Prepared in cooperation with the
KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT and the
KANSAS DEPARTMENT OF TRANSPORTATION

Estimates of Flow Duration, Mean Flow, and Peak-Discharge Frequency Values for Kansas Stream Locations

Scientific Investigations Report 2004–5033

Version 1.1, July 2025

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

Cover photographs—Taken by Trudy Bennett, U.S. Geological Survey, Wichita, Kansas. Top left: Little Arkansas River near Sedgwick, Kansas, low flow on February 27, 2003. Bottom right: Little Arkansas River near Sedgwick, Kansas, high flow on March 20, 2003.

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Conversion Factors, Abbreviations, Datum, and Definitions

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
inch (in.)	2.54	centimeter (cm)
inch per hour (in/h)	2.54	centimeter per hour (cm/h)
meter (m)	3.281	foot (ft)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

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

Vertical coordinate information in this report is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Water year in this report is the 12-month period being October 1 and ending September 30. The water year is designated by the calendar year in which it ends. For example, the period October 1, 1999, through September 30, 2000, is called the “2000 water year.”

Estimates of Flow Duration, Mean Flow, and Peak-Discharge Frequency Values for Kansas Stream Locations

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Abstract

Streamflow statistics of flow duration and peak-discharge frequency were estimated for 4,771 individual locations on streams listed on the 1999 Kansas Surface Water Register. These statistics included the flow-duration values of 90, 75, 50, 25, and 10 percent, as well as the mean flow value. Peak-discharge frequency values were estimated for the 2-, 5-, 10-, 25-, 50-, and 100-year floods.

Least-squares multiple regression techniques were used, along with Tobit analyses, to develop equations for estimating flow-duration values of 90, 75, 50, 25, and 10 percent and the mean flow for uncontrolled flow stream locations. The contributing-drainage areas of 149 U.S. Geological Survey streamflow-gaging stations in Kansas and parts of surrounding States that had flow uncontrolled by Federal reservoirs and used in the regression analyses ranged from 2.06 to 12,004 square miles. Logarithmic transformations of climatic and basin data were performed to yield the best linear relation for developing equations to compute flow durations and mean flow.

In the regression analyses, the significant climatic and basin characteristics, in order of importance, were contributing-drainage area, mean annual precipitation, mean basin permeability, and mean basin slope. The analyses yielded a model standard error of prediction range of 0.43 logarithmic units for the 90-percent duration analysis to 0.15 logarithmic units for the 10-percent duration analysis. The model standard error of prediction was 0.14 logarithmic units for the mean flow. Regression equations used to estimate peak-discharge frequency values were obtained from a previous report, and estimates for the 2-, 5-, 10-, 25-, 50-, and 100-year floods were determined for this report.

The regression equations and an interpolation procedure were used to compute flow durations, mean flow, and estimates of peak-discharge frequency for locations along uncontrolled flow streams on the 1999 Kansas Surface Water Register. Flow durations, mean flow, and peak-discharge frequency values determined at available gaging stations were used to interpolate the regression-estimated flows for the stream locations where available. Streamflow statistics for locations that had uncontrolled flow were interpolated using data from gaging stations weighted according to the drainage area and the bias between the regression-estimated and gaged flow information. On controlled reaches of Kansas streams, the streamflow statistics were interpolated between gaging stations using only gaged data weighted by drainage area.

Introduction

The expected amount and historical range of flow in Kansas streams are important considerations for the classification, evaluation, and regulation of water supplies, recreation, aquatic-life habitat, pollution control, and the design of hydrologic structures within the State. Water-quality regulations in Kansas apply numeric water-quality criteria to classified stream segments. These 2,232 stream segments are listed on the 1999 Kansas Surface Water Register. This register is maintained by the Kansas Department of Health and Environment (KDHE) and is used to identify designated uses of stream segments.

Flow-duration statistics for specific locations throughout Kansas and parts of surrounding States are available for 216 continuous-record streamflow-gaging stations where daily flow data have been collected by the U.S. Geological Survey (USGS) for 10 or more years (fig. 1). Peak-discharge frequency statistics for 253 peak streamflow-gaging stations in Kansas were used to develop regression equations to estimate peak streamflow at unregulated rural streams (Rasmussen and Perry, 2000). Two hundred and thirty-seven streamflow-gaging stations were used in the interpolation process described in a later section of this report (fig. 2). The current and historical streamflow information collected by the USGS provides a resource for estimating the expected amount and range of streamflow throughout the State. The measured streamflow record can be used to define statistics that summarize historical streamflow amounts at each stream gage. These statistics then can be related to the physical characteristics of the drainage basins that contribute to measured flow at the gage. Furthermore, statistical models that are based on these relations can be used to estimate streamflow statistics for ungaged locations.

To address the need for streamflow statistics, a study of flow durations, mean flow, and peak-discharge frequency information for Kansas streams was conducted by the USGS in cooperation with KDHE and the Kansas Department of Transportation. Streamflow data used in this study were collected by the USGS (Putnam and others, 2001) through other cooperative

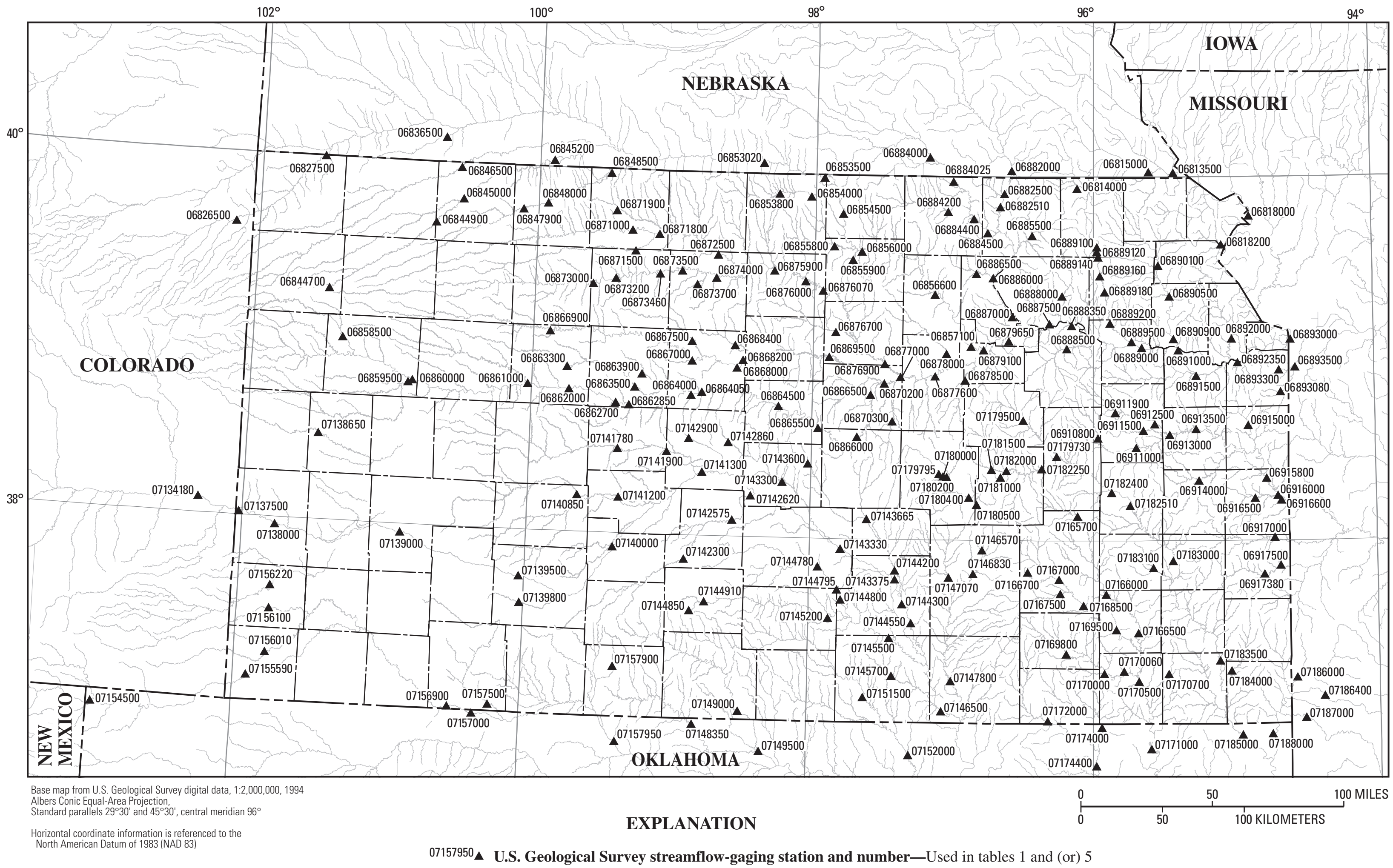
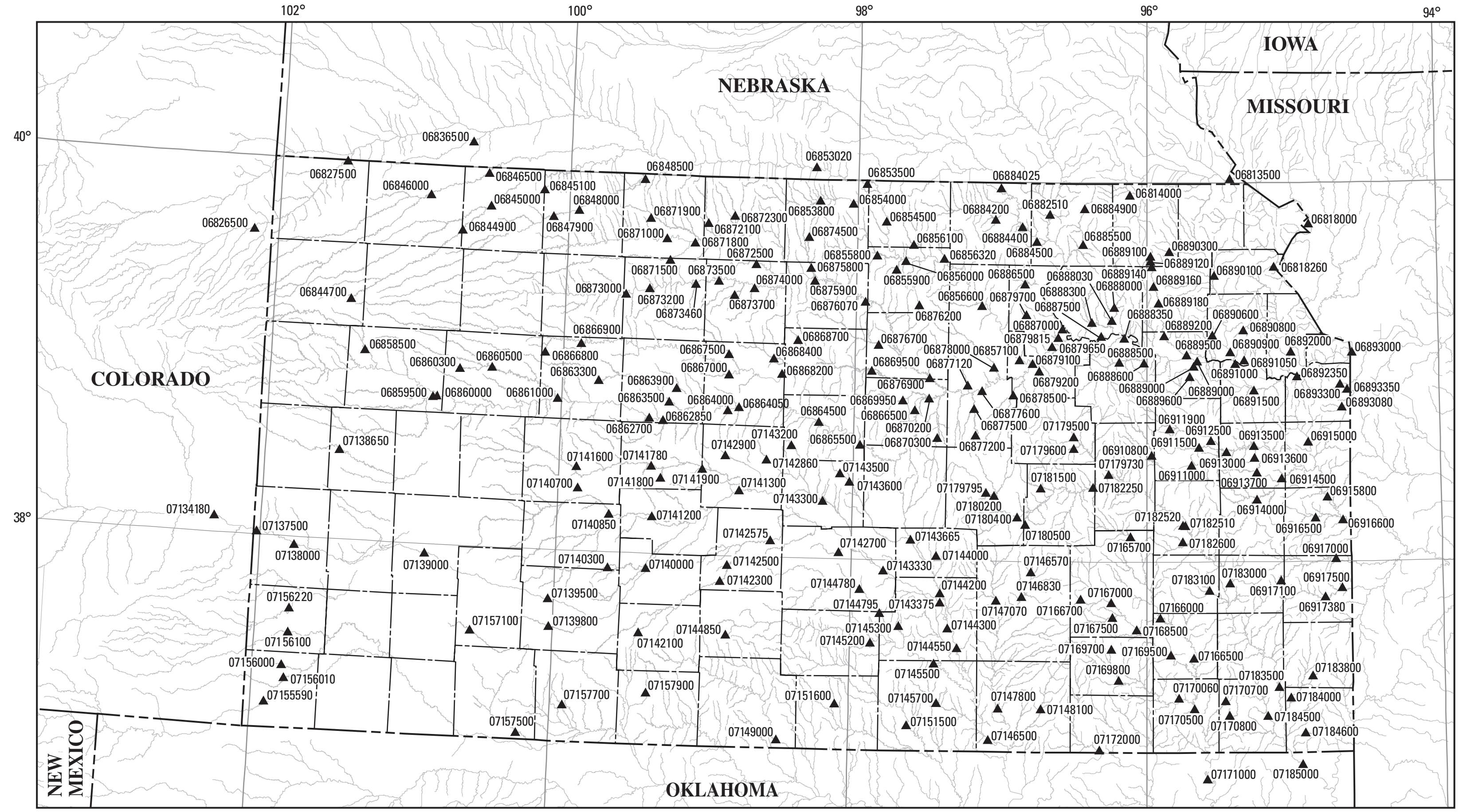


Figure 1. Location of U.S. Geological Survey streamflow-gaging stations in Kansas and parts of surrounding States with 10 or more years of record that were available for computing flow durations and mean flows.



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°

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

0 50 100 MILES
0 50 100 KILOMETERS

EXPLANATION

07142100▲ **U.S. Geological Survey streamflow-gaging station and number**—Used in table 6

Figure 2. Location of U.S. Geological Survey streamflow-gaging stations with peak-discharge frequency analysis in Kansas and parts of surrounding States with 10 or more years of record that were used in the interpolation process.

studies with various government agencies. This report includes analyses of flow durations of 90, 75, 50, 25, and 10 percent, mean flows, and the peak-discharge frequency values for the 2-, 5-, 10-, 25-, 50-, and 100-year floods.

Purpose and Scope

The purpose of this report is to document the methods and results of a study designed to estimate the flow durations, mean flow, and the peak-discharge frequency values for locations on streams on the 1999 Kansas Surface Water Register (KSWR). In this report, 5,427 locations along the KSWR stream coverage were identified as determination sites for which flow statistics were computed from upstream climatic and basin conditions. Flow statistics were not reported for 656 of these determination sites because they were located on reservoirs or irrigation ditches. Flow statistics for each determination site either were computed from gaged-location streamflow records, estimated from statewide regression models, or interpolated between gaged locations or gaged and regression-estimated locations.

This report documents the development of regression models to estimate flow durations and mean flow from climatic and basin characteristics. Regression equations for flow durations were developed using Tobit statistical analysis of uncontrolled flow durations determined at 149 gaging stations. “Uncontrolled flow” is defined as that streamflow that is unaffected by Federal reservoir releases. The entire period of record for each uncontrolled flow streamflow-gaging station was used in the analyses of flow durations. Regression equations for the estimation of peak discharge for unregulated rural streams in Kansas are available in (Rasmussen and Perry, 2000) and are used in this report. The equations were based on 253 streamflow-gaging stations in Kansas.

This report describes application of the drainage-area ratio method and the regression model method of estimating the flow statistics for stream locations on the 1999 KSWR, the interpolation of estimates for ungaged locations, and the Internet dissemination of results and a geographic-information-system (GIS) database. The information contained in this report can be used by State agencies and others to help in the effective management of Kansas surface-water resources. Optimal reservoir operations, legally distributed in-stream withdrawals, and water-quality concerns are issues directly linked to flow durations. Peak-discharge frequency information is used in the cost effective construction of hydraulic structures such as bridges and culverts and for flood-plain management. The methods described herein can be applied nationwide using USGS streamflow data that are available throughout the United States.

Previous Studies

A study by Perry and others (2004) determined the median flow (50-percent duration) for the 2,232 complete stream segments on the 1999 KSWR. The methods of analysis for the flow durations and mean flow in this report are similar to the study by Perry and others (2004).

Previous low-flow and flow-duration studies for Kansas include an investigation by Furness (1959) who developed a method for estimating flow-duration curves for ungaged sites that was based on regionalized flow-duration data from 122 continuous-record, streamflow-gaging stations with drainage areas of between 100 and 3,000 mi^2 for the period 1921–56. Maps were developed showing a variety of statewide low and mean streamflow. Furness (1959) also noted that the low-flow parts of the flow-duration curves could be verified or improved by relating base-flow measurements at the ungaged site to base-flow measurements at a nearby, index streamflow-gaging station.

Jordan (1983) updated the maps developed by Furness (1959) by including additional streamflow-gaging stations and data for the period 1957–76. Jordan’s study included a map that depicted the areas of Kansas where the median streamflow for a 500-mi^2 basin was greater than 0.1 ft^3/s. Two studies by Studley (2000, 2001) evaluated the application of the Furness method to ungaged stream sites in Kansas using nearby streamflow-gaging stations as index stations. The results of these two recent studies indicated that the Furness method continues to be a useful tool for estimating flow-duration curves for ungaged sites and that the method could be used for sites with drainage areas less than 100 mi^2.

Many studies have been conducted to evaluate low flow and peak flows from regression equations that relate low flow and peak flow to basin characteristics. In a recent USGS study (Ries and Friesz, 2000), basin characteristics were determined from digital map data, and flow statistics were computed for individual stream segments in Massachusetts using GIS techniques. Ries and Friesz (2000) used the drainage-area ratio method to compute streamflow characteristics for stream segments in Massachusetts that had between 0.5 and 1.5 times the drainage area of streamflow-gaging stations on the same stream. Many other States have used regression analysis to regionalize low-flow frequency statistics including New Hampshire, Rhode Island, and Vermont (Johnson, 1970); New York (Ku and others, 1975); Montana (Parrett and Hull, 1985); Indiana (Arihood and Glatfelter, 1991); and central New England (Wandle and Randall, 1994). All the States have conducted regression analyses to regionalize peak-discharge frequency values, and these studies have been collected into a national report by Ries and Crouse (2002).

Acknowledgments

The authors would like to thank Aldo “Skip” Vecchia, Timothy Cohn, and Gregory Schwarz of the USGS who helped with the Tobit analyses and with the review of the statistical methods used in this report. The authors also would like to acknowledge the efforts of Michael Butler from KDHE who provided the initial stream coverage and reviewed much of the data presented.

Factors Affecting Streamflow

Physical Setting

Physiographically, Kansas is located almost entirely within the Interior Plains as described by Schoewe (1949). A description of the hydrologic characteristics of the physiographic provinces within the Interior Plains is 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 flow characteristics across Kansas.

The topography of the western two-thirds of the State is typical of the High Plains region (Rasmussen and Perry, 2000) and is characterized by flat or gently sloping surfaces with little relief. The topography of the eastern one-third of the State is more variable, with alternating hills and lowlands. Land-surface elevations within the State range from about 700 ft above the North American Vertical Datum of 1988 (NAVD 88) at the Kansas-Oklahoma State line in southeast Kansas to about 4,135 ft above the NAVD 88 at a point near the Kansas-Colorado State line in western Kansas—a vertical difference of about 3,435 ft (fig. 3). The average land-surface slope for Kansas (fig. 4) using 30-m grid elevation data (U.S. Geological Survey, 1998) is about 1.9 degrees.

Other physical characteristics affecting the flow characteristics of watersheds are the types of soils and land-use and treatment practices within the watershed. For example, with all other factors being equal the low-flow potential from watersheds with soils of low permeability (fig. 5) is less than that from watersheds where highly permeable soils tend to allow greater infiltration and a greater ground-water contribution to base flow of the stream (Thomas, 1966). The western two-thirds of the State typically has soils of moderate to high permeability, whereas the eastern one-third has soils of lower permeability. Land-treatment practices, such as contour farming and construction of water-retention structures, can increase the amount of infiltration of runoff to ground water, which ultimately can return to stream channels as base flow. However, land-treatment practices are difficult to assess and apply to the various types of basins statewide.

Climatic Characteristics

The climate of Kansas is affected by the movement of various air masses of tropical and continental origin over the open, inland plains, and seasonal precipitation extremes are common. About 75 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 (Paulson and others, 1991).

Watersheds in Kansas exhibit a wide range of climatic characteristics that affect streamflow. Generally, precipitation varies 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 more humid, with sultry summer months and cold, damp winter months. Mean annual precipitation, the major climatic factor affecting streamflow in the State, varies from about 16 in. in extreme western Kansas to about 42 in. in southeastern Kansas (Daly and others, 1997) (fig. 6). Mean annual precipitation values for 149 streamflow-gaging station basins used in the regression analyses of flow durations and mean flow for uncontrolled flow stream locations on the KWSR are given in table 1.

Basin Characteristics

Basin characteristics used in the regression analyses were selected on the basis of their theoretical relation to differences in flow magnitudes of streams, results of previous studies in similar hydrologic environments, and on the ability to measure the characteristics. The basin characteristics considered in this report included contributing-drainage area, in square miles; mean basin elevation, in feet above NAVD 88; mean basin permeability, in inches per hour; mean basin slope, in degrees; a base-flow index (Wahl and Wahl, 1995); mean annual runoff for hydrologic basins in the United States, in cubic feet per second (Gebert and others, 1987); and runoff from a water-balance model (Wolock and McCabe, 1999) (parameter-elevation regressions on independent slope model), in cubic feet per second, using the mean annual precipitation grid for the United States developed by Daly and others (1994). The mean annual runoff reflects the difference between precipitation and evapotranspiration. Selected basin characteristics for the 149 streamflow-gaging stations used in the final regression analyses for uncontrolled flow stream locations are provided in table 1.

All basin characteristics were measured from digital-map data using automated GIS procedures. The automated procedure was created using the AML programming language of the ARC/INFO GIS software (Environmental Systems Research Institute, Inc., 1991). The automated procedure determined the drainage-basin boundary at the gaging station or for the downstream end of a stream segment and created a digital data layer of the basin boundary, then overlaid the boundary on the other digital data layers to determine the other basin characteristics for the station or location. The grid values then were averaged for the area within the contributing-drainage basin. Basin slope was determined from the 30-m elevation grid using the GIS command SLOPE (Burrough, 1986). The slope in degrees is essentially an average of the slope between the center grid cell and its eight surrounding cells.

The peak-discharge frequency regression equations developed by Rasmussen and Perry (2000) require channel slope as one of their variables. Channel slope is defined as the difference

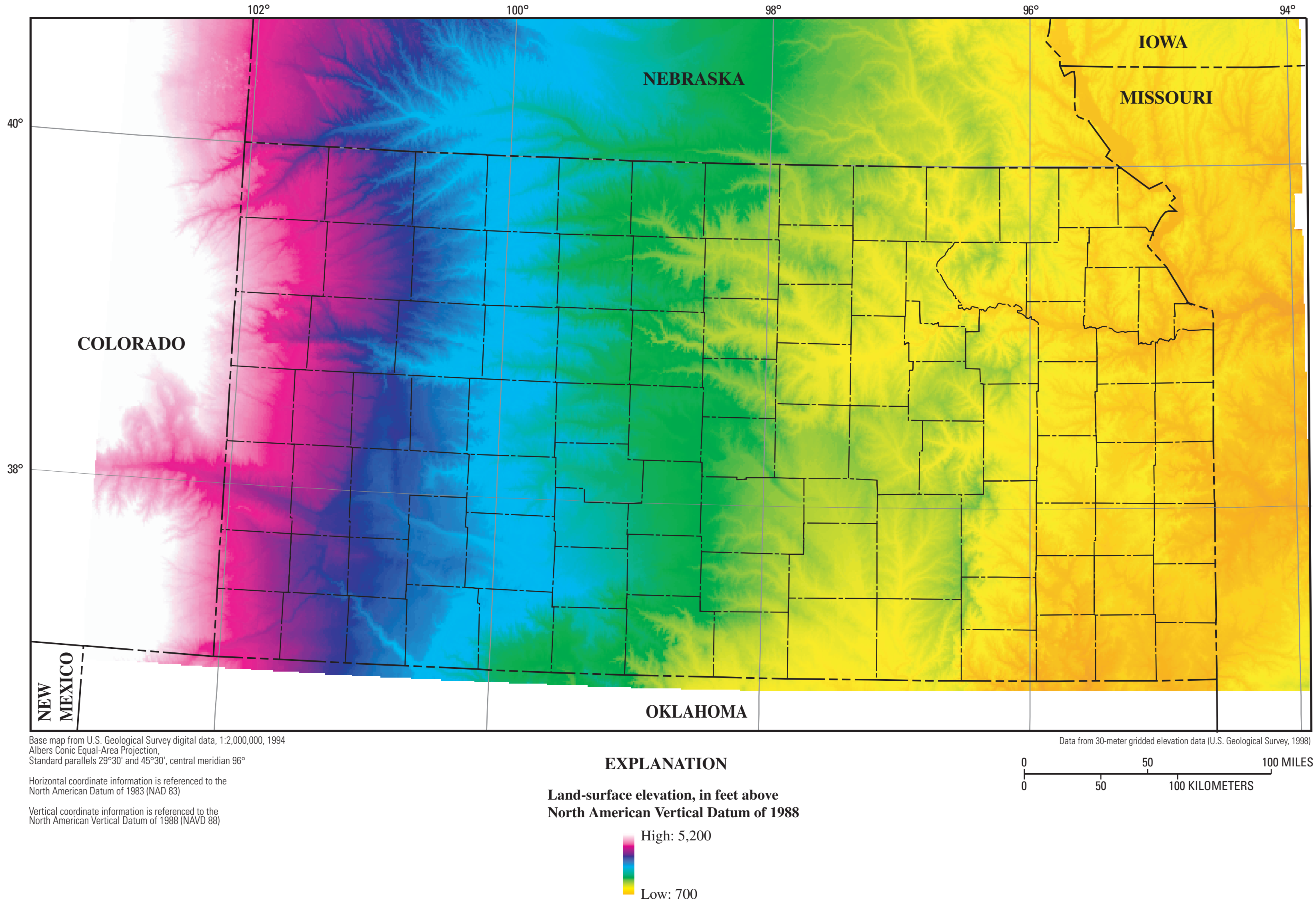
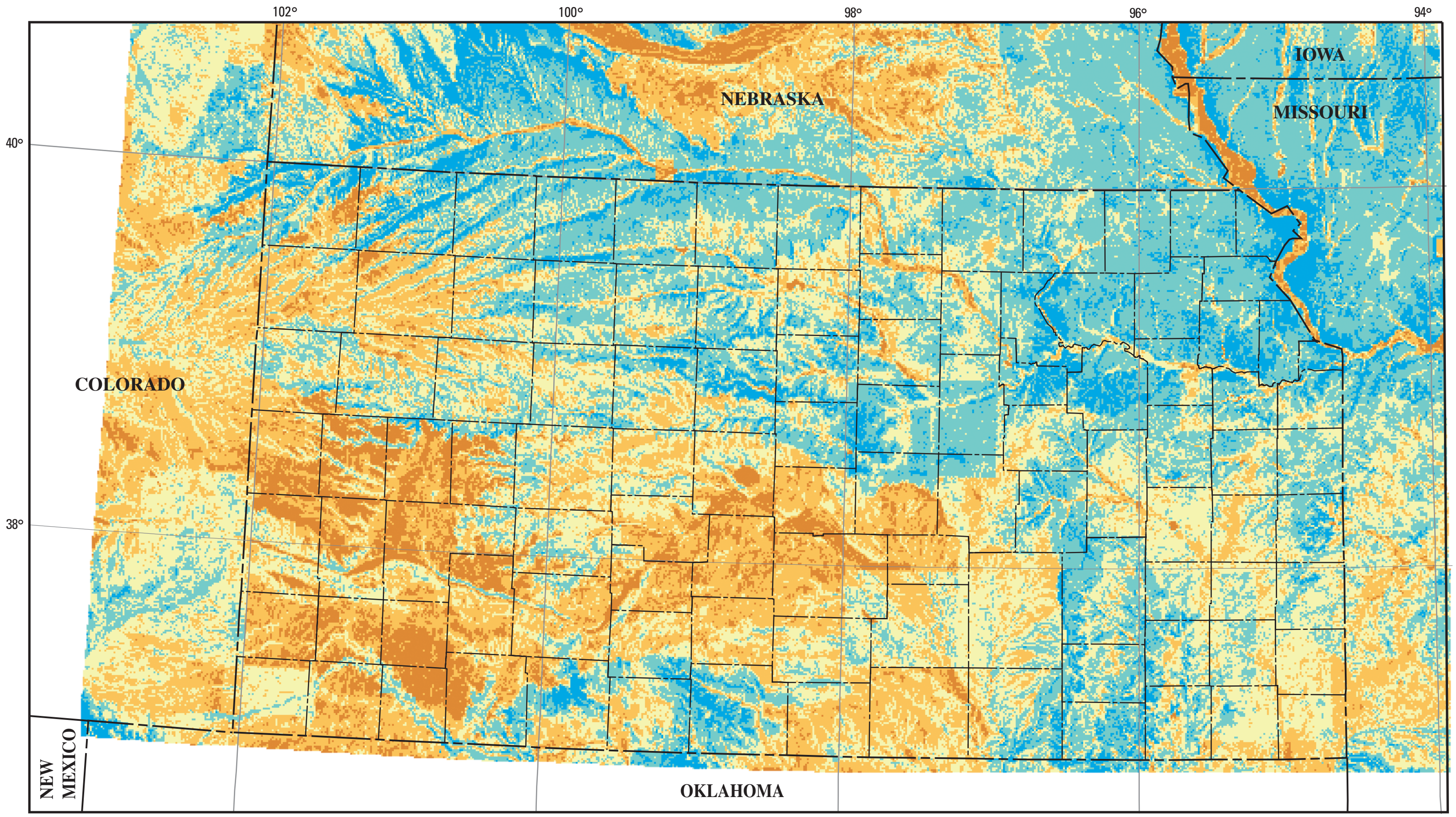


Figure 3. Land-surface elevation in Kansas and parts of surrounding States.



Base map from U.S. Geological Survey digital data, 1:2,000,000, 1994
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Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)

Data from 30-meter gridded elevation data (U.S. Geological Survey, 1998)

0 50 100 MILES
0 50 100 KILOMETERS

EXPLANATION

Land-surface slope, in degrees

- 0 to 0.3
- 0.3 to 1.0
- 1.0 to 2.0
- 2.0 to 4.0
- 4.0 to 20.0

Figure 4. Average land-surface slope in Kansas and parts of surrounding States.

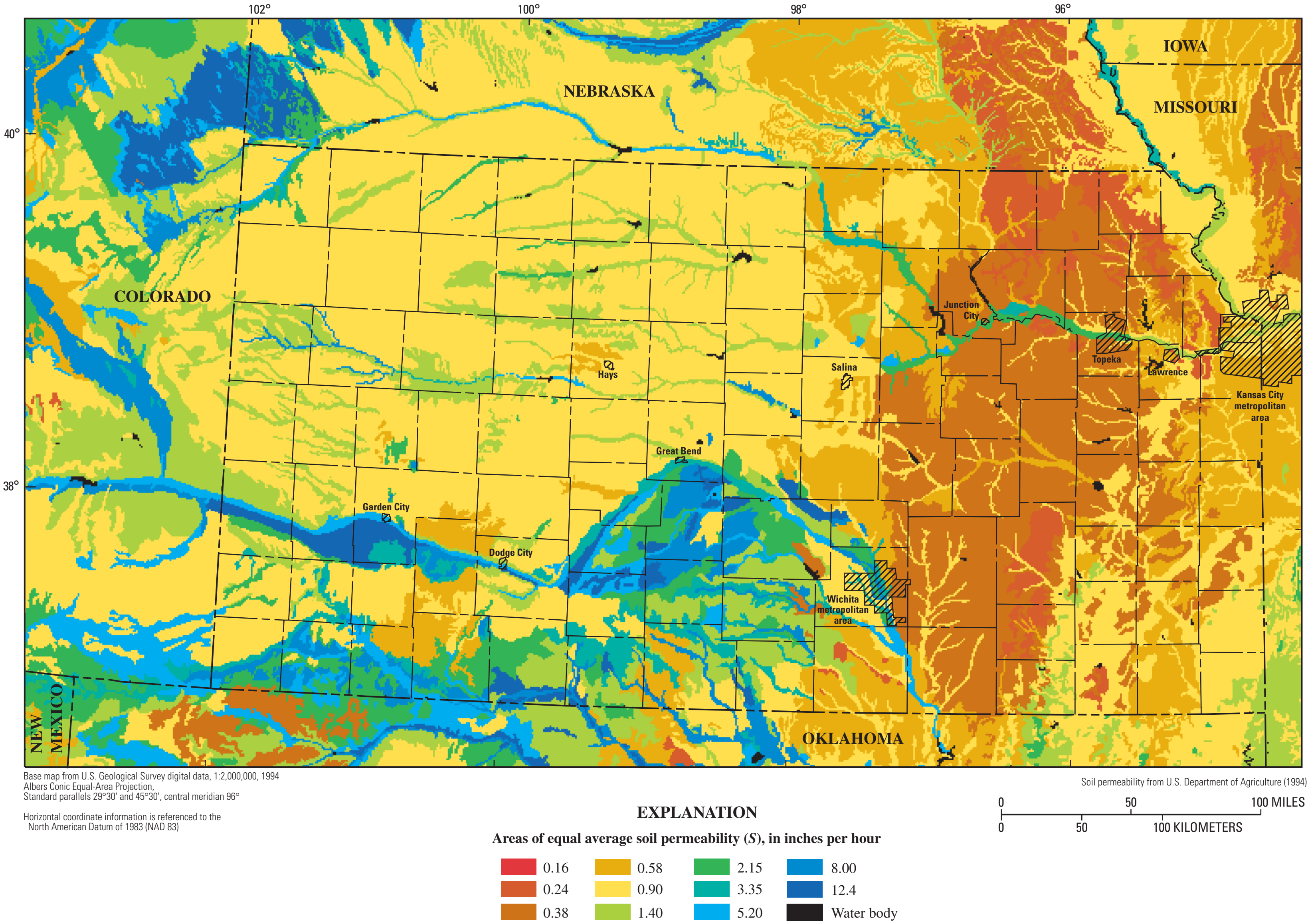

Figure 5. Areas of equal average soil permeability in Kansas and parts of surrounding States.

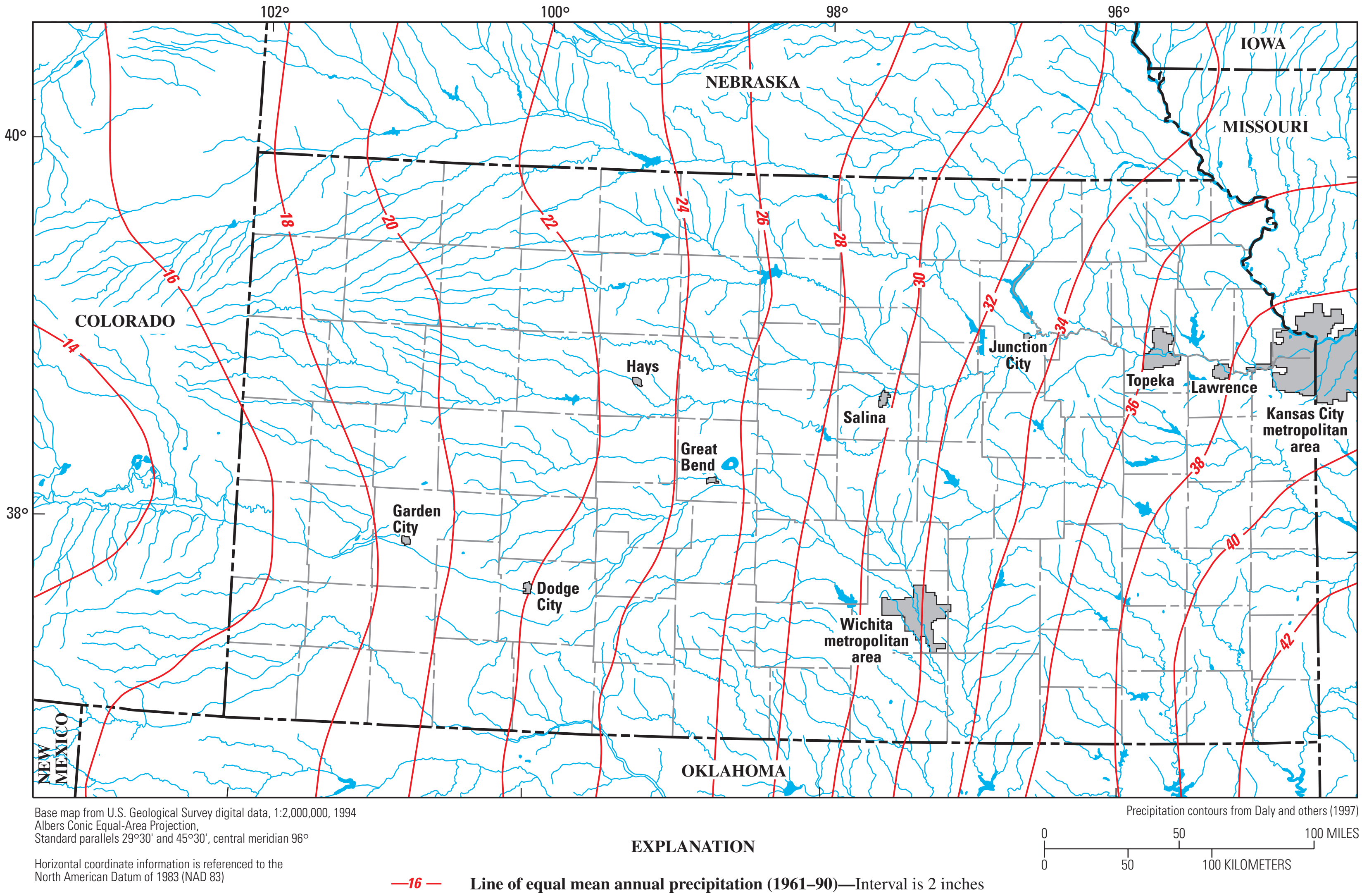

Figure 6. Mean annual precipitation in Kansas and parts of surrounding States (Daly and others, 1997).

Table 1. Streamflow-gaging stations and computed flow-duration values, mean discharge for period of uncontrolled flow record, and climatic and basin characteristics used in regression analyses of uncontrolled flow stream locations in Kansas.

[ft^3/s, cubic feet per second; mi^2, square miles; in/h, inches per hour]

Station number (fig. 1)	Station name	Period of record (water years)	Years of record	Flow-duration values (ft^3/s) for indicated percentage of time flow equaled or exceeded: 90-percent	75-percent	50-percent	25-percent	10-percent	Mean discharge for period of uncontrolled record (ft^3/s)	Contributing drainage area (mi^2)	Mean annual precipitation, 1961–90[1] (inches)	Mean basin permeability[2] (in/h)	Mean basin slope[3] (degrees)
06814000	Turkey Creek near Seneca, KS	1950–2000	51	2.1	7.4	22	69	203	129	276	32.35	0.467	3.1
06815000	Big Nemaha River at Falls City, NE	1944–2000	56	45	80	159	390	1,050	631	1,339	32.55	.510	2.8
06818200	Doniphan Creek at Doniphan, KS	1961–70	10	.24	.50	.87	1.6	3.8	3.0	4.15	36.71	1.08	4.8
06836500	Driftwood Creek near McCook, NE	1977–86	10	.30	2.1	4.8	6.7	11	9.5	361	20.94	1.30	2.9
06844700	South Fork Sappa Creek near Brewster, KS	1968–87	20	0	0	0	0	0	.23	71.3	18.40	1.30	.83
06844900	South Fork Sappa Creek near Achilles, KS	1960–2000	41	0	0	0	.32	2.3	3.4	412	19.20	1.30	1.4
06845000	Sappa Creek near Oberlin, KS	1930–2000	71	0	.10	.70	.54	18	16	1,086	19.82	1.32	1.5
06845200	Sappa Creek near Beaver City, NE	1938–72	35	0	1.1	5.0	17	60	38	1,500	20.57	1.36	1.9
06847900	Prairie Dog Creek above Keith Sebelius Lake, KS	1963–2000	38	0	.16	2.1	5.8	11	9.0	590	20.65	1.36	1.7
06848000	Prairie Dog Creek at Norton, KS	1945–63	19	.70	3.0	7.5	15	42	39	684	20.96	1.36	1.9
06848500	Prairie Dog Creek near Woodruff, KS	1930–63	34	0	3.7	10	23	71	57	1,007	21.56	1.37	2.1
06853800	White Rock Creek near Burr Oak, KS	1958–2000	43	.47	1.8	6.0	17	40	29	227	26.49	1.30	2.5
06854000	White Rock Creek at Lovewell, KS	1947–56	10	0	1.6	5.7	20	80	68	354	27.07	1.31	2.6
06855800	Buffalo Creek near Jamestown, KS	1960–89	30	.95	3.1	11	41	133	72	330	27.94	1.10	1.9
06855900	Wolf Creek near Concordia, KS	1963–81	19	0	.10	1.0	4.3	17	11	56	28.76	1.01	2.5
06858500	North Fork Smoky Hill River near McAllaster, KS	1948–84	27	0	0	0	1.0	3.0	3.7	752	17.12	1.53	1.3
06859500	Ladder Creek below Chalk Creek near Scott City, KS	1952–79	28	0	.39	1.9	4.0	10	8.0	1,432	17.65	1.40	1.0
06860000	Smoky Hill River at Elkader, KS	1940–2000	61	0	.11	1.5	6.0	22	24	3,555	17.67	1.53	1.3
06861000	Smoky Hill River near Arnold, KS	1951–2000	50	.01	.17	2.3	15	47	44	5,220	18.44	1.52	1.4
06863300	Big Creek near Ogallah, KS	1956–68	13	.20	1.2	2.9	6.6	16	22	297	21.43	1.28	1.1
06863500	Big Creek near Hays, KS	1947–2000	54	1.9	3.5	7.9	19	38	33	594	21.80	1.18	1.4
06863900	North Fork Big Creek near Victoria, KS	1963–86	24	0	0	0	0	.90	3.1	90.3	22.61	1.20	1.7
06864000	Smoky Hill River near Russell, KS	1940–49	10	5.0	15	40	104	356	184	6,965	19.48	1.46	1.4
06866000	Smoky Hill River near Lindsborg, KS	1906–47	42	18	30	57	148	498	244	8,110	20.60	1.46	1.5
06866500	Smoky Hill River near Mentor, KS	1925–47	23	35	60	116	218	560	329	8,358	20.84	1.45	1.6
06866900	Saline River near Wakeeney, KS	1956–2000	45	0	.03	2.6	12	24	21	696	20.60	1.37	1.5

Table 1. Streamflow-gaging stations and computed flow-duration values, mean discharge for period of uncontrolled flow record, and climatic and basin characteristics used in regression analyses of uncontrolled flow stream locations in Kansas. —Continued

[ft^3/s, cubic feet per second; mi^2, square miles; in/h, inches per hour]

Station number (fig. 1)	Station name	Period of record (water years)	Years of record	Flow-duration values (ft^3/s) for indicated percentage of time flow equaled or exceeded: 90-percent	75-percent	50-percent	25-percent	10-percent	Mean discharge for period of uncontrolled record (ft^3/s)	Contributing-drainage area (mi^2)	Mean annual precipitation, 1961–90[1] (inches)	Mean basin permeability[2] (in/h)	Mean basin slope[3] (degrees)
06867000	Saline River near Russell, KS	1946–2000	55	4.8	12	31	73	165	98	1,502	21.68	1.39	2.2
06868000	Saline River near Wilson, KS	1930–63	34	11	21	46	107	274	166	1,900	22.36	1.36	2.4
06868400	Wolf Creek near Lucas, KS	1960–71	12	.70	1.1	2.2	6.8	18	16	163	25.02	1.20	2.6
06869500	Saline River at Tescott, KS	1920–63	44	15	34	70	157	418	247	2,820	23.69	1.31	2.5
06870300	Gypsum Creek near Gypsum, KS	1955–2000	46	0	1.0	7.0	15	34	26	120	30.88	.882	2.9
06871000	North Fork Solomon River at Glade, KS	1953–2000	48	0	.20	8.4	22	48	28	849	21.31	1.34	2.5
06871500	Bow Creek near Stockton, KS	1952–2000	49	.44	2.6	5.6	10	18	14	341	21.57	1.45	1.8
06871800	North Fork Solomon River at Kirwin, KS	1920–54	35	4.4	15	31	52	120	87	1,367	21.47	1.38	2.3
06871900	Deer Creek near Phillipsburg, KS	1967–81	15	0	0	.69	1.5	2.7	4.0	65	23.00	1.37	3.0
06873000	South Fork Solomon River above Webster Reservoir, KS	1946–2000	55	.03	1.0	14	37	77	54	1,040	20.87	1.46	2.1
06873500	South Fork Solomon River at Alton, KS	1920–57	38	2.2	9.0	30	62	145	104	1,720	21.64	1.41	2.1
06873700	Kill Creek near Bloomington, KS	1964–81	18	0	0	0	0	1.8	2.1	49.4	24.57	1.25	2.6
06876000	Solomon River at Beloit, KS	1930–54	25	10	40	93	224	743	457	5,530	23.06	1.33	2.2
06876700	Salt Creek near Ada, KS	1960–2000	41	1.6	4.0	12	30	106	70	384	26.98	1.11	2.6
06877000	Smoky Hill River at Solomon, KS	1919–34	16	126	202	404	750	1,880	931	8,830	22.1	1.39	1.9
06878000	Chapman Creek near Chapman, KS	1955–2000	46	7.7	13	24	49	126	93	300	30.89	1.02	2.2
06878500	Lyon Creek near Woodbine, KS	1955–74	20	3.4	17	33	65	135	108	230	34.13	.533	2.4
06879650	Kings Creek near Manhattan, KS	1980–2000	20	0	0	.19	2.0	5.7	2.6	4.09	33.00	.458	5.9
06882000	Big Blue River near Barnestown, NE	1933–2000	78	103	167	280	616	1,800	867	4,447	28.54	.820	1.3
06882500	Big Blue River near Hull, KS	1931–40	10	88	130	217	365	895	470	4,685	28.66	.810	1.4
06882510	Big Blue River at Marysville, KS	1985–2000	16	200	286	467	924	2,590	1,190	4,777	28.67	.809	1.4
06884000	Little Blue River near Fairbury, NE	1911–2000	90	92	119	160	251	581	383	2,350	27.34	1.43	1.4
06884025	Little Blue River at Hollenberg, KS	1975–2000	26	109	141	211	377	885	535	2,752	27.64	1.37	1.6
06884200	Mill Creek at Washington, KS	1960–2000	41	3.2	7.5	19	56	181	108	344	30.62	.908	2.4
06884400	Little Blue River near Barnes, KS	1959–2000	42	128	170	268	525	1,340	704	3,324	28.23	1.28	1.7

Table 1. Streamflow-gaging stations and computed flow-duration values, mean discharge for period of uncontrolled flow record, and climatic and basin characteristics used in regression analyses of uncontrolled flow stream locations in Kansas. —Continued

[ft^3/s, cubic feet per second; mi^2, square miles; in/h, inches per hour]

Station number (fig. 1)	Station name	Period of record (water years)	Years of record	Flow-duration values (ft^3/s) for indicated percentage of time flow equaled or exceeded					Mean discharge for period of uncontrolled record (ft^3/s)	Contributing drainage area (mi^2)	Mean annual precipitation, 1961–90[1] (inches)	Mean basin permeability[2] (in/h)	Mean basin slope[3] (degrees)
				90-percent	75-percent	50-percent	25-percent	10-percent					
06884500	Little Blue River at Waterville, KS	1923–57	35	104	144	200	385	1,110	619	3,509	28.23	1.28	1.7
06885500	Black Vermillion River near Frankfort, KS	1954–2000	47	4.0	11	29	79	246	174	410	33.31	.359	2.4
06886000	Big Blue River at Randolph, KS	1919–60	42	270	380	600	1,240	3,410	1,690	9,100	28.94	.946	1.7
06886500	Fancy Creek at Winkler, KS	1955–71	17	0	2.0	11	23	59	47	174	30.98	.731	2.5
06888000	Vermillion Creek near Wamego, KS	1937–71	35	.40	2.5	17	53	143	87	243	34.94	.427	3.4
06888500	Mill Creek near Paxico, KS	1955–2000	46	4.8	19	56	156	339	194	316	34.67	.505	4.2
06889100	Soldier Creek near Goff, KS	1965–86	22	0	0	.08	.30	1.0	1.4	2.06	35.54	.318	2.6
06889120	Soldier Creek near Bancroft, KS	1965–87	23	.01	.15	.55	2.0	6.0	6.9	10.5	35.16	.344	2.6
06889140	Soldier Creek near Soldier, KS	1965–98	34	.21	.48	1.2	3.5	10	11	16.9	35.16	.359	2.7
06889160	Soldier Creek near Circleville, KS	1965–2000	36	.80	2.0	4.6	13	39	32	49.3	35.82	.381	2.8
06889180	Soldier Creek near St. Clere, KS	1965–80	16	2.3	5.0	10	28	75	51	80	35.53	.434	3.0
06889200	Soldier Creek near Delia, KS	1959–2000	42	2.9	8.4	21	58	153	99	157	35.63	.476	3.2
06889500	Soldier Creek near Topeka, KS	1930–2000	71	2.2	9.4	30	89	243	158	290	35.73	.557	3.3
06890100	Delaware River near Muscotah, KS	1970–2000	31	6.2	18	51	146	450	280	431	35.97	.398	3.1
06890500	Delaware River at Valley Falls, KS	1923–67	45	6.0	18	65	189	600	388	922	36.28	.432	3.1
06891500	Wakarusa River near Lawrence, KS	1930–76	47	0	2.0	23	105	333	195	425	36.61	.617	2.6
06892000	Stranger Creek near Tonganoxie, KS	1930–2000	71	2.0	9.0	40	135	433	247	406	37.89	.503	3.2
06893080	Blue River near Stanley, KS	1975–2000	26	.07	.69	5.0	19	57	36	46	39.35	.609	2.1
06910800	Marais des Cygnes River near Reading, KS	1970–2000	31	.18	2.3	15	56	174	113	177	35.80	.399	2.2
06911000	Marais des Cygnes River at Melvern, KS	1940–64	25	0	3.0	23	86	300	196	351	36.61	.421	2.2
06911500	Salt Creek near Lyndon, KS	1940–99	60	0	.54	5.1	24	82	66	111	36.60	.461	2.1
06911900	Dragoon Creek near Burlingame, KS	1961–2000	40	0	1.0	8.0	32	93	68	114	36.07	.443	2.7
06912500	Hundred and Ten Mile Creek near Quenemo, KS	1940–62	23	0	1.2	17	79	246	181	322	36.21	.465	2.3
06913000	Marais des Cygnes River near Pomona, KS	1923–62	40	1.0	3.0	26	126	417	303	1,040	36.54	.478	2.2
06913500	Marais des Cygnes River near Ottawa, KS	1903–62	60	1.5	10	70	306	1,040	627	1,250	36.70	.520	2.2
06914000	Pottawatomie Creek near Garnett, KS	1940–2000	61	.10	2.0	21	90	361	235	334	38.31	.545	1.3

Table 1. Streamflow-gaging stations and computed flow-duration values, mean discharge for period of uncontrolled flow record, and climatic and basin characteristics used in regression analyses of uncontrolled flow stream locations in Kansas.—Continued

[ft^3/s, cubic feet per second; mi^2, square miles; in/h, inches per hour]

Station number (fig. 1)	Station name	Period of record (water years)	Years of record	Flow-duration values (ft^3/s) for indicated percentage of time flow equaled or exceeded: 90-percent	75-percent	50-percent	25-percent	10-percent	Mean discharge for period of uncontrolled record (ft^3/s)	Contributing-drainage area (mi^2)	Mean annual precipitation, 1961–90[1] (inches)	Mean basin permeability[2] (in/h)	Mean basin slope[3] (degrees)
06915000	Big Bull Creek near Hillsdale, KS	1959–80	22	0.34	4.0	14	50	228	104	147	39.25	0.660	2.1
06916000	Marais des Cygnes River at Trading Post, KS	1929–58	30	2.9	23	209	884	4,208	1,690	2,880	38.14	.595	2.0
06916500	Big Sugar Creek at Farlinville, KS	1930–70	41	0	1.2	11	61	185	127	198	40.18	.657	2.2
06917000	Little Osage River at Fulton, KS	1950–2000	51	.20	2.9	32	129	396	238	295	40.67	.728	2.0
06917380	Marmaton River near Marmaton, KS	1972–2000	29	.46	4.1	43	159	470	302	292	41.34	.829	1.9
06917500	Marmaton River at Fort Scott, KS	1922–71	50	1.0	2.7	31	130	446	288	408	41.47	.827	1.9
07138650	White Woman Creek near Leoti, KS	1967–85	19	0	0	0	0	0	1.0	758	15.74	1.20	.57
07139800	Mulberry Creek near Dodge City, KS	1969–90	22	0	0	0	0	0	.64	217	21.70	1.23	.83
07140850	Pawnee River near Burdett, KS	1982–2000	19	0	0	0	2.4	10	11	1,252	20.49	1.11	1.1
07141200	Pawnee River at Rozel, KS	1925–2000	76	0	0	3.7	15	59	63	2,148	20.98	1.12	1.1
07141780	Walnut Creek at Nekoma, KS	1970–2000	31	0	0	1.0	13	30	25	1,192	21.02	1.17	1.1
07141900	Walnut Creek at Albert, KS	1959–2000	42	0	0	2.3	23	61	49	1,410	21.40	1.18	1.2
07142300	Rattlesnake Creek near Macksville, KS	1960–2000	41	1.2	6.5	15	28	40	26	784	24.14	5.57	.82
07142575	Rattlesnake Creek near Zenith, KS	1974–2000	27	4.6	12	29	50	82	50	1,047	24.41	5.90	.68
07142620	Rattlesnake Creek near Raymond, KS	1961–98	38	2.2	4.2	24	59	104	49	1,167	24.41	5.90	.68
07142860	Cow Creek near Claflin, KS	1967–81	15	0	0	.13	.80	4.0	7.0	43	25.85	1.04	1.3
07142900	Blood Creek near Boyd, KS	1963–80	18	0	.10	.48	1.2	4.0	7.1	61	24.45	1.07	1.5
07143300	Cow Creek near Lyons, KS	1939–2000	62	3.2	6.5	12	30	133	80	728	26.15	1.30	.87
07143600	Little Arkansas River near Little River, KS	1960–70	11	0	.20	.80	1.9	6.9	9.5	71	27.67	.856	1.3
07143665	Little Arkansas River at Alta Mills, KS	1974–2000	27	4.9	9.2	22	62	325	229	736	29.49	2.07	.759
07144200	Little Arkansas River at Valley Center, KS	1923–2000	78	21	33	60	127	488	312	1,327	30.34	2.02	.754
07144780	North Fork Ninnescah River above Cheney Reservoir, KS	1966–2000	35	24	47	76	126	222	147	787	26.87	5.48	.69
07144800	North Fork Ninnescah River near Cheney, KS	1951–64	14	9.3	38	85	148	262	160	930	27.47	4.96	.83
07144850	South Fork South Fork Ninnescah River near Pratt, KS	1962–80	19	0	0	0	0	0	2.6	23.1	25.58	2.02	.92

Table 1. Streamflow-gaging stations and computed flow-duration values, mean discharge for period of uncontrolled flow record, and climatic and basin characteristics used in regression analyses of uncontrolled flow stream locations in Kansas. —Continued

[ft^3/s, cubic feet per second; mi^2, square miles; in/h, inches per hour]

Station number (fig. 1)	Station name	Period of record (water years)	Years of record	Flow-duration values (ft^3/s) for indicated percentage of time flow equaled or exceeded: 90-percent	75-percent	50-percent	25-percent	10-percent	Mean discharge for period of uncontrolled record (ft^3/s)	Contributing-drainage area (mi^2)	Mean annual precipitation, 1961–90[1] (inches)	Mean basin permeability[2] (in/h)	Mean basin slope[3] (degrees)
07145200	South Fork Ninnescah River near Murdock, KS	1951–2000	50	66	97	135	194	304	209	650	27.25	3.08	1.3
07145500	Ninnescah River near Peck, KS	1939–63	25	78	156	272	450	920	550	2,129	28.06	3.78	1.1
07145700	Slate Creek at Wellington, KS	1970–2000	31	.91	3.3	8.0	21	73	73	154	30.73	.876	.81
07146570	Cole Creek near DeGraff, KS	1962–79	18	0	.07	1.8	4.8	13	17	30	33.68	.448	1.1
07147070	Whitewater River at Towanda, KS	1962–2000	39	7.6	17	36	85	242	206	426	33.05	.468	1.2
07147800	Walnut River at Winfield, KS	1922–80	58	18	48	152	430	1,300	793	1,880	34.31	.488	1.4
07148350	Salt Fork Arkansas near Winchester, OK	1960–93	24	.35	7.4	34	75	160	96	856	24.58	2.81	2.6
07149000	Medicine Lodge River near Kiowa, KS	1939–2000	62	12	47	85	141	271	154	903	25.47	2.56	2.7
07149500	Salt Fork Arkansas River near Cherokee, OK	1941–50	10	2.0	50	125	246	731	393	2,439	25.44	2.80	2.5
07151500	Chikaskia River near Corbin, KS	1951–2000	50	19	47	94	190	430	250	794	28.69	2.65	1.1
07152000	Chikaskia River near Blackwell, OK	1937–2000	64	23	66	144	324	895	585	1,859	32.94	.800	.95
07154500	Cimarron River near Kenton, OK	1951–2000	50	0	.06	.91	2.8	7.5	17	1,106	16.29	2.07	1.0
07155590	Cimarron River near Elkhart, KS	1972–2000	29	0	0	0	0	1.5	11	3,410	16.33	3.04	1.8
07156010	North Fork Cimarron River at Richfield, KS	1972–85	14	0	0	0	0	.12	5.6	492	16.12	3.27	.97
07156100	Sand Arroyo Creek near Johnson, KS	1972–85	14	0	0	0	0	0	.25	751	15.90	3.12	.93
07156220	Bear Creek near Johnson, KS	1967–98	32	0	0	0	0	0	3.4	1,093	15.85	1.27	1.2
07156900	Cimarron River near Forgan, OK	1966–2000	35	27	35	45	62	82	58	8,536	16.85	3.16	1.1
07157000	Cimarron River near Mocane, OK	1943–65	13	27	42	60	85	137	100	8,670	17.07	3.32	1.2
07157500	Crooked Creek near Englewood, KS	1943–2000	58	2.4	7.1	12	18	33	31	1,157	20.51	1.67	.72
07157900	Cavalry Creek at Coldwater, KS	1967–81	15	.65	1.0	1.5	2.0	2.9	3.4	39	24.81	2.73	1.1
07157950	Cimarron River near Buffalo, OK	1961–94	34	.03	10	56	123	232	128	12,004	19.53	3.19	1.3
07165700	Verdigris River near Madison, KS	1956–76	21	.50	4.9	28	78	204	123	181	36.14	.486	2.8
07166000	Verdigris River near Coyville, KS	1940–59	20	0.10	5.2	45	189	670	465	747	36.75	.541	2.4
07166500	Verdigris River near Altoona, KS	1940–59	20	0	10	71	295	1,230	691	1,138	37.51	.671	2.4
07167000	Fall River near Eureka, KS	1947–76	30	.70	5.2	40	134	324	190	307	35.32	.515	3.1

Table 1. Streamflow-gaging stations and computed flow-duration values, mean discharge for period of uncontrolled flow record, and climatic and basin characteristics used in regression analyses of uncontrolled flow stream locations in Kansas. —Continued

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Station number (fig. 1)	Station name	Period of record (water years)	Years of record	Flow-duration values (ft^3/s) for indicated percentage of time flow equaled or exceeded: 90-percent	75-percent	50-percent	25-percent	10-percent	Mean discharge for period of uncontrolled record (ft^3/s)	Contributing-drainage area (mi^2)	Mean annual precipitation, 1961–90[1] (inches)	Mean basin permeability[2] (in/h)	Mean basin slope[3] (degrees)
07167500	Otter Creek at Climax, KS	1947–2000	54	0	1.0	10	44	121	82	129	36.19	0.461	2.8
07168500	Fall River near Fall River, KS	1905–48	44	1.0	10	53	184	550	331	585	35.84	.518	2.8
07169500	Fall River at Fredonia, KS	1939–48	10	2.4	12	75	272	848	506	827	36.26	.616	2.7
07169800	Elk River at Elk Falls, KS	1967–2000	33	.64	2.9	22	91	271	154	220	36.46	.447	2.5
07170000	Elk River near Elk City, KS	1939–69	31	0	2.6	26	119	412	308	575	37.41	.740	2.6
07170700	Big Hill Creek near Cherryvale, KS	1958–2000	43	0	.03	1.3	10	48	27	37	41.31	.834	2.3
07172000	Caney River near Elgin, KS	1940–2000	61	.07	5.0	40	172	528	273	445	35.53	.556	3.2
07174000	Little Caney River near Copan, OK	1944–58	15	.10	.50	9.5	64	323	237	424	37.51	1.01	2.9
07174400	Caney River above Coon Creek near Bartlesville, OK	1986–2000	15	26	36	173	1,820	4,420	1,290	1,392	36.75	.970	3.1
07179500	Neosho River at Council Grove, KS	1939–63	25	0	1.0	16	48	134	123	250	33.77	.433	1.8
07180000	Cottonwood River near Marion, KS	1939–68	30	3.0	8.0	18	43	108	112	329	32.37	.662	1.5
07180500	Cedar Creek near Cedar Point, KS	1939–2000	62	1.8	6.0	16	36	76	58	110	33.33	.518	1.6
07181000	Cottonwood River at Elmdale, KS	1923–32	10	20	42	88	220	691	357	1,045	32.92	.566	1.6
07181500	Middle Creek near Elmdale, KS	1939–50	12	0	2.4	7.0	22	59	45	92	34.05	.456	2.2
07182000	Cottonwood River at Cottonwood Falls, KS	1933–67	35	10	34	108	302	785	511	1,740	33.09	.545	1.9
07182400	Neosho River at Strawn, KS	1949–62	14	5.0	54	285	920	3,040	1,390	2,933	34.11	.508	1.9
07183100	Owl Creek near Piqua, KS	1960–70	11	0	.57	4.0	21	115	122	177	40.36	.609	1.7
07183500	Neosho River near Parsons, KS	1922–63	42	29	133	472	1,600	5,820	2,450	4,905	36.39	.579	1.7
07184000	Lightning Creek near McCune, KS	1939–2000	62	0	1.4	12	52	270	169	197	42.25	1.02	1.2
07186000	Spring River at Waco, MO	1925–2000	76	66	124	301	730	1,816	947	1,164	43.38	1.41	1.2
07186400	Center Creek near Carterville, MO	1963–91	29	32	47	97	206	399	204	232	42.92	1.46	1.6
07187000	Shoal Creek above Joplin, MO	1942–2000	59	88	130	237	448	879	427	427	43.21	1.48	2.7
07188000	Spring River near Quapaw, OK	1940–2000	61	211	376	850	1,950	4,400	2,200	2,510	43.18	1.43	1.4

[1]Mean annual precipitation for each gaging station from Daly and others (1997).

[2]Mean basin permeability for each gaging station from U.S. Department of Agriculture (1994).

[3]Mean basin slope for each gaging staiton from U.S. Geological Survey (1998).

in elevation between 10- and 85-percent lengths of the main channel from the point of the stream statistic computation. In the GIS, the coverage for the streams was overlain on the elevation coverage. A program was developed to determine the longest continuous stream length upstream from the point of statistic computation. The 10-percent and 85-percent distance elevations were obtained, and along with the distance between the two points, a main-stream channel slope for each stream location was derived.

Methods for Estimating Flow Durations, Mean Flows, and Peak-Discharge Frequency Values

Climatic and basin characteristics were used in the analyses of flow durations and mean flows at gaged and ungaged sites on uncontrolled flow streams. For this study, ARC/INFO GIS software was used to estimate climatic and basin characteristics. Many spatial data sets were available for this task, including: (1) 30-year (1961–90) mean annual precipitation data (Daly and others, 1997), (2) 30-m gridded elevation data (U.S. Geological Survey, 1998) for determining contributing-drainage area, mean basin slope, and mean basin elevation, and (3) STATSGO soil-permeability data (U.S. Department of Agriculture, 1994).

The flow-duration information was computed for the 216 gaging stations in Kansas and the surrounding States with at least 10 years of streamflow record. Streamflow at 149 of these stations, which were on uncontrolled flow stream locations (table 1), were included in the regression analyses to develop predictive equations for streamflow. The flows of uncontrolled flow stream locations are unaffected by storage and release from Federal upstream reservoirs. One hundred thirty-one streamflow-gaging stations in Kansas and 18 in surrounding States (3 in Missouri, 5 in Nebraska, and 10 in Oklahoma) measured uncontrolled flow. All available records through water year (October through September) 2000 were used to compute the flow duration and mean flow for these gaging stations.

Three gaging stations in Kansas that measured uncontrolled flow and had at least 10 years of record were not included in the regression analyses. One station, Indian Creek at Overland Park, Kansas (station 06893300), was not used because it is affected by extensive urbanization. Two other stations, Beaver Creek at Cedar Bluffs, Kansas (station 06846500), and Paradise Creek near Paradise, Kansas (station 06867500), were not used because streamflow statistics developed for these stations were not consistent with statistics for other nearby stations. These two gaging stations were located on stream reaches that were losing surface flow to ground water (losing streams).

Estimates at Gaged Stream Sites

The USGS has established standard methods for estimating flow duration (Searcy, 1959) for streamflow-gaging stations. The computer software programs IOWDM, ANNIE, and SWSTAT were used to format input data, manage and display data, and complete the flow-duration statistical analyses (Lumb and others, 1990; Flynn and others, 1995). These programs are available on the World Wide Web (URL http:// water.usgs.gov/software/surface_water.html). For this study a computer software program was developed by the USGS (Xiaodong Jian, written commun., 2003) and was used to compute flow durations and mean flow using the data from the streamflow-gaging stations. This software program is on file at the USGS office in Lawrence, Kansas.

Daily mean flows for all complete water years of record were used to determine flow-duration statistics for continuous-record, streamflow-gaging stations. The water year begins on October 1 and ends on September 30 of the following year. Daily mean flows for USGS streamflow-gaging stations in Kansas are available on the World Wide Web (URL http://waterdata.usgs.gov/ks/nwis/).

A flow-duration curve (fig. 7) is a graphical representation of the percentage of time that streamflow for a given time step (usually daily) is equaled or exceeded during a specified period (usually the complete period of record) at a stream site. Flow-duration curves usually are constructed by first ranking all of the daily mean discharges for the period of record at a gaging station from largest to smallest, next computing the probability for each value being equaled or exceeded, then plotting the discharges against their associated exceedance probabilities (Loaiciga, 1989, p. 82). The daily mean discharges are not fit to an assumed distribution. Flow-duration analysis can be done by use of the USGS software described previously or by use of commercially available statistical software.

Flow-duration statistics are points along a flow-duration curve. For example, the 99-percent duration streamflow is equaled or exceeded 99 percent of the time, whereas the 50-percent duration streamflow (median) is equaled or exceeded 50 percent of the time. Strictly interpreted, flow-duration statistics reflect only the period for which they are calculated; however, when the period of record used to compute the statistics is sufficiently long, the statistics often are used as an indicator of probable future conditions (Searcy, 1959).

Estimates of peak discharge for selected frequencies can be computed by using observed annual peak-discharge data for streamflow-gaging stations. Log-Pearson Type-III distributions are fitted to the observed annual peak-discharge data for each streamflow-gaging station by using techniques recommended by the Interagency Committee on Water Data (1981).

Estimates at Ungaged Stream Sites

Estimates of streamflow statistics often are needed for sites on streams where no gaged data are available. The two

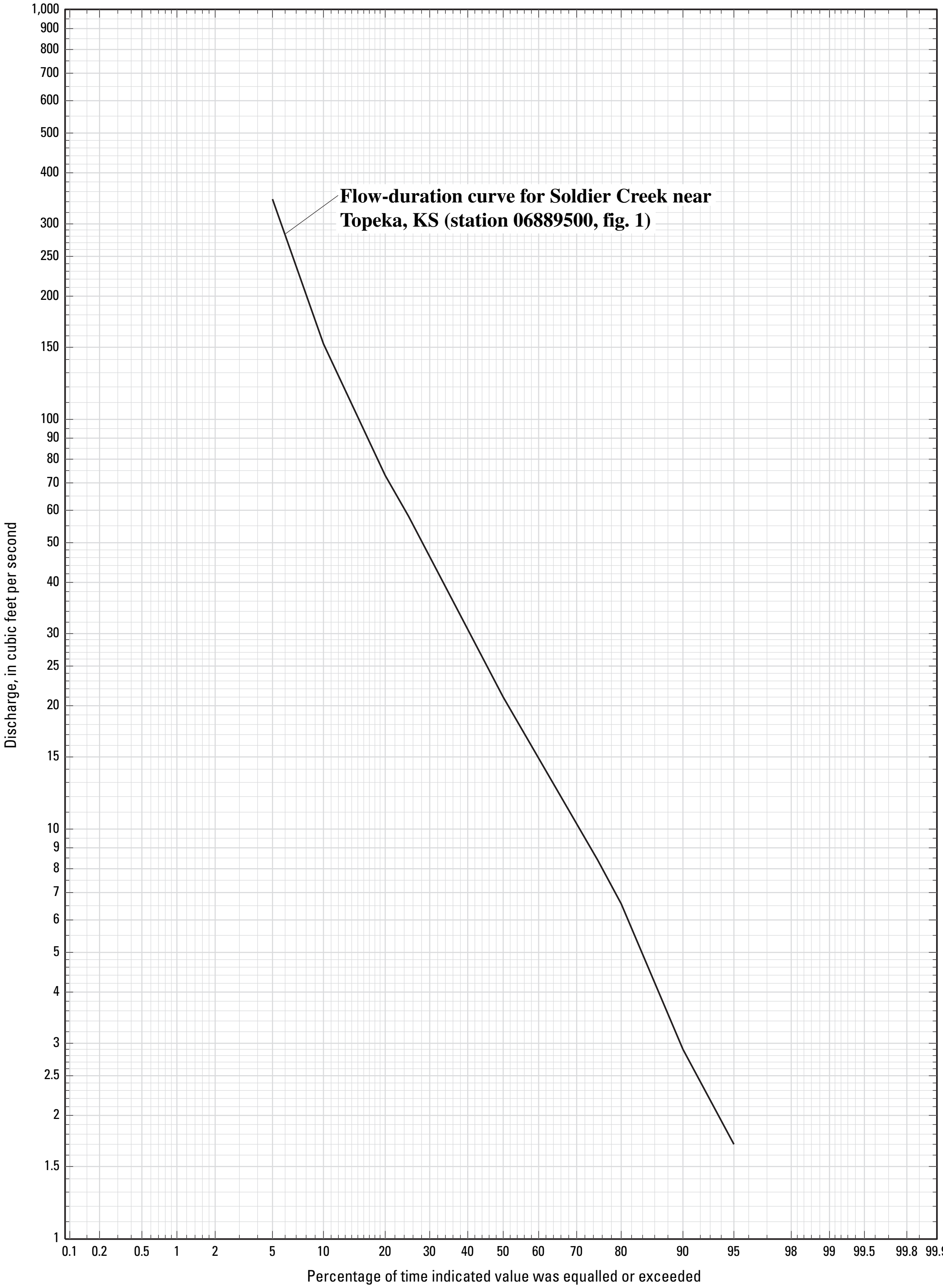

Figure 7. Flow-duration curve for Soldier Creek near Topeka, Kansas (station 06889500, fig. 1).

methods most commonly used to estimate statistics for ungaged sites are the drainage-area ratio method and multiple linear-regression analysis. The drainage-area ratio method is most appropriate for use when the ungaged site is near a streamflow-gaging station on the same stream. Multiple linear-regression analysis is used to obtain estimates for most other ungaged sites.

Drainage-Area Ratio Method

The drainage-area ratio method assumes that the streamflow at an ungaged site for the same stream is the same per unit area or at least responds in the same fashion as that at a nearby, hydrologically similar streamflow-gaging station used as an index. Drainage areas for the ungaged site and the index station are determined from topographic maps, digital elevation maps (DEMs), or by other GIS methods. Streamflow statistics are computed for the index station, then the statistics are divided by the drainage area to determine streamflow per unit area at the index station. These values are multiplied by the drainage area at the ungaged site to obtain estimated statistics for the site. This method is most commonly applied when the index gaging station is on the same stream as the ungaged site because the accuracy of the method depends on the proximity of the two sites and on similarities in drainage area and on other climatic and basin characteristics of the respective drainage basins.

Several researchers have provided guidelines as to how large the difference in drainage areas can be before use of multiple linear-regression analysis is preferred over use of the drainage-area ratio method. Guidelines have been provided for estimating peak-discharge statistics, and usually the preferred guideline has been that the drainage area for the ungaged site should be within 0.5 and 1.5 times the drainage area of the index station (Sauer, 1974; Choquette, 1988, p. 41; Koltun and Roberts, 1990, p. 6; Lumia, 1991, p. 34; Bisese, 1995, p. 13). One report (Koltun and Schwartz, 1986, p. 32) selected a range of 0.85 to 1.15 times the drainage area of the index station for estimating low flows at ungaged sites in Ohio. None of these researchers provided any scientific basis for use of these guidelines (R.E. Thompson, Jr., U.S. Geological Survey, written commun., 1999).

In this report, streamflow statistics at controlled, ungaged sites were determined by the drainage-area ratio method with no limit on the ratios between the gaged-location drainage area and the ungaged-location drainage area. Flow statistics for uncontrolled flow, ungaged sites were determined by an interpolation procedure that utilized a drainage-area weighted ratio of gaged site information and regression-equation estimates at ungaged sites. This procedure is explained in greater detail in a following section, "Estimates of Streamflow Statistics for Stream Locations."

Multiple Linear-Regression Analysis

Multiple linear-regression analysis (regression analysis) has been used by the USGS and other researchers throughout the United States and elsewhere to develop equations for estimating streamflow statistics at ungaged sites. In regression analysis, a streamflow statistic (the dependent variable) for a group of gaging stations is related statistically to the climatic or basin characteristics of the drainage basins for the stations (the independent variables). This results in an equation that can be used to estimate the statistic for sites where no streamflow data are available.

Equations can be developed by use of several different regression analysis algorithms. The various algorithms use different methods to minimize the differences between the values of the dependent variable for the stations used in the analysis (the observed values) and the corresponding values provided by the resulting regression equation (the estimated or fitted values). Choice of one algorithm over another depends on the characteristics of the data used in the analysis and on the underlying assumptions for use of the algorithm. The multiple linear-regression equation takes the general form:

$$\Upsilon_i = b_0 + b_1X_1 + b_2X_2 + \ldots + b_nX_n + \varepsilon_i \,, \qquad (1)$$

where Y_i is the value of the dependent variable for site i, X_1 to X_n are the n independent variables, b_0 to b_n are the $n + 1$ regression-model coefficients, and ε_i is the error (difference between the observed and estimated values of the dependent variable) for site i. Assumptions for use of regression analysis are (1) equation 1 adequately describes the relation between the dependent and the independent variables, (2) the variance of the ε_i is constant and independent of the values of X_n, (3) the ε_i are normally distributed for a Tobit analysis, and (4) the ε_i are independent of each other (Inman and Conover, 1983, p. 367). Tobit analysis is discussed in the following paragraph. Regression analysis results need to be evaluated to assure that these assumptions are met. Streamflow and basin characteristics used in hydrologic regression usually are log-normally distributed; therefore, transformation of the variables to logarithms is usually necessary to satisfy regression assumption 3. Transformation results in a model of the form:

$$\log Y_i = b_0 + b_1\log X_1 + b_2\log X_2 + \ldots + b_nX_n + \varepsilon_i \,. \qquad (2)$$

The algebraically equivalent form when logarithms-base 10 ($\log_{10}$) are used in the transformations, and the equation retransformed to original units is:

$$Y_i = 10^{b_o}\left(X_1^{b_1}\right)\left(X_2^{b_2}\right)\ldots\left(X_n^{b_n}\right)10 \,; \qquad (3)$$

$$Y_i = 10^{\left[b_0 + b_1\log X_1 + b_2\log X_2 + \ldots b_n\log X_n + \varepsilon_i\right]} \,. \qquad (4)$$

To include zero values in a logarithmic transformation analysis, the Tobit analysis was used. Tobit analysis is a widely accepted method for estimating a regression-like model when there are adjusted data (Tobin, 1958; Judge and others, 1985; Cohn, 1988). Adjusted data are data that either are censored or have had a discrete value of delta (δ) added to them. Censored data are values less than a threshold value and are increased to the censoring value (for example, all values less than 0.7 are increased to 0.7). Discrete values of delta (δ) are added to all data before transformation and then subtracted from the final regression model value. By applying these techniques, zero values of data can be transformed logarithmically. The Tobit procedure uses a maximum likelihood estimator (Cohn, 1988). The Survival Regression Procedure in the S-Plus 2000 software package (MathSoft, 1999) was used in this study to fit the Tobit model.

A Tobit analysis was conducted for each of the flow durations and for the mean flow data sets, and the resulting plots of observed and regression-estimated values are shown in figures 8*A* through 8*F*. The graphs show the observed specific flow plotted with the regression-estimated flow. All observed and regression-estimated flow duration have the delta value added.

The equations for regression-estimated flow durations and mean flow and uncertainty measures are listed in table 2. Only the 149 gaging stations on streams with uncontrolled flow with at least 10 years of record (table 1) were used in the regression analyses. The drainage area of these gaging stations ranged from 2.06 to 12,004 mi^2. The Chi^2 is a measure of the fit of the Tobit analysis model. The delta value is varied until the Chi^2 is maximized. For these analyses the contributing-drainage area (*CDA*) was divided by 1,000, the 30-year mean precipitation (*PREC*) was divided by 28, and the mean basin slope (*SLOPE*) was divided by 2 before the log transformation was made so that the log values of each of these parameters were balanced between greater than and less than zero. This eliminated the multi-colinearity problems that occur when using squared values (A.V. Vecchia, USGS, written commun., 2002). The addition of the squares of log contributing-drainage area and log mean annual precipitation to the regression equation improved the models substantially.

Regression equations for peak-discharge frequency estimates for Kansas are provided by Rasmussen and Perry (2000). Peak discharges were estimated at recurrence intervals (frequencies) ranging from 2 to 100 years using log-Pearson Type-III (distributions for 253 streamflow-gaging stations in Kansas (see Rasmussen and Perry, 2000, table 5). The annual peak-discharge data, through the 1997 water year, were from streamflow-gaging stations with uncontrolled 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 skewness estimates for the log-Pearson Type-III analyses than the previously developed equation for Kansas (Clement, 1987).

Rasmussen and Perry (2000) used a generalized least-squares regression model to develop equations for estimating peak streamflow for sites without stream gages for selected frequencies from selected physical and climatic basin characteristics for sites with stream gages. The equations can be used to estimate peak streamflow for selected frequencies using contributing-drainage area, mean annual precipitation, soil permeability, and slope of the main channel for ungaged sites in Kansas with contributing-drainage areas greater than 0.17 and less than 9,100 mi^2. The equations and their errors are provided in table 3.

1999 Kansas Surface Water Register

In 1994, KDHE adopted the Reach File Version 2 (RF2) stream-segment coverage within the State of Kansas as the basic coverage for stream classification. RF2 was completed in the late 1980s by the U.S. Environmental Protection Agency (USEPA) using the Feature File of the USGS Geographic Names Information System (GNIS) to add one new level of reach segments to the Reach File Version 1 (RF1) coverage (U.S. Environmental Protection Agency, 1996). The source of RF1 (completed in 1982) was the USGS's 1:250,000-scale hydrography that was photographically reduced to a scale of 1:500,000 by the National Oceanic and Atmospheric Administration (NOAA).

In addition to the RF2 segments, other segments have been added to the KSWR by KDHE primarily for the protection of aquatic life and other water-quality issues. The 1999 KSWR has 2,232 stream segments. Each segment on the 1999 KSWR is identified by a unique CUSEGA number (tables 7–111, at the end of this report). CUSEGA stands for catalog unit segment number alpha. Individual CUSEGA segments may have one or more subsegments associated with it. The KSWR of June 1, 1999, is a public document and can be obtained from the World Wide Web (URL http://www.kdhe.state.ks.us/pdf/befs/register99.pdf).

The original RF2 coverage had almost 30,000 subsegments in Kansas. By combining subsegments and by ending the stream segments at hydrologic breaks such as at the confluence of tributaries or at lakes, the total number of segments within Kansas was reduced to 5,427 for this report. Streamflow statistics were determined at the downstream end of these segments (called streamflow-statistics determination sites in this report). Of the 5,427 determination sites, 656 are located in lakes or along irrigation ditches where statistical computations are not reported. Therefore, stream statistics are reported at 4,771 sites and their associated stream segments.

Because many of the stream basins in Kansas extend into the surrounding States, the data used for developing the 1999 KSWR stream network, which is based on the more detailed RF2, were joined with the national RF1 coverage that is available for Colorado, Missouri, Nebraska, and Oklahoma. This process was done in a GIS procedure by clipping the Kansas extent of the original RF1 stream coverage and replacing it with the more detailed version of the RF2 stream coverage. The two coverages were joined at the State boundaries for continuity. The line topology was reconfigured so that spatial relations between connecting stream segments (from and to nodes) were updated. Then the updated stream coverage was rechecked to

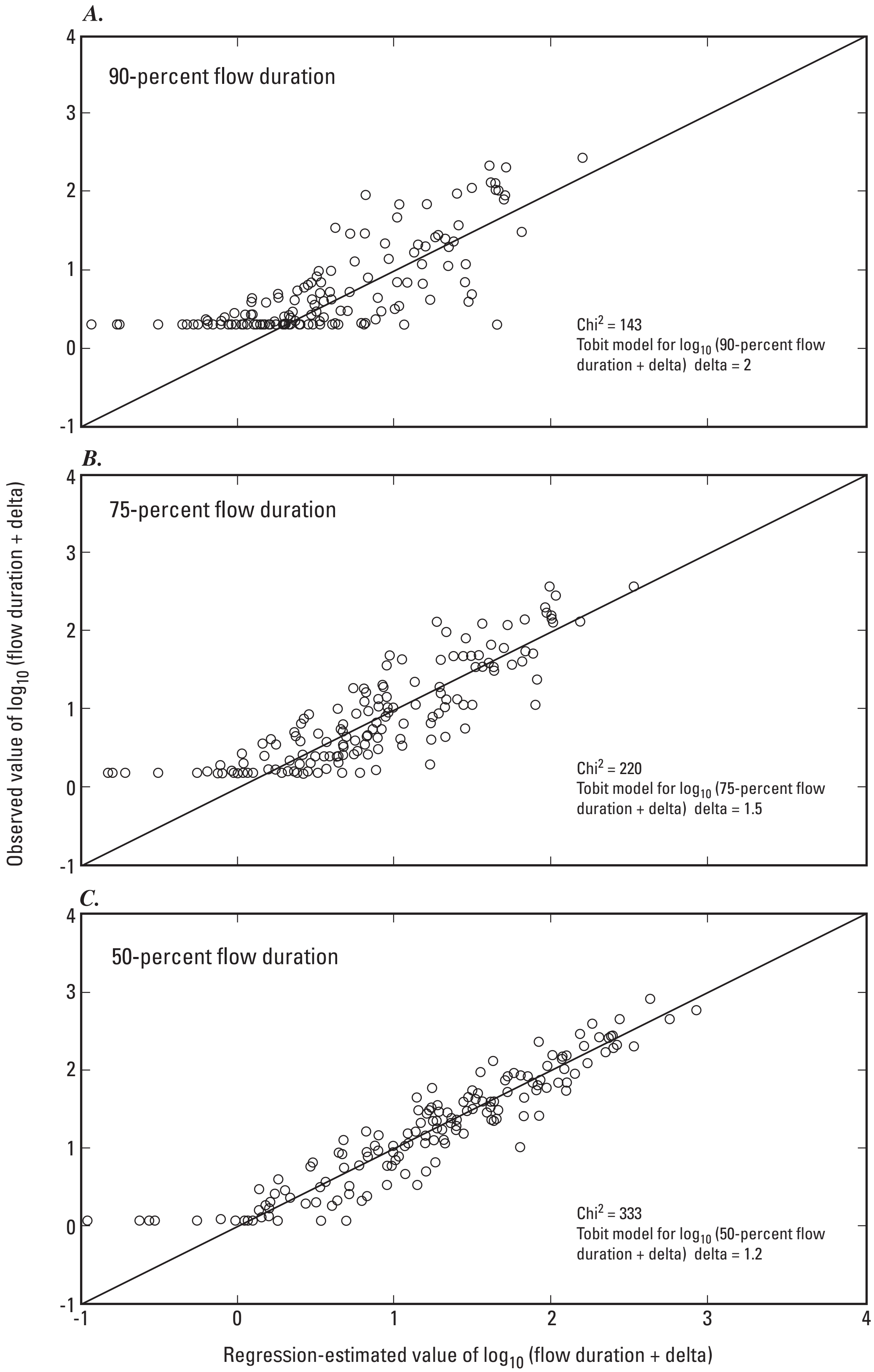

Figure 8. Results of regression with Tobit analysis for flow durations of *(A)* 90, *(B)* 75, *(C)* 50, *(D)* 25, and *(E)* 10 percent and *(F)* mean flow.

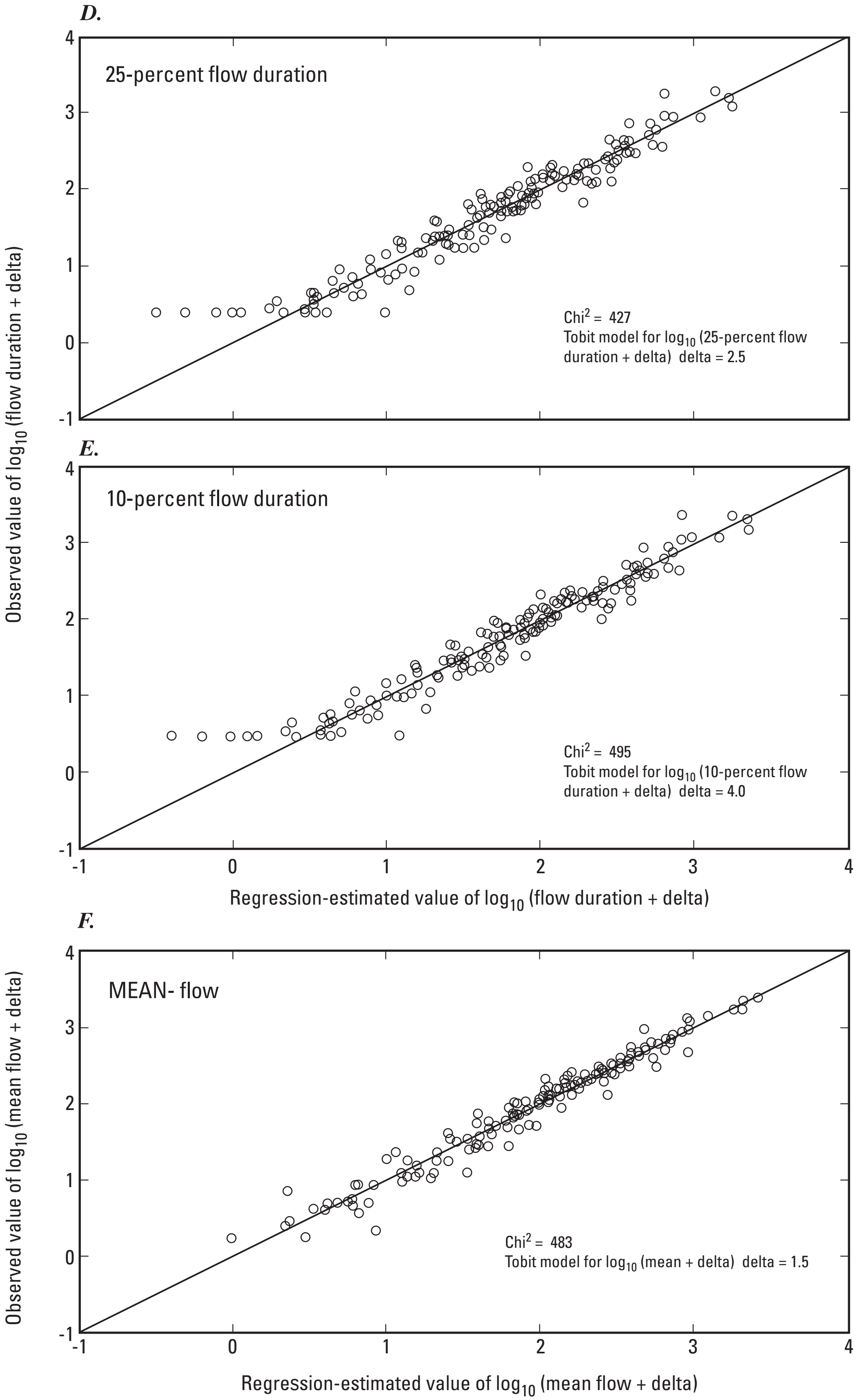

Figure 8. Results of regression with Tobit analysis for flow durations of *(A)* 90, *(B)* 75, *(C)* 50, *(D)* 25, and *(E)* 10 percent and *(F)* mean flow.—Continued

Table 2. Regression equations used to estimate 90-, 75-, 50-, 25-, and 10-percent flow durations and mean flow for uncontrolled flow stream locations on the 1999 Kansas Surface Water Register[1]

[Chi^2, Chi square statistical distribution; n, number of stations used in the analysis; *CDA*, contributing-drainage area, in square miles; *PREC*, precipitation, in inches; *PERM*, soil permeability, in inches per hour; *SLOPE*, land-surface slope, in degrees; $\log da = \log_{10}\left(\frac{CDA}{1{,}000}\right)$; $\log prec = \log_{10}\left(\frac{PREC}{28}\right)$; $\log perm = \log_{10} PERM$; $\log slope = \log_{10}\left(\frac{SLOPE}{2}\right)$]

Flow value	Equation	Chi^2	Standard error (log units)	Degrees of freedom	n
90-percent duration	$Q_{90} = \left[10^{[0.902 + 1.030\log da + 4.046\log prec + 0.732\log perm + 0.008\log slope + 0.292(\log da)^2 + (-17.89(\log prec)^2)]}\right] - 2.0$	143	0.434	6	149
75-percent duration	$Q_{75} = \left[10^{[1.268 + 1.073\log da + 4.310\log prec + 0.755\log perm + 0.339\log slope + 0.222(\log da)^2 + (-17.63(\log prec)^2)]}\right] - 1.5$	220	.344	6	149
50-percent duration	$Q_{50} = \left[10^{[1.685 + 1.124\log da + 5.283\log prec + 0.638\log perm + 0.517\log slope + 0.152(\log da)^2 + (-15.38(\log prec)^2)]}\right] - 1.2$	333	.250	6	149
25-percent duration	$Q_{25} = \left[10^{[2.082 + 1.079\log da + 5.365\log prec + 0.393\log perm + 0.490\log slope + 0.104(\log da)^2 + (-11.10(\log prec)^2)]}\right] - 2.5$	427	.177	6	149
10-percent duration	$Q_{10} = \left[10^{[2.502 + 1.109\log da + 5.638\log prec + 0.218\log perm + 0.434\log slope + 0.085(\log da)^2 + (-9.984(\log prec)^2)]}\right] - 4.0$	495	.154	6	149
Mean flow	$Q_{mean} = \left[10^{[2.286 + 0.978\log da + 4.884\log prec + 0.084\log perm + 0.279\log slope + 0.040(\log da)^2 + (-7.331(\log prec)^2)]}\right] - 1.5$	483	.143	6	149

[1]The Kansas Surface Water Register is maintained by the Kansas Department of Health and Environment (Topeka).

Table 3. Generalized least-squares regression equations for estimating 2- to 100-year peak-streamflow discharges for unregulated, rural streams in Kansas (modified from Rasmussen and Perry, 2000).

[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; *Sl,* 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)
	For contributing-drainage areas ranging from 30 to 9,100 square miles	
Q_2	$0.00001477(CDA)^{0.646}(P)^{4.307}(Sl)^{0.5266}(S)^{-0.1736}$	0.155
Q_5	$0.001336(CDA)^{0.590}(P)^{3.373}(Sl)^{0.4235}(S)^{-0.2231}$	.133
Q_{10}	$0.01085(CDA)^{0.568}(P)^{2.945}(Sl)^{0.374}(S)^{-0.248}$	.131
Q_{25}	$0.0829(CDA)^{0.549}(P)^{2.532}(Sl)^{0.326}(S)^{-0.275}$	.136
Q_{50}	$0.283(CDA)^{0.539}(P)^{2.283}(Sl)^{0.298}(S)^{-0.293}$	.144
Q_{100}	$0.810(CDA)^{0.532}(P)^{2.070}(Sl)^{0.272}(S)^{-0.309}$	.153
	For contributing-drainage areas ranging from 0.17 to less than 30 square miles	
Q_2	$0.0126(CDA)^{0.579}(P)^{2.824}$	.216
Q_5	$0.300(CDA)^{0.600}(P)^{2.138}$	.184
Q_{10}	$1.224(CDA)^{0.611}(P)^{1.844}$	.183
Q_{25}	$4.673(CDA)^{0.622}(P)^{1.572}$	.198
Q_{50}	$10.26(CDA)^{0.628}(P)^{1.415}$	.214
Q_{100}	$19.80(CDA)^{0.634}(P)^{1.288}$	.232

correct any remaining digitizing errors including cycles, overshoots, and undershoots (that is, an arc that does not extend far enough to intersect another arc). Finally, the topology was checked for consistency (that is, all segments point downstream). All GIS analyses were performed using the Environmental Systems Research Institute (ESRI) ArcGIS and ArcInfo software.

A GIS database was used to manage and display the basin characteristics and estimated streamflow statistics for stream locations on the 1999 KSWR. The relational database design facilitates identification and analysis of data unique to individual stream locations. The stream coverage and associated data are available on the World Wide Web (URL http://ks.water.usgs.gov/Kansas/studies/strmstats/index.shtml).

Basin Characteristics for Stream Locations

Drainage basins for each stream location on the 1999 KSWR were determined in the GIS by converting the vector stream-location coverage into a raster-grid network with a raster size of 492 by 492 ft (150 by 150 m). Euclidean allocation was performed on the rasterized stream network to calculate for each cell the identity of the closest source or stream cell using the Euclidean distance. Euclidean distance is defined as the shortest length between two points in two-dimensional space. GIS Euclidean allocation zones may not coincide with actual topographic basin divides. Therefore, basin contributing-drainage areas obtained by the GIS method used herein may differ from those obtained using conventional topographic planimetering methods.

Mean values for climatic and basin characteristics were calculated for stream-location drainage basins using zonal statistics on basin-characteristic grids with Euclidean allocation zones. Zonal statistics were recorded in an attribute table and included the area and mean of the values of all cells in the basin-characteristic grids that belong to the same Euclidean zone. The climatic and basin characteristics computed included contributing-drainage area, mean annual precipitation, mean basin elevation, mean basin permeability, mean basin slope, a base-flow index (BFI), and mean annual runoff (Gebert and others, 1987) and water-balance model runoff (Wolock and McCabe, 1999) flow values. Output zonal statistics tables were relationally joined back to the original vector streams coverage so that each stream location had an estimated value for each climatic and basin characteristic for the entire basin upstream from each stream location.

One parameter that needed a separate GIS computation was the main channel slope for each of the determination sites.

The slope of the main channel is measured by dividing the difference in elevation at points in the channel at 10 and 85 percent of the distance upstream along the main channel length by the intervening main channel length. A computer software program was written (D.M.Wolock, USGS, written commun., 2003) that searches upstream from each determination site, finds the longest stream distance, computes the 10- and 85-percent distance locations, and uses the elevation at those locations and distance along the stream channel to determine the main channel slope.

Estimates of Streamflow Statistics for Stream Locations

Initially, streamflow statistics were computed for each flow determination site. Flow durations and peak-discharge frequencies were checked at each site for a logical progression of flow values. At some determination sites with small drainage areas of less than 5 mi^2, the quadratic part of the equations for the lower (10- and 25-percent) flow durations resulted in flow values that decreased with increasing durations. If the drainage area resulted in a more negative logarithm, the square of that value could dominate the other factors in the equation, and an anomalously high value for flow would result. All determination sites were checked for decreasing flow with increasing flow duration. Of the few sites that were affected, the higher durations (50, 75, and 90 percent) were graphically extrapolated to recompute the 10- and 25-percent duration flows.

Next, different interpolation procedures were used to refine the estimate of flow durations, mean flow, and peak-discharge frequency values for each stream location depending on whether the location had controlled or uncontrolled flow and whether or not there was a streamflow-gaging station located either upstream or downstream from the location. These interpolation procedures utilize the previously defined drainage-area ratio method and multiple linear-regression equations and are summarized in table 4. The interpolation procedures outlined in table 4 for an ungaged location between two gaged locations selects the upstream gage location (if there is more than one) that has the largest drainage area. These procedures were applied to flow statistics developed for each stream location.

Flow-duration and mean flow value computations for controlled and uncontrolled flow streamflow-gaging stations used in the interpolation of the flow duration and mean flow are listed in table 5. Flow durations and mean flows at gages representing controlled stream locations (those with Federal reservoirs upstream) were computed from the controlled period of record only. These records had to be at least 10 years in length for the period 1961 to 2000. Use of the 1961-to-2000 time period maintains a degree of consistency for comparison and interpolation of flow durations and mean flow between gaging stations at controlled locations and is reasonably representative of long-term average precipitation.

Peak-discharge frequency values at controlled and uncontrolled flow streamflow-gaging stations (fig. 2) and used in the interpolation of peak-discharge-frequency values are listed in table 6. Peak-discharge frequency values at gaging stations representing uncontrolled flow stream locations were from Rasmussen and Perry (2000, see table 5). Peak-discharge-frequency values at gaging stations representing controlled stream locations were available from several sources. The U.S. Army Corps of Engineers (USCOE), Kansas City District (oral commun., 2003) was used as the primary source of peak-discharge frequency values for controlled stream locations. If no frequency values for a particular stream location were available from USCOE, then published Federal Emergency Management Agency's Flood Insurance Studies for communities in Kansas (Federal Emergency Management Agency, various years) served as a secondary source. The third and final source of peak-discharge frequency values was a log-Pearson Type-III analyses of the controlled period of record. This final source was a Bulletin 17B estimate (Interagency Advisory Committee on Water Data, 1981) using either the systematic record skew values or the regional skew values to generate the estimated peak-discharge frequency values. When systematic skew values were extremely negative (less than -1.2), the regional skew value was used.

Interpolation Example

Figure 9 shows part of a stream network and some streamflow-gaging stations in central Kansas. The large numbers next to the gaging stations are the 50-percent (median) flow-duration values observed for those stations. The regression equations used are described in the section on "Multiple Linear-Regression Analysis." The smaller numbers are the 50-percent flow-duration values estimated from those regression equations. A comparison of the regression-estimated 50-percent flow-duration values with the observed gaging-station 50-percent flow-duration values shows substantial "local" differences between the estimated and the observed values.

Figure 10 shows the effect of interpolating the observed gaging-station 50-percent (median) flow-duration values with the regression-estimated values to develop the best-estimated flow for each stream location. The local differences in estimated 50-percent flow-duration values noted in figure 9 (regression estimates) are not as large in figure 10 (estimates derived in this report) because of the effect of incorporating local gaging-station data. As a result, the interpolation procedure used in this report to develop stream-statistic estimates appears to provide more accurate estimates than those that result from using only the regression equations.

Estimated Stream Statistics

The interpolation procedure was performed on all the flow durations, the mean flow, and all the peak-discharge values for all uncontrolled and controlled flow determination sites. The

Table 4. Summary of interpolation procedures used to estimate flow duration, mean flow, and peak-discharge flow information for streamflow-statistics determination sites on the 1999 Kansas Surface Water Register (KSWR).

[Q, flow statistic; DA, drainage area; B, bias equals measured gaging station Q minus regression equation Q; Subscripts: r, regression-equation estimate of flow; s, segment (ungaged); b, with bias added; u, upstream gaging station; d, downstream gaging station; g, at streamflow gage]

Case number	Case	Controlled segment interpolation procedure	Uncontrolled segment interpolation procedure
1	No gage on stream.	Never occurs.	Use regression estimate (no adjustment).
2	Gage on determination site segment .	Use gaged value.	Use gaged value.
3	Gage on stream only upstream or downstream from that determination site segment.	Estimate flow from gage data using ratio of gage drainage area to the determination site drainage area. Ignore regression equations. $Q_s = \frac{Q_u}{DA_u} \times DA_s$ or $Q_s = \frac{Q_d}{DA_d} \times DA_s$	Use regression estimate adjusted by weighting the bias between the gaged value and the estimated value at the gaged site by the ratio of the gaged drainage area to the determination site drainage area. $B_s = \frac{B_u}{DA_u} \times DA_s \times \frac{DA_u}{DA_s}$; or $B_s = \frac{B_d}{DA_d} \times DA_s \times \frac{DA_s}{DA_d}$ $Q_{sb} = Q_{sr} + B_s$
4	Gage on stream both upstream and downstream from that flow determination site segment .	Estimate the flow from upstream and downstream gage data using weighted average ratios of gage drainage areas to the determination site drainage area. Ignore regression equations. $Q_s = \frac{Q_u(DA_d - DA_s) + Q_d(DA_s - DA_u)}{DA_d - DA_u}$	Use regression estimate adjusted by a weighted average bias between the two gages using drainage areas of gages and the determination site. $B_s = \frac{B_u(DA_d - DA_s) + B_a(DA_s - DA_u)}{DA_d - DA_u}$ $Q_{sb} = Q_{sr} + B_s$

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
06813500	Missouri River at Rulo, NE	22,000	33,500	40,800	53,900	69,000	44,800
06814000	Turkey Creek near Seneca, KS	2.10	7.40	22.0	69.0	203	129
06815000	Big Nemaha River at Falls City, NE	45.0	80.0	160	390	1,050	627
06818000	Missouri River at St. Joseph, MO	23,600	34,500	43,300	57,600	75,000	48,100
06826500	South Fork Republican River near Hale, CO	5.20	5.80	6.20	7.60	39.0	16.6
06827500	South Fork Republican River near Benkleman, NE	0	.52	16.0	31.0	61.0	26.9
06836500	Driftwood Creek near McCook, NE	.30	2.10	4.80	6.70	11.0	9.50
06844700	South Fork Sappa Creek near Brewster, KS	0	0	0	0	0	.23
06844900	South Fork Sappa Creek near Achilles, KS	0	0	0	.32	2.30	3.42
06845000	Sappa Creek near Oberlin, KS	0	.10	.70	5.40	18.0	16.3
06845200	Sappa Creek near Beaver City, NE	0	1.10	5.00	17.0	60.0	38.2
06846500	Beaver Creek at Cedar Bluffs, KS	0	0	.02	5.65	23.0	13.6
06847900	Prairie Dog Creek above Keith Sebelius Lake, KS	0	.16	2.10	5.80	11.0	9.05
06848000	Prairie Dog Creek at Norton, KS	0	.02	.10	.47	3.10	5.50
06848500	Prairie Dog Creek near Woodruff, KS	0	0	2.00	7.50	16.0	11.1
06853020	Republican River at Guide Rock, NE	6.80	55.0	111	170	448	212
06853500	Republican River near Hardy, NE	63.0	110	167	307	728	333
06853800	White Rock Creek near Burr Oak, KS	.47	1.80	6.00	17.0	40.0	28.6
06854000	White Rock Creek at Lovewell, KS	.06	.10	.20	.57	55.0	33.2
06854500	Republican River at Scandia, KS	120	155	244	537	1,100	484
06855800	Buffalo Creek near Jamestown, KS	.95	3.10	11.0	41.0	133	71.7
06855900	Wolf Creek near Concordia, KS	0	.10	1.00	4.30	17.0	11.0
06856000	Republican River at Concordia, KS	113	170	284	577	1,250	577
06856600	Republican River at Clay Center, KS	140	220	396	837	1,830	872
06857100	Republican River below Milford Dam, KS	57.0	126	357	1,020	2,400	960
06858500	North Fork Smoky Hill River near McAllaster, KS	0	0	0	1.00	3.00	3.68
06859500	Ladder Creek below Chalk Creek near Scott City, KS	0	.39	1.90	4.00	10.0	8.00

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register. —Continued

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
06860000	Smoky Hill River at Elkader, KS	0	0.11	1.50	6.00	22.0	23.9
06861000	Smoky Hill River near Arnold, KS	.01	.17	2.30	15.0	47.0	44.0
06862000	Smoky Hill River at Cedar Bluffs Dam, KS	0	0	.28	.90	6.50	7.98
06862700	Smoky Hill River near Schoenchen, KS	.37	2.70	11.0	18.0	29.0	23.7
06862850	Smoky Hill River below Schoenchen, KS	0	0	1.80	11.0	25.0	19.6
06863300	Big Creek near Ogallah, KS	.20	1.20	2.90	6.60	16.0	21.7
06863500	Big Creek near Hays, KS	1.90	3.50	7.90	19.0	38.0	33.3
06863900	North Fork Big Creek near Victoria, KS	0	0	0	0	.90	3.10
06864000	Smoky Hill River near Russell, KS	16.0	22.0	35.0	75.0	206	148
06864050	Smoky Hill River near Bunker Hill, KS	8.50	17.0	34.0	77.0	198	128
06864500	Smoky Hill River at Ellsworth, KS	19.0	34.0	65.0	138	357	223
06865500	Smoky Hill River near Langley, KS	20.0	40.0	78.0	194	672	267
06866500	Smoky Hill River near Mentor, KS	41.0	72.0	135	315	948	381
06866900	Saline River near Wakeeney, KS	0	.03	2.60	12.0	24.0	21.3
06867000	Saline River near Russell, KS	4.80	12.0	31.0	73.0	165	98.4
06867500	Paradise Creek near Paradise, KS	0	0	.13	4.00	26.0	19.4
06868200	Saline River at Wilson Dam, KS	5.10	8.70	16.0	21.0	191	91.6
06868400	Wolf Creek near Lucas, KS	.70	1.10	2.20	6.80	18.0	16.2
06869500	Saline River at Tescott, KS	15.0	24.0	45.0	126	490	212
06870200	Smoky Hill River at New Cambria, KS	70.5	116	224	557	1,870	688
06870300	Gypsum Creek near Gypsum, KS	0	1.00	7.00	15.0	34.3	25.9
06871000	North Fork Solomon River at Glade, KS	0	.20	8.40	22.0	48.0	27.9
06871500	Bow Creek near Stockton, KS	.44	2.60	5.60	10.0	18.0	13.7
06871800	North Fork Solomon River at Kirwin, KS	0	0	.03	.12	.50	8.76
06871900	Deer Creek near Phillipsburg, KS	0	0	.69	1.50	2.70	4.04
06872500	North Fork Solomon River at Portis, KS	12.0	20.0	34.0	75.0	162	98.4
06873000	South Fork Solomon River above Webster Reservoir, KS	.03	1.00	14.0	37.0	77.0	53.8
06873200	South Fork Solomon River below Webster Reservoir, KS	0	0	0	22.0	123	33.9

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register. —Continued

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
06873460	South Fork Solomon River at Woodston, KS	0.43	1.30	6.50	29.0	99.0	51.5
06873700	Kill Creek near Bloomington, KS	0	0	0	0	1.80	2.09
06874000	South Fork Solomon River at Osborne, KS	6.00	11.0	21.0	58.0	174	91.2
06875900	Solomon River near Glen Elder, KS	14.0	21.0	54.0	186	700	254
06876070	Solomon River near Simpson, KS	30.0	63.0	187	531	1,940	561
06876700	Salt Creek near Ada, KS	1.60	4.00	12.0	30.0	106	70.4
06876900	Solomon River at Niles, KS	57.0	85.0	174	457	1,400	562
06877600	Smoky Hill River at Enterprise, KS	190	299	595	1,470	3,930	1,570
06878000	Chapman Creek near Chapman, KS	7.70	13.0	24.0	49.0	126	93.3
06878500	Lyon Creek near Woodbine, KS	3.40	17.0	33.0	65.0	135	108
06879100	Kansas River at Fort Riley, KS	408	637	1,350	3,310	7,450	3,010
06882000	Big Blue River near Barnestown, NE	103	167	280	616	1,800	868
06882500	Big Blue River near Hull, KS	88.0	130	217	365	895	470
06882510	Big Blue River at Marysville, KS	200	286	467	924	2,590	1,190
06884000	Little Blue River near Fairbury, NE	92.0	119	160	251	581	383
06884025	Little Blue River at Hollenberg, KS	109	141	211	377	885	535
06884200	Mill Creek at Washington, KS	3.20	7.50	19.0	56.0	181	108
06884400	Little Blue River near Barnes, KS	128	170	268	525	1,340	704
06885500	Black Vermillion River near Frankfort, KS	4.00	11.0	29.0	79.0	246	174
06886500	Fancy Creek at Winkler, KS	0	2.00	11.0	23.0	59.0	47.4
06887000	Big Blue River near Manhattan, KS	178	444	974	2,450	6,500	2,490
06887500	Kansas River at Wamego, KS	846	1,360	2,720	6,340	13,600	5,650
06888000	Vermillion Creek near Wamego, KS	.40	2.50	17.0	53.0	143	87.4
06888350	Kansas River near Belvue, KS	960	1,790	3,480	7,800	18,700	7,180
06888500	Mill Creek near Paxico, KS	4.80	19.0	56.0	156	339	194
06889000	Kansas River at Topeka, KS	974	1,630	3,020	7,060	15,800	6,400
06889100	Soldier Creek near Goff, KS	0	0	.08	.30	1.10	1.38
06889120	Soldier Creek near Bancroft, KS	.01	.15	.55	2.00	6.60	6.94

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register. —Continued

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
06889140	Soldier Creek near Soldier, KS	0.21	0.48	1.20	3.50	10.0	10.7
06889160	Soldier Creek near Circleville, KS	.80	2.00	4.60	13.0	39.0	32.4
06889180	Soldier Creek near St. Clere, KS	2.30	5.00	10.0	28.0	75.0	51.2
06889200	Soldier Creek near Delia, KS	2.90	8.40	21.0	58.0	153	99.4
06889500	Soldier Creek near Topeka, KS	2.20	9.40	30.0	89.0	243	158
06890100	Delaware River near Muscotah, KS	6.20	18.0	51.0	146	450	280
06890900	Delaware River below Perry Dam, KS	25.0	25.0	100	562	2,040	728
06891000	Kansas River at Lecompton, KS	1,140	1,900	3,580	8,350	19,000	7,550
06891500	Wakarusa River near Lawrence, KS	5.60	14.0	29.0	260	893	265
06892000	Stranger Creek near Tonganoxie, KS	2.00	9.00	40.0	135	433	247
06892350	Kansas River at DeSoto, KS	1,250	2,100	4,000	9,605	21,600	8,460
06893000	Missouri River at Kansas City, MO	26,600	38,500	50,200	69,600	96,400	57,900
06893080	Big Blue River near Stanley, KS	.07	.69	5.00	19.0	57.0	36.0
06893300	Indian Creek at Overland Park, KS	1.30	4.70	13.0	22.0	56.0	34.6
06893500	Blue River near Kansas City, MO	6.30	20.0	46.0	114	279	166
06910800	Marais des Cygnes River near Reading, KS	.18	2.30	15.0	56.0	174	113
06911000	Marais des Cygnes River at Melvern, KS	2.50	14.0	33.0	99.0	382	208
06911500	Salt Creek near Lyndon, KS	0	.54	5.10	24.0	82.0	66.0
06911900	Dragoon Creek near Burlingame, KS	0	1.00	8.00	32.0	93.0	68.4
06912500	Hundred and Ten Mile Creek near Quenemo, KS	14.0	16.0	22.0	103	515	193
06913000	Marais des Cygnes River near Pomona, KS	38.0	48.0	106	712	2,350	738
06913500	Marias des Cygnes River near Ottawa, KS	40.0	51.0	146	791	2,573	850
06914000	Pottawatomie Creek near Garnett, KS	.10	2.00	21.0	90.0	361	235
06915000	Big Bull Creek near Hillsdale, KS	4.30	6.50	20.0	71.0	375	116
06915800	Marais des Cygnes River at La Cygne, KS	64.9	117	526	2,180	6,190	2,270
06916500	Big Sugar Creek at Farlinville, KS	0	1.20	11.0	61.0	185	127
06916600	Marais des Cygnes River near Kansas-Missouri State line, KS	41.0	109	579	2,310	6,440	2,380
06917000	Little Osage River at Fulton, KS	.20	2.90	32.0	129	396	238

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register. —Continued

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
06917380	Marmaton River near Marmaton, KS	0.46	4.08	43.0	159	470	302
06917500	Marmaton River near Fort Scott, KS	1.00	2.70	31.0	130	446	288
07134180	Arkansas River near Granado, CO	7.00	43.0	112	198	579	236
07137500	Arkansas River near Coolidge, KS	9.30	47.0	129	242	482	237
07138000	Arkansas River at Syracuse, KS	6.50	50.0	133	250	474	233
07138650	White Woman Creek near Leoti, KS	0	0	0	0	0	1.00
07139000	Arkansas River at Garden City, KS	0	1.10	32.0	161	314	163
07139500	Arkansas River at Dodge City, KS	0	0	8.70	71.0	180	86.5
07139800	Mulberry Creek near Dodge City, KS	0	0	0	0	0	.64
07140000	Arkansas River near Kinsley, KS	.71	2.60	32.0	104	203	101
07140850	Pawnee River near Burdett, KS	0	0	0	2.40	10.0	11.1
07141200	Pawnee River near Larned, KS	0	0	3.70	15.0	59.0	63.2
07141300	Arkansas River at Great Bend, KS	2.60	6.90	41.0	150	356	172
07141780	Walnut Creek near Rush Center, KS	0	0	1.00	13.0	30.0	24.8
07141900	Walnut Creek at Albert, KS	0	0	2.30	23.0	61.4	48.9
07142300	Rattlesnake Creek near Macksville, KS	1.20	6.50	15.0	28.0	40.0	25.9
07142575	Rattlesnake Creek near Zenith, KS	4.60	12.0	29.0	50.0	82.3	50.5
07142620	Rattlesnake Creek near Raymond, KS	2.20	4.20	24.0	59.0	104	49.1
07142860	Cow Creek near Claflin, KS	0	0	.13	.80	4.40	7.02
07142900	Blood Creek near Boyd, KS	0	.10	.48	1.20	4.40	7.09
07143300	Cow Creek near Lyons, KS	3.20	6.50	12.0	30.0	133	79.6
07143330	Arkansas River near Hutchinson, KS	95.0	153	275	512	1,120	541
07143375	Arkansas River near Maize, KS	64.0	134	303	600	1,260	730
07143600	Little Arkansas River near Little River, KS	0	.20	.80	1.90	6.90	9.46
07143665	Little Arkansas River at Alta Mills, KS	4.90	9.20	22.0	62.0	325	229
07144200	Little Arkansas River at Valley Center, KS	21.0	33.0	60.0	127	488	312
07144300	Arkansas River at Wichita, KS	126	226	433	858	2,220	1,050
07144550	Arkansas River at Derby, KS	192	304	541	1,110	2,590	1,210

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register. —Continued

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
07144780	North Fork Ninnescah River above Cheney Reservoir, KS	24.0	47.0	76.0	126	222	147
07144795	North Fork Ninnescah River at Cheney Dam, KS	.16	.24	.48	75.0	381	121
07144850	South Fork South Fork Ninnescah River near Pratt, KS	0	0	0	0	0	2.63
07144910	South Fork Ninnescah River near Pratt, KS	6.00	8.60	11.0	14.0	20.0	19.3
07145200	South Fork Ninnescah River near Murdock, KS	66.0	97.0	135	194	304	209
07145500	Ninnescah River near Peck, KS	76.4	125	212	483	1,126	511
07145700	Slate Creek at Wellington, KS	.91	3.30	8.00	21.0	73.2	73.1
07146500	Arkansas River at Arkansas City, KS	373	558	1,030	2,000	4,440	2,090
07146570	Cole Creek near DeGraff, KS	0	.07	1.80	4.80	13.0	16.5
07146830	Walnut River at Highway 54 east of El Dorado, KS	11.0	15.0	24.0	68.3	519	161
07147070	Whitewater River at Towanda, KS	7.60	17.0	36.0	85.0	242	206
07147800	Walnut River at Winfield, KS	60.0	104	262	860	2,655	1,140
07148350	Salt Fork Arkansas River near Winchester, OK	.35	7.40	34.0	75.0	161	96.0
07149000	Medicine Lodge River near Kiowa, KS	12.0	47.0	85.0	141	271	154
07149500	Salt Fork Arkansas River near Cherokee, OK	2.00	50.0	125	246	731	393
07151500	Chikaskia River near Corbin, KS	19.0	47.0	94.0	190	430	250
07152000	Chikaskia River near Blackwell, OK	23.0	66.0	144	324	895	589
07154500	Cimarron River near Kenton, OK	0	.06	.91	2.80	7.50	17.2
07155590	Cimarron River near Elkhart, KS	0	0	0	0	1.50	10.7
07156010	North Fork Cimarron River at Richfield, KS	0	0	0	0	.12	5.60
07156100	Sand Arroyo Creek near Johnson, KS	0	0	0	0	0	.25
07156220	Bear Creek near Johnson, KS	0	0	0	0	0	3.35
07156900	Cimarron River near Forgan, OK	27.0	35.0	45.0	62.0	82.0	58.4
07157500	Crooked Creek near Nye, KS	2.40	7.10	12.0	18.0	33.0	30.5
07157900	Cavalry Creek at Coldwater, KS	.65	1.00	1.50	2.00	2.90	3.45
07157950	Cimarron River near Buffalo, OK	.03	10.0	56.0	123	232	128
07165700	Verdigris River near Madison, KS	.50	4.90	28.0	78.0	204	123
07166000	Verdigris River near Coyville, KS	6.20	12.0	74.0	470	1,760	520

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register. —Continued

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
07166500	Verdigris River near Altoona, KS	10.0	24.0	138	800	2,590	808
07167000	Fall River near Eureka, KS	.70	5.20	40.0	134	324	190
07167500	Otter Creek at Climax, KS	0	1.00	10.0	44.0	121	82.0
07168500	Fall River near Fall River, KS	5.90	13.0	53.0	270	1,061	361
07169500	Fall River at Fredonia, KS	11.0	20.0	92.0	492	1,740	550
07169800	Elk River at Elk Falls, KS	.64	2.90	22.0	91.0	271	154
07170060	Elk River below Elk City Lake, KS	3.00	7.10	21.0	324	1,530	460
07170500	Verdigris River at Independence, KS	30.0	75.0	401	2,130	6,780	2,080
07170700	Big Hill Creek near Cherryvale, KS	0	.02	.88	18.0	69.0	29.2
07171000	Verdigris River near Lenopah, OK	35.0	104	570	2,690	8,425	2,580
07172000	Caney River near Elgin, KS	.07	5.00	40.0	172	528	273
07174000	Little Caney River near Copan, OK	.10	.50	9.5	64.0	323	238
07174400	Caney River above Coon Creek near Bartlesville, OK	26.0	36.0	173	1,820	4,420	1,290
07179500	Neosho River at Council Grove, KS	3.20	6.30	13.0	73.0	358	132
07179730	Neosho River near Americus, KS	12.0	21.0	70.0	240	937	341
07179795	North Cottonwood River below Marion Lake, KS	1.90	3.90	7.65	14.0	110	77.8
07180200	Cottonwood River at Marion, KS	8.70	13.0	32.0	107	576	214
07180400	Cottonwood River near Florence, KS	29.0	48.0	88.0	217	738	348
07180500	Cedar Creek near Cedar Point, KS	1.80	6.00	16.0	36.0	76.0	57.6
07181500	Middle Creek near Elmdale, KS	0	2.40	7.00	22.0	59.0	44.7
07182250	Cottonwood River near Plymouth, KS	48.0	105	298	794	2,080	950
07182510	Neosho River at Burlington, KS	28.0	67.0	397	1,620	5,420	1,660
07183000	Neosho River near Iola, KS	42.0	119	581	2,410	7,300	2,220
07183100	Owl Creek near Piqua, KS	0	.57	4.00	21.0	115	122
07183500	Neosho River near Parsons, KS	54.0	182	852	3,560	9,760	3,120
07184000	Lightning Creek near McCune, KS	0	1.40	12.0	52.0	270	169
07185000	Neosho River near Commerce, OK	77.0	281	1,140	4,450	11,700	4,020
07186000	Spring River at Waco, MO	66.0	124	301	730	1,816	942

Table 5. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of flow durations and mean flows at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register. —Continued

Station number (fig. 1)	Stream name	Computed flow duration, in cubic feet per second, for indicated percentage of time flow equaled or exceeded					Mean flow for period of record (cubic feet per second)
		90 percent	75 percent	50 percent	25 percent	10 percent	
07186400	Center Creek near Carterville, MO	32.0	47.0	97.0	206	399	205
07187000	Shoal Creek above Joplin, MO	88.0	130	237	448	879	427
07188000	Spring River near Quapaw, OK	211	376	850	1,950	4,400	2,200

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.

[mi^2, square miles; ft^3/s, cubic feet per second. Source of flood-frequency value code: (1) U.S. Army Corps of Engineers, Kansas City District, oral commun., 2003; (2) Rasmussen and Perry (2000); (3) Interagency Advisory Committee on Water Data (1981) using station skew from controlled flow period of record; (4) Interagency Advisory Committee on Water Data (1981) using regional skew from controlled flow period of record; and (5) Federal Emergency Management Agency (various years)]

Station number (fig. 2)	Stream name	Contri-buting-drainage area (mi^2)	Con-trolled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
06813500	Missouri River at Rulo, NE	418,859	yes	96,100	132,000	158,000	184,000	220,000	250,000	(1)
06814000	Turkey Creek near Seneca, KS	276	no	5,820	12,500	18,400	27,700	36,000	45,300	(2)
06818000	Missouri River at St. Joseph, MO	424,000	yes	109,000	147,000	174,000	199,000	233,000	261,000	(1)
06818260	White Clay Creek at Atchison, KS	13.1	no	1,100	2,180	3,120	4,610	5,950	7,490	(2)
06826500	South Fork Republican River near Hale, CO	1,825	yes	113	249	440	920	1,590	2,735	(3)
06827500	South Fork Republican River near Benkleman, NE	2,740	yes	1,000	3,700	7,180	14,400	22,300	32,900	(3)
06844700	South Fork Sappa Creek near Brewster, KS	74	no	52	382	996	2,600	4,670	7,740	(2)
06844900	South Fork Sappa Creek near Achilles, KS	446	no	342	1,210	2,290	4,430	6,730	9,730	(2)
06845000	Sappa Creek near Oberlin, KS	1,063	no	827	2,570	4,570	8,320	12,200	17,000	(2)
06845100	Long Branch Draw near Norcatur, KS	31.7	no	294	693	1,070	1,680	2,230	2,870	(2)
06846000	Beaver Creek at Ludell, KS	1,460	no	440	1,110	1,780	2,920	4,000	5,300	(2)
06846500	Beaver Creek at Cedar Bluffs, KS	1,620	no	413	1,060	1,730	2,960	4,190	5,740	(2)
06847900	Prairie Dog Creek above Keith Sebelius Lake, KS	590	no	599	1,680	2,820	4,820	6,760	9,100	(2)
06848000	Prairie Dog Creek at Norton, KS	684	yes	84	155	180	194	199	201	(3)
06848500	Prairie Dog Creek near Woodruff, KS	1,007	yes	652	1,610	2,330	3,220	3,830	4,380	(3)
06853020	Republican River at Guide Rock, NE	22,100	yes	3,870	5,970	7,380	9,140	10,400	11,700	(3)
06853500	Republican River near Hardy, NE	22,401	yes	4,940	8,500	11,000	14,000	16,300	18,490	(3)
06853800	White Rock Creek near Burr Oak, KS	227	no	1,520	3,040	4,430	6,680	8,760	11,200	(2)
06854000	White Rock Creek at Lovewell, KS	345	yes	460	1,300	2,260	3,760	5,080	6,380	(4)
06854500	Republican River at Scandia, KS	23,560	yes	6,450	10,700	24,800	36,000	47,200	59,000	(5)
06855800	Buffalo Creek near Jamestown, KS	330	no	1,670	3,890	6,140	10,100	14,000	18,900	(2)
06855900	Wolf Creek near Concordia, KS	56	no	910	1,770	2,490	3,570	4,490	5,520	(2)
06856000	Republican River at Concordia, KS	23,560	yes	6,720	11,700	16,300	24,000	31,400	40,400	(3)
06856100	West Creek near Talmo, KS	42	no	676	1,870	3,250	5,920	8,780	12,600	(2)
06856320	Elk Creek at Clyde, KS	73	no	546	1,350	2,170	3,640	5,100	5,910	(2)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

[mi², square miles; ft³/s, cubic feet per second. Source of flood-frequency value code: (1) U.S. Army Corps of Engineers, Kansas City District, oral commun., 2003; (2) Rasmussen and Perry (2000); (3) Interagency Advisory Committee on Water Data (1981) using station skew from controlled flow period of record; (4) Interagency Advisory Committee on Water Data (1981) using regional skew from controlled flow period of record; and (5) Federal Emergency Management Agency (various years)]

Station number (fig. 2)	Stream name	Contributing-drainage area (mi²)	Controlled flow (yes/no)	Peak-discharge estimate (ft³/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
06856600	Republican River at Clay Center, KS	24,542	yes	11,500	19,900	26,400	35,500	42,800	50,700	(3)
06857100	Republican River below Milford Dam, KS	24,880	yes	5,130	9,360	15,000	18,000	24,000	37,500	(5)
06858500	North Fork Smoky Hill River near McAllaster, KS	670	no	327	1,930	4,580	11,000	18,900	30,100	(2)
06859500	Ladder Creek below Chalk Creek near Scott City, KS	1,460	no	646	2,590	5,270	11,100	17,900	27,500	(2)
06860000	Smoky Hill River at Elkader, KS	3,560	no	1,510	6,400	13,000	26,900	42,200	62,500	(2)
06860300	South Branch Hackberry Creek near Orion, KS	49.6	no	397	1,190	2,050	3,590	5,110	6,970	(2)
06860500	Hackberry Creek near Gove, KS	426	no	508	2,340	5,100	11,500	19,300	30,600	(2)
06861000	Smoky Hill River near Arnold, KS	5,220	no	2,230	7,660	14,400	27,800	42,300	61,400	(2)
06862700	Smoky Hill River near Schoenchen, KS	5,750	yes	992	4,700	9,170	16,900	23,900	31,500	(3)
06862850	Smoky Hill River below Schoenchen, KS	5,810	yes	992	4,700	9,170	16,900	23,900	31,500	(3)
06863300	Big Creek near Ogallah, KS	297	no	1,340	4,430	8,090	15,100	22,500	31,900	(2)
06863500	Big Creek near Hays, KS	594	no	1,280	3,210	5,050	7,990	10,600	13,600	(2)
06863900	North Fork Big Creek near Victoria, KS	54	no	263	1,250	2,640	5,570	8,770	13,000	(2)
06864000	Smoky Hill River near Russell, KS	6,965	yes	7,340	14,400	19,900	27,900	34,300	41,100	(3)
06864050	Smoky Hill River near Bunker Hill, KS	7,075	yes	4,010	9,850	14,800	22,100	27,900	33,900	(3)
06864500	Smoky Hill River at Ellsworth, KS	7,580	yes	8,850	16,300	24,800	33,000	41,300	48,200	(5)
06865500	Smoky Hill River near Langley, KS	7,857	yes	2,120	4,760	7,230	11,200	14,900	19,200	(3)
06866500	Smoky Hill River near Mentor, KS	9,358	yes	4,360	7,890	8,800	15,000	22,000	32,000	(5)
06866800	Saline River tributary at Collyer, KS	3.13	no	161	565	1,050	1,980	2,930	4,130	(2)
06866900	Saline River near Wakeeney, KS	696	no	2,720	8,200	14,200	25,100	35,900	49,100	(2)
06867000	Saline River near Russell, KS	1,500	no	2,270	6,630	11,500	20,500	29,700	41,400	(2)
06867500	Paradise Creek near Paradise, KS	212	no	947	3,160	5,780	10,800	15,900	22,400	(2)
06868200	Saline River at Wilson Dam, KS	1,917	yes	744	1,610	2,190	2,840	3,250	3,610	(3)
06868400	Wolf Creek near Lucas, KS	163	no	1,570	3,660	5,600	8,730	11,600	14,800	(2)
06868700	North Branch Spillman Creek near Ash Grove, KS	26.1	no	342	1,100	1,960	3,600	5,260	7,360	(2)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

[mi², square miles; ft³/s, cubic feet per second. Source of flood-frequency value code: (1) U.S. Army Corps of Engineers, Kansas City District, oral commun., 2003; (2) Rasmussen and Perry (2000); (3) Interagency Advisory Committee on Water Data (1981) using station skew from controlled flow period of record; (4) Interagency Advisory Committee on Water Data (1981) using regional skew from controlled flow period of record; and (5) Federal Emergency Management Agency (various years)]

Station number (fig. 2)	Stream name	Contributing-drainage area (mi²)	Controlled flow (yes/no)	Peak-discharge estimate (ft³/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
06869500	Saline River at Tescott, KS	2,820	yes	2,530	5,030	6,790	8,970	10,500	12,000	(3)
06869950	Mulberry Creek near Salina, KS	250	no	2,310	4,530	6,380	9,100	11,400	13,900	(2)
06870200	Smoky Hill River at New Cambria, KS	11,730	yes	6,050	11,600	15,500	24,000	34,000	45,500	(5)
06870300	Gypsum Creek near Gypsum, KS	120	no	2,290	4,310	5,960	8,400	10,500	12,700	(2)
06871000	North Fork Solomon River at Glade, KS	849	no	1,580	4,790	8,320	14,700	21,000	28,800	(2)
06871500	Bow Creek near Stockton, KS	341	no	926	2,960	5,320	9,790	14,400	20,200	(2)
06871800	North Fork Solomon River at Kirwin, KS	1,367	yes	18	188	606	2,010	4,240	8,180	(3)
06871900	Deer Creek near Phillipsburg, KS	65.0	no	1,210	3,430	5,760	9,790	13,600	18,300	(2)
06872100	Middle Cedar Creek at Kensington, KS	58.9	no	577	1,350	2,100	3,390	4,610	6,100	(2)
06872300	Middle Beaver Creek near Smith Center, KS	71.0	no	765	1,390	1,880	2,590	3,170	3,790	(2)
06872500	North Fork Solomon River at Portis, KS	2,315	yes	2,860	6,380	9,620	14,800	19,500	24,900	(3)
06873000	South Fork Solomon River above Webster Reservoir, KS	1,040	no	2,800	8,330	14,600	26,300	38,300	53,600	(2)
06873200	South Fork Solomon River below Webster Reservoir, KS	1,150	yes	231	677	1,080	1,640	2,090	2,530	(4)
06873460	South Fork Solomon River at Woodston, KS	1,502	yes	554	2,000	3,610	6,370	8,900	11,800	(3)
06873500	South Fork Solomon River at Alton, KS	1,720	no	3,600	12,300	23,400	46,300	72,000	107,000	(2)
06873700	Kill Creek near Bloomington, KS	52.0	no	182	1,150	2,890	7,480	13,600	23,100	(2)
06874000	South Fork Solomon River at Osborne, KS	2,012	yes	1,400	4,850	9,310	18,700	29,500	44,300	(3)
06874500	East Limestone Creek near Ionia, KS	25.6	no	608	1,320	1,940	2,880	3,680	4,580	(2)
06875800	Limestone Creek near Glen Elder, KS	210	no	1,060	1,910	2,600	3,590	4,430	5,340	(2)
06875900	Solomon River near Glen Elder, KS	5,340	yes	1,720	3,630	5,170	7,350	9,080	10,900	(3)
06876070	Solomon River near Simpson, KS	5,538	yes	3,100	6,050	8,000	10,300	11,800	13,100	(3)
06876200	Middle Pipe Creek near Miltonvale, KS	10.2	no	532	1,270	2,000	3,220	4,380	5,760	(2)
06876700	Salt Creek near Ada, KS	384	no	1,430	4,030	6,800	11,700	16,600	22,500	(2)
06876900	Solomon River at Niles, KS	6,770	yes	5,190	10,500	18,300	28,000	38,600	50,700	(3)
06877120	Mud Creek at Abilene, KS	87.0	no	2,570	4,670	6,330	8,710	10,700	12,800	(2)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

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Station number (fig. 2)	Stream name	Contri-buting-drainage area (mi^2)	Con-trolled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
06877200	West Turkey Creek near Elmo, KS	26.6	no	1,200	2,220	3,000	4,080	4,940	5,850	(2)
06877500	Turkey Creek near Abilene, KS	143	no	2,960	6,550	9,870	15,300	20,200	25,900	(2)
06877600	Smoky Hill River at Enterprise, KS	19,260	yes	12,400	26,000	35,600	51,000	68,100	85,300	(5)
06878000	Chapman Creek near Chapman, KS	300	no	3,630	7,130	10,300	15,300	20,000	25,400	(2)
06878500	Lyon Creek near Woodbine, KS	230	no	6,410	18,000	30,300	52,200	73,600	99,800	(2)
06879100	Kansas River at Fort Riley, KS	44,870	yes	19,100	31,100	44,000	73,000	102,000	140,000	(5)
06879200	Clark Creek near Junction City, KS	200	no	4,320	8,970	13,100	19,400	25,000	31,3000	(2)
06879650	Kings Creek near Manhattan, KS	4.09	no	428	1,930	4,210	9,590	16,300	26,100	(2)
06879700	Wildcat Creek at Riley, KS	14	no	936	2,020	2,980	4,450	5,740	7,190	(2)
06879815	Wildcat Creek at Manhattan, KS	74	no	2,470	4,380	5,880	8,030	9,800	11,700	(2)
06882510	Big Blue River at Marysville, KS	4,780	no	19,100	32,800	42,900	56,700	67,500	78,800	(2)
06884025	Little Blue River at Hollenberg, KS	2,750	no	11,200	21,000	29,300	42,100	53,400	66,300	(2)
06884200	Mill Creek at Washington, KS	344	no	4,830	8,160	10,600	13,900	16,500	19,200	(2)
06884400	Little Blue River near Barnes, KS	3,320	no	13,100	21,200	27,200	35,400	41,900	48,700	(2)
06884500	Little Blue River at Waterville, KS	3,510	no	11,600	24,000	35,400	53,700	70,600	90,300	(2)
06884900	Robidoux Creek at Beattie, KS	40	no	1,850	3,930	5,780	8,700	11,300	14,300	(2)
06885500	Black Vermillion River near Frankfort, KS	410	no	7,030	15,700	24,100	38,000	51,200	66,900	(2)
06886500	Fancy Creek at Winkler, KS	174	no	5,690	10,600	14,600	20,500	25,400	30,700	(2)
06887000	Big Blue River near Manhattan, KS	9,640	yes	16,600	25,500	36,300	42,000	46,800	49,600	(5)
06887500	Kansas River at Wamego, KS	55,280	yes	28,600	54,500	78,400	108,000	156,000	202,000	(1)
06888000	Vermillion Creek near Wamego, KS	243	no	6,190	12,600	17,900	25,800	32,400	39,700	(2)
06888030	Vermillion Creek near Louisville, KS	297	no	6,610	9,650	11,800	14,600	16,800	19,100	(2)
06888300	Rock Creek near Louisville, KS	128	no	5,880	10,100	13,400	18,100	21,900	26,100	(2)
06888350	Kansas River near Belvue, KS	55,870	yes	33,800	59,800	82,100	117,000	148,000	183,000	(3)
06888500	Mill Creek near Paxico, KS	316	no	11,600	23,000	32,400	46,300	58,000	70,800	(2)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

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Station number (fig. 2)	Stream name	Contri-buting-drainage area (mi^2)	Con-trolled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
06888600	Dry Creek near Maple Hill, KS	15.6	no	1,670	3,080	4,280	6,110	7,730	9,560	(2)
06889000	Kansas River at Topeka, KS	56,720	yes	36,600	67,000	93,600	123,000	173,000	217,000	(1)
06889100	Soldier Creek near Goff, KS	2.06	no	402	880	1,340	2,120	2,870	3,770	(2)
06889120	Soldier Creek near Bancroft, KS	10.5	no	1,220	2,200	3,030	4,280	5,380	6,640	(2)
06889140	Soldier Creek near Soldier, KS	16.9	no	1,850	3,360	4,640	6,580	8,270	10,200	(2)
06889160	Soldier Creek near Circleville, KS	49.3	no	4,030	6,850	9,140	12,500	15,400	18,700	(2)
06889180	Soldier Creek near St. Clere, KS	80.0	no	4,440	7,220	9,250	12,000	14,200	16,400	(2)
06889200	Soldier Creek near Delia, KS	157	no	4,510	7,650	10,200	13,900	17,100	20,600	(2)
06889500	Soldier Creek near Topeka, KS	290	no	5,970	11,700	16,400	23,300	29,000	35,200	(2)
06889600	South Branch Shunganunga Creek near Pauline, KS	3.84	no	758	1,450	2,040	2,950	3,740	4,640	(2)
06889630	Shunganunga Creek at Topeka, KS	33.5	no	2,150	2,910	3,390	3,970	4,390	4,790	(2)
06890100	Delaware River near Muscotah, KS	431	no	12,500	18,700	23,000	28,600	32,900	37,400	(2)
06890300	Spring Creek near Wetmore, KS	21.0	no	1,600	3,680	5,750	9,360	12,900	17,200	(2)
06890600	Rock Creek near Meriden, KS	22.0	no	2,090	3,220	4,040	5,170	6,060	7,010	(2)
06890800	Slough Creek near Oskaloosa, KS	31.0	no	3,670	5,510	6,850	8,670	10,100	11,700	(2)
06890900	Delaware River below Perry Dam, KS	1,117	yes	6,290	9,960	17,600	24,000	29,900	32,000	(5)
06891000	Kansas River at Lecompton, KS	58,460	yes	44,600	80,000	109,000	138,000	190,000	231,000	(1)
06891050	Stone House Creek at Williamstown, KS	12.9	no	1,720	3,720	5,470	8,160	10,500	13,100	(2)
06891500	Wakarusa River near Lawrence, KS	425	yes	3,580	5,590	6,540	8,200	10,180	11,910	(5)
06892000	Stranger Creek near Tonganoxie, KS	406	no	6,170	11,300	15,500	21,700	27,000	32,900	(2)
06892350	Kansas River at DeSoto, KS	59,756	yes	50,100	88,900	119,000	148,000	200,000	240,000	(1)
06893000	Missouri River at Kansas City, MO	485,200	yes	142,000	201,000	245,000	289,000	351,000	401,000	(1)
06893080	Big Blue River near Stanley, KS	46.0	no	4,820	8,610	11,700	16,400	20,500	25,000	(2)
06893300	Indian Creek at Overland Park, KS	26.6	no	4,060	6,210	7,770	9,890	11,600	13,300	(2)
06893350	Tomahawk Creek near Overland Park, KS	23.9	no	2,630	4,890	6,760	9,,520	11,900	14,500	(2)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

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Station number (fig. 2)	Stream name	Contributing-drainage area (mi^2)	Controlled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
06910800	Marais des Cygnes River near Reading, KS	177	no	7,860	18,200	28,100	44,200	59,100	76,500	(2)
06911000	Marais des Cygnes River at Melvern, KS	351	no	7,050	17,300	27,300	43,800	59,000	76,900	(2)
06911500	Salt Creek near Lyndon, KS	111	no	4,270	9,170	13,400	19,800	25,200	31,200	(2)
06911900	Dragoon Creek near Burlingame, KS	114	no	4,780	8,780	12,000	16,600	20,500	24,700	(2)
06912500	Hundred and Ten Mile Creek near Quenemo, KS	322	yes	1,920	3,250	4,060	4,980	5,570	6,100	(4)
06913000	Marais des Cygnes River near Pomona, KS	1,040	yes	10,700	17,800	22,900	29,400	34,300	39,200	(3)
06913500	Marias des Cygnes River near Ottawa, KS	1,250	yes	12,400	19,600	24,000	28,900	32,100	35,000	(3)
06913600	Rock Creek near Ottawa, KS	10.2	no	597	1,300	1,960	3,060	4,090	5,310	(2)
06913700	Middle Creek near Princeton, KS	52.0	no	3,300	5,310	6,840	8,970	10,700	12,600	(2)
06914000	Pottawatomie Creek near Garnett, KS	334	no	11,300	20,100	27,100	37,200	45,700	54,900	(2)
06914500	Pottawatomie Creek at Lane, KS	513	no	13,400	25,500	36,000	52,100	66,500	82,800	(2)
06915000	Big Bull Creek near Hillsdale, KS	147	yes	986	2,140	3,040	4,230	5,130	6,020	(4)
06915800	Marais des Cygnes River at La Cygne, KS	2,669	yes	24,000	30,000	37,000	59,000	78,000	100,000	(5)
06916500	Big Sugar Creek at Farlinville, KS	198	no	6,490	13,100	19,200	29,000	38,100	48,800	(2)
06916600	Marais des Cygnes River near Kansas-Missouri State line, KS	3,230	yes	23,900	36,100	44,200	54,300	61,700	69,000	(3)
06917000	Little Osage River at Fulton, KS	295	no	8,560	14,800	19,900	27,500	34,000	41,400	(2)
06917100	Marmaton River tributary near Bronson, KS	.88	no	204	349	455	577	707	820	(2)
06917380	Marmaton River near Marmaton, KS	292	no	16,600	27,900	36,900	50,000	61,100	73,200	(2)
06917500	Marmaton River near Fort Scott, KS	408	no	11,800	22,900	32,100	45,600	56,900	69,300	(2)
07134180	Arkansas River near Granado, CO	23,707	yes	1,440	2,510	3,440	4,900	6,220	7,750	(3)
07137500	Arkansas River near Coolidge, KS	25,410	yes	2,380	6,750	13,200	29,800	53,500	94,000	(3)
07138000	Arkansas River at Syracuse, KS	25,763	yes	2,140	6,210	18,200	38,000	59,400	92,800	(5)
07138650	White Woman Creek near Leoti, KS	750	no	232	1,400	3,310	7,870	13,400	21,100	(2)
07139000	Arkansas River at Garden City, KS	27,071	yes	590	2,783	6,500	17,000	30,000	53,000	(5)
07139500	Arkansas River at Dodge City, KS	30,600	yes	759	3,260	11,300	22,000	34,200	49,900	(5)

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Station number (fig. 2)	Stream name	Contributing-drainage area (mi^2)	Controlled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
07139800	Mulberry Creek near Dodge City, KS	73.8	no	249	675	1,090	1,770	2,380	3,080	(2)
07140000	Arkansas River near Kinsley, KS	33,066	yes	606	3,090	8,500	16,000	25,500	39,000	(5)
07140300	Whitewoman Creek near Bellefont, KS	14.0	no	179	713	1,420	2,870	4,470	6,590	(2)
07140700	Guzzlers Gulch near Ness City, KS	582	no	425	1,260	2,130	3,650	5,080	6,780	(2)
07140850	Pawnee River near Burdett, KS	1,090	no	469	1,430	2,460	4,300	6,070	8,210	(2)
07141200	Pawnee River near Larned, KS	2,150	no	2,250	4,530	6,530	9,620	12,300	15,400	(2)
07141300	Arkansas River at Great Bend, KS	34,356	yes	2,960	7,570	15,000	22,500	29,500	36,900	(5)
07141600	Long Branch Creek near Ness City, KS	28	no	75	433	1,000	2,310	3,840	5,950	(2)
07141780	Walnut Creek near Rush Center, KS	1,260	no	1,000	2,390	3,700	5,790	7,670	9,830	(2)
07141800	Otter Creek near Rush Center, KS	17	no	394	955	1,470	2,280	2,990	3,790	(2)
07141900	Walnut Creek at Albert, KS	1,410	no	1,310	2,850	4,200	6,250	8,010	9,970	(2)
07142100	Rattlesnake Creek tributary near Mullinville, KS	10.3	no	416	1,090	1,730	2,750	3,650	4,670	(2)
07142300	Rattlesnake Creek near Macksville, KS	784	no	400	1,340	2,490	4,770	7,230	10,500	(2)
07142500	Spring Creek near Dillwyn, KS	14.3	no	305	1,170	2,260	4,400	6,650	9,530	(2)
07142575	Rattlesnake Creek near Zenith, KS	1,050	no	501	1,580	2,950	5,850	9,190	13,900	(2)
07142700	Salt Creek near Partridge, KS	85	no	1,150	2,160	2,950	4,070	4,980	5,950	(2)
07142860	Cow Creek near Claflin, KS	43	no	556	1,580	2,680	4,610	6,480	8,760	(2)
07142900	Blood Creek near Boyd, KS	61	no	955	2,320	3,570	5,540	7,270	9,220	(2)
07143200	Plum Creek near Holyrood, KS	19	no	657	1,230	1,690	2,370	2,950	3,580	(2)
07143300	Cow Creek near Lyons, KS	728	no	1,940	4,690	7,420	12,000	16,400	21,700	(2)
07143330	Arkansas River near Hutchinson, KS	38,910	yes	4,350	8,740	15,500	22,000	28,500	35,500	(5)
07143375	Arkansas River near Maize, KS	39,110	yes	8,270	20,800	24,000	34,500	44,800	55,200	(5)
07143500	Little Arkansas River near Geneseo, KS	25.0	no	927	1,360	1,630	1,970	2,210	2,440	(2)
07143600	Little Arkansas River near Little River, KS	71.0	no	1,200	2,360	3,360	4,900	6,240	7,760	(2)
07143665	Little Arkansas River at Alta Mills, KS	736	no	5,000	12,200	19,200	30,800	41,500	54,100	(2)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

[mi^2, square miles; ft^3/s, cubic feet per second. Source of flood-frequency value code: (1) U.S. Army Corps of Engineers, Kansas City District, oral commun., 2003; (2) Rasmussen and Perry (2000); (3) Interagency Advisory Committee on Water Data (1981) using station skew from controlled flow period of record; (4) Interagency Advisory Committee on Water Data (1981) using regional skew from controlled flow period of record; and (5) Federal Emergency Management Agency (various years)]

Station number (fig. 2)	Stream name	Contributing-drainage area (mi^2)	Controlled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
07144000	East Emma Creek near Halstead, KS	58.0	no	3,400	8,990	14,600	24,200	33,200	43,800	(2)
07144200	Little Arkansas River at Valley Center, KS	1,330	no	6,290	13,900	20,400	30,100	38,300	47,200	(2)
07144300	Arkansas River at Wichita, KS	40,490	yes	9,740	18,600	24,000	34,500	44,800	55,200	(5)
07144550	Arkansas River at Derby, KS	40,830	yes	14,200	24,000	27,200	37,000	46,200	55,200	(5)
07144780	North Fork Ninnescah River above Cheney Reservoir, KS	787	no	3,990	12,300	21,900	40,400	59,900	85,200	(2)
07144795	North Fork Ninnescah River at Cheney Dam, KS	901	yes	1,080	2,080	2,750	3,560	4,110	4,620	(4)
07144850	South Fork South Fork Ninnescah River near Pratt, KS	21	no	712	1,500	2,190	3,240	4,150	5,160	(2)
07145200	South Fork Ninnescah River near Murdock, KS	650	no	5,850	12,600	18,300	26,700	33,800	41,500	(2)
07145300	Clear Creek near Garden Plain, KS	5.03	no	612	1,060	1,380	1,800	2,120	2,430	(2)
07145500	Ninnescah River near Peck, KS	2,129	yes	11,500	21,700	26,900	34,000	41,300	47,300	(5)
07145700	Slate Creek at Wellington, KS	154	no	3,620	7,650	11,000	15,800	19,800	24,100	(2)
07146500	Arkansas River at Arkansas City, KS	43,713	yes	20,600	40,500	44,500	63,000	80,000	99,000	(5)
07146570	Cole Creek near DeGraff, KS	30	no	1,950	4,420	6,700	10,400	13,700	17,500	(2)
07146830	Walnut River at Highway 54 east of El Dorado, KS	350	yes	3,630	5,970	9,500	14,000	18,000	23,000	(5)
07147070	Whitewater River at Towanda, KS	426	no	7,490	17,300	26,200	40,500	53,300	67,900	(2)
07147800	Walnut River at Winfield, KS	1,880	yes	18,560	36,100	44,800	66,000	86,500	109,000	(5)
07148100	Grouse Creek near Dexter, KS	170	no	8,250	17,000	24,500	35,800	45,500	56,100	(2)
07149000	Medicine Lodge River near Kiowa, KS	903	no	4,030	7,450	10,000	13,500	16,300	19,100	(2)
07151500	Chikaskia River near Corbin, KS	794	no	8,530	18,700	27,400	40,300	51,200	63,000	(2)
07151600	Rush Creek near Harper, KS	12.0	no	1,190	2,290	3,140	4,310	5,250	6,220	(2)
07155590	Cimarron River near Elkhart, KS	2,900	no	1,330	4,000	6,800	11,600	16,000	21,300	(2)
07156000	North Fork Cimarron River tributary near Richfield, KS	103	no	791	2,420	4,100	6,930	9,510	12,500	(2)
07156010	North Fork Cimarron River at Richfield, KS	463	no	870	3,650	7,320	14,800	22,800	33,200	(2)
07156100	Sand Arroyo Creek near Johnson, KS	619	no	146	541	1,000	1,850	2,680	3,680	(2)
07156220	Bear Creek near Johnson, KS	835	no	724	3,020	5,940	11,600	17,300	24,400	(2)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

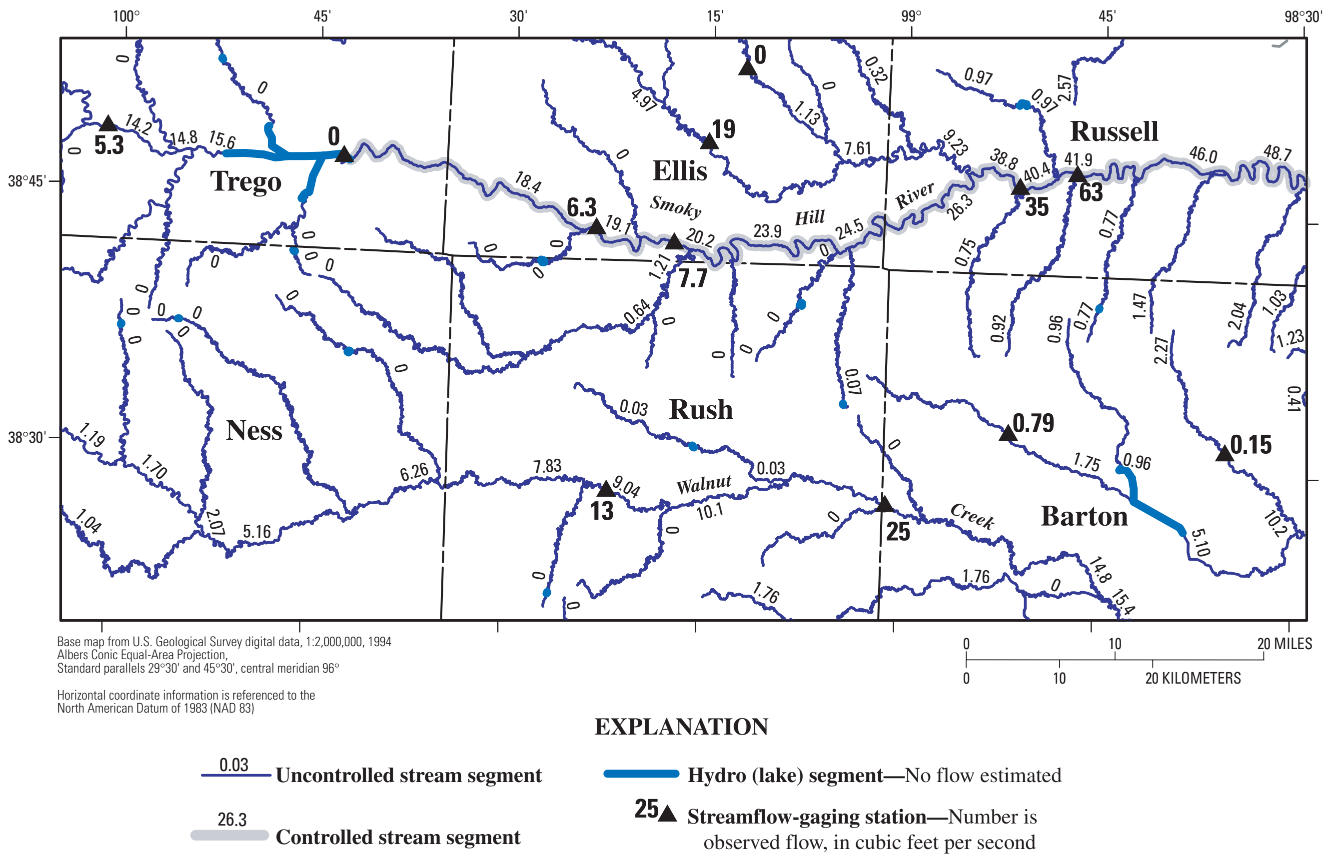
[mi^2, square miles; ft^3/s, cubic feet per second. Source of flood-frequency value code: (1) U.S. Army Corps of Engineers, Kansas City District, oral commun., 2003; (2) Rasmussen and Perry (2000); (3) Interagency Advisory Committee on Water Data (1981) using station skew from controlled flow period of record; (4) Interagency Advisory Committee on Water Data (1981) using regional skew from controlled flow period of record; and (5) Federal Emergency Management Agency (various years)]

Station number (fig. 2)	Stream name	Contri-buting-drainage area (mi^2)	Con-trolled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
07157100	Crooked Creek near Copeland, KS	44	no	488	1,630	2,860	4,960	6,900	9,120	(2)
07157500	Crooked Creek near Nye, KS	1,160	no	992	3,600	6,650	12,200	17,800	24,400	(2)
07157700	Kiger Creek near Ashland, KS	34	no	368	689	929	1,250	1,500	1,750	(2)
07157900	Cavalry Creek at Coldwater, KS	39	no	492	1,290	2,050	3,290	4,410	5,680	(2)
07165700	Verdigris River near Madison, KS	181	no	8,120	18,700	28,400	43,800	57,600	73,400	(2)
07166000	Verdigris River near Coyville, KS	747	yes	5,290	7,490	8,500	9,400	9,860	10,200	(3)
07166500	Verdigris River near Altoona, KS	1,138	yes	11,900	19,500	24,000	29,000	32,100	34,800	(3)
07166700	Burnt Creek at Reece, KS	8.85	no	1,630	4,100	6,570	10,800	14,800	19,600	(2)
07167000	Fall River near Eureka, KS	307	no	11,700	29,900	48,100	79,100	108,000	143,000	(2)
07167500	Otter Creek at Climax, KS	129	no	7,480	18,000	27,400	41,800	54,200	67,600	(2)
07168500	Fall River near Fall River, KS	585	yes	3,980	6,910	8,730	10,800	12,100	13,300	(4)
07169500	Fall River at Fredonia, KS	827	yes	9,750	17,000	21,800	27,500	31,500	35,200	(4)
07169700	Snake Creek near Howard, KS	1.84	no	497	969	1,360	1,920	2,390	2,890	(2)
07169800	Elk River at Elk Falls, KS	220	no	9,000	21,300	33,300	53,400	72,200	94,600	(2)
07170060	Elk River below Elk City Lake, KS	634	yes	4,740	7,170	8,600	10,200	11,200	12,100	(4)
07170500	Verdigris River at Independence, KS	2,892	yes	22,900	28,000	35,500	51,000	64,000	72,000	(5)
07170600	Cherry Creek near Cherryvale, KS	15.0	no	2,530	4,580	6,230	8,640	10,700	12,900	(2)
07170700	Big Hill Creek near Cherryvale, KS	37.0	yes	605	1,550	2,340	3,410	4,230	5,040	(4)
07170800	Mud Creek near Mound Valley, KS	4.22	no	1,270	2,180	2,870	3,840	4,630	5,460	(2)
07171000	Verdigris River near Lenopah, OK	3,639	yes	29,700	48,000	60,900	77,700	90,400	103,000	(3)
07172000	Caney River near Elgin, KS	445	no	14,900	30,100	42,200	59,400	73,100	87,600	(2)
07179500	Neosho River at Council Grove, KS	250	yes	1,870	3,060	3,820	4,740	5,370	5,960	(4)
07179600	Four Mile Creek near Council Grove, KS	55.0	no	5,370	11,300	16,700	25,400	33,400	42,600	(2)
07179730	Neosho River near Americus, KS	622	yes	7,400	11,600	27,500	45,000	62,500	83,500	(5)
07179795	North Cottonwood River below Marion Lake, KS	200	yes	1,090	2,320	3,140	4,070	4,660	5,170	(3)

Table 6. Streamflow-gaging stations in Kansas and parts of surrounding States used in the interpolation of peak-discharge frequency values at controlled and uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.—Continued

[mi^2, square miles; ft^3/s, cubic feet per second. Source of flood-frequency value code: (1) U.S. Army Corps of Engineers, Kansas City District, oral commun., 2003; (2) Rasmussen and Perry (2000); (3) Interagency Advisory Committee on Water Data (1981) using station skew from controlled flow period of record; (4) Interagency Advisory Committee on Water Data (1981) using regional skew from controlled flow period of record; and (5) Federal Emergency Management Agency (various years)]

Station number (fig. 2)	Stream name	Contri-buting-drainage area (mi^2)	Con-trolled flow (yes/no)	Peak-discharge estimate (ft^3/s) for indicated flood frequency						Source of flood-frequency value code
				2-year	5-year	10-year	25-year	50-year	100-year	
07180200	Cottonwood River at Marion, KS	502	yes	7,180	15,300	24,000	37,500	52,000	70,000	(5)
07180400	Cottonwood River near Florence, KS	754	yes	8,610	18,300	28,500	47,600	67,700	94,400	(3)
07180500	Cedar Creek near Cedar Point, KS	110	no	5,740	10,800	14,700	20,100	24,500	28,900	(2)
07181500	Middle Creek near Elmdale, KS	92.0	no	6,960	15,000	22,100	33,100	42,700	53,500	(2)
07182250	Cottonwood River near Plymouth, KS	1,740	yes	14,500	25,400	33,500	53,000	75,000	105,000	(5)
07182510	Neosho River at Burlington, KS	3,042	yes	10,900	14,100	16,000	40,000	71,000	125,000	(5)
07182520	Rock Creek at Burlington, KS	8.27	no	1,020	2,370	3,660	5,760	7,690	9,960	(2)
07182600	North Big Creek near Burlington, KS	46	no	3,210	4,850	6,000	7,500	8,660	9,830	(2)
07183000	Neosho River near Iola, KS	3,818	yes	22,000	31,300	33,800	59,500	86,000	122,300	(5)
07183100	Owl Creek near Piqua, KS	177	no	6,940	14,400	20,900	31,200	40,200	50,500	(2)
07183500	Neosho River near Parsons, KS	4,905	yes	29,400	42,100	50,410	60,000	86,000	121,000	(5)
07183800	Limestone Creek near Beulah, KS	12.0	no	3,140	6,540	9,400	13,600	17,200	21,100	(2)
07184000	Lightning Creek near McCune, KS	197	no	7,250	16,800	26,300	42,600	58,300	77,600	(2)
07184500	Labette Creek near Oswego, KS	211	no	8,330	13,200	16,600	21,200	24,700	28,300	(2)
07184600	Fly Creek near Faulkner, KS	27.0	no	4,190	11,000	17,900	29,700	40,900	54,200	(2)
07185000	Neosho River near Commerce, OK	5,876	yes	37,700	58,300	69,600	105,000	139,100	175,000	(3)



Note: Smaller numbers along the stream segments are flow values, in cubic feet per second, estimated from regression equations for 50-percent (median) flow duration.

Figure 9. 50-percent (median) flow values for stream locations in central Kansas estimated from regression equations and observed median obtained from streamflow-gaging-station data before interpolation (modified from Perry and others, 2004).

final streamflow statistics for each determination site for each county are listed in tables 7–111 located at the end of this report. A map of each county is provided to locate streams of interest (figs. 11–115, also at the end of this report). These figures show the location of the streamflow-statistics determination sites, the determination-site identification number, location of the gaging stations used in the interpolation process, and the names of the streams. The flow statistics in tables 7–111 are linked to the streamflow-statistics determination sites in figures 11–115 by the determination-site identification number. Although the streamflow-statistics determination sites are located in a unique county, the stream segment can occur in as many as four different counties. These other counties are included under the headings of second, third, and fourth in tables 7–111.

The uncertainty of each specific streamflow statistic varies depending on the analysis used to determine the estimate for that location. The greatest uncertainties exist for streams where no gaging-station information was available and only the regression estimates were used. For these locations, the uncertainty of the estimate is the model standard error of prediction. The uncertainty values are given with the various regression equations (tables 2 and 3). Smaller uncertainty values occur at determination sites where streamflow-gaging stations are available. At those locations the uncertainty is a function of the period of record of the gaging station (sample size) and the type and level of flow analysis conducted (90- , 75-, 50-, 25-, 10-percent flow durations, mean flow, or 5-, 10-, 25-, 50-, or 100-year flood frequency).

Internet Dissemination of Results

This report and its associated figures and tables and the GIS database are available and can be downloaded from the World Wide Web (URL http://ks.water.usgs.gov/streamstats). This Web page is maintained by the USGS and has links to the GIS database described in this report to display the streamflow statistics by county for the State of Kansas. The county-map format includes county boundaries, State and Federal highways, and the stream locations for spatial reference. The estimated streamflow statistics, indexed with their respective determination-site identification number, are displayed in a pop-up window as the cursor is placed over a stream location.

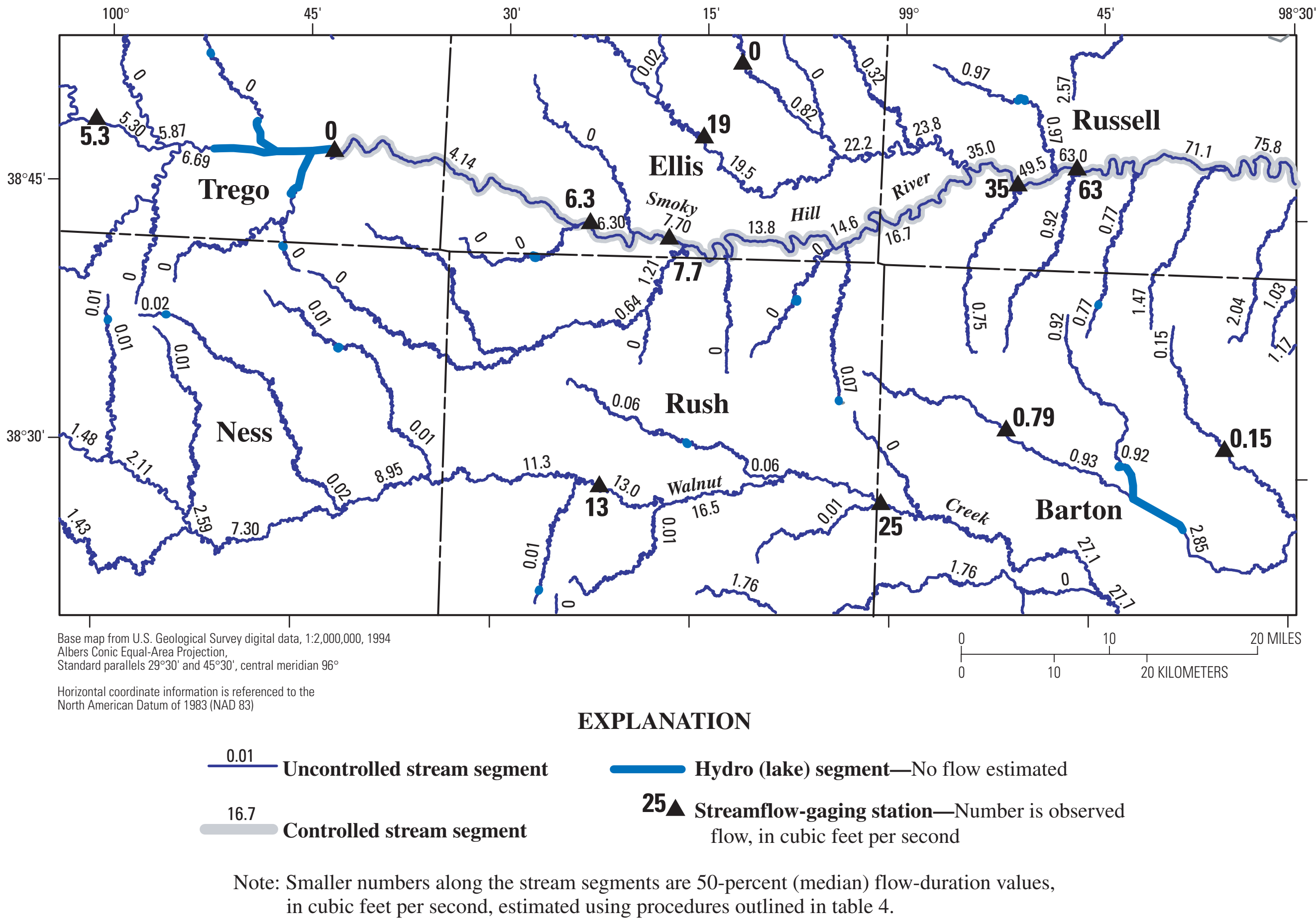


Figure 10. Estimated 50-percent (median) flow values for stream locations in central Kansas after using interpolation procedures outlined in table 4 and observed median obtained from streamflow-gaging-station data (modified from Perry and others, 2004).

Summary

Streamflow statistics of flow duration and peak-discharge frequency were estimated for 4,771 individual locations on streams listed on the 1999 Kansas Surface Water Register. These statistics included the flow-duration values of 90, 75, 50, 25, and 10 percent, as well as the mean flow value. Peak-discharge frequency values were estimated for the 2-, 5-, 10-, 25-, 50-, and 100-year floods.

Least-squares multiple-regression techniques, along with Tobit analyses, were used to develop equations for estimating flow durations and mean flows (dependent variables) for ungaged, uncontrolled flow stream locations. These streamflow statistics were determined from streamflow-gaging-station data using the entire period of record. Independent variables in the regression equations were the climatic and basin characteristics for streams flowing through Kansas. In the development of the regression equations, the significant climatic and basin characteristics, in order of importance, were contributing-drainage area, mean annual precipitation, mean basin permeability, and mean basin slope. Only the 149 gaging stations on uncontrolled flow streams (Kansas and parts of surrounding States) with at least 10 years of streamflow record were used in the regression analyses. The contributing-drainage areas of these gages ranged from 2.06 to 12,004 mi^2.

A logarithmic transformation of the basin characteristics was needed to develop a linear relation for computing flow durations and mean flow. Because there were numerous zero values for flow durations and mean flow in the gaging-station data, the Tobit analysis was used to include those zero values in the regression. The resulting regression equations were used to estimate flow durations and mean flow for the uncontrolled flow stream locations on the 1999 Kansas Surface Water Register.

Estimates of peak-discharge frequency for uncontrolled flow stream locations in Kansas were obtained using equations previously published in U.S. Geological Survey Water-Resources Investigations Report 00–4079 (Rasmussen and Perry, 2000), "Estimation of Peak Streamflows for Unregulated Rural Streams in Kansas." This report produced two sets of equations—one for basins between 0.17 and 30 mi^2 and one for basins between 30 and 9,100 mi^2. For streams with a basin size of between 0.17 and 30 mi^2, peak-discharge frequency values were computed from regression equations with contributing-drainage area and average mean annual precipitation for the basin as the predictor variables. For streams with basin sizes between 30 and 9,100 mi^2, the predictor variables were contributing-drainage area, average mean annual precipitation, mean soil permeability, and the slope of the main channel.

Streamflow-gaging-station data were used to improve the quality of the streamflow-statistic estimates along the streams that had gages. Streamflow statistics for the locations that had uncontrolled flow were interpolated using gaged data weighted according to the drainage area and the bias between the regression estimate and gaged flow information. On controlled reaches of Kansas streams, the streamflow-statistic information was interpolated between gaging stations by using only gaged data weighted by drainage area.

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