REPORT CDOT-2018-23 JANUARY 2023

Peak-, Mean-, and Low-streamflow Regional-Regression Equations for Natural Streamflow in Central and Western Colorado, 2019

APPLIED RESEARCH & INNOVATION BRANCH

Michael S. Kohn

M. Alisa Mast

Tara A. Gross

COLORADO
Department of Transportation

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CDOT-2018-23		

4. Title and Subtitle	5. Report Date
Peak-, Mean-, and Low-streamflow Regional-Regression Equations for Natural Streamflow in Central and Western Colorado, 2019	January 2023
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Michael S. Kohn, M. Alisa Mast, and Tara A. Gross	
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
U.S. Geological Survey Denver Federal Center Box 25046, MS 415 Denver, CO 80225	11. Contract or Grant No. 218.04-200
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Colorado Department of Transportation - Research 2829 W. Howard Pl. Denver CO, 80204	Final
	14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the US Department of Transportation, Federal Highway Administration

16. Abstract

The U.S. Geological Survey (USGS), in cooperation with the Colorado Department of Transportation, developed peak-, mean- and low-streamflow regional-regression equations for estimating various streamflow statistics for natural streamflow in central and western Colorado. At the completion of the streamgage selection process, a total of 418 streamgages, consisting of 15,202 years of record and a mean of approximately 36 years of record per streamgage, were used to develop the peak-streamflow regional-regression equations. No streamgages were used in more than one region. Many streamgages only collect annual-peak streamflow data and do not collect daily streamflow whereas other streamgages are only operated seasonally so daily streamflow is collected only a portion of the year. As a result, 323 of the 418 streamgages were used to develop the mean- and low-streamflow regional regression equations in this study. The estimated annual exceedance-probability discharges for each streamgage were computed using the USGS software program PeakFQ version 7.4. Mean-monthly streamflows and the 7-day minimum and maximum streamflows were computed using the USGS software program SWToolbox version 1.0.5. Streamflow-duration values were computed using an R script. The peak-, mean- and low-streamflow regional-regression equations were determined using data through water year 2019 (October 1, 2018, through September 30, 2019). Based on previous studies conducted in Colorado and neighboring States and on the availability of data, 97 characteristics (55 basin and 42 climatic characteristics) were evaluated as candidate explanatory variables in the regression analysis.

Implementation (Optional)

17. Keywords	18. Distribution Statement
StreamStats Streamflow Floods	This document is available on CDOT's website https://www.codot.gov/programs/research

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	99	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Prepared in cooperation with the Colorado Department of Transportation

Peak-, Mean-, and Low-streamflow Regional-Regression Equations for Natural Streamflow in Central and Western Colorado, 2019

By Michael S. Kohn, M. Alisa Mast, and Tara A. Gross

Acknowledgments

Amy McHugh of the U.S Geological Survey (USGS) offered invaluable technical assistance on the SWToolbox program, which was used to compute the mean-monthly streamflows and the 7-day minimum and maximum streamflows in the study. Samantha Sullivan of the USGS generated an R script to compute streamflow-duration values used in the study. William Farmer of the USGS provided support and technical guidance throughout the study. Matt Hardesty of the Colorado Division of Water Resources provided streamflow data collected by the Colorado Division of Water Resources used in this study.

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	cenitmeter (cm)
inch (in.)	25.4	millimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

Multiply	By	To obtain
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88) or National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Supplemental Information

Water year (WY) is the 12-month period from October 1 through September 30. The water year is designated by the year in which it ends.

Abbreviations

3DEP 3-dimensional elevation data

$adjR^2$ adjusted coefficient of determination

AEP annual exceedance probability

AEPD annual exceedance-probability discharge

CODWR Colorado Division of Water Resources

DAR drainage-area ratio

EMA	expected moments algorithm
GIS	geographic information system
GLS	generalized-least squares
LSRRE	low-streamflow regional-regression equations
Mallow's *Cp*	measure of the total squared error for a subset model containing the number (n) of independent variables
MGB	multiple Grubbs-Beck test
MLSRRE	mean- and low-streamflow regional-regression equations
MSRRE	mean-streamflow regional-regression equations
NWIS	National Water Information System
OLS	ordinary-least squares
PILF	potentially influential low flood
PRESS	predicted residual sum of squares
$pseudoR^2$	pseudo coefficient of determination
PMLSRRE	peak-, mean-, and low-streamflow regional-regression equations
PSRRE	peak-streamflow regional-regression equations
R^2	coefficient of determination
SEP	standard error of prediction
SME	standard model error
USGS	U.S. Geological Survey

VIF variance inflation factor

WLS weighted-least squares

WREG weighted-multiple-linear regression program

Abstract

The U.S. Geological Survey (USGS), in cooperation with the Colorado Department of Transportation, developed peak-, mean- and low-streamflow regional-regression equations for estimating various streamflow statistics for natural streamflow in central and western Colorado. At the completion of the streamgage selection process, a total of 418 streamgages, consisting of 15,202 years of record and a mean of approximately 36 years of record per streamgage, were used to develop the peak-streamflow regional-regression equations. No streamgages were used in more than one region. Many streamgages only collect annual-peak streamflow data and do not collect daily streamflow whereas other streamgages are only operated seasonally so daily streamflow is collected only a portion of the year. As a result, 323 of the 418 streamgages were used to develop the mean- and low-streamflow regional regression equations in this study. The estimated annual exceedance-probability discharges for each streamgage were computed using the USGS software program PeakFQ version 7.4. Mean-monthly streamflows and the 7-day minimum and maximum streamflows were computed using the USGS software program SWToolbox version 1.0.5. Streamflow-duration values were computed using an R script. The peak-, mean- and low-streamflow regional-regression equations were determined using data through water year 2019 (October 1, 2018, through September 30, 2019). Based on previous studies conducted in Colorado and neighboring States and on the availability of data, 97

characteristics (55 basin and 42 climatic characteristics) were evaluated as candidate explanatory variables in the regression analysis.

The peak-streamflow regional-regression equations in the Alpine, Sub-Alpine, Mid-Elevation, and Plateau hydrologic regions were developed using a total of 105, 104, 104, and 105 streamgages, respectively. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the peak-streamflow regional-regression equations were based on the 1-percent annual exceedance-probability discharge for each hydrologic region. The mean-streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 170, 42, 54, and 57 streamgages, respectively. The 7-day minimum streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 156, 40, 44, and 44 streamgages, respectively. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the 7-day minimum streamflow equations were based on the 10-percent annual-recurrence interval 7-day minimum streamflow statistic for each hydrologic region. The streamflow-duration values and regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 170, 42, 54, and 57 streamgages, respectively. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the streamflow-duration equations were based on the 50-percent streamflow-duration statistic for each hydrologic region. The 7-day maximum streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 167, 35, 52, and 52 streamgages, respectively. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the 7-day maximum streamflow equations were based on the 10-percent annual-recurrence interval 7-day maximum streamflow statistic for each hydrologic region.

After analyzing the study area for potential regional subdivisions based on river basin, elevation, latitude and longitude, and previous studies, central and western Colorado was divided into four new hydrologic regions based on mean basin elevation (less than 8,014 feet, less than 9,492 feet and greater than 8,014 feet, less than 10,490 feet and greater than 9,492 feet, and greater than 10,490 feet) for the peak-streamflow regional-regression equations. The study area was divided into four hydrologic regions based on river basin (Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores) for the mean-streamflow regional-regression equations, which resulted in the smallest standard model error and standard error of prediction and largest pseudo coefficient of determination.

Introduction

The U.S. Geological Survey (USGS), in cooperation with the Colorado Department of Transportation, developed peak-, mean-, and low-streamflow regional-regression equations (PMLSRREs) for estimating various statistics for natural streamflow in central and western Colorado. Reliable peak-streamflow information is critical for the proper design of stream-related infrastructure, such as bridges and dams, and flood-plain inundation maps (Kohn and others, 2016). At gaged sites, where sufficient long-term streamflow data have been collected, statistics can be obtained from available publications, by an analysis of available data in the USGS National Water Information System (NWIS) database (https://doi.org/10.5066/F7P55KJN), or other sources of flood information. However, streamflow estimates also are needed at ungaged sites where no site-specific streamflow data are available. The use of PMLSRREs with expressions of predictive uncertainty generally represents a reliable and cost-effective means for estimating peak, mean, and low streamflow at ungaged sites. PMLSRREs are a common tool used to estimate streamflow statistics at ungaged sites across the Nation (Farmer and others, 2019). The PMLSRREs are based on statistical relations between (1) peak streamflow from systematic, historic peak streamflow, censored, and paleoflood data at streamgages or mean or low streamflow from systematic data at streamgages and (2) basin and climatic characteristics, for which data are typically readily available using a geographic information system (GIS).

Purpose and Scope

The purpose of this report is to present an updated set of regional-regression equations for estimating annual exceedance-probability discharges (AEPD; also known as peak streamflow), mean, and low streamflows for use in central and western Colorado. As a result, new hydrologic regions for peak streamflow and mean and low streamflow are designated for this report. For this report, mean streamflow corresponds to mean-monthly and mean-annual streamflow, whereas low streamflow corresponds to flow-duration values and 7-day minimum and maximum streamflow. The PMLSRRE relate peak, mean, and low streamflows to drainage basin size, topography, hydrology, and climatology. This report presents four sets of peak-streamflow regional-regression equations to estimate 8 AEPD statistics that have probabilities of 50, 20, 10, 4, 2, 1, 0.5, and 0.2 percent, which are equivalent to annual flood-frequency recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years, respectively. Hereafter, in this report, these statistics are denoted as $Q_{50\%}$, $Q_{20\%}$, $Q_{10\%}$, $\mathrm{Q}_{4\%}$, $Q_{2\%}$, $Q_{1\%}$, $Q_{0.5\%}$, and $Q_{0.2\%}$, respectively. This report presents mean-streamflow regional-regression equations to estimate mean-annual streamflow

(Q_{ann}) and mean-monthly streamflow. Hereafter, in this report, these monthly statistics are denoted for each month in the water year as Q_{oct}, Q_{nov}, Q_{dec}, Q_{jan}, Q_{feb}, Q_{mar}, Q_{apr}, Q_{may}, Q_{jun}, Q_{jul}, Q_{aug}, and $Q_{sep.}$ This report also presents the 10-, 25-, 50-, 75-, and 90-percent exceedance probabilities for mean-daily streamflow; hereafter, these statistics are denoted as Q_{10th}, Q_{25th}, Q_{50th}, Q_{75th}, and Q_{90th}, respectively. This report presents four sets of low-streamflow regional-regression equations to estimate three different 7-day minimum streamflow statistics that have probabilities of 50, 10, and 2 percent, which are equivalent to annual-recurrence intervals of 2, 10, and 50 years, respectively. Hereafter, in this report, these statistics are denoted as Q_{50}^{min}, Q_{10}^{min}, and Q_{2}^{min}, respectively. This report also presents four sets of regional-regression equations to estimate three different 7-day maximum streamflow statistics that have probabilities of 50, 10, and 2 percent, which are equivalent to annual-recurrence intervals of 2, 10, and 50 years, respectively. Hereafter, in this report, these statistics are denoted as Q_{50}^{max} , Q_{10}^{max}, and Q_{2}^{max}, respectively. The procedure to develop the peak- and 7-day maximum streamflow regional-regression equations included generalized-least squares (GLS) multilinear regression using base-10 logarithmic transformations of streamflow and drainage area. The procedure to develop the mean streamflows, 7-day minimum streamflows, and streamflow-duration regional-regression equations included ordinary-least squares (OLS) multilinear regression based on base-10 logarithmic transformations of streamflow and drainage area.

Annual-peak streamflow data from streamgages with a record of at least 10 years were compiled from the USGS NWIS database (USGS, 2020a) and the Colorado Division of Water Resources (CODWR) (CODWR, 2020) through water year 2019. Daily mean streamflow data from streamgages with a record of at least 10 years were compiled from the USGS NWIS database (USGS, 2020b) and the CODWR (CODWR, 2020) through water year 2019. A water year is the 12-month period from October 1 through September 30 designated by the calendar year in which it ends.

The limitations and accuracy of the PMLSRREs are presented in this report. The study area was extended 50 miles outside Colorado for PMLSRRE development because hydrology is not affected by State boundaries; however, the PMLSRREs are only applicable in Colorado. Also, the PMLSRREs presented in this report are only applicable to natural streamflow with drainage areas between 0.22 and 22,600 square miles (mi^2). To clarify, the PMLSRREs are based on analysis of peak-, mean-, and low-streamflow data for streams relatively unaffected by anthropogenic activities such as storage, regulation, and diversion or return streamflows from a municipality or mining operation, or urban development in a basin. Kircher and others (1985) provide the most quantitative description of natural streamflow as streamflow from drainage basins relatively unaffected by urban development or water-management activities such as substantial reservoir storage, streamflow diversions, or return streamflows of previously diverted streamflow. Further, those authors defined natural streamflow as streamflow having less than about 10 percent of the mean-annual streamflow volume at the streamgage affected by anthropogenic activity. The definition by Kircher and others (1985) was used in Capesius and Stephens (2009), Kohn and others (2016), and this report.

Description of the Study Area

Colorado has a diverse landscape and climate and includes the headwaters of the major river basins of the Colorado, Green River, North Platte, San Juan, South Platte, and Arkansas Rivers and the Rio Grande. The physiographic and hydrologic differences are discussed below.

Colorado can be described by three major physiographic provinces, which trend north to south across the State (Fenneman, 1931). The Great Plains Province, in the eastern 40 percent of the State, consists mostly of grasslands with scattered hills, bluffs, shallow river valleys, and some cultivated areas. The Southern Rocky Mountains, west of the Great Plains, includes most of central Colorado from north to south and is characterized by mountain ranges and intermountain valleys. The Colorado Plateau Province is in western Colorado between the Utah State line to the west and the Rocky Mountains to the east. The landscape is distinguished by mesas, plateaus, and eroded canyon terrain that includes much of the western quarter of Colorado from north to south. More detailed descriptions of the major physiographic provinces can be found in Fenneman (1931) and Capesius and Stephens (2009).

Hydrologic regions of Colorado (fig. 1) were defined based on the physiographic and climatic characteristics that were used to develop best-fit PMLSRREs for previous studies (McCain and Jarrett, 1976; Kircher and others, 1985; Vaill, 2000; Capesius and Stephens, 2009; Kohn and others, 2016). For this report, a hydrologic region is qualitatively defined as a region of similar hydrology and climatology. The study area is identified as that region of central and western Colorado located between the Colorado-Wyoming State line and the Colorado-New Mexico State line. The study area includes areas in elevation from about 5,000 feet near the Colorado-Utah State line to more than 14,000 feet in the eastern parts of the study area on the east side of the Sangre de Cristo Mountains and Colorado Front Range. The study area encompasses the headwaters of most major river basins in Colorado where the annual-peak streamflow generally is produced by snowmelt runoff. Within Colorado, the study area is defined on the east side by the 7,500-foot (ft) contour from the Wyoming State line to the Chaffee-Fremont County line, then it follows the Chaffee-Fremont County line across the Arkansas River and transitions up to the 9,000-ft contour, which is followed south to the New Mexico State line (Kohn and others 2016). The north, west, and south extents of the study area are defined by the Wyoming, Utah, and New Mexico State lines. The Foothills and Plains hydrologic regions in Colorado as defined by Kohn and others (2016) was outside the scope of this report. For PMLSRREs development, data from streamgages within 50 miles of Colorado were which includes parts of Arizona, New Mexico, Utah, and Wyoming along with the entire Mountain, Northwest, Rio Grande, and Southwest hydrologic regions in Colorado as defined in Capesius and Stephens (2009); however, the PMLSRREs are only applicable in Colorado.

Previous Studies and Background Information

Previous studies computed peak-streamflow regional regression equations (PSRREs) in Colorado—Patterson (1964, 1965), Patterson and Somers (1966), Matthai (1968), Hedman and others (1972), McCain and Jarrett (1976), Kircher and others (1985), Livingston and Minges (1987), Vaill (2000), Capesius and Stephens (2009), and Kohn and others (2016). Fewer studies have developed mean-streamflow regional regression equations (MSRREs) and low-streamflow regional-regression equations (LSRREs), as was done by Kircher and others (1985) and Capesius and Stephens (2009). Hydrologic regions in Colorado were originally defined by McCain and Jarrett (1976) and were incorporated as the regional framework in Kircher and others (1985) and Capesius and Stephens (2009). Kircher and others (1985) developed regional-regression equations for mean-monthly streamflow in central and western Colorado for data collected

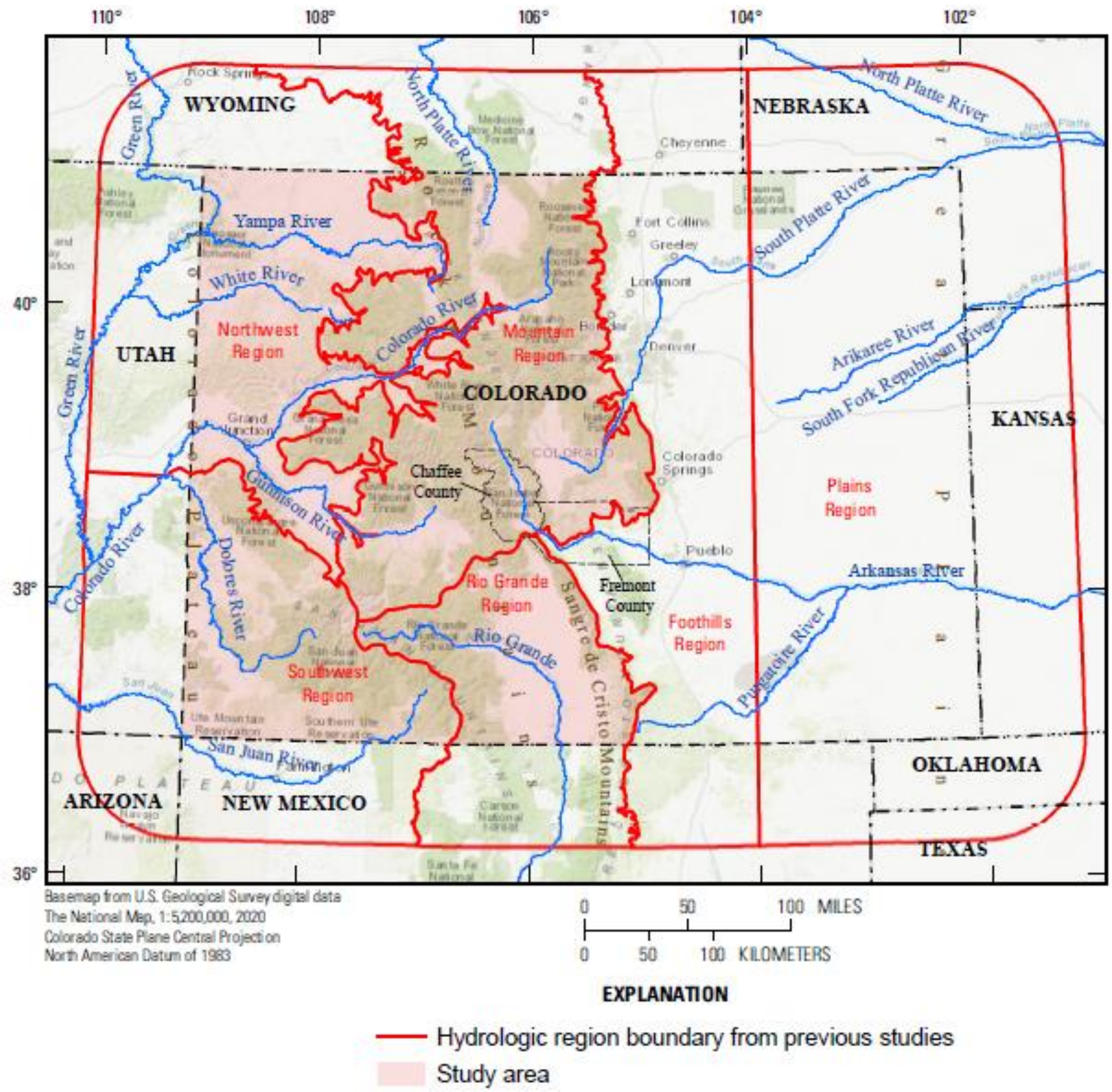

Figure 1. Boundaries of the hydrologic regions from previous flood-frequency studies in Colorado (modified from Kohn and others, 2016 and Capesius and Stephens, 2009).

through 1983. Capesius and Stephens (2009) published Statewide PMLSRRE (except for the Plains hydrologic region where only PSRREs were published) using USGS streamflow data from the beginning of the period of record at each streamgage through water years 2006 for peak streamflow and 2007 for mean and low streamflow. Kohn and others (2015) evaluated the predictive uncertainty of the MSRREs developed by Capesius and Stephens (2009). Kohn and others (2016) published PSRREs for the Foothills and Plains hydrologic regions in Colorado using USGS streamflow data from the beginning of the period of record at each streamgage through water year 2013 and used paleoflood data at 41 streamgages to improve the uncertainty of the PSRREs.

Methods for Data Development for Streamgages

The development of PMLSRREs in central and western Colorado consists of five steps:

1. Selection of unique streamgages with natural streamflow conditions with a minimum of 10 years of record for inclusion in multilinear regression analysis,
2. Flood-frequency analysis to compute AEPDs for all streamgages using systematic, historic peak streamflow, censored, and paleoflood data if available,
3. Mean- and low-streamflow analysis to compute streamflow statistics for all streamgages using daily mean streamflow,
4. Determination of basin and climate characteristics for all the streamgages, and
5. Regionalization and development of the PMLSRREs for central and western Colorado.

These steps are further described in the sections that follow.

Streamgage Selection

The selection of streamgages used for this report was based on streamgages selected by Kircher and others (1985), Vaill (2000), Capesius and Stephens (2009), Kohn and others (2015), Kohn and others (2016), and the authors' knowledge of hydrologic systems in Colorado. A comprehensive list of all CODWR streamgages in the Mountain, Northwest, Rio Grande, Southwest hydrologic regions, as defined by Capesius and Stephens (2009), was compiled from the CODWR historical peak database (CODWR, 2020). A comprehensive list of all USGS streamgages in the study area and within 50 miles of the Colorado State line adjacent to those same hydrologic regions was compiled from the USGS NWIS database (USGS, 2020a). From the comprehensive list of candidate streamgages, those streamgages with at least 10 years of combined streamflow record through water year 2019, identified as representative of natural streamflow, were selected for this study. Following Kircher and others (1985), natural streamflow was defined as streamflow having less than about 10 percent of the mean-annual streamflow volume at the streamgage affected by anthropogenic activity.

Streamgages that were adjacent to one another and located in the same stream network were evaluated for data independence using the drainage-area ratio (DAR) and the proximity of the basin centroids, which was measured by standardized distance. Standardized distance is a measure of the normalized, or unitless distance, between the centroids of two basins, and DAR is used to determine if the size of two basins, when one basin is contained in the other, is sufficiently different such that precipitation events generating the annual-maximum floods in each basin are likely to be different (Veilleux, 2009). Additional information on DAR and basin centroid proximity is found in Asquith and others (2006) and Veilleux (2009). If the DAR was less than or equal to 5.0 and the standardized distance was less than or equal to 0.5, the streamgages were determined to be redundant (Veilleux, 2009; Gotvald and others, 2012; Eash and others, 2013; Southard and Veilleux, 2014, Kohn and others 2016). In such cases, the streamgage with the longer record was selected, and the other was removed. Excluding redundant streamgages based on relative DAR and basin centroid location ensures the independence of the streamflow information among streamgages. This exclusion process served the purpose of removing redundant data or hydrologic information from the analysis. At the completion of the streamgage selection process, a total of 418 streamgages, consisting of 15,202 years of record and a mean of approximately 36 years of record per streamgage, were used to develop the PSRREs. Many streamgages only collect annual-peak streamflow data and do not collect daily streamflow whereas other streamgages are only operated seasonally, so daily streamflow is collected only a part of the year. As a result, only 323 of the 418 streamgages could be used to develop the mean- and low-streamflow regional regression equations (MLSRREs). Of those 418 streamgages, 379 streamgages were operated by USGS, 13 streamgages were operated by CODWR, and 26 streamgages have been operated by both USGS and CODWR over the period of record. A map showing the location of the streamgages is in figure 2, each of the 418 streamgages and ancillary information are listed in appendix table 1.1, and each of the 418 streamgages, ancillary information, and basin and climatic characteristics are available in Kohn and others (2023). The "home page" of each USGS streamgage, which provides authoritative streamgage names and other identifying characteristics, can be accessed online at *https://waterdata.usgs.gov/nwis/nwisman/?site_no=STREAMGAGE&agency_cd=USGS*, where the word *STREAMGAGE* is replaced by the eight-digit or sixteen-digit USGS streamgage number from table 1.1.

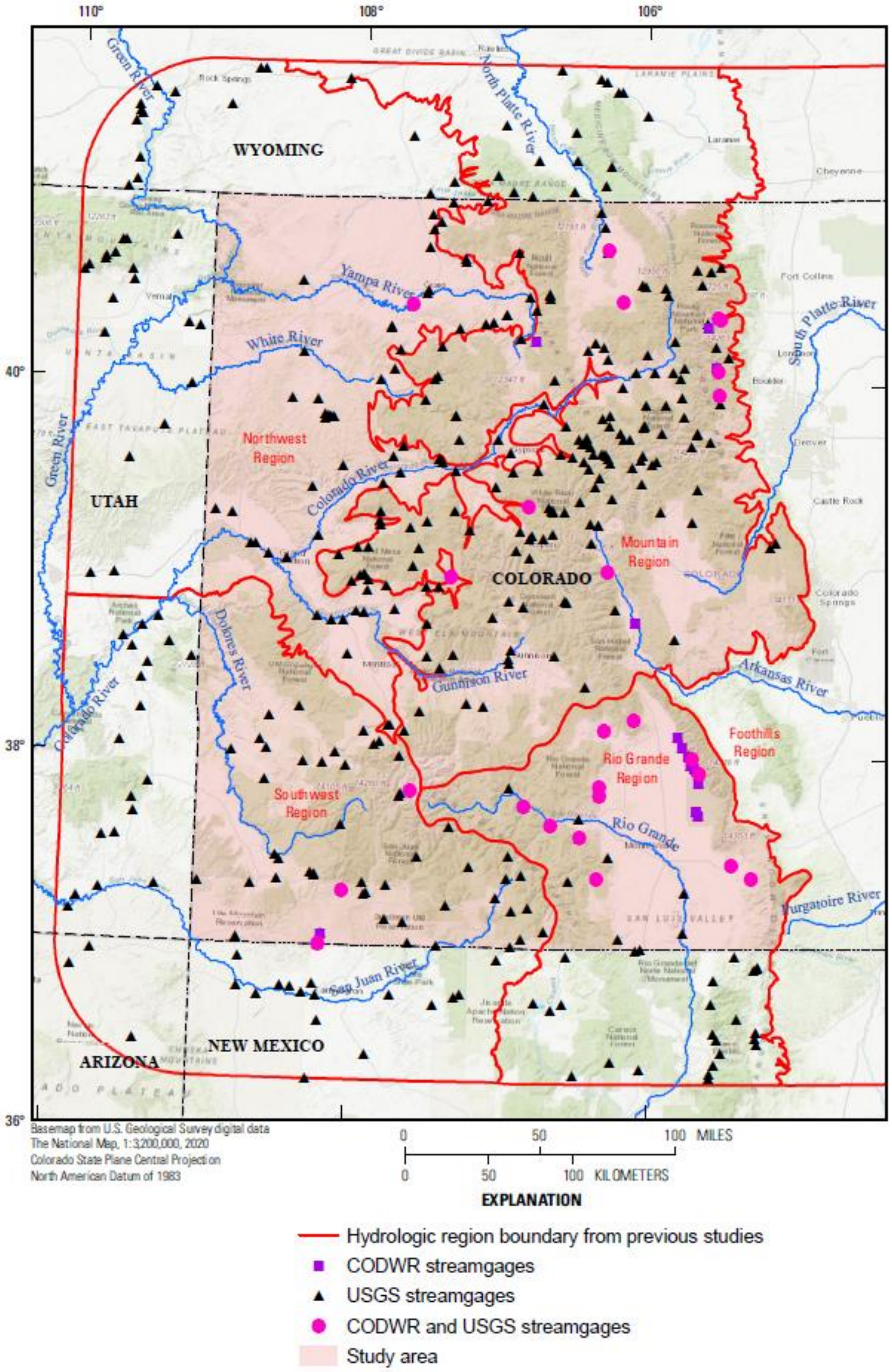

Figure 2. Location of the 418 U.S Geological Survey (USGS) and Colorado Division of Water Resources (CODWR) streamgages used to develop the peak-, mean-, and low-streamflow regional-regression

equations and the boundaries of the hydrologic regions from the previous flood-frequency studies in Colorado (modified from Kohn and others, 2016 and Capesius and Stephens, 2009).

Peak-Streamflow Analysis

The annual series of peak-streamflow data at 418 continuous-record, seasonal, and crest-stage streamgages were used to estimate AEPDs, such as the 100-year flood. The AEPDs from streamgage data provide the basis for developing PSRREs. The estimated AEPDs for each streamgage were computed using the USGS software program PeakFQ version 7.4 (Veilleux and others, 2014) for annual-peak streamflows. The AEPDs were determined using systematic data through water year 2019 (October 1, 2018, through September 30, 2019). The PSRREs in this report express flood-frequency estimates in terms of annual exceedance probabilities (AEP), which are the reciprocals of the recurrence intervals. AEP can also be represented in percent, and a particular flood-frequency estimate is then termed the "*P*-percent chance streamflow," where *P* is the probability, in percent, that the streamflow will be equaled or exceeded in any year. For example, a 10-year flood is the same as having a 0.10 AEP; this streamflow also is described as a 10-percent flood or $Q_{10\%}$ (Southard and Veilleux, 2014).

For this report, the log-Pearson Type III frequency distribution was fit to the logarithms of the annual-peak streamflows to determine flood-frequency estimates following the guidelines established by the Interagency Advisory Committee on Water Data (1982), hereinafter referred to as Bulletin 17B, and by England and others (2019), hereinafter referred to as Bulletin 17C. The mean, standard deviation, and streamgage skew coefficients at each streamgage were used to fit the distribution to describe the mid-point, slope, and curvature of the flood-frequency curve, respectively (Gotvald and others, 2012). Estimates of the *P*-percent AEPDs for each streamgage are computed by inserting the three statistics of the frequency distribution into the equation:

$$\log Q_p = \bar{X} + K_p S \tag{1}$$

where:

Q_p is the *P*-percent annual exceedance-probability discharge, in cubic feet per second (ft^3/s);

$\bar{X}$ is the mean of the base 10 logarithms of the annual-peak streamflows;

K_p is a factor based on the streamgage skew coefficient and the given percent AEP and is obtained from Appendix 3 in Bulletin 17B; and

S is the standard deviation of the logarithms of the annual-peak streamflows, which is a measure of the degree of variation of the annual-peak streamflows about the mean value.

The streamgage skew coefficient is a measure of the asymmetry of the frequency distribution and is greatly affected by the presence of high or low outliers (annual-peak streamflows that are substantially higher or lower than the trend of the data). Large positive streamgage skews typically are the result of high outliers, and large negative streamgage skews typically are the result of low outliers (Southard and Veilleux, 2014).

Skew Analysis

The streamgage skew coefficient for a streamgage is sensitive to outliers. Therefore, the streamgage skew coefficient for streamgages with short records (less than 30 years), common in Colorado, may not provide an accurate estimate of the data or true streamgage skew coefficient (Gotvald and others, 2009; Feaster and others, 2009; Weaver and others, 2009). Bulletin 17B and Bulletin 17C guidelines fit a Pearson Type III distribution to the product moments (mean, standard deviation, and streamgage skew) of the logarithms of annual-peak streamflow. To compensate for effects of short record at a streamgage, streamgage skew is combined with a generalized value that is derived from a regional skew map, which is included in Bulletin 17B. The weighted skew used in the analysis for this report was determined by weighting the streamgage skew and the regional skew and is inversely proportional to their respective mean square errors, as shown in equation 5 of Bulletin 17B:

$$G_w = \left[MSE_{G_R}(G_s) + MSE_{G_S}(G_R)\right] / \left(MSE_{G_R} + MSE_{G_S}\right) \quad (2)$$

where:

G_w is the weighted skew,

G_s is the streamgage skew,

G_R is the regional skew, and

MSE_{G_R} and MSE_{G_S} are the mean square errors of the regional and streamgage skews, respectively.

The regional skew values used in this report are from the national regional skew map (plate I, Bulletin 17B) based on streamgage data through water year 1973, which is the most current regional skew map in Colorado at this time (2022). Additional information on skew can be found in Bulletin 17B, Eash and others (2013), and Bulletin 17C.

Expected Moments Algorithm

In this study, the Expected Moments Algorithm (EMA) with the multiple Grubbs-Beck (MGB) test method (Grubbs and Beck, 1972) was used to compute Log-Pearson Type III exceedance-probability estimates for all 418 streamgages evaluated to develop PSRREs for central and western Colorado. The USGS software program PeakFQ version 7.4 (Veilleux and others, 2014) automates the EMA/MGB procedure described in this section of the report.

As described in Bulletin 17C, the EMA retains the essential structure and moments-based approach of the existing Bulletin 17B procedures to determine flood frequency but, addresses several concerns about the methods used in Bulletin 17B. The EMA can accommodate interval data, simplifying the analysis of datasets containing censored observations, historic peak streamflow data, low outliers, and data points with high and low uncertainties common in paleofloods, while also providing enhanced confidence intervals for the AEPDs. Unlike Bulletin 17B, which recognizes only two types of data: (1) systematic (annual-peak streamflows observed during systematic streamgage record) and (2) historic peak streamflow (annual-peak streamflows observed outside the streamgage record), Bulletin 17C recommends using the EMA which employs a more general description of the historical period (the length of time that includes both systematic and historic peak streamflow). This is accomplished through streamflow intervals to describe the peak streamflow in each year and perception thresholds to describe the range of measurable potential streamflows in each year. Additional information on the EMA can be found in Eash and others (2013), Southard and Veilleux (2014), and in Bulletin 17C.

Multiple Grubbs-Beck Test for Detecting Potentially Influential Low Floods

Bulletin 17B and Bulletin 17C recommend the use of the Grubbs-Beck test (Grubbs and Beck, 1972) to statistically identify low outliers in a sample of flood data. The MGB test is a generalization of the Grubbs-Beck method that creates the standard procedure for recognizing multiple Potentially Influential Low Floods (PILFs) (Cohn and others, 2013). In flood-frequency analysis, PILFs are annual-peak streamflows that meet three criteria: (1) their magnitude is much smaller than the flood quantile of interest; (2) PILFs occur below a statistically significant break in the flood-frequency plot; and (3) PILFs have great significance or leverage on the estimated frequency of large floods (Southard and Veilleux, 2014). The MGB test screens for PILFs at each streamgage and excludes them from the flood-frequency analysis. When an observation is identified as a PILF, the value of the smallest observation in the dataset determined to not be a PILF (Q_s) is used as the censoring threshold in the EMA analysis (Southard and Veilleux, 2014). All annual-peak streamflows smaller than this value will be treated as censored observations with streamflow intervals equal to (0, Q_s) and perception thresholds equal to (Q_s, *inf*) (Southard and Veilleux, 2014). Identifying PILFs and recording them as censored peaks can greatly improve estimator robustness with little or no loss of efficiency (Southard and Veilleux, 2014). Thus, the use of the MGB test can improve the fit of the AEPDs, while minimizing lack-of-fit because of unimportant PILFs in an annual-peak streamflow series (Cohn and others, 2013; Veilleux and others, 2014).

It is important to distinguish between low outliers and PILFs. The term low outlier typically refers to one or possibly two values in a dataset that are assumed to be homogenous and that do not conform to the trend of the other observations (Southard and Veilleux, 2014). In contrast, PILFs may constitute up to one-half of the observations and are assumed to result from physical processes that are not relevant to the processes associated with large floods. Consequently, the actual magnitudes of PILFs, because PILFs reflect physical processes that are not relevant to large floods, reveal little about the upper right-hand tail of the frequency distribution representing large floods, and thus, likely do not have an effect when estimating the risk of large floods (Southard and Veilleux, 2014). The term “low outlier” has been replaced with the term “PILF” to describe the situation more accurately in Bulletin 17C. Additional information on the MGB test and PILFs can be found in Gotvald and others (2012), Eash and others (2013), and Southard and Veilleux (2014).

The USGS software program PeakFQ version 7.4 (Veilleux and others, 2014) was used to compute the flood-frequency estimates for streamgages presented in this report for AEPs of 0.50, 0.20, 0.10, 0.04, 0.02, 0.01, 0.005, and 0.002 (return periods of 2-, 5-, 10-, 2-, 50-, 100-, 200-, and 500-years, respectively). PeakFQ automates the EMA/MGB procedure described in this section of the report. The AEPDs from all 418 streamgages used to develop the PSRREs and all output and input files used and generated by PeakFQ for all 418 streamgages including the specifications file are available in Kohn and others (2023).

Mean-Streamflow Analysis

Mean-annual streamflow data at the 418 streamgages were computed from daily mean streamflow data in the USGS NWIS database (USGS, 2020b) and in the CODWR database (CODWR, 2020) through water year 2019. Mean-annual streamflows were computed as the arithmetic mean of each mean-annual streamflow, which were computed as the arithmetic mean of the daily mean streamflow in each water year, in the period of record that was representative of natural-streamflow conditions. Streamgages that did not have a minimum of 10 years of mean-annual streamflow were excluded from the mean-annual streamflow computations. Streamgages that were operated seasonally were also omitted from this computation so as not to bias the statistics. As a result, mean-annual streamflows greater than zero were computed at 323 streamgages.

Mean-monthly streamflow data at the 418 streamgages were computed from daily mean streamflow data in the USGS NWIS database (USGS, 2020b) and in the CODWR database (CODWR, 2020) through water year 2019. Mean-monthly streamflows were computed as the arithmetic mean of each daily mean streamflow, in each month of the period of record representative of natural-streamflow conditions, by the USGS software program SWToolbox version 1.0.5 (Kiang and others, 2018). Streamgages that did not have a minimum of 10 years of daily mean streamflow in a month were excluded from the mean-annual streamflow computations for that month. As a result, mean-monthly streamflows were computed at streamgages ranging from a total of 325 for December to 347 for August with only three of those streamgages having mean-monthly streamflows of zero for four to seven months of the year. The mean-monthly streamflow data used and generated by SWToolbox for all streamgages are available in Kohn and others (2023).

Low-Streamflow Analysis

Daily mean streamflow data at the 418 streamgages were compiled from the USGS NWIS database (USGS, 2020b) and the CODWR database (CODWR, 2020) through water year 2019 to compute the 7-day minimum and maximum streamflows for return periods of 2-, 10, and 50-year (AEP of 0.50, 0.10, and 0.02). The USGS software program SWToolbox version 1.05

(Kiang and others, 2018) was used to compute the 7-day minimum and maximum streamflows from the daily mean streamflow data. SWToolbox assumes that the log-Pearson Type III distribution is suitable for low- and high-flow frequency analysis in Colorado. Daily mean streamflow data were computed as the arithmetic mean of the 15-minute streamflow recordings at a streamgage for each day in the entire period of record that is representative of natural-streamflow conditions. SWToolbox computed the 7-day streamflows by determining the product moments of mean, standard deviation, and streamgage skew of the logarithms of the streamflow values in a sliding window from April through March for minimum streamflows and from October through September for maximum streamflows. Finally, a log-Pearson Type III distribution is fit to the product moments, and the quantiles for the 2-year, 10-year, and 50-year recurrence intervals are extracted. Streamgages that did not have 10 years of non-zero daily mean streamflow, in a month, were excluded from the 7-day minimum and maximum streamflow computations. Streamgages that were operated seasonally were omitted from this computation so as not to bias the statistics. As a result, the 7-day minimum and maximum streamflows were computed at streamgages ranging from a total of 284 for the 7-day minimum streamflows to 319 for the 7-day maximum streamflows with between four and 44 streamgages having 7-day minimum streamflows of zero depending on the return period and with four streamgages having 7-day maximum streamflows of zero for all return periods. The 7-day minimum and maximum streamflow data used and generated by SWToolbox for all streamgages are available in Kohn and others (2023).

The streamflow-duration values were computed by ranking the daily mean streamflow data for the period of record representative of natural-streamflow conditions and linearly interpolating to the five exceedance percentiles of interest (10, 25, 50, 75, and 90) using an R script (R Core Team, 2019). As a result, the streamflow-duration values were computed at 323 of the 418 streamgages compiled for the study. At those 323 streamgages, the streamflow-duration values were zero at two to 27 streamgages depending on the exceedance probability, with two streamgages having streamflow-duration values of zero for all return periods. The streamflow-duration values used and generated by the R script (R Core Team, 2019) for all streamgages are available in Kohn and others (2023).

Basin and Climate Characteristics

Based on previous studies conducted in Colorado and neighboring States (Kircher and others, 1985; Soenksen and others, 1999; Vaill, 2000; Rasmussen and Perry, 2000; Miller, 2003; Waltemeyer, 2008; Capesius and Stephens, 2009; Lewis, 2010; and Kohn and others 2016) and on the availability of data, 97 characteristics (55 basin and 42 climatic characteristics) were evaluated as candidate explanatory variables in the regression analysis (table 1.2). The 97 characteristics consist of physical properties of the basin, precipitation amount, snowpack data, temperature, land cover, surficial lithology, and soil characteristics.

ESRI ArcMap 10.6.1 (ESRI, 2017) analyses were performed to determine basin and climate characteristics that could be used in the PSRREs at each of the 418 streamgages using various ESRI ArcMap 10.6.1 techniques, tools, and algorithms. The 1/3 arc-second 3-dimensional elevation data (3DEP; USGS, 2017) were processed through the ArcMap Spatial Analyst tool as well as through the StreamStats online application (USGS, 2022) to delineate basins for the 418 streamgages found in this report. Additionally, 3DEP data (USGS, 2017) were analyzed to produce the characteristics of outlet elevation; basin elevation minimum and maximum values; the mean, minimum, and maximum slope values; and the percentage of basin at an elevation above 7,500 feet, listed in table 1.2. The basin perimeter, drainage area, and centroid latitude and longitude characteristic calculations were performed on basin and pour point geometry using the ArcMap Geometry Calculator tool. The percentage of basin with slopes greater than 30 degrees characteristic was computed using StreamStats. The mean precipitation, precipitation amount, frequency, mean air temperature, soil, surficial lithology, snow data, and land cover data were processed with basin outlines using the National Water Quality Assessment Area-Characterization Toolset (Price, 2010) to produce the elevation-related characteristics for each basin in table 1.2.

Regional-Regression Analyses

Multilinear regression was used to define statistical relations between peak, mean, and low streamflow for 13 of the 97 basin and climatic characteristics from table 1.2. Detailed description of the principles of regional regression is available in Farmer and others (2019), Helsel and others (2020), or Montgomery and others (2001). The statistical tests to evaluate model performance are described in Tasker and Stedinger (1989), Eng and others (2009), and Eash and others (2013).

Definition of Peak-, Mean-, and Low-Streamflow Regions

McCain and Jarrett (1976) originally defined five unique hydrologic regions in Colorado based on physiographic and climatic characteristics and peak streamflow. These same five hydrologic regions have been used for all Colorado peak-, mean-, and low-streamflow studies with minor modifications (Kircher and others, 1985; Vaill, 2000; Capesius and Stephens, 2009) until Kohn and others (2016) subdivided the Plains hydrologic region into two unique hydrologic regions: the Plains and the Foothills hydrologic regions; which resulted in a total of six unique hydrologic regions in Colorado. The scope of this report was to update the PMLSRREs in central and western Colorado, which is defined as the Mountain, Northwest, Rio Grande, and Southwest hydrologic regions in Capesius and Stephens (2009). The study area was extended 50 miles into adjacent States to include more streamgages and improve statistical robustness for development of PMLSRREs.

After analyzing the study area for potential regional subdivisions based on river basin, elevation, latitude and longitude, and previous studies (Kircher and others, 1985; Vaill, 2000; Capesius and Stephens, 2009), central and western Colorado was divided into four new hydrologic regions based on mean basin elevation in feet above North American Vertical Datum of 1988 (less than 8,014 feet, less than 9,492 feet and greater than 8,014 feet, less than 10,490 feet and greater than 9,492 feet, and greater than 10,490 feet) for the PSRREs and based on river basin (Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores) for the MLSRREs, which resulted in the smallest standard model error (*SME*, in percent) and standard error of prediction (*SEP*, in percent) and largest pseudo coefficient of determination ($pseudoR^2$, dimensionless). The new hydrologic regions for the PSRREs will be designated as 1) Alpine (mean basin elevation greater than 10,490 feet), 2) Sub-Alpine (mean basin elevation less than 10,490 feet and greater than 9,492 feet), 3) Mid-Elevation (mean basin elevation less than 9,492 feet and greater than 8,014 feet), and 4) Plateau (mean basin elevation less than 8,014 feet) hydrologic regions (fig. 3). Figure 3 includes each streamgage used in the development of the PSRREs color coded by hydrologic region; the hydrologic regions are based on mean basin elevation so geographic region boundaries cannot be drawn. The distribution of the streamgage by color in figure 3 provide spatial context since each hydrologic region was comprised of 104 or 105 streamgages and figure 3 includes the previous hydrologic region boundaries from Capesius and Stephens (2009). The new hydrologic regions for the MLSRREs will be designated as 1) Colorado-East Slope Headwaters, 2) Green River, 3) Rio Grande, and 4) San Juan-Dolores hydrologic regions (fig. 4). Figure 4 includes each streamgage used in the development of the MLSRREs color coded by hydrologic region; the new hydrologic regions based on major river basin are also included. Figure 4 provide spatial context of the study are by color coding each streamgage; the Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores hydrologic regions were comprised of 170, 57, 42, and 54 streamgages, respectively. The eastern edge of the study area was established by Vaill (2000), and this report follows that boundary and this is described in the "Description of the Study Area" section." The hydrologic regions outside the study area in eastern Colorado remain unchanged and designated as the Foothills and Plains hydrologic regions as defined by Kohn and others (2016).

The subdivision of central and western Colorado into four hydrologic regions, for both PSRREs and MLSRREs, was determined by maximizing the coefficient of determination (R^2, dimensionless) and the adjusted coefficient of determination ($adjR^2$, dimensionless) and minimizing the standard error (Mallow's C_p), and the predicted residual sum of squares (PRESS) statistic through OLS regression procedures. Using GLS regression procedures, it was confirmed that the new regions reduced the uncertainty in the PSRREs as compared to the not-subdivided region used in previous studies (Kircher and others, 1985; Vaill, 2000; Capesius and Stephens, 2009). Prior to finalizing the new regions, maps of streamgage residuals were created and various other subdivisions were analyzed based on latitude, longitude, basin outlet elevation, mean basin elevation, maximum basin elevation, drainage area, and basin area.

Development of the Peak-Streamflow Regional-Regression Equations

The PSRREs were developed for use in estimating peak streamflow for selected AEPs, from 50 to 0.2 percent, at gaged and ungaged locations for basins in the Alpine, Sub-Alpine, Mid-Elevation, and Plateau hydrologic regions of central and western Colorado. Regression analyses using OLS were performed to select the basin and climate characteristics for use as independent variables. A linear relation between the dependent and independent variables are needed for OLS regression. To satisfy this criterion, variables often are transformed, and in hydrologic analyses, typically the log-transformation is used (Southard and Veilleux, 2014; Farmer and others, 2019). The dependent response variable is the AEPDs, and the independent explanatory variables are the basin and climate characteristics that describe the AEPDs. For the current (2022) study, the dependent variable AEPDs were transformed to base 10 logarithms, but

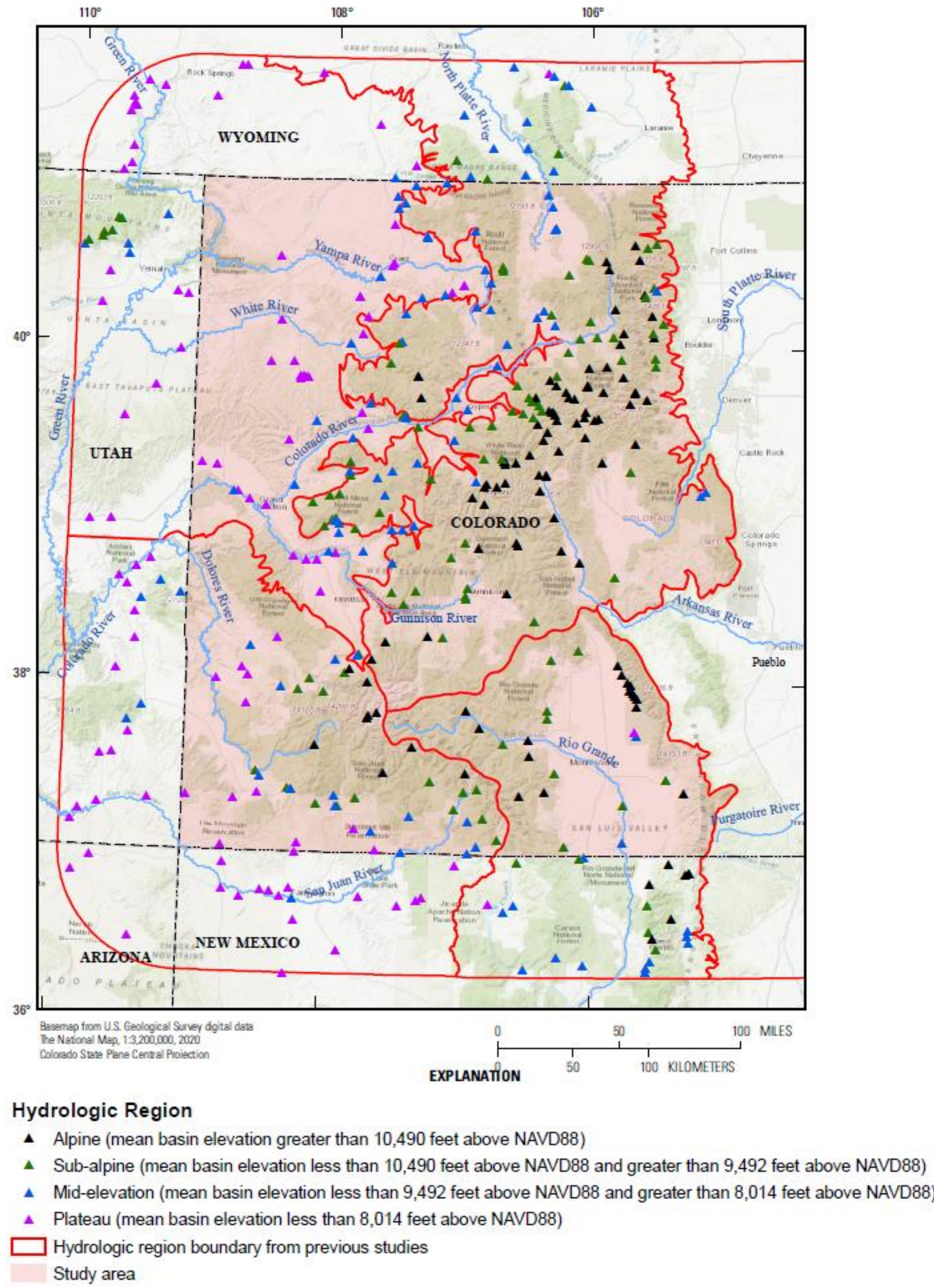

Figure 3. Map defining the new hydrologic regions created in central and western Colorado for the peak-streamflow regional regression equations: Alpine, Sub-Alpine, Mid-Elevation, and Plateau hydrologic regions with the location of the 105, 104, 104, and 105 streamgages that were used to develop the

peak-streamflow regional-regression equations in the Alpine, Sub-Alpine, Mid-Elevation, and Plateau hydrologic regions, respectively. [NAVD88, North American Vertical Datum of 1988]

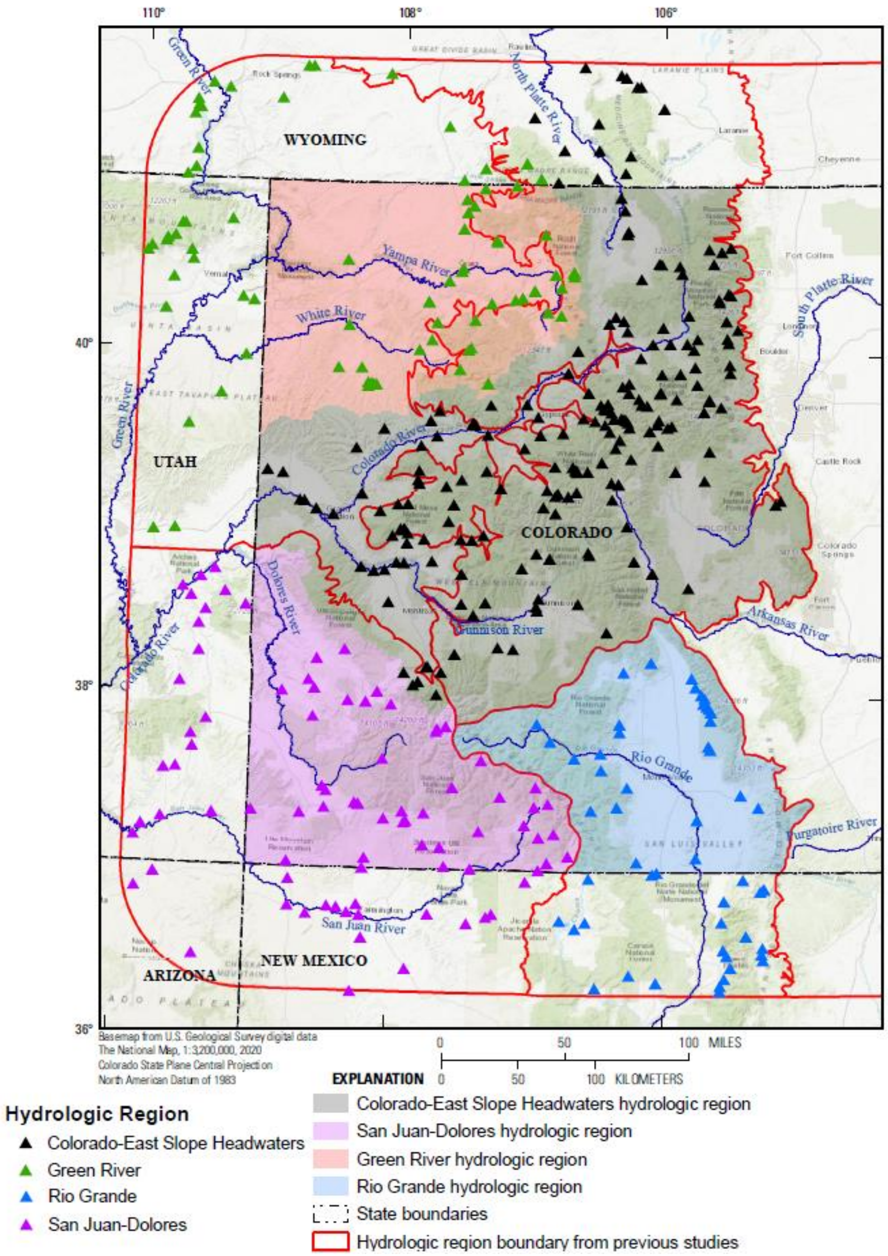

Figure 4. Map defining the new hydrologic regions created in central and western Colorado for the mean- and low-streamflow regional regression equations: Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores hydrologic regions with the location of the 170, 57, 42, and 54

streamgages that were used to develop the peak-streamflow regional-regression equations in the Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores hydrologic regions, respectively.

the drainage area was the only independent variable that was transformed to base 10 logarithms to increase linearity prior to the development of the PSRREs.

A constant variance in the dependent variable for the range of the independent variables, referred to as homoscedasticity, about the regression line and normality of residuals also is a criterion for OLS regression. Transformation of the AEPDs and certain other variables to base 10 logarithms can enhance the homoscedasticity of the data about the regression line (Southard and Veilleux, 2014). Linearity, homoscedasticity, and normality of residuals were examined in residual plots.

The hydrologic model used in the regression analysis in this report is of the form:

$$Q_P = aA^bB^cC^d \tag{3}$$

where:

Q_P is the dependent variable, P-percent AEPD, in cubic feet per second;

A, B, C are explanatory (independent) variables; and

a, b, c, d are regression coefficients.

If the dependent variable Q_P and the independent variable A are the only logarithmically transformed variables, then the hydrologic model has the following linear form:

$$\text{Log}\, Q_P = \log a + b(\log A) + c * B + d * C \tag{4}$$

where the variables are as previously defined. This equation is commonly written as:

$$Q_P = 10^a\ A^b\ 10^{(c*B+d*C)} \tag{5}$$

where the variables are as previously defined.

The basin and climate characteristics (table 1.2) with the strongest correlation to peak streamflow were identified, checked for any substantial cross-correlation with other variables in the group using the variance inflation factor (VIF) statistic, and were selected as the potential explanatory variables for the PSRREs. The final AEPDs for the 418 streamgages used in the regional-regression analysis are available in Kohn and others (2023).

Ordinary-Least Squares Regression

The OLS regression technique as described by Farmer and others (2019) was used in this report as an exploratory tool to determine potential explanatory variables for subsequent analysis by GLS regression. The subdivisions and explanatory variables were initially explored using OLS in R (R Core Team, 2019) with the allReg function in the 'smwrStats' R package (Lorenz, 2015). The potential explanatory variables were assessed for linear correlation with the $Q_{1\%}$ AEPD streamflow using plots, $adjR^2$, and the statistical significance (p-values) of each explanatory variable when regressed with peak streamflow to determine the strongest predictors of peak streamflow. Transformations of equation variables were considered to determine potential for improvement of correlations with streamflow and conformance to the assumptions of linear regression application. Logarithmic transformation (base 10) of both the streamflow and the drainage area explanatory variable, prior to OLS regression, was found to improve normality and homoscedasticity (assumptions for parametric regression), and in most cases, substantially improve both $adjR^2$ and statistical significance of the slope of each explanatory variable in a regression with streamflow.

The strongest OLS regression models (with one-, two-, three-, and four-explanatory variables using the best of all subsets routine) for prediction of $Q_{1\%}$ AEPD streamflow were identified and used to limit the number of potential explanatory variables in the subsequent GLS analyses. The strongest PSRREs were determined by assessing the following metrics for each model: Standard Error of Estimate, $adjR^2$, Mallow's Cp, and PRESS statistics. Statistical diagnostics and plots also were used to assess the regression model's robustness for meeting the assumptions of parametric regression methods. The $adjR^2$ statistic is maximized, and the standard error of estimate, Mallow's Cp, and PRESS statistics are minimized with accurate sets of independent variables in a regression model that explains more of the variance in the dependent variable. Additional information on OLS regression can be found in Eash and others (2013) and Southard and Veilleux (2014).

Multicollinearity (high correlation among the explanatory variables) can make results, based on a multiple linear regression model, misleading or erroneous and would generally disqualify the use of both variables within a single final PSRRE. Early in the variable selection process, the VIF statistic, and plots of a particular explanatory variable with each of the other explanatory variables were used to make preliminary assessments of potential multicollinearity. When assessing candidate variables and the apparent best OLS PSRRE for further refinement by GLS regression, multicollinearity was assessed primarily by using the VIF statistic (Gotvald and others, 2012) to screen for correlated or unnecessary variables in candidate PSRREs. There was no exact value of VIF above which the data were automatically excluded, but values below 3 were given preference, and values above 10 were scrutinized, as serious problems can occur when using those explanatory variables in a regression (Helsel and others, 2020). After removal of highly correlated variables via visual inspection of the plots, all calculated VIFs were below 3.

Generalized-Least Squares Regression

GLS multilinear regression, as described by Stedinger and Tasker (1985), Tasker and Stedinger (1989), Griffis and Stedinger (2007), and Farmer and others (2019), is a method of weighting streamgage AEPD data in the regression analysis according to differences in streamflow reliability (record lengths) and variability (record variance), and according to spatial cross correlations of concurrent streamflow among streamgages. Comparison of OLS, weighted-least squares (WLS), and GLS in a study by Stedinger and Tasker (1985) indicated that the weighted methods (WLS and GLS) produced results that were more accurate than the OLS regression method. When streamflow records of varying lengths or with correlated concurrent streamflows occurred in the dataset, the weighting technique used in GLS produces equations that are both improved in estimates of streamflow statistics and of the predictive accuracy of the statistics (Stedinger and Tasker, 1985).

Based on the exploratory results from OLS regression and explanatory variable multicollinearity analysis, the USGS R package WREG (Eng and others, 2009; Farmer, 2021) was used to compute GLS PSRREs from the most correlated candidate variables. Thirteen basin and climate characteristics were used as potential explanatory variables to develop the PSRREs with $Q_{1\%}$ AEPD streamflows based on OLS exploration. The general form of the equation was defined by equation 4. Final GLS regression models for PSRREs were selected based on minimizing values of the *SME* and the *SEP* and maximizing values of *pseudo*R^2 from OLS exploration.

In Capesius and Stephens (2009) and Kohn and others (2016), the error associated with the PMLSRREs was characterized using the *SEP*, *pseudo*R^2, *SME*, and *adj*R^2. The *SEP* describes the sum of the model error and sampling error. The *SEP* is the square root of the mean GLS variance of prediction (Tasker and Stedinger, 1989; Eng and others, 2009). The *pseudo*R^2 value is a measure of the percentage of the variation explained by the basin or climate characteristics (explanatory variables) included in the model and is calculated based on the degrees of freedom in the regression (Eash and others, 2013). The *adj*R^2 is a measure of the percentage of the variation explained by the basin or climate characteristics (explanatory variables) included in the model but also compensates for multiple explanatory variables such that adding additional explanatory variables increases the value of *adj*R^2 only when the predictive capability of the model increases (Lee and others, 2012). Griffis and Stedinger (2007) describe how the *pseudo*R^2 is more appropriate than the R^2 or *adj*R^2 in measuring the true variation explained by the explanatory variables in the GLS model. The *SME* measures only the error of the model and does not include sampling error regression (Eash and others, 2013). *SME* is the square root of the regression model error variance (Tasker and Stedinger, 1989).

GLS models need a correlation model and weighting matrix. The correlation smoothing function relates the correlation between annual-peak streamflows at two streamgages to the geographic distance between the streamgages for every paired combination of the streamgages with a given number of years of concurrent streamflow. The correlation smoothing function was defined in equation 18 in Eng and others (2009), with an alpha of 0.001 and theta of 0.99. The correlation smoothing function was used by WREG to compute a weighting matrix for the four hydrologic regions of streamgages based on the mean elevation included in the development of the GLS PSRREs. Figure 5 displays the predicted 100-year peak streamflow using the regression

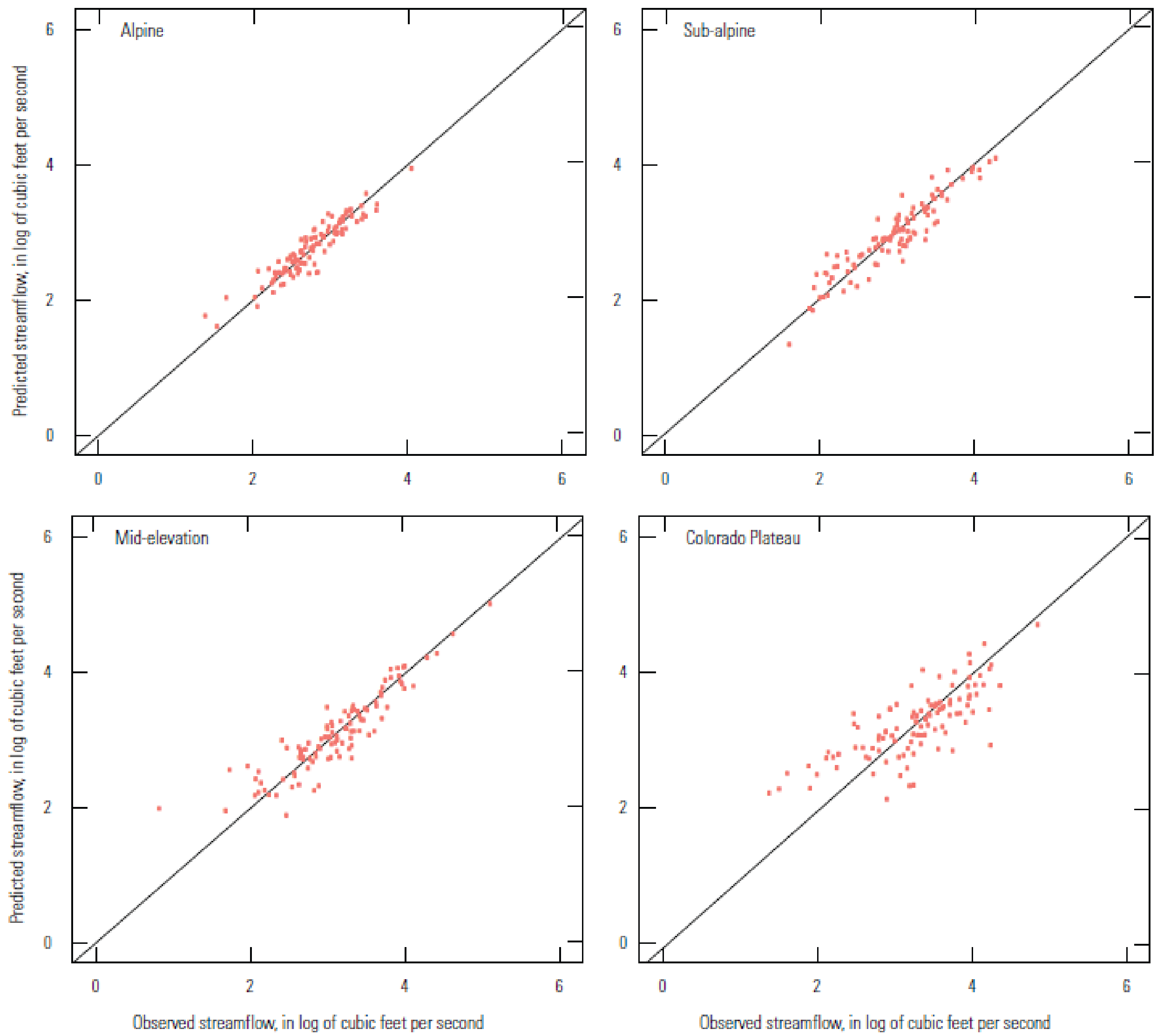

Figure 5. Plots showing predicted 100-year peak streamflow using the regression equations versus the observed at-site peak streamflow for each hydrologic region (Alpine, Sub-Alpine, Mid-Elevation, and Plateau.

equation versus the observed at-site peak streamflow for each hydrologic region. Figure 5 indicates a reasonable scatter distribution around the line of equality across the range of streamflows, particularly for the Alpine and Sub-Alpine hydrologic regions. A separate model was selected for each of the four hydrologic regions. Within each hydrologic region, the same explanatory variables were applied for each of the eight PSRREs in that region for consistency amongst different exceedance probabilities. All explanatory variables were statistically significant at a p-value of less than or equal to (≤) 0.05, and the VIF for explanatory variables was less than 3.

Development of the Mean-Streamflow Regional-Regression Equations

The MSRREs were developed for use in estimating the mean-annual and the 12 mean-monthly streamflows at gaged and ungaged locations for basins in the Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores hydrologic regions of central and western Colorado. Regression techniques using OLS were performed to select the basin and climate characteristics for use as independent variables following the same method as used for the PSRREs. The dependent response variables are the mean-annual and mean-monthly streamflows, and the independent explanatory variables are the basin and climate characteristics that describe the mean-annual and mean-monthly streamflows. For the current (2022) study, the dependent variables mean-annual and mean-monthly streamflows were transformed to base 10 logarithms, but the drainage area was the only dependent variable that was transformed to base 10 logarithms to increase linearity prior to the development of the MSRREs.

A constant variance in the dependent variable for the range of the independent variables, referred to as homoscedasticity, about the regression line and normality of residuals are criterion for OLS regression. Transformation of the mean-annual and mean-monthly streamflows and certain other variables to base 10 logarithms can enhance the homoscedasticity of the data about the regression line (Southard and Veilleux, 2014). Linearity, homoscedasticity, and normality of residuals were examined in residual plots.

The basin and climate characteristics (table 1.2) with the strongest correlation to mean streamflow were identified, checked for any substantial cross-correlation with other variables in the group, and were selected as the potential explanatory variables for the MSRREs. The final mean-annual and the 12 mean-monthly streamflows for the 323 streamgages used in the regional-regression analysis are available in Kohn and others (2023).

Ordinary-Least Squares Regression

The methods of Farmer and others (2019) were used to develop the MSRREs. The MSRREs were developed using OLS in R (R Core Team, 2019) with the “allReg” function in the smwrStats R package (Lorenz, 2015). Because the mean-annual and mean-monthly streamflows were computed without using the log-Pearson Type III frequency distribution, GLS regression cannot be used for the MSRREs. The potential explanatory variables were assessed for linear correlation with the mean-annual and the 12 mean-monthly streamflows using plots, VIF statistic, and the statistical significance (*p*-values) of each explanatory variable when regressed with peak streamflow to determine the strongest predictors of annual- and the 12 mean-monthly streamflows.

The most correlated OLS regression models (with one-, two-, three-, four- and five-explanatory variables using the best of all subsets routine) for prediction of the mean-annual and the 12 mean-monthly streamflows were identified. Following the PSRREs methods, multicollinearity (high correlation among the explanatory variables) can make results, which are based on a multiple linear regression model, misleading or erroneous. This generally disqualifies the use of both variables within a single final MSRRE. Early in the variable selection process, the VIF statistic and plots comparing explanatory variables, were used to make preliminary assessments of potential multicollinearity. Final OLS regression models for mean-annual and the 12 mean-monthly streamflows were selected based on minimizing values of *SEP* and maximizing values of $adjR^2$.

Figure 6 displays the predicted mean-annual streamflow using the OLS regression equation versus the observed at-site mean-annual streamflow for each hydrologic region. Figure 6 indicates a reasonable scatter distribution around the line of equality across the range of streamflows. Separate models were fit for each mean-annual and mean-monthly streamflow statistics for each of the hydrologic regions. All explanatory variables were statistically significant at a p-value of ≤ 0.05, and the VIF for explanatory variables was less than 3.

Development of the Low-Streamflow Regional-Regression Equations

The LSRREs were developed for use in estimating the 7-day minimum and maximum streamflows for return periods of 2-, 10-, and 50-years (AEP of 0.50, 0.10, and 0.02) and streamflow-duration values for five exceedance percentiles of interest (10, 25, 50, 75, and 90) at gaged and ungaged locations for basins in the Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores hydrologic regions of central and western Colorado. Regression techniques using OLS were performed to select the basin and climate characteristics for use as independent variables following the same method as used for the PSRREs. The dependent response variable is the 7-day minimum and maximum streamflows and streamflow-duration values, and the independent explanatory variables are the basin and climate characteristics that describe the 7-day minimum and maximum streamflows and streamflow-duration values. For the current (2022) study, the dependent variable 7-day minimum and maximum streamflows and streamflow-duration values were transformed to base 10 logarithms,

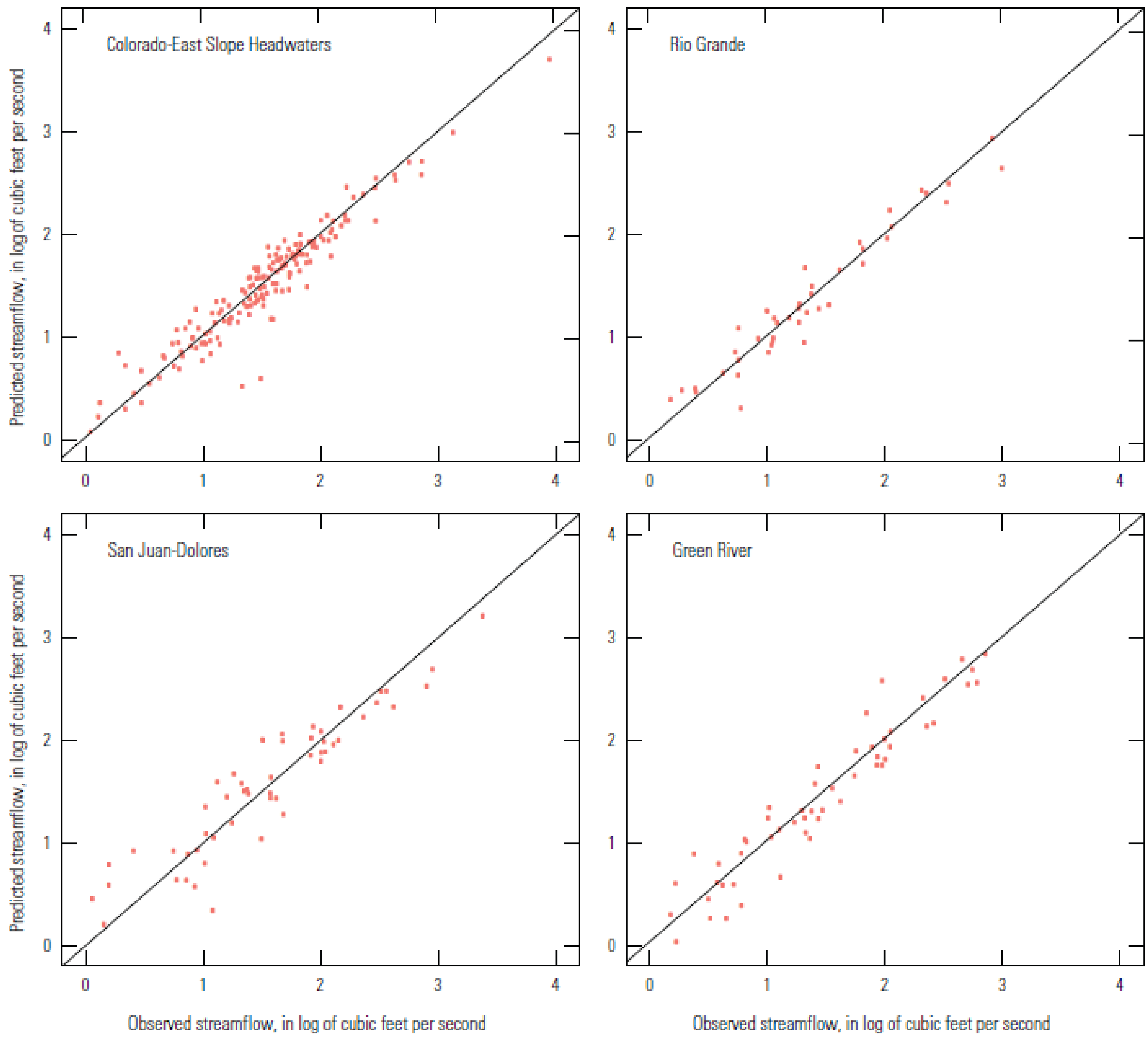

Figure 6. Plots showing predicted mean-annual streamflow using the regression equations versus the observed at-site mean-annual streamflow for each hydrologic region (Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, Green River).

but the drainage area was the only dependent variable that was transformed to base 10 logarithms to increase linearity prior to the development of the LSRREs.

For the 7-day minimum streamflows, all zero streamflow values were substituted with the smallest streamflow in each statistic (0.01 ft^3/s for ${}_{7}Q^{min}_{2\%}$, 0.001 ft^3/s for ${}_{7}Q^{min}_{10\%}$,, and 0.005 ft^3/s for ${}_{7}Q^{min}_{50\%}$) prior to model fitting so the dependent variable could be logarithmically transformed. In addition, for the 7-day minimum streamflows, a censored regression technique using the lowest non-zero value as the censoring level was analyzed. This technique yielded models and coefficients very similar to the OLS, so it was determined that an OLS would be the preferred approach for the 7-day minimum streamflows. For the streamflow-duration values, all zero streamflow values were substituted with a value of 0.005 ft^3/s prior to model fitting so the dependent variable could be logarithmically transformed. For the 7-day maximum streamflows, no zero streamflows were present, and no substitutions were made.

Homoscedasticity about the regression line and normality of residuals also is a criterion for OLS regression. Transformation of the 7-day minimum and maximum streamflows and streamflow-duration values and certain other variables to base 10 logarithms can enhance the homoscedasticity of the data about the regression line (Southard and Veilleux, 2014). Linearity, homoscedasticity, and normality of residuals were examined in residual plots.

The basin and climate characteristics (table 1.2) with the strongest correlation to peak streamflow were identified, checked for any substantial cross-correlation with other variables in the group, and were selected as the potential explanatory variables for the LSRREs. The final 7-day minimum and maximum streamflows and streamflow-duration values for the 323 streamgages used in the regional-regression analysis are available in Kohn and others (2023).

Ordinary-Least Squares Regression

The methods of Farmer and others (2019) were used to develop the LSRREs and are described in the previous sections. A previous study (Hortness, 2006) determined that using GLS regression techniques for 7-day minimum streamflows is not preferred over OLS or WLS because of the extreme cross-correlations present between streamgages. As a result, GLS regression was only used for the 7-day maximum streamflows. The WLS regression was analyzed for the 7-day minimum streamflows and streamflow-duration values using weights of record length and the variance of the logarithms of the observed values. After reviewing the uncertainty metrics for each model, it was determined that WLS regression did not improve the uncertainty of the models, and so the OLS regression methods would be used for the 7-day minimum streamflows and streamflow-duration values. The potential explanatory variables were assessed for linear correlation with the 7-day minimum streamflows and streamflow-duration values using plots, VIF statistic, and the statistical significance of each explanatory variable when regressed with peak streamflow (*p*-values), to determine the strongest predictors of 7-day minimum streamflows and streamflow-duration values. Final OLS regression models for 7-day minimum streamflows and streamflow-duration values were selected based on minimizing values of *SEP* and maximizing values of $adjR^2$.

Figures 7 and 8 display the predicted 7-day minimum streamflows and streamflow-duration values, respectively, using the OLS regression equation versus the observed at-site 7-day minimum streamflows and streamflow-duration values for each hydrologic region. Figures 7 and 8 indicate a reasonable scatter distribution around the line of equality across the range of streamflows with larger uncertainty present in all equations for lower streamflows. Figures 7 and 8 display the substituted zero streamflow values as a vertical line above the 1:1 line indicating the equations overpredict the statistic when streamflows are very low or zero, which is more common in the San Juan and Green River hydrologic regions. The plots are in log units, and this phenomenon occurs when almost all the predicted streamflows would be less than 1 ft^3/s so

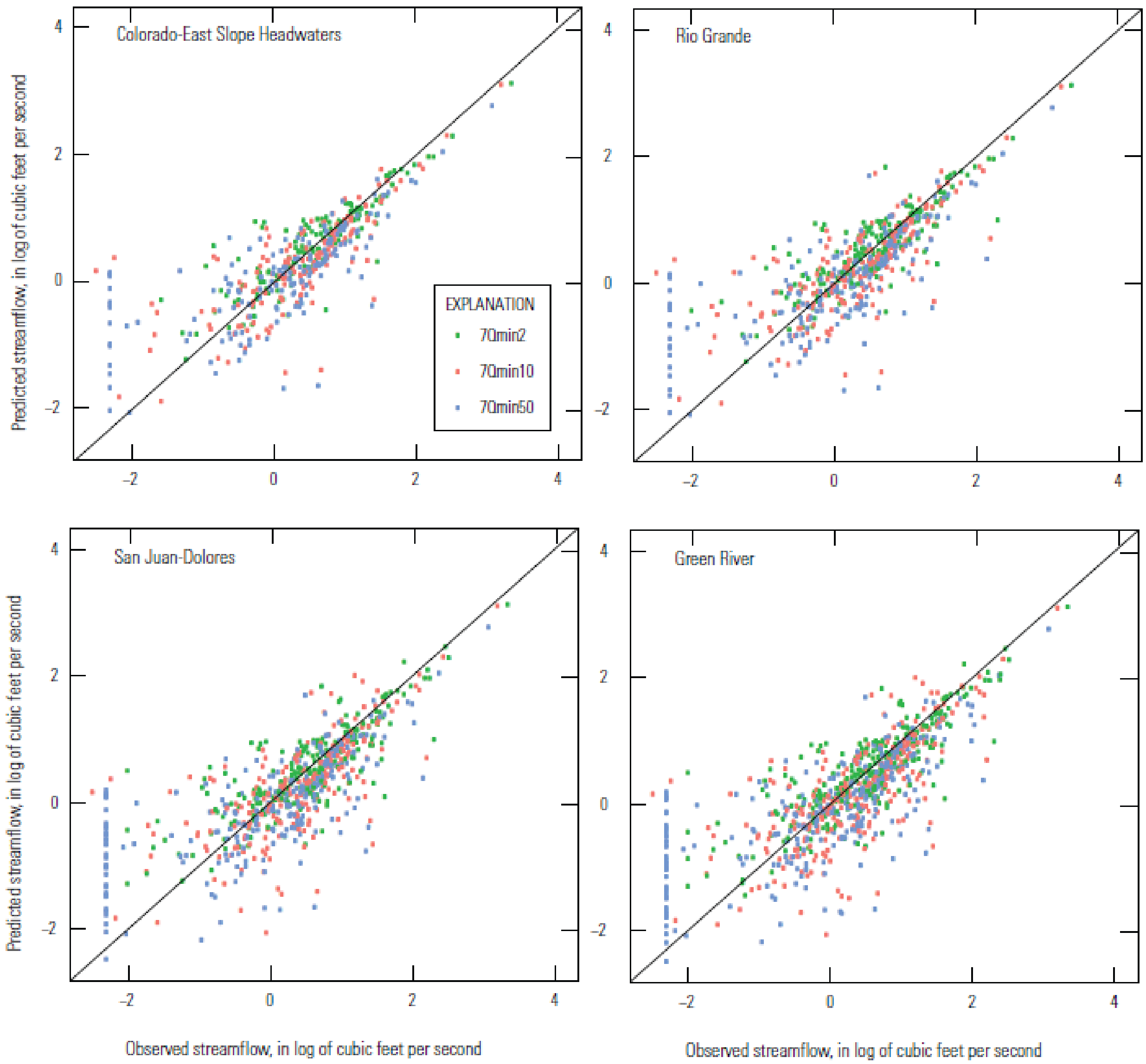

Figure 7. Plots showing predicted 7-day 2-, 10-, and 50-year minimum streamflow (7Qmin2, 7Qmin10, and 7Qmin50) using the regression equations versus the observed at-site 7-day minimum streamflow for each hydrologic region (Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, Green River).

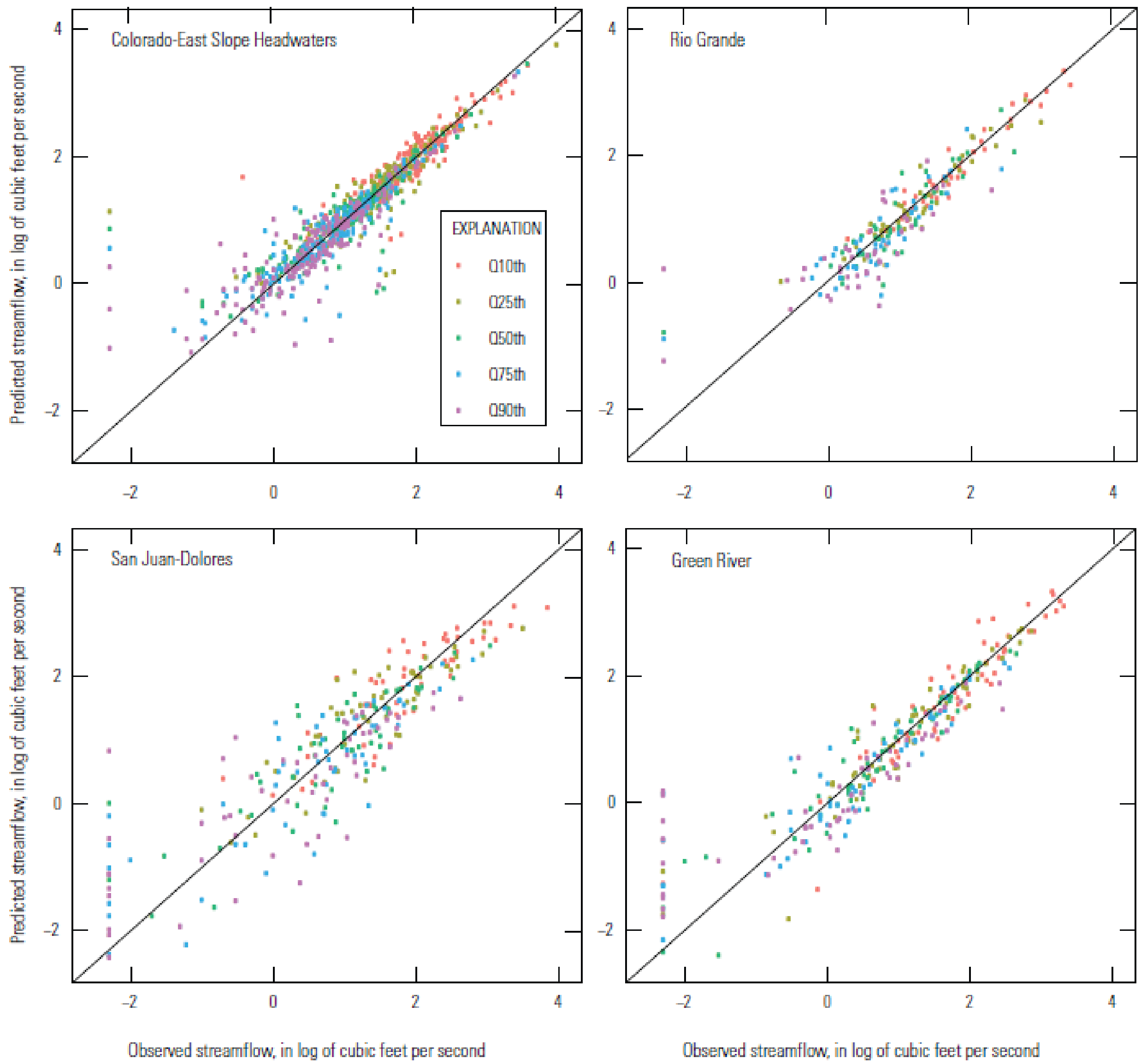

Figure 8. Plots showing predicted streamflow-duration values for annual exceedance probabilities of 10, 25, 50, 75, and 90 percent (Q10th, Q25th, Q50th, Q75th, and Q90th) using the regression equations versus the observed at-site streamflow-duration values for each hydrologic region (Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, Green River).

caution should be used when applying these equations when streamflows are very low (≤ 1 ft^3/s). Separate equations were fit for each 7-day minimum streamflow and streamflow-duration value statistic for each hydrologic region. For the 7-day minimum streamflow, within each hydrologic region, the same explanatory variables based on the ${}_7Q_{10\%}^{min}$ statistic were applied for each of the three flow-duration statistics (${}_7Q_{2\%}^{min}$, ${}_7Q_{10\%}^{min}$, ${}_7Q_{50\%}^{min}$) in that region for consistency amongst different exceedance probabilities. For the streamflow-duration values, within each hydrologic region, the same explanatory variables based on the Q_{50th} statistic were applied for each of the five flow-duration statistics (Q_{10th}, Q_{25th}, Q_{50th}, Q_{75th}, Q_{90th}) in that region for consistency amongst different exceedance probabilities. All explanatory variables were statistically significant at a p-value of ≤ 0.05, and the VIF for explanatory variables was less than 3.

Generalized-Least Squares Regression

For the 7-day maximum streamflows, regression techniques using GLS were performed to select the basin and climate characteristics for use as independent variables following the same method as used for the PSRREs. Thirteen basin and climate characteristics were used as potential explanatory variables to develop the 7-day maximum streamflows, and separate equations were created for each dependent variable in the four hydrologic regions. For the 7-day maximum streamflow, within each hydrologic region, the same explanatory variables based on the ${}_7Q_{10\%}^{min}$ statistic were applied for each of the three flow-duration statistics (${}_7Q_{2\%}^{min}$, ${}_7Q_{10\%}^{min}$, ${}_7Q_{50\%}^{min}$) in that region to maintain consistency between different exceedance probabilities.

The correlation smoothing function was defined in equation 18 in Eng and others (2009) with an alpha of 0.001 and theta of 0.99. The correlation smoothing function was used by WREG to compute a weighting matrix for the four hydrologic regions of streamgages based on the mean elevation included in the development of the GLS PSRREs. Final GLS regression models for 7-day maximum streamflows were selected based on minimizing values of *SME* and *SEP* and maximizing values of $pseudoR^2$.

Figure 9 displays the predicted 7-day maximum streamflow using the regression equation versus the observed at-site 7-day maximum streamflow for each hydrologic region. Figure 9 indicates a reasonable scatter distribution around the line of equality across the range of streamflows, particularly for the Rio Grande and San Juan hydrologic regions. All explanatory variables were statistically significant at a p-value of ≤0.05, and the VIF for explanatory variables was less than 3.

Final Peak-, Mean-, and Low-Streamflow Regional-Regression Equations

The PSRREs in the Alpine, Sub-Alpine, Mid-Elevation, and Plateau hydrologic regions were developed using a total of 105, 104, 104, and 105 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the PSRREs were based on the $Q_{1\%}$ AEPD for each hydrologic region. Maintaining consistency between explanatory variables minimizes the possibility of predictive inconsistencies between estimates of different probabilities, so that streamflow estimates will increase as the streamflow probability decreases. The final peak-streamflow regional-regression equations from GLS regression with $pseudoR^2$, *SEP*, *SME*, and the model coefficients are listed for each hydrologic region in table 1. The performance metrics $pseudoR^2$ and *SME* describe how well the PSRREs perform on the streamgages used in the regression analyses, and the *SEP* measures how well the GLS regression models can predict AEPDs at ungaged sites (Eash and others, 2013).

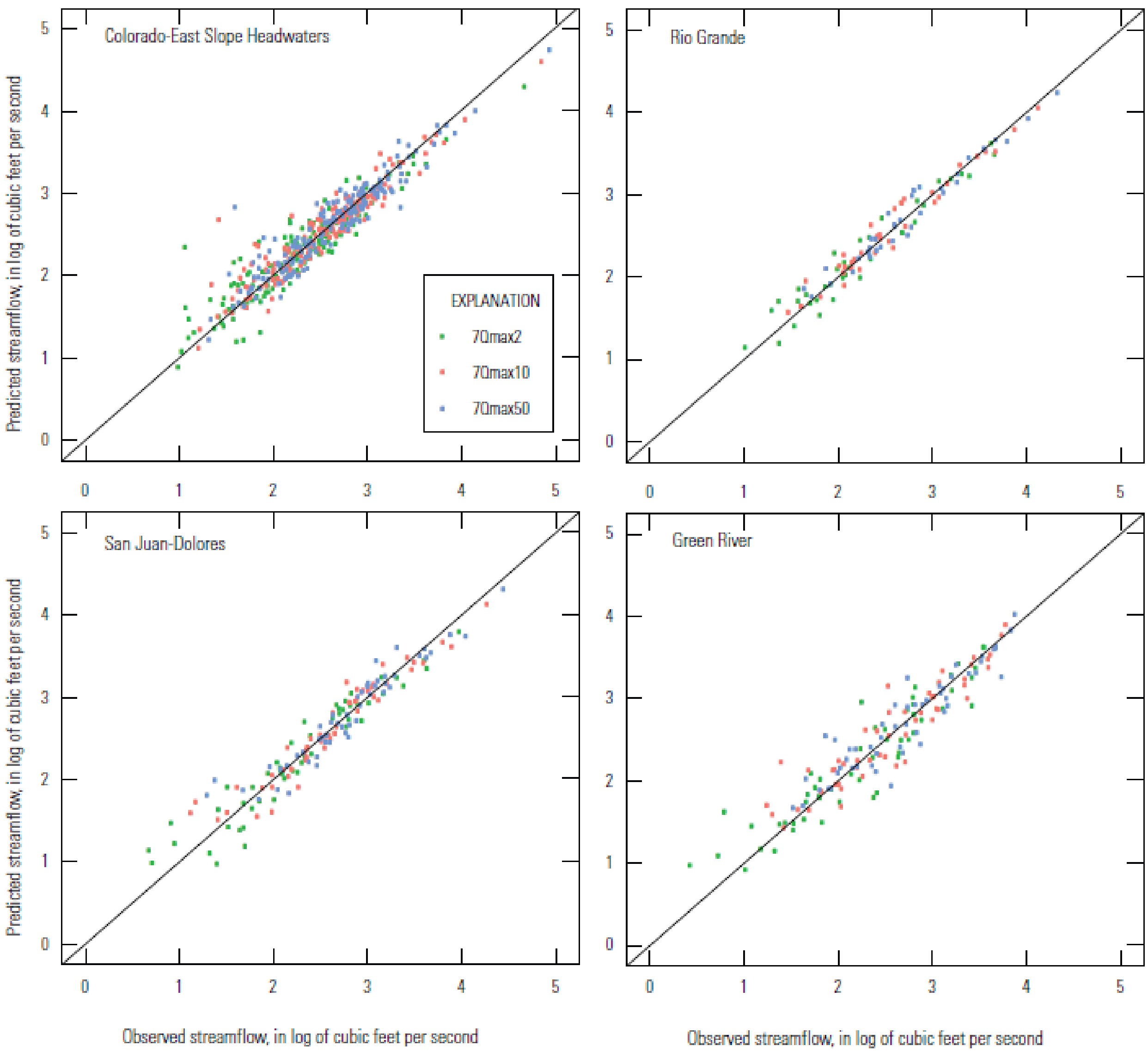

Figure 9. Plots showing predicted 7-day 2-, 10-, and 50-year maximum streamflow (7Qmax2, 7Qmax10, 7Qmax50) using the regression equation versus the observed at-site maximum streamflow for each hydrologic region (Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, Green River).

The MSRREs in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 170, 42, 54, and 57 streamgages, respectively, and no streamgages were used in more than one region. The final mean-annual and the 12 mean-monthly streamflow regional-regression equations from OLS regression with $adjR^2$, SEP, and the model coefficients are listed for each hydrologic region in table 2.

The 7-day minimum streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 156, 40, 44, and 44 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the 7-day minimum streamflow equations were based on the ${}_{7}Q_{10\%}^{min}$ statistic for each hydrologic region. Maintaining consistency between explanatory variables minimizes the possibility of predictive inconsistencies between estimates of different probabilities, so that predicted streamflow will increase as the streamflow probability decreases. The final 7-day 2-, 10-, and 50-year minimum streamflow regional-regression equations from OLS regression with $adjR^2$, SEP, and the model coefficients are listed for each hydrologic region in table 3.

The streamflow-duration values and regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 170, 42, 54, and 57 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the streamflow-duration equations were based on the Q_{50th} statistic for each hydrologic region. The final streamflow regional-regression equations for streamflow-duration values for annual exceedance probabilities of 10, 25, 50, 75, and 90 percent from OLS regression with $adjR^2$, *SEP*, and the model coefficients are listed for each hydrologic region in table 4.

The 7-day maximum streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 167, 35, 52, and 52 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the 7-day maximum streamflow equations were based on the ${}_{7}Q_{10\%}^{max}$ statistic for each hydrologic region. The final 7-day 2-, 10-, and 50-year maximum streamflow regional-regression equations from GLS regression with $pseudoR^2$, *SEP*, *SME*, and the model coefficients are listed for each hydrologic region in table 5. The final regression models for each equation and hydrologic region are available in Kohn and others (2023).

Table 1. Regional-regression equations and performance metrics determined by generalized-least squares for predicting 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year peak streamflow for natural streams in each hydrologic region in central and western Colorado.

[N, number of sites used in regression; PseudoR^2, pseudo coefficient of determination in percent; SEP, standard error of prediction in percent; SME, standard model error in percent; Q^{peak}, 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year instantaneous peak streamflow in cubic feet per second; AREA, drainage area in square miles; LONG, longitude of basin centroid in decimal degrees NAD 83; SLOPE, mean basin slope in percent; MEANELEV, mean basin elevation in feet NAVD 88; SWE, snow water equivalent on April 1 in inches; 100Y24H, 24-hour, 100-year precipitation, in inches; PPTANN, annual precipitation in inches; Colo., Colorado]

Regression equation	Region	N	PseudoR^2	SEP	SME
Approximate range of predictor variables: AREA: 0.22-22,629, LONG: -110.219- -105.093, SLOPE: 3.37-69.4, MEANELEV: 4,808-11,954, SWE: 0-33.8, 100Y24H: 2.19-5.21, PPTANN: 7.71-61.6					
$Q_2^{peak} = 10^{0.244} AREA^{0.807} 10^{(0.00898*SLOPE+0.0537*SWE)}$	Alpine	105	89.6	39	38
$Q_5^{peak} = 10^{0.526} AREA^{0.786} 10^{(0.00841*SLOPE+0.0472*SWE)}$	Alpine	105	90.8	34	33
$Q_{10}^{peak} = 10^{0.664} AREA^{0.775} 10^{(0.00819*SLOPE+0.0440*SWE)}$	Alpine	105	90.7	33	32
$Q_{25}^{peak} = 10^{0.803} AREA^{0.763} 10^{(0.00801*SLOPE+0.0410*SWE)}$	Alpine	105	89.7	34	33
$Q_{50}^{peak} = 10^{0.888} AREA^{0.756} 10^{(0.00794*SLOPE+0.0392*SWE)}$	Alpine	105	88.8	35	34
$Q_{100}^{peak} = 10^{0.961} AREA^{0.749} 10^{(0.00789*SLOPE+0.0377*SWE)}$	Alpine	105	87.5	37	36
$Q_{200}^{peak} = 10^{1.03} AREA^{0.742} 10^{(0.00787*SLOPE+0.0365*SWE)}$	Alpine	105	85.9	39	38
$Q_{500}^{peak} = 10^{1.10} AREA^{0.735} 10^{(0.00787*SLOPE+0.0350*SWE)}$	Alpine	105	83.8	42	40
$Q_2^{peak} = 10^{-6.29} AREA^{0.895} 10^{(-0.0604*LONG+0.115*P100Y24H+0.0363*SWE)}$	Sub-Alpine	104	87.1	54	52
$Q_5^{peak} = 10^{-6.05} AREA^{0.874} 10^{(-0.0606*LONG+0.119*P100Y24H+0.0303*SWE)}$	Sub-Alpine	104	88.4	49	47
$Q_{10}^{peak} = 10^{-5.94} AREA^{0.864} 10^{(-0.0607*LONG+0.124*P100Y24H+0.0273*SWE)}$	Sub-Alpine	104	88.9	47	46
$Q_{25}^{peak} = 10^{-5.79} AREA^{0.854} 10^{(-0.0604*LONG+0.131*P100Y24H+0.0241*SWE)}$	Sub-Alpine	104	88.5	48	46

$Q_{50}^{peak} = 10^{-5.67} AREA^{0.847} 10^{(-0.0600*LONG+0.137*P100Y24H+0.0222*SWE)}$	Sub-Alpine	104	88.0	49	47
$Q_{100}^{peak} = 10^{-5.56} AREA^{0.841} 10^{(-0.0595*LONG+0.142*P100Y24H+0.0205*SWE)}$	Sub-Alpine	104	87.4	50	48
$Q_{200}^{peak} = 10^{-5.43} AREA^{0.835} 10^{(-0.0588*LONG+0.148*P100Y24H+0.0189*SWE)}$	Sub-Alpine	104	86.6	52	50
$Q_{500}^{peak} = 10^{-5.27} AREA^{0.829} 10^{(-0.0578*LONG+0.154*P100Y24H+0.0171*SWE)}$	Sub-Alpine	104	85.5	54	52
$Q_{2}^{peak} = 10^{-6.73} AREA^{0.919} 10^{(-0.0594*LONG+0.0418*PPTANN)}$	Mid-Elevation	104	87.3	65	63
$Q_{5}^{peak} = 10^{-7.21} AREA^{0.893} 10^{(-0.0687*LONG+0.0332*PPTANN)}$	Mid-Elevation	104	88.2	59	57
$Q_{10}^{peak} = 10^{-7.33} AREA^{0.878} 10^{(-0.0723*LONG+0.0286*PPTANN)}$	Mid-Elevation	104	88.1	58	56
$Q_{25}^{peak} = 10^{-7.36} AREA^{0.860} 10^{(-0.0753*LONG+0.0239*PPTANN)}$	Mid-Elevation	104	87.1	60	58
$Q_{50}^{peak} = 10^{-7.36} AREA^{0.848} 10^{(-0.0769*LONG+0.0208*PPTANN)}$	Mid-Elevation	104	85.7	63	61
$Q_{100}^{peak} = 10^{-7.33} AREA^{0.837} 10^{(-0.0782*LONG+0.0182*PPTANN)}$	Mid-Elevation	104	84.4	66	64
$Q_{200}^{peak} = 10^{-7.29} AREA^{0.826} 10^{(-0.0791*LONG+0.0158*PPTANN)}$	Mid-Elevation	104	83.0	69	67
$Q_{500}^{peak} = 10^{-7.23} AREA^{0.814} 10^{(-0.0802*LONG+0.0129*PPTANN)}$	Mid-Elevation	104	80.9	74	72
$Q_{2}^{peak} = 10^{2.37} AREA^{0.646} 10^{(-0.000364*MEANELEV+0.478*100Y24H)}$	Plateau	105	73.9	112	108
$Q_{5}^{peak} = 10^{2.77} AREA^{0.573} 10^{(-0.000368*MEANELEV+0.514*100Y24H)}$	Plateau	105	75.8	89	86
$Q_{10}^{peak} = 10^{2.98} AREA^{0.539} 10^{(-0.000378*MEANELEV+0.548*100Y24H)}$	Plateau	105	73.4	90	86
$Q_{25}^{peak} = 10^{3.21} AREA^{0.506} 10^{(-0.000397*MEANELEV+0.598*100Y24H)}$	Plateau	105	67.8	99	94
$Q_{50}^{peak} = 10^{3.36} AREA^{0.486} 10^{(-0.000412*MEANELEV+0.635*100Y24H)}$	Plateau	105	62.8	109	104
$Q_{100}^{peak} = 10^{3.50} AREA^{0.469} 10^{(-0.000427*MEANELEV+0.669*100Y24H)}$	Plateau	105	58.2	120	114
$Q_{200}^{peak} = 10^{3.63} AREA^{0.453} 10^{(-0.000441*MEANELEV+0.702*100Y24H)}$	Plateau	105	53.9	133	126
$Q_{500}^{peak} = 10^{3.78} AREA^{0.435} 10^{(-0.000459*MEANELEV+0.742*100Y24H)}$	Plateau	105	48.4	153	144

Table 2. Regional-regression equations and performance metrics determined by ordinary-least squares for predicting mean-annual and the 12 mean-monthly streamflows for natural streams in each hydrologic region in central and western Colorado.

[Q_{xxx}; mean annual or monthly streamflow in cubic feet per second; N, number of sites used in regression; Adj-R^2, adjusted coefficient of determination in percent; SEP, standard error of prediction in percent; AREA, drainage area in square miles; LONG, longitude of basin centroid in decimal degrees NAD 83; LAT, latitude of basin centroid in decimal degrees NAD 83; OUTELEV, elevation at basin outlet in feet NAVD 88; ELEVMAX, maximum basin elevation in feet NAVD 88; RELIEF, basin relief in feet; SWE, snow water equivalent on April 1 in inches; PPTANN, annual precipitation in inches; PPTAUG, precipitation measured during August in inches; SLOPE, mean basin slope in percent; 100Y6H, hundred year 6-hour precipitation in inches]

Table 3.

Regression equation	River basin	N	Adj-R^2	SEP
Approximate range of predictor variables: AREA: 0.89-22,629, LONG: -110.052- -105.226, LAT: 36.088-41.472, OUTELEV: 3,995-10,499, ELEVMAX: 6,061-14,426, RELIEF: 533-10,035, SWE: 0-33.8, PPTANN: 8.60-61.6, PPTAUG: 0.90-4.89, SLOPE: 6.82-69.4, 100Y6H: 1.61-3.45				
$Q_{ann} = 10^{-0.704} AREA^{0.793} 10^{(0.00518*SLOPE+0.0000642*RELIEF+0.0459*SWE)}$	Colorado-East Slope Headwaters	170	86.4	53
$Q_{jan} = 10^{-1.61} AREA^{0.773} 10^{(0.000143*RELIEF+0.0440*SWE)}$	Colorado-East Slope Headwaters	170	75.7	98
$Q_{feb} = 10^{1.21} AREA^{0.847} 10^{(-0.0679*LAT+0.000103*RELIEF+0.0364*SWE)}$	Colorado-East Slope Headwaters	170	85.3	67
$Q_{mar} = 10^{-0.900} AREA^{0.906} 10^{(-0.0000646*RELIEF+0.0166*PPTANN-0.228*100Y6H)}$	Colorado-East Slope Headwaters	170	90.2	53
$Q_{apr} = 10^{0.224} AREA^{0.960} 10^{(-0.0000664*OUTELEV+0.0215*PPTANN-0.265*100Y6H)}$	Colorado-East Slope Headwaters	170	83.3	76
$Q_{may} = 10^{-0.259} AREA^{0.933} 10^{(0.0111*PPTANN+0.0332*SWE)}$	Colorado-East Slope Headwaters	170	82.7	65
$Q_{jun} = 10^{16.4} AREA^{0.690} 10^{(0.156*LONG+0.000127*RELIEF+0.0651*SWE)}$	Colorado-East Slope Headwaters	170	83.0	65
$Q_{jul} = 10^{-2.06} AREA^{0.780} 10^{(0.000118*ELEVMAX+0.0130*SLOPE+0.0517*SWE)}$	Colorado-East Slope Headwaters	170	75.7	88
$Q_{aug} = 10^{-2.21} AREA^{0.807} 10^{(0.000101*ELEVMAX+0.00862*SLOPE+0.0217*PPTANN)}$	Colorado-East Slope Headwaters	170	72.3	97
$Q_{sep} = 10^{-1.25} AREA^{0.707} 10^{(0.00750*SLOPE+0.00013*RELIEF+0.0374*SWE)}$	Colorado-East Slope Headwaters	170	75.3	89
$Q_{oct} = 10^{-1.06} AREA^{0.700} 10^{(0.000144*RELIEF+0.0333*SWE)}$	Colorado-East Slope Headwaters	170	81.2	73
$Q_{nov} = 10^{-1.28} AREA^{0.749} 10^{(0.000140*RELIEF+0.0363*SWE)}$	Colorado-East Slope Headwaters	170	82.8	72
$Q_{dec} = 10^{-1.42} AREA^{0.763} 10^{(0.000135*RELIEF+0.0383*SWE)}$	Colorado-East Slope Headwaters	170	79.9	81
$Q_{ann} = 10^{21.1} AREA^{0.839} 10^{(0.129*LAT+0.250*LONG+0.0783*SWE)}$	Rio Grande	42	93.0	42
$Q_{jan} = 10^{58.1} AREA^{0.817} 10^{(0.544*LONG+0.734*SWE-0.579*100Y6H)}$	Rio Grande	42	85.2	59
$Q_{feb} = 10^{50.9} AREA^{0.842} 10^{(0.478*LONG+0.0647*SWE-0.501*100Y6H)}$	Rio Grande	42	87.6	54
$Q_{mar} = 10^{-0.648} AREA^{0.845} 10^{(0.0255*SWE)}$	Rio Grande	42	89.3	52

$Q_{apr} = 10^{1.83} AREA^{0.705} 10^{(-0.000244*OUTELEV-0.00544*SLOPE+0.772*SWE)}$	Rio Grande	42	92.6	48
$Q_{may} = 10^{20.6} AREA^{0.878} 10^{(0.200*LONG+0.0000655*RELIEF+0.0847*SWE)}$	Rio Grande	42	92.4	52
$Q_{jun} = 10^{25.9} AREA^{0.789} 10^{(0.268*LONG+0.000181*ELEVMAX+0.0926*SWE)}$	Rio Grande	42	91.3	59
$Q_{jul} = 10^{0.160} AREA^{0.409} 10^{(0.000222*RELIEF+0.0946*SWE-0.436*100Y6H)}$	Rio Grande	42	86.4	67
$Q_{aug} = 10^{0.274} AREA^{0.398} 10^{(0.000187*RELIEF+0.067*SWE-0.393*100Y6H)}$	Rio Grande	42	85.3	57
$Q_{sep} = 10^{0.207} AREA^{0.424} 10^{(0.000189*RELIEF+0.068*SWE-0.441*100Y6H)}$	Rio Grande	42	83.1	65
$Q_{oct} = 10^{28.2} AREA^{0.815} 10^{(0.334*LAT+0.393*LONG+0.0778*SWE)}$	Rio Grande	42	85.3	61
$Q_{nov} = 10^{49.9} AREA^{0.739} 10^{(0.465*LONG+0.0814*SWE-0.543*100Y6H)}$	Rio Grande	42	86.5	55
$Q_{dec} = 10^{60.6} AREA^{0.798} 10^{(0.567*LONG+0.0785*SWE-0.590*100Y6H)}$	Rio Grande	42	84.2	62
$Q_{ann} = 10^{39.5} AREA^{0.631} 10^{(0.383*LONG+0.000175*ELEVMAX)}$	San Juan-Dolores	54	86.7	71
$Q_{jan} = 10^{42.0} AREA^{0.811} 10^{(0.407*LONG+0.0162*SLOPE+0.000117*RELIEF)}$	San Juan-Dolores	54	78.1	122
$Q_{feb} = 10^{33.5} AREA^{0.834} 10^{(0.324*LONG+0.0113*SLOPE+0.000083*RELIEF)}$	San Juan-Dolores	54	83.4	84
$Q_{mar} = 10^{27.7} AREA^{0.712} 10^{(0.270*LONG+0.000106*ELEVMAX)}$	San Juan-Dolores	54	79.3	83
$Q_{apr} = 10^{14.4} AREA^{0.701} 10^{(0.171*LONG+0.000200*ELEVMAX+0.770*100Y6H)}$	San Juan-Dolores	54	87.3	72
$Q_{may} = 10^{29.7} AREA^{0.561} 10^{(0.309*LONG+0.000261*ELEVMAX+0.502*100Y6H)}$	San Juan-Dolores	54	85.6	91
$Q_{jun} = 10^{52.3} AREA^{0.483} 10^{(0.509*LONG+0.000289*ELEVMAX)}$	San Juan-Dolores	54	78.5	150
$Q_{jul} = 10^{43.8} AREA^{0.964} 10^{(0.419*LONG+0.0322*SLOPE)}$	San Juan-Dolores	54	76.0	147
$Q_{aug} = 10^{36.7} AREA^{1.04} 10^{(0.353*LONG+0.0233*SLOPE)}$	San Juan-Dolores	54	75.1	142
$Q_{sep} = 10^{44.4} AREA^{1.03} 10^{(0.425*LONG+0.0211*SLOPE)}$	San Juan-Dolores	54	73.9	156
$Q_{oct} = 10^{42.1} AREA^{0.902} 10^{(0.401*LONG+0.0195*SLOPE)}$	San Juan-Dolores	54	78.6	107
$Q_{nov} = 10^{44.7} AREA^{0.719} 10^{(0.427*LONG+0.0140*SLOPE+0.000110*RELIEF)}$	San Juan-Dolores	54	78.9	105
$Q_{dec} = 10^{47.7} AREA^{0.745} 10^{(0.458*LONG+0.0147*SLOPE+0.000129*RELIEF)}$	San Juan-Dolores	54	78.4	119
$Q_{ann} = 10^{21.5} AREA^{0.753} 10^{(0.241*LONG+0.000305*ELEVMAX+0.587*100Y6H)}$	Green River	57	91.3	73
$Q_{jan} = 10^{13.4} AREA^{0.792} 10^{(0.164*LONG+0.000273*ELEVMAX+0.0295*SLOPE)}$	Green River	56	84.1	115
$Q_{feb} = 10^{13.9} AREA^{0.843} 10^{(0.165*LONG+0.000229*ELEVMAX+0.0277*SLOPE)}$	Green River	57	85.5	110
$Q_{mar} = 10^{23.5} AREA^{1.22} 10^{(0.237*LONG+0.504*PPTAUG)}$	Green River	57	86.4	107
$Q_{apr} = 10^{20.1} AREA^{1.23} 10^{(0.534*LAT+0.407*LONG+0.792*PPTAUG)}$	Green River	57	84.5	131
$Q_{may} = 10^{12.7} AREA^{1.21} 10^{(0.805*LAT+0.446*LONG+0.144*PPTAUG)}$	Green River	57	85.6	131

$Q_{jun} = 10^{-13.7} AREA^{0.885} 10^{(0.240*LAT+0.000276*ELEVMAX+0.0414*PPTANN)}$	Green River	57	91.3	90
$Q_{jul} = 10^{-2.44} AREA^{0.938} 10^{(0.000109*RELIEF+0.573*PPTAUG+0.0603*SWE)}$	Green River	57	90.5	83
$Q_{aug} = 10^{-1.90} AREA^{1.07} 10^{(1.05*PPTAUG+0.0419*SWE-0.638*100Y6H)}$	Green River	57	85.9	99
$Q_{sep} = 10^{-3.44} AREA^{1.13} 10^{(0.0228*SLOPE+0.732*PPTAUG+0.0382*SWE)}$	Green River	57	85.6	109
$Q_{oct} = 10^{-4.36} AREA^{0.877} 10^{(0.000242*ELEVMAX+0.0329*SLOPE+0.0293*SWE)}$	Green River	57	85.9	119
$Q_{nov} = 10^{-3.66} AREA^{0.903} 10^{(0.000182*ELEVMAX+0.0284*SLOPE+0.0276*SWE)}$	Green River	56	84.4	109
$Q_{dec} = 10^{-1.31} AREA^{1.12} 10^{(0.558*PPTAUG+0.0384*SWE-0.591*100Y6H)}$	Green River	56	84.5	104

Table 3. Regional-regression equations and performance metrics determined by ordinary-least squares for predicting 7-day 2-, 10-, and 50-year minimum streamflow for natural streams in each hydrologic region in central and western Colorado.

[$7Q^{min}$; 7-day 2, 10, and 50-year minimum streamflow in cubic feet per second; N, number of sites used in regression; Adj-R^2, adjusted coefficient of determination in percent; SEP, standard error of prediction in percent; AREA, drainage area in square miles; LAT, latitude of basin centroid in degrees NAD 83; RELIEF, basin relief in feet; SLOPE, mean basin slope in percent; OUTELEV, elevation at basin outlet in feet NAVD 88; MEANELEV, mean basin elevation in feet NAVD 88; 100Y6H, 6-hour, 100-year precipitation, in inches; PPTANN, annual precipitation in inches; SWE, snow-water equivalent on April 1 in inches]

Regression equation	River basin	N	Adj-R^2	SEP
Approximate range of predictor variables: AREA: 0.89-22,629, LAT: 36.246-41.472, RELIEF: 694-10,035, SLOPE: 6.82-69.4, OUTELEV: 3,995-10,499, MEANELEV: 4,808-11,954,100Y6H: 1.61-3.45, PPTANN: 8.60-60.4, SWE: 0-32.3				
$7Q_2^{min} = 10^{-2.08} AREA^{0.995} 10^{(0.0000356*RELIEF+0.0142*SLOPE+0.0382*SWE)}$	Colorado-East Slope Headwaters	156	76.1	102
$7Q_{10}^{min} = 10^{-3.38} AREA^{1.04} 10^{(0.000109*RELIEF+0.0209*SLOPE+0.0673*SWE)}$	Colorado-East Slope Headwaters	156	51.7	420
$7Q_{50}^{min} = 10^{-3.66} AREA^{1.09} 10^{(0.0000602*RELIEF+0.0275*SLOPE+0.0693*SWE)}$	Colorado-East Slope Headwaters	156	49.3	475
$7Q_2^{min} = 10^{(24.8-0.567*LAT+0.0127*SLOPE+0.100*SWE-1.50*100Y6H)}$	Rio Grande	40	36.6	203
$7Q_{10}^{min} = 10^{(33.8-0.797*LAT+0.0258*SLOPE+0.119*SWE-2.00*100Y6H)}$	Rio Grande	40	33.7	362
$7Q_{50}^{min} = 10^{(45.3-1.10*LAT+0.0335*SLOPE+0.141*SWE-2.31*100Y6H)}$	Rio Grande	40	29.8	785
$7Q_2^{min} = 10^{(86.8-2.05*LAT-0.000871*OUTELEV+0.202*PPTANN-3.59*100Y6H)}$	San Juan-Dolores	44	55.6	406
$7Q_{10}^{min} = 10^{(102-2.40*LAT-0.00118*OUTELEV+0.284*PPTANN-4.55*100Y6H)}$	San Juan-Dolores	44	46.1	5027
$7Q_{50}^{min} = 10^{(48.9-1.13*LAT-0.000732*OUTELEV+0.212*PPTANN-3.18*100Y6H)}$	San Juan-Dolores	44	40.1	2379
$7Q_2^{min} = 10^{20.5} AREA^{0.857} 10^{(-0.638*LAT+0.000270*MEANELEV+0.0415*PPTANN)}$	Green River	44	77.2	132
$7Q_{10}^{min} = 10^{45.7} AREA^{0.709} 10^{(-1.33*LAT+0.000432*MEANELEV+0.0679*PPTANN)}$	Green River	44	59.3	680
$7Q_{50}^{min} = 10^{54.3} AREA^{0.478} 10^{(-1.57*LAT+0.000547*MEANELEV+0.0586*PPTANN)}$	Green River	44	62.4	610

Table 4. Regional-regression equations and performance metrics determined by ordinary-least squares for predicting streamflow-duration values for annual exceedance probabilities of 10, 25, 50, 75, and 90 percent for natural streams in each hydrologic region in central and western Colorado.

[Q_{xxth}, xxth percentile of flow duration in cubic feet per second; N, number of sites used in regression; Adj-R^2, adjusted coefficient of determination in percent; SEP, standard error of prediction, in percent; LAT, latitude of basin centroid in decimal degrees NAD 83; LONG, longitude of basin centroid in decimal degrees NAD 83; AREA, drainage area in square miles; MEANELEV, mean basin elevation in feet NAVD 88; SLOPE, mean basin slope in percent; RELIEF, basin relief in feet; SWE, snow water equivalent on April 1 in inches; 100Y24H, 24-hour, 100-year precipitation, in inches]

Regression equation	River basin	N	Adj-R^2	SEP
Approximate range of predictor variables: AREA: 0.89-22,629, LAT: 36.088-41.472, LONG: -110.052- -105.226, MEANELEV: 4,808-11,954, SLOPE: 6.82-69.4, RELIEF: 533-10,035, SWE: 0-33.8, 100Y24H: 2.19-5.21				
$Q_{10th} = 10^{-0.785} AREA^{0.750} 10^{(0.0000935*RELIEF+0.0000587*MEANELEV+0.0503*SWE)}$	Colorado-East Slope Headwaters	170	80.7	69
$Q_{25th} = 10^{-1.50} AREA^{0.700} 10^{(0.000145*RELIEF+0.0000698*MEANELEV+0.0428*SWE)}$	Colorado-East Slope Headwaters	170	71.2	103
$Q_{50th} = 10^{-1.70} AREA^{0.741} 10^{(0.000141*RELIEF+0.0000477*MEANELEV+0.0365*SWE)}$	Colorado-East Slope Headwaters	170	72.3	105
$Q_{75th} = 10^{-2.38} AREA^{0.835} 10^{(0.000126*RELIEF+0.0000822*MEANELEV+0.0366*SWE)}$	Colorado-East Slope Headwaters	170	75.2	103
$Q_{90th} = 10^{-3.00} AREA^{0.891} 10^{(0.000129*RELIEF+0.000111*MEANELEV+0.0418*SWE)}$	Colorado-East Slope Headwaters	170	69.1	140
$Q_{10th} = 10^{21.9} AREA^{0.858} 10^{(0.117*LAT+0.251*LONG+0.0912*SWE)}$	Rio Grande	42	93.8	42
$Q_{25th} = 10^{39.4} AREA^{0.858} 10^{(0.301*LAT+0.486*LONG+0.0967*SWE)}$	Rio Grande	42	87.9	59
$Q_{50th} = 10^{70.1} AREA^{0.981} 10^{(0.456*LAT+0.836*LONG+0.103*SWE)}$	Rio Grande	42	74.6	108
$Q_{75th} = 10^{64.8} AREA^{0.928} 10^{(0.430*LAT+0.777*LONG+0.0955*SWE)}$	Rio Grande	42	70.0	117
$Q_{90th} = 10^{63.7} AREA^{0.803} 10^{(0.509*LAT+0.796*LONG+0.108*SWE)}$	Rio Grande	42	48.2	238
$Q_{10th} = 10^{(65.2+0.591*LONG+0.000300*RELIEF-0.360*100Y24H+0.0362*SWE)}$	San Juan-Dolores	54	74.4	135
$Q_{25th} = 10^{(71.9+0.650*LONG+0.000309*RELIEF-0.610*100Y24H+0.0446*SWE)}$	San Juan-Dolores	54	74.8	142
$Q_{50th} = 10^{(78.1+0.702*LONG+0.000353*RELIEF-1.03*100Y24H+0.0791*SWE)}$	San Juan-Dolores	54	69.6	249
$Q_{75th} = 10^{(82.8+0.753*LONG+0.000418*RELIEF-1.05*100Y24H+0.0971*SWE)}$	San Juan-Dolores	54	70.1	357
$Q_{90th} = 10^{(77.9+0.713*LONG+0.000392*RELIEF-0.987*100Y24H+0.118*SWE)}$	San Juan-Dolores	54	61.8	718
$Q_{10th} = 10^{22.1} AREA^{1.18} 10^{(0.249*LONG+0.000527*ELEV-0.00364*SLOPE)}$	Green River	57	84.7	130
$Q_{25th} = 10^{12.7} AREA^{1.21} 10^{(0.161*LONG+0.000425*ELEV+0.00537*SLOPE)}$	Green River	57	87.5	106
$Q_{50th} = 10^{11.3} AREA^{1.23} 10^{(0.157*LONG+0.000436*ELEV+0.0191*SLOPE)}$	Green River	57	88.3	107
$Q_{75th} = 10^{14.2} AREA^{1.28} 10^{(0.191*LONG+0.000463*ELEV+0.0300*SLOPE)}$	Green River	57	79.1	216

$Q_{90th} = 10^{9.10} AREA^{1.22} 10^{(0.162*LONG+0.000631*ELEV+0.0406*SLOPE)}$	Green River	57	67.8	512

Table 5. Regional-regression equations and performance metrics determined by ordinary-least squares for predicting 7-day 2-, 10-, and 50-year maximum streamflow for natural streams in each hydrologic region in central and western Colorado.

[$7Q^{max}$; 7 day 2-, 10-, and 50-year maximum streamflow in cubic feet per second; N, number of sites used in regression; PseudoR^2, pseudo coefficient of determination in percent; SEP, standard error of prediction in precent; SME, standard model error in percent; AREA, drainage area in square miles; LONG, longitude of basin centroid in decimal degrees NAD 83; LAT, latitude of basin centroid in decimal degrees NAD 83; SLOPE, mean basin slope in percent; MEANELEV, mean basin elevation in feet NAVD 88; 100Y6H, 6-hour, 100-year precipitation in inches; PPTANN, annual precipitation in inches; SWE, snow-water equivalent on April 1 in inches]

Regression equation	River basin	N	PseudoR^2	SEP	SME
Approximate range of predictor variables: AREA: 0.89-22,629, LONG: -110.052- -105.226, LAT: 36.088-41.472, SLOPE: 6.82-69.4, MEANELEV: 4,808-11,954, 100Y6H: 1.61-3.45, PPTANNUAL: 8.60-61.6, SWE: 0-33.8					
$7Q_2^{max} = 10^{-0.0371} AREA^{0.867} 10^{(0.00673*SLOPE+0.00969*PPTANN+0.0413*SWE)}$	Colorado-East Slope Headwaters	167	85.2	55	54
$7Q_{10}^{max} = 10^{0.397} AREA^{0.869} 10^{(0.00442*SLOPE+0.00945*PPTANN+0.0303*SWE)}$	Colorado-East Slope Headwaters	167	89.2	46	45
$7Q_{50}^{max} = 10^{0.596} AREA^{0.871} 10^{(0.00334*SLOPE+0.00942*PPTANN+0.0249*SWE)}$	Colorado-East Slope Headwaters	167	90.3	43	42
$7Q_2^{max} = 10^{-0.976} AREA^{0.845} 10^{(0.0000623*RELIEF+0.0740*SWE+0.259*100Y6H)}$	Rio Grande	35	93.9	44	41
$7Q_{10}^{max} = 10^{-0.643} AREA^{0.861} 10^{(0.0000662*RELIEF+0.0565*SWE+0.292*100Y6H)}$	Rio Grande	35	96.1	33	30
$7Q_{50}^{max} = 10^{-0.404} AREA^{0.861} 10^{(0.0000669*RELIEF+0.0488*SWE+0.282*100Y6H)}$	Rio Grande	35	96.5	31	27
$7Q_2^{max} = 10^{19.8} AREA^{0.932} 10^{(0.206*LONG+0.000237*MEANELEV+0.294*100Y6H)}$	San Juan-Dolores	52	91.1	58	55
$7Q_{10}^{max} = 10^{10.4} AREA^{0.887} 10^{(0.113*LONG+0.000200*MEANELEV+0.363*100Y6H)}$	San Juan-Dolores	52	93.7	43	40
$7Q_{50}^{max} = 10^{6.18} AREA^{0.865} 10^{(0.0705*LONG+0.000169*MEANELEV+0.388*100Y6H)}$	San Juan-Dolores	52	94.5	37	34
$7Q_2^{max} = 10^{-2.20} AREA^{0.970} 10^{(0.562*LAT+0.224*LONG+0.000481*MEANELEV)}$	Green River	52	87.0	78	73
$7Q_{10}^{max} = 10^{-2.99} AREA^{0.888} 10^{(0.413*LAT+0.146*LONG+0.000348*MEANELEV)}$	Green River	52	88.1	63	58
$7Q_{50}^{max} = 10^{-2.50} AREA^{0.854} 10^{(0.312*LAT+0.105*LONG+0.000277*MEANELEV)}$	Green River	52	87.9	58	54

Application and Limitations of Peak-, Mean-, and Low-Streamflow Regional-Regression Equations

This section provides four methods to estimate peak-, mean-, and low-streamflow at streams in central and western Colorado. The strongest method may depend on several factors and are grouped into four categories: (1) weighting of streamflow estimates using more than one method can result in more reliable AEPDs if the site of interest is located at a streamgage and sufficient record length exists, (2) the drainage-area ratio between the site of interest and the streamgage if the site of interest is on the same stream as the streamgage, (3) if the streamgage data are representative of the streamflow characteristics at the site of interest, and (4) whether or not the site of interest spans more than one hydrologic region.

Use of Peak-, Mean-, and Low-Streamflow Regional-Regression Equations at Streamgages

When determining streamflow statistics at streamgages, using the at-site streamflow estimates (as presented earlier in this report and available in Kohn and others [2023]), are preferred over the regional regression equations (England and others, 2019). Improved estimates of AEPDs at streamgages can also be obtained by weighting the AEPD EMA/MGB estimate with the PSRRE estimate as recommended by Bulletin 17C. Additional information on this method can be found in Gotvald and others (2012), Kohn and others (2016), and England and others (2019). An online database of historical floods (Kohn and others, 2013) exists for Colorado and can be used as a reference for historical floods that have occurred at streamgages.

Use of Peak-, Mean-, and Low-Streamflow Regional-Regression Equations on Gaged Streams

Sites of interest, on streams with streamgages, may have estimates determined by area weighting the AEPDs based on the drainage-area ratio between the site of interest and the streamgage on the same stream (Olson, 2014). The weighting procedure is not applicable when the drainage-area ratio is less than 0.5 or greater than 1.5 or when the flood characteristics substantially change between sites (Eash and others, 2013). To compute the area-weighted estimate at the ungaged site, the gaged streamflow for the streamgage must be known, then the area-weighted streamflow for the ungaged site can be computed using the following equation (Olson, 2014):

$$Q_{uaw} = \left(\frac{A_{(u)}}{A_{(g)}}\right)^{b} Q_g \qquad (6)$$

where:

Q_{uaw} is the area-weighted streamflow statistic estimate for the ungaged site, in cubic feet per second;

$A_{(u)}$ is the drainage area of the ungaged site, in square miles;

$A_{(g)}$ is the drainage area of the gaged site, in square miles;

Q_g is the gaged streamflow, in cubic feet per second; and

b is the exponent of drainage area adjustment for the streamflow statistic and hydrologic region of the streamgage (table 6).

Following McCarthy and others (2016), an OLS analysis using only drainage area as an independent variable was performed for each PMLSRRE to define the regional exponent for area-weighted estimates, and the resulting regional exponents and constants for each hydrologic region of central and western Colorado are in table 6. The regional constants represent the unit drainage area for a given streamflow event for the reference basin (Vogel and Sankarasubramanian, 2000; Farmer and others, 2015).

Table 6. Regional exponents and constants determined from regional regression of log-transformed drainage area for area-weighting method to estimate annual exceedance-probability discharges for ungaged sites on gaged streams.

[East Slope, Colorado-East Slope; San Juan, San Juan-Dolores; Q, streamflow in cubic feet per second; QX, 2, 5, 10, 25, 50, 100, 200, and 500-year peak streamflow; 7Qmin, 7-day 2-, 10-, and 50-year minimum streamflow; 7Qmax, 7-day 2, 10, and 50-year maximum streamflow; Annual Q, mean annual streamflow; Month Q; mean monthly streamflow; QXth, 10, 25, 50, 75, and 90-th annual exceedance-probability streamflow; Exp b, exponent b; Const., constant]

	River Basin Hydrologic Region								Mean Elevation Hydrologic Region							
	East Slope		Rio Grande		San Juan		Green River		Alpine		Sub-alpine		Mid-elevation		Plateau	
Flow statistic	Exp b	Const.	Exp b	Const.	Exp b	Const.	Exp b	Const.	Exp b	Const.	Exp b	Const.	Exp b	Const.	Exp b	Const.
Q2	0.718	1.31	0.861	0.758	0.620	1.54	0.703	1.17	0.808	1.26	0.751	1.27	0.852	0.954	0.610	1.28
Q5	0.727	1.46	0.869	0.984	0.553	1.95	0.619	1.60	0.783	1.45	0.750	1.44	0.836	1.20	0.531	1.78
Q10	0.731	1.54	0.872	1.10	0.520	2.17	0.577	1.81	0.770	1.54	0.750	1.53	0.828	1.33	0.491	2.03
Q25	0.734	1.63	0.874	1.22	0.486	2.39	0.535	2.03	0.756	1.64	0.749	1.62	0.818	1.46	0.450	2.30
Q50	0.735	1.68	0.875	1.30	0.466	2.53	0.508	2.16	0.747	1.71	0.749	1.68	0.813	1.54	0.424	2.46
Q100	0.735	1.73	0.875	1.37	0.448	2.66	0.485	2.28	0.738	1.76	0.749	1.73	0.807	1.62	0.401	2.61
Q200	0.736	1.78	0.875	1.44	0.432	2.77	0.464	2.39	0.730	1.82	0.748	1.78	0.802	1.68	0.381	2.75
Q500	0.735	1.83	0.875	1.51	0.413	2.91	0.440	2.51	0.721	1.88	0.748	1.83	0.796	1.76	0.357	2.91
7Qmin2	0.918	-0.897	0.861	-0.583	0.976	-1.3	0.777	-0.921	1.090	-0.972	0.984	-0.938	1.090	-1.57	0.773	-1.34
7Qmin10	0.892	-1.1	0.530	-0.649	0.589	-0.491	0.768	-1.19	1.090	-1.15	0.960	-1.13	1.050	-1.84	0.600	-1.15
7Qmin50	0.881	-1.14	0.765	-1.1	0.650	-0.757	0.799	-1.35	1.140	-1.37	1.040	-1.31	0.885	-1.52	0.673	-1.53
7Qmax2	0.721	1.16	0.917	0.464	0.653	0.945	0.587	1.15	0.808	1.14	0.766	1.09	0.963	0.524	0.763	0.21
7Qmax10	0.755	1.33	0.953	0.724	0.645	1.29	0.602	1.44	0.797	1.35	0.783	1.3	0.944	0.866	0.771	0.597
7Qmax50	0.772	1.42	0.975	0.839	0.643	1.48	0.621	1.57	0.790	1.46	0.786	1.42	0.936	1.03	0.781	0.808
Annual Q	0.776	0.277	0.850	-0.113	0.636	0.235	0.920	-0.314	0.876	0.249	0.840	0.203	1.000	-0.347	0.859	-0.719
January Q	0.900	-0.703	0.783	-0.608	0.776	-0.831	1.150	-1.45	1.040	-0.76	0.995	-0.806	1.120	-1.34	0.969	-1.6
February Q	0.938	-0.763	0.812	-0.623	0.805	-0.724	1.110	-1.29	1.070	-0.838	1.010	-0.827	1.110	-1.27	0.915	-1.21
March Q	0.972	-0.698	0.886	-0.551	0.682	-0.165	1.160	-1.17	1.120	-0.843	1.070	-0.797	1.020	-0.82	0.889	-0.877
April Q	0.973	-0.245	1.010	-0.346	0.573	0.461	1.120	-0.688	1.130	-0.496	1.020	-0.237	0.945	-0.0692	0.926	-0.757
May Q	0.810	0.613	0.974	0.116	0.463	0.916	1.100	-0.224	0.978	0.411	0.838	0.65	0.959	0.29	1.030	-0.867
June Q	0.709	0.924	0.842	0.239	0.482	0.763	1.020	-0.11	0.872	0.841	0.789	0.831	1.070	-0.109	0.983	-0.93
July Q	0.663	0.559	0.709	0.0426	0.751	-0.129	0.954	-0.532	0.875	0.476	0.824	0.32	1.100	-0.782	0.960	-1.13
August Q	0.737	0.0804	0.649	0.0131	0.881	-0.55	0.960	-0.911	0.937	0.0217	0.934	-0.205	1.070	-1.04	0.937	-1.15
September Q	0.799	-0.178	0.686	-0.195	0.868	-0.602	0.988	-1.04	0.970	-0.229	0.945	-0.382	1.110	-1.23	0.913	-1.12
October Q	0.851	-0.31	0.748	-0.332	0.745	-0.331	1.090	-1.16	0.984	-0.345	0.963	-0.465	1.080	-1.07	0.966	-1.21

November Q	0.888	-0.494	0.783	-0.51	0.720	-0.469	1.010	-1.02	1.010	-0.533	0.978	-0.608	1.090	-1.14	0.822	-1.03
December Q	0.891	-0.613	0.816	-0.651	0.758	-0.713	0.993	-1.05	1.040	-0.691	0.973	-0.707	1.110	-1.28	0.782	-1.06
Q10th	0.750	0.762	0.892	0.213	0.578	0.719	0.774	0.428	0.861	0.729	0.833	0.661	1.020	0.0473	0.703	-0.0544
Q25th	0.830	0.126	0.779	-0.0514	0.644	0.109	0.923	-0.431	0.951	0.103	0.948	-0.0535	1.080	-0.669	0.703	-0.413
Q50th	0.889	-0.41	0.730	-0.277	0.690	-0.418	1.020	-1.05	1.000	-0.428	0.994	-0.564	1.130	-1.22	0.716	-0.782
Q75th	0.936	-0.74	0.695	-0.439	0.652	-0.535	0.838	-0.875	1.050	-0.73	0.965	-0.727	1.090	-1.35	0.657	-0.924
Q90th	0.924	-0.869	0.622	-0.462	0.760	-0.848	0.790	-0.899	1.080	-0.919	0.983	-0.902	1.040	-1.42	0.655	-1.02

Use of Peak-, Mean-, and Low-Streamflow Regional-Regression Equations on Ungaged Streams

The PMLSRREs can be used if the ungaged site meets the criteria for use of this method. The PMLSRREs presented in tables 1-5 are applicable for streams that are minimally affected by anthropogenic activities and urbanization within the basin. The applicable range of basin characteristics that are used as explanatory variables for the PSRREs is listed in tables 1-5. These PMLSRREs are to be used with caution at ungaged locations for which the basin characteristics are outside the range of those used to develop the PMLSRREs. These PMLSRREs also are to be used with caution at ungaged locations outside Colorado or outside the study area.

Use of Peak-, Mean-, and Low-Streamflow Regional-Regression Equations on Ungaged Streams in Two Hydrologic Regions

For an ungaged site on a stream that crosses hydrologic regions, the PMLSRREs for each region can be applied separately using basin characteristics for the entire drainage basin above the ungaged site (Gotvald and others, 2012). The individual streamflows from each region can then be weighted by the proportion of drainage area within each region and added to produce final estimates for the ungaged site. For example, if 25 percent of the drainage area at an ungaged site is in the upstream region and 75 percent is in the downstream region, the streamflow estimate based on PMLSRREs for the upstream region are multiplied by 0.25 and added to 0.75 times the regression estimate based on PMLSRREs for the downstream region. The variance of prediction for such a weighted estimate can also be approximated by using the same weighting procedure based on proportional drainage areas (Gotvald and others, 2012).

StreamStats

The USGS has developed a Web-based computer program, StreamStats, (https://streamstats.usgs.gov/ss/) (Ries and others, 2004; USGS, 2022), which facilitates the computation of peak-, mean-, and low-streamflow using regional-regression equations published in this and previous reports for Colorado (Kohn and others, 2016). StreamStats allows the user to obtain streamflow statistics for both gaged and ungaged sites by selecting a specific stream location on a map interface. If a user selects the location of a USGS streamgage, the user will receive previously published streamflow statistics and related information for the streamgage from a database. If the location of interest lacks a streamgage, StreamStats delineates the basin upstream from the selected location, computes basin and climatic characteristics, and provides estimates of the streamflow statistics using the regional-regression equations. The results are presented in a report with a map showing the basin-boundary outline. The estimates are applicable for natural stream sites not substantially affected by regulation, diversions, channelization, backwater, or urbanization. StreamStats reduces the effort of estimating streamflow statistics to only a few minutes.

StreamStats makes the process of computing streamflow statistics for ungaged sites much faster, more accurate, and more consistent than previously used manual methods (Eash and others, 2013). It also makes streamflow statistics for streamgages available without the need to locate, obtain, and read the publications in which streamflow statistics were originally provided. Examples of streamflow statistics that can be provided by StreamStats include the $Q_{1\%}$ streamflow, the mean-daily and mean-annual streamflow, and the mean 7-day, 10-year low streamflow along with all the other equations presented in tables 1-5. Examples of basin characteristics include the drainage area, basin elevation, mean-annual precipitation, percent of area underlain by hydrologic soil types, and so forth. Basin characteristics provided by StreamStats are the physical, geologic, and climatic properties that have been statistically related to movement of water through a drainage basin to a stream site.

Explanatory variables used to develop the PMLSRREs presented in this report for Colorado are compatible for use with StreamStats and have been included in StreamStats to ease the computation of estimates of peak, mean, and low streamflow for users.

Summary

The U.S. Geological Survey (USGS), in cooperation with the Colorado Department of Transportation, developed peak-, mean- and low-streamflow regional-regression equations for estimating various streamflow statistics for natural streamflow in central and western Colorado. At the completion of the streamgage selection process, a total of 418 streamgages, consisting of 15,202 years of record and a mean of approximately 36 years of record per streamgage, were used to develop the peak-streamflow regional-regression equations. Many streamgages only collect annual-peak streamflow data and do not collect daily streamflow whereas other streamgages are only operated seasonally so daily streamflow is collected only a portion of the year. As a result, 323 of the 418 streamgages could be used to develop the mean- and low-streamflow regional regression equations. The estimated annual exceedance-probability discharges for each streamgage were computed using the USGS software program PeakFQ version 7.4. Mean-monthly streamflows and the 7-day minimum and maximum streamflows were computed by the USGS software program SWToolbox version 1.0.5. The streamflow-duration values were computed using an R script. The peak-, mean-, and low-streamflow regional-regression equations were determined using data through water year 2019 (October 1, 2018, through September 30, 2019). Based on previous studies conducted in Colorado and neighboring States and on the availability of data, 97 characteristics (55 basin and 42 climatic characteristics) were evaluated as candidate explanatory variables in the regression analysis.

After analyzing the study area for potential regional subdivisions based on river basin, elevation, latitude and longitude, and previous studies, central and western Colorado was divided into four new hydrologic regions based on mean basin elevation (less than 8,014 feet, less than 9,492 feet and greater than 8,014 feet, less than 10,490 feet and greater than 9,492 feet, and greater than 10,490 feet) for the peak-streamflow regional-regression equations and based on river basin (Colorado-East Slope Headwaters, Green River, Rio Grande, and San Juan-Dolores) for the mean-streamflow regional-regression equations and resulted in the smallest standard model error and standard error of prediction and largest pseudo coefficient of determination. Prior to finalizing the new regions, maps of streamgage residuals were created and various other subdivisions were analyzed based on latitude, longitude, basin outlet elevation, mean basin elevation, maximum basin elevation, drainage area, and basin area.

Final generalized-least squares regression models for peak-streamflow regional-regression equations were selected based on minimizing values of the standard model error and the standard error of prediction and maximizing values of pseudo coefficient of determination. Final ordinary-least squares regression models for mean-annual and the 12 mean-monthly streamflows were selected based on minimizing values of standard error of prediction and maximizing values of adjusted coefficient of determination. Final ordinary-least squares regression models for 7-day minimum streamflows and streamflow-duration values were selected based on minimizing values of standard error of prediction and maximizing values of adjusted coefficient of determination. Final generalized-least squares regression models for 7-day maximum streamflows were selected based on minimizing values of standard model error and standard error of prediction and maximizing values of pseudo coefficient of determination.

The peak-streamflow regional-regression equations in the Alpine, Sub-Alpine, Mid-Elevation, and Plateau hydrologic regions were developed using a total of 105, 104, 104, and 105 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the peak-streamflow regional-regression equations were based on the 1-percent annual exceedance-probability discharge for each hydrologic region. The mean-streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 170, 42, 54, and 57 streamgages, respectively, and no streamgages were used in more than one region. The 7-day minimum streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 156, 40, 44, and 44 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the 7-day minimum streamflow equations were based on the 10-percent annual-recurrence interval 7-day minimum streamflow statistic for each hydrologic region. The streamflow-duration values and regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 170, 42, 54, and 57 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the streamflow-duration equations were based on the 50-percent streamflow-duration statistic for each hydrologic region. The 7-day maximum streamflow regional-regression equations in the Colorado-East Slope Headwaters, Rio Grande, San Juan-Dolores, and Green River hydrologic regions were developed using a total of 167, 35, 52, and 52 streamgages, respectively, and no streamgages were used in more than one region. The selection of the final basin and climatic characteristics and the evaluation of the accuracy of the 7-day minimum streamflow equations were based on the 10-percent annual-recurrence interval 7-day maximum streamflow statistic for each hydrologic region.

References Cited

Asante, K.O., Artan, G.A., Pervez, S., Bandaragoda, C. and Verdin, J.P., 2008, Technical Manual for the Geospatial Stream Flow Model (GeoSFM): U.S. Geological Survey Open-File Report 2007–1441, 65 p.

Asquith, W.H., Roussel, M.C., and Vrabel, Joseph, 2006, Statewide analysis of the drainage-area ratio method for 34 streamflow percentile ranges in Texas: U.S. Geological Survey Scientific Investigations Report 2006–5286, 34 p., 1 appendix.

Bonnin, G.M., Martin, D., Lin, B., Parzybok, T., Yekta, M., and Riley, D., 2011, Precipitation-frequency atlas of the United States: National Weather Service, National Oceanic and Atmospheric Administration Atlas 14, v. 1, version 5.0 Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah), accessed August 1, 2020, at https://www.nws.noaa.gov/oh/hdsc/PF_documents/Atlas14_Volume1.pdf.

Capesius, J.P., and Stephens, V.C., 2009, Regional regression equations for the estimation of natural streamflow statistics in Colorado: U.S. Geological Survey Scientific Investigations Report 2009–5136, 46 p.

Cohn, T.A., England, J.F., Berenbrock, C.E., Mason, R.R., Stedinger, J.R., and Lamontagne, J.R., 2013, A generalized Grubbs-Beck test statistic for detecting multiple potentially influential low outliers in flood series: Water Resources Research, v. 49, no. 8, p. 5047–5058.

Colorado Division of Water Resources [CODWR], 2020, Colorado Division of Water Resources Surface Water Stations: Colorado Division of Water Resources Web site, accessed May 21, 2020, https://dwr.state.co.us/Tools/Stations/.

Cress, Jill, Soller, David, Sayre, Roger, Comer, Patrick, and Warner, Harumi, 2010, Terrestrial ecosystems—Surficial lithology of the conterminous United States: U.S. Geological Survey Scientific Investigations Map 3126, scale 1:5,000,000, 1 sheet.

Eash, D.A., Barnes, K.K., and Veilleux, A.G., 2013, Methods for estimating annual exceedance-probability discharges for streams in Iowa, based on data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2013–5086, 63 p. with appendix, http://pubs.usgs.gov/sir/2013/5086/.

Eng, Ken, Chen, Y., and Kiang, J.E., 2009, User’s guide to the weighted-multiple-linear regression program (WREG version 1.0): U.S. Geological Survey Techniques and Methods, book 4, chap. A8, 21 p.

England, J.F., Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas, W.O., Jr., Veilleux, A.G., Kiang, J.E., and Mason, R.R., Jr., 2019, Guidelines for determining flood flow frequency—Bulletin 17C (ver. 1.1, May 2019): U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p., accessed June 2, 2020, at https://doi.org/10.3133/tm4B5.

Esri, 2017, ArcGIS—A complete integrated system: Redlands, Calif., Esri, accessed July 17, 2020, at http://www.esri.com/software/arcgis/.

Farmer, W.H., 2021, WREG: Weighted Least Squares Regression for Streamflow Frequency Statistics: U.S. Geological Survey software release, R package, Reston, Va., https://doi.org/10.5066/P9ZCGLI1.

Farmer, W.H., Kiang, J.E., Feaster, T.D., and Eng, K., 2019, Regionalization of surface-water statistics using multiple linear regression: U.S. Geological Survey Techniques and Methods, book 4, chap. A12, 40 p., https://doi.org/10.3133/tm4A12.

Farmer, W.H., Over, T.M., and Vogel, R.M., 2015, Multiple regression and inverse moments improve the characterization of the spatial scaling behavior of daily streamflows in the Southeast United States, Water Resources Research., v. 51, no 3, p. 1775–1796, doi:10.1002/ 2014WR015924

Feaster, T.D., Gotvald, A.J., and Weaver, J.C., 2009, Magnitude and frequency of rural floods in the southeastern United States, 2006—Volume 3, South Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5043, 238 p.

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

Gotvald, A.J., Feaster, T.D., and Weaver, J.C., 2009, Magnitude and frequency of rural floods in the southeastern United States, 2006—Volume 1, Georgia: U.S. Geological Survey Scientific Investigations Report 2009–5043, 120 p., accessed June 1, 2020, at https://pubs.usgs.gov/sir/2009/5043/.

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles, 2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl., accessed June 1, 2020, at https://pubs.usgs.gov/sir/2012/5113/.

Griffis, V.W., and Stedinger, J.R., 2007, The use of GLS regression in regional hydrologic analyses: Journal of Hydrology, v. 344, p. 82–95, accessed June 1, 2020, at http://www.sciencedirect.com/science/article/pii/S0022169407003848.

Grubbs, F.E., and Beck, G., 1972, Extension of sample sizes and percentage points for significance test of outlying observations: Technometrics, v. 10, p. 211–219.

Hedman, E.R., Moore, D.O., and Livingston, R.K., 1972, Selected streamflow characteristics as related to channel geometry of perennial streams in Colorado: U.S. Geological Survey Open-File Report 72–160, 24 p.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chap. A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chap. A3, version 1.1.]

Homer, C. G., Dewitz, J. A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N. D., Wickham, J. D., & Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States - Representing a decade of land cover change information, Photogrammetric Engineering and Remote Sensing 81(5), 345-354, accessed September 6, 2019, at https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=309950

Hortness, J.E., 2006, Estimating low-flow frequency statistics for unregulated streams in Idaho: U.S. Geological Survey Scientific Investigations Report 2006-5035, 31 p.

Interagency Advisory Committee on Water Data, 1982, Subcommittee on Hydrology, Hydrologic Frequency Analysis Work Group, Guidelines for determining flood flow frequency: Reston, Va., Hydrology Subcommittee Bulletin 17B, 28 p., and appendixes, accessed March 18, 2022, at https://water.usgs.gov/osw/bulletin17b/dl_flow.pdf.

Kiang, J.E., Flynn, K.M., Zhai, Tong, Hummel, Paul, and Granato, Gregory, 2018, SWToolbox: A surface-water tool-box for statistical analysis of streamflow time series: U.S. Geological Survey Techniques and Methods, book 4, chap. A–11, 33 p., https://doi.org/10.3133/tm4A11.

Kircher, J.E., Choquette, A.F., and Richter, B.D., 1985, Estimation of natural streamflow characteristics in western Colorado: U.S. Geological Survey Water-Resources Investigations Report 85–4086, 28 p.

Kohn, M.S., Jarrett, R.D., Krammes, G.S., and Mommandi, Amanullah, 2013, Web-based flood database for Colorado, water years 1867 through 2011: U.S. Geological Survey Open-File Report 2012–1225, 26 p.

Kohn, M.S., M. Alisa Mast, and Tara A. Gross, 2023, Peak-, mean-, and low-streamflow data for central and western Colorado, 2019: U.S. Geological Survey data release, https://doi.org/10.5066/P9Q5AMFV.

Kohn, M.S., Stevens, M.R., Bock, A.R., and Char, S.J., 2015, Evaluation of mean-monthly streamflow-regression equations for Colorado, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5016, 53 p., http://dx.doi.org/10.3133/sir20155016.

Kohn, M.S., Stevens, M.R., Harden, T.M., Godaire, J.E., Klinger, R.E., and Mommandi, Amanullah, 2016, Paleoflood investigations to improve peak-streamflow regional-regression equations for natural streamflow in eastern Colorado, 2015: U.S. Geological Survey Scientific Investigations Report 2016–5099, 58 p., http://dx.doi.org/10.3133/sir20165099.

Lee, M.T., Asquith, W.H., and Oden, T.D., 2012, Regression model development and computational procedures to support estimation of real-time concentrations and loads of selected constituents in two tributaries to Lake Houston near Houston, Texas, 2005–9: U.S. Geological Survey Scientific Investigations Report 2012–5006, 40 p.

Lewis, J.M., 2010, Methods for estimating the magnitude and frequency of peak streamflows for unregulated streams in Oklahoma: U.S. Geological Survey Scientific Investigations Report 2010–5137, 41 p.

Livingston, R.K., and Minges, D.R., 1987, Techniques for estimating regional flood characteristics of small rural watersheds in the plains of western Colorado: U.S. Geological Survey Water-Resources Investigations Report 87–4094, 72 p.

Lorenz, D.L., 2015, smwrBase—an R package for managing hydrologic data, version 1.1.1: U.S. Geological Survey Open-File Report 2015–1202, 7 p.

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

McCain, J.F., and Jarrett, R.D., 1976, Manual for estimating flood characteristics of natural-flow streams in Colorado: Colorado Water Conservation Board Technical Manual 1, 68 p.

McCarthy, P.M., Sando, Roy, Sando, S.K., and Dutton, D.M., 2016, Methods for estimating streamflow characteristics at ungaged sites in western Montana based on data through water year 2009: U.S. Geological Survey Scientific Investigations Report 2015–5019–G, 19 p., http://dx.doi.org/10.3133/sir20155019G.

Miller, J.F., Frederick, R.H., and Tracy, R.J., 1973, Precipitation-frequency atlas of the Western United States: National Weather Service, National Oceanic and Atmospheric Administration Atlas 2, Volume II—Wyoming, accessed April 30, 2020, at http://www.nws.noaa.gov/oh/hdsc/PF_documents/Atlas2_Volume2.pdf

Miller, K.A., 2003, Peak-flow characteristics of Wyoming streams: U.S. Geological Survey Water-Resources Investigations Report 2003–4107, 79 p.

Montgomery, D.C., Peck, E.A., and Vining, G.G., 2001, Introduction to linear regression analysis (3d ed.): New York, Wiley, 641 p.

National Operational Hydrologic Remote Sensing Center, 2004, Snow Data Assimilation System Data Products at the National Snow and Ice Data Center, accessed April 30, 2020, at https://doi.org/10.7265/N5TB14TC.

Natural Resources Conservation Service, 2019, U.S. General Soil Map (STATSGO2): U.S. Department of Agriculture website accessed September 6, 2019, at https://data.nal.usda.gov/dataset/united-states-general-soil-map-statsgo2.

Natural Resources Conservation Service, 2020, Soil Survey Geodatabase (SSURGO): U.S. Department of Agriculture website accessed July 6, 2020, at https://data.nal.usda.gov/dataset/soil-survey-geographic-database-ssurgo.

Olson, S.A., 2014, Estimation of flood discharges at selected annual exceedance probabilities for unregulated, rural streams in Vermont, *with a section on* Vermont regional skew regression, by Veilleux, A.G.: U.S. Geological Survey Scientific Investigations Report 2014–5078, 27 p. plus appendixes, http://dx.doi.org/10.3133/sir20145078.

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

Patterson, J.L., 1965, Magnitude and frequency of floods in the United States—Part 8, Western Gulf of Mexico basins: U.S. Geological Survey Water-Supply Paper 1682, 506 p.

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

Patton, P.C., 1987, Measuring rivers of the past—A history of fluvial paleohydrology, *in* Landa, E.R., and Ince, S., eds., The history of hydrology—History of geophysics, volume 3: Washington, D.C., American Geophysical Union, p. 55–67.

Perica, Sanja, Martin, D., Pavlovic, S., Roy, I., St. Laurent, M., Trypaluk, C., Unruh, D., Yekta, M., and Bonnin, G., 2013, Precipitation-frequency atlas of the United States: National Weather Service, National Oceanic and Atmospheric Administration Atlas 14, v. 8, version 2.0; Midwestern States (Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, Wisconsin): accessed August 30, 2020, at http://www.nws.noaa.gov/oh/hdsc/PF_documents/Atlas14_Volume8.pdf

Price, C.V., Nakagaki, N., Hitt, K.J., and Clawges, R.C., 2006, Enhanced Historical Land-Use and Land-Cover Data Sets of the U.S. Geological Survey, U.S. Geological Survey Digital Data Series 240. [digital data set] accessed July 6, 2020, at https://pubs.usgs.gov/ds/2006/240.

Price, C.V., Nakagaki, Naomi, and Hitt, K.J., 2010, National Water-Quality Assessment (NAWQA) area-characterization toolbox, release 1.0: U.S. Geological Survey Open-File Report 2010–1268, accessed January 8, 2021, at http://pubs.usgs.gov/of/2010/1268.

PRISM Climate Group, 2018, PRISM Gridded Climate Data: Oregon State University, accessed November 6, 2018, at http://prism.oregonstate.edu.

Rasmussen, P.P. and Perry, C.A., 2000, Estimation of peak streamflows for unregulated rural streams in Kansas: U.S. Geological Survey Water-Resources Investigations Report 2000–4079, 33 p.

R Core Team, 2019, R: A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, accessed 3/11/2022 at, https://www.R-project.org

Ries, K.G., III, Steeves, P.A., Coles, J.D., Rea, A.H., and Stewart, D.W., 2004, StreamStats—A U.S. Geological Survey Web application for stream information: U.S. Geological Survey Fact Sheet 2004–3115.

Soenksen, P.J., Miller, L.D., Sharpe, J.B., and Watton, J.R., 1999, Peak-flow frequency relations and evaluation of the peak-flow gaging network in Nebraska: U.S. Geological Survey Water-Resources Investigations Report 99–4032, 48 p.

Southard, R.E., and Veilleux, A.G., 2014, Methods for estimating annual exceedance-probability discharges and largest recorded floods for unregulated streams in rural Missouri: U.S. Geological Survey Scientific Investigations Report 2014–5165, 39 p., *http://dx.doi.org/10.3133/sir20145165*.

Stedinger, J.R., and Baker, V.R., 1987, Surface water hydrology—Historical and paleoflood Information: Review of Geophysics, v. 25, no. 2, p. 119–124.

Stedinger, J.R., and Tasker, G.D., 1985, Regional hydrologic analysis I—Ordinary, weighted, and generalized least-squares compared: American Geophysical Union, Water Resources Research, v. 21, no. 9, p. 1421–1432.

Tasker, G.D., and Stedinger, J.R., 1986, Regional skew with weighted LS regression: American Society of Civil Engineers Journal of Water Resources Planning and Management, v. 112, no. 2, p. 225–237.

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

U.S. Geological Survey [USGS], 2017, 1/3rd arc-second Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection: U.S. Geological Survey Web site, accessed November 27, 2022, at https://apps.nationalmap.gov/downloader/.

U.S. Geological Survey [USGS], 2020a, Peak Streamflow for the Nation, *in* USGS water data for the Nation: U.S. Geological Survey National Water Information System database, accessed May 21, 2020, at https://doi.org/ 10.5066/F7P55KJN. [Peak streamflow directly accessible at https://nwis.waterdata.usgs.gov/usa/nwis/peak].

U.S. Geological Survey [USGS], 2020b, USGS water data for the Nation: U.S. Geological Survey National Water Information System database, accessed May 21, 2020, at https://doi.org/10.5066/F7P55KJN.

U.S. Geological Survey [USGS], 2020c, National Hydrography Dataset: U.S. Geological Survey Web site, accessed June 29, 2020, at https://www.usgs.gov/core-science-systems/ngp/national-hydrography.

U.S. Geological Survey [USGS], 2022, The StreamStats program: U.S. Geological Survey Web site, accessed February 27, 2022, at https://streamstats.usgs.gov/ss/.

Vaill, J.E., 2000, Analysis of the magnitude and frequency of floods in Colorado: U.S. Geological Survey Water-Resources Investigations Report 99–4190, 35 p.

Veilleux, A.G., 2009, Bayesian GLS regression for regionalization of hydrologic statistics, floods and bulletin 17 skew: Cornell University Master of Science Thesis, 155 p., accessed June 2, 2020, at https://ecommons.cornell.edu/bitstream/handle/1813/13819/Veilleux,%20Andrea.pdf?sequence=1.

Veilleux, A.G., Cohn, T.A., Flynn, K.M., Mason, R.R., Jr., and Hummel, P.R., 2014, Estimating magnitude and frequency of floods using the PeakFQ 7.0 program: U.S. Geological Survey Fact Sheet 2013-3108, 2 p., accessed June 2, 2020, at https://pubs.er.usgs.gov/publication/fs20133108.

Vogel, R.M., and Sankarasubramanian, A., 2000, Spatial scaling properties of annual streamflow in the United States: Hydrological Sciences Journal, v. 45, no. 3, p. 465–476, doi:10.1080/02626660009492342

Waltemeyer, S.D., 2008, Analysis of the magnitude and frequency of peak discharge and maximum observed peak discharge in New Mexico and surrounding areas: U.S. Geological Survey Scientific Investigations Report 2008–5119, 105 p.

Weaver, J.C., Feaster, T.D., and Gotvald, A.J., 2009, Magnitude and frequency of rural floods in the southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report, 2009–5158, 111 p., accessed June 2, 2020, at https://pubs.usgs.gov/sir/2009/5158/.

Appendix 1. Streamgage and Basin and Climatic Characteristics Summary

Information for each of the 418 streamgages used in this report are listed in table 1.1, and each of the 418 streamgages, ancillary information, and basin and climatic characteristics are available in Kohn and others (2023). Based on previous studies conducted in Colorado and neighboring States and on the availability of data, 97 characteristics (55 basin and 42 climatic characteristics) listed in table 1.2 were evaluated as candidate explanatory variables in the regression analysis. The 97 characteristics consist of physical properties of the basin, precipitation amount, snowpack data, temperature, land cover, surficial lithology, and soil characteristics.

Table 1.1. Summary of the streamgages used in the regression analysis of natural streams in central and western Colorado, 2019.

[CO, Colorado; WY, Wyoming; NM, New Mexico; UT, Utah; AZ, Arizona; U.S. Geological Survey information from U.S. Geological Survey (2020); Colorado Division of Water Resources information from Colorado Division of Water Resources (2020); Table is available as a comma separated values (csv) format file for download at https://doi.org/10.3133/sir2022XXXX.]

Table 1.2. Basin and climate characteristics compiled and evaluated for use in the peak-, mean-, and low-streamflow regional-regression equations in central and western Colorado, 2019.

[3DEP, 3D Elevation Program; USGS, U.S. Geological Survey; NWIS, National Water Information System; NAD83, North American Datum of 1983; PRISM, Parameter-Elevation Regressions on Independent Slopes Model;

NOAA, National Oceanic and Atmospheric Administration; STATSGO, State Soil Geographic; NLCD, National Land Cover Dataset; NHD, National Hydrography Dataset; SNODAS, Snow Data Assimilation System; NSIDC, National Snow and Ice Data Center; Table is available as a comma separated values (csv) format file for download at https://doi.org/10.3133/sir2022XXXX.]

References Cited

Colorado Division of Water Resources, 2020, Colorado Division of Water Resources Surface Water Stations: Colorado Division of Water Resources Web site, accessed May 21, 2020, https://dwr.state.co.us/Tools/Stations/.

Kohn, M.S., M. Alisa Mast, and Tara A. Gross, 2023, Peak-, mean-, and low-streamflow data for central and western Colorado, 2019: U.S. Geological Survey data release, https://doi.org/10.5066/P9Q5AMFV.

U.S. Geological Survey, 2020, USGS water data for the Nation: U.S. Geological Survey National Water Information System database, accessed May 21, 2020, at https://doi.org/10.5066/F7P55KJN.

Table 1.1. Summary of the streamgages used in the regression analysis of natural streams in central and western Colorado, 2019.

[CO, Colorado; WY, Wyoming; NM, New Mexico; UT, Utah; AZ, Arizona; Table is available as a comma separated values (csv) format file for download at https://doi.org/10.3133/sir2022XXXX.]

U.S. Geological Survey streamgage number	Colorado Division of Water Resources streamgage abbreviation	Streamgage name	Latitude, decimal degrees (North American Datum of 1983)	Longitude, decimal degrees (North American Datum of 1983)	Number of years of U.S. Geological Survey annual peaks	Number of years of Colorado Division of Water Resources annual peaks	Number of years of U.S. Geological Survey daily streamflow	Number of years of Colorado Division of Water Resources daily streamflow	Previous hydrologic regions	Peak-streamflow hydrologic regions	Mean- and low-streamflow hydrologic regions
06614800	NA	MICHIGAN RIVER NEAR CAMERON PASS, CO	40.49609409	-105.8650119	46	NA	46	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06615500	NA	MICHIGAN RIVER NEAR LINDLAND, CO	40.5535921	-106.0416849	10	NA	10	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06616000	NA	NORTH FORK MICHIGAN RIVER NEAR GOULD, CO	40.5494257	-106.0211287	32	NA	32	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06617100	MICWLDCO	MICHIGAN RIVER AT WALDEN, CO	40.7410876	-106.2794704	25	15	24	18	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06617500	ILLRANCO	ILLINOIS RIVER NEAR RAND, CO	40.46248127	-106.1769682	9	21	8	24	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06618500	NA	ILLINOIS CREEK AT WALDEN, CO	40.72636556	-106.2905819	25	NA	24	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06619500	NA	CANADIAN RIVER AT COWDREY, CO	40.86303036	-106.3114149	14	NA	12	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06620000	NA	NORTH PLATTE RIVER NEAR NORTHGATE, CO	40.93663889	-106.3391944	106	NA	104	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06620400	NA	DOUGLAS CREEK ABOVE KEYSTONE, WY	41.18330597	-106.2700179	10	NA	10	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06621000	NA	DOUGLAS CREEK NEAR FOXPARK, WY	41.0810838	-106.3075224	17	NA	17	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06622000	NA	BIG CREEK AT BIG CREEK RANGER STATION, WY	41.04997	-106.5255879	12	NA	0	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06622500	NA	FRENCH CREEK NEAR FRENCH, WY	41.21388889	-106.5119444	14	NA	13	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06622700	NA	NORTH BRUSH CREEK NEAR SARATOGA, WY	41.3702447	-106.5205815	60	NA	59	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06623800	NA	ENCAMPMENT RIVER ABOVE HOG PARK CREEK, NEAR ENCAMPMENT, WY	41.0235791	-106.824766	55	NA	55	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06624500	NA	ENCAMPMENT RIVER AT ENCAMPMENT, WY	41.2105211	-106.7789283	19	NA	15	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06627500	NA	JACK CREEK AT MATHESON RANCH, NEAR SARATOGA, WY	41.4011111	-107.0163889	10	NA	10	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06629100	NA	RATTLESNAKE CREEK NEAR WALCOTT, WY	41.6988512	-106.6266945	13	NA	0	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06630800	NA	BEAR CREEK NEAR ELK MOUNTAIN, WY	41.65302136	-106.3452959	13	NA	0	NA	Mountain	Plateau	Colorado-East Slope Headwaters
06631100	NA	WAGONHOUND CREEK NEAR ELK MOUNTAIN, WY	41.63996639	-106.3052944	13	NA	0	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06632400	NA	ROCK CREEK ABOVE KING CANYON CANAL, NEAR ARLINGTON, WY	41.58524549	-106.2227908	65	NA	65	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06632700	NA	ONEMILE CREEK NEAR ARLINGTON, WY	41.58552345	-106.191123	13	NA	0	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06661580	NA	SEVENMILE CREEK NEAR CENTENNIAL, WY	41.4580262	-106.0105609	23	NA	0	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06696980	NA	TARRYALL CREEK AT UPPER STATION NEAR COMO, CO	39.33943296	-105.9116813	27	NA	4	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06699005	NA	TARRYALL CREEK BELOW ROCK CREEK NEAR JEFFERSON, CO	39.28693314	-105.6958417	15	NA	14	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06701620	NA	TROUT CREEK BELOW FERN CREEK NEAR WESTCREEK, CO	39.16749104	-105.1222112	17	NA	0	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06701700	NA	WEST CREEK ABOVE SHREWSBURY GULCH NEAR WESTCREEK, CO	39.145425	-105.1600111	17	NA	0	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06706000	NA	NORTH FORK SOUTH PLATTE RIVER BELOW GENEVA CREEK, AT GRANT, CO	39.4572101	-105.6586159	26	NA	25	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06714800	NA	LEAVENWORTH CREEK AT MOUTH NEAR GEORGETOWN, CO	39.68720955	-105.7002821	25	NA	6	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06715000	NA	CLEAR CREEK ABOVE WEST FORK CLEAR CREEK NEAR EMPIRE CO	39.7519319	-105.661947	20	NA	16	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06716100	NA	WEST FORK CLEAR CREEK ABOVE MOUTH NEAR EMPIRE, CO	39.75887636	-105.6600025	25	NA	25	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06717400	NA	CHICAGO CREEK BELOW DEVILS CANYON NEAR IDAHO SPRGS, CO	39.71637678	-105.5713883	15	NA	5	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06721500	NA	NORTH SAINT VRAIN CREEK NEAR ALLENS PARK, CO	40.2188737	-105.5283329	15	NA	16	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06722500	SSVWARCO	SOUTH SAINT VRAIN CREEK NEAR WARD, CO	40.09081927	-105.514443	24	28	24	28	Mountain	Alpine	Colorado-East Slope Headwaters
06723000	NA	MIDDLE SAINT VRAIN CREEK NEAR ALLENS PARK, CO	40.16665194	-105.4444406	20	NA	0	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06725500	BOCMIDCO	MIDDLE BOULDER CREEK AT NEDERLAND, CO	39.9616536	-105.504442	87	15	87	15	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06729000	NA	SOUTH BOULDER CREEK NEAR ROLLINSVILLE, CO	39.9147094	-105.5019417	12	NA	10	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06732000	NA	GLACIER CREEK NEAR ESTES PARK, CO	40.34526186	-105.5855569	18	NA	18	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06733000	BTABESCO	BIG THOMPSON RIVER AT ESTES PARK, CO	40.37831704	-105.513887	52	19	52	21	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06734500	FISHESCO	FISH CREEK NEAR ESTES PARK, CO	40.36859486	-105.4938863	32	22	8	22	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
06746095	NA	JOE WRIGHT CREEK ABOVE JOE WRIGHT RESERVOIR, CO	40.5399822	-105.88279	36	NA	36	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06748200	NA	FALL CREEK NEAR RUSTIC, CO	40.55164929	-105.6269458	13	NA	13	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06748510	NA	LITTLE BEAVER CREEK NEAR IDYLWILDE, CO	40.63859264	-105.6616684	13	NA	13	NA	Mountain	Alpine	Colorado-East Slope Headwaters
06748530	NA	LITTLE BEAVER CREEK NEAR RUSTIC, CO	40.62303736	-105.5649975	13	NA	13	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
06748600	NA	SOUTH FORK CACHE LA POUDRE RIVER NEAR RUSTIC, CO	40.6469261	-105.493605	23	NA	23	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
07079500	NA	EAST FORK ARKANSAS RIVER NEAR LEADVILLE, CO	39.2597114	-106.3405807	13	NA	11	NA	Mountain	Alpine	Colorado-East Slope Headwaters

07081000	NA	TENNESSEE CREEK NEAR LEADVILLE, CO	39.26415578	-106.3408585	15	NA	11	NA	Mountain	Alpine	Colorado-East Slope Headwaters
07082000	NA	LAKE FORK ABOVE SUGAR LOAF RESERVOIR, CO	39.26971096	-106.3950266	22	NA	21	NA	Mountain	Alpine	Colorado-East Slope Headwaters
07083000	NA	HALFMOON CREEK NEAR MALTA, CO	39.17221259	-106.3891926	73	NA	73	NA	Mountain	Alpine	Colorado-East Slope Headwaters
07086500	CCACCRCO	CLEAR CREEK ABOVE CLEAR CREEK RESERVOIR, CO	39.0180493	-106.2778	50	24	49	24	Mountain	Alpine	Colorado-East Slope Headwaters
07089000	NA	COTTONWOOD CREEK BELOW HOT SPRINGS, NEAR BUENA VISTA, CO	38.81277374	-106.2222426	49	NA	49	NA	Mountain	Alpine	Colorado-East Slope Headwaters
07091015	CHCRNACO	CHALK CREEK AT NATHROP	38.74166667	-106.0830556	NA	27	NA	29	Mountain	Alpine	Colorado-East Slope Headwaters
07093740	NA	BADGER CREEK, UPPER STATION, NEAR HOWARD, CO	38.65888469	-105.8138942	23	NA	0	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
07204000	NA	MORENO CREEK AT EAGLE NEST, NM	36.5538722	-105.2679806	72	NA	1	NA	Rio Grande	Mid-Elevation	Rio Grande
07204500	NA	CIENEGUILLA CREEK NEAR EAGLE NEST, NM	36.48521667	-105.2653806	72	NA	2	NA	Rio Grande	Mid-Elevation	Rio Grande
07205000	NA	SIXMILE CREEK NEAR EAGLE NEST, NM	36.518525	-105.2752472	76	NA	17	NA	Rio Grande	Mid-Elevation	Rio Grande
08216500	NA	WILLOW CREEK AT CREEDE, CO	37.85611048	-106.9275456	32	NA	31	NA	Rio Grande	Alpine	Rio Grande
08218500	GOOWAGCO	GOOSE CREEK AT WAGONWHEEL GAP, CO	37.75194676	-106.8300442	37	28	37	28	Rio Grande	Alpine	Rio Grande
08219500	RIOSFKCO	SOUTH FORK RIO GRANDE AT SOUTH FORK, CO	37.65694884	-106.6492082	81	15	80	12	Rio Grande	Sub-Alpine	Rio Grande
08220000	NA	RIO GRANDE NEAR DEL NORTE, CO	37.6886111	-106.4598611	22	NA	12	NA	Rio Grande	Alpine	Rio Grande
08220500	PINDELCO	PINOS CREEK NEAR DEL NORTE, CO	37.5916708	-106.4500382	49	29	38	29	Rio Grande	Alpine	Rio Grande
08223500	NA	ROCK CREEK NEAR MONTE VISTA, CO	37.49028216	-106.2594768	25	NA	23	NA	Rio Grande	Sub-Alpine	Rio Grande
08224500	KERVILCO	KERBER CREEK ABOVE LITTLE KERBER CREEK NEAR VILLA GROVE, CO	38.22027745	-106.089741	61	17	58	12	Rio Grande	Sub-Alpine	Rio Grande
08226700	COCRMICO	COTTON CREEK NEAR MINERAL HOT SPRINGS, CO	38.131987	-105.788048	NA	21	3	21	Rio Grande	Alpine	Rio Grande
08227000	SAGSAGCO	SAGUACHE CREEK NEAR SAGUACHE, CO	38.16333294	-106.290583	88	12	95	12	Rio Grande	Sub-Alpine	Rio Grande
08227500	NOCRESCO	NORTH CRESTONE CREEK NEAR CRESTONE, CO	38.01361029	-105.6927882	46	29	34	29	Rio Grande	Alpine	Rio Grande
08229500	COCRESCO	COTTONWOOD CREEK NEAR CRESTONE, CO	37.933333	-105.6455666	5	21	3	21	Rio Grande	Alpine	Rio Grande
08230500	CARLAGCO	CARNERO CREEK NEAR LA GARITA, CO	37.85972315	-106.3194768	58	29	39	29	Rio Grande	Sub-Alpine	Rio Grande
08231000	LAGLAGCO	LA GARITA CREEK NEAR LA GARITA, CO	37.8133348	-106.318644	70	20	47	12	Rio Grande	Sub-Alpine	Rio Grande
08236000	ALATERCO	ALAMOSA RIVER ABOVE TERRACE RESERVOIR, CO	37.37472769	-106.3347558	56	29	55	29	Rio Grande	Alpine	Rio Grande
08240500	TRITURCO	TRINCHERA CREEK ABOVE TURNERS RANCH, NEAR FORT GARLAND, CO	37.37473306	-105.2950101	59	29	48	29	Rio Grande	Alpine	Rio Grande
08242500	UTEFTGCO	UTE CREEK NEAR FORT GARLAND, CO	37.4472222	-105.4258333	69	20	67	12	Rio Grande	Sub-Alpine	Rio Grande
08245500	NA	CONEJOS RIVER AT PLATORO, CO	37.3538946	-106.5250367	14	NA	14	NA	Rio Grande	Alpine	Rio Grande
08246500	NA	CONEJOS RIVER NEAR MOGOTE, CO	37.05390016	-106.1875269	43	NA	41	NA	Rio Grande	Sub-Alpine	Rio Grande
08247500	NA	SAN ANTONIO RIVER AT ORTIZ, CO	36.99306944	-106.0386325	96	NA	79	NA	Rio Grande	Mid-Elevation	Rio Grande
08248000	NA	LOS PINOS RIVER NEAR ORTIZ, CO	36.9822359	-106.0736334	101	NA	100	NA	Rio Grande	Sub-Alpine	Rio Grande
08249000	NA	CONEJOS RIVER NEAR LASAUSES, CO	37.30028754	-105.7469627	32	NA	31	NA	Rio Grande	Sub-Alpine	Rio Grande
08251500	NA	RIO GRANDE NEAR LOBATOS, CO	37.0786111	-105.7569444	10	NA	10	NA	Rio Grande	Mid-Elevation	Rio Grande
08252500	NA	COSTILLA CREEK ABOVE COSTILLA DAM, NM	36.8983611	-105.2546667	81	NA	0	NA	Rio Grande	Alpine	Rio Grande
08253000	NA	CASIAS CREEK NEAR COSTILLA, NM	36.89685556	-105.2604583	81	NA	0	NA	Rio Grande	Alpine	Rio Grande
08253500	NA	SANTISTEVAN CREEK NEAR COSTILLA, NM	36.88416667	-105.2811111	80	NA	0	NA	Rio Grande	Alpine	Rio Grande
08255000	NA	UTE CREEK NEAR AMALIA, NM	36.9528015	-105.4102847	10	NA	0	NA	Rio Grande	Alpine	Rio Grande
08263000	NA	LATIR CREEK NEAR CERRO, NM	36.82919166	-105.5477845	33	NA	25	NA	Rio Grande	Alpine	Rio Grande
08264000	NA	RED RIVER NEAR RED RIVER, NM	36.62225195	-105.3894505	24	NA	14	NA	Rio Grande	Alpine	Rio Grande
08265000	NA	RED RIVER NEAR QUESTA, NM	36.7033111	-105.5684306	89	NA	54	NA	Rio Grande	Sub-Alpine	Rio Grande
08267500	NA	RIO HONDO NEAR VALDEZ, NM	36.5417972	-105.5565222	86	NA	84	NA	Rio Grande	Sub-Alpine	Rio Grande
08269000	NA	RIO PUEBLO DE TAOS NEAR TAOS, NM	36.43944444	-105.5036111	85	NA	68	NA	Rio Grande	Sub-Alpine	Rio Grande
08271000	NA	RIO LUCERO NEAR ARROYO SECO, NM	36.50828889	-105.5309639	91	NA	75	NA	Rio Grande	Alpine	Rio Grande
08275000	NA	RIO FERNANDO DE TAOS NEAR TAOS, NM	36.3755825	-105.5491775	19	NA	17	NA	Rio Grande	Mid-Elevation	Rio Grande
08275500	NA	RIO GRANDE DEL RANCHO NEAR TALPA, NM	36.30310278	-105.5810028	66	NA	64	NA	Rio Grande	Mid-Elevation	Rio Grande
08275600	NA	RIO CHIQUITO NEAR TALPA, NM	36.33197084	-105.5789007	24	NA	23	NA	Rio Grande	Mid-Elevation	Rio Grande
08281200	NA	WOLF CREEK NEAR CHAMA, NM	36.95556705	-106.5367009	13	NA	0	NA	Rio Grande	Sub-Alpine	Rio Grande
08284000	NA	RITO DE TIERRA AMARILLA AT TIERRA AMAR, NM	36.6986255	-106.5575345	23	NA	0	NA	Rio Grande	Mid-Elevation	Rio Grande
08284100	NA	RIO CHAMA NEAR LA PUENTE, NM	36.6626583	-106.6333667	64	NA	64	NA	Rio Grande	Mid-Elevation	Rio Grande
08284300	NA	HORSE LAKE CREEK ABOVE HERON RE NEAR LOS OJOS, NM	36.70668056	-106.7455944	36	NA	39	NA	Rio Grande	Plateau	Rio Grande
08286650	NA	CANJILON CREEK ABOVE ABIQUIU RESERVOIR, NM	36.3172222	-106.4852778	47	NA	0	NA	Rio Grande	Mid-Elevation	Rio Grande
08288000	NA	EL RITO NEAR EL RITO, NM	36.39168416	-106.2394699	33	NA	19	NA	Rio Grande	Mid-Elevation	Rio Grande
08289000	NA	RIO OJO CALIENTE AT LA MADERA, NM	36.34974167	-106.0441861	87	NA	87	NA	Rio Grande	Mid-Elevation	Rio Grande
09012500	NA	NORTH INLET AT GRAND LAKE, CO	40.25085	-105.8144444	11	NA	8	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09016500	NA	ARAPAHO CREEK AT MONARCH LAKE OUTLET, CO	40.1124861	-105.7497297	27	NA	28	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09020000	NA	WILLOW CREEK NEAR GRANBY, CO	40.180541	-106.0091853	19	NA	18	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters

09022000	NA	FRASER RIVER AT UPPER STATION, NEAR WINTER PARK, CO	39.8458204	-105.7519507	40	NA	40	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09026500	NA	SAINT LOUIS CREEK NEAR FRASER, CO	39.90998657	-105.8783451	33	NA	33	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09032000	NA	RANCH CREEK NEAR FRASER, CO	39.94998694	-105.7655627	14	NA	14	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09033000	NA	MEADOW CREEK NEAR TABERNASH, CO	40.0508198	-105.7775082	21	NA	19	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09033500	NA	STRAWBERRY CREEK NEAR GRANBY, CO	40.0866111	-105.8276389	10	NA	9	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09034000	NA	FRASER RIVER AT GRANBY, CO	40.0852636	-105.9552936	21	NA	23	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09034500	NA	COLORADO RIVER AT HOT SULPHUR SPRINGS, CO	40.08331887	-106.0880765	28	NA	28	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09034900	NA	BOBTAIL CREEK NEAR JONES PASS, CO	39.76026447	-105.9064014	54	NA	54	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09035700	NA	WILLIAMS FORK ABOVE DARLING CREEK, NEAR LEAL, CO	39.79719444	-106.0256389	10	NA	10	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09035800	NA	DARLING CREEK NEAR LEAL, CO	39.8005418	-106.0264066	46	NA	46	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09035900	NA	SOUTH FORK OF WILLIAMS FORK NEAR LEAL, CO	39.79581958	-106.0305734	54	NA	54	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09036500	NA	KEYSER CREEK NEAR LEAL, CO	39.9074861	-106.0172398	10	NA	10	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09037500	NA	WILLIAMS FORK NEAR PARSHALL, CO	40.0002	-106.1803667	40	NA	40	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09039000	NA	TROUBLESOME CREEK NEAR PEARMONT, CO	40.2174844	-106.3130854	40	NA	40	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09040000	NA	EAST FORK TROUBLESOME CREEK NEAR TROUBLESOME, CO	40.15748477	-106.2833617	37	NA	36	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09041090	NA	MUDDY CREEK ABOVE ANTELOPE CREEK NEAR KREMMLING, CO	40.2024844	-106.4225335	30	NA	21	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09041100	NA	ANTELOPE CREEK NEAR KREMMLING, CO	40.24053974	-106.3736433	13	NA	13	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09046530	NA	FRENCH GULCH AT BRECKENRIDGE, CO	39.4930424	-106.0447409	10	NA	8	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09047000	NA	BLUE RIVER AT DILLON, CO	39.6138754	-106.0519632	43	NA	43	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09047500	NA	SNAKE RIVER NEAR MONTEZUMA, CO	39.6053611	-105.9431306	72	NA	58	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09047700	NA	KEYSTONE GULCH NEAR DILLON, CO	39.59443117	-105.9725158	62	NA	62	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09050100	NA	TENMILE CREEK BELOW NORTH TENMILE CREEK, AT FRISCO, CO	39.57526424	-106.1105765	62	NA	62	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09051050	NA	STRAIGHT CREEK BELOW LASKEY GULCH NEAR DILLON, CO	39.6397087	-106.040296	33	NA	33	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09052000	NA	ROCK CREEK NEAR DILLON, CO	39.72304159	-106.1286328	42	NA	42	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09052400	NA	BOULDER CREEK AT UPPER STATION, NEAR DILLON, CO	39.7280414	-106.1733569	27	NA	28	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09052800	NA	SLATE CREEK AT UPPER STATION, NEAR DILLON, CO	39.76304128	-106.1925244	28	NA	28	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09054000	NA	BLACK CREEK BELOW BLACK LAKE, NEAR DILLON, CO	39.7991522	-106.2683604	35	NA	35	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09055000	NA	OTTER CREEK ABOVE GREEN MOUNTAIN RESERVOIR, CO	39.85276334	-106.2678047	10	NA	9	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09055300	NA	CATARACT CREEK NEAR KREMMLING, CO	39.83526349	-106.316417	28	NA	28	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09058500	NA	PINEY RIVER BELOW PINEY LAKE, NEAR MINTURN, CO	39.70804158	-106.4266968	54	NA	48	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09058610	NA	DICKSON CREEK NEAR VAIL, CO	39.7041111	-106.45725	33	NA	33	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09058700	NA	FREEMAN CREEK NEAR MINTURN, CO	39.69831939	-106.445586	40	NA	40	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09058800	NA	EAST MEADOW CREEK NEAR MINTURN CO	39.73165269	-106.4266969	40	NA	40	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09058900	NA	MONIGER CREEK NEAR MINTURN, CO	39.72693059	-106.4811425	31	NA	0	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09059500	NA	PINEY RIVER NEAR STATE BRIDGE, CO	39.7957222	-106.5743472	75	NA	75	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09060500	NA	ROCK CREEK NEAR TOPONAS, CO	40.04109757	-106.6558716	28	NA	28	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09060770	NA	ROCK CREEK AT MCCOY, CO	39.9122094	-106.7255937	14	NA	14	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09061450	NA	SWEETWATER CREEK AT MOUTH NEAR DOTSERO, CO	39.72220729	-107.0400475	18	NA	0	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09061600	NA	EAST FORK EAGLE RIVER NEAR CLIMAX, CO	39.4102654	-106.2497468	17	NA	17	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09063400	NA	TURKEY CREEK NEAR RED CLIFF, CO	39.52260278	-106.33655	45	NA	45	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09063900	NA	MISSOURI CREEK NEAR GOLD PARK, CO	39.39026486	-106.4700294	47	NA	47	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09064500	NA	HOMESTAKE CREEK NEAR RED CLIFF, CO	39.4733198	-106.3678056	30	NA	30	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09065100	NA	CROSS CREEK NEAR MINTURN, CO	39.56829167	-106.4124306	58	NA	56	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09065500	NA	GORE CREEK AT UPPER STATION, NEAR MINTURN, CO	39.6258193	-106.2780823	65	NA	65	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09066000	NA	BLACK GORE CREEK NEAR MINTURN, CO	39.59637495	-106.2650264	65	NA	65	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09066100	NA	BIGHORN CREEK NEAR MINTURN, CO	39.6399859	-106.2933605	45	NA	45	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09066150	NA	PITKIN CREEK NEAR MINTURN, CO	39.64359705	-106.3025273	35	NA	42	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09066200	NA	BOOTH CREEK NEAR MINTURN, CO	39.64831927	-106.3230833	55	NA	55	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09066300	NA	MIDDLE CREEK NEAR MINTURN, CO	39.6458193	-106.3822512	55	NA	55	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09066400	NA	RED SANDSTONE CREEK NEAR MINTURN, CO	39.68276376	-106.4014184	45	NA	45	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09066510	NA	GORE CREEK AT MOUTH NEAR MINTURN, CO	39.60943048	-106.447808	24	NA	24	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09067000	NA	BEAVER CREEK AT AVON, CO	39.62970826	-106.5228096	46	NA	44	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09067200	NA	LAKE CREEK NEAR EDWARDS, CO	39.647486	-106.6092003	26	NA	26	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09068000	NA	BRUSH CREEK NEAR EAGLE, CO	39.5572073	-106.7630926	22	NA	22	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09069500	NA	GYPSUM CREEK NEAR GYPSUM, CO	39.5455398	-106.9347658	11	NA	12	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters

09070000	NA	EAGLE RIVER BELOW GYPSUM, CO	39.64942954	-106.9536554	73	NA	73	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09071300	NA	GRIZZLY CREEK NEAR GLENWOOD SPRINGS, CO	39.71664889	-107.3103326	20	NA	20	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09073500	NA	ROARING FORK RIVER AT ASPEN, CO	39.18943174	-106.814483	14	NA	13	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09073700	NA	HUNTER CREEK ABOVE MIDWAY CREEK, NEAR ASPEN, CO	39.21387669	-106.6558669	16	NA	16	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09073900	NA	NO NAME CREEK NEAR ASPEN, CO	39.1888767	-106.7183688	10	NA	10	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09074000	NA	HUNTER CREEK NEAR ASPEN, CO	39.20582037	-106.797538	54	NA	35	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09074800	NA	CASTLE CREEK ABOVE ASPEN, CO	39.08748945	-106.8122608	25	NA	25	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09075700	NA	MAROON CREEK ABOVE ASPEN, CO	39.1235994	-106.9053197	25	NA	25	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09076520	NA	OWL CREEK NEAR ASPEN, CO	39.22359737	-106.8797631	15	NA	15	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09078000	NA	FRYINGPAN RIVER AT NORRIE, CO	39.33081977	-106.6580895	26	NA	25	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09078200	NA	CUNNINGHAM CREEK NEAR NORRIE, CO	39.33415366	-106.5753095	16	NA	16	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09078475	NA	LAST CHANCE CREEK NEAR NORRIE, CO	39.343889	-106.656528	11	NA	0	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09078500	NA	NORTH FORK FRYINGPAN RIVER NEAR NORRIE, CO	39.34276407	-106.6658675	40	NA	40	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09079450	NA	LIME CREEK NEAR THOMASVILLE, CO	39.360411	-106.685244	11	NA	0	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09080300	RFCMERCO	ROCKY FORK CREEK NEAR MEREDITH, CO	39.3616519	-106.8205946	14	29	14	29	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09081600	NA	CRYSTAL RIVER ABOVE AVALANCHE CREEK, NEAR REDSTONE, CO	39.23263889	-107.2275	64	NA	64	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09082800	NA	NORTH THOMPSON CREEK NEAR CARBONDALE, CO	39.32970488	-107.3333859	16	NA	16	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09084000	NA	CATTLE CREEK NEAR CARBONDALE, CO	39.4666502	-107.0522697	15	NA	15	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09085000	NA	ROARING FORK RIVER AT GLENWOOD SPRINGS, CO	39.54359307	-107.3294984	60	NA	60	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09085200	NA	CANYON CREEK ABOVE NEW CASTLE, CO	39.60525897	-107.4483877	18	NA	17	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09085300	NA	EAST CANYON CREEK NEAR NEW CASTLE, CO	39.60914796	-107.4347767	15	NA	14	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09085400	NA	POSSUM CREEK NEAR NEW CASTLE, CO	39.5977591	-107.4239432	14	NA	13	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09089000	NA	WEST DIVIDE CREEK BELOW WILLOW CREEK, NEAR RAVEN, CO	39.2755366	-107.5200546	16	NA	16	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09091100	NA	MAMM CREEK NEAR SILT, CO	39.53164716	-107.7139504	14	NA	0	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09091500	NA	EAST RIFLE CREEK NEAR RIFLE, CO	39.67775819	-107.6983962	15	NA	15	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09092000	NA	RIFLE CREEK NEAR RIFLE, CO	39.61998016	-107.7633979	20	NA	19	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09092500	NA	BEAVER CREEK NEAR RIFLE, CO	39.47192409	-107.8325657	30	NA	30	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09093000	NA	PARACHUTE CREEK NEAR PARACHUTE CO	39.5669215	-108.1109117	24	NA	23	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09095000	NA	ROAN CREEK NEAR DE BEQUE, CO	39.45331117	-108.3170305	23	NA	22	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09096500	NA	PLATEAU CREEK NEAR COLLBRAN, CO	39.2505349	-107.84062	38	NA	38	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09096800	NA	BUZZARD CREEK BELOW OWENS CREEK, NEAR HEIBERGER, CO	39.23609184	-107.6339464	15	NA	15	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09097500	NA	BUZZARD CREEK NEAR COLLBRAN, CO	39.2722015	-107.8506206	59	NA	59	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09097600	NA	BRUSH CREEK NEAR COLLBRAN, CO	39.3249794	-107.8422873	12	NA	12	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09099500	NA	BIG CREEK AT UPPER STATION, NEAR COLLBRAN, CO	39.1319242	-107.9186779	11	NA	11	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09100500	NA	COTTONWOOD CREEK AT UPPER STATION, NEAR MOLINA, CO	39.12775718	-107.9964587	12	NA	12	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09104500	NA	MESA CREEK NEAR MESA, CO	39.08636939	-108.1267425	24	NA	20	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09105000	NA	PLATEAU CREEK NEAR CAMEO, CO	39.1836111	-108.2683333	74	NA	73	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09106200	NA	LEWIS WASH NEAR GRAND JUNCTION, CO	39.06053714	-108.4778683	10	NA	7	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09107000	NA	TAYLOR RIVER AT TAYLOR PARK, CO	38.86027127	-106.5666966	37	NA	32	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09107500	NA	TEXAS CREEK AT TAYLOR PARK, CO	38.84694444	-106.5546389	11	NA	10	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09112000	NA	CEMENT CREEK NEAR CRESTED BUTTE, CO	38.82443729	-106.8528174	15	NA	14	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09113300	NA	OHIO CREEK AT BALDWIN, CO	38.7655496	-107.0583812	12	NA	12	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09113980	NA	OHIO CREEK ABOVE MOUTH NEAR GUNNISON, CO	38.5877696	-106.931432	21	NA	20	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09114500	NA	GUNNISON RIVER NEAR GUNNISON, CO	38.54193567	-106.9497661	93	NA	93	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09115500	NA	TOMICHI CREEK AT SARGENTS, CO	38.39502778	-106.422625	68	NA	68	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09118000	NA	QUARTZ CREEK NEAR OHIO CITY, CO	38.55971538	-106.6364217	24	NA	24	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09119000	NA	TOMICHI CREEK AT GUNNISON, CO	38.5211111	-106.9409583	82	NA	82	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09122000	NA	CEBOLLA CREEK AT POWDERHORN, CO	38.291383	-107.1144958	18	NA	18	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09122500	NA	SOAP CREEK NEAR SAPINERO, CO	38.5608333	-107.325	11	NA	11	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09124500	NA	LAKE FORK AT GATEVIEW, CO	38.2988834	-107.2300557	82	NA	82	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09125000	NA	CURECANTI CREEK NEAR SAPINERO, CO	38.4877673	-107.415057	27	NA	27	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09126000	NA	CIMARRON RIVER NEAR CIMARRON, CO	38.25819444	-107.5461111	15	NA	15	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09127500	NA	CRYSTAL CREEK NEAR MAHER, CO	38.5519326	-107.506169	21	NA	18	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09128500	NA	SMITH FORK NEAR CRAWFORD, CO	38.72776785	-107.5067234	59	NA	59	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09130600	NA	WEST MUDDY CREEK NEAR RAGGED MOUNTAIN, CO	39.13081664	-107.5753341	10	NA	10	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters

09132500	NA	NORTH FORK GUNNISON RIVER NEAR SOMERSET, CO	38.9258228	-107.4342211	86	NA	27	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09132900	NA	WEST HUBBARD CREEK NEAR PAONIA, CO	39.03220668	-107.6136684	13	NA	13	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09132960	NA	HUBBARD CREEK AT HIGHWAY 133 AT MOUTH NEAR BOWIE, CO	38.92554385	-107.5183894	13	NA	12	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09134500	NA	LEROUX CREEK NEAR CEDAREDGE, CO	38.9263711	-107.793672	29	NA	29	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09135900	NA	LEROUX CREEK AT HOTCHKISS, CO	38.7980401	-107.7320033	21	NA	20	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09137050	NA	CURRANT CREEK NEAR READ, CO	38.7847057	-107.9389537	12	NA	11	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09137800	NA	DIRTY GEORGE CREEK NEAR GRAND MESA, CO	38.9447035	-108.0281249	12	NA	12	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09139200	NA	WARD CREEK NEAR GRAND MESA, CO	38.98359186	-107.9720117	12	NA	12	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09140200	NA	KISER CREEK NEAR GRAND MESA, CO	38.98664748	-107.9436774	12	NA	12	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
09140700	NA	COTTONWOOD CREEK NEAR GRAND MESA, CO	38.9773611	-107.9503056	11	NA	11	NA	Mountain	Mid-Elevation	Colorado-East Slope Headwaters
09141200	NA	YOUNGS CREEK NEAR GRAND MESA, CO	38.95803685	-107.9186764	12	NA	12	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09143500	NA	SURFACE CREEK AT CEDAREDGE, CO	38.9016487	-107.921176	103	NA	89	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09144200	NA	TONGUE CREEK AT CORY, CO	38.787761	-107.9953444	23	NA	22	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09145000	NA	UNCOMPAHGRE RIVER AT OURAY, CO	38.01916047	-107.676171	14	NA	8	NA	Southwest	Alpine	Colorado-East Slope Headwaters
09146200	NA	UNCOMPAHGRE RIVER NEAR RIDGWAY, CO	38.1838791	-107.7458924	61	NA	61	NA	Northwest	Sub-Alpine	Colorado-East Slope Headwaters
09146400	NA	WEST FORK DALLAS CREEK NEAR RIDGWAY, CO	38.0736029	-107.8511739	15	NA	15	NA	Southwest	Sub-Alpine	Colorado-East Slope Headwaters
09146500	NA	EAST FORK DALLAS CREEK NEAR RIDGWAY, CO	38.0933249	-107.8136727	16	NA	16	NA	Southwest	Alpine	Colorado-East Slope Headwaters
09146600	NA	PLEASANT VALLEY CREEK NEAR NOEL, CO	38.14554597	-107.9197868	12	NA	12	NA	Southwest	Mid-Elevation	Colorado-East Slope Headwaters
09147000	NA	DALLAS CREEK NEAR RIDGWAY, CO	38.17776806	-107.7583927	62	NA	61	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09147100	NA	COW CREEK NEAR RIDGWAY, CO	38.1494363	-107.6447816	18	NA	18	NA	Mountain	Alpine	Colorado-East Slope Headwaters
09149450	NA	DRY CREEK NEAR OLATHE, CO	38.5552638	-108.0459022	15	NA	0	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09149500	NA	UNCOMPAHGRE RIVER AT DELTA, CO	38.74194444	-108.0804167	80	NA	51	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09150500	NA	ROUBIDEAU CREEK AT MOUTH, NEAR DELTA, CO	38.7349843	-108.1617399	24	NA	23	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09151500	NA	ESCALANTE CREEK NEAR DELTA, CO	38.756651	-108.2600775	14	NA	13	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09152650	NA	LEACH CREEK AT DURHAM, CO	39.09081474	-108.607595	10	NA	10	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09152900	NA	ADOBE CREEK NEAR FRUITA, CO	39.1369254	-108.6973205	11	NA	10	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09153000	NA	COLORADO RIVER NEAR FRUITA, CO	39.137481	-108.7309327	17	NA	12	NA	Northwest	Mid-Elevation	Colorado-East Slope Headwaters
09153400	NA	WEST SALT CREEK NEAR MACK, CO	39.3085902	-108.9837197	10	NA	10	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09163310	NA	EAST SALT CREEK NEAR MACK, CO	39.29720137	-108.866771	11	NA	9	NA	Northwest	Plateau	Colorado-East Slope Headwaters
09165000	NA	DOLORES RIVER BELOW RICO, CO	37.63888428	-108.0603517	66	NA	66	NA	Southwest	Alpine	San Juan-Dolores
09166500	NA	DOLORES RIVER AT DOLORES, CO	37.47249296	-108.4975908	108	NA	108	NA	Southwest	Sub-Alpine	San Juan-Dolores
09166950	NA	LOST CANYON CREEK NEAR DOLORES, CO	37.44610459	-108.4692562	36	NA	35	NA	Southwest	Mid-Elevation	San Juan-Dolores
09168100	NA	DISAPPOINTMENT CREEK NEAR DOVE CREEK, CO	37.8766579	-108.5831496	29	NA	29	NA	Southwest	Plateau	San Juan-Dolores
09168700	NA	DISAPPOINTMENT CREEK TRIBUTARY NEAR SLICK ROCK, CO	38.02582559	-108.8148233	12	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09172000	NA	FALL CREEK NEAR FALL CREEK, CO	37.95832607	-108.0059013	18	NA	18	NA	Southwest	Sub-Alpine	San Juan-Dolores
09172500	NA	SAN MIGUEL RIVER NEAR PLACERVILLE, CO	38.03070556	-108.1102889	85	NA	82	NA	Southwest	Sub-Alpine	San Juan-Dolores
09173000	NA	BEAVER CREEK NEAR NORWOOD, CO	37.96999209	-108.1956327	25	NA	25	NA	Southwest	Sub-Alpine	San Juan-Dolores
09174500	NA	COTTONWOOD CREEK NEAR NUCLA, CO	38.27360057	-108.3628619	10	NA	9	NA	Southwest	Plateau	San Juan-Dolores
09175000	NA	WEST NATURITA CREEK NEAR NORWOOD, CO	37.9758253	-108.3278608	12	NA	12	NA	Southwest	Mid-Elevation	San Juan-Dolores
09175500	NA	SAN MIGUEL RIVER AT NATURITA, CO	38.2177684	-108.5664809	53	NA	53	NA	Southwest	Mid-Elevation	San Juan-Dolores
09175800	NA	DEAD HORSE CREEK NEAR NATURITA, CO	38.043603	-108.5778705	11	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09175900	NA	DRY CREEK NEAR NATURITA, CO	38.0922138	-108.6220386	12	NA	12	NA	Southwest	Plateau	San Juan-Dolores
09177500	NA	TAYLOR CREEK NEAR GATEWAY, CO	38.518876	-109.1098333	23	NA	0	NA	Southwest	Mid-Elevation	San Juan-Dolores
09181000	NA	ONION CREEK NEAR MOAB, UT	38.72498404	-109.3451166	13	NA	5	NA	Southwest	Plateau	San Juan-Dolores
09182000	NA	CASTLE CREEK ABOVE DIVERSIONS, NEAR MOAB, UT	38.5927639	-109.2656708	24	NA	23	NA	Southwest	Mid-Elevation	San Juan-Dolores
09182400	NA	CASTLE CREEK BELOW CASTLE VALLEY NEAR MOAB, UT	38.6738712	-109.4501174	24	NA	24	NA	Southwest	Plateau	San Juan-Dolores
09182600	NA	SALT WASH NEAR THOMPSON, UT	38.9527509	-109.6590119	15	NA	0	NA	Northwest	Plateau	Green River
09183000	NA	COURTHOUSE WASH NEAR MOAB, UT	38.61275926	-109.5798402	31	NA	29	NA	Southwest	Plateau	San Juan-Dolores
09183500	NA	MILL CREEK AT SHELEY TUNNEL, NEAR MOAB, UT	38.4830403	-109.4040043	37	NA	37	NA	Southwest	Mid-Elevation	San Juan-Dolores
09184000	NA	MILL CREEK NEAR MOAB, UT	38.56220477	-109.5140057	47	NA	12	NA	Southwest	Plateau	San Juan-Dolores
09185200	NA	KANE SPRINGS CANYON NEAR MOAB, UT	38.39998497	-109.4506707	15	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09185500	NA	HATCH WASH NEAR LA SAL, UT	38.24332	-109.4401142	22	NA	21	NA	Southwest	Plateau	San Juan-Dolores
09187000	NA	COTTONWOOD CREEK NEAR MONTICELLO, UT	38.06248946	-109.5742877	17	NA	8	NA	Southwest	Plateau	San Juan-Dolores
09216400	NA	GREASEWOOD CANYON NEAR GREEN RIVER, WY	41.5594085	-109.511247	16	NA	0	NA	Northwest	Plateau	Green River
09216537	NA	DELANEY DRAW NEAR RED DESERT, WY	41.6394042	-108.1292559	24	NA	0	NA	Mountain	Plateau	Green River

09216550	NA	DEADMAN WASH NEAR POINT OF ROCKS, WY	41.6749616	-108.7367777	21	NA	0	NA	Northwest	Plateau	Green River
09216560	NA	BITTER CREEK NEAR POINT OF ROCKS, WY	41.6741111	-108.7773056	15	NA	0	NA	Northwest	Plateau	Green River
09216700	NA	SALT WELLS CREEK NEAR ROCK SPRINGS, WY	41.48329706	-108.9673404	18	NA	0	NA	Northwest	Plateau	Green River
09216900	NA	BITTER CREEK TRIBUTARY NEAR GREEN RIVER WY	41.5327424	-109.3809658	24	NA	0	NA	Northwest	Plateau	Green River
09224810	NA	BLACKS FORK TRIBUTARY NO 2 NEAR GREEN RIVER, WY	41.4596849	-109.6229177	17	NA	0	NA	Northwest	Plateau	Green River
09224820	NA	BLACKS FORK TRIBUTARY NO 3 NEAR GREEN RIVER, WY	41.4249626	-109.6159734	20	NA	0	NA	Northwest	Plateau	Green River
09224840	NA	BLACKS FORK TRIBUTARY NO 4 NEAR GREEN RIVER, WY	41.41107387	-109.6020842	17	NA	0	NA	Northwest	Plateau	Green River
09224980	NA	SUMMERS DRY CREEK NEAR GREEN RIVER, WY	41.37357307	-109.6451415	17	NA	0	NA	Northwest	Plateau	Green River
09225200	NA	SQUAW HOLLOW NEAR BURNTFORK, WY	41.17051667	-109.6101425	20	NA	0	NA	Northwest	Plateau	Green River
09225300	NA	GREEN RIVER TRIBUTARY NO 2 NEAR BURNTFORK, WY	41.06107118	-109.6187552	22	NA	0	NA	Northwest	Plateau	Green River
09229450	NA	HENRYS FORK TRIBUTARY NEAR MANILA, UT	41.02051477	-109.6801475	10	NA	0	NA	Northwest	Plateau	Green River
09235600	NA	POT CREEK ABOVE DIVERSIONS, NEAR VERNAL, UT	40.768015	-109.3190219	36	NA	36	NA	Northwest	Mid-Elevation	Green River
09237450	NA	YAMPA RIVER ABOVE STAGECOACH RESERVOIR, CO	40.2642611	-106.8917667	31	NA	31	NA	Northwest	Mid-Elevation	Green River
09238500	WLTNCKCO	WALTON CREEK NEAR STEAMBOAT SPRINGS, CO	40.4080346	-106.7869917	20	NA	13	NA	Northwest	Mid-Elevation	Green River
09238710	NA	FISH CREEK TRIBUTARY BELOW LONG LAKE, NEAR BUFFLAO PASS, CO	40.4766454	-106.6875442	11	NA	11	NA	Mountain	Sub-Alpine	Green River
09238750	NA	MIDDLE FORK FISH CREEK NEAR BUFFALO PASS, CO	40.499	-106.6926389	11	NA	11	NA	Mountain	Sub-Alpine	Green River
09238770	NA	GRANITE CREEK NEAR BUFFALO PASS, CO	40.49303389	-106.6925446	11	NA	11	NA	Mountain	Sub-Alpine	Green River
09239500	NA	YAMPA RIVER AT STEAMBOAT SPRINGS, CO	40.4829861	-106.8324306	113	NA	109	NA	Northwest	Mid-Elevation	Green River
09241000	NA	ELK RIVER AT CLARK, CO	40.7174726	-106.9158832	78	NA	68	NA	Northwest	Mid-Elevation	Green River
09243700	NA	MIDDLE CREEK NEAR OAK CREEK, CO	40.38553335	-106.993107	26	NA	25	NA	Northwest	Plateau	Green River
09243800	NA	FOIDEL CREEK NEAR OAK CREEK, CO	40.34581144	-107.085053	24	NA	24	NA	Northwest	Plateau	Green River
09243900	NA	FOIDEL CREEK AT MOUTH NEAR OAK CREEK, CO	40.39025545	-106.9947738	25	NA	25	NA	Northwest	Plateau	Green River
09244100	NA	FISH CREEK NEAR MILNER, CO	40.33414469	-107.1392207	18	NA	18	NA	Northwest	Mid-Elevation	Green River
09245000	NA	ELKHEAD CREEK NEAR ELKHEAD, CO	40.6696938	-107.2850592	44	NA	43	NA	Northwest	Mid-Elevation	Green River
09245500	NA	NORTH FORK ELKHEAD CREEK NEAR ELKHEAD, CO	40.680527	-107.2872814	15	NA	15	NA	Northwest	Mid-Elevation	Green River
09246920	NA	FORTIFICATION CREEK NEAR FORTIFICATION, CO	40.74385785	-107.5408996	10	NA	10	NA	Northwest	Plateau	Green River
09247000	NA	FORTIFICATION CREEK AT CRAIG, CO	40.51413796	-107.5414539	13	NA	13	NA	Northwest	Plateau	Green River
09247500	NA	YAMPA RIVER AT CRAIG, CO	40.4958048	-107.5533986	10	NA	8	NA	Northwest	Plateau	Green River
09249000	NA	EAST FORK OF WILLIAMS FORK NEAR PAGODA, CO	40.312477	-107.3200577	18	NA	18	NA	Northwest	Mid-Elevation	Green River
09249200	NA	SOUTH FORK OF WILLIAMS FORK NEAR PAGODA, CO	40.21219945	-107.4428375	14	NA	14	NA	Northwest	Mid-Elevation	Green River
09249750	WMFKMHCO	WILLIAMS FORK AT MOUTH, NEAR HAMILTON, CO	40.43719419	-107.6478456	18	15	17	15	Northwest	Mid-Elevation	Green River
09250000	NA	MILK CREEK NEAR THORNBURGH, CO	40.19358547	-107.7322907	34	NA	34	NA	Northwest	Plateau	Green River
09250507	NA	WILSON CREEK ABOVE TAYLOR CREEK NEAR AXIAL, CO	40.3146948	-107.8000718	12	NA	12	NA	Northwest	Plateau	Green River
09250510	NA	TAYLOR CREEK AT MOUTH NEAR AXIAL, CO	40.3133059	-107.799794	17	NA	16	NA	Northwest	Plateau	Green River
09251800	NA	NORTH FORK LITTLE SNAKE RIVER NEAR ENCAMPMENT, WY	41.0425	-106.9572222	10	NA	9	NA	Mountain	Mid-Elevation	Green River
09253000	NA	LITTLE SNAKE RIVER NEAR SLATER, CO	40.99941048	-107.143388	73	NA	71	NA	Northwest	Mid-Elevation	Green River
09253400	NA	BATTLE CREEK NEAR ENCAMPMENT, WY	41.1322222	-107.0691667	12	NA	10	NA	Mountain	Sub-Alpine	Green River
09255000	NA	SLATER FORK NEAR SLATER, CO	40.9824657	-107.3828391	90	NA	88	NA	Northwest	Mid-Elevation	Green River
09256000	NA	SAVERY CREEK NEAR SAVERY, WY	41.09777778	-107.3819444	38	NA	36	NA	Northwest	Plateau	Green River
09257000	NA	LITTLE SNAKE RIVER NEAR DIXON, WY	41.02852778	-107.5488611	68	NA	46	NA	Northwest	Mid-Elevation	Green River
09257500	NA	WILLOW CREEK NEAR BAGGS, WY	40.87663397	-107.4645082	10	NA	0	NA	Mountain	Mid-Elevation	Green River
09258000	NA	WILLOW CREEK NEAR DIXON, WY	40.91552206	-107.521732	40	NA	40	NA	Northwest	Mid-Elevation	Green River
09258200	NA	DRY COW CREEK NEAR BAGGS, WY	41.33996098	-107.671181	12	NA	0	NA	Northwest	Plateau	Green River
09259500	NA	FOURMILE CREEK NEAR BAGGS, WY	40.8405232	-107.5150652	11	NA	0	NA	Northwest	Mid-Elevation	Green River
09260000	NA	LITTLE SNAKE RIVER NEAR LILY, CO	40.54901667	-108.4243222	98	NA	98	NA	Northwest	Plateau	Green River
09263700	NA	CLIFF CREEK NEAR JENSEN, UT	40.299965	-109.1340103	15	NA	0	NA	Northwest	Plateau	Green River
09263800	NA	COW WASH NEAR JENSEN, UT	40.3166307	-109.2173467	14	NA	0	NA	Northwest	Plateau	Green River
09264000	NA	ASHLEY CREEK BELOW TROUT CREEK NEAR VERNAL, UT	40.73329	-109.6784789	11	NA	11	NA	Northwest	Sub-Alpine	Green River
09264500	NA	SOUTH FORK ASHLEY CREEK NEAR VERNAL, UT	40.7332898	-109.7034799	12	NA	12	NA	Northwest	Sub-Alpine	Green River
09266500	NA	ASHLEY CREEK NEAR VERNAL, UT	40.57745816	-109.6220859	107	NA	104	NA	Northwest	Mid-Elevation	Green River
09268000	NA	DRY FORK ABOVE SINKS, NEAR DRY FORK, UT	40.6263445	-109.8201488	37	NA	36	NA	Northwest	Sub-Alpine	Green River
09268500	NA	NORTH FORK OF DRY FORK NEAR DRY FORK, UT	40.6427334	-109.810982	44	NA	43	NA	Northwest	Sub-Alpine	Green River
09268900	NA	BROWNIE CANYON ABOVE SINKS, NEAR DRY FORK, UT	40.65940095	-109.7509807	29	NA	29	NA	Northwest	Sub-Alpine	Green River
09270500	NA	DRY FORK AT MOUTH NEAR DRY FORK, UT	40.5263475	-109.6056958	35	NA	35	NA	Northwest	Mid-Elevation	Green River
09271800	NA	HALFWAY HOLLOW TRIBUTARY NEAR LAPOINT, UT	40.41662546	-109.7506998	15	NA	0	NA	Northwest	Plateau	Green River

09298000	NA	FARM CREEK NEAR WHITEROCKS, UT	40.56745407	-109.9615413	32	NA	32	NA	Northwest	Mid-Elevation	Green River
09299500	NA	WHITEROCKS RIVER NEAR WHITEROCKS, UT	40.5935653	-109.9323739	101	NA	90	NA	Northwest	Sub-Alpine	Green River
09301500	NA	UINTA RIVER AT RANDLETT, UT	40.23357228	-109.8037549	31	NA	26	NA	Northwest	Plateau	Green River
09302450	NA	LOST CREEK NEAR BUFORD, CO	40.0502564	-107.468948	25	NA	25	NA	Mountain	Mid-Elevation	Green River
09302500	NA	MARVINE CREEK NEAR BUFORD, CO	40.0383118	-107.488115	12	NA	12	NA	Mountain	Sub-Alpine	Green River
09303300	NA	SOUTH FORK WHITE RIVER AT BUDGES RESORT, CO	39.84331509	-107.3347778	20	NA	20	NA	Mountain	Alpine	Green River
09303320	NA	WAGONWHEEL CREEK AT BUDGES RESORT, CO	39.8427595	-107.3367223	14	NA	14	NA	Mountain	Alpine	Green River
09303500	NA	SOUTH FORK WHITE RIVER NEAR BUFORD, CO	39.9216455	-107.5517269	39	NA	38	NA	Mountain	Sub-Alpine	Green River
09304300	NA	COAL CREEK NEAR MEEKER, CO	40.0913633	-107.7700692	11	NA	11	NA	Northwest	Plateau	Green River
09304500	NA	WHITE RIVER NEAR MEEKER, CO	40.0335849	-107.8622946	111	NA	110	NA	Northwest	Mid-Elevation	Green River
09306007	NA	PICEANCE CREEK BELOW RIO BLANCO, CO	39.8260846	-108.1831384	25	NA	24	NA	Northwest	Plateau	Green River
09306036	NA	SORGHUM GULCH AT MOUTH, NEAR RIO BLANCO, CO	39.8249734	-108.19925	12	NA	11	NA	Northwest	Plateau	Green River
09306039	NA	COTTONWOOD GULCH NEAR RIO BLANCO, CO	39.82664	-108.2075837	12	NA	11	NA	Northwest	Plateau	Green River
09306042	NA	PICEANCE CREEK TRIBUTARY NEAR RIO BLANCO, CO	39.8335843	-108.2206398	19	NA	16	NA	Northwest	Plateau	Green River
09306052	NA	SCANDARD GULCH AT MOUTH, NEAR RIO BLANCO, CO	39.8141399	-108.2436962	11	NA	9	NA	Northwest	Plateau	Green River
09306058	NA	WILLOW CREEK NEAR RIO BLANCO, CO	39.8371952	-108.2442518	11	NA	11	NA	Northwest	Plateau	Green River
09306200	NA	PICEANCE CREEK BELOW RYAN GULCH, NEAR RIO BLANCO, CO	39.9210833	-108.2975876	54	NA	54	NA	Northwest	Plateau	Green River
09306242	NA	CORRAL GULCH NEAR RANGELY, CO	39.9202502	-108.4728719	46	NA	45	NA	Northwest	Plateau	Green River
09306255	NA	YELLOW CREEK NEAR WHITE RIVER, CO	40.1685813	-108.4012046	43	NA	41	NA	Northwest	Plateau	Green River
09306500	NA	WHITE RIVER NEAR WATSON, UT	39.97885629	-109.1787269	42	NA	39	NA	Northwest	Plateau	Green River
09306800	NA	BITTER CREEK NEAR BONANZA, UT	39.75330136	-109.3548415	19	NA	19	NA	Northwest	Plateau	Green River
09307500	NA	WILLOW CREEK ABOVE DIVERSIONS NEAR OURAY, UT	39.5663541	-109.5873527	27	NA	27	NA	Northwest	Plateau	Green River
09328900	NA	CRESENT WASH NEAR CRESENT JUNCTION, UT	38.9421935	-109.8212364	10	NA	0	NA	Northwest	Plateau	Green River
09339900	NA	EAST FORK SAN JUAN RIVER ABOVE SAND CREEK, NEAR PAGOSA SPRINGS, C	37.38972959	-106.8411509	45	NA	45	NA	Southwest	Sub-Alpine	San Juan-Dolores
09340500	NA	WEST FORK SAN JUAN RIVER ABOVE BORNS LAKE, NEAR PAGOSA SPRINGS, C	37.48556247	-106.930321	17	NA	16	NA	Southwest	Alpine	San Juan-Dolores
09342000	NA	TURKEY CREEK NEAR PAGOSA SPRINGS, CO	37.3694509	-106.9403184	13	NA	12	NA	Southwest	Sub-Alpine	San Juan-Dolores
09342500	NA	SAN JUAN RIVER AT PAGOSA SPRINGS, CO	37.26552778	-107.011	90	NA	84	NA	Southwest	Sub-Alpine	San Juan-Dolores
09343000	NA	RIO BLANCO NEAR PAGOSA SPRINGS, CO	37.21278565	-106.7944797	37	NA	36	NA	Southwest	Sub-Alpine	San Juan-Dolores
09343500	NA	RITO BLANCO NEAR PAGOSA SPRINGS, CO	37.19361845	-106.9053148	18	NA	17	NA	Southwest	Mid-Elevation	San Juan-Dolores
09344000	NAVBANCO	NAVAJO RIVER AT BANDED PEAK RANCH, NEAR CHROMO, CO	37.0852879	-106.6894796	41	NA	41	NA	Southwest	Sub-Alpine	San Juan-Dolores
09345500	NA	LITTLE NAVAJO RIVER AT CHROMO, CO	37.04556595	-106.8430919	17	NA	17	NA	Southwest	Mid-Elevation	San Juan-Dolores
09346000	NA	NAVAJO RIVER AT EDITH, CO	37.0027883	-106.9075366	36	NA	46	NA	Southwest	Mid-Elevation	San Juan-Dolores
09346200	NA	RIO AMARGO AT DULCE, NM	36.932575	-106.9985722	39	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09347500	NA	PIEDRA RIVER AT BRIDGE RANGER STATION, NEAR PAGOSA SPRINGS, CO	37.4286143	-107.1933809	14	NA	13	NA	Southwest	Sub-Alpine	San Juan-Dolores
09349500	NA	PIEDRA RIVER NEAR PIEDRA, CO	37.2222256	-107.3428258	34	NA	33	NA	Southwest	Mid-Elevation	San Juan-Dolores
09350500	NA	SAN JUAN RIVER AT ROSA, NM	37.00556086	-107.4033809	43	NA	0	NA	Southwest	Mid-Elevation	San Juan-Dolores
09350700	NA	RUBEN CANYON NEAR GOBERNADOR, NM	36.7408333	-107.2402778	47	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09350800	NA	VAQUEROS CANYON NEAR GOBERNADOR, NM	36.72305556	-107.2797222	49	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09352500	NA	LOS PINOS RIVER BELOW SNOSLDE CAN, NEAR WEMINUCHE PS, CO	37.6388892	-107.3339431	13	NA	0	NA	Southwest	Alpine	San Juan-Dolores
09352900	NA	VALLECITO CREEK NEAR BAYFIELD, CO	37.47750126	-107.5436688	57	NA	57	NA	Southwest	Alpine	San Juan-Dolores
09354000	NA	LOS PINOS RIVER AT IGNACIO, CO	37.12917036	-107.6270017	17	NA	0	NA	Southwest	Mid-Elevation	San Juan-Dolores
09355000	NA	SPRING CREEK AT LA BOCA, CO	37.01527778	-107.5953333	61	NA	60	NA	Southwest	Plateau	San Juan-Dolores
09355700	NA	GOBERNADOR CANYON NEAR GOBERNADOR, NM	36.68444444	-107.42	61	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09356400	NA	MANZANARES CANYON NEAR TURLEY, NM	36.7365722	-107.7062222	40	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09357200	NA	GALLEGOS CANYON TRIBUTARY NEAR NAGEEZI, NM	36.4165222	-107.8632361	35	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09357230	NA	WEST DRAW NEAR FARMINGTON, NM	36.5909111	-108.1851722	21	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09357500	ANIHOWCO	ANIMAS RIVER AT HOWARDSVILLE, CO	37.83305235	-107.5995046	47	29	47	29	Southwest	Alpine	San Juan-Dolores
09358550	NA	CEMENT CREEK AT SILVERTON, CO	37.8197187	-107.6636723	27	NA	27	NA	Southwest	Alpine	San Juan-Dolores
09359010	NA	MINERAL CREEK AT SILVERTON, CO	37.8027744	-107.6728392	27	NA	27	NA	Southwest	Alpine	San Juan-Dolores
09361400	NA	JUNCTION CREEK NEAR DURANGO, CO	37.33416764	-107.9095126	22	NA	6	NA	Southwest	Mid-Elevation	San Juan-Dolores
09361500	NA	ANIMAS RIVER AT DURANGO, CO	37.2791688	-107.8803445	111	NA	107	NA	Southwest	Sub-Alpine	San Juan-Dolores
09362000	NA	LIGHTNER CREEK NEAR DURANGO, CO	37.2705577	-107.8936782	22	NA	22	NA	Southwest	Mid-Elevation	San Juan-Dolores
09363000	NA	FLORIDA RIVER NEAR DURANGO, CO	37.3252804	-107.7489519	46	NA	42	NA	Southwest	Sub-Alpine	San Juan-Dolores
09363100	NA	SALT CREEK NEAR OXFORD, CO	37.13972537	-107.7533959	23	NA	23	NA	Southwest	Plateau	San Juan-Dolores
09364500	NA	ANIMAS RIVER AT FARMINGTON, NM	36.7225	-108.20175	49	NA	39	NA	Southwest	Mid-Elevation	San Juan-Dolores

09365500	LAPHESCO	LA PLATA RIVER AT HESPERUS, CO	37.28972246	-108.0406277	104	1	101	1	Southwest	Sub-Alpine	San Juan-Dolores
09366500	LAPMEXCO	LA PLATA RIVER AT COLORADO-NEW MEXICO STATE LINE	36.99972239	-108.1886882	99	1	98	1	Southwest	Plateau	San Juan-Dolores
09367400	NA	LA PLATA RIVER TRIBUTARY NEAR FARMINGTON, NM	36.7861111	-108.226	27	NA	4	NA	Southwest	Plateau	San Juan-Dolores
09367530	NA	LOCKE ARROYO NEAR KIRTLAND, NM	36.7382583	-108.2923528	36	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09367550	NA	STEVENS ARROYO NEAR KIRTLAND, NM	36.76666787	-108.3700793	21	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09367561	NA	SHUMWAY ARROYO NEAR WATERFLOW, NM	36.77333406	-108.4411926	16	NA	14	NA	Southwest	Plateau	San Juan-Dolores
09367930	NA	HUNTER WASH AT BISTI TRADING POST, NM	36.27648889	-108.2547583	18	NA	7	NA	Southwest	Plateau	San Juan-Dolores
09367950	NA	CHACO RIVER NEAR WATERFLOW , NM	36.72444488	-108.5914736	30	NA	18	NA	Southwest	Plateau	San Juan-Dolores
09367980	NA	RATTLESNAKE ARROYO NEAR SHIPROCK, NM	36.7705542	-108.7261994	17	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09368020	NA	MALPAIS ARROYO NEAR SHIPROCK, NM	36.9258333	-108.725	35	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09368500	NA	WEST MANCOS RIVER NEAR MANCOS, CO	37.38166257	-108.2581366	16	NA	15	NA	Southwest	Sub-Alpine	San Juan-Dolores
09369000	NA	EAST MANCOS RIVER NEAR MANCOS, CO	37.3702741	-108.2314689	15	NA	14	NA	Southwest	Sub-Alpine	San Juan-Dolores
09369500	NA	MIDDLE MANCOS RIVER NEAR MANCOS, CO	37.3738852	-108.2306356	15	NA	13	NA	Southwest	Mid-Elevation	San Juan-Dolores
09371000	NA	MANCOS RIVER NEAR TOWAOC, CO	37.02749425	-108.7414838	92	NA	90	NA	Southwest	Plateau	San Juan-Dolores
09371300	NA	MCELMO CREEK TRIBUTARY NEAR CORTEZ, CO	37.3474944	-108.4828671	11	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09371492	NA	MUD CREEK AT STATE HIGHWAY 32, NEAR CORTEZ, CO	37.3127716	-108.6612067	31	NA	31	NA	Southwest	Plateau	San Juan-Dolores
09372000	NA	MCELMO CREEK NEAR COLORADO-UTAH STATE LINE	37.32415968	-109.015666	69	NA	67	NA	Southwest	Plateau	San Juan-Dolores
09378170	NA	SOUTH CREEK ABOVE RESERVOIR NEAR MONTICELLO, UT	37.8466608	-109.3695625	34	NA	34	NA	Southwest	Mid-Elevation	San Juan-Dolores
09378600	NA	MONTEZUMA CREEK NEAR BLUFF, UT	37.29999845	-109.3006709	15	NA	8	NA	Southwest	Plateau	San Juan-Dolores
09378630	NA	RECAPTURE CREEK NEAR BLANDING, UT	37.7555504	-109.476511	54	NA	54	NA	Southwest	Mid-Elevation	San Juan-Dolores
09378650	NA	RECAPTURE CREEK BELOW JOHNSON CREEK NEAR BLANDING,UT	37.6808299	-109.4626212	18	NA	18	NA	Southwest	Plateau	San Juan-Dolores
09378700	NA	COTTONWOOD WASH NEAR BLANDING, UT	37.5605543	-109.5787353	29	NA	23	NA	Southwest	Plateau	San Juan-Dolores
09378950	NA	COMB WASH NEAR BLANDING, UT	37.5499982	-109.667349	10	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09379000	NA	COMB WASH NEAR BLUFF, UT	37.26611234	-109.6756784	10	NA	9	NA	Southwest	Plateau	San Juan-Dolores
09379060	NA	LUKACHUKAI CREEK TRIBUTARY NEAR LUKACHUKAI, AZ	36.46944549	-109.4062158	14	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09379180	NA	LAGUNA CREEK AT DENNEHOTSO, AZ	36.8538907	-109.8459491	10	NA	9	NA	Southwest	Plateau	San Juan-Dolores
09379200	NA	CHINLE CREEK NEAR MEXICAN WATER, AZ	36.943891	-109.7106684	57	NA	55	NA	Southwest	Plateau	San Juan-Dolores
09379300	NA	LIME CREEK NEAR MEXICAN HAT, UT	37.21666827	-109.8173454	15	NA	0	NA	Southwest	Plateau	San Juan-Dolores
09379500	NA	SAN JUAN RIVER NEAR BLUFF, UT	37.15067778	-109.8666889	39	NA	35	NA	Southwest	Plateau	San Juan-Dolores
99999987	MORBSCCO	MORRISON CREEK BELOW SILVER CREEK NEAR OAK CREEK, CO	40.245556	-106.786667	NA	11	NA	10	Mountain	Mid-Elevation	Green River
99999988	WINDESCO	WIND RIVER NEAR ESTES PARK, CO	40.327005	-105.581319	NA	25	NA	22	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
99999989	WILCRECO	WILLOW CREEK NEAR CRESTONE, CO	37.967534	-105.676505	NA	21	NA	21	Rio Grande	Alpine	Rio Grande
99999990	SPACRECO	SPANISH CREEK NEAR CRESTONE, CO	37.952719	-105.661811	NA	21	NA	21	Rio Grande	Alpine	Rio Grande
99999991	SOUCRECO	SOUTH CRESTONE CREEK NEAR CRESTONE, CO	37.983165	-105.702133	NA	21	NA	21	Rio Grande	Alpine	Rio Grande
99999992	SANCRECO	SAN ISABEL CREEK NEAR CRESTONE, CO	38.034342	-105.71813	NA	21	NA	21	Rio Grande	Alpine	Rio Grande
99999993	RITCRECO	RITO ALTO CREEK NEAR CRESTONE, CO	38.078152	-105.759833	NA	21	NA	21	Rio Grande	Alpine	Rio Grande
99999994	LONREDCO	LONG HOLLOW AT THE MOUTH NEAR RED MESA, CO	37.057267	-108.177271	NA	24	NA	24	Southwest	Plateau	San Juan-Dolores
99999995	LITSPGCO	LITTLE SPRING CREEK AT MEDANO RANCH NEAR MOSCA, CO	37.712921	-105.650222	NA	20	NA	20	Rio Grande	Mid-Elevation	Rio Grande
99999996	DEDCRECO	DEADMAN CREEK NEAR CRESTONE, CO	37.884719	-105.64696	NA	14	NA	14	Rio Grande	Alpine	Rio Grande
99999998	BIGSPGCO	BIG SPRING CREEK AT MEDANO RANCH NEAR MOSCA, CO	37.734378	-105.663676	NA	21	NA	20	Rio Grande	Plateau	Rio Grande
99999999	BEAVERCO	BEAVER CREEK ABOVE BEAVER CREEK RESERVOIR, CO	40.116649	-105.522224	NA	10	NA	0	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
385106106571000	NA	SLATE RIVER ABOVE BAXTER GL @HWY 135 NEAR CRESTED BUTTE, CO	38.85165929	-106.9533773	13	NA	13	NA	Mountain	Sub-Alpine	Colorado-East Slope Headwaters
385903107210800	MUDAPRCO	MUDDY CREEK ABOVE PAONIA RESERVOIR, CO	38.95414977	-107.347831	5	24	NA	27	Northwest	Mid-Elevation	Colorado-East Slope Headwaters

Table 1.2. Basin and climate characteristics evaluated for use in the peak-streamflow regional-regression equations in central and western Colorado, 2019.

[3DEP, 3D Elevation Program; USGS, U.S. Geological Survey; NWIS, National Water Information System; NAD83, North American Datum of 1983; PRISM, Parameter-Elevation Regressions on Independent Slopes Model; NOAA, National Oceanic and Atmospheric Administration; STATSGO, State Soil Geographic; NLCD, National Land Cover Dataset; NHD, National Hydrography Dataset; SNODAS, Snow Data Assimilation System; NSIDC, National Snow and Ice Data Center; Table is available as a comma separated values (csv) format file for download at https://doi.org/10.3133/sir2022XXXX.]

Characteristic	Unit	Dataset	Dataset source
[1]Drainage area	square miles	1/3 arc-second 3DEP	USGS (2017)
Latitude	NAD83 decimal degrees	NWIS	USGS (2020b)
Longitude	NAD83 decimal degrees	NWIS	USGS (2020b)
[1]Elevation of basin outlet	feet	1/3 arc-second 3DEP	USGS (2017)
Basin perimeter	feet	1/3 arc-second 3DEP	USGS (2017)
Minimum basin elevation	feet	1/3 arc-second 3DEP	USGS (2017)
[1]Maximum basin elevation	feet	1/3 arc-second 3DEP	USGS (2017)
[1]Elevation relief	feet	1/3 arc-second 3DEP	USGS (2017)
[1]Mean basin elevation	feet	1/3 arc-second 3DEP	USGS (2017)
Percentage of basin above 7,500 feet	percent	1/3 arc-second 3DEP	USGS (2017)
Percentage of basin with slopes greater than 30 percent	percent	1/3 arc-second 3DEP	USGS (2017)
Minimum basin slope	percent	1/3 arc-second 3DEP	USGS (2017)
Maximum basin slope	percent	1/3 arc-second 3DEP	USGS (2017)
[1]Mean basin slope	percent	1/3 arc-second 3DEP	USGS (2017)
Mean annual temperature	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in January	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in February	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in March	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in April	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in May	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in June	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in July	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in August	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in September	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in October	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in November	degrees C	800-meter PRISM	PRISM Climate Group (2018)
Mean temperature in December	degrees C	800-meter PRISM	PRISM Climate Group (2018)
[1]Mean annual precipitation	inches	800-meter PRISM	PRISM Climate Group (2018)

Mean precipitation in January	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in February	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in March	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in April	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in May	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in June	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in July	inches	800-meter PRISM	PRISM Climate Group (2018)
[1]Mean precipitation in August	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in September	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in October	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in November	inches	800-meter PRISM	PRISM Climate Group (2018)
Mean precipitation in December	inches	800-meter PRISM	PRISM Climate Group (2018)
[1]6-hour, 100-year precipitation	inches	NOAA Atlas 2, Volume 2; NOAA Atlas 14, Volumes 1, 8	Miller and others (1973), Bonnin and others (2011), Perica and others (2013)
[1]24-hour, 100-year precipitation	inches	NOAA Atlas 2, Volume 2; NOAA Atlas 14, Volumes 1, 8	Miller and others (1973), Bonnin and others (2011), Perica and others (2013)
Mean percent of soil consisting of clay	percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Mean percent of soil consisting of sand	percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Mean permeability of soil	percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Mean available water capacity	Percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Percent of hydrologic group A soils	Percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Percent of hydrologic group B soils	Percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Percent of hydrologic group C soils	Percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Percent of hydrologic group D soils	Percent	STATSGO2 dataset	Natural Resources Conservation Service (2020)
Percent carbonate residual material	Percent	USGS Surficial Lithology	Cress and others (2010)
Percent non-carbonate residual material	Percent	USGS Surficial Lithology	Cress and others (2010)
Percent alkaline intrusive volcanic rock	Percent	USGS Surficial Lithology	Cress and others (2010)
Percent silicic residual material	percent	USGS Surficial Lithology	Cress and others (2010)
Percent extrusive volcanic rock	percent	USGS Surficial Lithology	Cress and others (2010)

Percent colluvial sediment	percent	USGS Surficial Lithology	Cress and others (2010)
Percent glacial till, clayey	percent	USGS Surficial Lithology	Cress and others (2010)
Percent glacial till, loamy	percent	USGS Surficial Lithology	Cress and others (2010)
Percent glacial till, coarse textured	percent	USGS Surficial Lithology	Cress and others (2010)
Percent glacial outwash and glacial lake sediment	percent	USGS Surficial Lithology	Cress and others (2010)
Percent glacial lake sediment, fine textured	percent	USGS Surficial Lithology	Cress and others (2010)
Percent glacial outwash and glacial lake sediment	percent	USGS Surficial Lithology	Cress and others (2010)
Percent hydric, peat, and muck	percent	USGS Surficial Lithology	Cress and others (2010)
Percent eolian sediment, coarse textured	percent	USGS Surficial Lithology	Cress and others (2010)
Percent eolian sediment, fine textured	percent	USGS Surficial Lithology	Cress and others (2010)
Percent saline lake sediment	percent	USGS Surficial Lithology	Cress and others (2010)
Percent alluvium and fine textured coastal zone	percent	USGS Surficial Lithology	Cress and others (2010)
Percent coastal zone sediment, coarse textured	percent	USGS Surficial Lithology	Cress and others (2010)
Percent water	percent	USGS Surficial Lithology	Cress and others (2010)
Percent open water	percent	NLCD 2011	Homer and others (2015)
Percent perennial ice/snow	percent	NLCD 2011	Homer and others (2015)
Percent developed	percent	NLCD 2011	Homer and others (2015)
Percent barren land	percent	NLCD 2011	Homer and others (2015)
Percent deciduous, evergreen, mixed forest	percent	NLCD 2011	Homer and others (2015)
Percent shrub/scrub	percent	NLCD 2011	Homer and others (2015)
Percent grassland/herbaceous	percent	NLCD 2011	Homer and others (2015)
Percent pasture/hay, grasslands, pasture, and cultivated cro	percent	NLCD 2011	Homer and others (2015)
Percent woody and emergent herbaceous wetlands	percent	NLCD 2011	Homer and others (2015)
[1]Basin centroid latitude	decimal degrees	computed	Not applicable
[1]Basin centroid longitude	decimal degrees	computed	Not applicable
Storage	percent of area	NHD High Resolution	USGS (2020c)
Runoff curve number	dimensionless	computed	Price and others (2006), USGS (2014)
Snow water equivalent (SNODAS) March 1	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow water equivalent (SNODAS) March 15	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
[1]Snow water equivalent (SNODAS) April 1	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow water equivalent (SNODAS) April 15	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)

Snow water equivalent (SNODAS) May 1	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow depth (SNODAS) March 1	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow depth (SNODAS) March 15	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow depth (SNODAS) April 1	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow depth (SNODAS) April 15	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow depth (SNODAS) May 1	meters	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow pack average temp (SNODAS) March 1	Kelvin	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow pack average temp (SNODAS) March 15	Kelvin	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow pack average temp (SNODAS) April 1	Kelvin	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow pack average temp (SNODAS) April 15	Kelvin	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)
Snow pack average temp (SNODAS) May 1	Kelvin	SNODAS NSIDC 2004-2019	National Operational Hydrologic Remote Sensing Center (2004)

[1]Variable used in the regional regression equations.