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SEDIMENT TRANSPORT TO THE FOX CHAIN OF LAKES, ILLINOIS

U.S. GEOLOGICAL SURVEY

Open-File Report 77-867

Prepared in cooperation with

U.S. Army Corps of Engineers, Chicago District

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ABSTRACT

Two main tributaries to the Fox Chain of Lakes, the Fox River and Nippersink Creek, were sampled twice weekly and during periods of high runoff to determine the amount of suspended inorganic sediment being transported into the Chain of Lakes. Sediment yields were determined by using the transport-duration technique. It is estimated that 34,100 tons of suspended sediment are transported to the Lakes annually. Of this, 16,100 tons were from the Fox River and 14,400 tons from Nippersink Creek. Based on drainage-area ratios, it is estimated that the additional 3,600 tons were from Squaw Creek, a minor tributary. Assuming a density of 50 lbs/ft^3, it would take an average of 200 years to deposit 1 foot of sediment throughout the entire Chain of Lakes.

INTRODUCTION

The Fox Chain of Lakes is a group of lakes in the Fox River basin in northeastern Illinois (see figure 1). State agencies are currently involved in a project to design a restoration and management program that would achieve a desirable water quality in the Fox Chain of Lakes. Analyses of bottom-material samples show that the deposited sediment is mostly of organic origin. However, some data were needed to define the suspended-sediment loads contributed by the Fox River and other tributary streams in the basin and thus the magnitude of inorganic suspended-sediment supply to the lakes. The purpose of this investigation, which began in December 1975, was to estimate the long-term inorganic sediment supply to the Chain of Lakes based on short-term measured sediment loads.

The approach taken was to collect suspended-sediment samples at the gaging station on Nippersink Creek near Spring Grove and at the Fox River near Channel Lake (located at the Route 173 bridge). Discharge data at the gaging station at Wilmot, Wis. (approximately 5 miles upstream from the Channel Lake site) were used for the Fox River station. A number of discharge measurements were made at the Channel Lake site to compare with the discharge at Wilmot. All measurements were within 5 percent of the Wilmot discharge. Observers were contracted to collect samples routinely about twice per week and additional samples during periods of high runoff. U.S. Geological Survey (USGS) personnel coordinated the sampling and collected multivertical samples in each cross section every 6 weeks.

For this study the sediment samplers used (DH-59's) did not permit sampling closer than about 0.3 foot above the stream bottom. Therefore, the sediment below this level was not included in the sample analysis. The unmeasured part constituted primarily the bedload discharge plus a small percentage of the suspended-sediment discharge. Only suspended-sediment data are given in this report, and no attempt was made to estimate the unmeasured part.

DISCUSSION

Sediment yields were determined by using the transport-duration technique. This technique makes use of (1) sediment-transport curves (figures 3 and 5) which define the relation between instantaneous water and sediment discharges, and (2) streamflow-duration curves (figures 2 and 4) which define the percentage of time that any flow value was equaled or exceeded. The flow-duration curves for Nippersink Creek and Fox River (figures 2 and 4) are based on the entire period of record through the 1975 water year. This transport duration technique is used to estimate long-term average sediment loads (tables 1 and 2) when only short periods of sediment record are available.

To be able to estimate sediment yield, four assemptions were made: (1) that the sediment-transport and flow duration curves represent long-term relations; (2) that the observed instantaneous suspended-sediment discharge has the same relation to the concurrent flow measurement as that of the mean daily sediment and water discharge; (3) that the average unit weight of bottom sediments of the Fox Chain of Lakes is 50 lbs/ft^3; and (4) that the sediment yield from Squaw Creek was approximately one fourth that of Nippersink Creek based on drainage-area ratios.

CONCLUSIONS

The following is a summary of the results obtained: (1) Approximately 34,100 tons of suspended sediment are transported annually to the Fox Chain of Lakes. Assuming all sediments are retained in the Lakes (100 percent trap efficiency) and acquire a unit weight of about 50 lbs/ft^3, this amounts to an accumulation of about 31.27 acre-ft/yr (see table 3). (2) Using a surface area of 6,280 acres, it would take 200 years on the average to deposit 1 foot of sediment throughout the entire Chain of Lakes (Pistakee, Nippersink, Fox, and Grass Lakes) or the average rate of filling in the Chain of Lakes is 0.005 ft/yr (see table 4).

Table 5 was compiled to compare USGS results with those reported by Stall and Bhowmik (1974) to the State Department of Conservation and the State Division of Waterways. Their results, utilizing soil loss equations and sediment density of 60 lbs/ft^3, compare favorably with those of the USGS based on sediment-transport data.

The conclusions in this report should be used with due consideration given the assumptions. The extreme upper and lower ends of the sediment-transport curves were defined by only a few measurements, and these extremes were estimated by extending the curve to cover the desired range.

In summary, it is considered that the objectives of this reconnaissance have been met. However, the sediment-transport curves developed for Nippersink Creek and the Fox River were based on only 6 months of sediment record. The data points for Nippersink Creek define a good relation between suspended sediment and water discharge; however, the data points for the Fox River are widely scattered. The wide scatter for the Fox River is probably due to the effects of ponding upstream from the dam at Wilmot along with the different releases of water due to the regulation of the three lift gates.

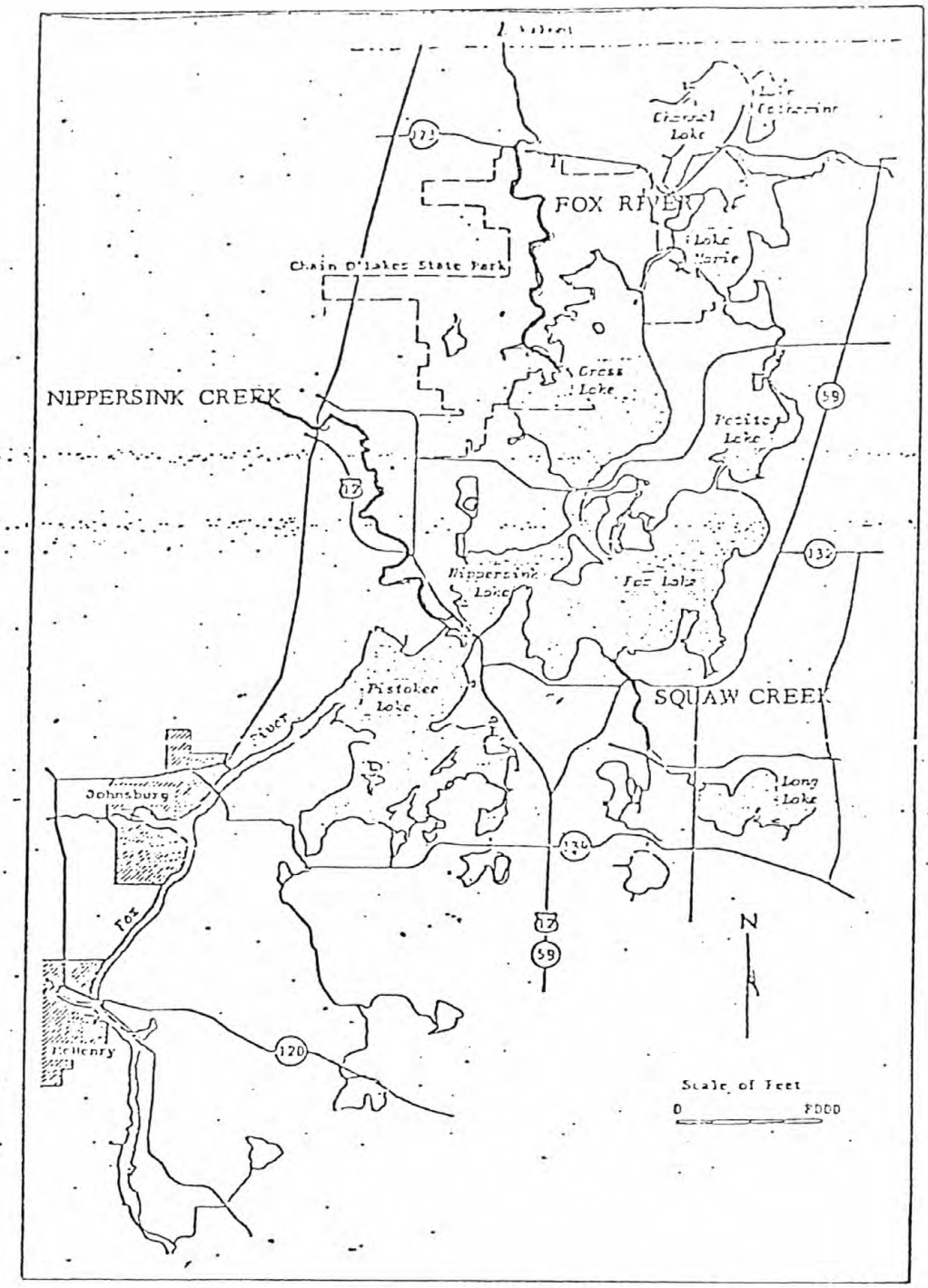

Figure 1.--Fox Chain-of-Lakes region

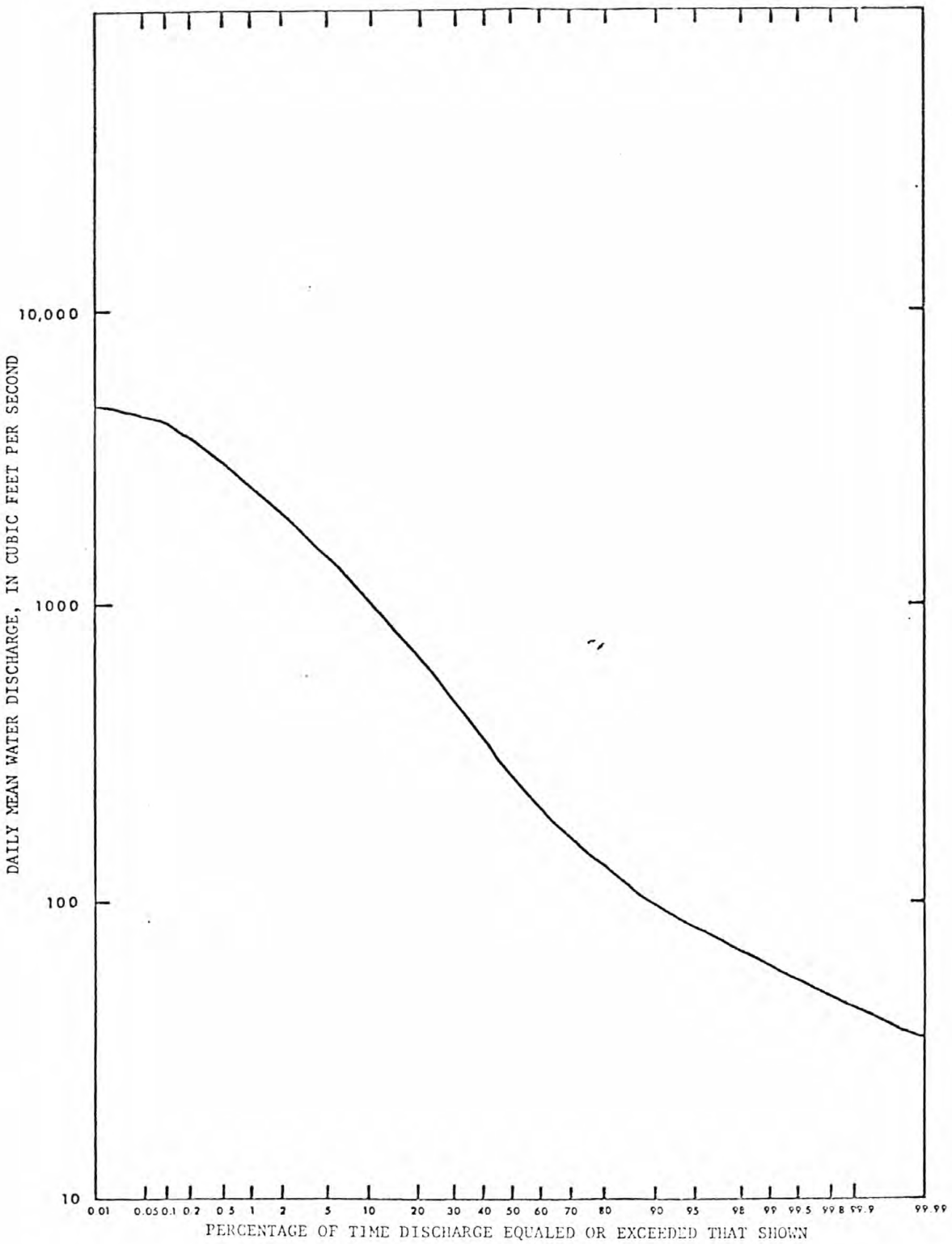

Figure 2.--Duration curve of daily mean discharge of Fox River near Channel Lake

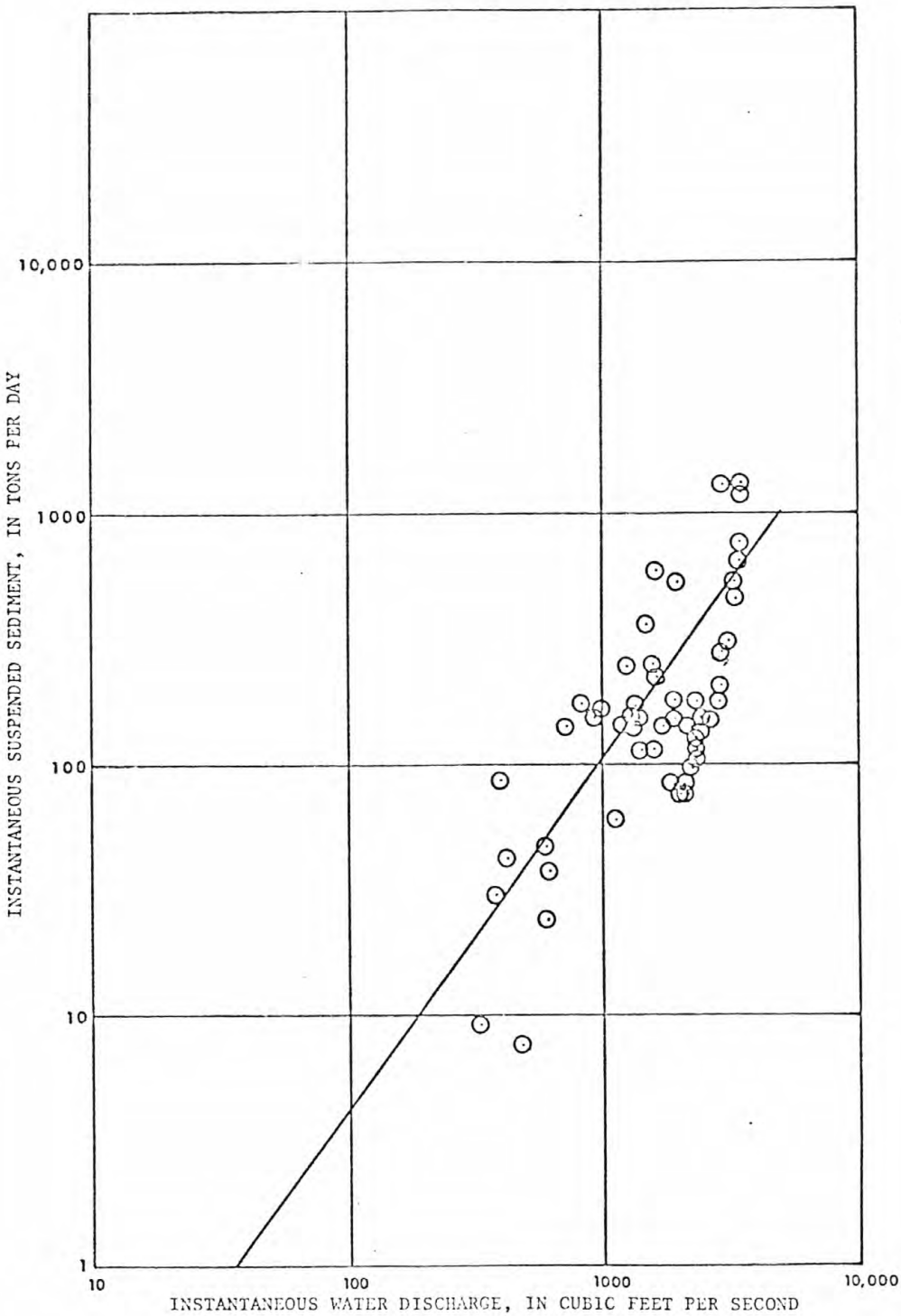

Figure 3.--Sediment-transport curve for Fox River near Channel Lake

Table 1.--Computations of average annual suspended-sediment yield of the Fox River near Channel Lake

Percentage of time	Water discharge equaled or exceeded[1] (cubic feet per second)	Suspended-sediment discharge[2] (tons per day)	Interval between succeeding percentages of time	Average suspended-sediment discharge for time interval (tons per day)	Sediment discharge multiplied by time interval
0	5,000	1,000	---	---	---
.1	4,300	800	0.1	900	0.9
.3	3,400	580	.2	690	1.38
.9	2,600	390	.6	485	2.91
2	2,000	270	1.1	330	3.63
4	1,680	210	2	240	4.80
6	1,400	160	2	185	3.70
9	1,150	120	3	140	4.20
15	850	80	6	100	6.00
20	700	60	5	70	3.50
30	490	36	10	48	4.80
40	350	22	10	29	2.90
50	270	15	10	18.5	1.85
60	210	10.5	10	12.8	1.28
70	170	8.0	10	9.2	.92
80	135	5.8	10	6.9	.69
90	100	4.0	10	4.9	.49
95	88	3.5	5	3.8	.19
100	35	1.0	5	2.2	.11
				Total (tons per day)	44.25

Note.--Average annual suspended-sediment discharge = 365 x 44.2 = 16,100 tons.
Drainage area = 871 mi^2.
Average annual sediment yield = 16,100 ÷ 871 mi^2 = 18.5 tons/mi^2.

[1] Computed from figure 2.
[2] From figure 3.

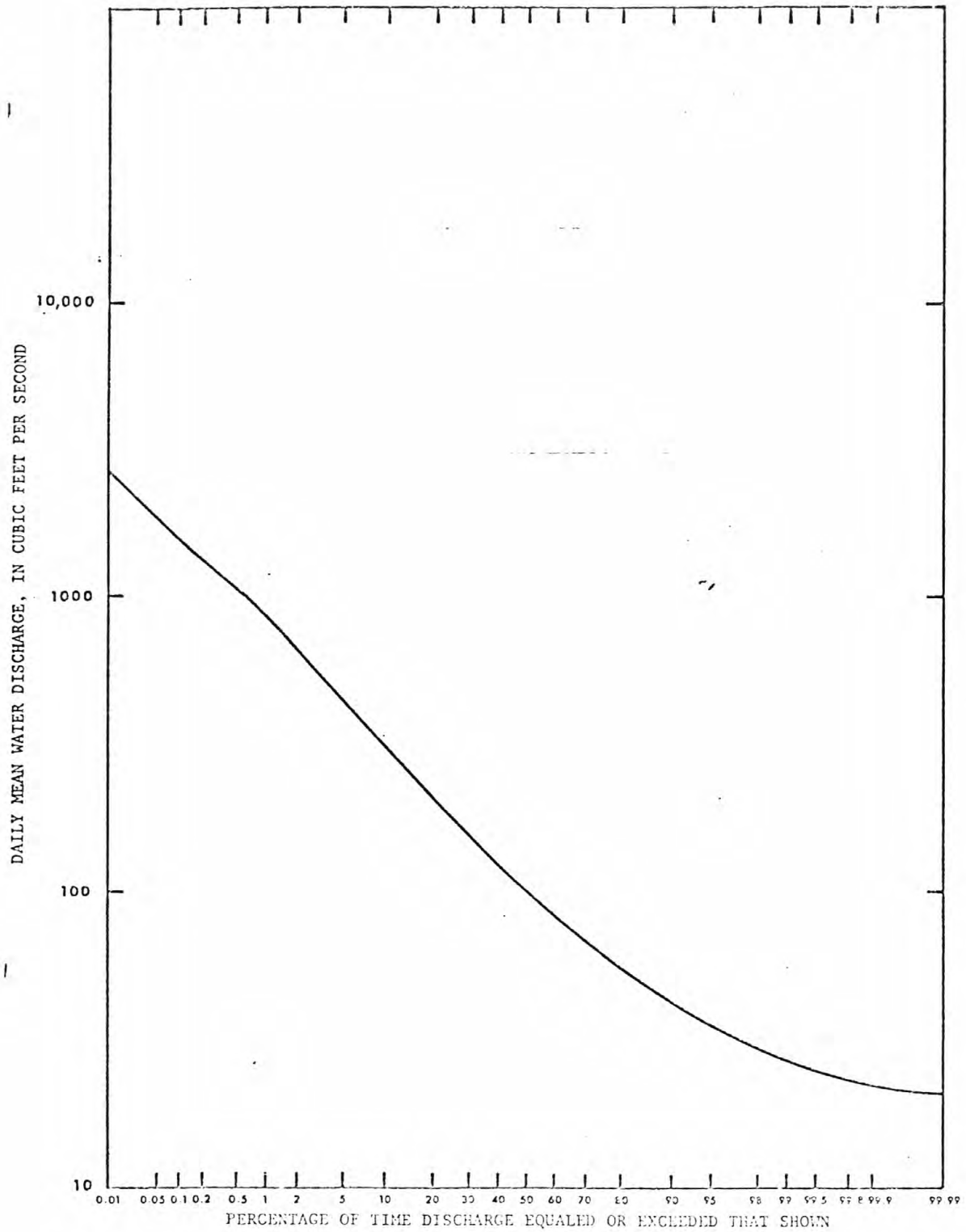

Figure 4.--Duration curve of daily mean discharge of Nippersink Creek near Spring Grove

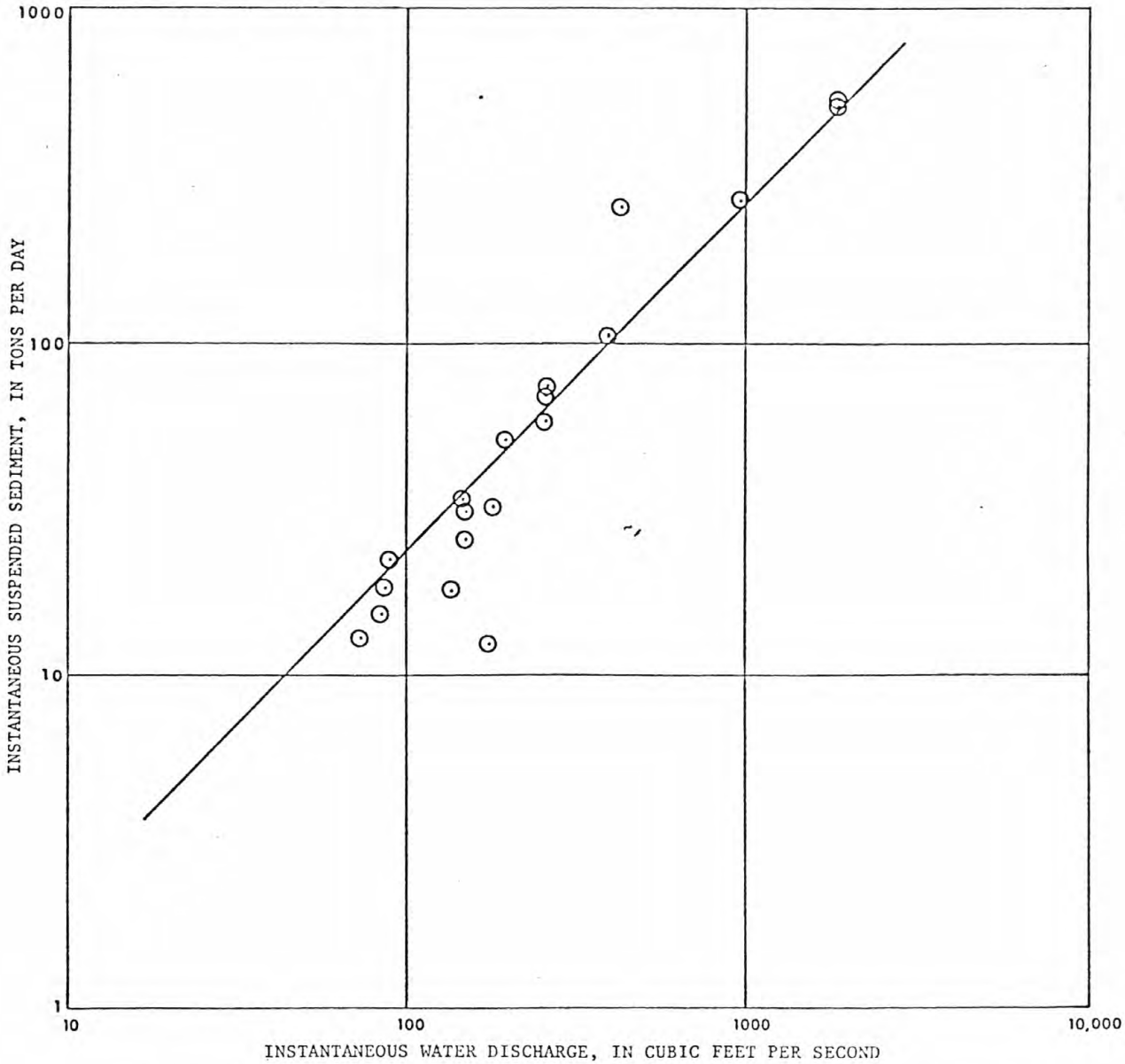

Figure 5.--Sediment-transport curve for Nippersink Creek near Spring Grove

Table 2.--Computations of average annual suspended-sediment yield of Nippersink Creek near Spring Grove

Percentage of time	Water discharge equaled or exceeded[1] (cubic feet per second)	Suspended-sediment discharge[2] (tons per day)	Interval between succeeding percentages of time	Average suspended-sediment discharge for time interval (tons per day)	Sediment discharge multiplied by time interval
0	2,900	780	---	---	---
.1	1,600	420	0.1	600	0.6
.3	1,300	340	.2	375	.75
.9	1,000	260	.6	295	1.77
2	700	180	1.1	220	2.20
4	520	130	2	155	3.1
6	440	110	2	120	2.4
9	360	86	3	98	2.9
15	270	64	6	75	4.5
20	230	55	5	60	3.0
30	175	41	10	48	4.8
40	130	30	10	36	3.6
50	100	23	10	26	2.6
60	84	19	10	21	2.1
70	72	16	10	18	1.8
80	58	12.8	10	14	1.4
90	45	10	10	12	1.2
95	36	8.0	5	9	.45
100	20	4.4	5	6.2	.31
				Total (tons per day)	39.48

Note.--Average annual suspended-sediment discharge = 365 x 39.48 = 14,400 tons.
Drainage area = 192 mi^2.
Average annual sediment yield = 14,400 tons ÷ 192 = 75.0 tons/mi^2.

[1] Computed from figure 4.
[2] From figure 5.

Table 3.--Total estimated sediment yield of the Fox Chain of Lakes

Stream	Drainage area (square miles)	Annual sediment (tons/square mile)	Total (tons)	Annual sediment (acre-feet)
Fox River.....	871	18.5	16,100	14.78
Nippersink Creek..	192	75.0	14,400	13.22
Squaw Creek.....	47.4	18.6	3,560	3.27
Total.....			34,100	31.27

Table 4.--Capacity of the Fox Chain of Lakes lost due to sedimentation

Lake	Fraction of the total capacity	Sediment deposited (acre-feet)	Surface area (acres)	Depth lost per year (feet)	Number of years needed to deposit 1 foot of sediment
Pistakee.....	0.3703	11.58	1,960	0.00591	169
Nippersink.....	.0762	2.38	730	.00326	307
Fox.....	.3984	12.46	1,830	.00681	147
Grass.....	.1551	4.85	1,760	.00276	362
Average.....		31.27	6,280	.005	200

Table 5.--Comparison of results

	U.S. Geological Survey	Illinois Water Survey (Stall and Bhowmik, 1974)
Density.....	50 pounds per cubic foot	60 pounds per cubic foot
Sediment accumulation in lakes.....	34,100 tons 31.27 acre-feet	35,535 tons 27.19 acre-feet
Number of years needed to deposit 1 foot of sediment:		
Pistakee Lake.....	169	194
Nippersink Lake.....	307	352
Fox Lake.....	147	168
Grass Lake.....	362	416

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