

Phosphorus Loads Entering Long Pond, A Small Embayment of Lake Ontario near Rochester, New York

Reductions in the amount of phosphorus in discharge from the Spencerport wastewater-treatment plant have decreased phosphorus loads in Northrup Creek and led to the improvement of water quality in Long Pond.

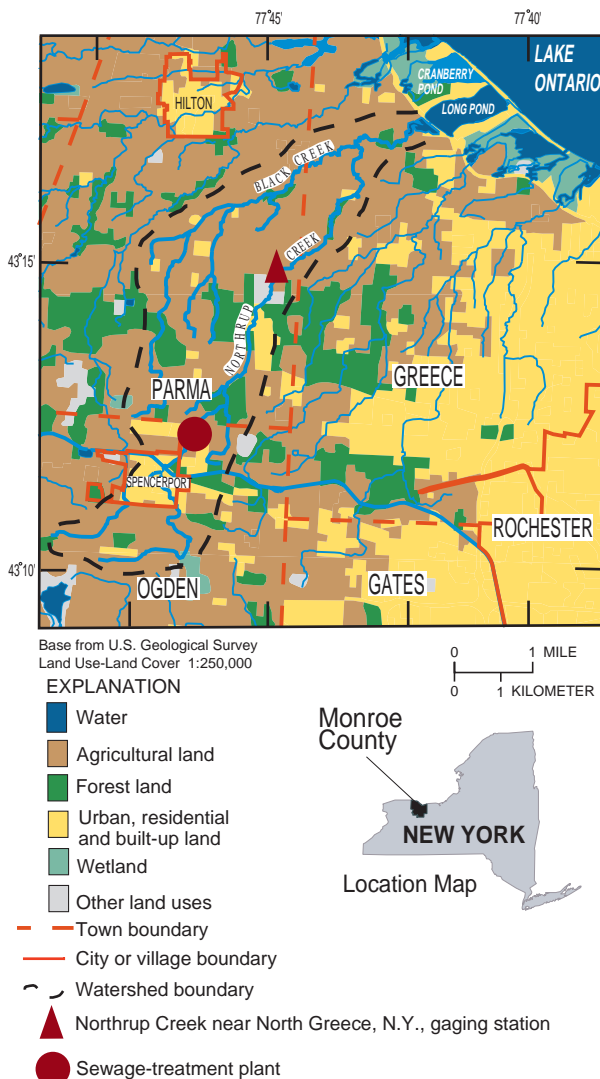


Figure 1. Location of principal geographic features of Long Pond study area, Monroe County, N.Y.

Introduction

Long Pond is one of many small, shallow embayments along the southern edge of Lake Ontario (fig. 1). These embayments are an important recreational resource and wildlife habitat; thus, maintaining their natural state is essential to their continued use. In recent decades, Long Pond and the adjacent Cranberry Pond have become hyper-eutrophic (overly enriched with nutrients) (Makarewicz and others, 1990) as a result of nitrogen and phosphorus transported to those waters by Northrup Creek from sources within the drainage basin.

In 1989, the Monroe County Department of Health and the Town of Greece, in cooperation with the U.S. Geological Survey (USGS), began a water-quality-monitoring program on Northrup Creek near North Greece at a site of a gaging station about 5 mi north (downstream) of the Village of Spencerport and the Spencerport wastewater-treatment plant. The program included the collection of water samples from October 1989 through September 1998 for chemical analysis and the collection of streamflow data for use in calculating phosphorus loads at the site. This fact sheet addresses the issue of concentration and loads of phosphorus in Northrup Creek, the principal tributary to Long Pond.

Northrup Creek begins just south of the Village of Spencerport in Monroe County and flows northward into Long Pond. It drains a total of 23.5 mi² in the towns of Ogden, Parma, and Greece (fig. 1). The drainage basin contains agricultural land, housing developments, and a small amount of urban land (table 1).

Table 1. Land use in Northrup Creek Basin, Monroe County, N.Y., 1996

[Data from Monroe County Planning Department]

Land-use category	Acres	Percentage of drainage basin
Suburban residential (< 1-acre lots)	2,277	15.0
Undeveloped (agricultural)	12,658	83.2
Rural residential (2 to 5-acre lots)	91	.6
Commercial/industrial	180	1.2
TOTAL	15,206	100

Phosphorus in Surface Waters

Two forms of phosphorus are considered in this article—total phosphorus, which is a measure of its suspended and dissolved states, and orthophosphate, a dissolved form that is readily available for biological uptake.

Generally, phosphorus (as orthophosphate) is the limiting nutrient in freshwater aquatic systems; that is, once all the available phosphorus is used, plant growth will cease, no matter how much nitrogen is available. Many freshwater bodies currently are receiving inputs of phosphorus and nitrogen from outside sources, and the increasing concentrations of phosphorus allow plants to assimilate additional nitrogen until the phosphorus is depleted. Thus, if sufficient phosphorus is available, accelerated plant growth and algal blooms will result.

Effects

Phosphorus-induced production of aquatic vegetation in freshwater has several detrimental effects:

- development of algal mats and decaying algal clumps that cause odors, discolor the water, and interfere with the esthetic quality of the pond and its recreational uses;
- extensive growth of rooted aquatic plants, which can interfere with aeration of the water and with powerboat operation;
- accumulation of dead plants and algae on the bottom of the pond where decomposition by microbial processes can deplete the oxygen from the water and result in the death of desirable fish species;
- clogging of water-treatment-plant filters by algae and aquatic plants;
- shading of submerged aquatic vegetation by algal blooms, which can reduce or eliminate photosynthesis and productivity.

Sources

Phosphorus, like most other chemical constituents of streams, is transported to the stream in runoff from point and nonpoint sources. Common nonpoint sources are runoff from agricultural areas and urban or residential areas, while the primary point source in many watersheds is the discharge from sewage-treatment plants. Most of the phosphates (phosphorus-based compounds) that enter a stream directly are derived from sewage-treatment plants. Primary treatment of sewage effluent removes only 10 percent of the phosphorus, and secondary treatment removes an additional 20 percent (Smith, 1990). Tertiary treatment is required to remove additional amounts of phosphorus from the water. The amount of additional phosphorus that can be removed depends on the success of the type of treatment used, such as biological removal and chemical precipitation.

Atmospheric deposition also can be a substantial source of nutrients within a watershed, but the amount that enters streams cannot be calculated with certainty because other factors, such as the interaction of phosphorus with the soil, cannot be quantified.

Phosphorus in Northrup Creek

The primary source of phosphorus in Northrup Creek is the Spencerport wastewater-treatment plant. Smaller amounts are contributed by agricultural activities within the basin, water diverted from the New York State Barge Canal, urban runoff, septic systems, and atmospheric deposition.

Atmospheric deposition of total phosphorus during water years¹ 1990–98 averaged about 170 pounds per square mile, about 24 percent of the phosphorus load in the Creek. Discharge from the wastewater-treatment plant represented 56 percent of the phosphorus load before August 1995 when the Spencerport treatment plant began adding iron salts and, as a result, decreased the amount of phosphorus in the treatment-plant effluent by 85 percent (Monroe County Planning and Development, written commun., 1988).

Concentrations

Median monthly concentrations of total phosphorus and orthophosphate in Northrup Creek are usually highest from late spring through early fall (fig. 2) when streamflow is low and provides minimal dilution. The application of fertilizer during these months also can be a contributing factor to concentrations of total phosphorus and orthophosphate in water.

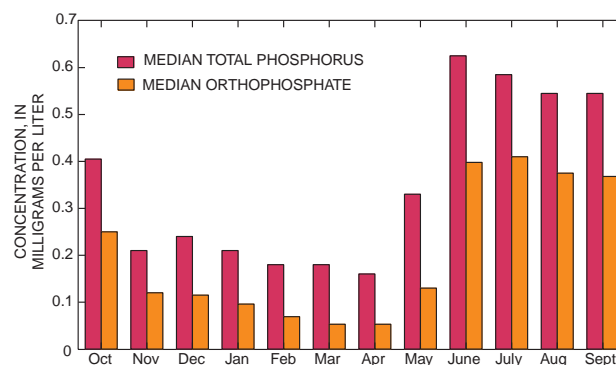


Figure 2. Median monthly concentrations of phosphorus in Northrup Creek, Monroe County, N.Y., water years 1990–1998. (Location is shown in fig. 1.)

Concentrations of chemical constituents in streams vary with the volume of streamflow at the time the sample is collected. If streamflow variability is not taken into consideration when data are tested for trends, it can produce misleading results; for example, an apparent upward trend in concentration could result from upward trends in flow rather than an actual increase in concentration. The concentration variability that results from differences in flow can be minimized through statistical procedures that produce “flow-adjusted” concentrations that then can be tested for trends.

Trend testing of flow-adjusted concentrations of orthophosphate in Northrup Creek for water years 1990–98 indicate an overall downward trend, although a short-term variability of direction and magnitude within the trend is indicated—an upward trend occurs from October 1989 until mid-1992 and in 1994 and 1998 (fig. 3, next page), and a downward trend occurs from mid-1992 through September 1993 and during 1995–97.

¹Water year: the 12-month period from October 1 through September 30 of the following year. Thus, the water year ending on September 30, 1996, is the 1996 water year.

The flow-adjusted phosphorus concentrations for the periods before and after October 1995, when phosphorus controls at the Spencerport wastewater-treatment plant were implemented, show no detectable trends for either period. The mean flow-adjusted concentrations of orthophosphate after October 1995 were about 30 percent lower than those before; those for total phosphorus were about 24 percent lower than those before.

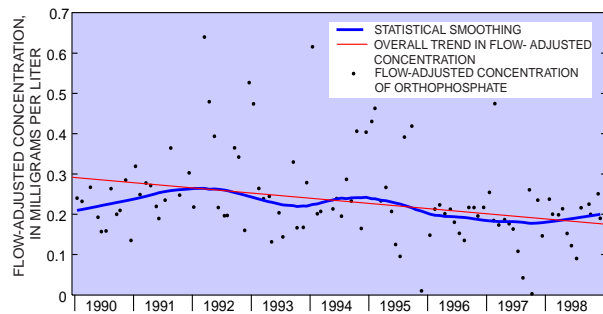


Figure 3. Overall trend and statistical smoothing of flow-adjusted concentrations of orthophosphate in Northrup Creek, Monroe County, N.Y., for water years 1990-98.

Loads

Total phosphorus loads at the Northrup Creek monitoring site during water years 1990-98 averaged 8,350 lb/yr (pounds per year), and orthophosphate loads averaged 3,430 lb/yr. The months with the largest loads of total phosphorus were January and April, which generally are the months with the greatest volume of streamflow. Orthophosphate loads showed less monthly variation, with loads fairly evenly distributed throughout the year (fig. 4).

Total phosphorus loads at the Northrup Creek site averaged 23.4 lb/d (pounds per day) in the 5 years before implementation of the phosphorus-control measures and 22.0 lb/d in the 3 years thereafter.

The corresponding orthophosphate loads averaged 11.0 lb/d before phosphorus-control measures and 6.22 lb/d thereafter. The apparent lack of significant improvement for total phosphorus is a result of the considerably higher daily mean streamflow for the 3 years that followed phosphorus control than those in the preceding period. Total phosphorus, which adheres to suspended particulate matter, generally shows a positive correlation with streamflow; that is, concentration increases as flow increases. Concentration of orthophosphate, which is in the dissolved phase, usually is less affected by streamflow volume. Thus, the daily loads of orthophosphate decreased markedly after the implementation of phosphorus controls, despite the greater-than-average flows.

Monthly orthophosphate loads showed an overall decline of about 8 percent per year for water years 1990-98, but neither the monthly loads of total phosphorus nor those of orthophosphate show any trends for the 5-year period preceding the implementation of phosphorus controls nor for the 3-year period thereafter.

Phosphorus in Long Pond

Long Pond has a surface area of about 0.75 mi² and an average depth of about 7 ft; it is connected to Lake Ontario by a narrow channel (fig. 1).

Phosphorus that is attached to sediment particles entering Long Pond from Northrup Creek accumulate in the sediments and can be recycled slowly into the water column (through chemical reaction) or released more rapidly when these sediments are disturbed, such as during a storm or flood. The phosphorus stored in bottom sediments, therefore, can cause water contamination for many years even though sources of phosphorus have been identified and controlled.

Annual phosphorus loads in Northrup Creek were used to calculate the potential phosphorus loading (an estimate of the available phosphorus, in milligrams per cubic meter) in Long Pond. The results indicate that

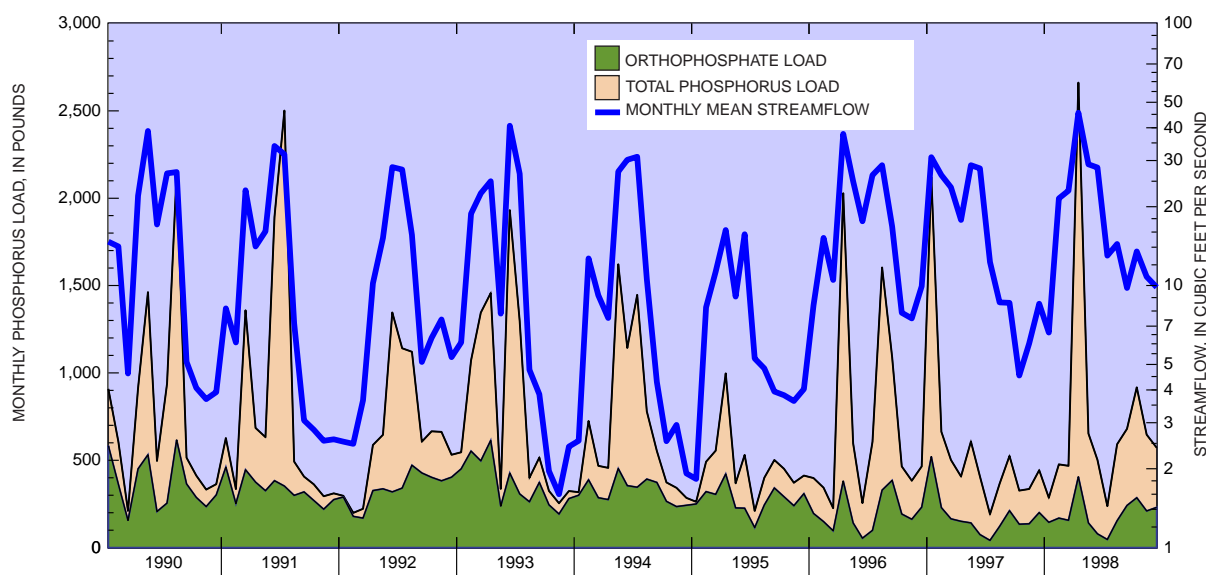


Figure 4. Monthly mean loads of total phosphorus, orthophosphate, and monthly mean streamflow for Northrup Creek, water years 1990-98.

potential phosphorus underwent a gradual increase in water year 1991, then a gradual decrease through 1995 (when the control measures were implemented), followed by larger decreases in water years 1996 and 1997, and a slight increase in 1998 (fig. 5).

The recent decreases in potential phosphorus in Long Pond, indicated by figure 5, result more from the high mean flows for water years 1996–98 than from the implementation of phosphorus controls. This is because the large flows increased the volume of water in Long Pond, thereby diluting the potential phosphorus loading (concentration). In addition to the calculation of potential phosphorus loading, measurements of phosphorus, chlorophyll, and dissolved oxygen are needed to provide a more definitive assessment of the improvement in eutrophic conditions in Long Pond and Cranberry Pond. Indications of improvement would be a decrease in the size and persistence of algal blooms, increase in the clarity of water, and a decrease in the odor from dead and decaying vegetation.

Conclusions

The effectiveness of wastewater treatment in improving the quality of eutrophic water bodies can be difficult to assess in the short term. Although an improvement in Long Pond is indicated by a decrease in the estimates of potential phosphorus loadings as calculated from phosphorus inputs from Northrup Creek, the estimates do not take into account variables that cause resuspension of phosphorus-bearing sediments such as wind, turbulence from boat traffic, and water-temperature gradients.

The phosphorus loads in Northrup Creek have been reduced through improved sewage treatment at the Spencerport wastewater-treatment plant, but phosphorus

remaining in the sediments of the stream channel and in Long Pond can be resuspended and recycled for years after sources of phosphorus have been identified and controlled. The water quality of Long Pond is expected to improve, however, as the pond receives decreased phosphorus loads from Northrup Creek, the principal source of nutrients.

—By Donald A. Sherwood

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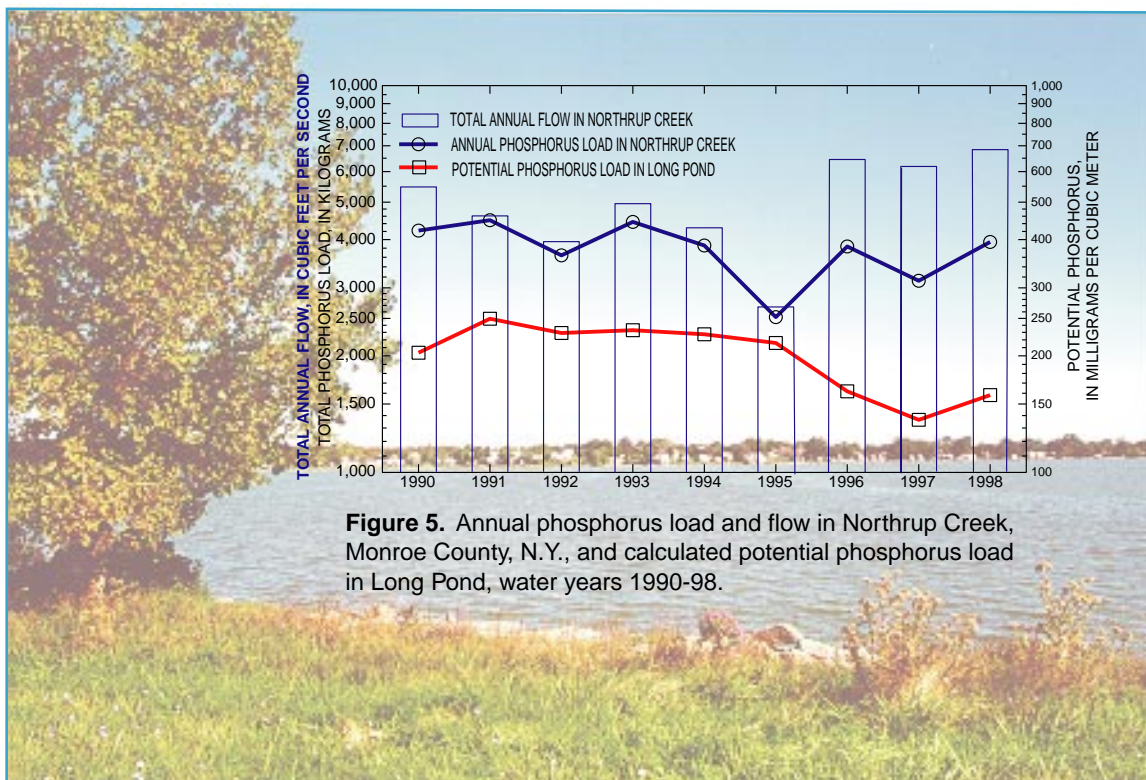


Figure 5. Annual phosphorus load and flow in Northrup Creek, Monroe County, N.Y., and calculated potential phosphorus load in Long Pond, water years 1990-98.