Darrin Fresh Water Institute

AT LAKE GEORGE

INTERNAL PHOSPHORUS LOADING ESTIMATES FOR COSSAYUNA LAKE WASHINGTON COUNTY, NEW YORK

prepared for

The Cossayuna Lake Watershed Management Committee

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Background

The Darrin Fresh Water Institute was commissioned by the Cossayuna Lake Watershed Management Committee to develop rates for internal phosphorus loading to Cossayuna Lake. Internal phosphorus loading is commonly associated with the release of phosphate bearing compounds from sediments underlying an anaerobic hypolimnion. When thermal stratification breaks up in the fall of the year, soluble phosphates in the hypolimnion are mixed through the water column, frequently spurring algal blooms.

Internal phosphorus loading rates can be determined in two ways: 1) bench scale in-lab experiments to determine the release rates of phosphorus from lake bottom sediments at differing oxygen concentrations and 2) in-lake measurement of hypolimnetic oxygen and phosphorus levels during the year. This project focuses on the first option, however option 2 should be implemented during the summer of 1998 to verify in-lab values.

On February 17, 1998, staff of the Darrin Fresh Water Institute, and the Lake Services Section of NYS DEC visited Cossayuna Lake to collect sediment cores, to be used to determine internal phosphorus loading rates for Cossayuna Lake.

Methods

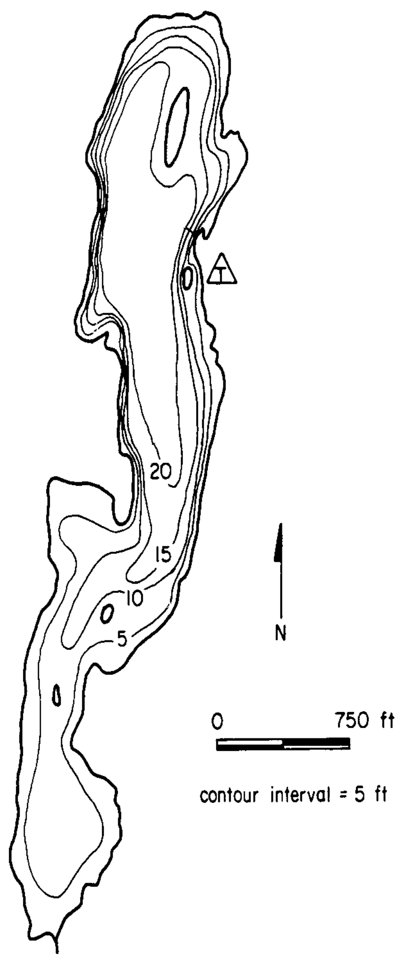
The following table describes the activities at Cossayuna Lake on February 17, 1998. Four stream delta locations and a midlake site in the area of maximum depth were selected for the collection of sediment cores (see Figure 1).

Midlake Site The midlake site, designated site 1, is located in the deepest portion of Cossayuna Lake. This location approximates the site where water chemistry data is collected by CSLAP. Maximum water depth at this location was 7.1 meters (26.5 ft). At the midlake site, profiles of dissolved oxygen, temperature and specific conductance were recorded at 1 meter intervals from the lake surface to the bottom. A surface grab sample approximately 0.5 meters below the lake surface was collected for chemical analysis of selected nutrients in the water column. Four sediment cores were collected in the area of maximum water depth. Two of the cores were maintained intact for determination of phosphorus release rates. The remaining two cores were sectioned into three sub-samples representing the upper, middle and bottom portions of the sediment cores. These sub-samples were analysed for total phosphorus content and total carbon via loss on ignition. Core samples were flocculent silts for the upper few centimeters and then medium brown consolidated materials below. Classic black layers associated with anoxia were not observed.

Summit Lake Outlet Stream The delta formed at the confluence of the Summit Lake Outlet stream and Cossayuna Lake was designated site 2. A number of wetlands occur over the course of this stream, including the section between the highway and Cossayuna Lake. The water depth at this location was 1.2 meters (4 feet). Sediments were consolidated silts and detrital materials. Numerous plant roots were present in the sediment cores. Two cores were collected at this location for analysis.

Figure 1. Sampling sites at Cossayuna Lake.

Cossayuna Lake



Sample Site Locations

1. Midlake
2. Inlet from Summit Lake
3. Baldwins Cove
4. Launch Ramp Bay
5. SE Cove – Area receiving farm field runoff

Baldwin Bay The delta formed at the confluence of several small streams and wetlands and Cossayuna Lake was designated site 3. A number of wetlands occur over the course of this stream, including the section between the highway and Cossayuna Lake. The water depth at this location was 1.5 meters (5 feet). Sediments were consolidated silts and detrital materials, however a distinct layer of white, fine grained materials was observed approximately 0.3 meters (1 foot) below the surficial sediments. Three cores were collected at this site.

Launch Ramp Bay The delta formed at the confluence of a small stream to the south of the launch ramp and Cossayuna Lake was designated site 4. A number of wetlands occur over the course of this stream, including the section between the highway and Cossayuna Lake. The water depth at this location was 1.0 meter (3 feet). Sediments were dark colored fine grained, consolidated silts and detrital materials. Two cores were collected at this site.

Southeast Cove Several small streams drain through culverts into the lake in this area. This area is reported to produce dense stands of Eurasian watermilfoil and receive drainage from a number of farm fields. The water depth at this location was 1.5 meter (5 feet). Sediments were dark colored fine-grained, consolidated silts and detrital materials with some fine-grained sands present. Numerous plant roots were present in the sediment cores. Two cores were collected at this site.

At the four stream delta sites, sediment cores were collected in water depths ranging from 1.0 to 1.5 meters. Cores were collected in duplicate, and analysed for total phosphorus content and total carbon via loss on ignition. At one stream delta location (Baldwin Bay), an additional core was maintained intact for determination of phosphorus release rates.

Samples were returned to the Darrin Fresh Water Institute site in Bolton Landing, NY. Cores were collected in polystyrene core tubes (Cadillac Plastics, Albany, NY) 10 cm in diameter. The sectioned core materials were dried to constant weight (103^{o}C) and then ashed (550^{o}C) to determine total carbon content via loss on ignition. Dried samples were digested prior to analysis for total phosphorus (APHA, 1995).

Intact cores were fitted to a water circulating system and placed in the dark in a temperature controlled cold room (5^{o}C). Cores were allowed to equilibrate for 48 hours to allow materials suspended during transport to settle. Dissolved oxygen and temperature were monitored for 30 days, and water for total and soluble phosphorus determinations collected at selected intervals. Nitrogen gas was bubbled through the cores to accelerate the depletion of oxygen. Phosphorus release from the sediment cores relative to dissolved oxygen concentrations were recorded.

Results

Temperature and oxygen profiles under the ice indicate weak inverse thermal stratification (Table 1). Ice thickness was approximately 0.3 meters (1 foot) at the time of sampling. High conductivity and temperature levels near the lake bottom suggest channeling of runoff waters, which tend to be high in dissolved salts. Dissolved salts increase the density of these waters. Some oxygen depletion was observed near the lake bottom, with oxygen less than 50% saturation below a depth of 6 meters (Table 2 & Figure 2).

Table 1. Profiles of temperature, dissolved oxygen and specific conductance for the midlake site on Cossayuna Lake on February 17, 1998.

Depth (m)	Temperature (C)	Dissolved Oxygen (mg/l)	Percent Saturation	Conductivity umhos
0	1.0	16.5	116%	171
1	3.9	14.3	109%	193
2	4.4	12.8	98%	203
3	4.4	12.8	98%	205
4	4.6	11.9	93%	212
5	4.9	10.6	83%	218
6	5.5	5.7	46%	235
7	5.9	2.3	18%	262

Lake-water chemistry was determined for the surface waters at the midlake site (Table 2). The combination of hypolimnetic oxygen depletion, particularly during the winter months, and moderate amounts of soluble nitrogen and phosphorus in the surface waters indicate that Cossayuna Lake is moderately eutrophic.

Table 2. Water chemistry data for the midlake site on Cossayuna Lake on February 17, 1998.

Nitrate mg N/l	Chloride mg/l	Sulfate mg S/l	Ammonia mg N/l	Soluble Phosphorus ug P/l	Total Phosphorus ug P/l
0.364	10.11	2.94	0.04	4.5	22.5

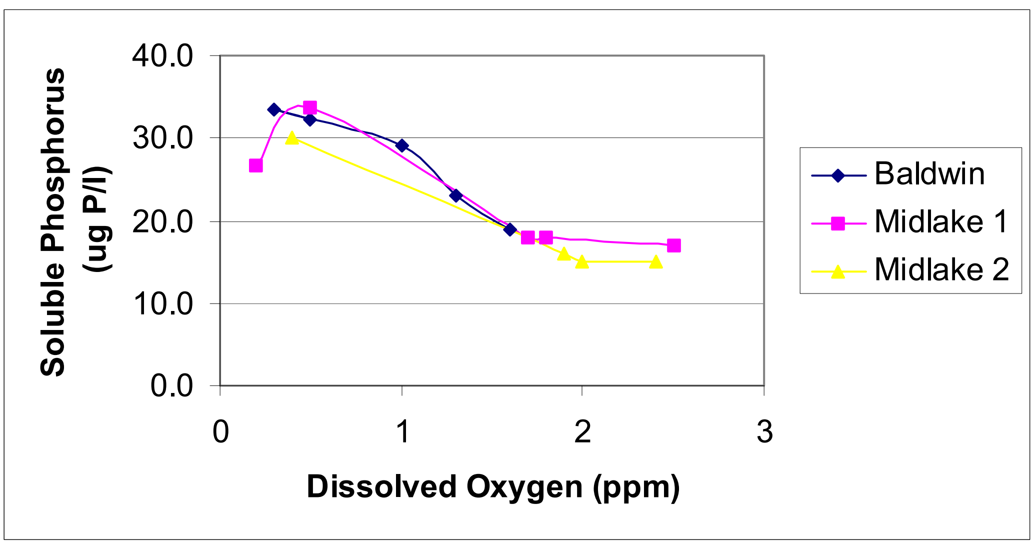
Chemical analysis of the sediments collected indicates a substantial pool of phosphorus present in the lake bottom. Sediment phosphorus concentrations are similar for most locations with the exception of the Southeast Cove. In this area, phosphorus concentrations are 3 to 5 times as high as all other locations. This area is reported to receive farm field runoff, which may account for the elevated levels of phosphorus present. Carbon content via loss on ignition is typical of lake bottom sediment (25-40%) and relatively uniform between sites. The Southeast cove site was lower than other sites. Fine sands observed in this sample may account for lower carbon levels. These may be due to erosion of soils and highway materials from the mainly dirt roads adjacent to the lake in this area.

Table 3. Analysis of core samples from Cossayuna Lake.

Site	Horizon	Total Phosphorus ug P/gr	Total Phosphorus % dry Wt.	Total Carbon mg/gr	Total Carbon % dry Wt.
Midlake	Upper	624.3	0.06%	270.7	27.1%
Midlake	Middle	501.6	0.05%	266.7	26.7%
Midlake	Lower	471.8	0.05%	355.4	35.5%
Summit Lake delta		851.5	0.09%	288.5	28.9%
Baldwin Bay		525.8	0.05%	249.4	24.9%
Launch Ramp		1023.3	0.10%	257.8	25.8%
S E Cove		3211.5	0.32%	162.0	16.2%

Intact cores recirculated with lake water declined in dissolved oxygen concentration over time. Soluble phosphorus concentrations remained stable until the dissolved oxygen concentration dropped below 1.5 ppm. Soluble phosphorus concentrations then nearly

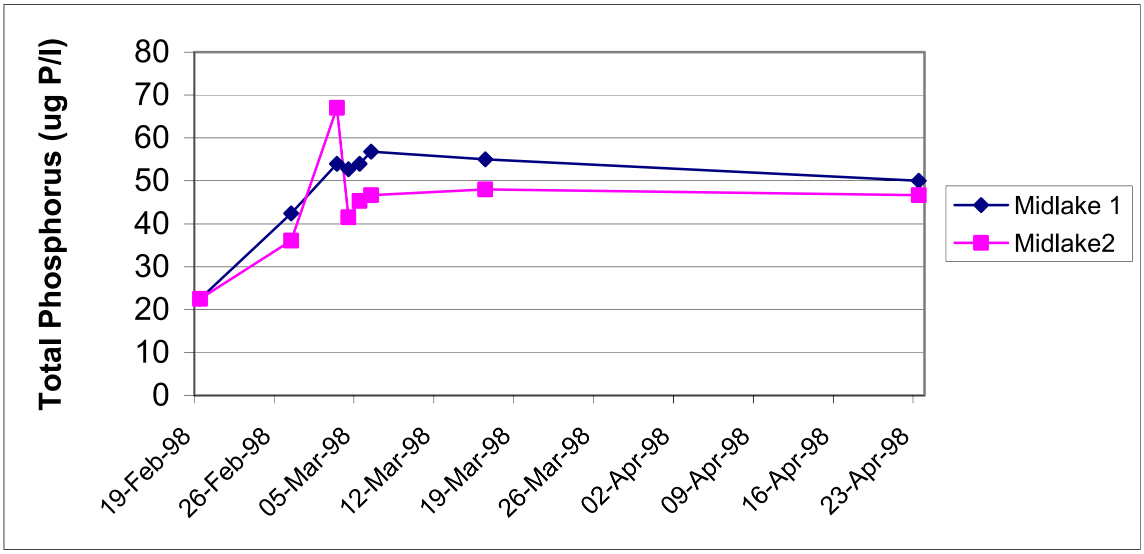
Figure 2. Soluble phosphorus concentration relative to dissolved oxygen in Cossayuna Lake sediment cores.



doubled as oxygen concentrations declined from 1.5 to 0.4 ppm at the Baldwin Bay site. The midlake site showed similar trends with declining dissolved oxygen. Rapid increases in soluble phosphorus concentration are typical as available oxygen is exhausted in the water column.

Concentrations of total phosphorus present when anaerobic conditions were reached in the core testing were used to determine the amount of phosphorus released from the sediments underlying the hypolimnion of Cossayuna Lake (Figure 4).

Figure 3. Total phosphorus release from Cossayuna Lake bottom sediments.



From the laboratory experiment, the maximum phosphorus release rate is determined by dividing the corrected maximum Total Phosphorus content (51.5 μg P/l) observed in water overlying the cores by the area of the core ($18cm^2$) and the time period required to reach this maximum for the first time (12 days). The volume of the water circulating system at the time of maximum phosphorus release was 4.25 liters. Using the data from the current experiment, we derived a release rate of 5.7 $mg/m^2/day$. Average, minimum and maximum calculated release rates are included as Table 4. These rates are in general agreement with rates calculated for other regional lakes.

Table 4. Total Phosphorus (TP) release rates for hypolimnetic sediments.

Site	TP Release Rate ($mg\ P/m^2/day$)	TP Release Rate minimum/maximum ($mg\ P/m^2/day$)
Midlake 1	6.2	5.4/6.7
Midlake 2	5.3	3.5/8.8

Conclusions

Laboratory studies examined the release of phosphorus from sediments underlying the hypolimnion of Cossayuna Lake. A single set of profiles of dissolved oxygen and temperature at a midlake location on Cossayuna Lake was also recorded in February of

1998. Oxygen concentrations were observed to fall below 20% saturation below a depth of 7 meters. Cossayuna Lake sediments show a classical phosphorus release pattern relative to declining oxygen concentration. As oxygen concentrations in the water column declined to near zero, total phosphorus concentrations climbed from 22.5 μg P/l to a maximum of 67 μg P/l. Actual release rates for total phosphorus were calculated and found to range from 3.5 to 8.8 mg P/m^2/day.

Profiles of dissolved oxygen collected during the period of summer stratification are necessary to develop the extent of the lake bottom which will be exposed to anaerobic conditions, and the depth at which anaerobic conditions occur in order to develop a loading rate for the entire lake. Without current lake data these can be estimated for preparation of the phosphorus budget, with a certain loss of accuracy.

References

APHA, 1995. Standard Methods for the Analysis of Water and Wastewater, 19th ed., APHA, AWWA, WEF, American Public Health Assn, Washington, DC. 1108 pp.