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Water Resources of Monroe County, New York, Water Years 1989-93, with Emphasis on Water Quality in the Irondequoit Creek Basin

Part 2. Atmospheric Deposition, Ground Water, Streamflow, Trends in Water Quality, and Chemical Loads to Irondequoit Bay

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 99-4084

Prepared in cooperation with the
Monroe County Department of Health

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By DONALD A. SHERWOOD

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CONVERSION FACTORS AND VERTICAL DATUM

MULTIPLY	BY	TO OBTAIN
	Length	
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.59	square kilometer
acre	0.40483	hectare
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch per year (in/yr)	25.4	millimeter per year
million gallons per day (Mgal/d)	3.785	cubic meters per day
gallons per minute (gal/min)	0.06309	liter per second
gallons per second (gal/s)	0.0010515	liter per second
	Volume	
cubic feet (ft^3)	0.02832	cubic meters
	Temperature	
degrees Fahrenheit (˚F)	˚C = 5/9 (˚F-32)	degrees Celsius

Specific Conductance

microsiemens per centimeter at 25˚ Celsius (mS/cm)

Equivalent Concentration Terms

milligrams per liter (mg/L) = parts per million
micrograms per liter (mg/L) = parts per billion

Load

Tons per day (tons/d) 907.1 Kilograms per day
Pounds per square mile 0.175 Kilograms per square kilometer

Vertical datum: 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 the United States and Canada, formerly called Sea Level Datum of 1929.

Water Resources of Monroe County, New York, Water Years 1989-93, with Emphasis on Water Quality In The Irondequoit Creek Basin

Part 2: Atmospheric Deposition, Ground Water, Streamflow, Trends in Water Quality, and Chemical Loads to Irondequoit Bay

By Donald A. Sherwood

ABSTRACT

Irondequoit Creek, which drains 169 square miles in the eastern part of Monroe County, has been recognized as a source of contaminants that contribute to the eutrophication of Irondequoit Bay on Lake Ontario. The discharge from sewage-treatment plants to the creek and its tributaries was eliminated in 1979 by diversion to another wastewater-treatment facility, but sediment and nonpoint-source pollution remain a concern. This report presents data from five surface-water sites in the Irondequoit Creek basin—Irondequoit Creek at Railroad Mills, East Branch Allen Creek, Allen Creek near Rochester, Irondequoit Creek at Blossom Road, and Irondequoit Creek at Empire Boulevard, to supplement published data from 1984-88. Data from Northrup Creek, which drains 11.7 square miles in western Monroe County, provide information on surface-water quality west of the Genesee River. Also presented are water-level and water-quality data from 12 observation-well sites in Ellison and Powdermill Parks and atmospheric-deposition data from 1 site (Mendon Ponds).

Concentrations of several chemical constituents in streams of the Irondequoit Creek basin showed statistically significant trends during 1989-93. Concentrations of total suspended-solids and volatile suspended-solids in Irondequoit Creek at Blossom Road decreased 13.5 and 12.5 percent per year, respectively, and those at Empire Boulevard decreased 33.5 and 22 percent per year, respectively. Concentrations of ammonia plus organic nitrogen increased 17.6 percent per year at one site in the basin, but decreased 8.5 and 22.3 percent per year at two sites. Nitrite plus nitrate decreased at only one site (3.5 percent per year). Concentrations of total phosphorus increased at two sites (about 7 percent per year) and decreased at two other sites (7.6 and 29.9 percent per year), and orthophosphate concentrations increased at one site (10.8 percent per year). Dissolved chloride increased at three sites (1.7 to 10.9 percent per year), and dissolved sulfate decreased at one site (2.1 percent per year) and increased at one site (6.8 percent per year).

Median concentrations of constituents were significantly lower in atmospheric deposition than in streamflow, although annual deposition of ammonia nitrogen, nitrite plus nitrate, total phosphorus, and orthophosphate in the basin exceeded the amounts removed by streamflow. Atmospheric deposition of chloride and sulfate, by contrast, represented only 1 and 12 percent, respectively, of the loads transported by Irondequoit Creek (Blossom Road site).

Comparison of water-quality data from the Allen Creek site and Irondequoit Creek at Blossom Road from water years 1989-93 with corresponding data from 1984-88 indicates significant changes in median concentrations of several constituents. The concentration of dissolved chloride increased at Blossom Road and was unchanged at Allen Creek, whereas sulfate decreased at both sites. Concentrations of ammonia plus organic nitrogen, and nitrite plus nitrate, were significantly lower during 1989-93 than during 1984-88 at both sites. Total phosphorus

concentration was lower during 1984-88 than during 1989-93 at Blossom Road but showed no change at Allen Creek, and orthophosphate concentration for 1989-93 was lower than in 1984-88 at both sites. Comparison of chemical loads in atmospheric deposition also indicates significant changes in many constituents. Five-year-mean loads of sodium, sulfate, and lead in atmospheric deposition for 1989-93 exceeded those for 1984-88, whereas 5-year-mean loads of calcium, magnesium, potassium, chloride, nitrite plus nitrate, ammonia nitrogen, and orthophosphate for 1989-93 were lower than in 1984-88.

The changes in surface-water quality resulted from several factors within the basin, including land-use changes, annual and seasonal variations in streamflow, and year-to-year variations in the application of deicing salts on area roads. Statistical analyses of long-term (9 years or more) flow records of three unregulated streams in Monroe County indicate that annual mean flows for water years 1989-93 were in the normal range (20th- to 80th-percentile). The greatest mean annual flow in this period—about 140 percent of normal at Irondequoit Creek and Black Creek—occurred in 1993, but the annual mean flow for that water year at Allen Creek was only 98 percent of normal. The lowest annual mean flows of these streams—ranging from 75 percent of normal to 93 percent of normal—occurred in 1989. The average annual mean flows for these streams for 1989-93 was 104 percent of normal, and that for 1984-88 was normal.

INTRODUCTION

Irondequoit Bay, near the City of Rochester, N.Y., has been eutrophic (overly enriched with nutrients) for several decades (Bubeck and Burton, 1989), largely as a result of sewage, sediment, and nutrients that enter the bay from Irondequoit Creek (fig. 1). The discharge of sewage to Irondequoit Creek was eliminated in 1979, when the Monroe County wastewater treatment facility along the shore of Lake Ontario began operation. The County is making a continuing effort to further improve the chemical quality of Irondequoit Creek and its tributaries to slow the eutrophication of Irondequoit Bay.

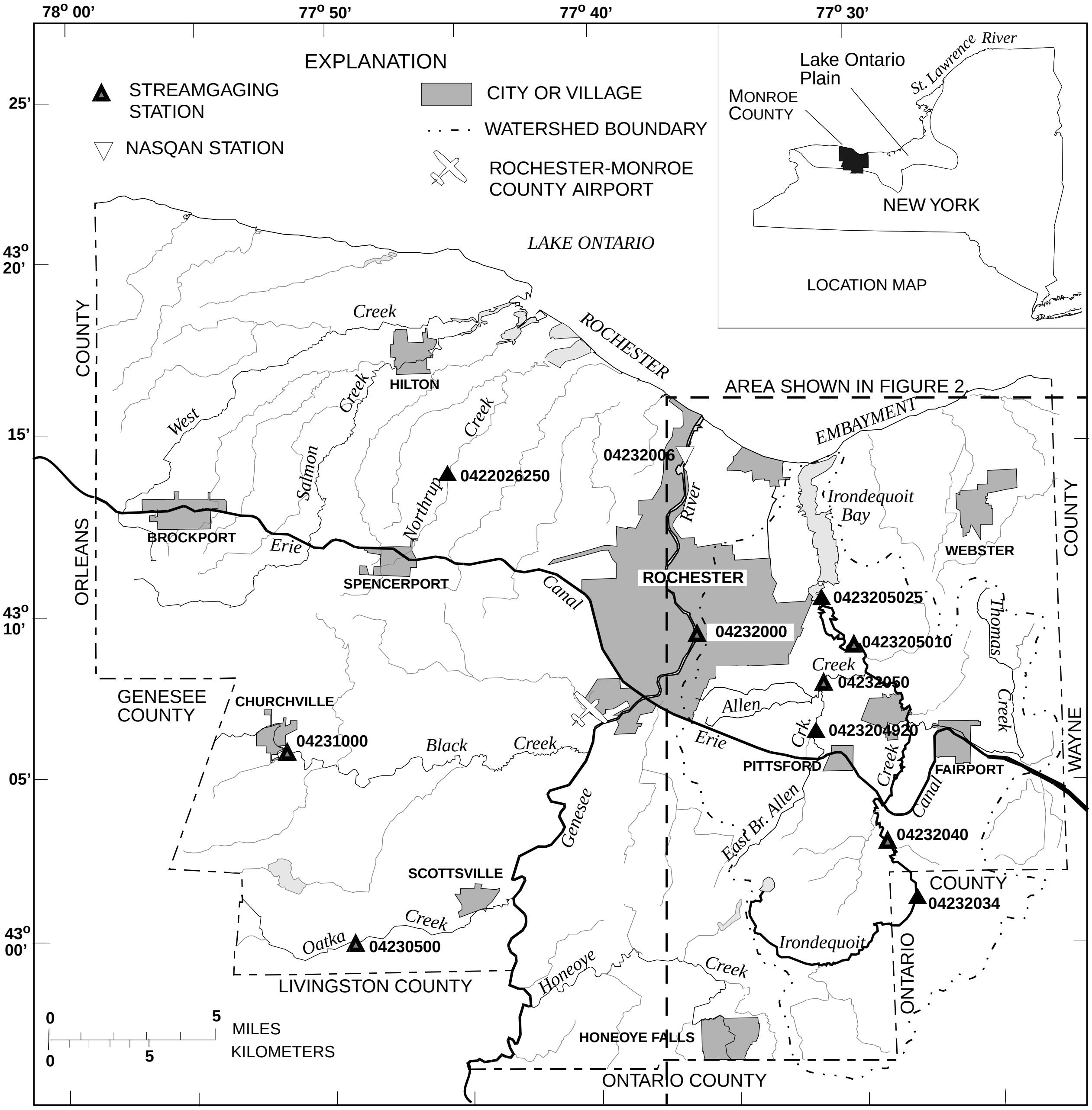
The U.S. Geological Survey (USGS), in cooperation with the Monroe County Health Department and the Monroe County Environmental Health Laboratory (MCEHL), has collected and analyzed water-resources information from the Irondequoit Creek basin since 1980 in an effort to identify sources of contamination and to quantify the annual loads of selected chemical constituents transported to Irondequoit Bay. During water years 1980-81, the USGS National Urban Runoff Program (NURP) study of the Irondequoit Creek basin investigated nonpoint-source contamination from selected areas representing specific land uses. The results of that study provided a basis from which changes in the nutrient and chemical loads of Irondequoit Creek could be identified. In 1993, the USGS, in cooperation with the Monroe County Health Department, began a program to publish and analyze water-resources data collected in Monroe County to detect any significant temporal trends in the concentrations of selected chemical constituents in streamflow and ground water. Statistical analyses of hydrologic data collected during water years 1984-88 are given in Johnston and Sherwood (1996). Data collection has continued since then for comparison with those results to detect changes since 1988 and to identify their causes.

Approach and Objectives

Evaluation of trends in chemical concentrations and loads transported by Irondequoit Creek and other streams in Monroe County entailed consideration of related factors such as (1) changes in the quantity and chemical quality of atmospheric deposition, a major source of some of the constituents in Irondequoit Creek (Kappel and others, 1986); (2) annual and seasonal variability of streamflow; (3) annual variability in the snowpack and spring runoff, which accounts for 50 to 75 percent of the annual chemical load transported by Irondequoit Creek; and (4) annual and seasonal variability in storm intensity because most of the annual load after the spring snowmelt period is derived from storm washoff.

Objectives of the study were to—

1. Investigate trends in ground-water, surface-water and atmospheric-deposition quality in the Irondequoit Creek basin and at sites in the adjacent Genesee River basin to provide a spatial and temporal basis for comparison between the two basins.
2. Document changes in loads of selected chemical constituents in the Genesee River and Northrup Creek (which are representative of western Monroe County) and loads transported to Irondequoit Bay by Irondequoit Creek.



Base from U.S. Geological Survey
Digital line graph, 1:100,000

EXPLANATION

STREAMGAGING STATIONS

0422026250	Northrup Creek near North Greece	04230500	Oatka Creek at Garbutt
04231000	Black Creek at Churchville	04232000	Genesee River at Rochester
04232006	Genesee River at Charlotte Docks	04232034	Irondequoit Creek at Railroad Mills
04232040	Irondequoit Creek at Pittsford	0423204920	East Branch Allen Creek at Rochester
04232050	Allen Creek at Rochester	0423205010	Irondequoit Creek at Blossom Road
0423205025	Irondequoit Creek at Empire Boulevard		

Figure 1. Principal geographic features of Monroe County, N.Y. and location of streamgaging stations in study area. (From Johnston and Sherwood, 1994, fig.1)

The study entailed—

1. Statistical analysis of (a) precipitation volume, to indicate whether the amount measured during 1989-93 study period was representative of a "normal" 5-year period, and (b) chemical quality of bulk atmospheric deposition to identify changes in the chemical contribution of atmospheric deposition to streamwater in the Irondequoit basin since the 1984-88 study;
2. Analyses of ground-water data to define the relation between ground-water and surface-water flow patterns;
3. Comparison the chemical quality of ground water with that of surface water to indicate their possible relation;
4. Statistical analyses of long-term (9 years or more) records of flow at three unregulated streams in Monroe County to determine whether streamflows during the 1989-93 study period were representative of a "normal" 5-year period;
5. Statistical analyses of surface-water, ground-water, and precipitation-quality data to document significant trends in the concentration of selected constituents (a) since the 1984-88 study, and (b) during 1989-93.
6. Analysis of streamflow and chemical-concentration data to estimate annual loads of selected constituents transported to Irondequoit Bay during 1989-93, and comparison of those results with annual loads reported for 1984-88.

Purpose and Scope

This report describes the hydrologic conditions within Monroe County and the Irondequoit Creek basin during 1989-93 and explains the methods of data analysis and the statistical methods used for trend analyses and estimation of constituent loads. It provides comparisons of precipitation volumes, and chemical quality of bulk atmospheric deposition during 1989-93, with those of the 1984-88 period. It also analyzes seasonal fluctuations in ground-water levels and water-table gradients in Powder Mill Park in the southern (upper) part of the basin and in Ellison Park in the northern (lower) part (fig. 2), and includes a comparison of chemical quality of ground water in the upper part with that in the lower part. Comparisons are made of streamflow in Monroe County during 1989-93 with historical streamflow records and with streamflow during 1984-88. Finally, it examines water-quality trends (upward or downward) in Monroe County during 1989-93, chemical concentrations in 1989-93 in relation to those of the 1984-88 period, and loads and yields of selected constituents transported by Irondequoit Creek to the Bay.

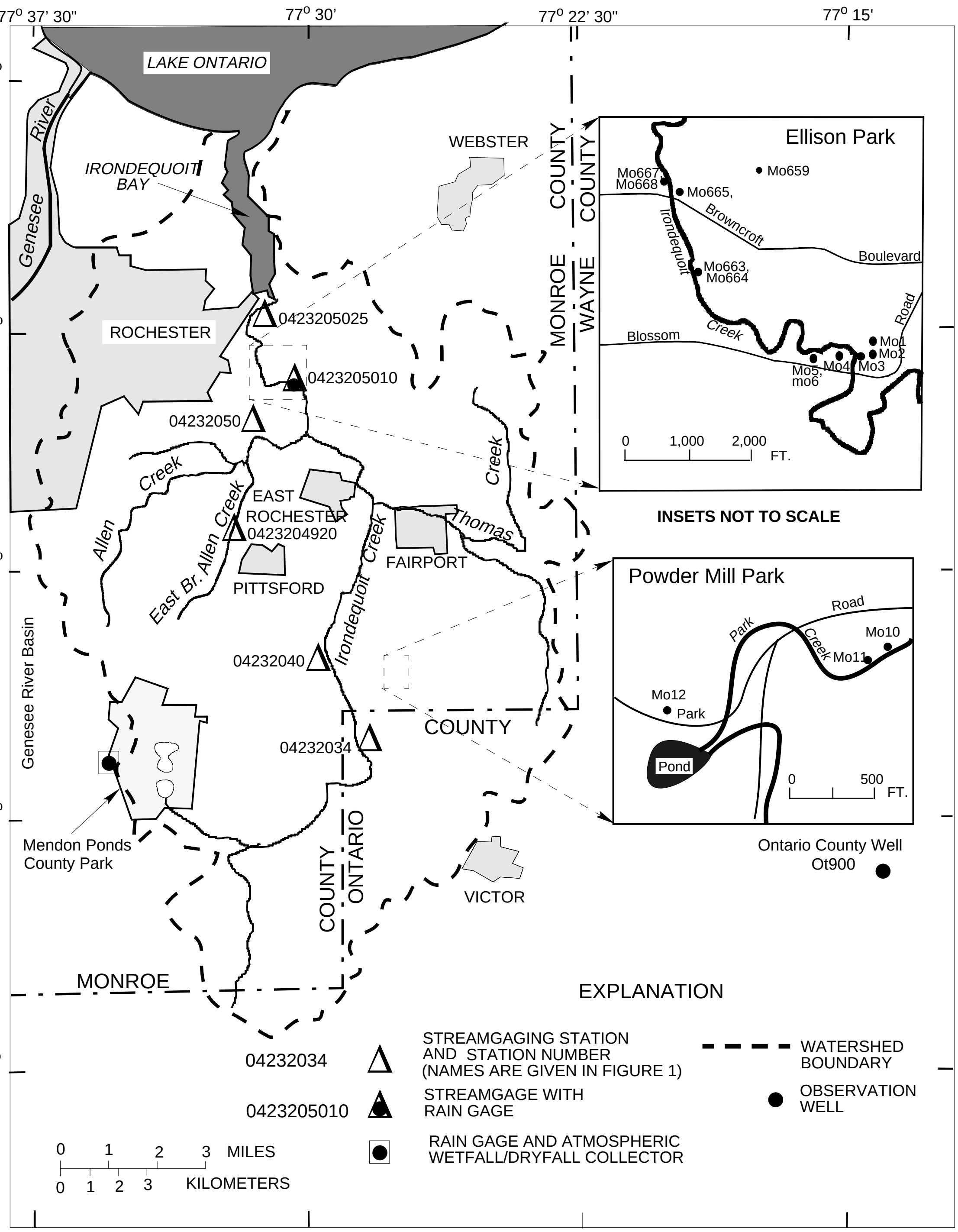
Acknowledgments

Special thanks are extended to the personnel of MCEHL for assistance in the collection, analysis, and verification of the data presented herein. Richard Burton, MCEHL laboratory administrator, provided guidance and suggestions throughout the data-collection period. Charles Knauf of MCEHL organized and prepared the chemical-quality data for entry into the USGS data base. The staff of the Powder Mill Park fish hatchery assisted in the measurement of ground-water levels at the Powder Mill Park wells.

Previous Studies

The 1980-81 NURP study of the Irondequoit Creek basin (Zarriello and others, 1985; Kappel and others, 1986) related the chemical constituents of storm runoff from areas representative of selected land uses to the chemical quality of Irondequoit Creek and its tributaries, and documented the total annual load of selected constituents transported to Irondequoit Bay. That study provided a basis for development of a water-quality-management plan for the Irondequoit Creek basin and detection of water-quality changes described in this report.

Other USGS studies in the Irondequoit Creek basin include those by Zarriello and Surface (1989), who simulated changes in stormwater quality at potential stormflow-attenuation sites; Zarriello and Sherwood (1993), who evaluated the effect of stormwater detention on chemical and sediment loads in runoff from a newly constructed housing development in the basin; Yager and others (1985), who summarized the geohydrology of the Irondequoit Creek basin and indicated locations of ground-water recharge areas, recharge rates, and directions of ground-water movement; and Kappel and Young (1989), who summarized the glacial history and geohydrology of the Irondequoit Creek valley and identified the geohydrologic characteristics that affect the flow of ground water in the lower Irondequoit



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

Figure 2. Locations of streamflow-gaging stations, atmospheric deposition sites, and observation wells within the Irondequoit Creek basin, Monroe County. (locations shown in fig.1. Modified from Johnston and Sherwood, 1996, fig 2.)

Creek basin. A report by Johnston and Sherwood (1994) presents surface-water, ground-water, water-quality and precipitation data collected in Monroe County during 1984-88 and explains the data-collection and computation methods, data presentation, and quality-assurance/quality-control procedures. A companion report (Johnston and Sherwood, 1996) examines trends in precipitation, ground-water, and surface-water quality in Monroe County during 1984-88 and provides estimates of chemical constituent loads delivered to Irondequoit Bay. The hydrologic data that provide the basis for this report are given in Sherwood (1997). A summary of earlier Irondequoit basin reports by the USGS and other investigators is given in Kappel and others (1986).

Study area

Monroe County encompasses 673 mi^2 in the Lake Ontario Plain region of western New York (fig. 1) (Heffner and Goodman, 1973). Rochester, the county seat and largest city, is in the northern part of the county. The Genesee River, the largest in Monroe County, has a drainage area of 2,480 mi^2 at its mouth (Wagner and Dixson, 1985) and flows northward through the city of Rochester into Lake Ontario. Streams in the several smaller drainage basins (ranging from less than 5 mi^2 to about 88 mi^2) west of the Genesee River flow northeastward into Lake Ontario or to one of the several bays of the western part of the Rochester Embayment, and those in several small drainage basins (ranging from less than 0.2 mi^2 to nearly 24 mi^2) east of the Genesee River flow north or northwestward into Lake Ontario and the Irondequoit Creek basin (169 mi^2).

Irondequoit Creek drains into Lake Ontario through Irondequoit Bay (fig. 2). Its drainage basin is mostly in eastern Monroe County and includes drainage from the east side of the city of Rochester and from neighboring Ontario and Wayne Counties. A more complete basin description that includes stormwater and sanitary-sewer systems, drinking-water supplies, surficial geology, and climate, is given in Kappel and others (1986). The glacial history and geohydrology of the Irondequoit Creek valley are discussed in Kappel and Young (1989).

The New York State Barge Canal flows southeastward through the middle of the county and receives flow from the headwater areas of many of these streams. Diversion structures at several points along the canal allow water to be diverted from the canal to augment the flow of several small streams during low-flow conditions. The canal crosses the Genesee River 11.8 mi upstream from the river's mouth. Water diverted by the canal from Lake Erie is discharged into the Genesee River from the west; a smaller amount of water is then diverted from the Genesee River eastward into the canal.

Methods of Data Collection, Computation, and Laboratory Analysis

Most of the data analyzed in this report were collected by the staff of MCEHL through procedures specified by the USGS. Streamflow data were collected and processed by methods described in Rantz and others (1982a, b). Water samples were collected, treated, and transported by procedures described in Britton and Greeson (1989), Goerlitz and Brown (1972), Guy and Norman (1970), Fishman and Friedman (1989), and Wood (1976). Samples were analyzed by the MCEHL through analytical methods described in American Public Health Association and others (1985). A complete description of analytical methods used along with the MCEHL internal quality-assurance/quality-control (QA/QC) program and instrument-calibration schedules, are given in appendix A of Johnston and Sherwood (1996).

Long-term data from the Genesee River basin and observation well Ot 900 in Ontario County near Manchester, N.Y. (fig. 2) were used to indicate seasonal trends of the study period (1989-94) and to supply background information from nearby streams not greatly affected by recent changes in land use. Data used in this study, as well as methods of collection and computation, are given in Sherwood (1997) and Johnston and Sherwood (1996).

Atmospheric Deposition

Precipitation-volume data representing the Irondequoit Creek basin were collected at four sites, one of which (Mendon Ponds Park, fig. 2) also provided data on chemical concentrations in atmospheric deposition. Records of precipitation volume collected at the Rochester-Monroe County Airport (fig. 1) and published by the National Oceanic and Atmospheric Administration (NOAA) (1983, 1989-93) were used for long-term comparisons. Data from Mendon Ponds Park included wetfall (liquid deposition), dustfall (dry deposition, that fraction that settles out of the atmosphere as dust), and bulk (composite) deposition, which consists of the two previous forms. The three forms of deposition were analyzed for common ions, nutrients, and lead, and for physical characteristics such as pH and specific conductance. These analyses provided information on the atmospheric contribution of these chemical constituents to the land surface and streams.

Ground Water

Ground-water monitoring at four wells in Ellison Park (Mo 1, Mo 4, Mo 5, and Mo 6, fig. 2) had been discontinued early in the study period. Although some data from these wells during the 1989-93 period are available, they are insufficient to warrant consideration in this report.

Ground-water data used in this report were obtained from 12 wells in the Irondequoit Creek basin (nine in Ellison Park, three in Powder Mill Park). The data consist of water levels, water-temperature profiles, and water-quality data from all wells except Mo 666 (water-level data only). Water levels in the three Powder Mill Park wells (fig. 2), and the nine Ellison Park wells, including well Mo 659 on the north side of the Pinnacle Hills Moraine (fig. 2), were measured periodically and recorded to the nearest 0.01 ft. Water temperature was measured seasonally at several equal interval depths in most wells and recorded to the nearest hundredth of a degree Celsius. Water temperatures inside the well casing were measured with minimal disturbance of the water to obtain temperatures representative of the water-table aquifer. Water samples were collected periodically from all wells except Mo 666, during water years 1989-93 and analyzed by MCEHL for specific conductance, pH, and concentrations of common ions, nutrients, metals, dissolved solids, alkalinity, and hardness.

Streamflow

Stage and discharge data were collected at five streamflow-gaging stations in the Irondequoit Creek basin and five in the Genesee River basin. Water-quality data were collected at the five streamflow-gaging stations in the Irondequoit Creek basin, at one site on the Genesee River (at Charlotte Docks, 3.6 mi downstream from the Genesee River station at Rochester, fig. 2), and at one site on Northrup Creek in western Monroe County (fig. 2). Water samples were composited for analysis on a discharge-weighted basis so that concentrations obtained for various mean flows could subsequently be matched with the Streamflow record for each sampling site to estimate constituent loads on a seasonal and annual basis. Data from the Irondequoit Creek sites were used to relate concentrations of selected constituents to discharge and to compute total loads to Irondequoit Bay. The Genesee River basin data are from sites with long periods of record (at least 20 years) and were used to relate annual and seasonal discharges during the study period (water years 1989-93) to long-term statistics.

Quality Assurance and Quality Control Program

A quality assurance/quality control (QA/QC) program has been an integral part of the cooperative program between Monroe County and USGS since the 1980-81 NURP study. The purpose of the QA/QC program is to ensure that the streamflow measurements and water-quality information meet USGS standards for publication.

The program entails collection of split samples and participation in the USGS Standard Reference Water Sample (SRWS) program. Split samples are used to compare concentrations of constituents in samples collected by the automatic sampler with those collected from the stream cross section and to assess any differences between analytical results obtained by the MCEHL and those obtained by the USGS National Water Quality Laboratory. Statistical analysis of the split samples showed some significant ($\alpha = 0.05$) differences between concentrations of some constituents collected by the automatic sampler and those collected from the stream cross section. Split samples that were used to compare USGS laboratory results with MCEHL laboratory results also showed a significant difference in one constituent.

Under the SRWS program, the USGS submits reference samples to cooperating laboratories, then rates each laboratory’s performance on the basis of results from all laboratories participating in the program. MCEHL results for all constituents were in the “good” category (0.5 to 1.0 standard deviation from the most probable value).

Measurements of streamflow made by Monroe County are routinely checked and verified through periodic measurements made by USGS personnel.

A detailed explanation and tables of results of the QA/QC program are presented in Sherwood (1997).

Trend analysis

A trend, as defined in this report, is a monotonic (overall) change in concentration of a chemical constituent in water samples from a specific sampling site over a specified time period. Trends, regardless of magnitude, were considered statistically significant for, $p < 0.05$ or to have weak statistically significance for $p > 0.05$ and < 0.10 (where p is the probability that an apparent trend resulted from chance arrangement of the data rather than an actual change in the trend of the data values).

Two software programs were used to test for the presence of trends—ESTREND (EStimate TREND) Schertz and others (1991), and the Kendall slope estimator. ESTREND is a USGS-developed program that incorporates statistical and graphical techniques that overcome some of the common problems inherent in the application of conventional trend tests to water-quality data. The ESTREND program uses two methods for trend testing, depending on the type of data to be analyzed. The first is the Seasonal Kendall test (Hirsch and others, 1982), a nonparametric test that ignores the magnitude of the data and instead uses the ranks of the data. This method was used for uncensored data sets (those with few or no values below the detection limit); it cannot be used for constituents for which more than about 5 percent of the data are below the detection limit (censored data). Trends for those constituents are usually tested by either the Seasonal Kendall test for censored data or the TOBIT test, which is applied when a large number of values are at or below one or more detection limits. The criteria for application of both tests are described in detail in Johnston and Sherwood (1996, p.38-40). ESTREND was used to test for trends in water-quality data where seasonality or flow adjustment was a concern. The program will produce a result from 3 years' worth of data, but 5 years are recommended. The other program used for trend testing was the Kendall slope estimator, a nonparametric approach that does not account for seasonality in the data or for flow adjustment. The Kendall slope estimator, like the ESTREND program, incorporates the Mann-Kendall test to determine the statistical significance of the trend. This test was generally used to test for trends in monthly streamflow and ground-water levels as well as water-quality data from sites with less than 3 years of record.

The results of the trend analyses used in this report yield a trend slope and a p-value. The trend slope is an estimate of the rate of change in the data units per year, and the p-value is the attained level of significance of the trend test, defined as the probability of incorrectly rejecting the null hypothesis of no trend. Results of the trend analysis are presented in tables, by station and by constituent. The tables contain summary statistics, magnitude (in concentration units per year and percent change per year) of the upward or downward trend, and the p-value.

A trend slope represents the overall change in a data record as a linear change over the selected period but does not provide information about short-term, nonlinear variations in the data. These short-term variations can help to indicate the cause of trends. A statistical smoothing technique, known as "locally weighted scatterplot smoothing" (LOWESS) was used to fit a curve to water-quality time-series data to identify short-term variations in the data (fig. 3). A smoothing factor of 0.5 was used for all applications of LOWESS.

The most common purpose of trend analysis is to identify changes in the data that can subsequently be related to some change in the environment, although a trend might result not only from a change in environment, but also from a change in any of the many components of sample collection, processing, and analysis. Therefore, information on the accuracy of water-quality measurements was examined for evidence of any change that could have produced an indication of water-quality trends.

The techniques used for addressing the effects of seasonal variation, streamflow variation, missing values, and censored data on trend analysis are

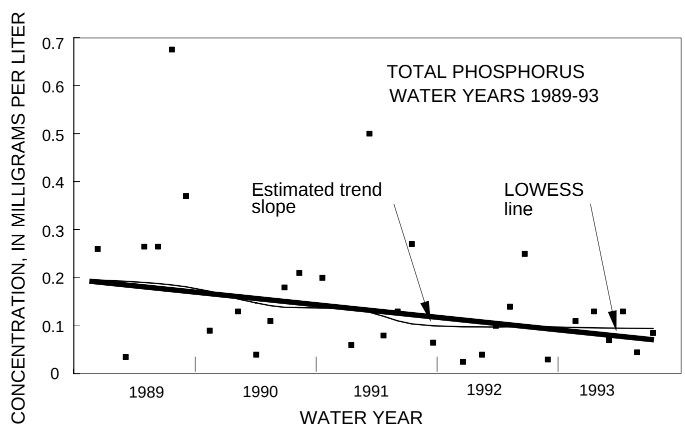


Figure 3. Example of locally weighted scatterplot smoothing (LOWESS) to indicate short-term departures from overall trend in constituent concentrations.

discussed in detail in Johnston and Sherwood (1996). As described in that report, water-quality data typically show seasonal variability. Use of the word “season” does not necessarily refer to climatic seasons, but can also refer to sampling frequency. The number and temporal distribution of samples (such as monthly or quarterly) is considered when designating the number of seasons to be used in the trend analysis. Chemical concentrations are affected by the volume of flow (stream discharge) at the time the sample is collected. Variability resulting from differences in flow can be minimized through regression of concentration as a function of flow. The residuals (flow-adjusted concentrations) are then tested for trends. Censored data (values at or below the reporting limit) are recoded to zero and considered tied.

Estimation of Constituent Loads in Surface Water and Atmospheric Deposition

Constituent loads provide an estimate of the total mass of a particular constituent moving past a given point (gaging station) or into a receiving body of water. This section describes methods used for the computation of constituent loads in surface water and atmospheric deposition.

The chemical loads from Irondequoit Creek to Irondequoit Bay, and in Northrup Creek, were estimated from data given in Sherwood (1997). Estimates of chemical loads were based on a log linear equation (Cohn and others, 1992) that uses a minimum-variance unbiased estimator (MVUE). The load estimation program also uses an adjusted maximum likelihood estimator (AMLE) of the moments of lognormal populations to estimate values for censored data. The equation used to estimate constituent concentrations is:

where

$$\ln[C] = \beta_0 + \beta_1 \ln[Q/\tilde{Q}] + \beta_2 \{\ln[Q/\tilde{Q}]\}^2 + \beta_3 [T/\tilde{T}] + \beta_4 [T/\tilde{T}]^2 + \beta_5 \sin[2\pi T] + \beta_6 \cos[2\pi T] + \varepsilon \quad (1)$$

C = constituent concentration, in milligrams per liter

Q = discharge at time of sample collection, in cubic feet per second

T = time, in years,

e = error (assumed to be independent and normally distributed with a mean and variance of zero);

b’s = parameters of the equation that must be estimated from the data; and

$\tilde{Q}$, $\tilde{T}$ = centering variables that simplify the numerical work and have no effect on the load estimates.

The trigonometric functions, sin (sine), and cos (cosine) are associated with cyclical patterns in the data and are used to remove the effects of seasonality. If additional cycles are needed, additional trigonometric terms with arguments larger than 2π may be used.

The corresponding load L is given by

where:

$$L = KQ\exp(\beta_0 + \beta_1 \ln[Q/\tilde{Q}] + \beta_2 \{\ln[Q/\tilde{Q}]\}^2 + \beta_3 [T/\tilde{T}] + \beta_4 [T/\tilde{T}]^2 + \beta_5 \sin[2\pi T] + \beta_6 \cos[2\pi T] + \varepsilon), \quad (2)$$

K = conversion factor;

Q = daily mean discharge, in cubic feet per second; and

all other variables are as defined for equation 1.

Equation 2 provides a load estimate for a given daily flow Q, and daily loads are then summed to provide monthly or annual loads.

The precision of the estimated loads can be described in terms of a confidence interval that is based on the estimated mean and the standard error of prediction. At the 95-percent confidence interval (α = 0.05), the confidence limits are the estimated load + 1.96 times the standard error of prediction. The value 1.96 is from a statistical table for a Student’s t-distribution at the $\alpha/2$ quantile with a large number of samples (more than 250). If, for example, the monthly load estimated for chloride was 145 tons, and the standard error of prediction was 12 tons, the approximate 95-percent confidence limits would be:

145 + (1.96 $\times$ 12) = 121.5 to 168.5 tons.

The wider the confidence limits, the greater the uncertainty and, hence, the less reliable are the load estimates. A more detailed explanation of the MVUE method is given in Cohn and others (1992).

A substantial percentage of the loads of certain chemical constituents transported in streams of Monroe County is derived from atmospheric deposition. The formula used to compute annual yield (load per unit area) from atmospheric sources is:

Yield = *C x P x* conversion factor,

where:

P = precipitation (annual), in inches; and

C = concentration, in milligrams per liter.

The conversion factor transforms the results to the desired units of yield, in weight per unit area. The yield is then multiplied by area to obtain load. This computation assumes that the precipitation recorded at the rain gage fell uniformly over the entire area represented by that particular gage and, therefore, may be subject to some error.

ATMOSPHERIC DEPOSITION

The Irondequoit Creek basin receives a substantial amount of certain chemical constituents from atmospheric deposition (Johnston and Sherwood, 1996). During 1989-93, the annual loads of ammonia nitrogen to the basin from atmospheric deposition were more than 3,000 percent greater than the loads measured in Irondequoit Creek at Blossom Road, and the annual loads of nitrite plus nitrate from atmospheric deposition were 144 percent greater than the loads at Blossom Road. In contrast, the loads of chloride and sulfate to the basin from atmospheric deposition equaled only 1 percent and 12 percent, respectively, of the loads in Irondequoit Creek at Blossom Road.   Although sampling and analysis of atmospheric deposition can provide relatively accurate estimates of the amounts of constituents that reach the land surface, the effect of these inputs on the loads transported by the streams should be interpreted with caution because of uncertainties associated with the interactions of chemicals from their deposition until assimilation by the streams.

Volume

The National Weather Service at the Rochester-Monroe County airport has collected precipitation data since May 1, 1929 (Johnston and Sherwood, 1996). Monthly total, annual total, and average monthly precipitation values for water years 1989-93 are shown in table1; “normal” values calculated from 1951-80 records are also included.   The 5-year average annual rainfall for 1989-93 was 1.6 inches (5 percent) above normal.

Chemical Quality

Data on chemical quality of atmospheric deposition were obtained from the Mendon Ponds site near the southwestern edge of the Irondequoit Creek basin. This site was selected to represent atmospheric deposition that is unaffected by localized deposition from urban areas. Of the three forms of deposition analyzed (bulk, wet, and dry), bulk-deposition samples appeared to provide the most reliable results and, therefore, were the only ones used to estimate chemical trends and loads.

Temporal Trends

Trend analysis of selected constituents in bulk atmospheric deposition (table 2) showed only two statistically significant (α = 0.05) trends. Dissolved potassium showed an upward trend of about 18 percent per year over the 5-year study period, and

Table 1. Monthly and annual total precipitation, with 5-year monthly average and normal monthly values, at Rochester-Monroe County Airport, N.Y., water years 1989-93.

[All values are in inches. Normal values are based on the average monthly or annual totals for 1951-80. Location is shown in fig.1]

Water year	Month												Annual total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	
1989	2.34	1.68	1.11	1.18	1.55	3.69	1.62	5.99	5.65	0.98	2.46	2.82	31.07
1990	3.13	2.01	1.58	1.61	3.93	1.56	3.58	5.76	2.88	3.05	3.59	3.36	36.04
1991	4.37	2.27	4.18	1.69	1.16	4.70	4.07	2.43	1.19	2.37	1.80	2.86	33.09
1992	1.65	2.39	2.92	1.46	1.87	3.53	3.43	2.83	1.98	6.03	4.45	3.02	35.56
1993	1.78	2.90	2.98	2.32	1.52	2.44	3.07	1.24	2.76	1.67	1.67	4.37	28.72
5-year average	2.65	2.25	2.55	1.65	2.01	3.18	3.15	3.65	2.89	2.82	2.79	3.29	32.88
Normal	2.54	2.65	2.59	2.30	2.32	2.53	2.64	2.58	2.78	2.48	3.20	2.66	31.27

specific conductance showed an upward trend of 9 percent per year. The results of trend testing for common ions were mixed—in addition to potassium, sodium and chloride showed small upward trends that were not statistically significant, and dissolved calcium and magnesium showed minor downward trends that were not statistically significant (50/50 chance of being due to chance). Nitrite plus nitrate and ammonia nitrogen showed slight downward trends, and ammonia plus organic nitrogen showed a slight upward trend; none of which were statistically significant. Total phosphorus showed no trend. Data for dissolved sulfate, orthophosphate, and total lead were too heavily censored to produce reliable trend results.

Trends determined for 1989-93 are, with few exceptions, similar to those determined for 1984-88. Dissolved sodium showed a slight downward trend during 1984-88 and a slight upward trend during 1989-93, and potassium reversed from a minor downward trend that was not statistically significant to an upward trend that was statistically significant.

Loads

Loads of selected constituents from atmospheric sources to the Irondequoit Creek basin, estimated from data from the Mendon Ponds site, are given in table 3. Estimated annual loads were calculated by taking the available average monthly load and multiplying by 12. The most abundant constituents derived from atmospheric deposition during 1989-93 study were sulfate and chloride, with average annual yields of 16.5 ton/mi^2 and 2.2 ton/mi^2, respectively; the least abundant was lead, with an average annual yield of 0.016 ton/mi^2.

Chemical loads deposited on the Irondequoit basin from atmospheric sources during 1989-93 were similar to those during 1984-88 (table 3). Loads of sodium, sulfate, and total lead in 1989-93 were slightly smaller than in the earlier period, whereas loads of calcium, magnesium, potassium, and chloride in 1989-93 were slightly greater, as were nitrite plus nitrate, ammonia nitrogen, and orthophosphate.

GROUND WATER

Water levels were measured quarterly in the Powder Mill Park wells and approximately monthly in the Ellison Park wells. Water-level data indicate local seasonal fluctuations in the water table, as well as changes in gradient of the water table in relation to other

Table 2. Statistical summary and trends of selected constituents of bulk atmospheric deposition at Mendon Ponds, Monroe County, N.Y., water years 1989-93.

[e, estimated for censored constituents with a log probability regression procedure. Units are in milligrams per liter unless otherwise noted. µS/cm, microsiemens per centimeter; mg/L, micrograms per liter. * denotes trend is statistically significant at α= 0.05. Dashes indicate insufficient data]

Physical property or constituent	Descriptive statistics: Sample size	mean	25th percentile	50th percentile (median)	75th percentile	Trend results[1]: n	Units per year	Percent per year	*P*
Rainfall (inches)	57	2.70	1.8	2.4	3.6	31	0.00	0.00	--
Calcium, dissolved	54	0.67	0.5	0.6	0.9	30	-0.03	-4.45	0.920
Magnesium, dissolved	56	0.17	0.1	0.2	0.2	31	0.00	-2.09	0.449
Sodium, dissolved	57	0.28	--	0.1	0.5	31	0.01	4.36	0.449
Potassium, dissolved	56	0.11	--	--	0.1	31	0.02	17.59	0.002 *
Sulfate, dissolved	55	e 5.00	e 10	2	6	55	--	--	--
Chloride, dissolved	56	0.87	0.4	0.6	1.0	31	0.04	4.23	0.449
Nitrite plus nitrate, dissolved as N, total	57	0.64	0.45	0.65	0.84	31	-0.01	-1.58	1.000
Ammonia nitrogen, as N, dissolved	52	0.37	0.17	0.29	0.48	31	-0.01	-2.24	0.850
Ammonia plus organic nitrogen, as N	55	0.88	0.5	0.8	1.1	31	0.02	2.36	0.850
Phosphorus, total as P	57	0.07	0.02	0.04	0.08	31	0.00	0.00	1.000
Orthophosphate as P, dissolved	56	e 0.03	--	--	0.02	56	--	--	--
Specific conductance (µS/cm)	56	38.57	30	40	50	31	3.50	9.07	0.036 *
Acidity, total	57	7.57	5.1	7.1	9.0	31	0.25	3.35	0.344
Lead, total (µg/L)	57	e 5.89	e 5	5	8	57	--	--	--

1 n = Number of samples selected by ESTREND for trend test (based on number of seasons).
p = Level of significance.

Table 3. Annual yields of selected constituents in bulk atmospheric deposition at Mendon Ponds, Monroe County, N. Y., water years 1989-93.

[Yields are in pounds per square mile; e, estimated load; dashes indicate insufficient data]

Water year	Dis-solved calcium	Dis-solved magne-sium	Dis-solved sodium	Dis-solved potas-sium	Dis-solved sulfate	Dis-solved chloride	Ammonia plus organic nitrogen	Nitrite plus nitrate	Am-monia nitrogen	Total phos-phorus	Ortho-phos-phate	Lead, total recover-able	Zinc, total recov-erable
1989	2,190	462	599	261	23,500	3,250	2,750	2,370	859	164	34.0	20.1	--
1990	3,100	820	959	715	30,500	3,420	4,650	3,470	2,320	426	265	31.5	e 216
1991	2,700	1,080	1,010	337	43,700	3,150	5,250	3,000	2,520	334	155	29.7	196
1992	2,790	874	1,340	591	41,500	7,190	3,880	2,310	1,310	208	50.1	47.2	179
1993	e 3,700	e 720	e 1,260	e 850	e25,600	e 4,500	e 4,000	e 3,400	e 1,460	e 270	e 79.0	e 33.0	e 360
1989-93 avg.	2,896	791	1,034	551	32,960	4,302	4,106	2,910	1,694	280	117	32.3	--
1984-88 avg.	3,578	862	912	980	27,440	5,780	--	3,308	2,591	--	255	31.1	--

parts of the aquifer or to the water surface in nearby streams. Sand and gravel aquifers in the glaciated northeastern United States are recharged by snowmelt and precipitation, either by direct infiltration or by underflow from the upgradient aquifer system. During a normal year, the recharge and ground-water levels are highest during the spring snowmelt period and are lowest during midsummer, when evapotranspiration is greatest. Significant recharge can also occur during fall, when evapotranspiration decreases.

Water-temperature profiles were measured quarterly at all wells. Seasonal changes in water-temperature profiles can be used to estimate the vertical hydraulic conductivity of the aquifer material because shallow ground water responds more quickly to changes in air temperature than does deep ground water temperature (Lapham, 1989). The vertical hydraulic conductivity of the material, together with concentration data for selected chemicals, can be used to predict the downward movement of chemical contaminants.

Water samples were collected quarterly at all but one well and analyzed for selected constituents. Comparison of analyses among wells indicates local differences in water quality within a given aquifer and also can indicate ground-water movement to or from a stream, as well as possible sources of contamination and the degree of mixing. Water-quality data are also used to estimate temporal trends in ground-water chemistry. Differences in water quality among wells can result from several factors, including well depth and location, direction of ground-water flow (vertical as well as horizontal), type of aquifer material, and precipitation amounts and intensity. These and other factors warrant consideration when local differences in ground-water quality are interpreted.

Powder Mill Park

Recharge to the Powder Mill Park aquifer is greatest in the areas east of Powder Mill Park and from southeast of the park to the ground-water divide in the town of Victor (fig. 2) (Yager and others, 1985). The general direction of ground-water flow is westward from these recharge areas toward Irondequoit Creek, then northward, following the surface drainage pattern, toward Irondequoit Bay.

Water Levels

Water levels in the Powder Mill Park wells were measured quarterly. Observation wells Mo 10 and Mo 11 are paired water-table wells finished at differing depths in sand and gravel and are on the bank of Park Road Creek in Powder Mill Park (fig. 2), about 7.5 ft above the channel bottom. Water levels in both wells were nearly identical and were lower than the Park Creek stream bed (fig. 4). Fluctuations ranged about 3 ft during 1989-93.

Average annual water-level fluctuation was about 1.7 ft in Mo 10 and 1.6 ft in Mo 11, but each well had a maximum annual fluctuation of about 2.9 ft in water year 1990, which decreased in each succeeding year to about 0.5 ft during water year 1993. Mo 12, which is downgradient from wells Mo 10 and Mo 11, is finished in lake silt and clay (Kappel and Young, 1989) and showed a more subdued and consistent average annual fluctuation (0.4 ft) than

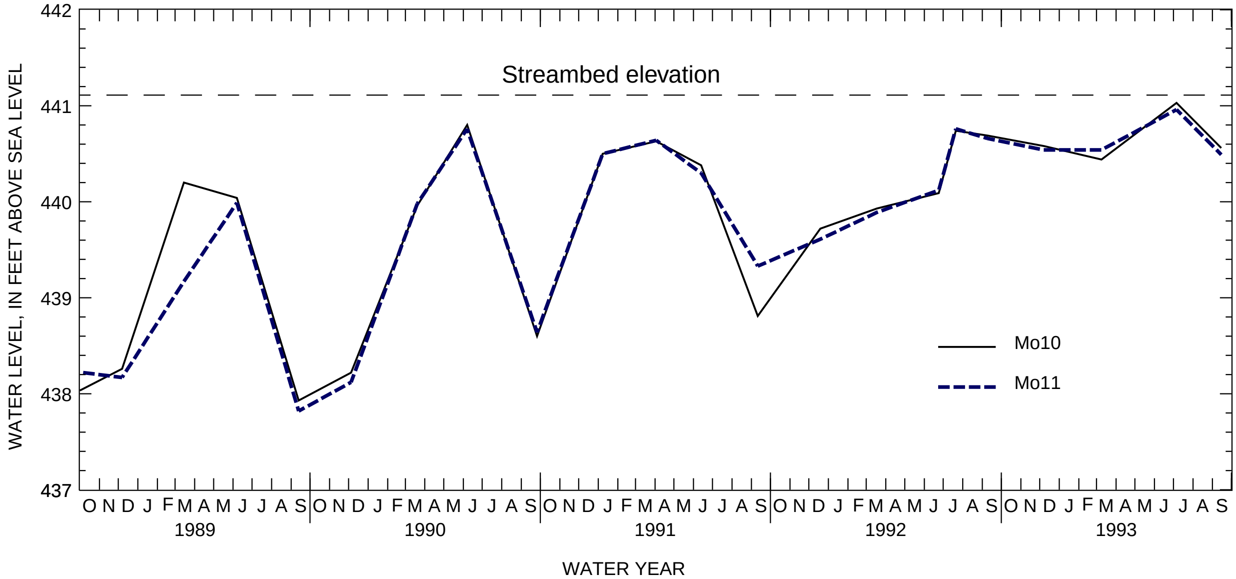


Figure 4. Monthly mean water levels in wells Mo 10 and Mo 11 and streambed elevation of Powder Mill Park Creek, Monroe County, N.Y., water years 1989-93. (Locations are shown in fig. 2 inset.)

wells Mo 10 and Mo 11. The greatest fluctuation was in water years 1990 and 1991, and the smallest was in water year 1993.

Water levels at wells Mo 11 and Mo 12 show a slight but statistically significant (p <.05) upward trend over the 1989-93 period. Those at Mo 10 also showed a distinct upward trend, but with a p value of 0.07, which indicates only weak statistical significance (table 4). This reversal from the downward trend at these wells during 1984-88, (Johnston and Sherwood, 1996) is probably the result of land-use changes east of Powder Mill Park, and the smaller amount of precipitation during 1989-93 than during 1984-88.

Results of seasonal trend testing indicated upward trends in water levels as follow

Mo 10	weak (α = 0.10)	January 1 - March 31
	weak (α = 0.10)	April 1 - June 30
Mo 11	weak (α = 0.10)	January 1 - March 31
Mo 12	significant (α = 0.05)	January 1 - March 31

Water Temperature

Water temperatures were measured three or four times a year (usually quarterly) during 1989-93 at Powder Mill Park and provided 17 to 19 profiles for each well. Temperature was generally measured during the same months of each year; therefore, not all months are represented in the profiles.

The rate of ground-water flow is determined by the hydraulic conductivity of the aquifer material and

Table 4. Statistical summary and trends of water levels in wells at Powder Mill Park, Monroe County, N.Y., water years 1989-93.

[Units are in feet unless otherwise noted, * denotes trend is statistically significant at α = 0.05, Locations are shown in fig. 2 inset]

Well	Descriptive statistics: Sample size	Max	Min	Mean	25th percentile	50th percentile (median)	75th percentile	Trend results[1]: n	Units per year	Percent per year	*p*
Mo 10	21	10.7	7.6	8.8	8.1	8.5	9.4	18	0.34	3.94	0.068
Mo 11	21	10.8	7.7	8.8	8.1	8.5	9.4	18	0.58	6.56	0.017 *
Mo 12	22	2.1	0.5	1.3	1.1	1.3	2.0	18	0.26	19.14	0.000

[1] n = Number of samples selected by ESTREND for trend test (based on number of seasons).
p = Level of significance.

the head difference between points in the aquifer. Lapham (1989) demonstrated that seasonal changes in water-temperature profiles can be used to estimate the vertical component of hydraulic conductivity because shallow ground water responds more quickly to seasonal changes in air temperature than does deep ground water. This vertical component of hydraulic conductivity can be used to predict the downward movement of chemical contaminants.

In Lapham's method, the vertical velocity is varied in the theoretical solution until the geometric temperature envelope for the predicted temperature profile produces a best-fit match of the profiles measured in the field. Darcey's Law is then used to convert vertical velocity to effective vertical hydraulic conductivity.

The Fourier Series model described by Lapham, when applied to temperature-profile data obtained during 1989-93, produced the same vertical velocity components as those estimated for 1984-88. Wells Mo 10 and Mo 11 showed an effective downward vertical-velocity of about 0.08 ft/d, and well Mo 12 had an effective downward vertical velocity of 0.03 ft/d. A more complete description of the application of the Fourier Series model as applied to Monroe County data is given in Johnston and Sherwood (1996).

Chemical Concentration

The median and range of concentration of selected constituents in samples from the Powder Mill Park wells were compared through box plots (fig. 5), and temporal trends were estimated with the ESTREND program (Schertz and others, 1991).

Spatial Variability

A statistical test, ANOVA (analysis of variance), was applied along with Tukey's Multiple Comparison Test to ranked concentration data to detect differences in median concentrations among the three Powder Mill Park wells (table 5). Median concentrations of some constituents (fig. 6) showed some statistically significant (α =.05) differences from well to well.

Nutrients. The only nutrients whose median concentration showed significant differences among wells were ammonia nitrogen, nitrite plus nitrate, and orthophosphate. The lowest median concentrations of nutrients were at Mo 11 (the shallow well), except for nitrite plus nitrate and orthophosphate, whose median concentrations were lowest in Mo 12 (screened in the confined aquifer). At the paired wells (Mo 10 and Mo 11), the lowest median concentrations of all nutrients except orthophosphate were at the shallow well (Mo 11); the orthophosphate median for the shallow well was higher than that for the deep well.

Common ions. Median concentrations of ions associated with hardness also showed significant differences among wells (table 5). Calcium, sodium, and chloride concentrations were significantly higher at Mo 10, than at Mo 11 or Mo12, and sulfate and magnesium concentrations were highest at Mo 12.

Temporal Trends

Powder Mill Park wells had few statistically significant trends in chemical concentrations (table 6). Mo 12 showed downward trends in turbidity, ammonia nitrogen, and total phosphorus; Mo 10 showed a downward trend in dissolved magnesium; and Mo 11 showed an upward trend in pH and a downward trend in sodium. Mo 12 also showed statistically weak (α = 0.10) upward trends for orthophosphate and potassium and a weak downward trend in iron.

Table 5. Statistical comparison of median concentrations of selected constituents in Powdermill Park wells, Monroe County, N.Y., water years 1989-93.

[Different letters indicate statistically significant (α = 0.05) differences among sites; A indicates significant difference from B, B indicates significant difference from C,].

Constituent	Mo 12	Mo 10	Mo 11
Turbidity	A	A	A
Specific conductance	A	B	A
pH	A	A	A
Total suspended solids	A	B	C
Ammonia, nitrogen as N, dissolved	A	B	B
Ammonia plus organic nitrogen, as N, total	A	A	A
Nitrite plus nitrate as N, total	A	B	C
Phosphorus, total as P	A	A	A
Orthophosphate as P, dissolved	A	B	C
Hardness	A	A	B
Calcium, dissolved	A	B	C
Magnesium, dissolved	A	B	B
Sodium, dissolved	A	B	C
Potassium, dissolved	A	AB	AC
Chloride, dissolved	A	B	A
Sulfate, dissolved	A	B	C
Iron, dissolved	A	A	B

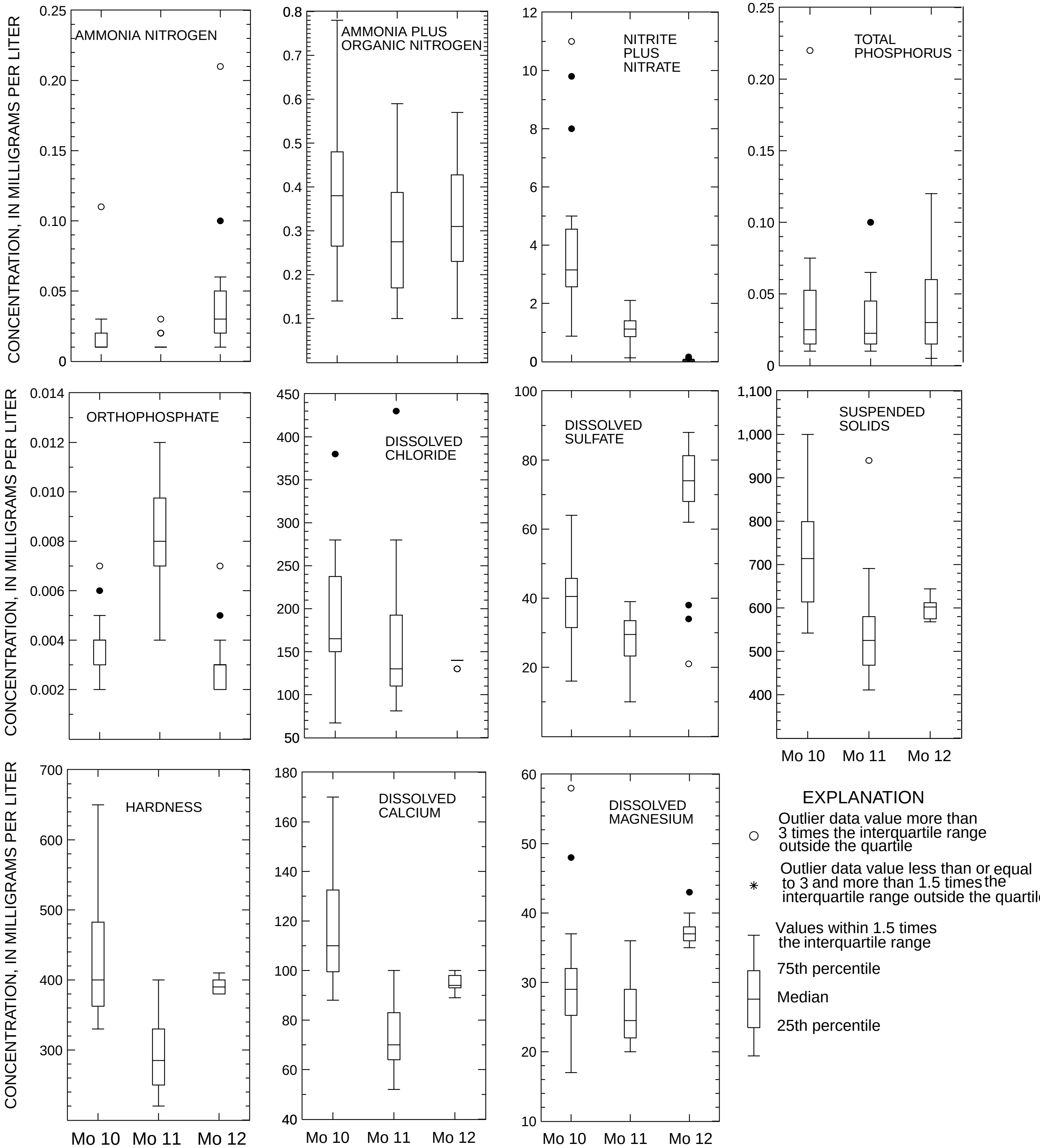


Figure 5.- Concentration ranges and median concentrations of selected constituents in Powder Mill Park wells, Monroe County, N.Y., water years 1989-93. (Well locations are shown in fig. 2 inset)

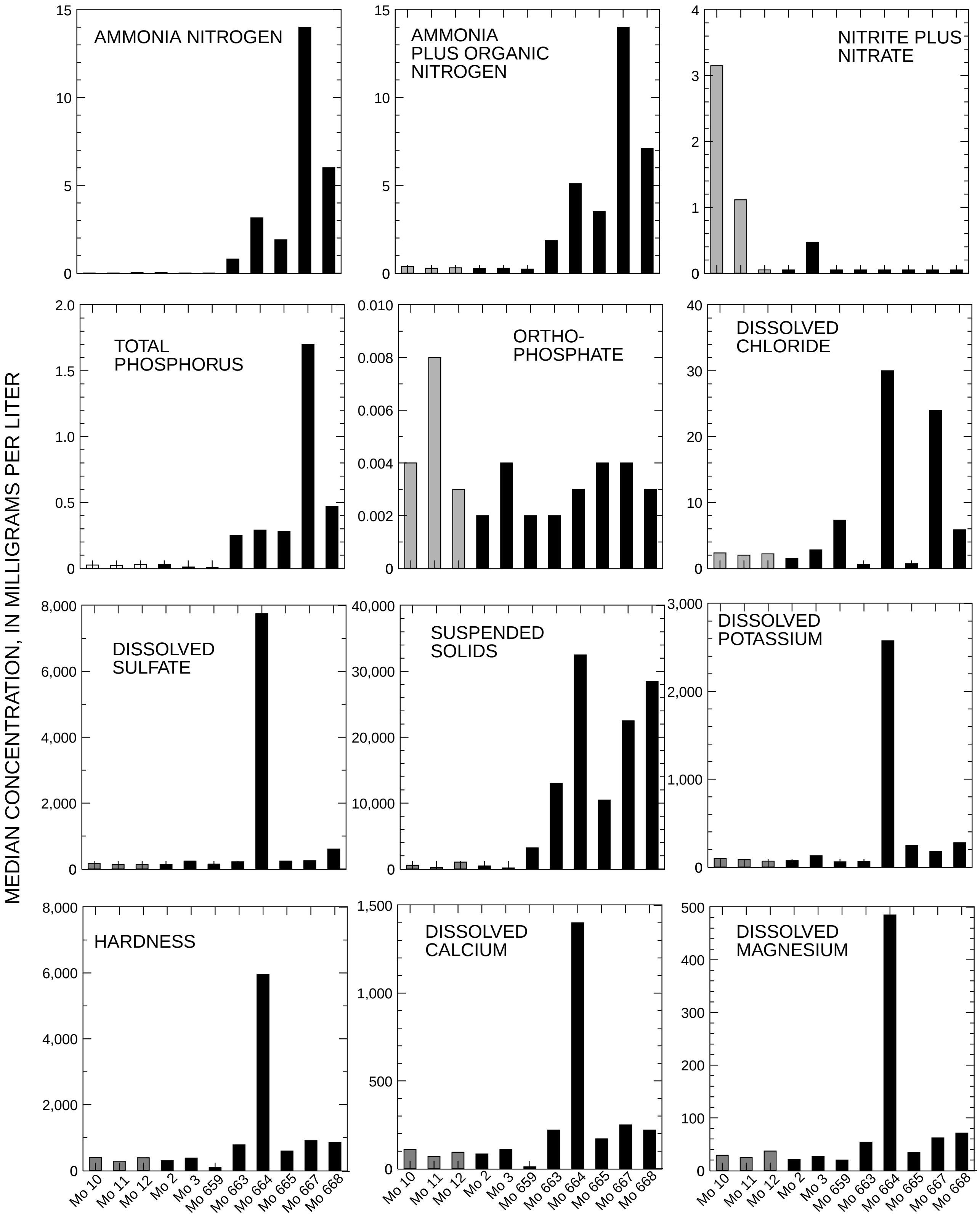


Figure 6. Median concentrations of selected constituents in water from Powder Mill Park and Ellison Park wells, Monroe County, N.Y., water years 1989-93. (Locations are shown in fig. 2 inset)

Ellison Park

Eight of the nine Ellison Park wells are on the Irondequoit Creek flood plain and screened in the unconfined part of the aquifer (fig. 2): their depths range from 10 ft to 41 ft below land surface. The ninth well (Mo 659) is at the eastern boundary of Ellison Park and screened at a depth of 215 ft in a confined part of the aquifer. All wells including Mo 659 (confined aquifer) showed similar seasonal water-level fluctuations and response to recharge (fig. 7). Well pairs Mo 663 and Mo 664 are on the south side of the Pinnacle Hills moraine, Mo 665 and 666 are on top of the moraine, and Mo 667 and 668 are north of the moraine (fig. 8).

Water levels

Water levels in Ellison Park wells indicate that water-table gradients undergo frequent reversals in direction of lateral flow toward or away from Irondequoit Creek, as well as vertically within the aquifer. Annual mean ground-water levels in well Mo 3, which is on the east bank of Irondequoit Creek (fig. 2 inset), averaged 2.3 ft lower than in Mo 2, which is near the east wall of the valley and upgradient of Mo 3. Water levels in Mo 2 during 1989-93 ranged from 1.24 ft above land surface to 3.32 ft below, and those in Mo 3 ranged from 1.01 ft to 4.11 ft below land surface. All wells except Mo 2 and Mo 659 are within the flood plain of Irondequoit Creek (fig. 2) and, thus, respond to stage fluctuations in the creek.

Water levels in well Mo 659 (215 ft deep and screened in the confined part of the aquifer) showed a significant ($\alpha = 0.05$) upward trend during 1989-93; water levels in all other wells showed no statistically significant trends during this period (table 7).

Results of the trend tests showed no statistically significant ($\alpha = 0.05$) seasonal water-level trends at

Table 6. Statistically significant ($\alpha = 0.05$) trends in concentrations of selected ground-water constituents at Ellison Park and Powder Mill Park wells, Monroe County, N.Y., water years 1989-93.

[-, downward trend; +, upward trend; o, no trend. Parentheses indicate weak statistical significance at $\alpha = 0.10$.
Well locations are shown in fig. 2]

Physical Property or Constituent	Powder Mill Park (5 years of data)			Ellison Park: 5 years of data		Ellison Park: Less than 5 years of data					
	Mo 10	Mo 11	Mo 12	Mo 2	Mo 3	Mo 659	Mo 663	Mo 664	Mo 665	Mo 667	Mo 668
Turbidity	o	o	-	o	o	o	o	-	o	+	o
Specific conductance	o	o	o	o	-	+	o	+	o	o (+)	o
Dissolved oxygen	--	o (-)	o	o	o	o	o	o	o	o	o
pH	o	+	o	o	o	-	o	o	o	o	o
Carbon dioxide, dissolved	o	o	o	o	o	o	o	o	o	o	-
Ammonia, Nitrogen, as N, dissolved	o	o	-	o	o	o	o	o	o	o	o
Ammonia plus organic nitrogen, as N, total	o	o	o	o	o	o	o	o	o	o	o
Nitrite plus nitrate as N, total	o	o	o	+	o	o	o	o	o	o	o
Phosphorus, total as P	o	o	-	o	o (-)	o	o	o	o	+	o (+)
Orthophosphate as P, dissolved	o	o	o (+)	+	+	o	o	o	o	+	o
Hardness	o	o	o	o	-	+	o	o	+	+	o (-)
Calcium, dissolved	o	o	o	o	o (-)	o	o	o	o	o (+)	o
Magnesium, dissolved	-	o	o	o	-	+	o	o	o	+	o
Sodium, dissolved	o	-	o	o	o	+	o	o	o	o	o (-)
Potassium, dissolved	o	o	o (+)	o	o	+	o	o	o (-)	o	-
Chloride, dissolved	o	o	o	o	-	+	o	o	o	o	-
Sulfate, dissolved	o	o	o	o (+)	o	o (-)	-	+	-	o (-)	-
Iron, dissolved	o	o	o (-)	o	o	o	o	o	o	+	o
Dissolved solids						+	o	o (+)	o	o (+)	o (-)

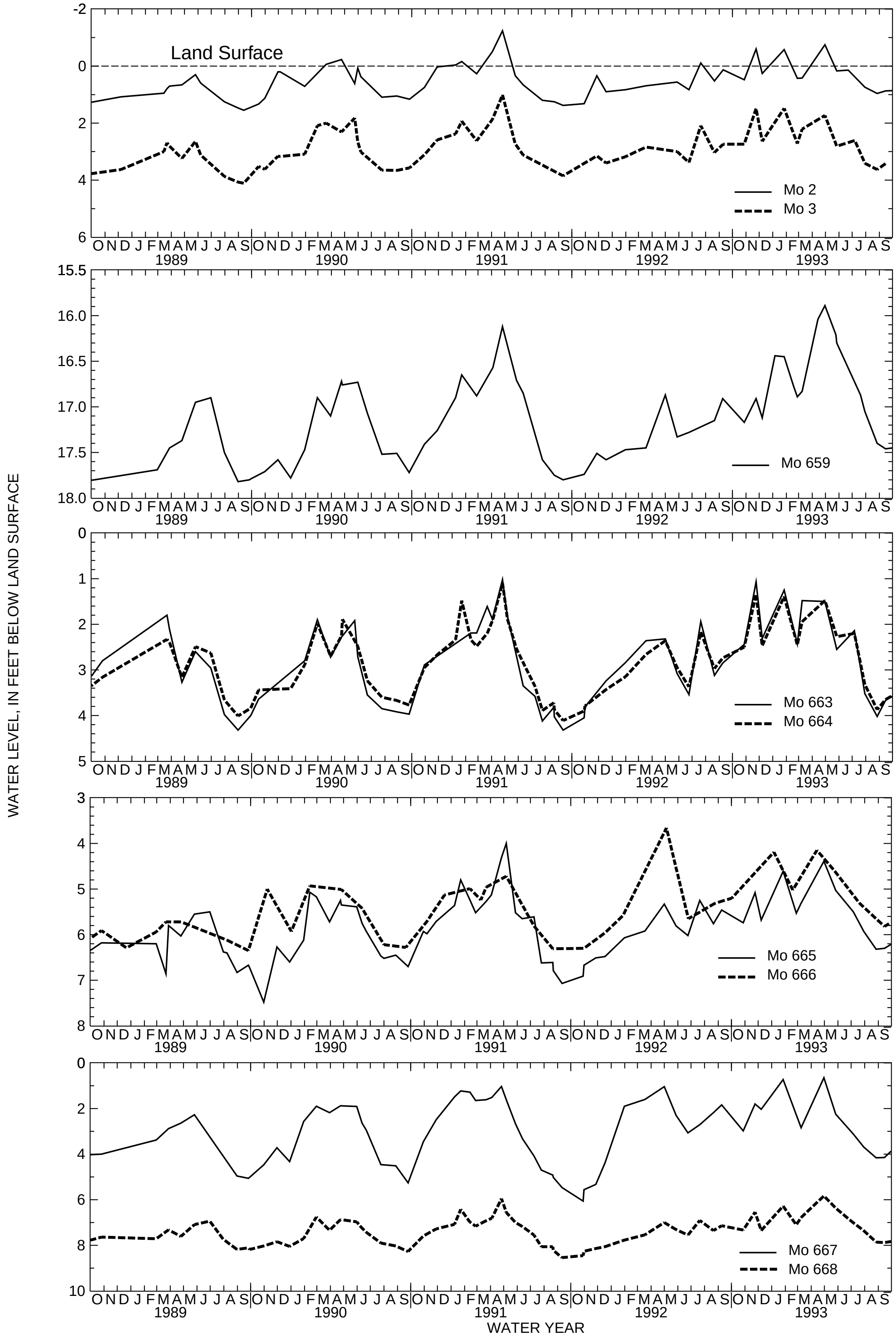


Figure 7. Water levels in Ellison Park wells, Monroe County, N.Y., water years 1989-93. (Locations are shown in fig. 2 inset.)

any of the Ellison Park wells. Statistically weak (α = 0.10) trends at these wells were as follows:

Mo 2	upward	January 1 - March 31
Mo 663	downward	July 1 - September 30
Mo 666	upward	October 1 - December 31

Water temperature

Water temperature profiles were measured quarterly during 1989-93 in all Ellison Park wells. The Fourier Series solution described in Lapham (1989) was applied to temperature profiles for wells Mo 2 and Mo 3; results indicated downward vertical velocities of 0.08 ft/d, the same as during 1984-88.

Chemical Concentration

Median and range of concentration of selected constituents in water samples from the Ellison Park wells were compared through box plots, and temporal trends were estimated with the ESTREND program (Schertz and others, 1991).

Spatial Variability

Analysis of variance and Tukey's Multiple Comparison Test was again used to detect difference in median concentrations among Ellison Park wells.

Nutrients. The highest median concentrations of all nutrients except nitrite plus nitrate were at well Mo 667, which is the shallower (depth 15 ft) of a well pair and is finished in the organic-rich silt and sediment of the historic Irondequoit Creek flood plain. Disturbance of this area during the construction of a local sewer project could be a contributing factor to the significantly high median concentrations of nutrients at this well (Young, 1993); this is supported to some extent by the similarity of median concentrations at well Mo 665 (depth 17 ft), finished in the same material about 400 ft upgradient of other wells in that area. The lowest median concentrations

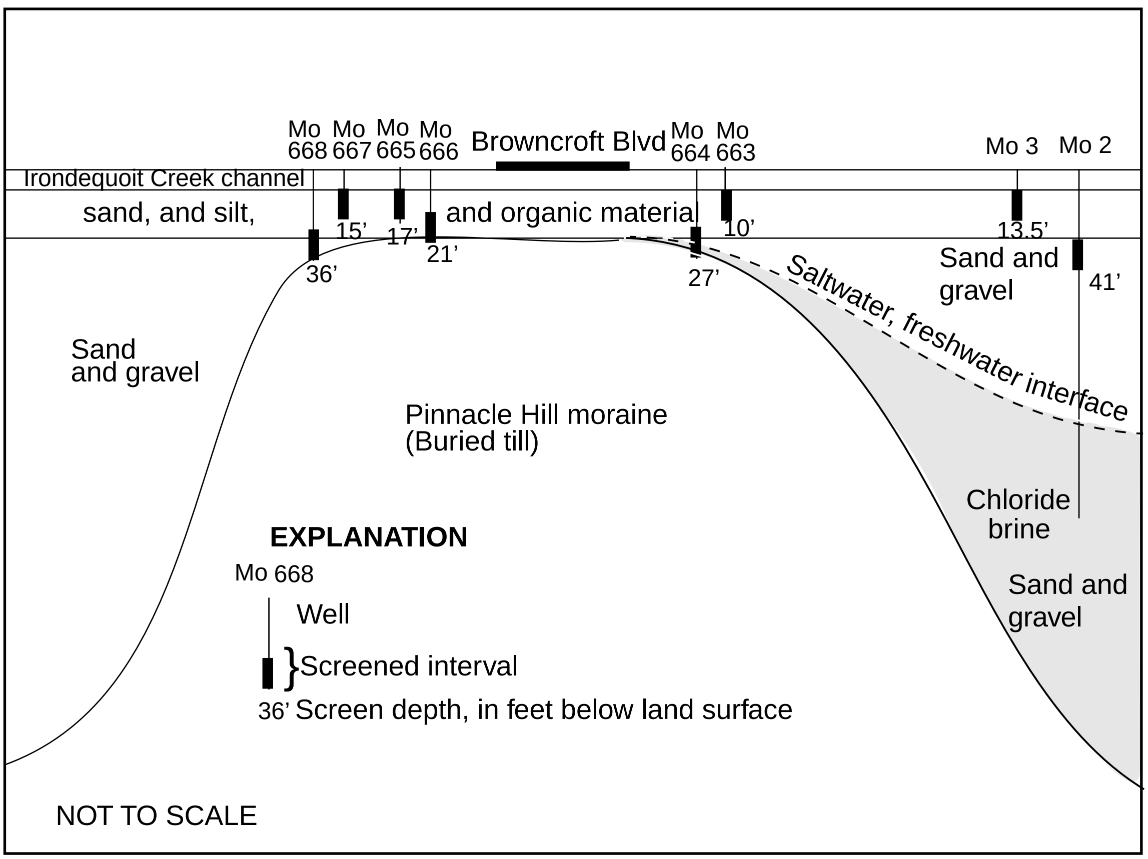


Figure 8. Vertical section through Pinnacle Hills moraine showing relative depths and locations of Ellison Park observation wells and aquifer material. (Modified from Young, 1993, fig. 2).

Table 7. Statistical summary and trends of water levels in Ellison park wells, Monroe County, N.Y., water years 1989-93.

[Units are in feet unless otherwise noted. * denotes trend is statistically significant at α = 0.05, Well locations are shown in fig. 2] n = Number of samples selected by the ESTREND program for the trend test (based on number of seasons).
p = level of significance.

		Descriptive statistics						Trend results[1]			
Well	Sample size	Max	Min	Mean	25th percentile	50th percentile (median)	75th percentile	n	Units per year	Percent per year	*P*
Mo 2	49	-1.24	3.32	0.56	0.16	0.60	0.95	22	0.04	5.69	0.203
Mo 3	57	1.01	4.11	2.86	2.59	3.00	3.40	22	.01	.35	.752
Mo 659	60	15.89	17.82	17.12	16.83	17.14	17.51	21	.07	.43	.024 *
Mo 663	57	1.02	4.32	2.84	2.16	2.80	3.66	21	-.10	-3.52	.498
Mo 664	60	1.10	4.11	2.80	2.30	2.70	3.44	21	-.03	-1.07	.498
Mo 665	70	4.00	7.48	5.86	5.36	5.80	6.46	22	.04	.74	.343
Mo 666	38	3.66	6.35	5.44	5.00	5.58	5.94	22	.13	2.31	.241
Mo 667	62	.65	6.06	3.05	1.90	2.78	4.34	21	.13	4.38	.211
Mo 668	65	5.83	8.54	7.40	6.98	7.35	7.90	22	.04	.55	.752

were generally at upstream wells Mo 2 and Mo 3, and well Mo 659 (215 ft deep and screened in the confined aquifer). Well Mo 3 also had the highest median concentration of nitrite plus nitrate.

Common ions. The highest median concentrations of common ions, by far, were at Mo 664, at the upstream edge of the buried Pinnacle Hills moraine (fig. 8). These high concentrations are probably the result of an upwelling of chloride from the dense brine pooled at the base of the impermeable buried moraine (Young, 1993).

Temporal Trends

Not all Ellison Park wells had 5 years of water-quality data; therefore, two methods were used to estimate concentration trends. Trends at Mo 2 and Mo 3, which had more than 5 years of data, were estimated through ESTREND, described earlier, whereas trends at wells Mo 659, Mo 663, Mo 664, Mo 665, Mo 667, and Mo 668, all with less than 5 years of data, were estimated with the Kendall Slope estimator.

Nutrients in samples from Ellison Park wells showed statistically significant (α = 0.05) trends at only three wells, and common ions showed statistically significant trends at six wells, as indicated in table 6 and summarized below. Wells Mo 659 and 667 showed the most trends.

Nutrients			
Orthophosphate	Mo 2, 3, 667	downward	significant (α = 0.05)
Total phosphorus	Mo 667	upward	significant (α = 0.05)
Total phosphorus	Mo 3	downward	weak (α = 0.10)
Nitrite plus nitrate	Mo 2	upward	significant (α = 0.05)
Common ions			
Hardness, magnesium, sodium, potassium, chloride, dissolved solids	Mo 659	upward	significant (α = 0.05)
Sulfate	Mo 659, 657	downward	weak (α = 0.10)
Sulfate	Mo 663, 665, 668	downward	significant (α = 0.05)
Sulfate	Mo 664	upward	significant (α = 0.05)
Sulfate	Mo 2	upward	weak (α = 0.10)
Iron	Mo 667	upward	significant (α = 0.05)

SURFACE WATER

Knowledge of long-term trends in streamflow is important in the interpretation of water-quality-trend analyses, particularly trend analyses that focus on seasonal and annual loads. Spring runoff generally carries 50 to 75 percent of the annual constituent load transported by Irondequoit Creek to Irondequoit Bay (Kappel and others, 1986). Streamflow during this period includes meltwater from the snowpack, which has been collecting atmospheric deposition through the winter, and nutrients from overfertilization of cropland, washoff of animal waste, and erosion of exposed soils. Runoff during the growing season generally is less than at other times and causes less erosion, and runoff during the fall and early winter generally causes little erosion because crop roots that have been left in fields help stabilize soils before the winter snowpack begins to accumulate.

Temporal Trends in Streamflow

The temporal variability in streamflow reflects climatic conditions and affects constituent concentrations in streams. For example, increasing runoff causes washoff of suspended constituents from nonpoint sources which increases their concentration in the stream, but increased runoff can also cause the concentration of dissolved constituents to decrease through dilution; thus, any observed trend in the concentration of a constituent could be due in part to a concurrent trend in streamflow. Thus, variability in streamflow can produce significant bias in the trends of constituent loads.

The Kendall Slope estimator was used to identify significant ($\alpha = 0.05$) trends in monthly mean streamflow at the five sites in the Irondequoit Creek basin and at Northrup Creek. Trends for 1989-93 were estimated for for the two sites with a complete record, and trends for the other four sites were estimated for the period of record (fig. 9). No statistically significant upward or downward trends were evident in the data for any of the six streamflow sites tested. The characteristics of each sites' record are discussed below and shown in table 8.

Irondequoit Creek. The Irondequoit Creek basin currently has two sites with at least 9 years of continuous streamflow record—Allen Creek near Rochester (33 years of record, water years 1962-93), and Irondequoit Creek at Blossom Road (12 years of record, water years 1982-93). Comparison of monthly streamflow at the Blossom Road site for water years 1989-93 with the 20th, 50th, and 80th percentile flows for the 1982-93 record showed that most monthly flows were within the normal (20th- to 80th-percentile) range (fig. 10A). The 1989-93 average annual mean flow was about 8 percent above the long-term average annual mean (table 9). Only November and December showed 5-year monthly mean flows that were lower (-14 percent and -15 percent) than the long-term means for those months; the values for the remaining months ranged from 1 percent greater (October) to 24 percent greater (April and May) than the long-term monthly means. The year with the greatest departure from the long-term mean

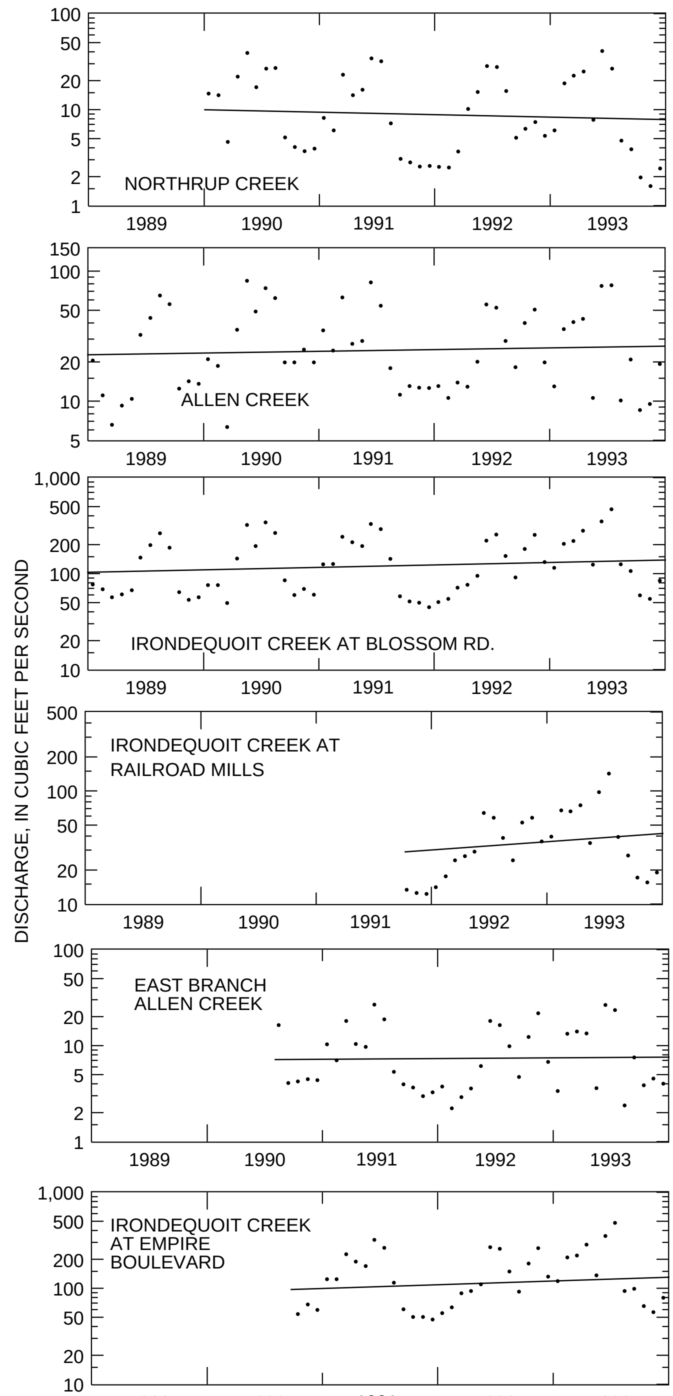


Figure 9. Monthly mean discharges and trend slope for water years 1989-93 at Northrup Creek and the five sites in the Irondequoit Creek basin, Monroe County, N.Y., 1989-93. (Locations are shown in fig. 2.)

Table 8. Monthly mean discharge, annual mean discharge, and departures and percent departure from normal at three stream-flow-gaging sites in Monroe County, N.Y., 1989-93.

[All values except percent difference (% diff) are in cubic feet per second. Departure refers to difference (+ or -) from the average monthly or annual discharge for the period of record for each location. locations are shown in fig. 2.

	1989			1990			1991			1992			1993			5-year period		
		Departure			Departure			Departure			Departure			Departure			Departure	
	Dis-charge	Value	% diff.	Dis-charge	Value	% diff.	Dis-charge	Value	% diff.	Dis-charge	Value	% diff.	Dis-charge	Value	% diff.	Dis-charge	Value	% diff.
A. Allen Creek near Rochester (04232050) water years 1961-93																		
Monthly mean																		
Oct.	20.5	-5.69	-22	21.2	-4.99	-19	35.1	+8.91	+34	13.1	-13.1	-50	13.0	-13.2	-50	20.6	-5.63	-21
Nov.	11.1	-21.2	-66	18.7	-13.6	-42	24.5	-7.83	-24	10.6	-21.7	-67	35.8	+3.47	+11	20.1	-12.2	-38
Dec.	6.56	-24.5	-79	6.33	-24.7	-80	62.9	+31.9	+103	13.9	-17.1	-55	40.5	+9.48	+31	26.0	-4.98	-16
Jan.	9.23	-13.1	-59	35.4	+13.0	+58	27.7	+5.34	+24	12.9	-9.46	-42	43.0	+20.6	+92	25.6	+3.29	+15
Feb.	10.4	-23.8	-70	84.2	+50.0	+146	29.0	-5.17	-15	20.1	-14.1	-41	10.6	-23.6	-69	30.9	-3.31	-10
Mar.	32.3	-23.8	-42	48.8	-7.32	-13	82.2	+26.1	+46	55.6	-0.52	-1	76.9	+20.8	+37	59.2	+3.04	+5
Apr.	43.6	-3.53	-7	73.9	+26.8	+57	54.2	+7.07	+15	52.2	+5.07	+11	77.9	+30.8	+65	60.4	+13.2	+28
May	65.0	+30.9	+90	62.2	+28.1	+82	17.9	-16.2	-48	29.1	-5.03	-15	10.1	-24.0	-70	36.9	+2.73	+8
June	55.8	+27.0	-94	19.9	-8.91	-31	11.2	-17.6	-61	18.3	-10.5	-36	20.9	-7.91	-27	25.2	-3.59	-12
July	12.5	-10.5	-46	19.9	-3.14	-14	13.1	-9.94	-43	39.9	+16.9	+73	8.57	-14.5	-63	18.8	-4.25	-18
Aug.	14.2	-0.87	-3	24.9	-0.87	-3	12.7	-13.1	-51	50.7	24.9	+97	9.51	-16.3	-63	22.4	-3.37	-13
Sept.	13.6	-4.58	-19	19.9	-4.58	-19	12.6	-11.9	-49	19.9	-4.58	-19	19.3	-5.18	-21	17.1	7.42	-30
Annual mean	24.6	-6.5	-25	35.9	+4.8	+15	32.0	+0.9	+3	28.1	-3.0	-10	30.6	-0.5	-2	30.2	-0.9	-3
B. Black Creek at Churchville (04231000) water years 1946-93																		
Monthly mean																		
Oct.	18.8	-19.7	-51	27.9	-10.6	-28	50.6	+12.1	+31	7.48	-31.0	-81	62.1	+23.6	+61	33.4	-5.10	-13
Nov.	29.1	-46.8	-62	47.1	-28.8	-38	65.2	-10.7	-14	9.55	-66.4	-87	225	+149	+196	75.2	-0.70	-1
Dec.	18.4	-108	-85	23.4	-103	-81	201	+75.0	+60	21.7	-104	-83	231	+105	+83	99.1	-26.9	-21
Jan.	31.2	-90.8	-74	166	+44.0	+36	216	+94.0	+77	35.5	-86.5	-71	376	+254	+208	165	+43.0	+35
Feb.	36.9	-146	-80	352	+169	+92	219	+36.0	+20	83.6	-99.4	-54	89.8	-93.0	-51	156	-27.0	-15
Mar.	122	-214	-64	238	-98.0	-29	433	+97.0	+29	218	-118	-35	388	+52.0	+15	280	-56.0	-17
Apr.	212	-46.0	-18	303	+45.0	+17	318	+60.0	+23	326	+68.0	+26	474	+216	+84	327	+69.0	+27
May	305	+181	+146	298	+174	+140	85.2	-38.8	-31	146	+22.0	+18	68.3	-55.7	-45	181	+57.0	+46
June	348	+287	+474	65.2	+4.60	+8	19.9	-40.7	-67	42.8	-17.8	-29	55.2	-5.40	-9	106	+45.4	+75
July	38.9	+13.0	+50	31.6	+5.70	+22	8.76	-17.1	-66	144	+118	+456	15.5	-10.4	-40	47.6	+21.7	+84
Aug.	21.4	-0.40	-2	18.6	-3.20	-15	4.98	-16.8	-77	201	+179	+822	9.32	-12.5	-57	51.0	+29.2	+134
Sept.	21.3	-4.60	-18	11.7	-14.2	-55	3.87	-22.0	-85	126	+100	+386	16.5	-9.40	-36	35.8	+9.90	+38
Annual mean	100	-16.2	-7	130	+13.8	+12	135	+18.8	+16	113	-3.2	+3	168	+51.8	+45	129	+12.8	+11
C. Irondequoit Creek at Blossom Road (0423205010) water years 1982-93																		
Monthly Mean																		
Oct.	76.8	-11.1	-13	75.7	-12.2	-14	125	+37.1	+42	50.5	-37.4	-43	115	+27.1	+31	88.5	+0.58	+1
Nov.	68.5	-54.5	-44	75.7	-47.3	-38	126	+2.97	+2	54.5	-68.5	-56	204	+80.0	+66	106	-17.0	-14
Dec.	56.5	-93.9	-62	49.5	-101	-67	242	+91.6	+61	71.5	-78.9	-52	218	+67.6	+45	128	-22.4	-15
Jan.	60.8	-73.7	-55	143	+8.46	+6	212	+77.5	+58	76.5	-58.0	-43	279	+144	+107	154	+19.5	+14
Feb.	67.1	-91.0	-58	321	+163	+103	193	+34.9	+22	94.5	-63.6	-40	124	-34.1	-22	160	+1.87	+1
Mar.	146	-72.2	-33	194	-24.2	-11	328	+110	+50	220	+1.85	+1	348	+130	+60	247	+28.8	+13
Apr.	199	-52.4	-21	341	+89.6	+36	290	+38.6	+15	256	+4.59	+2	468	+217	+86	311	+59.6	+24
May	263	+109	+71	265	+111	+72	142	-11.8	-8	152	-1.82	-1	125	-28.8	-19	190	+36.2	+24
June	186	+89.2	+92	85.1	-11.6	-12	58.1	-38.6	-40	91	-5.75	-6	107	+10.2	+11	105	+8.25	+9
July	64.3	-9.12	-12	60.0	-13.4	-18	51.3	-22.1	-30	181	+108	+147	59.3	-14.1	-19	83.2	+9.78	+13
Aug.	53.1	-34.4	-39	69.2	-18.3	-21	49.6	-37.9	-43	253	+165	+189	54.4	-33.1	-38	95.9	+8.36	+10
Sept.	56.6	-15.1	-21	60.2	-11.5	-16	44.6	-27.11	-38	132	+60.3	+84	84.7	+13.0	+18	75.6	+3.89	+5
Annual mean	108	-25.7	-19	144	+10.3	+8	155	+21.3	+16	136	+2.3	+2	182	+48.3	+36	145	+11.3	+8

was 1993 (36 percent). The 5-year monthly means were within the normal range for all months (fig. 10B).

The period of record for Allen Creek near Rochester (33 years) is nearly three times as long as that for Blossom Road and contains extremes that represent droughts as well as floods. The Allen Creek drainage area is primarily moderate- to high-density residential land with some commercial areas and, as such, is not representative of the rest of the Irondequoit basin. Comparison of monthly mean flows for water years 1989-93 with the 20th, 50th, and 80th percentiles for the period of record shows many monthly mean flows that were above or below normal (fig. 11A). Average monthly mean flows for the study period (1989-93) were well within the normal range, however (fig. 11B). The departure of the 1989-93 average annual mean flow from normal was 3 percent below the long-term average annual mean. Departures of 5-year monthly mean flows from normal were highly variable, ranging from -38 percent (November) to 28 percent (April). The year with the greatest departure from the long-term mean was water year 1989 (-25 percent, table 8).

Differences in monthly and annual departures between these two sites are attributed to the much longer period of record at Allen Creek than at

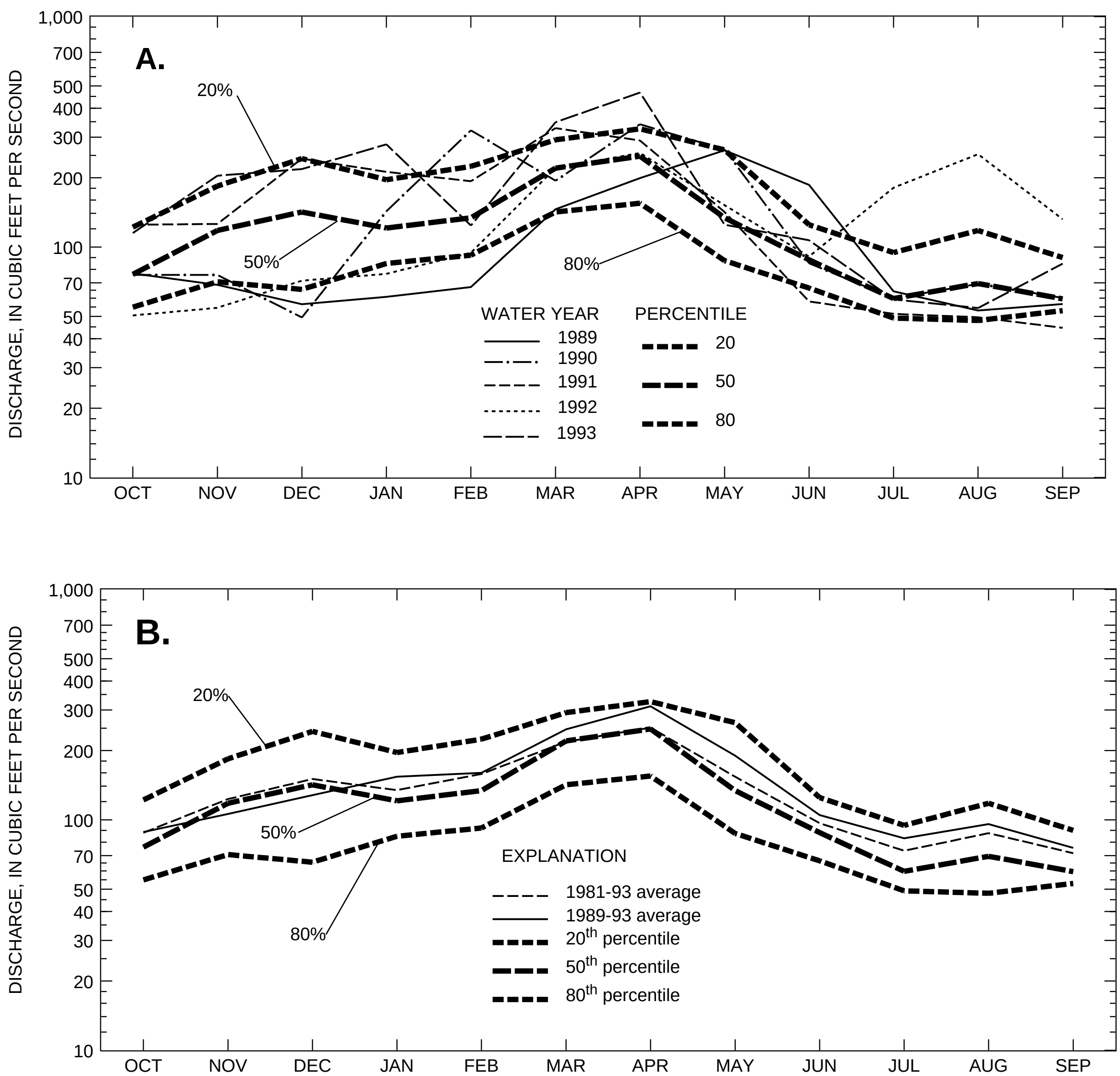


Figure 10. Mean discharge of Irondequoit Creek at Blossom Road, with 20th-, 50th- (median), and 80th-percentile discharges for period of record: A. Monthly mean for water years 1989-93. B. Average monthly mean for period of record (1982-93) and water years 1989-93. (Locations are shown in fig. 1)

Irondequoit Creek at Blossom Road, and to differences in basin characteristics.

Black Creek. The site chosen to represent the part of Monroe County west of the Genesee River was Black Creek at Churchville, which was the site closest to Northrup Creek at North Greece which had a long period of record (48 years, 1946-93) for comparison with 1989-93 flows. Monthly mean flows for water years 1989-93 were generally within the normal range (20th to 80th percentiles) except in water year 1989 (fig. 12A). Monthly mean flows for water year 1989 were below the 80th percentile for December through March, and above the 20th percentile for May, June, and July. Average mean monthly flows for May through September of 1989-93 exceeded the 20th percentile (fig. 12B). The 1989-93 average annual mean flow was 11 percent greater than the long-term average annual mean (table 8). The 5-year monthly means for April through September ranged from 27 percent (April) to 134 percent (August) above the long-term monthly means for those months. Water year 1993 showed the greatest departure from normal at 45 percent above normal. Water year 1989, which had the most months of flow outside the normal range, had an annual departure of only 7 percent below normal.

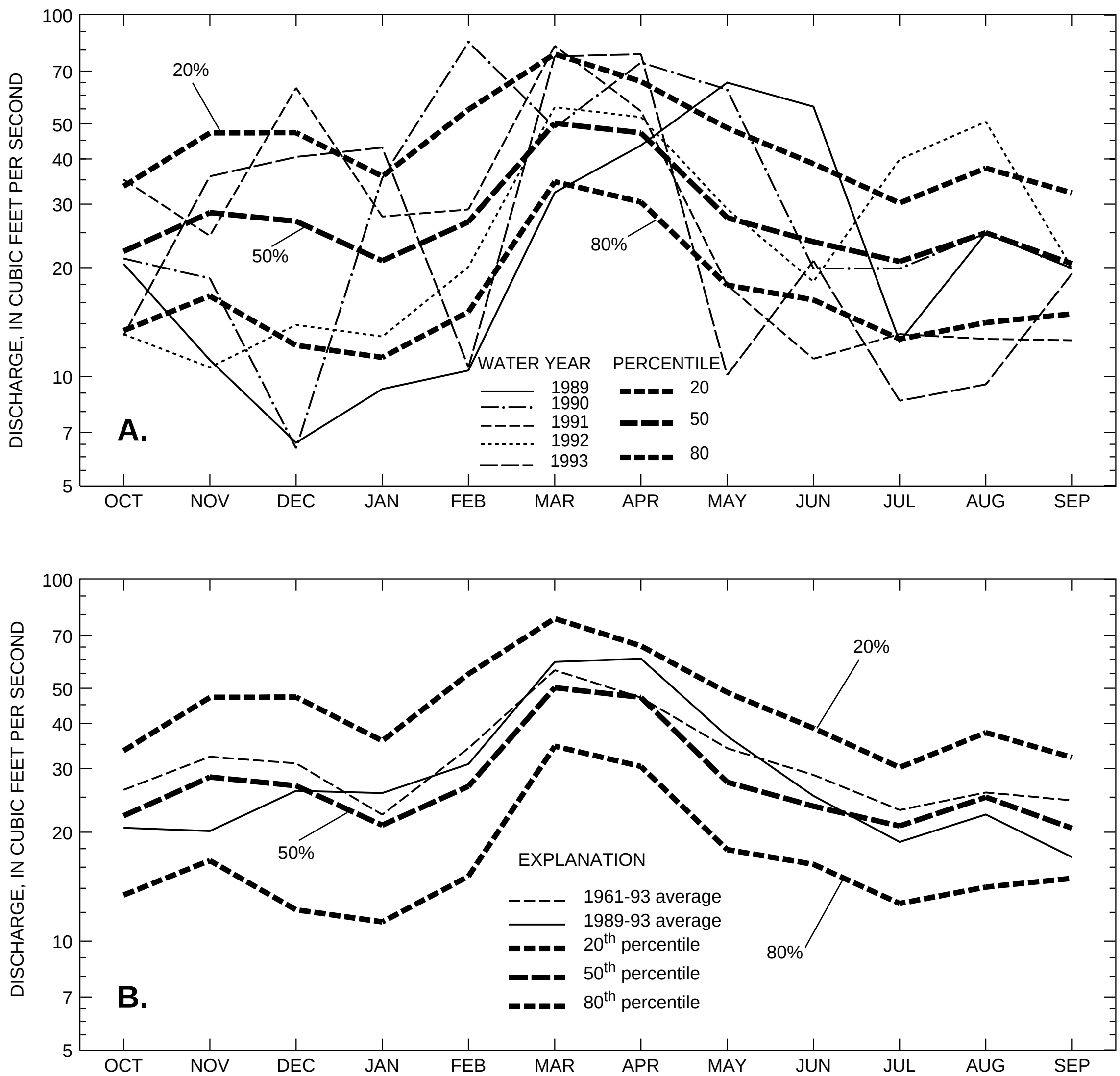


Figure 11. Mean discharge of Allen Creek near Rochester, with 20th-, 50th- (median), and 80th-percentile discharges: for period of record. A. Monthly mean for water years 1989-93. B. Average monthly mean for period of record (1961-93) and for study period (1989-93). (Locations are shown in fig. 1)

A t-test, which is used to evaluate matched pairs of data, was used to compare the 1989-93 average monthly means with those for the period of record of each of the three sites, but found no statistically significant differences in the means of either period.

Chemical Concentration

Two of the sites in the Irondequoit Creek basin (Allen Creek and Irondequoit Creek at Blossom Road) had complete data for the 1989-93 water years. The sites on Northrup Creek, East Branch Allen Creek, Irondequoit Creek at Railroad Mills, and Irondequoit Creek at Empire Boulevard were established during the period covered by this report, and the site on Irondequoit Creek at Pittsford was discontinued in 1991.

Spatial Variability

Local differences in 5-year median and range of concentration of selected chemical constituents were examined through a comparison of boxplots (fig. 13) and a statistical test, Tukey’s MCT (multiple comparison test) on ranks of the concentration data to identify any statistically significant ($\alpha = 0.05$)

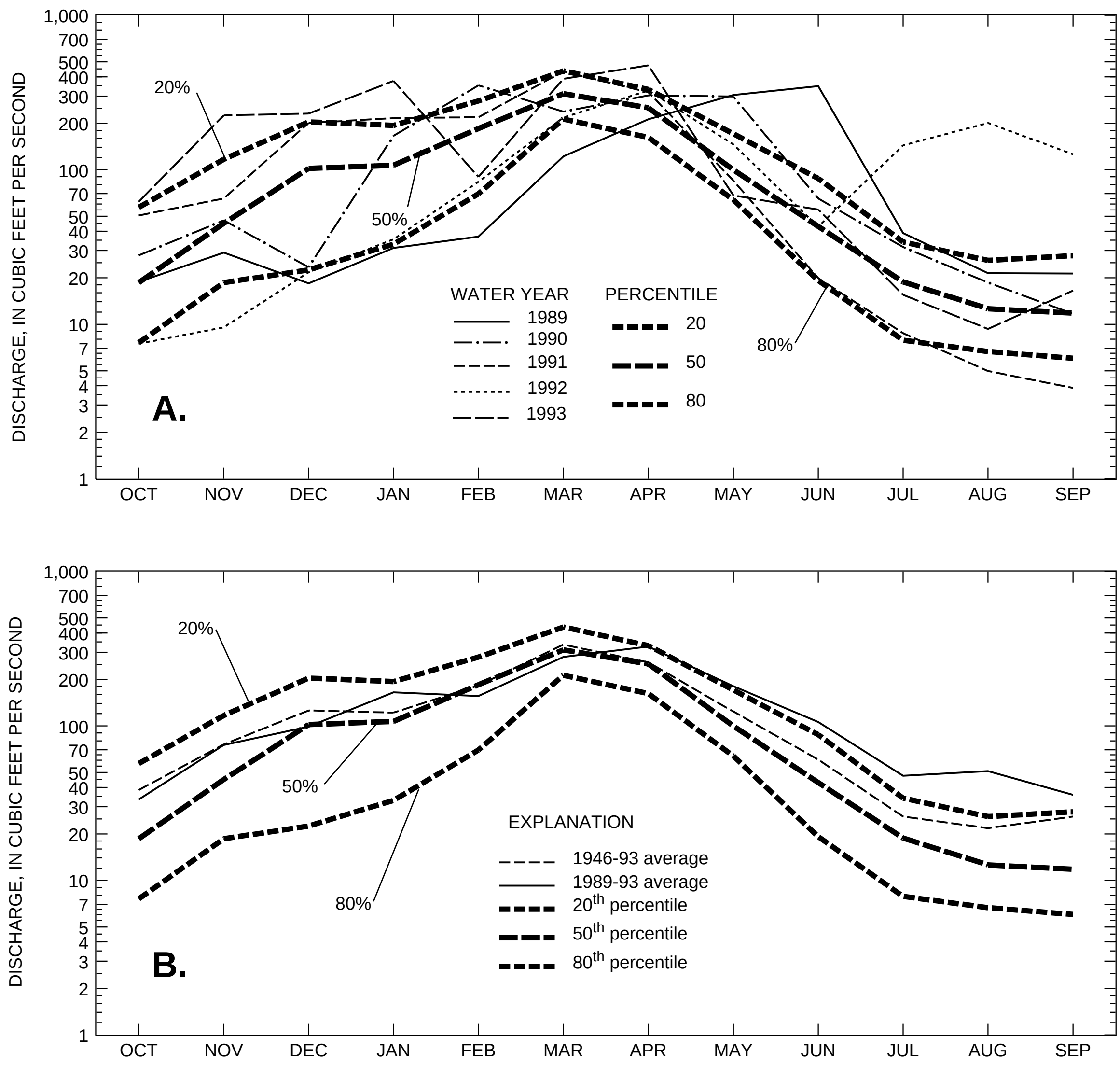


Figure 12. Mean discharge of Black Creek at Churchville, with 20th-, 50th- (median), and 80th-percentile discharges for period of record. A. Monthly mean for water years 1989-93. B. Average monthly mean for period of record (1961-93) and 1989-93. (Locations are shown in fig. 1.)

differences in median concentration among the seven sites (table 9).

The major cause of chemical variability among streams, or among reaches of a given stream, in the Irondequoit Creek basin, is land use. For example, median concentrations of dissolved chloride were considerably less at the three sites where the primary land use is agriculture (Northrup Creek, Irondequoit Creek at Railroad Mills, and Irondequoit Creek at Pittsford) than at the other sites, which have predominantly urban drainage areas.

In terms of median concentration, some constituents in the Irondequoit Creek basin differed more than others among sites (table 10). The median concentrations shown in table 10 were calculated from all samples collected for a constituent at that site. Some values in table 10 differ slightly from those shown in table 14 for the same constituent because the ESTREND program selects a subset of samples for trend testing. Median concentration of ammonia plus organic nitrogen was higher at Allen Creek than at any other Irondequoit basin site, and the median for nitrite plus nitrate was highest in East Branch Allen Creek. The median for total phosphorus was highest at Irondequoit Creek at Empire Boulevard. Median concentrations of ammonia nitrogen and orthophosphate were fairly consistent among Irondequoit basin sites. Of the nutrients, ammonia plus organic nitrogen showed the greatest number of statistically significant differences among the Irondequoit basin sites. The only sites to show no statistically significant differences in median concentration of ammonia plus organic nitrogen were (1) East Branch Allen Creek and Irondequoit Creek at Empire Boulevard, and (2) Irondequoit Creek at Pittsford and East Branch Allen Creek.

Median concentrations of chloride and sulfate differed significantly among most of the Irondequoit basin sites (table 9 and fig. 13). The highest median for chloride (130 mg/L) was at Allen Creek, and the highest median for sulfate was at Pittsford (170 mg/L). Site-to-site differences in chloride medians are probably directly related to the rate of road-salt application—sites representing the most urbanized subbasins showed the largest concentrations. The high sulfate medians for sites on Irondequoit Creek are probably associated with the dissolution of sulfate from bedrock and glacial deposits in the region (Young, 1993) as well as from atmospheric deposition.

The median concentrations of total suspended solids, volatile suspended solids, and turbidity were fairly consistent among all sites in the Irondequoit basin except at Irondequoit Creek at Blossom Road, which had a considerably higher median for total suspended solids (152 mg/L) and a slightly higher median for volatile suspended solids (21.0 mg/L). The lowest medians for total suspended solids (108 mg/L) were at Allen Creek and Empire Boulevard, and the lowest median for volatile suspended solids was at Pittsford (14.0 mg/L). The lowest median for turbidity (8.4 NTU) was at Pittsford, and the highest (22.0 NTU) was at Empire Blvd.

Median concentrations of constituents in Northrup Creek were generally within the range of those in the Irondequoit Creek basin except for total phosphorus and orthophosphate, which were considerably higher, and sulfate, which was considerably lower (table 10). The relatively high concentrations of nutrients, especially total phosphorus and orthophosphate at Northrup Creek, are primarily due to sewage-treatment-plant discharge upstream from the site.

Two sites (Allen Creek and Irondequoit Creek at Blossom Road) had sufficient data for comparisons of median concentrations for 1984-88 with those for 1989-93. The comparisons were based on box plots (fig. 14) and Tukey's Multiple comparison (HSD) test. The Blossom Road site showed a statistically significant ($\alpha = 0.05$) difference between the 1984-88 and 1989-93 medians for all constituents tested. Both sites showed lower median concentrations of ammonia plus organic nitrogen, nitrite plus nitrate, orthophosphate, and sulfate during 1989-93 than during 1984-88, and the Blossom Road site showed higher values for total phosphorus, suspended solids, volatile solids, and chloride in 1989-93 than in 1984-88. The other constituents showed no statistically significant differences between the two periods.

Temporal Trends

Rapid development in much of the Irondequoit Creek basin has increased residential land use and decreased agricultural land use. The combined effects of changing land use and water-quality-management practices in the basin can best be evaluated through an analysis of water-quality trends.

The Seasonal Kendall test used by the ESTREND program bases trend estimates on seasons. "Seasons" used in the trend analysis are not

Table 9. Results of Tukey's Multiple Comparison Test (MCT) showing statistically significant (α = 0.05) differences in median concentrations of selected constituents among Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y.

[Cr., creek, E., east. H; significantly higher, L; significantly lower, ND; no significant difference.]

Sites	Total suspended solids	Volatile suspended solids	Ammonia nitrogen, dissolved	Ammonia plus organic nitrogen, total	Nitrite plus nitrate, total	Total phosphorus	Orthophosphate, dissolved	Chloride, dissolved	Sulfate, dissolved
Irondequoit Creek at Blossom Road, versus:									
Irondequoit Cr. at Railroad Mills	H	H	ND	H	ND	H	H	H	ND
Irondequoit Cr. at Pittsford	ND	ND	L	H	ND	H	H	H	L
E. Branch Allen Cr. at Pittsford	H	H	ND	ND	L	ND	L	H	H
Allen Creek near Rochester	H	H	L	L	ND	ND	L	L	H
Irondequoit Cr. at Empire Blvd.	H	H	L	ND	ND	ND	L	ND	ND
Northrup Cr. at North Greece	H	ND	L	L	L	L	L	H	H
Irondequoit Creek at Railroad Mills, versus:									
Irondequoit Cr. at Pittsford	ND	ND	L	ND	ND	ND	ND	ND	ND
E. Branch Allen Cr. at Pittsford	ND	ND	L	L	ND	L	L	L	H
Allen Creek near Rochester	ND	ND	L	L	ND	L	L	L	H
Irondequoit Cr. at Empire Blvd.	ND	ND	L	L	H	L	L	L	H
Northrup Creek at North Greece, versus:									
Irondequoit Cr. at Pittsford	ND	ND	H	H	H	H	H	H	L
E. Branch Allen Cr. at Pittsford	ND	ND	H	H	ND	H	H	L	L
Allen Creek near Rochester	ND	ND	ND	ND	H	H	H	L	L
Irondequoit Cr. at Empire Blvd.	ND	ND	H	H	H	H	H	L	L
Irondequoit Creek at Pittsford, versus:									
E. Branch Allen Cr. at Pittsford	ND	ND	ND	ND	L	L	L	L	H
Allen Creek near Rochester	H	ND	ND	L	ND	L	L	L	H
Irondequoit Cr. at Empire Blvd.	H	ND	ND	L	ND	L	L	L	H
East Branch Allen Creek at Pittsford, versus:									
Allen Creek near Rochester	ND	ND	ND	L	H	ND	H	L	H
Irondequoit Cr. at Empire Blvd.	ND	ND	ND	ND	H	ND	ND	L	L
Allen Creek near Rochester, versus:									
Irondequoit Cr. at Empire Blvd.	ND	ND	ND	H	ND	ND	L	H	L

necessarily based on climatic seasons, but, rather, on the temporal distribution of the data. Each "season" must have only one observation. If more than one observation is available for a given "season," the ESTREND program selects the observation closest to the middle of the season. The dates of the seasons used for each constituent are listed in table 11.

Overall and seasonal trends at the six surface-water sites in the Irondequoit Creek basin and at Northrup Creek at North Greece were evaluated. Only the sites on Irondequoit Creek at Blossom Road and Allen Creek had the preferred 5 years of record (1989-93) for trend determination; Northrup Creek at North Greece had 4 years (1990-93); East Branch Allen Creek and Irondequoit Creek at Empire Boulevard had 3 years (1991-93); and Irondequoit Creek at Pittsford, which was discontinued in 1991, had data for 7 years (1984-91); and Irondequoit Creek at Railroad Mills had only 2 years (1992-93); therefore, trends for that site were estimated through a nonparametric approach (Kendall slope estimator) that does not take into account flow adjustment or seasonality in the data. The trend estimates for those sites with less than 5 years of record are statistically less reliable than those based on 5 years of record. Results of the analyses are given in table 12.

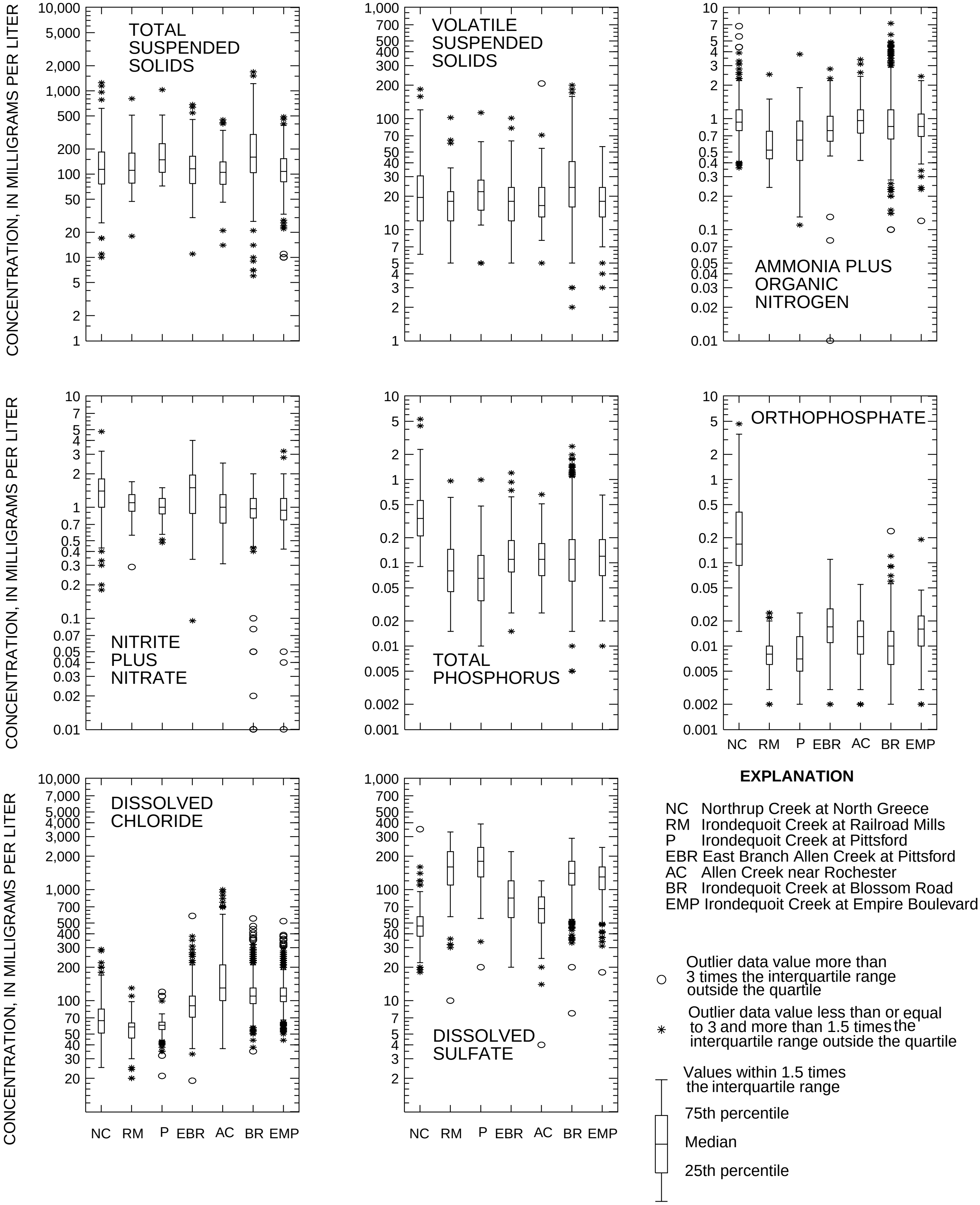


Figure 13. Concentration ranges of selected constituents in water samples from Northrup Creek and the six Irondequoit Creek basin sites, Monroe County, N.Y. (Locations are shown in fig. 1.)

Irondequoit Creek Basin

The nutrients tested for trends were ammonia nitrogen, ammonia plus organic nitrogen, nitrite plus nitrate, total phosphorus, and orthophosphate. Results varied from site to site and among constituents.

Nitrogen and phosphorus. Ammonia plus organic nitrogen showed statistically weak ($\alpha = 0.10$) downward trends of 8.5 percent per year and 20.2 percent per year at Blossom Road and Empire Boulevard respectively, and a statistically significant ($\alpha = 0.05$) upward trend of 17.6 percent per year at East Branch Allen Creek during 1989-93. Nitrite plus nitrate showed only one trend—a downward trend ($\alpha = 0.05$)—of 3.5 percent per year at Irondequoit Creek at Pittsford (period of record, April 1984 through May 1991, when the site was discontinued). Ammonia nitrogen showed no detectable trend at any site.

Total phosphorus showed statistically significant trends at four of the seven sites—Irondequoit Creek at Pittsford and Allen Creek showed upward trends of 6.3 and 7.0 percent per year, respectively, and Irondequoit Creek at Blossom Road and Empire Boulevard showed downward trends of 7.6 and 29.9 percent per year, respectively. No sites showed a significant trend for orthophosphate.

Only two sites—Allen Creek and Irondequoit Creek at Blossom Road—had sufficient record (5 years) for estimation of seasonal trends, and only three nutrients showed a statistically significant ($\alpha = 0.05$) seasonal trend at these sites. Allen Creek showed a statistically weak ($\alpha = 0.10$) downward trend in nitrogen ammonia plus organic nitrogen from March 1 through April 15 of 1989-93 and an upward trend in orthophosphate from September 1 through December 14, and Irondequoit Creek at Blossom showed a statistically weak upward trend in nitrite plus nitrate for June. Although the downward trend in ammonia plus organic nitrogen at Allen Creek for March 1 through April 15 was consistent with the overall downward trend, the upward trend in orthophosphate at that site during the fall (September 1 through December 14) contrasts with the absence of any overall trend for these two constituents over the 5-year period, and in nitrite plus nitrate for June at Blossom Road.

Comparison of statistically significant trends in nutrients at Allen Creek and at Irondequoit Creek at Blossom Road during 1989-93 with those for 1984-88 showed some differences. The 1984-88 data indicated statistically significant downward trends in ammonia nitrogen, nitrite plus nitrate, and orthophosphate, whereas the 1989-93 data indicated downward trends in ammonia plus organic nitrogen and total phosphorus. The trend analysis for the complete

Table 10. Median concentrations of selected constituents at six Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (or period of record).
[Units are milligrams per liter unless otherwise noted. NTU, nephelometric turbidity units; Locations are shown in fig. 1.]

Site	Turbidity (NTU)	Total suspended solids	Volatile suspended solids	Ammonia nitrogen as N, dissolved	Ammonia + organic nitrogen as N, total	Nitrite plus nitrate as N, total	Total phosphorus as P	Orthophosphate as P, dissolved	Chloride, dissolved	Sulfate, dissolved
Irondequoit Creek basin sites										
Irondequoit Creek at Railroad Mills	21.0	111	18.0	0.01	0.52	1.1	0.08	0.01	58	160
Irondequoit Creek at Pittsford	8.4	119	14.0	0.02	0.68	1.1	0.06	0.01	54	170
East Branch Allen Creek at Pittsford	20.0	116	18.0	0.02	0.78	1.5	0.11	0.02	90	84
Allen Creek near Rochester	19.0	108	16.0	0.03	1.10	1.1	0.10	0.02	130	72
Irondequoit Creek at Blossom Road	18.0	152	21.0	0.02	0.93	1.0	0.10	0.01	100	150
Irondequoit Creek at Empire Blvd	22.0	108	18.0	0.03	0.85	0.94	0.12	0.02	110	130
Northrup Creek at North Greece	10.0	114	19.5	0.03	0.93	1.4	0.34	0.17	66	47

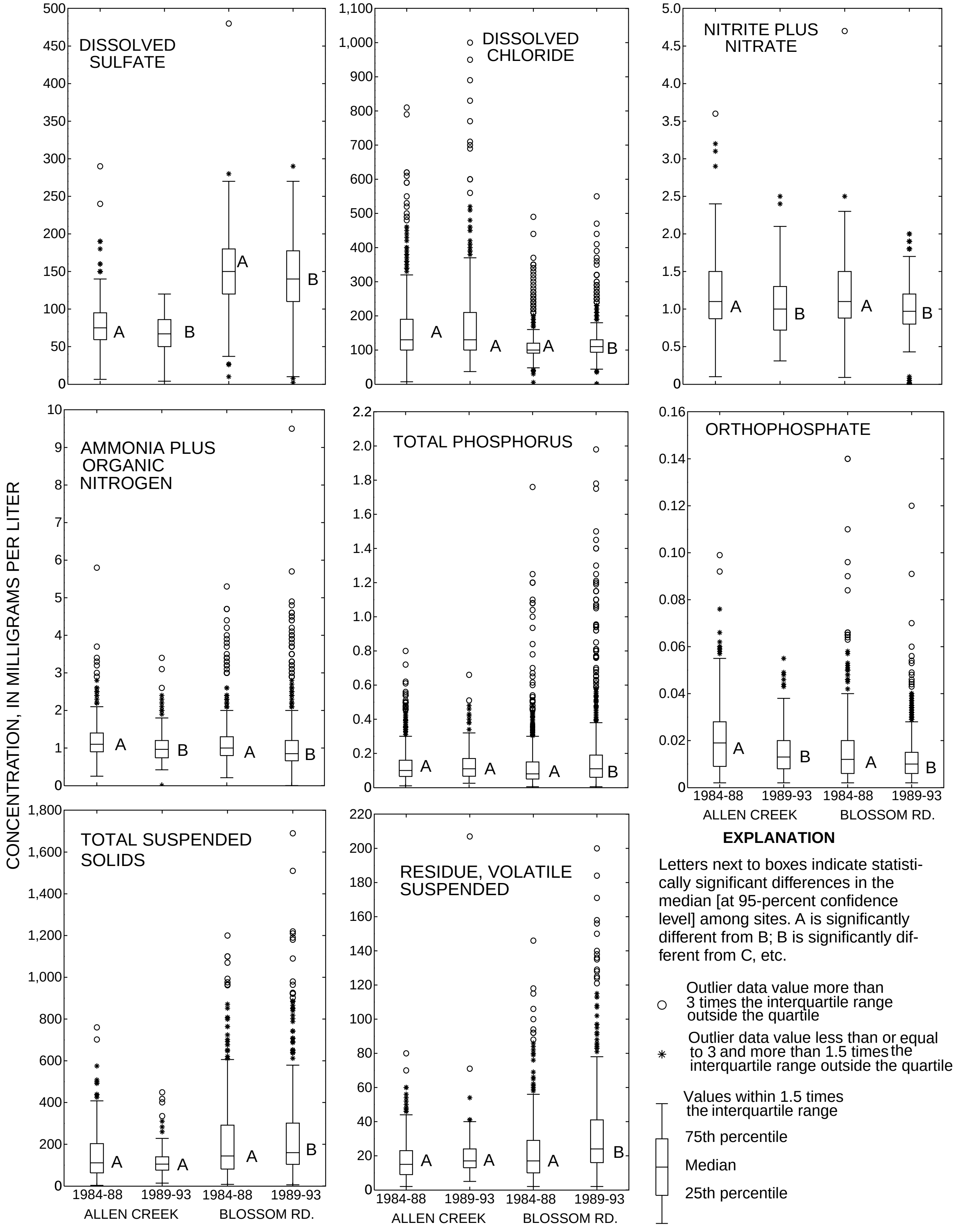


Figure 14. Concentration ranges of selected chemical constituents in water samples from Allen Creek and Irondequoit Creek at Blossom Road, Monroe County, N.Y., water years 1984-88 and 1989-93.

Table 11. Seasons used in trend analysis of water-quality data, 1989-93.

Number of seasons	Dates	Number of days
12 seasons		
1	January 1 - 31	31
2	February 1 - 29	29
3	March 1 - 31	31
4	April 1 - 30	30
5	May 1 - 31	31
6	June 1 - 30	30
7	July 1 - 31	31
8	August 1 - 31	31
9	September 1 - 30	30
10	October 1 - 31	31
11	November 1 - 30	30
12	December 1 - 31	31
6 seasons		
1	March 1 - April 15	46
2	April 16 - May 31	46
3	June 1 - July 15	45
4	July 16 - August 31	47
5	September 1 - December 14	105
6	December 15 - February 29	77
4 seasons		
1	March 1 - May 31	92
2	June 1 - September 30	122
3	October 1 - November 30	61
4	December 1 - February 29	91
3 seasons		
1	March 1 - May 31	92
2	June 1 - September 30	122
3	October 1 - February 29	152

period of record (1984-93) at Blossom Road showed statistically significant downward trends in ammonia plus organic nitrogen, nitrite plus nitrate, and orthophosphate. The 1984-88 data for Allen Creek indicated downward trends in ammonia nitrogen and nitrite plus nitrate that were not apparent in the 1989-93 record, and an upward trend in total phosphorus that was similar to that of 1989-93. The analysis for the combined period of record (1984-93) for Allen Creek showed only one statistically significant trend—a downward trend in ammonia plus organic nitrogen that was not evident during either of the two 5-year periods. The 1989-93 data for Allen Creek showed a nonsignificant downward trend in ammonia plus organic nitrogen, that probably resulted in the significant downward trend for the 1984-93 period. In contrast, total phosphorus showed significant upward trends for each of the two 5-year periods at this site, but no significant trend for the long term (1984-93).

Dissolved chloride and dissolved sulfate. Dissolved chloride showed statistically significant upward trends at two of the Irondequoit Creek sites—Pittsford (1984-91), Empire Boulevard (1991-93), and a statistically weak upward trend at Blossom Road (1989-93). Annual increases ranged from 1.7 percent at Blossom Road to 11 percent at Empire Boulevard.

Dissolved chloride showed no seasonal trends at Allen Creek but showed statistically weak upward trends at Irondequoit Creek at Blossom Road for March, June, and August. Dissolved chloride at Blossom Road showed no trend for 1984-88, but showed a minor but statistically significant upward trend of 0.8 percent for 1984-93. Dissolved chloride at Allen Creek showed no trend for either of the 5-year periods nor for the 10-year period (1984-93).

Dissolved sulfate showed a downward ($\alpha = 0.05$) trend of 2.1 percent per year (1989-93) at Irondequoit Creek at Pittsford and a upward trend of 6.8 percent per year at Irondequoit Creek at Empire Blvd. Dissolved sulfate at Blossom Road showed no trends for either 1984-88 or 1989-93 but showed a minor (0.8 percent per year) statistically significant upward trend for the combined 1984-93 period. Dissolved sulfate at Allen Creek showed a downward trend (5.1 percent per year) for 1984-88, but no trend for 1989-93 nor for the combined 1984-93 period. Although Irondequoit Creek at Blossom Road showed no detectable overall trends in sulfate, a statistically weak seasonal upward trend was indicated for April.

Suspended solids and turbidity. Irondequoit Creek at Blossom Road showed statistically significant downward trends in total suspended solids, volatile suspended solids, and turbidity (13.5, 12.5, and 8.5 percent per year, respectively) during 1989-93. Irondequoit Creek at Pittsford showed statistically significant upward trends in total suspended solids and volatile suspended solids (27.7 and 24.7 percent per year, respectively). Northrup Creek at North Greece showed an upward trend in turbidity (12.3 percent per year). The 1984-88 period, by contrast, showed no trend in total suspended solids and a strong upward trend in volatile suspended solids at Blossom Road, and a strong upward trend in volatile suspended solids at Allen Creek. Neither Irondequoit Creek at Blossom Road or Allen Creek showed any significant trends in total suspended solids or volatile suspended solids over the combined 10-year (1984-93) period.

Table 12. Statistical summary and results of trend tests for selected constituents at Northrup Creek and at five sites in the Irondequoit Creek basin, Monroe County, N.Y., for indicated period.

[--, insufficient data to calculate value; n, number of observations used in trend analysis; *p*, significance of trend. Units are in milligrams per liter, * indicates trend is statistically significant at $\alpha = 0.05$]

Constituent	Descriptive statistics					Trend results				
	Total number of samples	Mean	Percentile 25th	Percentile 50th (median)	Percentile 75th	number of seasons	n	Units per year	Percent per year	*p*
A. Northrup Creek at North Greece (0422026250). Period of trend analysis October 89 - September 93										
Turbidity, NTU	200	19.97	5.1	9.4	24	6	25	2.45	12.29	0.003*
Total suspended solids	56	163.7	71	100	170	4	14	-16.46	-10.05	1.000
Volatile suspended solids	55	23.9	12	17	30	--	--	--	--	--
Ammonia nitrogen, as N, dissolved	200	e 0.09	0.02	0.03	0.09	6	200	--	--	--
Ammonia plus organic nitrogen, as N, total	200	1.03	0.8	0.9	1.2	6	25	0.01	1.28	0.699
Nitrite plus nitrate, as N, total	197	1.45	1.10	1.40	1.80	6	25	0.09	6.06	0.156
Phosphorus, total as P	201	0.41	0.20	0.34	0.56	6	25	0.00	1.21	0.897
Orthophosphate, as P, dissolved	202	0.26	0.09	0.17	0.41	6	25	0.00	1.36	.897
Chloride, dissolved	202	71.94	50	66	82	6	25	0.42	0.58	0.897
Sulfate, dissolved	202	48.55	37	46	56	6	25	0.02	0.05	1.000
B. Irondequoit Creek at Pittsford (04232040). Period of trend analysis October 89 - April 91										
Turbidity, NTU	171	24.8	3.3	10.0	32.0	6	171	--	--	--
Total suspended solids	120	135.7	56.5	100.5	179.0	4	24	37.56	27.68	0.000*
Volatile suspended solids	119	19.0	7.0	14.0	25.0	4	24	4.69	24.73	0.001*
Ammonia nitrogen, as N, dissolved	363	< 0.01	< 0.01	< 0.01	< 0.01	6	363	--	--	--
Ammonia plus organic nitrogen, as N, total	362	0.7	0.5	0.6	0.9	6	46	0.01	1.50	0.557
Nitrite plus nitrate, as N, total	372	1.1	1.0	1.1	1.3	6	46	-0.04	-3.51	0.000*
Phosphorus, total as P	378	0.1	< 0.01	< 0.01	0.1	6	46	0.01	6.30	0.048*
Orthophosphate, as P, dissolved	383	<0.002	<0.002	<0.002	<0.002	6	383	0.00	0.00	0.602
Chloride, dissolved	380	55.2	49.0	55.0	60.0	12	85	1.36	2.47	0.001*
Sulfate, dissolved	379	179.9	130.0	180.0	240.0	6	46	-3.75	-2.09	0.016*
C. East Branch Allen Creek at Pittsford (0423204920). Period of trend analysis October 90 - September 93										
Turbidity NTU	109	34.2	9.2	17.0	36.5	6	19	3.82	11.17	0.248
Total suspended solids	46	146.09	75	100	150	4	11	--	--	--
Volatile suspended solids	45	21.57	12	17	23	4	11	--	--	--
Ammonia nitrogen, as N, dissolved	59	e 0.03	0.01	0.02	0.02	6	59	--	--	--
Ammonia plus organic nitrogen, as N, total	56	0.9	0.6	0.8	1.0	6	18	0.15	17.56	0.043*
Nitrite plus nitrate, as N, total	62	1.6	0.8	1.5	2.0	6	18	0.13	8.18	0.685
Phosphorus, total as P	108	0.1	0.1	0.1	0.2	6	19	0.01	6.81	0.700
Orthophosphate, as P, dissolved	108	<0.002	<0.002	<0.002	<0.002	6	19	0.00	-11.89	1.000
Chloride, dissolved	109	105.5	69.5	90.0	110.0	6	19	4.73	4.49	0.441
Sulfate, dissolved	107	85.9	55.0	80.0	120.0	6	18	5.84	6.80	0.685

e, parameter estimated for censored constituents by a log-probability regression procedure.

Table 12. Statistical summary and results of trend tests for selected chemical constituents at Northrup Creek and at five sites in the Irondequoit Creek basin, Monroe County, N.Y., for indicated period. (continued).

Constituent	Descriptive statistics: Total number of samples	Mean	Percentile: 25th	50th (median)	75th	Trend results: number of seasons	n	Units per year	Percent per year	*p*
D. Allen Creek near Rochester (04232050). Period of trend analysis October 88 - September 93										
Turbidity NTU	199	21.2	6.6	17.0	29.0	12	60	0.83	3.90	0.289
Total suspended solids	70	121.9	78.5	105.0	133.3	4	19	-1.92	-1.57	0.695
Volatile suspended solids	70	19.4	13.8	16.5	22.5	4	19	0.00	-0.02	1.000
Ammonia nitrogen, as N, dissolved	148	< 0.01	< 0.01	< 0.01	< 0.01	6	148	--	--	--
Ammonia plus organic nitrogen, as N, total	147	1.0	0.7	1.0	1.2	6	31	-0.04	-4.14	0.185
Nitrite plus nitrate, as N, total	154	1.1	0.7	1.0	1.4	6	30	0.00	0.16	1.000
Phosphorus, total as P	203	0.1	0.1	0.1	0.2	6	31	0.01	6.99	0.023*
Orthophosphate, as P, dissolved	203	<0.002	<0.002	<0.002	<0.002	6	31	0.00	10.80	0.058
Chloride, dissolved	202	170.2	100.0	130.0	202.5	12	60	-0.20	-0.11	0.944
Sulfate, dissolved	199	68.2	50.0	68.0	86.0	12	59	0.49	0.72	0.885
E. Irondequoit Creek at Blossom Road (0423205010). Period of trend analysis October 88 - September 93										
Turbidity NTU	510	31.8	6.3	17.0	35.0	12	60	-2.70	-8.49	0.077
Total suspended solids	189	262.6	101.0	159.0	296.0	6	30	-35.56	-13.54	0.008*
Volatile suspended solids	188	36.4	16.0	23.0	128.5	6	30	-4.54	-12.49	0.031
Ammonia nitrogen, as N, dissolved	509	< 0.01	< 0.01	< 0.01	< 0.01	12	509	--	--	--
Ammonia plus organic nitrogen, as N, total	512	1.0	0.6	0.8	1.1	12	60	-0.09	-8.47	0.077
Nitrite plus nitrate, as N, total	511	1.0	0.8	1.0	1.2	12	60	0.01	1.08	0.525
Phosphorus, total as P	513	0.2	0.1	0.1	0.2	12	60	-0.01	-7.60	0.040*
Orthophosphate, as P, dissolved	515	< 0.002	<0.002	< 0.002	<0.002	12	60	0.00	-2.85	0.358
Chloride, dissolved	515	123.1	98.0	110.0	130.0	12	60	2.12	1.72	0.077
Sulfate, dissolved	511	143.1	110.0	150.0	180.0	12	60	2.28	1.59	0.229
F. Irondequoit Creek at Empire Boulevard (0423205020). Period of trend analysis October 91 - September 93										
Turbidity NTU	306	25.26	10	21	32	12	36	-9.12	-37.59	0.000*
Total suspended solids	120	119.54	76	100	140	6	18	-38.74	-32.41	0.043*
Volatile suspended solids	120	18.16	12	16	23	6	18	-4.22	-22.66	0.105
Ammonia nitrogen, as N, dissolved	298	e 0.03	0.02	0.02	0.04	12	298	--	--	--
Ammonia plus organic nitrogen, as N, total	306	0.87	0.7	0.8	1.1	12	36	-0.19	-22.21	0.000*
Nitrite plus nitrate, as N, total	303	1.02	0.79	0.98	1.30	12	36	-0.07	-6.94	0.651
Phosphorus, total as P	307	0.13	0.06	0.12	0.18	12	36	-0.04	-29.89	0.000*
Orthophosphate, as P, dissolved	308	0.02	0.01	0.02	0.02	12	36	0.00	-2.35	0.451
Chloride, dissolved	306	124.63	98	110	130	12	36	13.61	10.92	0.010*
Sulfate, dissolved	300	132.71	100	130	160	12	36	8.98	6.77	0.033*

Total suspended solids showed an upward trend for the April 16 through May 30 season of 1989-93 at Blossom Road, and for March 1 through May 31 at Pittsford. Volatile suspended solids also showed a seasonal upward trend for the March 1 through May 31 season and the June 1 through September 30 season at Pittsford.

The analysis of 1991-93 data for Irondequoit Creek at Railroad Mills through the Kendall slope estimator revealed statistically significant upward trends in turbidity, total phosphorus, and orthophosphate, and downward trends in dissolved chloride and sulfate.

Genesee River

The trend analysis of constituents in the Genesee River was based on samples collected at Charlotte Docks (04232006) for the National Stream Quality Accounting Network (NASQAN) program during 1974-93. Samples were collected at varying frequencies ranging from eight times per year at the beginning of the program in 1974 to only four times per year toward the end of the program in 1993. Discharges associated with these samples were obtained from the streamflow-gaging station on the Genesee River at Rochester (04232000), about 3 mi upstream from the sampling site (fig. 2).

The trend analysis for the period of record (1974-93) revealed several statistically significant ($\alpha = 0.05$) trends—downward trends for ammonia plus organic nitrogen, nitrite plus nitrate, total phosphorus, and dissolved iron, and upward trends for dissolved chloride, dissolved sodium, and dissolved oxygen. The analysis for 1989-93 indicated statistically significant downward trends in nitrite plus nitrate, dissolved calcium, and dissolved magnesium, and no statistically significant upward trends. Long-term trends and 1989-93 trends are summarized in table 13.

An example of the importance of locally weighted scatterplot smoothing (LOWESS) is illustrated in figure 15, which shows the trend of ammonia plus organic nitrogen for the period of record (fig. 15A) and that for 1989-93 (fig. 15B). The LOWESS (0.5 smoothing factor) plot is included in each and shows the shorter term variations in concentrations. These shorter term differences can be important in the interpretation of cause-and-effect relations. For example, the difference between the slope of the 1989-93 part of the long-term record (fig. 15A) and the slope for 1989-93 alone (fig. 15B) is due to the difference in the number of data points used in the weighted smoothing for each plot. The LOWESS analysis, in weighing each segment of the curve, considers a percentage of the total number of data points available. The overall upward trend in figure 15B closely resembles the LOWESS plot for that period in the long term plot (fig. 15A).

Table 13. Long-term and 1989-93 trends in concentrations of selected constituents at the Genesee River at Charlotte Docks, Monroe County, N.Y., with statistical significance (*p*) of trends.

[* denotes trend is statistically significant at $\alpha = 0.05$]

	Long Term			1989-93	
Constituent	Period	percent per year	*p*	percent per year	*p*
Ammonia + organic nitrogen as N, total	5/74-9/93	-3.61	0.001 *	5.50	0.120
Nitrite plus nitrate as N, total	6/74-9/93	1.25	0.012 *	-13.5	0.034 *
Ammonia nitrogen, as N, dissolved	11/79-7/93	--	--	-8.16	0.556
Phosphorus, total as P	5/74-9/93	-5.47	0.000 *	-14.2	0.112
orthophosphate as P, dissolved	10/81-9/93	0.00	0.814	--	--
Oxygen, dissolved	10/74-6/93	0.96	0.006 *	1.89	0.671
Specific conductance	5/74-9/93	0.74	0.090	-4.00	0.556
Chloride, dissolved	5/74-9/93	1.97	0.026 *	-5.78	0.888
Sulfate, dissolved	5/74-9/93	0.23	0.615	-7.63	0.120
Calcium, dissolved	5/74-9/93	0.23	0.512	-6.30	0.031 *
Magnesium, dissolved	5/74-9/93	0.13	0.643	-7.41	0.031 *
Sodium, dissolved	5/74-9/93	2.29	0.003 *	-7.14	0.556
Iron, dissolved	5/74-9/93	-5.51	0.000 *	-6.32	0.391

Chemical Loads and Yields

This section presents total monthly loads (in tons) of selected constituents (by water year) for five of the six sites in the Irondequoit Creek basin; loads

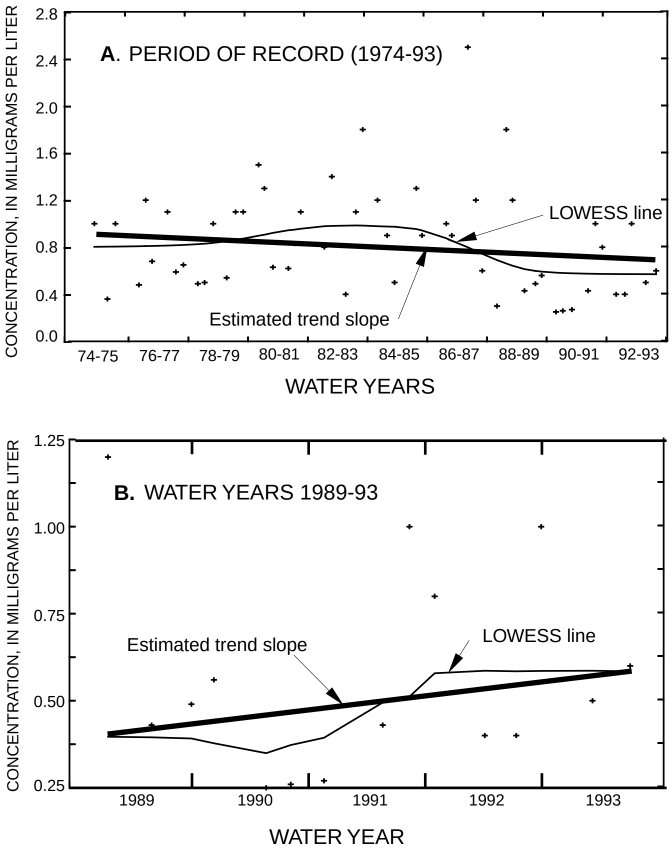


Figure 15. Example of estimated trend slope and locally weighted scatterplot smoothing (LOWESS) line for concentration of ammonia plus organic nitrogen in Genesee River at Charlotte Docks: A. Period of record (1974-93). B. Water years 1989-93.

for the sixth site (Irondequoit Creek at Empire Boulevard) are given in Coon 1999 (in press). This section also includes loads for Northrup Creek near North Greece, and estimated annual loads for the Genesee River at Charlotte Docks (table 16, further on). Total monthly loads of constituents for the five sites in the Irondequoit Creek basin and Northrup Creek are given by water year in the appendix.

The largest loads of most constituents generally are transported during the spring (February through May), when snowmelt and spring rains cause high runoff. The loads of constituents analyzed for total concentration (suspended and dissolved), such as ammonia plus organic nitrogen, nitrite plus nitrate, and total phosphorus, are greatest at these times. Although concentrations of dissolved constituents, such as orthophosphate, ammonia nitrogen, chloride, and sulfate vary with flow to a far lesser degree because they become diluted by high flows, generally the increase in the volume of flow during high flows is enough to overcome the dilution and causes these constituents to have high loads during periods of high flow.

Irondequoit Creek Basin

Total annual loads entering Irondequoit Bay from the Irondequoit Creek basin (table 14, fig. 16) are calculated as the loads for Blossom Road multiplied by 1.17 to account for the additional drainage area between Blossom Road and Irondequoit Bay. Residence time of constituents in the bay range from several months to several years (Bubeck and Burton, 1989); thus, a minor change in load of some of the conservative constituents could have a major effect on water quality of the bay because those constituents tend to accumulate in the sediments of the bay, where they are subject to resuspension when these sediments are disturbed.

Annual loads of suspended solids and volatile suspended solids entering Irondequoit Bay during 1989-93 were much greater than during 1984-88 (table 14). The largest annual loads occurred during the 1989 water year (suspended solids 68,800 tons; volatile suspended solids 8,780 tons) despite the smallest runoff for the 5-year period. Much of that load (28 percent of suspended solids and 26 percent of volatile suspended solids) occurred during a high flow in May. The mean total phosphorus load for 1989-93 was also considerably higher than that for 1984-88; some of the difference can be attributed to the adsorption of phosphorus onto suspended solids particles and, thus, is a reflection of the increased suspended-solids load (Hem, 1985). Loads of nutrients, especially phosphorus, strongly affect the eutrophic condition of the Bay. Loads of orthophosphate, which is the form of phosphorus readily available for plant uptake, decreased from 1984-88 to 1989-93.

The values in table 14 represent the loads of constituents entering the wetland at the south end of Irondequoit Bay. A report by Coon (1999, in press), which investigates the effect of the wetland at Empire Boulevard on reduction in chemical loads entering the bay, found significant reductions in loads of total phosphorus, total nitrogen, and total suspended solids.

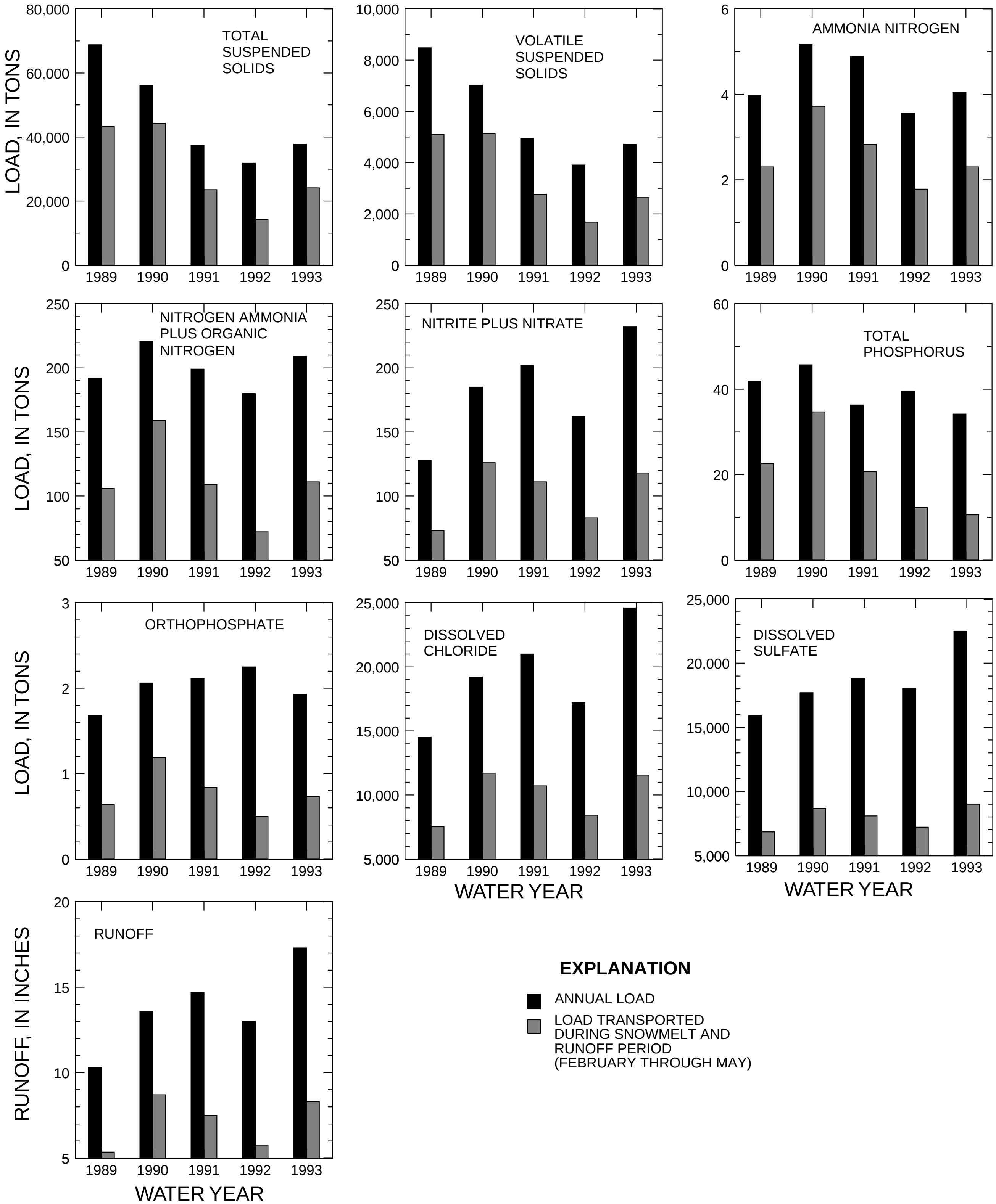


Figure 16. Estimated loads of selected constituents transported from Irondequoit Creek to Irondequoit Bay annually and during the spring snowmelt and runoff period each year, water years 1989-93.

Table 14. Annual loads of selected constituents transported by Irondequoit Creek to Irondequoit Bay, Monroe County, N.Y., water years 1989-93, and percentage of total annual load transported from February through May.
[Annual loads are in tons]

	Constituent									
Water year or period	Total Suspended solids	Volatile suspended solids	Sulfate dissolved	Ammonia nitrogen, dissolved	Ammonia plus organic nitrogen, total	Nitrite plus nitrate, total	Total phosphorus	Ortho phosphorus, dissolved	Chloride dissolved	Runoff (inches)
A. Annual loads (multiplied by 1.17 to account for drainage area between Blossom Road and mouth)										
1989	68,800	8,780	15,900	3.79	192	128	41.9	1.68	14,500	10.3
1990	56,100	7,020	17,700	5.17	221	185	45.7	2.06	19,200	13.6
1991	37,400	4,940	18,800	4.88	199	202	36.3	2.11	21,000	14.7
1992	31,800	3,910	18,000	3.56	180	162	39.6	2.25	17,200	13.0
1993	37,700	4,710	22,500	4.04	209	232	34.2	1.93	24,600	17.3
89-93 (Mean)	46,400	5,870	18,600	4.29	200	182	39.5	2.01	19,300	13.8
84-88 (Mean)	28,400	3,170	18,600	6.33	190	193	23.1	2.44	16,700	12.6
B. Percentage of total annual loads transported from February through May (spring snowmelt and runoff period).										
1989	63	58	43	58	55	57	54	38	52	52
1990	79	73	49	72	72	68	76	58	61	64
1991	63	56	43	58	55	55	57	40	51	51
1992	45	43	40	50	40	51	31	22	49	44
1993	64	56	40	57	53	51	61	38	47	48
89-93 (Mean)	63	57	43	59	55	56	56	39	52	52
84-88 (Mean)	55	50	38	42	47	48	47	31	47	45

Increases in orthophosphate and ammonia nitrogen reflect conversions among the various forms of nitrogen and phosphorus in the wetland.

Yields, (load per unit area) are helpful in in making comparisons from basin to basin. For example, one basin may have a greater total load than another simply because it has more area, but may have a lower yield than the other basin. Thus, the interpretation as to the difference in the loads from each basin might be quite different. Annual yields (in tons per square mile of watershed above the measuring point) for Northrup Creek, the five sites in the Irondequoit Creek basin, and the Genesee River at Charlotte Docks, are summarized in table 15 and figure 17. The East Branch Allen Creek had the highest annual yields of all nutrients, despite the lack of data for water years 1989-90, which had high yields at other sites. Irondequoit Creek at Railroad Mills, a predominantly agricultural drainage area, had the lowest annual yields of nutrients. Mean annual yields of orthophosphate were fairly consistent among all sites in the Irondequoit Creek basin.

The East Branch of Allen Creek had greater yields of all constituents (except for chloride) per square mile than the downstream site at Allen Creek. The downstream decrease in yield probably results from low stream gradients, which allow settling of constituents, and from wetlands, which also allow settling and provide filtration. Allen Creek had the highest mean annual chloride yield (173 ton/mi^2) of any of the sites. The high chloride yield is probably related to the amount and rate of road-salt application.

Mean annual yields of all constituents except volatile suspended solids and chloride at Allen Creek were slightly lower during 1989-93 than during 1984-88, whereas mean annual yields of suspended solids and volatile suspended solids at Blossom Road were considerably higher during 1989-93 than during 1984-88, as was chloride. Mean annual yields of other constituents at Blossom Road were about the same in 1989-93 as in 1984-88.

Table 15. Mean annual yield of selected constituents at the five Irondequoit Creek basin sites, Northrup Creek, and the Genesee River, Monroe County, N.Y., for indicated water years.

[All values are in tons per square mile; locations are shown in fig. 2.]

Constituent	Northrup Creek (1990-93)	Genesee River (1989-93)	Irondequoit Creek basin sites: Irond. Crk at Pittsford (1989-90)	Irond. Crk at Railroad Mills (1992-93)	E. Branch Allen Creek (1991-93)	Allen Creek (1984-88)	Allen Creek (1989-93)	Blossom Road (1984-88)	Blossom Road (1989-93)
Total suspended solids	240	147	153	124	199	143	117	170	277
Volatile suspended solids	30.8	11.8	21.3	16.9	28.5	17.4	19.0	19.0	35.1
Ammonia nitrogen, as N, dissolved	0.16	0.12	0.02	0.01	0.05	.044	0.04	.038	0.03
Ammonia plus organic nitrogen as N, total	1.37	0.87	0.70	0.62	1.34	1.26	1.06	1.13	1.18
Nitrite plus nitrate, as N, total	1.55	1.35	0.81	0.73	2.45	1.30	1.14	1.15	1.09
Phosphorus, total as P	0.38	0.15	0.11	0.10	0.26	.146	0.14	.138	0.24
Orthophosphate, as P, dissolved	0.18	0.019	0.01	0.01	0.03	.021	0.02	.015	0.01
Chloride, dissolved	84.1	67.6	46.7	42.3	136	161	173	99.7	115
Sulfate, dissolved	48.3	63.1	123	124	102	72.1	60.4	112	111

Northrup Creek and Genesee River

Mean annual yields of all constituents, especially nutrients at Northrup Creek (water years 1990-93), were higher than at any of the Irondequoit basin sites except East Branch Allen Creek, which had a higher yield of nitrite plus nitrate (table 15). Northrup Creek's drainage area is mainly agricultural, and the relatively high nutrient yields are derived primarily from sewage-treatment-plant discharge upstream from the sampling site and, to a lesser extent, from fertilizers and agricultural runoff. Northrup Creek also had fairly high annual yields of suspended and volatile solids and relatively low yields of dissolved chloride and sulfate, as would be expected, given the agricultural character of the area.

Annual yields for the Genesee River (table 15) were estimated from stream discharges recorded at Rochester and concentration data collected at the Charlotte pump station, 5 mi downstream. Yields for all constituents were within the range noted for Northrup Creek and the five Irondequoit basin sites.

Table 16. Annual constituent loads and associated error for Genesee River at Charlotte Docks, Monroe County, N.Y., water years 1989-93.

[Loads are in thousands of tons. Error, when multiplied by 1.96 and added to and subtracted from the estimated load, gives the approximate 95-percent confidence limits of the load estimate].

Constituent	1989 Load	1989 Error	1990 Load	1990 Error	1991 Load	1991 Error	1992 Load	1992 Error	1993 Load	1993 Error
Suspended solids	458	106	436	66.1	392	67.1	160	27.4	362	62.9
Volatile solids	33.5	7.39	34.8	4.84	31.7	4.80	15.8	2.48	30.3	4.78
Ammonia nitrogen as N, dissolved	0.27	0.035	0.32	0.034	0.33	0.035	0.28	0.030	0.31	0.033
Ammonia + organic nitrogen as N, total	2.03	0.16	2.24	0.15	2.28	0.15	1.77	0.12	2.42	0.17
Nitrite plus nitrate as N, total	2.85	0.16	3.65	0.17	3.67	0.16	2.72	0.13	3.73	0.17
Total phosphorus as P	0.46	0.046	0.40	0.033	0.36	0.03	0.24	0.021	0.43	0.038
Orthophosphate as P, dissolved	0.031	0.005	0.043	0.005	0.053	0.006	0.043	0.005	0.064	0.008
Chloride, dissolved	153	11.5	180	11.1	186	11.1	153	9.50	162	9.98
Sulfate, dissolved	146	7.6	155	6.58	156	6.47	148	6.41	173	7.45

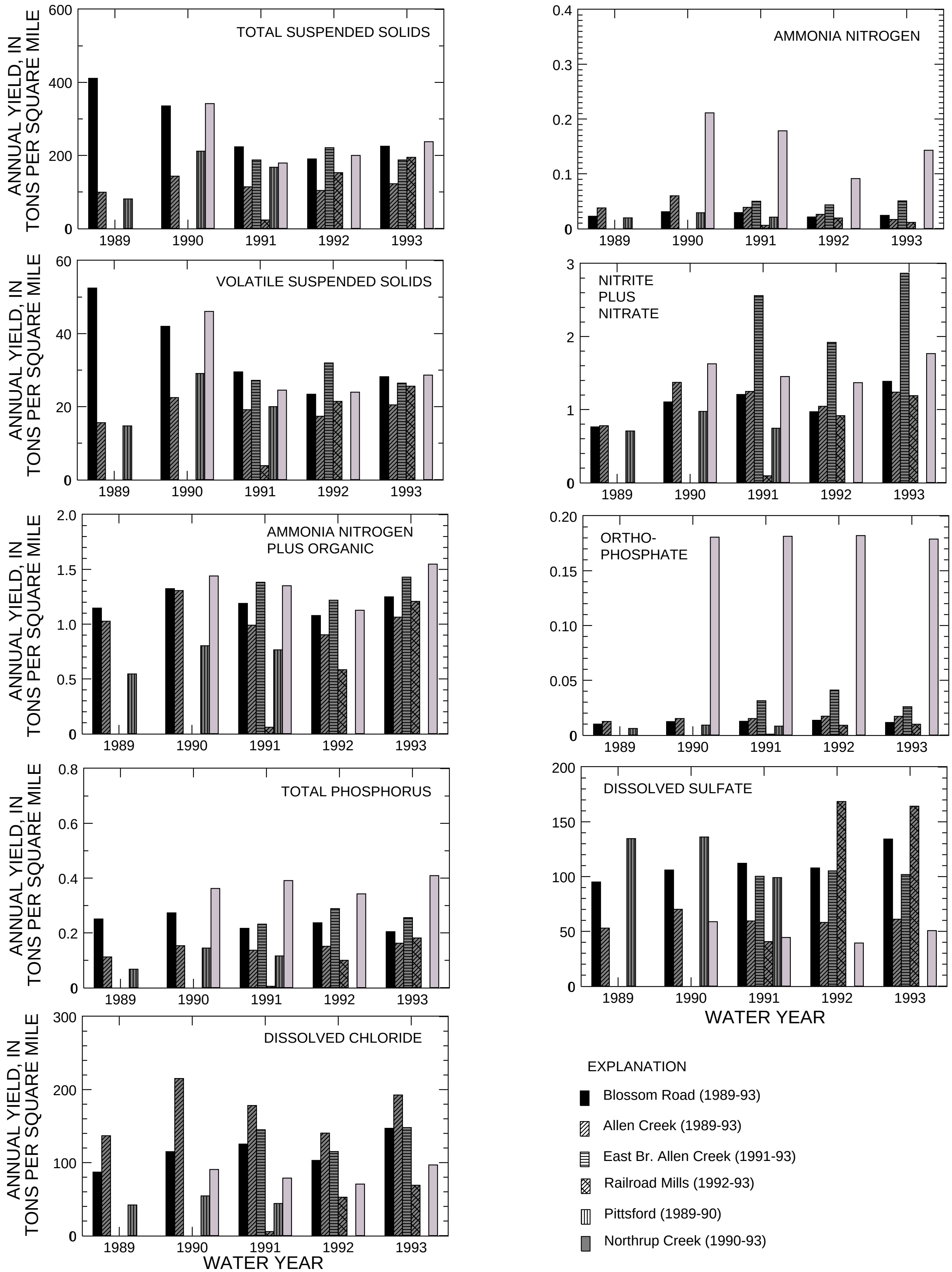


Figure 17. Annual yield of selected constituents at five sites in the Irondequoit Creek basin and at Northrup Creek, Monroe County, N.Y., for indicated water years.

Total annual loads of selected constituents entering Lake Ontario from the Genesee River (table 16) were estimated from daily mean discharges at Rochester. Loads of total suspended solids and volatile suspended solids were considerably less during water year 1992 than during the other years of the 1989-93 period, and loads of chloride and sulfate were about the same as during 1989. Annual mean flow for water years 1989 and 1992 (2,587 and 2,538 ft^3/s, respectively) were 12 and 13 percent lower than the 5-year mean annual of 2,928 ft^3/s.

SUMMARY AND CONCLUSIONS

Many years of systematic collection of hydrologic data in Monroe County have provided a foundation for a comprehensive assessment of the county’s water resources. Long-term records of unregulated streamflow and precipitation provide the basis for determining the normality of a much shorter period of record, such as the 1989-93 period analyzed in this report.

Precipitation records collected and analyzed by the National Weather Service at Rochester indicate that the average annual rainfall for 1989-93 was 1.6 in. (5 percent) greater than normal. Trend analyses of chemical concentrations in bulk atmospheric deposition samples collected at Mendon Ponds Park indicate statistically significant upward trends of nearly 18 percent per year over the 5-year period (1989-93) for dissolved potassium, and of 9 percent per year for specific conductance. Annual loads of chemicals deposited in the Irondequoit Creek basin from atmospheric sources ranged from 0.016 ton/mi^2 for dissolved lead to 16.5 ton/mi^2 for dissolved sulfate.

Ground-water levels in Ellison Park indicate that water-table gradients are subject to frequent reversals in direction of lateral flow to or from Irondequoit Creek as well as in direction of vertical flow in the aquifer. Measured water levels in Powder Mill Park (wells Mo 10 and Mo11) indicate that ground-water flow is well below the stream bottom of nearby Park Creek. Trend analysis of 1989-93 ground-water levels in both parks showed three statistically significant trends—an upward trend of 0.4 percent per year at Mo 659 in Ellison Park, and upward trends of 6.6 percent per year and 19 percent per year at wells Mo 11 and Mo 12, respectively, in Powder Mill Park.

All three Powder Mill Park wells showed statistically significant trends in chemical concentrations. Turbidity, ammonia nitrogen, and total phosphorus showed downward trends at Mo 12, and dissolved magnesium showed a downward trend at Mo 10. Dissolved carbon dioxide showed an upward trend, and dissolved sodium showed a downward trend, at Mo 11. Ellison Park wells showed few statistically significant trends in nutrients; these were upward trends were for orthophosphate at Mo 2, Mo 3, and Mo 667, total phosphorus at Mo 667, and nitrite plus nitrate at Mo 2. Ellison Park wells showed a greater number of trends for common ions; these were upward trends in hardness, magnesium, sodium, potassium, chloride, and dissolved solids at Mo 659, and downward trends for dissolved sulfate at Mo 663, Mo 665, and Mo 668, and an upward trend at Mo 664.

Streamflow for 1989-93 was in the normal range. Comparison of long-term (period-of-record) flows with the 1989-93 flows showed that Allen Creek flows were 3 percent below normal 1989-93, whereas those of Irondequoit Creek and Black Creek at Churchville were 8 percent and 11 percent above normal, respectively.

Median concentrations of some constituents in Irondequoit Creek basin streams varied more widely from site to site than others. The highest median concentration of ammonia plus organic nitrogen was in Allen Creek, whereas the highest median concentration of nitrite plus nitrate was in East Branch Allen Creek. The highest median concentration of total phosphorus was in Irondequoit Creek at Empire Boulevard. Median concentrations of ammonia nitrogen and orthophosphate were fairly consistent among the five Irondequoit basin sites. Of the nutrients, the median concentration of ammonia plus organic nitrogen showed the greatest number of statistically significant differences from site to site in the Irondequoit Creek basin. The largest median concentrations of dissolved chloride (130 mg/L) were in Allen Creek, and the largest median concentration of dissolved sulfate (170 mg/L) was in Irondequoit Creek at Pittsford. Site-to-site differences in chloride concentration are directly related to the rate of road-salt application, and the sites that represent urbanized watersheds had the highest concentrations. The high median concentrations of sulfate at sites on the main stem of Irondequoit Creek probably result from the dissolution of sulfate from bedrock and glacial deposits, as well as from atmospheric sources.

Median concentrations of constituents in Northrup Creek were generally within the range of those in the Irondequoit Creek basin sites, except those for total phosphorus and orthophosphate, which were considerably higher, and for sulfate, which was considerably lower. The relatively high median concentrations of nutrients in Northrup Creek are probably a result of sewage-treatment-plant discharge and agricultural runoff upstream from the site.

Trends in the concentrations of constituents during 1989-93 differed from site to site, and the individual sites differed in the number and type of trends for certain constituents. Ammonia plus organic nitrogen showed downward trends of 8.5 percent per year and 22.2 percent per year at Irondequoit Creek at Blossom Road and Empire Boulevard, respectively, and an upward trend of 17.6 percent per year at East Branch Allen Creek. Nitrite plus nitrate showed a downward trend of 3.5 percent per year at Irondequoit Creek at Pittsford. Total phosphorus showed upward trends of 6.3 and 7.0 percent per year at Irondequoit Creek at Pittsford and Allen Creek, respectively, and downward trends of 7.6 and 29.9 percent at Blossom Road and Empire Boulevard, respectively. Ammonia nitrogen and orthophosphate showed no detectable trends at any of the sites.

Dissolved chloride concentration at the three Irondequoit Creek sites showed upward trends ranging from 1.7 percent per year at Blossom Road to 11 percent per year at Empire Boulevard. Dissolved sulfate showed a downward trend of 2.1 percent per year at Irondequoit Creek at Pittsford. Total suspended solids, volatile suspended solids, and turbidity showed downward trends at Irondequoit Creek at Blossom Road (13.5, 12.5, and 8.5 percent per year, respectively). Suspended solids and volatile suspended solids showed upward trends at Irondequoit Creek at Pittsford (27.7 and 24.7 percent per year, respectively). The only detectable trend in concentration at Northrup Creek was an upward trend in turbidity (12.3 percent per year).

Total suspended solids were transported to Irondequoit Bay during 1989-93 at a rate of about 46,400 ton/yr, of which volatile suspended solids constituted about 5,900 tons. Nutrient transport to the bay averaged 200 ton/yr year for ammonia plus organic nitrogen, 182 ton/yr for nitrite plus nitrate, 4.3 ton/yr for ammonia nitrogen, 39.5 ton/yr for total phosphoru2.1, and 2.0 ton/yr for orthophosphate. Dissolved chloride transport to the bay averaged 19,300 ton/yr, and sulfate transport averaged 18,600 ton/yr.

East Branch Allen Creek had larger annual yields of all nutrients than the other sites, despite the absence of data for water years 1989-90. Flow for the years for which data were available (1991-93) was slightly above average. Allen Creek had the greatest mean annual chloride yield (173 ton/mi^2). Northrup Creek had larger mean annual constituent yields, especially of nutrients, than all Irondequoit basin sites except Allen Creek, which had higher yields of nitrite plus nitrate than the other sites. The relatively high nutrient yields are probably a result of fertilizer application, agricultural runoff, and discharge from an upstream wastewater-treatment plant.

Annual constituent yields of the Genesee River were within the range of those found at Northrup Creek and the five Irondequoit Creek basin sites.

Water quality issues remain an important focus of Monroe County planners. Data analysis provided by this report show that Monroe County, through the use of water quality management practices and improved treatment or diversion of sewage treatment plant effluent, has been generally successful in improving water quality conditions throughout the county, particularly in the Irondequoit Creek basin where nutrients delivered to Irondequoit Bay have been reduced.

REFERENCES CITED

American Public Health Association, American Water Works Association, and Water Pollution control Federation, 1995, Standard methods for the examination of water and wastewater: Washington, D.C., American Public Health Association, 19th ed., 1,134 p.

Britton, L.J., and Greeson, P.E., 1989, Methods for collection and analysis of aquatic biological and microbiological samples: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chap. A4, 363 p.

Bubeck, R. C. and Burton, R. S., 1989, Changes in chloride concentrations, mixing patterns, and stratification characteristics of Irondequoit Bay, Monroe County, New York, after decreased use of road-deicing salts, 1974-84: U.S. Geological Survey Water-Resources Investigation Report 87-4223, 52 p.

Cohn, T.A., Caulder, D.L., Gilroy, E.J., Zynjuk, L.D., and Summers, R.M., 1992, The validity of a simple statistical model for estimating fluvial constituent loads–An empirical study involving nutrient loads entering Chesapeake Bay: Water Resources Research, v. 28, no. 9, p. 2353-2363.

Fishman, M. J., and Friedman, L. C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chap. A1, 545 p.

Goerlitz, D.F., Brown, Eugene, 1972, Methods for analysis of organic substances in water: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chap. A3, 40 p.

Guy, H.P., and Norman, V.W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chap. C2, 59 p.

Heffner, R.L., and Goodman, S.D., 1973, Soil survey of Monroe County, New York: U.S. Department of Agriculture, 172 p.

Hem, J. D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Hirsch, R. M., Slack, J. R., and Smith, R. A., 1982, Techniques of trend analysis for monthly water quality data: Water Resources Research, v. 18, no. 1, p. 107-121.

Johnston, W.H., and Sherwood, D.A., 1994, Water Resources of Monroe County New York, Water Years 1984-88, part 1: U.S. Geological Survey Open-File Report 93-370, 311 p.

______ 1996, Water Resources of Monroe County New York, Water Years 1984-88, with emphasis on water quality in the Irondequoit Creek basin, part 2: U.S. Geological Survey Open-File Report 96-4054, 84 p.

Kappel, W. M., Yager, R. M., and Zarriello, P. J., 1986, Quantity and quality of urban storm runoff in the Irondequoit Creek basin near Rochester, New York, Part 2—Quality of storm runoff and atmospheric deposition, rainfall-runoff-quality modeling, and potential of wetlands for sediment and nutrient retention: U.S. Geological Survey Water-Resources Investigations Report 85-4113, 93 p.

Kappel, W. M. and Young, R. A., 1989, Glacial history and geohydrology of the Irondequoit Creek valley, Monroe County, New York: U.S. Geological Survey Water-Resources Investigations Report 88-4145, 34 p.

Lapham, W.W., 1989, Use of temperature profiles beneath streams to determine rates of vertical ground- water flow and vertical hydraulic conductivity: U.S. Geological Survey Water-Supply Paper 2337, 35 p.

National Oceanic and Atmospheric Administration, 1983-93, Climatological data annual summary, New York: Asheville, N.C., National Climatic Data Center, no. 13, v. 95-100, [issued annually].

Rantz, S. E., and others, 1982a, Measurement and computation of streamflow–volume 1, measurement of stage and discharge: U.S. Geological Survey Water-Supply Paper 2175, 284 p.

_____1982b, Measurement and computation of streamflow–volume 2, computation of discharge: U.S. Geological Survey Water-Supply Paper 2175, 347 p.

Schertz, T.L., Alexander, R.B., and Ohe, D.J., 1991, The computer program Estimate Trend (ESTREND), a system for the detection of trends in water-quality data: U.S. Geological Survey Water-Resources Investigations Report 91-4040, 63 p.

Sherwood, D.A., 1997, Water Resources of Monroe County New York, Water Years 1989-93, part 1: U.S. Geological Survey Open-File Report 97-587, 219 p.

Wagner, L.A., and Dixson, H.L., 1985, Drainage areas of New York streams by river basins—a stream gazetteer: U.S. Geological Survey Open-File Report 81-1055, 359 p.

Wood, W.W., 1976, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 1, Chap. D2, 24 p.

Yager, R.M., Zarriello, P.J., and Kappel, W.M., 1985, Geohydrology of the Irondequoit Creek basin near Rochester, New York: U.S. Geological Survey Water-Resources Investigations Report 84-4259, 6 pl.

Young, R. A., 1993, Analysis and recommendations for ground-water sampling program (1988-93), Irondequoit Creek basin, with emphasis on the Ellison Park-Browncroft Boulevard. reach: Monroe County Health Department, Rochester, N. Y., unpublished report, 20 p.

Zarriello, P.J. and Sherwood, D.A., 1993, Effect of stormwater detention on the chemical quality of runoff from a small residential development, Monroe County, New York: U.S. Geological Survey Water-Resources Investigations Report 92-4003, 57 p.

Zarriello, P.J., Harding, W.E., Yager, R.M., and Kappel, W.M., 1985, Quality and quantity of storm runoff in the Irondequoit Creek basin near Rochester, New York: U.S. Geological Survey Open-File Report 84-610, 44 p.

Zarriello, P. J. and Surface, J. M., 1989, Simulation of changes in stormwater quality at four potential flow-attenuation sites in the Irondequoit Creek watershed, Monroe County, New York: U.S. Geological Survey Water-Resources Investigations Report 88-4106, 52 p.

APPENDIX

Estimated monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, water years 1989-93.

Allen Creek near Rochester (1989-93) 43

Irondequoit Creek at Blossom Road (1989-93) 45

East Branch Allen Creek near Pittsford (1991-93) 47

Irondequoit Creek near Railroad Mills (1992-93) 48

Northrup Creek at North Greece (1990-93) 48

Irondequoit Creek at Pittsford (1990-93) 50

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, water years 1989-93

[Loads are in tons, Error when multiplied by 1.96 and added to or subtracted from the estimated load, provides the 95-percent confidence limits of the load estimate. Site locations are shown in fig. 2.]

Month	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
Allen Creek near Rochester (04232050)																		
WATER YEAR 1989																		
OCT	292	79.2	44.0	9.81	0.04	0.01	0.21	0.04	0.038	0.006	1.85	0.19	1.08	0.09	205	17.2	122	8.75
NOV	76.2	22.7	15.6	3.91	.01	.004	.07	.01	.012	.002	.80	.09	.61	.05	158	14.1	71.3	5.44
DEC	21.2	7.77	7.01	2.24	.01	.004	.03	.01	.004	.001	.46	.05	.47	.04	195	18.9	46.6	3.80
JAN	43.6	14.4	11.9	3.47	.04	.01	.05	.01	.006	.001	.79	.08	.91	.08	391	33.8	64.3	4.78
FEB	66.1	20.6	12.5	3.20	.04	.03	.06	.01	.006	.001	.92	.11	1.07	.10	375	34.2	68.8	5.39
MAR	332	73.7	47.5	8.77	.11	.04	.30	.06	.020	.003	3.86	.38	3.32	.26	730	57.8	193	13.3
APR	457	112	65.5	13.3	.14	.07	.45	.10	.027	.005	5.15	.57	3.92	.35	627	57.8	214	16.0
MAY	844	189	126	23.7	.30	.08	.86	.16	.069	.010	7.72	.77	5.67	.46	620	51.2	280	19.4
JUN	597	135	86.2	15.9	.30	.01	.94	.22	.133	.027	6.13	.70	4.26	.38	437	37.5	248	17.9
JUL	53.8	13.1	12.0	2.52	.05	.01	.13	.02	.018	.002	1.03	.09	.74	.05	132	10.2	98.2	6.56
AUG	74.3	19.0	15.9	3.47	.06	.01	.15	.02	.020	.003	1.20	.12	.72	.06	135	11.0	102	7.24
SEP	134	33.8	24.3	5.07	.04	.01	.13	.02	.019	.003	.98	.10	.69	.06	112	9.26	84.8	6.07
Total	2992	722	469	95.4	1.14	.29	3.37	.68	.374	.062	30.89	3.25	23.46	1.98	4117	353.0	1593.4	114.52

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (continued).

Allen Creek near Rochester (continued)

WATER YEAR 1990

Month	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
OCT	286	76.6	43.8	9.61	0.044	0.011	0.208	0.037	0.034	0.005	1.49	0.14	1.24	0.10	177	14.0	119	8.09
NOV	139	36.6	27.3	6.08	.029	.007	.128	.020	.019	.002	1.15	.11	1.16	.09	219	17.1	107	7.26
DEC	17.4	5.86	6.21	1.86	.011	.003	.025	.004	.003	.000	.32	.03	.47	.04	149	13.0	44.8	3.45
JAN	276	63.4	56.9	11.1	.198	.047	.258	.042	.032	.004	3.19	.31	4.00	.32	1040	81.3	175	11.7
FEB	902	193	127	22.9	.439	.102	.824	.140	.086	.012	8.26	.78	10.0	.79	1890	150	324	22.1
MAR	519	93.4	72.2	11.0	.185	.039	.464	.072	.030	.004	4.98	.43	5.78	.41	988	71.8	265	16.4
APR	773	165	110	19.6	.234	.060	.854	.177	.051	.009	7.40	.80	7.24	.64	810	70.4	298	21.2
MAY	774	169	119	21.5	.303	.076	.840	.168	.068	.011	6.05	.64	5.94	.50	510	42.0	258	17.9
JUN	146	27.0	27.6	4.35	.096	.020	.210	.030	.024	.003	1.51	.13	1.66	.12	185	13.2	124	7.71
JUL	109	22.2	21.2	3.66	.090	.019	.237	.036	.031	.004	1.56	.14	1.34	.10	178	13.4	137	8.90
AUG	162	41.6	29.9	6.08	.107	.032	.345	.084	.046	.009	2.06	.25	1.40	.13	187	16.6	146	11.0
SEP	204	49.7	35.9	7.29	.063	.017	.208	.038	.029	.004	1.33	.14	1.10	.09	144	11.8	114	8.15
Total	4308	943.54	676.07	124.95	1.799	.433	4.602	.848	.453	.068	39.31	3.90	41.33	3.33	6476	515.0	2111.7	143.89

WATER YEAR 1991

Month	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
OCT	548	161	77.0	18.9	0.076	0.020	0.409	0.074	0.064	0.009	2.34	0.24	2.26	0.19	246	20.1	171	12.2
NOV	207	60.8	37.4	9.17	.037	.010	.192	.034	.027	.004	1.41	.15	1.66	.14	248	20.3	127	9.08
DEC	443	120	90.0	20.4	.192	.064	.618	.158	.092	.020	4.83	.66	5.77	.64	947	95.1	221	17.5
JAN	203	50.3	43.3	8.89	.134	.036	.203	.038	.024	.004	2.16	.24	3.32	.29	767	64.2	137	9.72
FEB	249	57.0	41.6	7.93	.127	.032	.218	.039	.021	.003	2.24	.22	3.68	.30	764	63.2	145	10.2
MAR	818	216	112	25.0	.250	.081	1.13	.376	.108	.035	7.78	1.14	10.3	1.26	1250	130	315	24.6
APR	512	146	81.3	19.0	.143	.049	.680	.233	.045	.014	4.64	.70	5.41	.64	515	49.3	216	17.1
MAY	151	35.7	30.4	6.14	.063	.015	.156	.025	.011	.001	1.29	.12	1.80	.14	194	15.2	111	7.53
JUN	66.9	18.4	14.1	3.02	.039	.011	.110	.023	.013	.002	.70	.08	.97	.09	106	9.04	75.9	5.52
JUL	60.2	13.7	13.1	2.53	.044	.010	.145	.023	.019	.002	.87	.08	.93	.07	121	9.44	98.1	6.58
AUG	62.1	15.3	14.4	3.02	.037	.009	.131	.022	.017	.002	.82	.08	.73	.06	110	8.67	92.3	6.36
SEP	113	31.9	22.2	4.98	.027	.007	.119	.023	.017	.003	.71	.08	.73	.06	96.7	8.08	80.1	5.84
Total	3431.9	926.5	576.4	128.97	1.170	.344	4.115	1.067	.456	.100	29.81	3.77	37.60	3.88	5364.2	493.08	1788.8	132.27

WATER YEAR 1992

Month	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
OCT	131	36.0	25.0	5.87	0.018	0.004	0.111	0.017	0.017	0.002	0.67	0.06	0.86	0.07	111	8.92	84.4	5.94
NOV	61.3	18.0	14.2	3.53	.010	.003	.068	.012	.010	.001	.49	.06	.74	.07	125	11.2	66.1	5.00
DEC	75.2	21.8	18.6	4.27	.027	.010	.093	.022	.012	.002	.84	.11	1.28	.13	279	27.3	76.7	6.06
JAN	70.2	18.9	18.4	4.14	.040	.011	.077	.014	.009	.001	.84	.09	1.61	.14	429	35.3	80.1	5.62
FEB	171	37.2	29.0	5.34	.059	.014	.157	.027	.014	.002	1.52	.15	2.73	.22	575	46.9	118	8.30
MAR	571	137	81.6	16.0	.115	.033	.732	.214	.050	.013	5.14	.67	6.82	.69	875	74.3	257	18.7
APR	562	121	87.5	16.0	.112	.027	.595	.109	.033	.005	4.57	.44	5.57	.44	598	47.4	246	16.6
MAY	312	79.8	54.7	11.1	.075	.022	.353	.083	.025	.005	2.40	.29	3.05	.29	289	25.7	152	11.0
JUN	143	27.7	27.4	4.39	.051	.012	.223	.034	.025	.003	1.31	.12	1.67	.13	174	13.1	117	7.54
JUL	297	69.2	48.3	9.00	.114	.032	.793	.174	.116	.021	3.50	.41	2.89	.27	300	25.9	215	15.7
AUG	498	127	77.3	16.0	.124	.038	1.09	.252	.169	.032	4.53	.57	3.05	.31	317	30.0	226	18.2
SEP	240	58.4	40.5	8.06	.034	.009	.259	.048	.038	.006	1.35	.15	1.19	.11	150	12.6	114	8.36
Total	3132.2	752.0	522.4	103.64	.779	.214	4.548	1.006	.518	.093	27.16	3.12	31.46	2.85	4224	358.64	1750.9	127.06

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (continued).

Month	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
Allen Creek near Rochester (continued)																		
WATER YEAR 1993																		
OCT	147	40.5	26.5	6.10	0.012	0.003	0.130	0.023	0.021	0.003	0.72	0.08	0.88	0.08	118	9.94	83.5	6.12
NOV	365	103	62.0	14.6	.030	.009	.390	.073	.060	.009	2.29	.26	2.62	.24	374	32.6	170	12.6
DEC	308	76.6	65.3	13.3	.062	.020	.420	.090	.061	.011	3.15	.41	3.92	.41	764	73.0	175	13.6
JAN	392	91.0	78.3	15.2	.105	.028	.442	.080	.059	.009	3.81	.43	5.47	.50	1242	104	201	14.4
FEB	56.7	15.7	13.6	3.25	.016	.004	.065	.010	.007	.001	.68	.07	1.36	.11	388	32.7	74.7	5.50
MAR	930	210	125	23.7	.100	.028	1.24	.275	.088	.016	8.19	.96	9.40	.90	1241	109	336	26.1
APR	885	206	130	25.0	.093	.027	1.23	.308	.085	.019	7.84	.98	8.45	.88	935	90.3	323	25.1
MAY	70.6	20.1	17.1	4.21	.012	.004	.093	.016	.007	.001	.72	.08	1.02	.10	142	12.9	75.4	5.99
JUN	200	48.4	36.3	6.81	.036	.011	.328	.067	.041	.007	1.77	.22	1.91	.20	215	19.3	130	9.96
JUL	35.5	10.5	8.79	2.21	.010	.003	.111	.022	.017	.003	.61	.07	.59	.06	101	9.45	74.4	6.10
AUG	46.2	13.6	11.6	2.96	.010	.003	.120	.022	.018	.003	.69	.08	.55	.06	105	9.69	79.0	6.42
SEP	245	66.9	41.7	9.43	.019	.006	.130	.064	.050	.008	1.54	.21	.113	.13	169	16.6	117	9.99
Total	3680.1	903.3	615.52	126.78	.505	.144	4.878	1.050	.515	.088	31.00	3.83	37.30	3.67	5795	519.60	1838.8	141.89
Irondequoit Creek at Blossom Road (0423205010)																		
WATER YEAR 1989																		
OCT	2798	952	439	127	0.127	0.026	1.38	0.399	0.104	0.017	7.16	0.98	4.63	0.23	634	28.0	1016	42.5
NOV	1495	478	260	76.0	.108	.019	.70	.145	.059	.008	4.85	.55	4.55	.21	674	28.6	975	40.2
DEC	832	247	175	47.9	.101	.017	.40	.073	.035	.004	3.87	.41	4.90	.21	814	33.5	925	37.2
JAN	907	243	195	48.0	.128	.022	.40	.076	.036	.004	4.67	.50	6.64	.29	1122	46.2	961	38.7
FEB	1159	340	200	51.0	.147	.028	.43	.105	.032	.005	4.82	.60	7.00	.33	1112	48.4	895	37.6
MAR	5571	1442	687	154	.399	.075	1.98	.488	.077	.011	14.9	1.78	15.5	.70	1852	76.3	1496	59.7
APR	11026	3205	1201	298	.568	.130	4.85	1.42	.126	.022	24.5	3.49	17.7	.93	1722	79.9	1555	64.8
MAY	19370	4966	2282	509	.781	.161	12.2	3.12	.311	.048	46.3	5.92	22.3	1.07	1820	78.6	1853	75.3
JUN	11546	3209	1426	337	.519	.111	9.93	2.92	.394	.069	34.6	4.74	14.7	.72	1237	53.6	1490	60.9
JUL	1767	364	265	49.9	.154	.025	1.51	.266	.104	.012	7.79	.78	4.70	.19	549	21.3	892	34.1
AUG	1231	312	189	41.6	.112	.020	1.13	.250	.081	.011	5.59	.64	3.37	.15	443	17.8	770	29.8
SEP	1129	290	186	41.7	.098	.018	.96	.216	.081	.011	4.90	.57	3.23	.14	444	18.1	768	30.2
Total	58830	16049	7504	1782	3.239	.653	35.82	9.470	1.440	.221	163.84	20.96	109.16	5.18	12426	530.5	13595	550.9
WATER YEAR 1990																		
OCT	1458	396	232	55.2	0.124	0.023	1.11	0.251	0.104	0.014	5.87	0.69	4.65	0.21	607	24.8	964	37.6
NOV	934	254	161	40.2	.119	.020	.674	.120	.068	.008	4.59	.46	5.16	.21	713	27.9	999	38.6
DEC	377	106	79.9	20.6	.086	.014	.286	.052	.031	.004	2.71	.28	4.25	.18	693	27.3	813	31.5
JAN	2161	527	391	84.6	.327	.058	1.50	.326	.118	.016	13.1	1.46	16.6	.72	2147	86.2	1484	57.8
FEB	7572	1903	1007	225	.856	.168	5.23	1.25	.285	.042	33.4	4.04	34.2	1.59	3563	152	1970	81.0
MAR	4708	1059	568	113	.537	.095	2.53	.550	.116	.016	18.1	2.00	21.2	.91	2303	90.9	1692	64.2
APR	14021	3652	1430	318	1.03	.227	10.6	2.97	.271	.046	42.0	5.63	29.8	1.47	2457	108	1987	79.8
MAY	11836	3017	1403	311	.761	.156	11.5	3.01	.354	.056	41.7	5.36	22.7	1.07	1764	73.9	1796	71.0
JUN	1740	336	265	46.3	.196	.032	1.72	.301	.112	.013	9.50	.94	6.88	.28	697	26.8	1000	37.8
JUL	975	202	147	27.3	.136	.022	1.17	.215	.095	.011	6.13	.62	4.41	.18	506	19.5	829	31.3
AUG	1418	475	191	51.8	.148	.033	1.86	.626	.125	.023	7.64	1.19	4.55	.24	525	22.8	841	33.3
SEP	775	195	127	27.7	.098	.018	.894	.201	.085	.011	4.62	.53	3.52	.15	464	18.7	787	30.7
Total	47973	12123	6001.8	1320.4	4.415	.865	39.057	9.872	1.763	.260	189.33	23.20	157.90	7.20	16439	678.2	15163	594.5

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (continued).

	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
Month	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
Irondequoit Creek at Blossom Road																		
WATER YEAR 1991																		
OCT	2100	557	305	71.2	0.203	0.038	2.18	0.507	0.200	0.028	10.1	1.20	7.92	0.36	891	36.8	1251	49.7
NOV	1411	380	219	53.7	.194	.034	1.34	.261	.131	.017	8.09	.86	8.90	.38	1055	42.7	1299	51.6
DEC	3662	1146	554	150	.511	.121	4.53	1.52	.293	.055	22.7	3.38	22.2	1.14	2324	104	1807	72.8
JAN	2702	699	451	102	.472	.090	2.68	.687	.203	.031	19.5	2.35	24.2	1.09	2786	114	1765	69.7
FEB	2303	564	343	76.0	.426	.079	1.76	.388	.132	.018	15.1	1.74	21.5	.97	2501	104	1539	61.7
MAR	7244	1776	798	172	.929	.189	5.98	1.58	.256	.043	32.6	4.12	35.0	1.62	3271	136	2125	82.2
APR	7794	2174	842	198	.747	.162	7.40	2.44	.213	.039	31.2	4.32	25.7	1.19	2183	89.0	1893	73.8
MAY	2753	558	383	70.0	.316	.052	2.42	.425	.113	.013	14.7	1.45	12.9	.53	1195	46.2	1397	53.0
JUN	682	170	110	23.6	.117	.021	.829	.186	.066	.009	5.08	.58	4.60	.20	505	20.4	794	31.1
JUL	538	118	83.7	16.5	.102	.017	.766	.144	.072	.009	4.39	.46	3.76	.16	446	17.4	759	29.0
AUG	467	107	74.8	15.3	.087	.014	.679	.130	.066	.008	3.81	.40	3.21	.13	420	16.3	739	28.1
SEP	327	85.2	58.2	13.5	.062	.011	.436	.089	.052	.007	2.63	.29	2.55	.11	366	14.9	670	26.7
Total	31984	8335.6	4221.2	961.2	4.166	.827	30.996	8.347	1.795	.276	169.95	21.15	172.58	7.88	17943	741.3	16038	629.5
WATER YEAR 1992																		
OCT	320	80.6	58.0	13.4	0.065	0.011	0.371	0.068	0.052	0.006	2.51	0.26	3.07	0.13	442	17.7	779	30.9
NOV	265	77.6	49.0	13.1	.068	.012	.283	.056	.039	.005	2.31	.26	3.75	.17	547	23.0	817	33.4
DEC	409	124	76.9	20.4	.105	.021	.419	.108	.046	.007	3.84	.50	6.53	.32	929	40.0	980	39.4
JAN	391	97.0	80.9	18.2	.128	.022	.348	.069	.042	.005	4.33	.46	8.87	.38	1336	53.0	1072	41.4
FEB	653	163	104	23.6	.170	.031	.454	.096	.043	.006	5.39	.62	10.8	.49	1492	62.0	1100	44.2
MAR	3915	1253	419	111	.510	.123	3.36	1.20	.131	.026	18.7	2.92	22.7	1.14	2295	96.8	1713	67.6
APR	4854	1094	555	110	.528	.096	3.86	.889	.140	.019	22.9	2.58	23.6	1.01	2121	84.1	1892	72.6
MAY	2816	813	366	85.5	.300	.064	2.72	.843	.116	.018	15.3	2.04	13.6	.64	1241	51.4	1433	55.2
JUN	1172	239	177	32.2	.159	.027	1.34	.250	.101	.012	8.55	.88	7.53	.31	758	29.4	1079	40.7
JUL	4161	1242	476	118	.364	.083	6.95	2.36	.404	.076	24.6	3.60	13.6	.68	1183	50.5	1504	59.2
AUG	6464	1871	727	180	.471	.107	11.6	3.61	.620	.114	34.7	5.00	16.6	.83	1447	63.0	1744	69.7
SEP	1779	393	257	50.3	.169	.030	2.14	.442	.189	.025	11.1	1.22	8.20	.35	920	36.8	1310	51.0
Total	27199	7447.7	3345.5	775.1	3.035	.625	33.838	9.985	1.923	.320	154.26	20.33	138.85	6.46	14713	607.8	15425	605.2
WATER YEAR 1993																		
OCT	1134	272	175	37.3	0.130	0.022	1.16	.234	0.132	0.017	7.26	0.78	7.46	0.32	901	35.9	1314	51.1
NOV	2124	598	304	76.7	.243	.046	2.21	.510	.205	.029	13.2	1.56	14.6	.67	1587	67.0	1768	71.8
DEC	2065	578	332	82.0	.305	.062	2.16	.567	.178	.028	16.0	2.05	20.7	.98	2356	101	1918	76.7
JAN	2768	655	460	98.2	.444	.079	2.54	.532	.213	.028	22.9	2.50	32.4	1.40	3720	151	2259	89.6
FEB	775	180	132	28.7	.172	.029	.485	.089	.050	.006	6.76	.70	14.1	.60	1967	80.2	1377	55.5
MAR	7193	2396	725	204	.706	.182	6.30	2.28	.215	.044	31.8	5.18	34.6	1.85	3289	146	2266	94.6
APR	11016	3093	1122	266	.908	.219	9.80	3.09	.295	.056	46.2	6.53	40.9	2.12	3356	153	2609	109
MAY	1758	373	256	49.0	.181	.031	1.25	.225	.067	.008	10.5	1.08	11.5	.49	1180	47.4	1457	57.6
JUN	1496	339	222	44.4	.148	.027	1.40	.291	.102	.013	10.1	1.12	8.93	.40	911	37.3	1271	50.8
JUL	556	126	87.1	17.9	.076	.013	.603	.113	.060	.007	4.58	.48	4.44	.19	557	22.5	944	37.9
AUG	453	106	74.2	16.0	.060	.010	.485	.089	.051	.006	3.71	.39	3.58	.16	504	20.4	896	36.1
SEP	873	214	140	30.5	.079	.015	.802	.171	.083	.011	5.75	.66	5.19	.24	693	29.2	1119	46.5
Total	32209	8931	4027.5	951.1	3.452	.737	29.208	8.193	1.652	.255	178.64	23.05	198.37	9.41	21022	890.9	19198	777.2

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (continued).

Month	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
East Branch Allen Creek near Pittsford (0423204920)																		
WATER YEAR 1991																		
OCT	82.4	34.1	13.7	5.08	0.024	0.008	0.143	0.043	0.036	0.007	0.82	0.13	1.02	0.17	60.1	6.15	70.7	6.86
NOV	39.7	18.0	6.15	2.62	.014	.004	.069	.018	.012	.002	.56	.08	.90	.14	54.2	5.04	44.9	3.97
DEC	144	68.7	21.2	8.87	.046	.019	.276	.106	.046	.011	1.55	.30	3.07	.64	158	17.1	72.8	7.03
JAN	91.4	34.5	15.5	5.35	.027	.010	.101	.027	.016	.003	.74	.13	1.61	.31	152	14.2	56.5	4.96
FEB	94.9	34.2	16.3	5.28	.029	.010	.084	.022	.010	.002	.70	.11	1.54	.27	130	12.2	50.4	4.39
MAR	389	135	54.3	16.7	.101	.045	.446	.182	.039	.011	2.74	.52	5.66	1.10	206	20.5	104	9.13
APR	291	114	35.4	12.0	.059	.027	.291	.125	.026	.007	1.40	.28	2.75	.54	104	10.2	85.0	7.91
MAY	58.0	21.2	8.09	2.73	.019	.007	.048	.012	.006	.001	.28	.06	.48	.08	42.9	3.92	51.3	4.49
JUN	33.9	13.0	4.83	1.58	.016	.006	.045	.013	.007	.001	.22	.04	.27	.05	29.9	2.66	47.0	3.93
JUL	31.1	10.8	4.48	1.43	.006	.002	.045	.010	.007	.001	.24	.04	.22	.04	26.1	2.31	45.0	3.78
AUG	24.7	11.9	4.06	1.91	.002	.001	.033	.008	.006	.001	.18	.03	.14	.03	20.6	2.01	34.5	3.26
SEP	25.4	10.8	5.24	2.05	.004	.001	.031	.008	.007	.001	.18	.03	.16	.03	23.8	2.34	36.0	3.47
Total	1306.1	506.5	189.24	65.62	.348	.139	1.612	.576	.218	.049	9.62	1.76	17.83	3.40	1008.6	98.69	697.9	63.18
WATER YEAR 1992																		
OCT	25.6	9.40	5.31	1.85	0.009	0.003	0.036	0.008	0.007	0.001	0.25	0.04	0.29	0.06	31.1	2.96	39.3	3.59
NOV	10.1	4.67	1.93	.87	.005	.002	.016	.005	.002	.000	.15	.03	.21	.04	23.0	2.55	20.9	2.22
DEC	19.8	9.25	3.49	1.42	.006	.002	.026	.009	.003	.001	.20	.04	.38	.08	41.3	4.63	21.9	2.29
JAN	27.1	9.85	5.54	1.81	.010	.003	.025	.007	.003	.001	.22	.03	.45	.08	72.3	6.77	28.6	2.53
FEB	68.8	23.9	12.7	3.90	.021	.006	.051	.012	.004	.001	.45	.06	1.01	.16	94.1	8.42	39.7	3.36
MAR	317	118	44.0	13.9	.065	.025	.297	.122	.019	.005	1.74	.31	3.74	.70	144	13.1	82.4	7.24
APR	288	90.6	37.8	10.35	.049	.015	.209	.056	.015	.002	1.18	.17	2.55	.37	108	9.55	87.9	7.30
MAY	147	56.4	19.9	6.52	.045	.018	.131	.042	.013	.002	.60	.12	1.12	.21	68.3	6.33	77.7	6.59
JUN	45.3	14.7	6.64	1.89	.022	.008	.056	.013	.008	.001	.27	.05	.35	.06	36.4	3.01	55.9	4.36
JUL	169	64.5	21.5	7.11	.028	.011	.320	.112	.046	.010	1.07	.21	1.07	.23	61.3	6.19	99.2	9.56
AUG	342	138	49.0	17.3	.031	.014	.726	.273	.142	.034	1.91	.41	1.72	.37	81.8	9.16	122	13.7
SEP	81.5	34.6	14.4	5.17	.009	.003	.114	.042	.024	.006	.45	.09	.46	.09	39.3	3.92	56.5	5.59
Total	1540.5	573.11	222.27	72.11	.301	.111	2.007	.701	.286	.065	8.48	1.57	13.37	2.45	801.8	76.63	731.9	68.30
WATER YEAR 1993																		
OCT	23.1	9.29	4.55	1.76	0.009	0.004	0.037	0.011	0.006	0.001	0.24	0.05	.30	0.07	28.1	2.95	34.2	3.39
NOV	101	44.4	15.7	7.52	.038	.016	.188	.052	.024	.004	1.16	.24	2.06	.45	97.2	9.56	77.4	7.15
DEC	121	46.3	19.0	6.65	.037	.013	.195	.058	.024	.005	1.14	.20	2.50	.46	147	14.6	68.5	6.18
JAN	131	41.5	23.2	6.40	.046	.013	.157	.040	.019	.003	1.01	.16	2.40	.39	202	17.9	72.9	6.06
FEB	22.9	8.27	4.63	1.53	.010	.003	.021	.005	.002	.000	.22	.03	.47	.07	68.2	6.30	27.1	2.39
MAR	402	153	51.2	16.8	.088	.032	.486	.167	.030	.007	2.68	.48	6.00	1.16	184	18.6	101	9.94
APR	333	131	40.7	13.9	.072	.029	.410	.166	.027	.007	2.06	.41	4.48	.93	135	14.6	94.2	9.26
MAY	15.7	6.57	2.32	.92	.007	.003	.016	.004	.002	.000	.11	.02	.19	.03	23.7	2.56	27.2	2.95
JUN	65.1	23.9	8.43	2.77	.032	.012	.105	.029	.015	.003	.47	.09	.68	.13	51.8	5.08	73.0	6.95
JUL	25.8	9.56	3.47	1.19	.006	.002	.048	.012	.007	.001	.26	.04	.27	.05	28.3	2.82	44.6	4.43
AUG	31.7	15.9	4.74	2.32	.003	.001	.055	.014	.010	.002	.29	.04	.27	.05	30.3	3.11	44.9	4.82
SEP	34.8	16.5	5.93	2.59	.005	.002	.059	.017	.013	.003	.30	.05	.33	.06	33.1	3.65	44.2	5.07
Total	1306.4	505.90	183.94	64.38	.351	.129	1.777	.573	.180	.035	9.95	1.84	19.95	3.86	1029.3	101.64	708.7	68.59

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (continued).

	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
Month	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
Irondequoit Creek near Railroad Mills (04232034)																		
WATER YEAR 1992																		
OCT	268	171	49.8	25.1	0.027	0.017	0.078	0.025	0.009	0.001	0.31	0.12	1.43	0.19	75.5	5.55	466	47.1
NOV	276	160	53.0	24.3	.024	.010	.085	.022	.007	.001	.60	.12	1.56	.14	95.5	5.59	469	36.5
DEC	228	109	48.1	18.1	.035	.007	.106	.025	.010	.001	1.10	.14	2.43	.15	147	7.13	556	35.1
JAN	269	123	49.1	17.5	.050	.010	.095	.020	.013	.001	1.14	.15	3.09	.20	175	8.08	555	34.4
FEB	666	387	89.6	41.0	.059	.009	.111	.023	.018	.002	1.13	.11	3.34	.18	169	7.32	457	25.9
MAR	1458	570	184	56.6	.108	.020	.453	.140	.042	.005	2.85	.38	6.21	.38	273	11.3	619	32.8
APR	580	168	92.1	20.9	.067	.017	.289	.064	.024	.003	2.50	.32	4.84	.32	265	12.2	648	40.5
MAY	170	78.7	29.9	10.9	.041	.031	.227	.065	.017	.002	2.01	.91	2.32	.49	185	10.3	576	43.6
JUN	187	67.5	25.5	6.83	.035	.033	.168	.039	.015	.002	1.56	1.12	1.08	.35	121	6.10	467	32.0
JUL	844	224	86.5	17.7	.154	.061	.926	.290	.077	.012	5.56	2.15	2.58	.48	204	11.0	678	51.8
AUG	711	178	85.1	16.3	.121	.027	.984	.293	.084	.012	3.30	.58	4.00	.32	207	10.5	638	49.1
SEP	332	84.6	49.8	9.94	.036	.014	.391	.091	.035	.004	.78	.34	3.05	.31	146	7.04	475	33.2
Total	5990	2320.1	840.2	265.31	.758	.256	3.913	1.097	.351	.046	22.86	6.44	35.93	3.53	2062.3	102.13	6607	461.9
WATER YEAR 1993																		
OCT	476	120	70.6	13.9	0.021	0.017	0.519	0.131	0.034	0.004	1.00	0.58	2.97	0.40	167	8.65	524	35.8
NOV	698	161	107	19.2	.032	.019	.936	.224	.044	.005	3.20	1.19	4.25	.44	262	12.7	677	42.8
DEC	388	93.7	66.8	12.6	.038	.010	.650	.162	.034	.004	4.18	.71	4.95	.36	291	13.6	639	38.4
JAN	551	181	85.0	21.7	.060	.015	.650	.148	.049	.006	5.23	.90	6.56	.50	370	17.8	722	45.0
FEB	582	318	71.6	30.8	.028	.007	.172	.040	.018	.002	1.77	.29	3.43	.26	189	9.73	376	25.5
MAR	1926	644	214	56.9	.076	.016	1.20	.350	.062	.008	7.16	.99	7.90	.51	348	15.7	593	36.0
APR	1458	429	187	42.6	.094	.022	1.75	.448	.077	.009	11.7	1.76	9.37	.69	461	20.8	837	51.3
MAY	205	103	34.8	13.8	.021	.016	.316	.085	.016	.002	3.97	2.17	2.21	.53	205	12.5	557	49.6
JUN	277	119	34.0	11.7	.022	.020	.314	.089	.017	.003	3.91	3.17	1.09	.40	141	8.95	490	48.8
JUL	402	164	40.7	13.1	.024	.009	.193	.056	.013	.002	2.52	1.56	.93	.23	90.8	5.97	348	38.4
AUG	325	142	39.3	13.5	.016	.006	.156	.043	.011	.002	1.38	.46	1.30	.15	80.0	4.97	304	33.6
SEP	349	127	52.3	15.0	.013	.004	.243	.068	.015	.002	1.25	.24	1.74	.17	95.8	5.90	370	41.5
Total	7636	2602.6	1002.8	264.7	.445	.161	7.101	1.845	.389	.049	47.31	14.02	46.70	4.64	2701.1	137.30	6438	485.8
Northrup Creek at North Greece (0422026250)																		
WATER YEAR 1990																		
OCT	195	97.7	34.8	15.6	0.044	0.011	0.352	0.037	0.269	0.037	0.91	0.08	1.27	0.10	52.5	3.79	60.7	4.24
NOV	131	66.1	27.8	12.4	.096	.025	.256	.026	.163	.022	.95	.09	1.25	.10	70.5	5.02	62.1	4.26
DEC	32.4	17.0	7.24	3.33	.100	.028	.102	.012	.070	.011	.37	.04	.63	.06	40.7	3.25	24.9	1.95
JAN	506	215	65.2	24.4	.950	.257	.450	.051	.223	.033	2.63	.27	3.02	.26	211	16.3	105	7.87
FEB	791	312	82.3	28.9	.865	.246	.695	.084	.273	.041	3.65	.40	4.51	.40	252	19.9	146	11.1
MAR	364	146	37.1	13.2	.159	.047	.247	.031	.105	.015	1.33	.15	2.05	.17	110	8.37	68.8	5.06
APR	779	318	95.3	33.4	.113	.038	.438	.063	.124	.018	2.41	.31	2.21	.20	124	10.1	72.4	5.70
MAY	1058	401	161	55.5	.093	.032	.926	.145	.297	.049	3.34	.46	2.64	.22	120	10.4	76.6	6.41
JUN	71.3	26.5	13.5	4.31	.017	.004	.246	.025	.176	.023	.45	.04	.61	.05	27.6	1.93	23.3	1.57
JUL	24.8	8.94	5.45	1.69	.013	.003	.204	.020	.139	.018	.31	.03	.43	.03	19.3	1.29	18.9	1.22
AUG	22.0	8.18	4.36	1.37	.011	.003	.163	.016	.117	.015	.26	.02	.36	.03	15.4	1.08	14.8	1.00
SEP	26.1	9.08	4.77	1.44	.010	.002	.161	.016	.159	.021	.24	.02	.42	.03	14.8	1.02	15.0	1.00
Total	3999.9	1626.21	539.10	195.54	2.472	.697	4.240	.524	2.115	.302	16.84	1.91	19.03	1.64	1058.6	82.33	688.4	51.38

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (continued).

Month	Total suspended solids Load	Total suspended solids Error	Volatile suspended solids Load	Volatile suspended solids Error	Nitrogen, ammonia as N, dissolved Load	Nitrogen, ammonia as N, dissolved Error	Total phosphorus as P Load	Total phosphorus as P Error	Ortho-phosphate as P, dissolved Load	Ortho-phosphate as P, dissolved Error	Ammonia plus organic nitrogen as N, total Load	Ammonia plus organic nitrogen as N, total Error	Nitrite plus nitrate as N, total Load	Nitrite plus nitrate as N, total Error	Dissolved chloride Load	Dissolved chloride Error	Dissolved sulfate Load	Dissolved sulfate Error
Northrup Creek at North Greece (continued)																		
WATER YEAR 1991																		
OCT	66.7	28.0	12.1	4.25	0.022	0.006	0.259	0.028	0.246	0.033	0.52	0.06	0.84	0.07	31.8	2.35	33.2	2.37
NOV	28.9	12.2	6.52	2.31	.036	.009	.152	.016	.130	.018	.39	.04	.68	.06	33.9	2.46	27.6	1.95
DEC	251	102	45.7	16.1	.637	.259	.638	.112	.232	.038	3.06	.47	2.44	.25	170	15.3	83.1	7.01
JAN	225	84.5	28.5	9.14	.572	.164	.358	.042	.209	.029	1.75	.19	2.24	.19	147	11.2	66.4	4.87
FEB	240	94.2	24.0	8.42	.365	.112	.331	.040	.188	.028	1.51	.17	2.40	.21	131	10.3	67.7	5.15
MAR	459	165	50.5	16.8	.299	.134	.859	.206	.212	.041	3.39	.59	3.61	.39	178	15.7	100	8.68
APR	596	246	82.8	32.7	.102	.047	1.046	.325	.183	.041	3.64	.83	2.47	.30	128	12.5	67.3	6.41
MAY	181	68.2	25.6	8.35	.024	.006	.249	.026	.158	.021	.72	.07	.92	.07	47.0	3.36	27.4	1.89
JUN	21.1	8.82	4.49	1.65	.009	.002	.203	.022	.164	.023	.26	.03	.44	.04	17.7	1.31	14.0	1.01
JUL	10.3	3.97	2.42	.81	.008	.002	.186	.019	.138	.018	.22	.02	.35	.03	14.2	.99	13.0	.87
AUG	9.34	3.56	1.96	.65	.007	.002	.149	.015	.115	.015	.18	.02	.29	.02	11.4	.80	10.2	.70
SEP	10.7	4.34	2.06	.72	.006	.001	.142	.015	.149	.021	.16	.02	.32	.03	10.4	.77	9.90	.72
Total	2098.41	820.64	268.64	101.82	2.088	.746	4.573	.864	2.124	.326	15.80	2.50	16.99	1.64	920.8	77.06	520.10	41.64
WATER YEAR 1992																		
OCT	7.38	3.25	1.64	0.64	0.006	0.002	0.129	0.015	0.156	0.024	0.14	0.02	0.36	0.03	11.3	0.91	11.4	0.90
NOV	5.11	2.57	1.36	.59	.014	.005	.094	.012	.091	.015	.15	.02	.37	.04	15.9	1.43	12.0	1.03
DEC	24.0	12.2	4.15	1.65	.082	.030	.118	.014	.088	.031	.36	.05	.62	.06	38.0	3.39	18.4	1.54
JAN	144	66.1	16.7	6.52	.354	.125	.314	.046	.184	.028	1.32	.19	1.85	.18	112	9.70	48.3	4.07
FEB	215	87.6	20.2	7.51	.271	.079	.347	.042	.195	.028	1.48	.17	2.52	.21	132	10.3	66.0	4.99
MAR	441	182	47.4	18.1	.151	.049	.649	.135	.174	.027	2.82	.46	3.11	.29	157	12.8	82.9	6.49
APR	771	315	85.3	30.6	.090	.025	.576	.073	.180	.024	2.86	.32	2.74	.22	153	10.8	76.0	5.21
MAY	497	200	65.0	22.4	.044	.015	.551	.074	.244	.034	1.90	.25	1.74	.16	90.7	7.31	49.4	3.75
JUN	66.1	23.2	11.2	3.30	.013	.004	.306	.031	.215	.028	.51	.05	.70	.06	30.9	2.19	22.7	1.54
JUL	51.5	18.2	9.09	2.56	.016	.005	.344	.037	.200	.026	.59	.06	.68	.06	31.2	2.31	26.6	1.90
AUG	68.5	23.4	10.9	3.09	.018	.005	.337	.037	.194	.026	.66	.07	.72	.06	32.8	2.50	27.4	2.02
SEP	47.2	17.7	7.15	2.16	.010	.003	.243	.025	.210	.028	.38	.04	.61	.05	21.8	1.59	19.7	1.41
Total	2338.98	951.50	280.01	99.18	1.069	.345	4.008	.541	2.131	.303	13.18	1.69	16.02	.34	826.5	65.16	460.8	34.85
WATER YEAR 1993																		
OCT	40.0	13.6	7.02	2.02	0.013	0.003	0.238	0.024	0.230	0.031	0.40	0.04	0.78	0.06	28.4	2.01	26.7	1.84
NOV	155	50.7	28.5	7.94	.093	.026	.488	.053	.270	.037	1.62	.16	1.95	.16	106	7.74	74.0	5.19
DEC	291	103	46.6	13.8	.442	.158	.664	.095	.240	.036	3.17	.41	2.80	.26	194	16.0	87.5	6.80
JAN	489	167	56.1	16.4	.722	.206	.755	.092	.311	.045	3.71	.41	4.07	.35	264	20.0	109	8.06
FEB	104	39.0	9.59	3.38	.124	.035	.187	.021	.123	.018	.70	.07	1.61	.14	82.2	6.34	40.3	3.03
MAR	829	354	85.1	32.5	.173	.051	.933	.142	.204	.031	4.36	.58	4.49	.41	225	18.2	117	9.18
APR	663	300	70.7	28.1	.077	.031	.623	.119	.142	.023	2.83	.45	2.73	.28	143	12.4	71.7	6.12
MAY	121	46.2	16.3	5.31	.011	.003	.204	.022	.116	.016	.50	.05	.77	.06	36.1	2.66	20.3	1.46
JUN	60.2	21.4	9.68	2.77	.008	.002	.256	.028	.160	.023	.39	.04	.59	.05	24.8	1.95	18.3	1.38
JUL	7.39	2.95	1.66	.58	.004	.001	.165	.019	.100	.015	.16	.02	.30	.03	10.9	.87	9.81	.76
AUG	4.89	2.16	1.08	.44	.003	.001	.126	.015	.079	.012	.11	.01	.23	.02	7.84	.65	7.01	.58
SEP	14.4	5.54	2.51	.86	.004	.001	.146	.017	.119	.018	.16	.02	.35	.03	10.9	.87	10.3	.82
Total	2778.35	1105.80	334.83	114.10	1.675	.518	4.786	.647	2.094	.305	18.11	2.26	20.68	1.85	1132.34	89.64	592.87	45.22

Appendix. Monthly chemical loads and associated error for the five Irondequoit Creek basin sites and Northrup Creek, Monroe County, N.Y., water years 1989-93 (continued).

Irondequoit Creek at Pittsford (04232040)

WATER YEAR 1989

	Total suspended solids		Volatile suspended solids		Nitrogen, ammonia as N, dissolved		Total phosphorus as P		Ortho-phosphate as P, dissolved		Ammonia plus organic nitrogen as N, total		Nitrite plus nitrate as N, total		Dissolved chloride		Dissolved sulfate	
Month	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
OCT	31.5	18.3	7.07	4.97	0.019	0.004	0.052	0.013	0.012	0.002	0.93	0.14	1.38	0.09	96.5	4.00	476	36.5
NOV	61.7	43.9	12.7	10.9	.034	.007	.057	.014	.012	.002	1.29	.19	2.00	.13	136	5.41	553	40.4
DEC	48.0	33.7	11.6	9.87	.041	.008	.033	.007	.006	.001	.75	.11	1.89	.12	119	4.63	458	33.2
JAN	70.9	37.5	17.7	11.4	.048	.009	.057	.012	.009	.001	1.00	.13	2.32	.13	139	5.05	444	29.9
FEB	104	41.3	23.1	11.3	.031	.006	.079	.020	.009	.001	1.19	.16	2.18	.12	130	4.66	379	25.0
MAR	459	120	75.7	24.1	.053	.009	.262	.060	.018	.002	3.00	.38	3.33	.17	226	7.32	567	33.4
APR	770	192	121	36.6	.090	.015	.481	.129	.025	.004	3.94	.56	3.73	.20	249	8.30	611	36.0
MAY	1236	342	213	71.1	.245	.042	1.10	.276	.071	.010	6.34	.86	5.70	.31	309	10.3	749	45.4
JUN	580	195	122	49.7	.181	.029	.571	.164	.066	.010	3.70	.52	4.21	.23	199	3.77	597	36.6
JUL	114	64.0	27.6	19.0	.061	.010	.105	.023	.017	.002	.88	.11	1.96	.10	95.1	3.27	406	25.9
AUG	54.6	34.4	11.4	8.72	.038	.007	.079	.018	.011	.001	.54	.07	1.37	.09	78.9	3.07	372	26.9
SEP	60.0	29.0	10.4	6.23	.027	.006	.101	.025	.012	.002	.65	.10	1.28	.10	83.6	3.39	367	27.5
Total	3590.4	1151.6	652.86	263.85	.868	.151	2.975	.759	.268	.038	24.19	3.35	31.37	1.80	1862.6	66.12	5980	396.5

WATER YEAR 1990

Month	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
OCT	121	50.6	19.3	9.85	0.029	0.007	0.124	0.031	0.016	0.002	1.09	0.17	1.77	0.13	110	4.05	417	28.0
NOV	195	127	29.9	23.5	.049	.013	.111	.026	.015	.002	1.36	.25	2.47	.19	153	6.29	496	37.7
DEC	110	75.4	20.5	17.0	.048	.012	.048	.012	.006	.001	.64	.12	2.03	.15	115	4.87	375	29.7
JAN	519	156	83.7	30.6	.138	.027	.343	.080	.027	.004	2.87	.42	4.63	.28	269	9.88	585	39.5
FEB	1103	280	153	46.7	.159	.033	1.30	.374	.069	.011	7.10	1.13	7.32	.48	373	14.4	653	45.2
MAR	1193	326	150	49.5	.079	.014	.515	.111	.026	.003	3.92	.53	4.37	.24	279	9.45	573	35.7
APR	2742	722	322	103	.202	.039	1.67	.477	.062	.010	7.56	1.12	6.68	.41	385	13.5	734	46.2
MAY	2323	707	323	119	.299	.053	1.51	.380	.088	.013	6.44	.86	6.10	.34	313	10.5	685	41.8
JUN	623	267	114	59.2	.128	.021	.285	.056	.036	.004	1.96	.24	3.07	.16	147	5.02	450	28.6
JUL	207	111	38.8	25.8	.068	.012	.140	.033	.020	.003	.94	.13	1.97	.11	92.9	3.44	363	25.0
AUG	170	77.1	23.8	13.4	.057	.013	.236	.091	.021	.004	1.04	.22	1.61	.11	93.0	4.03	371	28.3
SEP	96.9	44.2	13.4	7.71	.030	.006	.132	.041	.014	.002	.71	.12	1.25	.09	82.0	3.53	341	27.0
Total	9403.2	2944.2	1290.7	505.57	1.287	.249	6.422	1.710	.402	.060	35.64	5.32	43.25	2.70	2411.3	89.00	6044	412.7

WATER YEAR 1991

Month	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error	Load	Error
OCT	384	131	46.0	18.8	0.057	0.011	0.364	0.082	0.041	0.005	2.61	0.36	2.67	.16	180	6.39	565	36.7
NOV	426	266	50.8	38.2	.072	.016	.220	.053	.028	.004	2.43	.40	3.06	.21	198	8.07	574	43.3
DEC	960	449	123	68.8	.253	.064	.941	.353	.072	.015	5.83	1.07	6.61	.51	353	15.2	765	59.4
JAN	730	249	99.0	41.0	.158	.035	.464	.120	.040	.006	3.91	.62	4.82	.34	287	11.8	611	46.5
FEB	794	216	102	33.8	.091	.021	.494	.130	.039	.006	4.16	.70	4.28	.32	256	10.7	520	40.5
MAR	1804	451	207	63.2	.130	.033	1.50	.520	.080	.016	8.33	1.56	6.57	.53	355	15.2	682	52.8
APR	2351	738	260	98.6	.167	.046	1.16	.414	.063	.013	6.70	1.32	5.06	.45	318	15.6	684	62.4
MAY	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
JUN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
JUL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AUG	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SEP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--