WATER-QUALITY AND FLUVIAL-SEDIMENT CHARACTERISTICS OF SELECTED STREAMS IN NORTHEAST KANSAS

by Hugh E. Bevans

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CONVERSION FACTORS

Inch-pound units of measurement used in this report may be converted to International System of Units (SI) using the following factors:

Multiply inch-pound unit	By	To obtain SI unit
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
inch per square mile (in/mi^2)	9.807	millimeter per square kilometer (mm/km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
ton (2,000 pounds)	0.9072	megagram (Mg)
ton per day (ton/d)	0.9072	megagram per day (Mg/d)
ton per square mile (ton/mi^2)	2.350	megagram per square kilometer (Mg/km^2)
ton per square mile per year [(ton/mi^2)/yr]	2.350	megagram per square kilometer per year [(Mg/km^2)/yr]
micromhos per centimeter (µmhos/cm)	1.00	microsiemens per centimeter (µS/cm)

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ABSTRACT

The U.S. Geological Survey, in cooperation with the U.S. Soil Conservation Service, investigated the water-quality and fluvial-sediment characteristics of selected streams in northeast Kansas for which the construction of floodwater-retarding and grade-stabilization structures to control soil erosion is being considered.

The predominant chemical type of water in streams draining the study area is calcium bicarbonate. During low streamflow, ground-water inflow to Pony and Walnut Creeks introduces high concentrations of sulfate ion that change the water type to calcium bicarbonate sulfate. In-stream concentrations of chemical constituents generally decrease with increasing streamflow. Exceptions to this are nitrate and phosphorus, which enter the streams as components of surface runoff. Computed mean annual discharges of dissolved solids ranged from 512 tons for Pony Creek at Sabetha, Kansas, to 23,900 tons for the Wolf River near Sparks, Kansas.

Sediment yields in the study area, predominantly silt and clay, are among the largest in the State. Drainage basins in the northern part of the study area yielded the most suspended sediment, with Pony Creek at Sabetha and near Reserve, Kansas, yielding 5,100 tons per square mile per year. Drainage basins in the southern parts of the study area yielded less suspended sediment, with Little Grasshopper Creek near Effingham, Kansas, yielding 493 tons per square mile per year and the Little Delaware River near Horton, Kansas, yielding 557 tons per square mile per year.

INTRODUCTION

The U.S. Soil Conservation Service is currently (1982) constructing floodwater-retarding and grade-stabilization structures in selected watersheds of northeast Kansas. Information concerning water-quality and fluvial-sediment characteristics of streams that may be affected by these erosion-control structures is necessary to document current conditions, predict future impacts, and quantify changes.

Purpose and Scope

The U.S. Geological Survey, in cooperation with the U.S. Soil Conservation Service, investigated the water-quality and fluvial-sediment characteristics of selected streams in northeast Kansas for the period July 1976 through September 1980. The purposes of this investigation were to: (1) establish a data base for water-quality and fluvial-sediment characteristics of selected streams that will serve as a basis for documenting current (1982) conditions, (2) develop relationships between streamflow or specific conductance and water-quality characteristics that can be used to describe water-quality characteristics and determine discharges of dissolved solids, and (3) develop relationships between streamflow and suspended sediment that can be used to determine suspended-sediment discharges of streams in the study area.

Study Area

The study area, shown in figure 1, is located in northeast Kansas and includes parts of Atchison, Brown, Doniphan, Jefferson, Nemaha, Osage, Shawnee, and Wabaunsee Counties. This area is included in the Dissected Till Plains physiographic province (Fenneman, 1931). The influence of glaciation is predominant over other geomorphic processes. Post-glacial history has been characterized by dissection of till, deepening of valleys, deposition of alluvium in stream valleys, and the deposition of loess over extensive areas of upland and high terrace surfaces (Frye and Leonard, 1952). Upland areas between major streams generally are smooth, broad, and well rounded. Near major streams the topography is more dissected with gentle slopes and wide valleys. Adjacent to major streams the topography is extensively dissected into rough hills. Most bluffs are very steep with outcrops of limestone and shale.

The mean annual precipitation for the study area is about 36 in. This value was determined from an unpublished map distributed by the Kansas Agricultural Experimental Station, which is based on U.S. Weather Bureau data for 1941-70. Most of the precipitation occurs as rain during the growing season, which averages 6 months, May through October.

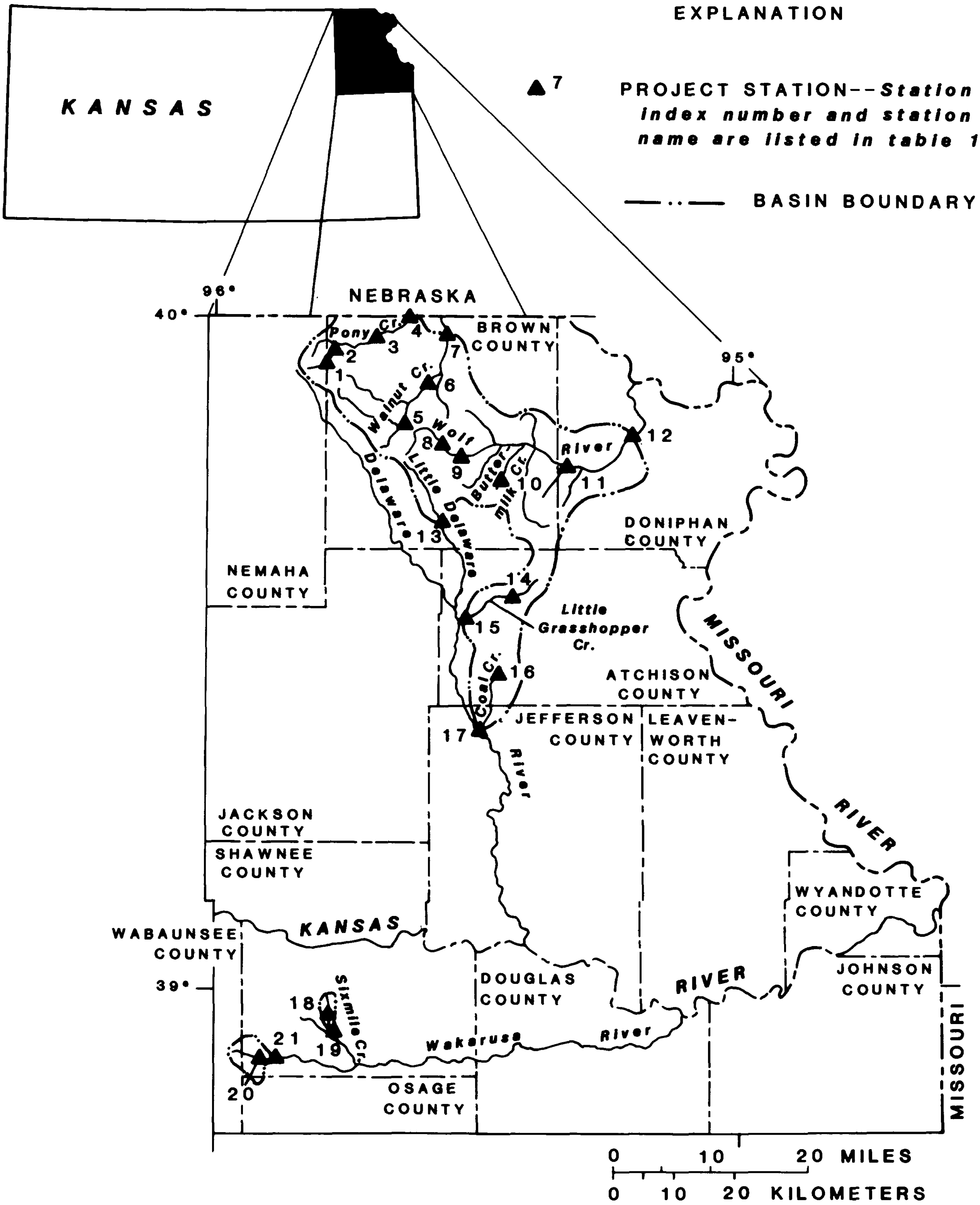

Figure 1.--Location of study area and project stations.

The favorable combination of fertile soil, adequate precipitation, and a long growing season makes the study area an excellent crop-producing region. Land use for Brown County, the principal county in the study area, includes 62 percent cropland (U.S. Department of Agriculture, 1960). The large percentage of land being cultivated during the part of the year when most of the precipitation falls, in combination with massive loess deposits providing fine-grained soil particles for erosion, results in high in-stream concentrations and large discharges of suspended sediment in the study area.

Previous studies have shown that the largest annual discharges of sediment in Kansas occur in the northeast. An early study (Collins and Culbertson, 1965) indicated that mean annual discharges of sediment range from 750 ton/mi^2 in the southwest part of the study area to greater than 5,000 ton/mi^2 in the northeast part. Data from a more recent study (Osterkamp, Curtis, and Crowther, 1982) indicated mean annual discharges of sediment to be about 500 ton/mi^2 in the Wakarusa River basin and about 2,000 ton/mi^2 in the Delaware River, Little Grasshopper Creek, and Coal Creek basins.

Sample Collection and Analyses

Sample-collection activities for this study were initiated in July 1976 and continued through September 1980. Twenty-one project stations, described in table 1 and shown in figure 1, were established for streamflow measurement and the collection of water samples for suspended-sediment analyses. Water samples for chemical analyses were collected at some of these stations.

Streamflow measurements (Buchanan and Somers, 1976) were used to develop stage-discharge relations for each station. Crest-stage gages, which record the peak stage that occurs at a station during the time period between inspections of the gage, were installed at selected stations. Additional stage data were obtained from wire-weight or staff-gage readings made by local observers.

Fluvial-sediment samples were collected according to procedures described by Guy and Norman (1976), and the analyses were made in Lawrence, Kans., according to procedures described by Guy (1969). The concentrations of suspended sediment presented in this report do not include the bedload.

Water samples for chemical analyses were collected and analyzed according to procedures described by Skougstad and others (1979) and Goerlitz and Brown (1972). Physical measurements of pH, temperature, specific conductance, and dissolved oxygen were made at the time of sample collection. Chemical analyses were made by the U.S. Geological Survey in Arvada, Colo. Data for this study have been published (U.S. Geological Survey, 1977-81).

Table 1.--Description of project stations

Station index number (figure 1)	Station name	Period of record	Drainage area (square miles)	Data collection: Streamflow	Fluvial sediment	Chemical
1	Pony Creek at Sabetha, Kans.	10/1/79 - 9/30/80	2.86	X	X	X
2	Pony Creek near Sabetha, Kans.	10/1/79 - 9/30/80	6.55	X	X	X
3	Pony Creek near Morrill, Kans.	10/1/79 - 9/30/80	25.1	X	X	X
4	Pony Creek near Reserve, Kans.	10/1/79 - 9/30/80	53.0	X	X	X
5	Walnut Creek near Fairview, Kans.	10/1/76 - 9/30/79	27.0	X	X	--
6	Walnut Creek near Hamlin, Kans.	10/1/76 - 9/30/79	57.0	X	X	--
7	Walnut Creek at Reserve, Kans.	10/1/76 - 9/30/79	111	X	X	X
8	Wolf River 3 miles southwest of Hiawatha, Kans.	10/1/77 - 9/30/80	11.9	X	X	X
9	Wolf River near Hiawatha, Kans.	10/1/76 - 9/30/80	29.0	X	X	X
10	Buttermilk Creek near Willis, Kans.	10/1/76 - 9/30/80	3.74	X	X	--
11	Wolf River at Leona, Kans.	10/1/76 - 9/30/80	160	X	X	--
12	Wolf River near Sparks, Kans.	10/1/76 - 9/30/80	220	X	X	X
13	Little Delaware River near Horton, Kans.	10/1/76 - 9/30/78	19.0	X	X	X
14	Little Grasshopper Creek near Effingham, Kans.	10/1/76 - 9/30/78	22.0	X	X	--
15	Little Grasshopper Creek at Muscotah, Kans.	10/1/77 - 9/30/78	52.0	X	X	X
16	Coal Creek near Arrington, Kans.	10/1/77 - 9/30/78	5.00	X	X	--
17	Coal Creek near Halfmound, Kans.	10/1/77 - 9/30/78	27.0	X	X	--
18	Sixmile Creek tributary 5 miles northeast of Auburn, Kans.	10/1/79 - 9/30/80	1.67	X	X	--
19	Sixmile Creek tributary 4 miles northeast of Auburn, Kans.	10/1/79 - 9/30/80	2.34	X	X	--
20	Wakarusa River 5 miles west of Auburn, Kans.	10/1/79 - 9/30/80	7.10	X	X	--
21	Wakarusa River 4 miles west of Auburn, Kans.	10/1/79 - 9/30/80	10.7	X	X	--

Methods of Investigation

Streamflow measurements made concurrently with the collection of water samples for water-quality and suspended-sediment analyses were used to develop stage-discharge relations and relations between water-quality and fluvial-sediment characteristics and streamflow for project stations. However, these streamflow data were not adequate for computing flow-duration curves.

Flow-duration curves computed for nearby continuous-record streamflow-gaging stations were used to develop regional, nondimensional, flow-duration curves for three ranges of drainage-area size. These regional curves were used in conjunction with estimated values of mean streamflow and the 10-year flood peak to produce synthetic flow-duration curves for project stations, except stations in the Walnut Creek basin where streamflow is regulated by erosion-control structures.

Correlation and regression analyses were used to develop and interpret relationships between water-quality characteristics and streamflow and specific conductance, except for Wakarusa River basin stations where no water samples for chemical analyses were collected. Analysis-of-covariance tests indicated that regional regression equations relating concentrations of dissolved calcium, magnesium, and bicarbonate (in milligrams per liter) to specific conductance (in micromhos per centimeter at 25°C) and relating the discharge of dissolved solids(in tons per day) to streamflow (in cubic feet per second) were valid at the 0.01 probability level.

Synthetic flow-duration curves and regression equations relating the discharge of dissolved solids to streamflow were used to compute mean discharges of dissolved solids at project stations, except those in the Walnut Creek and Wakarusa River basins.

Correlation and regression analyses were used to develop and interpret relationships between concentrations (in milligrams per liter) and discharges (in tons per day) of suspended sediment and streamflow (in cubic feet per second) for each project station. An analysis-of-covariance test indicated that a regional regression equation relating the discharge of suspended sediment to streamflow was not valid at the 0.01 probability level. However, the regression equations for individual project stations relating the discharge of suspended sediment to streamflow are valid and were used with the synthetic flow-duration curves to compute mean discharges of suspended sediment for project stations, except those in the Walnut Creek basin.

Statistical summaries of suspended-sediment and bed-material data were compiled.

STREAMFLOW ANALYSIS

Development of Regional, Nondimensional, Flow-Duration Curves

The collection of streamflow data for this study was limited to streamflow measurements made concurrently with the collection of water samples for water-quality or fluvial-sediment analyses. These streamflow data were used to develop stage-discharge relations at project stations, but the data were inadequate for developing flow-duration curves.

The development of flow-duration curves requires long-term continuous streamflow records. Because none of the stations in this study were equipped with continuously recording streamflow gages, the data were not available for direct development of flow-duration curves.

A method of computing synthetic flow-duration curves for ungaged streams in Kansas was developed by Furness (1959). He developed regional, nondimensional, flow-duration curves for drainage areas ranging from 100 to 3,000 mi^2. Because the present study involves some drainage areas of less than 100 mi^2, the Furness method was modified to develop regional, nondimensional, flow-duration curves for stations in the study area from flow-duration curves determined at nearby continuous-record streamflow stations with similarly sized drainage basins.

Continuous-record streamflow stations used for determining regional flow-duration curves, listed in table 2, were selected by using the following criteria:

(1) Location--The stations needed to be in close geographic proximity to the study area so that the physiography (topography, history of glaciation, and soil types) and climate (precipitation amounts and types) are relatively uniform.

(2) Drainage area--The drainage areas needed to include the range of drainage-area sizes sampled in the study area.

(3) Unregulated flow--The streamflow needed to be virtually unregulated. Numerous or large reservoirs should not be present in the drainage basin.

(4) Period of record--The period of continuous-record streamflow measurements needed to exceed 10 years.

Regional, nondimensional, flow-duration curves for the study area, shown in figure 2, were developed by the following procedure:

(1) Flow-duration curves for each of the continuous-record streamflow stations were nondimensionalized by dividing the streamflow values on the curve by the mean streamflow for the period of record used in developing the curve.

(2) The resulting nondimensional, flow-duration curves were then plotted. Similarities between the curves and drainage-area distribution were noted, and the curves were grouped into three ranges of drainage areas--less than 15 mi^2, 15 to 100 mi^2, and 100 to 300 mi^2.

(3) For each range of drainage areas, the individual nondimensional, flow-duration curves were averaged and smoothed to produce a single regional, nondimensional, flow-duration curve. The average error in the regional, nondimensional, flow-duration curve was estimated to be 0.1075 log-to-the-base-10 units ($\pm$25 percent) by comparing them with the dimensionless, flow-duration curves computed for the stations listed in table 2.

Table 2.--Periods of record and drainage areas of continuous-record streamflow stations used to develop regional, nondimensional, flow-duration curves

Station name	Period of record	Drainage area (square miles)
Soldier Creek near Goff, Kans.	1964-79	2.10
Soldier Creek near Bancroft, Kans.	1964-79	10.5
Soldier Creek near Soldier, Kans.	1964-79	16.9
Soldier Creek near Circleville, Kans.	1964-79	49.3
Soldier Creek near St. Clere, Kans.	1964-79	80.0
East Fork 102 River near Beford, Iowa	1959-79	92.1
Soldier Creek near Delia, Kans.	1958-79	157
Soldier Creek near Topeka, Kans.	1935-79	290
Turkey Creek near Seneca, Kans.	1948-79	276
Little Platte River at Smithville, Mo.	1965-79	234

Computation of Synthetic Flow-Duration Curves

The computation of a synthetic flow-duration curve from a regional, nondimensional, flow-duration curve requires estimates of streamflow that would be equaled or exceeded zero percent of the time and mean streamflow (table 3). The 10-year flood peak, the instantaneous streamflow (in cubic feet per second) that would have a 10-percent chance of being equaled in any 1 year, was computed (Jordan and Irza, 1975) and used as an estimate of the streamflow that would be equaled or exceeded zero percent of the time. These computed 10-year flood peaks have a standard error of estimate of about $\pm$43 percent.

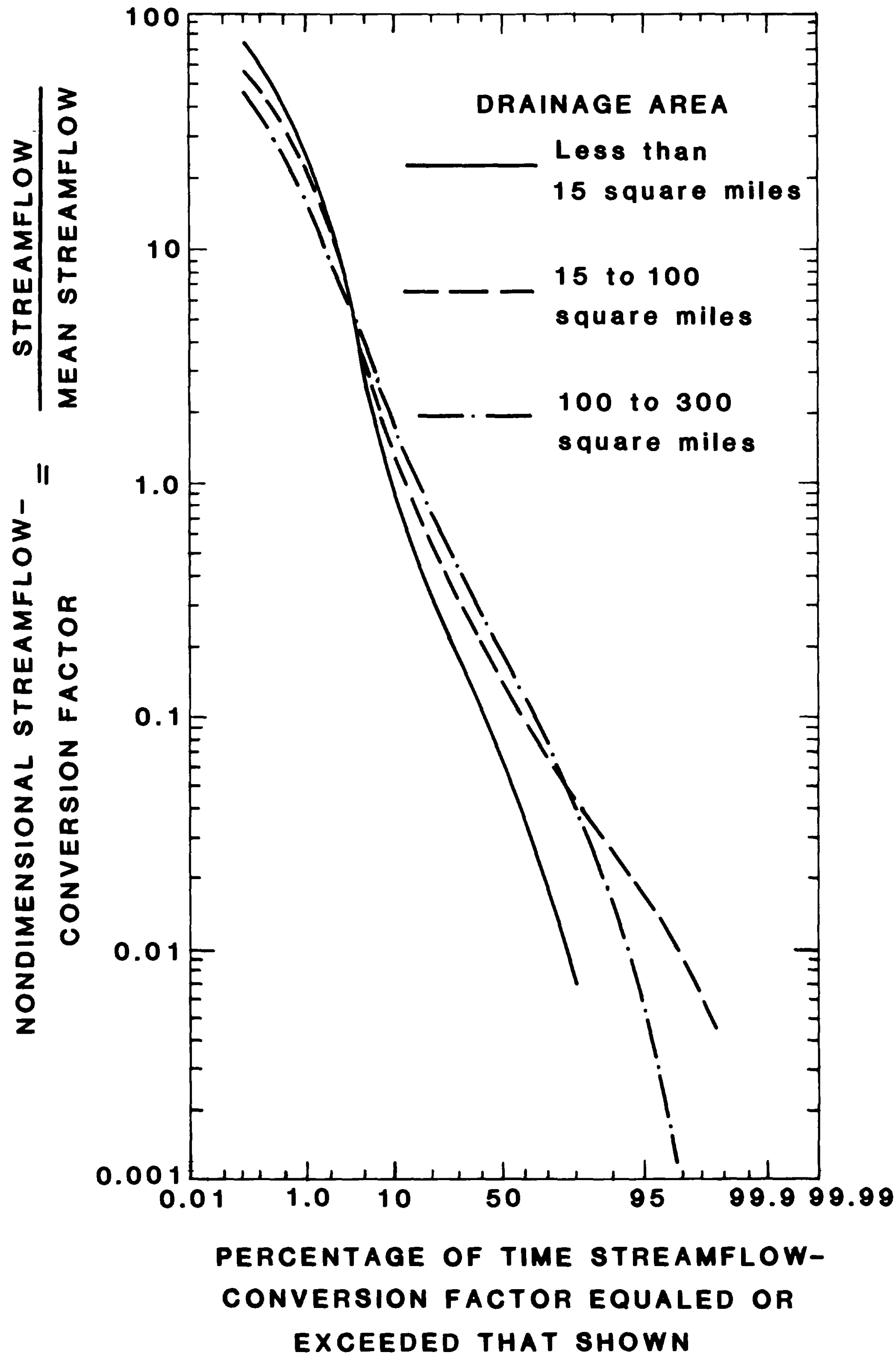

Figure 2.--Regional, nondimensional, flow-duration curves.

Table 3.--Estimated mean streamflows and 10-year flood peaks for project stations [1/]

Station index number (figure 1)	Station name	Mean streamflow (cubic feet per second)	10- year flood peak (cubic feet per second)
1	Pony Creek at Sabetha, Kans.	1.33	1,240
2	Pony Creek near Sabetha, Kans.	3.04	1,920
3	Pony Creek near Morrill, Kans.	11.7	3,920
4	Pony Creek near Reserve, Kans.	24.5	5,870
8	Wolf River 3 miles southwest of Hiawatha, Kans.	5.50	2,740
9	Wolf River near Hiawatha, Kans.	13.5	4,370
10	Buttermilk Creek near Willis, Kans.	1.73	1,490
11	Wolf River at Leona, Kans.	75.5	10,700
12	Wolf River near Sparks, Kans.	106	12,700
13	Little Delaware River near Horton, Kans.	8.60	3,540
14	Little Grasshopper Creek near Effingham, Kans.	10.3	3,860
15	Little Grasshopper Creek at Muscotah, Kans.	24.1	6,130
16	Coal Creek near Arrington, Kans.	2.41	1,830
17	Coal Creek near Halfmound, Kans.	13.4	4,530
18	Sixmile Creek tributary 5 miles northeast of Auburn, Kans.	.84	1,230
19	Sixmile Creek tributary 4 miles northeast of Auburn, Kans.	1.18	1,470
20	Wakarusa River 5 miles west of Auburn, Kans.	3.56	2,630
21	Wakarusa River 4 miles west of Auburn, Kans.	5.36	3,260

[1/] Mean streamflows and 10-year flood peaks were not computed for stations in the Walnut Creek basin because streamflow is regulated by erosion-control structures.

Mean streamflow, in cubic feet per second, was converted from a map of Kansas showing lines of equal mean runoff, in inches per year (Carswell, 1982). This map was determined with continuous-record streamflow data from unregulated streams. The average error for determining mean streamflow from this map was about ±19 percent.

The synthetic flow-duration curve is derived by using the 10-year flood peak as an estimate of the streamflow that would be equaled or exceeded zero percent of the time and multiplying the nondimensional, streamflow-conversion factors (streamflows divided by mean streamflow for the period of record) obtained from the ordinate of the appropriate regional, nondimensional, flow-duration curve (fig. 2) by the estimated mean streamflow to compute the rest of the synthetic flow-duration curve.

The error estimated in the computation of a synthetic flow-duration curve was about 0.1709 log-to-the-base-10 units (±40 percent). This error was computed by taking the average of the errors involved in computing the 10-year flood peak and the mean streamflow (0.1325 log-to-the-base-10 units) and combining it with the error involved in computing the regional, nondimensional, flow-duration curve (0.1075 log-to-the-base-10 units) by taking the square root of the sum of the squared errors.

Streamflows at all stations in the study area, with the exception of the Walnut Creek stations, are virtually unregulated. Streamflow in the Walnut Creek basin is regulated by erosion-control structures constructed by the U.S. Soil Conservation Service. Twenty-one floodwater-retarding structures, regulating 52.18 mi^2, and 23 grade-stabilization structures, regulating 14.20 mi^2, have been constructed in the Walnut Creek drainage basin. About 60 percent of the drainage area of Walnut Creek at Reserve, Kans., is regulated by these structures. Because of the regulating effect of the erosion-control structures, mean streamflows, 10-year flood peaks, and synthetic flow-duration curves were not computed for the Walnut Creek stations.

WATER-QUALITY CHARACTERISTICS

Relations of Water-Quality Characteristics to Streamflow

The chemical and physical characteristics of streamflow in the study area are dependent on the sources of that streamflow. Chemical constituents and water-quality parameters discussed in this section are listed in table 10 at the back of the report. During periods of sparse precipitation, winter and midsummer, most of the streamflow is provided by ground-water discharge. Streamflow from ground-water discharge, termed base flow, is much more mineralized than surface runoff. The types and concentrations of dissolved chemical constituents in the base flow depend on the mineral composition of the aquifer and the length of time the ground water is in contact with it. During periods of excessive precipitation, when streamflow increases due to surface runoff, the in-stream concentrations of dissolved chemical constituents generally decrease. However, surface runoff can come into contact with and transport constituents that are not available to ground water.

Relationships between water-quality characteristics and streamflow can be interpreted by examining results of correlation and regression analyses presented in table 11 at the back of the report.

The regression equations are of the form:

$$Y = bQ^m \qquad (1)$$

where

Y is the predicted concentration of the constituent, in milligrams per liter, or discharge, in tons per day, computed by the regression equation;

b is a constant computed by the regression analysis that is the antilog of the Y intercept;

Q is measured, instantaneous streamflow, in cubic feet per second; and

m is a constant computed by the regression analysis that is the slope of the regression line.

The relative strengths of the relationships are indicated by the correlation coefficients and standard error of estimates associated with the regression equations. The stronger relationships have correlation coefficients approaching ± 1.0, with positive values indicating direct relationships and negative values indicating inverse relationships. Squaring the correlation coefficient computes the coefficient of determination or the proportion of the variance in the value of the chemical constituent that results from the variance of streamflow. The remaining variance is not explained by the regression equations and results from measurement errors and undetermined factors. The standard error of estimate is an indicator of the accuracy of the regression equation; the smaller the standard error of estimate, the more accurate the regression equation.

Concentrations of dissolved chemical constituents that generally are inversely related to streamflow are calcium, magnesium, sodium, bicarbonate, sulfate, and chloride. The concentration of dissolved solids (the sum of these dissolved constituents plus silica, potassium, fluoride, and nitrate) and specific conductance (a physical property that measures the ability of water to conduct an electrical current) also are inversely related to streamflow. Dissolved constituents that are major components in the base flow exhibit relations of this type.

Concentrations of chemical constituents that are directly related to streamflow are total organic carbon, a measure of the organic material, and the nutrients nitrate and phosphorus, which are carried into the streams by surface runoff. Discharges of dissolved solids are directly related to streamflow, primarily because streamflow is used in the computation of the discharge of dissolved solids. Turbidity, a physical property that is inversely related to light penetration, generally increases with streamflow as a result of increased concentrations of suspended sediment.

The dominant ions in the stream water of the study area are calcium, magnesium, bicarbonate, and sulfate. The principal chemical type of water in the study area is calcium bicarbonate at all stages of streamflow. Analyses of chemical data for Pony Creek and Walnut Creek indicate that during low stages of streamflow, concentrations of dissolved sulfate are high enough that the chemical type of the water becomes calcium bicarbonate sulfate. These high concentrations of sulfate are provided by base flow to reaches of these streams that traverse outcrops of limestone and shale in northwest Brown County that are known to contain water with high concentrations of sulfate (Bayne and Schoewe, 1967).

Relations of Water-Quality Characteristics to Specific Conductance

Specific conductance is directly related to the concentration of dissolved constituents in the stream water. Concentrations of individual dissolved constituents are directly related to specific conductance only if they are major components of the total. Examination of results of correlation and regression analyses presented in table 12 at the back of the report shows that concentrations of dissolved solids, calcium, magnesium, sodium, bicarbonate, alkalinity, sulfate, and, in some instances, chloride are directly related to specific conductance in the study area. These regression equations are arithmetic linear equations of the form:

$$Y = m(SPCOND) + b \qquad (2)$$

where

- Y is the predicted concentration of the constituent, in milligrams per liter, computed by the regression equation;
- m is a constant computed by the regression analysis that is the slope of the regression line;
- SPCOND is the measured specific conductance, in micromhos per centimeter at 25° C; and
- b is a constant computed by the regression analysis that is the Y-intercept value, in milligrams per liter.

Regional Water-Quality Relations

Regression equations developed for the individual stations are useful for predicting concentrations or discharges of chemical constituents at these stations during periods when no chemical samples are collected. However, these equations are not applicable to unsampled streams in the study area or outside of the range of sampled values shown in tables 11 and 12 at the back of the report.

Analysis of covariance was utilized to determine if regional regression equations relating concentrations of dissolved solids, calcium, magnesium, bicarbonate, and sulfate to specific conductance and relating discharges of dissolved solids to streamflow could be developed for the study area. The analysis of covariance was conducted in two parts. The first part tested for parallel slopes of corresponding individual station regression equations. This part of the test was conducted at the 0.001 probability level in order to minimize the possibility of rejecting the hypothesis that the slopes are parallel. The second part of the test was used to determine if a regression equation computed from corresponding data combined from all stations was adequate. This part of the test was conducted at the 0.01 probability level to increase the possibility of rejecting the hypothesis that one regression equation adequately fits all the data.

The analysis-of-covariance summaries, presented in table 4, indicate that regional regression equations relating concentrations of dissolved calcium, magnesium, and bicarbonate to specific conductance and relating discharges of dissolved solids to streamflow are valid at the 0.01 probability level. These regression equations are presented in table 5. Regional regression equations relating concentrations of dissolved solids and sulfate to specific conductance are not valid at the 0.01 probability level. The high concentrations of sulfate that occur in Pony and Walnut Creeks during low stages of flow cause the relationships between concentrations of dissolved solids or sulfate and specific conductance to shift due to the relatively low ionic activity of the sulfate ion as compared to the bicarbonate ion (Hem, 1975).

The regional equations were not applied to the Wakarusa River basin because water samples for chemical analyses were not collected in this basin and it is located too far away from the rest of the study area to assume similarity.

Discharge of Dissolved Solids

Mean annual discharges of dissolved solids for stations in the study area, excluding stations in the Walnut Creek and Wakarusa River basins, were computed by utilizing the regional regression equation from table 5 and individual station regression equations from table 11 (which relate

Table 4.--Summaries of analysis of covariance

Independent variable	Dependent variable	*F* statistic computed: Slope	*F* statistic computed: Regression equation	*F* statistic tabular: Slope (0.001 probability)	*F* statistic tabular: Regression equation (0.01 probability)
[1]SPCOND	[3]CA	1.24	1.75	4.20	2.52
SPCOND	[4]MG	1.40	1.38	4.21	2.54
SPCOND	[5]HCO_3	0.91	2.82	5.80	3.09
SPCOND	[6]SO_4	5.75	8.67	4.17	3.38
SPCOND	[7]DSC	3.87	3.94	4.20	2.52
[2]Q	[8]DSD	3.15	1.98	4.20	2.52

[1] SPCOND = specific conductance, in micromhos per centimeter at 25° C.
[2] Q = instantaneous streamflow, in cubic feet per second.
[3] CA = dissolved calcium, in milligrams per liter.
[4] MG = dissolved magnesium, in milligrams per liter.
[5] HCO_3 = bicarbonate, in milligrams per liter.
[6] SO_4 = dissolved sulfate, in milligrams per liter.
[7] DSC = concentration of dissolved solids, in milligrams per liter.
[8] DSD = discharge of dissolved solids, in tons per day.

streamflow, in cubic feet per second, to the discharge of dissolved solids, in tons per day) in conjunction with synthetic flow-duration curves that were described in the foregoing streamflow section. This method produced acceptable results when used to compute mean annual discharge of suspended sediment in previous studies (Kister and Mundorff, 1963; Jordan, Jones, and Petri, 1964) and was used in this study to compute mean annual discharge of dissolved solids in the following manner:

(1) The regression equations were used to compute discharges of dissolved solids for streamflows that were equaled or exceeded for selected percentages of time on the synthetic flow-duration curve.

(2) The discharges of dissolved solids were summed for the beginning and end of each time interval and divided by two to compute the mean.

(3) The mean discharge of dissolved solids for each time interval was multiplied by the interval between succeeding percentages of time, expressed as a decimal, to compute the discharge of dissolved solids.

(4) Discharges of dissolved solids in all time intervals were summed to compute the mean discharge of dissolved solids, in tons per day. Mean discharge of dissolved solids, in tons per day, was multiplied by 365 to compute the mean discharge of dissolved solids, in tons per year. An example of this computation is given in table 6.

Table 5.--Results of regional correlation and regression analyses relating dissolved concentrations of calcium (CA), magnesium (MG), and bicarbonate (HCO_3), in milligrams per liter, to specific conductance (SPCOND), in micromhos per centimeter, and relating discharge of dissolved solids (DSD), in tons per day, to streamflow (Q), in cubic feet per second[1/]

Regression equation	Number of samples	Correlation coefficient	Standard error of estimate (Milligrams per liter)	Standard error of estimate (Log-to-the-base-10 units)	Standard error of estimate (Percentage of predicted value) Above regression line	Standard error of estimate (Percentage of predicted value) Below regression line
CA = 0.1403 SPCOND -6.85	55	0.95	8.0	--	--	--
MG = 0.0397 SPCOND -3.78	54	.94	2.4	--	--	--
HCO_3 = 0.8356 SPCOND +41.3	38	.87	32	--	--	--
DSD = 0.9629 $Q^{0.9351}$	55	.99	--	0.1422	38.7	27.9

1/ Water samples for chemical analyses were not collected from the Wakarusa River basin stations, so these equations are not applicable.

Table 6.--Computation of mean annual discharge of dissolved solids for Pony Creek near Reserve, Kans.

Percentage of time	Streamflow equaled or exceeded, from synthetic flow-duration curve (cubic feet per second)	Discharge of dissolved solids, computed with regional regression equation from table 5 (tons per day)	Interval between succeeding percentage of time (expressed as a decimal)	Mean discharge of dissolved solids for time interval (tons per day)	Discharge of dissolved solids in time interval (tons per day)
0	[1]5,870	3,218	0.001	2,030	2.03
0.1	1,400	842	.001	757	0.757
.2	1,100	672	.001	626	0.626
.3	940	580	.002	524	1.05
.5	745	467	.002	430	0.860
.7	620	393	.003	354	1.06
1.0	490	315	.004	282	1.13
1.4	380	249	.006	215	1.29
2	270	181	.01	147	1.47
3	164	113	.02	84.1	1.68
5	76.0	55.2	.02	45.9	0.918
7	49.0	36.6	.03	29.9	.897
10	30.0	23.2	.05	19.0	.950
15	18.4	14.7	.05	12.4	.620
20	12.5	10.2	.1	8.23	.823
30	7.40	6.26	.1	5.14	.514
40	4.60	4.01	.1	3.44	.344
50	3.20	2.86	.1	2.44	.244
60	2.20	2.01	.1	1.72	.172
70	1.53	1.43	.1	1.22	.122
80	1.05	1.01	.1	0.80	.080
90	0.60	0.60	.1	.30	.030
100	0.00	0.00	--		--
				Total =	17.7 tons per day

Mean annual discharge of dissolved solids = 17.7 X 365 = 6,460 tons per year.

[1] Estimated 10-year flood peak from table 3.

The computed mean annual discharges of dissolved solids, presented in table 7, have errors estimated to be 0.2223 log-to-the-base-10 units (±53.5 percent). This estimated error was computed by taking the square root of the sum of the squared errors, in log-to-the-base-10 units, involved in computing the synthetic flow-duration curves (0.1709 log units) and associated with the regional regression equation for predicting the discharge of dissolved solids from table 5 (0.1422 log units).

Table 7.--Mean annual discharges of dissolved solids computed for project stations[1]

Station index number (figure 1)	Station name	Mean annual discharge of dissolved solids (tons)	
		Computed with individual station regression equations, from table 11, and synthetic flow-duration curves	Computed with regional regression equation, from table 5, and synthetic flow-duration curves
1	Pony Creek at Sabetha, Kans.	604	512
2	Pony Creek near Sabetha, Kans.	1,180	1,020
3	Pony Creek near Morrill, Kans.	3,770	3,340
4	Pony Creek near Reserve, Kans.	7,060	6,460
8	Wolf River 3 miles southwest of Hiawatha, Kans.	2,320	1,690
9	Wolf River near Hiawatha, Kans.	4,050	3,800
10	Buttermilk Creek near Willis, Kans.	--	637
11	Wolf River at Leona, Kans.	--	17,500
12	Wolf River near Sparks, Kans.	25,000	23,900
13	Little Delaware River near Horton, Kans.	1,780	2,560
14	Little Grasshopper Creek near Effingham, Kans.	--	3,000
15	Little Grasshopper Creek at Muscotah, Kans.	5,620	6,390
16	Coal Creek near Arrington, Kans.	--	852
17	Coal Creek near Halfmound, Kans.	--	3,680

[1] Water samples for chemical analyses were not collected from the Wakarusa River basin stations. Streamflows in the Walnut Creek basin are regulated, and synthetic flow-duration curves could not be developed for use in computing discharges of dissolved solids.

FLUVIAL-SEDIMENT CHARACTERISTICS

Relations of Suspended Sediment to Streamflow

Concentrations, in milligrams per liter, and discharges, in tons per day, of suspended sediment in the study area generally are related directly to streamflow, in cubic feet per second. Fluvial-sediment parameters discussed in this section are listed in table 13 at the back of the report. The direct relations of concentrations and discharges of suspended sediment to streamflow are indicated by the positive correlation coefficients and slopes for regression equations presented in table 14 at the back of the report. These regression equations are of the same form as equation 1. The only station that did not show a direct relationship between the concentration of suspended sediment and streamflow was Little Grasshopper Creek at Muscotah, Kans. This station is located within 0.5 mi of the confluence of Little Grasshopper Creek and the Delaware River. Backwater effects of the Delaware River during high stages of flow resulted in decreased streamflow velocities and, consequently, decreased concentrations of suspended sediment during high stages of flow for Little Grasshopper Creek at Muscotah. Regression equations relating the discharge of suspended sediment to streamflow have positive slopes and correlation coefficients for all stations in the study area, primarily because streamflow is used to compute the discharge of suspended sediment.

An attempt to produce a regional regression equation for the study area relating suspended-sediment discharge to streamflow was unsuccessful. An analysis-of-covariance test computed F statistics of 1.78 for equivalent slopes and 3.67 for a common regression equation. Comparing the computed F statistics to tabular F statistics of 2.41 for equivalent slopes at the 0.001 probability level and 1.65 for a common regression equation at the 0.01 probability level indicates that the slopes of the individual station regression equations are statistically equivalent, but a common regression line will not represent the entire study area.

Discharge of Suspended Sediment

Synthetic flow-duration curves developed for each station in the study area, except those in the Walnut Creek basin where streamflow is regulated, were used in conjunction with regression equations, from table 14, relating the discharge of suspended sediment and streamflow to compute mean discharges of suspended sediment. The same procedure used to compute discharges of dissolved solids in the preceding section was applied. An example computation is presented in table 8. Computed discharges of suspended sediment for all project stations, except those in the Walnut Creek basin, are presented in table 9. The discharges of suspended sediment range from 493 (ton/mi^2)/yr for Little Grasshopper Creek near Effingham, in the southern part of the study area, to 5,100 (ton/mi^2)/yr for Pony Creek at Sabetha and near Reserve, in the northern part of the study area.

Table 8.--Computation of mean discharge of suspended sediment for Pony Creek near Reserve, Kans.

Percentage of time	Streamflow equaled or exceeded (cubic feet per second) 1/	Discharge of suspended sediment (tons per day) 2/	Interval between succeeding percentage of time (expressed as a decimal)	Mean discharge of suspended sediment for time interval (tons per day)	Discharge of suspended sediment in time interval (tons per day)
0.0	[3]5,870	999,000	0.001	526,000	526
.1	1,400	52,500	.001	42,200	42.2
.2	1,100	32,000	.001	27,600	27.6
.3	940	23,200	.002	18,800	37.6
.5	745	14,400	.002	12,100	24.2
.7	620	9,850	.003	7,960	23.9
1.0	490	6,070	.004	4,840	19.4
1.4	380	3,600	.006	2,690	16.1
2	270	1,780	.01	1,210	12.1
3	164	640	.02	386	7.72
5	76.0	132	.02	92.8	1.86
7	49.0	53.5	.03	36.5	1.10
10	30.0	19.5	.05	13.3	0.665
15	18.4	7.15	.05	5.19	.260
20	12.5	3.23	.1	2.16	.216
30	7.40	1.10	.1	0.76	.076
40	4.60	0.41	.1	.31	.031
50	3.20	.20	.1	.14	.014
60	2.20	.09	.1	.06	.006
70	1.53	.04	.1	.03	.003
80	1.05	.02	.1	.01	.001
90	0.60	.01	.1	.00	.000
100	0.00	0.00	--	--	--
				Total =	741 tons per day

Mean discharge of suspended sediment:

Tons per day = 741
Tons per year = 741 X 365 = 270,000
Tons per square mile per year = 270,000/53.0 = 5,100

[1] From synthetic flow-duration curve.
[2] Computed with regression equation from table 14.
[3] Estimated 10-year flood peak from table 3.

Table 9.--Mean discharges of suspended sediment computed for project stations[1]

Station index number (figure 1)	Station	Mean discharge of suspended sediment: Tons per day	Tons per year	Tons per square mile per year
1	Pony Creek at Sabetha, Kans.	39.7	14,500	5,100
2	Pony Creek near Sabetha, Kans.	36.4	13,300	2,030
3	Pony Creek near Morrill, Kans.	129	47,300	1,880
4	Pony Creek near Reserve, Kans.	741	270,000	5,100
8	Wolf River 3 miles southwest of Hiawatha, Kans.	81.6	29,800	2,500
9	Wolf River near Hiawatha, Kans.	177	64,800	2,230
10	Buttermilk Creek near Willis, Kans.	20.4	7,430	1,990
11	Wolf River at Leona, Kans.	1,110	406,000	2,540
12	Wolf River near Sparks, Kans.	1,640	600,000	2,730
13	Little Delaware River near Horton, Kans.	29.1	10,600	559
14	Little Grasshopper Creek near Effingham, Kans.	29.7	10,900	493
15	Little Grasshopper Creek at Muscotah, Kans.	131	47,700	917
16	Coal Creek near Arrington, Kans.	37.4	13,700	2,730
17	Coal Creek near Halfmound, Kans.	142	51,800	1,920
18	Sixmile Creek tributary 5 miles northeast of Auburn, Kans.	3.54	1,290	775
19	Sixmile Creek tributary 4 miles northeast of Auburn, Kans.	18.0	6,580	2,810
20	Wakarusa River 5 miles west of Auburn, Kans.	17.3	6,320	890
21	Wakarusa River 4 miles west of Auburn, Kans.	22.3	8,150	762

[1] Streamflow in the Walnut Creek basin is regulated, and synthetic flow-duration curves could not be developed for computing the discharge of suspended sediment.

The error expected in computing the discharge of suspended sediment is estimated to range from 0.2580 log-to-the-base-10 units (+81 percent and -45 percent) to 0.6176 log-to-the-base-10 units (+310 percent and -76 percent). This range of errors was computed by taking the square root of the sum of the squared errors, in log-to-the-base-10 units, involved in computing the synthetic flow-duration curves (0.1709 log units) and associated with the regression equations used to predict the discharge of suspended sediment from table 14 (ranging from 0.1933 to 0.5935 log units).

Statistical Summaries of Fluvial-Sediment Data

Statistical summaries of fluvial-sediment data are presented in table 15 at the back of the report. Measured concentrations of suspended sediment in the study area ranged from 3 to 61,700 mg/L (milligrams per liter) for the Wolf River near Sparks, Kans. Measured discharges of suspended sediment ranged from 0.03 to 556,000 ton/d for the Wolf River near Sparks, Kans.

Suspended-sediment particle-size data (table 15) show that the largest particles determined were in the coarse-sand range (0.5 to 1.0 mm). Particle sizes in the clay-silt range (less than 0.062 mm) provided from 61 to 100 percent of the suspended sediments. It should be noted that suspended-sediment samples analyzed for particle-size distribution were collected during periods of runoff when suspended-sediment concentrations were very high and streamflow velocities were adequate for transporting large-size particles. Therefore, the minimum of 61 percent silt-clay collected from the Wolf River at high streamflow probably is about the minimum for the study area. The other project stations, excluding the Wolf River, have 80 to 100 percent of their suspended sediments in the clay-silt particle sizes.

Bed-material particle-size data are sparse for the study area. Data presented in table 15 at the back of the report show bed-material particle sizes ranging from coarse clay to coarse gravel (less than 0.004 to 32.0 mm). Only three stations had bed-material particle analyses, and each had only one analysis. The Little Delaware River near Horton, Kans., had the greatest percentage, 22 percent, of its bed material in the medium-gravel range (8.0 to 16.0 mm); Little Grasshopper Creek at Muscotah, Kans., had the greatest percentage, 33 percent, of its bed material in the coarse-sand range (0.5 to 1.0 mm); and the Wolf River near Hiawatha, Kans., had the greatest percentage, 30 percent, of its bed material in the coarse-sand range.

SUMMARY

Regional, nondimensional, flow-duration curves were developed for northeast Kansas. These curves were used to compute synthetic flow-duration curves for project stations, except those in the Walnut Creek basin where streamflow is regulated by erosion-control structures.

The predominant chemical type of water in streams draining the study area is calcium bicarbonate. During low streamflow, base flow to Pony and Walnut Creeks adds high concentrations of sulfate ion that change the water type to calcium bicarbonate sulfate. In-stream concentrations of chemical constituents generally decrease with increasing streamflow. Exceptions to this are nitrate and phosphorus, which enter the streams as components of surface runoff.

Regression equations relating concentrations of chemical constituents to streamflow were developed for selected project stations. A regional regression equation relating the discharge of dissolved solids to streamflow was developed for the study area. Regression equations relating concentrations of dissolved chemical constituents to specific conductance were developed for selected project stations. Regional regression equations relating concentrations of dissolved calcium, magnesium, and bicarbonate to specific conductance were developed. Because no water samples for chemical analyses were collected in the Wakarusa River basin, none of the equations are applicable to that basin.

Synthetic flow-duration curves were used in conjunction with the regional regression equation relating the discharge of dissolved solids and streamflow to compute mean annual discharges of dissolved solids for all project stations except those in the Walnut Creek and Wakarusa River basins. Computed mean annual discharges of dissolved solids ranged from 512 tons for Pony Creek at Sabetha, Kans., to 23,900 tons for the Wolf River near Sparks, Kans.

Sediment yields in the study area, predominantly silt and clay (particle size less than 0.062 mm), are among the largest in the State. Regression equations relating concentrations and discharges of suspended sediment to streamflow were developed for each station. Results of an analysis-of-covariance test indicated that a regional regression equation relating the discharge of suspended sediment to streamflow could not be developed at the 0.01 probability level. Synthetic flow-duration curves were used in conjunction with individual station regression equations relating discharges of suspended sediment and streamflow to compute mean discharges of suspended sediment for each station, except those in the Walnut Creek basin. Drainage basins in the northern part of the study area yielded the most suspended sediment. Pony Creek at Sabetha and near Reserve, Kans., yielded 5,100 $(ton/mi^2)/yr$. Basins in the southern part of the study area yielded less suspended sediment. Little Grasshopper Creek near Effingham, Kans., yielded 493 $(ton/mi^2)/yr$, and the Little Delaware River near Horton, Kans., yielded 559 $(ton/mi^2)/yr$.

Bed materials in the study area ranged from coarse clay to coarse gravel. The greatest percentages of bed material were in the coarse-sand to medium-gravel ranges.

Conclusions reached in this report concerning discharges of dissolved solids and suspended sediment depend on the accuracy of the synthetic flow-duration curves. Extension of the periods of record used to develop the synthetic flow-duration curves may affect these conclusions.

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SUPPLEMENTAL INFORMATION

Table 10.--List of chemical constituents and water-quality parameters used in correlation of and regression analyses

Parameter or constituent	Symbols used in regression equations	Unit of measurement	Detection limits
Streamflow, instantaneous	Q	ft^3/s (cubic feet per second)	0.01
Specific conductance	SPCOND	μmhos/cm at 25°C (micromhos per centimeter at 25°C)	1
Turbidity	TURBN	NTU (nephelometric turbidity units)	1
Calcium, dissolved	CA	mg/L (milligrams per liter)	.1
Magnesium, dissolved	MG	mg/L	.1
Sodium, dissolved	NA	mg/L	.1
Bicarbonate	HCO_3	mg/L	1
Alkalinity, as $CaCO_3$	ALK	mg/L	1
Sulfate, dissolved	SO_4	mg/L	5
Chloride, dissolved	CL	mg/l	.1
Dissolved solids, concentration	DSC	mg/L	1
Dissolved solids, discharge	DSD	ton/d (tons per day)	.01
Carbon, organic total	TOC	mg/L	.1
Nitrogen, total as nitrate (NO_3)	NO_3	mg/L	.1
Phosphorous, total as P	P	mg/L	.01

Table 11.--Results of correlation and regression analyses relating chemical constituents and water-quality parameters to streamflow for selected stations

Regression equation (presented only if it is significant at the 0.05 level of significance	Number of samples	Corre- coef- ficient	Standard error of estimate (Log-to-the-base-10 units)	Standard error of estimate (Percentage of predicted value) Above regression line	Standard error of estimate (Percentage of predicted value) Below regression line
Pony Creek, Kans.[1] (stations 1, 2, 3 and 4; figure 1) (Valid for Q between 0.14 and 176 cubic feet per second)					
SPCOND = 768 $Q^{-0.1162}$	11	[2]-0.79	0.0961	24.8	19.8
TURBN =	4	.84	--	--	--
CA = 102 $Q^{-0.1050}$	11	[2]-.75	.0980	25.3	20.2
MG = 28.3 $Q^{-0.1424}$	11	[2]-.83	.1000	25.9	20.6
NA =	11	-.58	--	--	--
HCO_3 = 334 $Q^{-0.1023}$	12	[2]-.90	.0517	12.6	11.2
SO_4 =	12	-.52	--	--	--
CL = 17.3 $Q^{-0.1563}$	11	[2]-.61	.2137	63.6	38.9
DSC = 482 $Q^{-0.1076}$	11	[2]-.73	.1057	27.6	21.6
[3]DSD = 1.34 $Q^{0.8889}$	11	[2].99	.1020	26.5	20.9
NO_3 = 19.8 $Q^{0.0872}$	7	[2].91	.0316	7.5	7.0
P =	10	.36	--	--	--
Walnut Creek at Reserve, Kans.(station 7, figure 1) (Valid for Q between 1.7 and 145 cubic feet per second)					
SPCOND =	10	-0.62	--	--	--
TURBN = 0.087 $Q^{1.4818}$	5	[2].95	0.2461	76.2	43.2
CA = 133 $Q^{-0.1669}$	10	[2]-.68	.1148	30.2	23.2
MG =	9	-.55	--	--	--
NA = 27.7 $Q^{-0.1698}$	10	[2]-.70	.1108	29.1	22.5
HCO_3 =	8	-.43	--	--	--
SO_4 = 302 $Q^{-0.3985}$	10	[2]-.90	.1277	34.2	25.5
CL = 23.3 $Q^{-0.2126}$	10	[2]-.81	.1004	26.0	20.6
DSC = 636 $Q^{-0.1932}$	10	[2]-.76	.1070	27.9	21.8
[3]DSD = 1.69 $Q^{0.8279}$	10	[2].98	.1070	27.9	21.8
NO_3 =	10	.57	--	--	--
P = 0.039 $Q^{0.4740}$	10	[2].67	.3423	20.0	54.5
TOC =	8	.67	--	--	--

Table 11.--Results of correlation and regression analyses relating chemical constituents and water-quality parameters to streamflow for selected stations--Continued

Regression equation (presented only if it is significant at the 0.05 level of significance)		Number of samples	Correlation coefficient	Standard error of estimate (Log-to-the-base-10 units)	(Percentage of predicted value) Above regression line	Below regression line
Wolf River 3 miles southwest of Hiawatha, Kans. (station 8, figure 1) (Valid for Q between 0.55 and 6.6 cubic feet per second)						
SPCOND	=	4	0.14	--	--	--
TURBN	=	4	.61	--	--	--
CA	=	4	.55	--	--	--
MG	=	4	-.28	--	--	--
NA	=	4	-.79	--	--	--
HCO_3	=	4	.25	--	--	--
SO_4	=	4	.38	--	--	--
CL	=	4	-.93	--	--	--
DSC	=	4	.21	--	--	--
[3]DSD	= $0.798\ Q^{1.0391}$	4	[2] .99	0.1035	26.9	21.2
NO_3	=	4	.60	--	--	--
P	= $0.072\ Q^{0.4978}$	4	[2] .99	.0435	10.5	9.5
TOC	=	4	.60	--	--	--
Wolf River near Hiawatha, Kans. (station 9, figure 1) (Valid for Q between 0.78 and 19.6 cubic feet per second)						
SPCOND	=	6	0.00	--	--	--
TURBN	= $3.37\ Q^{0.8332}$	6	[2] .90	0.2266	68.5	40.6
CA	=	6	.32	--	--	--
MG	=	6	-.11	--	--	--
NA	=	6	-.73	--	--	--
HCO_3	=	6	-.05	--	--	--
SO_4	=	6	.62	--	--	--
CL	=	6	-.37	--	--	--
DSC	=	6	.03	--	--	--
[3]DSD	= $0.820\ Q^{0.9953}$	6	[2] .99	.0669	16.6	14.3
NO_3	=	6	.76	--	--	--
P	= $0.034\ Q^{0.6700}$	6	[2] .90	.2020	59.2	37.2
TOC	=	6	.27	--	--	--

Table 11.--Results of correlation and regression analyses relating chemical constituents and water-quality parameters to streamflow for selected stations--Continued

Regression equation (presented only if it is significant at the 0.05 level of significance)	Number of samples	Correlation coefficient	Standard error of estimate (Log-to-the-base-10 units)	Standard error of estimate (Percentage of predicted value) Above regression line	Standard error of estimate (Percentage of predicted value) Below regression line
Wolf River near Sparks, Kans. (station 12, figure 1) (Valid for Q between 1.0 and 167 cubic feet per second)					
SPCOND =	10	-0.04	--	--	--
TURBN =	5	.65	--	--	--
CA =	10	.15	--	--	--
MG =	10	-.21	--	--	--
NA =	10	-.46	--	--	--
HCO_3 =	10	.02	--	--	--
SO_4 =	10	-.14	--	--	--
CL = 12.5 $Q^{-0.0978}$	10	[2]-.73	0.0664	16.5	14.2
DSC =	10	.01	--	--	--
[3]DSD = 0.706 $Q^{0.9918}$	10	[2].99	.1219	32.4	24.5
NO_3 =	10	-.37	--	--	--
P =	10	.48	--	--	--
TOC = 2.52 $Q^{0.1927}$	10	[2].78	.1218	32.4	24.4
Little Delaware River near Horton, Kans. (station 13, figure 1) (Valid for Q between 0.08 and 23 cubic feet per second)					
SPCOND =	7	-0.49	--	--	--
TURBN =	4	.67	--	--	--
CA =	6	-.19	--	--	--
MG =	6	-.15	--	--	--
NA =	6	-.09	--	--	--
HCO_3 =	7	-.63	--	--	--
SO_4 =	7	-.33	--	--	--
CL =	7	-.61	--	--	--
DSC =	6	-.20	--	--	--
[3]DSD = 0.787 $Q^{0.8986}$	7	[2].99	0.1488	40.9	29.0
NO_3 =	7	.38	--	--	--
P = 0.119 $Q^{0.3443}$	7	[2].88	.1897	54.8	35.4
TOC =	7	.72	--	--	--

Table 11.--Results of correlation and regression analyses relating chemical constituents and water-quality parameters to streamflow for selected stations--Continued

Regression equation (presented only if it is significant at the 0.05 level of significance)		Number of samples	Correlation coefficient	Standard error of estimate (Log-to-the-base-10 units)	Standard error of estimate (Percentage of predicted value) Above regression line	Standard error of estimate (Percentage of predicted value) Below regression line
Little Grasshopper Creek at Muscotah, Kans. (station 15, figure 1) (Valid for Q between 0.14 and 81 cubic feet per second)						
SPCOND	=	7	-0.21	--	--	--
TURBN	=	4	.83	--	--	--
CA	=	7	- .25	--	--	--
MG	=	7	- .28	--	--	--
NA	=	7	- .35	--	--	--
HCO_3	=	7	- .34	--	--	--
SO_4	=	7	- .27	--	--	
CL	=	7	- .14	--	--	--
DSC	=	7	- .29	--	--	--
[3]DSD	$= 0.762\ Q^{0.9549}$	7	[2] .99	0.1542	42.6	29.9
NO_3	$= 7.24\ Q^{0.2372}$	7	[2] .87	.1343	36.2	26.6
P	=	7	.58	--	--	--
TOC	=	7	.66	--	--	--

[1] Due to the limited chemical data collected in the Pony Creek basin, all data from the four stations located on Pony Creek were combined to compute the regression equations.

[2] The correlation coefficient is significant at the 0.05 level of significance.

[3] DSD (discharge of dissolved solids, in tons per day) is computed by multiplying Q (streamflow, in cubic feet per second) by DSC (concentration of dissolved solids, in milligrams per liter) and by 0.027 to convert to tons per day. The increase in the correlation coefficient relating DSD and Q over the correlation coefficient relating DSC and Q is a result of Q being used to compute DSD.

Table 12.--Results of correlation and regression analyses relating concentrations of chemical constituents and water-quality parameters to specific conductance for selected stations

Regression equation (presented only if it is significant at the 0.05 level of significance)	Number of samples	Correlation coefficient	Standard error of estimate (milligrams per liter)
Pony Creek, Kans.[1] (stations 1, 2, 3, and 4; figure 1) (Valid for SPCOND between 329 and 865 micromhos per centimeter at 25°C)			
CA = 0.1263 SPCOND +5.22	12	[2]0.96	7.9
MG = 0.0401 SPCOND -2.65	12	[2].97	2.1
NA = 0.0289 SPCOND -0.310	12	[2].81	4.3
ALK = 0.2496 SPCOND +66.5	12	[2].88	27
SO_4 = 0.2482 SPCOND -56.8	12	[2].84	34
CL = 0.0327 SPCOND -6.42	12	[2].80	5.0
DSC = 0.6503 SPCOND -12.7	12	[2].99	21
Walnut Creek at Reserve, Kans. (station 7, figure 1) (Valid for SPCOND between 358 and 758 micromhos per centimeter at 25°C)			
CA = 0.1557 SPCOND -11.7	10	[2]0.94	8.9
MG = 0.0478 SPCOND -9.34	9	[2].93	3.0
NA = 0.0309 SPCOND -1.69	10	[2].95	1.7
HCO_3= 0.3703 SPCOND +16.0	8	[2].94	23
ALK = 0.3089 SPCOND +9.81	10	[2].95	17
SO_4 = 0.2709 SPCOND -65.0	10	[2].77	36
CL = 0.0202 SPCOND +0.343	10	[2].72	3.1
DSC = 0.7096 SPCOND -65.6	10	[2].94	41
Wolf River 3 miles southwest of Hiawatha, Kans. (station 8, figure 1) (Valid for SPCOND between 415 and 713 micromhos per centimeter at 25°C)			
CA =	4	0.91	--
MG =	4	.91	--
NA =	4	.53	--
HCO_3= 0.5219 SPCOND +0.92	4	[2]1.0	8.1
ALK = 0.4003 SPCOND +16.6	4	[2]1.0	3.8
SO_4 =	4	.87	--
CL =	4	- .36	--
DSC = 0.4569 SPCOND +63.8	4	[2]1.0	6.4
Wolf River near Hiawatha, Kans. (station 9, figure 1) (Valid for SPCOND between 440 and 733 micromhos per centimeter at 25°C)			
CA = 0.0977 SPCOND +9.50	6	[2]0.88	6.4
MG = 0.0205 SPCOND +5.59	6	[2].94	0.9
NA =	6	.54	--
HCO_3= 0.4093 SPCOND +48.8	6	[2].98	14
ALK = 0.3317 SPCOND +46.4	6	[2].97	11
SO_4 =	6	.74	--
CL =	6	-.04	--
DSC = 0.3683 SPCOND +98.2	6	[2].98	8.9

Table 12.--Results of correlation and regression analyses relating concentrations of chemical constituents and water-quality parameters to specific conductance for selected stations--Continued

Regression equation (presented only if it is significant at the 0.05 level of significance)	Number of samples	Correlation coefficient	Standard error of estimate (milligrams per liter)
Wolf River near Sparks, Kans. (station 12, figure 1) (Valid for SPCOND between 275 and 512 micromhos per centimeter at 25°C)			
CA = 0.1764 SPCOND -23.5	10	[2]0.95	6.8
MG = 0.0335 SPCOND -0.808	10	[2].82	2.7
NA =	10	.35	--
HCO_3 = 0.5186 SPCOND -21.6	8	[2].95	22
ALK = 0.4337 SPCOND -24.3	10	[2].95	17
SO_4 = 0.0465 SPCOND +11.8	10	[2].83	3.6
CL =	10	.30	--
DSC = 0.5755 SPCOND -10.4	10	[2].96	19
Little Delaware River near Horton, Kans. (station 13, figure 1) (Valid for SPCOND between 214 and 828 micromhos per centimeter at 25°C)			
CA = 0.1084 SPCOND +6.93	6	[2]0.97	4.8
MG = 0.0305 SPCOND +1.03	6	[2].97	1.3
NA =	6	73	--
HCO_3 = 0.3352 SPCOND +74.0	7	[2].84	43
ALK = 0.2799 SPCOND +58.6	7	[2].86	34
SO_4 =	7	.72	--
CL =	7	.59	--
DSC = 0.3255 SPCOND +121	6	[2].95	17
Little Grasshopper Creek at Muscotah, Kans. (station 15, figure 1) (Valid for SPCOND between 242 and 760 micromhos per centimeter at 25°C)			
CA = 0.1340 SPCOND -1.42	7	[2]0.99	3.6
MG = 0.0372 SPCOND -3.80	7	[2].98	1.2
NA = 0.0303 SPCOND +1.22	7	[2].98	1.0
HCO_3 = 0.4049 SPCOND +37.0	7	[2].97	18
ALK = 0.3358 SPCOND +28.5	7	[2].97	15
SO_4 = 0.0612 SPCOND +2.34	7	[2].94	3.7
CL = 0.0718 SPCOND +0.758	7	[2].85	1.9
DSC = 0.4860 SPCOND +33.5	7	[2].99	14

[1] Due to the limited data collected in the Pony Creek basin, all data from the four stations located on Pony Creek were combined to compute the regression equations.

[2] The correlation coefficient is significant at the 0.05 level of significance.

Table 13.--List of fluvial-sediment parameters used in correlation and regression analyses and statistical summaries

Parameter	Symbol used in regression equations	Unit of measurement	Detection limits
Streamflow, instantaneous	Q	ft^3/s (cubic feet per second)	0.01
Sediment concentration, suspended	SSC	mg/L (milligrams per liter)	1
Sediment discharge, suspended	SSD	ton/d (tons per day)	.01
Sediment, suspended, fall diameter, distilled water, percent finer than			
0.002 millimeter	--	percent	1
0.004 millimeter	--	do	1
0.008 millimeter	--	do	1
0.016 millimeter	--	do	1
0.031 millimeter	--	do	1
0.062 millimeter	--	do	1
0.125 millimeter	--	do	1
0.250 millimeter	--	do	1
0.500 millimeter	--	do	1
1.00 millimeter	--	do	1
Sediment, bed material, fall diameter,	--		
distilled water, percent finer than	--		
0.004 millimeter	--	percent	1
0.125 millimeter	--	do	1
0.250 millimeter	--	do	1
0.500 millimeter	--	do	1
1.00 millimeter	--	do	1
Sediment, bed material sieve diameter, percent finer than			
2.00 millimeters	--	do	1
4.00 millimeters	--	do	1
8.00 millimeters	--	do	1
16.00 millimeters	--	do	1
32.00 millimeters	--	do	1

Table 14.--Results of correlation and regression analyses relating suspended-sediment concentrations (SSC) and discharges (SSD) to streamflow (Q)

Station index number (figure 1)	Station name	Number of samples	Correlation coefficient	Regression equation (presented only if it is significant at the 0.05 level of significance)	Standard error or estimate: (Log-to-the-base-10 units)	Standard error or estimate (Percentage of predicted value): Above regression line	Standard error or estimate (Percentage of predicted value): Below regression line
1	Pony Creek at Sabetha, Kans.	18	[1]0.67	SSC = $47.2\ Q^{0.8622}$	0.3153	107	51.6
		18	[1].89	[2]SSD = $0.129\ Q^{1.8599}$	.3147	106	51.
2	Pony Creek near Sabetha, Kans.	19	[1].67	SSC = $246\ Q^{0.4768}$	.3597	129	56.3
		19	[1].94	[2]SSD = $0.673\ Q^{1.4742}$	.3581	128	56.
3	Pony Creek near Morrill, Kans.	8	[1].85	SSC = $12.6\ Q^{0.8773}$	.2732	86.8	46.7
		8	[1].96	[2]SSD = $0.034\ Q^{1.8760}$	.2715	86.8	46.
4	Pony Creek near Reserve, Kans.	7	.73	SSC =	--	--	--
		7	[1].90	[2]SSD = $0.018\ Q^{2.0549}$	.5935	292	74.
5	Walnut Creek near Fairview, Kans.	26	[1].75	SSC = $4.03\ Q^{1.1019}$	.3961	149	59.8
		26	[1].91	[2]SSD = $0.011\ Q^{2.1026}$	.3965	149	59.
6	Walnut Creek near Hamlin, Kans.	31	[1].83	SSC = $58.0\ Q^{0.5030}$	.1929	55.9	35.9
		31	[1].97	[2]SSD = $0.156\ Q^{1.5834}$	.1933	56.1	35.
7	Walnut Creek at Reserve, Kans.	30	[1].45	SSC = $570\ Q^{0.2135}$	.2941	96.8	49.
		30	[1].94	[2]SSD = $1.53\ Q^{1.2137}$	.2941	96.8	49
8	Wolf River 3 miles southwest of Hiawatha, Kans.	58	[1].73	SSC = $294\ Q^{0.4812}$	.3031	101	50.
		58	[1].95	[2]SSD = $0.898\ Q^{1.4526}$	.3148	106	51
9	Wolf River near Hiawatha, Kans.	112	[1].73	SSC = $163\ Q^{0.5416}$	.3321	115	53.
		112	[1].95	[2]SSD = $0.460\ Q^{1.5338}$	.3374	117	54
10	Buttermilk Creek near Willis, Kans.	84	[1].65	SSC = $256\ Q^{0.4796}$	.3757	138	57.
		84	[1].91	[2]SSD = $0.782\ Q^{1.4408}$	.4269	167	62
11	Wolf River at Leona, Kans.	44	[1].74	SSC = $29.1\ Q^{0.7428}$	.3842	142	58.
		44	[1].93	[2]SSD = $0.077\ Q^{1.7449}$	.3822	141	58.
12	Wolf River near Sparks, Kans.	120	[1].71	SSC = $19.7\ Q^{0.7814}$	.4717	196	66.
		120	[1].91	[2]SSD = $0.051\ Q^{1.7832}$	4824	204	67.1
13	Little Delaware River near Horton, Kans.	108	[1].39	SSC = $358\ Q^{0.2121}$	.3329	115	53.
		108	[1].92	[2]SSD = $0.985\ Q^{1.2084}$	.3337	116	53.6
14	Little Grasshopper Creek near Effingham, Kans.	14	.26	SSC =	--	--	--
		14	[1].86	[2]SSD = $0.917\ Q^{1.1928}$	.4482	181	64.4

Table 14.--Results of correlation and regression analyses relating suspended-sediment concentrations (SSC) and discharges (SSD) to streamflow (Q)--Continued

Station index number (figure 1)	Station name	Number of samples	Correlation coefficient	Regression equation (presented only if it is significant at the 0.05 level of significance)	Standard error or estimate (Log-to-the-base-10 units)	Standard error or estimate (Percentage of predicted value) Above regression line	Standard error or estimate (Percentage of predicted value) Below regression line
15	Little Grasshopper Creek at Muscotah, Kans.	23	-0.05	SSC =	--	--	--
		23	[1] .90	[2]SSD = 5.13 $Q^{0.9979}$	0.3265	112	52.8
16	Coal Creek near Arrington, Kans.	13	[1] .69	SSC = 178 $Q^{0.5537}$	.3262	112	
		13	[1] .93	[2]SSD = 0.480 $Q^{1.5537}$	.3269	112	52.9
17	Coal Creek near Halfmound, Kans.	19	[1] .76	SSC = 105 $Q^{0.5660}$	.2837	92.2	
		19	[1] .96	[2]SSD = 0.285 $Q^{1.5649}$	.2836	92.2	48.0
18	Sixmile Creek tributary 5 miles northeast of Auburn, Kans.	22	[1] .55	SSC = 241 $Q^{0.2584}$	.3290	113	
		22	[1] .96	[2]SSD = 0.645 $Q^{1.2611}$	.3292		
19	Sixmile Creek tributary 4 miles northeast of Auburn, Kans.	22	[1] .72	SSC = 288 $Q^{0.4431}$	.3389	118	
		22	[1] .96	[2]SSD = 0.769 $Q^{1.4463}$	.3390		
20	Wakarusa River 5 miles west of Auburn, Kans.	25	[1] .44	SSC = 410 $Q^{0.2218}$	.4508	182	
		25	[1] .94	[2]SSD = 1.11 $Q^{1.2212}$	.4512		
21	Wakarusa River 4 miles west of Auburn, Kans.	26	[1] .39	SSC = 309 $Q^{0.2455}$	.4930	211	
		26	[1] .91	[2]SSD = 0.830 $Q^{1.2460}$	.4937		

[1] The correlation coefficient is significant at the 0.05 level of significance.

[2] SSD (discharge of suspended sediment, in tons per day) is computed by multiplying Q (streamflow, in cubic feet per second) by SSC (concentration of suspended sediment, in milligrams per liter) and by 0.027 to convert to tons per day. The increase in the correlation coefficient relating SSD and Q over the correlation coefficient relating SSC and is a result of Q being used to compute SSD.

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Pony Creek at Sabetha, Kans. (station 1, figure 1)					
Streamflow, instantaneous (cubic feet per second)	23	59	7.6	182	40
Sediment concentration, suspended (milligrams per liter)	23	2,800	136	15,400	3,340
Sediment discharge, suspended (tons per day)	18	374	2.8	1,680	442
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	6	52	39	75	14
0.004 millimeter	6	58	46	80	13
0.008 millimeter	6	65	53	85	13
0.016 millimeter	6	76	66	92	10
0.031 millimeter	6	90	84	97	6
0.062 millimeter	6	97	93	100	3
0.125 millimeter	5	99	97	100	2
0.250 millimeter	3	100	100	100	--
Pony Creek near Sabetha, Kans. (station 2, figure 1)					
Streamflow, instantaneous (cubic feet per second)	21	72	1.4	170	56
Sediment concentration, suspended (milligrams per liter)	21	2,370	86	8,560	2,100
Sediment discharge, suspended (tons per day)	19	403	0.33	1,980	510
Sediment, suspended, fall diameter, percent finer than 0.002 millimeter	2	49	31	67	--
0.004 millimeter	2	56	36	76	--
0.008 millimeter	2	62	42	83	--
0.016 millimeter	2	73	55	91	--
0.031 millimeter	2	90	84	97	--
0.062 millimeter	2	100	99	100	--
0.125 millimeter	1	100	100	100	--
Pony Creek near Morrill, Kans. (station 3, figure 1)					
Streamflow, instantaneous (cubic feet per second)	8	191	45	474	194
Sediment concentration, suspended (milligrams per liter)	8	1,350	149	3,920	1,430
Sediment discharge, suspended (tons per day)	8	1,310	20	5,020	2,060

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Pony Creek near Reserve, Kans. (station 4, figure 1)					
Streamflow, instantaneous (cubic feet per second)	9	253	16	693	281
Sediment concentration, suspended (milligrams per liter)	9	4,330	120	16,500	6,120
Sediment discharge, suspended (tons per day)	7	2,970	6.8	19,300	7,220
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	2	34	30	39	--
0.004 millimeter	2	43	39	47	--
0.016 millimeter	2	68	64	71	--
0.031 millimeter	2	90	88	93	--
0.062 millimeter	2	99	99	99	--
0.125 millimeter	2	100	100	100	--
Walnut Creek near Fairview, Kans. (station 5, figure 1)					
Streamflow, instantaneous (cubic feet per second)	36	270	36	1,200	271
Sediment concentration, suspended (milligrams per liter)	36	4,010	46	25,400	5,500
Sediment discharge, suspended (tons per day)	27	2,790	7.2	25,000	5,440
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	10	37	22	67	15
0.004 millimeter	10	47	33	76	13
0.008 millimeter	4	68	49	81	14
0.016 millimeter	10	67	57	88	11
0.031 millimeter	4	86	76	96	10
0.062 millimeter	10	96	85	100	4
0.125 millimeter	9	98	91	100	3
0.250 millimeter	4	97	94	100	3
0.500 millimeter	2	98	96	99	--
1.00 millimeter	2	100	99	100	--

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Walnut Creek near Hamlin, Kans. (station 6, figure 1)					
Streamflow, instantaneous (cubic feet per second)	46	716	48	3,400	788
Sediment concentration, suspended (milligrams per liter)	46	4,090	249	16,400	3,660
Sediment discharge, suspended (tons per day)	35	11,800	32	91,500	20,100
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	11	37	26	68	13
0.004 millimeter	12	48	36	74	12
0.008 millimeter	5	64	48	77	11
0.016 millimeter	12	69	58	86	9
0.031 millimeter	5	90	82	93	5
0.062 millimeter	12	98	95	100	1
0.125 millimeter	10	99	95	100	2
0.250 millimeter	4	99	95	100	2
0.500 millimeter	1	99	99	99	--
1.00 millimeter	1	100	100	100	--
Walnut Creek at Reserve, Kans. (station 7, figure 1)					
Streamflow, instantaneous (cubic feet per second)	35	966	18	4,500	1,150
Sediment concentration, suspended (milligrams per liter)	35	3,080	378	7,060	1,920
Sediment discharge, suspended (tons per day)	32	9,020	66	71,300	13,400
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	9	43	29	67	14
0.004 millimeter	11	55	33	74	14
0.008 millimeter	6	68	47	80	12
0.016 millimeter	11	74	56	88	12
0.031 millimeter	6	93	82	99	6
0.062 millimeter	11	98	96	100	1
0.125 millimeter	8	99	96	100	1
0.250 millimeter	2	98	97	100	-
0.500 millimeter	1	99	99	99	-
1.00 millimeter	1	100	100	100	-

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Wolf River 3 miles southwest of Hiawatha, Kans. (station 8, figure 1)					
Streamflow, instantaneous (cubic feet per second)	80	171	2.0	1,000	214
Sediment concentration, suspended (milligrams per liter)	80	4,840	164	29,900	6,000
Sediment discharge, suspended (tons per day)	61	1,900	1.2	29,200	4,420
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	9	41	20	61	15
0.004 millimeter	9	51	33	79	17
0.008 millimeter	3	57	48	65	--
0.016 millimeter	10	72	54	96	15
0.031 millimeter	3	89	84	93	--
0.062 millimeter	10	98	96	100	1
0.125 millimeter	8	100	99	100	0
0.250 millimeter	1	100	100	100	--
Wolf River near Hiawatha, Kans. (station 9, figure 1)					
Streamflow, instantaneous (cubic feet per second)	142	379	2.5	2,300	528
Sediment concentration, suspended (milligrams per liter)	143	4,140	84	23,200	4,200
Sediment discharge, suspended (tons per day)	115	3,480	0.68	35,200	6,320
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	22	42	21	78	14
0.004 millimeter	23	50	27	87	14
0.008 millimeter	15	61	31	95	14
0.016 millimeter	23	68	40	96	13
0.031 millimeter	14	86	53	97	11
0.062 millimeter	24	95	61	100	8
0.125 millimeter	23	97	63	100	8
0.250 millimeter	12	95	66	100	10
0.500 millimeter	8	97	81	100	6
1.00 millimeter	5	97	87	100	6
Bed material, fall diameter, percent finer than					
0.062 millimeter	1	3	3	3	--
0.125 millimeter	1	3	3	3	--

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Wolf River near Hiawatha, Kans.--Continued					
Bed material, fall diameter, percent finer than					
0.250 millimeter	1	7	7	7	--
0.500 millimeter	1	30	30	30	--
1.00 millimeter	1	60	60	60	--
Bed material, sieve diameter, percent finer than					
2.00 millimeter	1	78	78	78	--
4.00 millimeter	1	92	92	92	--
8.00 millimeter	1	99	99	99	--
16.00 millimeter	1	100	100	100	--
Buttermilk Creek near Willis, Kans. (station 10, figure 1)					
Streamflow, instantaneous (cubic feet per second)	105	87	0.32	1,200	151
Sediment concentration, suspended (milligrams per liter)	105	2,810	95	15,700	3,250
Sediment discharge, suspended (tons per day)	94	1,270	0.21	28,600	3,510
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	12	42	24	90	18
0.004 millimeter	13	50	28	93	18
0.008 millimeter	9	58	42	77	13
0.016 millimeter	13	71	46	100	16
0.031 millimeter	8	90	82	97	6
0.062 millimeter	15	97	89	100	3
0.125 millimeter	13	99	91	100	2
0.250 millimeter	3	98	94	100	--
0.500 millimeter	1	99	99	99	--
1.00 millimeter	1	100	100	100	--

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Wolf River at Leona, Kans. (station 11, figure 1)					
Streamflow, instantaneous (cubic feet per second)	76	1,070	31	6,500	1,250
Sediment concentration, suspended (milligrams per liter)	76	7,200	132	49,600	7,630
Sediment discharge, suspended (tons per day)	49	18,100	15	86,900	25,300
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	24	38	19	61	10
0.004 millimeter	26	44	26	63	9
0.008 millimeter	20	51	33	72	11
0.016 millimeter	26	64	44	85	11
0.031 millimeter	19	84	66	97	9
0.062 millimeter	26	96	84	99	4
0.125 millimeter	26	98	89	100	2
0.250 millimeter	15	99	92	100	2
0.500 millimeter	9	100	99	100	0
1.00 millimeter	1	100	100	100	--
Wolf River near Sparks, Kans. (station 12, figure 1)					
Streamflow, instantaneous (cubic feet per second)	156	1,660	4.1	20,200	2,600
Sediment concentration, suspended (milligrams per liter)	167	8,920	3	61,700	9,390
Sediment discharge, suspended (tons per day)	127	40,700	0.03	566,000	69,200
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	61	35	16	78	14
0.004 millimeter	63	42	24	85	15
0.008 millimeter	39	52	31	90	15
0.016 millimeter	60	62	28	95	16
0.031 millimeter	36	86	68	99	7
0.062 millimeter	63	96	62	100	6
0.125 millimeter	58	98	74	100	4
0.250 millimeter	25	99	95	100	2
0.500 millimeter	11	100	99	100	0
1.00 millimeter	1	100	100	100	--

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Little Delaware River near Horton, Kans. (station 13, figure 1)					
Streamflow, instantaneous (cubic feet per second)	119	231	1.2	4,000	416
Sediment concentration, suspended (milligrams per liter	119	1,960	143	17,000	2,830
Sediment discharge, suspended (tons per day)	117	1,310	0.46	22,600	2,690
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	16	46	24	82	19
0.004 millimeter	17	58	36	96	19
0.008 millimeter	8	72	49	96	19
0.016 millimeter	16	75	59	97	13
0.031 millimeter	7	93	88	98	5
0.062 millimeter	17	98	90	99	2
0.125 millimeter	17	100	99	100	0
0.250 millimeter	2	100	100	100	--
Bed material, fall diameter, percent finer than					
0.004 millimeter	1	4	4	4	--
0.062 millimeter	1	10	10	10	--
0.125 millimeter	1	12	12	12	--
0.250 millimeter	1	18	18	18	--
Bed material, fall diameter, percent finer than					
0.500 millimeter	1	39	39	39	--
1.00 millimeter	1	55	55	55	--
Bed material, sieve diameter, percent finer than					
2.00 millimeter	1	57	57	57	--
4.00 millimeter	1	65	65	65	--
8.00 millimeter	1	72	72	72	--
16.0 millimeter	1	94	94	94	--
32.0 millimeter	1	100	100	100	--

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Little Grasshopper Creek near Effingham, Kans. (station 14, figure 1)					
Streamflow, instantaneous (cubic feet per second)	23	268	9.0	810	298
Sediment concentration, suspended (milligrams per liter)	23	1,840	95	7,350	1,840
Sediment discharge, suspended (tons per day)	23	1,670	2.8	10,500	2,660
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	5	62	47	77	12
0.004 millimeter	5	69	52	92	17
0.008 millimeter	5	76	61	98	16
0.016 millimeter	5	86	76	100	11
0.031 millimeter	3	94	90	97	--
0.062 millimeter	5	98	97	100	1
0.125 millimeter	4	100	99	100	0
0.250 millimeter	1	100	100	100	--
Little Grasshopper Creek at Muscotah, Kans. (station 15, figure 1)					
Streamflow, instantaneous (cubic feet per second)	36	821	24	4,050	1,100
Sediment concentration, suspended (milligrams per liter)	36	2,720	518	12,200	2,660
Sediment discharge, suspended (tons per day)	35	4,500	54	32,600	6,600
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	5	49	38	61	9
0.004 millimeter	5	59	46	78	13
0.008 millimeter	5	65	53	89	14
0.016 millimeter	5	77	67	97	12
0.031 millimeter	4	93	89	95	3
0.062 millimeter	5	98	96	100	2
0.125 millimeter	4	100	100	100	0

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Little Grasshopper Creek at Muscotah, Kans. (station 15, figure 1)--Continued					
Bed material, fall diameter, percent finer than					
0.062 millimeter	1	4	4	4	--
0.125 millimeter	1	10	10	10	--
0.250 millimeter	1	38	38	38	--
0.500 millimeter	1	66	66	66	--
1.00 millimeter	1	99	99	99	--
Bed material, sieve diameter, percent finer than					
2.00 millimeter	1	99	99	99	--
4.00 millimeter	1	99	99	99	--
16.0 millimeter	1	100	100	100	--
Coal Creek near Arrington, Kans. (station 16, figure 1)					
Streamflow, instantaneous (cubic feet per second)	14	33	3.0	180	53
Sediment concentration, suspended (milligrams per liter)	14	1,340	158	4,750	1,310
Sediment discharge, suspended (tons per day)	14	193	3.4	1,200	371
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	1	37	37	37	--
0.004 millimeter	1	45	45	45	--
0.016 millimeter	1	62	62	62	--
0.062 millimeter	1	96	96	96	--
0.125 millimeter	1	99	99	99	--
0.250 millimeter	1	100	100	100	--

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Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Coal Creek near Halfmound, Kans. (station 17, figure 1)					
Streamflow, instantaneous (cubic feet per second)	29	160	5.0	925	220
Sediment concentration, suspended (milligrams per liter)	29	3,000	115	9,550	2,880
Sediment discharge, suspended (tons per day)	29	2,020	3.0	16,800	3,740
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	7	41	25	68	19
0.004 millimeter	7	49	30	77	20
0.008 millimeter	5	63	37	85	21
0.016 millimeter	7	70	49	94	18
0.031 millimeter	4	86	70	99	12
0.062 millimeter	7	96	80	100	7
0.125 millimeter	6	97	84	100	6
0.250 millimeter	3	97	90	100	--
0.500 millimeter	1	99	99	99	--
1.00 millimeter	1	100	100	100	--
Sixmile Creek tributary 5 miles northeast of Auburn, Kans. (station 18, figure 1)					
Streamflow, instantaneous (cubic feet per second)	25	58	0.35	278	73
Sediment concentration, suspended (milligrams per liter)	25	1,480	108	15,000	3,010
Sediment discharge, suspended (tons per day)	22	136	0.10	677	226
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	4	48	35	77	20
0.004 millimeter	3	56	38	84	--
0.008 millimeter	3	68	56	88	--
0.016 millimeter	4	83	75	93	8
0.031 millimeter	2	88	86	91	--
0.062 millimeter	4	96	94	98	2
0.125 millimeter	3	99	97	100	--
0.250 millimeter	1	98	98	98	--
0.500 millimeter	1	100	100	100	--

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Sixmile Creek tributary 4 miles northeast of Auburn, Kans. (station 19, figure 1)					
Streamflow, instantaneous (cubic feet per second)	27	74	0.17	335	103
Sediment concentration, suspended (milligrams per liter)	27	3,200	78	26,300	5,340
Sediment discharge, suspended (tons per day)	22	401	0.12	3,560	967
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	5	53	35	73	15
0.004 millimeter	4	62	44	86	18
0.008 millimeter	3	76	64	92	--
0.016 millimeter	5	81	69	95	10
0.031 millimeter	3	94	89	98	--
0.062 millimeter	5	99	98	100	1
0.125 millimeter	4	100	100	100	0
Wakarusa River 5 miles west of Auburn, Kans. (station 20, figure 1)					
Streamflow, instantaneous (cubic feet per second)	34	143	0.30	504	172
Sediment concentration, suspended (milligrams per liter)	34	2,490	49	8,590	2,690
Sediment discharge, suspended (tons per day)	25	618	0.21	5,160	1,390
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	2	43	41	45	--
0.004 millimeter	3	53	52	54	--
0.008 millimeter	2	63	62	64	--
0.016 millimeter	3	76	75	76	--
0.031 millimeter	2	90	90	90	--
0.062 millimeter	3	97	95	99	--
0.125 millimeter	3	100	100	100	--

Table 15.--Statistical summaries of fluvial-sediment data collected at project stations--Continued

Fluvial-sediment parameters	Number of samples	Mean	Minimum value	Maximum value	Standard deviation
Wakarusa River 4 miles west of Auburn, Kans. (station 21, figure 1)					
Streamflow, instantaneous (cubic feet per second)	32	154	1.5	550	165
Sediment concentration, suspended (milligrams per liter)	32	1,900	52	7,670	1,990
Sediment discharge, suspended (tons per day)	26	752	0.47	7,180	1,660
Sediment, suspended, fall diameter, percent finer than					
0.002 millimeter	1	42	42	42	--
0.004 millimeter	1	53	53	53	--
0.008 millimeter	1	60	60	60	--
0.016 millimeter	1	72	72	72	--
0.031 millimeter	1	85	85	85	--
0.062 millimeter	1	94	94	94	--
0.125 millimeter	1	100	100	100	--