EVALUATION OF A HYDROGRAPH-SHIFTING METHOD FOR ESTIMATING SUSPENDED-SEDIMENT LOADS IN ILLINOIS STREAMS

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CONVERSION FACTORS AND ABBREVIATIONS

The following factors may be used to convert the inch-pound units published herein to the International System of Units (SI). These factors are shown to four significant figures, but the conventional SI system equivalents should be consistent with the values in inch-pound system.

Multiply inch-pound units	By	To obtain SI units
square mile (mi^2)	2.590	square kilometer (km^2)
ton, short	0.9072	megagram (Mg)

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ABSTRACT

A hydrograph-shifting method for estimating monthly and annual suspended-sediment loads was applied to suspended-sediment records for 12 streams in Illinois. Transport equations for each station were obtained from 2 years of suspended-sediment discharge and streamflow data. Synthetic sediment-discharge hydrographs were generated by using the transport equations and daily records of streamflow. These hydrographs were shifted to measured values of daily sediment discharge (control points) selected to represent weekly, biweekly, and monthly sampling frequencies. Estimates of monthly suspended-sediment load ranged from 16 to 326 percent of measured values. Estimates of annual suspended-sediment loads ranged from 41 to 136 percent of measured values, which indicates that the method provides a reasonable means of estimating annual loads for most sites. An experiment designed to measure the subjectivity of the method showed it to be more dependent on the particular days selected as control points than on the person applying the method. An evaluation of the effect of the length of record used to develop transport equations on sediment load estimates was not conclusive. Although standard errors of estimate showed no improvement, the comparison of estimated loads with measured loads showed slight improvement when an additional 1 or 2 years of data were added to the first year of data used to develop transport equations.

INTRODUCTION

Water-resource planning and water-quality assessment require information on sediment concentrations and loads in streams. Studies under Section 208 of Public Law 92-500 have suggested that sediment may be a major cause of water-quality degradation in Illinois (Illinois Environmental Protection Agency, 1979). Sources of sediment include agricultural lands, highway construction sites, and industrial and residential development sites. The increasing cost of operating a daily suspended-sediment station has heightened interest by governmental agencies in using alternate methods to compute sediment loads.

Purpose

The primary purpose of this study is to evaluate a hydrograph-shifting method for calculating suspended-sediment discharges and loads in Illinois streams. In addition, the frequency of sampling and subjectivity involved in applying the hydrograph-shifting method are evaluated.

Scope

Twelve stations, for which at least 2 years of daily suspended-sediment discharge were available, were selected for evaluation of the method. Eight sites, for which there were more than 3 years of data, were selected to evaluate the effect of different lengths of record on the quality of the sediment transport equation. Estimates of monthly and annual loads were compared to published (measured) data to determine the accuracy of the method. Nine people used the method on data for one station to investigate the subjectivity of the method. Shifting of sediment-discharge hydrographs to published values for every 7th, 14th, and 28th day was done to simulate weekly, biweekly, and monthly sampling frequencies.

METHOD

A method of shifting a generalized sediment-discharge hydrograph to known values was referred to as the "shift-control" method by Colby (1956, p. 46).

The application of such a method requires that sufficient data be available to define a sediment transport curve (a relation between suspended-sediment discharge and streamflow). The relation, along with daily water discharges, is used to generate estimated daily sediment discharges. These estimated discharges are plotted in semi-logarithmic hydrograph form and then the hydrograph is adjusted (shifted) to pass through or near known daily suspended-sediment discharges (control points). In practice, the control points are periodic instantaneous or daily discharges determined from suspended-sediment concentrations and streamflow. After shifting the base hydrograph to the control points, daily values are determined from the graph and are summed to give monthly and annual sediment loads. The method has potential usefulness in making estimates of suspended-sediment loads for sites where daily sampling has been discontinued but less frequent sampling occurs.

Data

From 18 sites in Illinois for which 2 or more years of sediment data are available, 12 were selected for evaluation of the shift-control method. Eight of the 18 sites had 3 or more years of record and were selected for an evaluation of the effects of varying lengths of record on the quality of the sediment transport equations. The basis for selection was the degree of linear correlation between the logarithms of suspended-sediment concentration and water discharge, and the completeness of daily records. The stations, corresponding drainage areas, and periods of record are shown in table 1.

Transport Equations

Linear relations, from least-squares regression analyses, between the logarithms of suspended-sediment discharge and streamflow were developed for the 12 stations as shown in figures 1 through 12. A single regression line does not always represent the transport relation best; however, the effort required to sort sediment discharges by their relation to stage, water discharge, seasonality, or land use during the period of record was beyond the scope of this study. Figures 1 through 12 indicate that single linear segments were adequate for the purposes of this report. Factors which affect suspended-sediment concentrations also affect the scatter of points in the sediment discharge versus water discharge plots. Such variations may be accounted for by more sophisticated transport equations than those used in this report. The variations in the lower values in figures 6 and 7, for examples, might be explained by changes in land use, channel morphology, or by the use of two different sampling techniques for low flows. The stringing-out or looping of data points in figure 10 may represent the commonly occurring effect that varying sediment availability (generally more is available during rising than falling stages) has on daily sediment concentrations and discharges. Seasonality in the sediment discharges is shown in figure 13 which is a plot of the residuals from the regression of the logarithms of sediment discharges on the logarithms of water discharges for the Iroquois River near Chebanse. As an example of the improvement in regression equations that is possible when accounting for seasonality, an additional regression analysis was done after adding day of the year as a second independent variable. The standard error of estimate for the transport equations was reduced from an average of 94 percent to an average of 45 percent by relating the logarithm of sediment discharge to a function of the day of the year as well as to the logarithm of water discharge. Correlation coefficients between daily mean suspended-sediment concentrations and daily mean water discharges, regression coefficients, and average standard errors of estimate for the transport equations are shown in table 2.

Transport equations were also developed from 1, 2, and 3 years of sediment discharge and streamflow records for eight stations to evaluate the effect of using various lengths of record to obtain transport curves. No shifts were applied to these estimates. Standard errors of estimate indicated that little or no improvement was made by adding the second or third years' data to the analyses. However, as shown in table 3, comparison of loads estimated by the three transport equations with those computed from daily suspended-sediment data generally showed slight improvement. Ratios of these estimated loads to measured loads improved by 2.5 and 2.4 percent, respectively, when increasing the data set from 1 to 2 years and from 2 to 3 years. The improvement affected by adding 2 years of data to the first year averaged 4.1 percent.

Hydrograph Shifting

Hydrographs generated from transport equations and streamflow data were shifted to control points spaced at 7-, 14-, and 28-day intervals to represent weekly, biweekly, and monthly sampling frequencies. Actual values used for control points in this study were daily suspended-sediment discharges from published data (U.S. Geological Survey, 1980-82). In practice, the control points would be instantaneous or daily discharges computed from streamflow and periodic sample data.

Generally, the shifted hydrograph was similar in shape to the base hydrograph with some deviation near the control points. When large changes in the base hydrograph were made, they were done by starting the deviation from the shape of the base at or near the onset of the streamflow change that seemed responsible for the change in sediment discharge.

Some guidelines were established to keep the application of the method as uniform as possible. They were: (1) selection of control points would start with the value for October 1, and (2) the shifted hydrograph would pass through all control points. Other guidelines for shifting the base hydrographs were developed for evaluation of the subjectivity of the method.

SUBJECTIVITY OF THE METHOD

The use of from one to five control points to shift a month's sediment discharge record leaves room for personal judgment in the placement of the shifted hydrograph. When fewer control points are used, the method becomes, in general, more subjective because of the need for considerable interpolation between the points.

In addition, selection of different points will result in different shifting of the hydrograph. The control points selected at fixed intervals will depend on the starting date and the sampling frequency. A simple experiment was designed to evaluate the subjective aspects of the hydrograph-shifting procedure described in this report.

Nine people independently used the shift-control procedure on the 1981 hydrograph for the Kankakee River near Wilmington. All control points were used (shifted hydrograph would pass through all control points) in order to reduce the participants' tendencies to rely heavily upon their experience to draw the curves instead of shifting the base hydrograph to the control points.

The nine participants were divided into groups of three. The first group selected control points (published daily sediment discharges) starting with the October 1, 1980, value; the second group with the October 10, 1980, value; and the third group with the October 20, 1980, value. Each group used every 7th, 14th, and 28th daily sediment discharge to represent weekly, biweekly, and monthly sampling frequencies, respectively.

Analysis of variance was used to evaluate the relative importance of starting date and sampling frequency. Results indicated that starting date was the more important of the two for this site and year of record. The starting date (and subsequent dates at the prescribed fixed intervals) may be important because of differences between sediment availability on these and other dates and on the several days preceding them. The differences could be particularly significant during spring runoff when large percentages of the annual suspended-sediment loads are discharged in several days' runoff.

Ratios of the annual sediment discharges calculated by using the hydrograph-shifting method to those computed from daily sediment-discharge records were plotted as a histogram in figure 14 to show the distribution of results.

Means and standard deviations of the ratios of shifted to measured sediment discharges are as follows:

Sampling frequency	Mean	Standard deviation
Monthly	0.80	0.29
Biweekly	.83	.25
Weekly	.78	.13

These statistics indicate that although greater reproducibility (decreased dispersion of estimates) resulted from increasing the sampling frequency, accuracy (closeness of ratio to unity) did not improve. The decrease in the standard deviation, with increasing sampling frequency, may be interpreted as less opportunity for subjectivity in the shifting of the hydrograph between control points. The differences of the relatively constant mean values from unity represents a bias in the estimated discharge. The bias probably results, in part, from the use of a simple linear model for the sediment discharge-water discharge relation.

The ratios of estimated to measured sediment loads for each sampling frequency and starting date for Kankakee River near Wilmington are shown in table 4. In general, results obtained from the method seem more influenced by differences in control points used (resulting from use of different starting dates) than by the individuals doing the hydrograph shifting.

ESTIMATES OF MONTHLY AND ANNUAL SUSPENDED-SEDIMENT LOADS

Suspended-sediment loads estimated for each month of the 1981 water year (1980 water year for Iroquois River at Iroquois) and annual suspended-sediment load estimates are shown in table 5.

The monthly load estimates ranged from 16 to 326 percent of measured loads. Monthly estimates are influenced more than annual estimates by differences in the amount of sediment available for transport during higher flows. The differences between estimated and measured annual loads probably reflect differences in sediment availability and storm characteristics between the estimated year and the years used to generate the transport curve rather than a change in the ability of the stream to transport sediment. In addition, some differences may result from representing the transport curve with a simple linear relation.

Estimated annual loads ranged from 41 to 136 percent of measured loads. For all 12 sites, the average ratios of estimated to measured annual loads were: 0.68 for the unshifted base hydrograph, 0.83 for the monthly shift, 0.90 for the biweekly shift, and 0.96 for the weekly shift.

SUMMARY

A synthetic sediment-discharge hydrograph developed from sediment-water discharge relations and records of streamflow can be shifted to once-monthly, or more frequent, values of daily suspended-sediment discharge to provide estimates of monthly and annual suspended-sediment loads. The estimates of monthly suspended-sediment loads were poor, ranging from 16 to 326 percent of measured loads. Estimates of annual loads based on shifting to once-monthly measured values were more accurate, ranging from 41 to 128 percent of measured loads. Estimates made by shifting to biweekly and weekly values were increasingly accurate, ranging from 60 to 136 percent and 71 to 129 percent of measured loads, respectively.

The method seems sensitive to the values used as control points which probably results from variations in sediment availability prior to, and on, days used for control points in the hydrograph-shifting process.

Improvement in accuracy of the method may be possible through better representation of the data by a curvilinear transport curve, a multi-segmented linear transport curve, or one in which seasonality and hysteresis can be quantified or compensated for. The method as applied to Illinois streams is presented herein with errors quantified. Applicability of the method will depend on the magnitude of error acceptable to the user.

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FIGURES 1-14; TABLES 1-5

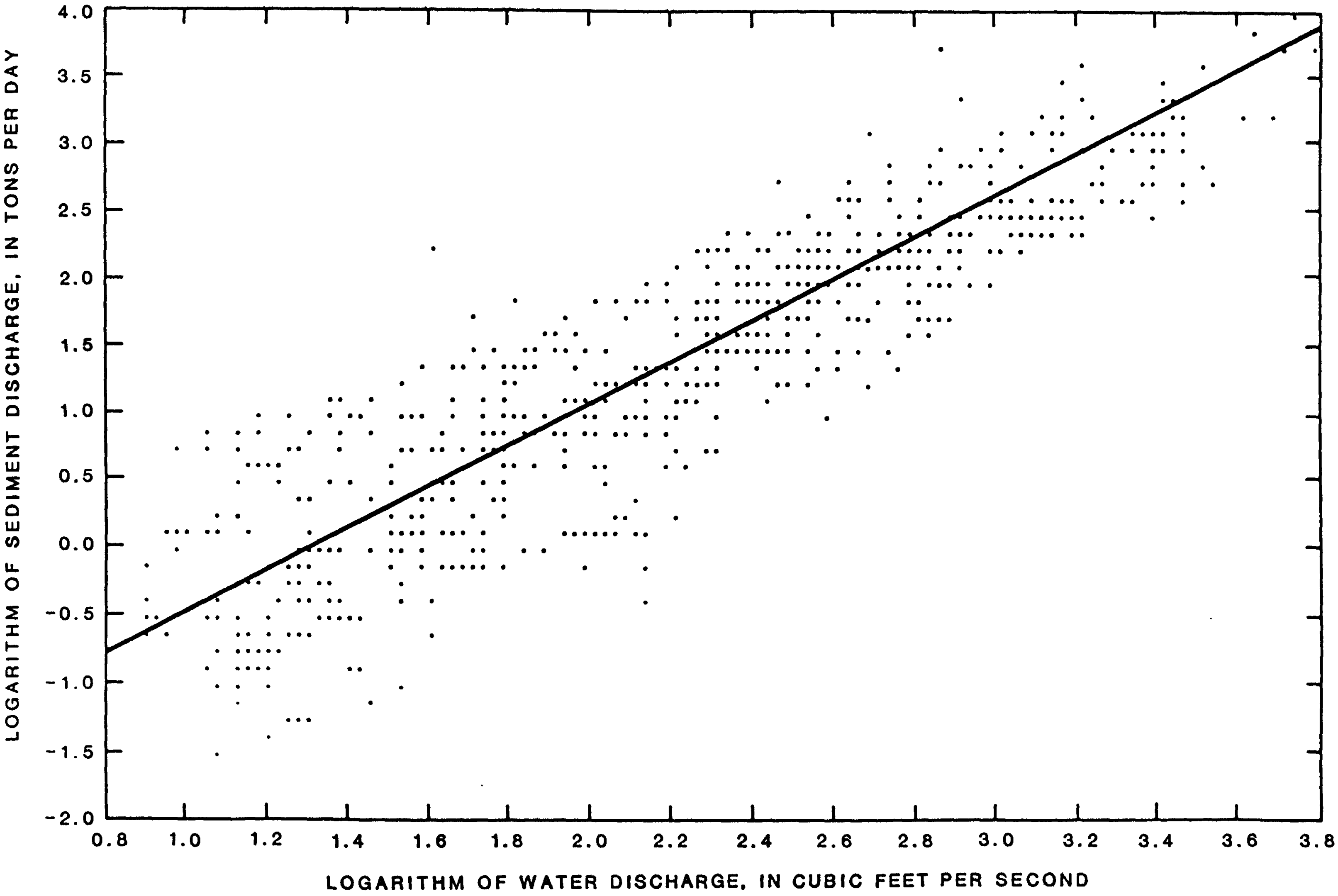

Figure 1.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Embarras River at State Highway 133 near Oakland, 1980-81.

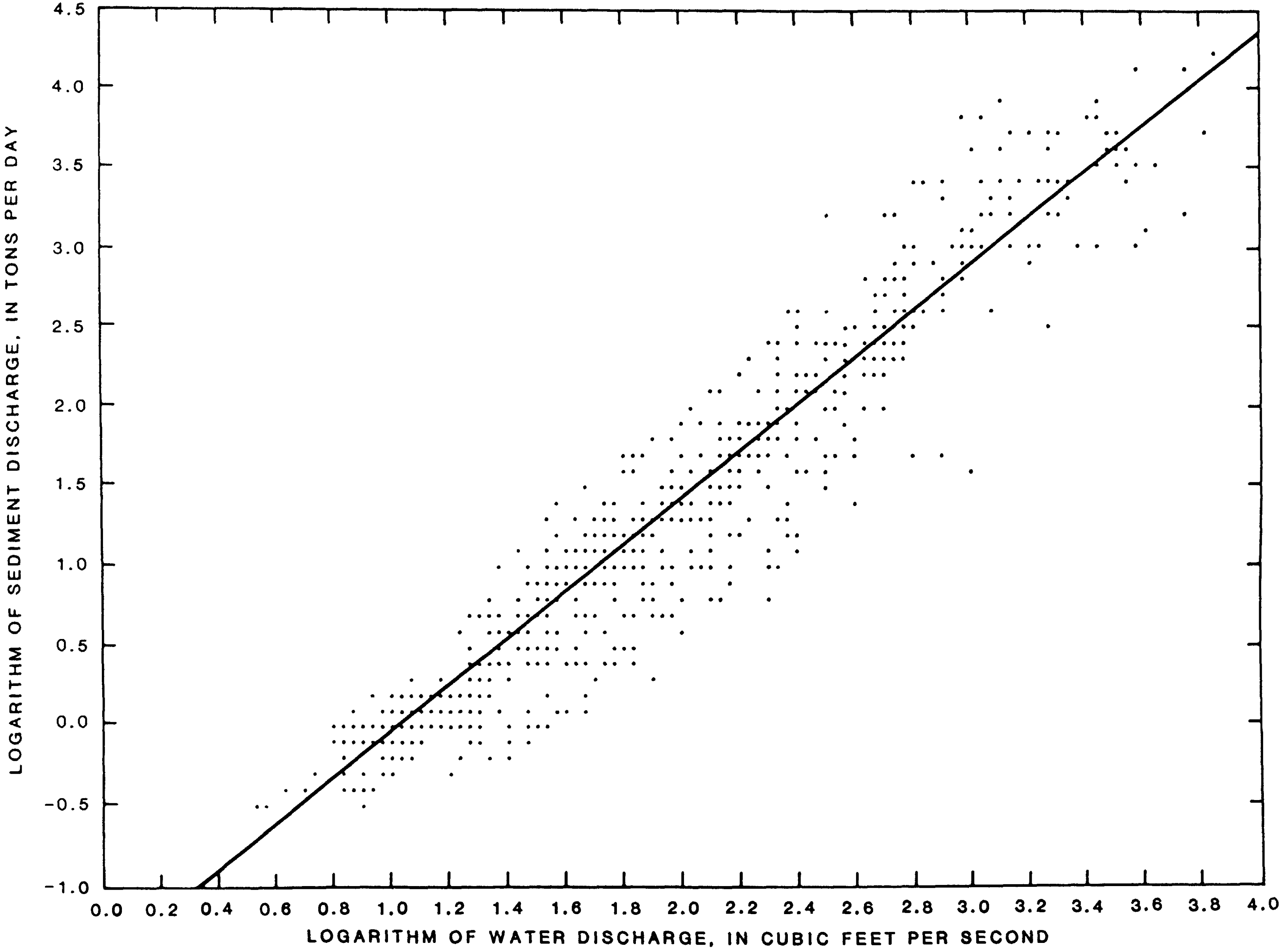

Figure 2.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Little Wabash River at Louisville, 1979-80.

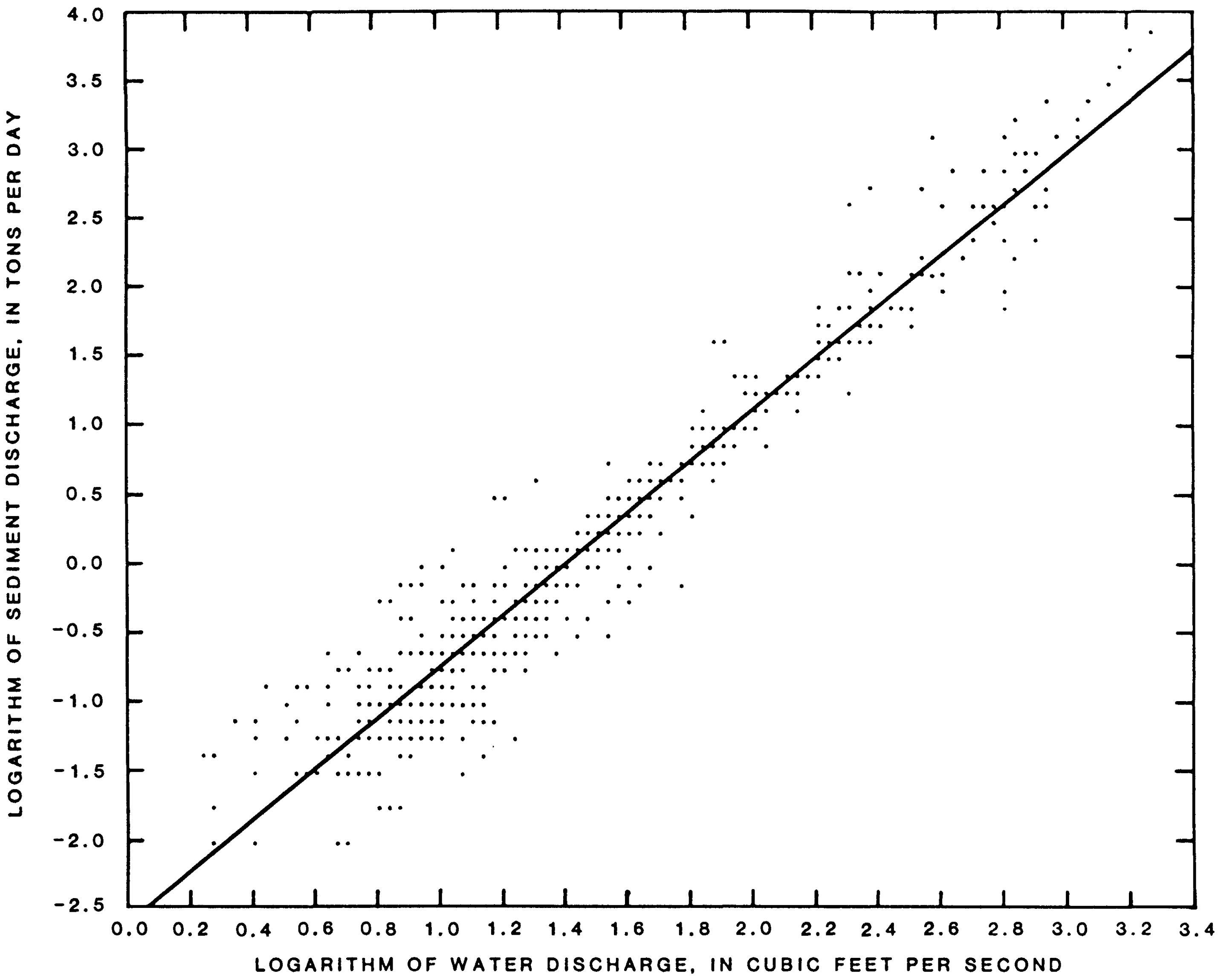

Figure 3.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for South Fork Saline River near Carrier Mills, 1980-81.

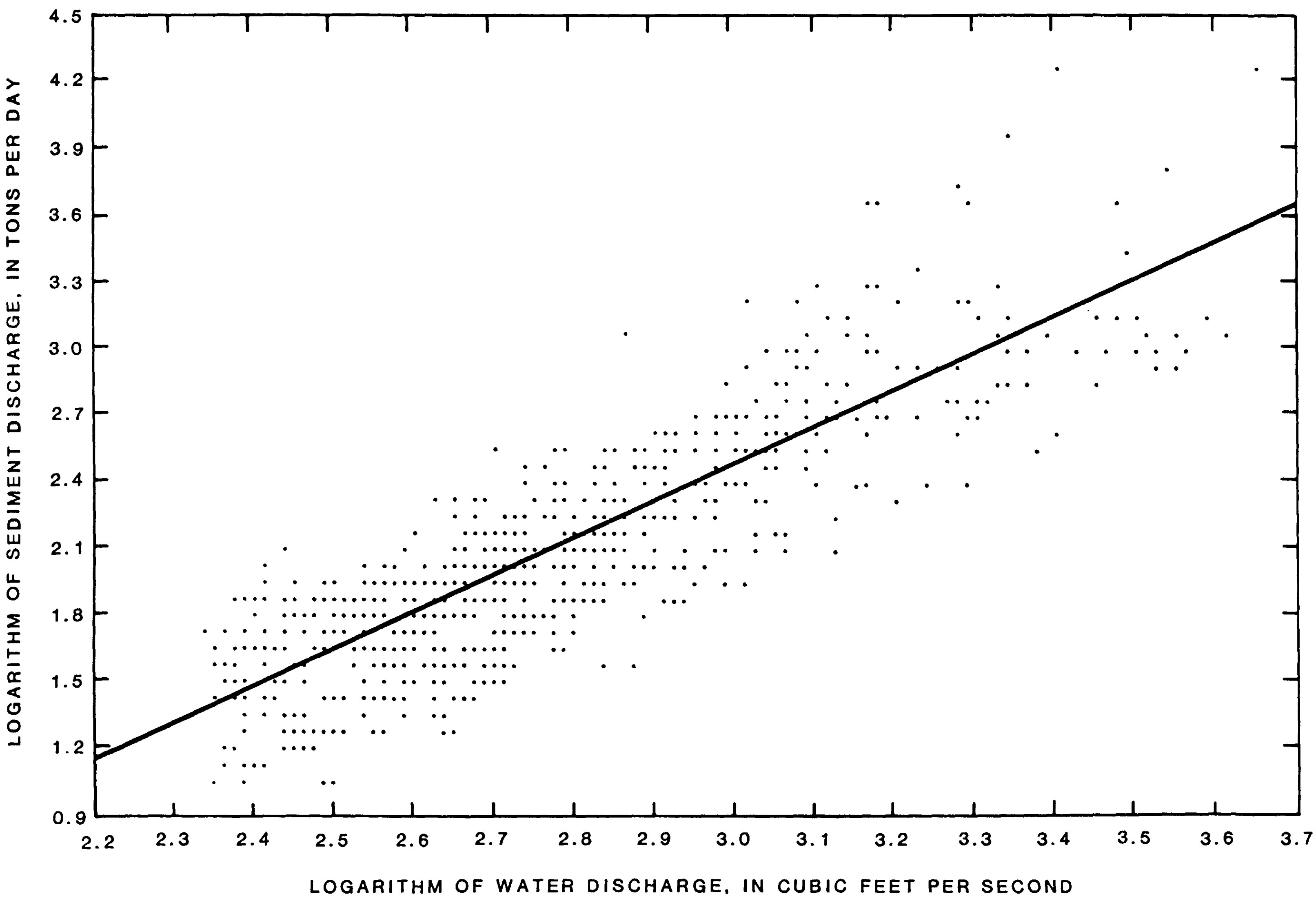

Figure 4.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Kishwaukee River near Perryville, 1980-81.

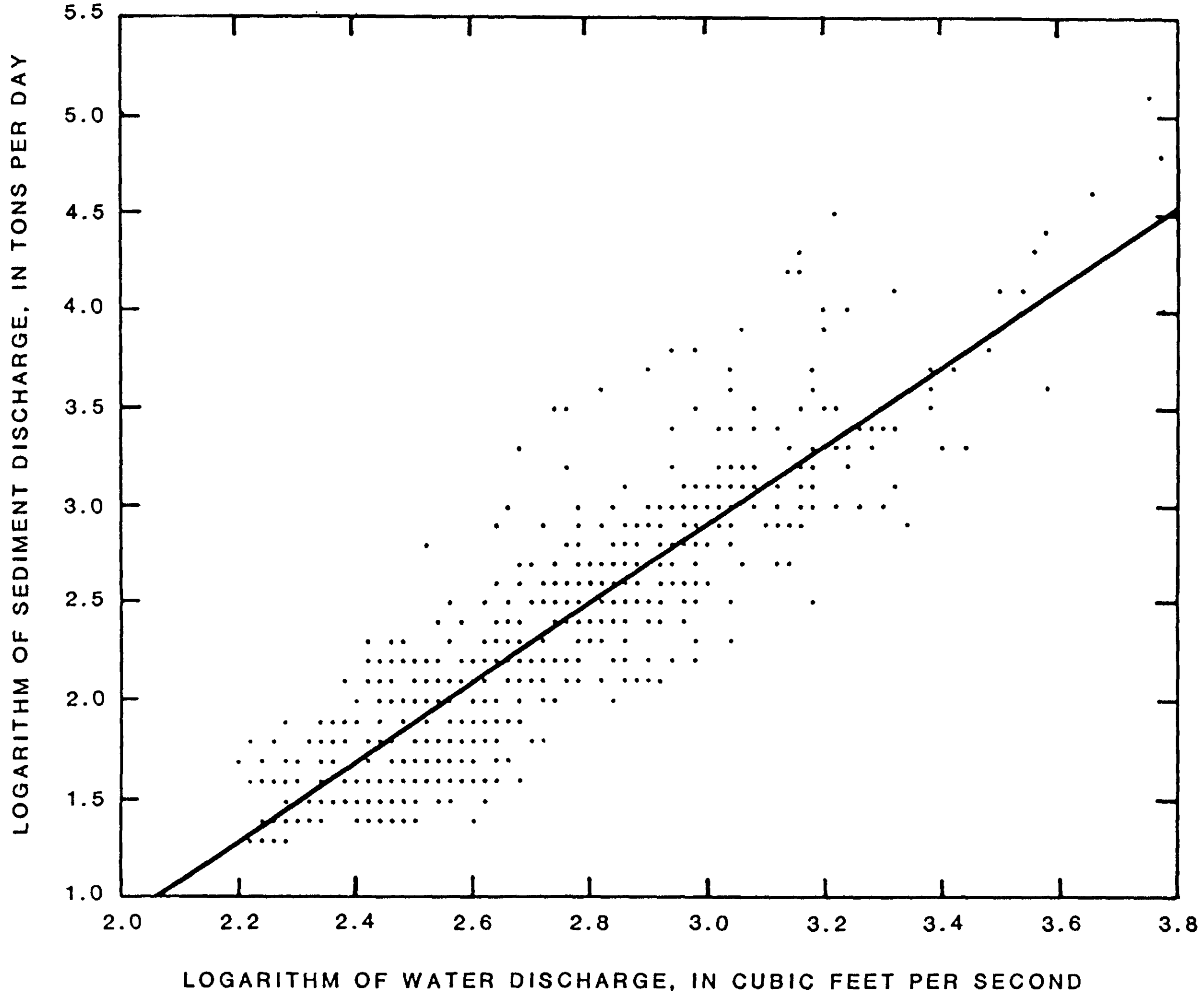

Figure 5.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Green River near Geneseo, 1980-81.

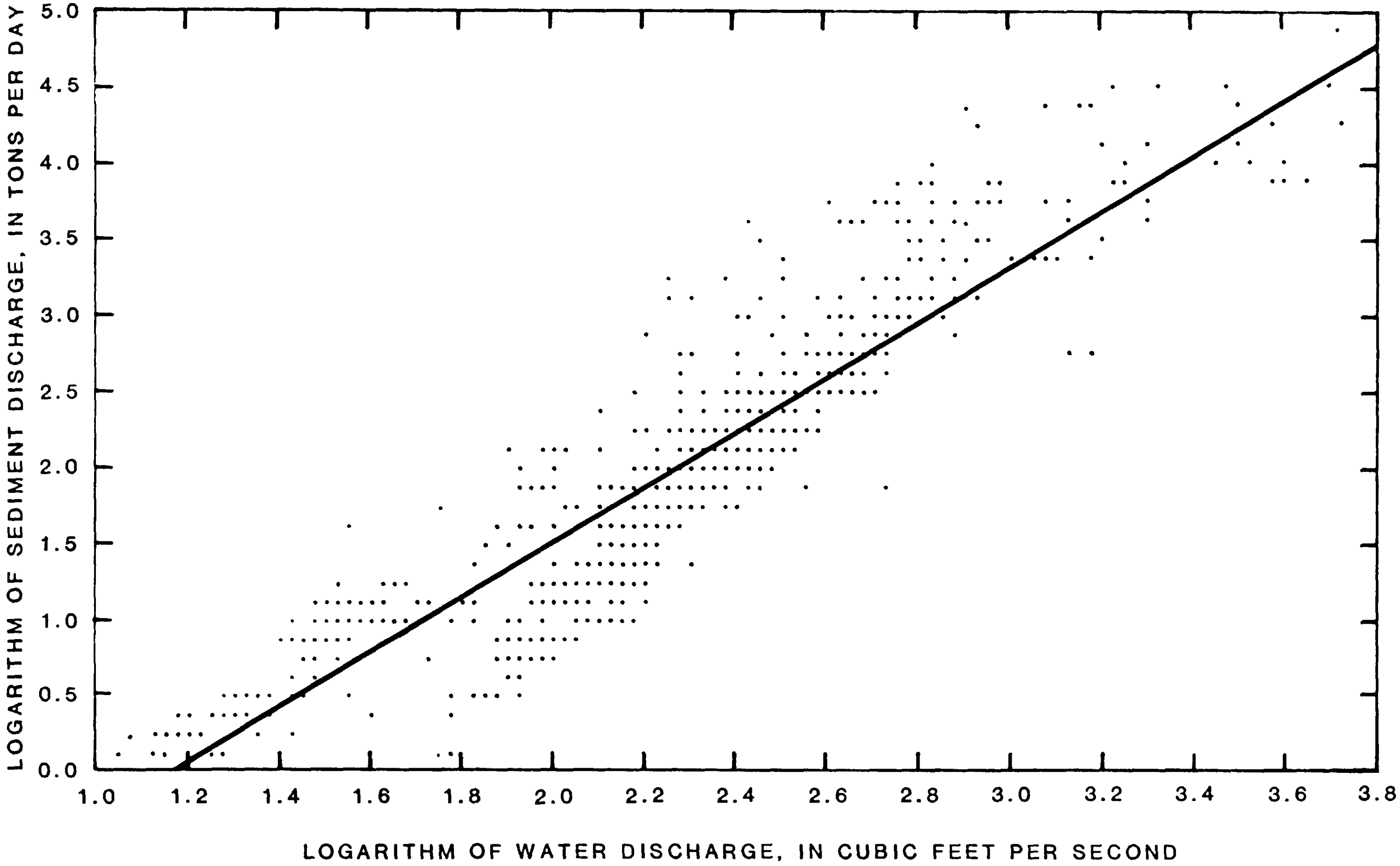

Figure 6.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Edwards River near New Boston, 1980-81.

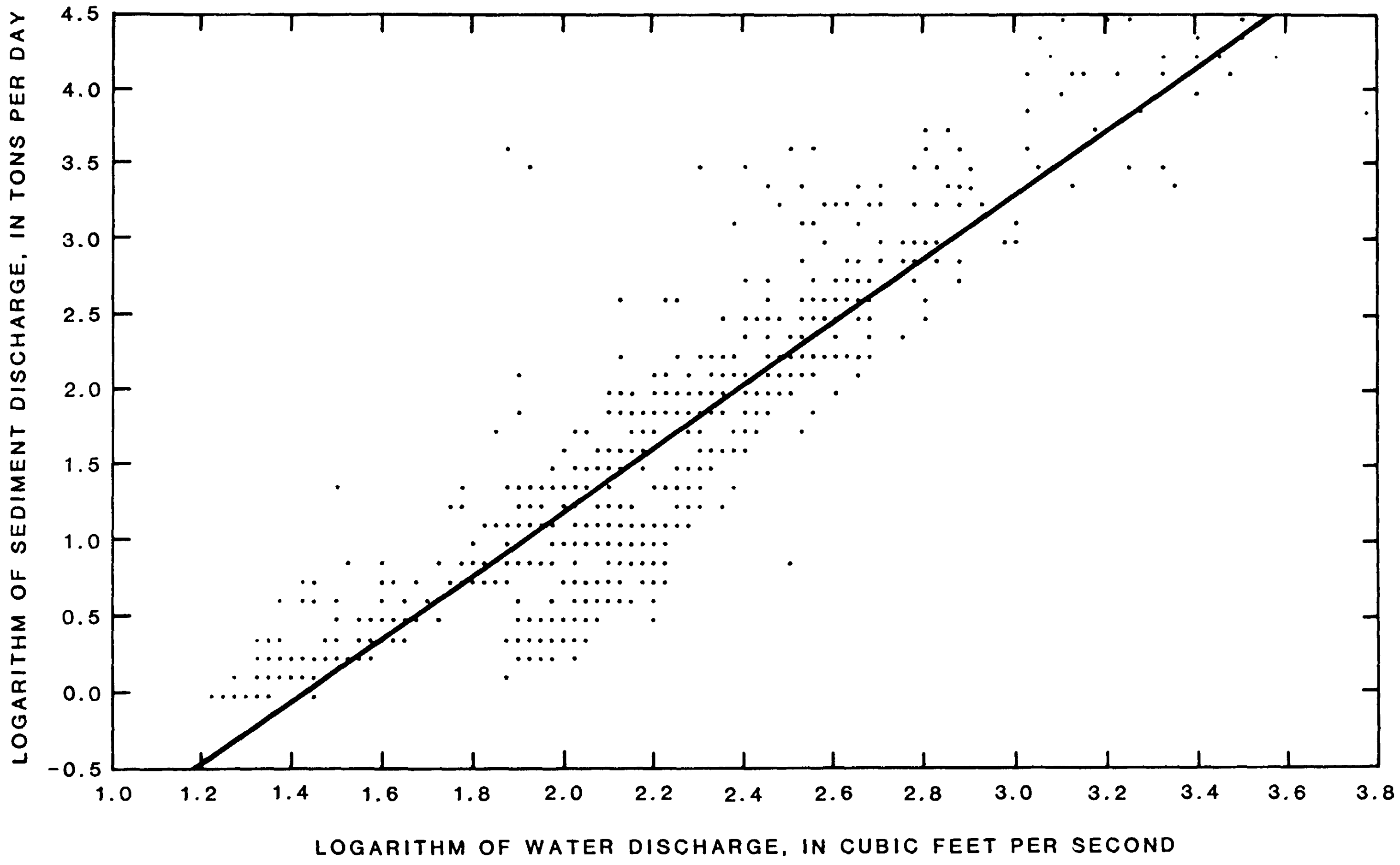

Figure 7.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Henderson Creek near Oquawka, 1980-81.

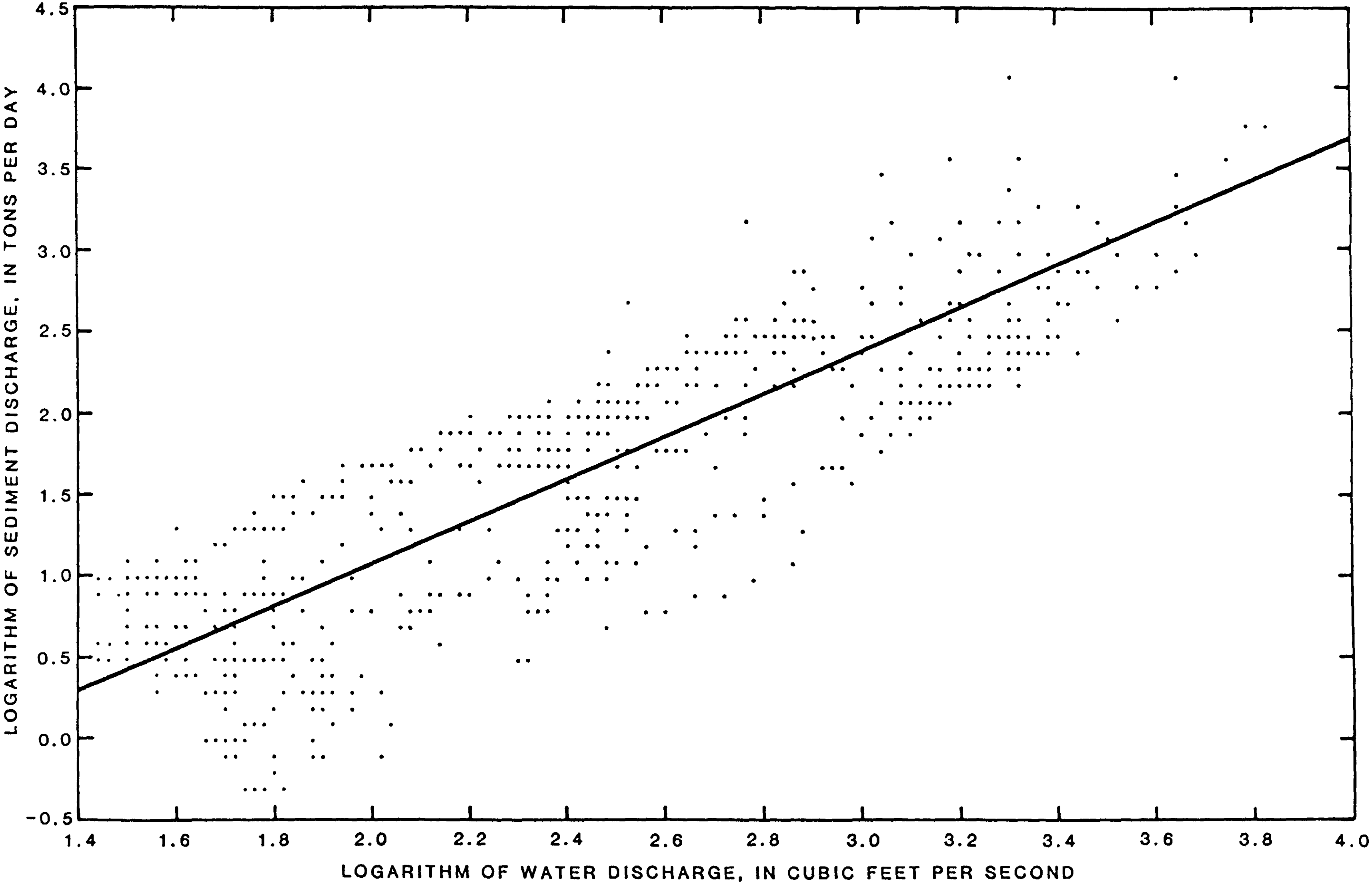

Figure 8.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Iroquois River at Iroquois, 1979-80.

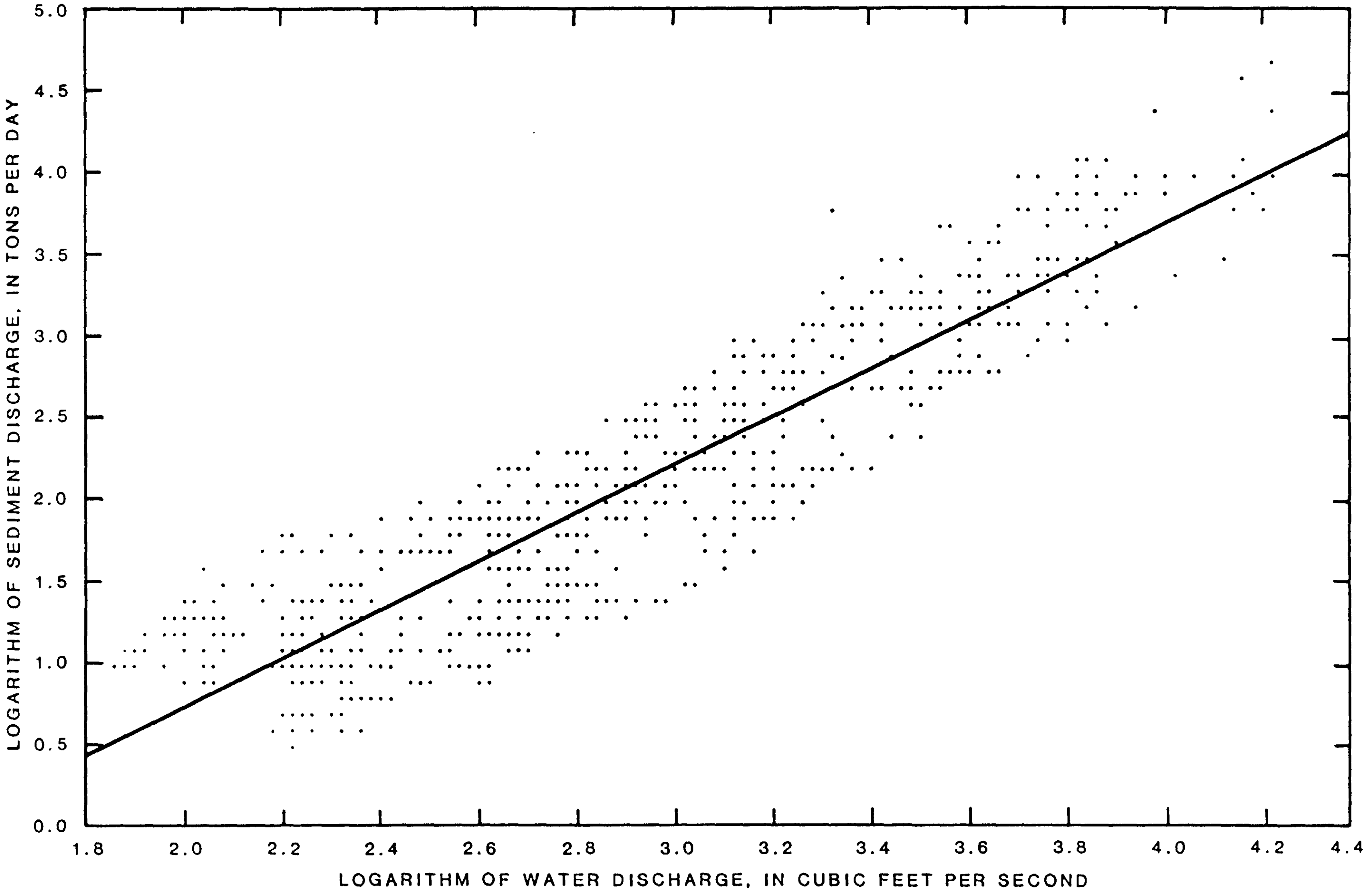

Figure 9.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Iroquois River near Chebanse, 1980-81.

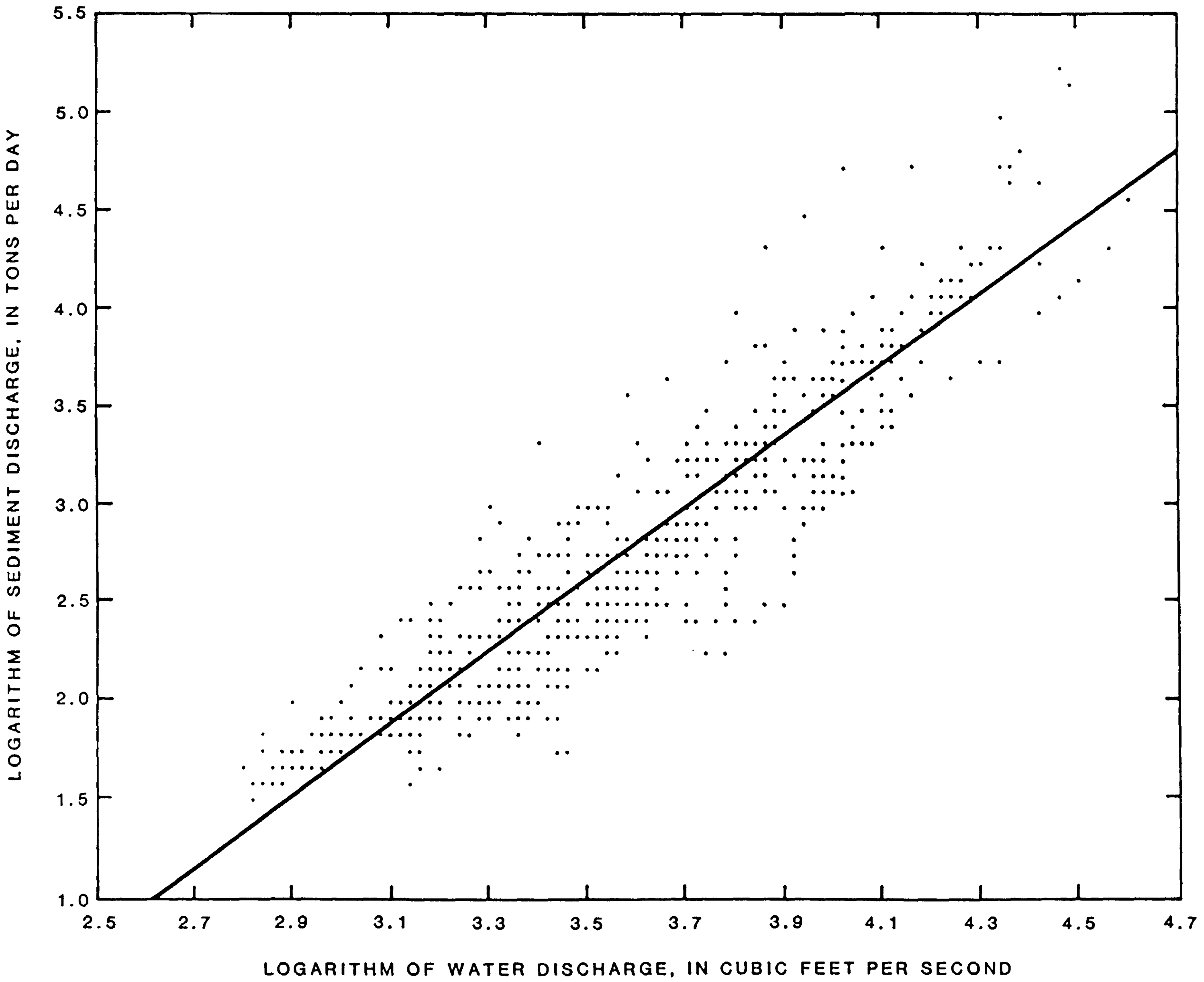

Figure 10.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Kankakee River near Wilmington, 1980-81.

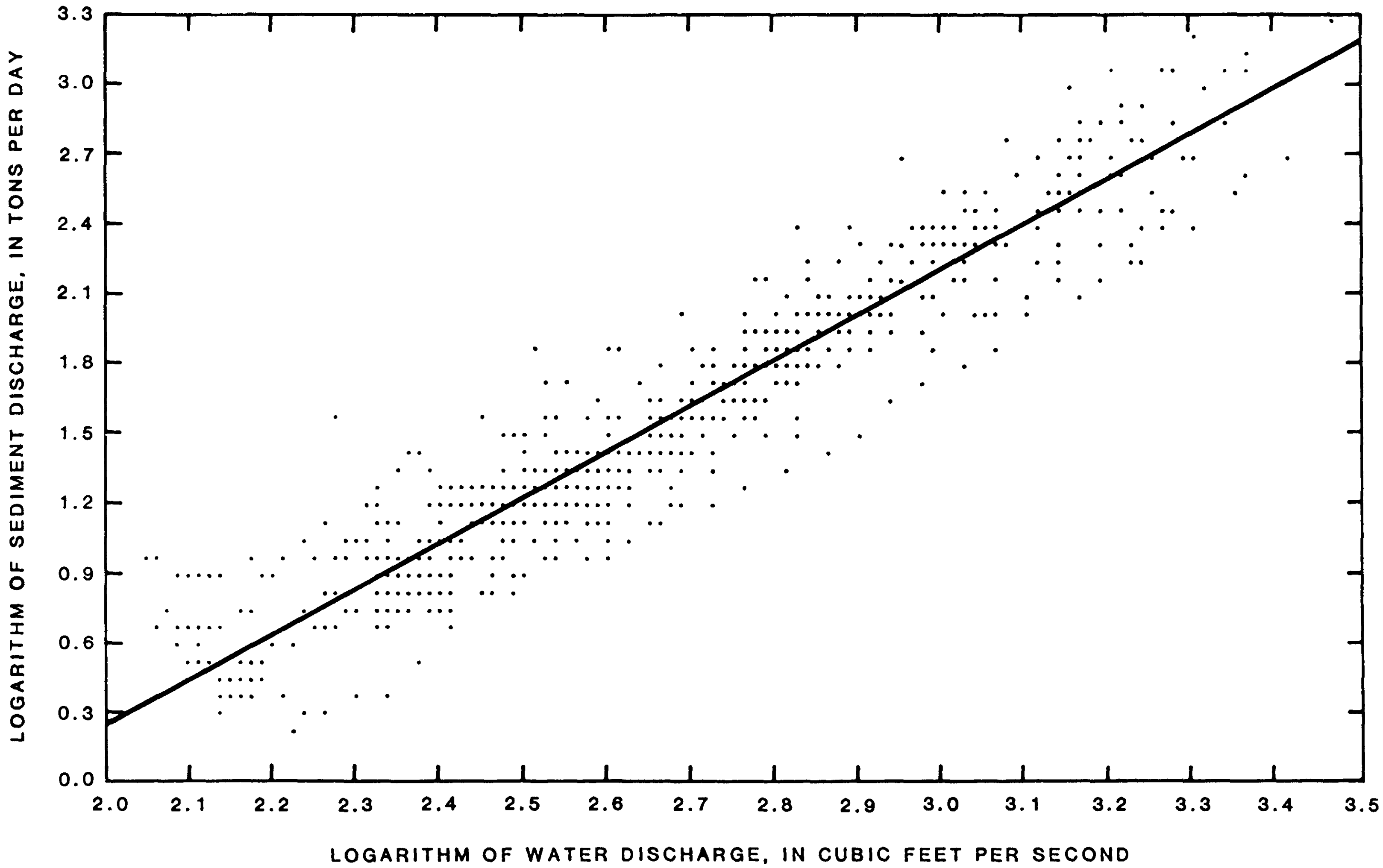

Figure 11.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Des Plaines River at Riverside, 1980-81.

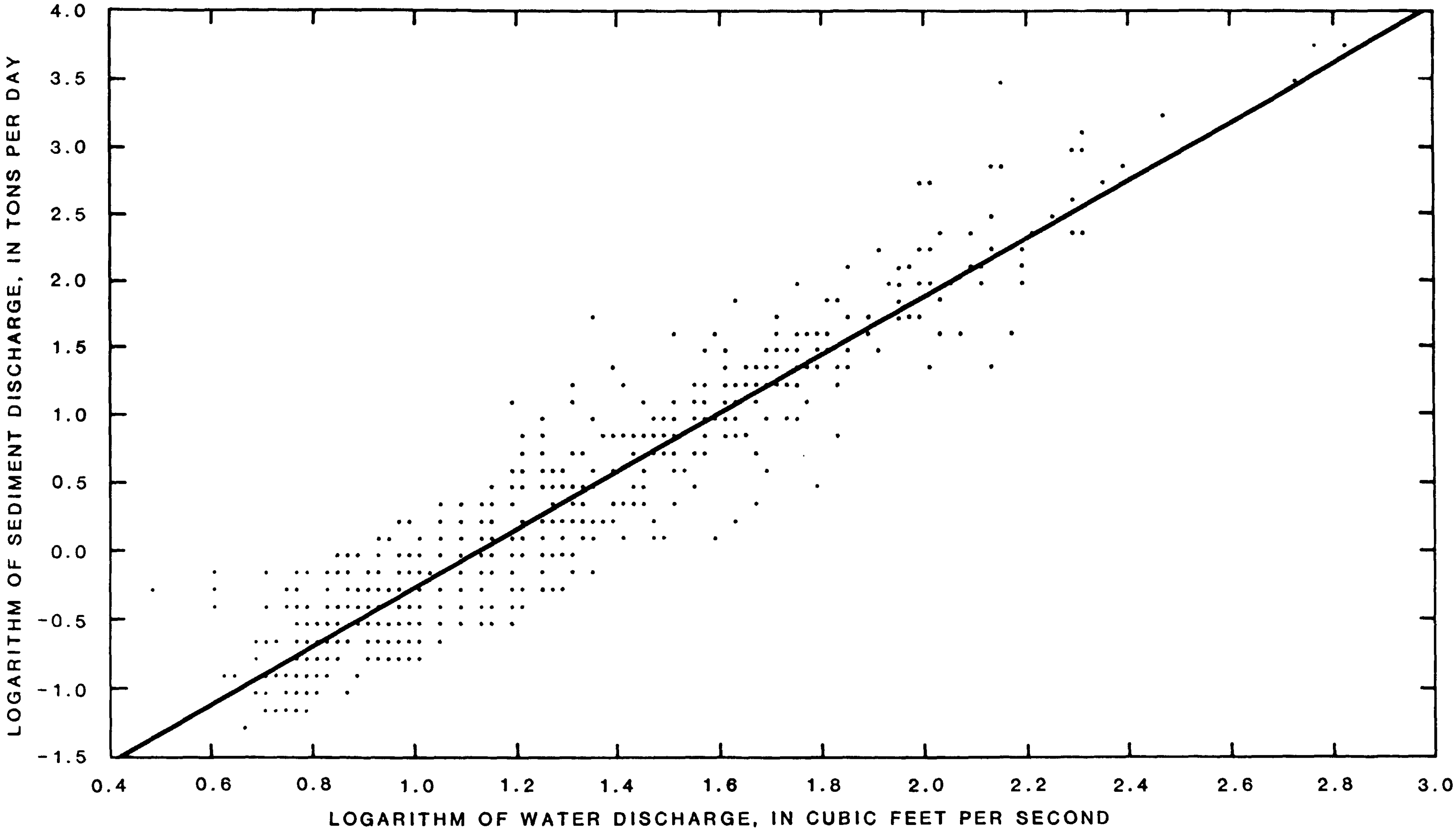

Figure 12.--Logarithm of suspended-sediment discharge versus logarithm of water discharge for Big Creek near Bryant, 1980-81.

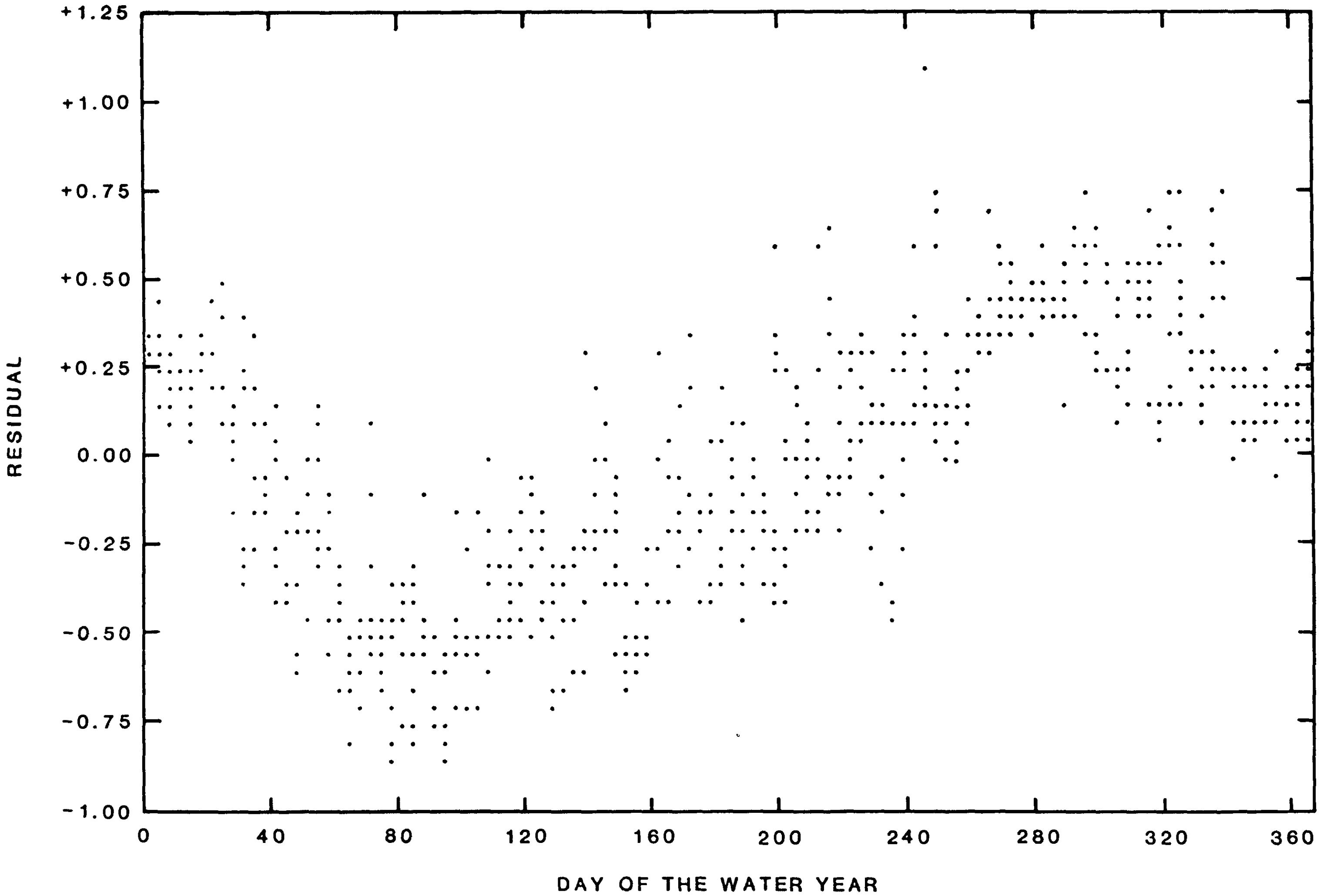

Figure 13.--Residuals versus day of the water year for the regression of logarithms of suspended-sediment discharge on logarithms of water discharge for Iroquois River near Chebanse, 1980-81.

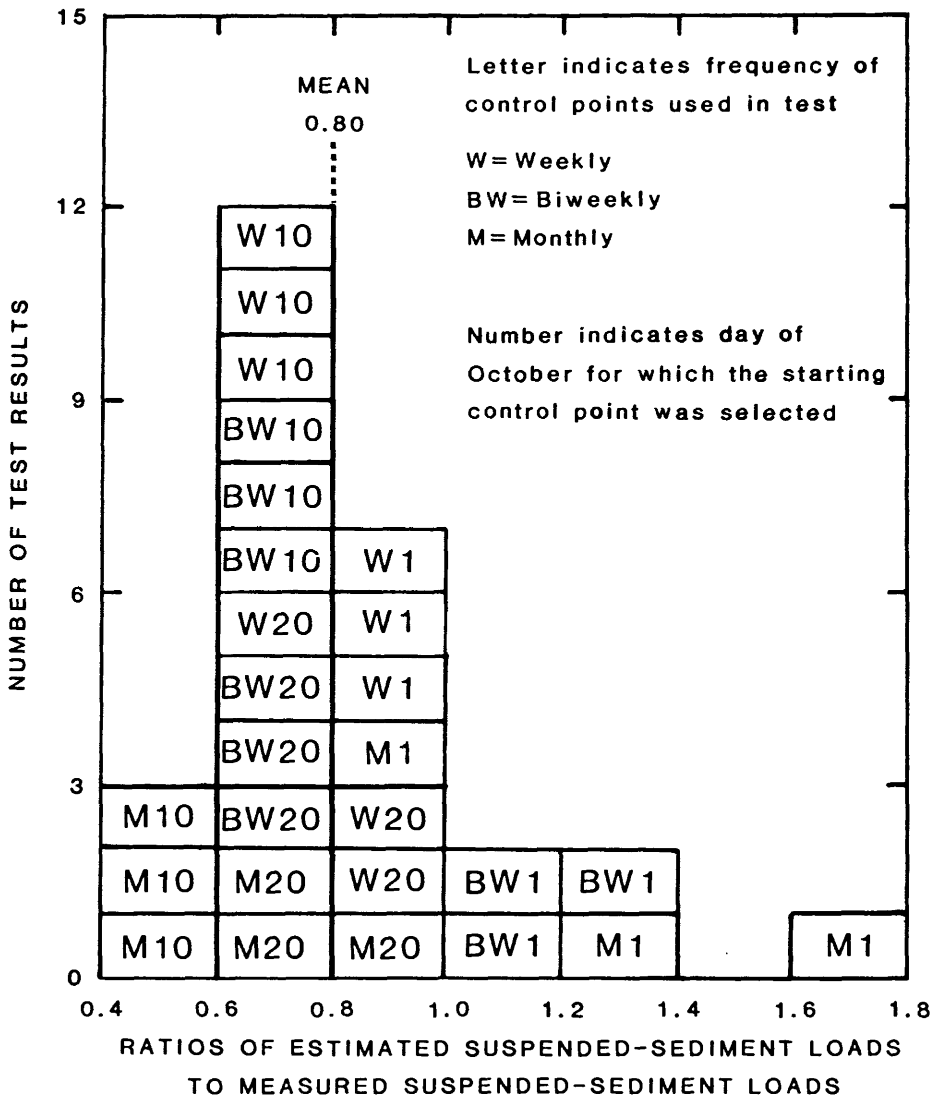

Figure 14.--Distribution of results of subjectivity test

Table 1.--Stations selected for evaluation of shift-control method and effects of length of record on transport equations

Station number	Station name	Drainage area (mi^2)	Period of record (Month/year)
03343550	Embarras River at State Highway 133 near Oakland[1]	542	01/79-09/81
03378900	Little Wabash River at Louisville[1,2]	745	03/77-09/81
03382100	South Fork Saline River near Carrier Mills[1]	147	10/79-09/81
05440000	Kishwaukee River near Perryville[1]	1,099	04/79-09/81
05447500	Green River near Geneseo[1,2]	1,003	04/78-09/81
05466500	Edwards River near New Boston[1]	445	01/79-09/81
05469000	Henderson Creek near Oquawka[1,2]	432	04/78-09/81
05520500	Kankakee River at Momence[2]	2,294	10/78-09/81
05525000	Iroquois River at Iroquois[1]	686	10/78-09/80
05526000	Iroquois River near Chebanse[1,2]	2,091	10/78-09/81
05527500	Kankakee River near Wilmington[1,2]	5,150	10/78-09/81
05532500	Des Plaines River at Riverside[1]	630	04/79-09/81
05570370	Big Creek near Bryant[1,2]	41.2	12/71-09/81
05570380	Slug Run near Bryant[2]	7.12	10/75-09/80

[1] Selected for evaluation of shift-control method.

[2] Evaluated for effects of length of record on loads estimated by sediment transport equations.

Table 2.--Coefficients for correlation between sediment concentration and water discharge and regression parameters and standard errors of estimate for transport equations

Station number	Station name	Years of record used	Correlation coefficient (r)[1]	Regression parameters: Logarithm of intercept	Regression parameters: Slope	Average standard error of estimate, in percent[2]
03343550	Embarras River at State Highway 133 near Oakland	1980-81	0.34	-2.00	1.518	11.6
03378900	Little Wabash River at Louisville	1980-81	.54	-1.61	1.498	80.6
03382100	South Fork Saline River near Carrier Mills	1980-81	.78	-2.60	1.873	74.7
05440000	Kishwaukee River near Perryville	1980-81	.39	-2.64	1.699	64.3
05447500	Green River near Geneseo	1980-81	.54	-3.35	2.082	74.7
05466500	Edwards River near New Boston	1980-81	.50	-2.17	1.839	116
05469000	Henderson Creek near Oquawka	1980-81	.57	-2.92	2.073	131
05525000	Iroquois River at Iroquois	1979-80	.10	-1.43	1.258	127
05526000	Iroquois River near Chebanse	1980-81	.36	-2.22	1.488	95.7
05527500	Kankakee River near Wilmington	1980-81	.52	-3.71	1.800	71.9
05532500	Des Plaines River at Riverside	1980-81	.68	-3.62	1.938	50.3
05570370	Big Creek near Bryant	1980-81	.69	-2.45	2.199	80.6

[1] Coefficient for correlation between daily mean sediment concentration and daily mean water discharge.

[2] Riggs, 1968.

Table 3.--Regression parameters, standard errors of estimate, and estimated suspended-sediment loads for eight stations for which transport equations were derived from 1, 2, and 3 years' data

Station number and water year for which estimate is made	Measured loads, in tons	Years of record	Intercept, in logarithm of sediment load, in tons	Slope	Standard error or estimate, in percent[1]	Estimated load, in tons and as percentage, in parentheses, of measured load
03378900	132,000	1979	-1.04	1.209	196	45,100 (34)
1981		1979-80	-1.27	1.310	150	55,800 (42)
		1979-81	-1.36	1.365	127	67,600 (51)
05447500	569,000	1979	-3.55	2.093	63.5	248,000 (44)
1981		1979-80	-3.23	2.015	71.9	282,000 (50)
		1979-81	-3.37	2.070	71.9	308,000 (54)
05469000	386,000	1979	-2.16	1.777	77.6	127,000 (33)
1981		1979-80	-2.34	1.867	83.5	161,000 (42)
		1979-81	-2.60	1.943	116	150,000 (39)
05520500	326,000	1979	-2.29	1.391	63.5	135,000 (41)
1981		1979-80	-2.29	1.411	63.5	157,000 (48)
		1979-81	-2.62	1.503	69.0	161,000 (49)
05526000	422,000	1979	-2.13	1.490	89.6	329,000 (78)
1981		1979-80	-1.94	1.406	95.7	249,000 (59)
		1979-81	-1.86	1.368	120	213,000 (50)
05527500	1,370,000	1979	-3.25	1.672	92.7	631,000 (46)
1981		1979-80	-3.15	1.648	80.6	632,000 (46)
		1979-81	-3.48	1.738	77.6	703,000 (51)
05570370	21,100	1979	-2.07	1.892	92.7	6,380 (30)
1981		1979-80	-2.16	1.970	86.5	7,560 (36)
		1979-81	-2.31	2.083	86.5	9,500 (45)
05570380	442	1978	-1.00	1.496	92.7	250 (57)
1980		1978-79	-1.05	1.525	86.5	238 (54)
		1978-80	-1.00	1.497	83.5	250 (57)

[1] Riggs, 1968

Table 4.--Ratios of annual suspended-sediment loads, from shifted hydrographs, to measured suspended-sediment loads for Kankakee River near Wilmington, 1981 water year

Sampling frequency	Starting date for selecting control points: Oct. 1	Oct. 10	Oct. 20	Row means
Monthly	1.22	0.45	0.79	
(every 28 days)	1.28	.45	.62	0.80
	.92	.55	.88	
Biweekly	1.29	.66	.76	
(every 14 days)	1.17	.60	.63	.83
	1.08	.69	.62	
Weekly	.94	.60	.94	
(every 7 days)	.86	.61	.81	.78
	.87	.63	.75	
Column means	1.07	.58	.76	Overall mean = 0.80

Table 5.--Estimated monthly and annual suspended-sediment loads, in tons, and in percentages of measured loads, in parentheses

03343550 Embarras River at State Highway 133 near Oakland
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	24	23 (96)	47 (196)	30 (125)	29 (121)
November	18	33 (183)	13 (72)	10 (56)	13 (72)
December	456	452 (99)	349 (77)	696 (153)	539 (118)
January	57	92 (161)	44 (77)	42 (74)	62 (109)
February	1,450	3,690 (254)	1,330 (92)	1,630 (112)	1,280 (88)
March	614	1,420 (231)	729 (119)	755 (123)	519 (85)
April	9,400	9,410 (100)	5,980 (64)	6,800 (72)	6,820 (73)
May	37,900	33,600 (89)	28,400 (75)	24,600 (65)	35,200 (93)
June	15,300	5,400 (35)	22,100 (144)	17,700 (116)	17,300 (113)
July	25,900	18,800 (73)	14,500 (56)	19,200 (74)	15,800 (61)
August	16,300	18,100 (111)	14,400 (88)	14,800 (91)	13,400 (82)
September	2,660	3,400 (128)	2,130 (80)	2,120 (80)	2,600 (98)
Annual total	110,000	94,400 (86)	90,000 (82)	88,300 (80)	93,600 (85)

03378900 Little Wabash River at Louisville
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	42	55 (131)	42 (100)	54 (129)	42 (100)
November	23	28 (122)	18 (78)	19 (83)	22 (96)
December	100	176 (176)	166 (166)	130 (130)	110 (110)
January	39	28 (72)	34 (87)	38 (97)	39 (100)
February	11,900	12,100 (102)	9,810 (82)	12,000 (101)	9,650 (81)
March	1,590	1,430 (90)	955 (60)	608 (38)	716 (45)
April	7,690	2,440 (32)	1,740 (23)	3,270 (43)	2,600 (34)
May	29,700	24,300 (82)	18,500 (62)	33,500 (113)	34,100 (115)
June	21,000	5,530 (26)	15,800 (75)	15,200 (72)	19,000 (90)
July	26,400	11,200 (42)	33,100 (125)	10,100 (38)	16,100 (61)
August	26,700	21,700 (81)	14,400 (54)	17,900 (67)	17,100 (64)
September	7,160	24,600 (344)	13,000 (182)	17,000 (237)	17,200 (240)
Annual total	132,000	104,000 (79)	108,000 (82)	110,000 (83)	117,000 (89)

Table 5.--Estimated monthly and annual suspended-sediment loads, in tons, and in percentages of measured loads, in parentheses--Continued

03382100 South Fork Saline River near Carrier Mills
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	6.7	5.1 (76)	12 (179)	7.7 (115)	6.0 (90)
November	23	4.0 (17)	15 (65)	21 (91)	14 (61)
December	5.0	7.6 (152)	13 (260)	6.8 (136)	4.6 (92)
January	8.8	7.0 (80)	7.5 (85)	8.7 (99)	8.6 (98)
February	173	155 (90)	193 (112)	179 (103)	160 (92)
March	61	60 (98)	73 (120)	62 (102)	65 (107)
April	35	29 (83)	29 (83)	32 (91)	46 (131)
May	40,100	21,600 (54)	21,400 (53)	30,600 (76)	45,200 (113)
June	14,300	9,300 (65)	6,820 (48)	11,800 (83)	9,400 (66)
July	2,430	2,000 (82)	1,300 (53)	1,330 (55)	2,630 (108)
August	37	61 (165)	53 (143)	34 (92)	41 (111)
September	8.1	9.0 (111)	7.4 (91)	7.0 (86)	7.4 (91)
Annual total	57,100	33,300 (58)	30,000 (53)	44,100 (77)	57,500 (101)

05440000 Kishwaukee River near Perryville
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	3,990	6,760 (169)	3,770 (94)	3,340 (84)	3,680 (92)
November	1,260	2,690 (213)	1,300 (103)	1,280 (102)	1,270 (101)
December	7,960	9,550 (120)	6,800 (85)	3,440 (43)	4,080 (51)
January	3,120	1,900 (61)	2,800 (90)	3,490 (112)	2,820 (90)
February	6,850	5,930 (87)	7,860 (115)	6,930 (101)	5,450 (80)
March	2,420	4,490 (186)	3,050 (126)	2,170 (90)	2,160 (89)
April	9,110	6,560 (72)	6,240 (68)	20,600 (226)	9,340 (103)
May	8,450	7,070 (84)	7,220 (85)	12,800 (151)	8,020 (95)
June	30,900	15,500 (50)	25,200 (82)	29,600 (96)	18,300 (59)
July	2,790	1,830 (66)	1,880 (67)	2,330 (84)	2,390 (86)
August	6,790	3,380 (50)	6,890 (101)	4,080 (60)	3,830 (56)
September	8,090	4,290 (53)	4,300 (53)	3,790 (47)	3,730 (46)
Annual total	91,800	70,000 (76)	77,300 (84)	93,800 (102)	65,100 (71)

Table 5.--Estimated monthly and annual suspended-sediment loads, in tons, and in percentages of measured loads, in parentheses--Continued

05447500 Green River near Geneseo
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	2,100	4,340 (207)	2,130 (101)	3,060 (146)	2,740 (130)
November	1,110	2,400 (216)	1,180 (106)	1,250 (113)	1,190 (107)
December	5,690	12,000 (211)	6,650 (117)	4,810 (85)	4,600 (81)
January	1,110	1,500 (135)	1,010 (91)	668 (60)	1,130 (102)
February	14,500	9,160 (63)	11,300 (78)	14,900 (103)	13,900 (96)
March	8,530	6,400 (75)	6,060 (71)	9,020 (106)	7,970 (93)
April	199,000	65,900 (33)	78,200 (39)	96,500 (48)	82,200 (41)
May	17,600	20,100 (114)	20,000 (114)	25,500 (145)	23,300 (132)
June	140,000	65,100 (47)	162,000 (116)	236,000 (169)	149,000 (106)
July	22,000	7,540 (34)	17,100 (78)	13,900 (63)	19,800 (90)
August	127,000	119,000 (94)	196,000 (154)	166,000 (131)	179,000 (141)
September	30,000	42,000 (140)	25,000 (83)	25,100 (84)	27,400 (91)
Annual total	569,000	356,000 (63)	527,000 (93)	597,000 (105)	512,000 (90)

05466500 Edwards River near New Boston
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	525	1,150 (219)	645 (123)	516 (98)	522 (99)
November	200	743 (372)	361 (180)	236 (118)	203 (102)
December	11,400	10,500 (92)	5,590 (49)	17,400 (153)	13,400 (118)
January	300	1,380 (460)	611 (204)	313 (104)	306 (102)
February	7,760	3,630 (47)	5,370 (69)	4,570 (59)	7,510 (97)
March	1,580	2,790 (177)	1,270 (80)	1,410 (89)	1,600 (101)
April	216,000	195,000 (90)	149,000 (69)	157,000 (73)	159,000 (74)
May	19,100	8,380 (44)	3,030 (16)	9,240 (48)	9,010 (47)
June	109,000	31,200 (29)	59,700 (55)	50,300 (46)	163,000 (150)
July	46,900	10,800 (23)	16,600 (35)	9,830 (21)	114,000 (243)
August	119,000	185,000 (155)	106,000 (89)	64,800 (54)	201,000 (169)
September	21,400	16,500 (77)	16,800 (79)	14,500 (68)	13,700 (64)
Annual total	553,000	467,000 (84)	365,000 (66)	330,000 (60)	683,000 (124)

Table 5.--Estimated monthly and annual suspended-sediment loads, in tons, and in percentages of measured loads, in parentheses--Continued

05469000 Henderson Creek near Oquawka
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	259	1,050 (405)	400 (154)	312 (120)	289 (112)
November	85	475 (559)	104 (122)	95 (112)	80 (94)
December	20,800	22,800 (110)	13,000 (63)	12,600 (61)	12,500 (60)
January	191	1,150 (602)	219 (115)	175 (92)	196 (103)
February	7,950	3,990 (50)	4,120 (52)	4,770 (60)	4,880 (61)
March	922	1,780 (193)	787 (85)	916 (99)	970 (105)
April	131,000	77,800 (59)	54,300 (41)	68,600 (52)	68,500 (52)
May	41,900	13,000 (31)	10,500 (25)	37,800 (90)	35,400 (84)
June	115,000	44,000 (38)	45,900 (40)	140,000 (122)	123,000 (107)
July	36,000	7,620 (21)	10,600 (29)	41,400 (115)	21,500 (60)
August	26,800	6,670 (25)	14,600 (54)	11,500 (43)	10,000 (37)
September	5,540	1,280 (23)	4,260 (77)	1,770 (32)	1,760 (32)
Annual total	386,000	181,000 (47)	159,000 (41)	320,000 (83)	279,000 (72)

05525000 Iroquois River at Iroquois
1980 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	142	130 (92)	183 (129)	162 (114)	160 (113)
November	664	896 (135)	410 (62)	367 (55)	321 (48)
December	514	1,980 (385)	495 (96)	458 (89)	333 (65)
January	651	1,220 (187)	600 (92)	632 (97)	475 (73)
February	625	1,380 (221)	280 (45)	497 (80)	524 (84)
March	12,200	9,840 (81)	15,900 (130)	18,100 (148)	16,100 (132)
April	5,660	7,950 (140)	6,690 (118)	6,750 (119)	6,830 (121)
May	1,900	1,040 (55)	1,620 (85)	1,810 (95)	2,140 (113)
June	39,200	11,100 (28)	12,500 (32)	13,700 (35)	54,700 (140)
July	689	257 (37)	819 (119)	725 (105)	659 (96)
August	1,080	244 (23)	931 (86)	1,060 (98)	1,080 (100)
September	5,330	1,950 (37)	5,740 (108)	5,490 (103)	5,430 (102)
Annual total	68,700	38,000 (55)	46,100 (67)	49,700 (72)	88,800 (129)

Table 5.--Estimated monthly and annual suspended-sediment loads, in tons, and in percentages of measured loads, in parentheses--Continued

05526000 Iroquois River near Chebanse
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	683	470 (69)	836 (122)	722 (106)	725 (106)
November	357	499 (140)	216 (61)	252 (71)	350 (98)
December	1,860	4,540 (244)	1,620 (87)	2,030 (109)	1,680 (90)
January	409	976 (239)	555 (136)	507 (124)	322 (79)
February	10,700	14,100 (132)	8,560 (80)	6,430 (60)	7,060 (66)
March	2,780	5,620 (202)	3,590 (129)	2,530 (91)	2,370 (85)
April	68,400	37,000 (54)	87,700 (128)	87,800 (128)	73,000 (107)
May	111,000	106,000 (95)	171,000 (154)	195,000 (176)	151,000 (136)
June	102,000	35,700 (35)	49,800 (49)	96,600 (95)	111,000 (109)
July	58,100	24,820 (43)	98,300 (169)	92,500 (159)	76,900 (132)
August	33,000	14,400 (44)	31,300 (95)	45,300 (137)	32,700 (99)
September	32,500	18,000 (55)	45,100 (139)	45,500 (140)	45,700 (141)
Annual total	422,000	262,000 (62)	499,000 (118)	575,000 (136)	503,000 (119)

05527500 Kankakee River near Wilmington
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	4,520	3,580 (79)	3,420 (76)	3,730 (83)	4,220 (93)
November	2,210	2,850 (129)	1,880 (85)	2,060 (93)	2,520 (114)
December	9,260	19,400 (210)	11,000 (119)	12,600 (136)	12,300 (133)
January	3,110	5,530 (178)	3,210 (103)	3,290 (106)	3,360 (108)
February	15,600	22,800 (146)	31,800 (204)	18,500 (119)	12,500 (80)
March	7,580	22,900 (302)	24,700 (326)	7,210 (95)	9,940 (131)
April	368,000	110,000 (30)	454,000 (123)	379,000 (103)	349,000 (95)
May	299,000	268,000 (90)	400,000 (134)	364,000 (122)	245,000 (82)
June	459,000	166,000 (36)	615,000 (134)	420,000 (92)	331,000 (72)
July	104,000	55,100 (53)	82,500 (79)	114,000 (110)	118,000 (113)
August	47,100	38,700 (82)	54,800 (116)	50,800 (108)	48,600 (103)
September	46,100	31,600 (69)	64,200 (139)	59,000 (128)	45,900 (100)
Annual total	1,370,000	746,000 (54)	1,750,000 (128)	1,430,000 (104)	1,180,000 (86)

Table 5.--Estimated monthly and annual suspended-sediment loads, in tons, and in percentages of measured loads, in parentheses--Continued

05532500 Des Plaines River at Riverside
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	1,820	1,460 (80)	1,690 (93)	1,370 (75)	1,570 (86)
November	400	346 (86)	410 (103)	423 (106)	491 (123)
December	2,270	3,270 (144)	4,800 (211)	1,900 (84)	2,410 (106)
January	221	365 (165)	320 (145)	247 (112)	231 (105)
February	2,480	3,350 (135)	3,570 (144)	3,560 (144)	2,240 (90)
March	746	1,730 (232)	1,450 (194)	899 (121)	784 (105)
April	8,540	5,370 (63)	6,690 (78)	7,480 (88)	8,460 (99)
May	3,090	2,900 (94)	2,830 (92)	3,180 (103)	3,440 (111)
June	3,620	3,760 (104)	2,780 (77)	2,710 (75)	4,240 (117)
July	3,010	1,910 (63)	5,110 (170)	3,300 (110)	2,300 (76)
August	6,620	3,960 (60)	3,200 (48)	6,900 (104)	6,560 (99)
September	2,070	1,440 (70)	1,990 (96)	1,730 (84)	1,960 (95)
Annual total	34,900	29,900 (86)	34,900 (100)	33,700 (97)	34,700 (99)

05570370 Big Creek near Bryant
1981 water year

Month	Measured load, in tons	Loads estimated by shifting to indicated number of annual control points			
		0	13	26	52
October	23	24 (104)	27 (117)	30 (130)	24 (104)
November	13	22 (169)	9.6 (74)	10 (77)	8.7 (67)
December	88	139 (158)	67 (76)	54 (61)	144 (164)
January	10	19 (190)	8.0 (80)	9.6 (96)	11 (110)
February	100	357 (357)	140 (140)	148 (148)	150 (150)
March	57	44 (77)	17 (30)	26 (46)	37 (65)
April	5,620	1,150 (20)	1,060 (19)	1,110 (20)	1,870 (33)
May	2,400	2,490 (104)	3,500 (146)	4,560 (190)	3,450 (144)
June	8,620	5,740 (67)	8,120 (94)	6,010 (70)	10,600 (123)
July	2,050	1,180 (58)	1,150 (56)	1,750 (85)	1,510 (74)
August	2,060	1,370 (67)	2,520 (122)	1,900 (92)	1,930 (94)
September	44	29 (66)	63 (143)	63 (143)	137 (311)
Annual total	21,100	12,600 (60)	16,700 (79)	15,700 (74)	19,800 (94)

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