3,000 feet. It may contain subwatersheds with mean elevations less than 3,000 feet. An areally delineated region containing the large, high elevation watershed cannot also contain the smaller, lower elevation watersheds. This dilemma cannot be resolved on a map.

To facilitate identification and labeling of the regions, western Oregon first is divided into two regions: Region 1, west of the crest the coastal mountains, and Region 2, east of the crest of the coastal mountains. All of the gaged watersheds with elevations above 3,000 feet occur in Region 2. Region 2, then, is divided into two subregions, 2A and 2B, based

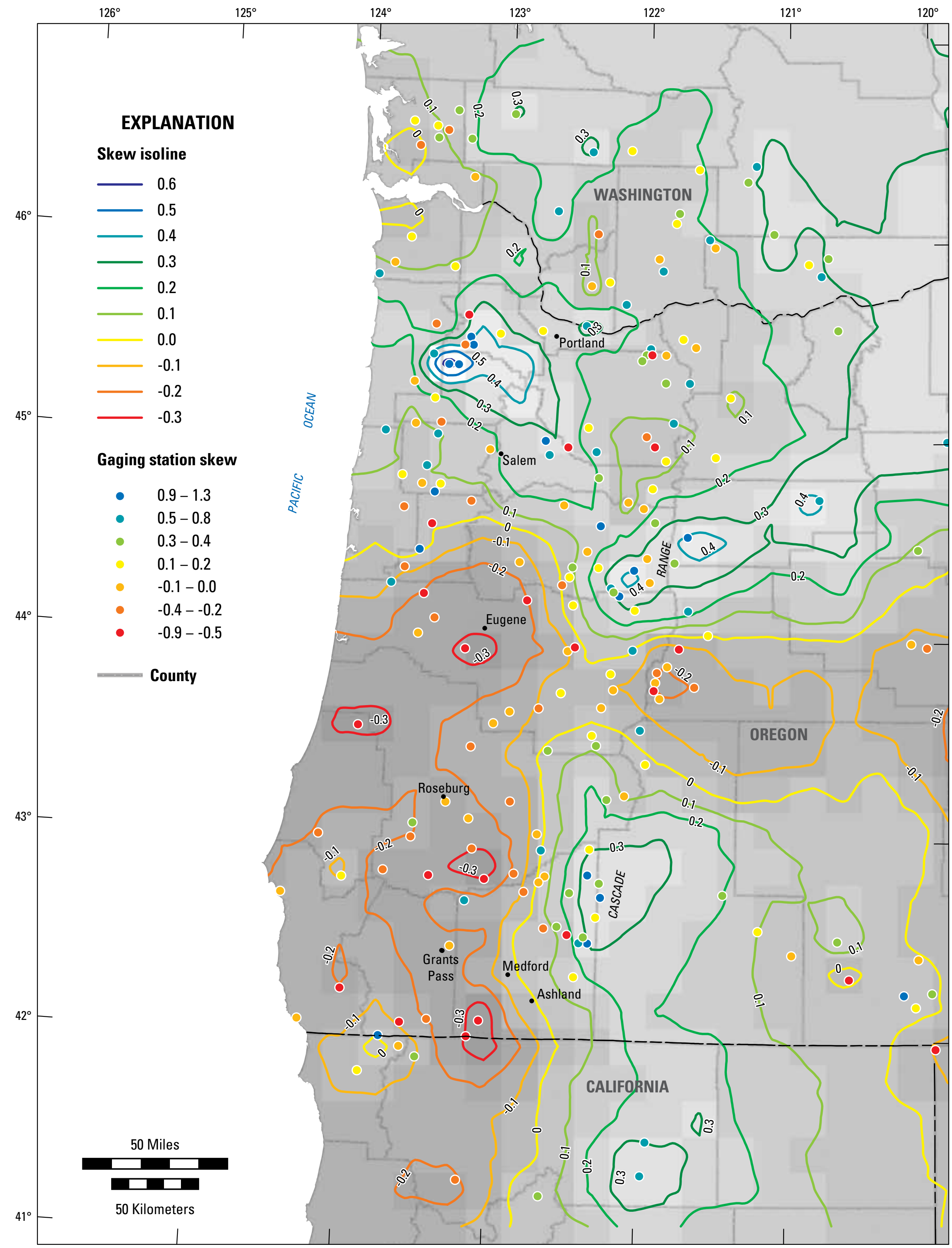

Figure 8. Generalized logarithmic skew coefficients for western Oregon. Isoline interval is 0.1. The colored circles represent skew coefficients of long-term gaging stations and are located at the centroids of their respective watersheds. The shaded background represents the Geologic Information System grid on which the isolines are based. Darker shades represent negative skews, and lighter shades, positive skews. The value of the skew cofficient for each grid cell was calculated as a weighted average of nearby gaging station skews.

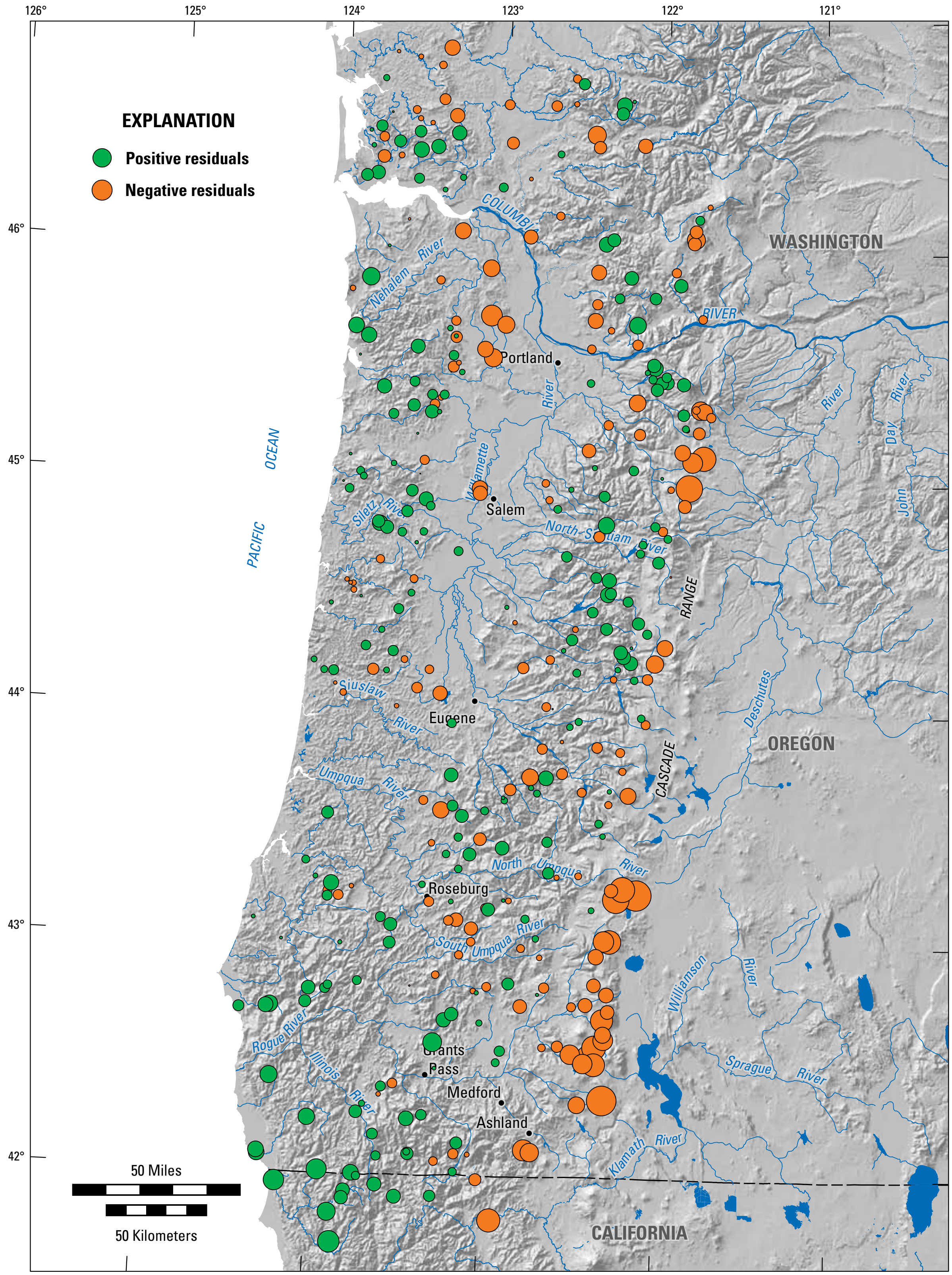

Figure 9. Residuals from a regression of 100-year peak discharges on watershed area for all gaging stations in western Oregon. The size of each circle is proportional to the absolute value of the residual. Negative residuals are shown in orange, and positive residuals in green. Note the line of large negative residuals along the crest of the Cascade Range.

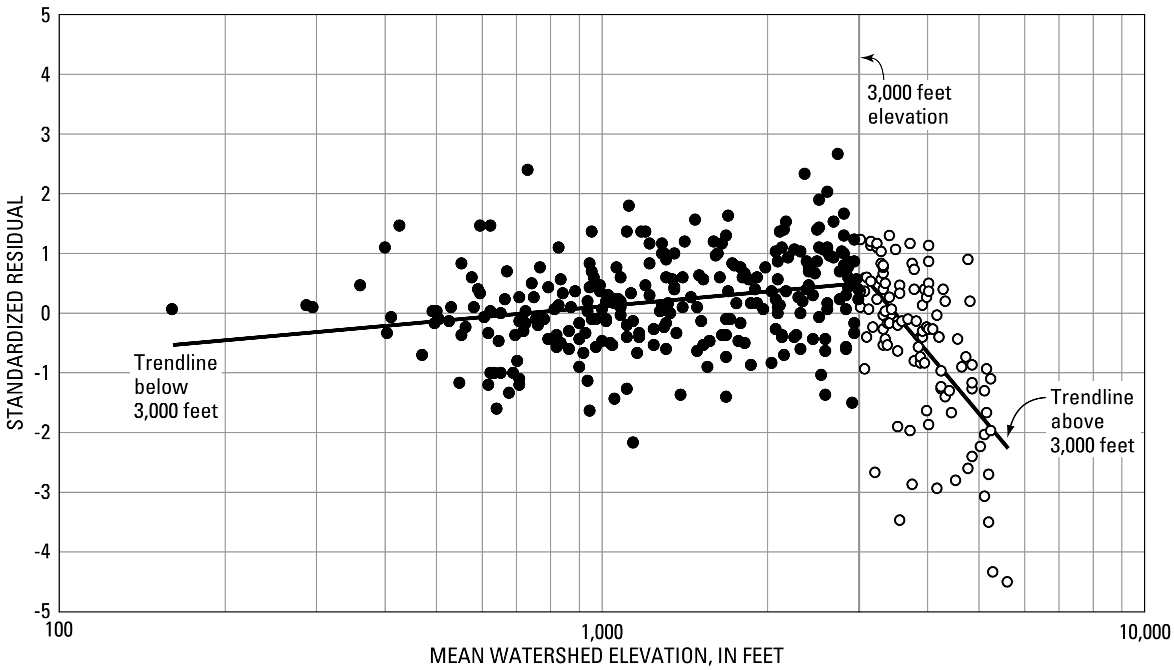

Figure 10. Relation of standardized residuals from a regression of 100-year peak discharges on watershed area to the mean elevation of their respective watersheds.

on mean watershed elevation. Region 2A represents gaging stations with mean watershed elevations above 3,000 feet, and Region 2B, gaging stations with mean watershed elevations below 3,000 feet. Although Regions 2A and 2B cannot be delineated on a map, the locations of the gaging stations associated with each region are shown to give a rough approximation of the areal extent of each region.

Watershed Characteristics

Ninety-two watershed characteristics were available for this study (Appendix F). For each gaging station, the 92 watershed characteristics were estimated using the GIS computer program ARC/INFO 7.2.1 (Environmental Systems Research Institute, Inc., Redlands, California).

In a GIS analysis of watershed characteristics, each characteristic is associated with either a coverage (vector data) or a grid (raster data). For this study, the elevation grid (digital elevation model) came from the National Center for Earth Resources Observation & Science (1999). The precipitation and temperature grids came from the Oregon Climate Service (G.H. Taylor, Oregon State Climatologist, written commun., 2000, 2001). The soils coverage came from the National Cartography and Geospatial Center (1994). The climatologic characteristic grids from the Oregon Climate Service were generated using PRISM (Daly and others, 1997). PRISM stands for Parameter-elevation Regressions on Independent Slopes Model.

To begin, each watershed was delineated from U.S. Geological Survey 1:24,000 scale topographic maps and digitized into a coverage of all watersheds. The locations of the outlet and the centroid, the area, and the perimeter of each watershed were calculated directly from this coverage. For other characteristics, the watershed coverage was over-laid on the respective watershed characteristic coverage or grid. Stream length and percent area of lakes and ponds were determined from an overlay of the hydrography coverage. Relief was calculated simply as the difference of the highest and lowest elevations in the watershed determined from the elevation grid. For all others, the value of the characteristic was calculated as its average over the area of the watershed. The GIS analysis of watershed characteristics was implemented using an Arc Macro Language script. The script is available from the Oregon Water Resources Department on request (*webmaster@wrd.state.or.us*).

Most of the 92 characteristics were not used in the regression analysis. Some of the characteristics, such as the location of the centroid of a watershed, perimeter length or minimum watershed elevation, are poorly (or not at all) related to peak discharges. Others, such as percent of a watershed above 3,000 feet, tend to cluster at one or two values. For example, most coastal watersheds have zero percent of their area above 3,000 feet. Many of the characteristics, including the various monthly precipitation or temperature characteristics, are highly correlated with each other. Using combinations of these characteristics in a regression analysis does not add information and may lead to unstable and unreliable regression coefficients. Based on these considerations and some trial regressions using ordinary least-squares regression analysis, 15 characteristics were selected for the generalized least-squares regression analysis

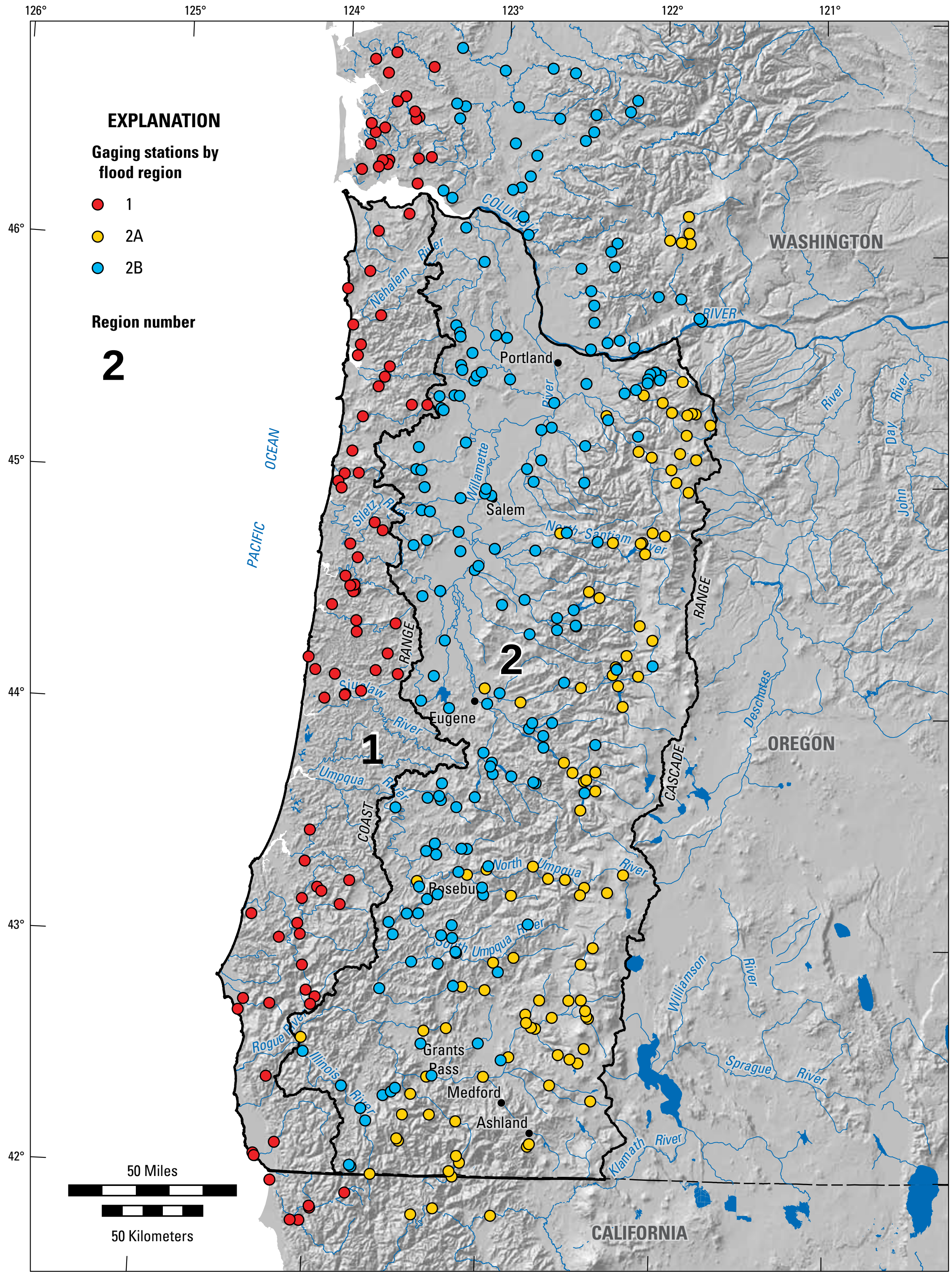

Figure 11. Flood regions of western Oregon. Regions 2A and 2B cannot be separated into discrete areas and are shown together as Region 2; however, the gaging stations associated with Regions 2A and 2B give a rough approximation of the areal extent of each region.

(table 2). These 15 characteristics for each of the 376 gaged watersheds used in the regional regression analysis are given in Appendix G.

The 15 selected characteristics were checked for collinearity. Matrices of the correlation coefficients for the characteristics of the watersheds for each of the three flood regions are shown in tables 3, 4, and 5. High correlation coefficients (absolute values greater than about 0.80) were detected. These pairs of characteristics were not allowed to appear together in a prediction equation.

The area determined for each gaged watershed from the spatial analysis was compared to its published value. Where significant differences occurred, the delineation of the watershed was checked. Errors in both the delineations and in the published areas were discovered in this way. The distribution of gaged watersheds by area and region is shown in table 6.

Description of the Watershed Characteristics

The computed characteristics represent the contributing watershed upstream of the gaging station, or other point of interest. The watershed is delineated based on topography as shown on U.S. Geological Survey 1:24,000-scale topographic maps.

Drainage area is the size of the watershed in square miles.

Maximum watershed relief is the maximum difference in elevation, in feet, between the lowest and the highest points in a watershed. The lowest point in the watershed is the outlet (or pour point) of the watershed. Relief is often highly correlated with area.

Mean watershed slope is calculated as the average of the slope of all the cells of the digital elevation model found within the watershed boundaries. Slope is given in degrees. For example, a 0 degree slope is horizontal, and a 90 degree slope is vertical.

Mean watershed elevation is calculated as the average of the elevations of all the cells of the digital elevation model found within the watershed boundaries. It is reported in feet.

Mean January precipitation, mean July precipitation, 24-hour 2-year precipitation intensity, and annual snowfall are calculated as the average of the values of all the cells of their respective grids found within the watershed boundary. All are reported in inches. Each of the grids represents averages for water years 1961 to 1990.

Mean minimum January temperature, mean minimum July temperature, mean maximum January temperature, and mean maximum July temperature are calculated as the average of the values of all the cells of their respective grids found within the watershed boundary. All are reported in degrees Fahrenheit. Each of the grids represents averages for water years 1961 to 1990.

Table 2. Watershed characteristics considered for the regression analysis.

[Units: mi², square miles; ft, feet; in, inches; in/hr, inches per hour; °, degrees; °F, degrees Fahrenheit]

Characteristic	Units	Data type	Scale or resolution	Source
Drainage area	mi^2	vector	1:24,000	Water Resources Department
Maximum watershed relief	ft	grid	30 m	U.S. Geological Survey
Mean watershed slope	°	grid	30 m	U.S. Geological Survey
Mean watershed elevation	ft	grid	30 m	U.S. Geological Survey
Mean January precipitation	in	grid	4,000 m	Oregon Climate Service
Mean July precipitation	in	grid	4,000 m	Oregon Climate Service
2-year 24-hour precipitation intensity	in	grid	3,000 m	Oregon Climate Service
Annual snowfall	in	grid	4,000 m	Oregon Climate Service
Mean minimum January temperature	°F	grid	4,000 m	Oregon Climate Service
Mean minimum July temperature	°F	grid	4,000 m	Oregon Climate Service
Mean maximum January temperature	°F	grid	4,000 m	Oregon Climate Service
Mean maximum July temperature	°F	grid	4,000 m	Oregon Climate Service
Soil storage capacity	in	vector	1:250,000	Natural Resources Conservation Service
Soil permeability	in/hr	vector	1:250,000	Natural Resources Conservation Service
Soil depth	in	vector	1:250,000	Natural Resources Conservation Service

Table 3. Correlation matrix of predictor variables for the 91 gaging stations of Region 1, coastal watersheds.

[Variables: All variables are log-transformed. Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soil storage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches. Correlations greater than 0.80 are in bold face.

	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mn Jul T	Mx Jan T	Mx Jul T	Soil C	Soil P	Soil D
Area	1.00														
Relief	**0.82**	1.00													
Slope	0.26	0.64	1.00												
Elev	0.28	0.64	0.77	1.00											
Jan P	0.11	0.29	0.26	0.27	1.00										
Jul P	-0.05	0.07	-0.02	0.13	0.49	1.00									
I24-2	0.18	0.40	0.42	0.42	**0.91**	0.38	1.00								
Snow	0.35	0.63	0.57	0.71	0.61	0.27	0.66	1.00							
Mn Jan T	0.01	-0.15	-0.14	-0.30	-0.48	-0.50	-0.40	-0.54	1.00						
Mn Jul T	-0.09	-0.20	-0.14	-0.16	-0.60	-0.47	-0.53	-0.38	0.59	1.00					
Mx Jan T	0.01	-0.15	-0.12	-0.26	-0.64	-0.62	-0.54	-0.62	**0.86**	0.48	1.00				
Mx Jul T	-0.11	-0.19	-0.07	-0.08	-0.66	-0.66	-0.51	-0.48	0.39	0.53	0.62	1.00			
Soil C	-0.14	-0.31	-0.41	-0.53	0.24	0.37	0.03	-0.20	-0.14	-0.37	-0.21	-0.49	1.00		
Soil P	0.30	0.41	0.35	0.38	0.28	0.44	0.34	0.39	-0.32	-0.15	-0.39	-0.38	-0.09	1.00	
Soil D	-0.09	-0.15	-0.30	-0.30	0.32	0.57	0.05	0.01	-0.21	-0.25	-0.35	-0.54	0.59	0.15	1.00

Table 4. Correlation matrix of predictor variables for the 107 gaging stations of Region 2A, western interior watersheds with mean elevations above 3,000 feet.

[Variables**:** All variables are log-transformed. Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C**,** soil storage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches. Correlations greater than 0.80 are in bold face]

	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mn Jul T	Mx Jan T	Mx Jul T	Soil C	Soil P	Soil D
Area	1.00														
Relief	**0.81**	1.00													
Slope	-0.13	-0.02	1.00												
Elev	-0.06	0.05	-0.52	1.00											
Jan P	-0.16	-0.07	0.18	-0.29	1.00										
Jul P	-0.13	-0.05	-0.31	0.15	0.70	1.00									
I24-2	-0.15	-0.07	0.20	-0.04	**0.85**	0.61	1.00								
Snow	0.08	0.13	-0.56	0.51	0.44	**0.80**	0.41	1.00							
Mn Jan T	-0.02	-0.08	0.71	-0.76	0.20	-0.32	0.18	-0.60	1.00						
Mn Jul T	-0.11	-0.13	0.59	-0.68	0.11	-0.36	0.10	-0.65	**0.88**	1.00					
Mx Jan T	0.21	0.09	0.47	-0.46	-0.31	-0.63	-0.22	-0.68	0.69	0.46	1.00				
Mx Jul T	0.18	0.04	0.31	-0.48	-0.39	-0.62	-0.32	-0.69	0.54	0.43	**0.88**	1.00			
Soil C	0.11	-0.01	-0.16	-0.18	0.39	0.53	0.20	0.41	-0.11	-0.31	-0.08	-0.04	1.00		
Soil P	0.10	0.13	-0.29	0.33	0.35	0.53	0.27	0.66	-0.48	-0.61	-0.43	-0.42	0.39	1.00	
Soil D	0.16	0.03	-0.52	0.04	0.33	0.54	0.11	0.56	-0.26	-0.29	-0.30	-0.20	0.69	0.44	1.00

Table 5. Correlation matrix of predictor variables for the 178 gaging stations of Region 2B, western interior watersheds with mean elevations less than 3,000 feet.

[Variables**:** All variables are log-transformed. Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C**,** soil storage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches. Correlations greater than 0.80 are in bold face]

	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mn Jul T	Mx Jan T	Mx Jul T	Soil C	Soil P	Soil D
Area	1.00														
Relief	**0.84**	1.00													
Slope	0.24	0.54	1.00												
Elev	0.28	0.64	0.65	1.00											
Jan P	0.11	0.29	0.19	0.28	1.00										
Jul P	-0.06	0.07	-0.08	0.14	0.50	1.00									
I24-2	0.18	0.39	0.37	0.43	**0.92**	0.39	1.00								
Snow	0.35	0.62	0.45	0.71	0.63	0.29	0.67	1.00							
Mn Jan T	0.00	-0.16	-0.03	-0.30	-0.48	-0.51	-0.41	-0.55	1.00						
Mn Jul T	-0.10	-0.21	-0.10	-0.18	-0.60	-0.48	-0.53	-0.40	0.60	1.00					
Mx Jan T	0.01	-0.15	0.00	-0.26	-0.65	-0.64	-0.55	-0.63	**0.87**	0.49	1.00				
Mx Jul T	-0.10	-0.18	-0.03	-0.09	-0.66	-0.67	-0.52	-0.50	0.40	0.53	0.64	1.00			
Soil C	-0.13	-0.30	-0.41	-0.53	0.23	0.37	0.02	-0.19	-0.12	-0.35	-0.21	-0.49	1.00		
Soil P	0.31	0.42	0.34	0.36	0.30	0.46	0.36	0.39	-0.33	-0.17	-0.39	-0.41	-0.08	1.00	
Soil D	-0.09	-0.14	-0.33	-0.30	0.31	0.56	0.05	0.01	-0.21	-0.24	-0.35	-0.53	0.60	0.17	1.00

Table 6. Numbers of gaging stations and their average record length by area and region.

Area, in square miles	Region 1		Region 2A		Region 2B	
	Number of gages	Average record length, in years	Number of gages	Average record length, in years	Number of gages	Average record length, in years
<1	13	15. 8	1	14.0	12	19.9
1–3	16	18.1	7	15.0	23	18.4
3–10	14	16.9	10	21.9	22	18.0
10–30	14	17.0	15	23.1	21	23.4
30–100	15	25.9	24	27.7	48	28.0
100–300	14	39.1	25	42.8	30	40.6
300–1,000	5	46.8	17	37.9	15	34.9
1,000–3,000	0	N/A	7	36.1	4	35.3
>3,000	0	N/A	1	16.0	3	67.3
Total	91	23.5	107	31.2	178	28.0

Soil capacity is the maximum volume of water the soil is expected to hold. It is calculated as the area-weighted average of the soil capacity for all the soils found within the watershed boundary. Soil capacity for a given soil is its porosity times its depth. Soil capacity is reported in inches.

Soil permeability is the rate at which water is expected to infiltrate the soil. It is calculated as the area-weighted average of the infiltration rate for all the soils found within the watershed boundary. It is reported in inches per hour.

Soil depth is the depth of soil to bedrock averaged over the watershed. It is reported in inches.

Selection of Gaging Stations

Within the study area and adjacent parts of Washington and California there are between 450 and 500 gaging stations where peak discharges have been systematically recorded. Of these, 399 stations had more than 10 years of record and were in rural watersheds unaffected by significant diversion, regulation or urbanization. Twenty-four of these stations were eliminated for a variety of reasons.

The locations of four gaging stations could not be determined: Darlingtonia Creek at Darlingtonia, California (11530950), Lookout Creek tributary no. 3 near Blue River, Oregon (14161200), South Fork Weiss Creek near Waldport, Oregon (14306850), and Buck Creek tributary near Scottsburg, Oregon (14323020). Published information about the station location (latitude and longitude, physical description, public land survey, and drainage area) could not be reconciled with any actual watershed on 1:24,000 scale topographic maps.

Peak discharges at four gaging stations are located at the outlets of large natural lakes: Tenmile Creek near Lakeside, Oregon (14323200), Eel Creek at Lakeside, Oregon (14323300), Waldo Lake outlet near Oakridge, Oregon (14147000), and McKenzie River at outlet of Clear Lake, Oregon (14158500). The lakes all occupy more than 5 percent of the drainage area above their respective stations. Peak discharges are presumed to be significantly attenuated.

Peak discharges at eight gaging station poorly fitted the log-Pearson Type III distribution: Beaver Creek near Klamath River, California (11517800), Soap Creek tributary near Fort Jones, California (11518610), Middle Fork Willamette River at Jasper, Oregon (14152000), Grant Creek near Falls City, Oregon (14190350), Collawash River tributary near Breitenbush Hot Springs, Oregon (14208200), Kink Creek near Government Camp, Oregon (14209100), South Fork Deer Creek near Dixonville, Oregon (14312170), and Star Gulch near Ruch, Oregon (14362250). For each station, the upper end of the distribution is poorly defined, and peak discharges estimated from it are uncertain. As an example, the fit for gaging station Collawash River tributary near Breitenbush Hot Springs, Oregon (14208200) is shown on figure 12.

Thielsen Creek near Diamond Lake, Oregon (14312700) is underlain by young, highly porous volcanic rock. The watershed boundary is uncertain and significant stream losses occur.

In several cases, gaging stations occur near each other on the same stream reach. In six of these cases, one or other of each pair was eliminated: Middle Santiam River near Upper Soda, Oregon (14185700), Wiley Creek at Foster, Oregon (14187100), North Umpqua River below Steamboat Creek near Glide, Oregon (14316800), Rogue River below Prospect, Oregon (14330000), Applegate River near Ruch, Oregon (14363000), and Illinois River at Kerby, Oregon (14377000). For each pair, estimated peak discharges at the upstream station are greater than at the downstream station. The apparent decrease in discharge occurs not because of stream losses, but because of uncertainty in estimating the peak discharges. For each pair, only the station considered the most reliable was retained. The stations were judged on their length and quality of record and their fit to the probability distribution.

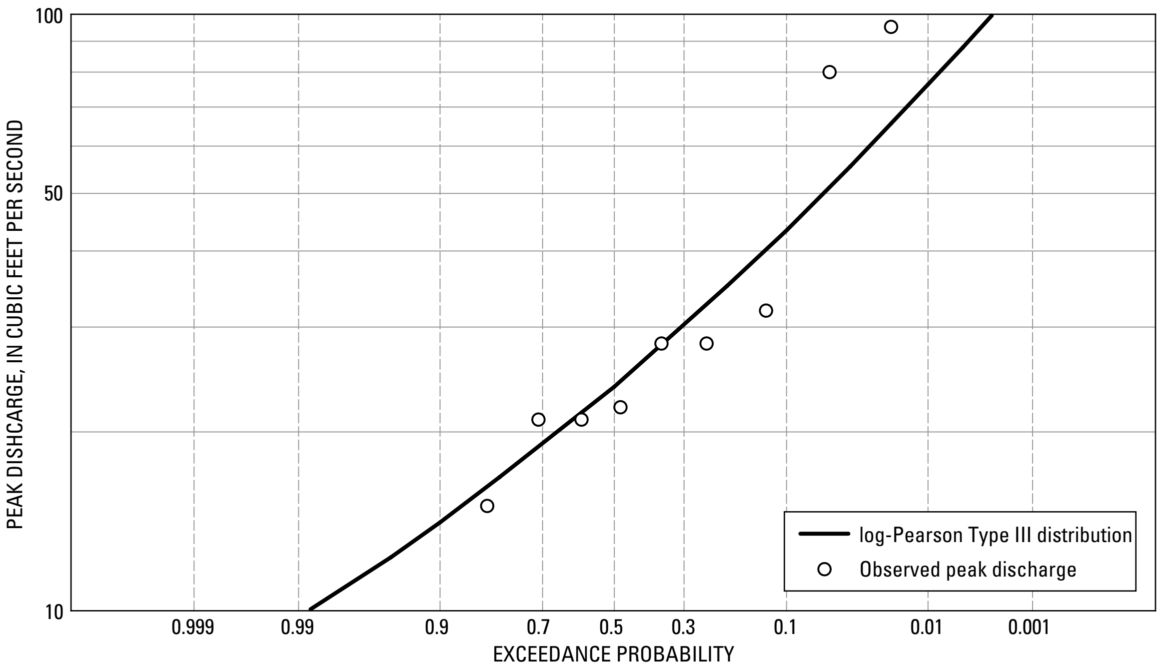

Figure 12. The fitted log-Pearson Type III distribution for gaging station Collawash River Tributary near Breitenbush Hot Springs, Oregon (14208200). The upper end of the distribution is poorly defined, and peak discharges estimated from it are uncertain. This station was one of eight eliminated because of its poor fit to the probability distribution.

The Regression Analysis

A regional regression analysis is based on the assumption that streamflow is related to various physical and climatological characteristics. For example, streamflow increases with watershed size, other factors, such as precipitation, being equal. A 100-square-mile watershed produces more runoff than a 25-square-mile watershed.

As an example, the relationship between 100-year peak discharges and watershed area for Region 1 is shown in figure 13. The line shown on the plot minimizes the sum of the squared vertical differences between the line and the points. The line “models” the relationship between peak discharge and watershed area. It can be used to predict the peak discharge for a watershed in the same region given its area. The variation about the line is due, in part, to other watershed characteristics not included in the model.

Similar relationships exist between peak discharge and other watershed characteristics (table 2), each characteristic accounting for part of the variability in streamflow. These relationships can be quantified in a mathematical form. For this analysis, a linear relationship is assumed between streamflow and watershed characteristics. The linear mathematical model takes the form

$$y = b_0 + b_1x_1 + b_2x_2 + b_mx_m \tag{4}$$

where y represents streamflow and $x_1, x_2, \ldots, x_m$ represent the *m* watershed characteristics. The regression coefficients, $b_1, b_2, \ldots, b_m$ define the relationship among variables and are determined from the data. The data consist of *n* observations of y and x_m, from which *n* equations of the type of Equation 4 can be written. The regression coefficients are determined by minimizing the sum of the squared differences between the actual values of y and the values of y estimated by the *n* equations. The equations resulting from this minimization are called the normal equations.

While regression analysis assumes a linear relationship between the response and predictor variables, the true relationship for peak discharges is nonlinear. A log-transformation of peak discharges and watershed characteristics allows the nonlinear relationship to be modeled by a linear relationship (Riggs, 1968; 1973).

The nonlinear model of the relationship between streamflow and watershed characteristics looks like this:

$$y = 10^{b_0} x_1^{b_1} x_2^{b_2} \cdots x_m^{b_m} \tag{5}$$

A logarithmic transformation of Equation 5 yields the linear relationship

$$\log_{10}(y) = b_0 + b_1\log_{10}(x_1) + b_2\log_{10}(x_2) + \cdots + b_m\log_{10}(x_m) \tag{6}$$

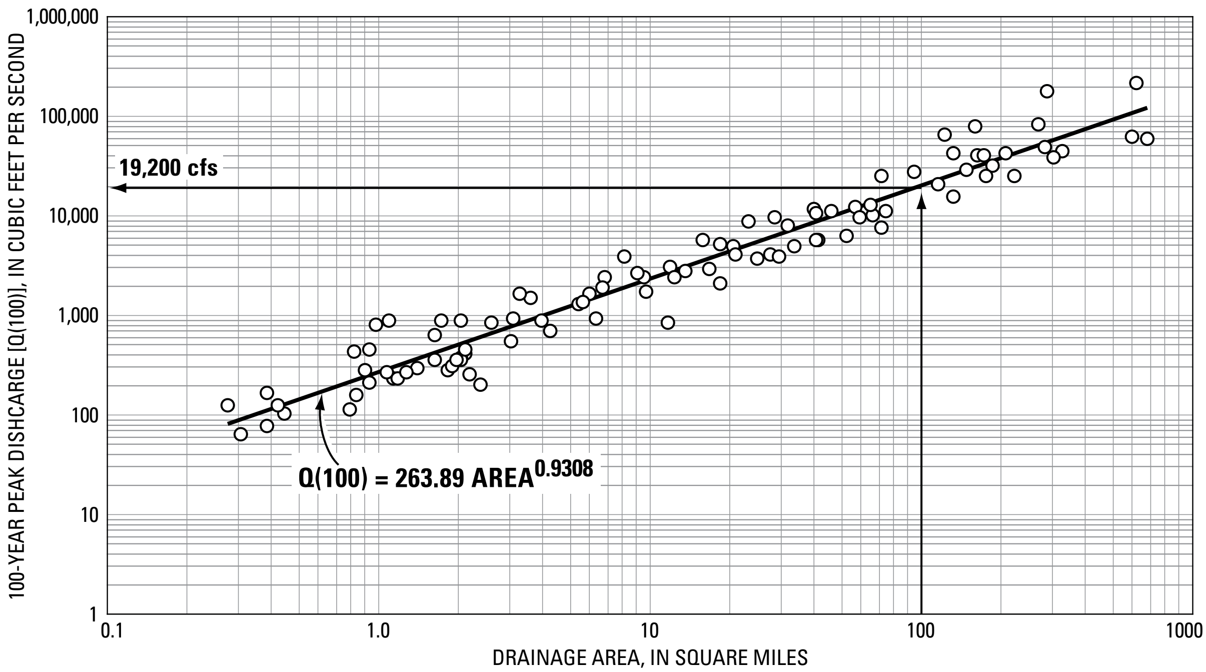

Figure 13. A simple regional regression model. 100-year peak discharges are plotted against watershed area for Region 1, coastal watersheds. The line (i.e., the model) through the data points was fitted by ordinary least squares regression analysis and is represented mathematically by the equation shown on the graph. Based on this model, a watershed of 100 square miles has a 100-year peak discharge of about 19,200 cfs (cubic feet per second).

Previous studies in Oregon have used ordinary least-squares regression to derive the prediction equations. Ordinary least-squares regression assumes that peak discharge records are equally reliable, i.e., of the same length and variance, and that concurrent flows at any pair of stations are independent. These conditions are seldom met in practice.

Tasker and Stedinger (1989) proposed an operational generalized least-squares model for deriving prediction equations for streamflow characteristics such as peak discharge. This model accounts for the unequal lengths and variances of streamflow records and cross-correlation between series of streamflow characteristics. Tasker and others (1986) showed that generalized least squares, compared to ordinary least squares, provides (1) estimates of regression parameters with smaller mean square errors, (2) relatively unbiased estimates of the variance of the regression parameters, and (3) a more accurate estimate of the model error. The prediction equations in this study were derived using generalized least-squares regression.

Defining the Prediction Equations

Only some of the 15 watershed characteristics are correlated with peak discharge. Since only correlated watershed characteristics can explain the observed variability in peak discharges, there is no benefit to including all characteristics in a prediction equation. The goal, then, is to find the prediction equation that explains as much of the observed variability in peak discharges as possible with the fewest number of watershed characteristics.

With 15 watershed characteristics, the number of possible prediction equations is $2^{15} - 1$ or 32,767. Rather than test all possible prediction equations, a backward-step analysis may be used to determine the best prediction equation. In a backward step analysis, a regression is done using all candidate watershed characteristics. The characteristic that has the least significant coefficient is eliminated and the regression is run again. This process is repeated until only one characteristic remains.

Each regression is associated with a set of watershed characteristics and their respective coefficients, and each set of characteristics and coefficients represents a candidate prediction equation. The best prediction equation generally is considered the combination of watershed characteristics that gives the smallest model error while its regression coefficients are all significantly different from zero. The significance of the regression coefficients is determined by a statistical test (Student's t-test was used).

The null hypothesis, H_o, is that the coefficient in question is equal to zero. The statistical test determines the probability, P, that the coefficient is *not* different from zero. H_o is rejected, and the coefficient retained, for small values of P. In this analysis, H_o is rejected for P less than 0.05.

The computer program used to do the generalized least squares regressions (GLSNET, version 2.5), limits the number of predictor variables to 9, so the set of 15 watershed characteristics had to be reduced to 9 or fewer for each region. First, highly correlated pairs of watershed characteristics ($r \geq 0.8$) were identified for each region. A regression was done for each characteristic from each pair. Only the characteristic with the most significant regression coefficient was retained. Second, regressions were done using ordinary least squares analysis to determine the characteristics most likely to be significantly correlated to peak discharge from among the remaining characteristics.

When the set of nine or fewer characteristics was determined for each region, a backward step analysis was done using the 100-year peak discharges. The results of the backward-step analyses for Regions 1, 2A, and 2B are shown in tables 7, 8, and 9, respectively.

The set of characteristics determined for the 100-year peak discharges was used for all frequencies. If a backward step analysis is done independently at each frequency, the resulting prediction equations may incorporate different predictor variables. While this may lead to the smallest model errors for each equation, it may lead to undesirable results overall. Specifically, flood magnitude may not vary smoothly with frequency—a plot of magnitude versus frequency likely will show discontinuities. It is even possible that the magnitude of a high frequency event will exceed the magnitude of a low frequency event. For example, the 10-year event could be larger than the 25-year event.

The final prediction equations are shown by region in tables 10, 11, and 12. Maps of all of the characteristics used in the prediction equations are shown in figures 14, 15, 16, 17, 18, and 19. These maps are for illustration only. It is strongly recommended that estimates of watershed characteristics be made from the digital grids and coverages described in table 2 using GIS techniques.

Accuracy of the Prediction Equations

Measures of the accuracy of the prediction equations are average prediction error (Wiley and others, 2000) and equivalent years of record (Hardison, 1971). These measures are reported in tables 10, 11, or 12 for all prediction equations developed in this analysis. The average prediction error ranged from 25.3 to 39.1 percent over the three flood regions. Equivalent years of record varied from 2.0 to 13.6 years. Flood Regions 2A and 2B had the highest average prediction errors, and Region 1, the lowest.

The average prediction error is the square root of the sum of the squared standard error of the model and the average squared standard error of sampling, in log units. Model error is the uncertainty due to a model that does not account for all the variability in peak discharges. Sampling error is the uncertainty due to estimating model parameters from a sample, i.e., not from the whole population (Tasker and Stedinger, 1989). For the prediction equations, the average error of prediction is within 3.5 percentage points of the model error in all cases. Sampling error is a small part of the total error.

In practical terms, the small sampling error compared to the large model error means increasing the length of record available for estimating the peak discharges at gaged watersheds will not significantly decrease the average error of prediction. More benefit would result from improving the models by increasing the accuracy with which current watershed characteristics are estimated or by adding new characteristics to account for previously unaccounted for variability. The preceding comment does not mean that estimates of peak discharge at individual gaging stations could not be improved by additional years of record. Estimates at short record stations likely would be improved by additional record.

An equivalent number of years of record is the number of years of actual record required to give the same average prediction error as the regression. It is also used as a weighting factor in estimating peak discharges at gaging stations (Equation 9—discussed later). Hardison (1971) describes the calculation for estimating an equivalent number of years of record.

Transition Zone between Regions 2A and 2B

Although watersheds with mean watershed elevations above and below 3,000 feet are assigned to different flood regions (2A and 2B), the effect of elevation on peak discharge should change smoothly as elevation increases through 3,000 feet. Ideally, then, there should be a smooth transition of peak discharge estimates from one flood region into the other. In fact, there is often a discontinuity. For a watershed with a mean elevation near 3,000 feet, calculation of peak discharges by prediction equations for both Regions 2A and 2B generally do not yield the same result.

To ensure a smooth transition between Flood Regions 2A and 2B, peak discharges for watersheds with mean elevations near 3,000 feet are estimated by a weighted average of peak discharges estimated by prediction equations for both regions. For watersheds with mean elevations within a given transition zone, the following equation assumes that there is a linear change in peak discharges from one region into the other.

$$Q_T = Q_{2b}\left(\frac{3,000 + W/2 - E}{W}\right) + Q_{2a}\left(\frac{E - 3,000 + W/2}{W}\right) \tag{7}$$

where

Q_T = the weighted discharge of the watershed in the transition zone,
Q_{2a} = the discharge estimated by the prediction equation for Region 2A,
Q_{2b} = the discharge estimated by the prediction equation for Region 2B,
W = the width of the transition zone in feet of elevation, and
E = the mean elevation of the watershed.

Table 7. Backward-step generalized least-squares regression analysis for 100-year peak discharges for Region 1, coastal watersheds.

[Variables: All variables are log-transformed. Area, drainage area, in square miles; Slope, mean watershed slope, in degrees; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soil storage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches; --, variable removed. Selected model is indicated by the shaded area]

Predictor Variable	Step								
	a	b	c	d	e	f	g	h	i
	Table values represent the probability that the coefficient for the predictor variable is not significantly different from zero.								
Area	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Slope	0.537	0.725	-----	-----	-----	-----	-----	-----	-----
Jul P	0.167	0.205	0.222	-----	-----	-----	-----	-----	-----
I24-2.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-----
Mx Jan T	0.254	0.232	0.194	0.020	0.009	-----	-----	-----	-----
Mx Jul T	0.033	0.040	0.038	0.092	-----	-----	-----	-----	-----
Soil C	0.007	0.007	0.004	0.002	0.007	0.013	-----	-----	-----
Soil P	0.002	0.001	0.001	0.001	0.002	0.002	0.013	-----	-----
Soil D	0.541	-----	-----	-----	-----	-----	-----	-----	-----
Model error, in log units	0.013013	0.012895	0.012732	0.012828	0.013179	0.014355	0.015489	0.016724	0.024422
Model error, in percent	26.7	26.6	26.4	26.5	26.9	28.1	29.3	30.5	37.2
Sampling error, in percent	13.2	12.6	12.0	11.2	10.7	10.1	9.5	8.9	8.6
Prediction error, in percent	30.0	29.6	29.2	29.0	29.1	30.0	30.9	31.8	38.3
Equivalent years of record	7.5	7.7	7.9	8.0	7.9	7.5	7.1	6.7	4.7

Table 8. Backward-step generalized least-squares regression analysis for 100-year peak discharges for Region 2A, western interior watersheds with mean elevations greater than 3,000 feet.

[Variables: All variables are log-transformed. Area, drainage area, in square miles; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; I24-2, 2-year 24-hour precipitation intensity, in inches; Jul P, mean July precipitation, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches; --, variable removed Selected model is indicated by the shaded area]

Predictor Variable	Step								
	a	b	c	d	e	f	g	h	i
	Table values represent the probability that the coefficient for the predictor variable is not significantly different from zero.								
Area	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Slope	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	--
Elev	0.425	0.373	0.359	0.335	--	--	--	--	--
I24-2	0.001	0.001	0.000	0.000	0.000	0.000	0.000	--	--
Jul P	0.926	0.916	--	--	--	--	--	--	--
Mn Jan T	0.001	0.000	0.000	0.000	0.000	0.000	--	--	--
Mx Jan T	0.045	0.028	0.018	0.014	0.008	--	---	--	--
Soil P	0.931	0.914	0.885	--	--	--	--	--	--
Soil D	0.989	--	--	--	--	--	--	--	--
Model error, in log units	0.018649	0.018405	0.018169	0.017940	0.017926	0.019367	0.025294	0.033326	0.092706
Model error, in percent	32.2	32.0	31.8	31.6	31.6	32.9	37.9	44.0	79.7
Sampling error, in percent	15.5	15.0	14.4	13.6	12.9	12.3	12.3	11.8	13.5
Prediction error, in percent	36.1	35.7	35.2	34.7	34.4	35.3	40.1	45.8	81.5
Equivalent years of record	10.5	10.7	11.0	11.4	11.6	11.0	8.7	6.8	2.6

Table 9. Backward-step generalized least-squares regression analysis for 100-year peak discharges for Region 2b, western interior watersheds with mean elevations less than 3,000 feet.

[Variables: All variables are log-transformed. Area, drainage area, in square miles; Slope, mean watershed slope, in degrees; I24-2, 2-year 24-hour precipitation intensity, in inches; Jul P, mean July precipitation, in inches; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches; Soil C, soil storage capacity, in inches; --, variable removed. Selected model is indicated by the shaded area]

Predictor Variable	Step								
	a	b	c	d	e	f	g	h	i
	Table values represent the probability that the coefficient for the predictor variable is not significantly different from zero.								
Area	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Slope	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	--
I24-2	0.003	0.003	0.004	0.006	0.005	0.001	0.001	--	--
Jul P	0.153	0.179	0.238	0.332	0.313	--	---	--	--
Mx Jan T	0.344	0.367	0.354	--	--	--	--	--	--
Mx Jul T	0.601	0.496	--	--	--	--	--	--	--
Soil P	0.618	--	--	--	--	--	--	--	--
Soil D	0.050	0.043	0.029	0.035	0.038	0.066	--	--	--
Soil C	0.492	0.412	0.499	0.655	--	--	--	--	--
Model error, in log units	0.021748	0.021634	0.021553	0.021533	0.021414	0.021418	0.021778	0.023288	0.030465
Model error, in percent	35.0	34.9	34.8	34.8	34.7	34.7	35.0	36.3	41.9
Sampling error, in percent	12.1	11.6	11.1	10.7	10.2	9.6	8.8	8.2	7.9
Prediction error, in percent	37.2	37.0	36.7	36.6	36.3	36.1	36.2	37.3	42.7
Equivalent years of record	5.9	6.0	6.1	6.1	6.2	6.2	6.2	5.9	4.6

Table 10. Prediction equations for estimating peak discharges for ungaged watersheds in Region 1, coastal watersheds.

[Variables**:** Q(n), discharge in cubic feet per second for the n-year recurrence interval; Area, drainage area, in square miles; I24-2, 2-year 24-hour precipitation intensity, in inches; MxJanT, mean maximum January temperature, in degrees Fahrenheit; Soil C**,** soil storage capacity, in inches; Soil P, soil permeability, in inches per hour]

Prediction equation	Percent standard error of the model, in percent	Average standard error of sampling, in percent	Average prediction error, in percent	Average equivalent years of record
$Q(2) = 0.05056\text{Area}^{0.9489}\ \text{I24-2}^{1.360}\text{MxJanT}^{1.280}\ \text{Soil C}^{-0.4421}\text{Soil P}^{-0.1576}$	25.5	8.19	26.8	2.4
$Q(5) = 0.01316\text{Area}^{0.9385}\ \text{I24-2}^{1.272}\text{MxJanT}^{1.738}\ \text{Soil C}^{-0.5026}\text{Soil P}^{-0.2234}$	23.9	8.23	25.3	3.7
$Q(10) = 0.008041\text{Area}^{0.9324}\ \text{I24-2}^{1.226}\ \text{MxJanT}^{1.926}\ \text{Soil C}^{-0.5267}\text{Soil P}^{-0.2552}$	23.9	8.68	25.6	5.0
$Q(25) = 0.005122\text{Area}^{0.9258}\ \text{I24-2}^{1.179}\ \text{MxJanT}^{2.109}\ \text{Soil C}^{-0.5484}\text{Soil P}^{-0.2888}$	24.8	9.44	26.6	6.4
$Q(50) = 0.003888\text{Area}^{0.9215}\ \text{I24-2}^{1.151}\text{MxJanT}^{2.223}\ \text{Soil C}^{-0.5605}\text{Soil P}^{-0.3111}$	25.8	10.1	27.8	7.2
$Q(100) = 0.003048\text{Area}^{0.9176}\ \text{I24-2}^{1.126}\text{MxJanT}^{2.325}\ \text{Soil C}^{-0.5701}\text{Soil P}^{-0.3319}$	26.9	10.7	29.1	7.9
$Q(500) = 0.001890\text{Area}^{0.9099}\ \text{I24-2}^{1.078}\text{MxJanT}^{2.527}\ \text{Soil C}^{-0.5855}\text{Soil P}^{-0.3770}$	30.0	12.2	32.6	8.9

Table 11. Prediction equations for estimating peak discharges for ungaged watersheds in Region 2A, western interior watersheds with mean elevations greater than 3,000 feet.

[Variables: Q(n), discharge in cubic feet per second for the n-year recurrence interval; Area, drainage area, in square miles; Slope, mean watershed slope, in degrees; I24-2, 2-year 24-hour precipitation intensity, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit]

Prediction equation	Percent standard error of the model, in percent	Average standard error of sampling, in percent	Average prediction error, in percent	Average equivalent years of record
$Q(2) = 0.003119\mathrm{Area}^{1.021}\mathrm{Slope}^{0.8124}\mathrm{I24\text{-}2}^{2.050}\mathrm{MnJanT}^{3.541}\mathrm{MxJanT}^{-1.867}$	37.1	10.5	38.7	2.2
$Q(5) = 0.007824\mathrm{Area}^{1.020}\mathrm{Slope}^{0.9022}\mathrm{I24\text{-}2}^{1.649}\mathrm{MnJanT}^{3.611}\mathrm{MxJanT}^{-2.017}$	32.0	10.2	33.8	4.2
$Q(10) = 0.01546\mathrm{Area}^{1.021}\mathrm{Slope}^{0.9506}\mathrm{I24\text{-}2}^{1.471}\mathrm{MnJanT}^{3.620}\mathrm{MxJanT}^{-2.137}$	30.6	10.6	32.5	6.1
$Q(25) = 0.03353\mathrm{Area}^{1.021}\mathrm{Slope}^{0.9930}\mathrm{I24\text{-}2}^{1.321}\mathrm{MnJanT}^{3.624}\mathrm{MxJanT}^{-2.278}$	30.2	11.4	32.5	8.6
$Q(50) = 0.05501\mathrm{Area}^{1.022}\mathrm{Slope}^{1.014}\mathrm{I24\text{-}2}^{1.243}\mathrm{MnJanT}^{3.624}\mathrm{MxJanT}^{-2.366}$	30.7	12.2	33.2	10.3
$Q(100) = 0.08492\mathrm{Area}^{1.022}\mathrm{Slope}^{1.030}\mathrm{I24\text{-}2}^{1.182}\mathrm{MnJanT}^{3.621}\mathrm{MxJanT}^{-2.440}$	31.6	12.9	34.4	11.6
$Q(500) = 0.1974\mathrm{Area}^{1.023}\mathrm{Slope}^{1.053}\mathrm{I24\text{-}2}^{1.079}\mathrm{MnJanT}^{3.601}\mathrm{MxJanT}^{-2.566}$	34.6	14.7	37.9	13.6

Table 12. Prediction equations for estimating peak discharges for ungaged watersheds in Region 2B, western interior watersheds with mean elevations less than 3,000 feet.

[Variables: Q(n), discharge in cubic feet per second for the n-year recurrence interval; Area, drainage area, in square miles; Slope, mean watershed slope, in degrees; I24-2, 2-year 24-hour precipitation intensity, in inches]

Prediction Equation	Percent standard error of the model, in percent	Average standard error of sampling, in percent	Average prediction error, in percent	Average equivalent years of record
$Q(2) = 9.136\ Area^{0.9004} Slope^{0.4695}\ I24\text{-}2^{0.8481}$	31.9	6.53	32.6	2.0
$Q(5) = 14.54\ Area^{0.9042}\ Slope^{0.4735}\ I24\text{-}2^{0.7355}$	31.6	6.85	32.4	2.8
$Q(10) = 18.49\ Area^{0.9064}\ Slope^{0.4688}\ I24\text{-}2^{0.6937}$	32.0	7.28	33.0	3.6
$Q(25) = 23.72\ Area^{0.9086}\ Slope^{0.4615}\ I24\text{-}2^{0.6578}$	33.0	7.90	34.1	4.8
$Q(50) = 27.75\ Area^{0.9101}\ Slope^{0.4559}\ I24\text{-}2^{0.6390}$	34.0	8.37	35.1	5.5
$Q(100) = 31.85\ Area^{0.9114}\ Slope^{0.4501}\ I24\text{-}2^{0.6252}$	35.0	8.83	36.2	6.2
$Q(500) = 41.72\ Area^{0.9141}\ Slope^{0.4365}\ I24\text{-}2^{0.6059}$	37.7	9.87	39.1	7.5

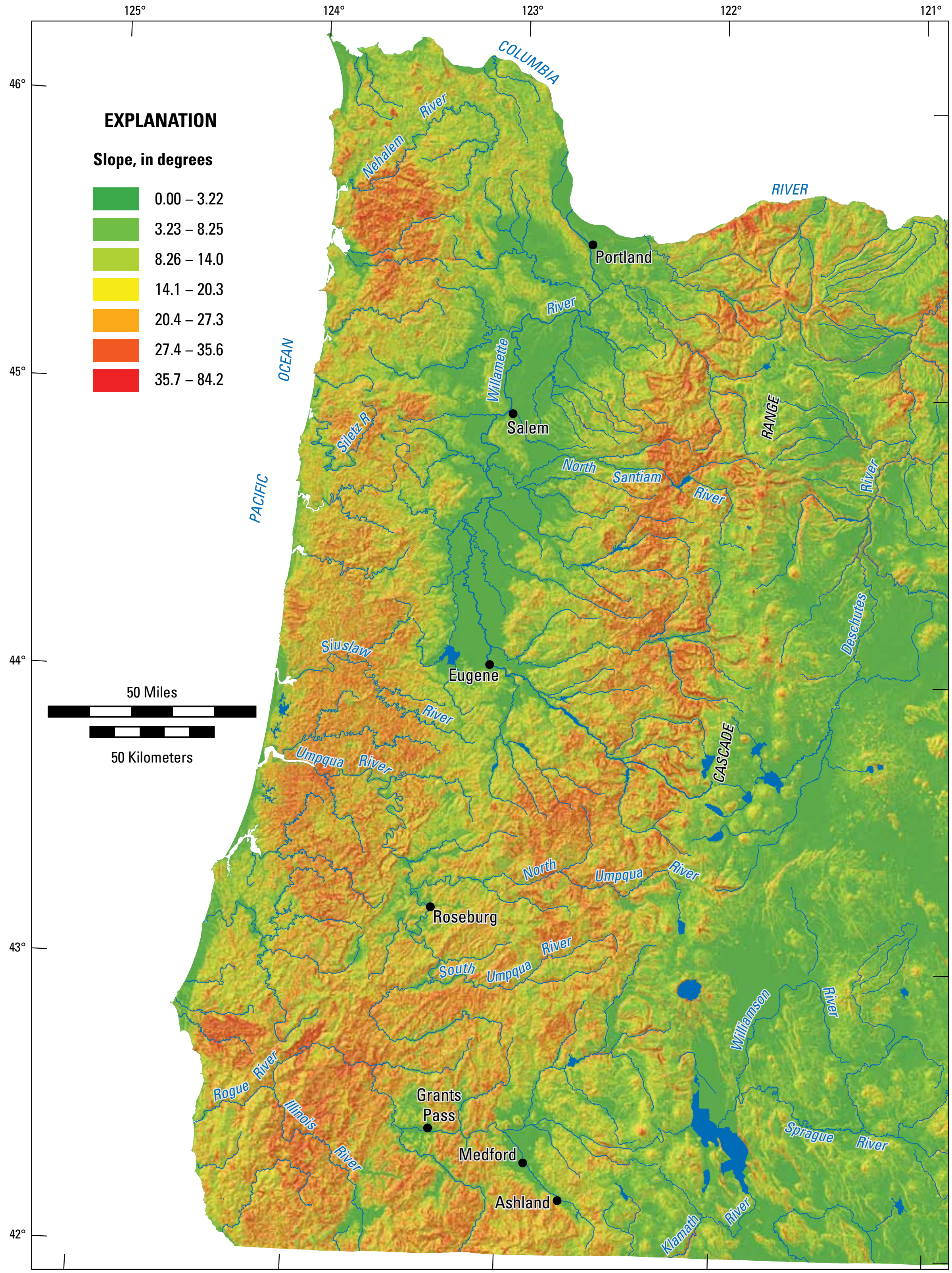

Figure 14. Areal distribution of slope.

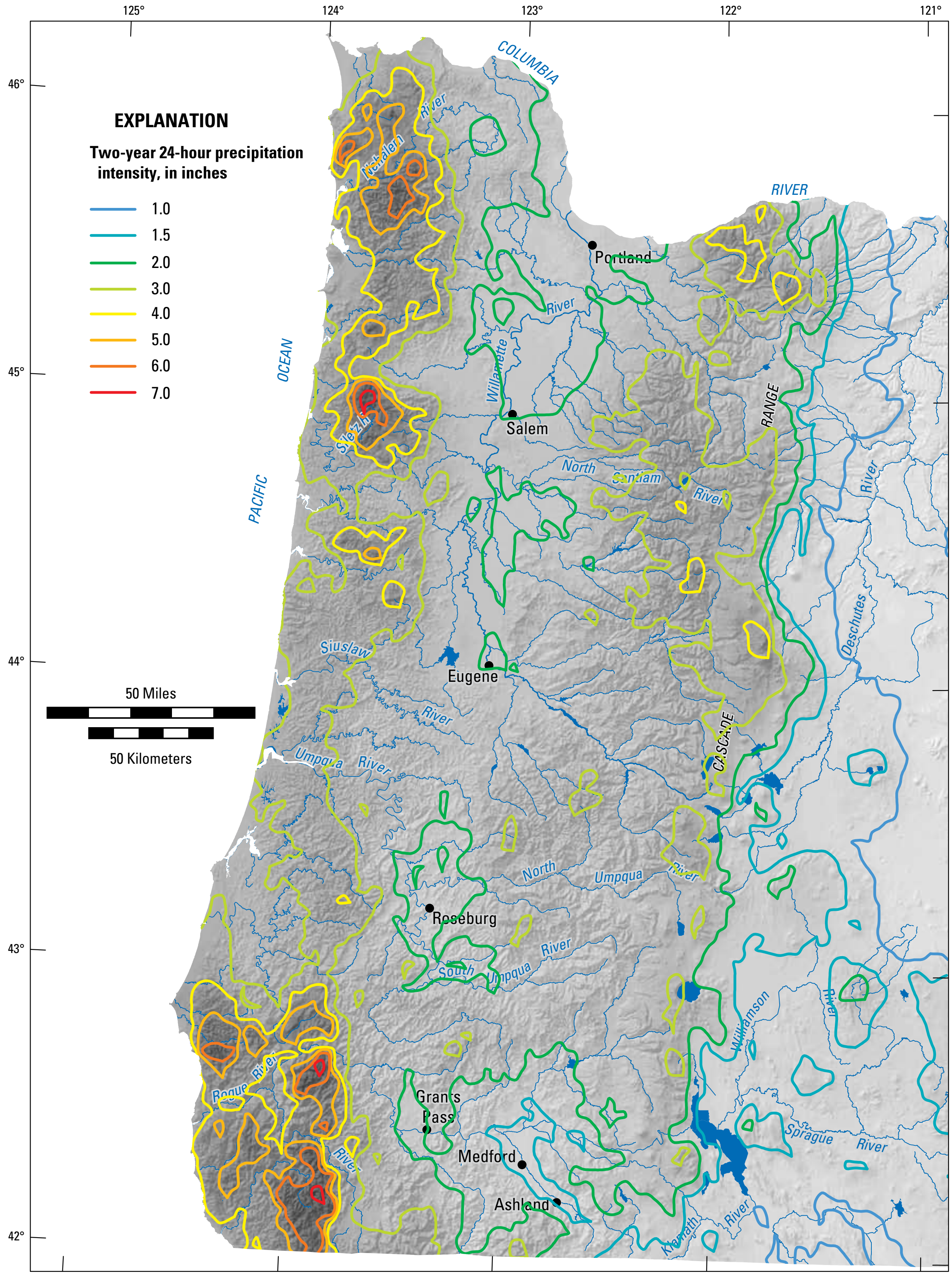

Figure 15. 2-year 24-hour precipitation intensity (1961–90). The isolines are superimposed on both a shaded relief map of elevation and the Geographic Information System grid of the 2-year 24-hour precipitation intensities on which the isolines are based. Darker areas represent higher precipitation intensities.

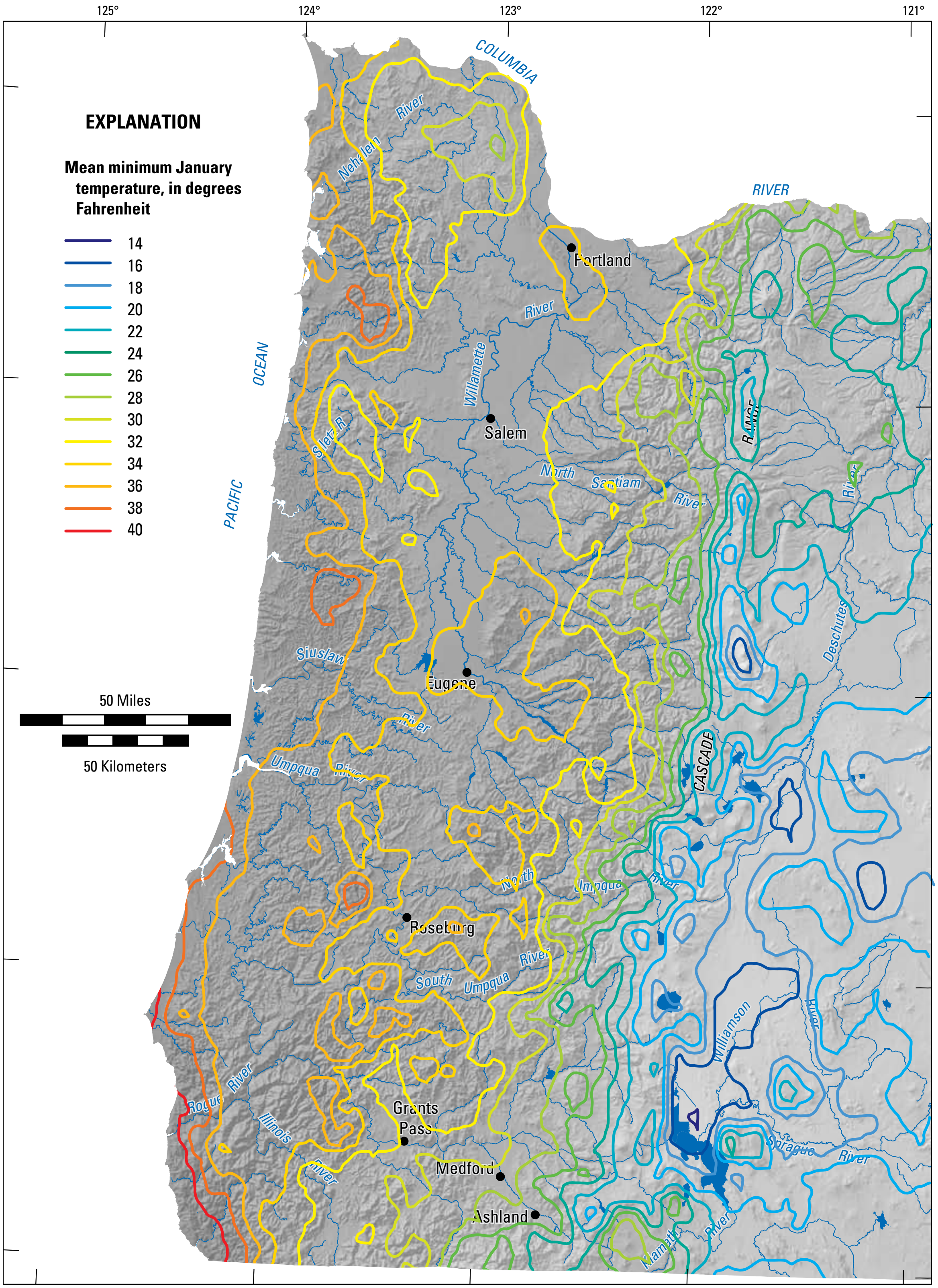

Figure 16. Mean minimum January temperature (1961–90). The isolines are superimposed on both a shaded relief map of elevation and the Geographic Information System grid of the mean minimum January temperatures on which the isolines are based. Darker areas represent higher temperatures.

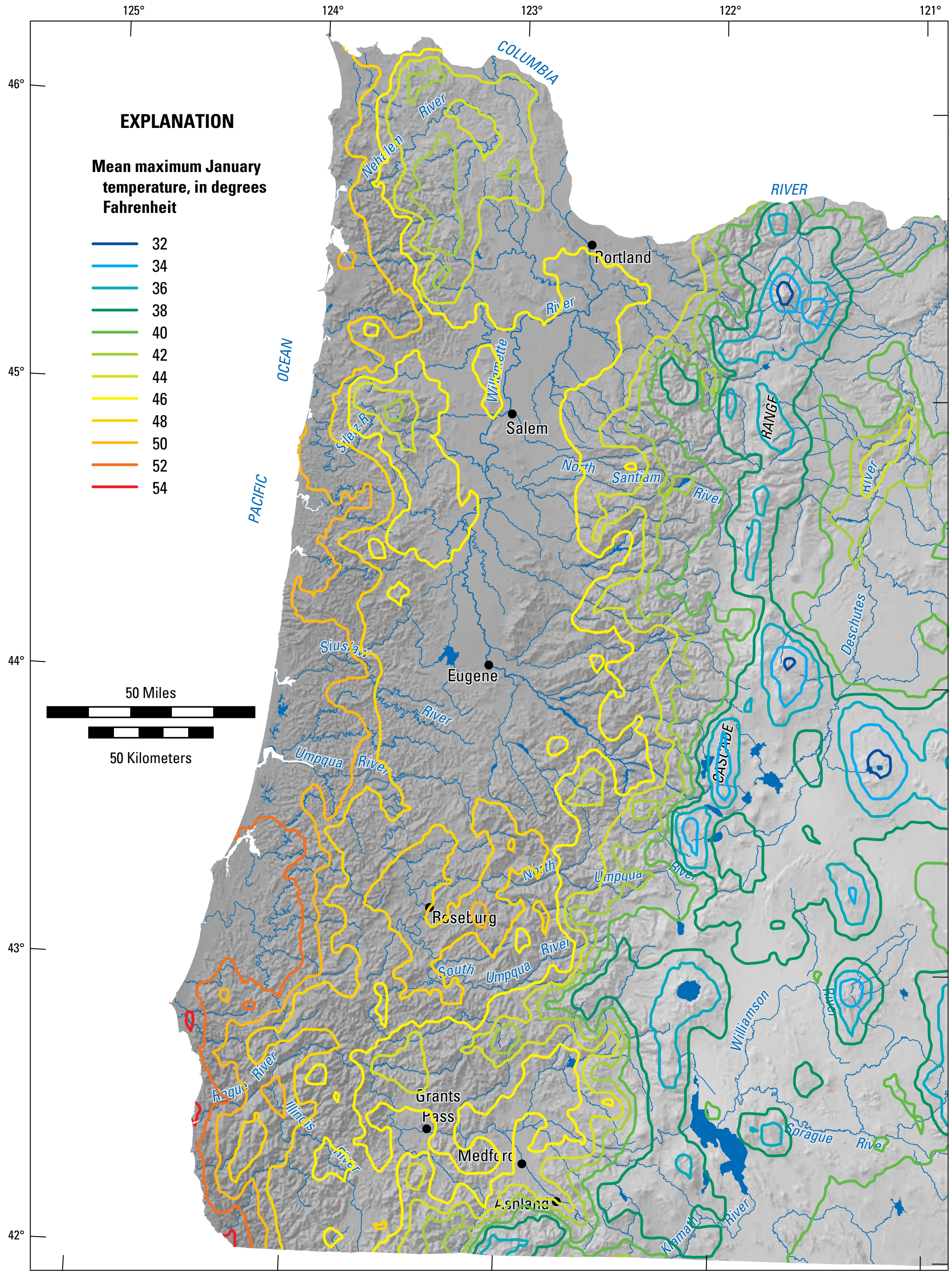

Figure 17. Mean maximum January temperature (1961–90). The isolines are superimposed on both a shaded relief map of elevation and the Geographic Information System grid of the mean maximum January temperatures on which the isolines are based. Darker areas represent higher temperatures.

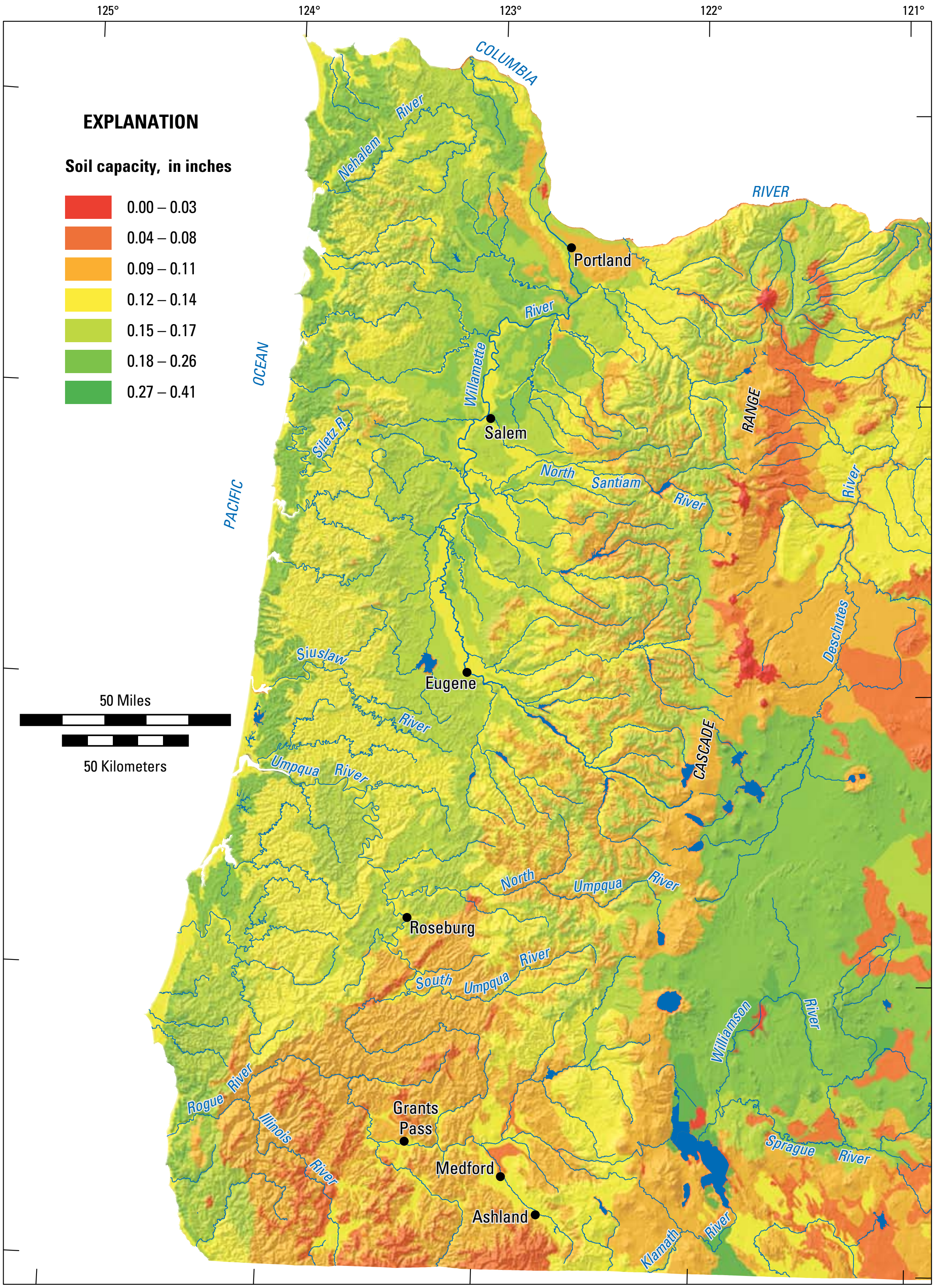

Figure 18. Areal distribution of soil storage capacity.

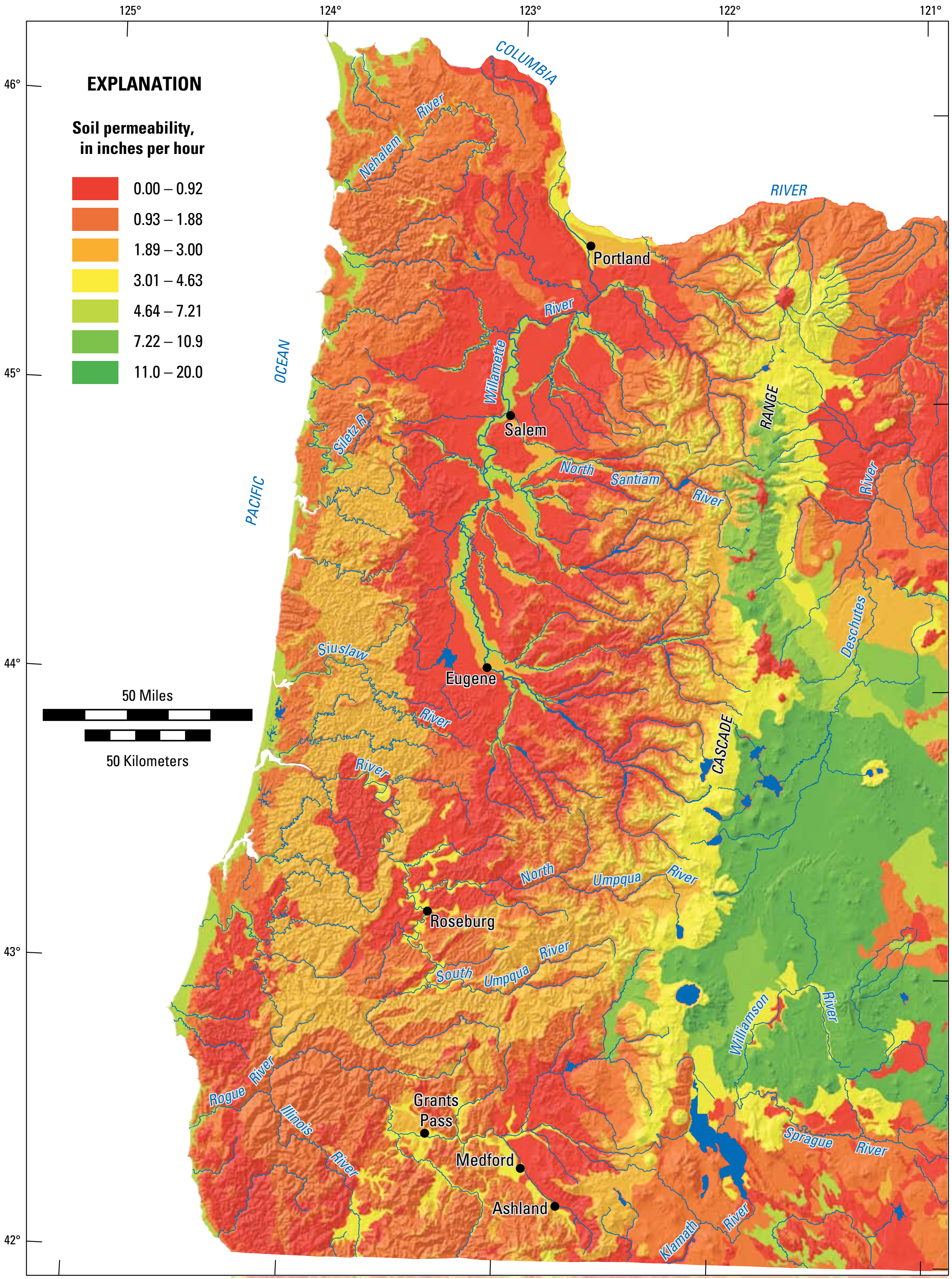

Figure 19. Areal distribution of soil permeability.

A transition zone is an increment of elevation centered on 3,000 feet. For example, a transition zone of 500 feet would fall between 2,750 and 3,250 feet. Nine transition zones varying from 100 to 1,000 feet were evaluated to determine the best increment (table 13). The 250-foot transition zone was selected. The evaluation was based on the difference, or residual, between predicted 100-year peak discharges and actual 100-year peak discharges. For each transition width, the means and standard deviations of the residuals for gaging stations above, below and in the transition zone were calculated.

Means and standard deviations for stations above and below the transition zone did not change appreciably until the transition zone became large. Means and standard deviations for stations within the transition zone were more sensitive. The 250-foot transition zone was selected because of its small mean for the transition zone.

For a 250-foot transition zone, equation 7 becomes

$$Q_T = Q_{2b}\left(\frac{3{,}125 - E}{250}\right) + Q_{2a}\left(\frac{E - 2{,}875}{250}\right) \qquad (8)$$

where

Q_T = the weighted discharge of the watershed in the transition zone,
Q_{2a} = the discharge estimated by the prediction equation for Region 2A,
Q_{2b} = the discharge estimated by the prediction equation for Region 2B, and
E = the mean elevation of the watershed.

For watersheds with mean elevations between 2,875 and 3,125 feet, equation 8 should be used together with the appropriate prediction equations for Regions 2A and 2B. For watersheds with mean elevations below 2,875 feet, use the prediction equations for Region 2B alone. For watersheds above 3,125 feet, use the prediction equations for Region 2A alone.

Table 13. Comparison of summary statistics of residuals from application of the prediction models for the 100-year peak discharge for Region 2A, Region 2B, and a transition zone between the regions, for transition zones of various widths.

[A transition zone is centered on 3,000 feet, the boundary between Regions 2A and 2B. The 350-foot transition zone, for example, is from 2,825 to 3,175 feet. The selected transition zone is shaded]

Width of transition zone, in feet of elevation	Stations below the transition zone			Stations in the transition zone			Stations above the transition zone		
	Region 2B			Weighted average of Regions 2A and 2B			Region 2A		
	Number of stations	Mean of residuals	Standard deviation of residuals	Number of stations	Mean of residuals	Standard deviation of residuals	Number of stations	Mean of residuals	Standard deviation of residuals
100	135	-0.030	0.165	7	-0.033	0.059	95	-0.048	0.165
200	131	-0.029	0.166	14	-0.019	0.112	92	-0.052	0.167
250	129	-0.032	0.165	17	-0.009	0.115	91	-0.051	0.168
300	127	-0.029	0.165	22	-0.035	0.118	88	-0.050	0.169
350	125	-0.030	0.166	25	-0.026	0.115	87	-0.052	0.169
400	122	-0.033	0.167	28	-0.015	0.118	87	-0.052	0.169
600	117	-0.028	0.168	39	-0.050	0.125	81	-0.046	0.172
800	110	-0.017	0.162	58	-0.074	0.140	69	-0.038	0.176
1,000	106	-0.020	0.161	66	-0.065	0.142	65	-0.034	0.179

Estimating Peak Discharges

The procedure for estimating peak discharges depends on whether the location of interest is gaged or ungaged, and if ungaged, whether it is near a gaged location on the same stream.

Gaged Locations

If the watershed of interest is one of the gaged watersheds listed in Appendix D, the frequency specific discharges may be read directly from the table. For Oregon gaging stations, the table gives three discharges at every frequency. The first discharge, designated S, is based on the systematic and historical peak discharge record and is estimated by the guidelines of Bulletin 17B. The second, designated R, is estimated from the appropriate prediction equation given in table 10, 11, or 12. The third discharge, designated W, is a weighted average of the first two discharges (Wiley and others, 2000):

$$Q_W = \frac{(Q_S N + Q_R E)}{(N + E)} \tag{9}$$

where

Q_W = the weighted discharge,
Q_S = the discharge from the Pearson type III distribution fitted to logarithms of the annual peak discharges at the gaging station,
Q_R = the discharge estimated from the regional regression analysis,
N = the number of years of peak discharge record, and
E = the equivalent years of record.

All discharges are at a selected frequency and are in cubic feet per second.

For example, the weighted 100-year peak discharge at the gaging station McKenzie River near Vida, Oregon (14162500) is 75,400 cfs. The station (S) and prediction equation (R) estimated discharges are 70,800 cfs and 99,900 cfs, respectively.

Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) recommends using the weighted discharge (W) as the estimate of peak discharge at the gaging station because its variance is less than the variance of either estimate (S or R). The weighting is discussed in detail in Appendix 8 of Bulletin 17B.

Limitations on the Use of Gaging Station Peak Discharges.—Streamflows at some of the gaging stations used in this report are now regulated. The peak discharges estimated from the frequency analysis and reported in Appendix D are based on peak discharges observed before the streams were regulated. The peak discharge estimates for each station represent the stream in its unregulated state, not its current regulated condition. The currently regulated stations are identified in Appendix D.

Ungaged Location

If the watershed of interest is ungaged, the frequency-specific discharge is calculated from the appropriate prediction equation given in table 10, 11, or 12. For example, for an ungaged watershed in Region 1, the 100-year peak discharge is given by

$$Q_{100} = 0.003048 Area^{0.9176} I24-2^{1.126} MxJanT^{2.325} SoilP^{-0.3319} SoilC^{-0.5701} \tag{10}$$

where

Q_{100} = the 100-year peak discharge, in cubic feet per second,
$Area$ = the drainage area of the watershed, in square miles,
$I24-2$ = the 2-year 24-hour precipitation intensity, in inches,
$MxJanT$ = the mean maximum January temperature, in degrees Fahrenheit,
$SoilP$ = the mean soil permeability, in inches per hour, and
$SoilC$ = the mean soil storage capacity, in inches.

Lobster Creek, a tributary to Five Rivers, is an ungaged watershed in Region 1. The watershed above the mouth has a drainage area of 58.3 square miles, a 2-year 24-hour precipitation intensity of 3.69 inches, a mean maximum January temperature of 47.6 degrees Fahrenheit, a mean soil permeability of 2.51 inches per hour, and a mean soil storage capacity of 0.134 inches. Substituting these values into Equation 10 yields

$$Q_{100} = 0.003048 \times 58.3^{0.9176} 3.69^{1.126} 47.6^{2.325} 2.51^{-0.3319} 0.134^{-0.5701}$$

$$Q_{100} = 10,200 cfs$$

Transition Zone between Regions 2A and 2B

Consider Quartz Creek, a tributary of the McKenzie River. The watershed at the mouth of Quartz Creek has a mean elevation of 2,960 feet—within the transition zone between Regions 2A and 2B. The estimated 100-year peak discharge for Region 2A is 7,690 cfs and for Region 2B, 8,380. Substituting into Equation 8,

$$Q_T = 7,690\left(\frac{3,125 - 2,970}{250}\right) + 8,380\left(\frac{2,970 - 2,875}{250}\right)$$

$$Q_T = 7{,}950 cfs$$

Selected watershed characteristics for Quartz Creek are shown in table 14.

Table 14. Selected characteristics for the ungaged watershed Quartz Creek at the mouth.

Watershed characteristic	
Drainage area, in square miles	42.1
Mean watershed elevation, in feet	2,970
Mean watershed slope, in degrees	23.8
2-year 24-hour precipitation intensity, in inches	2.84
Mean minimum January temperature, in degrees Fahrenheit	31.0
Mean maximum January temperature in degrees Fahrenheit	44.3

Limitations on the Use of the Prediction Equations

The prediction equations may be used to estimate peak flows for any stream. However, the prediction equations do not account for reservoir operations, diversion, urbanization, or significant contributions from spring flow. Many streams are affected by these factors. In these cases, the estimates of peak flow represent a hypothetical condition of the watershed, not the actual condition.

Unless the user intends to predict peak discharges for the hypothetical condition of a watershed, the prediction equations should be used only on rural, unregulated streams and where streamflow arises primarily from storm runoff or snowmelt rather than spring flow. They should not be used where there are significant areas of impervious surface due to pavement or buildings, or where streams have been lined or diverted through culverts or artificial channels. They also should not be used for streams regulated by reservoirs, diversion, or large natural lakes. Also to be avoided are streams with large losses to ground water.

There are not many streams in western Oregon dominated by spring flow, but they do occur occasionally. They are most likely to be found in areas of young volcanic rock in the Cascade Range. Streams with large losses also occur in young volcanic rock in the Cascades and perhaps in coastal streams flowing over unconsolidated sand.

In all cases, hypothetical or not, the equations should not be used for watersheds that have characteristics that fall outside the range of characteristics of the watersheds used to develop the prediction equations. The ranges of characteristics for these watersheds are given in table 15.

Ungaged Location, near a Gaging Station on the Same Stream

If an ungaged watershed is on the same stream as a gaged watershed listed in this report, and the ungaged watershed has an area between 0.50 and 1.50 times the area of the gaged watershed, peak discharges at the ungaged site may be calculated from the peak discharges at the gaged site by this equation (Thomas and others, 1993; Sumioka and others, 1997):

$$Q_u = Q_g \left(\frac{A_u}{A_g} \right)^a \tag{11}$$

where

- Q_u = the estimated discharge for the ungaged watershed,
- Q_g = the weighted discharge (W) from Appendix D for the gaging station,
- A_u = the area of the ungaged watershed,
- A_g = the area of the gaged watershed, and
- a = the exponent of area from the prediction equations in table 10, 11, or 12.

All discharges are at a selected frequency and are in cubic feet per second. The exponent is from the prediction equation for the selected frequency.

Equation 11 should be used only if the gaged and ungaged watersheds have similar characteristics. If the watersheds differ appreciably in topography, vegetative cover, or geology, the peak discharge estimates should be made by way of the appropriate prediction equations.

Consider the Applegate River, a tributary of the Rogue River. This stream, at its mouth, is ungaged, and peak discharges could be estimated by the prediction equations for Region 2A—the mean watershed elevation is greater than 3,000 feet. However, there is a gaging station, Applegate River at Wilderville (14369500), 7.6 miles upstream. Selected characteristics for the gaged and ungaged watersheds are given in table 16. The watersheds are similar and use of Equation 11 is appropriate.

From table 11 for the 100-year peak discharge for Region 2A, the area coefficient is 1.022. Taking the areas from table 16 and the 100-year peak discharge for the Applegate River at Wilderville from Appendix D, then making the substitutions into Equation 11,

$$Q_u = 101{,}000 \left(\frac{771}{699} \right)^{1.022}$$

$$Q_u = 112{,}000\, cfs$$

Table 15. Ranges of characteristics for the gaged watersheds used to develop the prediction equations, by region.

[--, characteristic not in equation]

Region	Number of stations	Drainage area, in square miles	Mean 2-year 24-hour precipitation intensity, in inches	Mean watershed slope, in degrees	Mean minimum January temperature, in degrees Fahrenheit	Mean maximum January temperature, in degrees Fahrenheit	Mean soil storage capacity, in inches	Mean soil permeability, in inches per hour
1	91	0.28–673	2.52–5.79	--	--	42.4–53.9	0.10–0.23	0.72–4.76
2A	107	0.22–3,940	1.72–4.34	6.24–28.0	20.5–34.0	33.9–47.3	--	--
2B	178	0.37–7,270	1.53–4.48	5.62–28.3	--	--	--	--

Table 16. Selected characteristics for the ungaged watershed Applegate River at the mouth and for the gaged watershed Applegate River at Wilderville, Oregon (14369500).

Watershed characteristic	Ungaged watershed	Gaged watershed
	Applegate River at the mouth	Applegate River at Wilderville (14369500)
Drainage area, in square miles	771	699
Mean watershed elevation, in feet	3,140	3,280
Mean watershed slope, in degrees	20.7	21.0
Mean 2-year 24-hour precipitation intensity, in inches	2.31	2.29
Mean minimum January temperature, in degrees Fahrenheit	28.6	28.3
Mean maximum January temperature, in degrees Fahrenheit	42.5	42.1
Mean soil depth, in inches	36.0	35.8

Making Estimates of Peak Discharge at the Oregon Water Resources Department Web Site

At the Oregon Water Resources Department Web site (*http://www.wrd.state.or.us/*), a user can make estimates of peak discharge magnitudes at the selected frequencies by one of four methods:

1. Selecting from among about 1,200 watersheds for which the physical characteristics are already known,
2. Manually entering the required watershed characteristics,
3. Submitting a user-delineated watershed, or
4. Using a utility on the Web site to autodelineate the watershed.

Because of the inherent difficulties in independently estimating watershed characteristics, it is strongly recommended the user take advantage of options 1, 3, and 4 listed above rather than option 2. In all cases, a report detailing peak discharges and how they were determined for the specified watershed is returned to the user.

Selecting among already delineated watersheds (Option 1) is done onscreen using interactive maps. For manual input (Option 2), a form is provided. If the user supplies the watershed delineation (Option 3), it must be submitted as a "shape file" in Oregon Lambert coordinates. A shape file is an open specification for a GIS theme developed by Environmental Systems Research Institute, Inc.

For Option 4, the user need only select a point on a stream where the magnitude of a specified peak discharge is desired. Selection of the point is done interactively from topographic maps displayed onscreen. Nothing further is required from the user. Delineation of the watershed above the selected point, determination of the watershed characteristics, and calculation of the peak discharges are done automatically. The autodelineation program, however, *does not* account for the effects of reservoir operations, diversion or urbanization. Please refer to Oregon Water Resources Department's Web site (*http://www.wrd.state.or.us/surface_water/flood/index.shtml*) for more information.

The user may also obtain, online, the peak discharge characteristics for the 376 gaging stations used in this study. In addition to the discharge magnitudes given in Appendix D of this report, the online version includes the 95 percent confidence intervals.

Summary

An analysis of the magnitude and frequency of peak discharges in western Oregon has been completed with financial assistance from the Federal Emergency Management Agency, the Oregon Department of Transportation, and the Association of Oregon Counties, and with the cooperation of the U.S. Geological Survey. The study was undertaken to provide engineers and land managers with the information needed to make informed decisions about development in or near watercourses in the study area.

This report describes the results of an analysis of the peak discharges of rural streams in Oregon west of the Cascade crest. These results include (1) the magnitude of annual peak discharges for selected frequencies at 376 gaging stations, (2) generalized logarithmic skew coefficients for Oregon, and (3) sets of equations relating the magnitude of peak discharges at selected frequencies to physical and climatological watershed characteristics such as drainage area or mean January precipitation. There is a set of frequency specific prediction equations for each of three hydrologically homogeneous "flood regions" within western Oregon. The selected frequencies give the interval at which a peak discharge of given magnitude is likely to recur. The recurrence intervals are 2, 5, 10, 20, 25, 50, 100, and 500 years.

The logarithms of peak discharges at 376 streamflow gaging stations in western Oregon, southwestern Washington, and northwestern California were fitted to the Pearson Type III distribution. The parameters of the Pearson Type III distribution were adjusted for the effects of high and low outliers, for historic peaks, for zero peaks, and for peaks below the gage threshold based on guidelines in Interagency Advisory Committee on Water Data's Bulletin 17B. Station skew values also were adjusted by a "generalized" skew value based on the skews for long-term stations in the area.

The areal distribution of the generalized logarithmic skew coefficients of annual peak discharge for Oregon was determined using GIS techniques. Generalized skew coefficients derived from the distribution were used to improve estimates of skew for short record gaging stations. The areal distribution is a GIS grid but is represented in this report as an isoline map. In practice, generalized skew coefficients are determined from the grid, not the isoline map. The grid is available on request (*webmaster@wrd.state.or.us*).

A combination of regression techniques was used to derive the prediction equations. A preliminary analysis using ordinary least-squares regression was conducted to define flood regions of homogeneous hydrology and to determine which climatological and physical characteristics of the watersheds would be most useful in the prediction equations. The final prediction equations were derived using generalized least-squares regression. The computer model, GLSNET (version 2.5), developed by the U.S. Geological Survey was used to do the generalized least-squares regression analysis. Average standard error of prediction for the equations for the three flood regions ranged from 25.3 to 39.1 percent. Equivalent years of record varied from 2.0 to 13.6 years.

The prediction equation may be used to estimate peak flows for any stream. However, the prediction equations do not account for reservoir operations, diversion or urbanization. Many streams are affected by these factors. In these cases, the estimates of peak flow represent a hypothetical condition of the watershed, not the actual condition.

Use of the prediction equations requires estimates of several physical and climatological characteristics of the watershed in question. Because the watershed characteristics can be difficult to estimate, the Oregon Water Resources Department has developed an interactive utility, available on its Web site, to facilitate the use of the equations. The user need only select a site on a stream from an onscreen interactive map and the magnitude of floods at various frequencies will be reported for that location. To use the interactive utility, go to *http://www.wrd.state.or.us/OWRD/SW/peak_flow.shtml*

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Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
11517840	Dona Creek near Klamath River, CA	2A	18010206	41.840	122.921
11520520	Fort Goff Creek near Seiad Valley, CA	2A	18010209	41.864	123.257
11521500	Indian Creek near Happy Camp, CA	2A	18010209	41.835	123.382
11530850	Middle Fork Smith River tributary near O’Brien, OR	1	18010101	41.918	123.767
11531000	Middle Fork Smith River at Gasquet, CA	1	18010101	41.847	123.966
11531500	North Fork Smith River at Gasquet, CA	1	18010101	41.855	123.969
11532000	South Fork Smith River near Crescent City, CA	1	18010101	41.792	124.025
11532500	Smith River near Crescent City, CA	1	18010101	41.792	124.075
11533000	Lopez Creek near Smith River, CA	1	18010101	41.960	124.202
12009500	Bear Br near Naselle, WA	1	17100106	46.330	123.910
12010000	Naselle River near Naselle, WA	1	17100106	46.374	123.742
12010500	Salmon Creek near Naselle, WA	1	17100106	46.356	123.750
12010600	Lane Creek near Naselle, WA	1	17100106	46.372	123.783
12010700	South Fork Naselle River near Naselle, WA	1	17100106	46.344	123.806
12010800	South Nemah River near Naselle, WA	1	17100106	46.441	123.861
12011000	North Nemah River near South Bend, WA	1	17100106	46.492	123.833
12011100	North Nemah River tributary near South Bend, WA	1	17100106	46.513	123.775
12011200	Williams Creek near South Bend, WA	1	17100106	46.530	123.861
12011500	Willapa River at Lebam, WA	1	17100106	46.564	123.564
12012000	Fork Creek near Lebam, WA	1	17100106	46.555	123.583
12012200	Green Creek near Lebam, WA	1	17100106	46.587	123.592
12013500	Willapa River near Willapa, WA	1	17100106	46.651	123.651
12014500	South Fork Willapa River near Raymond, WA	1	17100106	46.628	123.703
12015100	Clearwater Creek near Raymond, WA	1	17100106	46.750	123.766
12015500	North River near Brooklyn, WA	1	17100106	46.782	123.481
12016700	Joe Creek near Cosmopolis, WA	1	17100106	46.839	123.718
12017000	North River near Raymond, WA	1	17100106	46.807	123.849
12019600	Water Mill Creek near Pe Ell, WA	2B	17100103	46.564	123.309
12020000	Chehalis River near Doty, WA	2B	17100103	46.617	123.276
12020500	Elk Creek near Doty, WA	2B	17100103	46.628	123.331
12024000	South Fork Newaukum River near Onalaska, WA	2B	17100103	46.576	122.684
12025000	Newaukum River near Chehalis, WA	2B	17100103	46.620	122.944
12025700	Skookumchuck River near Vail, WA	2B	17100103	46.773	122.593
12026150	Skookumchuck River below Bloody Run Creek near Centralia, WA	2B	17100103	46.790	122.734
12027500	Chehalis River near Grand Mound, WA	2B	17100103	46.776	123.034
12030000	Rock Creek at Cedarville, WA	2B	17100103	46.868	123.307
14126300	Columbia River tributary at Home Valley, WA	2B	17070105	45.714	121.778
14127000	Wind River above Trout Creek near Carson, WA	2B	17070105	45.809	121.908
14127200	Layout Creek near Carson, WA	2B	17070105	45.817	122.047
14128500	Wind River near Carson, WA	2B	17070105	45.727	121.794
14131000	Little Zigzag River Twin Bridges Rhododendron, OR	2A	17080001	45.314	121.808
14131200	Lady Creek near Rhododendron, OR	2A	17080001	45.317	121.831
14131400	Zigzag River near Rhododendron, OR	2A	17080001	45.309	121.859
14134000	Salmon River near Government Camp, OR	2A	17080001	45.267	121.717
14134500	Salmon River below Linney Creek, OR	2A	17080001	45.222	121.861
14135000	Salmon River at Welches, OR	2A	17080001	45.319	121.953

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14135500	Salmon River above Boulder Creek near Brightwood, OR	2A	17080001	45.361	122.011
14137000	Sandy River near Marmot, OR	2A	17080001	45.392	122.128
14138400	Cedar Creek near Sandy, OR	2B	17080001	45.399	122.246
14138800	Blazed Alder Creek near Rhododendron, OR	2A	17080001	45.453	121.890
14138870	Fir Creek near Brightwood, OR	2B	17080001	45.480	122.024
14138950	Deer Creek near Bull Run, OR	2B	17080001	45.492	122.058
14138960	Cougar Creek near Bull Run, OR	2B	17080001	45.491	122.061
14139510	Fivemile Creek near Bull Run, OR	2B	17080001	45.483	122.090
14139600	Camp Creek near Bull Run, OR	2B	17080001	45.461	122.104
14139700	Cedar Creek near Brightwood, OR	2B	17080001	45.458	122.031
14139800	South Fork Bull Run River near Bull Run, OR	2B	17080001	45.444	122.106
14141500	Little Sandy River near Bull Run, OR	2B	17080001	45.415	122.175
14143200	Canyon Creek near Washougal, WA	2B	17080001	45.596	122.192
14143500	Washougal River near Washougal, WA	2B	17080001	45.625	122.282
14144000	Little Washougal River near Washougal, WA	2B	17080001	45.614	122.357
14144550	Shanghai Creek near Hockinson, WA	2B	17080001	45.701	122.440
14144600	Groenveld Creek near Camas, WA	2B	17080001	45.585	122.458
14144800	Middle Fork Willamette River near Oakridge, OR	2A	17090001	43.597	122.456
14144870	Middle Fork Willamette River tributary near Oakridge, OR	2B	17090001	43.672	122.433
14144900	Hills Creek above Hills Creek Reservoir, near Oakridge, OR	2A	17090001	43.681	122.369
14145500	Middle Fork Willamette River above Salt Creek, near Oakridge, OR	2A	17090001	43.722	122.438
14146000	Salt Creek near Oakridge, OR	2A	17090001	43.728	122.425
14146500	Salmon Creek near Oakridge, OR	2A	17090001	43.763	122.372
14147400	Tumble Creek near Westfir, OR	2B	17090001	43.881	122.375
14147500	North Fork of Middle Fork Willamette River near Oakridge, OR	2A	17090001	43.758	122.508
14148000	Middle Fork Willamette River below North Fork near Oakridge, OR	2A	17090001	43.801	122.560
14148700	Fern Creek near Lowell, OR	2B	17090001	43.864	122.685
14150300	Fall Creek near Lowell, OR	2B	17090001	43.971	122.637
14150800	Winberry Creek near Lowell, OR	2B	17090001	43.914	122.688
14151000	Fall Creek below Winberry Creek near Fall Creek, OR	2B	17090001	43.944	122.774
14151500	Little Fall Creek near Fall Creek, OR	2B	17090001	43.969	122.756
14152500	Coast Fork Willamette River at London, OR	2B	17090002	43.642	123.085
14153800	Layng Creek above Prather Creek near Disston, OR	2B	17090002	43.709	122.726
14153900	Prather Creek near Disston, OR	2B	17090002	43.713	122.740
14154500	Row River above Pitcher Creek near Dorena, OR	2B	17090002	43.736	122.872
14155500	Row River near Cottage Grove, OR	2B	17090002	43.793	122.990
14156000	Mosby Creek near Cottage Grove, OR	2B	17090002	43.744	122.983
14156500	Mosby Creek at Mouth, near Cottage Grove, OR	2B	17090002	43.776	122.999
14157000	Coast Fork Willamette River at Saginaw, OR	2B	17090002	43.835	123.042
14158000	Willamette River at Springfield, OR	2B	17090003	44.046	123.028
14158250	Hackelman Creek near Upper Soda, OR	2A	17090004	44.397	122.125
14158790	Smith River above Smith River Reservoir near Belknap Springs, OR	2A	17090004	44.335	122.046
14158950	Twisty Creek near Belknap Springs, OR	2B	17090004	44.225	122.043
14159000	McKenzie River at McKenzie Bridge, OR	2A	17090004	44.179	122.129
14159200	South Fork McKenzie River above Cougar Lake near Rainbow, OR	2A	17090004	44.047	122.217
14159500	South Fork McKenzie River near Rainbow, OR	2A	17090004	44.136	122.247

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14161000	Blue River above Quentin Creek, OR	2A	17090004	44.267	122.200
14161100	Blue River below Tidbits Creek near Blue River, OR	2A	17090004	44.218	122.264
14161500	Lookout Creek near Blue River, OR	2A	17090004	44.210	122.256
14161600	Lookout Creek tributary near Blue River, OR	2B	17090004	44.207	122.258
14162000	Blue River near Blue River, OR	2A	17090004	44.183	122.281
14162500	McKenzie River near Vida, OR	2A	17090004	44.125	122.469
14163000	Gate Creek at Vida, OR	2B	17090004	44.146	122.571
14164000	McKenzie River near Springfield, OR	2A	17090004	44.056	122.829
14165000	Mohawk River near Springfield, OR	2B	17090004	44.093	122.956
14165500	McKenzie River near Coburg, OR	2A	17090004	44.112	123.046
14166500	Long Tom River near Noti, OR	2B	17090003	44.050	123.425
14167000	Coyote Creek near Crow, OR	2B	17090003	44.022	123.255
14169700	Bear Creek near Cheshire, OR	2B	17090003	44.158	123.353
14170000	Long Tom River at Monroe, OR	2B	17090003	44.313	123.295
14170500	Rock Creek near Philomath, OR	2B	17090003	44.501	123.439
14171000	Marys River near Philomath, OR	2B	17090003	44.526	123.333
14172000	Calapooia River at Holley, OR	2B	17090003	44.351	122.786
14172300	Butte Creek near Plainview, OR	2B	17090003	44.474	122.957
14173500	Calapooia River at Albany, OR	2B	17090003	44.621	123.128
14174000	Willamette River at Albany, OR	2B	17090003	44.639	123.106
14178000	North Santiam River below Boulder Creek near Detroit, OR	2A	17090005	44.707	122.100
14178600	Short Creek at Breitenbush Hot Springs, OR	2A	17090005	44.786	121.982
14178700	East Humbug Creek near Detroit, OR	2A	17090005	44.799	122.058
14178800	Wind Creek near Detroit, OR	2A	17090005	44.756	122.119
14179000	Breitenbush River above French Creek near Detroit, OR	2A	17090005	44.753	122.128
14181500	North Santiam River at Niagara, OR	2A	17090005	44.753	122.297
14181700	North Santiam River tributary near Gates, OR	2B	17090005	44.756	122.390
14182500	Little North Santiam River near Mehama, OR	2B	17090005	44.792	122.578
14183000	North Santiam River at Mehama, OR	2A	17090005	44.789	122.617
14184900	Sheek Creek near Cascadia, OR	2B	17090006	44.390	122.507
14185000	South Santiam River below Cascadia, OR	2B	17090006	44.393	122.510
14185800	Middle Santiam River near Cascadia, OR	2A	17090006	44.515	122.371
14185900	Quartzville Creek near Cascadia, OR	2A	17090006	44.540	122.435
14186000	Middle Santiam River near Foster, OR	2B	17090006	44.460	122.524
14186500	Middle Santiam River at Mouth near Foster, OR	2B	17090006	44.424	122.624
14187000	Wiley Creek near Foster, OR	2B	17090006	44.372	122.622
14187500	South Santiam River at Waterloo, OR	2B	17090006	44.499	122.822
14188800	Thomas Creek near Scio, OR	2B	17090006	44.712	122.765
14189000	Santiam River at Jefferson, OR	2B	17090005	44.715	123.011
14189500	Luckiamute River near Hoskins, OR	2B	17090003	44.719	123.503
14190000	Luckiamute River at Pedee, OR	2B	17090003	44.743	123.424
14190100	Little Luckiamute River at Falls City, OR	2B	17090003	44.871	123.461
14190200	Waymire Creek near Falls City, OR	2B	17090003	44.867	123.412
14190500	Luckiamute River near Suver, OR	2B	17090003	44.783	123.233
14190600	Soap Creek tributary near Suver, OR	2B	17090003	44.700	123.219
14190800	Rickreall Creek at Rickreall, OR	2B	17090007	44.929	123.228

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14191000	Willamette River at Salem, OR	2B	17090007	44.944	123.042
14192100	Glenn Creek near Doaks Ferry Rd Salem, OR	2B	17090007	44.952	123.082
14192200	Gibson Creek near Salem, OR	2B	17090007	44.972	123.075
14192500	South Yamhill River near Willamina, OR	2B	17090008	45.047	123.503
14192800	South Yamhill River tributary near Willamina, OR	2B	17090008	45.044	123.472
14193000	Willamina Creek near Willamina, OR	2B	17090008	45.143	123.493
14193300	Mill Creek near Willamina, OR	2B	17090008	44.971	123.449
14194000	South Yamhill River near Whiteson, OR	2B	17090008	45.169	123.207
14194300	North Yamhill River near Fairdale, OR	2B	17090008	45.365	123.378
14195000	Haskins Creek near McMinnville, OR	2B	17090008	45.314	123.365
14196500	Yamhill River near Pike, OR	2B	17090008	45.371	123.286
14197000	North Yamhill River at Pike, OR	2B	17090008	45.369	123.254
14197300	Panther Creek near Carlton, OR	2B	17090008	45.306	123.350
14198500	Molalla River above Pc near Wilhoit, OR	2B	17090009	45.010	122.479
14199700	Bull Creek near Colton, OR	2B	17090009	45.168	122.479
14200000	Molalla River near Canby, OR	2B	17090009	45.244	122.686
14200300	Silver Creek at Silverton, OR	2B	17090009	45.009	122.787
14201000	Pudding River near Mt Angel, OR	2B	17090009	45.063	122.829
14201500	Butte Creek at Monitor, OR	2B	17090009	45.102	122.745
14202000	Pudding River at Aurora, OR	2B	17090009	45.233	122.749
14202500	Tualatin River near Gaston, OR	2B	17090010	45.438	123.168
14202850	Scoggins Creek above Henry Hagg Lake near Gaston, OR	2B	17090010	45.502	123.252
14202920	Sain Creek near Gaston, OR	2B	17090010	45.481	123.244
14203000	Scoggins Creek near Gaston, OR	2B	17090010	45.459	123.154
14203500	Tualatin River near Dilley, OR	2B	17090010	45.475	123.123
14203800	Beaver Creek near Glenwood, OR	2B	17090010	45.672	123.290
14204000	Gales Creek near Gales Creek, OR	2B	17090010	45.642	123.265
14204100	Bateman Creek near Glenwood, OR	2B	17090010	45.625	123.261
14204500	Gales Creek near Forest Grove, OR	2B	17090010	45.556	123.185
14205500	East Fork Dairy Creek at Mountaindale, OR	2B	17090010	45.635	123.043
14206000	McKay Creek near North Plains, OR	2B	17090010	45.626	122.975
14206500	Tualatin River at Farmington, OR	2B	17090010	45.447	122.949
14207500	Tualatin River at West Linn, OR	2B	17090010	45.351	122.675
14207920	Poop Creek near Big Bottom, OR	2A	17090011	44.976	121.843
14208000	Clackamas River at Big Bottom, OR	2A	17090011	45.017	121.919
14208500	Oak Grove Fork at Timothy Meadows, OR	2A	17090011	45.117	121.800
14208850	East Fork Shellrock Creek near Government Camp, OR	2A	17090011	45.142	121.899
14209000	Oak Grove Fork above power plant Intake, OR	2A	17090011	45.072	121.950
14209500	Clackamas River above Three Lynx Creek, OR	2A	17090011	45.125	122.072
14209700	Fish Creek near Three Lynx, OR	2A	17090011	45.148	122.152
14209750	Whisky Creek near Estacada, OR	2B	17090011	45.214	122.158
14209900	Dubois Creek at Estacada, OR	2B	17090011	45.282	122.343
14210000	Clackamas River at Estacada, OR	2A	17090011	45.300	122.353
14210800	Rock Creek near Boring, OR	2B	17090011	45.436	122.480
14212000	Salmon Creek near Battle Ground, WA	2B	17080001	45.774	122.444
14213200	Lewis River near Trout Lake, WA	2A	17080002	46.165	121.869

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14213500	Big Creek below Skookum Meadow near Trout Lake, WA	2A	17080002	46.093	121.864
14214500	Meadow Creek below Lone Butte Meadow near Trout Lake, WA	2A	17080002	46.047	121.856
14215000	Rush Creek above Falls near Cougar, WA	2A	17080002	46.053	121.911
14216000	Lewis River above Muddy River near Cougar, WA	2A	17080002	46.061	121.983
14218300	Dog Creek at Cougar, WA	2B	17080002	46.044	122.308
14219000	Canyon Creek near Amboy, WA	2B	17080002	45.942	122.321
14219800	Speelyai Creek near Cougar, WA	2B	17080002	46.008	122.346
14221500	Cedar Creek near Ariel, WA	2B	17080002	45.932	122.528
14222500	East Fork Lewis River near Heisson, WA	2B	17080002	45.837	122.465
14223800	Columbia River tributary at Carrolls, WA	2B	17080003	46.072	122.861
14235300	Tilton River near Mineral, WA	2B	17080005	46.661	122.199
14235500	West Fork Tilton River near Morton, WA	2B	17080005	46.611	122.243
14236200	Tilton River above Bear Canyon Creek near Cinebar, WA	2B	17080005	46.596	122.458
14237000	Klickitat Creek at Mossyrock, WA	2B	17080005	46.521	122.469
14237500	Winston Creek near Silver Lake, WA	2B	17080005	46.483	122.520
14239000	Salmon Creek near Toledo, WA	2B	17080005	46.414	122.821
14239700	Olequa Creek tributary near Winlock, WA	2B	17080005	46.464	122.957
14242600	Toutle River tributary near Castle Rock, WA	2B	17080005	46.324	122.858
14243000	Cowlitz River at Castle Rock, WA	2B	17080005	46.275	122.913
14243500	Delameter Creek near Castle Rock, WA	2B	17080005	46.264	122.966
14245000	Coweman River near Kelso, WA	2B	17080005	46.149	122.896
14247020	Fall Creek near Clatskanie, OR	2B	17080003	46.095	123.249
14247500	Elochoman River near Cathlamet, WA	2B	17080003	46.221	123.341
14248100	Risk Creek near Skamokawa, WA	2B	17080003	46.251	123.397
14248200	Jim Crow Creek near Grays River, WA	1	17080006	46.277	123.560
14248510	Little Creek near Knappa, OR	1	17080006	46.146	123.604
14249000	Grays River above South Fork near Grays River, WA	1	17080006	46.393	123.478
14250500	West Fork Grays River near Grays River, WA	1	17080006	46.385	123.558
14251500	Youngs River near Astoria, OR	1	17080006	46.067	123.789
14299000	South Fork Necanicum River near Seaside, OR	1	17100201	45.893	123.832
14299500	Asbury Creek near Cannon Beach, OR	1	17100201	45.815	123.964
14300200	Oak Ranch Creek near Vernonia, OR	2B	17100202	45.950	123.128
14301000	Nehalem River near Foss, OR	1	17100202	45.704	123.754
14301250	Jetty Creek near Brighton, OR	1	17100202	45.659	123.923
14301300	Miami River near Garibaldi, OR	1	17100202	45.575	123.872
14301400	Patterson Creek at Bay City, OR	1	17100203	45.528	123.887
14301500	Wilson River near Tillamook, OR	1	17100203	45.485	123.689
14302500	Trask River near Tillamook, OR	1	17100203	45.440	123.717
14302600	Killam Creek near Tillamook, OR	1	17100203	45.398	123.753
14303000	Nestucca River near McMinnville, OR	1	17100203	45.325	123.450
14303200	Tucca Creek near Blaine, OR	1	17100203	45.324	123.545
14303600	Nestucca River near Beaver, OR	1	17100203	45.266	123.842
14303650	Squaw Creek near Neskowin, OR	1	17100203	45.116	123.897
14303700	Alder Brook near Rose Lodge, OR	1	17100204	45.022	123.853
14303750	Salmon River near Otis, OR	1	17100204	45.017	123.938
14303800	Rock Creek near Lincoln City, OR	1	17100204	44.983	123.974

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14303950	Schooner Creek near Lincoln City, OR	1	17100204	44.955	123.953
14304350	Sunshine Creek near Valsetz, OR	1	17100204	44.811	123.743
14304850	Big Rock Creek near Valsetz, OR	1	17100204	44.778	123.693
14305500	Siletz River at Siletz, OR	1	17100204	44.715	123.886
14306030	Yaquina River near Chitwood, OR	1	17100204	44.658	123.838
14306036	Mill Creek near Toledo, OR	1	17100204	44.576	123.907
14306100	North Fork Alsea River at Alsea, OR	1	17100205	44.379	123.594
14306340	East Fork Lobster Creek near Alsea, OR	1	17100205	44.248	123.635
14306400	Five Rivers near Fisher, OR	1	17100205	44.337	123.826
14306500	Alsea River near Tidewater, OR	1	17100205	44.386	123.831
14306600	Drift Creek near Salado, OR	1	17100205	44.514	123.847
14306700	Needle Br near Salado, OR	1	17100205	44.510	123.856
14306800	Flynn Creek near Salado, OR	1	17100205	44.539	123.851
14306810	Deer Creek near Salado, OR	1	17100205	44.535	123.876
14306830	Lyndon Creek near Waldport, OR	1	17100205	44.451	123.981
14306880	Mill Creek near Yachats, OR	1	17100205	44.221	124.108
14306900	Big Creek near Roosevelt Beach, OR	1	17100205	44.168	124.065
14307500	Lake Creek at Triangle Lake, OR	1	17100206	44.161	123.569
14307550	Deadwood Creek tributary at Alpha, OR	1	17100206	44.174	123.703
14307580	Lake Creek near Deadwood, OR	1	17100206	44.083	123.785
14307610	Siuslaw River tributary near Rainrock, OR	1	17100206	44.067	123.879
14307620	Siuslaw River near Mapleton, OR	1	17100206	44.063	123.882
14307640	Sam Creek near Minerva, OR	1	17100206	44.152	123.947
14307645	North Fork Siuslaw River near Minerva, OR	1	17100206	44.047	124.003
14307685	Mult Creek near Tiller, OR	2B	17100302	43.100	122.749
14307700	Jackson Creek near Tiller, OR	2A	17100302	42.954	122.828
14308000	South Umpqua River at Tiller, OR	2A	17100302	42.931	122.947
14308500	Elk Creek near Drew, OR	2B	17100302	42.890	122.917
14308600	South Umpqua River at Days Creek, OR	2B	17100302	42.967	123.166
14308700	Days Creek at Days Creek, OR	2B	17100302	42.973	123.170
14308900	Canyon Creek at Canyonville, OR	2B	17100302	42.919	123.272
14308950	Beaver Creek near Drew, OR	2A	17100302	42.811	122.992
14308990	Cow Creek above Galesville Reservoir, near Azalea, OR	2A	17100302	42.823	123.127
14309000	Cow Creek near Azalea, OR	2B	17100302	42.825	123.178
14309500	West Fork Cow Creek near Glendale, OR	2B	17100302	42.804	123.610
14310000	Cow Creek near Riddle, OR	2B	17100302	42.924	123.428
14310700	South Myrtle Creek near Myrtle Creek, OR	2B	17100302	43.032	123.192
14310900	West Fork Frozen Creek near Myrtle Creek, OR	2B	17100302	43.087	123.197
14311000	North Myrtle Creek near Myrtle Creek, OR	2B	17100302	43.042	123.258
14311200	Olalla Creek near Tenmile, OR	2B	17100302	43.039	123.543
14311300	Tenmile Creek at Tenmile, OR	2B	17100302	43.091	123.569
14311500	Lookingglass Creek at Brockway, OR	2B	17100302	43.131	123.464
14312000	South Umpqua River near Brockway, OR	2B	17100302	43.133	123.397
14312100	Parrott Creek at Roseburg, OR	2B	17100302	43.196	123.347
14312200	Deer Creek near Roseburg, OR	2B	17100302	43.218	123.287
14312300	Marks Creek near Roseburg, OR	2A	17100302	43.249	123.397

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14313500	North Umpqua River below Lemolo Lake near Toketee Falls, OR	2A	17100301	43.322	122.194
14314500	Clearwater River above Trap Creek near Toketee Falls, OR	2A	17100301	43.244	122.286
14315500	North Umpqua River at Toketee Falls, OR	2A	17100301	43.264	122.422
14316000	Fish Creek at Big Creek Ran Station near Toketee Falls, OR	2A	17100301	43.231	122.446
14316500	North Umpqua River above Copeland Creek near Toketee Falls, OR	2A	17100301	43.296	122.536
14316600	Dog Creek near Idleyld Park, OR	2A	17100301	43.299	122.637
14316700	Steamboat Creek near Glide, OR	2A	17100301	43.350	122.728
14317500	North Umpqua River above Rock Creek near Glide, OR	2A	17100301	43.331	123.002
14317600	Rock Creek near Glide, OR	2B	17100301	43.346	122.992
14317700	White Creek near Peel, OR	2A	17100301	43.222	122.853
14317800	Cavitt Creek near Peel, OR	2B	17100301	43.222	123.018
14318000	Little River at Peel, OR	2B	17100301	43.253	123.025
14318500	North Umpqua River near Glide, OR	2A	17100301	43.306	123.117
14318600	North Umpqua River tributary near Glide, OR	2B	17100301	43.317	123.168
14319200	Sutherlin Creek at Sutherlin, OR	2B	17100301	43.389	123.303
14319500	North Umpqua River at Winchester, OR	2A	17100301	43.272	123.411
14319850	Gassy Creek near Nonpareil, OR	2B	17100303	43.417	123.121
14319900	Calapooya Creek at Nonpareil, OR	2B	17100303	43.418	123.154
14320600	Cabin Creek tributary near Oakland, OR	2B	17100303	43.436	123.313
14320700	Calapooya Creek near Oakland, OR	2B	17100303	43.403	123.362
14321000	Umpqua River near Elkton, OR	2B	17100303	43.586	123.554
14321400	Elk Creek near Elkhead, OR	2B	17100303	43.596	123.193
14321900	Yoncalla Creek near Yoncalla, OR	2B	17100303	43.625	123.286
14322000	Elk Creek near Drain, OR	2B	17100303	43.642	123.297
14322400	Pass Creek near Drain, OR	2B	17100303	43.697	123.283
14322700	Bear Creek near Drain, OR	2B	17100303	43.633	123.365
14323500	Tioga Creek near Tioga, OR	1	17100304	43.265	123.811
14323997	Priorli Creek near Dellwood, OR	1	17100304	43.341	124.079
14324500	West Fork Millicoma River near Allegany, OR	1	17100304	43.476	124.056
14324600	South Fork Coquille River above Panther Creek near Illahe, OR	1	17100305	42.758	123.986
14324700	South Fork Coquille River near Illahe, OR	1	17100305	42.725	124.011
14324900	South Fork Coquille River near Powers, OR	1	17100305	42.785	124.040
14325000	South Fork Coquille River at Powers, OR	1	17100305	42.892	124.069
14326500	Middle Fork Coquille River near Myrtle Point, OR	1	17100305	43.025	124.089
14326600	Gettys Creek near Myrtle Point, OR	1	17100305	43.008	124.211
14326800	North Fork Coquille River near Fairview, OR	1	17100305	43.179	124.086
14326815	Middle Creek near McKinley, OR	1	17100305	43.231	123.999
14326850	Cherry Creek near McKinley, OR	1	17100305	43.214	123.973
14326950	West Fork Brummit Creek near Sitkum, OR	1	17100305	43.160	123.862
14327000	North Fork Coquille River near Myrtle Point, OR	1	17100305	43.071	124.106
14327100	Geiger Creek near Bandon, OR	1	17100305	43.104	124.379
14327240	Milbury Creek near Port Orford, OR	1	17100306	42.722	124.250
14327250	Elk River above Anvil Creek, near Port Orford, OR	1	17100306	42.737	124.404
14327400	Dry Run Creek near Port Orford, OR	1	17100306	42.689	124.433
14327490	National Creek near Union Creek, OR	2A	17100307	43.004	122.364
14327500	Rogue River above Bybee Creek, near Union Creek, OR	2A	17100307	42.933	122.433

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14328000	Rogue River above Prospect, OR	2A	17100307	42.775	122.499
14330500	South Fork Rogue River above Imnaha Creek near Prospect, OR	2A	17100307	42.700	122.383
14331000	Imnaha Creek near Prospect, OR	2A	17100307	42.700	122.383
14332000	South Fork Rogue River near Prospect, OR	2A	17100307	42.708	122.392
14333000	Middle Fork Rogue River near Prospect, OR	2A	17100307	42.733	122.400
14333500	Red Blanket Creek near Prospect, OR	2A	17100307	42.778	122.426
14335000	Rogue River below South Fork Rogue River near Prospect, OR	2A	17100307	42.700	122.594
14335080	Fireline Creek near Butte Falls, OR	2A	17100307	42.569	122.403
14335100	Fourbit Creek near Butte Falls, OR	2A	17100307	42.506	122.438
14335200	South Fork Big Butte Creek above Willow Creek near B Falls, OR	2A	17100307	42.522	122.485
14335500	South Fork Big Butte Creek near Butte Falls, OR	2A	17100307	42.540	122.554
14337500	Big Butte Creek near McLeod, OR	2A	17100307	42.651	122.690
14337600	Rogue River near McLeod, OR	2A	17100307	42.656	122.714
14337800	Elk Creek near Cascade Gorge, OR	2A	17100307	42.774	122.671
14337870	West Br Elk Creek near Trail, OR	2A	17100307	42.711	122.749
14338000	Elk Creek near Trail, OR	2A	17100307	42.675	122.744
14339000	Rogue River at Dodge Br near Eagle Point, OR	2A	17100307	42.525	122.842
14339200	Constance Creek near Sam's Valley, OR	2B	17100307	42.511	122.886
14339500	South Fork L Butte Creek Big Elk Ranger Station, OR	2A	17100307	42.344	122.358
14341500	South Fork L Butte Creek near Lakecreek, OR	2A	17100307	42.408	122.600
14353000	West Fork Ashland Creek near Ashland, OR	2A	17100308	42.142	122.719
14353500	East Fork Ashland Creek near Ashland, OR	2A	17100308	42.153	122.708
14359000	Rogue River at Raygold near Central Pt, OR	2A	17100308	42.438	122.986
14359500	Evans Creek near Bybee Springs near Rogue River, OR	2B	17100308	42.581	123.022
14361300	Jones Creek near Grants Pass, OR	2B	17100308	42.436	123.286
14361500	Rogue River at Grants Pass, OR	2A	17100308	42.431	123.317
14361600	Elliott Creek near Copper, OR	2A	17100309	42.004	123.150
14361700	Carberry Creek near Copper, OR	2A	17100309	42.026	123.169
14362000	Applegate River near Copper, OR	2A	17100309	42.064	123.110
14362050	Kinney Creek near McKee Bridge, OR	2A	17100309	42.093	123.128
14366000	Applegate River near Applegate, OR	2A	17100309	42.242	123.139
14368500	Powell Creek near Williams, OR	2A	17100309	42.267	123.294
14369500	Applegate River near Wilderville, OR	2A	17100309	42.354	123.406
14369800	Butcherknife Creek near Wonder, OR	2B	17100309	42.344	123.567
14370000	Slate Creek at Wonder, OR	2B	17100309	42.361	123.519
14370200	Round Prairie Creek near Wilderville, OR	2B	17100309	42.378	123.496
14370600	Jumpoff Joe Creek near Pleasant Valley, OR	2B	17100310	42.572	123.356
14371500	Grave Creek at Pease Bridge near Placer, OR	2A	17100310	42.642	123.211
14372000	Grave Creek near Placer, OR	2A	17100310	42.628	123.342
14372300	Rogue River near Agness, OR	2A	17100310	42.581	124.058
14372500	East Fork Illinois River near Takilma, OR	2A	17100311	42.003	123.625
14375000	Sucker Creek near Holland, OR	2A	17100311	42.150	123.467
14375100	Sucker Creek below Little Grayback Creek near Holland, OR	2A	17100311	42.160	123.478
14375400	Elk Creek near O'Brien, OR	2B	17100311	42.032	123.737
14375500	West Fork Illinois River below Rock Creek near O'Brien, OR	2B	17100311	42.039	123.747
14377100	Illinois River near Kerby, OR	2B	17100311	42.232	123.662

Appendix A. Peak Flow Gaging Stations in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

Station number	Station name	Flood region	Hydrologic unit	Latitude (decimal degrees)	Longitude (decimal degrees)
14377500	Deer Creek near Dryden, OR	2A	17100311	42.264	123.450
14377800	Snailback Creek near Selma, OR	2B	17100311	42.285	123.694
14378000	Illinois River near Selma, OR	2B	17100311	42.379	123.811
14378200	Illinois River near Agness, OR	2B	17100311	42.521	124.043
14378550	Hunter Creek near Gold Beach, OR	1	17100312	42.407	124.251
14378800	Harris Creek near Brookings, OR	1	17100312	42.074	124.308
14378900	Ransom Creek near Brookings, OR	1	17100312	42.063	124.300
14400000	Chetco River near Brookings, OR	1	17100312	42.124	124.186

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
11517840	1961–1973	13	0	0	0	0	0	0	0	0	0.214	0.214	-0.209	-0.116	0.205	0.329
11520520	1961–1973	13	0	0	0	0	0	0	0	0	0.249	0.249	-0.258	-0.148	0.282	0.180
11521500	1912–1999	48	0	0	0	0	0	1	0	0	-0.198	0.203	-0.087	0.050	-0.074	0.460
11530850	1962–1973	12	0	0	0	0	0	0	0	0	-0.071	-0.071	0.034	0.012	-0.121	0.583
11531000	1912–1965	16	68	0	0	1	0	0	0	0	0.295	-0.227	-0.005	-0.126	0.133	0.471
11531500	1912–1957	11	0	0	0	0	0	0	0	0	-0.415	-0.415	-0.098	-0.158	0.309	0.186
11532000	1955–1979	21	0	0	0	0	0	1	0	0	-0.343	0.366	-0.103	0.032	-0.114	0.469
11532500	1932–1999	68	0	0	0	0	0	1	0	0	-0.432	-0.001	-0.079	-0.033	0.158	0.057
11533000	1962–1973	12	0	0	0	0	0	0	0	0	-0.086	-0.086	-0.121	-0.114	-0.030	0.891
12009500	1964–1979	16	0	0	0	0	0	1	0	0	-1.292	0.236	0.026	0.079	0.167	0.368
12010000	1930–1999	70	0	0	0	0	0	0	0	0	-0.230	-0.230	-0.038	-0.144	0.169	0.038
12010500	1954–1965	12	55	0	0	1	0	1	0	0	-0.042	2.661	-0.042	0.301	0.168	0.447
12010600	1950–1970	21	0	0	0	0	0	0	0	0	-0.447	-0.447	-0.057	-0.167	0.077	0.627
12010700	1965–1979	15	0	0	0	0	0	1	0	0	-0.919	0.129	0.019	0.046	0.268	0.164
12010800	1962–1977	16	0	0	0	0	0	1	0	0	-1.802	-0.737	-0.057	-0.209	0.150	0.418
12011000	1947–1977	19	0	0	0	0	0	1	0	0	-1.114	-0.174	-0.057	-0.090	-0.029	0.860
12011100	1949–1966	18	0	0	0	0	0	0	0	0	-0.328	-0.328	-0.057	-0.129	-0.216	0.211
12011200	1965–1979	15	0	0	0	0	0	0	0	0	0.228	0.228	-0.040	0.024	0.211	0.274
12011500	1949–1974	26	0	0	0	0	0	0	0	0	-0.191	-0.191	0.116	0.011	-0.034	0.808
12012000	1954–1979	26	0	0	0	0	0	0	0	0	0.321	0.321	0.155	0.210	0.028	0.842
12012200	1950–1969	20	0	0	0	0	0	0	0	0	0.612	0.612	0.138	0.262	-0.211	0.194
12013500	1949–1999	48	0	0	0	0	0	1	0	0	-0.690	-0.266	0.098	-0.070	0.192	0.054
12014500	1954–1979	25	0	0	0	0	0	0	0	0	0.026	0.026	0.049	0.041	0.134	0.347
12015100	1965–1979	15	0	0	0	0	0	0	0	0	-0.120	-0.120	0.083	0.033	0.029	0.882
12015500	1954–1965	12	0	0	0	0	0	0	0	0	-0.533	-0.533	0.153	0.019	-0.061	0.784
12016700	1949–1970	22	0	0	0	0	0	0	0	0	0.024	0.024	0.199	0.142	-0.252	0.101
12017000	1935–1999	48	0	0	0	0	0	0	0	0	0.888	0.888	0.344	0.547	0.185	0.064
12019600	1950–1970	21	0	0	0	0	0	0	0	0	-0.332	-0.332	0.212	0.054	-0.038	0.808
12020000	1940–1999	60	0	0	0	0	0	0	0	0	0.384	0.384	0.192	0.287	0.080	0.368

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
12020500	1945–1979	33	0	0	0	0	0	0	0	0	0.289	0.289	0.152	0.204	0.171	0.162
12024000	1945–1999	27	0	0	0	0	0	0	0	0	-0.383	0.216	0.216	0.017	0.317	0.020
12025000	1929–1999	59	0	0	0	0	0	0	0	0	-0.085	-0.085	0.225	0.058	0.218	0.015
12025700	1968–1999	32	0	0	0	0	0	0	0	0	-0.071	-0.071	-0.132	-0.108	-0.004	0.974
12026150	1930–1970	35	0	0	0	0	0	0	0	0	-0.112	-0.112	-0.129	-0.122	0.155	0.190
12027500	1929–1999	71	0	0	0	0	0	0	0	0	0.328	0.328	0.224	0.280	0.058	0.471
12030000	1945–1974	30	0	0	0	0	0	0	0	0	-0.381	-0.381	0.138	-0.049	0.120	0.352
14126300	1950–1970	21	0	0	0	0	0	0	0	0	0.082	0.082	0.163	0.138	0.091	0.563
14127000	1945–1969	25	0	0	0	0	0	0	0	0	-0.161	-0.161	0.141	0.039	-0.080	0.575
14127200	1966–1975	10	0	0	0	0	0	0	0	0	-0.283	-0.283	0.187	0.102	0.333	0.180
14128500	1935–1997	47	0	0	0	0	0	0	0	0	0.146	0.146	0.158	0.152	0.238	0.018
14131000	1927–1936	10	0	0	0	1	0	0	0	0	0.927	0.927	0.149	0.272	0.180	0.469
14131200	1953–1965	13	89	0	0	1	0	0	0	0	0.868	0.497	0.120	0.329	-0.194	0.357
14131400	1981–1993	13	16	0	0	1	0	0	0	0	1.117	1.075	0.136	0.313	-0.564	0.007
14134000	1911–1994	69	0	0	0	0	0	0	0	0	0.435	0.435	0.178	0.310	0.052	0.531
14134500	1928–1950	23	0	0	0	0	0	0	0	0	0.281	0.281	0.175	0.208	-0.079	0.597
14135000	1914–1936	13	37	0	0	1	0	0	0	0	0.973	0.816	0.171	0.390	0.128	0.542
14135500	1937–1952	16	0	0	0	0	0	0	0	0	0.764	0.764	0.167	0.299	0.109	0.557
14137000	1912–2000	89	0	0	0	0	5,000	2	0	0	-0.069	0.277	0.152	0.226	0.179	0.013
14138400	1972–1985	14	0	0	0	0	0	1	0	0	-1.067	-0.370	0.170	0.050	-0.297	0.139
14138800	1964–2000	37	0	0	0	0	0	1	0	0	-1.243	-0.036	0.119	0.051	-0.021	0.854
14138870	1976–2000	25	0	0	0	0	0	1	0	0	-0.597	0.375	0.122	0.203	0.013	0.926
14138950	1979–1991	13	0	0	0	1	0	0	0	0	0.431	0.431	0.208	0.255	-0.168	0.425
14138960	1979–1991	13	0	0	0	0	0	1	0	0	-1.081	0.368	0.208	0.242	0.077	0.714
14139510	1979-1991	12	0	0	0	0	0	0	0	0	0.484	0.484	0.194	0.251	-0.333	0.131
14139600	1979-1991	12	0	0	0	0	0	0	0	0	-0.260	-0.260	0.171	0.083	-0.061	0.784
14139700	1965–2000	36	0	0	0	0	0	0	0	0	-0.451	-0.451	0.122	-0.095	0.116	0.320
14139800	1975–2000	26	0	0	0	0	0	1	0	0	-0.976	0.149	0.141	0.144	0.179	0.200
14141500	1913–2000	82	0	0	0	0	0	0	0	0	0.175	0.175	0.150	0.165	-0.058	0.441

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
14143200	1949–1970	22	0	0	0	0	0	0	0	0	0.628	0.628	0.208	0.324	-0.182	0.235
14143500	1945–1996	38	0	0	0	0	0	1	0	0	-0.212	0.459	0.195	0.298	0.151	0.181
14144000	1952–1968	17	0	0	0	0	0	0	0	0	0.007	0.007	0.196	0.144	0.176	0.323
14144550	1950–1970	21	0	0	0	0	0	0	0	0	-0.228	-0.228	0.073	-0.017	0.139	0.378
14144600	1958–1986	25	77	0	0	1	0	0	0	1	0.593	0.333	0.339	0.336	0.043	0.761
14144800	1959–1997	39	0	0	0	0	0	1	0	0	-0.507	0.219	0.058	0.126	0.005	0.961
14144870	1960–1983	20	0	0	0	0	0	1	0	0	-0.689	0.116	0.002	0.036	-0.106	0.514
14144900	1959–1981	23	67	0	0	1	0	1	0	0	0.081	0.736	-0.004	0.333	0.071	0.634
14145500	1914–1960	26	0	0	0	0	0	0	0	0	0.041	0.041	0.031	0.035	0.203	0.145
14146000	1914–1951	19	0	0	0	0	0	0	0	0	-0.179	-0.179	-0.043	-0.082	0.364	0.030
14146500	1913–1994	67	0	0	0	0	0	0	0	0	-0.035	-0.035	-0.090	-0.058	0.100	0.234
14147400	1965–1977	11	0	0	0	0	0	1	0	0	-1.627	-0.640	-0.007	-0.122	-0.236	0.312
14147500	1910–1994	62	0	0	0	0	0	1	0	0	-0.218	0.112	-0.046	0.040	-0.071	0.412
14148000	1890–1960	39	0	0	0	0	0	0	0	0	-0.116	-0.116	-0.019	-0.062	0.051	0.645
14148700	1954–1977	22	0	0	0	0	0	1	0	2	-1.307	-0.491	-0.063	-0.185	0.004	0.977
14150300	1964–1999	36	0	0	0	0	0	0	0	0	-0.568	-0.568	-0.065	-0.248	0.011	0.924
14150800	1964–1981	18	0	0	0	0	0	0	0	0	-0.656	-0.656	-0.153	-0.275	-0.046	0.791
14151000	1936–1965	30	0	0	0	0	4,000	2	0	0	-0.613	-0.050	-0.103	-0.082	0.203	0.115
14151500	1936–1948	13	0	0	0	0	1,000	2	0	0	-0.826	0.146	-0.134	-0.072	0.205	0.329
14152500	1936–1987	52	0	0	0	0	0	1	0	0	-0.425	-0.050	-0.125	-0.087	-0.002	0.981
14153800	1977–2000	23	0	0	0	0	0	0	0	0	-0.348	-0.348	-0.056	-0.145	0.012	0.937
14153900	1953–1964	12	0	0	0	0	0	1	0	0	-1.088	-0.968	-0.189	-0.323	0.015	0.945
14154500	1936–2000	65	0	0	0	0	0	2	0	0	-0.742	-0.262	-0.093	-0.182	-0.018	0.830
14155500	1939–1949	11	0	0	0	0	0	0	0	0	-0.221	-0.221	-0.114	-0.135	0.345	0.139
14156000	1936–1946	11	0	0	0	0	0	0	0	0	0.314	0.314	-0.139	-0.052	0.257	0.271
14156500	1947–1981	35	0	0	0	0	2,000	2	0	0	-0.751	-0.087	-0.147	-0.122	-0.013	0.909
14157000	1924–1942	19	0	0	0	0	0	0	0	0	0.046	0.047	-0.139	-0.085	-0.112	0.504
14158000	1912–1950	33	0	0	0	0	0	0	0	0	0.156	0.156	-0.096	0.004	0.017	0.889
14158250	1953–1968	14	0	0	0	0	0	2	0	0	-0.570	-0.182	0.403	0.264	-0.376	0.061

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Syste-matic	His-tori-cal	His-tori-cal	User thresh-old	High out-lier	User thresh-old	Low out-lier	Zero peaks	Below thresh-old	Station	Bulletin 17b	Gene-ralized	Weigh-ted	Kendall's Tau	Signifi-cance level
14158790	1961–2000	40	72	0	0	1	0	1	0	0	0.471	1.173	0.435	0.705	0.181	0.100
14158950	1965–1977	13	72	0	0	1	0	1	0	0	0.372	2.439	0.378	0.716	-0.065	0.759
14159000	1911–1962	48	0	0	0	0	0	0	0	0	-0.075	-0.075	0.325	0.128	0.031	0.755
14159200	1958–1987	30	0	0	0	0	0	1	0	0	-0.351	0.491	-0.009	0.161	0.044	0.735
14159500	1948–1962	15	29	1	0	0	0	0	0	0	-0.417	-0.291	0.048	-0.072	-0.105	0.586
14161000	1948–1958	11	0	0	0	0	750	3	0	0	-1.574	-0.017	0.435	0.344	-0.273	0.243
14161100	1964–2000	37	0	0	0	0	0	1	0	0	-0.027	0.556	0.332	0.415	0.072	0.530
14161500	1950–2000	43	0	0	0	0	0	1	0	0	0.073	0.902	0.358	0.548	-0.034	0.745
14161600	1954–1968	15	0	0	0	0	0	1	0	0	-0.974	-0.440	0.152	0.016	-0.251	0.192
14162000	1936–1965	30	0	0	0	0	0	0	0	0	0.280	0.280	0.328	0.310	0.182	0.159
14162500	1925–1962	38	0	0	0	0	12,000	2	0	0	-0.379	0.004	0.205	0.115	0.068	0.545
14163000	1952–1990	39	0	0	0	0	1,000	2	0	0	-1.878	0.036	0.039	0.038	-0.092	0.409
14164000	1906–1915	10	0	0	0	0	0	0	0	0	-0.069	-0.069	0.167	0.123	-0.244	0.325
14165000	1936–2000	51	61	1	0	8	0	1	0	0	-0.796	-0.445	-0.189	-0.313	0.126	0.191
14165500	1945–1962	18	0	0	0	0	0	0	0	0	-0.434	-0.434	0.099	-0.038	-0.098	0.570
14166500	1936–2000	65	0	0	0	0	0	0	0	0	-0.329	-0.329	-0.280	-0.306	-0.015	0.861
14167000	1941–1987	47	0	0	0	0	700	0	0	0	-0.753	-0.753	-0.313	-0.484	-0.085	0.399
14169700	1957–1977	21	0	0	0	0	0	0	0	0	-0.316	-0.316	-0.287	-0.296	0.014	0.928
14170000	1921–1941	21	0	0	0	0	0	0	0	0	0.067	0.067	-0.284	-0.175	-0.138	0.380
14170500	1946–1979	21	0	0	0	0	0	0	0	0	0.468	0.468	0.010	0.138	-0.301	0.057
14171000	1941–1985	45	0	0	0	0	0	0	0	0	-0.528	-0.528	0.008	-0.213	0.115	0.264
14172000	1936–1990	55	0	0	0	0	0	0	0	0	-0.247	-0.247	0.020	-0.112	-0.030	0.744
14172300	1955–1968	14	0	0	0	0	0	0	0	0	0.397	0.397	-0.097	0.012	0.011	0.956
14173500	1941–1981	41	0	0	0	0	3,000	2	0	0	-0.518	-0.049	-0.093	-0.073	-0.009	0.937
14174000	1878–1941	56	80	1	0	0	0	0	0	0	0.156	0.226	-0.062	0.105	-0.209	0.023
14178000	1907–2000	75	0	0	0	0	0	1	0	0	-0.126	0.158	0.246	0.195	0.048	0.540
14178600	1965–1977	12	0	0	0	0	0	1	0	0	-2.801	0.242	0.092	0.123	-0.061	0.784
14178700	1979–1994	16	0	0	0	0	0	0	0	0	0.366	0.366	0.075	0.146	-0.226	0.222
14178800	1954–1977	24	0	0	0	0	0	0	0	0	0.095	0.095	0.075	0.082	0.043	0.766

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
14179000	1933–2000	57	0	0	0	0	0	1	0	0	-0.522	0.128	0.138	0.133	0.088	0.331
14181500	1909–1952	26	0	0	0	0	0	0	0	0	-0.083	-0.083	0.179	0.086	-0.028	0.843
14181700	1952–1968	17	0	0	0	0	0	0	0	0	0.115	0.115	0.220	0.192	-0.015	0.934
14182500	1932–2000	68	0	0	0	0	0	1	0	0	-0.219	0.256	0.181	0.222	0.030	0.714
14183000	1906–1952	37	0	0	0	0	0	0	0	0	-0.169	-0.169	0.184	0.036	-0.014	0.906
14184900	1953–1977	25	0	0	0	0	10	2	0	0	-2.507	-0.266	-0.031	-0.108	-0.077	0.591
14185000	1936–2000	65	0	0	0	0	0	1	0	0	-0.319	-0.026	0.232	0.086	0.110	0.196
14185800	1964–1981	18	60	0	0	1	0	1	0	0	-1.031	0.517	0.206	0.352	0.124	0.472
14185900	1964–2000	36	72	0	0	1	0	0	0	0	0.965	0.746	0.175	0.442	-0.037	0.753
14186000	1932–1947	16	0	0	0	0	0	0	0	0	0.083	0.083	0.173	0.150	-0.042	0.821
14186500	1951–1966	16	0	0	0	0	0	0	0	0	0.067	0.067	0.164	0.139	-0.117	0.528
14187000	1948–2000	38	0	0	0	0	0	0	0	0	0.026	0.026	0.049	0.039	-0.166	0.141
14187500	1906–1966	45	0	0	0	0	0	0	0	0	-0.073	-0.073	0.137	0.037	0.174	0.092
14188800	1963–1987	25	69	0	0	1	0	0	0	0	0.254	-0.072	0.190	0.040	-0.033	0.815
14189000	1908–1952	23	0	0	0	0	0	0	0	0	0.033	0.033	0.156	0.115	0.043	0.771
14189500	1935–1978	44	0	0	0	0	0	0	0	0	-0.075	-0.075	0.080	0.007	0.059	0.570
14190000	1941–1971	31	0	0	0	0	0	0	0	0	0.741	0.741	0.081	0.292	0.073	0.563
14190100	1965–2000	35	0	0	0	0	0	0	0	0	0.512	0.512	0.097	0.249	-0.066	0.579
14190200	1954–1968	15	0	0	0	0	0	0	0	0	-0.147	-0.147	0.107	0.045	0.200	0.299
14190500	1906–2000	66	0	0	0	0	0	0	0	0	0.126	0.126	0.092	0.111	-0.094	0.263
14190600	1953–1977	25	0	0	0	0	0	1	1	0	-1.803	-0.199	0.046	-0.036	-0.131	0.360
14190800	1966–1984	19	0	0	0	0	0	0	0	0	-0.968	-0.968	0.105	-0.133	0.006	0.972
14191000	1881–1941	50	81	1	0	0	0	0	0	0	0.280	0.347	-0.007	0.192	-0.202	0.039
14192100	1952–1977	26	0	0	0	0	0	0	1	0	-0.117	-0.145	-0.116	-0.126	-0.059	0.674
14192200	1952–1966	15	0	0	0	1	0	0	0	0	0.262	0.262	-0.116	-0.026	0.106	0.583
14192500	1935–1995	61	0	0	0	0	0	0	0	0	-0.178	-0.178	-0.184	-0.181	-0.085	0.331
14192800	1954–1983	30	0	0	0	0	0	1	0	0	-3.183	-0.458	-0.392	-0.415	-0.131	0.309
14193000	1931–1995	62	0	0	0	0	0	0	0	0	0.117	0.118	-0.029	0.051	-0.095	0.274
14193300	1959–1973	15	0	0	0	0	0	0	0	0	0.241	0.241	-0.193	-0.089	0.105	0.586

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Syste-matic	His-tori-cal	His-tori-cal	User thresh-old	High out-lier	User thresh-old	Low out-lier	Zero peaks	Below thresh-old	Station	Bulletin 17b	Gene-ralized	Weigh-ted	Kendall's Tau	Signifi-cance level
14194000	1941–1994	54	0	0	0	0	10,000	3	0	0	-0.632	-0.231	-0.172	-0.201	-0.081	0.390
14194300	1959–1995	36	61	0	0	1	0	0	0	0	0.783	0.697	0.511	0.594	-0.286	0.014
14195000	1929–1951	21	0	0	0	0	0	0	0	0	0.352	0.352	0.654	0.567	0.119	0.449
14196500	1941–1951	11	0	0	0	0	0	0	0	0	0.065	0.065	0.644	0.529	0.055	0.815
14197000	1949–1973	25	0	0	0	0	0	0	0	0	0.772	0.772	0.609	0.655	0.050	0.726
14197300	1953–1968	16	39	0	0	1	0	0	0	0	0.861	0.737	0.633	0.670	0.233	0.207
14198500	1936–1993	58	69	0	0	1	0	1	0	0	-0.401	0.582	0.167	0.369	-0.062	0.493
14199700	1953–1968	13	0	0	0	0	0	1	0	0	-0.480	0.463	0.196	0.252	-0.168	0.425
14200000	1929–1978	46	0	0	0	0	0	0	0	0	0.014	0.014	0.186	0.101	0.192	0.059
14200300	1964–1979	14	0	0	0	0	0	1	0	0	-0.583	0.245	0.279	0.271	-0.077	0.702
14201000	1940–1966	26	0	0	0	0	0	0	0	0	-0.248	-0.248	0.275	0.099	0.249	0.074
14201500	1941–1985	31	0	0	0	0	1,100	2	0	0	-0.500	-0.253	0.274	0.078	0.058	0.646
14202000	1923–1997	42	0	0	0	0	0	0	0	0	0.794	0.794	0.283	0.469	0.150	0.162
14202500	1941–1984	28	44	0	0	1	0	0	0	0	-0.102	-0.307	0.331	0.051	-0.053	0.691
14202850	1977–1995	18	0	0	0	0	0	0	0	0	-0.089	-0.089	0.298	0.190	-0.066	0.704
14202920	1977–1995	18	23	0	0	1	0	0	0	0	0.359	0.275	0.294	0.288	-0.124	0.472
14203000	1941–1974	34	0	0	0	0	0	0	0	0	1.110	1.110	0.339	0.547	0.201	0.095
14203500	1940–1974	35	0	0	0	0	0	0	0	0	0.956	0.956	0.362	0.543	0.165	0.163
14203800	1952–1968	17	0	0	0	0	0	0	0	0	0.144	0.144	0.252	0.223	0.382	0.032
14204000	1936–1970	17	0	0	0	0	0	1	0	0	-0.597	0.304	0.213	0.236	0.059	0.742
14204100	1952–1977	26	0	0	0	0	0	1	0	0	-2.965	0.248	0.406	0.353	0.025	0.859
14204500	1941–1981	27	0	0	0	0	0	0	0	0	-0.395	-0.395	0.305	0.074	0.126	0.357
14205500	1941–1951	11	0	0	0	0	0	1	0	0	-2.465	-0.610	0.236	0.082	0.309	0.186
14206000	1941–1956	11	27	0	0	1	0	0	0	0	1.628	1.488	0.202	0.435	-0.147	0.530
14206500	1940–1958	19	0	0	0	0	0	0	0	0	-0.766	-0.766	0.336	0.067	0.099	0.552
14207500	1929–1974	46	0	0	0	0	0	0	0	0	0.070	0.070	0.333	0.206	0.197	0.053
14207920	1966–1983	15	0	0	0	0	0	1	1	0	-1.247	-0.860	0.045	-0.144	0.116	0.547
14208000	1921–1970	50	0	0	0	0	0	0	0	0	0.003	0.003	0.080	0.040	-0.072	0.461

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
14208500	1913–1929	16	0	0	0	0	0	0	0	0	-0.070	-0.070	0.126	0.075	0.092	0.619
14208850	1965–1977	11	0	0	0	0	0	1	0	0	-1.944	0.003	0.168	0.135	-0.055	0.815
14209000	1910–1956	43	0	0	0	0	0	0	0	0	0.399	0.399	0.091	0.221	0.031	0.769
14209500	1910–1955	38	0	0	0	0	0	0	0	0	-0.415	-0.415	0.076	-0.117	-0.017	0.880
14209700	1990–2000	11	0	0	0	0	0	0	0	0	0.272	0.272	0.063	0.103	0.273	0.243
14209750	1965–1977	12	50	0	0	1	0	1	1	0	0.544	1.690	0.146	0.474	0.000	1.000
14209900	1957–1977	20	50	0	200	2	0	0	1	0	1.413	1.321	0.196	0.504	-0.121	0.454
14210000	1909–1955	47	0	0	0	0	7,000	1	0	0	-0.338	-0.176	0.091	-0.035	0.012	0.905
14210800	1957–1966	10	0	0	0	0	0	0	0	0	-0.170	-0.170	0.153	0.094	0.289	0.245
14212000	1944–1989	37	66	0	0	1	0	1	0	0	-0.706	-0.073	0.073	-0.009	0.005	0.969
14213200	1959–1971	13	0	0	0	0	0	0	0	0	0.119	0.119	0.180	0.166	0.103	0.625
14213500	1929–1979	26	0	0	0	0	0	0	0	0	0.036	0.036	0.164	0.118	-0.317	0.023
14214500	1929–1965	13	0	0	0	0	0	0	0	0	0.627	0.627	0.158	0.253	0.426	0.043
14215000	1929–1974	21	28	0	0	1	0	0	0	0	0.782	0.669	0.153	0.313	0.268	0.089
14216000	1928–1977	28	0	0	0	0	0	0	0	0	-0.289	-0.289	0.168	0.009	0.088	0.513
14218300	1956–1974	18	0	0	0	0	0	0	0	0	0.599	0.599	0.091	0.216	0.124	0.472
14219000	1923–1934	12	0	0	0	0	0	0	0	0	0.262	0.262	0.136	0.162	0.015	0.945
14219800	1960–1999	40	0	0	0	0	0	0	0	0	-0.349	-0.349	0.091	-0.090	0.005	0.963
14221500	1952–1989	13	0	0	0	0	0	0	0	0	0.466	0.466	0.093	0.171	-0.116	0.581
14222500	1930–1999	69	0	0	0	1	0	0	0	0	0.011	0.011	0.129	0.060	-0.023	0.776
14223800	1950–1970	21	0	0	0	0	0	0	0	0	0.369	0.369	0.150	0.213	-0.082	0.605
14235300	1950–1970	21	0	0	0	0	0	0	0	0	-0.356	-0.356	0.229	0.060	-0.062	0.694
14235500	1951–1979	28	0	0	0	0	0	1	0	0	-0.354	0.837	0.229	0.408	-0.079	0.553
14236200	1957–1999	43	0	0	0	0	0	0	0	0	-0.464	-0.464	0.220	-0.062	0.040	0.706
14237000	1949–1972	24	0	0	0	0	0	0	0	0	-0.615	-0.615	0.331	0.057	0.091	0.531
14237500	1950–1977	28	0	0	0	0	0	1	0	0	-0.342	0.416	0.331	0.359	-0.077	0.565
14239000	1962–1979	18	0	0	0	0	0	0	0	0	-0.610	-0.610	0.225	0.019	0.059	0.733
14239700	1950–1969	20	0	0	0	0	0	0	0	0	0.159	0.159	0.222	0.203	0.074	0.646

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Syste-matic	His-tori-cal	His-tori-cal	User thresh-old	High out-lier	User thresh-old	Low out-lier	Zero peaks	Below thresh-old	Station	Bulletin 17b	Gene-ralized	Weigh-ted	Kendall's Tau	Signifi-cance level
14242600	1950–1970	21	0	0	0	0	0	0	0	0	0.164	0.164	0.161	0.162	-0.005	0.976
14243000	1927–1962	36	0	0	0	1	0	0	0	0	0.044	0.044	0.204	0.134	0.070	0.549
14243500	1950–1996	21	0	0	0	0	0	0	0	0	0.393	0.393	0.159	0.226	0.038	0.809
14245000	1950–1996	36	0	0	0	0	0	1	0	0	-0.193	0.532	0.235	0.345	0.073	0.531
14247020	1972–1984	11	0	0	0	0	0	0	0	0	-0.878	-0.878	0.097	-0.072	0.200	0.392
14247500	1941–1979	39	0	0	0	0	0	0	0	0	-0.117	-0.117	0.093	0.001	0.045	0.689
14248100	1949–1970	22	0	0	0	0	0	0	0	0	-0.394	-0.394	0.052	-0.079	-0.208	0.175
14248200	1965–1979	15	0	0	0	0	0	1	0	0	-1.151	0.055	0.052	0.053	0.219	0.255
14248510	1972–1984	12	0	0	0	0	0	0	0	0	-0.248	-0.248	-0.011	-0.060	-0.198	0.369
14249000	1956–1979	24	0	0	0	0	0	0	0	0	-0.270	-0.270	0.089	-0.026	-0.080	0.585
14250500	1949–1969	21	0	0	0	0	0	0	0	0	0.441	0.441	0.089	0.188	0.038	0.808
14251500	1928–1958	31	0	0	0	0	0	1	0	0	-0.761	-0.017	0.008	-0.002	-0.198	0.117
14299000	1953–1995	34	0	0	0	0	0	0	0	0	-0.120	-0.120	0.062	-0.012	0.002	0.988
14299500	1952–1977	26	0	0	0	0	0	1	0	0	-0.231	0.451	0.100	0.212	-0.028	0.842
14300200	1959–1968	10	0	0	0	0	0	0	0	0	0.054	0.054	0.141	0.125	-0.067	0.788
14301000	1940–2000	61	0	0	0	0	0	1	0	0	-0.350	0.012	0.125	0.062	0.047	0.596
14301250	1976–1995	19	0	0	0	0	0	0	0	0	0.145	0.145	0.189	0.177	-0.223	0.182
14301300	1974–1995	20	0	0	0	0	0	0	0	0	-0.179	-0.179	0.226	0.107	-0.053	0.743
14301400	1952–1968	17	0	0	0	0	0	0	0	0	0.659	0.659	0.255	0.350	0.007	0.967
14301500	1915–2000	69	0	0	0	0	0	0	0	0	-0.315	-0.315	0.172	-0.088	0.137	0.096
14302500	1932–1972	36	0	1	0	0	0	0	0	0	0.408	0.408	0.375	0.388	0.054	0.642
14302600	1976–1995	11	24	0	0	1	0	0	0	0	0.873	0.584	0.195	0.309	-0.091	0.697
14303000	1929–1944	16	0	0	0	0	0	0	0	0	-0.349	-0.349	0.568	0.344	-0.092	0.619
14303200	1984–2000	17	0	0	0	0	0	0	0	0	0.527	0.527	0.602	0.584	0.382	0.032
14303600	1965–1995	29	0	0	0	0	0	0	0	0	-0.151	-0.151	0.231	0.090	-0.172	0.189
14303650	1965–1977	13	0	0	0	0	100	2	0	0	-0.649	0.251	0.166	0.185	0.039	0.854
14303700	1954–1983	30	0	0	0	0	0	1	0	0	-3.131	0.457	0.161	0.263	-0.012	0.929
14303750	1975–1995	20	0	0	0	0	3,500	1	0	0	-0.500	-0.244	0.129	0.019	-0.137	0.399

Station number	Period of record	Length of record: Systematic	Length of record: Historical	High peaks: Historical	High peaks: User threshold	High peaks: High outlier	Low peaks: User threshold	Low peaks: Low outlier	Low peaks: Zero peaks	Low peaks: Below threshold	Skew: Station	Skew: Bulletin 17b	Skew: Generalized	Skew: Weighted	Trend: Kendall's Tau	Trend: Significance level
14303800	1973–1992	19	0	0	0	0	0	0	0	0	0.504	0.504	0.161	0.251	-0.236	0.158
14303950	1973–1986	14	0	0	0	0	400	1	0	0	-0.586	-0.257	0.161	0.063	-0.165	0.412
14304350	1973–1995	22	0	0	0	0	0	0	0	0	-0.897	-0.897	0.092	-0.160	-0.074	0.630
14304850	1973–1989	17	0	0	0	0	0	1	0	0	-1.039	-0.669	0.092	-0.087	-0.353	0.048
14305500	1906–2000	83	0	0	0	1	0	0	0	0	0.054	0.054	0.074	0.062	-0.089	0.234
14306030	1973–2000	28	0	0	0	0	0	0	0	0	-0.295	-0.295	0.015	-0.093	0.026	0.843
14306036	1960–1973	14	0	0	0	0	0	0	0	0	0.540	0.540	0.054	0.158	0.000	1.000
14306100	1958–1989	31	0	0	0	0	0	1	0	0	-0.139	0.858	0.064	0.308	-0.108	0.395
14306340	1984–2000	17	0	0	0	0	0	0	0	0	0.847	0.847	-0.149	0.075	-0.015	0.934
14306400	1959–1990	28	0	0	0	0	0	0	0	0	0.386	0.386	-0.086	0.074	-0.034	0.797
14306500	1940–2000	61	0	0	0	0	0	0	0	0	-0.268	-0.268	0.034	-0.121	-0.048	0.583
14306600	1959–1970	11	61	0	0	1	0	0	0	0	1.355	0.855	-0.001	0.358	-0.147	0.530
14306700	1959–1973	15	0	0	0	1	0	0	0	0	1.241	1.241	0.030	0.228	0.282	0.143
14306800	1959–1973	15	0	0	0	0	0	0	0	0	1.271	1.271	0.010	0.212	0.077	0.691
14306810	1959–1973	15	0	0	0	0	0	0	0	0	0.942	0.942	-0.021	0.170	0.183	0.342
14306830	1965–1977	12	0	0	0	0	0	0	1	0	0.329	0.248	-0.001	0.050	-0.107	0.629
14306880	1966–1975	10	0	0	0	0	0	0	0	0	0.990	0.990	-0.040	0.117	-0.022	0.929
14306900	1973–1992	20	0	0	0	0	0	0	0	0	0.159	0.159	-0.158	-0.065	-0.084	0.604
14307500	1932–1975	32	0	0	0	0	0	0	0	0	-0.465	-0.465	-0.192	-0.289	0.034	0.782
14307550	1957–1968	12	0	0	0	0	0	0	0	0	0.130	0.130	-0.248	-0.169	0.290	0.189
14307580	1968–1989	22	0	0	0	0	0	0	0	0	0.251	0.251	-0.200	-0.062	-0.126	0.414
14307610	1957–1977	21	0	0	0	0	0	0	0	0	-0.349	-0.349	-0.152	-0.209	0.187	0.236
14307620	1968–1994	27	0	0	0	0	0	0	0	0	-0.035	-0.035	-0.226	-0.156	-0.285	0.037
14307640	1965–1977	13	27	0	790	1	0	0	0	0	0.220	-0.048	-0.152	-0.113	-0.051	0.807
14307645	1968–1985	18	0	0	0	0	0	0	0	0	0.659	0.659	-0.154	0.044	0.230	0.182
14307685	1965–1977	13	0	0	0	0	0	1	0	0	-1.149	0.273	-0.170	-0.074	-0.154	0.464
14307700	1956–1986	31	77	0	0	1	2,000	2	0	0	-0.969	0.362	-0.025	0.187	0.004	0.973
14308000	1911–2000	62	0	0	0	0	0	1	0	0	-0.757	-0.116	-0.043	-0.083	0.017	0.846

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
14308500	1955–2000	42	0	0	0	0	0	1	0	0	-0.838	-0.353	-0.156	-0.239	-0.026	0.811
14308600	1975–1990	16	0	0	0	0	0	1	0	0	-1.807	-0.183	-0.111	-0.129	-0.008	0.964
14308700	1955–1972	18	0	0	0	0	0	1	0	0	-0.506	0.256	-0.224	-0.095	-0.203	0.240
14308900	1951–1970	16	0	0	0	0	0	1	0	0	-2.177	-0.259	-0.298	-0.288	0.050	0.787
14308950	1965–1977	13	0	0	0	0	0	0	0	0	0.088	0.088	-0.370	-0.267	-0.182	0.387
14308990	1986–2000	15	0	0	0	0	0	0	0	0	-0.449	-0.449	-0.311	-0.343	0.219	0.255
14309000	1928–1985	57	0	0	0	0	1,000	9	0	0	-1.086	0.261	-0.318	-0.028	0.247	0.007
14309500	1956–2000	45	0	0	0	0	0	1	0	0	-0.710	-0.345	-0.242	-0.287	-0.263	0.011
14310000	1955–1985	31	0	1	0	0	0	1	0	0	-1.588	-0.622	-0.265	-0.383	-0.142	0.261
14310700	1956–1972	17	0	0	0	0	0	0	0	0	-0.644	-0.644	-0.224	-0.323	-0.140	0.432
14310900	1955–1968	14	0	0	0	0	0	0	0	0	-1.040	-1.040	-0.254	-0.395	-0.011	0.956
14311000	1956–1986	31	0	0	0	0	1,000	3	0	0	-1.958	-0.043	-0.225	-0.153	-0.121	0.341
14311200	1957–1976	20	24	1	0	0	0	1	0	0	-0.872	0.267	-0.197	-0.048	-0.116	0.475
14311300	1968–1978	11	0	0	0	1	1,000	2	0	0	-1.525	0.821	-0.196	-0.018	-0.236	0.312
14311500	1956–1979	24	0	0	0	0	2,000	2	0	0	-1.384	0.116	-0.197	-0.092	-0.439	0.003
14312000	1906–1979	49	0	0	0	0	15,000	4	0	0	-1.291	-0.207	-0.194	-0.200	0.020	0.843
14312100	1952–1984	31	0	0	0	0	50	3	0	0	-2.635	-0.169	-0.240	-0.213	-0.179	0.157
14312200	1956–1973	17	0	0	0	0	0	1	0	0	-2.480	-0.348	-0.220	-0.252	-0.140	0.432
14312300	1952–1968	17	0	0	0	0	75	2	0	0	-0.815	-0.044	-0.240	-0.187	0.015	0.934
14313500	1928–1954	27	0	0	0	0	0	0	0	0	-0.119	-0.119	0.112	0.029	0.340	0.013
14314500	1928–1978	51	77	0	0	1	0	0	0	0	0.573	0.368	0.182	0.284	0.327	0.001
14315500	1925–1948	24	0	0	0	0	0	0	0	0	-0.341	-0.341	0.142	-0.010	-0.022	0.881
14316000	1948–1983	35	73	0	12,000	1	0	0	0	0	0.172	0.045	0.216	0.113	0.002	0.989
14316500	1950–2000	51	77	0	0	1	0	0	0	0	0.310	0.227	0.150	0.194	-0.059	0.542
14316600	1965–1977	13	0	0	800	0	0	0	0	0	0.415	0.142	0.084	0.154	-0.128	0.542
14316700	1956–2000	44	65	0	0	1	4,000	2	0	0	-0.781	0.253	0.009	0.138	-0.109	0.297
14317500	1925–1956	23	0	0	0	0	0	0	0	0	0.472	0.472	0.078	0.194	0.087	0.560
14317600	1957–1973	17	0	0	0	0	0	0	0	0	0.406	0.406	-0.093	0.032	-0.088	0.621

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
14317700	1965–1977	13	43	0	0	1	35	0	0	0	0.581	0.002	-0.169	-0.088	-0.039	0.854
14317800	1956–1967	12	0	0	0	0	0	0	0	0	-0.243	-0.243	-0.188	-0.199	-0.121	0.583
14318000	1955–2000	36	0	0	0	0	0	1	0	0	-1.094	-0.330	-0.169	-0.232	-0.160	0.169
14318500	1910–1956	20	0	0	0	0	0	0	0	0	0.530	0.530	0.017	0.154	0.237	0.143
14318600	1956–1967	12	0	0	0	1	0	0	0	0	0.550	0.550	-0.148	-0.012	-0.246	0.265
14319200	1956–1967	12	0	0	0	0	600	1	0	0	-0.694	-0.242	-0.179	-0.192	0.030	0.891
14319500	1909–2000	58	0	0	0	0	0	2	0	0	-0.739	0.149	-0.004	0.076	-0.064	0.477
14319850	1989–2000	12	0	0	0	0	0	1	0	0	-0.682	-0.106	-0.148	-0.139	0.212	0.337
14319900	1976–1988	13	34	0	0	1	600	2	0	0	-2.284	0.288	-0.140	0.026	0.231	0.272
14320600	1957–1975	19	0	0	0	0	150	6	0	0	-0.953	-0.500	-0.182	-0.265	-0.298	0.074
14320700	1956–2000	43	0	0	0	0	3,000	2	0	0	-0.604	-0.032	-0.159	-0.099	-0.267	0.012
14321000	1906–2000	94	0	0	0	0	25,000	2	0	0	-0.744	-0.056	-0.126	-0.081	0.116	0.097
14321400	1987–1999	13	0	0	0	0	0	0	0	0	-0.013	-0.013	-0.128	-0.102	-0.077	0.714
14321900	1956–1967	12	0	0	0	0	0	1	0	0	-1.454	-0.372	-0.189	-0.226	-0.290	0.189
14322000	1956–1978	23	0	0	0	0	1,500	2	0	0	-1.084	-0.283	-0.166	-0.202	-0.225	0.132
14322400	1956–1967	12	0	0	0	0	0	0	0	0	-0.310	-0.310	-0.266	-0.275	0.000	1.000
14322700	1952–1966	15	0	0	0	0	200	2	0	0	-0.501	-0.021	-0.189	-0.147	0.268	0.164
14323500	1983–1996	14	0	0	0	0	1,000	2	0	0	-0.926	-0.215	-0.220	-0.219	-0.155	0.441
14323997	1984–1996	13	0	0	0	0	0	0	0	0	-0.094	-0.094	-0.254	-0.218	-0.410	0.051
14324500	1955–1981	27	0	0	0	0	0	1	0	0	-0.756	-0.520	-0.323	-0.386	-0.245	0.073
14324600	1957–1970	14	82	0	0	1	0	0	0	0	1.258	0.296	-0.163	0.100	0.033	0.870
14324700	1957–1974	18	82	0	0	1	0	1	0	0	-0.338	0.109	-0.153	0.006	-0.144	0.403
14324900	1957–1970	14	82	0	0	1	0	0	0	0	1.216	0.246	-0.134	0.087	0.033	0.870
14325000	1917–2000	82	0	0	0	0	0	0	0	0	-0.013	-0.013	-0.111	-0.050	0.113	0.135
14326500	1925–1946	17	0	0	0	0	0	0	0	0	0.062	0.062	-0.171	-0.108	-0.029	0.869
14326600	1953–1977	25	0	0	0	0	50	2	0	0	-0.999	-0.201	-0.213	-0.209	-0.258	0.071
14326800	1964–1981	18	0	0	0	0	0	1	0	0	-0.889	-0.429	-0.233	-0.284	-0.137	0.426
14326815	1984–1996	13	0	0	0	0	0	0	0	0	-0.434	-0.434	-0.220	-0.265	-0.256	0.222

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
14326850	1984–1996	13	14	0	0	1	0	1	0	0	-0.726	0.371	-0.220	-0.088	-0.128	0.542
14326950	1985–1996	11	0	0	0	0	300	2	0	0	-1.196	-0.338	-0.220	-0.243	-0.418	0.073
14327000	1929–1968	24	0	0	0	0	0	0	0	0	0.746	0.746	-0.218	0.051	0.403	0.006
14327100	1953–1968	16	0	0	0	0	0	0	0	0	-0.110	-0.110	-0.215	-0.188	-0.254	0.170
14327240	1966–1977	12	0	0	0	0	0	0	0	0	0.149	0.149	-0.160	-0.095	-0.121	0.583
14327250	1975–1999	18	35	0	0	1	0	0	0	0	0.987	0.680	-0.159	0.132	0.118	0.494
14327400	1954–1980	26	0	0	0	0	0	0	0	0	-0.162	-0.162	-0.174	-0.170	-0.111	0.425
14327490	1965–1977	12	0	0	0	0	0	0	0	0	0.067	0.067	0.223	0.190	-0.152	0.493
14327500	1931–1952	22	0	0	0	0	0	0	0	0	0.483	0.483	0.237	0.307	0.078	0.611
14328000	1909–1998	77	0	0	0	0	0	0	0	0	0.090	0.091	0.246	0.153	0.016	0.832
14330500	1932–1949	18	0	0	0	0	0	0	0	0	0.319	0.319	0.355	0.346	-0.026	0.879
14331000	1932–1949	18	0	0	0	0	60	0	0	0	-0.150	-0.150	0.375	0.230	0.125	0.469
14332000	1925–1978	36	77	0	0	1	0	0	0	0	0.283	0.074	0.360	0.189	0.029	0.806
14333000	1927–1956	30	0	0	0	0	0	0	0	0	0.804	0.804	0.370	0.503	0.216	0.093
14333500	1927–1981	45	0	0	0	0	0	0	0	0	0.220	0.220	0.366	0.300	0.085	0.411
14335000	1932–1965	34	77	0	0	1	0	0	0	0	1.087	0.935	0.283	0.568	0.111	0.358
14335080	1966–1977	12	43	0	0	1	0	0	0	0	1.415	1.155	0.333	0.572	0.000	1.000
14335100	1950–1978	28	0	0	0	0	0	0	0	0	0.658	0.658	0.333	0.434	-0.079	0.553
14335200	1950–2000	44	0	0	0	0	0	0	0	0	0.190	0.190	0.305	0.253	-0.166	0.112
14335500	1911–1995	75	77	0	0	1	0	0	0	0	0.522	0.512	0.243	0.384	-0.075	0.343
14337500	1946–2000	44	0	0	0	0	2,000	14	0	0	-0.632	0.378	0.190	0.271	-0.163	0.119
14337600	1966–1976	11	77	1	0	0	0	0	0	0	0.287	0.500	0.251	0.381	0.236	0.312
14337800	1974–2000	27	0	0	0	0	1,000	3	0	0	-1.683	-0.145	0.074	-0.004	-0.066	0.632
14337870	1974–2000	26	0	0	0	0	0	1	0	0	-0.637	-0.189	-0.091	-0.125	-0.348	0.013
14338000	1946–2000	55	0	0	0	0	1,000	2	0	0	-1.143	-0.044	0.012	-0.017	-0.162	0.081
14339000	1939–1976	38	0	0	0	0	0	0	0	0	0.350	0.350	0.189	0.254	0.183	0.105
14339200	1959–1968	10	0	0	0	0	0	0	0	0	0.770	0.770	0.043	0.164	0.289	0.245
14339500	1927–1962	25	0	0	0	0	50	6	0	0	-1.242	-0.840	0.222	-0.072	-0.107	0.452

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Systematic	Historical	Historical	User threshold	High outlier	User threshold	Low outlier	Zero peaks	Below threshold	Station	Bulletin 17b	Generalized	Weighted	Kendall's Tau	Significance level
14341500	1922–1982	61	0	0	0	0	200	1	0	0	-0.144	0.014	0.160	0.079	0.119	0.174
14353000	1925–1982	24	0	0	0	0	0	0	0	0	0.201	0.201	-0.085	0.008	-0.138	0.346
14353500	1925–1982	24	0	0	0	0	0	0	0	0	0.112	0.112	-0.085	-0.019	-0.033	0.822
14359000	1906–1976	71	0	0	0	0	0	0	0	0	0.257	0.257	0.128	0.199	0.137	0.091
14359500	1926–1956	13	0	0	0	0	0	1	0	0	-0.570	0.116	-0.162	-0.100	0.333	0.113
14361300	1952–1977	26	0	0	0	0	0	0	0	0	-0.059	-0.059	-0.218	-0.162	0.034	0.808
14361500	1939–1976	38	0	0	0	0	0	0	0	0	-0.249	-0.249	0.076	-0.059	0.214	0.059
14361600	1978–1987	10	0	0	0	0	0	0	0	0	0.084	0.084	-0.346	-0.266	-0.111	0.655
14361700	1978–1987	10	0	0	0	0	0	0	0	0	0.078	0.078	-0.251	-0.190	0.067	0.788
14362000	1939–1980	42	0	0	0	0	0	0	0	0	-0.578	-0.578	-0.296	-0.407	0.057	0.595
14362050	1965–1981	17	0	0	0	0	0	0	0	0	0.646	0.646	-0.300	-0.077	-0.214	0.231
14366000	1939–1980	42	0	0	0	0	0	0	0	0	-0.641	-0.641	-0.268	-0.411	0.008	0.939
14368500	1947–1958	12	0	0	0	0	0	1	0	0	-1.351	-0.561	-0.251	-0.311	0.212	0.337
14369500	1939–1980	20	0	0	0	0	0	0	0	0	-0.230	-0.230	-0.260	-0.251	0.189	0.243
14369800	1953–1968	16	0	0	0	0	0	1	0	0	-1.382	-0.591	-0.201	-0.291	-0.127	0.494
14370000	1944–1966	19	0	0	0	0	1,000	2	0	0	-1.068	-0.624	-0.212	-0.316	0.352	0.035
14370200	1953–1968	16	0	0	0	0	100	3	0	0	-1.653	-0.685	-0.212	-0.319	-0.100	0.589
14370600	1970–1992	20	0	0	0	0	500	3	0	0	-0.670	0.310	-0.188	-0.047	-0.211	0.194
14371500	1941–1989	47	0	0	0	0	0	2	0	0	-1.371	0.443	-0.146	0.109	0.024	0.811
14372000	1942–1954	13	0	0	0	0	0	0	0	0	-0.467	-0.467	-0.141	-0.209	0.282	0.180
14372300	1961–1976	16	0	0	0	0	0	0	0	0	-0.487	-0.487	-0.040	-0.146	-0.075	0.684
14372500	1929–1995	58	0	0	0	0	0	1	0	0	-0.706	-0.146	-0.048	-0.099	0.002	0.979
14375000	1942–1965	24	0	0	0	0	0	0	0	0	-0.274	-0.274	-0.193	-0.219	0.159	0.275
14375100	1966–1996	30	71	1	0	0	0	1	0	0	-0.744	-0.206	-0.192	-0.200	-0.170	0.186
14375400	1970–1994	21	0	0	0	0	0	2	0	0	-1.427	0.042	0.033	0.036	-0.390	0.013
14375500	1955–1985	30	0	0	0	0	0	1	0	0	-0.341	0.844	0.020	0.270	-0.336	0.009
14377100	1962–1999	38	71	0	0	1	8,000	2	0	0	-0.687	0.288	-0.114	0.105	-0.167	0.140
14377500	1942–1956	15	0	0	0	0	0	1	0	0	-0.811	-0.221	-0.183	-0.192	0.162	0.400

Appendix B. Peak-Discharge Statistics for Gaging Stations Used in the Regional Regression Analysis—Continued

		Length of record		High peaks			Low peaks				Skew				Trend	
Station number	Period of record	Syste-matic	His-tori-cal	His-tori-cal	User thresh-old	High out-lier	User thresh-old	Low out-lier	Zero peaks	Below thresh-old	Station	Bulletin 17b	Gene-ralized	Weigh-ted	Kendall's Tau	Signifi-cance level
14377800	1956–1974	17	0	0	0	0	0	1	0	0	-0.813	0.048	-0.147	-0.094	0.147	0.410
14378000	1957–1968	12	71	0	0	1	0	0	0	0	1.273	0.748	-0.134	0.276	-0.121	0.583
14378200	1961–1981	21	71	0	0	1	0	1	0	0	-1.302	-0.110	-0.150	-0.127	-0.048	0.763
14378550	1965–1977	13	71	0	0	1	0	0	0	0	1.469	0.922	-0.167	0.298	-0.333	0.113
14378800	1953–1968	14	0	0	0	0	0	0	0	0	0.391	0.391	-0.115	-0.003	-0.319	0.112
14378900	1953–1977	24	0	0	0	0	0	0	0	0	-0.120	-0.120	-0.115	-0.117	-0.240	0.100
14400000	1970–2000	30	0	0	0	0	0	0	0	0	-0.501	-0.501	-0.174	-0.285	-0.083	0.520

Appendix C. Plotting Position

For this study, plotting positions for the observed peak discharges were determined following the recommendations of Cunnane (1978). Many plotting position formulae are special cases of the general formula:

$$F_i = \frac{i - \alpha}{N + 1 - 2\alpha} \tag{C-1}$$

where

i = the rank of the peak discharge, the largest peak being number 1,
F_i = the probability associated with peak i,
N = the number of peak discharges, and
α = a constant greater than 0 and less than 1.

The value of α determines how well the calculated plotting positions fit a given theoretical distribution. For example, the Hazen formula, α equal to 0.5, gives a good approximation of the extreme value distribution. Plotting positions for the Weibell distribution, recommended by Bulletin 17B, are obtained from Equation C-1 setting α equal to 0.0.

Cunnane (1978) gives recommendations for unbiased plotting positions for a variety of theoretical probability distributions. For the Pearson Type-III distribution Cunnane recommends α be between 0.44 and 0.375. For this analysis, α has been given a value of 0.4075, the average of 0.44 and 0.375.

Reference

Cunnane, C., 1978, Unbiased plotting positions—A review: Journal of Hydrology, v. 37, p. 205–222.

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
11517840[a]	S	12.2	27.6	41.7	64.4	84.8	108	177
11520520[a]	S	517	1,030	1,460	2,110	2,650	3,250	4,880
11521500[a]	S	6,590	11,500	15,500	21,200	26,100	31,400	45,900
11530850[a]	S	39.5	59.9	74.7	94.4	110	126	166
11531000[a]	S	13,700	18,800	22,100	26,100	29,100	32,000	38,600
11531500[a]	S	20,500	34,400	44,700	58,700	69,700	81,200	110,000
11532000[a]	S	45,400	73,500	94,800	124,000	148,000	174,000	240,000
11532500[a]	S	77,400	112,000	135,000	166,000	190,000	214,000	273,000
11533000[a]	S	150	286	396	559	695	844	1,240
12009500[a]	S	1,140	1,640	1,990	2,450	2,810	3,180	4,090
12010000[a]	S	5,880	7,850	9,090	10,600	11,700	12,700	15,100
12010500[a]	S	1,680	1,870	1,990	2,130	2,230	2,320	2,530
12010600[a]	S	176	203	219	236	248	258	281
12010700[a]	S	2,300	3,120	3,660	4,350	4,860	5,380	6,610
12010800[a]	S	234	295	332	374	403	431	490
12011000[a]	S	1,410	1,640	1,770	1,920	2,020	2,110	2,320
12011100[a]	S	48.8	65	75.2	87.5	96.4	105	124
12011200[a]	S	704	1,110	1,400	1,810	2,140	2,480	3,350
12011500[a]	S	2,850	3,650	4,150	4,770	5,210	5,650	6,650
12012000[a]	S	2,320	3,010	3,470	4,060	4,510	4,960	6,050
12012200[a]	S	126	167	195	231	259	288	358
12013500[a]	S	8,450	10,500	11,800	13,300	14,400	15,400	17,700
12014500[a]	S	1,640	2,300	2,750	3,330	3,770	4,220	5,300
12015100[a]	S	264	399	495	624	725	831	1,090
12015500[a]	S	1,650	2,210	2,580	3,040	3,380	3,720	4,520
12016700[a]	S	152	208	247	297	335	375	471
12017000[a]	S	8,500	12,000	14,600	18,400	21,500	24,900	34,300
12019600[a]	S	88.5	119	139	164	183	202	247
12020000[a]	S	9,780	14,300	17,700	22,400	26,200	30,300	41,100
12020500[a]	S	1,710	2,410	2,910	3,580	4,110	4,650	6,040
12024000[a]	S	2,340	3,160	3,700	4,390	4,890	5,400	6,600
12025000[a]	S	5,880	8,000	9,420	11,200	12,600	13,900	17,200
12025700[a]	S	2,710	4,270	5,380	6,870	8,020	9,200	12,100
12026150[a]	S	3,570	4,660	5,340	6,150	6,720	7,280	8,530
12027500[a]	S	25,300	35,900	43,600	54,100	62,400	71,300	94,200
12030000[a]	S	1,110	1,350	1,480	1,640	1,750	1,860	2,100
14126300[a]	S	43.6	62	75	92.3	106	120	155
14127000[a]	S	5,200	6,790	7,810	9,080	10,000	10,900	13,100
14127200[a]	S	337	482	583	716	820	927	1,190

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14128500[a]	S	14,100	22,200	28,300	36,800	43,800	51,400	71,300
14131000	S	76.5	122	158	211	255	304	440
	R	105	151	183	228	263	301	393
	W	79.7	128	165	217	258	303	418
14131200	S	219	305	368	453	521	593	779
	R	163	242	300	379	441	506	666
	W	213	294	352	431	494	561	733
14131400	S	306	428	516	636	732	833	1,090
	R	605	887	1,100	1,380	1,610	1,840	2,420
	W	329	488	621	812	966	1,130	1,530
14134000	S	277	442	573	765	929	1,110	1,620
	R	165	255	321	412	483	557	744
	W	273	430	549	719	861	1,020	1,440
14134500	S	1,360	2,090	2,650	3,430	4,080	4,780	6,630
	R	977	1,560	2,000	2,600	3,070	3,560	4,790
	W	1,330	2,020	2,530	3,230	3,800	4,410	6,000
14135000	S	5,130	6,820	8,020	9,620	10,900	12,200	15,500
	R	3,260	5,240	6,720	8,720	10,300	11,900	16,000
	W	4,870	6,480	7,650	9,300	10,700	12,100	15,700
14135500	S	4,800	7,270	9,170	11,900	14,100	16,500	23,100
	R	3,640	5,810	7,440	9,630	11,400	13,100	17,600
	W	4,670	7,010	8,740	11,200	13,100	15,200	20,700
14137000	S	14,600	22,300	28,200	36,300	43,100	50,300	69,500
	R	12,300	18,700	23,400	29,800	34,800	40,000	52,700
	W	14,600	22,200	27,900	35,900	42,400	49,300	67,600
14138400	S	407	544	633	747	831	915	1,110
	R	615	892	1,080	1,330	1,510	1,690	2,130
	W	427	588	704	859	978	1,100	1,390
14138800	S	1,110	1,500	1,760	2,080	2,330	2,570	3,160
	R	599	807	953	1,150	1,310	1,470	1,870
	W	1,100	1,460	1,690	1,980	2,200	2,420	2,950
14138870	S	553	751	888	1,070	1,210	1,350	1,700
	R	507	705	839	1,010	1,130	1,260	1,550
	W	550	747	883	1,060	1,190	1,330	1,670
14138950	S	252	361	441	550	637	730	968
	R	116	164	197	239	270	301	373
	W	229	318	374	446	501	557	696
14138960	S	344	465	549	659	744	833	1,050
	R	197	276	330	398	449	499	617
	W	323	430	499	586	652	720	885

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14139510	S	51.7	71.2	84.9	103	117	132	170
	R	41	58	69.6	84.2	95.1	106	131
	W	50.2	68.7	81.3	97.8	110	123	155
14139600	S	305	423	504	609	688	770	967
	R	193	273	329	399	452	505	631
	W	288	394	461	547	611	676	833
14139700	S	1,000	1,380	1,620	1,920	2,140	2,360	2,870
	R	647	903	1,080	1,300	1,460	1,620	2,010
	W	983	1,340	1,570	1,850	2,050	2,250	2,720
14139800	S	1,830	2,480	2,930	3,500	3,940	4,390	5,480
	R	1,110	1,560	1,870	2,260	2,560	2,850	3,540
	W	1,770	2,380	2,790	3,300	3,680	4,070	5,020
14141500	S	2,140	3,060	3,720	4,600	5,290	6,010	7,820
	R	1,370	1,960	2,360	2,870	3,250	3,630	4,530
	W	2,120	3,020	3,660	4,490	5,140	5,820	7,500
14143200[a]	S	128	181	220	273	316	362	481
14143500[a]	S	14,600	20,000	23,900	29,100	33,200	37,500	48,500
14144000[a]	S	1,240	1,710	2,030	2,450	2,770	3,110	3,920
14144550[a]	S	75.4	107	128	156	177	198	248
14144600[a]	S	40.7	53.9	63.1	75.3	84.8	94.6	119
14144800	S	8,210	13,600	17,900	24,000	29,100	34,700	49,900
	R	7,550	11,700	14,800	18,800	21,900	25,200	33,200
	W	8,180	13,400	17,400	23,000	27,500	32,300	45,000
14144870	S	27.9	42.1	52.3	66	76.8	88	116
	R	31.7	46.3	56.2	68.7	77.9	87.1	108
	W	28.3	42.7	53	66.6	77.1	87.7	114
14144900	S	1,810	2,760	3,480	4,530	5,400	6,350	8,950
	R	2,060	3,330	4,240	5,430	6,350	7,290	9,590
	W	1,830	2,830	3,630	4,750	5,670	6,650	9,180
14145500[b]	S	11,900	20,900	28,100	38,700	47,600	57,400	83,900
	R	13,400	21,200	26,700	34,100	39,800	45,700	60,100
	W	12,000	20,900	27,900	37,500	45,300	53,500	74,800
14146000	S	1,710	2,850	3,700	4,880	5,810	6,800	9,310
	R	3,440	5,360	6,720	8,510	9,900	11,300	14,900
	W	1,840	3,190	4,280	5,810	7,020	8,270	11,400
14146500	S	3,170	5,300	6,910	9,150	11,000	12,900	17,800
	R	4,710	7,460	9,420	12,000	14,000	16,000	21,000
	W	3,210	5,400	7,080	9,430	11,300	13,300	18,300

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14147400	S	42.6	73.9	97.9	131	158	187	260
	R	88.8	128	155	189	214	238	296
	W	47.8	82.9	110	147	176	205	274
14147500	S	7,280	11,100	13,800	17,600	20,500	23,600	31,300
	R	8,250	12,600	15,700	19,800	22,900	26,100	34,100
	W	7,300	11,200	14,000	17,800	20,800	23,900	31,700
14148000[b]	S	27,400	45,200	58,500	76,800	91,500	107,000	146,000
	R	33,100	52,000	65,500	83,300	97,000	111,000	146,000
	W	27,600	45,700	59,300	77,900	92,500	108,000	146,000
14148700	S	22.1	35.1	44.4	56.5	65.8	75.2	97.9
	R	30.9	45.2	54.7	66.8	75.8	84.7	105
	W	22.8	36.3	46	58.5	68	77.5	100
14150300	S	6,500	9,710	11,800	14,500	16,500	18,400	22,800
	R	6,400	9,400	11,400	14,000	15,900	17,800	22,300
	W	6,500	9,680	11,800	14,400	16,400	18,300	22,700
14150800	S	1,810	2,890	3,640	4,600	5,320	6,040	7,730
	R	2,380	3,490	4,240	5,190	5,900	6,610	8,250
	W	1,860	2,960	3,730	4,720	5,450	6,180	7,880
14151000[b]	S	10,300	14,700	17,700	21,500	24,300	27,100	33,800
	R	9,030	13,300	16,200	20,000	22,700	25,500	31,900
	W	10,200	14,600	17,500	21,200	24,000	26,800	33,400
14151500	S	2,850	4,070	4,900	5,940	6,730	7,520	9,390
	R	2,700	3,960	4,820	5,910	6,730	7,540	9,430
	W	2,830	4,050	4,880	5,940	6,730	7,530	9,410
14152500	S	3,690	5,760	7,240	9,210	10,700	12,300	16,200
	R	3,790	5,560	6,760	8,280	9,410	10,500	13,200
	W	3,690	5,750	7,200	9,110	10,600	12,100	15,700
14153800	S	3,520	6,340	8,540	11,700	14,200	16,900	23,900
	R	3,230	4,710	5,720	6,990	7,940	8,880	11,100
	W	3,490	6,130	8,080	10,700	12,600	14,700	19,700
14153900	S	221	286	324	367	397	425	484
	R	310	451	547	669	760	850	1,060
	W	232	313	368	440	493	545	665
14154500	S	11,400	16,600	20,100	24,500	27,700	30,900	38,300
	R	11,400	16,700	20,300	24,800	28,200	31,600	39,500
	W	11,400	16,600	20,100	24,500	27,700	30,900	38,400
14155500[b]	S	11,400	17,400	21,700	27,200	31,400	35,600	45,900
	R	13,200	19,500	23,700	29,100	33,200	37,200	46,600
	W	11,600	17,800	22,200	27,700	31,900	36,200	46,200

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14156000	S	3,640	5,850	7,480	9,700	11,500	13,300	17,900
	R	4,740	6,980	8,490	10,400	11,800	13,200	16,500
	W	3,800	6,080	7,740	9,920	11,600	13,300	17,300
14156500	S	4,900	7,090	8,560	10,400	11,800	13,200	16,500
	R	5,020	7,400	9,010	11,100	12,600	14,100	17,600
	W	4,910	7,120	8,600	10,500	11,900	13,300	16,700
14157000[b]	S	18,500	24,400	28,200	32,700	36,000	39,200	46,500
	R	22,500	33,400	40,800	50,200	57,300	64,400	81,000
	W	18,900	25,400	29,900	35,700	40,100	44,500	54,700
14158000[b]	S	54,900	76,700	91,400	110,000	124,000	139,000	173,000
	R	72,900	109,000	133,000	165,000	188,000	212,000	268,000
	W	55,700	78,600	94,600	116,000	132,000	148,000	187,000
14158250	S	32.4	46.1	56	69.5	80.3	91.6	121
	R	19.4	25.8	30.3	36.2	40.9	45.8	57.8
	W	30.8	41.9	48.8	57.6	64.6	71.9	91
14158790	S	1,100	1,560	1,930	2,480	2,950	3,480	4,980
	R	1,020	1,410	1,690	2,060	2,350	2,650	3,390
	W	1,100	1,550	1,910	2,420	2,850	3,330	4,640
14158950	S	36.2	48.6	58	71.3	82.4	94.5	128
	R	62.8	88.5	106	130	147	164	205
	W	38.6	53.1	64.9	81.8	95.5	110	148
14159000[b]	S	6,420	9,380	11,500	14,400	16,600	18,900	24,900
	R	8,800	12,100	14,400	17,500	20,000	22,500	28,900
	W	6,480	9,500	11,700	14,600	17,000	19,400	25,400
14159200	S	5,050	7,510	9,300	11,800	13,700	15,800	21,100
	R	6,030	9,100	11,300	14,200	16,400	18,800	24,500
	W	5,100	7,650	9,550	12,200	14,200	16,400	22,000
14159500[b]	S	9,380	14,700	18,500	23,500	27,500	31,600	41,700
	R	8,840	13,400	16,600	21,000	24,300	27,700	36,200
	W	9,330	14,500	18,100	22,800	26,500	30,200	39,500
14161000	S	1,070	1,320	1,490	1,700	1,860	2,010	2,390
	R	718	1,020	1,230	1,510	1,720	1,950	2,500
	W	1,030	1,260	1,410	1,630	1,800	1,990	2,440
14161100	S	4,020	5,850	7,240	9,220	10,900	12,600	17,500
	R	3,120	4,640	5,720	7,140	8,240	9,370	12,100
	W	3,970	5,740	7,050	8,860	10,300	11,900	16,100
14161500	S	1,710	2,710	3,550	4,840	5,990	7,320	11,300
	R	1,500	2,160	2,620	3,230	3,700	4,190	5,380
	W	1,700	2,670	3,450	4,590	5,570	6,660	9,770

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14161600	S	37.1	53.4	64.7	79.3	90.5	102	130
	R	43.1	62.2	74.7	90.3	102	113	138
	W	37.7	54.6	66.4	81.7	93.2	105	132
14162000	S	5,830	8,840	11,100	14,400	17,200	20,200	28,200
	R	4,950	7,340	9,020	11,200	13,000	14,700	19,100
	W	5,780	8,680	10,800	13,800	16,200	18,700	25,500
14162500[b]	S	28,900	39,600	46,900	56,300	63,500	70,800	88,600
	R	34,700	50,400	61,600	76,400	87,900	99,900	129,000
	W	29,100	40,300	48,200	58,800	67,000	75,400	95,800
14163000	S	2,880	4,230	5,180	6,440	7,410	8,420	10,900
	R	2,820	4,150	5,050	6,170	7,010	7,840	9,770
	W	2,880	4,230	5,170	6,410	7,360	8,340	10,700
14164000	S	29,700	51,100	68,500	94,000	116,000	140,000	206,000
	R	43,000	63,200	77,500	96,500	111,000	126,000	164,000
	W	31,300	53,700	71,200	94,900	114,000	133,000	183,000
14165000	S	6,180	8,750	10,400	12,300	13,700	15,000	17,900
	R	6,870	10,200	12,400	15,400	17,500	19,700	24,900
	W	6,200	8,810	10,500	12,500	14,000	15,500	18,700
14165500[b]	S	50,200	68,900	81,200	96,600	108,000	119,000	146,000
	R	53,000	78,900	96,900	121,000	139,000	158,000	205,000
	W	50,400	70,200	84,100	102,000	117,000	131,000	165,000
14166500	S	3,010	4,520	5,510	6,740	7,630	8,510	10,500
	R	4,100	6,010	7,320	8,990	10,200	11,500	14,400
	W	3,040	4,580	5,610	6,890	7,840	8,760	10,900
14167000	S	4,050	7,370	9,760	12,900	15,200	17,500	22,700
	R	3,300	4,920	6,040	7,490	8,570	9,660	12,200
	W	4,010	7,170	9,360	12,100	14,100	16,000	20,500
14169700	S	227	356	444	557	640	723	914
	R	258	375	456	558	635	711	891
	W	230	359	446	557	639	720	907
14170000[b]	S	8,320	12,600	15,600	19,300	22,200	25,000	31,800
	R	10,900	16,300	20,100	25,000	28,700	32,400	41,200
	W	8,550	13,100	16,200	20,400	23,600	26,700	34,300
14170500	S	996	1,430	1,740	2,150	2,470	2,800	3,640
	R	1,110	1,570	1,880	2,280	2,570	2,860	3,550
	W	1,010	1,450	1,760	2,170	2,490	2,820	3,620
14171000	S	6,150	8,940	10,800	13,100	14,800	16,400	20,200
	R	6,870	9,990	12,100	14,900	17,000	19,000	23,900
	W	6,180	9,000	10,900	13,200	15,000	16,700	20,700

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14172000	S	5,500	7,920	9,540	11,600	13,100	14,700	18,300
	R	5,490	8,030	9,760	11,900	13,600	15,200	19,000
	W	5,500	7,920	9,550	11,600	13,200	14,700	18,300
14172300	S	241	393	507	666	795	931	1,290
	R	227	333	406	499	568	638	801
	W	239	380	480	612	712	815	1,060
14173500	S	12,500	19,300	24,000	30,300	35,200	40,200	52,500
	R	10,300	15,400	19,000	23,600	27,100	30,600	38,900
	W	12,400	19,000	23,600	29,600	34,200	38,800	50,200
14174000[b]	S	108,000	162,000	202,000	257,000	300,000	346,000	462,000
	R	145,000	217,000	266,000	330,000	379,000	427,000	542,000
	W	109,000	164,000	205,000	261,000	306,000	352,000	470,000
14178000	S	7,570	11,600	14,700	18,900	22,400	26,200	36,100
	R	7,740	11,000	13,400	16,600	19,100	21,700	28,100
	W	7,580	11,600	14,600	18,700	22,100	25,700	35,000
14178600	S	96.9	142	174	217	250	286	375
	R	67.6	108	137	175	205	236	313
	W	93.1	134	163	202	233	265	347
14178700	S	701	956	1,130	1,360	1,530	1,710	2,140
	R	351	561	714	919	1,080	1,240	1,640
	W	656	876	1,020	1,210	1,370	1,530	1,930
14178800	S	82.5	125	156	198	231	266	354
	R	67.3	104	131	165	192	220	286
	W	81.6	123	152	191	222	254	335
14179000	S	6,270	8,990	10,900	13,500	15,500	17,500	22,700
	R	5,350	8,090	10,100	12,700	14,800	17,000	22,300
	W	6,240	8,940	10,800	13,400	15,400	17,500	22,700
14181500[b]	S	21,200	34,600	45,000	59,700	71,800	84,900	120,000
	R	24,000	35,000	42,800	53,200	61,400	69,800	90,600
	W	21,300	34,700	44,700	58,400	69,400	81,000	111,000
14181700	S	60.7	85.6	103	127	145	164	213
	R	87.8	126	151	183	207	231	286
	W	63.1	90.3	110	137	158	180	233
14182500	S	13,300	18,900	22,800	28,200	32,400	36,800	48,100
	R	7,450	10,700	12,900	15,600	17,700	19,700	24,500
	W	13,100	18,500	22,300	27,200	31,100	35,200	45,300
14183000[b]	S	34,000	48,600	58,600	71,700	81,700	91,900	117,000
	R	37,200	54,400	66,500	82,600	95,200	108,000	140,000
	W	34,100	48,900	59,300	73,000	83,600	94,500	121,000

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14184900	S	53.1	80.5	99.6	125	143	163	209
	R	65.1	94.7	114	139	158	176	217
	W	54.1	82.1	102	127	146	166	212
14185000	S	12,000	17,900	22,200	27,900	32,400	37,200	49,100
	R	10,300	14,900	18,000	21,900	24,900	27,800	34,700
	W	12,000	17,800	21,900	27,500	31,800	36,300	47,500
14185800	S	7,680	10,500	12,500	15,100	17,300	19,500	25,200
	R	7,630	11,000	13,300	16,400	18,800	21,200	27,200
	W	7,680	10,500	12,600	15,400	17,700	20,000	25,900
14185900	S	10,800	14,700	17,500	21,300	24,300	27,600	36,000
	R	9,140	13,500	16,500	20,400	23,500	26,600	34,100
	W	10,800	14,600	17,400	21,100	24,200	27,400	35,600
14186000	S	20,900	28,400	33,500	40,200	45,300	50,500	63,300
	R	16,000	23,100	27,900	34,000	38,600	43,100	53,700
	W	20,300	27,600	32,500	38,800	43,600	48,500	60,300
14186500	S	27,400	38,900	47,000	57,700	66,000	74,600	96,200
	R	16,600	24,000	29,100	35,400	40,200	44,900	56,100
	W	26,100	36,500	43,300	52,000	58,600	65,400	81,800
14187000	S	3,220	5,080	6,470	8,370	9,900	11,500	15,700
	R	2,940	4,300	5,220	6,380	7,250	8,110	10,100
	W	3,210	5,030	6,350	8,130	9,520	11,000	14,600
14187500[b]	S	37,700	54,200	65,700	80,600	92,100	104,000	133,000
	R	29,800	43,600	53,000	65,000	74,000	83,000	104,000
	W	37,400	53,600	64,700	79,100	90,100	101,000	128,000
14188800	S	7,180	10,600	13,000	16,200	18,700	21,300	27,600
	R	5,190	7,570	9,190	11,300	12,800	14,400	18,000
	W	7,010	10,200	12,400	15,300	17,400	19,600	24,900
14189000	S	77,500	120,000	152,000	196,000	231,000	269,000	367,000
	R	69,500	102,000	125,000	153,000	175,000	197,000	248,000
	W	77,000	118,000	148,000	189,000	221,000	254,000	337,000
14189500	S	3,010	3,990	4,640	5,440	6,020	6,610	7,970
	R	2,720	3,810	4,550	5,490	6,190	6,880	8,530
	W	2,990	3,980	4,630	5,440	6,040	6,640	8,040
14190000	S	6,390	8,670	10,300	12,400	14,100	15,800	20,200
	R	6,370	9,110	11,000	13,400	15,200	17,000	21,300
	W	6,390	8,710	10,300	12,500	14,200	16,000	20,400
14190100	S	1,930	2,730	3,320	4,100	4,730	5,390	7,070
	R	1,870	2,580	3,060	3,680	4,140	4,600	5,690
	W	1,920	2,720	3,290	4,050	4,640	5,260	6,810

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14190200	S	250	385	484	618	725	837	1,120
	R	211	301	363	442	500	559	698
	W	244	368	453	563	646	731	937
14190500	S	11,000	16,700	20,900	26,600	31,200	36,000	48,300
	R	10,800	15,500	18,800	23,000	26,200	29,300	36,900
	W	11,000	16,700	20,800	26,300	30,700	35,300	46,900
14190600	S	42.5	60.1	71.9	87.1	98.5	110	137
	R	21.1	30.9	37.5	45.9	52.1	58.3	72.7
	W	39.7	55.2	64.7	76.5	85.2	93.9	115
14190800	S	4,170	6,440	8,030	10,100	11,700	13,300	17,200
	R	2,890	4,090	4,910	5,960	6,750	7,540	9,390
	W	4,020	6,070	7,400	9,060	10,300	11,500	14,400
14191000[b]	S	166,000	244,000	300,000	378,000	440,000	506,000	675,000
	R	215,000	319,000	392,000	487,000	558,000	629,000	799,000
	W	167,000	247,000	305,000	385,000	449,000	516,000	688,000
14192100	S	72.1	116	147	190	223	257	341
	R	101	149	182	225	256	288	363
	W	74.2	119	152	196	229	264	347
14192200	S	142	213	264	331	382	435	566
	R	194	287	351	434	496	558	704
	W	148	225	281	356	413	472	614
14192500	S	9,040	11,900	13,600	15,700	17,200	18,600	21,800
	R	7,190	10,200	12,300	14,900	16,900	18,900	23,700
	W	8,970	11,800	13,600	15,700	17,200	18,700	22,000
14192800	S	130	194	236	286	321	355	430
	R	106	153	186	227	257	288	359
	W	128	190	229	276	309	342	413
14193000	S	3,560	4,970	5,930	7,160	8,100	9,050	11,400
	R	3,580	5,150	6,210	7,580	8,600	9,620	12,000
	W	3,560	4,980	5,940	7,190	8,140	9,110	11,400
14193300	S	3,100	4,110	4,750	5,530	6,090	6,640	7,890
	R	2,610	3,660	4,350	5,240	5,890	6,540	8,060
	W	3,040	4,040	4,670	5,460	6,040	6,610	7,940
14194000	S	21,100	27,700	31,800	36,600	40,000	43,200	50,400
	R	17,900	26,100	31,800	39,200	44,800	50,400	63,700
	W	21,000	27,700	31,800	36,800	40,400	44,000	51,900
14194300	S	501	794	1,040	1,430	1,770	2,170	3,370
	R	807	1,130	1,350	1,620	1,830	2,030	2,510
	W	513	813	1,070	1,450	1,780	2,150	3,210

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14195000	S	280	392	478	599	701	812	1,110
	R	546	760	906	1,090	1,230	1,360	1,680
	W	297	425	527	672	791	917	1,250
14196500	S	2,730	3,520	4,090	4,850	5,460	6,090	7,720
	R	2,700	3,880	4,690	5,710	6,480	7,250	9,050
	W	2,720	3,600	4,240	5,110	5,800	6,510	8,260
14197000	S	3,940	5,550	6,810	8,630	10,200	11,900	16,700
	R	3,270	4,740	5,750	7,040	8,000	8,960	11,200
	W	3,880	5,460	6,650	8,330	9,700	11,200	15,100
14197300	S	209	296	363	462	546	640	904
	R	270	380	454	548	617	687	849
	W	216	307	379	482	565	654	885
14198500	S	7,250	10,100	12,100	15,000	17,200	19,600	25,900
	R	6,500	9,280	11,200	13,600	15,300	17,100	21,300
	W	7,220	10,000	12,100	14,900	17,100	19,400	25,400
14199700	S	121	187	237	309	368	432	605
	R	176	256	312	383	437	490	617
	W	128	198	253	328	388	451	609
14200000	S	13,500	20,200	25,000	31,600	36,800	42,200	56,000
	R	14,300	20,800	25,200	31,000	35,200	39,600	49,700
	W	13,600	20,200	25,100	31,500	36,600	41,900	55,100
14200300	S	2,720	3,980	4,910	6,210	7,260	8,380	11,300
	R	2,210	3,190	3,870	4,740	5,390	6,040	7,590
	W	2,640	3,830	4,660	5,770	6,630	7,530	9,760
14201000	S	6,090	9,470	12,000	15,500	18,300	21,200	29,000
	R	6,340	9,360	11,500	14,200	16,200	18,300	23,200
	W	6,110	9,460	11,900	15,200	17,900	20,600	27,500
14201500	S	3,050	4,490	5,520	6,890	7,970	9,090	11,900
	R	2,700	3,930	4,780	5,860	6,670	7,480	9,390
	W	3,030	4,440	5,440	6,750	7,760	8,800	11,400
14202000	S	8,840	15,000	20,400	28,800	36,400	45,400	72,800
	R	11,000	16,500	20,400	25,400	29,200	33,100	42,300
	W	8,930	15,100	20,400	28,400	35,500	43,600	67,200
14202500	S	2,660	3,720	4,450	5,390	6,100	6,830	8,590
	R	2,410	3,510	4,260	5,210	5,930	6,640	8,320
	W	2,640	3,700	4,430	5,360	6,070	6,800	8,530
14202850	S	841	1,410	1,860	2,530	3,090	3,720	5,470
	R	998	1,440	1,750	2,130	2,420	2,700	3,370
	W	856	1,410	1,840	2,430	2,910	3,420	4,710

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14202920	S	336	515	653	851	1,010	1,190	1,680
	R	549	800	972	1,190	1,350	1,520	1,900
	W	354	549	702	917	1,090	1,280	1,750
14203000	S	1,780	2,580	3,210	4,120	4,890	5,750	8,130
	R	1,940	2,860	3,490	4,290	4,890	5,490	6,890
	W	1,790	2,610	3,240	4,140	4,890	5,700	7,870
14203500[b]	S	5,020	7,550	9,580	12,600	15,200	18,100	26,500
	R	4,830	7,130	8,720	10,800	12,300	13,800	17,400
	W	5,010	7,520	9,490	12,300	14,700	17,300	24,500
14203800	S	208	294	355	438	503	572	745
	R	261	379	459	559	634	709	881
	W	214	306	374	466	537	610	790
14204000	S	1,970	2,800	3,390	4,200	4,840	5,510	7,230
	R	1,950	2,830	3,420	4,170	4,730	5,300	6,610
	W	1,970	2,800	3,400	4,190	4,810	5,450	7,010
14204100	S	58.6	85.5	106	134	158	183	250
	R	106	153	185	225	254	283	350
	W	61.3	90.9	114	146	173	200	272
14204500	S	3,110	4,660	5,770	7,270	8,450	9,680	12,800
	R	3,190	4,670	5,680	6,970	7,930	8,890	11,100
	W	3,120	4,660	5,760	7,220	8,350	9,510	12,400
14205500	S	1,120	1,310	1,410	1,540	1,630	1,710	1,900
	R	1,820	2,690	3,290	4,050	4,630	5,200	6,550
	W	1,220	1,530	1,780	2,120	2,390	2,660	3,280
14206000	S	903	1,110	1,260	1,440	1,580	1,720	2,070
	R	1,150	1,710	2,090	2,570	2,940	3,300	4,150
	W	942	1,230	1,450	1,750	1,990	2,230	2,820
14206500	S	10,200	15,000	18,500	23,000	26,600	30,300	39,500
	R	14,600	21,900	27,100	33,700	38,800	43,800	55,900
	W	10,600	15,800	19,700	25,000	29,100	33,400	43,900
14207500[b]	S	9,980	14,500	17,700	22,100	25,700	29,400	38,900
	R	16,900	25,500	31,500	39,400	45,300	51,300	65,500
	W	10,200	15,000	18,500	23,500	27,400	31,600	42,100
14207920	S	11.4	18.5	23.7	30.6	36	41.5	55.3
	R	24.6	39.6	50.7	65.6	77.3	89.5	120
	W	12.3	21	28.1	38.2	46.2	54.5	74.8
14208000	S	3,000	4,740	6,040	7,830	9,270	10,800	14,700
	R	2,510	3,790	4,710	5,960	6,940	7,970	10,500
	W	2,980	4,680	5,920	7,600	8,940	10,300	13,900

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14208500	S	501	711	857	1,050	1,200	1,350	1,720
	R	358	556	697	887	1,040	1,190	1,590
	W	484	681	816	996	1,140	1,290	1,660
14208850	S	59.6	89.3	111	141	164	189	253
	R	40.7	63	79.2	101	118	136	181
	W	56.7	82.6	100	124	143	163	215
14209000[b]	S	1,660	2,420	2,980	3,730	4,330	4,970	6,620
	R	1,480	2,350	2,980	3,830	4,500	5,200	6,960
	W	1,660	2,420	2,980	3,740	4,360	5,010	6,690
14209500[b]	S	16,900	25,100	30,600	37,800	43,100	48,600	61,400
	R	13,400	20,700	26,000	33,100	38,700	44,400	58,800
	W	16,800	24,700	30,100	37,100	42,400	47,800	60,900
14209700	S	3,550	4,920	5,870	7,100	8,030	8,990	11,300
	R	2,990	4,570	5,730	7,280	8,490	9,740	12,800
	W	3,470	4,850	5,830	7,160	8,210	9,300	12,000
14209750	S	51.1	71.2	86.2	107	124	143	192
	R	66.8	95.7	115	140	159	177	220
	W	53.1	75.3	92.3	116	134	154	203
14209900	S	78.1	124	162	221	273	332	506
	R	96.7	140	171	210	239	268	338
	W	79.9	126	164	218	263	313	445
14210000[b]	S	24,600	37,200	46,200	58,000	67,200	76,700	99,900
	R	22,800	35,200	44,200	56,300	65,700	75,500	99,700
	W	24,500	37,100	46,000	57,800	67,000	76,500	99,900
14210800	S	150	234	297	383	453	527	719
	R	93.5	138	169	209	238	268	337
	W	138	207	252	310	354	399	509
14212000[a]	S	830	1,150	1,370	1,640	1,850	2,050	2,540
14213200[a]	S	5,500	7,790	9,400	11,600	13,200	15,000	19,400
14213500[a]	S	388	601	761	981	1,160	1,350	1,840
14214500[a]	S	278	377	447	538	609	683	867
14215000[a]	S	713	1,060	1,320	1,690	1,990	2,310	3,190
14216000[a]	S	9,140	15,100	19,700	26,200	31,400	37,000	51,700
14218300[a]	S	313	427	506	610	690	773	980
14219000[a]	S	5,900	8,530	10,400	12,900	14,900	17,000	22,300
14219800[a]	S	1,680	2,440	2,960	3,620	4,120	4,620	5,810
14221500[a]	S	1,480	1,880	2,150	2,470	2,720	2,960	3,530
14222500[a]	S	8,950	12,500	14,900	18,100	20,400	22,900	28,700
14223800[a]	S	51.6	69.4	81.6	97.4	110	122	153
14235300[a]	S	84.4	109	124	144	158	172	205

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14235500[a]	S	2,120	2,990	3,630	4,530	5,260	6,050	8,130
14236200[a]	S	10,400	15,700	19,300	24,100	27,800	31,600	40,800
14237000[a]	S	101	139	164	196	221	245	304
14237500[a]	S	1,190	1,700	2,080	2,610	3,040	3,510	4,730
14239000[a]	S	3,530	5,560	7,060	9,110	10,800	12,500	16,900
14239700[a]	S	21.8	30.8	37.2	45.8	52.5	59.5	77.2
14242600[a]	S	39.2	60.5	76.4	98.6	117	136	187
14243000[a, b]	S	51,000	68,200	79,700	94,500	106,000	117,000	144,000
14243500[a]	S	1,310	1,920	2,370	2,990	3,490	4,010	5,380
14245000[a]	S	5,010	6,790	8,060	9,760	11,100	12,500	16,100
14247020	S	85	118	140	167	187	207	253
	R	138	199	241	294	333	372	464
	W	91.3	131	159	197	226	255	323
14247500[a]	S	4,890	6,430	7,410	8,620	9,510	10,400	12,400
14248100[a]	S	77.4	119	149	188	219	250	326
14248200[a]	S	562	774	916	1,100	1,240	1,380	1,710
14248510	S	87	140	179	231	273	317	426
	R	124	170	202	243	274	304	376
	W	92.4	146	185	235	273	312	404
14249000	S	5,340	7,160	8,340	9,800	10,900	11,900	14,400
14250500	S	2,430	3,250	3,810	4,530	5,080	5,650	7,020
14251500	S	2,960	3,600	3,990	4,450	4,770	5,090	5,780
	R	2,950	3,950	4,620	5,460	6,090	6,700	8,130
	W	2,960	3,630	4,050	4,570	4,940	5,310	6,130
14299000	S	1,890	2,480	2,860	3,330	3,680	4,020	4,800
	R	995	1,370	1,620	1,940	2,180	2,420	2,990
	W	1,830	2,370	2,710	3,120	3,420	3,730	4,440
14299500	S	209	251	276	308	331	354	405
	R	312	443	533	650	738	828	1,040
	W	215	264	299	345	379	412	488
14300200	S	285	416	509	634	732	834	1,090
	R	502	742	906	1,120	1,270	1,430	1,800
	W	313	471	593	760	891	1,030	1,350
14301000	S	27,500	36,300	42,100	49,400	54,800	60,200	73,000
	R	32,800	43,700	50,900	60,000	66,600	73,100	88,200
	W	27,600	36,600	42,600	50,100	55,700	61,300	74,300
14301250	S	143	274	390	574	740	934	1,510
	R	192	280	342	423	484	546	697
	W	148	275	379	529	654	791	1,170

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14301300	S	3,230	4,740	5,810	7,260	8,390	9,580	12,600
	R	2,850	4,000	4,770	5,760	6,500	7,240	8,980
	W	3,200	4,640	5,630	6,930	7,930	8,960	11,500
14301400	S	107	163	207	269	322	380	540
	R	156	223	269	329	374	419	526
	W	112	173	220	285	338	393	535
14301500	S	17,600	24,100	28,300	33,500	37,300	41,000	49,700
	R	12,800	17,000	19,800	23,300	25,900	28,500	34,400
	W	17,500	23,800	27,800	32,700	36,300	39,900	48,200
14302500	S	12,400	16,000	18,400	21,600	24,100	26,600	32,900
	R	11,200	15,300	18,100	21,500	24,100	26,600	32,500
	W	12,400	15,900	18,400	21,600	24,100	26,600	32,900
14302600	S	378	567	710	913	1,080	1,260	1,750
	R	372	541	658	811	927	1,050	1,330
	W	377	561	695	877	1,020	1,170	1,560
14303000	S	716	1,130	1,450	1,930	2,340	2,800	4,070
	R	758	1,070	1,280	1,560	1,770	1,980	2,480
	W	721	1,120	1,410	1,820	2,150	2,500	3,420
14303200	S	218	349	461	635	793	976	1,530
	R	290	422	516	638	732	827	1,060
	W	227	363	474	636	772	921	1,330
14303600	S	11,500	16,500	20,100	24,800	28,500	32,300	41,600
	R	14,000	19,500	23,100	27,700	31,100	34,500	42,400
	W	11,600	16,800	20,400	25,200	28,900	32,600	41,800
14303650	S	185	244	283	334	372	410	504
	R	176	257	315	391	449	509	654
	W	184	247	292	352	398	446	561
14303700	S	82.8	124	155	198	234	272	373
	R	95.5	140	172	214	246	279	360
	W	83.7	126	157	201	236	273	370
14303750	S	5,700	6,910	7,650	8,530	9,160	9,750	11,100
	R	5,400	7,270	8,530	10,100	11,300	12,500	15,200
	W	5,670	6,950	7,770	8,790	9,530	10,300	11,900
14303800	S	123	207	276	381	471	572	861
	R	220	323	396	492	566	642	827
	W	132	224	299	408	497	593	849
14303950	S	1,010	1,460	1,760	2,170	2,490	2,810	3,600
	R	1,080	1,530	1,850	2,250	2,560	2,880	3,630
	W	1,020	1,470	1,780	2,190	2,510	2,830	3,610

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14304350	S	1,070	1,510	1,790	2,150	2,410	2,670	3,260
	R	842	1,150	1,360	1,630	1,820	2,010	2,460
	W	1,050	1,460	1,720	2,040	2,280	2,510	3,050
14304850	S	951	1,270	1,470	1,720	1,900	2,080	2,480
	R	685	936	1,100	1,320	1,480	1,630	1,990
	W	917	1,210	1,390	1,610	1,770	1,940	2,310
14305500	S	20,000	26,300	30,400	35,600	39,400	43,200	52,200
	R	18,100	24,000	27,800	32,600	36,000	39,400	47,100
	W	19,900	26,200	30,300	35,400	39,200	43,000	51,800
14306030	S	3,330	4,580	5,400	6,410	7,160	7,890	9,600
	R	3,590	5,130	6,160	7,480	8,450	9,420	11,700
	W	3,350	4,650	5,520	6,620	7,430	8,240	10,100
14306036	S	356	454	518	597	657	715	855
	R	319	469	572	706	807	909	1,150
	W	350	457	533	633	709	786	967
14306100	S	4,790	6,640	7,970	9,770	11,200	12,700	16,500
	R	4,500	6,350	7,600	9,210	10,400	11,600	14,400
	W	4,770	6,620	7,930	9,680	11,100	12,500	16,100
14306340	S	471	697	858	1,070	1,240	1,420	1,860
	R	522	726	866	1,040	1,180	1,310	1,620
	W	477	702	860	1,070	1,220	1,380	1,770
14306400	S	8,330	11,500	13,700	16,500	18,700	20,900	26,100
	R	7,380	10,300	12,200	14,600	16,400	18,100	22,100
	W	8,250	11,400	13,500	16,200	18,200	20,300	25,200
14306500	S	19,500	26,600	31,100	36,700	40,700	44,700	53,700
	R	21,200	29,200	34,500	41,100	46,000	50,800	61,900
	W	19,600	26,700	31,300	37,000	41,200	45,200	54,600
14306600	S	1,860	2,240	2,480	2,780	3,010	3,230	3,760
	R	1,940	2,690	3,190	3,820	4,290	4,750	5,820
	W	1,880	2,330	2,650	3,080	3,410	3,730	4,480
14306700	S	30	38.9	44.9	52.6	58.4	64.4	78.6
	R	27.5	41	50.5	63	72.5	82.2	105
	W	29.6	39.4	46.4	55.9	63.2	70.6	88.5
14306800	S	62.6	85.9	102	124	140	157	200
	R	64.5	96.3	119	148	171	193	248
	W	62.9	88.3	107	132	151	171	219
14306810	S	102	135	157	185	206	228	280
	R	95.1	141	174	216	248	281	358
	W	101	136	161	195	221	247	310

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14306830	S	51	83.9	109	145	174	205	288
	R	51.8	80.1	101	129	151	174	230
	W	51.2	82.7	106	138	163	189	256
14306880	S	129	185	224	277	318	360	465
	R	127	193	241	303	352	402	526
	W	128	187	230	288	333	380	495
14306900	S	1,010	1,380	1,630	1,930	2,150	2,370	2,880
	R	884	1,300	1,590	1,960	2,250	2,540	3,230
	W	998	1,370	1,620	1,940	2,180	2,420	2,990
14307500	S	2,290	3,420	4,160	5,090	5,760	6,420	7,910
	R	3,230	4,510	5,370	6,460	7,260	8,060	9,920
	W	2,350	3,520	4,310	5,290	6,010	6,720	8,320
14307550	S	53.7	70.7	81.3	94	103	112	131
	R	57.6	84.8	104	129	148	167	213
	W	54.5	74.6	88.8	107	121	135	167
14307580	S	9,510	13,500	16,100	19,500	22,000	24,500	30,500
	R	9,840	13,600	16,100	19,200	21,500	23,800	29,000
	W	9,540	13,500	16,100	19,400	21,900	24,300	30,100
14307610	S	23.5	37	46.4	58.6	67.8	77.1	99.3
	R	29	44.7	56	71.2	83.1	95.5	126
	W	24.2	38.3	48.5	61.9	72.3	82.8	108
14307620	S	24,500	34,600	41,200	49,500	55,600	61,500	75,300
	R	26,200	36,700	43,600	52,400	58,800	65,100	79,800
	W	24,600	34,800	41,600	50,000	56,200	62,300	76,400
14307640	S	307	422	496	588	656	722	875
	R	209	309	379	470	539	609	777
	W	286	390	456	542	607	673	830
14307645	S	2,840	3,640	4,150	4,780	5,240	5,690	6,730
	R	2,440	3,520	4,260	5,200	5,920	6,640	8,350
	W	2,790	3,620	4,170	4,890	5,420	5,960	7,220
14307685	S	219	324	397	491	563	635	810
	R	215	316	383	466	527	587	725
	W	219	323	394	485	553	621	782
14307700	S	5,710	8,470	10,500	13,300	15,500	17,900	24,000
	R	3,960	6,620	8,580	11,200	13,200	15,300	20,400
	W	5,570	8,220	10,100	12,800	14,900	17,100	22,800
14308000	S	17,500	27,500	34,700	44,300	51,800	59,600	78,700
	R	13,800	23,100	29,800	38,800	45,600	52,700	70,100
	W	17,400	27,200	34,200	43,600	50,800	58,400	77,000

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14308500	S	2,720	5,000	6,770	9,240	11,200	13,300	18,500
	R	2,590	3,860	4,720	5,810	6,630	7,440	9,340
	W	2,720	4,930	6,600	8,850	10,600	12,400	16,800
14308600	S	21,000	30,700	37,300	45,700	51,900	58,200	73,000
	R	25,100	37,800	46,400	57,400	65,600	73,800	93,000
	W	21,300	31,500	38,600	47,800	54,800	61,800	78,300
14308700	S	1,660	2,310	2,730	3,260	3,640	4,030	4,920
	R	1,580	2,380	2,920	3,610	4,120	4,630	5,810
	W	1,650	2,320	2,760	3,320	3,750	4,170	5,150
14308900	S	2,570	3,160	3,500	3,890	4,150	4,390	4,900
	R	2,310	3,410	4,130	5,050	5,730	6,410	7,960
	W	2,540	3,190	3,600	4,100	4,470	4,830	5,640
14308950	S	54.6	97.7	130	174	209	245	334
	R	70.3	117	150	193	226	259	342
	W	56.9	102	136	182	217	252	338
14308990	S	2,360	4,100	5,360	7,020	8,280	9,560	12,600
	R	3,180	5,160	6,540	8,350	9,730	11,200	14,600
	W	2,490	4,370	5,770	7,590	8,970	10,400	13,700
14309000[b]	S	2,860	4,440	5,580	7,110	8,310	9,560	12,700
	R	4,040	5,950	7,240	8,890	10,100	11,300	14,200
	W	2,890	4,500	5,660	7,220	8,440	9,710	12,800
14309500	S	6,180	8,840	10,500	12,600	14,100	15,500	18,700
	R	6,070	8,690	10,500	12,700	14,400	16,000	19,900
	W	6,180	8,840	10,500	12,600	14,100	15,600	18,900
14310000[b]	S	20,000	29,300	35,200	42,200	47,200	52,000	62,500
	R	21,600	32,000	39,000	47,900	54,600	61,300	76,800
	W	20,100	29,500	35,500	42,900	48,200	53,400	64,900
14310700	S	1,870	2,520	2,910	3,370	3,680	3,980	4,630
	R	2,140	3,220	3,950	4,880	5,570	6,260	7,850
	W	1,900	2,600	3,060	3,640	4,060	4,470	5,400
14310900	S	153	233	286	351	397	442	541
	R	191	286	349	429	487	545	679
	W	157	241	298	369	421	472	586
14311000	S	1,900	2,600	3,050	3,590	3,990	4,380	5,260
	R	2,580	3,890	4,770	5,880	6,710	7,530	9,430
	W	1,930	2,680	3,190	3,830	4,310	4,790	5,880
14311200[b]	S	4,220	6,580	8,280	10,600	12,300	14,200	18,800
	R	3,360	4,930	5,990	7,340	8,340	9,340	11,700
	W	4,140	6,360	7,900	9,870	11,400	12,900	16,600

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14311300	S	2,730	3,690	4,310	5,090	5,670	6,240	7,580
	R	1,530	2,250	2,740	3,360	3,830	4,290	5,360
	W	2,490	3,330	3,840	4,480	4,950	5,430	6,560
14311500[b]	S	10,700	16,700	21,100	26,800	31,300	35,900	47,200
	R	6,600	9,820	12,000	14,800	16,900	19,000	23,900
	W	10,300	15,800	19,500	24,300	27,800	31,400	40,000
14312000	S	50,100	72,700	87,500	106,000	120,000	133,000	164,000
	R	59,600	89,600	110,000	136,000	156,000	176,000	222,000
	W	50,400	73,400	88,800	108,000	123,000	137,000	170,000
14312100	S	141	199	238	284	318	352	427
	R	143	214	261	321	365	409	510
	W	141	201	240	290	326	362	444
14312200	S	4,000	5,260	6,020	6,910	7,540	8,130	9,420
	R	2,270	3,400	4,180	5,160	5,890	6,620	8,320
	W	3,780	4,960	5,660	6,500	7,110	7,710	9,080
14312300	S	143	192	222	258	284	309	365
	R	60	90.4	111	137	157	176	220
	W	132	174	198	227	248	268	315
14313500[b]	S	715	931	1,070	1,240	1,370	1,490	1,780
	R	1,340	1,930	2,350	2,920	3,360	3,830	5,010
	W	746	1,020	1,220	1,490	1,710	1,920	2,430
14314500[b]	S	316	415	482	569	636	704	873
	R	317	474	584	730	845	964	1,270
	W	316	418	491	588	664	743	937
14315500	S	2,600	3,570	4,220	5,040	5,650	6,260	7,710
	R	3,680	5,490	6,790	8,510	9,870	11,300	14,800
	W	2,670	3,780	4,610	5,730	6,590	7,480	9,600
14316000[b]	S	2,020	3,620	4,950	6,940	8,670	10,600	16,000
	R	989	1,580	2,010	2,590	3,050	3,520	4,700
	W	1,940	3,320	4,330	5,720	6,860	8,090	11,400
14316500	S	7,080	11,900	15,800	21,500	26,300	31,700	46,800
	R	6,390	9,810	12,300	15,600	18,100	20,800	27,500
	W	7,050	11,700	15,300	20,500	24,800	29,400	41,900
14316600	S	140	293	436	672	894	1,160	1,990
	R	115	194	250	322	377	434	572
	W	136	267	369	509	624	748	1,090
14316700	S	14,100	20,300	24,700	30,500	35,100	39,900	51,800
	R	11,600	18,600	23,600	30,100	35,000	40,100	52,400
	W	14,000	20,200	24,600	30,500	35,100	39,900	51,900

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14317500	S	24,400	37,000	46,400	59,600	70,300	81,800	112,000
	R	23,500	37,300	47,300	60,300	70,500	80,900	107,000
	W	24,300	37,000	46,600	59,800	70,400	81,500	110,000
14317600	S	6,320	10,300	13,300	17,600	21,000	24,700	34,400
	R	5,810	8,470	10,300	12,500	14,200	15,900	19,800
	W	6,260	10,000	12,800	16,400	19,200	22,000	29,100
14317700	S	148	246	319	420	501	585	799
	R	191	292	359	444	508	574	733
	W	152	253	328	427	503	581	774
14317800	S	3,630	6,140	7,990	10,500	12,400	14,500	19,400
	R	3,040	4,440	5,390	6,590	7,490	8,390	10,500
	W	3,540	5,800	7,330	9,260	10,700	12,100	15,500
14318000	S	9,470	13,400	15,900	18,900	21,100	23,300	28,100
	R	8,520	12,600	15,300	18,800	21,400	24,000	30,100
	W	9,420	13,300	15,800	18,900	21,200	23,400	28,400
14318500	S	39,200	57,200	70,200	87,700	102,000	116,000	153,000
	R	39,900	63,200	79,700	101,000	118,000	135,000	177,000
	W	39,200	58,100	72,200	91,500	107,000	123,000	162,000
14318600	S	55.8	87.5	111	142	167	193	258
	R	49.1	72.9	88.7	109	123	138	171
	W	54.7	84.4	105	131	151	171	219
14319200	S	1,380	1,880	2,200	2,580	2,850	3,120	3,710
	R	658	990	1,220	1,510	1,720	1,930	2,430
	W	1,260	1,690	1,940	2,240	2,460	2,680	3,190
14319500	S	45,700	67,200	82,500	103,000	119,000	135,000	177,000
	R	43,400	69,300	87,600	112,000	130,000	149,000	195,000
	W	45,700	67,400	83,000	104,000	120,000	138,000	180,000
14319850	S	581	1,040	1,410	1,920	2,340	2,780	3,940
	R	631	914	1,100	1,340	1,520	1,700	2,110
	W	590	1,010	1,310	1,700	1,990	2,280	2,970
14319900	S	3,540	4,490	5,090	5,820	6,340	6,860	8,040
	R	4,580	6,680	8,110	9,920	11,300	12,600	15,800
	W	3,670	4,840	5,670	6,780	7,620	8,470	10,500
14320600	S	175	212	233	256	272	286	317
	R	77.3	116	142	175	199	224	280
	W	162	196	215	237	254	270	306
14320700	S	10,300	15,900	19,800	25,000	28,900	33,000	42,800
	R	8,150	12,200	14,900	18,400	21,100	23,700	29,900
	W	10,200	15,600	19,300	24,100	27,800	31,500	40,400

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14321000	S	94,200	137,000	167,000	204,000	233,000	261,000	330,000
	R	119,000	180,000	221,000	274,000	314,000	354,000	449,000
	W	94,600	138,000	168,000	207,000	236,000	266,000	337,000
14321400	S	1,290	2,500	3,510	5,010	6,290	7,690	11,500
	R	1,370	2,030	2,480	3,040	3,470	3,890	4,870
	W	1,300	2,400	3,210	4,290	5,110	5,960	8,020
14321900	S	1,290	1,460	1,540	1,640	1,700	1,760	1,880
	R	976	1,460	1,800	2,230	2,550	2,870	3,620
	W	1,250	1,460	1,600	1,790	1,930	2,080	2,410
14322000	S	6,240	9,900	12,500	15,800	18,400	21,000	27,200
	R	4,050	6,060	7,430	9,190	10,500	11,800	14,900
	W	6,030	9,380	11,600	14,400	16,400	18,500	23,300
14322400	S	4,180	6,770	8,580	10,900	12,700	14,500	18,700
	R	2,280	3,410	4,180	5,150	5,880	6,610	8,310
	W	3,850	5,980	7,300	8,890	10,000	11,200	13,800
14322700	S	373	479	544	621	675	727	843
	R	300	444	540	663	753	843	1,050
	W	364	474	543	630	694	758	904
14323500	S	1,690	2,230	2,560	2,950	3,230	3,490	4,080
	R	1,880	2,620	3,120	3,760	4,220	4,680	5,750
	W	1,720	2,320	2,720	3,220	3,580	3,940	4,740
14323997	S	32.1	53.3	68.7	89.2	105	121	161
	R	33	51.3	64.3	81.7	95.1	109	142
	W	32.3	52.7	67	85.8	100	115	151
14324500	S	5,300	7,090	8,150	9,360	10,200	11,000	12,600
	R	3,160	4,520	5,430	6,600	7,460	8,320	10,300
	W	5,060	6,680	7,610	8,710	9,490	10,300	12,000
14324600	S	3,500	4,270	4,740	5,310	5,720	6,120	7,020
	R	3,770	5,070	5,910	6,970	7,740	8,490	10,200
	W	3,540	4,390	4,970	5,700	6,240	6,770	7,960
14324700	S	4,740	5,860	6,540	7,360	7,940	8,510	9,780
	R	4,860	6,510	7,590	8,940	9,910	10,900	13,000
	W	4,750	5,940	6,710	7,670	8,370	9,060	10,600
14324900	S	12,200	14,700	16,300	18,200	19,500	20,800	23,800
	R	10,200	13,900	16,400	19,400	21,700	23,900	28,900
	W	11,900	14,600	16,300	18,500	20,100	21,700	25,400
14325000	S	14,900	21,700	26,300	32,200	36,700	41,300	52,300
	R	15,900	21,800	25,600	30,400	33,900	37,400	45,200
	W	15,000	21,700	26,300	32,100	36,500	41,000	51,600

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14326500	S	14,600	21,000	25,200	30,600	34,600	38,700	48,100
	R	16,800	23,800	28,500	34,400	38,700	43,100	53,000
	W	14,900	21,500	26,000	31,700	35,900	40,100	49,800
14326600	S	138	182	209	242	264	286	335
	R	88.3	146	188	246	293	341	464
	W	128	173	203	243	274	306	381
14326800	S	4,660	6,500	7,660	9,040	10,000	11,000	13,100
	R	4,580	6,780	8,290	10,200	11,700	13,100	16,600
	W	4,650	6,560	7,810	9,380	10,500	11,700	14,300
14326815	S	2,220	3,640	4,650	5,970	6,970	7,990	10,400
	R	1,580	2,290	2,770	3,390	3,850	4,310	5,390
	W	2,080	3,210	3,920	4,790	5,440	6,090	7,640
14326850	S	333	471	562	677	763	849	1,050
	R	460	684	839	1,040	1,190	1,350	1,710
	W	356	524	647	807	929	1,050	1,330
14326950	S	683	845	939	1,050	1,120	1,190	1,330
	R	744	1,070	1,290	1,570	1,780	1,990	2,490
	W	696	908	1,060	1,250	1,390	1,530	1,840
14327000	S	13,100	20,800	26,700	34,800	41,300	48,200	66,200
	R	16,500	23,700	28,500	34,600	39,100	43,500	53,900
	W	13,400	21,200	27,000	34,700	40,700	47,000	62,500
14327100	S	94.5	140	171	210	239	268	336
	R	89.9	132	161	199	227	255	321
	W	93.7	138	168	206	235	263	329
14327240	S	117	192	246	321	379	440	594
	R	138	209	258	325	376	430	561
	W	121	195	250	322	378	436	580
14327250	S	8,710	11,900	14,100	16,900	19,100	21,300	26,600
	R	10,100	14,500	17,500	21,200	24,100	27,000	34,000
	W	8,820	12,200	14,600	17,700	20,000	22,500	28,300
14327400	S	99.2	147	180	222	253	284	357
	R	106	162	201	254	294	337	442
	W	99.8	149	183	228	261	295	377
14327490	S	160	249	317	413	492	578	804
	R	165	243	299	373	432	493	649
	W	161	248	313	400	470	543	734
14327500	S	2,230	3,060	3,650	4,440	5,070	5,720	7,380
	R	1,620	2,450	3,050	3,860	4,500	5,160	6,830
	W	2,180	2,980	3,540	4,300	4,910	5,550	7,200

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14328000	S	4,650	7,490	9,690	12,800	15,400	18,300	25,900
	R	3,790	5,780	7,240	9,200	10,700	12,400	16,400
	W	4,630	7,410	9,520	12,500	14,900	17,500	24,500
14330500	S	724	1,100	1,390	1,810	2,160	2,550	3,600
	R	566	860	1,070	1,350	1,580	1,810	2,400
	W	703	1,050	1,300	1,640	1,910	2,210	2,990
14331000	S	170	285	379	518	638	772	1,150
	R	193	294	367	464	541	621	822
	W	173	287	376	500	600	707	992
14332000[b]	S	990	1,740	2,360	3,300	4,120	5,050	7,700
	R	780	1,190	1,480	1,870	2,180	2,500	3,310
	W	975	1,670	2,190	2,930	3,540	4,200	6,010
14333000	S	882	1,490	2,020	2,860	3,620	4,520	7,280
	R	817	1,260	1,590	2,030	2,380	2,740	3,660
	W	877	1,460	1,930	2,620	3,200	3,860	5,710
14333500	S	622	1,090	1,490	2,110	2,660	3,300	5,170
	R	607	950	1,210	1,550	1,830	2,110	2,820
	W	621	1,080	1,450	1,990	2,450	2,970	4,410
14335000	S	8,510	14,000	18,800	26,300	33,200	41,200	66,000
	R	8,140	12,600	15,800	20,100	23,500	27,100	36,000
	W	8,480	13,900	18,300	25,000	30,700	37,300	56,000
14335080	S	32.3	54.8	74.7	107	136	172	283
	R	33.9	52	64.8	81.5	94.6	108	143
	W	32.5	54.1	71.4	95.9	116	139	200
14335100	S	110	224	336	533	728	975	1,820
	R	230	356	445	564	657	753	997
	W	116	238	354	540	708	903	1,490
14335200	S	313	558	768	1,090	1,380	1,710	2,690
	R	482	750	938	1,190	1,380	1,580	2,080
	W	319	573	787	1,110	1,380	1,690	2,530
14335500	S	717	1,430	2,110	3,280	4,410	5,810	10,400
	R	956	1,510	1,910	2,430	2,830	3,250	4,310
	W	724	1,430	2,100	3,170	4,170	5,360	9,070
14337500	S	3,130	4,570	5,630	7,100	8,280	9,550	12,900
	R	1,920	3,080	3,910	4,990	5,820	6,690	8,860
	W	3,050	4,400	5,360	6,660	7,700	8,810	11,700
14337600[b]	S	11,700	19,600	26,200	36,300	45,200	55,500	85,700
	R	10,600	16,600	20,900	26,600	31,100	35,800	47,500
	W	11,600	19,000	24,700	32,800	39,500	46,800	66,500

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14337800	S	2,780	4,000	4,850	5,950	6,780	7,630	9,700
	R	2,210	3,690	4,790	6,250	7,370	8,540	11,400
	W	2,730	3,960	4,840	6,020	6,950	7,910	10,300
14337870	S	458	671	815	999	1,140	1,270	1,600
	R	448	765	994	1,290	1,520	1,760	2,330
	W	457	684	848	1,070	1,240	1,410	1,830
14338000	S	4,810	7,680	9,800	12,700	15,000	17,400	23,600
	R	3,600	6,120	7,980	10,400	12,300	14,300	19,100
	W	4,750	7,550	9,580	12,300	14,500	16,800	22,500
14339000[b]	S	20,800	35,200	47,100	65,000	80,500	98,000	148,000
	R	16,200	26,000	33,000	42,400	49,700	57,200	76,100
	W	20,500	34,200	44,800	59,800	72,300	86,000	123,000
14339200	S	420	628	781	990	1,160	1,340	1,800
	R	131	201	250	313	361	409	521
	W	331	465	542	638	712	788	977
14339500	S	86.6	117	136	160	177	194	234
	R	85.5	132	165	209	244	280	373
	W	86.5	119	141	171	193	217	273
14341500	S	1,110	2,200	3,180	4,720	6,100	7,710	12,400
	R	1,070	1,780	2,300	3,010	3,560	4,140	5,580
	W	1,110	2,170	3,060	4,400	5,550	6,830	10,400
14353000	S	67.7	134	193	283	362	453	712
	R	258	438	576	763	910	1,060	1,440
	W	84.9	186	285	437	564	700	1,050
14353500	S	70.2	143	207	306	395	495	784
	R	130	224	296	394	470	550	749
	W	77.6	161	234	341	428	522	765
14359000[b]	S	26,100	46,400	63,500	89,500	112,000	138,000	213,000
	R	22,900	38,000	49,100	63,800	75,300	87,100	117,000
	W	26,000	45,800	61,900	85,700	106,000	128,000	191,000
14359500	S	4,180	7,060	9,240	12,300	14,700	17,200	23,700
	R	5,040	7,570	9,280	11,500	13,100	14,700	18,500
	W	4,280	7,150	9,250	12,000	14,200	16,400	21,700
14361300	S	302	529	703	943	1,140	1,340	1,850
	R	421	630	769	946	1,080	1,200	1,500
	W	309	538	710	943	1,120	1,310	1,770
14361500[b]	S	39,500	71,700	97,600	135,000	166,000	200,000	292,000
	R	32,200	54,200	70,400	91,800	108,000	126,000	169,000
	W	38,900	69,300	92,300	124,000	149,000	176,000	246,000

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14361600	S	1,320	2,230	2,880	3,750	4,420	5,110	6,750
	R	2,350	3,810	4,920	6,430	7,610	8,830	11,900
	W	1,580	2,840	3,870	5,270	6,360	7,480	10,200
14361700	S	1,810	3,110	4,080	5,410	6,450	7,540	10,200
	R	4,250	6,760	8,560	10,900	12,800	14,600	19,200
	W	2,320	4,360	6,050	8,350	10,100	11,900	16,100
14362000[b]	S	6,560	12,800	17,700	24,400	29,600	35,000	48,000
	R	10,500	17,200	22,100	28,700	33,900	39,200	52,200
	W	6,860	13,500	18,600	25,600	30,900	36,400	49,600
14362050	S	50.2	106	156	233	302	381	605
	R	72.8	135	183	247	297	349	475
	W	54.1	114	166	240	300	362	524
14366000[b]	S	8,800	17,900	25,100	35,100	43,000	51,300	71,500
	R	14,800	25,200	33,100	43,700	52,000	60,500	81,400
	W	9,250	18,900	26,700	37,400	45,800	54,400	75,300
14368500	S	477	855	1,140	1,520	1,810	2,120	2,860
	R	362	589	749	958	1,120	1,280	1,680
	W	449	751	946	1,190	1,380	1,570	2,040
14369500[b]	S	12,600	30,700	47,500	74,400	98,500	126,000	203,000
	R	20,700	35,100	45,900	60,200	71,300	82,700	111,000
	W	13,700	31,800	46,900	67,700	84,100	101,000	145,000
14369800	S	242	332	387	453	500	544	641
	R	238	343	413	501	567	632	782
	W	242	334	392	464	516	567	683
14370000	S	2,820	3,930	4,610	5,430	6,010	6,560	7,760
	R	2,110	3,060	3,690	4,490	5,090	5,680	7,060
	W	2,740	3,800	4,440	5,210	5,770	6,310	7,540
14370200	S	214	290	336	391	429	465	542
	R	211	313	380	465	528	591	734
	W	214	293	344	407	452	497	597
14370600	S	2,180	4,590	6,760	10,200	13,200	16,700	26,800
	R	1,800	2,660	3,240	3,970	4,520	5,060	6,310
	W	2,140	4,290	6,000	8,410	10,400	12,400	17,700
14371500	S	1,670	2,700	3,490	4,610	5,530	6,520	9,160
	R	1,380	2,150	2,670	3,350	3,870	4,400	5,690
	W	1,660	2,640	3,360	4,330	5,110	5,930	8,030
14372000	S	2,800	5,110	6,910	9,420	11,400	13,600	19,000
	R	2,790	4,430	5,550	7,010	8,130	9,270	12,000
	W	2,800	4,890	6,340	8,180	9,570	11,000	14,500

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14372300[b]	S	105,000	181,000	239,000	319,000	384,000	452,000	624,000
	R	89,800	149,000	192,000	249,000	293,000	339,000	451,000
	W	102,000	172,000	222,000	288,000	339,000	392,000	525,000
14372500	S	4,000	6,010	7,400	9,210	10,600	12,000	15,400
	R	4,480	6,210	7,370	8,880	10,000	11,200	14,100
	W	4,020	6,020	7,400	9,160	10,500	11,800	15,100
14375000	S	3,210	6,150	8,510	11,900	14,600	17,600	25,200
	R	5,190	7,770	9,530	11,800	13,600	15,400	19,700
	W	3,410	6,460	8,790	11,900	14,200	16,600	22,500
14375100	S	3,310	5,620	7,320	9,630	11,400	13,300	17,900
	R	5,540	8,350	10,300	12,800	14,700	16,700	21,400
	W	3,460	5,980	7,880	10,400	12,400	14,400	19,200
14375400	S	2,280	3,030	3,520	4,140	4,600	5,050	6,120
	R	2,400	3,350	4,000	4,810	5,420	6,020	7,420
	W	2,290	3,070	3,590	4,260	4,760	5,270	6,450
14375500	S	5,240	7,410	8,980	11,100	12,800	14,600	19,200
	R	3,940	5,450	6,470	7,770	8,730	9,700	12,000
	W	5,140	7,210	8,650	10,500	12,000	13,500	17,300
14377100	S	24,000	33,200	39,500	47,700	54,000	60,400	76,000
	R	21,800	31,200	37,600	45,700	51,800	58,000	72,400
	W	23,900	33,100	39,400	47,500	53,700	60,100	75,400
14377500	S	2,070	3,360	4,280	5,500	6,440	7,400	9,730
	R	1,190	1,910	2,410	3,070	3,570	4,090	5,330
	W	1,870	2,830	3,430	4,170	4,750	5,350	6,840
14377800	S	161	220	257	303	337	371	447
	R	172	244	292	351	395	439	539
	W	163	223	264	314	352	390	476
14378000	S	48,300	64,300	75,300	89,700	101,000	112,000	141,000
	R	37,900	54,200	65,400	79,600	90,200	101,000	126,000
	W	46,800	62,300	72,900	86,800	97,500	108,000	135,000
14378200	S	75,900	105,000	124,000	147,000	164,000	181,000	220,000
	R	61,800	87,500	105,000	127,000	144,000	161,000	200,000
	W	74,600	103,000	121,000	143,000	160,000	176,000	214,000
14378550	S	228	307	362	435	492	552	701
	R	131	198	246	311	361	413	540
	W	207	276	323	386	437	490	626

Appendix D. Estimated Peak Discharges for Gaged Watersheds in Western Oregon and Surrounding States Used in the Regional Regression Analysis—Continued

[Estimate types: S, systematic and historical record; R, regionalized regression equations; and W, weighted average of S and R]

Station number	Estimate type	Peak discharges (in cubic feet per second for the indicated recurrence interval)						
		2	5	10	25	50	100	500
14378800	S	182	284	358	460	539	623	834
	R	123	183	226	281	324	367	471
	W	169	254	310	383	440	499	647
14378900	S	118	196	253	332	394	458	620
	R	79	118	145	181	208	236	302
	W	113	179	224	283	327	374	489
14400000	S	36,200	49,800	58,400	68,500	75,700	82,600	97,700
	R	35,800	50,400	60,000	72,200	81,300	90,300	112,000
	W	36,100	49,900	58,500	69,000	76,500	83,800	100,000

[a]Station is located outside the State of Oregon.

[b]Streamflow at this station is now regulated.

Appendix E. A Test for Random Peaks.

A usual test for randomness is to check each series of annual peaks for a statistically significant linear correlation, i.e., a trend (Thomas and others, 1993; Wiley and others, 2000). A significant trend suggests that systematic, non-random changes in peak discharge characteristics are occurring in time. A trend test is not definitive; it is cause for investigation, not necessarily for the elimination of a gaging station from the analysis.

The peak discharges from the 376 gaging stations were tested for linear correlation. The resulting information was analyzed in two ways: (1) to check for regional, climate dependent trends, and (2) to check for local trends resulting from significant physical changes to a watershed. Local trends can be caused by changes in land use or water management as well as by natural changes such as a volcanic eruption. Local trends that can be attributed to physical changes in the watershed may require all or part of a gaging station's period of record to be removed from consideration.

Almost all gaging station records exhibit some degree of linear correlation. Most of these trends result from natural random variation in peak flows, not from either long-term climate change or physical changes to the watershed. A statistical test determines which of the trends is significant, that is, the least likely to have occurred by chance. These unlikely trends represent the gaging station records to be investigated.

A significant trend does not necessarily mean a series of peaks is non-random. For any group of gaging stations, a few of the annual series will have significant trends by chance. The level of significance of the statistical test determines how many of these significant but chance trends are to be expected. For example, for a 0.05 level of significance, about five percent of stations should show a significant trend. Although all significant trends should be investigated for physical changes to the gaging station's watershed, a regional trend requires that the number of significant trends is greater than is expected by chance.

In the regional analysis, no consistent long-term trend was found, although there is evidence of a regional fluctuation of peak discharges between wet and dry periods. This fluctuation led to a higher than expected number of significant trends in long-term gaging station records. The evidence is too weak, however, to support a strong conclusion as to whether the fluctuation is truly periodic or what the period might be. Locally, no significant trend could be linked to physical changes in the associated watershed. Note, however, that no watersheds significantly affected by regulation, diversion, urbanization or the eruption of Mount St. Helens were included in the analysis.

The Statistical Test—Kendall's tau, a nonparametric measure of linear correlation, was used to determine the degree and direction of correlation, and the correlation's statistical significance, for each of the 376 annual series of peaks. A positive value of tau indicated a positive correlation, and a negative value, a negative correlation. Small values of the probability associated with tau indicated a significant correlation. Calculations of Kendall's tau and its associated probability for each series were made using the algorithm given by Press and others (1986). Appendix B shows the value of tau and its associated probability for each gaging station.

Test for Significance—Statistical significance was determined by a two-sided test at the 0.05 level. For this test, the null hypothesis, H_o, states there is no trend. H_o is accepted if the probability associated with tau is greater than 0.05 and is rejected otherwise. By chance, five percent of the gaging stations are likely to show a significant trend. The significant, but chance, trends are likely to be about half positive and half negative.

Checking for Regional Trends—In an initial check for regional trends, only the 129 gaging stations with more than 30 years of record were used. These long-term records were considered least likely to be affected by random variation in the annual series of peak discharges. By chance, five percent of the gaging stations (about 7 stations) are likely to show a significant trend.

Table E-1 summarizes the results of the test for significance for the long-term stations. Twelve stations (9.4 percent) showed a significant trend. Of these, six showed a positive trend and six a negative trend. Region 2B had the highest percentage of statistically significant trends (13.8 percent) and region 2A, the fewest (4.2 percent).

More significant trends occurred than are expected by chance. Further, if the twelve gaging stations are sorted by beginning year of period of record, a pattern emerges (table E-2). All but two of the stations fall into three distinct groups: (1) stations with records beginning about 1880 (negative trends), (2) stations with records beginning from 1928 to 1930 (positive trends), and (3) stations with records beginning from 1955 to 1959 (positive trends). Figure E-1 shows the trend line for a gaging station from each group.

These results suggest that peak discharges are not entirely random; that they exhibit long-term fluctuations between wet and dry periods—dry around 1930 and 1985 and wet around 1890 and 1960. These observations are consistent with observations made about precipitation in Oregon by Taylor and Hannan (1999) who suggest alternating periods of relatively high and low precipitation. Based on long-term precipitation records from the coast and in Portland, weather was cool and wet from 1896 to 1916, warm and dry from 1916 to 1946, cool and wet from 1946 to 1976, and warm and dry from 1976 to 1995. Precipitation records after 1995 suggest the start of another wet period.

If peak discharges are in fact subject to serial correlation due to long-term fluctuations in weather, it should be possible

Table E-1. Trends in annual series of peak discharges by region for gaging stations with 30 or more years of record.

Region	Total number of stations	Positive trend		Negative trend		No trend	
		Number of stations	Percent of total	Number of stations	Percent of total	Number of stations	Percent of total
1	16	1	6.3	0	0.0	15	93.7
2a	48	2	4.2	0	0.0	46	95.8
2b	65	3	4.6	6	9.2	56	86.2
All	129	6	4.7	6	4.7	117	90.7

Table E-2. The 12 gaging stations with significant trends and more than 30 years of record. The list is sorted on the beginning year of the period of record.

Gage number	Period of record	Number of peaks	Trend direction	Region
14174000	1878–1882, 1884, 1890, 1893–1941	56	-	2B
14191000	1881, 1890, 1893–1941	50	-	2B
14137000	1912–2000	89	+	2A
14314500	1928–1976, 1978	50	+	2A
14309000	1928–1931, 1933–1985	57	+	2B
12025000	1929–1931, 1943–1981, 1983–1999	59	+	2B
12010000	1930–1999	70	+	1
14128500	1935–1979, 1996–1997	47	+	2B
14375500	1955–1978, 1980–1985	30	-	2B
14320700	1956–1976, 1978–1986, 1988–2000	43	-	2B
14309500	1956–2000	45	-	2B
14194300	1959–1966, 1968–1995	36	-	2B

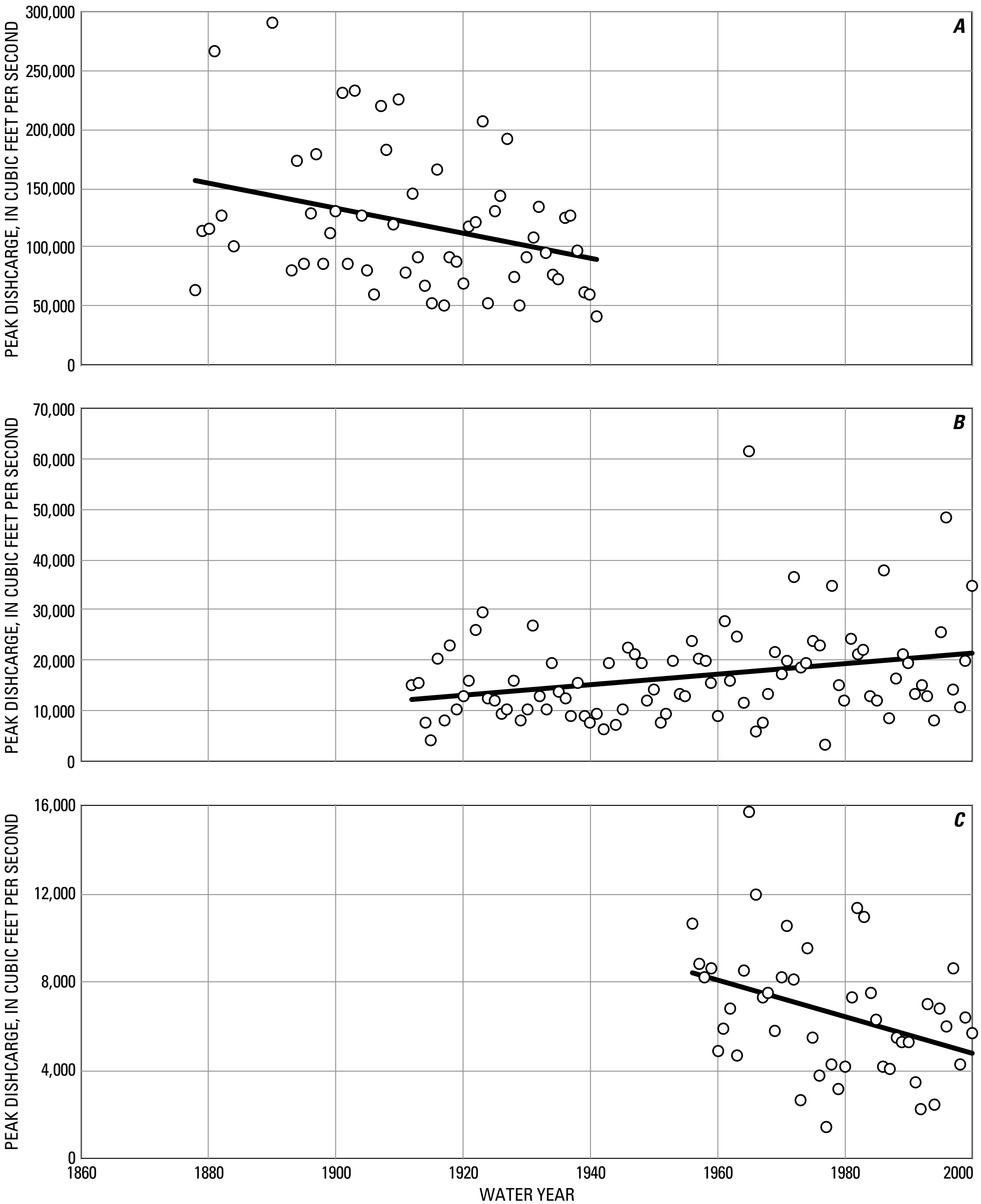

Figure E-1. Trend as a function of period of record (A) the Willamette River at Albany, Oregon (14147000), (B) the Sandy River near Marmot, Oregon (14137000), and (C) the West Fork Cow Creek near Glendale, Oregon (14309500).

to demonstrate that the direction and the statistical significance of a trend are functions of the length of the record on which the trend is based and the record's location in time. In order to make this test, all record lengths must be the same. To that end, the gaging station records were divided into all possible records of 10, 20, 30, 40, 50, 60, 70, and 80 years and Kendall's tau determined for each. Of the 376 gaging stations, five were not used because they had gaps of longer than five years.

A long-term gage contributes a number of records in this scheme. For example, a gaging station with 50 years of data yields 21 records 30 years in length. The total number of sampled records varies as a function of total record length—the longer the sample, the fewer the possible records (table E-3).

Table E-3 shows that trend direction and statistical significance are functions of record length. Trends are about equally positive and negative for record lengths of 40 years or less, but the percentage of positive trends increases rapidly with longer records.

Finally, for record lengths of 30 years or less, the percentage of significant trends is about what is expected by chance. For record lengths of more than 30 years, the percentage of significant trends increases rapidly with increasing record length.

In figure E-2, for each record, the number of standard deviations Kendall's tau departs from the mean (i.e., its z score) is plotted against the beginning year of the period of record. Plotted in this way, tau gives the direction of the trend and is proportional to its statistical significance. All records of a given length are plotted on the same chart. The solid black sinusoidal line on each chart is a fourth order polynomial fitted to the plotted points. Each represents the trend of its associated z scores.

Figure E-2 shows that, for records longer than about 30 years, the likelihood a trend will be in a certain direction or will be significant or both varies as both a function of length of record and the record's place in time. For example, for records 30 years in length (fig. E-2C) a record beginning between 1915 and 1951 is more likely to be positive than negative, and if beginning before 1915 or after 1951, more likely to be negative. Significant trends (tau more than about two standard deviations from the mean) are most likely to occur near the maximum and minimum points of the fitted line: 1930 and 1965.

The sinusoidal trend lines of the z scores in figure E-2 suggest that the linear trends on which the z scores are based fluctuate systematically between positive and negative. These region-wide fluctuations explain the over abundance of significant trends in the long-term gages and the pattern of alternating negative and positive trends shown in table E-2. They also explain why the percentage of significant trends and the number of positive trends both increase with record length (table E-3).

To understand how the z scores of the linear trends relate to the original time series of peak discharges, it is helpful to look at the behavior of z scores of linear trends sampled from a theoretical, perfectly sinusoidal population. A sine curve with a period of 60 years and beginning in 1880 was sampled for all possible periods of lengths of 10, 20, 30, 40, 50, and 60 years. Kendall's tau and the associated z score were calculated for each sample. The population curve and the z scores of the trend lines for each period of record are plotted in figure E-3.

The z scores based on the samples from the sine curve (fig. E-3) behave in a fashion similar to the z scores from the actual peak discharges (fig. E-2). The z scores are sinusoidal in both cases and their periods shorten as the length of sampled record increases. Also the most significant trends occur near the maximum and minimum points of the curves.

Note that when the length of the sampled record is half that of the period of the population curve, the z scores and the population curve are exactly 180 degrees out of phase. This means that for periods beginning in wet years, trend lines will tend to be negative, and beginning in dry years, positive.

For the z scores for actual peak discharges, the z scores and the sine curve are 180 degrees out of phase for a period of 75 years and a period of record of 35 years (fig. E-4). The time line is divided into wet and dry periods. The breaks occur where the two sinusoidal curves meet as they cross zero. Interestingly these periods match reasonably well those observed by Taylor and Hannan (1999).

Although this analysis suggests a periodicity to peak discharges, only a little over one complete period is represented in the record. Whether these observed fluctuations are truly periodic with a constant period remains to be seen. Further, the data points are scattered widely about the trend lines indicating that a trend line of the z scores for any single gaging station may vary considerably from the trend line for z scores from all gaging stations (fig. E-5). So, while the fluctuations appear to have a general, regional basis, locally there is considerable variation.

Based on this analysis, it is concluded that while the time series of peak discharges exhibit some serial correlation, the correlation is due to fluctuations between wet and dry periods and not to a continuous upward or downward trend. Over the long term, peak discharge characteristics remain constant. Further, it is concluded that the available peak discharge records represent long-term peak discharge characteristics and that they adequately represent the variability exhibited by long-term peak discharges.

Checking for Local Trends—Table E-4 summarizes the results of the tests for significance for all 376 stations. For these stations, 27 (7.3 percent) showed a significant trend. Of these, 14 showed a positive trend and 13, a negative trend. Region 2B had the highest percentage of significant trends (7.9 percent), and region 1, the fewest (5.5 percent). While the number of significant trends slightly exceeds that expected by chance, the trends are not predominately either positive or negative. The slight excess of significant trends is attributed to the fluctuations discussed in the previous section.

The 27 gaging stations with significant trends were examined to determine if the trends were the result of physical changes in the associated watersheds. Because no physical cause could be determined for any of the trends, the trends

Table E-3. Trend direction and number of significant trends as a function of record length.

Record length (years)	Number of observations	Trend direction				Significant trends	
		Positive	Negative	Zero	% Positive	Number	Percent
10	6,761	3,332	3,361	68	49.3	289	4.3
20	3,794	1,777	1,936	81	46.8	161	4.2
30	2,184	1,083	1,087	14	49.6	149	6.8
40	1,214	614	592	8	50.6	161	13.3
50	641	375	265	1	58.5	109	17.0
60	285	186	98	1	65.3	59	20.7
70	96	71	25	0	74.0	35	36.5
80	30	28	2	0	93.3	13	43.3

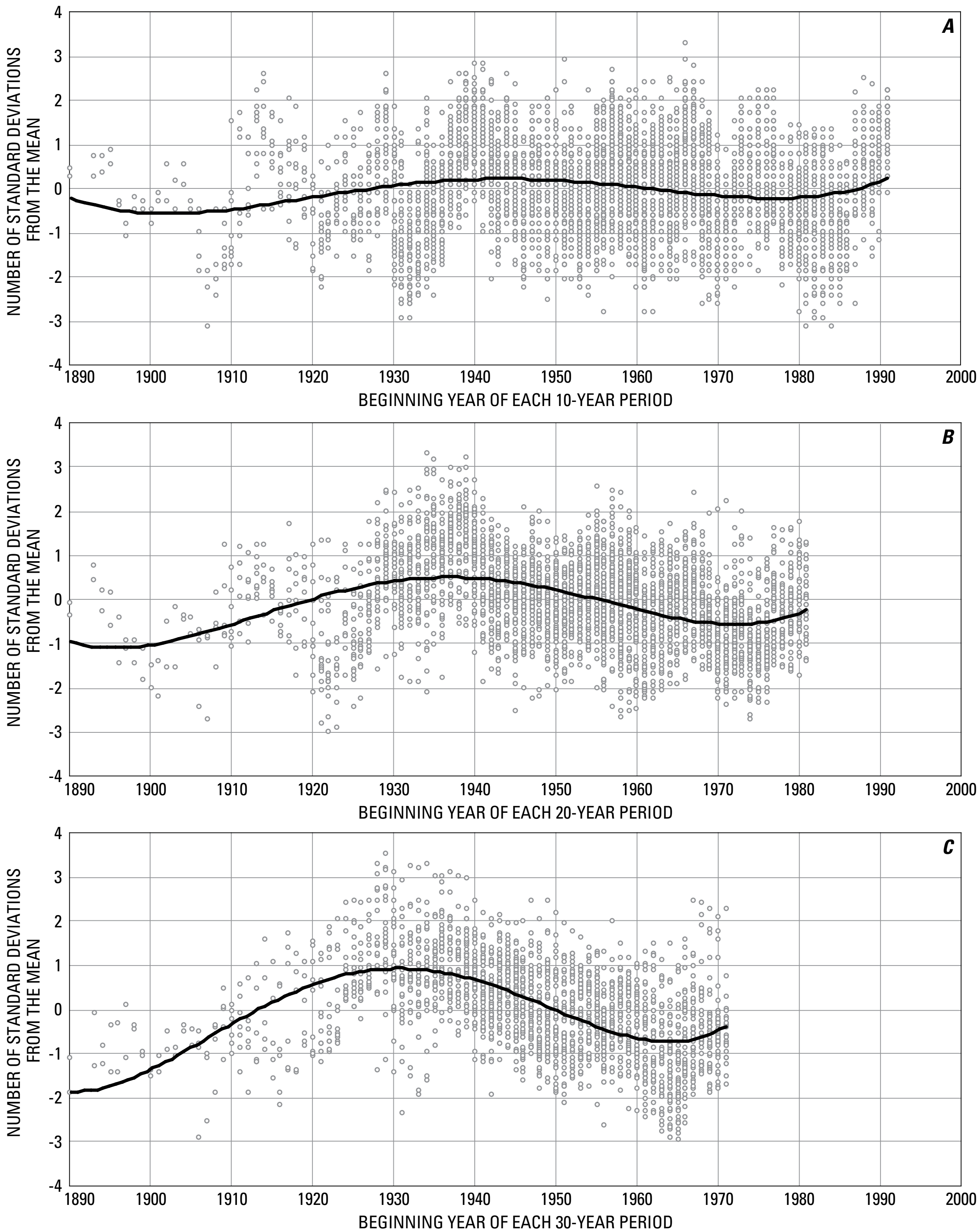

Figure E–2. These graphs show how Kendall's tau varies in time and as a function of the length of the period of record. The number of standard deviations Kendall's tau departs from the mean (i.e., its z score) for the specified periods of record are plotted against the beginning year of each period. Plotted in this way, tau gives the direction of the trend, and is proportional to its statistical significance, for the period of record that follows its plotted position. The solid line on each graph is a fourth order polynomial fitted to the plotted points. The graphs are for uniform periods of record of (A) 10 years, (B) 20 years, (C) 30 years, (D) 40 years, (E) 50 years, and (F) 60 years.

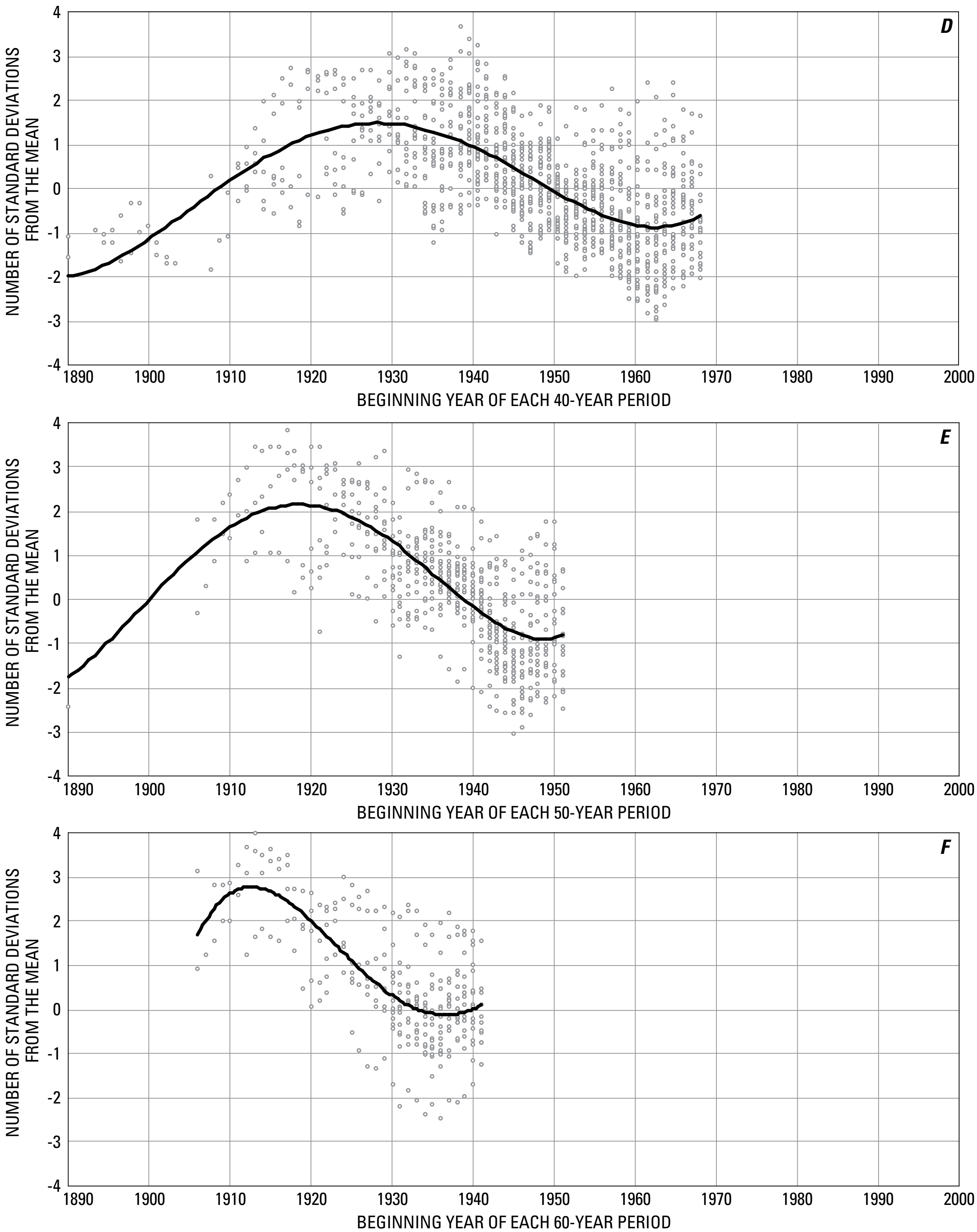

Figure E–2.—Continued.

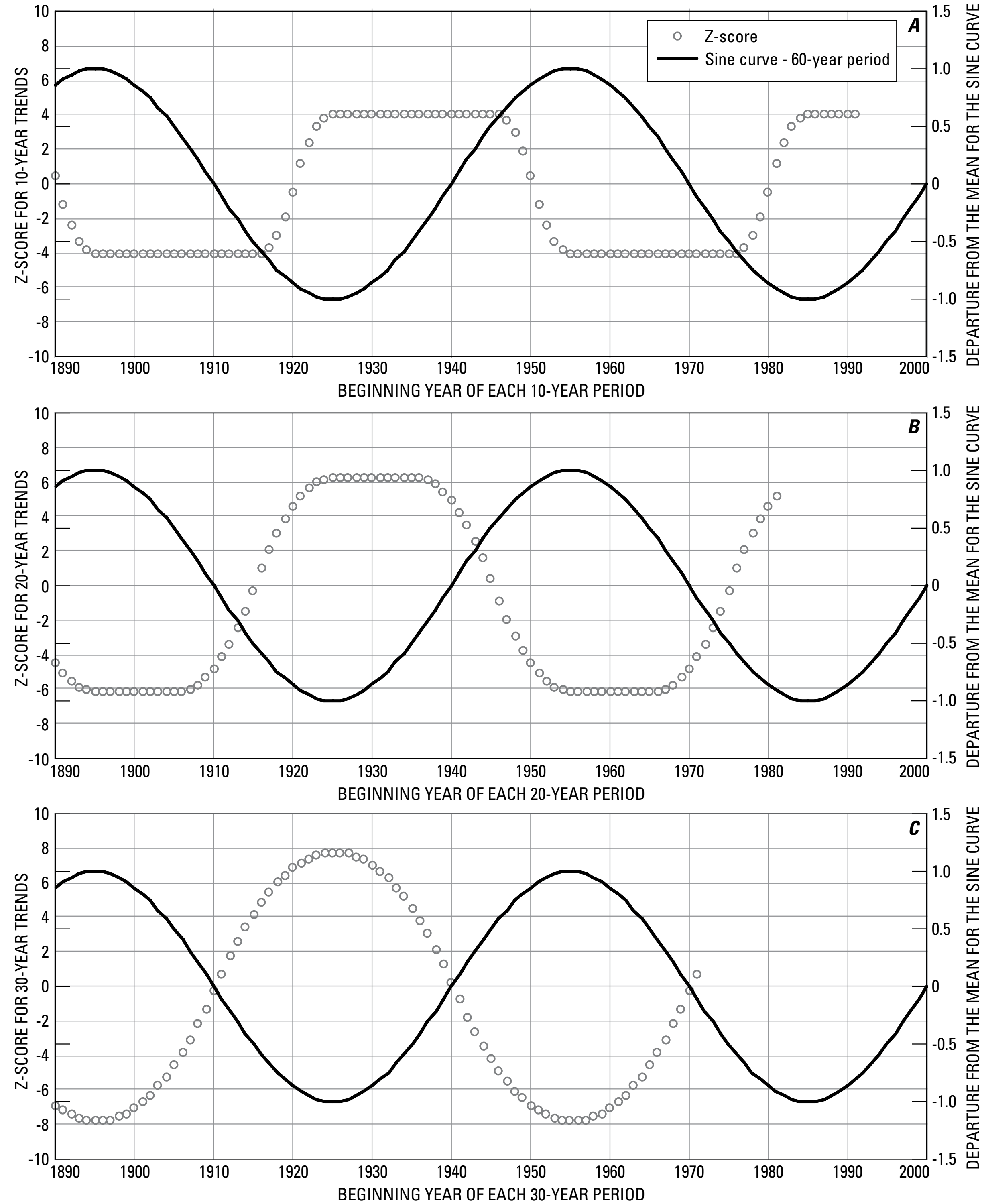

Figure E–3. Kendall's tau was calculated for samples of specified length taken from a population based on a sine curve with a period of 60 years and beginning in 1880 (solid line). The values of the population represent departures from a mean of zero. Z scores for the tau values are shown plotted against time. These z scores exhibit behavior similar to the z scores in figure E–2. Note that when the length of the sample is half the period of the sine curve, the two curves are 180 degrees out of phase. The graphs are for uniform periods of record of (A) 10 years, (B) 20 years, (C) 30 years, (D) 40 years, (E) 50 years, and (F) 60 years.

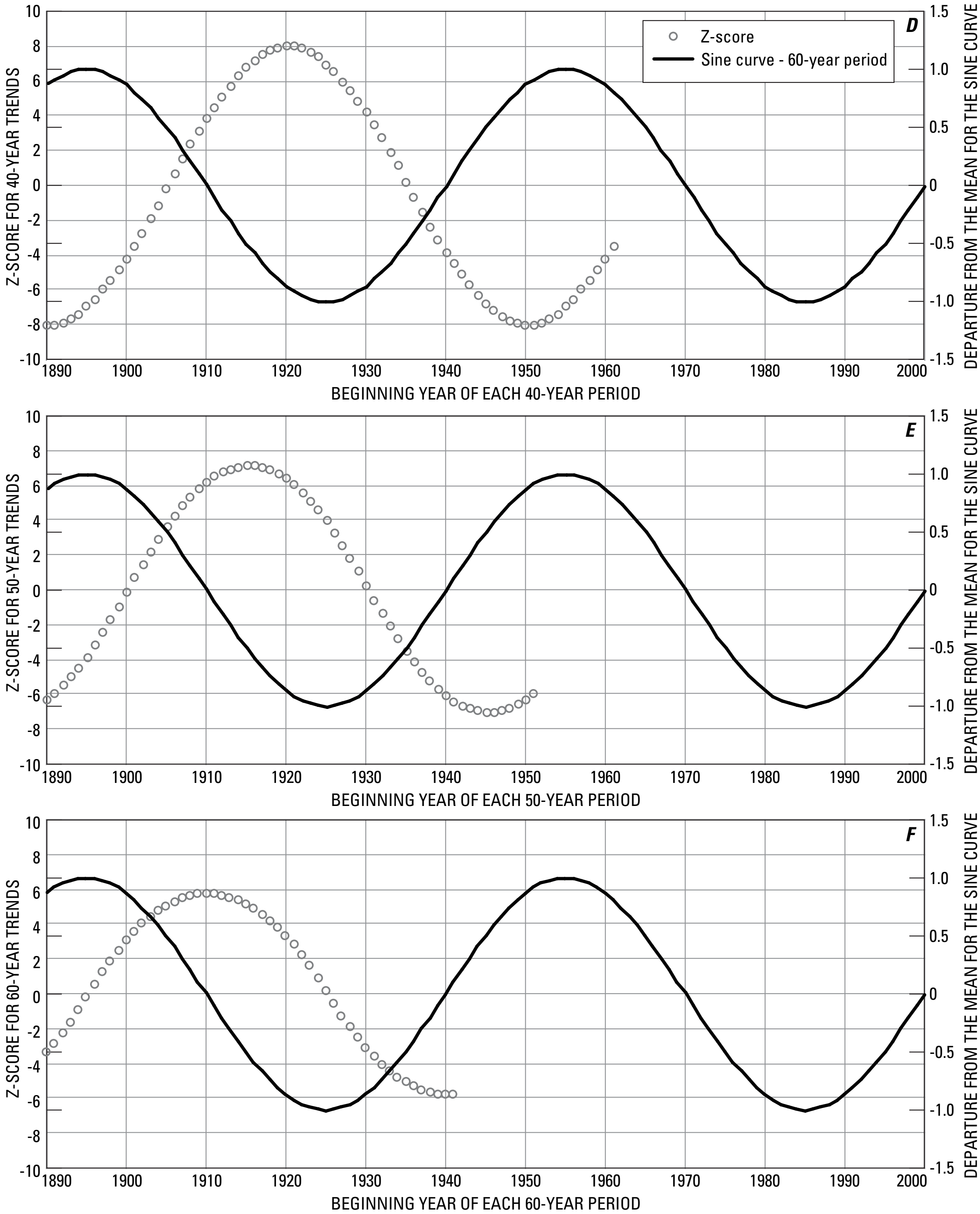

Figure E–3.—Continued.

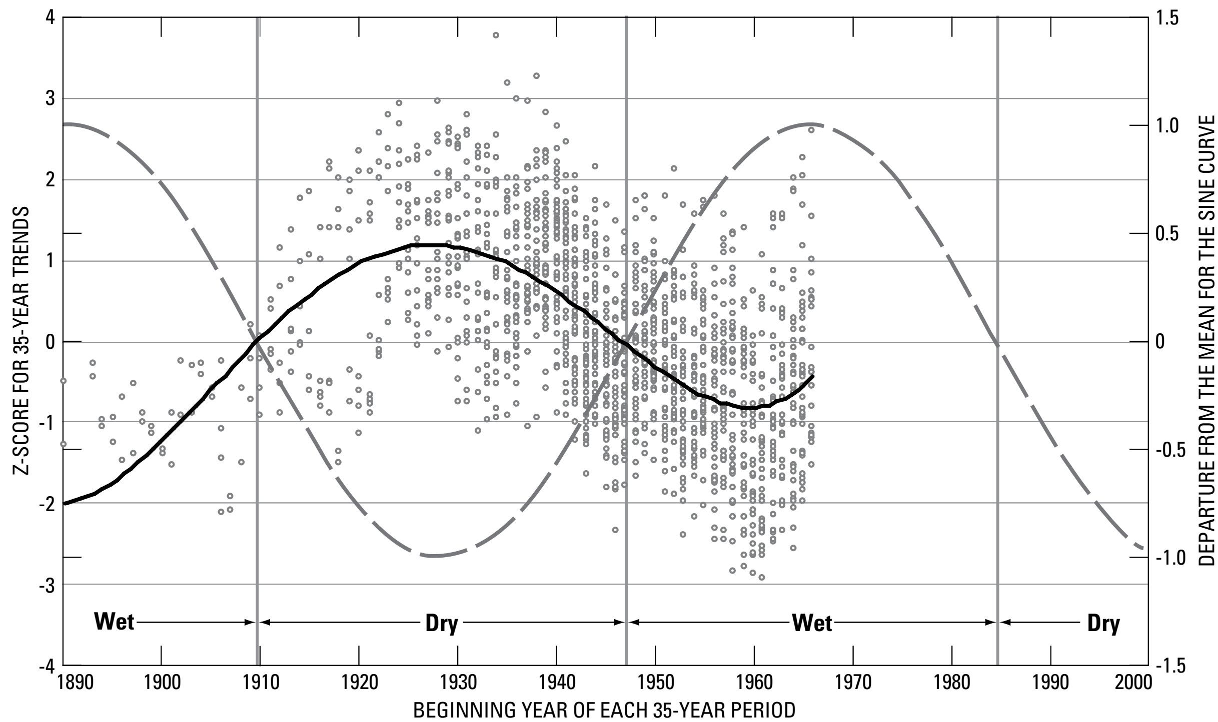

Figure E–4. Z scores for Kendall's tau calculated for all possible periods of 35 years are plotted against the beginning year of each period. The solid black curved line is a fourth-order polynomial fitted to the plotted points. The dashed line is a sine curve with a period of 75 years and beginning in 1872. The parameters of the sine curve and the length of record were selected so that the two curves were 180 degrees out of phase. The boundaries of the wet and dry periods are located where the two curves cross each other and zero.

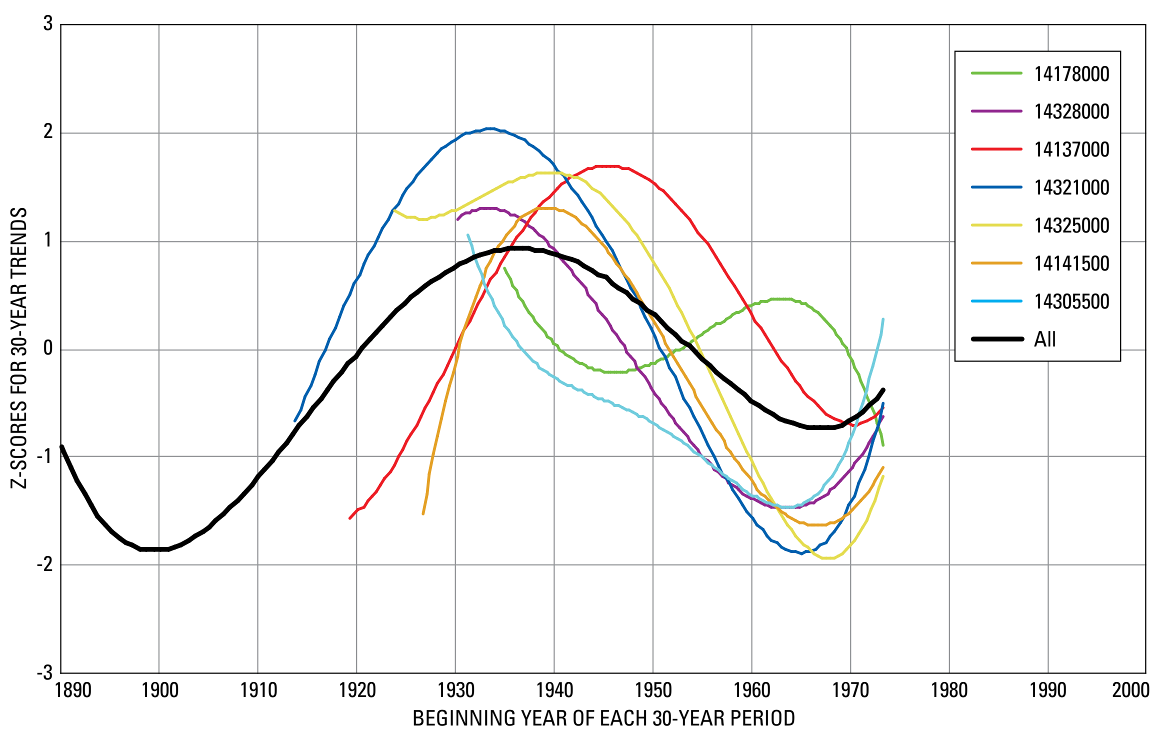

Figure E–5. Trend line of z scores for the seven gaging stations with the longest periods of record compared to the trend line for z scores of all gaging stations.

Table E-4. Trends in annual series of peak discharges by region for all gaging stations.

Region	Total number of stations	Positive trend		Negative trend		No Trend	
		Number of stations	Percent of total	Number of stations	Percent of total	Number of stations	Percent of total
1	91	3	3.3	2	2.2	86	94.5
2A	107	5	4.7	3	2.8	99	92.5
2B	178	6	3.4	8	4.5	164	92.1
All	376	14	3.7	13	3.6	349	92.7

were assumed to be due to chance alone, and the 27 gaging stations were retained in the analysis.

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Appendix F. Available Watershed Characteristics

[%, percent; mi², square miles; ft, feet; m, meters; in, inches; in/hr, inches per hour; °, degrees, °F; degrees Fahrenheit]

Characteristic	Units	Data type	Scale or resolution	Source
Latitude of the outlet	°	vector	1:24,000	Oregon Water Resources Department
Longitude of the outlet	°	vector	1:24,000	Oregon Water Resources Department
Latitude of the centroid	°	vector	1:24,000	Oregon Water Resources Department
Longitude of the centroid	°	vector	1:24,000	Oregon Water Resources Department
Drainage area	mi^2	vector	1:24,000	Oregon Water Resources Department
Stream length	mi	vector	1:24,000	U.S. Geological Survey
Perimeter	mi	vector	1:24,000	Oregon Water Resources Department
Area of lakes and ponds	%	vector	1:24,000	U.S. Geological Survey
Minimum watershed elevation	ft	grid	30 m	U.S. Geological Survey
Maximum polygon elevation	ft	grid	30 m	U.S. Geological Survey
Maximum watershed elevation	ft	grid	30 m	U.S. Geological Survey
Maximum relief	ft	grid	30 m	U.S. Geological Survey
Mean watershed slope	°	grid	30 m	U.S. Geological Survey
Mean watershed aspect	°	grid	30 m	U.S. Geological Survey
Mean watershed elevation	ft	grid	30 m	U.S. Geological Survey
Area above 3,000 feet	%	grid	30 m	U.S. Geological Survey
Area above 4,000 feet	%	grid	30 m	U.S. Geological Survey
Area above 5,000 feet	%	grid	30 m	U.S. Geological Survey
Area above 6,000 feet	%	grid	30 m	U.S. Geological Survey
Mean soils storage capacity	in	vector	1:250,000	Natural Resources Conservation Service
Mean soils mean permeability	in/hr	vector	1:250,000	Natural Resources Conservation Service
Mean soils depth to bedrock	in	vector	1:250,000	Natural Resources Conservation Service
Mean annual precipitation	in	grid	4,000 m	Oregon Climate Service
Mean January precipitation	in	grid	4,000 m	Oregon Climate Service
Mean February precipitation	in	grid	4,000 m	Oregon Climate Service
Mean March precipitation	in	grid	4,000 m	Oregon Climate Service
Mean April precipitation	in	grid	4,000 m	Oregon Climate Service
Mean May precipitation	in	grid	4,000 m	Oregon Climate Service
Mean June precipitation	in	grid	4,000 m	Oregon Climate Service
Mean July precipitation	in	grid	4,000 m	Oregon Climate Service
Mean August precipitation	in	grid	4,000 m	Oregon Climate Service
Mean September precipitation	in	grid	4,000 m	Oregon Climate Service
Mean October precipitation	in	grid	4,000 m	Oregon Climate Service

Appendix F. Available Watershed Characteristics—Continued

[%, percent; mi^2, square miles; ft, feet; m, meters; in, inches; in/hr, inches per hour; °, degrees, °F; degrees Fahrenheit]

Characteristic	Units	Data type	Scale or resolution	Source
Mean November precipitation	in	grid	4,000 m	Oregon Climate Service
Mean December precipitation	in	grid	4,000 m	Oregon Climate Service
Precipitation intensity 2-year 1-day	in	grid	3,000 m	Oregon Climate Service
Precipitation intensity 2-year 2-day	in	grid	3,000 m	Oregon Climate Service
Precipitation intensity 2-year 3-day	in	grid	3,000 m	Oregon Climate Service
Precipitation intensity 2-year 4-day	in	grid	3,000 m	Oregon Climate Service
Precipitation intensity 2-year 5-day	in	grid	3,000 m	Oregon Climate Service
Mean annual snowfall	in	grid	4,000 m	Oregon Climate Service
Mean January snowfall	in	grid	4,000 m	Oregon Climate Service
Mean February snowfall	in	grid	4,000 m	Oregon Climate Service
Mean March snowfall	in	grid	4,000 m	Oregon Climate Service
Mean April snowfall	in	grid	4,000 m	Oregon Climate Service
Mean May snowfall	in	grid	4,000 m	Oregon Climate Service
Mean June snowfall	in	grid	4,000 m	Oregon Climate Service
Mean July snowfall	in	grid	4,000 m	Oregon Climate Service
Mean August snowfall	in	grid	4,000 m	Oregon Climate Service
Mean September snowfall	in	grid	4,000 m	Oregon Climate Service
Mean October snowfall	in	grid	4,000 m	Oregon Climate Service
Mean November snowfall	in	grid	4,000 m	Oregon Climate Service
Mean December snowfall	in	grid	4,000 m	Oregon Climate Service
Mean annual minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean January minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean February minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean March minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean April minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean May minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean June minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean July minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean August minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean September minimum temperature	°F	grid	4,000 m	Oregon Climate Service

Appendix F. Available Watershed Characteristics—Continued

[%, percent; mi², square miles; ft, feet; m, meters; in, inches; in/hr, inches per hour; °, degrees, °F; degrees Fahrenheit]

Characteristic	Units	Data type	Scale or resolution	Source
Mean October minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean November minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean December minimum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean annual temperature	°F	grid	4,000 m	Oregon Climate Service
Mean January temperature	°F	grid	4,000 m	Oregon Climate Service
Mean February temperature	°F	grid	4,000 m	Oregon Climate Service
Mean March temperature	°F	grid	4,000 m	Oregon Climate Service
Mean April temperature	°F	grid	4,000 m	Oregon Climate Service
Mean May temperature	°F	grid	4,000 m	Oregon Climate Service
Mean June temperature	°F	grid	4,000 m	Oregon Climate Service
Mean July temperature	°F	grid	4,000 m	Oregon Climate Service
Mean August temperature	°F	grid	4,000 m	Oregon Climate Service
Mean September temperature	°F	grid	4,000 m	Oregon Climate Service
Mean October temperature	°F	grid	4,000 m	Oregon Climate Service
Mean November temperature	°F	grid	4,000 m	Oregon Climate Service
Mean December temperature	°F	grid	4,000 m	Oregon Climate Service
Mean annual maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean January maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean February maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean March maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean April maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean May maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean June maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean July maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean August maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean September maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean October maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean November maximum temperature	°F	grid	4,000 m	Oregon Climate Service
Mean December maximum temperature	°F	grid	4,000 m	Oregon Climate Service

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
11517840	2.91	3,650	24.40	3,200	4.47	0.273	1.72	5.32	26.5	41.7	51.4	80.5	0.074	2.25	33.7
11520520	12.90	5,040	27.00	3,770	7.33	0.293	2.66	36.20	29.4	43.4	49.8	78.9	0.071	1.59	33.1
11521500	120.00	6,030	22.90	3,700	11.00	0.379	3.46	49.20	30.3	45.2	50.2	80.1	0.071	2.18	32.4
11530850	0.28	2,340	27.80	2,520	13.70	0.433	4.09	42.80	30.4	45.9	47.7	86.2	0.100	1.03	43.5
11531000	131.00	5,940	25.20	2,560	15.80	0.568	4.96	71.50	31.8	46.2	50.2	82.0	0.097	1.29	39.4
11531500	158.00	4,330	22.10	2,370	18.30	0.655	5.50	73.70	34.6	47.4	53.1	79.5	0.100	0.74	35.0
11532000	291.00	6,210	24.50	2,740	17.80	0.583	5.33	89.50	33.2	47.6	51.8	79.9	0.100	1.27	41.0
11532500	613.00	6,310	23.70	2,530	17.30	0.588	5.24	77.20	33.5	47.4	51.9	79.9	0.099	1.13	39.1
11533000	0.95	1,210	16.60	735	12.10	0.433	3.75	0.00	40.3	53.9	52.1	68.1	0.141	0.72	43.8
12009500	11.70	1,700	20.30	552	17.90	2.030	4.01	11.40	33.6	46.5	50.2	72.8	0.174	1.32	51.2
12010000	55.20	2,660	19.00	956	17.90	2.110	4.23	33.80	31.2	44.7	48.4	71.6	0.163	1.56	49.4
12010500	16.40	2,200	12.30	493	16.80	2.020	3.90	10.20	32.3	46.4	49.2	72.0	0.179	1.17	55.0
12010600	2.16	1,850	19.40	698	16.70	1.940	3.85	18.60	33.4	46.2	49.9	72.3	0.139	2.01	46.1
12010700	17.90	1,680	15.00	399	16.60	1.930	3.78	7.08	33.9	46.9	50.4	72.1	0.176	1.46	52.1
12010800	2.09	1,460	12.10	585	18.00	1.960	4.09	18.20	33.4	46.1	49.8	72.5	0.152	2.09	49.1
12011000	18.10	1,790	18.30	645	18.20	2.060	4.27	34.20	32.5	45.2	48.5	72.6	0.159	1.58	50.1
12011100	0.45	322	8.87	162	15.80	1.790	3.91	8.43	34.2	46.9	50.7	72.5	0.183	1.79	60.0
12011200	9.46	1,920	17.80	769	19.20	2.150	4.92	29.30	33.0	45.1	49.0	72.6	0.131	2.26	44.8
12011500	41.70	2,400	13.00	788	16.30	1.840	4.26	42.60	31.5	44.2	50.1	72.3	0.174	2.08	52.5
12012000	20.10	2,650	19.40	1,070	17.70	2.060	4.34	47.10	30.7	43.7	49.1	72.1	0.173	2.03	51.9
12012200	1.80	655	10.40	402	14.00	1.510	3.68	8.31	33.5	46.7	50.3	72.8	0.205	2.26	56.5
12013500	130.00	2,800	14.60	710	15.80	1.760	4.10	29.80	32.0	44.8	49.8	72.2	0.177	1.90	53.5
12014500	27.80	1,710	14.40	726	18.40	1.860	4.65	21.60	33.0	44.9	49.3	72.3	0.132	2.20	45.2
12015100	3.97	1,100	15.50	663	16.20	1.540	4.08	6.68	34.3	45.8	51.2	72.7	0.138	2.01	45.4
12015500	29.80	1,680	14.50	720	13.60	1.230	3.54	23.30	32.1	43.4	49.1	73.4	0.183	1.99	53.6

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
12016700	2.01	805	12.20	409	13.00	1.320	3.46	7.48	34.4	45.7	50.9	72.6	0.180	0.96	52.2
12017000	220.00	2,460	12.70	523	13.20	1.250	3.47	14.70	33.2	44.8	49.9	73.2	0.180	1.96	54.8
12019600	1.91	672	12.50	687	10.30	1.040	2.82	22.00	32.1	43.6	50.5	74.1	0.160	3.00	57.9
12020000	114.00	2,800	19.30	1,290	14.00	1.410	3.45	52.00	30.7	42.7	50.6	73.7	0.138	2.61	46.2
12020500	47.00	2,030	12.50	873	13.60	1.360	3.57	32.30	32.2	43.4	48.3	72.8	0.179	3.08	53.6
12024000	40.70	3,290	14.20	1,530	9.67	1.160	2.78	30.00	30.0	42.9	49.1	76.1	0.156	2.34	53.0
12025000	155.00	3,630	9.37	982	8.13	1.030	2.47	16.50	31.2	43.9	49.7	76.8	0.159	2.03	56.6
12025700	39.90	3,120	19.50	2,000	11.80	1.330	3.14	54.10	29.0	41.4	48.4	74.9	0.146	2.22	47.0
12026150	65.70	3,520	17.40	1,670	10.00	1.220	2.83	39.50	29.9	42.3	49.1	75.4	0.144	1.94	49.5
12027500	897.00	3,710	11.50	844	9.63	1.060	2.67	22.90	31.9	43.9	50.7	75.7	0.152	2.58	54.0
12030000	24.70	1,720	15.80	547	12.40	1.180	3.25	14.80	32.8	44.2	50.0	74.3	0.160	2.59	58.2
14126300	0.70	1,110	6.85	693	9.94	0.456	2.39	53.70	28.9	40.6	53.7	78.9	0.114	1.44	53.9
14127000	108.00	4,450	14.70	2,600	17.60	1.300	3.89	111.00	26.7	37.1	48.3	75.6	0.131	1.49	54.2
14127200	3.11	2,270	19.50	2,810	20.10	1.180	4.48	139.00	26.8	37.8	48.2	75.8	0.149	1.69	46.9
14128500	224.00	5,300	16.60	2,320	17.10	1.080	3.81	108.00	27.1	37.9	49.1	76.6	0.136	1.42	54.8
14131000	3.61	5,520	12.10	4,810	13.70	2.060	3.32	393.00	23.7	33.8	44.4	63.6	0.095	2.70	35.5
14131200	3.93	3,450	18.50	3,920	14.00	1.800	3.27	320.00	24.5	35.2	45.7	66.9	0.125	3.19	43.4
14131400	14.30	7,880	17.50	4,420	13.90	1.990	3.35	368.00	24.1	34.4	44.9	64.9	0.103	2.63	37.6
14134000	8.55	6,100	11.90	4,550	10.60	1.500	2.69	287.00	24.0	34.4	45.2	65.5	0.086	3.23	42.3
14134500	52.90	6,930	13.10	3,880	9.75	1.250	2.50	222.00	24.2	35.2	45.6	68.0	0.124	3.12	43.0
14135000	99.10	8,280	19.00	3,520	10.70	1.270	2.68	180.00	25.5	36.6	46.6	70.0	0.129	2.80	44.1
14135500	106.00	8,470	18.90	3,400	10.80	1.270	2.71	172.00	25.8	36.9	46.8	70.3	0.127	2.84	44.8
14137000	260.00	10,500	19.00	3,310	12.60	1.550	3.03	193.00	26.5	37.4	47.3	70.5	0.122	2.69	45.1
14138400	13.40	3,560	8.98	1,700	10.60	1.410	2.71	26.30	32.3	43.4	51.3	77.0	0.125	1.52	52.6
14138800	8.26	1,880	16.90	3,290	18.20	2.480	4.05	214.00	26.6	37.5	48.1	72.4	0.155	2.95	40.1

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14138870	5.47	2,770	17.20	2,960	17.00	2.240	3.89	122.00	28.6	39.3	49.1	73.4	0.132	3.08	43.0
14138950	1.58	2,000	12.30	2,180	11.50	1.480	3.05	35.60	31.6	41.9	50.7	75.6	0.124	1.68	50.6
14138960	2.35	2,760	14.20	2,790	13.80	1.780	3.48	52.50	31.4	41.6	50.5	75.2	0.143	2.47	44.0
14139510	0.54	1,160	10.60	1,880	12.50	1.650	3.03	29.20	32.2	43.0	51.1	76.3	0.120	1.55	51.8
14139600	3.28	1,580	8.34	1,920	13.20	1.710	3.20	36.20	31.8	42.6	50.8	76.1	0.132	1.93	49.3
14139700	7.67	2,230	15.70	2,800	16.80	2.210	3.80	129.00	28.2	38.9	48.8	73.0	0.150	2.86	41.3
14139800	15.50	3,260	14.10	2,630	15.80	2.040	3.61	91.90	29.5	40.2	49.5	74.1	0.143	2.48	44.3
14141500	23.30	3,500	12.40	2,390	13.70	1.740	3.23	59.70	30.8	41.8	50.3	75.5	0.134	2.00	48.5
14143200	2.68	1,480	10.40	1,250	11.30	1.200	2.69	11.60	31.4	44.8	49.6	78.7	0.159	1.33	59.9
14143500	107.00	4,160	19.40	1,720	15.10	1.520	3.50	52.10	29.4	41.9	48.4	77.2	0.158	1.46	56.9
14144000	23.20	3,380	10.40	1,120	13.00	1.390	2.97	27.00	31.4	44.1	49.6	78.5	0.171	1.21	59.0
14144550	2.00	861	7.91	710	9.91	1.210	2.48	14.10	31.8	44.8	50.6	78.5	0.180	1.00	60.0
14144600	0.53	407	6.13	552	6.88	0.794	1.73	2.43	33.5	45.6	53.5	80.2	0.170	1.42	60.0
14144800	258.00	7,180	18.70	4,290	8.72	0.981	2.77	177.00	25.6	40.6	45.7	76.5	0.124	2.68	44.3
14144870	0.51	1,010	11.80	2,160	8.13	0.551	2.26	29.90	32.6	46.8	51.0	77.4	0.140	0.48	49.6
14144900	53.10	4,790	21.00	4,010	8.97	0.987	2.59	118.00	29.2	42.9	48.4	75.1	0.127	2.54	44.0
14145500	393.00	7,520	19.40	3,950	8.77	0.948	2.69	143.00	27.4	41.9	47.1	76.2	0.124	2.41	44.1
14146000	114.00	6,490	15.80	4,400	8.52	1.150	2.69	157.00	27.6	41.1	46.2	73.7	0.115	2.74	45.6
14146500	116.00	5,650	19.40	4,070	9.05	1.040	2.68	125.00	29.2	42.5	48.2	74.1	0.127	2.56	44.1
14147400	1.30	1,890	13.50	2,820	9.65	0.815	2.61	53.00	32.9	45.9	51.1	77.3	0.133	0.99	47.9
14147500	247.00	6,260	15.10	3,920	9.38	1.040	2.77	140.00	28.3	41.7	47.1	74.6	0.125	2.10	43.4
14148000	929.00	7,790	17.80	3,910	8.90	0.995	2.69	135.00	28.2	42.1	47.3	75.3	0.124	2.30	44.3
14148700	0.47	984	13.20	1,540	7.93	0.561	2.27	10.90	34.2	46.8	50.9	79.0	0.140	0.48	49.6
14150300	117.00	4,130	21.10	2,450	9.68	0.867	2.66	40.70	33.3	45.8	49.4	77.6	0.130	1.27	46.9
14150800	43.80	4,110	17.80	2,520	9.32	0.832	2.59	35.00	33.6	46.0	49.6	77.0	0.132	1.20	46.6

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14151000	186.00	4,300	19.30	2,320	9.34	0.821	2.58	34.70	33.5	46.0	49.8	77.8	0.130	1.16	45.8
14151500	53.00	3,470	16.20	2,130	9.39	0.833	2.58	18.40	34.0	46.4	50.0	78.8	0.138	0.94	47.6
14152500	71.70	3,530	17.90	2,070	10.10	0.468	2.66	26.90	34.3	47.8	51.2	79.6	0.138	0.72	48.3
14153800	57.00	3,780	18.30	2,930	9.97	0.979	2.77	46.30	32.6	45.4	49.1	73.8	0.127	1.46	46.3
14153900	5.56	2,450	12.50	2,590	9.21	0.659	2.55	25.00	32.7	46.3	49.4	77.8	0.124	0.95	48.4
14154500	211.00	5,130	21.70	2,830	10.90	0.732	2.76	48.00	32.3	45.5	49.2	75.1	0.132	1.46	46.8
14155500	269.00	5,280	19.90	2,620	10.30	0.736	2.69	41.70	32.5	45.7	49.3	75.8	0.131	1.32	46.3
14156000	85.50	4,020	21.60	2,090	10.20	0.470	2.59	26.80	33.6	47.1	50.2	78.3	0.134	0.85	47.9
14156500	95.00	4,060	20.50	1,990	9.86	0.487	2.54	24.90	33.5	47.0	50.1	78.4	0.135	0.87	47.5
14157000	531.00	5,380	17.90	2,170	9.75	0.607	2.59	30.90	33.0	46.5	49.8	77.5	0.135	1.11	46.2
14158000	2,030.00	8,310	16.70	2,820	8.98	0.792	2.58	74.80	31.0	44.5	48.9	76.9	0.130	1.67	45.1
14158250	0.22	1,580	21.60	4,740	13.10	2.130	4.34	220.00	26.6	39.2	46.0	72.5	0.112	3.44	44.6
14158790	16.30	3,090	19.60	4,010	12.00	1.590	3.80	162.00	26.0	39.2	45.9	76.3	0.144	3.08	41.3
14158950	1.15	785	5.86	2,900	11.20	0.941	3.14	99.80	27.1	40.5	47.2	80.6	0.127	1.90	44.7
14159000	351.00	8,640	12.20	4,220	12.20	1.190	3.43	277.00	23.4	39.2	43.0	74.8	0.115	5.13	42.1
14159200	159.00	5,070	18.00	4,210	10.40	1.080	3.00	163.00	26.6	40.4	46.0	74.0	0.136	2.75	42.7
14159500	207.00	5,580	19.30	4,020	10.50	1.040	3.00	148.00	27.1	41.0	46.3	74.6	0.133	2.65	42.5
14161000	12.00	3,350	18.70	3,440	11.60	1.520	3.57	129.00	27.2	39.8	46.5	74.8	0.144	2.49	42.0
14161100	45.60	3,910	23.40	3,210	11.40	1.300	3.31	98.90	28.3	40.9	47.1	76.0	0.137	2.27	43.0
14161500	24.10	3,900	20.70	3,230	11.80	1.390	3.47	101.00	27.7	41.0	46.7	77.6	0.130	2.34	43.8
14161600	0.40	1,870	28.30	2,360	10.20	0.818	2.57	50.30	30.0	43.6	48.3	81.0	0.110	1.38	47.3
14162000	74.90	3,980	22.60	3,140	11.40	1.290	3.31	95.60	28.2	41.2	47.0	76.9	0.134	2.21	43.6
14162500	930.00	9,480	16.40	3,850	11.30	1.110	3.20	194.00	25.8	40.6	44.9	75.4	0.125	3.44	43.0
14163000	47.80	3,590	22.20	2,200	9.35	0.886	2.56	23.60	32.1	45.5	49.6	79.7	0.131	1.12	47.7
14164000	1,100.00	9,790	16.60	3,550	11.00	1.060	3.09	167.00	26.9	41.4	45.7	76.1	0.126	3.09	43.9

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14165000	177.00	3,380	12.60	1,510	8.85	0.774	2.48	11.20	34.6	46.4	51.8	78.5	0.137	1.16	47.8
14165500	1,340.00	9,940	15.60	3,160	10.50	0.998	2.97	139.00	28.3	42.4	46.8	76.6	0.129	2.78	44.6
14166500	89.40	1,690	13.90	832	10.70	0.341	2.64	6.48	34.0	46.8	50.4	81.9	0.149	0.82	46.0
14167000	97.90	1,610	9.93	747	7.92	0.277	2.24	5.28	33.7	47.1	50.9	81.1	0.152	0.50	43.2
14169700	5.16	833	9.71	831	9.67	0.410	2.56	6.10	34.2	46.8	52.0	81.5	0.150	0.55	41.2
14170000	398.00	1,820	7.99	634	8.54	0.326	2.34	5.22	33.9	46.8	51.3	81.6	0.148	0.61	44.7
14170500	14.90	3,720	16.20	1,460	15.00	0.512	3.50	28.20	33.1	45.2	51.5	77.0	0.148	1.58	40.9
14171000	157.00	3,860	11.90	938	12.80	0.493	2.91	14.90	32.8	45.9	50.6	78.1	0.148	1.39	43.5
14172000	103.00	4,600	18.40	2,130	10.10	1.000	2.73	35.00	31.9	44.7	49.4	77.1	0.134	1.41	45.1
14172300	4.96	1,240	9.44	883	8.42	0.680	2.33	3.48	34.1	46.7	51.6	78.8	0.150	0.52	37.8
14173500	370.00	4,950	8.49	981	8.11	0.647	2.29	12.40	33.4	45.9	50.9	79.1	0.150	1.28	50.1
14174000	4,850.00	10,200	13.40	2,260	9.32	0.738	2.61	72.00	31.0	44.5	49.0	77.9	0.136	1.87	46.3
14178000	216.00	8,910	14.90	4,140	11.70	1.220	3.34	209.00	24.8	38.1	45.0	74.4	0.118	5.81	47.3
14178600	1.93	2,330	19.90	3,340	10.90	0.946	2.74	124.00	26.9	38.7	46.8	75.8	0.147	3.04	41.0
14178700	7.40	2,700	24.20	3,330	11.60	0.985	2.84	114.00	27.3	39.1	47.4	75.4	0.135	3.18	42.2
14178800	1.03	2,290	27.00	3,010	12.20	0.803	3.11	61.30	28.6	40.8	49.1	79.1	0.160	2.90	39.7
14179000	106.00	5,410	21.90	3,780	11.90	1.090	3.16	162.00	26.2	38.7	46.1	74.7	0.127	4.51	42.5
14181500	453.00	9,350	18.80	3,730	12.70	1.160	3.35	157.00	26.6	39.3	46.5	74.7	0.124	4.49	44.9
14181700	1.15	2,700	14.40	2,330	11.90	0.879	2.85	24.60	31.2	44.4	49.6	76.7	0.115	1.23	47.7
14182500	111.00	4,880	22.00	2,680	15.70	0.943	3.31	75.50	30.1	42.2	48.9	74.2	0.139	2.37	43.4
14183000	652.00	9,890	18.70	3,310	13.20	1.090	3.29	126.00	27.8	40.5	47.3	74.9	0.128	3.74	45.2
14184900	0.86	1,840	17.30	1,810	8.87	0.904	2.45	13.70	30.9	44.9	48.6	77.4	0.141	0.48	50.2
14185000	176.00	4,670	20.00	2,920	10.60	1.350	3.11	83.40	29.2	41.9	47.5	75.2	0.140	1.93	44.7
14185800	104.00	4,700	20.40	3,280	11.70	1.550	3.50	124.00	28.7	41.1	47.5	73.8	0.139	2.39	42.6
14185900	99.60	3,900	24.50	3,020	13.60	1.340	3.41	70.40	30.5	42.8	48.9	73.9	0.135	2.15	43.4

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14186000	267.00	4,790	21.70	2,860	12.00	1.320	3.23	79.50	30.0	42.8	48.4	74.8	0.130	2.06	43.0
14186500	285.00	5,150	21.40	2,800	11.90	1.290	3.17	75.20	30.2	43.0	48.5	75.0	0.130	2.00	43.1
14187000	51.50	3,760	19.20	2,420	10.20	1.060	2.68	32.70	30.5	44.0	48.2	76.1	0.132	1.52	46.2
14187500	635.00	5,440	18.50	2,480	10.80	1.180	2.93	60.70	30.5	43.5	48.6	75.9	0.135	1.75	44.6
14188800	108.00	4,030	14.10	1,850	12.00	0.995	2.83	35.30	31.5	44.8	49.5	76.5	0.141	1.15	46.7
14189000	1,780.00	10,300	15.70	2,420	11.30	1.050	2.91	72.60	30.0	42.9	48.5	76.2	0.135	2.48	46.1
14189500	34.40	2,840	17.80	1,360	16.80	0.682	3.93	28.60	32.0	45.0	48.0	75.2	0.145	2.11	44.0
14190000	116.00	2,960	14.40	1,000	14.30	0.425	3.32	18.90	32.3	45.3	49.2	77.6	0.151	1.06	45.3
14190100	22.40	2,830	14.50	1,810	17.70	0.682	4.47	54.60	32.7	43.6	48.1	71.9	0.154	1.15	44.9
14190200	3.52	1,050	9.99	801	11.20	0.442	2.98	12.00	31.9	45.8	48.7	79.7	0.150	0.52	36.4
14190500	240.00	3,140	11.50	893	13.30	0.438	3.22	19.10	32.3	45.3	49.1	78.0	0.151	1.10	44.2
14190600	0.37	504	9.77	361	8.96	0.399	2.21	6.90	32.6	46.0	50.2	80.4	0.158	0.40	56.0
14190800	46.00	3,380	14.10	1,230	13.10	0.540	3.52	36.60	32.9	44.7	48.8	76.5	0.152	1.06	42.6
14191000	7,270.00	10,400	13.40	2,160	9.87	0.792	2.69	67.00	30.9	44.2	48.9	77.6	0.137	1.99	46.4
14192100	2.49	815	7.38	624	7.14	0.591	2.12	6.78	32.5	45.9	49.7	81.0	0.150	0.54	40.1
14192200	5.08	949	7.33	620	7.51	0.583	2.17	7.30	32.6	45.8	49.7	81.0	0.157	0.59	43.8
14192500	130.00	3,220	12.90	1,060	14.40	0.968	3.61	36.70	33.5	45.9	48.7	75.4	0.149	1.21	46.1
14192800	1.82	799	10.50	652	9.17	0.516	2.60	17.00	32.0	45.6	48.9	79.4	0.147	0.79	37.4
14193000	64.40	2,750	14.30	1,330	12.10	0.672	3.15	46.80	35.1	47.2	49.5	76.4	0.146	1.22	45.4
14193300	27.50	2,970	24.80	1,770	14.70	0.576	3.95	59.40	33.9	43.4	49.1	72.9	0.154	1.49	43.5
14194000	495.00	3,460	10.30	800	10.80	0.658	2.88	25.40	33.4	46.0	49.3	78.3	0.155	1.00	46.2
14194300	9.09	2,850	18.90	1,930	14.60	0.613	3.71	83.10	31.7	41.9	49.2	73.3	0.152	1.44	44.0
14195000	6.26	2,080	15.80	1,780	15.10	0.552	3.84	73.70	32.0	43.2	49.1	74.3	0.162	0.98	45.8
14196500	47.60	3,150	14.40	1,320	11.90	0.556	3.10	48.20	31.8	42.9	49.8	75.9	0.151	0.96	44.6
14197000	65.00	3,200	13.50	1,200	11.10	0.557	2.90	43.50	31.8	43.1	49.9	76.6	0.153	0.89	45.4

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14197300	3.23	1,730	15.40	1,410	13.20	0.551	3.43	47.10	32.3	44.7	49.4	75.5	0.150	0.91	47.4
14198500	96.40	4,170	20.50	2,820	14.90	1.160	3.39	100.00	29.2	40.8	48.6	71.6	0.134	2.35	45.0
14199700	4.16	1,140	6.74	908	9.26	0.948	2.51	15.90	32.4	45.2	50.9	78.3	0.133	0.80	45.7
14200000	325.00	4,840	13.60	1,940	11.90	1.070	2.96	61.90	30.8	42.7	50.0	74.3	0.135	1.96	46.8
14200300	47.30	3,590	10.70	1,710	11.70	1.100	2.90	38.20	31.2	44.5	48.7	75.6	0.130	0.88	46.8
14201000	202.00	4,270	8.05	1,250	9.79	0.919	2.53	28.60	31.7	45.1	50.1	76.8	0.142	0.98	47.0
14201500	58.80	4,240	11.70	1,770	11.10	1.020	2.78	60.20	31.5	44.4	49.3	74.8	0.130	1.38	48.2
14202000	480.00	4,320	5.91	876	8.54	0.805	2.30	22.30	32.4	45.7	51.1	78.2	0.156	1.15	51.7
14202500	48.40	3,290	13.40	1,340	10.40	0.712	2.77	66.20	31.5	42.8	50.2	75.5	0.159	1.07	48.4
14202850	16.90	3,100	14.90	1,540	10.50	0.754	2.82	85.80	31.5	42.4	50.3	74.5	0.158	1.05	49.6
14202920	10.50	1,860	12.20	1,320	9.59	0.650	2.57	64.90	31.7	42.9	50.5	76.3	0.161	0.91	51.6
14203000	43.30	3,200	12.70	1,140	9.27	0.656	2.49	55.30	31.8	43.3	50.8	76.4	0.167	0.94	52.8
14203500	125.00	3,310	11.50	1,020	9.23	0.644	2.49	47.90	31.8	43.5	50.7	76.8	0.164	0.91	50.9
14203800	4.08	1,240	15.20	912	11.40	0.525	2.60	53.90	31.2	42.9	50.0	76.1	0.150	0.61	48.8
14204000	33.70	2,680	15.80	1,330	12.40	0.619	2.90	81.00	31.1	42.3	50.1	74.6	0.153	0.79	47.6
14204100	1.35	1,590	18.80	1,160	10.90	0.618	2.56	67.50	31.5	43.0	50.5	75.8	0.148	0.78	48.2
14204500	66.30	2,930	14.40	1,090	11.00	0.605	2.65	67.10	31.4	42.9	50.5	75.7	0.157	0.77	49.8
14205500	44.70	2,070	11.30	1,140	10.50	0.589	2.37	48.10	30.6	42.9	50.2	75.8	0.143	0.74	50.8
14206000	27.40	1,670	11.50	1,060	9.88	0.585	2.31	36.90	30.5	43.4	51.0	77.2	0.113	0.71	57.1
14206500	562.00	3,360	8.56	710	8.51	0.592	2.19	30.00	31.9	44.2	51.5	77.9	0.159	0.77	54.8
14207500	707.00	3,380	7.96	642	8.14	0.600	2.13	25.00	32.1	44.5	51.8	78.2	0.161	0.77	55.6
14207920	1.71	1,860	13.50	3,540	9.33	1.030	2.44	184.00	23.6	36.4	43.9	71.7	0.145	4.07	42.9
14208000	139.00	5,160	11.00	3,870	10.20	1.120	2.74	190.00	24.2	36.6	44.3	72.4	0.120	5.16	48.2
14208500	54.10	2,360	6.24	3,740	8.38	0.866	2.23	201.00	23.4	36.5	44.5	70.5	0.086	3.51	44.7
14208850	2.07	1,320	12.80	4,230	10.80	1.210	2.70	204.00	24.4	35.7	44.9	69.6	0.104	3.52	45.3

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14209000	126.00	3,520	9.71	3,710	8.94	0.955	2.36	185.00	24.0	36.6	44.7	71.3	0.102	3.36	44.9
14209500	489.00	6,120	14.30	3,540	11.10	1.030	2.75	152.00	25.7	37.7	46.0	72.8	0.120	3.49	46.1
14209700	45.30	4,350	24.50	3,130	13.70	1.060	3.19	92.50	27.2	38.0	48.3	70.2	0.141	2.56	43.9
14209750	1.01	997	10.90	2,580	11.00	1.400	2.77	37.70	30.6	41.6	50.5	76.0	0.121	1.59	51.1
14209900	2.31	729	5.93	1,010	8.85	1.090	2.48	4.81	33.5	45.1	52.0	78.8	0.140	0.48	49.6
14210000	680.00	6,910	15.60	3,330	11.30	1.070	2.80	131.00	26.5	38.2	46.9	72.8	0.124	3.11	46.1
14210800	2.25	521	7.89	596	7.97	0.888	2.09	3.24	33.9	45.7	53.3	79.8	0.110	0.71	57.5
14212000	18.10	1,870	9.78	1,050	13.30	1.430	3.15	23.00	31.3	44.2	49.7	78.1	0.177	1.05	60.0
14213200	127.00	10,500	15.20	3,810	15.60	1.510	3.62	224.00	26.7	35.5	52.7	72.2	0.108	3.33	51.6
14213500	13.80	1,480	7.77	3,770	13.70	1.740	3.51	167.00	26.6	35.4	51.1	71.2	0.120	1.76	53.1
14214500	11.30	2,440	8.41	3,980	14.40	1.820	3.71	194.00	26.4	34.2	50.8	69.5	0.123	1.46	55.0
14215000	25.40	3,600	8.47	3,960	15.60	1.800	3.78	198.00	26.4	34.0	50.6	69.3	0.123	1.49	54.8
14216000	228.00	11,000	13.30	3,540	15.40	1.550	3.60	186.00	26.9	35.8	51.8	72.4	0.113	2.69	52.5
14218300	2.25	2,370	19.00	1,630	14.80	1.250	3.23	24.50	31.4	42.5	50.9	77.6	0.120	1.39	55.5
14219000	64.50	3,890	19.30	2,270	19.10	1.400	4.15	81.20	29.2	39.4	49.9	76.7	0.138	1.57	47.2
14219800	12.60	3,290	19.80	2,140	15.00	1.340	3.33	30.90	31.0	42.5	50.6	77.6	0.117	2.23	54.3
14221500	40.80	1,880	10.10	945	12.80	1.160	2.96	15.80	31.7	43.7	50.8	78.3	0.200	1.13	57.9
14222500	126.00	4,050	16.10	1,880	17.80	1.490	3.93	69.40	30.1	41.1	49.9	77.0	0.155	1.62	51.3
14223800	1.08	1,190	13.50	653	7.73	1.030	1.99	4.15	32.1	44.7	50.6	76.8	0.170	1.67	59.5
14235300	0.77	1,860	22.00	2,610	14.10	1.470	3.49	61.40	28.0	41.0	48.2	74.4	0.213	1.12	50.6
14235500	16.50	3,180	23.40	2,510	13.50	1.420	3.38	63.30	28.0	41.2	48.0	74.7	0.159	2.09	45.7
14236200	139.00	4,140	21.60	2,210	12.30	1.350	3.19	54.00	28.6	42.0	48.6	75.0	0.163	2.48	50.6
14237000	3.56	951	9.24	956	8.01	1.030	2.47	13.90	30.8	44.2	49.6	76.7	0.220	1.13	59.2
14237500	37.90	3,080	11.60	1,700	10.90	1.170	2.59	31.20	29.8	43.1	49.2	76.1	0.197	1.32	57.3
14239000	78.10	2,520	8.23	707	8.25	1.040	2.16	8.85	31.0	44.3	49.1	77.3	0.162	1.92	58.1

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14239700	0.40	476	5.96	470	7.48	0.846	1.93	4.97	32.5	44.9	50.5	77.5	0.170	1.32	60.0
14242600	0.66	484	8.51	501	7.69	1.000	2.03	5.06	31.6	44.5	49.7	77.6	0.176	0.68	59.0
14243000	2,230.00	14,000	16.20	2,540	12.10	1.240	2.96	110.00	27.7	39.2	48.8	73.5	0.121	4.19	52.1
14243500	19.70	2,410	11.70	997	10.40	1.020	2.53	18.50	31.0	43.9	49.8	75.1	0.161	2.02	55.6
14245000	118.00	4,490	15.20	1,380	12.60	1.290	3.00	30.50	30.8	42.6	49.7	76.8	0.165	1.53	54.8
14247020	2.34	1,580	10.70	1,110	11.00	0.846	2.68	27.30	32.0	43.7	51.5	73.7	0.170	1.34	47.1
14247500	65.60	2,600	15.30	1,080	12.80	1.380	3.13	28.30	30.6	42.8	50.4	72.6	0.156	2.04	50.2
14248100	1.12	913	16.00	286	10.90	1.220	2.71	5.87	32.7	46.7	49.7	72.6	0.210	2.31	56.7
14248200	5.47	1,490	11.10	580	15.70	1.920	3.70	7.64	32.2	46.6	49.3	71.5	0.174	1.02	53.4
14248510	1.64	1,990	12.80	1,090	17.00	2.080	3.90	50.80	31.7	43.3	49.4	71.9	0.172	2.04	49.5
14249000	39.70	2,670	19.40	1,430	18.60	2.210	4.35	70.70	30.5	42.4	52.0	72.9	0.142	1.92	45.2
14250500	15.50	2,780	24.30	1,180	18.60	2.280	4.31	38.90	30.6	44.0	49.0	72.2	0.154	1.63	47.2
14251500	33.70	3,240	13.20	943	21.70	2.180	4.65	46.10	32.5	45.1	48.7	71.2	0.178	1.80	48.5
14299000	8.07	2,510	14.30	1,130	22.90	2.240	5.41	7.09	34.7	46.9	48.5	70.4	0.180	1.57	47.1
14299500	2.00	3,040	16.90	1,030	25.50	2.400	5.79	5.62	34.9	48.4	48.9	70.6	0.176	1.39	46.2
14300200	11.70	1,210	10.20	1,400	10.40	0.642	2.30	44.00	28.6	43.1	48.3	73.9	0.176	1.28	51.3
14301000	673.00	3,620	14.20	1,180	15.00	1.160	3.35	65.40	30.8	43.1	49.5	73.5	0.163	1.47	48.9
14301250	1.99	1,290	17.80	626	17.20	1.850	4.13	3.32	36.5	48.8	49.5	69.6	0.180	1.54	47.9
14301300	28.20	2,750	26.10	964	20.80	2.060	4.62	22.30	35.7	47.7	49.9	71.7	0.162	1.49	46.7
14301400	1.93	1,630	14.60	489	16.60	1.780	3.79	5.52	36.0	49.1	49.7	69.7	0.178	2.53	50.8
14301500	161.00	3,630	24.10	1,670	19.00	1.620	4.38	130.00	33.3	43.6	49.6	71.2	0.150	1.49	44.0
14302500	145.00	3,460	22.10	1,660	17.30	1.420	4.17	105.00	34.4	45.1	49.5	73.1	0.155	1.39	44.3
14302600	3.32	2,800	22.50	1,610	20.70	1.900	4.54	72.40	37.6	48.2	49.5	72.9	0.168	1.30	44.9
14303000	9.01	1,450	11.60	2,110	16.30	0.584	4.08	92.70	33.0	44.7	48.9	73.4	0.170	1.20	44.0
14303200	3.11	1,470	16.90	2,110	16.40	1.160	4.02	107.00	37.0	47.0	49.3	72.8	0.170	1.20	44.0

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14303600	181.00	3,130	17.60	1,320	17.20	1.470	4.11	60.90	37.2	48.1	49.4	73.1	0.169	1.52	46.0
14303650	2.07	1,200	13.50	822	17.10	1.820	3.97	5.58	35.8	48.4	49.8	70.8	0.230	1.17	45.6
14303700	1.07	1,330	15.10	1,000	17.70	1.830	4.04	17.80	34.6	48.2	49.4	71.5	0.230	1.17	45.6
14303750	58.90	3,390	15.50	1,230	22.20	1.860	4.92	62.10	33.2	45.9	48.2	70.5	0.209	1.35	44.6
14303800	3.05	1,200	18.10	627	15.30	1.670	3.57	5.31	35.9	48.3	49.7	70.6	0.230	1.17	45.6
14303950	13.50	1,910	18.10	950	17.90	1.780	4.11	16.70	34.9	47.8	49.5	72.5	0.230	1.17	45.6
14304350	6.75	1,860	20.80	1,200	22.00	1.360	5.19	25.10	31.9	46.5	47.6	75.7	0.136	2.23	41.8
14304850	6.60	1,930	17.00	1,290	19.60	1.100	4.60	23.60	31.9	46.1	47.6	76.3	0.132	2.62	40.0
14305500	203.00	3,450	18.80	1,320	19.80	1.150	4.69	42.00	32.8	46.2	48.5	72.7	0.144	2.19	42.9
14306030	70.80	2,650	17.40	617	12.00	0.736	2.85	8.70	34.8	49.2	50.3	73.8	0.138	2.70	43.5
14306036	4.26	1,510	19.70	759	14.40	0.890	3.29	3.80	36.8	50.1	51.2	71.8	0.130	2.68	39.9
14306100	64.10	3,820	17.60	1,410	16.00	0.705	3.66	30.40	34.3	46.1	51.4	78.7	0.152	1.36	45.6
14306340	5.64	2,830	25.40	1,820	19.20	0.816	4.23	27.70	35.9	46.4	53.2	79.7	0.145	2.21	39.7
14306400	114.00	3,300	20.60	845	14.90	0.769	3.46	8.48	37.8	48.3	52.6	79.9	0.133	2.60	40.6
14306500	331.00	4,050	18.80	1,060	15.10	0.735	3.61	16.30	36.6	47.5	52.3	79.6	0.143	1.96	43.8
14306600	20.40	2,350	21.10	1,290	19.80	1.040	4.35	15.50	35.5	48.0	50.9	75.6	0.136	2.46	40.5
14306700	0.31	783	18.80	726	16.10	0.879	3.46	5.44	36.0	49.0	51.3	74.4	0.130	2.68	39.9
14306800	0.83	865	16.70	911	14.40	0.824	3.20	4.41	36.6	49.9	51.4	73.3	0.130	2.68	39.9
14306810	1.18	1,070	21.40	1,020	15.00	0.844	3.31	4.32	36.7	50.0	51.4	73.3	0.130	2.68	39.9
14306830	0.92	629	17.60	530	12.30	0.775	2.75	0.00	37.0	50.2	50.7	70.5	0.230	1.17	45.6
14306880	1.61	1,900	22.40	944	15.00	0.901	3.40	2.54	36.6	50.3	51.2	72.8	0.188	1.30	45.6
14306900	12.30	2,190	19.00	1,030	15.60	0.865	3.43	3.62	36.7	50.2	51.7	73.9	0.173	1.63	44.0
14307500	52.80	2,710	19.90	1,310	14.20	0.463	3.36	14.10	35.5	46.9	53.2	81.2	0.145	2.19	44.4
14307550	0.78	999	21.60	930	13.00	0.675	3.16	8.59	37.8	48.1	52.9	80.1	0.130	2.68	39.9
14307580	173.00	3,190	21.70	1,090	13.90	0.569	3.27	11.70	36.3	47.6	52.4	80.4	0.138	2.48	42.0

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14307610	0.39	941	20.20	561	14.10	0.748	3.23	2.91	37.4	51.8	51.6	75.0	0.219	1.53	46.7
14307620	590.00	3,360	19.70	961	11.20	0.496	2.81	7.96	35.2	47.8	51.1	80.3	0.140	2.13	42.9
14307640	2.69	1,940	18.40	973	14.90	0.787	3.39	2.96	37.1	50.2	51.9	74.3	0.149	2.22	41.5
14307645	41.00	2,320	19.80	608	14.20	0.772	3.26	2.44	37.1	51.0	51.3	73.7	0.196	1.91	45.7
14307685	2.63	3,080	28.20	2,970	8.18	0.588	2.33	43.90	32.6	47.1	51.1	81.0	0.120	2.29	51.1
14307700	155.00	5,030	17.90	3,410	7.74	0.504	2.33	77.40	27.7	40.8	47.2	74.7	0.130	2.24	49.0
14308000	451.00	5,680	19.20	3,210	7.73	0.522	2.32	65.70	29.4	43.2	48.7	77.8	0.126	2.27	49.1
14308500	56.80	3,570	16.20	2,860	8.11	0.380	2.29	50.80	30.4	43.4	50.3	77.8	0.118	2.27	51.0
14308600	643.00	5,950	19.50	2,930	7.63	0.490	2.29	57.50	30.3	43.9	49.6	78.5	0.120	2.23	48.0
14308700	34.50	3,310	18.90	1,700	6.81	0.393	1.99	18.50	33.1	47.0	52.3	82.0	0.105	1.58	38.3
14308900	35.70	3,180	26.20	2,100	6.94	0.517	2.51	40.00	35.5	47.5	54.4	79.8	0.110	2.11	47.0
14308950	1.59	1,500	21.00	3,080	7.96	0.574	2.48	76.00	31.6	42.8	50.9	76.9	0.111	2.37	48.4
14308990	64.70	3,210	18.50	3,020	7.31	0.636	2.54	66.30	32.7	43.6	53.3	79.3	0.095	2.20	40.3
14309000	77.90	3,380	18.90	2,930	7.25	0.625	2.54	64.40	33.0	44.2	53.4	79.3	0.096	2.08	39.8
14309500	87.10	3,270	22.30	2,420	11.40	0.379	3.32	46.50	36.0	47.3	54.1	76.9	0.122	2.38	43.2
14310000	460.00	4,450	20.90	2,340	8.21	0.428	2.63	55.40	34.6	45.9	54.1	78.5	0.106	1.83	40.4
14310700	47.70	3,640	18.30	1,880	6.97	0.408	2.05	19.30	33.8	47.6	52.8	82.2	0.105	1.55	38.7
14310900	3.18	2,010	20.00	1,590	4.52	0.582	2.02	12.10	33.9	48.0	52.7	81.5	0.092	1.01	34.0
14311000	54.20	2,680	21.20	1,570	5.56	0.552	2.06	12.80	34.1	48.3	52.8	82.2	0.097	1.19	34.7
14311200	61.40	2,730	19.00	1,750	9.00	0.284	2.63	22.60	34.7	47.4	54.2	78.6	0.125	1.64	37.7
14311300	29.60	2,500	16.40	1,360	7.66	0.216	2.43	6.97	33.3	47.6	52.6	81.6	0.141	1.14	38.3
14311500	156.00	2,950	16.00	1,370	7.69	0.298	2.38	12.00	34.0	47.7	53.3	80.9	0.136	1.18	39.0
14312000	1,630.00	6,200	19.40	2,290	7.48	0.440	2.36	43.30	32.7	45.7	52.0	79.5	0.115	1.91	43.3
14312100	2.51	1,320	17.60	1,040	5.62	0.439	1.97	6.42	33.4	47.5	52.5	82.6	0.150	0.60	40.4
14312200	53.20	2,960	16.00	1,300	5.54	0.598	2.11	10.50	34.8	48.9	53.2	82.5	0.113	1.50	39.4

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14312300	1.31	894	11.50	752	5.51	0.269	1.79	2.68	34.0	48.5	53.2	83.5	0.145	1.45	45.1
14313500	180.00	5,140	8.59	5,600	6.76	1.030	2.74	248.00	20.5	38.9	40.5	72.4	0.113	4.40	45.5
14314500	40.70	4,520	9.07	5,190	6.34	0.956	2.56	189.00	21.8	39.8	41.9	74.1	0.124	3.30	43.3
14315500	336.00	6,740	10.80	5,100	7.11	0.943	2.67	205.00	22.2	39.7	42.4	74.7	0.123	3.76	44.8
14316000	68.50	4,090	15.70	4,780	7.39	0.852	2.49	148.00	22.9	39.1	42.9	73.8	0.127	3.20	44.4
14316500	472.00	7,550	12.80	4,830	7.19	0.887	2.59	177.00	23.1	40.0	43.3	75.4	0.125	3.49	45.1
14316600	3.95	3,400	18.60	3,320	7.41	0.572	2.26	45.90	31.3	45.3	50.2	81.8	0.137	2.34	46.5
14316700	227.00	4,850	22.60	3,100	10.00	0.545	2.63	57.50	31.3	45.5	49.9	79.1	0.127	2.10	48.2
14317500	889.00	8,360	17.20	3,970	8.15	0.741	2.57	119.00	26.9	42.5	46.3	77.4	0.126	2.79	46.3
14317600	97.00	3,780	21.90	2,610	10.50	0.609	2.85	35.40	34.5	48.3	51.5	80.5	0.124	1.49	50.0
14317700	3.55	3,620	18.10	3,370	11.80	0.708	2.85	66.60	33.5	47.3	50.7	79.4	0.136	2.08	47.9
14317800	57.30	4,300	16.30	2,640	10.10	0.605	2.73	49.20	34.2	48.0	51.8	79.9	0.122	1.92	49.7
14318000	177.00	4,470	18.10	2,830	9.55	0.635	2.62	49.10	33.5	47.5	50.9	79.6	0.127	1.85	48.8
14318500	1,220.00	8,480	17.60	3,580	8.50	0.707	2.59	97.20	28.8	43.9	47.6	78.2	0.126	2.46	46.7
14318600	0.74	932	18.20	1,130	5.53	0.621	2.01	5.16	33.1	47.6	51.0	82.9	0.149	0.80	41.5
14319200	16.20	1,400	12.70	847	5.05	0.748	1.97	2.14	33.4	47.8	51.8	82.6	0.142	2.00	47.5
14319500	1,360.00	8,760	17.30	3,310	8.17	0.693	2.52	87.60	29.3	44.4	48.0	78.7	0.128	2.35	46.5
14319850	9.18	3,480	18.80	1,650	10.20	0.602	2.76	20.20	33.0	47.8	49.9	81.9	0.147	0.62	41.8
14319900	83.60	3,730	18.20	2,070	10.20	0.620	2.79	28.50	34.5	48.3	51.4	81.1	0.140	0.91	44.4
14320600	1.65	782	11.10	765	4.88	0.727	1.92	0.00	34.0	48.4	52.6	83.0	0.146	1.22	42.8
14320700	211.00	4,060	14.50	1,360	7.35	0.668	2.33	13.20	33.9	48.0	51.4	81.8	0.145	0.91	42.3
14321000	3,640.00	9,030	17.90	2,460	7.56	0.552	2.39	53.60	31.7	45.6	50.5	79.7	0.124	1.99	44.4
14321400	28.10	2,170	15.10	1,300	8.11	0.531	2.37	11.90	34.1	47.8	51.1	80.4	0.150	0.54	39.8
14321900	26.40	1,580	10.80	679	5.94	0.580	2.05	2.85	33.5	47.6	50.5	82.0	0.143	1.41	42.5
14322000	103.00	2,350	14.10	965	7.08	0.533	2.22	6.44	33.6	47.6	50.6	81.1	0.143	1.08	40.3

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14322400	53.00	1,770	15.10	835	7.07	0.556	2.21	4.55	33.3	47.6	49.9	81.6	0.133	1.50	38.1
14322700	5.25	1,340	16.60	1,180	6.89	0.579	2.23	5.39	32.9	47.3	49.6	81.3	0.130	1.66	37.0
14323500	24.50	2,390	24.20	1,700	12.30	0.689	3.73	28.50	35.6	47.8	53.6	77.8	0.130	2.68	39.9
14323997	0.43	924	18.40	592	10.30	0.669	2.95	3.78	34.7	52.5	50.7	75.2	0.130	2.68	39.9
14324500	46.70	2,060	24.80	1,230	12.70	0.762	3.34	20.40	35.3	50.1	51.6	76.0	0.130	2.68	39.9
14324600	31.80	1,940	17.20	2,860	19.10	0.476	5.26	67.00	35.4	47.2	52.5	77.4	0.130	2.68	39.8
14324700	41.10	2,090	16.60	2,860	19.10	0.466	5.28	63.50	35.3	47.4	52.4	78.2	0.130	2.68	39.8
14324900	93.80	3,480	19.70	2,510	17.30	0.441	4.83	48.30	35.2	47.8	52.0	80.2	0.118	2.27	41.0
14325000	171.00	3,880	19.60	2,150	15.80	0.422	4.44	38.30	35.1	48.5	51.9	79.5	0.124	2.36	41.6
14326500	306.00	3,660	18.00	1,510	10.50	0.394	3.06	19.80	35.0	49.6	52.5	77.7	0.132	2.30	41.4
14326600	1.39	921	19.20	497	7.42	0.315	2.52	1.84	35.4	53.5	50.7	75.5	0.160	1.03	56.2
14326800	73.80	2,380	18.50	832	10.70	0.615	3.05	5.81	34.9	52.0	51.5	76.6	0.140	2.01	44.4
14326815	23.10	2,310	25.30	1,120	11.00	0.623	3.26	16.30	35.4	50.4	52.9	77.1	0.130	2.65	40.0
14326850	6.24	2,280	22.10	1,110	10.90	0.621	3.22	15.70	35.6	51.1	53.0	76.8	0.132	2.43	40.9
14326950	9.72	2,020	24.90	1,840	11.90	0.673	3.50	25.80	36.2	49.2	54.1	76.8	0.130	2.68	39.9
14327000	283.00	3,200	19.50	1,090	10.60	0.565	3.14	12.60	35.4	51.0	52.4	76.8	0.136	2.27	42.9
14327100	1.25	447	3.30	295	11.40	0.433	3.16	0.87	37.7	53.1	50.6	70.7	0.141	4.76	59.9
14327240	0.81	1,610	24.60	1,490	19.30	0.970	5.41	43.70	36.0	49.3	52.3	77.9	0.160	0.87	56.1
14327250	70.80	3,960	27.80	1,700	20.00	0.989	5.59	40.20	36.9	49.5	53.0	77.4	0.158	0.92	54.7
14327400	0.88	1,300	20.50	670	16.80	0.894	4.53	0.00	39.5	53.2	52.9	71.3	0.229	1.17	45.7
14327490	19.20	3,710	8.68	5,180	7.50	0.885	2.67	252.00	21.4	37.5	42.0	70.7	0.154	6.81	49.7
14327500	155.00	4,650	9.98	5,080	7.39	0.826	2.60	220.00	22.0	37.5	42.4	70.6	0.145	6.13	49.8
14328000	311.00	5,510	10.70	4,840	7.66	0.735	2.58	210.00	22.6	37.4	43.0	70.6	0.137	5.07	49.3
14330500	59.50	4,050	9.62	5,230	6.28	0.939	2.55	175.00	22.1	37.6	43.3	73.2	0.107	2.73	44.7
14331000	21.60	3,840	8.68	4,840	6.24	0.695	2.48	165.00	22.6	37.3	43.9	73.3	0.111	2.39	44.5

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14332000	82.20	4,130	9.36	5,110	6.26	0.870	2.53	171.00	22.2	37.6	43.5	73.3	0.108	2.62	44.6
14333000	56.30	4,940	13.30	5,130	6.80	0.783	2.66	223.00	22.2	36.7	43.7	73.0	0.105	2.68	45.5
14333500	44.80	4,890	14.60	5,230	7.01	0.737	2.61	244.00	21.6	36.6	42.8	71.0	0.103	2.96	45.7
14335000	649.00	6,260	10.90	4,620	7.04	0.708	2.52	178.00	23.2	38.2	43.8	72.7	0.126	3.86	47.7
14335080	5.27	2,960	7.75	4,510	5.84	0.825	2.33	130.00	22.7	39.5	44.2	75.6	0.118	1.94	43.7
14335100	32.00	6,570	9.39	4,740	6.09	1.020	2.37	155.00	22.1	39.9	43.1	76.1	0.111	2.17	45.1
14335200	73.90	6,850	8.00	4,170	5.67	0.773	2.25	116.00	23.3	41.1	44.4	77.7	0.116	1.72	45.2
14335500	140.00	7,080	8.58	4,010	5.50	0.741	2.18	103.00	23.7	41.6	45.3	78.6	0.118	1.57	45.4
14337500	247.00	7,940	9.09	3,530	5.29	0.581	2.11	74.00	25.0	42.9	46.6	80.5	0.118	1.20	42.5
14337600	938.00	7,980	10.50	4,250	6.52	0.660	2.39	145.00	23.9	39.8	44.8	75.3	0.123	3.01	45.6
14337800	78.70	3,980	19.40	3,380	8.30	0.445	2.35	64.80	27.9	41.1	48.0	76.0	0.122	1.03	42.3
14337870	14.00	2,970	22.20	3,060	8.55	0.316	2.28	36.90	30.1	44.5	51.3	82.3	0.120	0.92	46.2
14338000	130.00	4,310	20.30	3,120	7.94	0.394	2.27	51.30	28.6	42.7	49.0	78.7	0.120	0.95	42.3
14339000	1,210.00	8,210	11.80	3,890	6.51	0.591	2.31	120.00	25.1	40.8	46.1	76.9	0.121	2.50	43.7
14339200	5.22	1,090	5.62	1,520	4.02	0.276	1.54	10.90	29.6	46.2	52.8	88.3	0.120	0.32	26.7
14339500	17.20	2,660	6.78	5,270	5.78	1.190	2.27	174.00	21.4	37.4	41.9	72.6	0.113	2.31	44.7
14341500	141.00	5,630	10.70	4,320	5.14	0.739	2.05	117.00	23.3	39.3	45.5	76.6	0.115	1.60	38.7
14353000	10.60	4,240	23.40	5,000	5.65	0.589	2.42	85.10	24.3	37.2	47.9	72.0	0.075	1.84	33.4
14353500	8.11	4,580	20.20	5,130	5.52	0.455	2.22	73.20	23.7	37.9	48.1	74.1	0.075	1.77	32.9
14359000	2,050.00	8,370	11.60	3,520	5.54	0.532	2.09	89.40	25.6	41.6	47.4	79.2	0.117	2.04	40.7
14359500	115.00	3,690	18.70	2,740	5.60	0.475	2.19	40.40	32.7	44.4	55.0	83.4	0.098	1.52	34.8
14361300	7.43	2,580	20.20	2,110	5.66	0.316	2.06	17.80	31.3	45.5	52.5	85.6	0.102	1.38	34.7
14361500	2,450.00	8,590	12.70	3,300	5.43	0.506	2.06	78.80	26.6	42.2	48.5	80.1	0.115	2.00	40.2
14361600	56.50	5,400	23.60	4,700	6.09	0.581	2.75	71.60	25.6	36.4	48.8	68.8	0.081	1.49	32.1
14361700	69.50	5,030	24.60	4,190	6.62	0.354	2.83	48.70	30.0	42.0	49.8	73.9	0.087	1.39	32.6

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14362000	224.00	5,660	23.80	4,250	6.07	0.419	2.66	52.00	27.9	39.6	49.5	72.0	0.085	1.38	32.4
14362050	2.83	2,390	28.00	3,310	5.12	0.409	1.98	17.10	28.6	42.1	50.5	78.0	0.098	1.24	33.0
14366000	484.00	6,130	22.40	3,690	5.27	0.431	2.30	41.10	27.6	40.8	49.6	75.1	0.091	1.50	34.1
14368500	8.45	3,600	23.80	3,300	7.69	0.385	2.62	26.60	29.8	44.3	50.4	81.4	0.085	0.91	31.6
14369500	699.00	6,470	21.00	3,280	5.49	0.402	2.29	34.90	28.3	42.1	49.9	77.6	0.095	1.65	35.8
14369800	3.13	1,710	18.30	1,730	9.32	0.290	2.78	28.70	31.6	45.8	50.0	85.9	0.101	1.26	33.6
14370000	31.40	3,290	20.90	2,120	9.80	0.301	2.93	39.00	32.5	45.5	51.1	83.7	0.090	0.93	32.8
14370200	3.32	1,560	19.10	1,590	6.63	0.236	2.22	21.00	31.9	45.6	51.8	86.8	0.100	1.21	33.2
14370600	33.00	3,250	18.70	2,610	6.36	0.541	2.46	65.20	32.3	44.9	53.1	81.4	0.094	1.00	32.3
14371500	22.40	2,860	17.60	3,500	6.96	0.735	2.77	83.50	34.0	44.3	54.9	80.3	0.097	1.62	41.3
14372000	45.80	3,950	18.90	3,150	6.76	0.676	2.70	81.10	33.8	44.5	54.7	80.2	0.100	1.69	41.6
14372300	3,940.00	9,380	15.70	3,050	6.13	0.462	2.26	65.20	28.3	42.9	49.6	80.0	0.108	1.84	38.7
14372500	42.10	4,530	23.40	4,000	11.70	0.431	3.88	75.30	30.6	44.6	50.0	77.2	0.073	3.16	31.2
14375000	76.10	5,270	22.10	4,020	7.42	0.335	3.17	55.30	30.6	44.6	50.2	76.4	0.088	1.33	32.6
14375100	83.90	5,310	22.20	3,970	7.37	0.341	3.11	52.90	30.7	44.8	50.3	76.8	0.088	1.33	32.7
14375400	26.50	3,720	22.40	2,400	12.90	0.418	3.92	52.80	31.4	46.3	50.1	83.4	0.100	1.01	43.1
14375500	42.60	3,780	21.30	2,530	14.30	0.481	4.38	62.20	31.6	46.3	50.1	83.5	0.097	0.88	40.8
14377100	381.00	5,840	17.90	2,890	10.70	0.383	3.55	49.30	31.1	46.0	50.1	82.2	0.093	1.70	37.7
14377500	22.30	3,860	24.90	3,410	7.43	0.387	2.73	35.40	30.6	44.9	50.8	79.3	0.091	1.16	32.4
14377800	1.65	3,220	24.70	2,980	10.40	0.351	3.18	37.70	30.9	45.9	49.4	84.0	0.084	0.66	31.0
14378000	664.00	6,240	19.50	2,760	11.10	0.399	3.59	50.20	31.5	46.1	50.4	82.3	0.093	1.48	36.3
14378200	983.00	6,910	21.50	2,680	12.80	0.467	3.99	53.70	32.7	46.6	50.8	82.2	0.094	1.39	35.2
14378550	0.97	1,030	15.90	2,800	16.10	0.612	4.62	63.20	35.9	48.6	53.0	81.9	0.160	0.87	56.1
14378800	1.28	1,420	13.60	601	13.10	0.530	3.94	0.00	40.8	53.2	52.7	69.7	0.192	2.13	51.5

Appendix G. Selected Characteristics for Gaged Watersheds Used in the Regional Regression Analysis—Continued

[Area, drainage area, in square miles; Relief, maximum difference in elevation, in feet; Slope, mean watershed slope, in degrees; Elev, mean watershed elevation, in feet; Jan P, mean January precipitation, in inches; Jul P, mean July precipitation, in inches; I24-2, 2-year 24-hour precipitation intensity, in inches; Snow, annual snowfall, in inches; Mn Jan T, mean minimum January temperature, in degrees Fahrenheit; Mn Jul T, mean minimum July temperature, in degrees Fahrenheit; Mx Jan T, mean maximum January temperature, in degrees Fahrenheit; Mx Jul T, mean maximum July temperature, in degrees Fahrenheit; Soil C, soilstorage capacity, in inches; Soil P, soil permeability, in inches per hour; Soil D, soil depth, in inches]

Station number	Watershed characteristics														
	Area	Relief	Slope	Elev	Jan P	Jul P	I24-2	Snow	Mn Jan T	Mx Jan T	Mn Jul T	Mx Jul T	Soil C	Soil P	Soil D
14378900	0.90	795	10.70	423	12.40	0.512	3.71	0.00	40.8	53.4	52.3	69.1	0.197	2.50	50.9
14400000	271.00	5,040	23.40	2,200	17.80	0.706	5.34	70.70	35.3	47.8	53.0	79.1	0.121	1.05	42.1

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