ASSESSMENT OF NONPOINT-SOURCE NUTRIENT DISCHARGES FROM THE SWITZER CREEK BASIN, STEUBEN COUNTY, NEW YORK

By Donald A. Sherwood

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CONVERSION FACTORS AND ABBREVIATIONS

Factors for converting the units used in this report to International System of Units (SI) are shown below.

Multiply	By	To obtain SI units
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)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
foot per day (ft/d)	0.3048	meter per day (m/d)
degrees Fahrenheit (°F)	5/9 (°F-32)	degrees Celsius (°C)
cubic foot per second (ft3/s)	0.02832	cubic meter (m^3)
acre	0.4047	hectare (ha)
pound	0.4536	kilogram (kg)
ton	0.9072	megagram (Mg)
ton per acre (ton/acre)	2.242	megragram per hectare (Mg/ha)
inch per year (in/yr)	2.54	centimeter per year (cm/a)

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Abstract

Switzer Creek is a small tributary to the Cohocton River, which flows into the Susquehanna River north of the New York-Pennsylvania border. Switzer Creek drains a 3.55-square-mile watershed that is typical of the many small, predominantly agricultural subbasins of the upper Susquehanna River basin. This basin is 51 percent agricultural and 49 percent forested.

Switzer Creek discharged a total of 1,000 tons of suspended sediment, or an average of 0.44 tons per acre, from November 1978 through September 1980. Forty-eight percent of this load was transported during two high-water events on March 5, 1979 and March 21, 1980. The maximum instantaneous sediment concentration (3,840 milligrams per liter) occurred during high water on September 14, 1979.

Approximately 80 percent of the annual nitrogen load was transported during base flow. Nitrite plus nitrate load totaled 11 pounds per acre, and total kjeldahl nitrogen load 3.5 pounds per acre. During base flow, nitrite plus nitrate constituted 88 percent of the nitrogen load; during high flows, organic nitrogen constituted 85 percent of the nitrogen load. During the study, 90 percent of the total phosphorus load was transported during high flows as a result of its affinity to particulate matter. Discharge of total phosphorus as P totaled 0.63 pounds per acre, and total orthophosphorus as P totaled 0.19 pounds per acre. Concentrations of suspended organic carbon and dissolved organic carbon varied widely and showed little relation to stream discharge. Total loads of suspended and dissolved organic carbon during the study were 6.8 pounds per acre and 27 pounds per acre, respectively. The largest nutrient and sediment loads occurred during February through May of both years; the smallest loads occurred during June through September.

Nitrite plus nitrate loads from atmospheric sources totaled 8.4 pounds per acre during the study; ammonia totaled 3.9 pounds per acre, and phosphorus totaled less than 0.34 pounds per acre. Nitrogen from the application of fertilizer and manure to agricultural areas total 47 pounds per acre; and phosphorus from these sources totaled 53 pounds per acre.

INTRODUCTION

In recent years, the upper reaches of Chesapeake Bay have undergone accelerated eutrophication, as indicated by the increasing frequency and persistence of nuisance algal blooms and significant changes in the aquatic biota. The major factor influencing the increased eutrophication of the Bay has been identified as plant nutrients, especially nitrogen and phosphorus, which promote algal growth.

The largest contributor of sediment and nutrients to the upper part of Chesapeake Bay is the Susquehanna River (Guide and Villa, 1972). Much of the nutrient load of the Susquehanna can be traced to point sources, which are relatively easy to identify and control. Nonpoint discharges, which enter the stream by overland runoff, are no less significant but are more difficult to quantify and control. Takita (1975) indicated that the available water-quality data were adequate only for gross assessment of pollution from nonpoint sources. Recognizing this, the Susquehanna River Basin Commission in 1977 initiated a program to assess nonpoint-source pollution in the basin and to identify contributions of differing land uses.

Streams draining agricultural basins typically receive nutrients from fertilizers, the atmosphere, and animal populations. The quantities received are directly related to the extent of farming and the methods used. Switzer Creek, a tributary to the Cohocton River in western New York (fig. 1), is a typical small agricultural and forested subbasin of the Susquehanna River. It is assumed to be representative of similar basins providing nonpoint discharges of nutrients and sediment to the upper Susquehanna basin.

Purpose and Scope

From November 1978 through September 1980, the U.S. Geological Survey, in cooperation with the Susquehanna River Basin Commission, measured streamflow and the discharge of suspended sediment, phosphorus, nitrogen, and organic carbon from Switzer Creek basin. This report describes the physical setting, land use, and farming methods in the basin and relates concentrations of phosphorus, nitrogen, and organic carbon to stream discharge. The relationships between nutrient concentrations and streamflow were plotted (fig. 10); also the atmospheric contributions of nutrients to the basin were calculated and are compared to nutrient loads discharged by Switzer Creek (figs. 5-9).

Methods

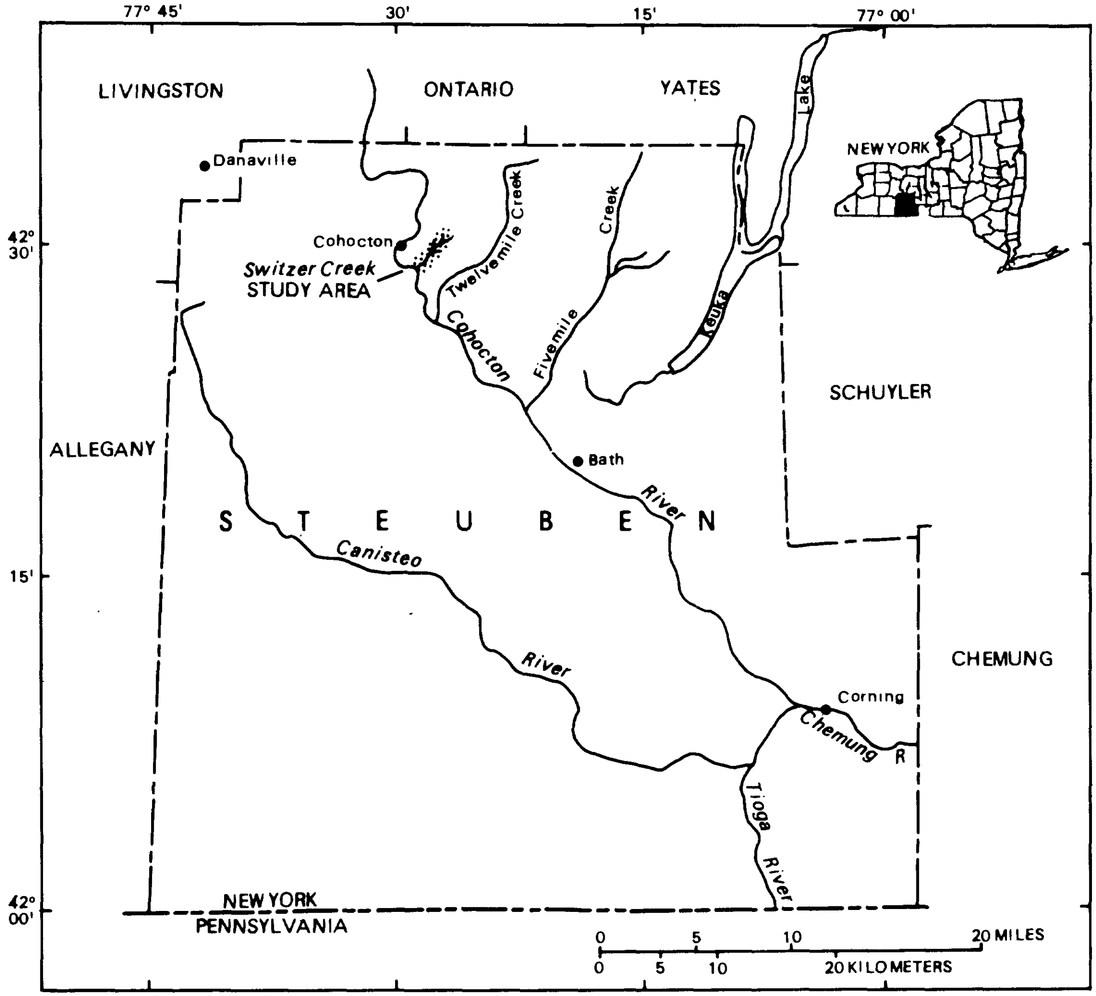
An abandoned U.S. Department of Agriculture gaging station on Switzer Creek was repaired and reactivated to provide continuous flow data. An automatic sampler was installed to collect samples during high flows. A local observer collected daily suspended-sediment samples and twice-weekly nutrient samples. Data on chemical quality of precipitation were obtained from U.S. Geological Survey precipitation stations at Allegany State Park in southwestern New York, Stillwater in northeastern New York, and Mays Point in north-central New York to calculate atmospheric loadings of nitrogen and phosphorus to the basin.

Nitrogen and phosphorus concentrations in streamflow and precipitation are reported as total concentrations (suspended plus dissolved). Organic carbon samples were analyzed for both suspended and dissolved concentrations. (Dissolved refers to material in a water sample that will pass through a 0.45-µ filter.) Analyses for dissolved organic carbon were performed on the filtrate.

Statistical analysis was done by the Statistical Analysis System (SAS) general linear models procedure (SAS, 1979) to provide a predictive relationship between streamflow and nutrient and organic carbon concentrations and loads. Daily mean streamflow and daily mean suspended-sediment concentrations and discharges, along with the analyses of all samples collected during the study, are published by the U.S. Geological Survey (1979, 1980).

Acknowledgments

Thanks are extended to the Steuben Soil and Water Conservation District, who provided information on land use and agricultural practices within the Switzer Creek basin.



Base from U.S. Geological Survey
State base map, 1:500,000, 1974

Figure 1.--Location of Switzer Creek basin, Steuben County, N.Y.

BASIN DESCRIPTION

Physiography

Switzer Creek drains a 3.55-mi^2 area in north-central Steuben County and flows 3.8 mi southwestward from its headwaters to its junction with the Cohocton River, 1.6 mi south of the village of Cohocton (fig. 1). The Switzer Creek basin is in the northern limits (Appalachian uplands) of the glaciated section of the Allegheny Plateau and is characterized by a long, narrow valley having steep walls and broad, gently sloping hilltops.

The watershed altitude ranges from slightly less than 1,300 ft above sea level at the Switzer Creek outlet to about 2,000 ft in the uplands. The average stream gradient is relatively steep, approximately 175 ft/mi. The stream drops from an altitude of 1,900 ft at the headwaters to 1,230 ft at the mouth (fig. 2).

The soils of the basin fall within three major series--Bath, Howard, and Mardin, with some smaller areas of Lordstown (U.S. Soil Conservation Service, 1978). These soils are similar in that they are formed in glacial deposits of silty sandy till or sand and gravel outwash derived from sandstone and shale. All are deep and range from moderately well drained to excessivley drained, with slopes ranging from nearly level to steep. Within this basin, the Bath soils are found mainly on the steep valley sides; the others are generally found on gently sloping hilltops.

Climate and Streamflow

The climate of the basin is marked by four well-defined seasons. Mean annual temperature is 46°F, with extremes ranging from about -30°F to 100°F. Precipitation averages 31 in/yr. From October 1, 1978 to September 30, 1979 (water year 1979)[1] , annual precipitation was 34.1 in., about 3 in. above normal, and from October 1979 to September 1980, annual precipitation was 28.8 in., about 2 in. below normal.

Runoff from Switzer Creek was 15.5 in/yr during the 1979 water year and 11.8 in/yr during the 1980 water year and averaged 13.6 in/yr during the study. The average monthly runoff was 1.18 in. Runoff at the nearby Cohocton River gaging station was 16.1 in. in the 1979 water year (1.1 in. above normal) and 12.1 in. during the 1980 water year (2.9 in. below normal) and averaged approximately 14.1 in/yr during the study, compared with a long-term average of 15.0 in/yr.

Annual mean flow of Switzer Creek during the study was 3.64 ft^3/s. A maximum mean daily discharge of 84 ft^3/s was observed on March 5, 1979, and minimum flows of 0.3 ft^3/s occurred on several days during September 1980.

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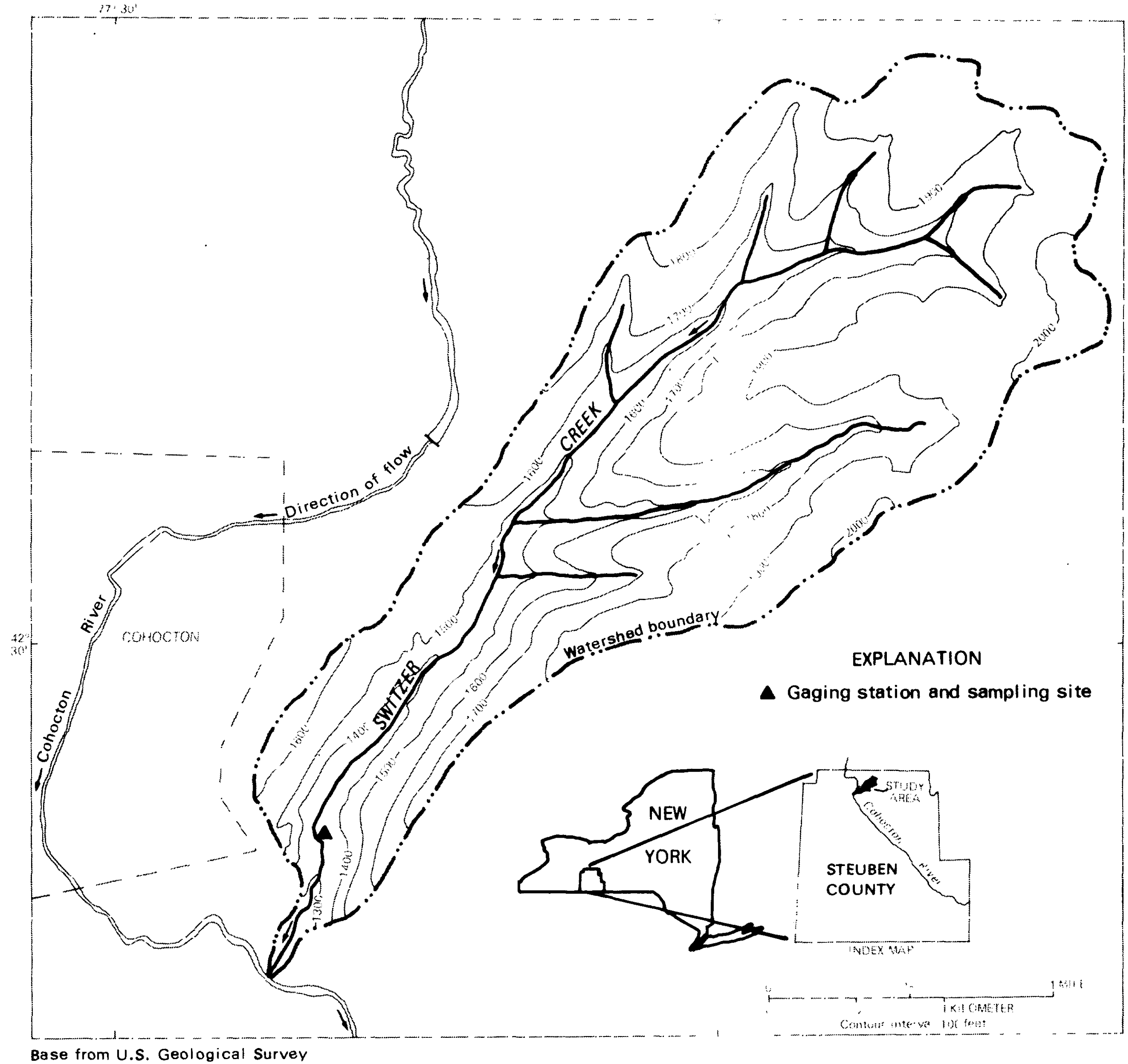
[1] October 1 through September 30 is known as a water year.

The 1979 water year was unusual in that maximum precipitation occurred in December, January, and September (fig. 3). Maximum precipitation usually occurs from April through July. The driest months, in terms of runoff and consequently streamflow, are usually May through October because of higher evapotranspiration rates during the growing season.



Base from U.S. Geological Survey
Avoca, 1978 and Naples, 1942, NY, 1:24,000

Figure 2.--Topography and location of stream-sampling site in Switzer Creek basin.

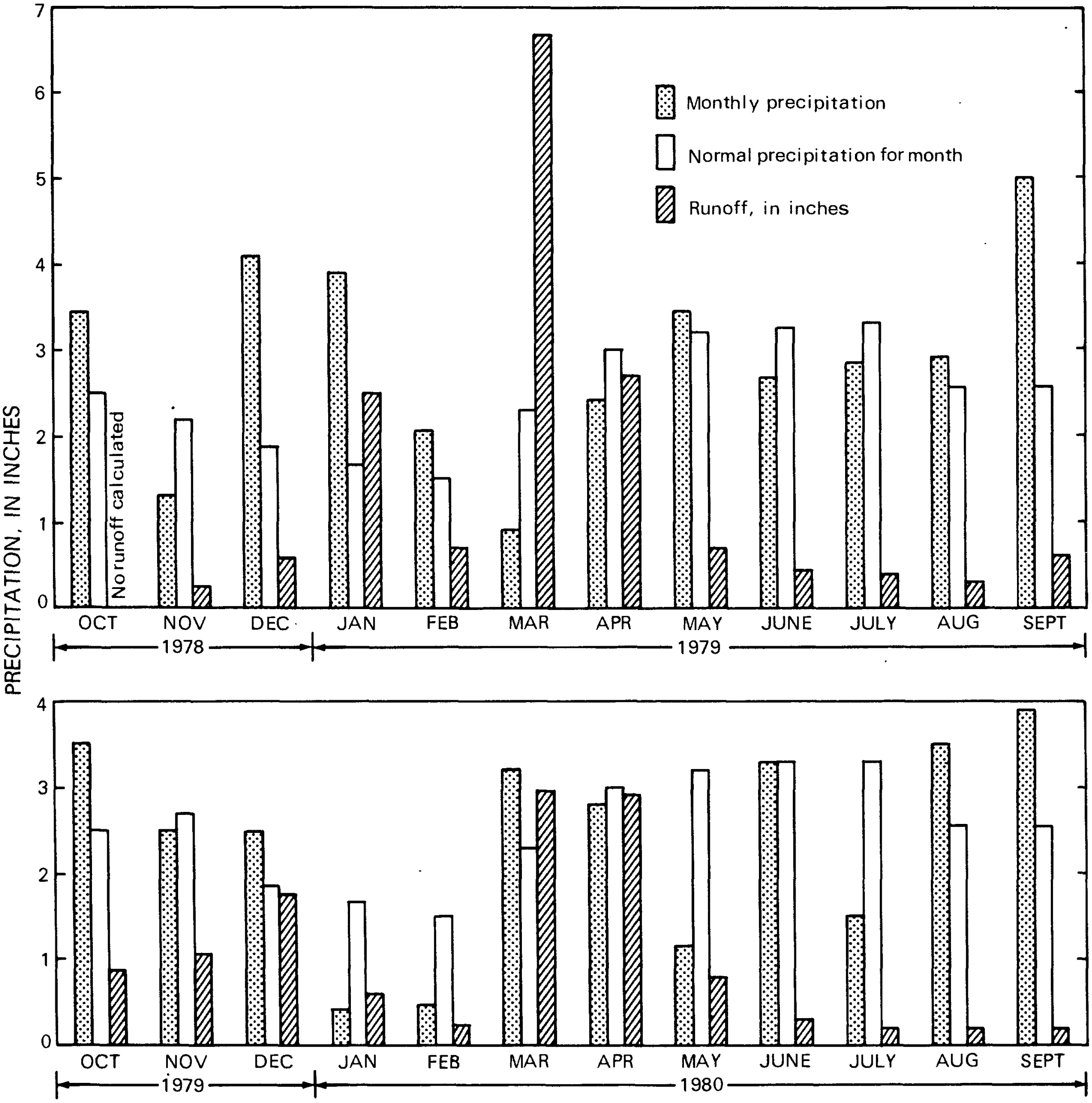


Figure 3.--Monthly precipitation and runoff in Switzer Creek basin, October 1978 through September 1980. (Precipitation data from National Oceanic and Atmospheric Administration precipitation station in Dansville, N.Y.)

Land Use

The Switzer Creek basin contains approximately 2,273 acres above its mouth at the Cohocton River (2,208 above the Switzer Creek gaging station), of which 49 percent is forest and 51 percent is agricultural. Acreage and percentages of land use are summarized in table 1.

Table 1.--Land use in Switzer Creek basin, by acreage and percent, in 1977.

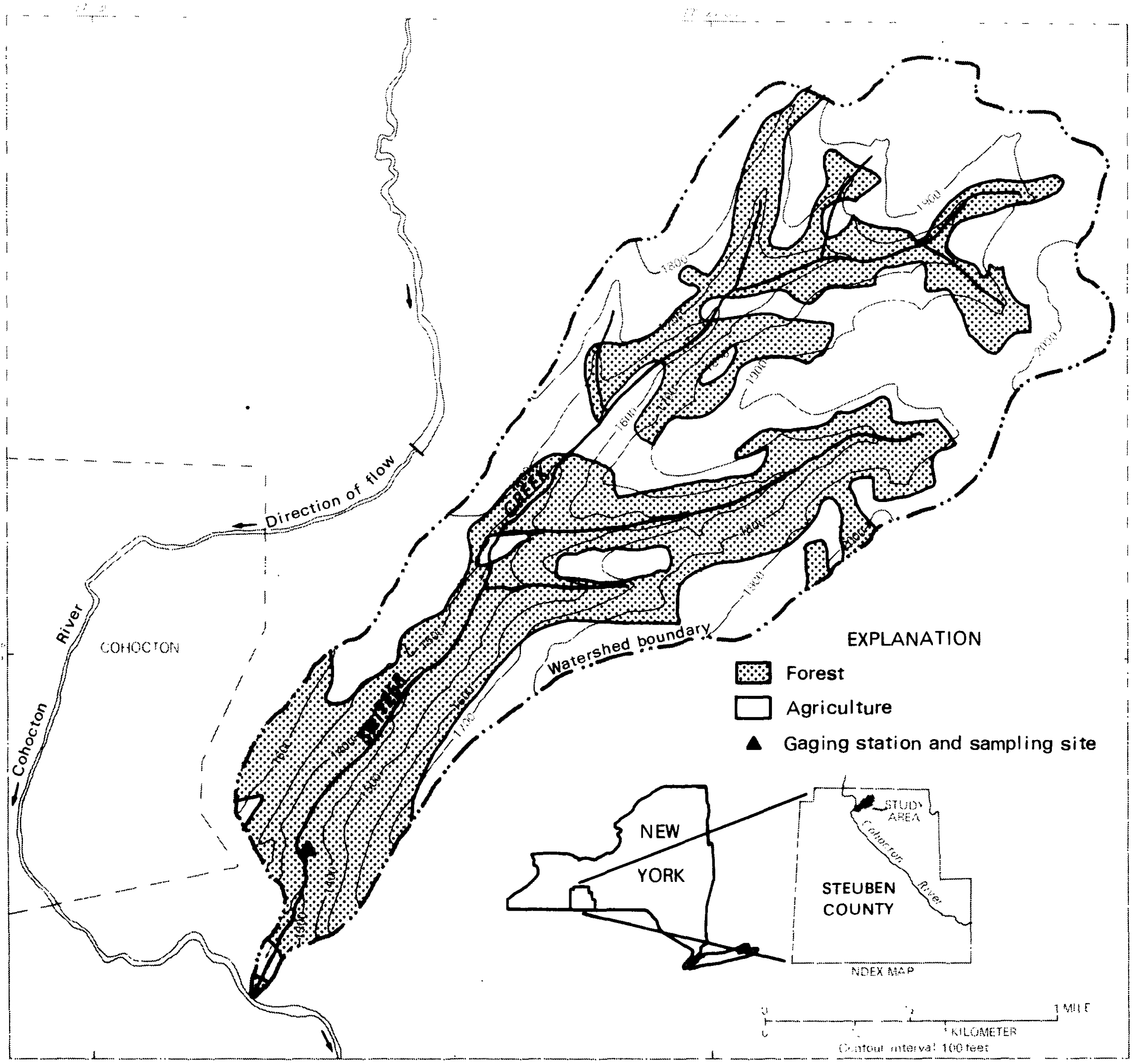
[Data from Steuben County Soil and Water Conservation District, 1978]

Land use	Number of acres	Percentage of total basin area
Forest	1,125	49
Other land and brushland	60	3
Agriculture		
Pasture	113	5
Hayland	378	16
Hayland stripped	114	5
Grain crops	242	11
Grain crops stripped	54	2
Row crops	131	3
Row crops stripped	56	6
Total	2,273	100

Comparison of the topographic contour map (fig. 2) with the generalized land-use map (fig. 4) indicates that agricultural lands occupy gently sloping hilltops in the upstream part of the basin. The downstream part of the basin contains steep valley slopes that are unsuitable for farming and are forested; as a result, most agricultural runoff enters Switzer Creek in the upstream part of the basin, where the farmlands are adjacent to the stream. Little agricultural runoff enters within the lower reaches, where the forest forms a buffer between the agricultural lands and the stream.

The main soil-conservation measures practiced in the basin are diversion ditches, strip cropping, and conservation-cropping systems. Soil-conservation measures are used on 23 percent of the hayland and 38 percent of the cropland, or 31 percent of the total agricultural land.

Use of fertilizer within the basin is summarized in table 2; annual loadings of nitrogen and phosphorus generated by fertilizers are summarized in table 3.



Base from U.S. Geological Survey
Avoca, 1978 and Naples, 1942, NY, 1:24,000

Figure 4.--Distribution of forest and agricultural areas within Switzer Creek basin.

Table 2.--Summary of fertilizer use in Switzer Creek basin, 1978-80.

[Data from Steuben County Soil and Water Conservation District, 1978]

Crop	Fertilizer[1] type	Quantity (lb/acre)	Time of application
Corn	10-10-10	400 lb	Spring
Corn	Manure	10,000-20,000 lb	Late fall to early spring
Potatoes	10-20-10	1,000 lb	Spring
Hayland in strip	0-15-30	100-150 lb	July, August
Grain	0-15-30	100-150 lb	Early April

---

[1] Fertilizer types generally are identified by three numbers; the first is the percentage of nitrogen, the second is percentage of phosphorus, and the third is percentage of potash.

Table 3.--Summary of nitrogen and phosphorus loadings from fertilizers in Switzer Creek basin, 1978-80.

[Data from Steuben County Soil and Water Conservation District, 1978.]

					Pounds per Year	
Fertilizer[1] type	Quantity (lb/acre)	Nitrogen (lb/acre)	Phosphorus (lb/acre)	Number of Acres	Nitrogen (total)	Phosphorus (total)
10-10-10	400	40	40	185	7,400	7,400
10-20-10	1,000	100	200	56	5,600	11,200
0-15-30	150	0	22.5	750	0	16,875
Manure	16,000	80	50	500	40,000	25,000

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[1] Fertilizer types generally are identified by three numbers; the first is the percentage of nitrogen, the second is percentage of phosphorus, and the third is percentage of potash.

SUSPENDED-SEDIMENT YIELD

From November 1978 through September 1980, Switzer Creek discharged 1,001 tons of suspended sediment, or about 0.44 tons/acre. Two high-water events, one on March 5, 1979, the other March 21, 1980, accounted for approximately 48 percent of the total. The average daily sediment discharge was 1.4 ton/d or about 0.41 (ton/mi^2)/d.

The two highest mean daily concentrations observed during the study occurred on March 5, 1979 (mean daily sediment concentration 1,120 mg/L; sediment load 290 tons) and on March 21, 1980 (mean daily concentration 1,310 mg/L; sediment load 188 tons). A maximum instantaneous sediment concentration of 3,840 mg/L occurred during high flow on September 14, 1979. On many days of low flow, mostly in late summer, mean daily sediment concentrations ranged from 0 to only 3 or 4 mg/L, which resulted in sediment loads of less than 0.01 ton/d. Daily mean suspended-sediment discharge for Switzer Creek is plotted in figure 5.

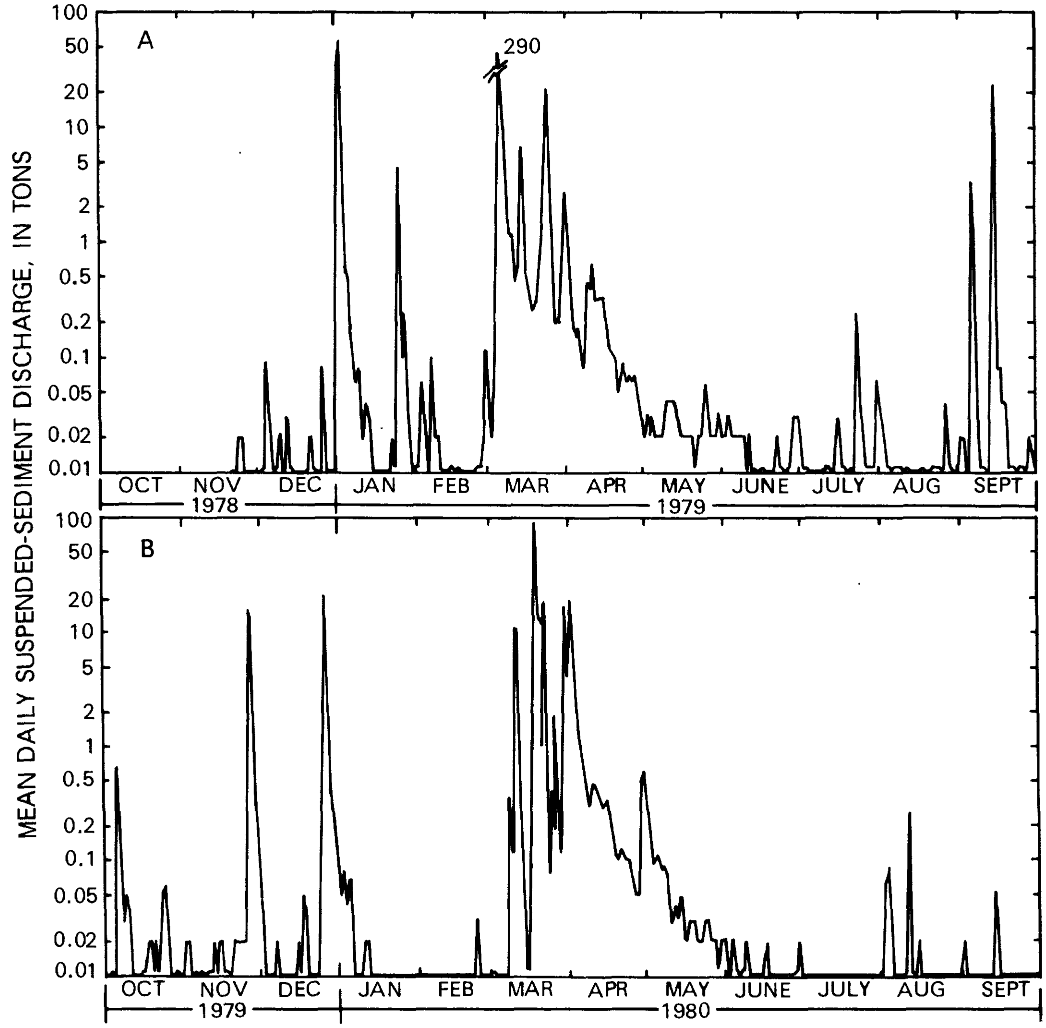


Figure 5.--Daily mean suspended-sediment discharge in Switzer Creek: A, November 1978 through September 1979; B, October 1979 through Septemer 1980.

RELATIONSHIPS BETWEEN NUTRIENT LOADS AND STREAM DISCHARGE

Nitrogen and phosphorus are essential nutrients for plant growth. Increased algal growth (algal blooms) generally occur in bodies of water that receive large quantities of these nutrients. Such growth can make the water unsuitable for many purposes. Algal blooms occur only when nutrients are available in sufficient quantity. The greatest amounts of most of these nutrients are carried during periods of high flow. During this study, nutrient loads transported by Switzer Creek were greatest during high flows of January, March, and December 1979 and in March and April 1980 (fig. 6).

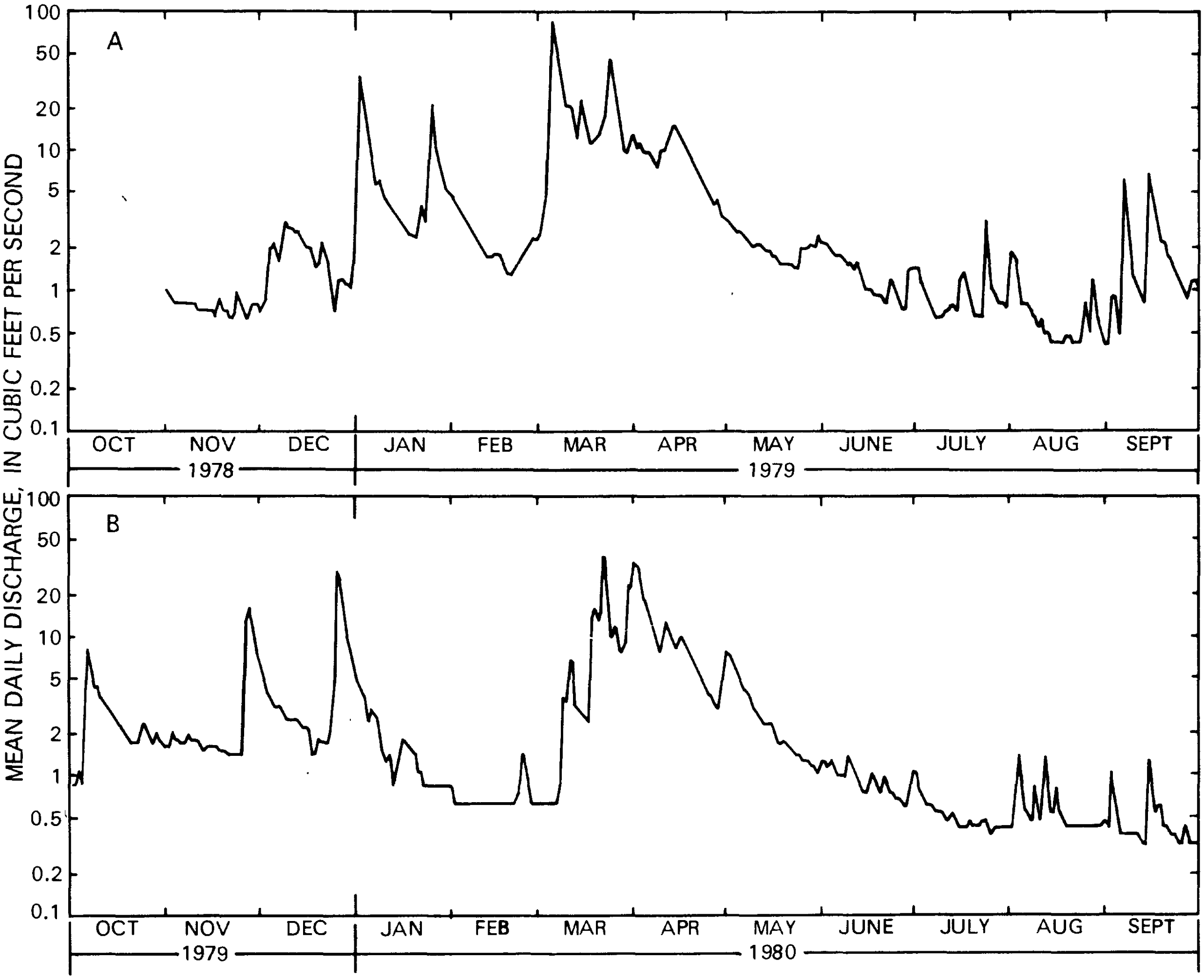


Figure 6. Mean daily discharge in Switzer Creek: A, November 1978 through September 1979; B, October 1979 through September 1980.

Nitrogen

Nitrite plus nitrate was the most abundant form of nitrogen (mean concentration 1.7 mg/L during the study). Total nitrite plus nitrate (NO_2 plus NO_3) concentrations were closely related to streamflow; maximum concentrations occurred during high-flow and low-temperature conditions. This relationship reflects the reduced biological uptake at low temperatures and also the high mobility of the NO_3 ion (Clark and others, 1974). The load of nitrite plus nitrate discharged during the study was about 25,400 lb or 11.2 lb/acre. Concentrations of total ammonium (as N) were low and fairly constant, ranging from less than 0.01 mg/L (detection limit) during much of the sampling period to a high of 0.65 mg/L (January 26, 1980) and showed little response to fluctuations in streamflow. Ammonium concentrations were highest during March 1980.

Total kjeldahl nitrogen (TKN), which is ammonium plus organic nitrogen, showed little relation to streamflow during late fall and winter, but concentrations increased sharply during storms from early spring through early fall. This seems to result from the heavy fertilizer applications that take place in early spring and late fall. High TKN values during spring and fall also may result from erosion of humus, which can contribute particulate organic matter to runoff. Humus carried in overland runoff and periphyton detritus abraded from the stream channel during high flow would contribute substantially to observed TKN. When humus is covered by snowpack or frozen in place during winter, the amount of particulate organic matter in overland runoff is greatly reduced. TKN loads during the study totaled 8,040 lb or 3.5 lb/acre.

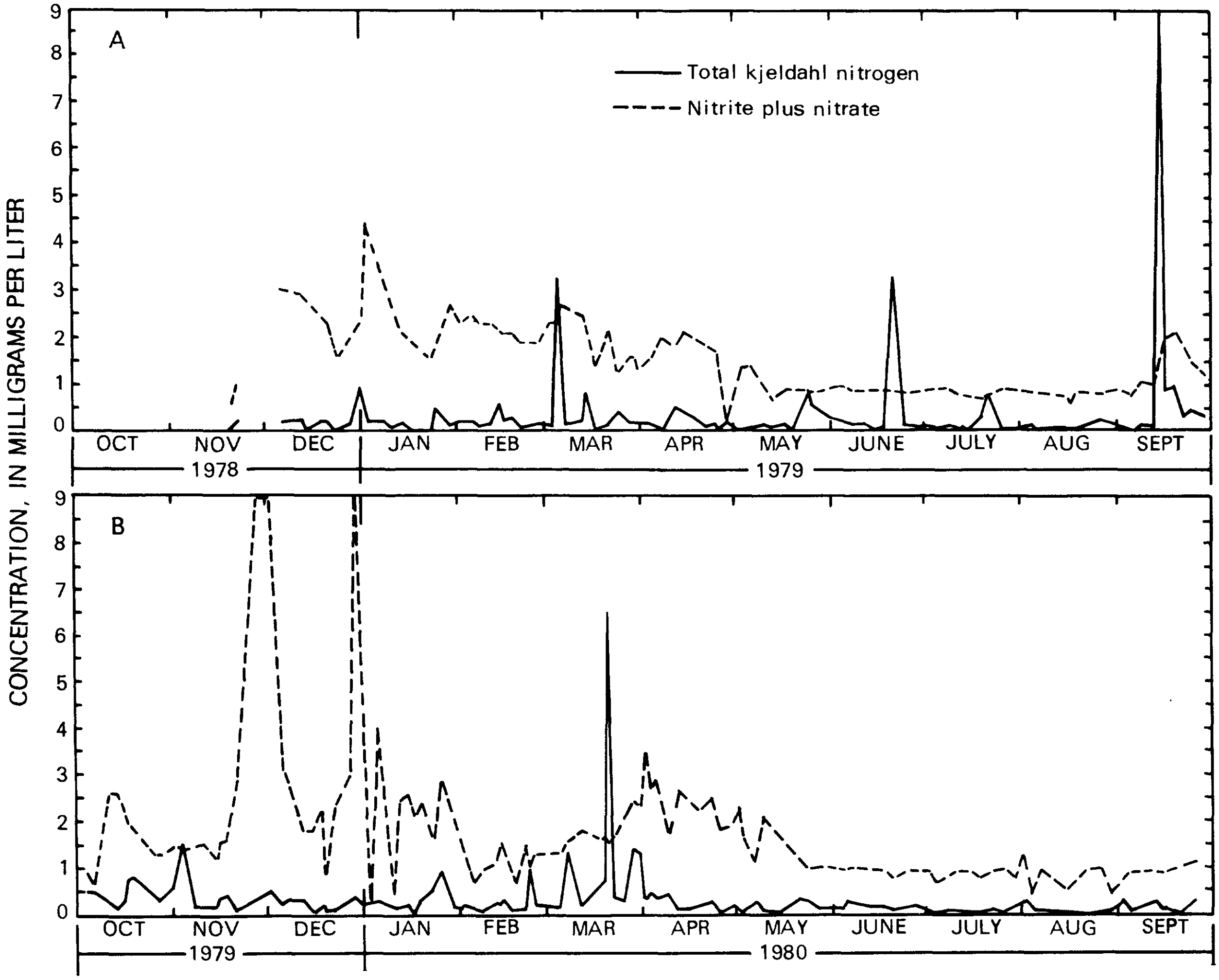


Figure 7. Concentrations of total nitrogen in Switzer Creek; A, November 1978 through September 1979; B, October 1979 through September 1980.

Approximately 80 percent of the total annual nitrogen load was transported during base flow. Nitrite plus nitrate formed 88 percent of the total nitrogen load transported during base flow; organic nitrogen accounted for nearly 85 percent of the nitrogen transported during high flows. (Organic nitrogen is not considered a nutrient.) The graph in figure 7 shows relationships between observed concentrations of nitrite plus nitrate and total kjeldahl nitrogen.

Phosphorus

Concentrations of total phosphorus were relatively uniform during periods of base flow throughout the study and seldom exceeded 0.1 mg/L (fig. 8). Slightly elevated concentrations were noted during winter, particularly January through March 1979, when flows were higher than during the same months in 1980. Storms produced markedly higher concentrations of phosphorus, and 90 percent of the annual load of total phosphorus was transported during high flows, which reflects the affinity of phosphate for particulate matter. Phosphorus loads during the study totaled 1,430 lb or 0.63 lb/acre. The total load of orthophosphorus as P was 431 lb or 0.19 lb/acre.

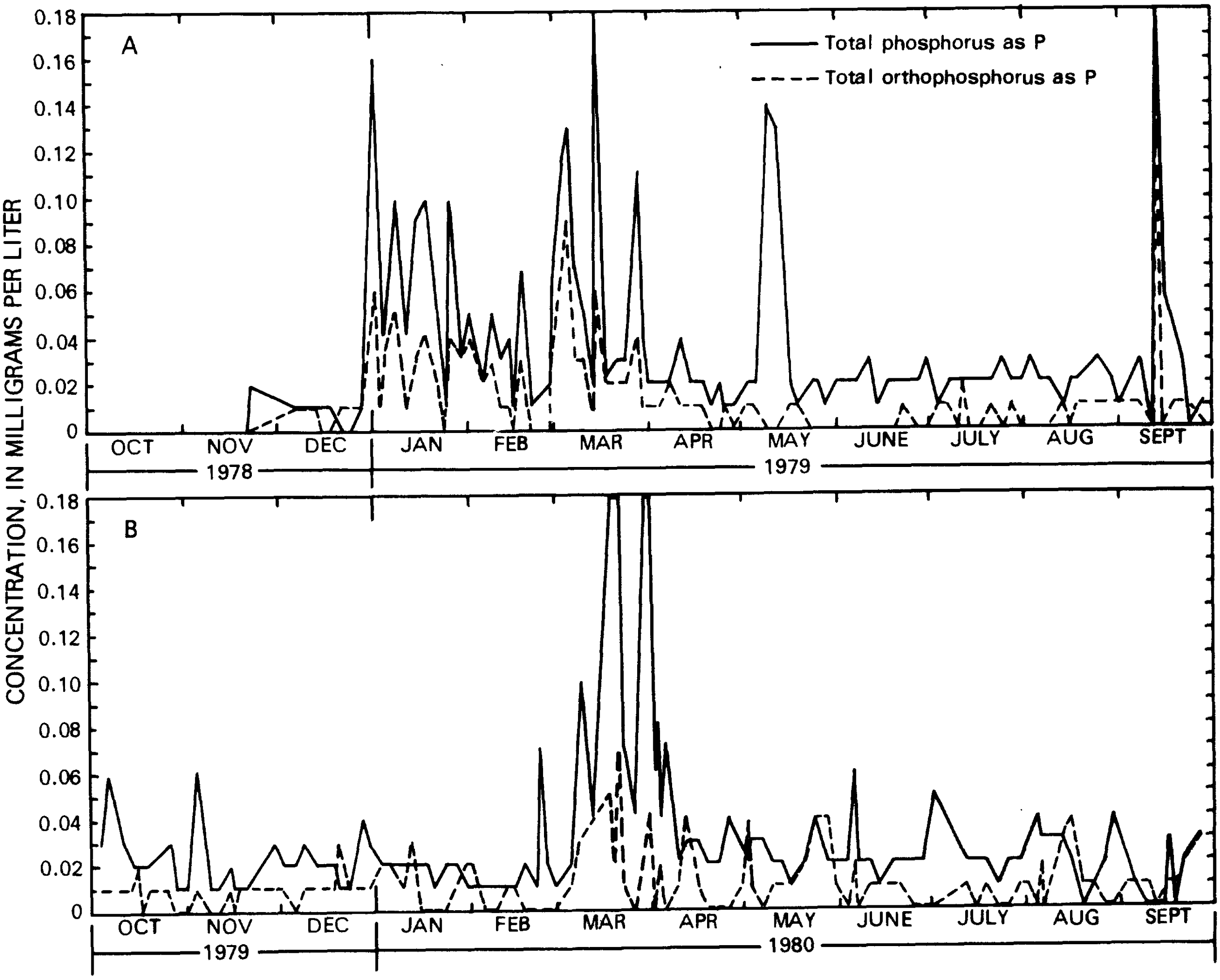


Figure 8. Concentrations of total phosphorus in Switzer Creek; A, November 1978 through September 1979; B, October 1979 through September 1980.

Organic Carbon

Dissolved organic carbon (DOC) and suspended organic carbon (SOC) concentrations in Switzer Creek (fig. 9) varied widely and showed little relation to streamflow. Generally the dissolved organic carbon made up 75 to 90 percent of the load of total organic carbon. Concentrations of dissolved organic carbon at Switzer Creek exceeded 20 mg/L in several samples collected at different times during the study and on four occasions equaled or exceeded 50 mg/L. Minimum concentrations were below 1 mg/L on only a few occasions. In only two months (May 1979 and March 1980) were DOC concentrations less than 1 mg/L in two or more successive samples. SOC concentrations seldom exceeded 1 mg/L, although suspended concentration did exceed the dissolved concentration in seven samples collected during the study. Minimum concentrations of SOC generally were in the range of 0.2 to 0.3 mg/L, and a few were as low as 0.1 mg/L. Total loads of suspended and dissolved organic carbon were 15,550 lb (6.8 lb/acre) and 60,580 lb (27 lb/acre), respectively.

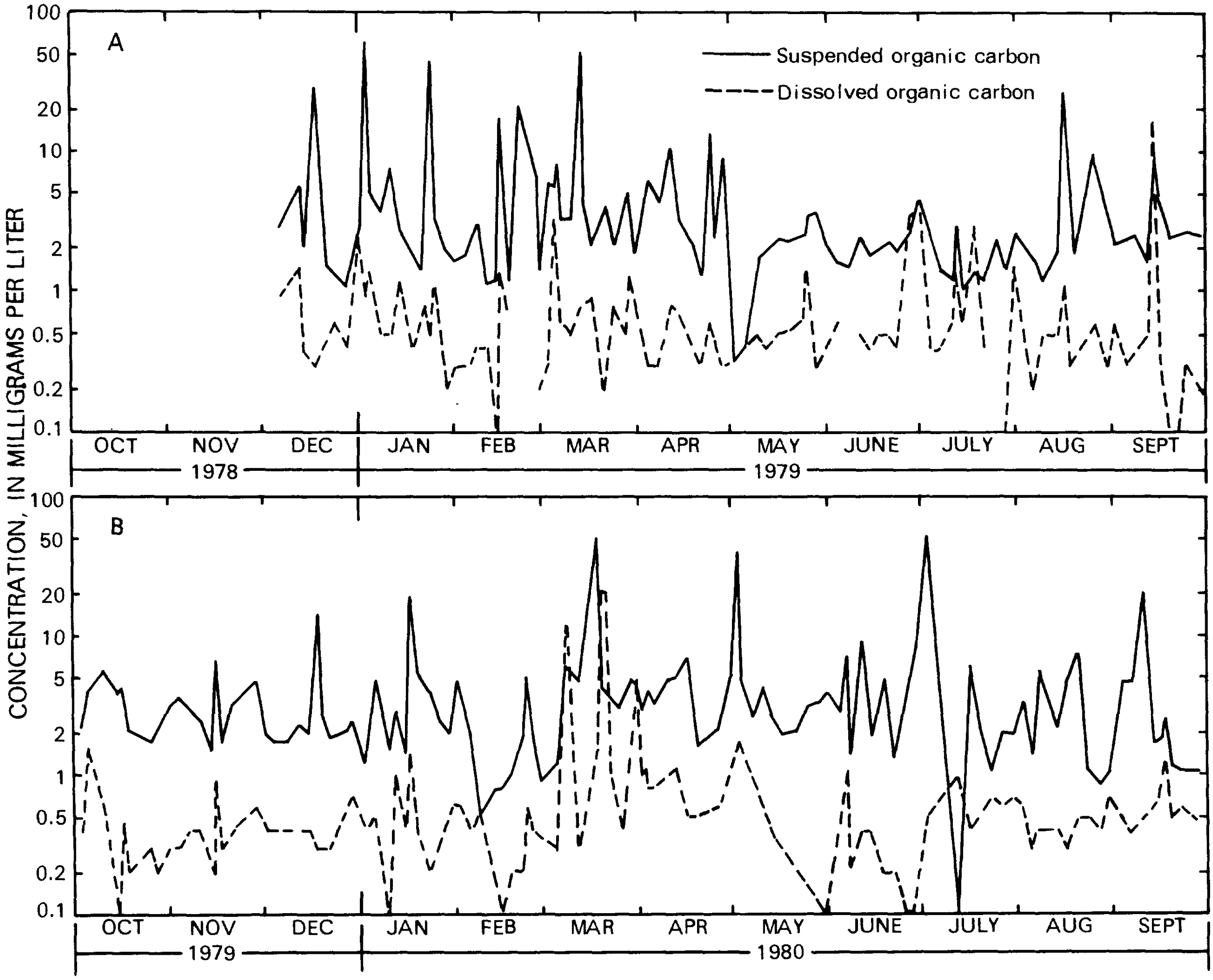


Figure 9.--Concentrations of organic carbon in Switzer Creek; A, November 1978 through September 1979; B, October 1979 through September 1980.

Statistical Relationships

A primary purpose of this report is to provide data on the amounts (loads) of nutrients being transported by Switzer Creek and to examine the relationships between nutrient concentration and streamflow. Nutrient loads are calculated from the equation:

$$L = 5.39\ CQ \tag{1}$$

where

L = nutrient load, in pounds;
C = nutrient concentration, in milligrams per liter;
Q = streamflow, in cubic feet per second;
5.39 = factor to convert nutrient concentration and discharge to load.

Two different approaches were used to relate nutrients to streamflow--the first relates streamflow to nutrient concentrations, the second relates streamflow to load. Both approaches use the Statistical Analysis System (SAS) general-linear-models procedure (SAS, 1979).

Plots of nutrient concentration in relation to streamflow and the line of best fit are shown in figure 10. All lines have a positive slope (nutrient concentration increases as streamflow increases), which indicates that the nutrients are derived from nonpoint sources. As overland runoff increases, it washes greater amounts of nutrients to the stream, resulting in increased nutrient concentration during high flows (Takita, 1975). Conversely, the quantity of nutrients from point sources tends to be relatively constant and therefore becomes diluted at high flows. The concentrations of nutrients from point sources decrease at high flows, which would result in best-fit lines with a negative slope. The analysis of variance by the F and T tests at $\alpha = 0.01$ indicates a definite linear relationship between the log of the nutrient concentration and the log of streamflow.

Nutrient Concentrations

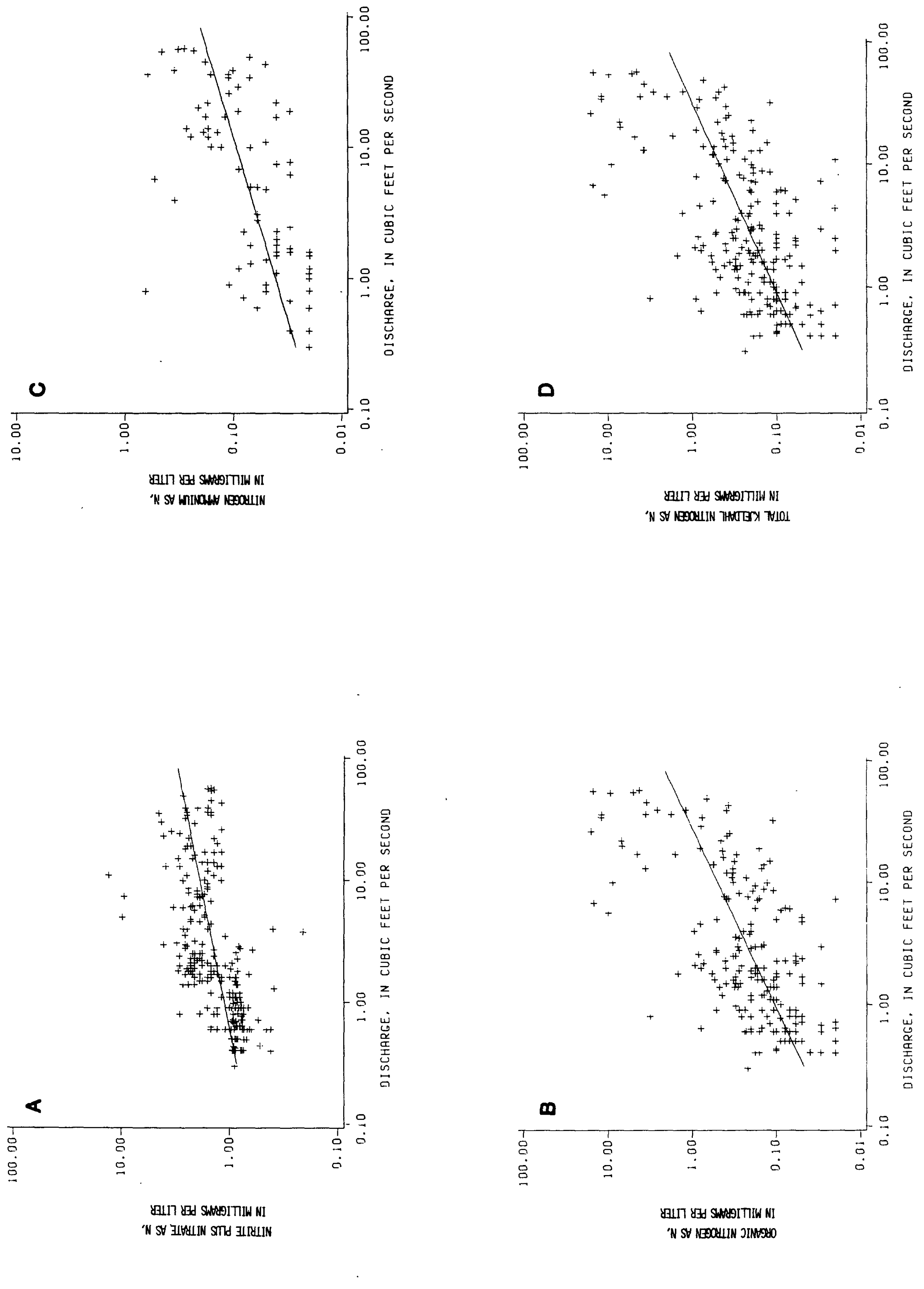
In the first approach, regression analysis was performed on linear and log transforms of instantaneous streamflow and instantaneous nutrient-concentration data. The log transforms provided the highest coefficients of determination (r^2) and yielded equations of the form:

$$\log C = \log a + b \log Q, \tag{2}$$

where

C = nutrient concentration, in milligrams per liter;
Q = streamflow, in cubic feet per second;
a = Y intercept on log-log plot;
b = exponent defining the slope of the regression line.

The least-squares regression equations that were transformed to the form $C = aQ^b$ are listed in table 4 along with associated coefficients of determination and confidence factors for each equation. These equations can be used to predict the concentration of a particular nutrient at a given stream discharge. In this manner, daily mean concentrations of nutrients can be estimated from daily streamflow values through equation 2. Daily mean nutrient loads can then be determined from equation 1 and summed to yield total monthly nutrient loads.


A
NITRITE PLUS NITRATE AS N, IN MILLIGRAMS PER LITER
100.00
10.00
1.00
0.10
DISCHARGE, IN CUBIC FEET PER SECOND
0.10
1.00
10.00
100.00
B
ORGANIC NITROGEN AS N, IN MILLIGRAMS PER LITER
100.00
10.00
1.00
0.10
0.01
DISCHARGE, IN CUBIC FEET PER SECOND
0.10
1.00
10.00
100.00
C
NITROGEN AMMONIUM AS N, IN MILLIGRAMS PER LITER
10.00
1.00
0.10
0.01
DISCHARGE, IN CUBIC FEET PER SECOND
0.10
1.00
10.00
100.00
D
TOTAL KJELDAHL NITROGEN AS N, IN MILLIGRAMS PER LITER
100.00
10.00
1.00
0.10
0.01
DISCHARGE, IN CUBIC FEET PER SECOND
0.10
1.00
10.00
100.00

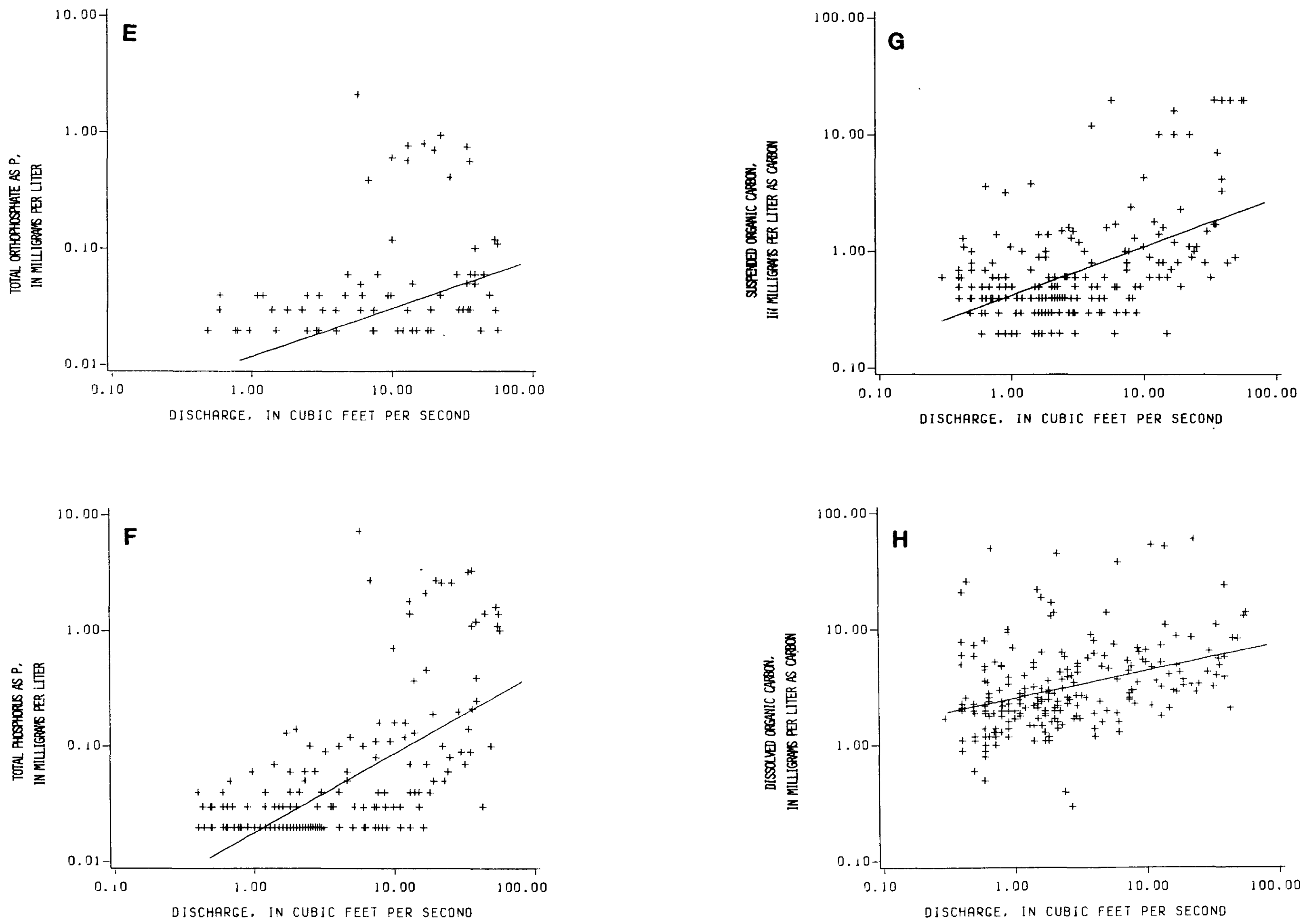


Figure 10.--Relationship between stream discharge and concentration of selected constituents in Switzer Creek: A, nitrite plus nitrate; B, total organic nitrogen; C, Ammonium; D, total kjeldahl nitrogen; E, total orthophosphate as P; F, total phosphorous as P; G, suspended organic carbon; H, dissolved organic carbon.

Nutrient Loads

In the second approach, instantaneous nutrient loads were calculated from equation 1, and regression analysis was then performed on the linear and log transforms of instantaneous streamflow and instantaneous nutrient loads. Again, the log transforms provided the highest coefficients of determination (r^2) and produced equations of the form:

$$\log L = \log a + b \log Q, \tag{3}$$

where

L = nutrient load, in pounds per day;
Q = streamflow, in cubic feet per second;
a = Y intercept on log-log plot
b = exponent defining the slope of the regression line.

The least-squares regression equations transformed to the form $L = aQ^b$ are also listed in table 4. These equations were used to estimate daily mean nutrient loads directly from daily mean streamflow data. The daily nutrient load values were then summed to obtain the total monthly nutrient loads listed in table 5.

Table 4.--Equations relating nutrient concentrations and load to streamflow, Switzer Creek, November 1978 through September 1980.

Constituent	Regression equation	Coefficient of determination r^2	Confidence factor[1]	Number of observations
Concentration				
$NO_2 + NO_3$ as N	$C = 1.13Q^{0.225}$	0.31	1.59	240
Organic nitrogen as N	$C = .106Q^{0.678}$	.38	3.39	207
Nitrogen ammonium as N	$C = .015Q^{0.425}$	.51	2.00	174
Total kjeldahl nitrogen as N	$C = .108Q^{0.648}$	.51	3.17	238
Total orthophosphate as P	$C = .012Q^{0.412}$	.27	2.69	199
Total phosphorus as P	$C = .018Q^{0.682}$	.45	2.81	235
Suspended organic carbon	$C = .425Q^{0.414}$	.28	2.44	214
Dissolved organic carbon	$C = 2.57Q^{0.236}$	.13	2.24	226
Load				
$NO_2 + NO_3$ as N	$L = 6.11Q^{1.22}$	.93	1.59	240
Organic nitrogen as N	$L = .570Q^{1.68}$	.79	3.38	207
Nitrogen ammonium as N	$L = .082Q^{1.43}$	.80	2.78	174
Total kjeldahl nitrogen as N	$L = .614Q^{1.65}$	.80	3.08	238
Total orthophosphate as P	$L = .061Q^{1.43}$	.82	2.49	199
Total phosphorus as P	$L = .097Q^{1.69}$	.83	2.80	235
Suspended organic carbon	$L = 2.29Q^{1.41}$	.82	2.44	214
Dissolved organic carbon	$L = 13.9Q^{1.24}$	.81	2.24	226

[1] This value, if divided into or multiplied by a given dependent variable, will give a range of values associated with the standard error about the mean of the predicted values.

Table 5.--Predicted monthly nutrient loads in Switzer Creek, November 1978 through September 1980.

[All loads are in pounds except as noted, and were calculated from equations in table 4.]

Month	Mean flow ft^3/s)	Measured sediment-suspended load (tons)	Total phosphorus as P	Total orthophosphorus as P	Total kjeldahl nitrogen as N	Nitrite + nitrate as N	Ammonium nitrogen as N	Organic nitrogen as N[1]	Suspended organic carbon	Dissolved organic carbon
					Water Year 1979					
1978										
Nov	0.8	([2])	2.0	1.3	12.5	137	1.7	11.4	48.3	308
Dec	1.7	.4	8.3	4.4	51.3	380	5.9	48.4	161	875
1979										
Jan	7.4	95.5	129	40.3	729	2,370	54.1	735	1,620	5,670
Feb	2.2	.5	11.2	5.5	68.1	458	7.8	65.0	203	1,060
Mar	20.0	379	633	159	3,480	7,820	216	3,590	5,590	19,000
Apr	8.3	6.0	113	39.8	662	2,480	53.4	658	1,430	5,910
May	2.0	.8	9.8	5.1	59.8	442	7.0	57.6	190	1,020
June	1.3	.4	4.6	2.7	29.3	250	3.6	27.2	99.6	573
July	1.0	.6	3.4	2.0	20.7	190	2.6	19.4	73.3	434
Aug	.7	.2	1.7	1.1	10.8	117	1.5	9.9	41.7	264
Sept	1.8	27.4	10.4	4.9	63.2	395	6.6	60.8	168	916
Total		511	926	266	5,190	15,040	360	5,280	9,620	36,000
					Water Year 1980					
1979										
Oct	2.6	1.6	17.6	8.0	105	621	11.0	102	291	1,450
Nov	3.1	18.3	32.7	12	191	830	16.4	188	440	1,960
Dec	5.2	24.8	86.4	27.3	490	1,630	36.3	494	971	3,880
1980										
Jan	1.6	.3	8.1	4.0	49.3	356	5.3	47.0	152	810
Feb	.6	.0	1.4	1.0	9.0	106	1.3	8.3	36.8	241
Mar	8.8	424	183	54.1	1,030	3,000	72.7	1,050	1,920	7,220
Apr	9.0	18.7	149	47.8	851	2,830	67.2	849	1,710	6,760
May	2.4	1.5	15.7	7.2	94.8	570	9.6	91.3	265	1,330
June	.9	.1	2.4	1.6	15.1	157	2.1	14.0	57.4	356
July	.5	.0	.9	.8	5.7	77.3	.9	5.2	25.3	173
Aug	.6	.5	1.3	.9	7.8	93.4	1.1	7.1	31.9	213
Sept	.4	.1	.8	.6	5.4	71.0	.9	5.0	23.5	153
Total		490	499	165	2,850	10,340	225	2,860	5,920	24,550

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[1] Organic nitrogen is not equal to total kjeldahl nitrogen minus ammonium because mean monthly loads were calculated from equations in table 4, and difference reflects the effects of averaging to obtain line of best fit.

[2] Only partial data available.

The relationship between nutrient load and streamflow has a much higher coefficient of determination than that for nutrient concentration, and this relationship was used to calculate the loads reported in tables 5 and 6. The relationship between nutrient concentration and streamflow is included only to emphasize the large variability of nutrient concentrations at given streamflows (due to seasonal and antecedent conditions) and to indicate the importance of streamflow in the calculation of nutrient loads.

SEASONAL TRENDS

To discern seasonal trends in data from Switzer Creek, the sampling period was divided into three 4-month segments representing the low, moderate, and high-flow conditions that generally prevail each year. June through September is the period of low flows, October through January is usually one of moderate flows, and February through May is the period of high flows. (Although February is included in the high-flow period, February flows in 1979 were moderate and in 1980 were low.) Nutrient loads during the respective seasons are listed in table 6.

High suspended-sediment discharge typically occurs during high-flow periods, and low suspended-sediment discharge occurs during low-flow periods. Maximum suspended-sediment discharges occurred during February through May of 1979 and 1980, when runoff was highest. These months also produced the highest suspended-sediment concentrations because overland flow accompanying snowmelt and early spring rains subjected freshly plowed soil to greater erosion. The smallest discharges of suspended sediment in Switzer Creek were during June through September 1980 and amounted to only 0.75 ton.

Table 6.--Seasonal nutrient loads in Switzer Creek, November 1978 through September 1980.

[All loads are in pounds, except as noted.]

Month	Mean flow (ft^3/s)	Total phosphorus as P	Total orthophosphorus as P	Total kjeldahl nitrogen as N	Nitrite + nitrate as N	Ammonia nitrogen as N	Organic nitrogen as N	Suspended organic carbon	Dissolved organic carbon
1978-79									
Nov-Jan[1]	3.3	139	46.0	793	2,890	61.7	795	1,830	6,850
Feb-May	8.1	767	209	4,270	11,200	284	4,370	7,410	27,000
Jun-Sept	1.0	20.1	10.7	124.0	952	14.3	117.3	383	2,190
1979-80									
Oct-Jan	3.1	145	51.3	835	3,440	69.0	831	1,854	8,100
Feb-May	5.2	349	110.1	1,980	6,510	150.8	2,000	4,010	15,550
Jun-Sept	.6	5.4	3.9	34.0	399	5.0	31.3	138.1	895

[1] Data collection started in November 1978.

High nutrient discharges also occurred during the high-flow periods. The periods from February through May in 1979 and 1980 produced predictably higher discharges of all nutrients as a result of higher flows and concentrations. Maximum discharges of nutrients and streamflow for the entire study occurred during February through May 1979 (table 6).

Mean streamflow and nutrient loads during November 1978 through January 1979 were similar to those of October 1979 through January 1980. Although the first period had a slightly lower mean stream discharge, the phosphorus and nitrate loads were slightly higher, and DOC was nearly 30 percent higher (table 6). This is attributed to three high flows that were not sustained long enough to significantly affect mean streamflow for the period but produced increased loadings of nutrients. A relatively low daily mean discharge of 0.59 ft^3/s during June through September 1980 resulted in minimum concentrations and loads of nitrogen and phosphorus.

ATMOSPHERIC CONTRIBUTION OF NUTRIENTS

To evaluate the contribution of nitrogen and phosphorus from the atmosphere to the Switzer Creek basin, data from several precipitation-sampling sites were examined. The sites, operated as part of the U.S. Geological Survey's statewide precipitation-observation network, collect composite samples over periods of approximately 1 month. Samples are then removed and sent to the Geological Survey laboratory in Atlanta, Ga., for analysis for various chemical constituents, including nitrite plus nitrate, ammonium, and phosphorus. Samples collected in this manner, called bulk samples, contain contributions from both wetfall and dryfall; the proportions contributed by either source differ among sites as well as by constituent.

The stations at Allegany State Park in southwestern New York, Mays Point in north-central New York, and Stillwater Reservoir in northeastern New York were selected as the most representative of conditions in the Switzer Creek basin. Computed mean concentrations of nitrite plus nitrate, ammonium, and phosphorus over the 2-year study differed by less than 20 percent among the three sites. The atmospheric loads calculated for the Switzer Creek basin are given in table 7. Although the data are listed by month, the actual period of collection may include parts of 2 or 3 months, in which case data are tabulated for the month during which the most collection days occurred. Loads were calculated by multiplying precipitation (inches) by concentration (mg/L) and then multiplying the result by a conversion factor to yield loads, in lb/acre.

Precipitation data were not available for all months at all sites. If precipitation data from more than one site were available for a given month, those values were averaged to provide a load figure; otherwise the site providing the data was used. During May and June 1979, no data were available from any of the sites; therefore, concentrations for these months were estimated by linear-regression equations developed by Peters, Schroeder, and Troutman (1982).

Atmospheric loads of all nutrients to the Switzer Creek basin varied from month to month except phosphorus, which was relatively constant during the period of study. Maximum loads of nitrite plus nitrate occurred during December 1978 and September 1980; maximum loads of ammonium occurred during December 1978 and June 1980 (table 7).

Nitrite plus nitrate loads discharged by Switzer Creek during January, March, and April 1979 exceeded the atmospheric loads of these constituents during those months. Nitrite plus nitrate loads during December 1979 and March-April 1980 also exceeded the atmospheric loads. During the rest of the study, the amounts of nutrients deposited on the basin exceeded those removed by the creek and reflect storage in the snowpack, volatilization, and uptake by plants.

Table 7.--Atmospheric contribution of nutrients to Switzer Creek basin, November 1978 through September 1980.

[All loads are in pounds.]

Month of collection	Nitrite plus nitrate	Ammonium	Phosphorus	Month of collection	Nitrite plus nitrate	Ammonium	Phosphorus
	WATER YEAR 1979				WATER YEAR 1980		
Oct 1978	--	--	--	Oct 1979	1000	386	45.5
Nov	454	159	22.7	Nov	864	705	22.7
Dec	2180	523	22.7	Dec	841	341	22.7
Jan 1979	955	364	22.7	Jan 1980	159	68.2	<22.7
Feb	727	318	<22.7	Feb	455	90.9	<22.7
Mar	432	182	<22.7	Mar	864	250	22.7
Apr	818	409	22.7	Apr	1140	636	22.7
May[1]	909	477	22.7	May	659	659	45.5
June[1]	886	500	22.7	June	841	796	68.2
July	523	273	45.5	July	409	341	45.5
Aug	546	273	45.5	Aug	1250	614	68.2
Sept	932	45.5	68.2	Sept	1300	523	22.7
Total	9360	3524	<340.8	Total	9780	5410	<431.8

[1] Loads were estimated by linear regression according to the method of Peters, Schroeder, and Troutman (1982).

SUMMARY AND CONCLUSIONS

Switzer Creek basin (3.55 mi^2) consists of about 49 percent forest and 51 percent farmland. Runoff from agricultural land enters Switzer Creek in the upstream parts of the basin, where the cultivated areas are adjacent to streams. In the lower part of the basin, little agricultural runoff reaches the creek because the forested hillsides between the stream and the farmland provide a buffer. Fertilizers and manure that are applied to farmland in the basin in spring and fall seem to be the primary source of nutrients in Switzer Creek.

Concentrations of nitrogen and phosphorus in Switzer Creek varied directly with stream discharge during the 1978-80 study. Although phosphorus concentrations seldom exceeded 0.1 mg/L, it was the nutrient that correlated most closely with streamflow because of its sorption on sediment particles. Nitrite plus nitrate also correlated closely with streamflow, and maximum concentrations occurred during high flows. High flows during spring and early fall produced significant increases in total kjeldahl nitrogen concentrations, but high flows during late fall and early winter did not. A possible explanation is that humus, a likely source of total kjeldahl nitrogen, is exposed and easily erodable from spring through early fall but is covered by snow or frozen in place during winter. Other sources of organic nitrogen may be the abrasion of periphyton from the stream channel during the growing season and application of fertilizer during spring and fall.

The largest nutrient loads occurred during periods of maximum runoff--from February through May of both years. Runoff and average stream discharge during the study were about normal, and nutrient loads were assumed to be typical of those during a year with normal runoff.

Dissolved and suspended organic carbon showed wide fluctuations in concentation with time and little relation to streamflow. Dissolved carbon generally formed about 75 to 90 percent of the load of total organic carbon, and suspended organic carbon formed the remainder.

Atmospheric contributions of nitrogen and ammonium varied monthly, whereas phosphorus contributions remained relatively constant. Slightly higher loadings of ammonium and phosphorus were noted during the drier months (June through September). Loads of nitrite plus nitrate deposited on the basin by precipitation during winter significantly exceeded loads of nitrite plus nitrate discharged by Switzer Creek during the same period, but loads deposited by precipitation during spring were much smaller than those discharged by the creek. This is attributed to storage of the atmospheric load in the snowpack during winter and its rapid discharge during the spring snowmelt.

Positive slopes of linear-regression equations relating nutrient concentrations to streamflow indicate that nitrogen and phosphorus are supplied from nonpoint sources (Takita, 1975). The high r^2 values achieved by correlating nutrient load with streamflow, and results of regression analyses comparing nutrient concentration to streamflow, seem to indicate that, despite the definite linear relationship between concentration and streamflow, loads (calculated from equations obtained from nutrient-load versus streamflow relationships) yield a higher degree of confidence. The calculated nutrient contributions from Switzer Creek can be helpful in estimating nutrient loadings from other similar watersheds in the Susquehanna River basin.

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