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Estimation of Peak Streamflows for Unregulated Rural Streams in Kansas

Water-Resources Investigations Report 00–4079

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

Photograph on cover is Kansas River at Wamego, Kansas, March 1997.

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Estimation of Peak Streamflows for Unregulated Rural Streams in Kansas

By PATRICK P. RASMUSSEN and CHARLES A. PERRY

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Lawrence, Kansas
2000

U.S. Department of the Interior

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CONVERSION FACTORS, ABBREVIATIONS, VERTICAL DATUM, AND DEFINITIONS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
inch (in.)	25.4	millimeter
inch per hour (in/h)	25.4	millimeter per hour
meter (m)	3.281	foot
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Temperature can be converted to degrees Celsius (^oC) or degrees Farenheit (^oF) by the equations:

$$^oC = 5/9(^oF - 32)$$
$$^oF = 9/5\ (^oC) + 32.$$

Vertical Datum

Sea Level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Definitions

Water year: In U.S. Geological Survey reports dealing with surface-water supply, water year is the 12-month period, October 1 through September 30. The water year is designated by the calender year in which it ends and which includes 9 of the 12 months. Thus the year ending September 30, 1998, is called the “1998 water year.”

CDA—Contributing-drainage area
G_g—Generalized skewness coefficient
G_s—Station skewness coefficient
GLS–Generalized least squares
*I*ACWD—Interagency Advisory Committee on Water Data
Lat—Latitude
Lng—Longitude
P—Mean annual precipitation
RMSE—Root-mean-square error
S—Soil permeability
S*l*—Main channel slope
STATSGO—State soil geographic data base
WLS—Weighted least squares

Estimation of Peak Streamflows for Unregulated Rural Streams in Kansas

By Patrick P. Rasmussen *and* Charles A. Perry

Abstract

Peak streamflows were estimated at selected recurrence intervals (frequencies) ranging from 2 to 200 years using log-Pearson Type III distributions for 253 streamflow-gaging stations in Kansas. The annual peak-streamflow data, through the 1997 water year, were from streamflow-gaging stations with unregulated flow in mostly rural basins. A weighted least-squares regression model was used to generalize the coefficients of station skewness. The resulting generalized skewness equation provides more reliable estimates than the previously developed equation for Kansas.

A generalized least-squares regression model then was used to develop equations for estimating peak streamflows for sites without stream gages for selected frequencies from selected physical and climatic basin characteristics for sites without stream gages. The equations can be used to estimate peak streamflows for selected frequencies using contributing-drainage area, mean annual precipitation, soil permeability, and slope of the main channel for ungaged sites in Kansas with a contributing-drainage area greater than 0.17 and less than 9,100 square miles. The errors of prediction for the generalized least-squares-generated equations range from 31 to 62 percent.

INTRODUCTION

There is a continuing need for peak-streamflow information on Kansas streams. Information concerning frequency of peak streamflows in rural areas is vital to the safe and economic design of transportation drainage structures, such as bridges and culverts, and flood-control structures, such as dams, levees, and floodways. Effective flood-plain management programs and flood-insurance rates also are based on the analysis of peak-streamflow frequency.

A study of peak-streamflow frequencies was conducted by the U.S. Geological Survey in cooperation with the Kansas Department of Transportation. Much of the data used in this study, especially for many of the partial-record streamflow-gaging stations located on small streams, were collected by the U.S. Geological Survey (Putnam and others, 1998) as part of a cooperative program initiated with the Kansas Department of Transportation in 1956.

Purpose and Scope

The purpose of this report is to present results from an analysis of peak-streamflow frequencies for unregulated, mostly rural streams at streamflow-gaging stations with 10 or more years of record, and to present equations for determining peak-streamflow frequencies at ungaged sites in Kansas. This report includes data through the 1997 water year and supersedes previous U.S. Geological Survey reports that provide flood-frequency results and (or) techniques for Kansas streams.

The scope of the analyses included (1) determination of peak-streamflow frequencies for 253 streamflow-gaging stations in Kansas (fig. 1) using log-Pearson Type III techniques; (2) derivation of an equation to estimate the generalized skewness coefficients of the distribution of peak flows for each station, and (3) development of equations for relating the gaged, peak streamflow to respective physical and climatic characteristics and for estimating peak streamflows for selected recurrence intervals (frequencies) at ungaged, unregulated, mostly rural stream sites.

Previous Studies

Since 1960, seven studies have investigated various generalization techniques for estimating peak-streamflow frequencies for Kansas streams. Studies by Ellis and Edelen (1960), Irza (1966), Jordan and Irza (1975), and Clement (1987) analyzed peak-streamflow frequencies by using the available data and techniques to develop regression equations to estimate peak streamflows. Both Patterson (1964) and Matthai (1968) used the index-flood method, and Hedman and others (1974 used an active-channel-width concept to estimate the peak streamflow for selected recurrence intervals.

The generalization technique presented in this report incorporates the most recent analytical methods for estimating peak-streamflow frequency and is considered more reliable than those techniques previously reported for use with unregulated, rural streams in Kansas.

Acknowledgments

Some of the peak-streamflow data used in the flood-frequency analysis were collected through cooperative agreements between the U.S. Geological Survey and numerous Federal, State, and local government agencies, including: U.S. Army Corps of Engineers; Kansas Water Office; Kansas Department of Agriculture, Division of Water Resources; Arkansas River Compact Administration; Johnson County Department of Public Works; city of Hays; city of Wichita; city of Topeka; Hillsdale Lake Resource and Conservation District; U.S. Fish and Wildlife Service; and Kansas Department of Transportation.

FACTORS AFFECTING OCCURRENCE OF FLOODS

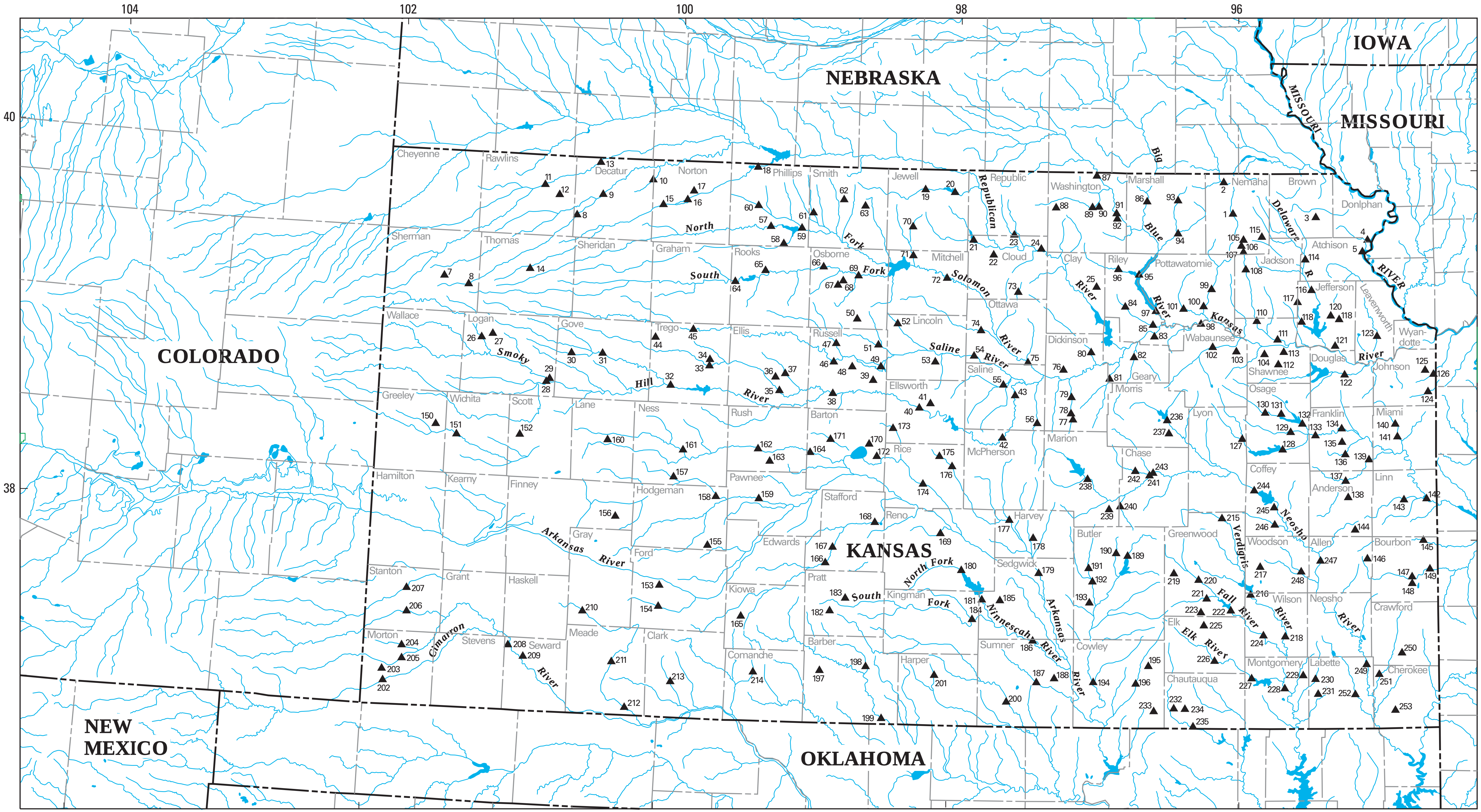
Flooding on small streams in Kansas is generally the result of very intense thunderstorms that affect almost all of the watershed and produce rainfall rates that exceed soil-infiltration rates. Within large watersheds, flooding generally is the result of prolonged rainfall that affects a major part of the total drainage basin. The prolonged rainfall eventually saturates the soil to the point that only a small part of the subsequent rainfall can infiltrate the soil. Physical constrictions in the stream channels, such as bridges or culverts, logs or ice jams, or backwater from high flows in other interconnected channels, can increase the depth of flooding. Kansas streams rarely experience flooding that results from snowmelt or dam failures.

Physical Characteristics

Physical characteristics within the respective watersheds have a pronounced effect on the nature of flooding. Watersheds with various basin and channel slopes, shapes, and drainage patterns have varying effects on the potential for flooding. For example, steep slopes tend to allow excess rainfall to move more rapidly away from the headwater areas but allow more rapid accumulation at downstream locations where flood conditions occur. Varying watershed shapes also cause different responses to excess rainfall. Long, narrow watersheds generally are less affected by small, isolated storms because usually only a part of the watershed receives intense rainfall. On the other hand, compact-shaped watersheds have a greater chance to be affected entirely by storms of comparable size, and the dendritic (tree-like) stream pattern facilitates more rapid concentration of runoff at or near the watershed's outlet; this increases the likelihood of downstream flooding.

Other physical characteristics affecting the flood potential of watersheds are the types of soils and land-use and treatment practices within the watershed. For example, the flood potential from watersheds with soils of low permeability (fig. 2) is greater than that from watersheds where highly permeable soils tend to allow greater infiltration and less runoff. Land-treatment practices, such as contour farming and construction of water-retention structures, can reduce the amount of rapid runoff to a stream system and thus reduce stream peaks.

Physiographically, Kansas is located almost entirely within the Interior Plains as described by Schoewe (1949). The hydrologic characteristics of the physiographic provinces within the Interior Plains are beyond the scope of this report, but the fact that there are significant variations denotes the complex nature of and difficulty in attempting to define flood-frequency relations across the State.

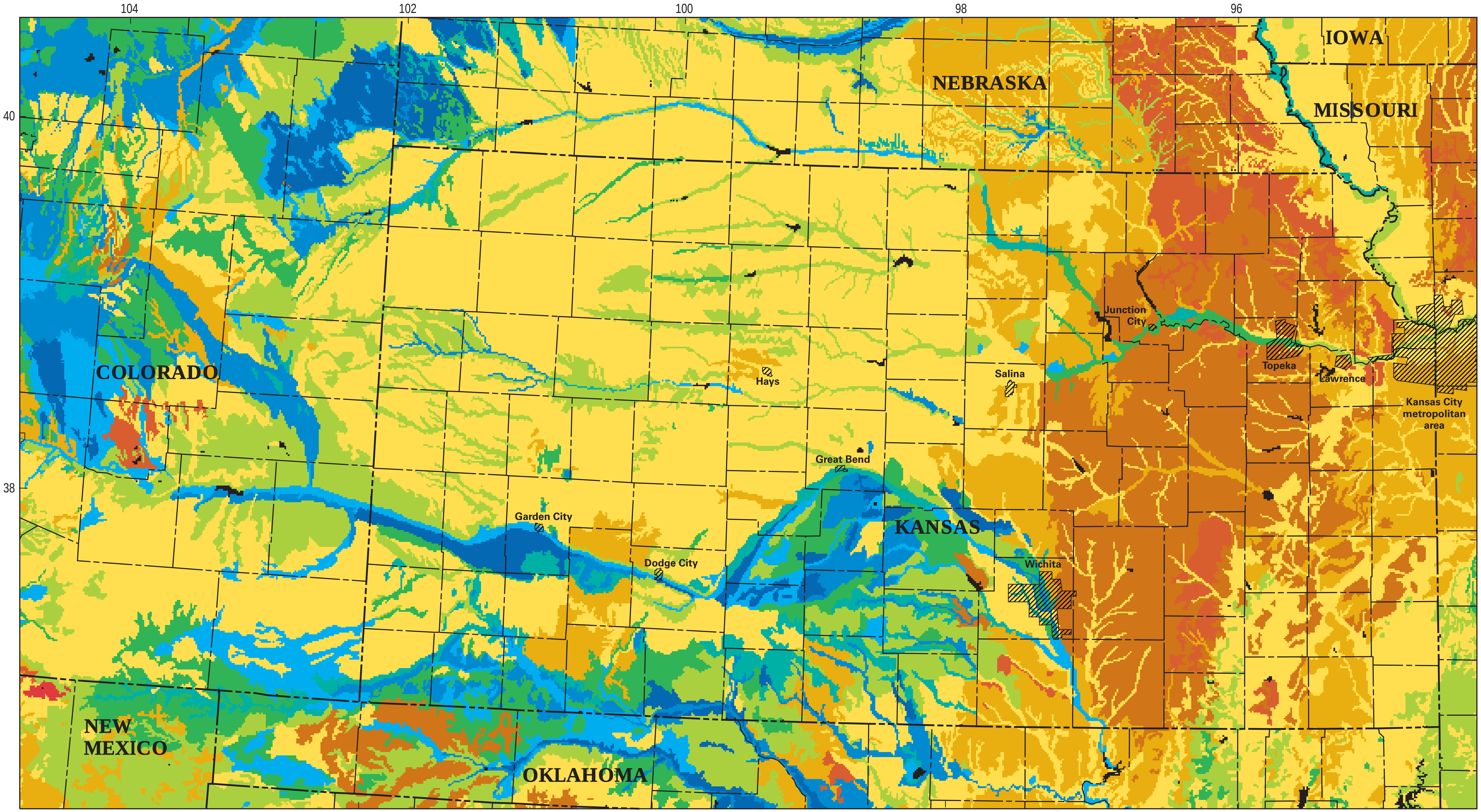


Base map from U.S. Geological Survey digital data, 1:2,000,000, 1994
Albers Conic Equal-Area Projection,
Standard parallels 29 30' and 45 30', central meridian 96

EXPLANATION

212▲ **Streamflow-gaging station—**Number corresponds to map index number used in tables 1 and 5

Figure 1. Location of unregulated streamflow-gaging stations in Kansas used for estimation of peak-streamflow frequencies.



Base map from U.S. Geological Survey digital data, 1:2,000,000, 1994
Albers Conic Equal-Area Projection,
Standard parallels 29 30' and 45 30', central meridian 96

Soil permeability from U.S. Department of Agriculture (1994)

EXPLANATION

Areas of equal average soil permeability (*S*), in inches per hour

0.16	0.58	2.15	8.00
0.24	0.90	3.35	12.4
0.38	1.40	5.20	Water body

0 50 100 MILES
0 50 100 KILOMETERS

Figure 2. Generalized soil permeability for Kansas and surrounding areas.

Generally, it has been accepted that the nature of flooding follows one of two patterns—one typical of the eastern one-third of the State and one typical of the western two-thirds. The arbitrary dividing line passes through Wichita and west of Junction City (locations shown in fig. 2). Crippen and Bue (1977) identified a similarly located boundary within the State when dividing the conterminous United States into flood regions for a study of maximum floodflows. The topography of the western two-thirds of the State is typical of the high plains region and is characterized by flat or gently sloping surfaces with little relief and soils of high permeability (fig. 2). The topography of the eastern one-third of the State is more variable, with alternating hills and lowlands having soils of low permeability (fig. 2).

Land-surface elevations within the State range from about 700 ft above sea level at the Kansas-Oklahoma State line in southeast Kansas to about 4,135 ft above sea level at a point near the Kansas-Colorado State line in western Kansas—a vertical difference of about 3,435 ft. Average basin slope for the 253 streamflow-gaging stations in Kansas is about 10 ft/mi.

Climatic Characteristics

The climate of Kansas is affected by the movement of frontal air masses over the open, inland plains, and seasonal precipitation extremes are common. About 70 percent of the mean annual precipitation falls from April through September. Precipitation during early spring and late fall occurs in association with frontal air masses that produce low-intensity rainfall of regional coverage. During the summer months, the weather is dominated by warm, moist air from the Gulf of Mexico or by hot, dry air from the Southwest. Summer precipitation generally occurs as high intensity thunderstorms.

Watersheds in Kansas exhibit a wide range of climatic characteristics that affect peak-streamflow frequency. Generally, the climatic characteristics vary in an east-west direction, with little north-south variation. The general climate of the western part of Kansas is semiarid with hot, dry summer months and cold, windy winter months. The eastern part of the State tends to be considerably more humid, with sultry summer months and cold winter months. Mean annual precipitation in the State varies from about 16 in. in the extreme western part to about 42 in. in the southeast (Daly and others, 1997) (fig. 3).

OCCURRENCE OF EXTREME FLOODS

Moderate flooding is an annual occurrence in Kansas; however, the State has experienced several extreme floods. Notably, the floods of 1951 in river basins of eastern and north-central Kansas were the result of a large storm system. Likewise, the floods that occurred on the Elk River during 1976 were extreme. The Great Bend area experienced extreme flooding during June 1981 when an isolated but very intense storm system produced up to 20 in. of rain during a 12-hour period (Clement and Johnson, 1982). Several storm systems during the summer of 1993 caused flooding in the Saline and Solomon River Basins of central Kansas (fig. 1) and all of the river basins in northeast and east-central Kansas. In 1995, intense storms caused widespread flooding in the eastern two-thirds of Kansas.

These are but a few of many floods that have been experienced on Kansas streams that are among the largest of floods recorded. The maximum observed discharges in relation to the respective contributing-drainage areas for the largest observed floods in Kansas are listed in table 1. The relation between maximum discharge and contributing-drainage area for the data presented in table 1 are depicted graphically in figure 4. Envelope curves have been drawn through the highest points for both eastern and western Kansas. No recurrence interval can be assigned to the curves although they represent peak discharges generally several times greater than those having 100-year recurrence intervals.

ESTIMATION OF PEAK-STREAMFLOW FREQUENCIES AT GAGING STATIONS ON UNREGULATED, RURAL STREAMS

Techniques from Bulletin 17B of the Interagency Advisory Committee on Water Data (1981) for estimating peak-streamflow frequency were used with annual maximum peak-streamflow data from 253 streamflow-gaging stations with 10 or more years of unregulated, rural peak-streamflow record. Unregulated, rural peak-streamflow record is defined as less than 10 percent of the basin is regulated by a dam or is impervious. The drainage areas for these

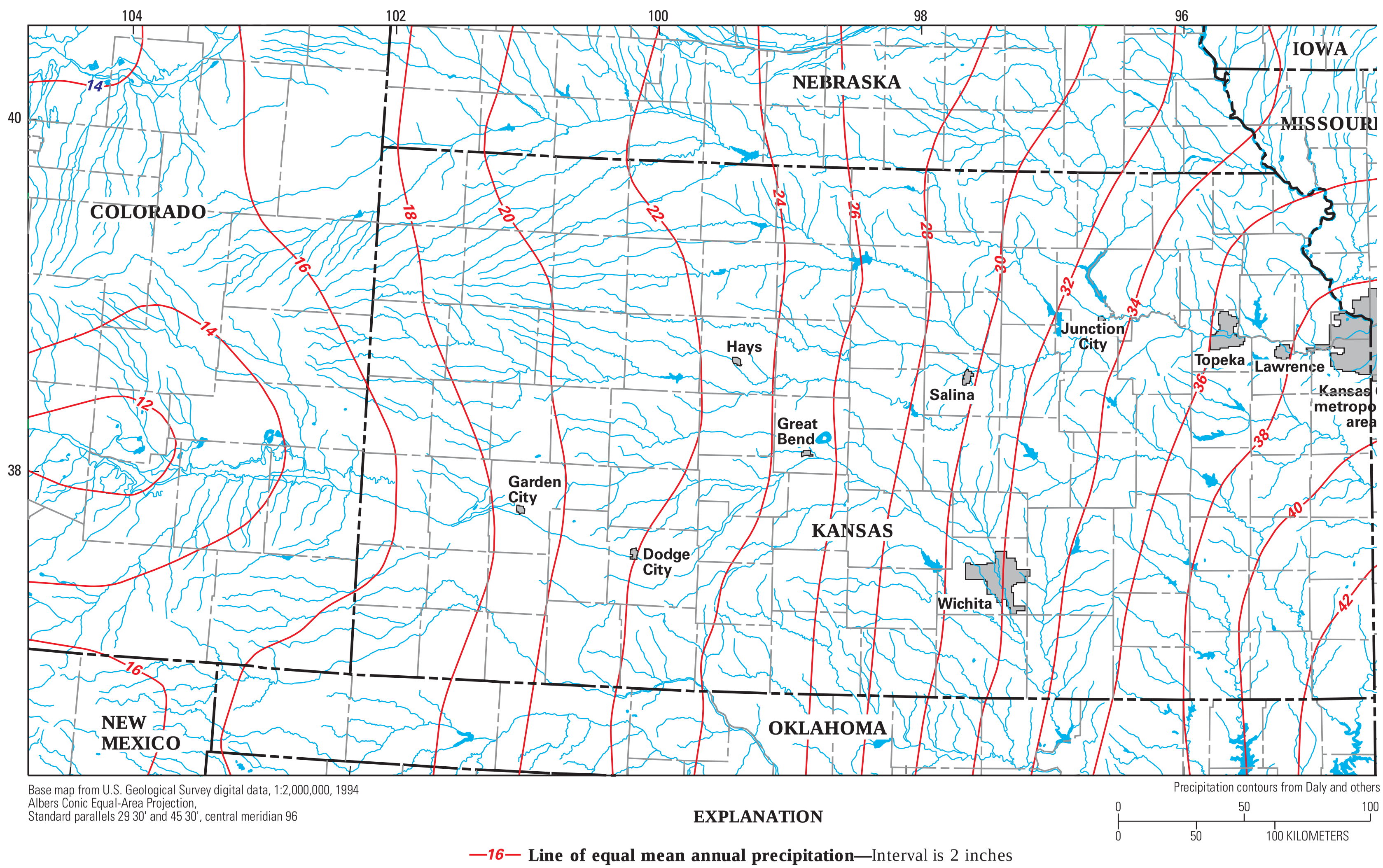


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Figure 3. Distribution of mean annual precipitation for Kansas and surrounding areas, 1961–90.

Table 1. Maximum observed discharge relative to contributing-drainage area for largest observed floods in Kansas

[--not applicable; *, indicates that station is not listed in table 5 at the end of this report and is not in figure 1]

Station map index number (fig. 1)	U.S. Geological Survey station number	U.S. Geological Survey station name or location	Contributing-drainage area (square miles)	Maximum observed discharge	
				Date	Magnitude (cubic feet per second)
		Eastern Kansas			
--	06815600*	Wolf River near Hiawatha	41	Aug. 9, 1968	40,000
81	06878500	Lyon Creek near Woodbine	230	July 1951	93,000
83	06879650	Kings Creek near Manhattan	4.09	May 13, 1995	10,200
105	06889100	Soldier Creek near Goff	2.06	May 10, 1970	7,080
131	06912300	Dragoon Creek tributary near Lyndon	3.76	June 11, 1981	8,200
134	06913500	Marais des Cygnes River near Ottawa	1,250	July 11, 1951	142,000
191	07147020	Whitewater River tributary near Towanda	.17	June 5, 1965	510
215	07165700	Verdigris River near Madison	181	July 11, 1951	128,000
219	07166700	Burnt Creek at Reece	8.85	June 9, 1965	20,500
221	07167500	Otter Creek at Climax	129	July 3, 1976	107,000
226	07169800	Elk River at Elk Falls	220	July 3, 1976	200,000
236	07179500	Neosho River at Council Grove	250	July 11, 1951	121,000
237	07179600	Four Mile Creek near Council Grove	55	June 26, 1969	68,100
242	07181500	Middle Creek near Elmdale	92	June 27, 1969	90,000
243	07182000*	Cottonwood River at Cottonwood Falls	1,327	July 11, 1951	196,000
244	07182400	Neosho River at Strawn	2,933	July 11, 1951	400,000
247	07183000	Neosho River near Iola	3,818	July 13, 1951	436,000
249	07183500	Neosho River near Parsons	4,905	July 14, 1951	410,000
		Western Kansas			
14	06847600	Prairie Dog Creek tributary at Colby	7.53	June 18, 1975	4,300
37	06863900	North Fork Big Creek near Victoria	54	Aug. 9, 1974	26,400
66	06873500	South Fork Solomon River at Alton	1,720	July 12, 1951	91,900
68	06873800	Kill Creek tributary near Bloomington	1.45	May 21, 1961	2,000
73	06876200	Middle Pipe Creek near Miltonvale	10.2	Sept. 26, 1973	6,400
75	06876900	Solomon River at Niles	6,770	July 14, 1951	178,000
80	06878000	Chapman Creek near Chapman	300	July 1951	46,700
165	07142100	Rattlesnake Creek tributary near Mullinville	10.3	Sept. 26, 1973	7,000
--	07143800*	Black Kettle Creek tributary near Halstead	1.65	June 2, 1962	2,440
178	07144000	East Emma Creek near Halstead	58	Aug. 25, 1960	18,000
180	07144780	North Fork Ninnescah River above Cheney Reservoir	787	Oct. 30, 1979	87,000
183	07144900	South Fork Ninnescah River tributary near Pratt	1.48	July 5, 1987	2,310
--	*	Dry Walnut Creek tributary near Great Bend	2.28	June 15, 1981	5,720
--	*	Dry Walnut Creek tributary near Great Bend	1.19	June 15, 1981	3,080
--	*	Dry Walnut Creek tributary near Great Bend	.92	June 15, 1981	1,870
--	*	Dry Walnut Creek tributary near Great Bend	.66	June 15, 1981	1,340

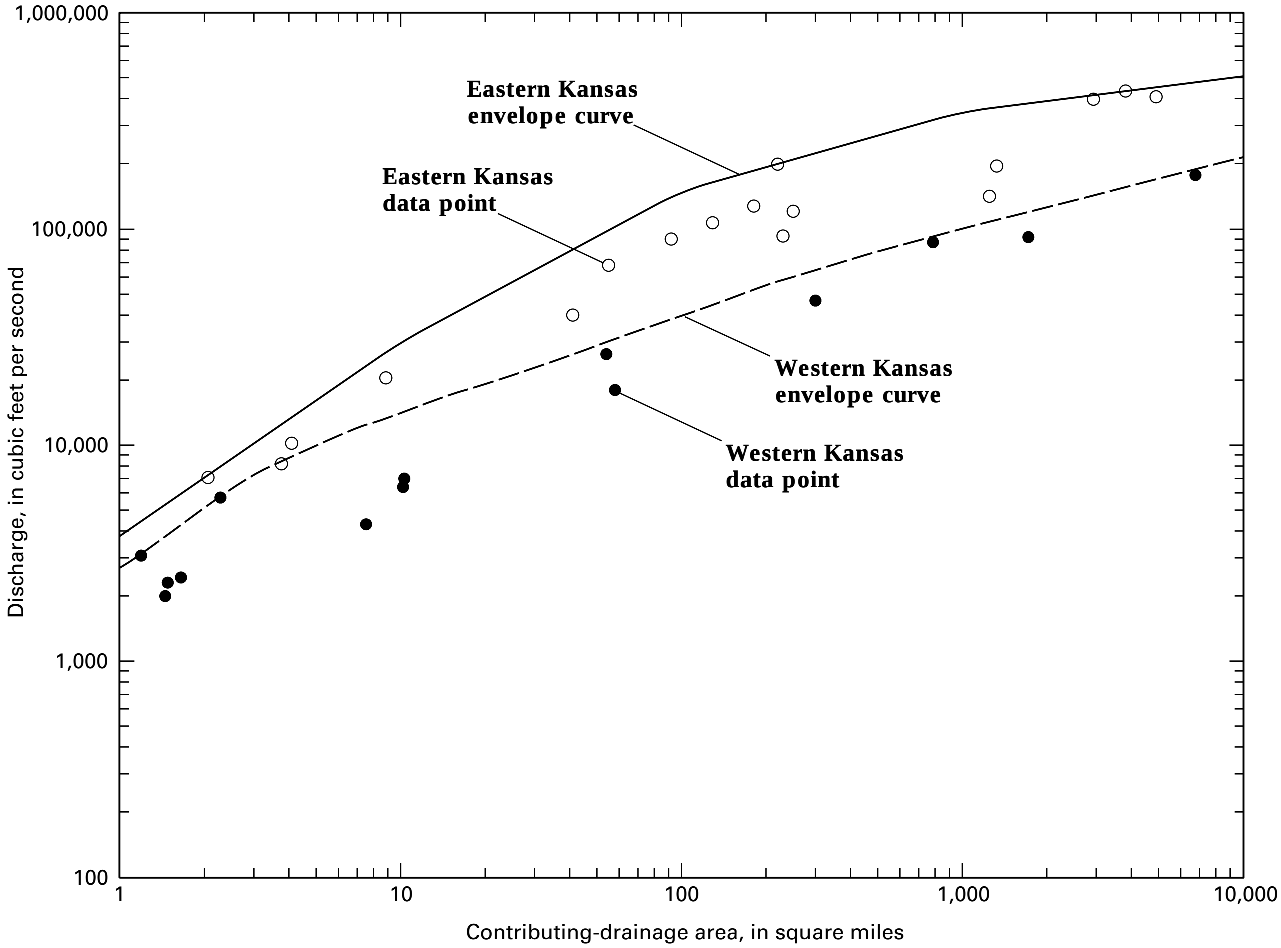

Figure 4. Relation between maximum observed discharge and contributing-drainage area (modified from Crippen and Bue, 1977).

stations ranged from 0.17 to 9,100 mi^2 and extend into parts of Nebraska, Colorado, New Mexico, or Oklahoma for some stations. A summary of drainage-area distribution and average observed length of record per station for those stations used in the analysis is given in table 2. Peak streamflows for 2-, 5-, 10-, 25-, 50-, 100-, and 200-year recurrence intervals were calculated.

Log-Pearson Type III Techniques

In 1966, under the authority of House Document 465 (1966), the Interagency Advisory Committee on Water Data (IACWD) investigated various techniques for the analysis of peak-streamflow frequency and in 1967 recommended that the log-Pearson Type III frequency distribution be adopted as the standard technique to be used in Federal practice (U.S. Water Resources Council, 1967). Subsequently, the U.S. Water Resources Council conducted additional studies that resulted in improvements to the initial log-Pearson Type III technique. The improvements were reported in Bulletin 17B (Interagency Advisory Committee on Water Data, 1981).

The log-Pearson Type III technique transforms the arithmetic values of peak discharges to log values, then three statistics of the log values (mean, standard deviation, and skewness) are computed by the method of moments. The skewness coefficient is adjusted by weighting the computed station skewness with a generalized skew coefficient.

The reliability of the estimated peak-streamflow frequency is dependent on the assumption that the distribution to which the data are fit is correct and that the data are accurate and drawn from a representative sample of random and independent events. The length of the period used to compute the estimates of peak-streamflow frequencies and the variability of the data

Table 2. Number of streamflow-gaging stations for selected ranges of contributing-drainage areas and average length of record for those stations

Contributing-drainage area (square miles)	Number of streamflow-gaging stations	Average observed length of record (years)
0.17 to less than 1	13	30.2
1 to less than 3	17	28.8
3 to less than 10	28	31.5
10 to less than 30	33	25.1
30 to less than 100	37	25.2
100 to less than 300	37	33.8
300 to less than 1,000	45	34.2
1,000 to less than 3,000	31	36.4
3,000 to 9,100	14	35.9

are the principal measures of the reliability. Generally, the longer the record the more reliable the estimates become because the size of the sampling error is proportional to the inverse of the square root of the length of the record.

Historical Peak Discharges and Outlier Thresholds

Many of the records of annual peak discharges at streamflow-gaging stations used in this study contained additional information relating to peak discharges that occurred before, during, or after the period of systematic record collection and represented maximum occurrences during an extended period. For example, it may be known that the maximum peak discharge recorded during the systematic record collection was the largest since a point in time before the beginning or after the ending of the recorded period. Likewise, a peak discharge that occurred outside of the period of systematic record may be known to be larger than any peak discharge that occurred during that period. This "historical data" can be used to make adjustments to the original distribution of the data by assigning a historical period of record that is longer than the systematic period, resulting in adjusted recurrence intervals of the annual maximum peak discharges.

Many drainage areas in Kansas, primarily western Kansas, have physical and climatic characteristics that can yield small annual peak streamflows. These small annual peak streamflows are considered low outliers if they are less than a certain threshold. The outlier thresholds identify data points that depart significantly from the trend of the remaining data, are defined by the *I*ACWD (1981), and are accounted for in the analysis. In some situations, usually where there is more than one low outlier, the threshold appears too low. A visual inspection of the log-Pearson Type III distribution curve allows the analyst to observe the low-outlier threshold relative to the peak-discharge data set and adjust as deemed appropriate. Low-outlier thresholds were increased for 25 stations in Kansas to improve the fit of the data to the log-Pearson Type III distribution. Higher outliers were computed using the *I*ACWD (1981) method.

Skew Coefficient

The *I*ACWD (1981) recommends that the skewness coefficient computed from station records be weighted with a generalized skewness coefficient to reduce the bias caused primarily by records having relatively short lengths. The default method entails estimating the generalized skewness coefficient from a map showing lines of equal skewness for the entire United States (Interagency Advisory Committee on Water Data, 1981). The map showing generalized skewness coefficients of logarithms of annual peak streamflows is based on the skewness coefficients computed from station records collected through 1973 at 2,972 streamflow-gaging stations nationwide having 25 or more years of unregulated record and drainage areas less than 3,000 mi^2. The root-mean-square error (RMSE) between the isolines on the map and the station data for the entire country is 0.55.

Although using the *I*ACWD (1981) map of generalized skewness probably improves most peak-streamflow frequency computations, the spatial position of the lines of equal skewness is subjective. The *I*ACWD (1981) recommends that skewness coefficients be regionalized by one of three techniques—
(1) averaging the station skewness coefficients within a specific area, (2) developing a local skewness map, or (3) relating the coefficients to predictor variables, such as physical and climatic characteristics of the drainage basins.

The greatest problem encountered when estimating the value of the skewness coefficient is the large error in results that are computed from short-term gaging-station records. A weighted least-squares (WLS) regression model was developed by Tasker and Stedinger (1986) to solve this problem. This WLS model weights the error variances on the basis of the length of the data record and variability in the data. The WLS model is well adapted for analysis of hydrologic data having variable accuracy because of the ability to separate the error of prediction into the sampling error and model error and to treat each error separately on the basis of length of the peak-streamflow record at the gaging station. The sampling error is a function of the length of the record and the degree of deviation from the average predictor variables. The model error, in this case, is the error associated with the formulation of the model. The error that can be expected when using the regression equation is the error of prediction, which includes both the sampling and model errors.

The WLS regression model weights each unbiased estimate of skewness on the basis of the length of the record of annual peak discharges. The technique relates the station skewness coefficient determined from the log-Pearson Type III distribution to one or more physical or climatic characteristics of the respective drainage basins. The result of the computations yields the coefficients and constants of a regression equation, as well as their significance to the equation. The resulting equation can be used to estimate the generalized skewness coefficient.

The WLS regression model in this report used station skewness computed from 253 streamflow-gaging-station records in Kansas as the dependent variable and several physical and climatic characteristics for each station as independent (predictor) variables. A summary of the results, including description and dimensions of the various physical and climatic characteristics for each gaging station used in the analysis, is provided in table 5 (at the end of this report).

The computation of the generalized skewness coefficient was limited to those stations having drainage areas no larger than 9,100 mi^2. The length of record for all stations was 11 or more years, and the value of station skewness ranged from -1.76 to 1.99. Contributing drainage area *(CDA)*, latitude *(Lat)*, and longitude *(Lng)* were the independent variables that yielded the best equation on the basis of the magnitude of the RMSE.

The equation used for estimating the generalized skewness coefficient at streamflow-gaging stations in Kansas is:

$$G_g = 1.191 + 0.0641 \log_{10}(CDA) + 0.0935\,(Lat) - 0.0519\,(Lng), \qquad (1)$$

where

G_g = generalized skewness coefficient for the selected gaging station to be used in lieu of the *I*ACWD Bulletin 17B map of generalized skewness (Interagency Advisory Committee on Water Data, 1981);

CDA = contributing-drainage area, in square miles;

Lat = latitude of the gaging station, in decimal degrees; and

Lng = longitude of the gaging station, in decimal degrees.

A weighted skewness coefficient used to compute the frequency of peak streamflows was the result of weighting estimates of the station skewness coefficient (G_s) and generalized skewness coefficient (G_g), where the weights were estimates as recommended in *I*ACWD Bulletin 17B (1981, p. 12–13). In this case, the RMSE associated with the generalized skewness coefficient (G_g) is the error of prediction of the estimating equation. The RMSE is 0.19 for equation 1, whereas it is 0.35 in the most recent previously published peak-streamflow report for Kansas (Clement, 1987). Increased record length is most likely the reason the RMSE has improved.

Peak-Streamflow Frequencies at Gaging Stations

Using the unregulated annual peak streamflows recorded for 253 streamflow-gaging stations with lengths of record equal to or greater than 10 years, log-Pearson Type III distributions were fitted to the peak-streamflow data for each site. Adjustments then were made to account for data that represented low or high outliers and for historical data where necessary. Final estimates of peak-streamflow frequencies (table 5) were computed using the generalized skewness coefficients (G_g) obtained for each station using equation 1 and weighted with the station skewness coefficient (G_s) as recommended in *I*ACWD Bulletin 17B (1981).

A study by Perry and Rasmussen (in press) points out that the effects of streamflow trends are not accounted for using the peak-streamflow frequency techniques in Bulletin 17B. Further investigation may be required to fully understand the effects of trends on peak streamflow and how to adjust the peak-streamflow analysis accurately. Peak-streamflow frequency analysis assumes a random sampling of a stable population of annual peak streamflows. If that population is not stable (that is, mean and standard deviations are not constant), it may be necessary to adjust the peak-streamflow data to obtain the best-fit peak-streamflow frequency analysis. However, the persistence of trends must be considered also.

REGRESSION EQUATIONS FOR ESTIMATION OF PEAK-STREAMFLOW FREQUENCIES AT UNGAGED SITES ON UNREGULATED, RURAL STREAMS

Regression Analysis

Although information concerning peak-streamflow frequencies is available at many streamflow-gaging-station locations in Kansas, often such information is needed at stream sites where insufficient or no data are available. Generalization of the peak-streamflow frequency information at gaging stations will facilitate estimates at ungaged sites. Multiple-regression analysis was used in this study to relate the peak streamflow at selected frequency intervals to various physical and climatic characteristics.

Research by Tasker and Stedinger (1989) indicates that generalized least squares (GLS) is appropriate for hydrologic regression. GLS regression takes into consideration the time-sampling error (length of record at each site) and the cross correlation of annual peak streamflows between sites.

The GLS regression model in this study used base-10 logarithmic transformation for both dependent and independent variables. The form of the model equation is:

$$\log_{10}Q_t = \log_{10}a + b_1\log_{10}X_1 + b_2\log_{10}X_2 .... + b_n\log_{10}X_n, \quad (2)$$

which is equivalent to:

$$Q_t = 10^a X_1^{b_1} X_2^{b_2} \ldots X_n^{b_n}, \quad (3)$$

where

- Q_t is peak discharge for recurrence interval t, in years (dependent variable);
- X_1 - X_n are physical and climatic characteristics (independent variables);
- a is the regression constant; and
- b_1 - b_n are the regression coefficients.

Selected Physical and Climatic Characteristics

The independent variables tested in the regression analysis were physical and climatic characteristics of each drainage basin. Initially, eight physical and climatic characteristics were tested: contributing-drainage area *(CDA)*, mean annual precipitation *(P)*, soil permeability *(S)*, latitude and longitude, main channel length, main channel slope *(Sl)*, basin slope, basin shape, and basin elevation.

In previous peak-streamflow frequency studies for Kansas, characteristics describing the physiography and climate of each drainage basin were calculated using rough approximations with paper maps. Depending on the scale of the map or the techniques used to calculate the characteristic, a variety of errors could occur. Some physical characteristics that possibly could improve the regression estimates were nearly impossible to calculate and either were estimated or ignored for the analysis.

For this study, ARC/INFO geographical information systems (GIS) software was used to estimate physical and climatic characteristics. Many spatial-data sets were available for this task, including: (1) 30-m gridded elevation data (U.S. Geological Survey, 1998) for determining the drainage-basin boundary, contributing-drainage area, basin slope, and mean basin elevation, (2) STATSGO soil-permeability data (U.S. Department of Agriculture, 1994), and (3) 30-year (1961–90) mean annual precipitation data (Daly and others, 1997). Drainage boundaries were determined using GIS for all 253 gaging stations used in the report. The drainage boundaries and the spatial-data sets just mentioned were used to calculate average physical and climatic characteristics for each basin (table 3).

Regression analysis relies on the assumption that independent variables are not closely interrelated. Violation of this rule generally results in regression coefficients that are unstable, and it becomes difficult to evaluate the interrelated variables' importance to the respective equations. Therefore, a simple cross-correlation matrix was computed for all independent variables and was used in the analysis to identify variables that might pose problems if included in the same analysis. Pairs of variables having correlation coefficients greater than 0.8 were considered closely interrelated, were evaluated further in the initial analysis, and only the more significant variable of the pair was included in the final analysis.

The ability of a regression equation to reliably estimate the peak streamflow having selected recurrence intervals at ungaged sites is measured by the error of prediction. The error of prediction is the mea-

Table 3. Selected physical and climatic characteristics as predictors of peak-streamflow discharges for unregulated, rural streams in Kansas

Basin characteristics code	Description of basin physical or climatic characteristic
CDA	Contributing-drainage area upstream from the streamflow-gaging station that contributes directly to the streamflow, in square miles.
P	Mean annual precipitation for the entire basin, in inches.
Sl	Slope of the main channel, in feet per mile, as measured by dividing the difference in elevation at points in the channel at 10 and 85 percent of the main channel length by the intervening main channel length.
S	Average soil permeability for the entire basin, in inches per hour.

sure of confidence in the estimated peak streamflow and describes the range within which an estimate would occur two-thirds of the time. Computed in logarithmic units, the RMSE, or the error of prediction, can be expressed as a percentage as shown in Hardison (1971). The percentages are unequal in the positive and negative directions. For example, the standard error of estimate of 0.17 logarithmic units represents errors of +48 and -32 percent; the average of the two percentages without regard to sign is 40 percent.

Regression Equation Results

Regression analysis was performed, and equations were developed for peak streamflow having recurrence intervals of 2, 5, 10, 25, 50, 100, and 200 years. The independent variables that most contribute to the explanation of the variance in the dependent variable (the peak streamflow) were *CDA*, *P*, *Sl,* and *S*. Table 4 gives the equations, the errors of prediction, and the equivalent years of record for each recurrence interval.

Attempts were made to improve the error of prediction for the regression equations by developing regional equations for smaller parts of the State. The first attempt was to divide the State along 97^{o} longitude, similar to the division developed by Crippen and Bue (1977) as discussed earlier. Separate equations were developed for the gaging stations in the eastern and western divisions. The prediction error for the equations representing the eastern division decreased slightly, whereas the prediction error for the equations representing the western division increased.

Another attempt to reduce the prediction error was to group gaging stations according to drainage areas. The prediction errors for most of the equations developed for various groups tested were greater than the original error of prediction for equations developed from all 253 gaging stations. The best results were achieved when stations with contributing-drainage areas ranging from 30 to 9,100 mi^2 were grouped together. Standard errors of prediction were reduced between 12 and 20 percent from predictions errors using all 253 stations. Standard error of prediction for equations developed for stations with contributing-drainage areas ranging from 0.17 to less than 30 mi^2 were equal to or slightly greater than the standard errors for the equations developed using all the stations. The error of prediction for the most reliable equations ranged from 0.131 (31 percent) for the 10-year recurrence interval in large basins to 0.248 (62 percent) for the 200-year recurrence interval in small basins.

A direct statistical comparison of the equations from Clement (1987) to the equations from the current investigation is not possible because of differing data and groups of gages upon which the equations are based. Clement (1987) developed equations that were based on 218 gaging stations compared to the two groups of 91 and 164 gaging stations used in the current investigation. A review of the standard error of prediction of the equations indicates the errors in the 1987 study are generally about 15 percent less than those of the current investigation. However, separate regression analysis (not included in this report) was done using (1) peak streamflow record through 1903 for 237 gaging stations, (2) the same basin characteristics as in this investigation, and (3) the same drainage-area grouping as described in this investigation. The standard errors of prediction of the resulting equations are about 13 percent greater than those for the equations presented in this report.

Hardison (1971) related prediction error and streamflow variability to equivalent years of record.

Table 4. Generalized least-squares regression equations for estimating 2- to 200-year peak-streamflow discharges for unregulated, rural streams in Kansas

[Q_t, estimated peak discharge, in cubic feet per second, for a *t*-year recurrence interval; CDA, contributing-drainage area for the site, in square miles; P, average mean annual precipitation for the entire basin, in inches; S*l*, slope of the main channel, in feet per mile; S, average soil permeability for the entire basin, in inches per hour]

Q_t	Regression equations	Model standard error of prediction (log_{10} units)	Model standard error of prediction (percent)	Average equivalent years of record
	For drainage areas ranging from 30 to 9,100 square miles			
Q_2	$0.000182\ (CDA)^{0.532}(P)^{4.055}$	0.177	+50/-33	6.0
	$0.00000501(CDA)^{0.648}(P)^{4.614}(Sl)^{0.557}$	.157	+44/-30	7.6
	$0.00001477(CDA)^{0.646}(P)^{4.307}(Sl)^{0.5266}(S)^{-0.1736}$	.155	+43/-30	7.8
Q_5	$0.007166(CDA)^{0.494}(P)^{3.281}$	.154	+43/-30	10
	$0.000344(CDA)^{0.592}(P)^{3.760}(Sl)^{0.4596}$	.138	+37/-27	13
	$0.001336(CDA)^{0.590}(P)^{3.373}(Sl)^{0.4235}(S)^{-0.2231}$	.133	+36/-26	14
Q_{10}	$0.0390(CDA)^{0.480}(P)^{2.931}$	.150	+41/-29	14
	$0.00245(CDA)^{0.570}(P)^{3.371}(Sl)^{0.4117}$	.137	+37/-27	17
	$0.01085(CDA)^{0.568}(P)^{2.945}(Sl)^{0.374}(S)^{-0.248}$	.131	+35/-26	19
Q_{25}	$0.195(CDA)^{0.469}(P)^{2.603}$	.153	+42/-30	19
	$0.0163(CDA)^{0.550}(P)^{3.001}(Sl)^{0.365}$	.144	+39/-28	21
	$0.0829(CDA)^{0.549}(P)^{2.532}(Sl)^{0.326}(S)^{-0.275}$	.136	+37/-27	24
Q_{50}	$0.508(CDA)^{0.465}(P)^{2.411}$	.159	+44/-31	21
	$2.482(CDA)^{0.473}(P)^{1.916}(S)^{-0.318}$	.150	+41/-29	24
	$0.283(CDA)^{0.539}(P)^{2.283}(S)^{-0.293}(Sl)^{0.298}$	.144	+39/-28	26
Q_{100}	$1.16(CDA)^{0.462}(P)^{2.250}$	.166	+47/-32	23
	$5.93(CDA)^{0.471}(P)^{1.733}(S)^{-0.332}$	.156	+43/-30	26
	$0.810(CDA)^{0.532}(P)^{2.070}(S)^{-0.309}(Sl)^{0.272}$	.153	+42/-30	27
Q_{200}	$2.30(CDA)^{0.461}(P)^{2.110}$	.174	+49/-33	24
	$12.7(CDA)^{0.470}(P)^{1.575}(S)^{-0.344}$	.164	+46/-31	27
	$2.050(CDA)^{0.526}(P)^{1.882}(S)^{-0.324}(Sl)^{0.250}$	.163	+46/-31	28
	For drainage areas ranging from 0.17 to less than 30 square miles			
Q_2	$0.0126(CDA)^{0.579}(P)^{2.824}$	.216	+64/-39	4.1
Q_5	$0.300(CDA)^{0.600}(P)^{2.138}$	.184	+53/-35	7.0
Q_{10}	$1.224(CDA)^{0.611}(P)^{1.844}$	.183	+58/-37	9.0
Q_{25}	$4.673(CDA)^{0.622}(P)^{1.572}$	.198	+58/-37	10
Q_{50}	$10.26(CDA)^{0.628}(P)^{1.415}$	.214	+64/-39	11
Q_{100}	$19.80(CDA)^{0.634}(P)^{1.288}$	.232	+71/-44	11
Q_{200}	$34.68(CDA)^{0.640}\ (P)^{1.181}$	.248	+77/-44	11

The equivalent years of record is the number of years of streamflow record necessary to provide an estimate equal in accuracy to the regression equation. The accuracy of the regression equations for unregulated, rural streams, expressed in average equivalent years of record, is summarized in table 4.

Use of Regression Equations

The GLS regression equations shown in table 4 may be used to estimate the peak streamflow for specific recurrence intervals (frequencies) at ungaged sites by determining the values of the physical and climatic characteristics relative to the site and substituting the values into the respective equations. The values for contributing-drainage area *(CDA)* can be determined from digital data using GIS or paper topographic maps. The values for mean annual precipitation *(P)* and soil permeability *(S)* can be determined from digital data using GIS or from figures 2 or 3. Both *P* and *S* are areal averages for the entire drainage area. Main channel slope *(Sl)* can be measured and calculated from topographic maps.

The equations shown in table 4 were developed using data from streams located in rural basins, whose contributing-drainage areas ranged from 0.17 to 9,100 mi^2, during periods of record when flows were unregulated. Therefore, the equations should not be used to estimate peak streamflow if the watershed is not predominately rural, if the contributing-drainage area is smaller than 0.17 mi^2 or larger than 9,100 mi^2, or if streamflow is affected by regulation.

SUMMARY

Estimates of peak streamflow for selected frequencies were computed by using observed annual peak-streamflow data collected through the 1997 water year for streamflow-gaging stations located on unregulated rural streams in Kansas with 10 or more years of record. Log-Pearson Type III distributions were fitted to the observed annual peak-streamflow data for each streamflow-gaging station by using techniques recommended by the Interagency Committee on Water Data. Peak streamflows for 2-, 5-, 10-, 25-, 50-, 100-, and 200-year recurrence intervals were calculated.

A weighted least-squares (WLS) regression model was used to estimate a generalized skew coefficient for all the stations in this analysis. The WLS regression model used station skew coefficients computed from 253 streamflow-gaging-station records in Kansas as the dependent variable and several physical and climatic characteristics for each station as independent (predictor) variables in a regression equation. The root-mean-square error (RMSE) for this equation (0.19) decreased from a RMSE of 0.35 for a previously developed equation.

Regression equations then were developed to compute peak streamflows for ungaged sites at selected recurrence intervals by using generalized least-square regression to relate peak streamflow at gaging stations to physical and climatic characteristics. The significant independent variables in the regression equations were contributing-drainage area, mean annual precipitation, average soil permeability, and slope of the main channel. Standard error of prediction did not improve when the State was divided into eastern and western areas. The standard error of prediction for the regression equations was smallest when the group of 253 streamflow-gaging stations was divided into two groups on the basis of contributing-drainage area. Standard error of prediction for equations developed for stations with contributing-drainage areas greater than 0.17 and less than 30 mi^2 were equal to or slightly greater than the standard errors for the equations developed using all the stations. Standard errors of prediction for equations developed for stations with contributing-drainage areas between 30 and 9,100 mi^2 were reduced between 12 and 20 percent from predictions errors using all 253 stations. The errors of prediction for all the generated equations ranged from 31 to 62 percent.

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Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas

[ft^3/s, cubic feet per second; mi^2, square miles; in., inches; ft/mi, feet per mile; in/h, inches per hour; --, not determined]

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft^3/s)	Low-outlier threshold (ft^3/s)	Total drainage area (mi^2)
1	6813700	Tennessee Creek tributary near Seneca, Kansas	39.81278	96.04556	33	--	--	--	0.90
2	6814000	Turkey Creek near Seneca, Kansas	39.94778	96.10833	49	--	--	226	276
3	6815700	Buttermilk Creek near Willis, Kansas	39.75444	95.45056	40	--	--	--	3.74
4	6818200	Doniphan Creek at Doniphan, Kansas	39.63556	95.08194	11	--	--	--	4.15
5	6818260	White Clay Creek at Atchison, Kansas	39.55917	95.12722	25	--	--	--	13.1
6	6844700	South Fork Sappa Creek near Brewster, Kansas	39.28528	101.46556	22	--	--	--	74.0
7	6844800	South Fork Sappa Creek tributary near Goodland, Kansas	39.32056	101.63250	33	--	--	--	4.98
8	6844900	South Fork Sappa Creek near Achilles, Kansas	39.67694	100.72167	38	--	--	10	446
9	6845000	Sappa Creek near Oberlin, Kansas	39.81250	100.53333	35	--	--	--	1,063
10	6845100	Long Branch Draw near Norcatur, Kansas	39.90167	100.17861	41	--	--	--	31.7
11	6846000	Beaver Creek at Ludell, Kansas	39.84806	100.96111	42	--	--	--	1,460
12	6846200	Beaver Creek tributary near Ludell, Kansas	39.81472	100.87194	33	--	--	70	10.2
13	6846500	Beaver Creek at Cedar Bluffs, Kansas	39.98500	100.55972	52	--	--	--	1,620
14	6847600	Prairie Dog Creek tributary at Colby, Kansas	39.39111	101.04528	41	55	4,290	--	7.53
15	6847900	Prairie Dog Creek above Keith Sebelius Lake, Kansas	39.77028	100.10000	35	54	65,400	--	590
16	6848000	Prairie Dog Creek at Norton, Kansas	39.81000	99.92167	20	--	--	--	684
17	6848200	Prairie Dog Creek tributary near Norton, Kansas	39.85417	99.88806	35	--	--	--	1.02
18	6848500	Prairie Dog Creek near Woodruff, Kansas	39.98583	99.47750	23	--	--	--	1,010
19	6853800	White Rock Creek near Burr Oak, Kansas	39.89861	98.25139	40	129	15,700	--	227
20	6854000	White Rock Creek at Lovewell, Kansas	39.88611	98.02222	11	88	23,200	--	345
21	6855800	Buffalo Creek near Jamestown, Kansas	39.61528	97.85556	31	--	--	--	330
22	6855900	Wolf Creek near Concordia, Kansas	39.54306	97.72222	19	--	--	--	56.0
23	6856100	West Creek near Talmo, Kansas	39.66667	97.61333	33	107	14,900	--	42.0
24	6856320	Elk Creek at Clyde, Kansas	39.59444	97.39694	26	--	--	--	73.0
25	6856800	Moll Creek near Green, Kansas	39.38000	97.00778	34	--	--	36	3.6
26	6858500	North Fork Smoky Hill River near McAllaster, Kansas	39.01694	101.34750	33	--	--	--	670
27	6858700	North Fork Smoky Hill River tributary near Winona, Kansas	39.03083	101.28528	16	--	--	--	1.13
28	6859500	Ladder Creek below Chalk Creek near Scott City, Kansas	38.78889	100.86944	29	80	17,900	--	1,460
29	6860000	Smoky Hill River at Elkader, Kansas	38.79250	100.85528	58	60	70,900	--	3,560
30	6860300	South Branch Hackberry Creek near Orion, Kansas	38.94167	100.70278	12	--	--	--	49.6
31	6860500	Hackberry Creek near Gove, Kansas	38.95417	100.48472	36	--	--	--	426
32	6861000	Smoky Hill River near Arnold, Kansas	38.80861	100.02028	50	60	86,900	--	5,220
33	6863300	Big Creek near Ogallah, Kansas	38.91111	99.74444	13	--	--	--	297
34	6863400	Big Creek tributary near Ogallah, Kansas	38.93333	99.74250	41	--	--	--	4.81
35	6863500	Big Creek near Hays, Kansas	38.81250	99.25389	51	90	19,800	--	594

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s)						
							2-year	5-year	10-year	25-year	50-year	100-year	200-year
1	0.90	34.0	0.395	62.1	-0.0742	-0.047	201	497	794	1,300	1,790	2,390	3,090
2	276	32.3	.467	5.89	.0946	-.1089	5,820	12,500	18,400	27,700	36,000	45,300	55,900
3	3.74	36.6	.367	67.2	-.0091	-.1147	1,520	2,760	3,750	5,160	6,320	7,580	8,930
4	4.15	36.7	1.083	44.6	.0018	-.0627	1,080	2,480	3,820	6,030	8,070	10,500	13,300
5	13.1	36.8	.955	37.7	.0243	.0788	1,100	2,180	3,120	4,610	5,950	7,490	9,260
6	74.0	18.3	1.296	10.8	-.2821	-.3779	52	382	996	2,600	4,670	7,740	12,100
7	4.98	18.2	1.296	14.4	-.3626	-.3187	54	389	1,020	2,690	4,900	8,260	13,100
8	378	19.2	1.297	7.00	-.1614	-.1685	342	1,210	2,290	4,430	6,730	9,730	13,600
9	900	19.8	1.321	7.33	-.1148	-.1415	827	2,570	4,570	8,320	12,200	17,000	23,100
10	31.7	21.9	1.299	12.8	-.1812	-.1514	294	693	1,070	1,680	2,230	2,870	3,600
11	1,120	18.5	1.325	8.11	-.1277	-.1046	440	1,110	1,780	2,920	4,000	5,300	6,840
12	10.2	21.3	1.291	33.2	-.2569	-.3999	298	665	974	1,430	1,800	2,190	2,610
13	1,320	18.8	1.326	7.72	-.0893	.064	413	1,060	1,730	2,960	4,190	5,740	7,680
14	7.53	19.2	1.296	16.7	-.314	-.437	215	568	898	1,410	1,860	2,350	2,880
15	590	20.7	1.362	7.11	-.1081	-.1862	599	1,680	2,820	4,820	6,760	9,100	11,900
16	689	21.0	1.361	7.03	-.0908	.0372	2,760	7,180	11,900	20,400	29,000	39,800	53,200
17	1.02	22.8	1.299	67.8	-.2663	-.3926	185	366	507	701	854	1,010	1,180
18	1,000	21.6	1.368	5.61	-.0409	.0823	2,300	5,020	7,610	11,900	16,000	20,800	26,600
19	227	26.5	1.299	6.95	-.0267	.1703	1,520	3,040	4,430	6,680	8,760	11,200	14,100
20	345	27.1	1.306	6.12	-.0043	.2749	2,790	4,910	6,710	9,480	11,900	14,800	18,000
21	330	27.9	1.103	6.15	-.0222	.1535	1,670	3,890	6,140	10,100	14,000	18,900	25,000
22	56.0	28.8	1.013	8.79	-.0714	-.0863	910	1,770	2,490	3,570	4,490	5,520	6,640
23	42.0	29.6	.843	7.07	-.0622	.1582	676	1,870	3,250	5,920	8,780	12,600	17,600
24	73.0	30.1	.993	11.0	-.0424	.072	546	1,350	2,170	3,640	5,100	6,910	9,150
25	3.60	31.1	.778	20.4	-.126	-.2802	371	809	1,190	1,750	2,230	2,750	3,320
26	650	17.1	1.448	7.84	-.2405	-.3164	327	1,930	4,580	11,000	18,900	30,100	45,700
27	1.13	18.4	1.296	69.2	-.4129	-.3056	342	611	810	1,080	1,290	1,500	1,730
28	1,330	17.7	1.395	6.87	-.2171	-.0893	646	2,590	5,270	11,100	17,900	27,500	40,400
29	3,390	17.7	1.530	13.2	-.19	-.2754	1,510	6,400	13,000	26,900	42,200	62,500	88,700
30	49.6	19.6	1.294	9.34	-.2857	-.2099	397	1,190	2,050	3,590	5,110	6,970	9,210
31	421	19.5	1.288	6.71	-.2137	-.1192	508	2,340	5,100	11,500	19,300	30,600	46,500
32	5,220	18.4	1.522	11.4	-.1331	-.1133	2,230	7,660	14,400	27,800	42,300	61,400	86,100
33	297	21.4	1.278	6.27	-.189	-.165	1,340	4,430	8,090	15,100	22,500	31,900	43,800
34	4.81	21.8	1.201	15.8	-.3016	-.1102	211	707	1,310	2,510	3,790	5,470	7,630
35	594	21.8	1.175	5.82	-.1535	-.2795	1,280	3,210	5,050	7,990	10,600	13,600	17,000

Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas—Continued

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft^3/s)	Low-outlier threshold (ft^3/s)	Total drainage area (mi^2)
36	6863700	Big Creek tributary near Hays, Kansas	38.85222	99.24667	39	--	--	--	6.19
37	6863900	North Fork Big Creek near Victoria, Kansas	38.88667	99.20583	25	300	25,000	--	54.0
38	6864000	Smoky Hill River near Russell, Kansas	38.77667	98.85444	11	37	69,900	--	6,970
39	6864300	Smoky Hill River tributary at Dorrance, Kansas	38.84778	98.59556	41	--	--	21	5.39
40	6864500	Smoky Hill River at Ellsworth, Kansas	38.72667	98.23333	42	--	--	--	7,580
41	6864700	Spring Creek near Kanopolis, Kansas	38.73972	98.16861	33	--	--	28	9.84
42	6866000	Smoky Hill River at Lindsborg, Kansas	38.56583	97.67222	18	53	32,000	--	8,110
43	6866500	Smoky Hill River near Mentor, Kansas	38.79833	97.57444	10	104	32,000	--	8,360
44	6866800	Saline River tributary at Collyer, Kansas	39.04611	100.12667	33	--	--	--	3.13
45	6866900	Saline River near Wakeeney, Kansas	39.10611	99.86944	12	88	20,000	--	696
46	6867000	Saline River near Russell, Kansas	38.96667	98.85556	46	80	41,500	100	1,500
47	6867500	Paradise Creek near Paradise, Kansas	39.07361	98.85417	20	--	--	--	212
48	6867800	Cedar Creek tributary near Bunker Hill, Kansas	38.93417	98.71250	21	--	--	11	.99
49	6868000	Saline River near Wilson, Kansas	38.93333	98.53333	36	--	--	--	1,900
50	6868300	Coon Creek tributary near Luray, Kansas	39.17500	98.70056	41	--	--	--	6.53
51	6868400	Wolf Creek near Lucas, Kansas	39.05833	98.55278	32	--	--	50	163
52	6868700	North Branch Spillman Creek near Ash Grove, Kansas	39.15222	98.39583	15	--	--	--	26.1
53	6868900	Bullfoot Creek tributary near Lincoln, Kansas	38.97417	98.15083	31	--	--	--	2.64
54	6869500	Saline River at Tescott, Kansas	39.00417	97.87389	45	61	61,300	--	2,820
55	6869950	Mulberry Creek near Salina, Kansas	38.84444	97.66806	36	--	--	--	250
56	6870300	Gypsum Creek near Gypsum, Kansas	38.65306	97.41944	36	88	12,000	200	120
57	6871000	North Fork Solomon River at Glade, Kansas	39.67778	99.30833	45	--	--	--	849
58	6871500	Bow Creek near Stockton, Kansas	39.56278	99.28444	47	--	--	--	341
59	6871800	North Fork Solomon River at Kirwin, Kansas	39.66000	99.11528	24	40	53,900	--	1,370
60	6871900	Deer Creek near Phillipsburg, Kansas	39.78056	99.42222	15	--	--	--	65.0
61	6872100	Middle Cedar Creek at Kensington, Kansas	39.75583	99.03444	21	--	--	--	58.9
62	6872300	Middle Beaver Creek near Smith Center, Kansas	39.80000	98.85278	10	--	--	--	71.0
63	6872600	Oak Creek at Bellaire, Kansas	39.79833	98.66667	33	--	--	40	4.75
64	6873000	South Fork Solomon River above Webster Reservoir, Kansas	39.37389	99.58167	53	90	55,200	40	1,040
65	6873300	Ash Creek tributary near Stockton, Kansas	39.43750	99.37111	39	--	--	--	.89
66	6873500	South Fork Solomon River at Alton, Kansas	39.45917	98.94333	28	--	--	5	1,720
67	6873700	Kill Creek near Bloomington, Kansas	39.37917	98.85917	18	--	--	--	52.0
68	6873800	Kill Creek tributary near Bloomington, Kansas	39.39944	98.84056	21	--	--	--	1.45
69	6874000	South Fork Solomon River at Osborne, Kansas	39.42861	98.69444	10	79	80,000	--	2,010
70	6874500	East Limestone Creek near Ionia, Kansas	39.69778	98.33861	38	--	--	--	25.6

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s)						
							2-year	5-year	10-year	25-year	50-year	100-year	200-year
36	6.19	22.2	1.035	14.8	-.2765	-0.1364	63	209	382	717	1,070	1,530	2,100
37	54.0	22.9	1.258	8.30	-.2108	-.2145	263	1,250	2,640	5,570	8,770	13,000	18,300
38	6,970	19.5	1.462	9.70	-.0676	-.192	7,810	16,000	22,900	33,100	41,800	51,400	61,800
39	5.39	26.2	1.076	24.8	-.2469	-.1911	245	631	1,010	1,660	2,250	2,960	3,780
40	7,580	20.0	1.457	8.95	-.0377	-.1724	6,920	16,700	26,000	41,200	55,000	71,100	89,500
41	9.84	27.8	1.138	17.8	-.2181	-.235	461	1,170	1,870	3,000	4,040	5,250	6,630
42	8,110	20.6	1.463	7.41	-.0217	.1793	5,910	11,000	15,500	22,400	28,600	35,800	44,100
43	8,360	20.8	1.450	6.65	.0059	.2919	5,080	10,400	15,500	24,100	32,400	42,600	55,000
44	3.13	22.1	1.201	33.2	-.323	-.2645	161	565	1,050	1,980	2,930	4,130	5,620
45	696	20.6	1.369	7.17	-.1536	-.2084	2,720	8,200	14,200	25,100	35,900	49,100	65,000
46	1,500	21.7	1.388	6.86	-.0926	-.0769	2,270	6,630	11,500	20,500	29,700	41,400	55,900
47	212	23.9	1.307	7.29	-.137	-.2027	947	3,160	5,780	10,800	15,900	22,400	30,500
48	0.99	25.9	1.118	99.3	-.2921	-.162	130	223	292	387	462	541	623
49	1,900	22.4	1.362	6.28	-.0724	-.1429	4,940	10,900	16,300	24,800	32,300	40,800	50,500
50	6.53	24.9	1.188	43.2	-.2165	-.2587	357	1,070	1,830	3,170	4,470	6,040	7,890
51	163	25.0	1.195	16.4	-.1301	-.1601	1,570	3,660	5,600	8,730	11,600	14,800	18,500
52	26.1	25.8	1.029	14.0	-.1642	-.1866	342	1,100	1,960	3,600	5,260	7,360	9,950
53	2.64	27.5	1.186	31.0	-.2319	-.2033	104	239	362	555	727	922	1,140
54	2,820	23.7	1.313	5.02	-.0206	-.0468	3,110	6,940	10,500	16,300	21,700	27,900	35,200
55	250	28.3	1.123	9.67	-.0923	-.1365	2,310	4,530	6,380	9,100	11,400	13,900	16,700
56	120	30.9	.881	9.54	-.1177	-.0709	2,290	4,310	5,960	8,400	10,500	12,700	15,200
57	849	21.3	1.335	7.79	-.0655	-.2132	1,580	4,790	8,320	14,700	21,000	28,800	38,200
58	341	21.6	1.451	6.73	-.1004	.159	926	2,960	5,320	9,790	14,400	20,200	27,500
59	1,370	21.5	1.377	7.60	-.0439	.0564	3,950	10,100	16,700	28,500	40,400	55,300	73,900
60	65.0	23.0	1.366	16.5	-.1333	-.2286	1,210	3,430	5,760	9,790	13,600	18,300	23,700
61	58.9	23.8	1.223	8.61	-.1183	.0345	577	1,350	2,100	3,390	4,610	6,100	7,890
62	71.0	24.5	1.248	11.1	-.0995	-.1213	765	1,390	1,880	2,590	3,170	3,790	4,460
63	4.75	24.8	1.222	22.0	-.1653	-.0569	91	273	481	875	1,290	1,810	2,470
64	1,040	20.9	1.463	8.29	-.1026	-.085	2,800	8,330	14,600	26,300	38,300	53,600	72,700
65	.89	22.9	1.201	58.9	-.2822	-.1342	37	150	304	637	1,020	1,540	2,240
66	1,680	21.6	1.410	8.38	-.048	-.0095	3,600	12,300	23,400	46,300	72,000	107,000	154,000
67	52.0	24.4	1.203	10.9	-.1478	-.1976	182	1,150	2,890	7,480	13,600	23,100	37,000
68	1.45	25.0	1.165	23.9	-.2446	-.284	208	585	970	1,630	2,240	2,960	3,790
69	2,010	22.1	1.391	7.93	-.0329	.0914	3,130	7,070	10,900	17,400	23,700	31,300	40,400
70	25.6	26.9	1.228	11.8	-.1108	-.2317	608	1,320	1,940	2,880	3,680	4,580	5,550

Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas—Continued

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft^3/s)	Low-outlier threshold (ft^3/s)	Total drainage area (mi^2)
71	6875800	Limestone Creek near Glen Elder, Kansas	39.53833	98.31611	22	--	--	--	210
72	6876000	Solomon River at Beloit, Kansas	39.41917	98.05917	44	89	124,000	--	5,530
73	6876200	Middle Pipe Creek near Miltonvale, Kansas	39.35000	97.56889	21	--	--	--	10.2
74	6876700	Salt Creek near Ada, Kansas	39.14167	97.83611	38	101	15,900	--	384
75	6876900	Solomon River at Niles, Kansas	38.96889	97.47611	44	89	178,000	--	6,770
76	6877120	Mud Creek at Abilene, Kansas	38.92972	97.22750	28	--	--	--	87.0
77	6877200	West Turkey Creek near Elmo, Kansas	38.66778	97.17167	21	--	--	--	26.6
78	6877400	Turkey Creek tributary near Elmo, Kansas	38.68250	97.18444	21	--	--	--	2.48
79	6877500	Turkey Creek near Abilene, Kansas	38.80611	97.18139	30	88	23,600	--	143
80	6878000	Chapman Creek near Chapman, Kansas	39.03111	97.04000	44	47	46,600	--	300
81	6878500	Lyon Creek near Woodbine, Kansas	38.88472	96.90972	21	--	--	--	230
82	6879200	Clark Creek near Junction City, Kansas	39.00778	96.73889	32	--	--	--	200
83	6879650	Kings Creek near Manhattan, Kansas	39.10194	96.59500	18	--	--	--	4.09
84	6879700	Wildcat Creek at Riley, Kansas	39.29278	96.83056	21	--	--	--	14.0
85	6879815	Wildcat Creek at Manhattan, Kansas	39.18472	96.61028	16	--	--	--	74.0
86	6882510	Big Blue River at Marysville, Kansas	39.84222	96.66083	13	95	39,700	--	4,780
87	6884025	Little Blue River at Hollenberg, Kansas	39.98000	97.00444	22	--	--	--	2,750
88	6884100	Mulberry Creek tributary near Haddam, Kansas	39.81361	97.29889	32	--	--	--	1.64
89	6884200	Mill Creek at Washington, Kansas	39.81389	97.03889	38	95	14,600	--	344
90	6884300	Mill Creek tributary near Washington, Kansas	39.81333	97.00833	41	--	--	--	3.2
91	6884400	Little Blue River near Barnes, Kansas	39.77583	96.85806	40	95	41,900	2,400	3,320
92	6884500	Little Blue River at Waterville, Kansas	39.77778	96.86111	33	55	72,900	--	3,510
93	6884900	Robidoux Creek at Beattie, Kansas	39.86333	96.42972	19	--	--	157	40.0
94	6885500	Black Vermillion River near Frankfort, Kansas	39.68417	96.43750	44	50	38,200	--	410
95	6886000	Big Blue River at Randolph, Kansas	39.45000	96.71667	43	--	--	--	9,100
96	6886500	Fancy Creek at Winkler, Kansas	39.47222	96.83194	35	46	24,000	880	174
97	6887200	Cedar Creek near Manhattan, Kansas	39.25861	96.56333	32	--	--	--	13.4
98	6887600	Kansas River tributary near Wamego, Kansas	39.17444	96.26250	34	--	--	--	.83
99	6888000	Vermillion Creek near Wamego, Kansas	39.35000	96.21944	43	71	26,000	--	243
100	6888030	Vermillion Creek near Louisville, Kansas	39.27833	96.24278	14	--	--	--	297
101	6888300	Rock Creek near Louisville, Kansas	39.26472	96.37972	32	--	--	--	128
102	6888500	Mill Creek near Paxico, Kansas	39.06222	96.18111	44	63	77,100	--	316
103	6888600	Dry Creek near Maple Hill, Kansas	39.05167	96.02056	21	75	7,290	--	15.6
104	6888900	Blacksmith Creek tributary near Valencia, Kansas	39.02222	95.83500	33	--	--	60	1.31
105	6889100	Soldier Creek near Goff, Kansas	39.62417	95.96583	23	37	7,080	--	2.06

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s)						
							2-year	5-year	10-year	25-year	50-year	100-year	200-year
71	210	26.6	1.219	6.66	-0.0659	-0.0209	1,060	1,910	2,600	3,590	4,430	5,340	6,340
72	5,530	23.1	1.333	6.30	.0273	.215	8,000	16,100	23,700	36,200	47,800	61,800	78,500
73	10.2	30.0	.951	29.6	-.1289	-.044	532	1,270	2,000	3,220	4,380	5,760	7,400
74	384	27.0	1.105	4.65	-.0613	-.151	1,430	4,030	6,800	11,700	16,600	22,500	29,600
75	6,770	24.0	1.286	5.23	.0211	.242	6,510	12,600	18,100	27,100	35,400	45,200	56,800
76	87.0	30.8	1.220	6.09	-.0908	-.119	2,570	4,670	6,330	8,710	10,700	12,800	15,000
77	26.6	32.7	.550	12.2	-.1454	-.2651	1,200	2,220	3,000	4,080	4,940	5,850	6,790
78	2.48	32.5	.462	26.3	-.2108	-.1978	292	840	1,430	2,460	3,470	4,700	6,160
79	143	32.8	.480	6.67	-.0862	-.0511	2,960	6,550	9,870	15,300	20,200	25,900	32,500
80	300	30.9	1.022	4.25	-.0372	.17	3,630	7,130	10,300	15,300	20,000	25,400	31,800
81	230	34.1	.532	5.45	-.0515	-.1501	6,410	18,000	30,300	52,200	73,600	99,800	131,000
82	200	33.8	.460	6.12	-.035	-.0839	4,320	8,970	13,100	19,400	25,000	31,300	38,400
83	4.09	33.6	.457	20.0	-.127	-.0565	428	1,930	4,210	9,590	16,300	26,100	40,000
84	14.0	31.9	.538	10.2	-.0872	-.1633	936	2,020	2,980	4,450	5,740	7,190	8,810
85	74.0	32.4	.564	8.0	-.0395	-.07	2,470	4,380	5,880	80,30	9,800	11,700	13,800
86	4,780	28.7	.808	3.0	.1354	-.1965	19,100	32,800	42,900	56,700	67,500	78,800	90,500
87	2,750	27.6	1.367	4.5	.1151	.1123	11,200	21,000	29,300	42,100	53,400	66,300	81,000
88	1.64	30.5	1.031	52.0	-.1225	.0343	166	414	669	1,120	1,560	2,110	2,790
89	349	30.6	.907	4.58	.0403	-.1853	4,830	8,160	10,600	13,900	16,500	19,200	22,000
90	3.20	31.4	.737	52.4	-.0888	-.0264	524	1,090	1,600	2,400	3,120	3,940	4,880
91	3,320	28.2	1.279	4.33	.1088	-.0704	13,100	21,200	27,200	35,400	41,900	48,700	55,900
92	3,510	28.2	1.281	4.26	.1104	.0719	11,600	24,000	35,400	53,700	70,600	90,300	113,000
93	40.0	32.2	.325	13.5	.0162	-.0726	1,850	3,930	5,780	8,700	11,300	14,300	17,600
94	410	33.3	.359	5.72	.0638	.0525	7,030	15,700	24,100	38,000	51,200	66,900	85,700
95	9,100	28.9	.946	2.69	.1138	.1151	23,600	40,700	54,500	74,700	91,900	111,000	132,000
96	174	31.0	.731	8.40	-.0003	-.0993	5,690	10,600	14,600	20,500	25,400	30,700	36,500
97	13.4	33.0	.400	37.6	-.0777	-.1361	1,530	3,560	5,470	8,560	11,400	14,600	18,400
98	.83	34.2	.446	96.4	-.1474	-.2128	217	457	663	972	1,240	1,530	1,850
99	243	34.9	.426	5.50	.0294	-.2083	6,190	12,600	17,900	25,800	32,400	39,700	47,500
100	297	34.9	.431	4.63	.027	.0541	6,610	9,650	11,800	14,600	16,800	19,100	21,500
101	128	33.9	.602	10.6	-.0048	-.0209	5,880	10,100	13,400	18,100	21,900	26,100	30,600
102	316	34.7	.505	10.5	.0117	-.1791	11,600	23,000	32,400	46,300	58,000	70,800	84,600
103	15.6	35.3	.427	16.8	-.0646	.1227	1,670	3,080	4,280	6,110	7,730	9,560	11,600
104	1.31	35.5	.394	65.9	-.1267	-.1193	385	724	999	1,400	1,730	2,090	2,490
105	2.06	35.5	.317	25.1	-.0646	.136	402	880	1,340	2,120	2,870	3,770	4,860

Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas—Continued

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft^3/s)	Low-outlier threshold (ft^3/s)	Total drainage area (mi^2)
106	6889120	Soldier Creek near Bancroft, Kansas	39.59500	95.97139	24	37	13,100	--	10.5
107	6889140	Soldier Creek near Soldier, Kansas	39.56583	95.96250	33	--	--	--	16.9
108	6889160	Soldier Creek near Circleville, Kansas	39.46306	95.95000	33	--	--	--	49.3
109	6889180	Soldier Creek near St. Clere, Kansas	39.37583	95.91806	18	--	--	--	80.0
110	6889200	Soldier Creek near Delia, Kansas	39.20222	95.87361	39	89	29,000	--	157
111	6889500	Soldier Creek near Topeka, Kansas	39.10000	95.72417	68	--	--	--	290
112	6889600	South Branch Shunganunga Creek near Pauline, Kansas	39.97889	95.70972	21	--	--	--	3.84
113	6889630	Shunganunga Creek at Topeka, Kansas	39.03167	95.68250	28	--	--	--	33.5
114	6890100	Delaware River near Muscotah, Kansas	39.52139	95.53250	28	73	40,000	--	431
115	6890300	Spring Creek near Wetmore, Kansas	39.63667	95.84528	21	--	--	--	21.0
116	6890500	Delaware River at Valley Falls, Kansas	39.35083	95.45444	46	103	86,900	--	922
117	6890560	Rock Creek 6 miles north of Meriden, Kansas	39.28861	95.58250	14	--	--	--	1.89
118	6890600	Rock Creek near Meriden, Kansas	39.19278	95.55139	14	--	--	--	22.0
119	6890700	Slough Creek tributary near Oskaloosa, Kansas	39.20139	95.30250	21	--	--	--	.83
120	6890800	Slough Creek near Oskaloosa, Kansas	39.22361	95.33667	21	--	--	--	31.0
121	6891050	Stone House Creek at Williamstown, Kansas	39.06667	95.33583	26	--	--	--	12.9
122	6891500	Wakarusa River near Lawrence, Kansas	38.91111	95.26028	43	93	24,100	--	425
123	6892000	Stranger Creek near Tonganoxie, Kansas	39.11639	95.01083	68	--	--	--	406
124	6893080	Blue River near Stanley, Kansas	38.81250	94.67528	28	--	--	--	46.0
125	6893300	Indian Creek at Overland Park, Kansas	38.94167	94.66944	34	--	--	--	26.6
126	6893350	Tomahawk Creek near Overland Park, Kansas	38.91306	94.63167	13	--	--	--	23.9
127	6910800	Marais des Cygnes River near Reading, Kansas	38.56667	95.96389	29	--	--	350	177
128	6911000	Marais des Cygnes River at Melvern, Kansas	38.51500	95.69139	33	--	--	--	351
129	6911500	Salt Creek near Lyndon, Kansas	38.60889	95.63806	58	--	--	--	111
130	6911900	Dragoon Creek near Burlingame, Kansas	38.70833	95.83889	37	98	15,000	--	114
131	6912300	Dragoon Creek tributary near Lyndon, Kansas	38.69250	95.68500	34	--	--	100	3.76
132	6912500	Hundred and Ten Mile Creek near Quenemo, Kansas	38.64472	95.55944	24	44	38,500	1,500	322
133	6913000	Marais des Cygnes River near Pomona, Kansas	38.58417	95.45333	15	--	--	--	1,040
134	6913500	Marais des Cygnes River near Ottawa, Kansas	38.61667	95.25694	48	100	141,000	--	1,250
135	6913600	Rock Creek near Ottawa, Kansas	38.55417	95.26722	21	--	--	--	10.2
136	6913700	Middle Creek near Princeton, Kansas	38.47750	95.25222	33	--	--	--	52.0
137	6914000	Pottawatomie Creek near Garnett, Kansas	38.33361	95.24861	58	--	--	--	334
138	6914250	South Fork Pottawatomie Creek tributary near Garnett, Kansas	38.23333	95.24778	34	--	--	35	.35
139	6914500	Pottawatomie Creek at Lane, Kansas	38.44389	95.08389	25	--	--	--	513
140	6915000	Big Bull Creek near Hillsdale, Kansas	38.63667	94.89139	24	71	45,100	--	147

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s) 2-year	5-year	10-year	25-year	50-year	100-year	200-year
106	10.5	35.2	0.343	18.0	-0.0223	0.1683	1,220	2,200	3,030	4,280	5,380	6,640	8,060
107	16.9	35.2	.358	14.6	-.0113	.1298	1,850	3,360	4,640	6,580	8,270	10,200	12,400
108	49.3	35.8	.381	10.8	.0095	.1819	4,030	6,850	9,140	12,500	15,400	18,700	22,300
109	80.0	35.5	.434	9.20	.0165	-.0964	4,440	7,220	9,250	12,000	14,200	16,400	18,800
110	159	35.6	.476	6.56	.0217	.1723	4,510	7,650	10,200	13,900	17,100	20,600	24,600
111	290	35.7	.556	5.55	.0366	-.1996	5,970	11,700	16,400	23,300	29,000	35,200	41,900
112	3.84	35.8	.394	18.3	-.0008	.0426	758	1,450	2,040	2,950	3,740	4,640	5,660
113	34.0	35.7	.422	9.33	-.0273	-.1863	2,150	2,910	3,390	3,970	4,390	4,790	5,180
114	431	36	.398	5.80	.097	-.0452	12,500	18,700	23,000	28,600	32,900	37,400	41,900
115	21.0	35.4	.393	20.2	.0074	.1332	1,600	3,680	5,750	9,360	12,900	17,200	22,500
116	922	36.3	.432	4.63	.1063	-.0373	14,000	27,500	39,000	56,400	71,600	88,600	108,000
117	1.98	36.7	.441	51.7	-.0772	-.1584	413	853	1,230	1,800	2,300	2,840	3,440
118	22.0	36.6	.489	11.9	-.0175	.0635	2,090	3,220	4,040	5,170	6,060	7,010	8,010
119	.83	38.9	.370	59.4	-.095	-.182	173	486	817	1,400	1,960	2,650	3,470
120	31.0	38.6	.462	13.3	.006	.1123	3,670	5,510	6,850	8,670	10,100	11,700	13,300
121	12.9	38.7	.777	34.7	-.033	-.1827	1,720	3,720	5,470	8,160	10,500	13,100	16,000
122	425	36.6	.617	3.78	.0537	-.1667	6,130	12,000	16,800	23,800	29,600	36,000	43,000
123	406	37.9	.503	2.86	.0845	.0173	6,170	11,300	15,500	21,700	27,000	32,900	39,500
124	46.0	39.3	.608	15.0	.0129	.109	4,820	8,610	11,700	16,400	20,500	25,000	30,100
125	26.6	39.3	.643	12.1	.01	.0431	4,060	6,210	7,770	9,890	11,600	13,300	15,200
126	23.9	39.4	.634	16.8	.0063	-.0243	2,630	4,890	6,760	9,520	11,900	14,500	17,300
127	177	35.8	.399	6.21	-.0394	-.0879	7,860	18,200	28,100	44,200	59,100	76,500	96,800
128	351	36.6	.421	4.17	-.0111	-.1561	7,050	17,300	27,300	43,800	59,000	76,900	97,600
129	111	36.6	.460	5.80	-.0316	-.2327	4,270	9,170	13,400	19,800	25,200	31,200	37,700
130	114	36.1	.443	6.63	-.032	-.0881	4,780	8,780	12,000	16,600	20,500	24,700	29,300
131	3.76	36.5	.493	36.1	-.1204	-.0747	1,220	2,940	4,610	7,430	10,100	13,200	16,900
132	322	36.2	.464	6.70	.0055	.181	7,990	14,100	19,200	26,800	33,500	41,100	49,600
133	1,040	36.5	.477	3.41	.038	.0908	9,310	21,200	32,800	52,700	71,800	95,000	123,000
134	1,250	36.7	.520	2.84	.0563	.1246	11,200	25,200	38,900	62,500	85,200	113,000	147,000
135	10.2	38.5	.365	12.0	-.0839	.0624	597	1,300	1,960	3,060	4,090	5,310	6,760
136	52.0	38.1	.649	8.74	-.0449	.0677	3,300	5,310	6,840	8,970	10,700	12,600	14,600
137	334	38.3	.545	4.40	-.0064	-.0162	11,300	20,100	27,100	37,200	45,700	54,900	65,000
138	.35	39.8	.656	125	-.2068	-.1288	183	310	405	535	639	747	861
139	513	38.8	.579	3.27	.0244	.0999	13,400	25,500	36,000	52,100	66,500	82,800	101,000
140	147	39.2	.659	8.12	.0176	.1503	6,880	14,300	21,100	32,500	43,000	55,600	70,600

Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas—Continued

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft³/s)	Low-outlier threshold (ft³/s)	Total drainage area (mi²)
141	6915100	Big Bull Creek at Paola, Kansas	38.57667	94.89556	26	--	--	--	230
142	6916000	Marais des Cygnes River at Trading Post, Kansas	38.25056	94.68639	34	--	--	--	2,880
143	6916500	Big Sugar Creek at Farlinville, Kansas	38.23528	94.85361	24	--	--	--	198
144	6916700	Middle Creek near Kincaid, Kansas	38.05667	95.18750	34	--	--	--	2.02
145	6917000	Little Osage River at Fulton, Kansas	38.01917	94.71333	49	--	--	1,600	295
146	6917100	Marmaton River tributary near Bronson, Kansas	37.90556	95.09528	34	--	--	31	.88
147	6917380	Marmaton River near Marmaton, Kansas	37.81750	94.79167	26	--	--	--	292
148	6917400	Marmaton River tributary near Fort Scott, Kansas	37.79056	94.79639	41	--	--	--	2.80
149	6917500	Marmaton River near Fort Scott, Kansas	37.86306	94.67667	46	--	--	--	408
150	7138600	White Woman Creek tributary near Selkirk, Kansas	38.52500	101.62111	40	--	--	10	38.0
151	7138650	White Woman Creek near Leoti, Kansas	38.48111	101.48778	20	--	--	1	750
152	7138800	Lion Creek tributary near Modoc, Kansas	38.48000	101.05000	21	--	--	--	7.00
153	7139700	Arkansas River tributary near Dodge City, Kansas	37.71444	100.01472	39	--	--	40	8.66
154	7139800	Mulberry Creek near Dodge City, Kansas	37.59806	100.01444	22	--	--	--	73.8
155	7140300	Whitewoman Creek near Bellefont, Kansas	37.92389	99.64194	33	--	--	--	14.0
156	7140600	Pawnee River tributary near Kalvesta, Kansas	38.06167	100.35000	33	--	--	--	6.89
157	7140700	Guzzlers Gulch near Ness City, Kansas	38.29444	99.95278	19	--	--	--	58.2
158	7140850	Pawnee River near Burdett, Kansas	38.20667	99.64306	14	--	--	--	1,090
159	7141200	Pawnee River near Larned, Kansas	38.20000	99.34722	73	--	--	--	2,150
160	7141400	South Fork Walnut Creek tributary near Dighton, Kansas	38.48278	100.41500	21	--	--	--	.81
161	7141600	Long Branch Creek near Ness City, Kansas	38.45028	99.88056	33	--	--	6	28.0
162	7141780	Walnut Creek near Rush Center, Kansas	38.46861	99.36861	28	--	--	--	1,260
163	7141800	Otter Creek near Rush Center, Kansas	38.40444	99.30722	33	--	--	--	17.0
164	7141900	Walnut Creek at Albert, Kansas	38.46111	99.01389	39	--	--	--	1,410
165	7142100	Rattlesnake Creek tributary near Mullinville, Kansas	37.58639	99.42139	33	--	--	11	10.3
166	7142300	Rattlesnake Creek near Macksville, Kansas	37.87222	98.87500	38	--	--	--	784
167	7142500	Spring Creek near Dillwyn, Kansas	37.95667	98.84083	21	--	--	--	14.3
168	7142575	Rattlesnake Creek near Zenith, Kansas	38.09361	98.54583	25	107	29,300	--	1,050
169	7142700	Salt Creek near Partridge, Kansas	38.03944	98.08694	33	--	--	--	85.0
170	7142860	Cow Creek near Claflin, Kansas	38.52222	98.58333	22	--	--	20	43.0
171	7142900	Blood Creek near Boyd, Kansas	38.53611	98.85972	33	--	--	--	61.0
172	7143100	Little Cheyenne Creek tributary near Claflin, Kansas	38.45694	98.53556	41	--	--	30	1.48
173	7143200	Plum Creek near Holyrood, Kansas	38.59806	98.42417	20	--	--	120	19.0
174	7143300	Cow Creek near Lyons, Kansas	38.30833	98.19167	52	69	24,000	--	728
175	7143500	Little Arkansas River near Geneseo, Kansas	38.45667	98.09000	21	--	--	100	25.0

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s)						
							2-year	5-year	10-year	25-year	50-year	100-year	200-year
141	230	39.4	0.660	4.26	0.0242	0.177	5,650	9,180	12,000	15,900	19,300	23,000	27,000
142	2,880	38.1	.594	2.08	.075	.1356	19,900	39,600	57,400	85,900	112,000	142,000	178,000
143	198	40.2	.657	8.03	-.0097	.1418	6,490	13,100	19,200	29,000	38,100	48,800	61,400
144	2.02	40.0	.903	36.2	-.1714	-.2962	677	1,340	1,860	2,610	3,210	3,860	4,530
145	295	40.7	.727	4.97	-.0115	.1765	8,560	14,800	19,900	27,500	34,000	41,400	49,600
146	.88	40.4	.755	29.9	-.2038	-.2541	204	349	455	597	707	820	935
147	292	41.3	.828	5.89	-.0347	.126	16,600	27,900	36,900	50,000	61,100	73,200	86,600
148	2.80	41.7	.687	35.6	-.1668	-.3272	923	1,430	1,770	2,190	2,500	2,800	3,100
149	408	41.5	.826	4.55	-.0152	-.1524	11,800	22,900	32,100	45,600	56,900	69,300	82,700
150	7.59	16.3	1.104	16.3	-.4246	-.3256	61	169	278	459	626	818	1,040
151	750	15.9	1.225	12.6	-.2939	-.3653	232	1,400	3,310	7,870	13,400	21,100	31,600
152	1.19	19.0	1.096	31.8	-.4508	-.5317	92	182	250	340	408	476	544
153	8.66	21.8	1.088	14.0	-.4134	-.3366	229	487	702	1,020	1,270	1,550	1,840
154	73.8	21.7	1.302	7.30	-.3646	-.3526	249	675	1,090	1,770	2,380	3,080	3,860
155	14.0	22.9	1.062	10.7	-.3611	-.2303	179	713	1,420	2,870	4,470	6,590	9,320
156	6.89	20.3	.745	15.3	-.4047	-.3166	255	745	12,60	2,130	2,950	3,910	5,020
157	58.2	21.0	1.200	9.64	-.3029	-.304	425	1,260	2,130	3,650	5,080	6,780	8,760
158	1,090	20.3	1.167	5.00	-.2134	-.2757	469	1,430	2,460	4,300	6,070	8,210	10,700
159	2,010	21.0	1.116	4.18	-.1817	-.0317	2,250	4,530	6,530	9,620	12,300	15,400	18,900
160	.81	20.6	1.111	15.8	-.4283	-.5225	56	107	145	194	231	267	303
161	28.0	20.9	1.128	9.99	-.3049	-.3916	75	433	1,000	2,310	3,840	5,950	8,740
162	1,150	21.0	1.168	5.97	-.1732	-.2096	1,000	2,390	3,700	5,790	7,670	9,830	12,300
163	17.0	22.9	1.110	13.1	-.2933	-.3003	394	955	1,470	2,280	2,990	3,790	4,670
164	1,310	21.4	1.176	5.36	-.152	-.2257	1,310	2,850	4,200	6,250	8,010	9,970	12,100
165	10.3	24.5	1.062	13.1	-.3897	-.3568	416	1,090	1,730	2,750	3,650	4,670	5,800
166	356	24.1	5.569	4.96	-.236	-.0969	400	1,340	2,490	4,770	7,230	10,500	14,600
167	14.3	24.4	3.750	10.7	-.3158	-.2993	305	1,170	2,260	4,400	6,650	9,530	13,100
168	519	24.4	5.899	4.10	-.1877	.1833	501	1,580	2,950	5,850	9,190	13,900	20,400
169	72.0	28.3	3.666	5.11	-.224	-.2187	1,150	2,160	2,950	4,070	4,980	5,950	6,970
170	43.0	25.8	1.041	6.73	-.2189	-.1905	556	1,580	2,680	4,610	6,480	8,760	11,500
171	61.0	24.5	1.074	9.82	-.2222	-.2981	955	2,320	3,570	5,540	7,270	9,220	11,400
172	1.48	25.6	1.041	21.7	-.3164	-.1319	105	175	227	297	353	411	472
173	19.0	26.7	1.041	9.40	-.2263	-.0736	657	1,230	1,690	2,370	2,950	3,580	4,260
174	499	26.1	1.297	3.44	-.1504	-.047	1,940	4,690	7,420	12,000	16,400	21,700	28,000
175	25.0	27.6	.830	20.8	-.2146	-.3314	927	1,360	1,630	1,970	2,210	2,440	2,670

Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas—Continued

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft^3/s)	Low-outlier threshold (ft^3/s)	Total drainage area (mi^2)
176	7143600	Little Arkansas River near Little River, Kansas	38.41389	98.01667	26	--	--	--	71.0
177	7143665	Little Arkansas River at Alta Mills, Kansas	38.11222	97.59167	25	--	--	--	736
178	7144000	East Emma Creek near Halstead, Kansas	38.02778	97.42778	14	--	--	--	58.0
179	7144200	Little Arkansas River at Valley Center, Kansas	37.83222	97.38778	79	--	--	--	1,330
180	7144780	North Fork Ninnescah River above Cheney Reservoir, Kansas	37.84472	97.93583	25	--	--	--	787
181	7144800	North Fork Ninnescah River near Cheney, Kansas	37.66667	97.76667	14	--	--	--	930
182	7144850	South Fork South Fork Ninnescah River near Pratt, Kansas	37.58611	98.82778	19	--	--	80	21.0
183	7144900	South Fork Ninnescah River tributary near Pratt, Kansas	37.67500	98.72306	32	--	--	80	1.48
184	7145200	South Fork Ninnescah River near Murdock, Kansas	37.56417	97.85278	47	--	--	--	650
185	7145300	Clear Creek near Garden Plain, Kansas	37.66333	97.65611	33	--	--	100	5.03
186	7145500	Ninnescah River near Peck, Kansas	37.45722	97.42222	26	41	69,900	--	2,130
187	7145700	Slate Creek at Wellington, Kansas	37.25000	97.40333	38	--	--	--	154
188	7145800	Antelope Creek tributary near Dalton, Kansas	37.27611	97.28361	33	--	--	25	.41
189	7146570	Cole Creek near Degraff, Kansas	37.94722	96.78056	19	34	22,000	--	30.0
190	7146700	West Branch Walnut River tributary near Degraff, Kansas	37.95528	96.85111	21	--	--	--	11.0
191	7147020	Whitewater River tributary near Towanda, Kansas	37.85083	97.06028	34	--	--	10	.17
192	7147070	Whitewater River at Towanda, Kansas	37.79583	97.01250	36	--	--	--	426
193	7147200	Dry Creek tributary near Augusta, Kansas	37.67972	97.03056	21	--	--	--	.90
194	7147800	Walnut River at Winfield, Kansas	37.22417	96.99444	61	105	104,000	--	1,880
195	7147990	Cedar Creek tributary near Cambridge, Kansas	37.32194	96.62583	35	--	--	--	2.41
196	7148100	Grouse Creek near Dexter, Kansas	37.22722	96.71222	30	89	50,900	--	170
197	7148700	Dog Creek near Deerhead, Kansas	37.28056	98.87333	21	--	--	--	5.31
198	7148800	Medicine Lodge River tributary near Medicine Lodge, Kansas	37.31167	98.58889	21	--	--	--	2.04
199	7149000	Medicine Lodge River near Kiowa, Kansas	37.03806	98.46778	51	--	--	--	903
200	7151500	Chikaskia River near Corbin, Kansas	37.12889	97.60111	38	75	59,900	--	794
201	7151600	Rush Creek near Harper, Kansas	37.25333	98.07972	33	--	--	--	12.0
202	7155590	Cimarron River near Elkhart, Kansas	37.12500	101.89722	26	--	--	100	2,900
203	7155900	North Fork Cimarron River tributary near Elkhart, Kansas	37.19083	101.89833	33	--	--	10	75.0
204	7156000	North Fork Cimarron River tributary near Richfield, Kansas	37.31000	101.77167	21	--	--	--	103
205	7156010	North Fork Cimarron River at Richfield, Kansas	37.25833	101.77500	15	--	32,000	--	463
206	7156100	Sand Arroyo Creek near Johnson, Kansas	37.50000	101.76111	15	--	--	5	619
207	7156220	Bear Creek near Johnson, Kansas	37.62639	101.76111	31	--	--	--	835
208	7156600	Cimarron River tributary near Moscow, Kansas	37.33528	101.05000	33	--	--	--	13.0
209	7156700	Cimarron River tributary near Satanta, Kansas	37.27083	100.92667	38	--	--	--	2.41
210	7157100	Crooked Creek near Copeland, Kansas	37.56528	100.55417	33	--	--	10	44.0

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s)						
							2-year	5-year	10-year	25-year	50-year	100-year	200-year
176	71.0	27.7	0.855	8.32	-0.1857	-0.0068	1,200	2,360	3,360	4,900	6,240	7,760	9,470
177	681	29.5	2.071	3.58	-.1289	-.1466	5,000	12,200	19,200	30,800	41,500	54,100	68,700
178	58.0	31.5	.796	9.00	-.1969	-.1965	3,400	8,990	14,600	24,200	33,200	43,800	56,300
179	1,250	30.3	2.025	2.30	-.1276	-.319	6,290	13,900	20,400	30,100	38,300	47,200	56,800
180	550	26.9	5.484	5.85	-.1777	-.0545	3,990	12,300	21,900	40,400	59,900	85,200	117,000
181	693	27.5	4.962	5.36	-.1792	-.2024	4,050	10,600	17,100	28,200	38,500	50,600	64,700
182	21.0	25.5	2.002	10.6	-.3391	-.1672	712	1,500	2,190	3,240	4,150	5,160	6,280
183	1.48	25.7	2.126	18.8	-.3992	-.2609	373	680	915	1,240	1,500	1,760	2,040
184	543	27.3	3.085	7.13	-.2	-.2904	5,850	12,600	18,300	26,700	33,800	41,500	49,900
185	5.03	30.4	1.184	15.3	-.3109	-.3807	612	1,060	1,380	1,800	2,120	2,430	2,750
186	1,790	28.1	3.774	4.80	-.1545	-.0223	11,700	20,300	27,000	36,600	44,400	53,000	62,200
187	154	30.7	.876	6.08	-.2411	-.3367	3,620	7,650	11,000	15,800	19,800	24,100	28,600
188	.41	32.0	.681	56.5	-.3975	-.2376	135	244	327	441	532	627	726
189	30.0	33.7	.447	7.36	-.1892	-.1115	1,950	4,420	6,700	10,400	13,700	17,500	21,900
190	11.0	33.9	.436	13.2	-.22	-.1583	1,310	2,440	3,350	4,640	5,710	6,850	8,080
191	.17	33.5	.365	66.2	-.3567	-.2749	84	173	246	352	440	535	636
192	426	33.0	.468	4.15	-.1415	-.1801	7,490	17,300	26,200	40,500	53,300	67,900	84,300
193	.90	35.8	.365	42.9	-.3248	-.2169	225	373	478	619	728	839	952
194	1,870	34.3	.488	2.50	-.1528	-.1497	19,900	39,100	55,000	78,600	98,400	120,000	144,000
195	2.41	35.6	.493	53.2	-.3098	-.4033	575	1,660	2,740	4,530	6,150	8,000	10,100
196	170	35.4	.497	8.16	-.2046	-.1768	8,250	17,000	24,500	35,800	45,500	56,100	67,800
197	5.31	25.2	2.986	30.9	-.4083	-.3587	271	938	1,710	3,110	4,490	6,170	8,160
198	2.04	26.3	1.444	27.4	-.4173	-.4663	135	508	944	1,740	2,510	3,430	4,500
199	903	25.5	2.562	8.27	-.267	-.3332	4,030	7,450	10,000	13,500	16,300	19,100	22,000
200	794	28.7	2.648	7.79	-.2171	-.3124	8,530	18,700	27,400	40,300	51,200	63,000	75,700
201	12.0	28.9	1.881	21.5	-.347	-.3305	1,190	2,290	3,140	4,310	5,250	6,220	7,230
202	2,420	16.2	2.782	17.5	-.4094	-.3623	1,330	4,000	6,800	11,600	16,000	21,300	27,200
203	10.0	16.3	1.098	16.4	-.5561	-.5442	72	722	2,090	5,820	10,700	17,800	27,600
204	58.9	16.1	1.893	13.8	-.489	-.4275	791	2,420	4,100	6,930	9,510	12,500	15,800
205	463	16.0	3.157	16.5	-.4366	-.3256	870	3,650	7,320	14,800	22,800	33,200	46,300
206	619	15.9	3.462	15.2	-.4052	-.438	146	541	1,000	1,850	2,680	3,680	4,850
207	835	15.9	1.180	13.9	-.385	-.4388	724	3,020	5,940	11,600	17,300	24,400	33,000
208	8.0	18.0	2.14	29.2	-.5048	-.5664	468	1,400	2,310	3,740	4,970	6,310	7,730
209	2.41	19.0	1.895	41.6	-.5378	-.5524	202	576	931	1,480	1,950	2,450	2,990
210	44.0	19.9	.940	11.4	-.4101	-.4883	488	1,630	2,860	4,960	6,900	9,120	11,600

Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas—Continued

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft³/s)	Low-outlier threshold (ft³/s)	Total drainage area (mi²)
211	7157400	Crooked Creek tributary at Meade, Kansas	37.29639	100.33944	33	--	--	--	6.57
212	7157500	Crooked Creek near Nye, Kansas	37.03167	100.20806	55	--	--	--	1,160
213	7157700	Kiger Creek near Ashland, Kansas	37.19333	99.91333	32	--	--	--	34.0
214	7157900	Cavalry Creek at Coldwater, Kansas	37.26667	99.34444	28	--	--	--	39.0
215	7165700	Verdigris River near Madison, Kansas	38.13750	96.10139	21	73	127,000	--	181
216	7166000	Verdigris River near Coyville, Kansas	37.70556	95.90556	20	--	--	--	747
217	7166200	Sandy Creek near Yates Center, Kansas	37.84639	95.83528	41	--	--	--	6.8
218	7166500	Verdigris River near Altoona, Kansas	37.49056	95.68028	21	--	--	1,600	1,140
219	7166700	Burnt Creek at Reece, Kansas	37.78528	96.23111	13	--	--	--	8.85
220	7167000	Fall River near Eureka, Kansas	37.78528	96.23111	30	--	--	--	307
221	7167500	Otter Creek at Climax, Kansas	37.70833	96.22500	50	94	106,000	--	129
222	7168500	Fall River near Fall River, Kansas	37.64278	96.05917	10	27	47,900	--	585
223	7169200	Salt Creek near Severy, Kansas	37.62000	96.25194	21	--	--	900	7.59
224	7169500	Fall River at Fredonia, Kansas	37.50833	95.83333	13	46	48,900	4,000	827
225	7169700	Snake Creek near Howard, Kansas	37.54111	96.24000	21	--	--	40	1.84
226	7169800	Elk River at Elk Falls, Kansas	37.37556	96.18528	30	--	--	--	220
227	7170000	Elk River near Elk City, Kansas	37.26639	95.91778	31	--	--	--	575
228	7170500	Verdigris River at Independence, Kansas	37.22389	95.67861	31	--	--	--	2,890
229	7170600	Cherry Creek near Cherryvale, Kansas	37.29611	95.54750	21	--	--	501	15.0
230	7170700	Big Hill Creek near Cherryvale, Kansas	37.26667	95.46806	24	--	--	--	37.0
231	7170800	Mud Creek near Mound Valley, Kansas	37.19389	95.44778	34	--	--	--	4.22
232	7171700	Spring Branch near Cedar Vale, Kansas	37.11333	96.45806	38	--	--	--	3.10
233	7171800	Cedar Creek tributary near Hooser, Kansas	37.10750	96.57417	34	--	--	--	.56
234	7171900	Grant Creek near Wauneta, Kansas	37.10944	96.39861	21	--	--	200	20.0
235	7172000	Caney River near Elgin, Kansas	37.00361	96.31500	59	--	--	--	445
236	7179500	Neosho River at Council Grove, Kansas	38.66500	96.49389	27	62	120,000	210	250
237	7179600	Four Mile Creek near Council Grove, Kansas	38.59972	96.49833	14	--	--	1,500	55.0
238	7180000	Cottonwood River near Marion, Kansas	38.35139	97.05833	30	97	65,000	--	329
239	7180300	Spring Creek tributary near Florence, Kansas	38.18333	96.91361	34	--	--	--	.55
240	7180500	Cedar Creek near Cedar Point, Kansas	38.19861	96.82278	59	142	52,300	--	110
241	7181000	Cottonwood River at Elmdale, Kansas	38.37083	96.62917	10	--	--	--	1,050
242	7181500	Middle Creek near Elmdale, Kansas	38.39333	96.71778	40	--	--	--	92.0
243	7182000	Cottonwood River at Cottonwood Falls, Kansas	38.38528	96.60528	37	111	--	--	1,330
244	7182400	Neosho River at Strawn, Kansas	38.26667	95.86667	61	--	--	--	2,930
245	7182520	Rock Creek at Burlington, Kansas	38.19611	95.75667	21	--	--	--	8.27

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s)						
							2-year	5-year	10-year	25-year	50-year	100-year	200-year
211	6.57	21.4	1.034	33.1	-0.477	-0.4638	292	1,300	2,620	5,220	7,900	11,200	15,300
212	813	20.5	1.673	4.23	-.3608	-.4016	992	3,600	6,650	12,200	17,800	24,400	32,300
213	34.0	22.3	1.993	29.9	-.4187	-.4052	368	689	929	1,250	1,500	1,750	2,000
214	39.0	24.8	2.725	8.61	-.3785	-.3149	492	1,290	2,050	3,290	4,410	5,680	7,110
215	181	36.1	.485	11.2	-.0861	-.1726	8,120	18,700	28,400	43,800	57,600	73,400	91,300
216	747	36.7	.540	4.98	-.0768	-.0697	18,300	43,400	67,500	108,000	145,000	190,000	242,000
217	6.80	39.3	.660	19.3	-.1908	-.249	1,240	1,990	2,530	3,220	3,740	4,270	4,810
218	1,140	37.5	.670	3.33	-.0735	-.067	16,400	32,800	46,900	68,300	87,000	108,000	131,000
219	8.85	35.3	.493	36.0	-.2098	-.0977	1,630	4,100	6,570	10,800	14,800	19,600	25,300
220	307	35.3	.515	9.95	-.111	-.1376	11,700	29,900	48,100	79,100	108,000	143,000	184,000
221	129	36.2	.461	13.2	-.142	-.3741	7,480	18,000	27,400	41,800	54,200	67,600	82,200
222	585	35.8	.517	6.28	-.0975	-.1541	16,200	31,700	44,500	63,300	79,100	96,300	115,000
223	7.59	36.6	.390	21.9	-.2306	-.2731	2,950	5,110	6,700	8,830	10,500	12,200	13,900
224	827	36.3	.616	5.46	-.0887	-.1442	18,800	32,600	43,000	57,400	69,000	81,100	94,000
225	1.84	36.8	.320	38.4	-.2768	-.185	497	969	1,360	1,920	2,390	2,890	3,440
226	220	36.5	.446	9.21	-.1563	-.0541	9,000	21,300	33,300	53,400	72,200	94,600	121,000
227	575	37.4	.740	5.25	-.1258	-.2147	12,600	30,400	47,000	73,800	97,900	125,000	157,000
228	2,890	37.3	.695	2.68	-.0724	-.0243	34,400	60,400	81,000	111,000	135,000	162,000	190,000
229	15.0	41.7	.851	16.5	-.2053	-.0413	2,530	4,580	6,230	8,640	10,700	12,900	15,300
230	37.0	41.3	.833	9.10	-.1788	-.0072	3,540	6,770	9,510	13,600	17,200	21,200	25,700
231	4.22	43.0	.952	25.7	-.245	-.0775	1,270	2,180	2,870	3,840	4,630	5,460	6,350
232	3.10	34.8	.510	50.1	-.3136	-.4588	816	2,150	3,390	5,310	6,960	8,750	10,700
233	.56	34.9	.510	165	-.3678	-.4608	147	331	485	705	883	1,070	1,270
234	20.0	35.7	.561	33.6	-.2589	-.2909	3,160	5,510	7,230	9,530	11,300	13,100	15,000
235	445	35.5	.555	7.39	-.1781	-.3575	14,900	30,100	42,200	59,400	73,100	87,600	103,000
236	250	33.8	.433	4.88	-.0481	.1393	10,100	23,000	35,900	58,000	79,600	106,000	139,000
237	55.0	33.4	.444	13.4	-.0966	.017	5,370	11,300	16,700	25,400	33,400	42,600	53,300
238	329	32.4	.662	5.54	-.0991	-.167	6,460	12,200	16,800	23,300	28,800	34,600	40,900
239	.55	33.0	.682	43.2	-.2853	-.4216	116	291	450	694	902	1,130	1,370
240	110	33.3	.518	9.42	-.1317	-.3073	5,740	10,800	14,700	20,100	24,500	28,900	33,600
241	1,050	32.9	.566	3.74	-.0428	-.0091	9,600	16,000	20,900	27,800	33,300	39,300	45,700
242	92.0	34.1	.456	3.69	-.113	-.1693	6,960	15,000	22,100	33,100	42,700	53,500	65,400
243	1,330	33.1	.544	3.19	-.0336	.0969	10,300	24,500	39,000	64,400	89,500	121,000	159,000
244	2,930	34.1	.508	2.75	.0157	.1201	20,400	44,800	68,300	108,000	145,000	191,000	246,000
245	8.27	37.4	.471	8.34	-.1486	-.0919	1,020	2,370	3,660	5,760	7,690	9,960	12,600

Table 5. Streamflow-gaging station information, physical and climatic characteristics, and peak-streamflow magnitude and frequency estimates for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas—Continued

Station map index no. (fig. 1)	U.S. Geological Survey station no.	U.S. Geological Survey station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Systematic record (years)	Historical record (years)	High-outlier threshold (ft^3/s)	Low-outlier threshold (ft^3/s)	Total drainage area (mi^2)
246	7182600	North Big Creek near Burlington, Kansas	38.11028	95.75722	33	--	--	--	46.0
247	7183000	Neosho River near Iola, Kansas	37.89083	95.43056	55	--	--	--	3,820
248	7183100	Owl Creek near Piqua, Kansas	37.85000	95.57500	11	--	--	--	177
249	7183500	Neosho River near Parsons, Kansas	37.34000	95.10972	42	--	--	6,500	4,910
250	7183800	Limestone Creek near Beulah, Kansas	37.40333	94.88778	33	--	--	--	12.0
251	7184000	Lightning Creek near McCune, Kansas	37.28167	95.03222	47	--	--	--	197
252	7184500	Labette Creek near Oswego, Kansas	37.19167	95.19167	37	43	20,100	--	211
253	7184600	Fly Creek near Faulkner, Kansas	37.10417	94.93917	21	--	--	--	27.0

Station map index no. (fig. 1)	Contributing drainage area (mi^2)	Mean annual precipitation (in.)	Soil permeability (in/h)	Main channel slope (ft/mi)	Generalized skewness coefficient	Weighted skewness coefficient	Discharge for indicated recurrence interval (ft^3/s) 2-year	5-year	10-year	25-year	50-year	100-year	200-year
246	46.0	37.6	0.489	5.93	-0.1089	-0.0739	3,210	4,850	6,000	7,500	8,660	9,830	11,000
247	3,820	35.1	.531	1.84	.0105	.1231	23,700	48,300	70,700	107,000	140,000	180,000	226,000
248	177	40.4	.608	5.87	-.0863	-.0531	6,940	14,400	20,900	31,200	40,200	50,500	62,200
249	4,910	36.4	.578	1.85	-.0173	.1787	28,700	50,800	69,300	97,300	122,000	149,000	181,000
250	12.0	42.4	.993	16.2	-.1673	-.2453	3,140	6,540	9,400	13,600	17,200	21,100	25,300
251	197	42.2	1.021	3.43	-.1083	.087	7,250	16,800	26,300	42,600	58,300	77,600	101,000
252	211	40.9	.813	4.74	-.123	-.1391	8,330	13,200	16,600	21,200	24,700	28,300	32,000
253	27.0	42.1	1.227	7.80	-.1753	-.1696	4,190	11,000	17,900	29,700	40,900	54,200	69,900

Back cover

Cimarron River near Elkhart, Kansas, May 3, 1999. View upstream from left bank. Photograph by Craig Dare, USGS.

Arkansas River near Coolidge, Kansas, May 6, 1999. View downstream from right bank. Photograph by Craig Dare, USGS.

Cow Creek near Hutchinson, Kansas, July 22, 1999. View upstream from left bank. Photograph by Mike Holt, USGS.

Kansas River at Wamego, Kansas, July, 1993. View upstream from left bank. Photograph by Charles Perry, USGS.

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