US Army Corps
of Engineers
Waterways Experiment
Station

Water Operations Technical Support

VOL E-91-3 October 1991

Water Quality Management Initiatives at East Sidney Lake, New York

by
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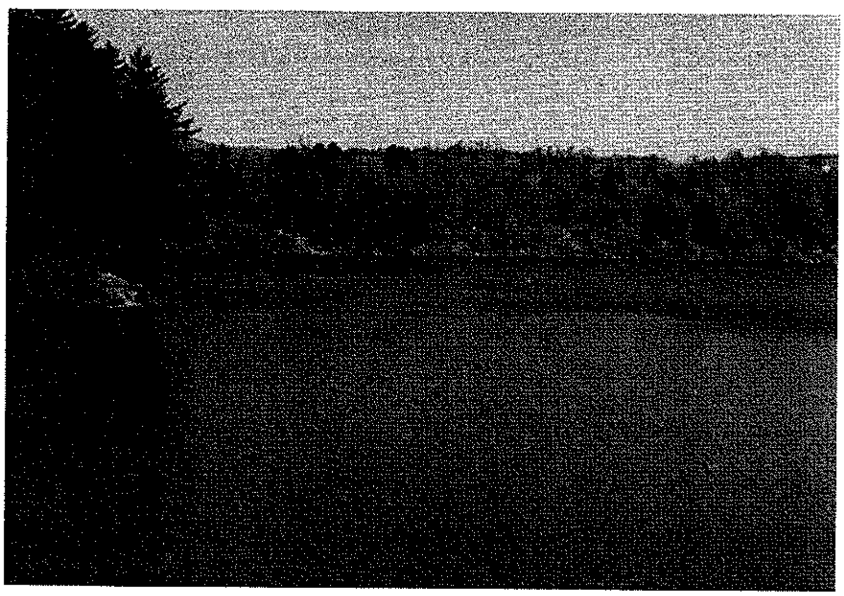


East Sidney Lake, New York

The US Army Engineer District, Baltimore, and the Environmental Laboratory (EL) of the US Army Engineer Waterways Experiment Station (WES) are jointly conducting a water quality management initiative at East Sidney Lake, New York. Preliminary efforts included assessment of existing data from Baltimore District and other sources, supplementary field investigations, data interpretation, and application of simplified techniques (Walker 1985) to quantify nutrient loading and in-lake physicochemical processes. Detailed studies were conducted and included assessment of aerial photographs of the project watershed to describe land use patterns, intensive water quality monitoring to quantify nutrient loading and describe temporal patterns in water quality, and a survey of project users to identify user perceptions of water quality.

Study findings indicated that excessive nutrient loads to the project result in adverse conditions during the summer recreation season (Kennedy and others 1988 and Ashby and Kennedy 1990). These adverse conditions include nuisance algal "blooms," hypolimnetic anoxia, excessive nutrient and metal concentrations, and reduced water clarity. Inventories of land uses in the watershed and seasonal water quality studies suggested that both external and internal sources provided excessive loads of nutrients. While user perceptions of water quality were generally favorable, water quality enhancement was deemed desirable.

Evaluation of the efficacy of various water quality enhancement techniques led to the development of a two-part management approach. Cooperative efforts with state and local agencies were initiated to foster control of nonpoint source nutrient loading from the watershed. Maintenance of aerobic conditions in the lake via mixing was recommended to decrease internal nutrient loading. This article describes study results, management recommendations, and the status of current water quality management initiatives at East Sidney Lake.

Site Location and Description

East Sidney Lake, an impoundment of Ouleout Creek in Delaware County, New York (Figure 1), provides flood control for portions of southern New York and eastern Pennsylvania. The watershed is situated in a rural area where forests and agriculture are predominant land uses. A conservation pool is maintained for storage of spring flood waters from November to April. In April, the pool elevation is increased for summer recreation. Recreational opportunities include fishing, swimming, boating, hiking, picnicking, and camping.

Study Synopsis

Aerial, color-infrared photography, conducted in the spring of 1988, provided the means for establishing a land use inventory for the 102-square mile East Sidney Lake watershed. Land uses, types of vegetative cover, conditions of fields and pastures, location of animal operations, and hydrologic drainages were identified and quantified. This information, coupled with soil characteristics, allowed for identification of erosion potential and estimation of runoff. A user atlas of various maps overlaying topographic quadrangles was prepared and data were placed on computer diskette for additional analyses.

Approximately one-half of the watershed is primarily forested cover. Nearly one-third of the watershed, classified using land uses associated with agricultural practices, was primarily fair pastures of uneven growth with minimal maintenance. Nondairy and dairy cattle operations accounted for 97 percent of the animal activity. The remaining area of the watershed included minor areas of water bodies, urban development, wetlands, and heavily overgrazed pastures.

From May to September, limnological surveys were conducted routinely. Variables monitored included temperature, dissolved oxygen, specific conductance, light transparency, total phosphorus, nitrogen, iron, manganese, and sodium. Sampling for chemical variables was conducted biweekly at inflow and outflow stations. In-lake sampling consisted of vertical profiles of in-situ variables at 1-metre intervals and sample collection at 2-metre intervals for chemical analyses. Integrated samples were also collected from the mixed-layer for chlorophyll *a* analysis and phytoplankton species identification.

Nutrient loadings from external and internal sources were calculated for the growing season during thermal stratification (June through mid-August 1988). Initially, external loads and loading rates were calculated using FLUX (Walker 1985) for Ouleout Creek and Handsome Brook. Since flow data for these inflows were not available, the total inflow was assumed to be equal to the discharge from the

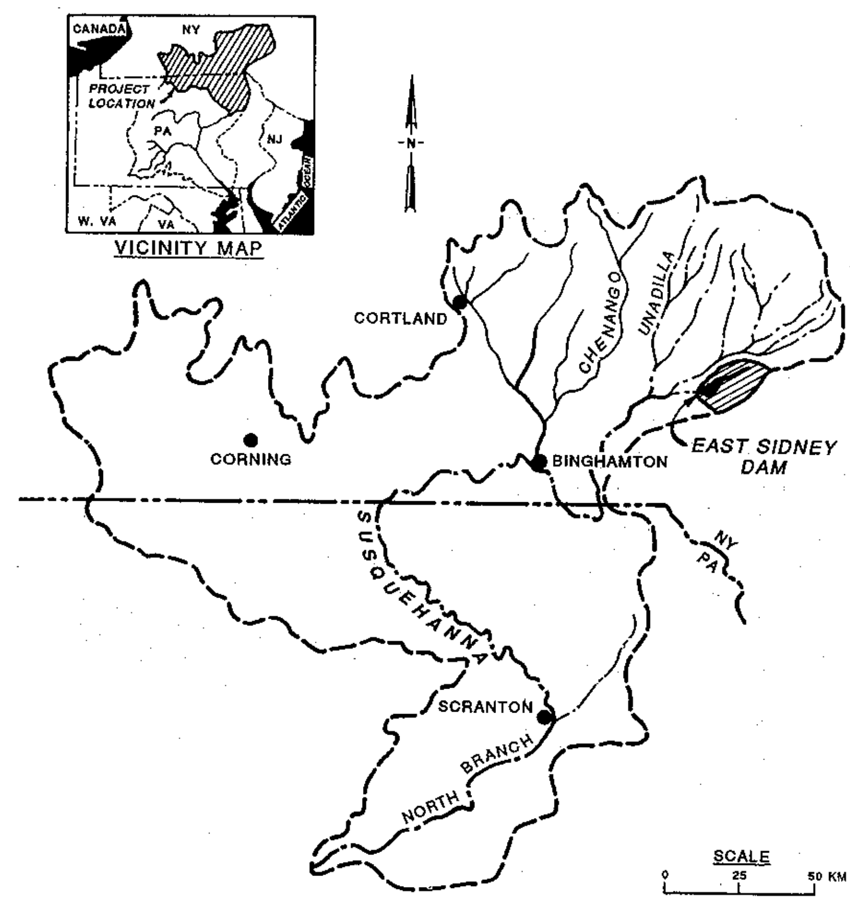


Figure 1. Location of the East Sidney Lake Project

dam, as calculated by the Baltimore District. Then, based on the area of the respective subwatershed, 75 percent of the inflow was assigned to Ouleout Creek and 25 percent of the inflow was assigned to Handsome Brook. Within the lake, concentrations were weighted by strata, and change in storage was calculated for the period of stratification from initial and final mass values. Nutrient loss due to discharge was also calculated with FLUX. Internal loading rates were then calculated for the hypolimnion using the following equation:

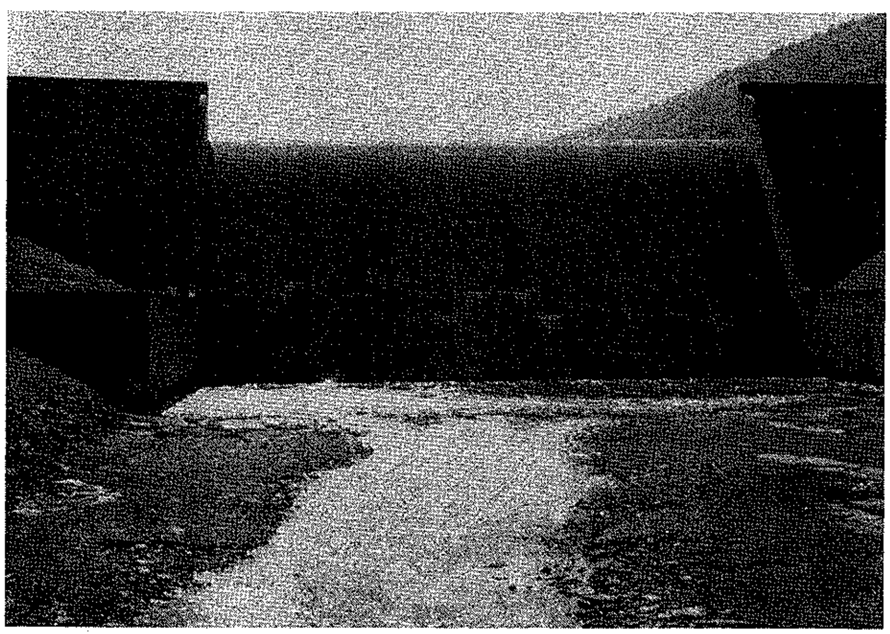
$$L = \frac{X_C - (X_i - X_O)}{t \times A}$$

where

- L = net internal load rate, milligrams/square metre/day
- X_C = change in storage, milligrams
- X_i = external load, milligrams
- X_O = loss due to discharge, milligrams
- t = period of stratification based on in-situ profiles, days
- A = area of hypolimnion, square metres

Results indicated that during stratification, external sources provided approximately 30 percent of the phosphorus supply to the lake, while internal loading of sedimentary phosphorus accounted for approximately 70 percent of the total phosphorus load (Ashby and Kennedy 1990).

Mechanisms for internal loading may be attributed to the combined effects of thermal stratification, which isolates bottom waters and prevents reaeration, and high oxygen demand from degradation of organic matter. Seasonal anoxia in the sediments and hypolimnion is often a result of these effects. During anoxia, solubilization and transport of sedimentary metals and nutrients are enhanced and hypolimnetic concentrations increase (Mortimer 1941, 1942). Partial mixing, which may be attributed to low thermal stability in the lake and energy input associated with passage of weather fronts, redistributes nutrient-rich bottom waters to surface waters, increasing nutrient availability for phytoplankton production (Gaugush 1984). Results of these processes are an increase in algal production, reduced water clarity, increased organic and nutrient cycling, and overall diminished water quality.


Tailwater region of East Sidney Dam

East Sidney Lake Project Characteristics

- Volume: 4.1 million cubic metres
- Maximum depth: 13.0 metres
- Mean depth: 4.9 metres
- Average inflow rate: 4.9 cubic metres/second
- Hydraulic residence time: 9.8 days
- Drainage area at dam: 264.0 square kilometres
- Surface area: 85.0 hectares
- Outlet works: bottom withdrawal

Approximately 45 project users were interviewed in mid-July to identify user perceptions of water quality. Most of the users were local (within 40 kilometres) and frequent visitors to the project. Generally, users perceived water quality to be good or "acceptable," but they were aware of late summer algal blooms and considered them to be a nuisance. Improved water clarity was the main desire of the individuals polled. When asked about water quality management techniques, most were supportive of measures to improve agricultural practices but were opposed to in-lake application of chemicals, such as algicides.

Management Recommendations

Since excessive nutrient concentrations from both external and internal sources were determined to be a major factor in seasonal nuisance algal blooms and diminished water quality, a two-part management approach was developed. First, interactions with watershed landowners, managers, and agencies were recommended as a means to address the management of external nutrient loading. Second, the Baltimore District agreed to install and operate a pneumatic mixing system to prevent thermal stratification. Artificial mixing increases the area of the oxygenated region and should decrease internal loading of nutrients and metals which occurs during anoxia. The study is discussed in more detail in Ashby and Kennedy (1990).

Watershed Management

The US Department of Agriculture recently selected the East Sidney Lake watershed as one of 37 hydrologic units in which various watershed management programs will be demonstrated. Emphasis will be on nonpoint source management and will include identifying and managing both agricultural and nonagricultural sources. A work-plan for a cost-sharing demonstration program was jointly prepared by the New York Water Resources Institute (located at Cornell University and associated with the Cornell Cooperative Extension) and the Soil Conservation Service. The plan provides for research and development, cost-sharing demonstrations, and technology transfer within the state.

One of the major thrusts of the plan is to promote interagency interactions throughout the study. Toward this end, Baltimore District and WES personnel participated at a local organizational meeting to discuss US Army Corps of Engineers (USACE) interests in water quality and provide an overview of ongoing studies at East Sidney Lake. Following this meeting, aerial photographs and data from recent studies have been made available to other agencies. In-lake enhancement efforts at East Sidney Lake were also described in a recent publication of the local extension agency (Bank 1989). USACE involvement was well received by local and professional interests, and continued involvement throughout the duration of the study is likely.

In-lake Enhancement

A pneumatic mixing system was installed at East Sidney Lake by the Baltimore District and WES in July 1989 and was fully operational for the 1990 summer season. Initial operation consisted of cycles of varied duration (from 23 hours on and 1 hour off to 12 hours on and 12 hours off). The system was operated to maintain a temperature difference between the surface and bottom of less than 2 degrees Celsius.

System design, following the guidance of Davis (1980), is based on lake volume, temperature stratification, and thermal stability of the lake. Diffused air bubbles are introduced near the bottom of the reservoir to induce vertical and lateral circulation. The volume of water circulated is based on depth and the volume of air delivered to each diffuser port by the compressor.

The system was designed and constructed at the WES and transported to the site for installation. The diffuser consists of eight, 30.5-metre (100-foot) sections of 3.8-centimetre (1.5-inch) polyvinyl chloride (PVC) pipe joined to form a linear diffuser with 0.8-millimetre holes drilled every 0.3 metre (1 foot). To facilitate operation of the system, each section is controlled by a valve from a manifold on the main air supply line from the compressor. The main supply line consists of 121.9 metres (400 feet) of 5.0-centimetre (2-inch) pipe and 304.8 metres (1,000 feet) of 4.0-centimetre (1.5-inch) flexible rubber hose. The 15-horsepower compressor, located on top of the dam, is designed to deliver 64 cubic feet of air per minute at a pressure of 50 pounds per square inch.

Comparisons of temperature and dissolved oxygen data collected during summer seasons without mixing (1988) and with mixing (1990) indicate that water quality may be enhanced with seasonal mixing (Figure 2). Temperature isopleths indicate near-isothermal conditions were maintained with system operation. Consequently, aerobic conditions were present throughout the lake during the summer season.

Concentrations of total iron and phosphorus were lower in 1990 than in 1988 (Figure 3), suggesting improved chemical conditions with mixing. Lower iron and phosphorus concentrations may be the result of decreased release from deep-water sediments due to the maintenance of aerobic conditions. Internal loading of phosphorus during the 1988 summer growing season was 70 percent of the total load, while during a similar time period in 1990 internal phosphorus loading was 30 percent of the total load. Additionally, water quality of the discharge was improved as indicated by decreased nutrient and metal concentrations (Figure 4).

Additional evaluation of impacts of management initiatives on water quality at East Sidney Lake is necessary. Responses in temperature and dissolved oxygen profiles to varied mixing durations were discernible suggesting system operation could be optimized. Additionally, a considerable blue-green algal bloom occurred in mid- to late

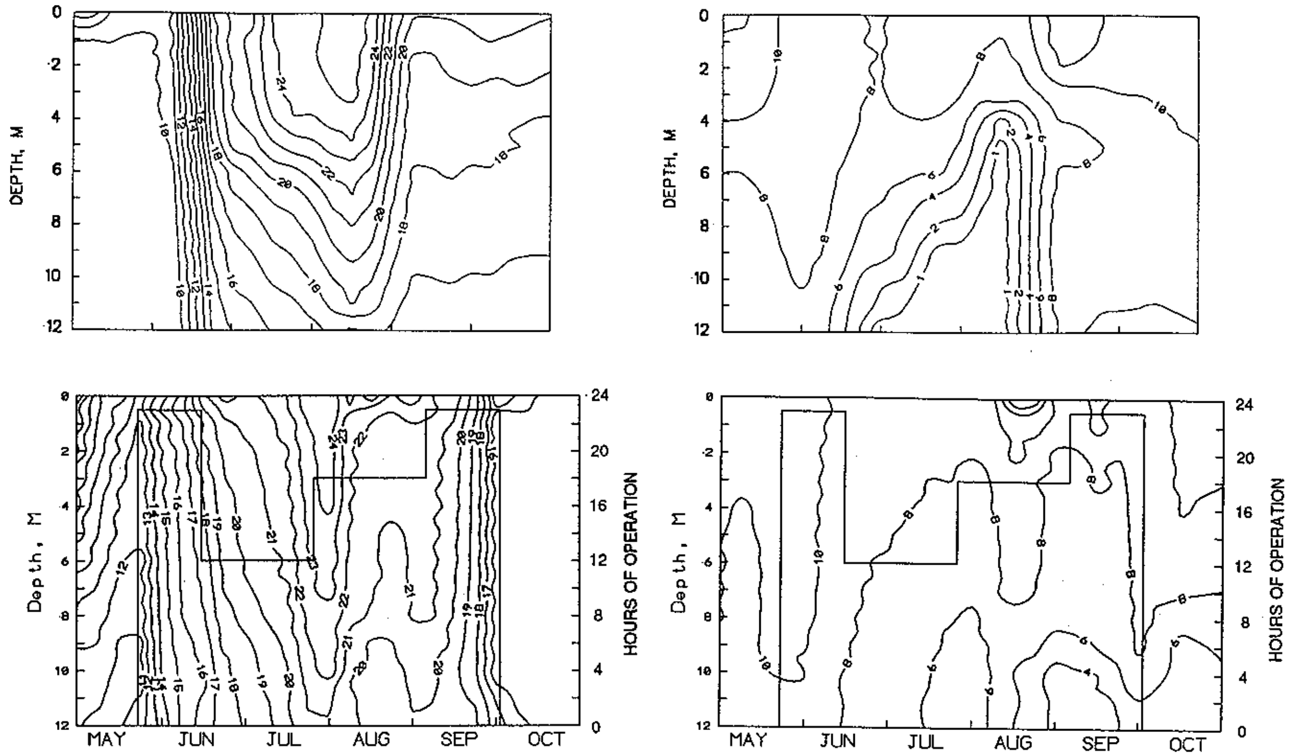


Figure 2. Temperature (left) and dissolved oxygen (right) for 1988 and no mixing (top) and 1990 with mixing (bottom); solid line denotes duration of mixing system operation

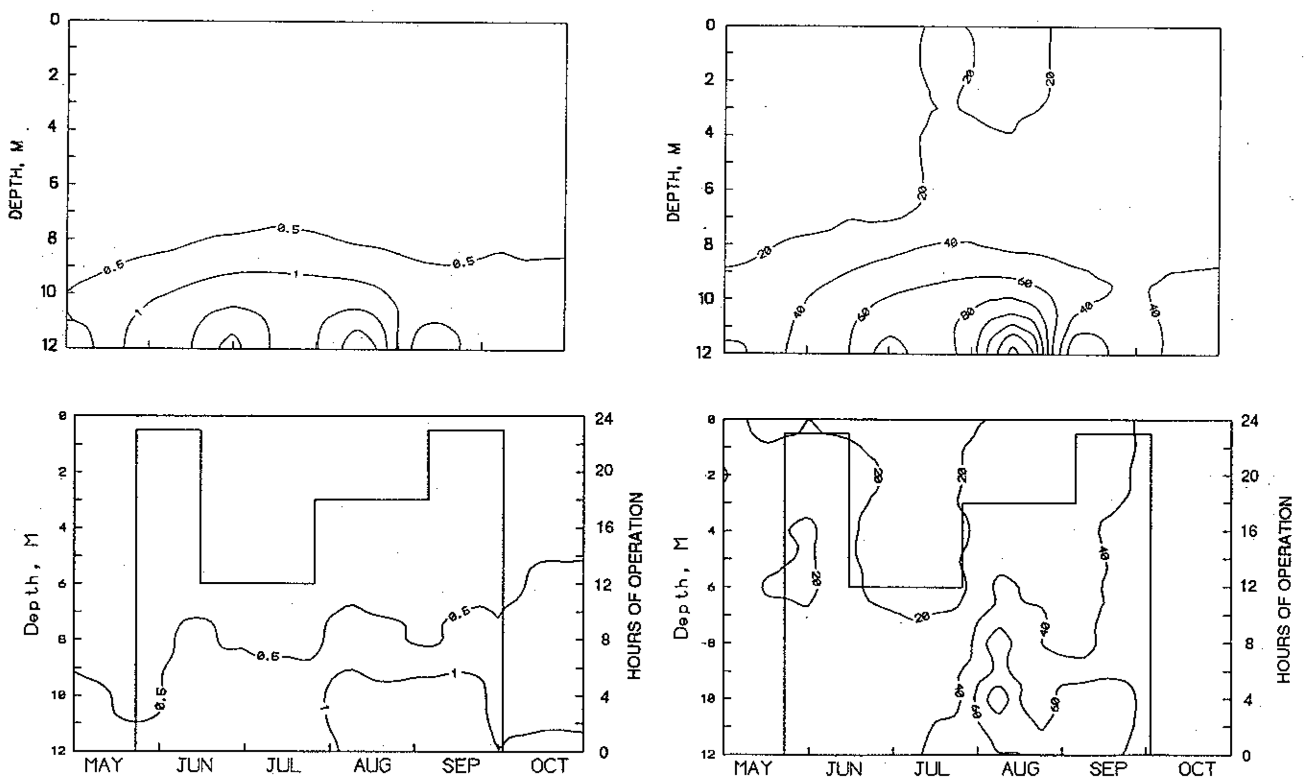


Figure 3. Total iron (left) and total phosphorus (right) for 1988 and no mixing (top) and 1990 with mixing (bottom); solid line denotes duration of mixing system operation

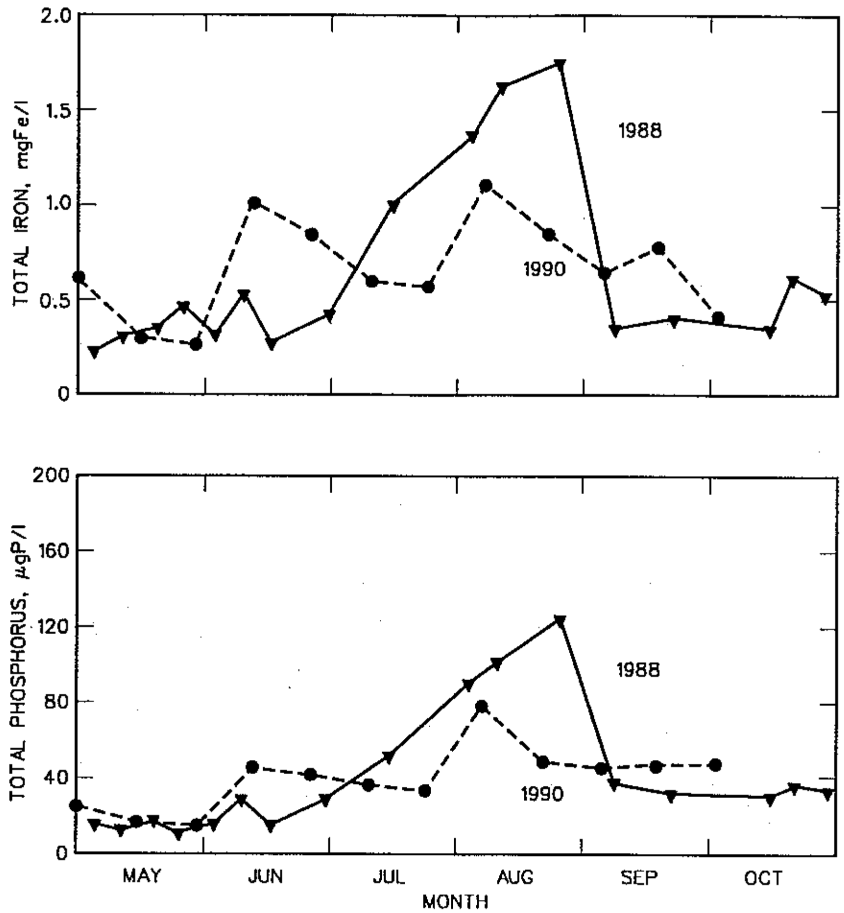
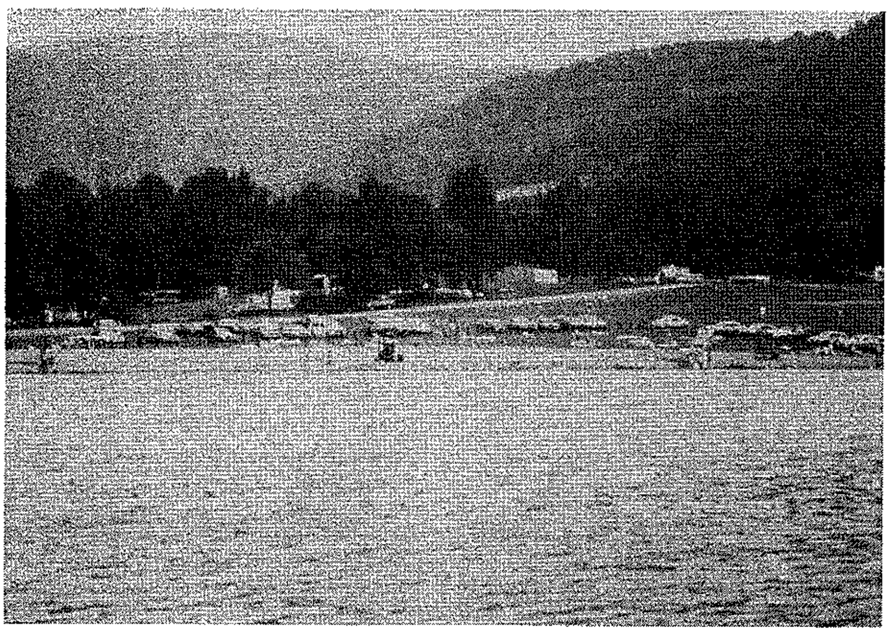


Figure 4. Total iron and phosphorus concentrations in the discharge from East Sidney Lake, with (1990) and without (1988) in-lake mixing



Summer recreation at East Sidney Lake

August, reducing water clarity and significantly impacting recreational activities at the lake. Heavy precipitation and subsequent runoff during mid-August preceded the algal bloom and may have even precipitated the observed adverse conditions. Hence, impacts of seasonal external loading events on in-lake water quality need further evaluation.

Summary

Development of a water quality management strategy for East Sidney Lake provides a demonstration of the resource management decision-making process. Strategy development followed a logical path from problem diagnosis to the identification of potential solutions. While specific for East Sidney Lake, lessons learned here will certainly be applicable at other projects. The insight gained from working with those agencies involved in nonpoint source management at East Sidney Lake will be invaluable, since such interactions will be required if the USACE is to continue to provide sound management of its water resources.

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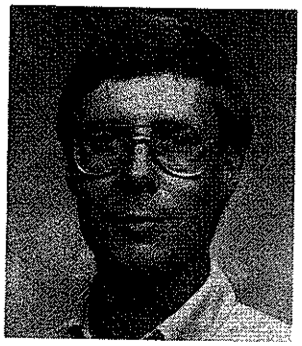

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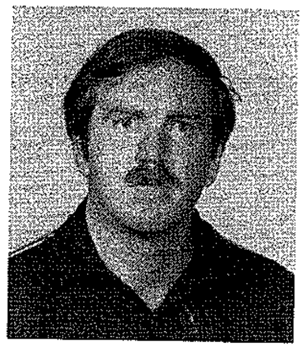

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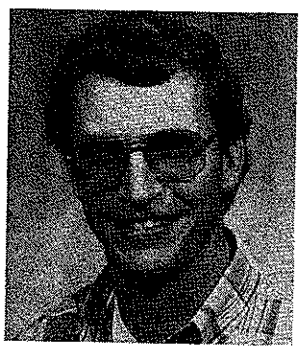

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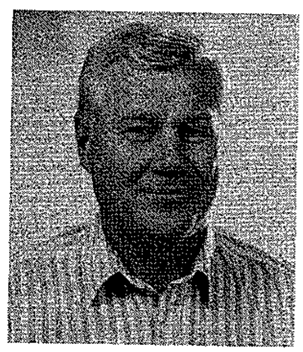

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The Baltimore District and the US Army Engineer Waterways Experiment Station are jointly conducting a water quality management initiative at East Sidney Lake, New York. This issue describes the site location, presents study results, and gives management recommendations.

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