WATER-QUALITY CHARACTERISTICS OF INFLOW TO AND OUTFLOW FROM FALLS LAKE, NORTH CAROLINA, 1982-87

By Ronald G. Garrett

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INTERNATIONAL SYSTEM UNITS

The following factors may be used to convert inch-pound units published herein to the International System of Units (SI).

Multiply inch-pound unit	By	To obtain SI unit
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
acre	0.4047	hectare
	Volume	
gallon (gal)	3.785	liter (L)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	28.32	liter per second (L/s)
	Mass	
pound (lb)	453.6	gram
ton (short, 2,000 pounds)	0.9072	megagram (Mg)
ton per square mile (ton/mi^2)	0.3503	megagram per square kilometer (Mg/km^2)
	Specific conductance	
micromho (umho) per centimeter at 25 degrees Celsius	1.000	microsiemen per centimeter ($\mu S/cm$) at 25 degrees Celsius

Temperature: In this report temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\ (°C) + 32$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

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ABSTRACT

Falls Lake, an 11,300-acre reservoir in the north-central Piedmont of North Carolina, was completed in December 1983. Hydrologic data were collected at seven inflow sites and one outflow site to define water-quality characteristics. Hydrologic data collected include streamflow data and 56 physical and chemical characteristics of streamwater.

Compared to background concentrations in streams relatively unaffected by man, certain constituents at inflow sites were as much as 10- to 110-times greater. At the outflow site, however, these constituents were 2- to 3-times greater than background values.

The minimum dissolved-oxygen concentration measured at an inflow site was 0.6 milligrams per liter, whereas the minimum concentration measured at the outflow site was 6.7 milligrams per liter. Significant differences in other physical characteristics between inflow and outflow sites include a reduction in maximum concentration of suspended sediment from 1,850 milligrams per liter in an inflow sample to 100 milligrams per liter in the outflow sample and a reduction of maximum specific conductance values from more than 1,200 microsiemens per centimeter in an inflow sample to 140 microsiemens per centimeter in the outflow.

The maximum concentration of total nitrogen was 33 milligrams per liter at inflow sites and 4.5 milligrams per liter at the outflow site. Similarly, the maximum total phosphorus concentration was 20 milligrams per liter at inflow sites and 0.22 milligrams per liter at the outflow site.

Average annual loads of nitrogen and phosphorus in the outflow were as much as 66 and 21 percent of estimated inflow loads, respectively. Although

maximum inflow yields were 13 tons per square mile per year for nitrogen and 2.8 tons per square mile per year for phosphorus, outflow yields for the basin averaged about 1.1 and 0.05 tons per square mile, respectively.

INTRODUCTION

Falls Lake, an 11,300-acre multi-purpose reservoir for water supply, flood control, fish and wildlife conservation, and recreation, is located in the north-central Piedmont region of North Carolina. The Falls Lake basin is 772 mi^2 (square miles) and constitutes approximately 15 percent of the Neuse River basin (fig. 1).

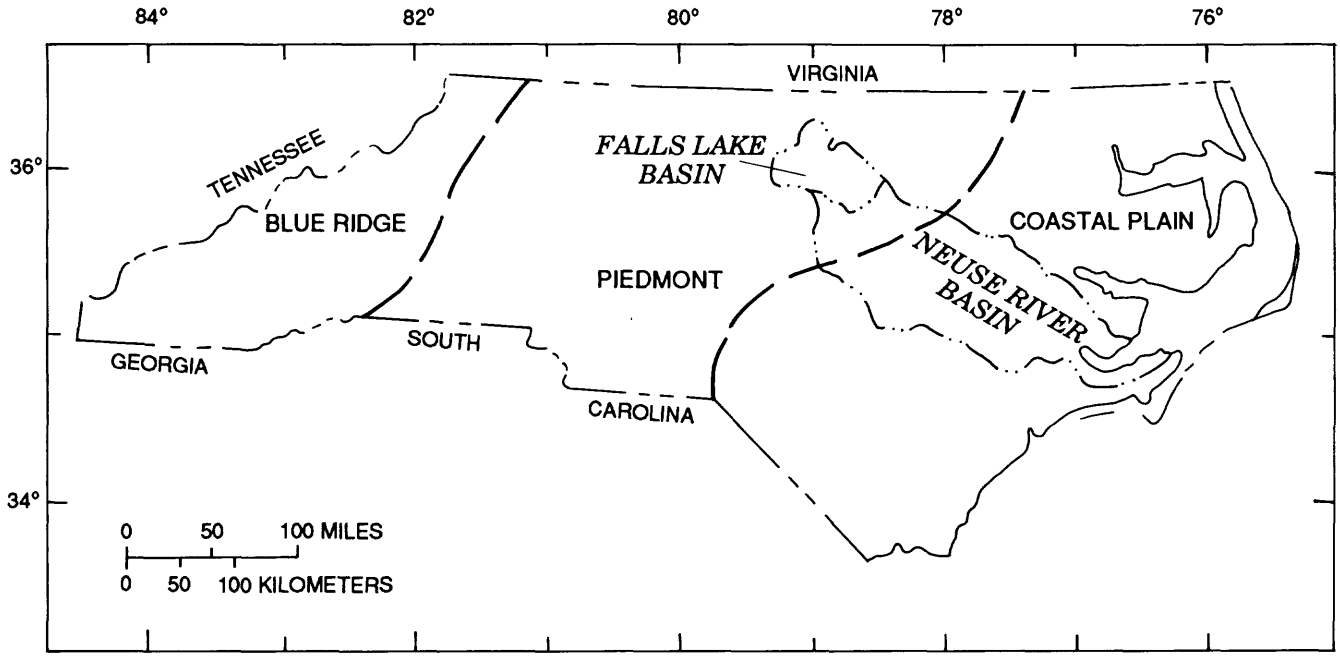

Figure 1.--Falls Lake basin and physiographic regions of North Carolina.

The Flood Control Act of 1965 authorized the U.S. Army Corps of Engineers to construct the Falls Dam and Reservoir in northern Wake County. Construction began in the summer of 1978 and was completed in February 1981.

As a water-supply source for the City of Raleigh and several surrounding communities, water-quality information for Falls Lake is critical for effective water management, planning, and protection activities for the resource. In October 1982, the U.S. Geological Survey (USGS), in cooperation with the U.S. Army Corps of Engineers, began a study to determine water-quality characteristics of inflow to and outflow from Falls Lake. The collection of data was completed in June 1987. All streamflow and water-quality data collected at the study sites were published annually in U.S. Geological Survey Water-Data Reports (1983-87).

Purpose and Scope

This report describes the water-quality characteristics of streams flowing into and out of Falls Lake for the period October 1982 through June 1987. Hydrologic data collection included measurements of streamflow, physical characteristics such as dissolved-oxygen concentrations, water temperature, pH, suspended-sediment concentrations, and specific conductance, and concentrations of major dissolved constituents, nutrients, and selected minor elements.

The study was designed to allow for comparisons of the physical and chemical constituents of the inflow from major tributaries to Falls Lake and those of the outflow, and for comparisons with background water-quality characteristics of streams in relatively undeveloped basins. Estimated annual nitrogen and phosphorus loads and yields into and out of Falls Lake were also determined.

Basin Description

Falls Lake basin lies in parts of Durham, Franklin, Granville, Orange, Person, and Wake Counties and includes the Eno, Flat, and Little Rivers (fig. 2). These stream basins comprise approximately one-half of the Falls Lake basin. Other direct tributaries to the lake are Knap of Reeds, Ellerbe, Ledge, Lick, Little Lick, and Beaverdam Creeks.

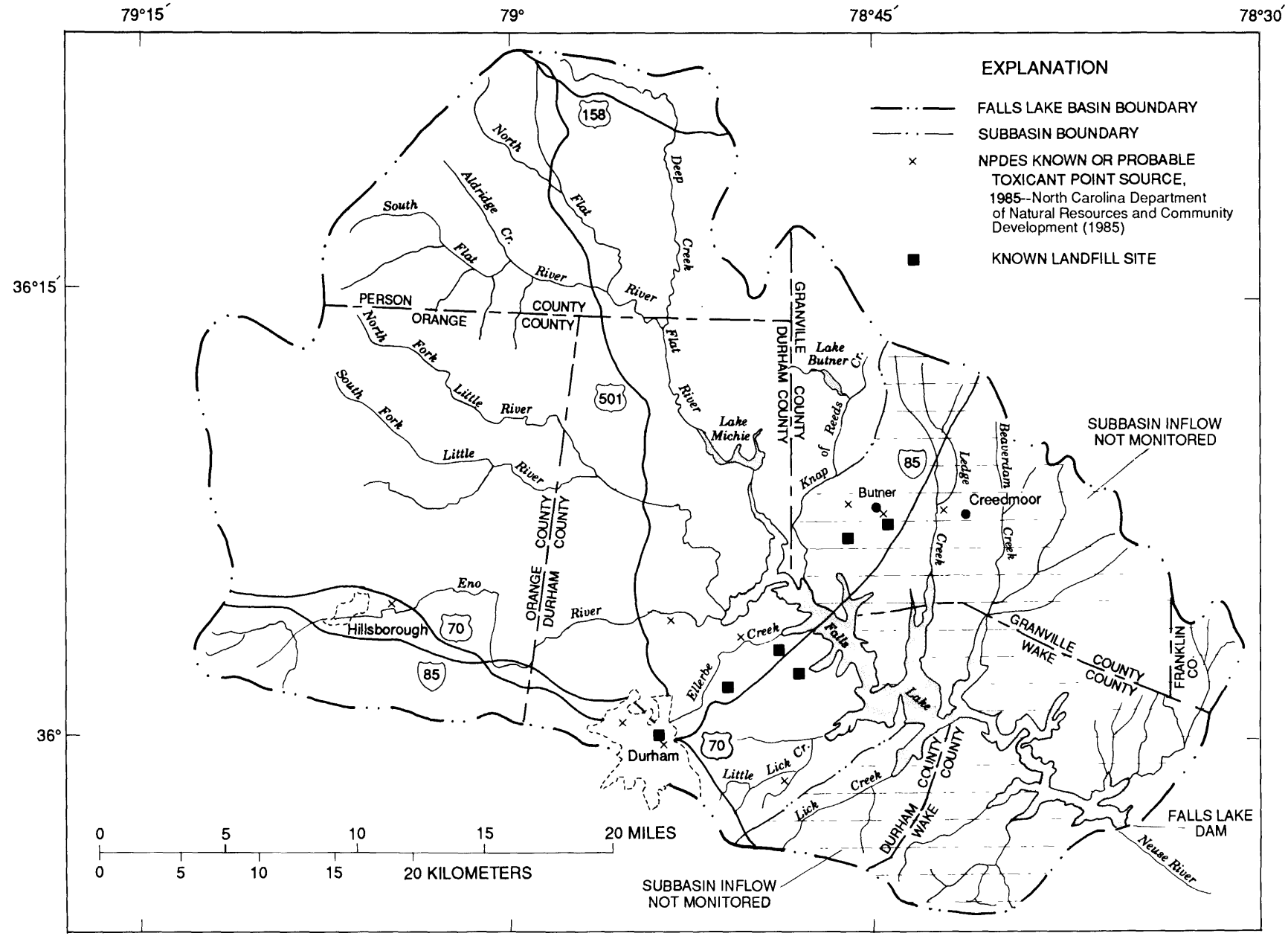

Figure 2.--Tributaries, subbasins, known or probable National Pollutant Discharge Elimination System (NPDES) toxicant point sources (1985), and known landfills in the Falls Lake basin.

The predominant land uses in the Falls Lake basin are forests and agriculture, with approximately 10 percent of the study basin urbanized (North Carolina Department of Natural Resources and Community Development, 1985). The principal municipalities in the basin are the city of Durham and the towns of Hillsborough, Creedmoor, and Butner.

Durham had a population of approximately 100,500 in 1980 (North Carolina Office of State Budget and Management, 1985) and comprises the largest area of commercial, industrial, and urban development in the basin. Populations for Creedmoor and Hillsborough were about 1,640 and 3,020, respectively (North Carolina Office of State Budget and Management, 1985). Populations increased between 1970 and 1980 at rates ranging from approximately 5 percent for Durham to 52 percent for Hillsborough.

The climate of Falls Lake basin is characterized by moderate winters and hot, humid summers with a long growing season. The mean monthly temperature ranges from about 40 °F (Fahrenheit) in January to 78 °F in July. The average annual precipitation during 1930-86 was approximately 45 inches with extremes being a high of 57 inches in 1931 and 1975 and a low of 27 inches in 1941. During the study period (1982-87), the average annual precipitation was 45 inches. The average annual precipitation was below average at 41 inches during the calendar years 1985 and 1986 but was above average during 1984 at 51 inches (National Oceanic and Atmospheric Administration, 1984, 1985, 1986).

Lake and Dam

Falls Lake extends from its dam approximately 28 mi (miles) up the Neuse River to just above the confluence of the Eno and Flat Rivers (fig. 2). The length of the shoreline is about 175 mi. Filling of the lake began in January 1983, and normal pool elevation of 250.1 ft above sea level was reached in December 1983. The reservoir has a capacity of 114,740 acre-ft (acre-feet) at normal pool elevation with a maximum capacity of 335,620 acre-ft at the flood-control pool elevation of 264.0 ft above sea level (A. Piner, U.S. Army Corps of Engineers, oral commun., 1989).

The dam is an earthen structure with a side-channel, free-flowing spillway. The structure has a top elevation of 291.5 ft above sea level and an overall length of 1,915 ft.

Potential Sources for Contamination

Potential nonpoint sources of contamination of Falls Lake include agricultural lands, landfills, and urban areas. Approximately 3 percent of agricultural land is highly erodible, with erosion rates greater than 12 tons per acre per year (U.S. Soil Conservation Service, 1983). Potential contaminants that may be derived from agricultural sources include metals and organic compounds that can be sorbed to soil particles transported to receiving waters by erosion.

Six known sanitary landfills are located in the basin; all are near streams. Two landfills are near Butner, and the remaining four are in or near Durham (fig. 2).

As of 1985 there were 57 National Pollutant Discharge Elimination System (NPDES) permits issued to point-source dischargers in the Falls Lake basin (North Carolina Department of Natural Resources and Community Development, 1985). Nine of those dischargers are known or are probable sources of toxicants (fig. 2). Six of the dischargers are wastewater-treatment plants; the remaining three are industries and hospitals.

The town of Butner and Umstead Hospital discharge wastewater into Knap of Reeds Creek. The town of Creedmoor discharges water from wastewater-treatment plants into Ledge Creek, while the city of Durham and the town of Hillsborough discharge wastewater into the Eno River. Durham also discharges water from wastewater-treatment plants into Ellerbe Creek and Little Lick Creek.

DATA COLLECTION AND ANALYSES

Study Sites

Hydrologic and water-quality data were collected at eight study sites around Falls Lake that include seven inflow sites and one outflow site downstream from the dam on the Neuse River (site 8) (fig. 3). Streamflow in the Eno River is continuously monitored at site 1 and was used for calculations at water-quality monitoring site 2 about $1\frac{1}{2}$ mi downstream (fig. 2). Information related to type of water-quality data and frequency of chemical and physical analyses for each of the study sites is presented in table 1.

Four inflow study sites were located between wastewater-treatment plants and Falls Lake (sites 2, 5, 6, and 7). The wastewater-treatment plants are: the Durham Lick Creek Plant, which discharges into Little Lick Creek; Eno River Plant, which discharges into Eno River; and Northside Plant, which discharges into Ellerbe Creek. The plant for Butner discharges into Knap of Reeds Creek.

One study site was located downstream from Lake Michie, a 507-acre lake on the Flat River (site 4). This site and a site on the Little River (site 3) were chosen because their drainage areas were considered representative of that part of the study area (about 32 percent) not affected by wastewater discharges. The data-collection network accounted for inflow to Falls Lake from 61 percent of the study basin; about 39 percent of subbasin inflow, mostly in Granville and Wake Counties (fig. 2), was not monitored.

Sampling and Laboratory Procedures

Water-quality samples were collected for a wide range of flow conditions. For comparative purposes, these data were generally collected synoptically at all sites to minimize differences in quality between sites caused by variations in flow and climatic conditions. Samples were collected monthly for most constituents with additional samples collected during selected high-flow periods to better define the effects of storm runoff.

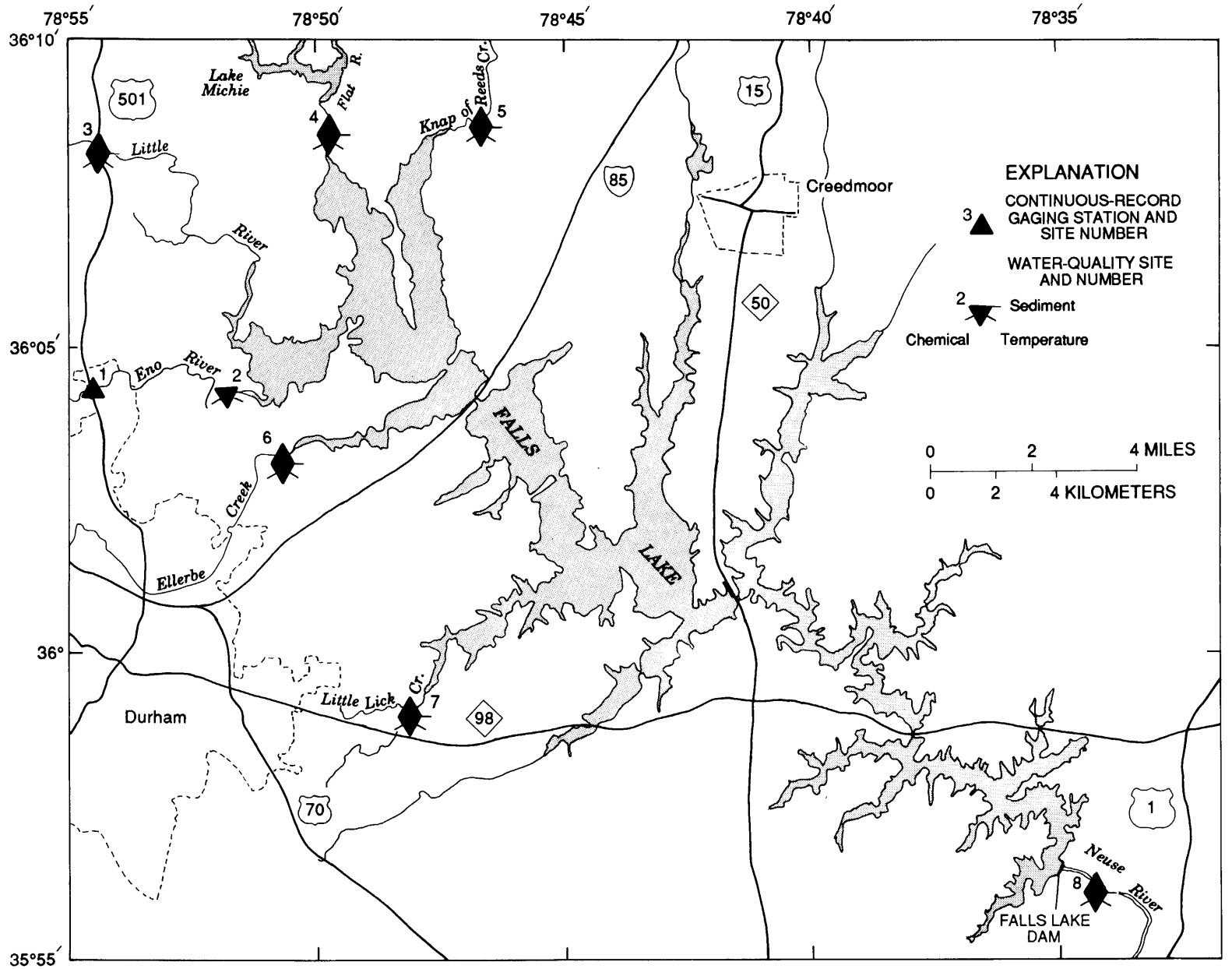

Figure 3.--Study sites in the Falls Lake basin.

Table 1.--*Types and frequency of data collection at study sites in the Falls Lake basin, October 1982 to June 1987*

[C, continuous; --, data not collected; M, monthly]

Site number (figure 3)	Station name and number[1]	Drainage area (square miles)	Percent drainage area to total basin area	Sampling frequency for indicated type of data						
				Discharge	Specific conductance	Temperature	Major dissolved constituents	Nutrients	Minor elements	Suspended sediment
1	Eno River near Durham 02085070	141	18	C[2]	--	--	--	--	--	--
2	Eno River 02085079	148	19	C[2]	C	C	M	M	M	M
3	Little River[3] 02085220	80.4	10	C	C	C	M	M	M	M
4	Flat River 02086500	168	22	C	C	C	M	M	M	M
5	Knap of Reeds Creek 02086624	43	6	C	C	C	M	M	M	M
6	Ellerbe Creek 02086849	21.9	3	C	C	C	M	M	M	M
7	Little Lick Creek 0208700780	10.1	1	C	C	C	M	M	M	M
8	Neuse River 02087183	772	100	C	C	C	M	M	M	M

[1]U.S. Geological Survey downstream order identification number.
[2]Discharge values for site 1 used for calculations at site 2.
[3]Data-collection period September 1984 through June 1987.

To ensure the collection of representative samples and consistency in sampling techniques, all samples were collected using depth-integrating methods as discussed by Guy and Norman (1970). Depending upon flow conditions, the following samplers were used: DH-48TM, DH-76TM, or the D-74TM. Samples analyzed for dissolved constituents were filtered through a 0.45 micron membrane filter immediately after collection. Sample preservation, if required, was done after filtration. Samples collected for nutrients were preserved with mercuric chloride and chilled to 4 °C (Celsius). Samples for the analysis of selected major constituents and minor elements were preserved immediately after collection by the addition of nitric acid to a pH of less than 2. Physical and chemical characteristics, such as pH, alkalinity, dissolved oxygen, and specific conductance, were analyzed in the field at the time of sample collection.

Chemical analyses were performed in the U.S. Geological Survey National Water-Quality Laboratories. The methods and procedures used by the Survey laboratories are documented in the report, "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments" (Fishman and Friedman, 1985). Concentrations of suspended sediment were determined in the U.S. Geological Survey District sediment laboratory in Raleigh, North Carolina.

Nutrient Load Estimation Technique

During the second year of the study, the U.S. Army Corps of Engineers requested the computation of annual loadings of nitrogen and phosphorus for inflow to and outflow from Falls Lake. No attempt was made to define seasonal variations or seasonal loads because of the inherent inaccuracies caused by minimal sampling frequency. The method chosen to calculate loads uses logarithmic regression equations to relate the independent variable (instantaneous water discharge) to the dependent variable (nutrient load) at the time each sample is collected (R.M. Hirsch, U.S. Geological Survey, oral commun., 1983). The regression equation developed was:

$$\log (\text{load}) = b \log (\text{discharge}) + \log a \qquad (1)$$

When transformed back to the original form of the data, the equation is:

$$\text{load} = a\ (\text{discharge})^{b} \qquad (2)$$

where: a is the regression constant and
b is the regression coefficient.

Because a continuous record of stream discharge was available for each study site, resultant equations can be applied to values of daily discharge data to estimate corresponding daily nutrient loads. Daily nutrient loads were then summed for the water year to estimate annual nutrient loads.

The equations developed for the nutrient-water discharge relations as well as the coefficient of determination (r^2) are listed in table 2. The r^2 value is a statistic that indicates the extent to which the changes in the independent variable (instantaneous water discharge) account for changes in the dependent variable (nutrient load). Generally, the closer the r^2 value

Table 2.--*Regression equations for daily nitrogen and phosphorus loads at the study sites, 1982-87*

[r^2, coefficient of determination; Q, daily mean discharge in cubic feet per second]

Site number (figure 3)	Station name and number[a]	Regression analysis for nitrogen (N) load, in tons per day			Regression analysis for phosphorus (P) load, in tons per day		
		Number of samples	Regression equation	r^2	Number of samples	Regression equation	r^2
2	Eno River 02085079	58	$N=0.0057Q^{0.92}$	0.95	59	$P=0.0029Q^{0.71}$	0.81
3	Little River 02085220	26	$N=.0016Q^{1.13}$	.97	32	$P=.0001Q^{1.18}$	.88
4	Flat River 02086500	53	$N=.0025Q^{1.03}$	.99	61	$P=.0002Q^{.99}$	.97
5	Knap of Reeds Creek 02086624	55	$N=.0399Q^{.56}$	.82	60	$P=.0274Q^{.25}$	.26
6	Ellerbe Creek 02086849	60	$N=.1111Q^{.58}$	.93	61	$P=.0332Q^{.48}$	.69
7	Little Lick Creek 0208700780	59	$N=.0168Q^{.69}$	.92	60	$P=.0051Q^{.55}$	.83
8	Neuse River 02087183	34	$N=.0039Q^{.97}$	.87	56	$P=.00005Q^{1.12}$	.80

[a]U.S. Geological Survey downstream order identification number.

is to 1.0, the better the relation between discharge and nutrient load. The statistical and related values presented were computed using various Statistical Analysis System[1] programs (SAS Institute, Inc., 1982 and 1985).

STREAMFLOW CONDITIONS

Streamflow has been continuously monitored at Eno River near Durham (site 1) since August 1963 and at Neuse River (site 8) since July 1970. Continuous streamflow data were collected at sites 3 through 7 during the study and, in some cases, beyond this period. Discharge data from these sites for water years[2] 1983-86, the period of water-quality data collection and analysis, are presented in table 3.

Table 3.--*Mean, maximum, and minimum daily discharges at the study sites, water years 1983-86*

Site number (figure 3)	Station name and number[a]		Discharge (cubic feet per second) 1983	1984	1985	1986
1	Eno River near Durham 02085070	Mean	170	196	105	97
		Maximum	2,590	3,850	3,250	3,530
		Minimum	.14	1	2.3	1.1
3	Little River 02085220	Mean	104	119	52	58
		Maximum	2,080	2,600	1,660	3,120
		Minimum	.77	.25	1.7	.45
4	Flat River at Dam 02086500	Mean	225	239	66	93
		Maximum	5,830	5,510	2,870	4,730
		Minimum	.09	.06	.14	.08
5	Knap of Reeds Creek 02086624	Mean	67	69	22	26
		Maximum	987	1,660	930	1,050
		Minimum	1.3	1.6	1.2	1.5
6	Ellerbe Creek 02086849	Mean	50	61	33	43
		Maximum	1,250	752	728	1,260
		Minimum	3.9	5.8	6.9	6.5
7	Little Lick Creek 0208700780	Mean	14	18	5.9	9.4
		Maximum	424	359	271	515
		Minimum	.13	.13	.21	.15
8	Neuse River 02087183	Mean	965	1,160	401	491
		Maximum	4,940	4,620	4,460	4,820
		Minimum	60	64	67	68

[a]U.S. Geological Survey downstream order identification number.

[1]Use of firm or trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.
[2]Period extending from October 1 through the following September 30. See Glossary.

During two of these years, streamflow conditions were extreme; 1984 was unusually wet and 1985 was unusually dry. The effects of wet and dry conditions on streamflow are shown in figure 4, which gives a graphic comparison of monthly mean discharges at Eno River near Durham (site 1) for water years 1984 and 1985 and for the period of record, 1964 through 1986. The average discharge of 196 ft^3/s (cubic feet per second) for water year 1984 was approximately 55 percent higher than the long-term average of 128 ft^3/s; for water year 1985, the average discharge of 105 ft^3/s was approximately 20 percent lower than the long-term average.

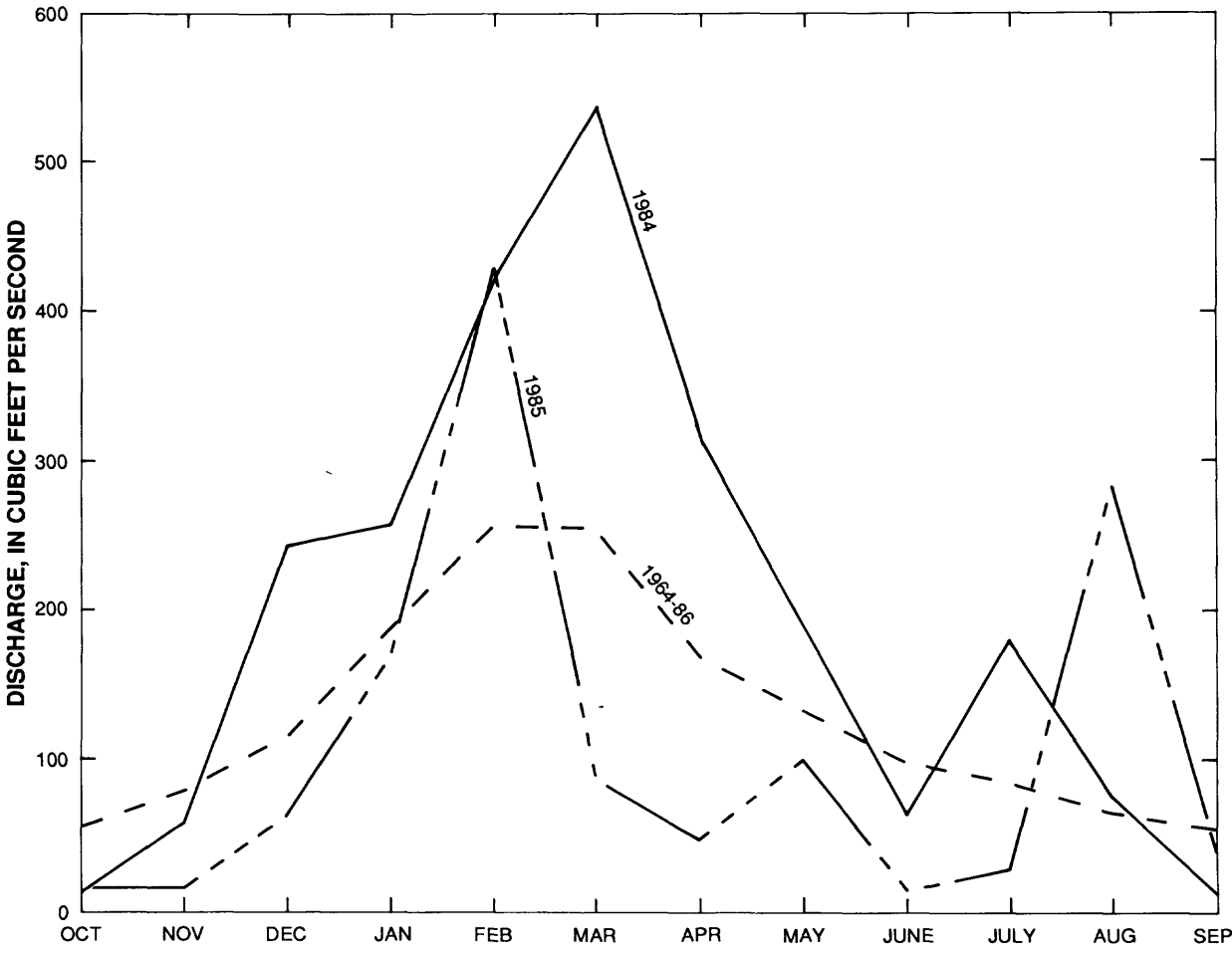

Figure 4.--Monthly mean discharge at Eno River near Durham (site 1) for water years 1984 and 1985 and mean monthly discharge for the period of record, 1964-86.

Flow-duration curves for Eno River near Durham (site 1) are shown in figure 5 for the water years 1964 through 1986 and for 1984 and 1985. This

provides a comparison of the percentages of time that discharges equaled or exceeded certain flow rates during the two extreme years and for the period of record. In general, low flows less than about 4 ft^3/s did not occur as frequently during 1984 and 1985 as during the longer period.

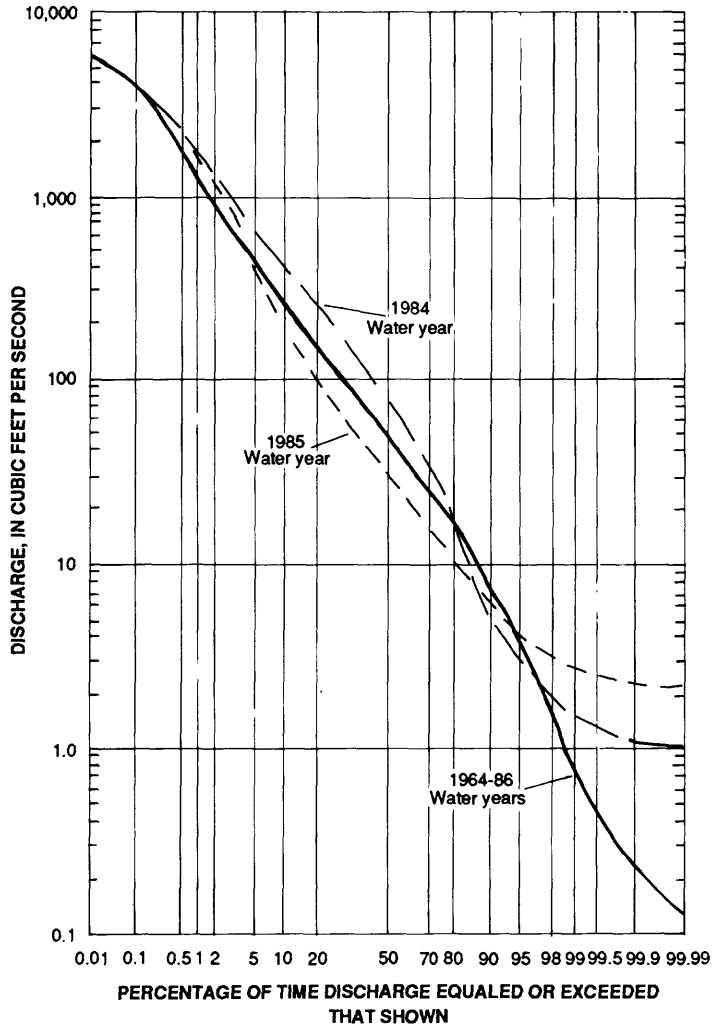

Figure 5.--Flow-duration curves of daily discharge at Eno River near Durham (site 1).

WATER-QUALITY CHARACTERISTICS OF INFLOW AND OUTFLOW

Selected physical and chemical characteristics at inflow and outflow sites in the Falls Lake basin are summarized in this section. Discussions of background water quality of the basin and of nutrient loads are also included. Where pertinent, brief comparisons between inflow and outflow data are made.

Descriptive statistics for streamflow and for 56 physical and chemical characteristics for each of the sites are presented in table 8 beginning on page 32. The table is divided into three parts: physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements. The values shown include the number of samples collected and the mean, range, and standard deviation of the properties and constituents. For an indepth discussion of the importance of each of these physical and chemical characteristics, the reader is referred to Hem (1985).

Background Water Quality

Simmons and Heath (1979) describe the background water-quality characteristics of North Carolina streams relatively unaffected by man, generally those streams with 90- to 100-percent forested basins. They define five geochemical zones on the basis of similar water characteristics in North Carolina. Falls Lake basin lies within geochemical zones I and II (fig. 6). Zone II coincides with the Carolina Slate Belt and the Durham and Wadesboro Triassic basins with rock types of mainly slates and schists, whereas the rocks in zone I are mainly granite. Background water-quality data from zone II were considered representative of inflow to Falls Lake because all of the inflow sites were in that zone.

Mean concentrations of selected constituents at the study sites and mean background concentrations of the same constituents in geochemical zone II can be compared in table 4. At the inflow sites, mean concentrations of certain major constituents or nutrients were as much as 10- to 110-times greater than background concentrations reported for streams in geochemical zone II. However, mean concentrations at the outflow site were approximately 2- to 3-times greater than background concentrations reported for the streams in zone II.

Physical Characteristics

The following physical characteristics were measured: dissolved-oxygen concentrations, water temperature, pH, suspended-sediment concentrations, and specific conductance. Concentrations of dissolved oxygen (DO) in

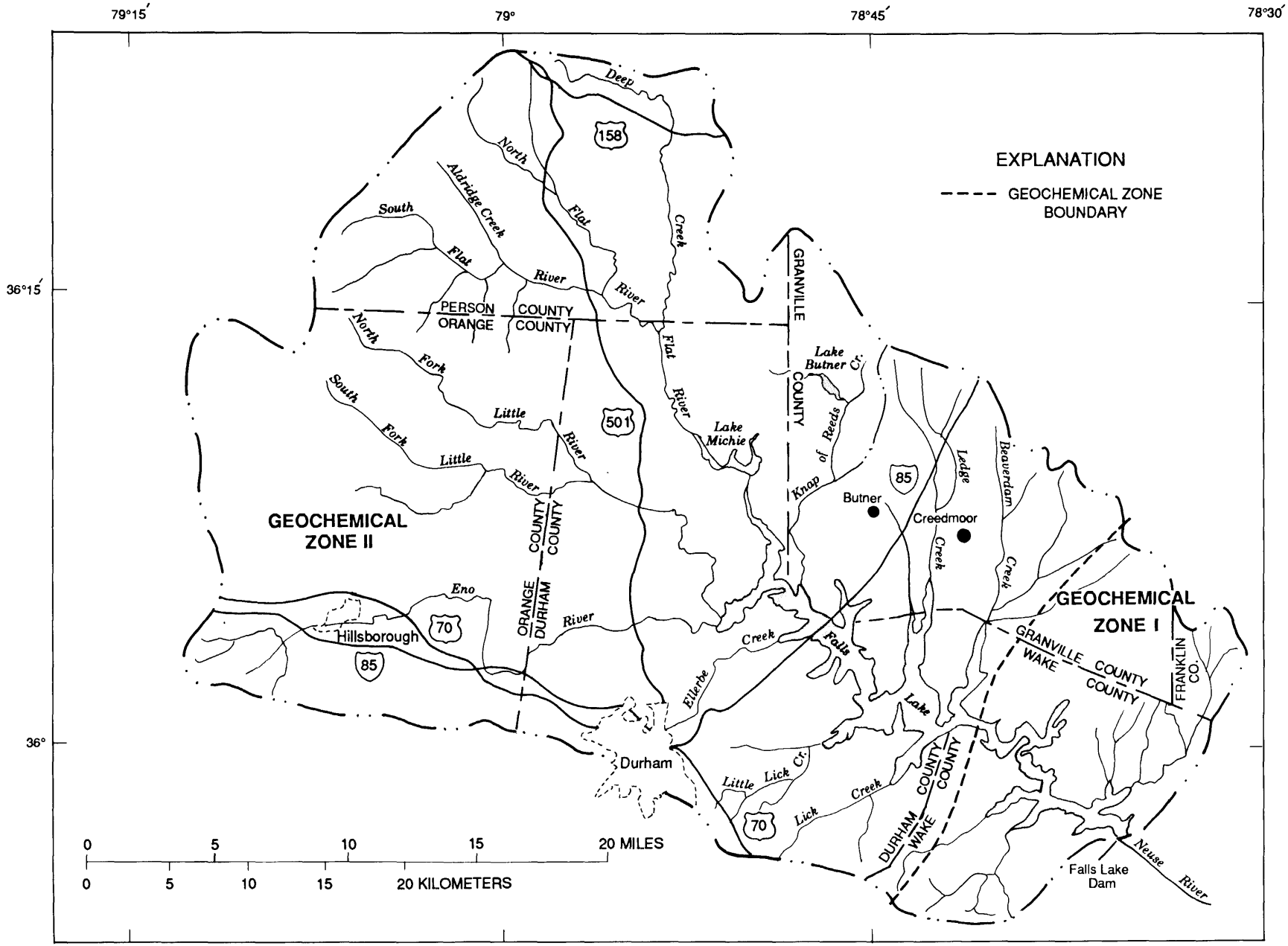

Figure 6.--The Falls Lake basin and geochemical zones of North Carolina (Simmons and Heath, 1979).

Table 4.--*Mean concentrations of selected constituents at the study sites, 1982-87, and mean background concentrations in geochemical zone II, 1973-78 (Simmons and Heath, 1979)*

Site number (figure 3)	Station name and number[1]	Constituent concentrations (milligrams per liter)							
		Calcium	Magnesium	Sodium	Potassium	Sulfate	Chloride	Nitrogen, total	Phosphorus, total
2	Eno River 02085079	6.8	2.9	10	2.2	11	8.5	1.7	0.49
3	Little River 02085220	6.2	2.5	4.4	1.9	6.4	4.8	1.2	.09
4	Flat River 02086500	5.2	2	4.3	1.8	7.9	4.9	1.1	.07
5	Knap of Reeds Creek 02086624	10	3	43	3.8	34	38	19	2.9
6	Ellerbe Creek 02086849	11	3.7	39	7.1	30	28	12	3.3
7	Little Lick Creek 0208700780	11	4.1	28	4.5	25	22	6.4	2.2
8	Neuse River 02087183	5.7	2.4	5.5	2.2	8.5	5.7	1.3	.05
--	Geochemical zone II	4.1	1.7	3.9	1	4.7	3.8	.5	.03

[1]U.S. Geological Survey downstream order identification number.

samples collected at the inflow sites ranged from a maximum of 14.8 mg/L (milligrams per liter) at Little River (site 3) to a minimum of 0.6 mg/L at Ellerbe Creek (site 6). The maximum DO concentration observed at the outflow site, Neuse River (site 8), was 15.2 mg/L, and the minimum concentration was 6.7 mg/L (fig. 7). A minimum concentration of about 3 mg/L is needed to support a varied fish population (U.S. Environmental Protection Agency, 1986).

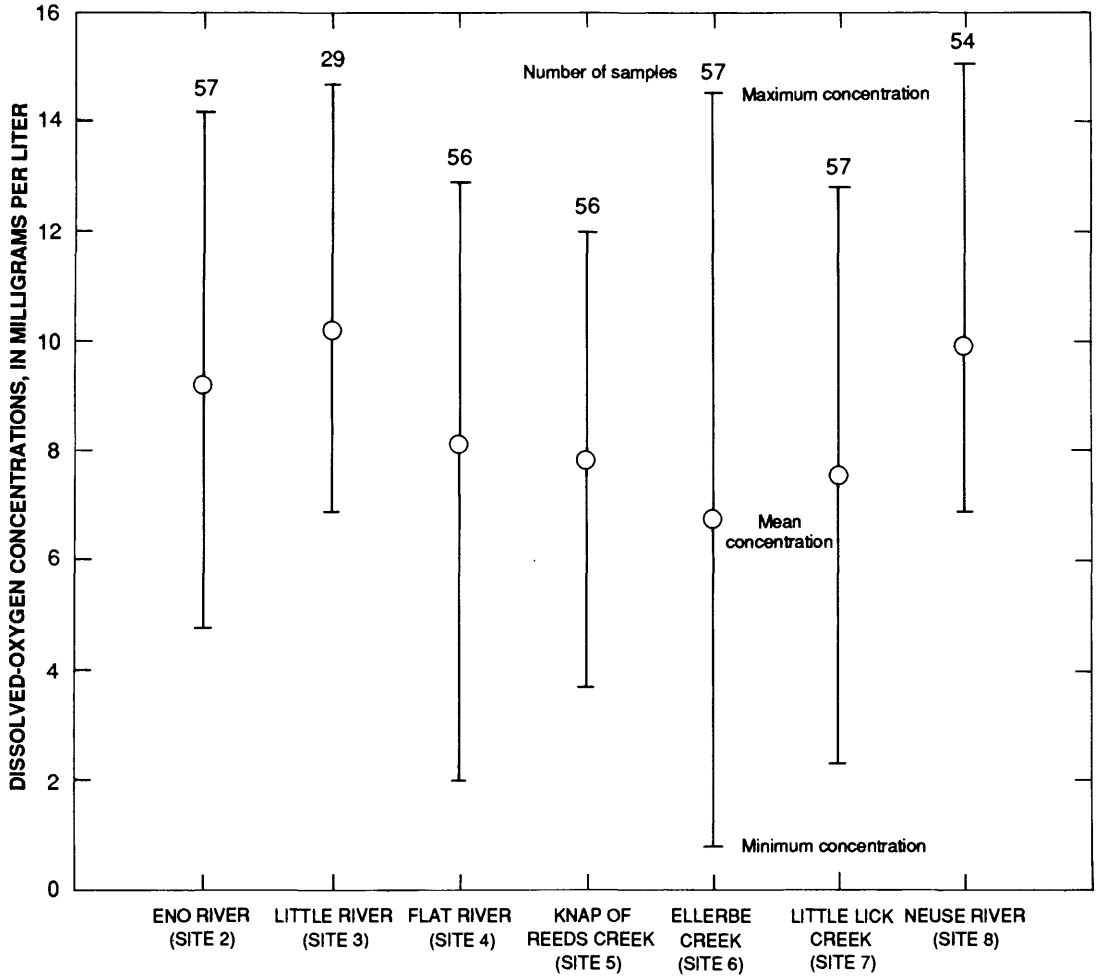

Figure 7.--Dissolved-oxygen concentrations in water at the study sites, 1982-87.

Water temperature is an important factor on water quality because it affects not only oxygen solubility in the streams but also the chemical and biologic processes. Water temperature at both the inflow sites and the outflow site averaged about 16 °C. The maximum water temperature measured at the inflow sites was 30.0 °C at Flat River (site 4), whereas the maximum temperature measured at the outflow site (site 8) was 29.5 °C.

The pH values for samples at the inflow sites ranged from a maximum of 8.1 units at Little River (site 3) to a minimum of 5.4 units at Flat River and Little Lick Creek (sites 4 and 7, respectively). At the outflow site (site 8), the maximum pH value was 7.8 units and the minimum pH value was 5.7 units.

Suspended-sediment concentrations in streams are affected by numerous factors, including basin soil characteristics, topography, stream discharge, land use, and rainfall intensity. Because samples were collected at varying flow conditions, a wide range of suspended-sediment concentrations was observed at each inflow site. The maximum concentration of suspended sediment observed at the inflow sites was 1,850 mg/L at Ellerbe Creek (site 6), which occurred during runoff conditions. The maximum concentration observed at the Neuse River outflow site (site 8) was 100 mg/L. This was considerably less than maximum concentrations observed at most of the inflow sites and is an indication of the sediment trapping ability of the Falls Lake reservoir.

Specific conductance is a measure of the ionic strength of water and is an indicator of the amount of mineral matter dissolved in water; thus, higher concentrations of dissolved constituents produce greater values of specific conductance. Because concentrations of most major dissolved constituents vary inversely with stream discharge, maximum specific-conductance values occur during low flows, whereas minimum values occur at high flows. The maximum specific conductance observed at an inflow site was greater than or equal to 1,200 µS/cm (microsiemens per centimeter at 25 °C) at Little Lick Creek (site 7). The maximum observed value at the outflow site (site 8) was 140 µS/cm. These values were obtained from hourly data from monitors operated at the sites (table 5).

Chemical Characteristics

The chemical characteristics described in this report are presented in three main categories: major dissolved constituents, major nutrients, and minor elements. Flow conditions often influence chemical quality in a stream, and maximum and minimum values of various constituents generally occur during extreme hydrologic events. In most cases, concentrations of

Table 5.--*Maximum, minimum, and mean specific conductance from monitors at the study sites, water years 1983-85*

[Specific conductance based on hourly measurements from monitor; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; Max, maximum; Min, minimum; --, not determined; ≥, greater than or equal to; ≤, less than or equal to; ≅, approximately equal to]

Site number (figure 3)	Station name and number[1]	Specific conductance (µS/cm at 25 °C)									
		1983			1984			1985			1983-85
		Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Mean
2	Eno River 02085079	257	33	117	283	46	113	293	32	128	119
3	Little River[2] 02085220	--	--	--	--	--	--	123	37	85	--
4	Flat River 02086500	94	39	68	89	40	65	112	53	73	69
5	Knap of Reeds Creek 02086624	[3]≥768	53	≥238	[3]≥1,100	39	≥308	874	55	415	≥320
6	Ellerbe Creek 02086849	653	24	377	811	38	355	858	47	432	388
7	Little Lick Creek 0208700780	564	33	265	556	[3]≤26	≤255	[3]≥1,200	61	≥334	≅285
8	Neuse River[4] 02087183	140	54	78	123	52	74	--	--	--	76

[1]U.S. Geological Survey downstream order identification number.
[2]Specific-conductance monitor operated for the 1985 water year only.
[3]Values exceeded the limits of monitor.
[4]Specific-conductance values are from once-daily observer samples.

major dissolved constituents, major nutrients, and minor elements were generally lower during periods of high flow when overland runoff causes a dilution effect.

With respect to major dissolved constituents, the chemical composition of the water is similar at all study sites. The proportions of major ions at the sites are shown in figure 8. Sodium and calcium are the predominant cations, with bicarbonate being the major anion at each site.

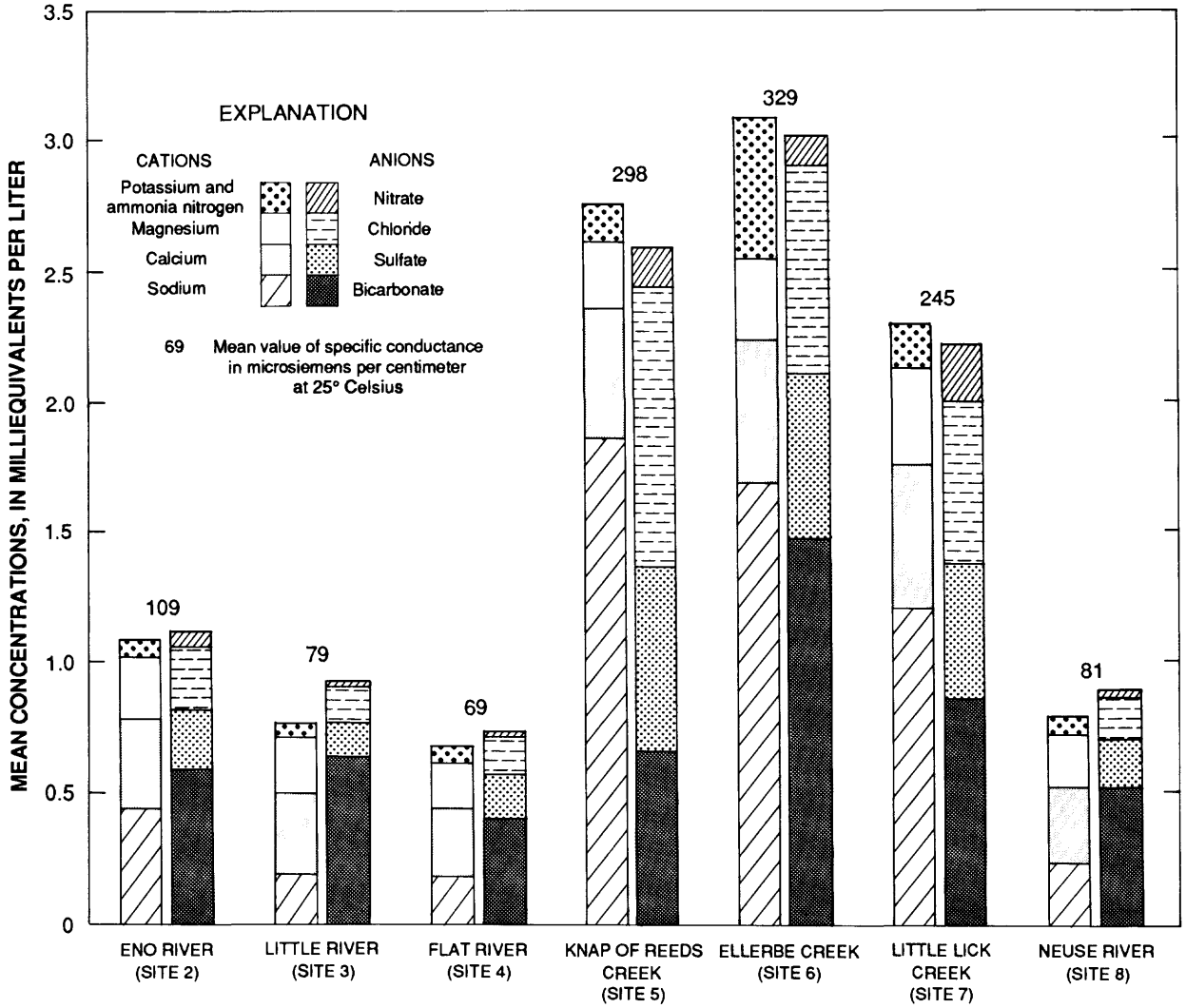

Figure 8.--Mean chemical composition of water at the study sites, 1982-87.

The nutrients nitrogen and phosphorus are required by aquatic plants for growth. They are available from many sources throughout the study area. Mean total nitrogen concentration in samples collected at each of the study

sites ranged from 12 mg/L in Ellerbe Creek (site 6) to 1.1 mg/L in Flat River (site 4) (fig. 9). The maximum concentration of total nitrogen at an inflow site was 33 mg/L (Ellerbe Creek, site 6); the minimum was 2.8 mg/L in Little River and Flat River (sites 3 and 4, respectively). The outflow site (site 8) had a maximum total nitrogen concentration of 4.5 mg/L. The maximum concentration of total phosphorus was 20 mg/L in Knap of Reeds Creek (site 5), whereas the maximum concentration at the Neuse River outflow site (site 8) and the Flat River inflow site (site 4) was 0.22 mg/L (table 8).

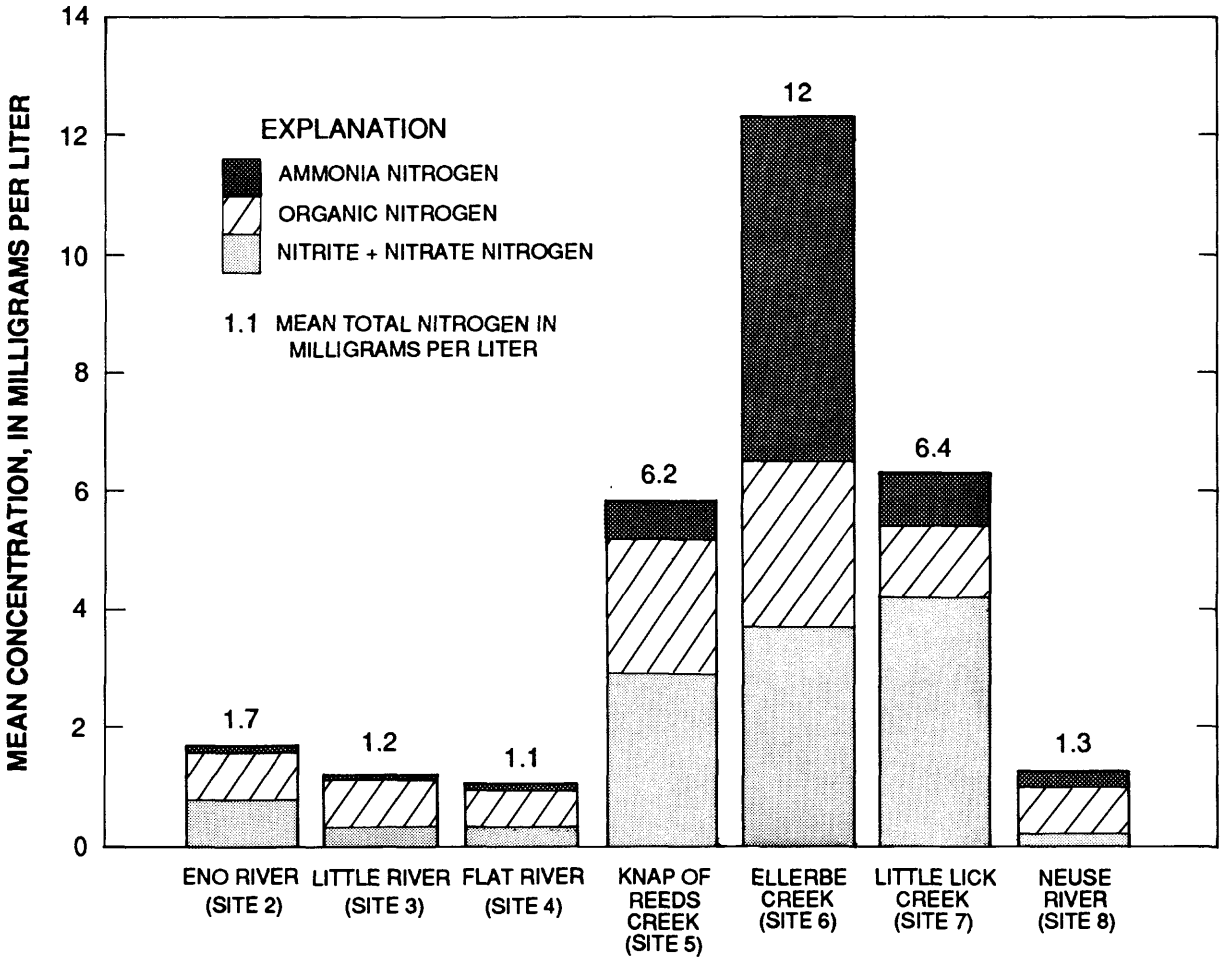

Figure 9.--Mean composition of nitrogen species in water at the study sites, 1982-87.

The two minor elements that were most frequently detected in the waters at the study sites were iron and manganese. Maximum concentrations of iron and manganese occurred during periods of overland runoff. Because maximum concentrations of these elements occurred during these periods and because

most of the iron and manganese concentrations were from suspended sediment, it is apparent that soils are the primary sources of these constituents.

The maximum observed iron concentration was 30,000 µg/L (micrograms per liter) at site 2 and occurred during severe flooding on the Eno River (fig. 10). The maximum concentration of iron at site 8, the outflow site, was 2,800 µg/L. The maximum manganese concentration at the inflow sites was 1,800 µg/L at site 2, which also occurred during flooding on the Eno River (fig. 10); the maximum manganese concentration at the outflow site (site 8) was 2,800 µg/L.

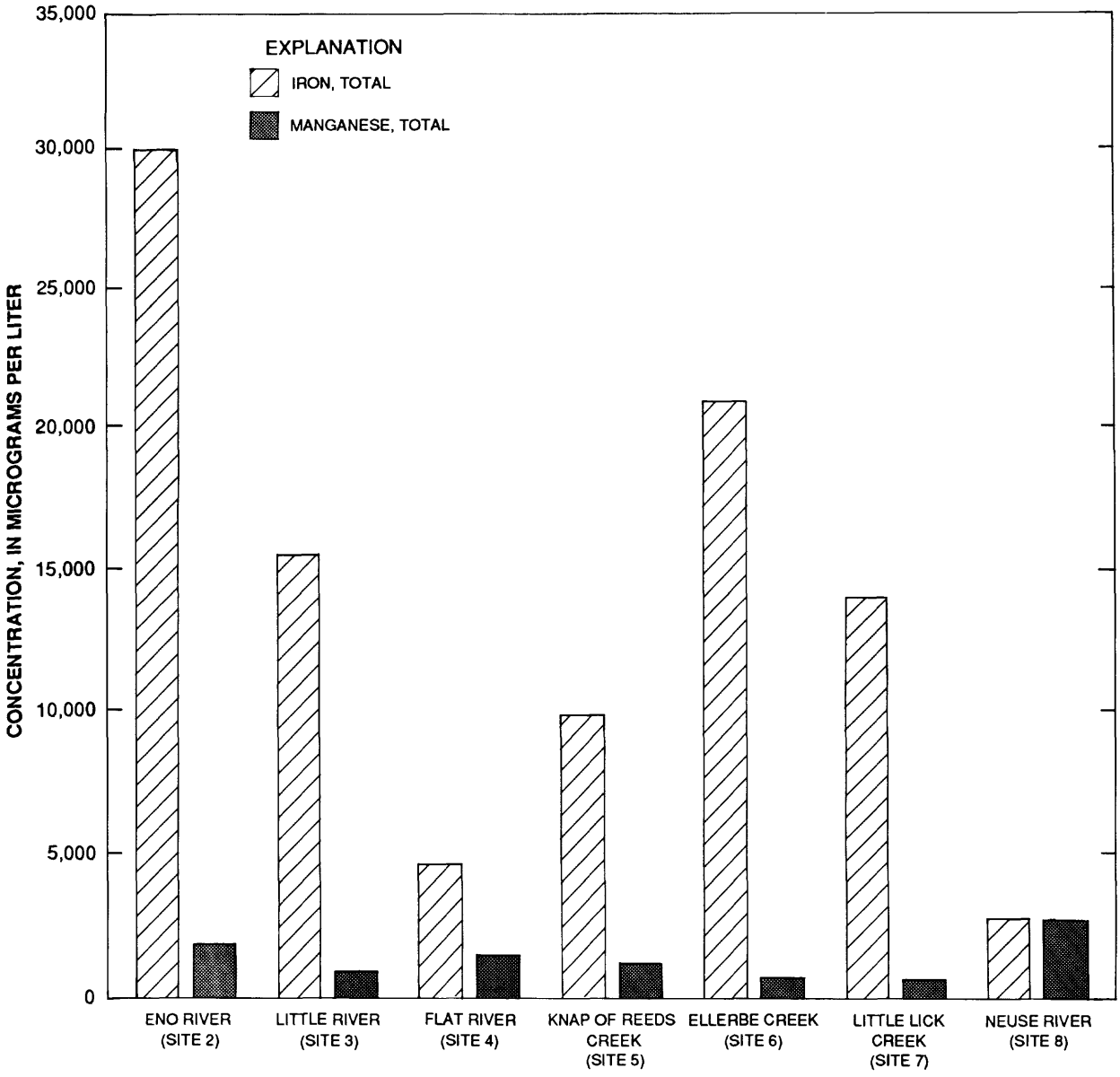

Figure 10.--Maximum iron and manganese concentrations in water at the study sites, 1982-87.

Annual Nutrient Loads

Estimates of annual nutrient loads were determined for the study sites. A summary of annual nitrogen and phosphorus loads flowing into and out of Falls Lake for water years 1983-86 is presented in table 6. For the 39 percent (301 mi^2) of the watershed not monitored, it was assumed that load characteristics were similar to the gaged area of the study basin. Loadings from the ungaged area of the basin were then calculated as 39/61 times total loading from the gaged area.

Table 6.--*Estimated annual nitrogen and phosphorus loads in the study basin, water years 1983-86*

Site number (figure 3)	Station name and number[1]	Nitrogen load, tons per year (Percent of total inflow load)				Phosphorus load, tons per year (Percent of total inflow load)			
		1983	1984	1985	1986	1983	1984	1985	1986
2	Eno River 02085079	220 (13)	250 (13)	140 (14)	130 (12)	33 (14)	38 (14)	22 (13)	21 (12)
3	Little River 02085220	140 (8)	160 (8)	65 (7)	74 (7)	9 (4)	10 (4)	4 (2)	5 (3)
4	Flat River 02086500	240 (14)	260 (14)	70 (7)	99 (9)	12 (5)	12 (5)	3 (2)	5 (3)
5	Knap of Reeds Creek 02086624	120 (7)	120 (6)	57 (6)	62 (6)	23 (10)	23 (9)	17 (10)	17 (9)
6	Ellerbe Creek 02086849	300 (17)	350 (18)	250 (26)	270 (25)	62 (26)	71 (27)	54 (32)	57 (32)
7	Little Lick Creek 0208700780	27 (2)	32 (2)	14 (1)	18 (2)	6 (2)	6 (2)	3 (2)	4 (2)
--	Ungaged area of basin	670 (39)	750 (39)	381 (39)	418 (39)	93 (39)	102 (39)	66 (39)	70 (39)
8	Neuse River 02087183	1,050	1,260	450	540	46	56	18	22

[1]U.S. Geological Survey downstream order identification number.

Even though the total nitrogen and phosphorus loads varied greatly among sites, the percentage of the total annual contribution for each site was similar. Figures 11 and 12 give graphic comparisons of the total annual nitrogen and phosphorus loads for water years 1984 and 1985, unusually wet and dry years, respectively.

Estimates of nitrogen and phosphorus loads were also determined for the outflow site on Neuse River (site 8). The annual outflow nitrogen loads

ranged from 66 percent of inflow loads in water year 1984 to 46 percent in water year 1985. Annual outflow loads of phosphorus ranged from 21 percent of inflow loads in water year 1984 to 11 percent in water year 1985. These percentages are an indication of the nutrient retention ability of Falls Lake reservoir.

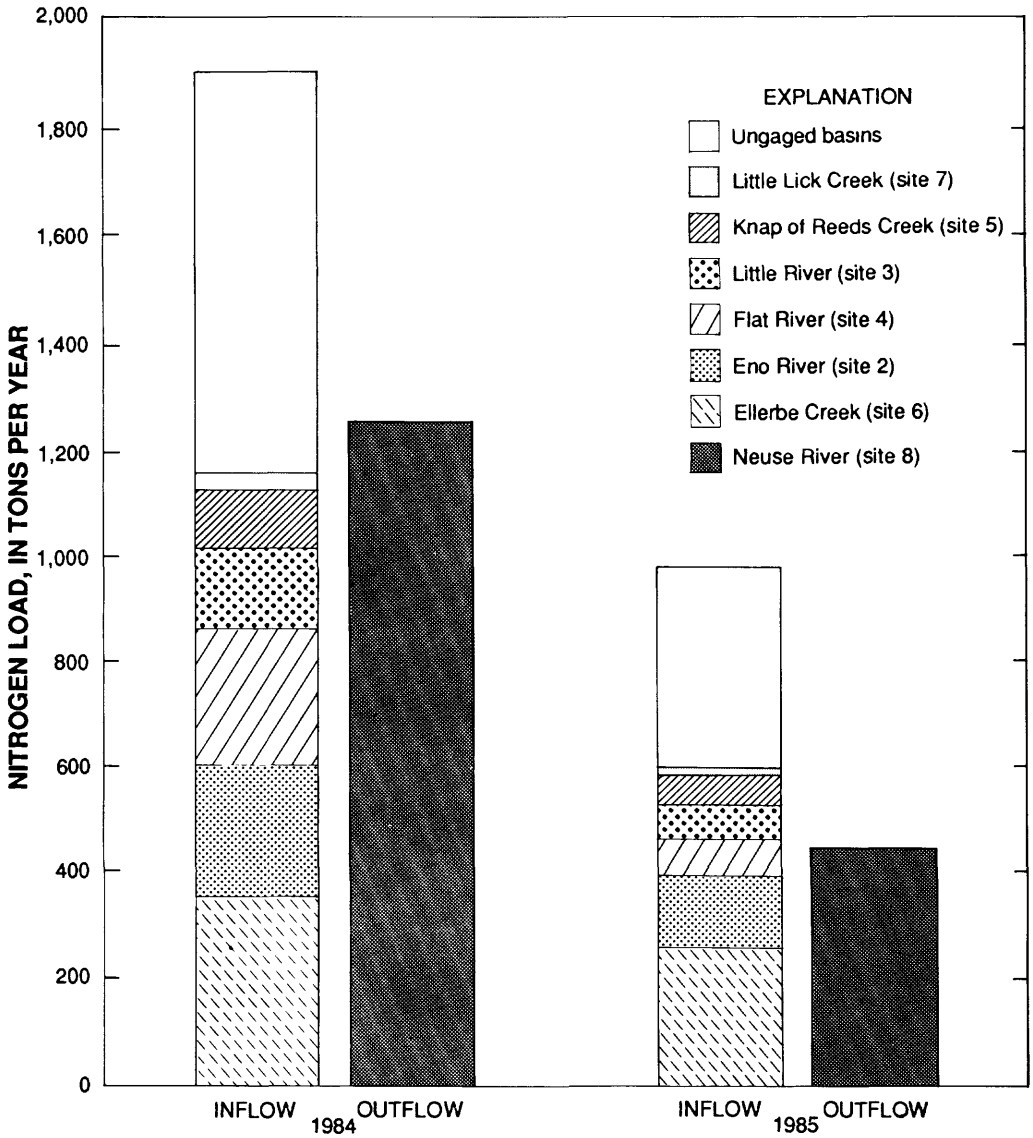

Figure 11.--Estimated inflow and outflow nitrogen loads for Falls Lake, water years 1984 and 1985.

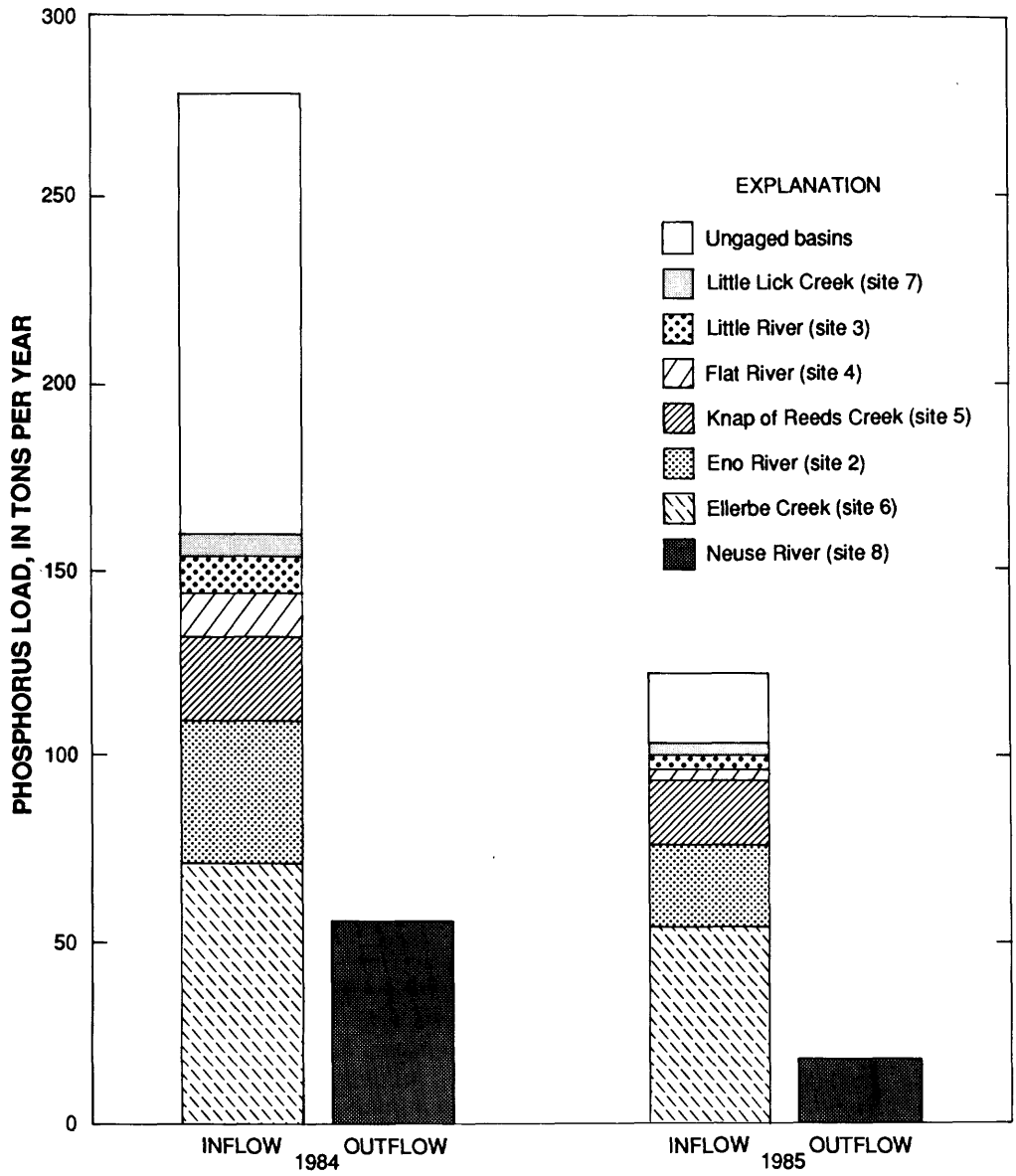

Figure 12.--Estimated inflow and outflow phosphorus loads for Falls Lake, water years 1984 and 1985.

Estimated average annual nitrogen and phosphorus yields are presented in table 7. The yields are expressed as load per unit area of a drainage basin. Among the inflow sites, Ellerbe Creek (site 6) had the greatest nitrogen and phosphorus yields, 13 and 2.8 ton/mi^2 (tons per square mile), respectively. The smallest yields for nitrogen and phosphorus at the inflow sites were at Flat River (site 4) where the yields were 1.0 and 0.05 ton/mi^2, respectively, and were comparable with the yields at the Neuse River outflow site (site 8).

Table 7.--*Estimated mean annual nutrient yields in the study basin, water years 1982-87*

Site number (figure 3)	Station name and number[1]	Average annual yield (tons per square mile)	
		Nitrogen	Phosphorus
2	Eno River 02085079	1.2	0.2
3	Little River 02085220	1.4	.1
4	Flat River 02086500	1	.05
5	Knap of Reeds Creek 02086624	2.1	.5
6	Ellerbe Creek 02086849	13	2.8
7	Little Lick Creek 0208700780	2.3	.5
--	Ungaged area of basin	1.8	.3
8	Neuse River 02087183	1.1	.05

[1]U.S. Geological Survey downstream order identification number.

SUMMARY

This study was undertaken to define the chemical quality of inflow to and outflow from Falls Lake, an 11,300-acre reservoir in the north-central Piedmont of North Carolina. The reservoir capacity is 114,740 acre-ft at normal pool elevation of about 250 feet. Falls Lake basin drains 772 mi^2, of which 471 mi^2 was monitored for inflow water quality.

Falls Lake basin contains 57 known point-source dischargers that include 9 known or probable sources of toxicants. Potential nonpoint sources of contamination include farmland, urban areas, and six known landfills.

For this investigation, hydrologic data were collected at seven sites on major tributaries to the reservoir and one outflow site downstream from the reservoir dam. The inflow sites were located on the Little River, Flat River, Knap of Reeds Creek, Ellerbe Creek, Little Lick Creek, and the Eno River (two sites). The outflow site was located on the Neuse River.

Streamflow in the study basin during water years 1984 and 1985 reflected unusually wet and dry climatic conditions, respectively. On the basis of long-term records for the Eno River, streamflow into Falls Lake was about 55 percent greater in 1984 and about 20 percent lower in 1985 than the long-term mean. For the period 1964 through 1986, mean discharge in the Eno River was 128 ft^3/s.

Water samples were collected at approximately monthly intervals at each site, but emphasis was placed on collecting samples during a wide variety of flow conditions. Streamflow, specific conductance, and temperature were continuously monitored, and water samples were analyzed for 56 physical and chemical characteristics.

Background water-quality data for streams in relatively undeveloped basins were used as a basis of comparison with which to estimate the effects of development on the water quality of inflow to and outflow from Falls Lake. Generally, mean concentrations of major constituents or nutrients at inflow sites ranged from 10- to 110-times greater than background concentrations. However, at the outflow site mean concentrations generally were 2- to 3-times greater than background concentrations.

Concentrations of dissolved oxygen measured at the inflow sites ranged from a maximum of 14.8 mg/L at Little River (site 3) to a minimum of 0.6 mg/L at Ellerbe Creek (site 6). The maximum dissolved-oxygen concentration observed at the Neuse River outflow site (site 8) was 15.2 mg/L; the minimum concentration was 6.7 mg/L.

Water temperature at the inflow sites and the outflow site averaged about 16 °C. The maximum temperature measured at the inflow sites was

30.0 °C at Flat River (site 4), whereas the maximum temperature measured at the outflow site (site 8) was 29.5 °C.

The pH values for samples at the inflow sites ranged from a maximum of 8.1 at Little River (site 3) to a minimum of 5.4 at Flat River and Little Lick Creek (sites 4 and 7, respectively). The maximum and minimum pH values at the outflow site (site 8) were 7.8 and 5.7, respectively.

A comparison of suspended-sediment concentrations in inflow to Falls Lake with concentrations in outflow gives an indication of the sediment trapping ability of the reservoir. The maximum suspended-sediment concentration observed at an inflow site was 1,850 mg/L at Ellerbe Creek (site 6). The maximum observed suspended-sediment concentration at the Neuse River outflow site (site 8) was 100 mg/L.

Specific conductance was continuously monitored at the water-quality sites. The maximum observed value was greater than or equal to 1,200 µS/cm and occurred at the inflow site on Little Lick Creek (site 7). The maximum observed value at the outflow site (site 8) was 140 µS/cm.

The chemical composition of the water at the study sites was similar with respect to major dissolved constituents. Sodium and calcium were the predominant cations, and bicarbonate was the predominant anion.

Nitrogen and phosphorus were the major nutrients of interest during the study. The maximum total nitrogen concentration at the inflow sites was 33.0 mg/L at Ellerbe Creek (site 6), whereas the maximum concentration at the Neuse River outflow site (site 8) was 4.5 mg/L. The maximum total phosphorus concentration at the inflow sites was 20.0 mg/L at Knap of Reeds Creek (site 5), and the maximum concentration at the outflow site (site 8) was 0.22 mg/L.

Of the minor elements investigated, iron and manganese were detected in the greatest concentrations. The maximum concentration of iron detected in samples from an inflow site was 30,000 µg/L at Eno River (site 2). The maximum iron concentration detected in samples from the outflow site on

Neuse River (site 8), was 2,800 µg/L. The maximum observed concentration of manganese at an inflow site was 1,800 µg/L, also at site 2. The maximum manganese concentration at the outflow site was somewhat higher (2,800 µg/L).

Mean annual outflow loads of nitrogen and phosphorus were as much as 66 and 21 percent of inflow loads, respectively. Maximum inflow yields were observed in Ellerbe Creek (site 6) and averaged 13 ton/mi^2 for nitrogen and 2.8 ton/mi^2 for phosphorus. Yields of these nutrients for the Falls Lake basin as determined at the outflow site were 1.1 and 0.05, respectively.

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Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 2, ENO RIVER

LOCATION.--Latitude 36°04'19", longitude 78°51'47", Durham County, at bridge on Secondary Road 1004, 1.3 mi above Little River, and 1.5 mi northwest of Weaver, North Carolina; Hydrologic Unit 03020201; USGS downstream order identification number 02085079.

DRAINAGE AREA.--148 mi^2.

PERIOD OF RECORD.--November 1982 to June 1987.

Physical properties and concentrations of major dissolved constituents						
Property/constituent	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Instantaneous discharge (ft^3/s)	00061	72	691	6,950	0.19	--
Instantaneous specific conductance (µS/cm)	00095	59	109	250	37	52
pH (pH units)	00400	59	6.7	7.7	5.7	.43
Color (Platinum-cobalt units)	00080	50	78	1,000	7	150
Dissolved oxygen (mg/L)	00300	57	9.2	14.3	4.6	2.5
Water temperature (°C)	00010	58	15.2	27	3	7
Hardness (mg/L)	00900	50	29	46	10	9.6
Calcium (mg/L)	00915	50	6.8	11	2.4	2.2
Magnesium (mg/L)	00925	50	2.9	5.1	1	1
Sodium (mg/L)	00930	50	10	31	1.6	7.3
Potassium (mg/L)	00935	50	2.2	4.6	1	1
Sulfate (mg/L)	00945	49	11	25	4.4	5.2
Chloride (mg/L)	00940	50	8.5	20	2.2	4.5
Fluoride (mg/L)	00950	50	.2	.5	<.1	.1
Silica (mg/L)	00955	50	10	14	4.5	2.7
Dissolved solids, residue at 180° C (mg/L)	70300	50	81	158	42	31
MBAS (mg/L)	38260	15	.11	.9	<.01	.23
Suspended sediment (mg/L)	80154	72	121	1,670	4	256

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 2, ENO RIVER --Continued

Property/constituent (mg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Major nutrients						
Nitrogen, nitrate, total	00620	46	0.85	4.6	0.09	1
Nitrogen, nitrite, total	00615	53	.03	.11	<.01	.02
Nitrogen, nitrite plus nitrate, total	00630	59	.80	4.6	.10	.89
Nitrogen, nitrite plus nitrate, dissolved	00631	14	.90	3.9	.25	1.1
Nitrogen, ammonia, total	00610	52	.10	.45	<.01	.08
Nitrogen, ammonia, dissolved	00608	14	.08	.17	<.01	.06
Nitrogen, organic, total	00605	50	.78	2.6	.21	.49
Nitrogen, organic, dissolved	00607	10	.69	1.4	.29	.36
Nitrogen, ammonia plus organic, total	00625	58	.88	3	.26	.54
Nitrogen, ammonia plus organic, dissolved	00623	11	.75	1.4	.30	.35
Nitrogen, total	00600	58	1.7	5.7	.40	1
Nitrogen, dissolved	00602	9	1.4	3.7	.75	.95
Phosphorus, total	00665	59	.49	2.5	.04	.59
Phosphorus, dissolved	00666	15	.41	2.2	<.01	.64
Phosphorus, ortho, total	70507	51	.43	2.2	.03	.54
Phosphorus, ortho, dissolved	00671	14	.44	2.4	<.01	.71
Carbon, organic, total	00680	52	7.6	23	2.1	4.6

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 2, ENO RIVER--Continued

Minor elements						
Property/constituent (µg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Arsenic, total	01002	42	1.1	3	<1	0.34
Arsenic, dissolved	01000	7	1	1	<1	0
Cadmium, total	01027	42	1.1	2	<1	--
Cadmium, dissolved	01025	7	1.3	2	<1	.49
Chromium, total	01034	42	12	30	<10	4.8
Chromium, dissolved	01030	7	1	1	<1	0
Cobalt, total	01037	7	6.4	16	<1	5.5
Cobalt, dissolved	01035	7	1.7	3	<1	.95
Copper, total	01042	42	8.7	35	<1	7.5
Copper, dissolved	01040	7	3.6	8	1	2.4
Iron, total	01045	41	4,250	30,000	390	6,330
Iron, dissolved	01046	7	243	450	35	160
Lead, total	01051	41	8	33	<1	7.5
Lead, dissolved	01049	7	3.4	6	1	2
Manganese, total	01055	41	260	1,800	30	356
Manganese, dissolved	01056	7	28	40	17	8.8
Mercury, total	71900	42	.17	.9	<.1	<.17
Mercury, dissolved	71890	4	.10	.1	<.1	0
Selenium, total	01147	42	1	<1	<1	0
Selenium, dissolved	01145	7	1	<1	<1	0
Zinc, total	01092	42	40	190	<10	37
Zinc, dissolved	01090	7	9.1	18	4	4.8

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 3, LITTLE RIVER

LOCATION.--Latitude 36°08'20", longitude 78°54'24", Durham County, on right bank 125 ft upstream from bridge on U.S. Highway 501, 1 mi upstream from Mountain Creek, and 1.2 mi northwest of Orange Factory, North Carolina; Hydrologic Unit 03020201; USGS downstream order identification number 02085220.

DRAINAGE AREA.--80.4 mi^2.

PERIOD OF RECORD.--September 1984 to June 1987.

Physical properties and concentrations of major dissolved constituents						
Property/constituent	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Instantaneous discharge (ft^3/s)	00061	32	335	4,280	1.1	--
Instantaneous specific conductance (µS/cm)	00095	32	79	122	33	22
pH (pH units)	00400	32	6.8	8.1	5.8	.64
Color (Platinum-cobalt units)	00080	31	83	550	7	123
Dissolved oxygen (mg/L)	00300	29	10.2	14.8	6.7	2
Water temperature (°C)	00010	32	15.5	27	3.5	6.9
Hardness (mg/L)	00900	30	26	41	9	8.7
Calcium (mg/L)	00915	30	6.2	10	2.2	2.1
Magnesium (mg/L)	00925	30	2.5	3.9	.94	.83
Sodium (mg/L)	00930	30	4.4	6.1	1.2	1.4
Potassium (mg/L)	00935	30	1.9	3.5	.9	.77
Sulfate (mg/L)	00945	30	6.4	14	2.1	3.1
Chloride (mg/L)	00940	31	4.8	6.8	1.8	1.4
Fluoride (mg/L)	00950	31	.1	.2	<.1	.02
Silica (mg/L)	00955	30	9.9	14	4.8	2.9
Dissolved solids, residue at 180° C (mg/L)	70300	29	59	81	31	11
MBAS (mg/L)	38260	7	.04	.07	.02	.02
Suspended sediment (mg/L)	80154	31	89	898	1	200

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 3, LITTLE RIVER--Continued

Property/constituent (mg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Major nutrients						
Nitrogen, nitrate, total	00620	16	0.41	0.76	0.09	0.21
Nitrogen, nitrite, total	00615	32	.02	.08	<.01	.02
Nitrogen, nitrite plus nitrate, total	00630	32	.33	.82	.07	.21
Nitrogen, nitrite plus nitrate, dissolved	00631	8	.29	.48	<.10	.13
Nitrogen, ammonia, total	00610	32	.05	.33	<.01	.07
Nitrogen, ammonia, dissolved	00608	8	.06	.15	<.01	.05
Nitrogen, organic, total	00605	20	.81	2.3	.24	.57
Nitrogen, organic, dissolved	00607	5	.94	1.3	.71	.25
Nitrogen, ammonia plus organic, total	00625	31	.75	2.4	.20	.53
Nitrogen, ammonia plus organic, dissolved	00623	7	.89	1.3	.50	.28
Nitrogen, total	00600	26	1.2	2.8	.43	.63
Nitrogen, dissolved	00602	4	1.2	1.5	.77	.31
Phosphorus, total	00665	32	.09	.27	<.01	.07
Phosphorus, dissolved	00666	8	.06	.14	<.01	.05
Phosphorus, ortho, total	70507	30	.05	1.15	<.01	.04
Phosphorus, ortho, dissolved	00671	8	.04	.08	<.01	.03
Carbon, organic, total	00680	32	7.9	34	3	6.5

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 3, LITTLE RIVER--Continued

Minor elements						
Property/constituent (µg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Arsenic, total	01002	22	1.1	3	<1	0.43
Arsenic, dissolved	01000	--	--	--	--	--
Cadmium, total	01027	22	1	1	<1	0
Cadmium, dissolved	01025	--	--	--	--	--
Chromium, total	01034	22	11	20	<10	2.9
Chromium, dissolved	01030	--	--	--	--	--
Cobalt, total	01037	--	--	--	--	--
Cobalt, dissolved	01035	--	--	--	--	--
Copper, total	01042	22	5.1	23	<1	5.9
Copper, dissolved	01040	--	--	--	--	--
Iron, total	01045	21	3,000	16,000	290	4,460
Iron, dissolved	01046	--	--	--	--	--
Lead, total	01051	22	5.1	18	<1	5.4
Lead, dissolved	01049	--	--	--	--	--
Manganese, total	01055	22	183	850	10	270
Manganese, dissolved	01056	--	--	--	--	--
Mercury, total	71900	21	.11	.3	<.1	.05
Mercury, dissolved	71890	--	--	--	--	--
Selenium, total	01147	22	1	<1	<1	0
Selenium, dissolved	01145	--	--	--	--	--
Zinc, total	01092	22	30	190	<10	42
Zinc, dissolved	01090	--	--	--	--	--

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 4, FLAT RIVER

LOCATION.--Latitude 36°08'55", longitude 78°49'43", Durham County, on right bank 900 ft downstream from Durham municipal dam, 3 mi southeast of Bahama, North Carolina, and 5 mi upstream from confluence with Eno River; Hydrologic Unit 03020201; USGS downstream order identification number 02086500.

DRAINAGE AREA.--168 mi^2.

PERIOD OF RECORD.--November 1982 to June 1987.

Physical properties and concentrations of major dissolved constituents						
Property/constituent	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Instantaneous discharge (ft^3/s)	00061	71	403	4,850	0.06	--
Instantaneous specific conductance (µS/cm)	00095	61	69	98	44	12
pH (pH units)	00400	61	6.5	7.8	5.4	.45
Color (Platinum-cobalt units)	00080	52	50	150	5	37
Dissolved oxygen (mg/L)	00300	56	8.1	13	1.8	3
Water temperature (°C)	00010	58	15.6	30	4.5	1.3
Hardness (mg/L)	00900	52	21	29	13	4.5
Calcium (mg/L)	00915	52	5.2	7.5	3	1.3
Magnesium (mg/L)	00925	52	2	2.6	1.4	.33
Sodium (mg/L)	00930	52	4.3	5.5	3	.64
Potassium (mg/L)	00935	52	1.8	2.8	1.2	.39
Sulfate (mg/L)	00945	52	7.9	17	4	2.8
Chloride (mg/L)	00940	52	4.9	6.2	3.5	.63
Fluoride (mg/L)	00950	52	.1	.2	<.1	.04
Silica (mg/L)	00955	52	9.2	12	6.8	1.1
Dissolved solids, residue at 180° C (mg/L)	70300	52	58	73	39	7.4
MBAS (mg/L)	38260	16	.08	.7	<.01	.81
Suspended sediment (mg/L)	80154	68	16	47	1	10

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 4, FLAT RIVER--Continued

Major nutrients						
Property/constituent (mg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Nitrogen, nitrate, total	00620	36	0.29	0.49	0.02	0.13
Nitrogen, nitrite, total	00615	55	.02	.04	<.01	.01
Nitrogen, nitrite plus nitrate, total	00630	60	.26	.50	.03	.14
Nitrogen, nitrite plus nitrate, dissolved	00631	14	.23	.39	<.01	.10
Nitrogen, ammonia, total	00610	55	.12	.41	<.01	.08
Nitrogen, ammonia, dissolved	00608	15	.13	.27	.01	.08
Nitrogen, organic, total	00605	52	.67	2.7	.12	.46
Nitrogen, organic, dissolved	00607	11	.61	1.6	.07	.48
Nitrogen, ammonia plus organic, total	00625	60	.84	2.8	.20	.49
Nitrogen, ammonia plus organic, dissolved	00623	13	.65	1.6	<.1	.45
Nitrogen, total	00600	53	1.1	2.8	.40	.45
Nitrogen, dissolved	00602	6	.86	1.2	.55	.26
Phosphorus, total	00665	61	.07	.22	<.01	.05
Phosphorus, dissolved	00666	15	.04	.08	<.01	.02
Phosphorus, ortho, total	70507	53	.03	.09	<.01	.02
Phosphorus, ortho, dissolved	00671	16	.02	.05	<.01	.01
Carbon, organic, total	00680	52	6.9	17	4.2	2.2

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 4, FLAT RIVER--Continued

Minor elements						
Property/constituent (µg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Arsenic, total	01002	43	1.1	2	<1	0.21
Arsenic, dissolved	01000	8	1	1	<1	0
Cadmium, total	01027	42	1	3	<1	--
Cadmium, dissolved	01025	8	1	1	<1	0
Chromium, total	01034	42	11	20	<10	3.5
Chromium, dissolved	01030	8	1.2	2	<1	.46
Cobalt, total	01037	8	2.5	5	<1	1.5
Cobalt, dissolved	01035	8	1.8	4	<1	1
Copper, total	01042	43	9.9	170	2	26
Copper, dissolved	01040	8	3.5	7	1	2.1
Iron, total	01045	42	1,330	4,700	300	766
Iron, dissolved	01046	8	323	510	84	156
Lead, total	01051	42	4	14	<1	2.8
Lead, dissolved	01049	8	3	9	<1	2.7
Manganese, total	01055	42	246	1,500	20	284
Manganese, dissolved	01056	8	127	500	10	159
Mercury, total	71900	43	.13	.5	<.1	.09
Mercury, dissolved	71890	8	.11	.2	<.1	.04
Selenium, total	01147	43	1	1	<1	0
Selenium, dissolved	01145	8	1	1	<1	0
Zinc, total	01092	43	28	320	<10	49
Zinc, dissolved	01090	8	8.5	26	3	7.7

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 5, KNAP OF REEDS CREEK

LOCATION.--Latitude 36°07'40", longitude 78°48'55", Granville County, on left bank 60 ft downstream of Butner, North Carolina, sewage outfall, 1.5 mi downstream from bridge on Secondary Road 1120, and 2.5 mi upstream from mouth; Hydrologic Unit 03020201; USGS downstream order identification number 02086624.

DRAINAGE AREA.--43 mi^2.

PERIOD OF RECORD.--November 1982 to June 1987.

Physical properties and concentrations of major dissolved constituents						
Property/constituent	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Instantaneous discharge (ft^3/s)	00061	72	196	2,040	2.2	--
Instantaneous specific conductance (µS/cm)	00095	60	298	810	40	241
pH (pH units)	00400	60	6.5	7.5	5.8	.38
Color (Platinum-cobalt units)	00080	50	62	210	8	46
Dissolved oxygen (mg/L)	00300	56	7.8	12.1	3.5	2.7
Water temperature (°C)	00010	60	17.5	29	5	7.2
Hardness (mg/L)	00900	50	38	65	14	16
Calcium (mg/L)	00915	50	10	19	3.1	5.1
Magnesium (mg/L)	00925	50	3	5.8	1.4	1
Sodium (mg/L)	00930	50	43	130	1.7	41
Potassium (mg/L)	00935	50	3.8	9	1.1	2.4
Sulfate (mg/L)	00945	50	34	120	5.3	27
Chloride (mg/L)	00940	50	38	110	2.5	35
Fluoride (mg/L)	00950	50	1.7	9.6	<.1	2.3
Silica (mg/L)	00955	50	11	17	6.2	2.6
Dissolved solids, residue at 180° C (mg/L)	70300	50	196	469	32	139
MBAS (mg/L)	38260	15	.15	.9	.01	.22
Suspended sediment (mg/L)	80154	71	43	403	6	63

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 5, KNAP OF REEDS CREEK--Continued

Property/constituent (mg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Major nutrients						
Nitrogen, nitrate, total	00620	38	2.6	13	0.09	3.1
Nitrogen, nitrite, total	00615	54	.02	.04	<.01	.01
Nitrogen, nitrite plus nitrate, total	00630	60	2.9	15	<.1	3.5
Nitrogen, nitrite plus nitrate, dissolved	00631	13	2.1	8.7	<.1	2.5
Nitrogen, ammonia, total	00610	53	.63	3.7	<.01	.82
Nitrogen, ammonia, dissolved	00608	13	.50	3.2	.03	.86
Nitrogen, organic, total	00605	51	2.3	9.4	.05	2
Nitrogen, organic, dissolved	00607	12	1.2	2.2	.47	.65
Nitrogen, ammonia plus organic, total	00625	59	3	10	.10	2.4
Nitrogen, ammonia plus organic, dissolved	00623	13	1.7	5	.60	1.3
Nitrogen, total	00600	55	6.2	19	.50	5.1
Nitrogen, dissolved	00602	8	3.9	11	.74	3.3
Phosphorus, total	00665	60	2.9	20	.03	3.7
Phosphorus, dissolved	00666	15	2	8	<.01	2.7
Phosphorus, ortho, total	70507	52	2.2	8	.01	2.6
Phosphorus, ortho, dissolved	00671	14	1.7	7.5	.02	2.5
Carbon, organic, total	00680	53	14	40	5.9	6.8

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 5, KNAP OF REEDS CREEK--Continued

Minor elements						
Property/constituent (µg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Arsenic, total	01002	43	1.2	3	<1	0.47
Arsenic, dissolved	01000	7	1.1	2	<1	.38
Cadmium, total	01027	42	1.3	8	<1	--
Cadmium, dissolved	01025	7	1.1	2	<1	.38
Chromium, total	01034	43	14	30	<10	6.6
Chromium, dissolved	01030	7	1	1	<1	0
Cobalt, total	01037	7	3.4	8	<1	2.6
Cobalt, dissolved	01035	7	1	1	<1	0
Copper, total	01042	42	71	310	2	77
Copper, dissolved	01040	7	40	130	2	46
Iron, total	01045	42	1,760	9,900	400	1,920
Iron, dissolved	01046	7	307	710	100	233
Lead, total	01051	41	8.2	22	<1	4.8
Lead, dissolved	01049	7	4.3	9	2	2.4
Manganese, total	01055	42	221	1,200	50	234
Manganese, dissolved	01056	7	120	300	49	82
Mercury, total	71900	42	.16	.6	<.1	.10
Mercury, dissolved	71890	6	.12	.2	<.1	.04
Selenium, total	01147	42	1	<1	<1	0
Selenium, dissolved	01145	7	1	<1	<1	0
Zinc, total	01092	43	64	590	<10	91
Zinc, dissolved	01090	7	18	43	4	13

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 6, ELLERBE CREEK

LOCATION.--Latitude 36°03'33", longitude 78°49'58", Durham County, on left bank 10 ft upstream of bridge on Secondary Road 1636, 1.6 mi northwest of Gorman, North Carolina, and 3 mi upstream from mouth; Hydrologic Unit 03020201; USGS downstream order identification number 02086849.

DRAINAGE AREA.--21.9 mi^2.

PERIOD OF RECORD.--November 1982 to June 1987.

Physical properties and concentrations of major dissolved constituents						
Property/constituent	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Instantaneous discharge (ft^3/s)	00061	76	295	2,410	3.1	--
Instantaneous specific conductance (µS/cm)	00095	61	329	630	36	181
pH (pH units)	00400	61	6.8	7.7	5.9	.41
Color (Platinum-cobalt units)	00080	48	67	300	10	80
Dissolved oxygen (mg/L)	00300	57	6.7	14.6	.6	3.4
Water temperature (°C)	00010	59	16.3	27	3	6.3
Hardness (mg/L)	00900	49	44	70	8	17
Calcium (mg/L)	00915	49	11	18	2.1	4.3
Magnesium (mg/L)	00925	49	3.7	6.1	.7	1.5
Sodium (mg/L)	00930	49	39	85	1.7	24
Potassium (mg/L)	00935	49	7.1	12	1.7	3.3
Sulfate (mg/L)	00945	49	30	84	6.3	14
Chloride (mg/L)	00940	49	28	49	1.7	16
Fluoride (mg/L)	00950	49	.7	1.8	<.1	.51
Silica (mg/L)	00955	49	12	20	2.9	4.6
Dissolved solids, residue at 180° C (mg/L)	70300	49	208	373	30	103
MBAS (mg/L)	38260	14	.27	1.1	<.01	.30
Suspended sediment (mg/L)	80154	74	228	1,850	4	451

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 6, ELLERBE CREEK--Continued

Major nutrients						
Property/constituent (mg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Nitrogen, nitrate, total	00620	55	3.2	19	0.06	4.4
Nitrogen, nitrite, total	00615	55	.43	3	.02	.53
Nitrogen, nitrite plus nitrate, total	00630	61	3.7	19	.23	4.5
Nitrogen, nitrite plus nitrate, dissolved	00631	14	1.5	10	.29	2.6
Nitrogen, ammonia, total	00610	52	5.8	20	.22	5.3
Nitrogen, ammonia, dissolved	00608	12	4.9	19	.17	6.8
Nitrogen, organic, total	00605	51	2.8	13	0	2.3
Nitrogen, organic, dissolved	00607	11	1.7	8	0	2.5
Nitrogen, ammonia plus organic, total	00625	60	8.7	30	.80	6.7
Nitrogen, ammonia plus organic, dissolved	00623	13	7.9	24	.50	7.9
Nitrogen, total	00600	60	12	33	1.1	8.1
Nitrogen, dissolved	00602	12	9.2	25	.79	8.7
Phosphorus, total	00665	61	3.3	17	.14	2.9
Phosphorus, dissolved	00666	15	2.3	6	.06	2.4
Phosphorus, ortho, total	70507	53	2.6	6.5	.11	2.2
Phosphorus, ortho, dissolved	00671	14	2.1	5.9	.06	2.3
Carbon, organic, total	00680	52	17	53	5.9	7.7

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 6, ELLERBE CREEK--Continued

Minor elements						
Property/constituent (µg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Arsenic, total	01002	44	1.5	4	<1	0.73
Arsenic, dissolved	01000	8	1.1	2	1	.35
Cadmium, total	01027	43	1.4	5	<1	--
Cadmium, dissolved	01025	8	1.6	4	<1	1.2
Chromium, total	01034	44	16	50	10	9.2
Chromium, dissolved	01030	8	1.3	3	<1	.71
Cobalt, total	01037	8	12	36	1	12
Cobalt, dissolved	01035	8	2.3	5	1	1.4
Copper, total	01042	44	18	63	6	13
Copper, dissolved	01040	8	10	19	4	4.9
Iron, total	01045	42	4,400	21,000	290	6,020
Iron, dissolved	01046	8	203	370	77	100
Lead, total	01051	43	32	200	<1	49
Lead, dissolved	01049	8	5.6	17	1	4.9
Manganese, total	01055	42	262	660	50	141
Manganese, dissolved	01056	7	130	270	55	88
Mercury, total	71900	44	.19	.8	<.1	.16
Mercury, dissolved	71890	6	.23	.5	<.1	.15
Selenium, total	01147	44	1	2	<1	.15
Selenium, dissolved	01145	8	1.1	2	<1	.35
Zinc, total	01092	43	90	320	30	56
Zinc, dissolved	01090	8	39	77	17	24

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 7, LITTLE LICK CREEK

LOCATION.--Latitude 35°59'11", longitude 78°47'58", Durham County, on right bank 300 ft upstream from bridge on Secondary Road 1814, and 1.3 mi northeast of Oak Grove, North Carolina; Hydrologic Unit 03020201; USGS downstream order identification number 0208700780.

DRAINAGE AREA.--10.1 mi^2.

PERIOD OF RECORD.--November 1982 to June 1987.

Physical properties and concentrations of major dissolved constituents						
Property/constituent	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Instantaneous discharge (ft^3/s)	00061	79	83	815	0.09	--
Instantaneous specific conductance (µS/cm)	00095	60	245	530	34	154
pH (pH units)	00400	60	6.6	7.5	5.4	.41
Color (Platinum-cobalt units)	00080	50	93	500	8	101
Dissolved oxygen (mg/L)	00300	57	7.5	12.9	2.1	3.1
Water temperature (°C)	00010	59	14.5	25	2	6.6
Hardness (mg/L)	00900	50	45	75	7	19
Calcium (mg/L)	00915	50	11	19	1.8	4.8
Magnesium (mg/L)	00925	50	4.1	6.8	.6	1.7
Sodium (mg/L)	00930	50	28	73	2.1	22
Potassium (mg/L)	00935	50	4.5	10	.3	2.7
Sulfate (mg/L)	00945	50	25	53	7.3	13
Chloride (mg/L)	00940	50	22	51	2.1	15
Fluoride (mg/L)	00950	50	.3	1	<.1	.26
Silica (mg/L)	00955	50	12	23	4.6	4.7
Dissolved solids, residue at 180° C (mg/L)	70300	49	167	362	36	98
MBAS (mg/L)	38260	16	.19	1.1	<.01	.28
Suspended sediment (mg/L)	80154	79	94	1,040	5	180

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 7, LITTLE LICK CREEK--Continued

Property/constituent (mg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Major nutrients						
Nitrogen, nitrate, total	00620	54	3.9	21	0.06	5.6
Nitrogen, nitrite, total	00615	54	.19	.72	.02	.20
Nitrogen, nitrite plus nitrate, total	00630	60	4.2	21	.10	5.7
Nitrogen, nitrite plus nitrate, dissolved	00631	13	2.9	21	.23	5.7
Nitrogen, ammonia, total	00610	51	.88	7.3	.05	1.3
Nitrogen, ammonia, dissolved	00608	15	.53	3.7	.06	.95
Nitrogen, organic, total	00605	50	1.2	7.2	.37	1.1
Nitrogen, organic, dissolved	00607	12	1.1	2.3	.23	.65
Nitrogen, ammonia plus organic, total	00625	59	2.1	12	.45	2.1
Nitrogen, ammonia plus organic, dissolved	00623	13	2	6	.30	1.9
Nitrogen, total	00600	59	6.4	23	.90	6.3
Nitrogen, dissolved	00602	9	4.4	22	.55	6.8
Phosphorus, total	00665	60	2.2	7.4	.13	2.4
Phosphorus, dissolved	00666	15	1.6	7.1	.05	2.3
Phosphorus, ortho, total	70507	52	2	7.9	.08	2.3
Phosphorus, ortho, dissolved	00671	15	1.6	7.3	.05	2.3
Carbon, organic, total	00680	52	12	40	5.2	5.6

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 7, LITTLE LICK CREEK--Continued

Minor elements						
Property/constituent (µg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Arsenic, total	01002	43	1.1	2	1	0.32
Arsenic, dissolved	01000	8	1	1	1	0
Cadmium, total	01027	42	1.1	2	<1	--
Cadmium, dissolved	01025	8	1.3	2	<1	.46
Chromium, total	01034	43	12	20	<10	4.3
Chromium, dissolved	01030	8	1.1	2	<1	.35
Cobalt, total	01037	8	7.5	28	<1	8.8
Cobalt, dissolved	01035	8	1.4	3	<1	.74
Copper, total	01042	43	9.8	23	3	5.2
Copper, dissolved	01040	8	5.4	11	2	3.2
Iron, total	01045	41	3,100	14,000	310	3,740
Iron, dissolved	01046	8	197	580	45	178
Lead, total	01051	41	9.8	41	<1	10
Lead, dissolved	01049	8	3.9	7	1	2.2
Manganese, total	01055	41	173	600	60	129
Manganese, dissolved	01056	8	126	410	41	25
Mercury, total	71900	43	.15	.5	<.1	.10
Mercury, dissolved	71890	7	.17	.3	<.1	.08
Selenium, total	01147	43	1	<1	<1	0
Selenium, dissolved	01145	8	1	<1	<1	0
Zinc, total	01092	43	53	390	<10	61
Zinc, dissolved	01090	8	19	37	8	8.5

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 8, NEUSE RIVER

LOCATION.--Latitude 35°56'24", longitude 79°34'32", Wake County, on left bank 0.3 mi downdownstream from bridge on Secondary Road 2000, 0.4 mi northeast of Falls, North Carolina, and 0.5 mi downstream from Falls Dam; Hydrologic Unit 03020201; USGS downstream order identification number 02087183.

DRAINAGE AREA.--772 mi^2.

PERIOD OF RECORD.--December 1982 to June 1987.

Physical properties and concentrations of major dissolved constituents						
Property/constituent	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Instantaneous discharge (ft^3/s)	00061	57	1,010	4,940	63	--
Instantaneous specific conductance (µS/cm)	00095	55	81	120	53	168
pH (pH units)	00400	57	6.6	7.8	5.7	.46
Color (Platinum-cobalt units)	00080	51	52	350	5	60
Dissolved oxygen (mg/L)	00300	54	9.9	15.2	6.7	2.3
Water temperature (°C)	00010	56	16.4	29.5	3	7.4
Hardness (mg/L)	00900	50	24	32	16	4.5
Calcium (mg/L)	00915	50	5.7	7.9	3.8	1.2
Magnesium (mg/L)	00925	50	2.4	3.2	1.6	.40
Sodium (mg/L)	00930	50	5.5	8.5	3.8	1.2
Potassium (mg/L)	00935	51	2.2	2.9	1.4	.40
Sulfate (mg/L)	00945	51	8.5	17	3.9	2.8
Chloride (mg/L)	00940	51	5.7	8.3	3.6	1.2
Fluoride (mg/L)	00950	51	.1	.3	<.1	.05
Silica (mg/L)	00955	50	6.8	12	3.2	1.9
Dissolved solids, residue at 180° C (mg/L)	70300	50	62	90	39	10
MBAS (mg/L)	38260	16	.05	.09	.02	.02
Suspended sediment (mg/L)	80154	57	14	100	3	16

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 8, NEUSE RIVER--Continued

Major nutrients						
Property/constituent (mg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Nitrogen, nitrate, total	00620	23	0.25	0.54	0.02	0.13
Nitrogen, nitrite, total	00615	52	.02	.06	<.01	.01
Nitrogen, nitrite plus nitrate, total	00630	57	.20	.70	.02	.14
Nitrogen, nitrite plus nitrate, dissolved	00631	15	.26	.55	<.1	.13
Nitrogen, ammonia, total	00610	51	.21	.90	.01	.19
Nitrogen, ammonia, dissolved	00608	16	.15	.51	.03	.12
Nitrogen, organic, total	00605	49	.81	4.2	.12	.81
Nitrogen, organic, dissolved	00607	13	.54	.89	.19	.21
Nitrogen, ammonia plus organic, total	00625	55	1.1	4.8	.30	.94
Nitrogen, ammonia plus organic, dissolved	00623	14	.70	1.4	.30	.27
Nitrogen, total	00600	34	1.3	4.5	.50	.94
Nitrogen, dissolved	00602	8	1	1.3	.77	.22
Phosphorus, total	00665	56	.05	.22	<.01	.05
Phosphorus, dissolved	00666	16	.04	.14	<.01	.03
Phosphorus, ortho, total	70507	50	.03	.14	<.01	.03
Phosphorus, ortho, dissolved	00671	15	.03	.06	<.01	.02
Carbon, organic, total	00680	48	7.9	17	3	2.3

Table 8.--*Statistical summary of physical properties and concentrations of major dissolved constituents, major nutrients, and minor elements in water from the study sites, 1982-87*--Continued

[mi, mile; mi^2, square mile; ft^3/s, cubic feet per second; --, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; <, less than (Detection limits are minimum values shown with this symbol; where minimum values are the detection limits, means are calculated as if minimum values are equal to detection limits.); MBAS, methylene blue active substances; µg/L, micrograms per liter; ft, feet]

SITE 8, NEUSE RIVER--Continued

Minor elements						
Property/constituent (µg/L)	Parameter code	Number of samples	Mean	Maximum	Minimum	Standard deviation
Arsenic, total	01002	41	1	2	<1	0.16
Arsenic, dissolved	01000	18	1.1	2	<1	.24
Cadmium, total	01027	41	1.1	3	<1	.40
Cadmium, dissolved	01025	18	1	1	<1	0
Chromium, total	01034	29	13	30	<10	5.4
Chromium, dissolved	01030	6	1	<1	<1	0
Cobalt, total	01037	6	3	5	1	1.6
Cobalt, dissolved	01035	6	1.7	3	<1	.82
Copper, total	01042	27	5.7	22	<1	5.3
Copper, dissolved	01040	6	3	11	1	4
Iron, total	01045	27	872	2,800	240	706
Iron, dissolved	01046	6	338	710	74	263
Lead, total	01051	41	5.9	43	<1	7.3
Lead, dissolved	01049	18	3.3	15	<1	3.6
Manganese, total	01055	28	606	2,800	10	669
Manganese, dissolved	01056	6	440	840	40	289
Mercury, total	71900	41	.12	.3	<.1	.06
Mercury, dissolved	71890	17	.12	.2	<.1	.04
Selenium, total	01147	41	1	<1	<1	0
Selenium, dissolved	01145	18	1	<1	<1	0
Zinc, total	01092	28	30	250	<10	48
Zinc, dissolved	01090	6	6.8	12	3	3.8

GLOSSARY

Some of the technical terms used in this report are defined here for the convenience of the reader. See Langbein and Iseri (1960) for additional information and associated hydrologic terminology. Statistical terms are defined with respect to the estimation of nutrient loads and data tables presented in this report.

Anion is an ion having a negative charge.

Cation is an ion having a positive charge.

Correlation coefficient is a term relating the standard error of estimate and the standard deviation of the values of the dependent variable. It is expressed as:

$$r = \frac{bs_x}{s_y}$$

where: r is the correlation coefficient,
b is the slope of the regression line,
s_x is the standard deviation of the independent variable, and
s_y is the standard deviation of the dependent variable.

Cubic foot per second (ft^3/s) is the rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second, 448.8 gallons per minute, or 0.02832 cubic meters per second.

Discharge is the volume of water (or more broadly, volume of fluid plus suspended sediment) that passes a given point within a given period of time.

Dissolved is that material in a representative water sample which passes through a 0.45 micron membrane filter. This is a convenient operational definition used by Federal agencies that collect water data. Determinations of "dissolved" constituents are made on subsamples of the filtrate.

Drainage area of a stream at a specific location is that area, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the river above the specified point. Figures of drainage area given herein include all closed basins, or noncontribution areas, within the area unless otherwise noted.

Drainage basin is a part of the surface of the Earth that is occupied by a drainage system which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Hydrologic unit is a geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as delineated by the Office of Water Data Coordination on the State Hydrologic Unit Maps; each hydrologic unit is identified by an 8-digit number.

Maximum is the largest value in a group of observations.

Mean is the sum of the numerical values of individual observations divided by the total number of observations in the group.

Mean discharge is the arithmetic mean of individual daily mean discharges during a specific period.

Instantaneous discharge is the discharge at a particular instant of time.

Microgram per liter (µg/L) is a unit expressing the concentration of chemical constituents in solution as the weight (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Minimum is the smallest value in a group of observations.

Parameter code is a 5-digit number used in the U.S. Geological Survey computerized data system, WATSTORE, to uniquely identify a specific

constituent. The codes used in WATSTORE are the same as those used in the U.S. Environmental Protection Agency data system, STORET. The Environmental Protection Agency assigns and approves all requests for new codes.

r^2 is the square of the correlation coefficient "r," often called the coefficient of determination. A perfect relationship has a value of ± 1, and a completely random relation has a value of zero.

Regression equation is an equation defining the relation between a dependent and an independent variable. For a logarithmic relation, the equation is:

$$y = ax^b$$

where: log x and log y are values of the independent and dependent variables, respectively,
coefficient b is the slope of the line, and
constant a is the y-axis intercept.

Standard deviation is the square root of the sum of the squares of deviations from the mean of all observations in a group divided by the number of observations minus one. It is expressed mathematically as:

$$S = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{N-1}}$$

where: S is the standard deviation,
x_i is the i'th value of x,
$\bar{x}$ is the mean value of x, and
N is the total number of observations.

Tons per day is the quantity of substance in solution or suspension that passes a stream section during a 24-hour day.

Total is the whole amount of a given constituent in a representative water suspended-sediment sample, regardless of the constituent's physical or chemical form. This term is used only when the analytical procedure assures

measurement of at least 95 percent of the constituent present in both the dissolved and suspended phases of the sample. A knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to judge when the results should be reported as "total." (Note that the word "total" does double duty here, indicating both that the sample consists of a water suspended-sediment mixture and that the analytical method determines all of the constituent in the sample.)

Total load (tons) is the whole quantity of any individual constituent, as measured mass or volume, that is dissolved in a specific amount of water during a given time. It is computed by multiplying the total discharge (in ft^3/s) times the concentration (in mg/L) of the constituent times the factor 0.0027 times the number of days.

Water year of the U.S. Geological Survey is the 12-month period October 1 through September 30. The water year is determined by the calendar year in which it ends and includes 9 of the 12 months. Thus, the year ended September 30, 1986, is called the "1986 water year."

Yield is the quantity of substance in solution or suspension per unit area of drainage basin, commonly measured in tons per square mile per time unit.