Beaver Dam Lake

Lake Improvement and Protection Project
1994 Report

Beaver Dam Lake Management District
Barron County, Wisconsin

SEH No. A-BEAVE9402.00

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SHORT ELLIOTT HENDRICKSON INC.

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Barron County, Wisconsin

Executive Summary

The Beaver Dam Lake Improvement Project was initiated in 1992 following the receipt in late 1991 of a Wisconsin Lake Management Planning Grant of $10,000 by the Beaver Dam Lake Management District. The goals of the study were:

- To acquire water quality data on Beaver Dam Lake over a series of growing seasons;
- Thorough a lake modelling effort, evaluate the water quality impact from existing development around the lakeshore and the associated land use within its drainage area;
- To evaluate the impact of the Cumberland Ditch on the water quality of Norwegian Bay of Beaver Dam Lake;
- To gather sociological information from users of the lake on recreational uses and the identify problems in need of examination; and
- To review and evaluate existing land use regulations and controls within the Beaver Dam Lake drainage area and suggest recommended changes to reduce or eliminate nonpoint source pollution.

There were 25 conclusions in the 1992 report (not repeated here) along with the following five recommendations:

1. Water quality monitoring of Beaver Dam Lake should be undertaken for one or two more growing seasons to confirm the water quality trend in the upper Upper lake and determine whether the Lower lake is reaching a steady state (leveling off in quality).

2. Serious consideration should be given to water quality and flow monitoring of selected inflows to Beaver Dam Lake to validate nutrient loading and subsequent lake modelling with BATHTUB.

3. The District should apply for an additional WDNR lake planning grant by August 1, 1993.

4. The District should approach the WDNR about participation in the U.S. Environmental Protection Agency's Clean Lakes grant program for Beaver Dam Lake in Fiscal Year 1994 (October 1, 1993) to offset the cost of a more complex monitoring and modelling effort.

5. The District should develop a newsletter for communication to its members on its actions.

The District applied for a second $10,000 grant in 1993 to partially fund and additional season of water quality data collection on Beaver Dam Lake in 1994. The 1994 study was undertaken to specifically satisfy the first recommendation of the 1992 study.

Sampling Methodology

Water quality data were collected from Beaver Dam Lake during the months of May through August, 1992. Based on the conclusions and recommendations of the 1992 monitoring analysis, additional monitoring was performed from May through September, 1994. The following is a summary of the monitoring performed and the analysis of the results.

A total of seven near surface (epilimnetic) lake stations (C1, C2, C2A, C4, C5, C6, and C7) were established in Beaver Dam Lake. The seven sites were sampled in five occasions in 1994 including 17 May, 21 June, 19 July, 16 August, 20 September. The 1994 study included one more month of sampling than that performed in 1992. The lake remains stratified through September and offers and additional opportunity for data collection.

The parameters selected for monitoring the water quality of Beaver Dam Lake in 1994 include alkalinity, chloride, chlorophyll *a*, dissolved oxygen, pH, secchi disc, specific conductivity, temperature, total Kjeldahl nitrogen, total nitrogen, and total phosphorus.

Temperature and Dissolved Oxygen

All of the bays of Beaver Dam Lake, with the exception of Cemetery Bay, show fairly strong to stable stratification. The lack of thermal stratification in a basin allows recycling of nutrients throughout the water column. As the thermocline acts as a barrier to nutrient circulation, it also prevents the overall mixing of surface waters with water at the bottom of a basin. In doing so, the supply of oxygen to the hypolimnion is eliminated and often results in diminished oxygen concentrations near the bottom of the basin. The hypolimnion becomes uninhabitable for fish and other organisms.

The results of the 1992 Study indicated that the hypolimnetic oxygen deficit in the bays of Beaver Dam Lake may be increasing when the 1992 data was compared to the historic data collected by WDNR. When the 1994 data was added, the increase does not seem as apparent and may be either beginning to improve, or a function of variation in growing season temperatures and precipitation.

Nutrients, Productivity and Transparency

The trophic characteristics of the bays of Beaver Dam Lake show considerable variation as measured by total phosphorus, chlorophyll *a* and secchi disc transparency. The upper Upper lake exhibited the lowest average nutrient (phosphorus) and primary productivity levels for the entire lake. Nutrient and primary productivity in the lower Upper lake is slightly higher than the upper Upper lake. In contrast to the Upper Lake, the bays of the Lower lake exhibit much higher levels of nutrients and primary productivity and lower secchi disc depths. Phosphorus and chlorophyll *a* concentrations are two to three times higher in Cemetery and Norwegian bays than concentrations recorded in the bays of the Upper lake. Of the two bays in the Lower lake, Cemetery Bay has the highest levels of phosphorus and primary productivity. However, the data recorded in Cemetery and Norwegian bays indicates continued improvement of the water quality in the Lower lake.

Trend Analysis

An important objective of a monitoring program is the detection of changes or trends in water quality. Statistical analysis of trends indicated by the recent two years of water quality data recorded at Beaver Dam Lake and data collected in the past by WDNR was performed. The statistical analysis showed a downward trend in total phosphorus concentrations in the upper Upper lake. A conclusion as to whether or not the Upper lake is in a "steady state" condition or if an actual trend in phosphorus decline is present cannot be determined because of the changes in sampling and analytical procedures.

Cemetery Bay and Norwegian Bay have also experienced a decrease in total phosphorus concentration. The question of laboratory analytical procedures is not an issue in the Lower lake because none of the recorded total phosphorus concentrations were near or below the analytical detection limits. The phosphorus concentrations in Cemetery and Norwegian bays were order of magnitude greater than those recorded in the Upper Lake most likely due to the historic inflow of the City's wastewater treatment works discharge. Since this discharge was removed in November 1981 (personal communication, Dennis Rockow, 1995) the total phosphorus concentration in Cemetery Bay declined rapidly and the quality of the bay continues to improve today.

Oxygen Prediction

One of the hypotheses suggested after the 1992 analysis is that the hypolimnetic oxygen depletion observed in nearly all of the bays of Beaver Dam Lake is due to the lake morphometry and not necessarily the external or internal phosphorus loading. To address this hypothesis, a model for predicting end-of-summer oxygen profiles in stratified lakes was utilized. The model utilizes lake morphometry, total phosphorus concentration and initial oxygen concentration at spring turnover to predict mean end-of-summer oxygen profiles in a lake's hypolimnion.

The model was used to predict oxygen concentrations in the hypolimnion of each of the bays of Beaver Dam Lake, except for Cemetery Bay (Station C4) which does not stratify and Library Lake (Station C7) because of its shallow depth. The predicted hypolimnetic oxygen profiles were then compared to the data recorded during August of the 1992 and 1994 sampling seasons. The model revealed that even without any anthropogenic (man-caused) impacts, it is not likely that the lake would be capable of supporting a trout fishery. Hypolimnetic oxygen depletion would likely occur in each of the stratified basins because of the shape of each basin. The model predicts that slight to moderate increases in hypolimnetic oxygen depletion occur today as the result of water quality impacts.

Conclusions

1. Water quality data was acquired from Beaver Dam Lake once each month from May through September, 1994 at seven monitoring stations.

2. Temperature profiles indicate vertical stratification by mid-May in all seven bays except Cemetery Bay because of its shallow depth.

3. Oxygen depletion was observed in the hypolimnion at all stations but was less severe than that recorded by WDNR and by SEH, Inc. in 1992.

4. As in 1992, the trophic state of the upper Upper lake is oligotrophic and is considered in good to very good condition with a recreational suitability of beautiful and a physical appearance of crystal clear.

5. The condition of Rabbit Island Bay appeared to improve slightly since 1992. The bay is still considered mesotrophic with minor aesthetic impact and a physical appearance of some algae.

6. The quality of Library Bay did not change significantly and is considered mesotrophic with a recreational suitability of minor aesthetic impact and a physical appearance of some algae, but contains extensive emergent and submergent weed growth.

7. Cemetery and Norwegian bays continue to exhibit high productivity as a result of the City of Cumberland wastewater treatment works discharge.

8. The water quality of the Lower lake continues to show improvement apparent since the removal of the wastewater treatment works discharge in 1981.

9. Norwegian and Cemetery bays are considered eutrophic, however, the recreational suitability of both bays improved from nearly swimming impaired to minor aesthetic impact and the physical appearance has improved from definite algae to some algae since 1992.

10. The downward trend in total phosphorus in the Upper lake determined in 1992 was strengthened with the addition of the 1994 data, but may still be an artifact of improved laboratory analytical procedures and not actual water quality improvements.

11. The downward trend in total phosphorus concentration in the Lower lake was also strengthened with the addition of the 1994 data and is the result of the diversion of the City of Cumberland's wastewater treatment plant discharge to Cemetery Bay.

12. Oxygen prediction modelling indicates the hypolimnetic oxygen depletion occurring in late summer in the bays of the Upper lake may not be the result of basin morphometry but from internal and/or external nutrient loading.

13. The oxygen prediction modelling confirmed that the Lower lake continues to be influenced by internal nutrient loading from residuals in the bottom sediments from past wastewater treatment works discharges.

Recommendations

1. Water quality and flow monitoring of selected inflows to and within Beaver Dam Lake should be performed to validate and calibrate subsequent lake modeling with BATHTUB.

2. Additional monitoring of the water quality of Beaver Dam Lake should be performed concurrent with the hydraulic monitoring for BATHTUB calibration.

3. The BATHTUB model should be utilized to assess the external loading and internal hydrology of Beaver Dam Lake.

4. The District should apply for an additional WDNR lake planning grant by August 1, 1995.

Project Background

The Beaver Dam Lake Improvement Project was initiated in 1992 following the receipt in late 1991 of a Wisconsin Lake Management Planning Grant of $10,000 by the Beaver Dam Lake Management District. The goals of the study were:

- To acquire water quality data on Beaver Dam Lake over a series of growing seasons;
- Thorough a lake modelling effort, evaluate the water quality impact from existing development around the lakeshore and the associated land use within its drainage area;
- To evaluate the impact of the Cumberland Ditch on the water quality of Norwegian Bay of Beaver Dam Lake;
- To gather sociological information from users of the lake on recreational uses and the identify problems in need of examination; and
- To review and evaluate existing land use regulations and controls within the Beaver Dam Lake drainage area and suggest recommended changes to reduce or eliminate nonpoint source pollution.

Water quality data were collected from Beaver Dam Lake during the months of May through August, 1992. The following conclusions and recommendations resulted from the 1992 study:

Conclusions of 1992 Study

1. Water quality data was successfully acquired from May through August on seven monitoring stations on Beaver Dam Lake and on the Cumberland Ditch during April through August in 1992.

2. Temperature profiles of Beaver Dam Lake indicated strong vertical stratification in all the bays except Cemetery due to its shallow depth.

3. Approximately 13 percent of the volume of the hypolimnion (water column portion below the thermocline) was depleted of dissolved oxygen in upper Upper lake (C1, C2, & C2A) of Beaver Dam Lake during June, July, and August of 1992.

4. Approximately 86 percent of the volume of the hypolimnion (water column portion below the thermocline) was depleted of dissolved oxygen in Rabbit Island Bay (C6) of Beaver Dam Lake during June, July, and August of 1992.

5. More than 100 percent of the volume of the hypolimnion (water column portion below the thermocline) was depleted of dissolved oxygen in Norwegian Bay (C5) of Beaver Dam Lake during June, July, and August of 1992.

6. The trophic state (nutrients and algae) of the upper Upper lake is considered in good to very good condition with a recreational suitability of beautiful and a physical appearance of crystal clear.

7. The trophic state of Library Bay is considered to have a minor aesthetic impacts due to algae, but extensive emergent and submergent weed growths.

8. Norwegian Bay in the Lower lake is considered to be in a highly productive trophic state with a range of recreational suitability impacts of minor to swimming impaired.

9. Cemetery Bay in the Lower lake is also considered to be in a highly productive trophic state with recreational suitability of swimming being impaired or eliminated.

10. A downward trend in total phosphorus concentrations was statistically confirmed in the upper Upper lake over the period of 1975 through 1992, but may well be an artifact of changed laboratory analytical procedures and not environmental causes.

11. A dramatic downward trend in total phosphorus concentrations was statistically confirmed in the Lower lake and has likely the resulted from the diversion of the City of Cumberland's wastewater treatment plant discharge to Cemetery Bay.

12. Lake modelling of the upper Upper lake confirmed the in-lake total phosphorus concentration, but does not support the contention that the nutrient loading from Rabbit Island and Library bays could be a significant source.

13. Lake modelling of Library Bay indicated that urban runoff sources contribute 86 percent of its annual total phosphorus loading.

14. Lake modelling of the Lower lake (Norwegian Bay) revealed that the Cumberland Ditch would contribute only 17 percent of the phosphorus loading on an annual basis.

15. The existing lake models used in this study are not sophisticated enough to permit an accurate simulation of Cemetery Bay's water quality.

16. Of the 300 questionnaires sent out to Beaver Dam Lake Management District members, a total of 102 or 34 percent were returned for analysis of results.

17. About 48 percent of lakeshore owners are year around residents with only 14 percent being weekend users.

18. About 89 percent of the respondents in Zone 1 (upper Upper lake) felt the lake's clarity was "clear to crystal clear"; conversely 55 to 66 percent of the respondents in Zone 2 (Library Bay) and Zone 3 (Lower lake) believe the clarity was "cloudy to murky".

19. Nearly 40 percent of the respondents in Zone 1 believe that the water quality has stayed the same, while 12 percent felt it had gotten worse; conversely 55 percent of the persons in Zone 2 indicated that the water quality had slightly or considerably degraded.

20. Most surprising and encouraging was that 42 percent of the respondents in Zone 3 (Norwegian and Cemetery bays) believed that the water quality had gotten better.

21. Plant growth was thought to be just right for fish and wildlife by 54 percent of the respondents overall, but in Zones 2 and 3, a total of 44 to 67 percent felt conditions were heavy or weed choked.

22. Boat traffic was considered moderate by 55 percent of the lakeshore owners and that little or moderate conflict had been experienced by 87 percent of the respondents.

23. Public access is considered by more than two-thirds (67 percent) of the persons to be adequate for Beaver Dam Lake.

24. More than half (57 percent) of the respondents believe that the Beaver Dam Lake Management District is most important in managing the lake along with the development of a long-term lake management plan as the most important action by 45 percent of the respondents.

25. A newsletter is considered by 68 percent of the questionnaire respondents to be the best manner for the District to communicate with the membership.

Recommendations of 1992 Study

1. Water' quality monitoring of Beaver Dam Lake should be undertaken for one or two more growing seasons to confirm the water quality trend in the upper Upper lake and determine whether the Lower lake is reaching a steady state (leveling off in quality).

2. Serious consideration should be given to water quality and flow monitoring of selected inflows to Beaver Dam Lake to validate nutrient loading and subsequent lake modelling with BATHTUB.

3. The District should apply for an additional WDNR lake planning grant by August 1, 1993.

4. The District should approach the WDNR about participation in the U.S. Environmental Protection Agency's Clean Lakes grant program for Beaver Dam Lake in Fiscal Year 1994 (October 1, 1993) to offset the cost of a more complex monitoring and modelling effort.

5. The District should develop a newsletter for communication to its members on its actions.

Based on these conclusions and recommendations, a second grant was requested in 1993 to fund an additional season of water quality data collection on Beaver Dam Lake in 1994. This second $10,000 grant partially funded the $14,495 monitoring study of 1994. The 1994 study was undertaken to specifically satisfy the first recommendation from the 1992 study.

Methodology

Evaluating a lake's water quality requires establishing criteria and tasks which will result in a definitive study satisfying the District's needs and reflecting a technical content and discussion suitable for appropriate review by WDNR staff. The District's 1991 grant application outlined a five-step process by Sanders, et al. (1983) which was modified as follows:

1. Review and evaluate background lake data and watershed information, determine adequacy, and scope additional work areas;
2. Design a monitoring system;
3. Establish statistical data review and analysis procedures; and
4. Establish information reporting procedures.

A review of existing water quality data within the Beaver Dam Lake files at the WDNR, Northwest District was undertaken during the initial phase of the project. Water quality sampling and analysis of Beaver Dam Lake was conducted by WDNR in 1975, '76, '77, '78, '79, '81, '82, '83, '84, '85, '86, '87 and '89 at several stations. However, in many years only one sample was taken from a lake station and often only during the Fall, Winter or Spring. While such data is very valuable over the long-term, a systematic sampling program throughout a growing season had not previously been implemented.

A monitoring program was designed to acquire adequate information which could be evaluated from the perspective of accurately describing the lake's condition. The program was based upon the need to answer hypotheses established for Beaver Dam Lake. The following hypotheses were established and tested on Beaver Dam Lake in 1992:

1. The west basin of Beaver Dam is oligotrophic or mesotrophic and of a high quality condition.
2. The east basin of Beaver Dam Lake is eutrophic or hypereutrophic and of a poor water quality condition.
3. Internal phosphorus loading is an insignificant portion of the annual contribution to the west basin of Beaver Dam Lake.
4. Internal phosphorus loading is a significant portion of the annual contribution to the east basin of Beaver Dam Lake.

Based on the results of the 1992 study, the following additional hypotheses were tested in 1994:

- Hypolimnetic oxygen depletion in the lake is due to lake morphometry and not external or internal phosphorus loading.
- The water quality in Norwegian Bay is improving.
- The water quality in Library and Rabbit Island bays is deteriorating.

The monitoring design involved the selection of water quality sampling sites, sample parameters, sampling frequency, and field methodology.

Sampling Sites

The location of in-lake sampling sites was made in the first phase of the lake study. Sampling locations were made in consideration of the potential for thermal stratification, lake water circulation patterns, basin morphology, and whether a particular location had been a previous historic WDNR station. Figure 1 illustrates the sampling stations.

A total of seven near surface (epilimnetic) lake stations (C1, C2, C2A, C4, C5, C6, and C7) were established in Beaver Dam Lake. Stations C1, C2, C4 and C5 were similar locations used in the WDNR lake studies. Stations C2A, C6 and C7 were newly added stations to better describe the Williams Bay (C2A), Rabbit Island Bay (C6), and Library Bay (C7) areas of Beaver Dam Lake.

Stations C1, C2, C5 and C6 had companion bottom water (hypolimnetic) stations to evaluate the potential magnitude of internal nutrient loading. An additional hypolimnetic sample was added to Station C7 following the May 27, 1992 sampling period and was carried through the 1994 sampling season. Another additional hypolimnetic sample was added to Station C2A following the August 16, 1994 sampling.

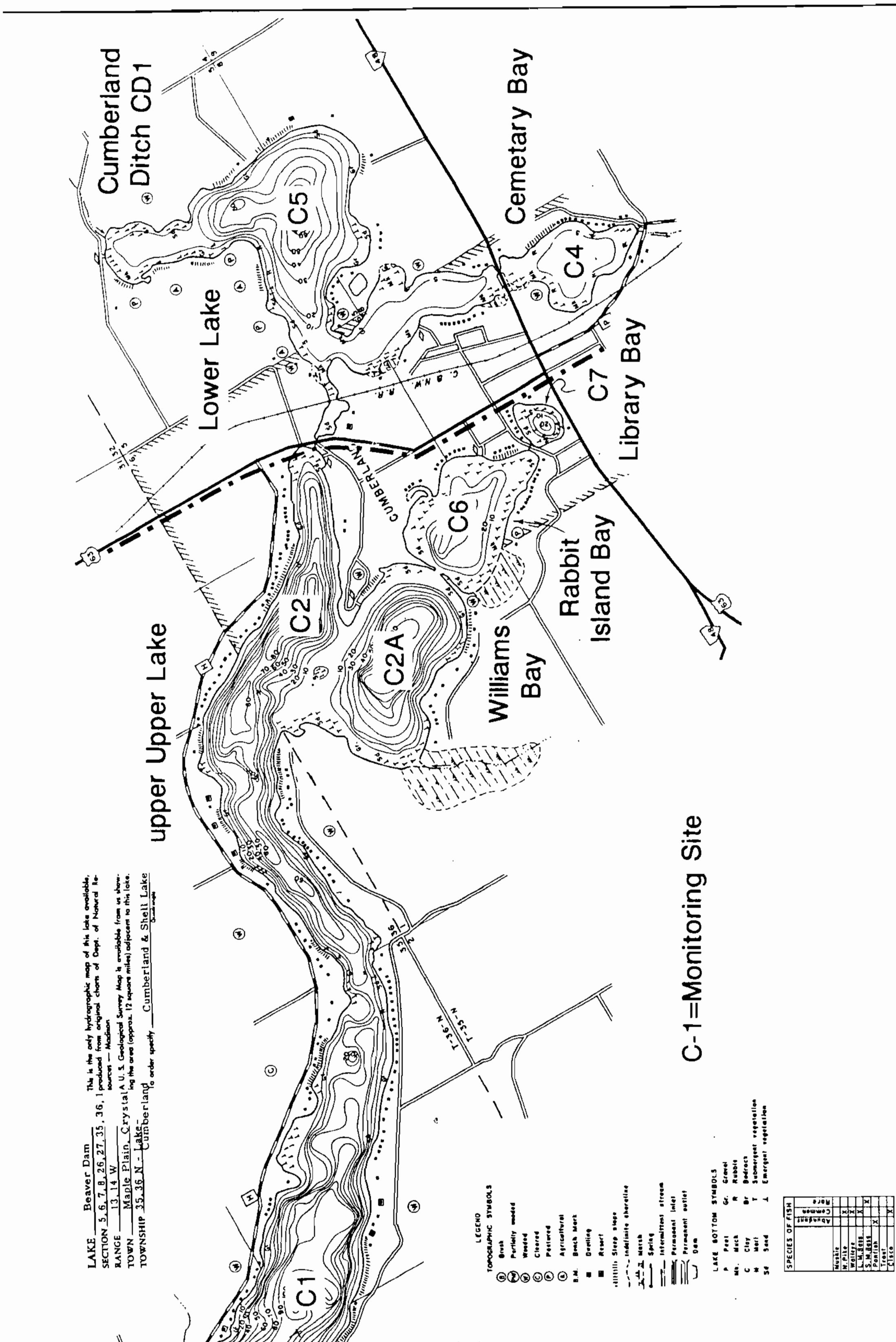


Figure 1

Beaver Dam Lake Monitoring Sites

Sample Parameters

The parameters selected for monitoring the water quality of Beaver Dam Lake in 1994 are listed in Table 1. The following is a short summary description for each parameter and its importance in water quality.

Table 1
Water Quality Parameters and Monitoring Frequency

Parameter	Field/Lab (F,L)	Frequency	Sample Location
Secchi Disk	F	ALL	S
Dissolved Oxygen (profile)	F	ALL	S,B
Temperature (profile)	F	ALL	S,B
Total phosphorus	L	ALL	S,B
Total Kjeldahl nitrogen	L	ALL	S,B
Nitrite + nitrate nitrogen	L	ALL	S,B
Ammonia nitrogen	L	ALL	S,B
Total alkalinity	L	ALL	S,B
pH (profile)	F	ALL	S,B
Chloride	L	ALL	S,B
Conductivity (profile)	F	ALL	S,B
Chlorophyll *a*	L	ALL	S

Lake sampling consisted of one monthly sample during the months of May, June, July, August and September.

S - Lake surface sample B - Lake bottom sample

Alkalinity

Alkalinity is a measure of the water's capacity to neutralize acids with little or no change in pH. Waters with high alkalinity are effective in resisting changes in pH when acid is added. Sources of acid additions to lakes can include acid precipitation (rain or snow), acidification resulting from removal of carbon dioxide from the water column during photosynthetic growth of weeds or algae or addition of carbon dioxide from the water column during respiration of organisms. Water with an alkalinity of less than about 75 mg/L (milligrams per liter or parts per million) is considered soft; 76 to 150 mg/L moderately hard; 151 to 300 mg/L hard; and those greater than 300 mg/L very hard. Lakes with alkalinities less than 10 to 20 mg/L may be considered potentially sensitive to acid precipitation or surface runoff inputs of acidic waters.

Chloride

Chloride is a dissolved constituent which occurs in all fresh waters, but generally at low levels (less than 5-10 mg/L). Increasing chloride (as a sodium, calcium or magnesium salt) concentrations in a lake may result chloride from inputs from outside sources including subsurface seepage from septic tanks or runoff from streets receiving deicer applications. Permanent stratification of the lake's water column may occur from the increased density of chloride waters and a lack of lake flushing if concentrations in the hundreds of parts per million are observed.

Chlorophyll *a*

Chlorophyll *a* is a green pigment produced by algae to capture light energy for photosynthesis. Measurement of the concentration of chlorophyll *a* in a water sample can be used to estimate the amount or standing crop of algal populations. Except for brown stained or sediment-ladened lake waters, algae most often causes the decrease in secchi disk transparency. Concentrations of chlorophyll *a* are reported in μg/L (micrograms per liter or parts per billion).

Dissolved Oxygen

The amount of oxygen dissolved (solubility) in water increases with decreasing temperature. Lakes often have higher concentrations of dissolved oxygen near the surface because of photosynthetic algae growth. Conversely, plant matter or other organic wastes decaying through the water column and on the lake bottom coupled with the respiration of organisms, all consume oxygen. Because of temperature stratification, nutrients, oxygen and other substances present near the surface of a lake are often inaccessible to its deeper waters. Oxygen depletion in a lake's bottom region results from organism respiration and decomposition of organic matter which cannot be recharged with oxygen produced by photosynthesizing organisms at the surface. Water with an oxygen concentration less than 1 mg/L is of poor quality. Smallmouth bass require more than 6 mg/L of dissolved oxygen for optimum growth. Wisconsin Administrative Code, NR 102.04(4)(a) requires a minimum of 5.0 mg/L of dissolved oxygen for the protection of fish and aquatic life.

pH

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions in a liquid. A pH of 7 is considered neutral. Acidity increases as pH falls from 7 to 0, while alkalinity increases as pH falls from 7 to 14. The pH of most lakes ranges between 6.5 and 8.5. The pH of lake water can increase with photosynthetic activity. However, waters with higher alkalinity resist changes in pH with the removal of carbon dioxide (CO_2) from photosynthesis or the addition of CO2 from respiration. Immature fish and insects are sensitive to acidity and can be affected in lakes with a pH below 5.

Secchi Disc

A secchi disc is an 8 inch in diameter black and white disk used to measure the extent to which algae, water color or other suspended and dissolved materials interfere with the penetration of light into the water. The secchi depth is a measure of the transparency of the water and can also be used to estimate the approximate density of algal populations. It is the average of the depth to which a secchi disc disappears when lowered over the side of a boat and the depth at which it reappears upon raising it again towards the surface. Transparency values are most often reported in meters (m).

Specific Conductivity

Specific conductivity is a measurement of the reciprocal (1/x) of resistance (x). Conductance reflects the ability of water to carry an electrical current, thus loading more salts and inorganic compounds in a lake increases the specific conductivity value. Distilled water as well as soft waters have very low specific conductivities (less than 100 µmhos/cm or micromhos per centimeter). Conversely, hypereutrophic (very over-nourished) lakes have high specific conductivities (greater than 250 µmhos/cm).

Temperature

The balance of physical and chemical characteristics within a lake is governed by differences in water density which is affected by temperature. Temperature also affects the amount of oxygen dissolved in water(solubility) and the rates of chemical and biological processes such as plant photosynthesis(oxygen production) and organism growth(respiration or oxygen consumption). Temperature stratification prevents mixing of the surface and deeper waters of a lake during the summer months. Temperature is most often reported in degrees Centigrade (C).

Total Kjeldahl Nitrogen

An analytical technique and term which represents the combination of ammonia-nitrogen and organic-nitrogen. Therefore, subtracting ammonia-nitrogen from Kjeldahl nitrogen leaves organic-nitrogen. Kjeldahl nitrogen is most often reported in parts per million.

Total Nitrogen

Nitrogen is an essential nutrient for submerged/emergent plant and algal growth. It is present in the atmosphere mostly as molecular nitrogen (N_2). In lake water, it occurs in many compounds but is measured in three basic forms: first various organic compounds as organic-N, second as NH_3 or ammonia-N, and third as $NO_2^- + NO_3^-$ ions or nitrite plus nitrate-N. Total nitrogen is equal to the combination of ammonia-nitrogen and organic-nitrogen (a.k.a. Kjeldahl nitrogen) with nitrate-nitrogen plus nitrite nitrogen. Natural sources of nitrogen include precipitation, atmospheric nitrogen fixation by photosynthetic plants and algae and surface and groundwater inflow. Nitrogen enrichment of lakes can occur from human sources including runoff from agricultural fields and feedlots, seepage from leaking septic tanks or properly operating drainfields, and municipal/industrial wastes. Total nitrogen is most often reported in parts per million.

Total Phosphorus

Primary productivity (algal growth) in a lake is dependent on the availability of nutrients (phosphorus, nitrogen, and other minor constituents). Total phosphorus, often the limiting nutrient in a lake, increases with lake primary productivity. Phosphorus in a lake may come from many sources both natural and cultural. Most oligotrophic (low nutrients and productivity) lakes are limited by phosphorus. Increasing lake productivity or eutrophication is caused by abundance phosphorus loading over both the short- and long-term. In general, a total phosphorus goal of 0.030 mg/L will avoid nuisance algal growths and impaired recreational use such as swimming.

Sampling Frequency

The seven sites on Beaver Dam Lake were sampled in five occasions in 1994 including 17 May, 21 June, 19 July, 16 August, 20 September. The 1994 study included one more month of sampling than that performed in 1992. The lake remains stratified through September and offers and additional opportunity for data collection.

Field Methods

Sample sites in each particular basin were located in the field using a portable sonar. The lake sites are typically the deepest portion of a given basin. Water transparency was measured with a standard secchi disk. Profiles (surface to near bottom) were performed at each site for temperature, dissolved oxygen concentration, percent saturation of dissolved oxygen, total dissolved solids (TDS) concentration, specific conductivity, pH and redox (oxidation-reduction). Profiles at the sites were acquired using a Hydrolab Multi-parameter Water Quality Monitor. Readings from the sites were recorded on field data sheets as the instrument was lowered at increments of one meter from the surface through the thermocline followed by every three meters to near bottom.

Water samples were retrieved from the surface and near bottom at each site, except Station C4 which included only a surface sample because of the shallow depth of Cemetery Bay. All samples were collected in bottles supplied by the WDNR. The bottles were rinsed several times with surface water before a sample was collected at a depth of one-half meter below the surface. Bottom samples were retrieved using a two-liter alpha bottle (Wildco) lowered to a depth approximately one meter above the lake bottom. The collected water was transferred into sample bottles provided by the WDNR after rinsing the bottles several times with water obtained from the alpha bottle. Water samples to be analyzed for nitrogen and total phosphorus were preserved with sulfuric acid.

Chlorophyll *a* samples were collected at a depth of approximately one-half meter below the surface. The samples were bottled and immediately placed in a dark cooler with ice until they were filtered.

Sample preparation consisted of vacuum filtration of 500 to 1000 milliliters of water through a 0.45μ (micron) glass fiver filter with a hand-operated pump. The filter was immediately folded and wrapped in aluminum foil, labelled with the sample station and filtrate volume and placed in the shipping container.

All collected samples were packed with ice in styrofoam mailing containers provided by the WDNR. The mailers were sent via priority mail to the State Laboratory of Hygiene in Madison, Wisconsin for analyses.

Sampling Results

The project results are presented in four areas; Physical Characteristics, Temperature and Dissolved Oxygen, Nutrients, and Productivity and Transparency. All of these characteristics are interrelated in every lake and they reflect the ecological classification and potential recreational uses.

Physical Characteristics

Beaver Dam Lake is a 1,112-acre, soft water seepage lake (Sather and Threinan, 1964). While monitoring stations were located throughout the lake's major basins, initial review of the historical and 1992 water quality data revealed chemical characteristics which effectively divide the lake into an upper and lower basins. For the purposes of the 1992 study, United States Highway (USH) #63, which intersects the City of Cumberland, Wisconsin, was be considered the boundary between the upper and lower basins of the lake. The upper and lower lake are further divided into several basins or bays. The same segregation was utilized in the analysis of the 1994 water quality data.

Upper Lake

The upper lake is divided into two basins. The first area, or the upper Upper lake is the largest, comprising a long, 6.1 kilometers (3.8 miles), "S"-shaped and narrow 0.3 kilometer (0.2 mile) basin. It contains monitoring stations C1, C2 and C2A in Williams Bay west of the Eagle Point peninsula. This is the largest basin of Beaver Dam Lake as shown in Table 2. It is 293 hectares (723 acres) in area and makes up about 65 percent of the lake. It also contains the deepest location of 31 meters (103 feet) at the north end of the basin. The volume of this basin is approximately 83 percent of Beaver Dam Lake, making its average depth of 12.5 meters (41 feet) two and one-half times greater than Norwegian Bay in the lower lake.

The second area, or the lower Upper lake, includes Rabbit Island and Library bays. Rabbit Island Bay contains monitoring station C6 and is bounded on the south by Library Bay and on the north by an isthmus known as Beaver Dam (personal communication, C. Christianson, 1993). Rabbit Island, as it is locally known, is actually a peninsula surrounded by open water on the west and southeast with wetland habitat around the remainder of its perimeter. A man-

Table 2
Physical Characteristics of Beaver Dam Lake

Upper Lake **upper Upper Lake**	**Surface Area**	**Lake Volume**	**Average Depth**	**Tributary Area**
Station C1	312 acres (126 ha)	14,335 ac-ft (1.45 x $10^7 m^3$)	46.0 ft (14.0 m)	1,540 acres (623 ha)
Station C2	279 acres (113 ha)	9,745 ac-ft (9.85 x $10^6 m^3$)	34.9 ft (10.7 m)	635 acres (257 ha)
Station C2A	132 acres (53 ha)	5,600 ac-ft (5.66 x $10^6 m^3$)	42.4 ft (12.9 m)	935 acres (378 ha)
lower Upper Lake				
Rabbit Island Bay Station C6	92 acres (37 ha)	1,309 ac-ft (1.61 x $10^6 m^3$)	14.2 ft (4.3 m)	158 acres (64 ha)
Library Bay Station C7	13 acres (5 ha)	72 ac-ft (8.86 x $10^4 m^3$)	5.5 ft (1.7 m)	33 acres (13 ha)
SUBTOTAL:	828 acres (335 ha)	31,061 ac-ft (3.14 x $10^7 m^3$)	37.5 ft (11.4 m)	
Lower Lake	**Surface Area**	**Lake Volume**	**Average Depth**	**Tributary Area**
Cemetery Bay Station C4	52 acres (21 ha)	181 ac-ft (2.22 x $10^5 m^3$)	3.5 ft (1.1 m)	185 acres (75 ha)
Norwegian Bay Station C5	288 acres (116 ha)	4,494 ac-ft (5.53 x $10^5 m^3$)	15.6 ft (4.8 m)	806 acres (326 ha)
SUBTOTAL:	340 acres (138 ha)	4,675 ac-ft (5.38 x $10^6 m^3$)	13.7 ft (4.2 m)	
Beaver Dam Lake	1,168 acres (473 ha)	35,736 ac-ft (3.68 x $10^7 m^3$)	30.6 ft (9.3 m)	4,292 acres (1,737 ha)

made channel, nearly 1,000 feet in length, connects the wetland area with the bay. This channel is a source of storm water runoff from the older, developed portion of the City of Cumberland.

The second bay of the lower Upper lake is known as Library Bay (a.k.a. Library Lake). This small, 5.3 hectare (13 acres) bay contains monitoring station C7 and is bounded on the south by USH #63 and on the north by Grove Street. It is a shallow basin with a maximum depth of 5.5 meters (18 feet) and an average depth of 1.7 meters (5.5 feet). The surface area of Library Bay was apparently much larger historically and extended south into the Elm Street (USH #63), Webb and Donatelle streets area (personal communication, C. Christianson, 1993).

Overall, the Upper lake comprises 71 percent of the surface area and 87 percent of the volume of Beaver Dam Lake as a whole. Outflow from the Upper lake into the Lower lake occurs through the culvert crossing at Superior Avenue (a.k.a. USH #63).

Lower Lake

The Lower lake includes two principle areas: Norwegian and Cemetery bays. Norwegian Bay is the larger of the two at 116 hectares (288 acres) and deeper, averaging 4.8 meters (15.6 feet) in depth. The Cumberland Ditch, sampled for water quality inputs in 1992, flows into Norwegian Bay at its northeast corner while the channel connecting the bay to the Upper lake is located at the northwest end. Outflow from Norwegian Bay is typically south into Cemetery Bay. Norwegian Bay is slightly more than three times the area of Rabbit Island Bay in the Upper lake. However, it is similar with respect to average depth.

In contrast, Cemetery Bay is only 21 hectares (52 acres) in area and is the most shallow basin of Beaver Dam Lake with an average depth of only 1.1 meters (3.5 feet). For many years, cemetery Bay was the receiving water of the City of Cumberland's wastewater treatment works (WWTW) discharge. Construction of a new plant resulted in diversion of the discharge from the bay in 1981. Typically, water flows into Cemetery Bay from Norwegian Bay and flows out into a tributary of the Hay River to the south. However, it is well known in the area that there were periods prior to the diversion of the WWTW discharge when Cemetery Bay "backed up" into Norwegian Bay. A hypothetical scenario in which seepage and surface evaporation during the growing season in the much larger Norwegian Bay could have resulted in an elevation differential with respect to Cemetery Bay, causing the WWTW discharge to impact Norwegian Bay as well as Cemetery Bay. The historically poor quality of Norwegian Bay, discussed later, appears to support this hypothesis.

Overall, the Lower lake is much smaller than the upper lake, comprising 138 hectares (340 acres) and more shallow, averaging only 4.2 meters (13.75 feet) in depth. The Lower lake makes up 29 percent of the surface area and 13 percent of the volume of Beaver Dam Lake as a whole.

Temperature and Dissolved Oxygen

Because of the differences in morphometry in each of the basins, Beaver Dam Lake exhibits a variety of thermal and dissolved oxygen regimes. Overall, the results of the temperature and dissolved oxygen data collection in 1994 were similar to those in 1992. Appendix A contains a summary of a portion of the historic data collected on Beaver Dam Lake by WDNR in the past and by SEH, Inc. in 1992 and

1994. Appendix B contains a summary of all the monitoring data collected by SEH, Inc. during the 1994 sampling season.

All of the bays of Beaver Dam Lake, with the exception of Cemetery Bay, show fairly strong to stable stratification. The importance of thermal stability relates to the ability of nutrient contribution to the photic zone of the lake. In basins with strong thermal stratification, the thermocline acts as a barrier to the mixing of water and nutrients contained in the hypolimnion with the surface waters containing the algae and sunlight required for photosynthesis. Conversely, the lack of thermal stratification in a basin allows recycling of nutrients throughout the water column.

As the thermocline acts as a barrier to nutrient circulation, it also prevents the overall mixing of surface waters with water at the bottom of a basin. In doing so, the supply of oxygen to the hypolimnion is eliminated and often results in diminished oxygen concentrations near the bottom of the basin. Without a supply of oxygen from the surface, the oxygen levels at the lake bottom are depleted by the respiration of fish, other organisms and the processes of decomposition and can result in complete anoxia. Diminished oxygen concentrations can make the hypolimnion uninhabitable for fish and other organisms.

The results of the 1992 Study indicated that the hypolimnetic oxygen deficit in the bays of Beaver Dam Lake may be increasing when the 1992 data was compared to the historic data collected by WDNR. When the 1994 data was added, the increase does not seem as apparent and may be either beginning to improve, or a function of growing season temperatures and precipitation. Wetzel (1983) has noted, along with many other authors, that hypolimnetic oxygen deficits are positively correlated to increasing algae populations and higher total phosphorus concentrations and inversely proportional to secchi disc transparency. Additional years of data and a comparison of weather conditions in the years of sampling may help to identify whether these changes are actually improvements in lake quality or the result of fluctuations in algal populations and/or flushing of the lake from increases in precipitation and runoff.

Upper Lake

As discussed in the 1992 Study Report, the Upper Lake contains the majority of the volume of Beaver Dam Lake. From a thermal standpoint, this portion of the lake is dimictic, meaning it "turns over" twice each year, once in the spring and once in the fall. According to the historical, 1992 and 1994 data, the lake begins to thermally stratify during late April to mid May after mixing at ice-out. A thermocline develops at approximately 15 feet (5 m) and is maintained through September. By late October, the lake surface has cooled to the point where it has become more dense than the hypolimnion and turnover occurs again.

As shown in Figures 2, 3, and 4, the thermal regimes at stations C1, C2 and C2A were very similar during each of the sampling periods in 1994. Very strong thermal stability was recorded at stations C1, C2 and C2A corresponding to the depth of the basins and the limited susceptibility to wind mixing.

Anoxia, or complete loss of oxygen was observed in the lower ten feet (3 m) and the lower 20 feet (6 m) of the lake at Station C1 on August 16, 1994 and September 20, 1994, respectively. A similar zone of anoxia was observed in the lower ten feet of the basin in August 1992, in the lower 35 feet in October 1987, in the lower 20 feet in November 1982, and in the lower 20 feet August 1983 during SEH and WDNR lake surveys.

Similar zones of anoxia were recorded at stations C2 and C2A in August and September, 1994. The anoxic zone at Station C2 was deeper than that recorded at Station C1 and at Station C2A. The anoxic zone at Station C2A was deeper than that recorded at Station C1 but not as deep as that recorded at Station C2.

Rabbit Island Bay in the lower Upper lake is significantly more shallow than the upper Upper lake. The thermal regime at Station C6 (Figure 5) was similar to that recorded in 1992. The data were similar throughout the sampling period (May - September) displaying less of a difference between spring and fall temperatures.

As in 1992, anoxic conditions in the hypolimnion were evident earlier at Station C6 than at stations in the upper Upper lake. The lower six meters (20 feet) were anoxic by July 19, 1994 and remained through September.

Library Bay, containing Station C7, is even more shallow than Rabbit Island Bay. The thermal regime in Library Bay (Figure 6) is similar to that of Rabbit Island Bay, however, the stratification of the basin is not as pronounced because of the more shallow depth of the basin.

As in Rabbit Island Bay, the hypolimnion of Library Bay became anoxic relatively early in the season in 1992 and in 1994. The lower meter (3 feet) of the basin was anoxic by June 21, 1994 and remained and deepened to 2 meters (6 feet) by September.

Lower Lake
The Lower Lake is dominated by Norwegian Bay (Station C5). As shown in Table 1, Norwegian Bay is similar in morphometry to Rabbit Island Bay in the lower Upper Lake. Both basins have similar mean or average depth and display similar thermal regimes. Norwegian Bay begins to stratify in late April to early May (Figure 7) and the thermocline is well developed at 3 to 10 meters (10 to 33 feet) by mid-May.

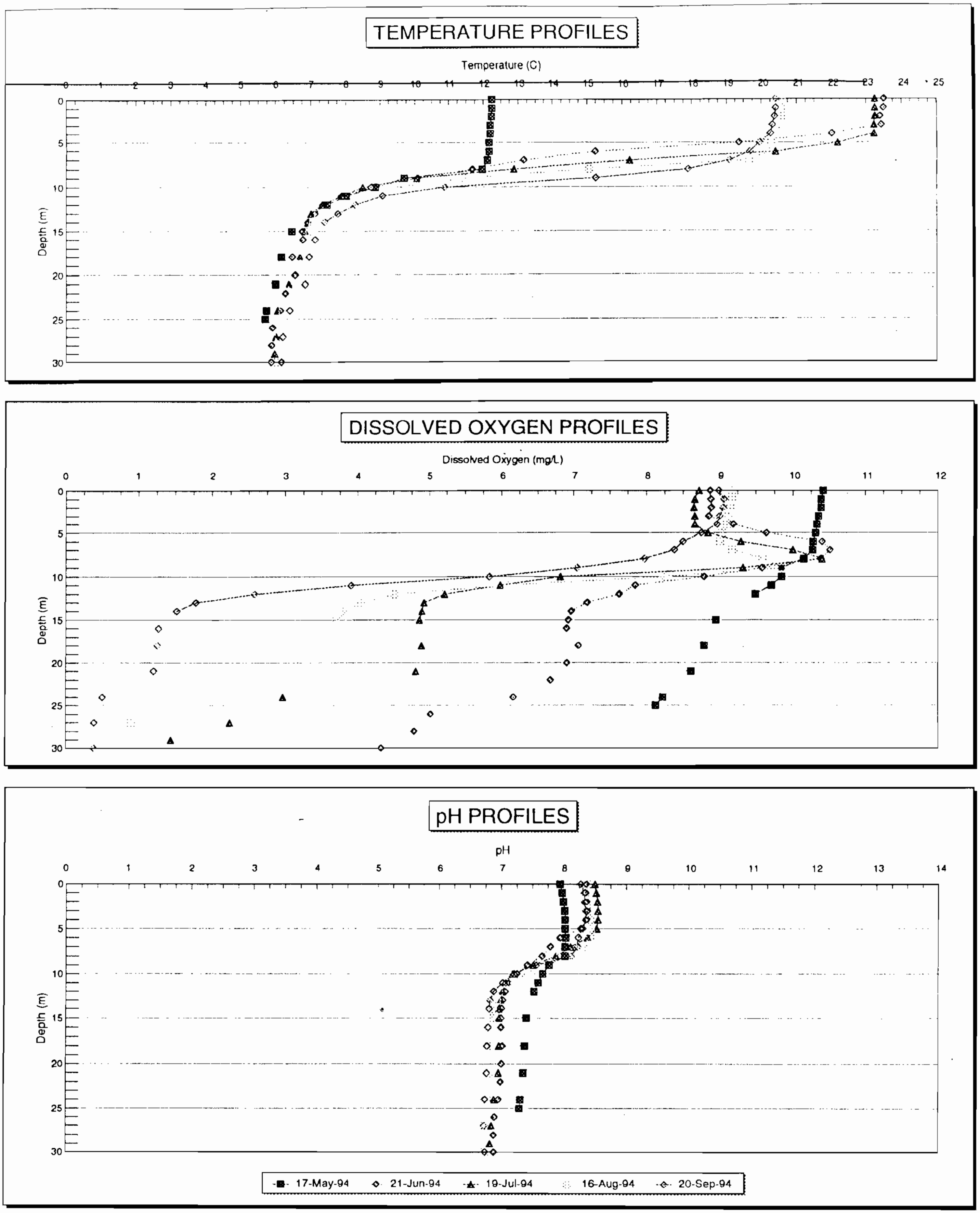


Figure 2
1994 Sampling at Site C1

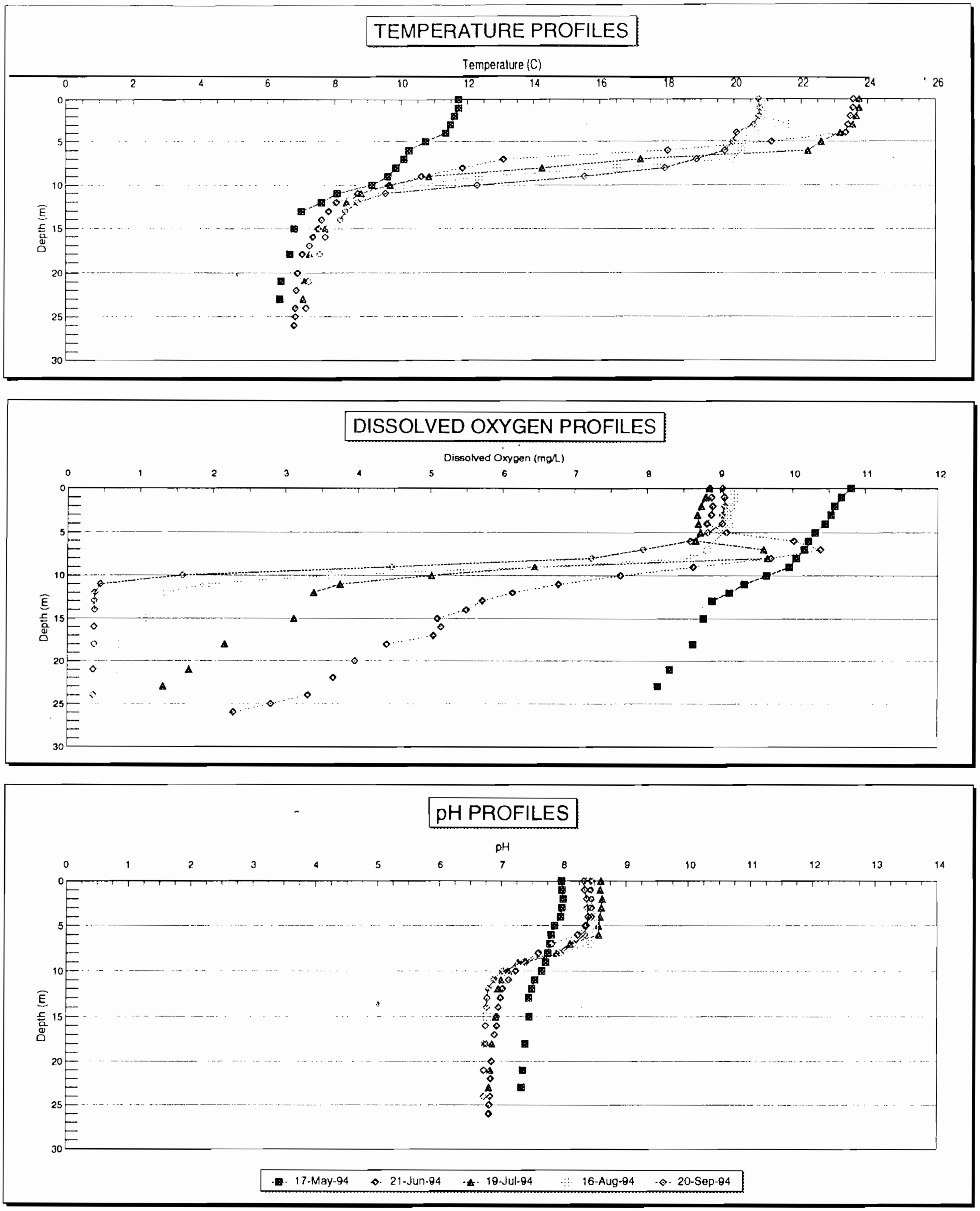


Figure 3
1994 Sampling at Site C2

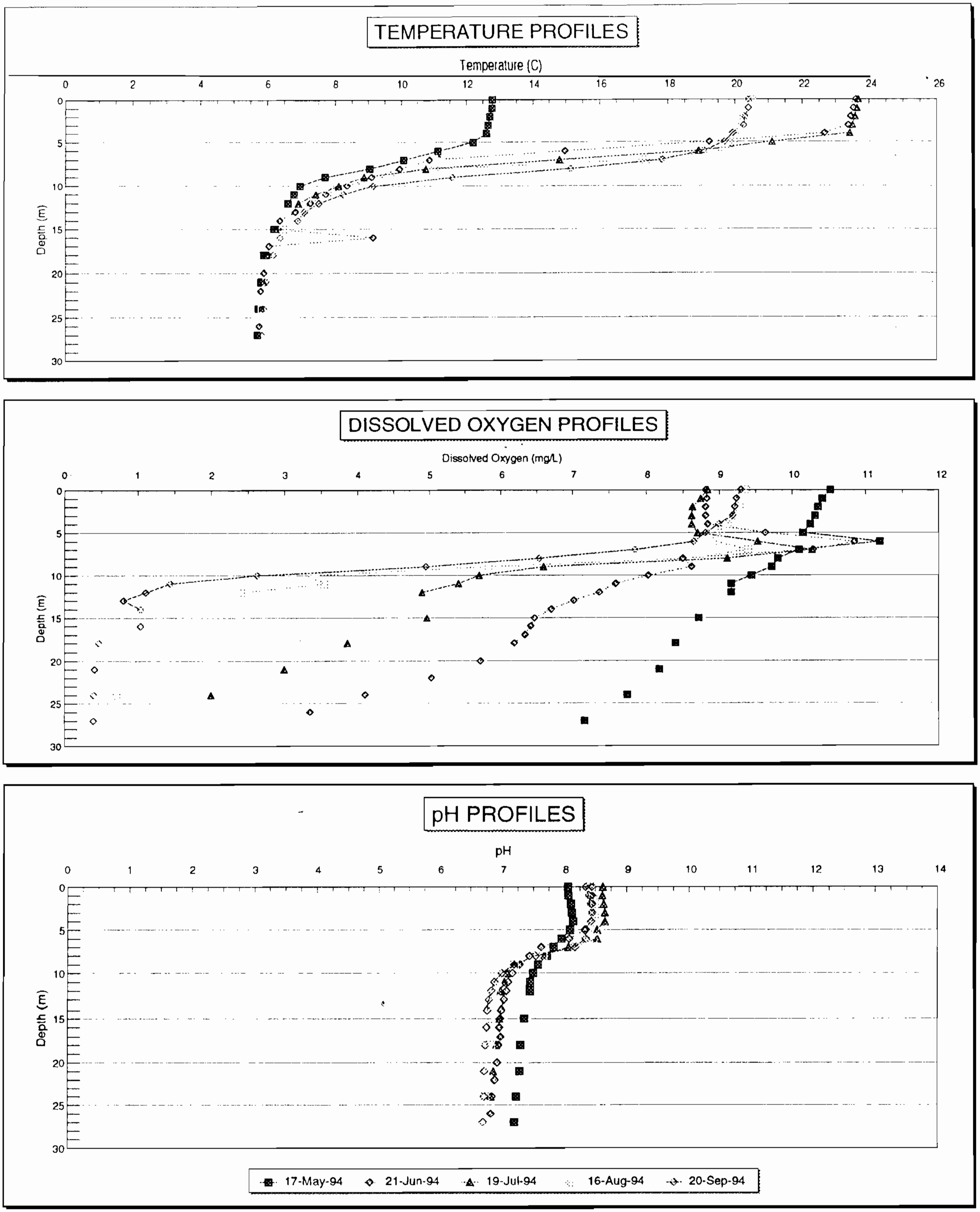


Figure 4
1994 Sampling at Site C2A

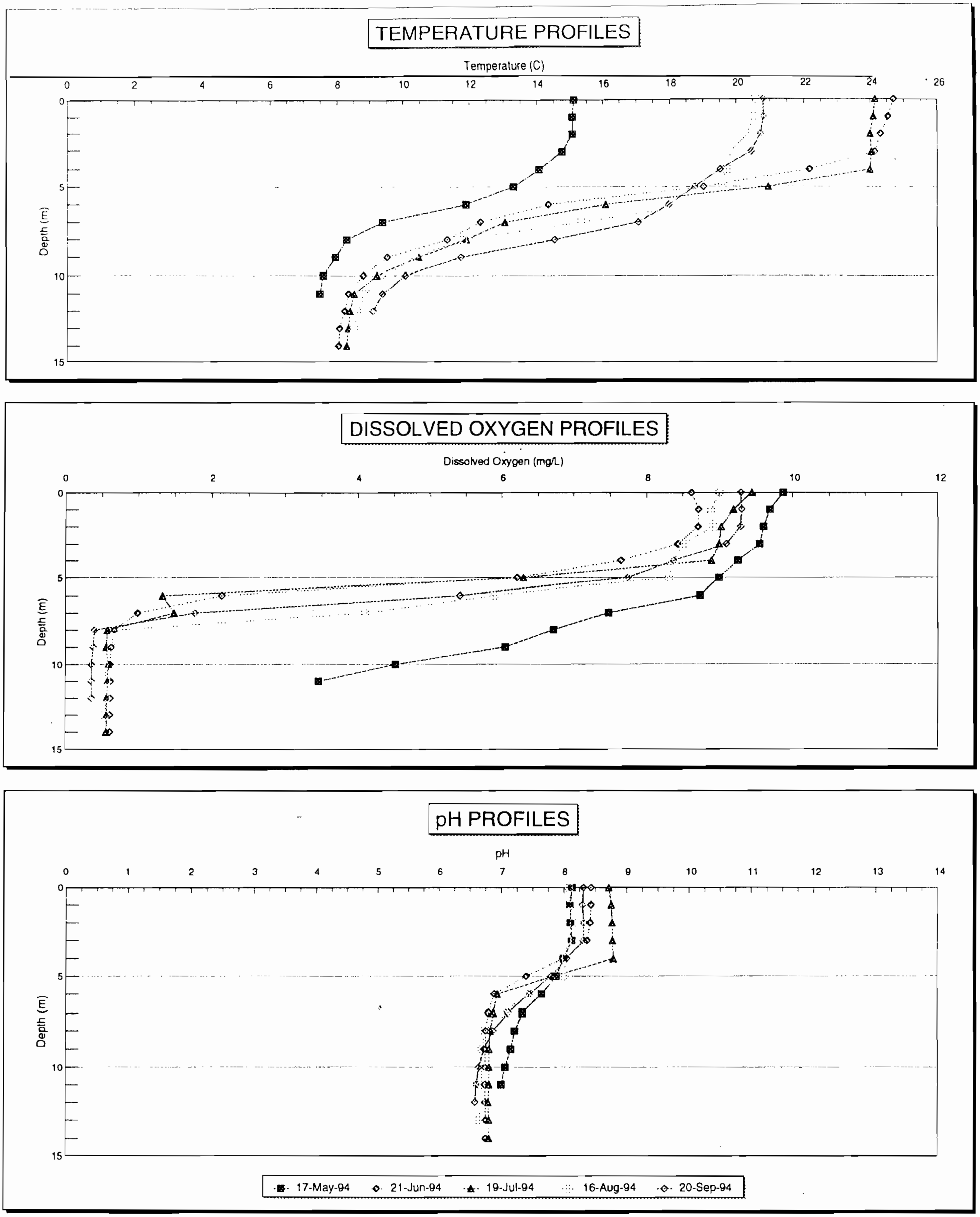


Figure 5
1994 Sampling at Site C6

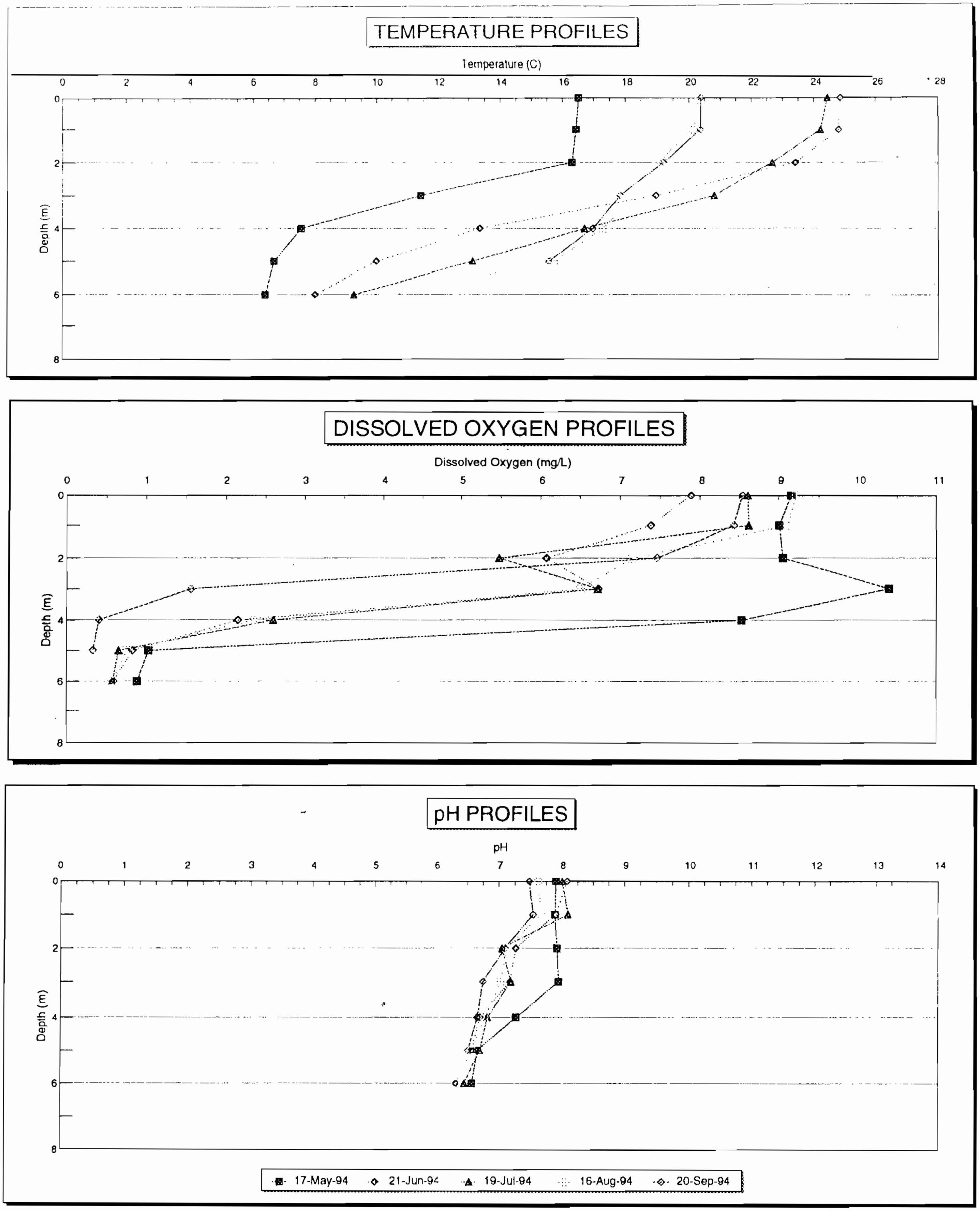


Figure 6
1994 Sampling at Site C7

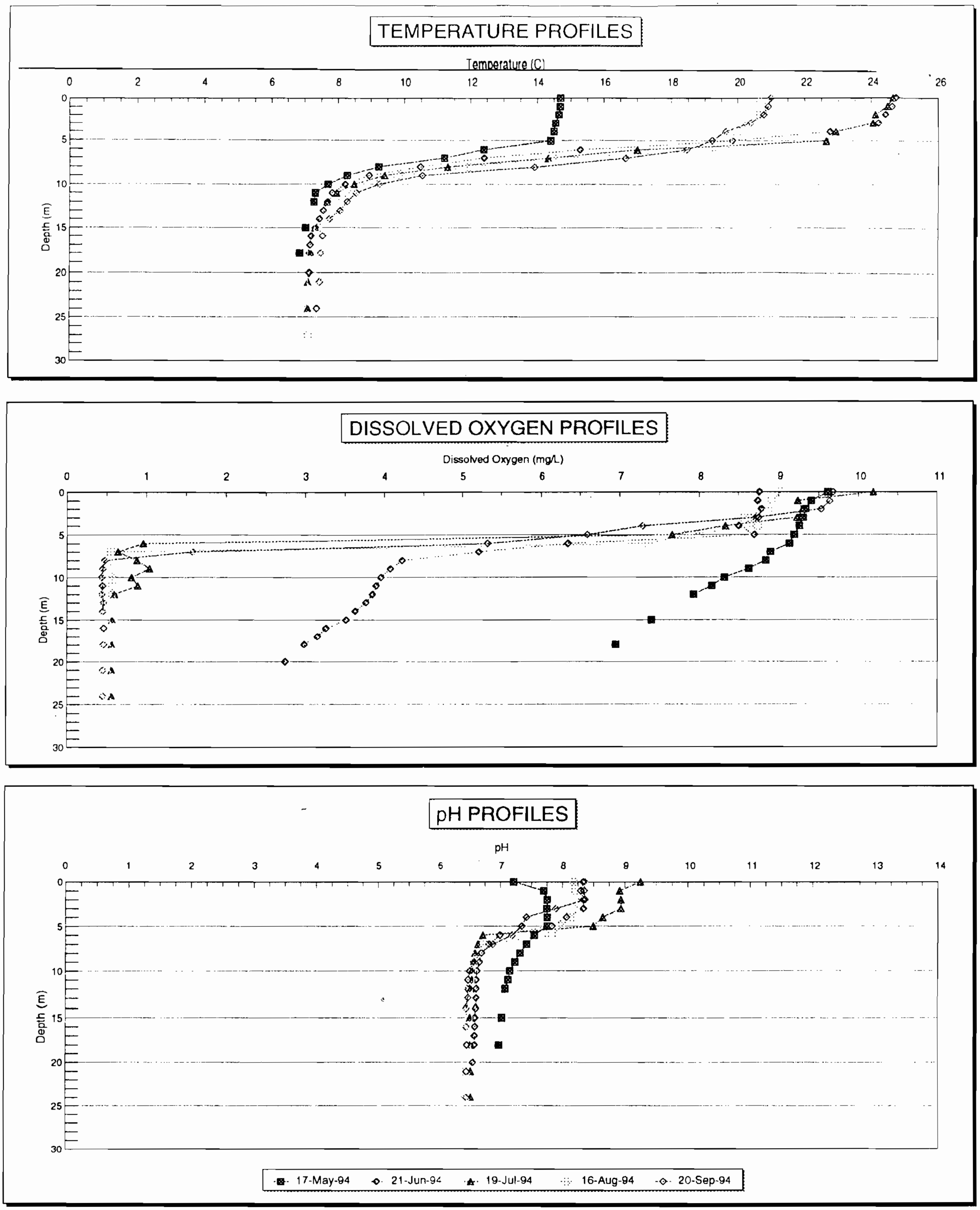


Figure 7
1994 Sampling at Site C5

Dissolved oxygen concentrations throughout the water column are also similar to Rabbit Island Bay and Library Bay. Anoxia was observed in the lower 50 to 65 feet (15 to 20 m) during July, August and September of the 1994 sampling season, an area and volume similar to that recorded in July and August of 1992. Similar anoxic conditions were recorded by WDNR on July 27, 1978 and August 16, 1983.

Cemetery Bay (Station C4) is the most shallow bay in the lower lake and in Beaver Dam Lake as a whole. Thermally it is polymictic, meaning it doesn't stratify and turns over several times each year as it is mixed by the wind (Figure 8). Because the basin is nearly always mixed, the dissolved oxygen profile shows only a small decrease in oxygen from the surface to the bottom.

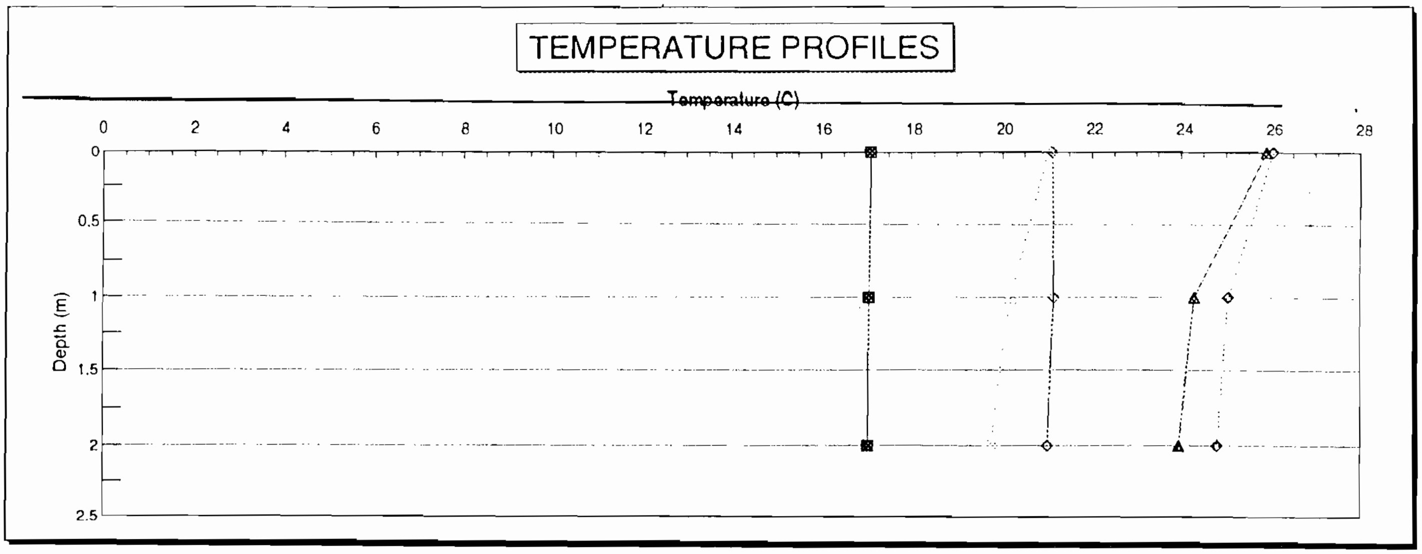
Nutrients, Productivity and Transparency

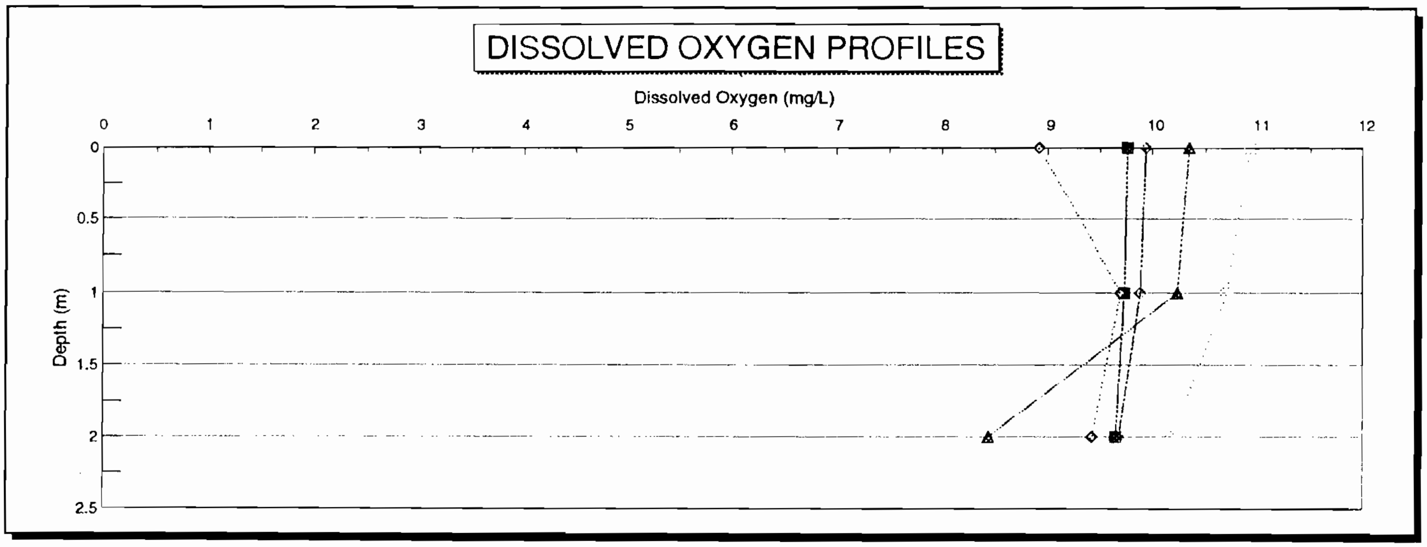
The growth of algae in a lake is most often limited by the supply of phosphorus. Increasing or decreasing the mass of phosphorus discharged into the lake over an annual or seasonal time scale will increase or decrease the average concentrations of phosphorus, and therefore algae, in the lake. In other words, the condition of Beaver Dam Lake depends upon how much phosphorus it receives from both internal and external sources. Algal growth or primary productivity is usually expressed in terms of mean (average) growing season chlorophyll *a* in the surface water of a lake. Because the amount of chlorophyll *a* is typically related directly to the amount of phosphorus, long-term monitoring of this nutrient is an important factor in assessing the existing trophic state and predicting the future condition of Beaver Dam Lake.

Transparency, or secchi disc measurements, are performed to measure the amount of sunlight entering a lake. The light is often scattered due to suspended algae or other particulate and dissolved matter. Secchi disc readings are inversely related to chlorophyll *a* concentrations and therefore to phosphorus loading. The greater the secchi disc reading, the lower level of primary productivity and vice versa. Transparency is important in reflecting the degree to which a lake may support various uses such as drinking water, swimming, boating and fishing.

These three parameters, total phosphorus, chlorophyll *a* and secchi disc depth, combine to reflect the trophic state of the lake. Lake trophic states are often described by the following limnological terms and their corresponding parameter ranges:

Trophic State	Total Phosphorus	Chlorophyll *a*	Secchi Depth
Oligotrophic	10 - 20 µg/l	< 4 µg/l	> 13 ft.
Mesotrophic	11 - 25 µg/l	4 - 10 µg/l	6.6 - 13 ft.
Eutrophic	26 - 60 µg/l	11 - 25 µg/l	3.3 - 6.6 ft.
Hypereutrophic	60 - 120+ µg/l	> 25 µg/l	< 3.3 ft.





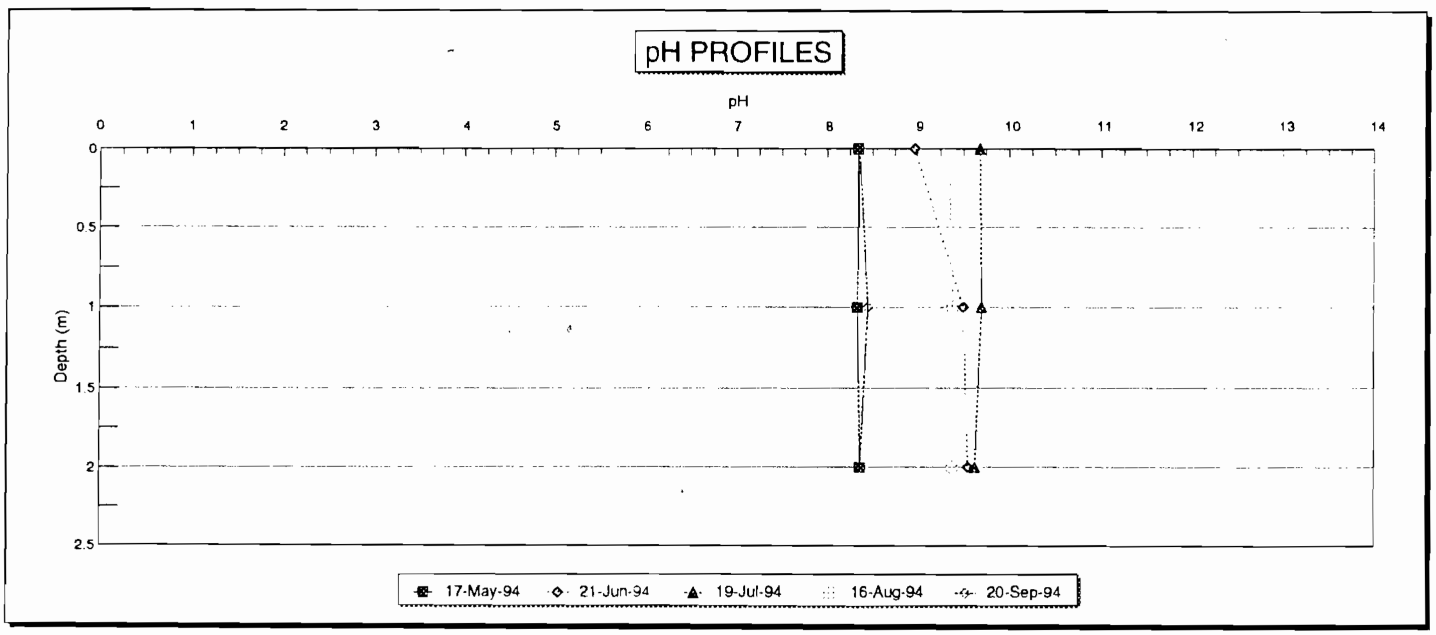


Figure 8
1994 Sampling at Site C4

Heiskary, et. al. (1987) developed a statewide assessment methodology for lakes in Minnesota in which phosphorus impacts were related to lake conditions as measured by chlorophyll *a* and secchi disc depths. These parameters and respective ranges were correlated to an individual lake's uses and user's perceptions. The Minnesota methodology is useful in Wisconsin because of the similar geographical latitude and growing season in the Beaver Dam Lake area. The following two tables were adapted from Heiskary and Walker (1988). Basically, the values shown represent the median (50th percentile) of the user's responses and the parameters describing the lakes' trophic states.

Recreational Suitability	Total Phosphorus	Chlorophyll *a*	Secchi Depth
Beautiful	< 20 µg/l	< 4 µg/l	> 1 ft.
Minor aesthetic impact	30 µg/l	8 µg/l	7 ft.
Swimming impaired	80 µg/l	40 µg/l	2.5 ft.
No swimming	100 µg/l	53 µg/l	2 ft.

Physical Appearance	Total Phosphorus	Chlorophyll *a*	Secchi Depth
Crystal clear	< 13 µg/l	< 3 µg/l	> 13 ft.
Some algae	24 µg/l	4 µg/l	9 ft.
Definite algae	33 µg/l	11 µg/l	6 ft.
High algae	87 µg/l	47 µg/l	2.5 ft.

Another useful table is from a WDNR publication (1990) regarding its statewide lake monitoring program.

Lake Description	Secchi Disc	
Excellent	> 20 ft.	(> 6.1 m)
Very Good	10 - 20 ft.	(3 - 6.1 m)
Good	6.5 - 10 ft.	(2 - 3 m)
Fair	5 - 6.5 ft.	(1.5 - 2 m)
Poor	3.2 - 5 ft.	(1 - 1.5 m)
Very Poor	< 3.2 ft.	(< 1 m)

Source: Lillie and Mason, 1983
U.S. Environmental Protection Agency, 1980.

Upper Lake

The trophic characteristics of the bays of Beaver Dam Lake show considerable variation as measured by total phosphorus, chlorophyll *a* and secchi disc transparency. Table 3 depicts the average values for these three parameters based upon the sampling periods of 1994.

Table 3
Trophic Characteristics of Beaver Dam Lake
(Average ± one standard deviation)

Upper Lake **upper Upper Lake**	**TP** **(µg/l)**	**Chl *a*** **(µg/l)**	**Secchi** **Depth (m)**
Station C1	9 ± 1	2.7 ± 1.6	4.5 ± 0.6
Station C2	8 ± 1	2.5 ± 2.0	4.2 ± 0.5
Station C2A	8 ± 1	2.8 ± 1.3	4.1 ± 0.6
lower Upper Lake			
Rabbit Island Bay Station C6	13 ± 2	4.1 ± 0.9	3.9 ± 0.6
Library Bay Station C7	17 ± 2	4.9 ± 0.9	3.3 ± 0.3
Lower Lake	**TP** **(mg/l)**	**Chl *a*** **mg/l**	**Secchi** **Depth (m)**
Cemetery Bay Station C4	30 ± 6	8.5 ± 4.6	1.9 ± 0.2
Norwegian Bay Station C5	16 ± 5	4.7 ± 2.7	3.9 ± 1.4

Following each average value in Table 3 is the standard deviation of the data preceded by plus (+) and minus (-) signs. Small standard deviations reflect little variation in the data set at each sampling station. Little variation in the nutrient and chlorophyll *a* data is indicative of a more stable condition and consistent quality.

As in 1992, the upper Upper lake exhibited the lowest average nutrient (phosphorus) and primary productivity levels for the entire lake. The data shows concentrations of phosphorus at approximately the same levels as those recorded in 1992. Chlorophyll *a* and secchi disc readings indicate a slight decrease in standing algae populations. This may be the result of lower primary productivity (algae) or, more likely, increased grazing by zooplankton (algae-eaters).

Nutrient and primary productivity in the lower Upper lake is slightly higher than the upper Upper lake. The data recorded in 1994 show nutrient concentrations similar to those recorded in 1992. However, a slight decrease in chlorophyll *a* indicates a slightly lower standing algal population and somewhat deeper secchi disc readings. Again, these slight improvements may be the result of an actual decrease in algal populations or an increase in zooplankton grazing.

The data recorded in 1994 reflect the same trophic results as those recorded in 1992. The upper Upper lake should be considered to be in "Very Good" condition. The data again reflect an oligotrophic condition with a recreational suitability of "Beautiful" and a physical appearance classification of "Crystal clear."

The characteristics of the lower Upper lake are borderline between "Very Good" and "Good" condition. Both Rabbit Island and Library bays are mesotrophic with a recreational suitability between "Beautiful" and "Minor aesthetic impact" and a physical appearance classification between "Crystal clear" and "Some algae." In the case of Library Bay, the traditional trophic classification system does not address the impact of a basin with extensive submergent and emergent macrophyte (weed) growth. Very heavy populations of weeds are apparent to the 12-foot depth in this basin and because of the macrophyte populations could be considered eutrophic.

Lower Lake

In contrast to the Upper Lake, the bays of the Lower lake exhibit much higher levels of nutrients and primary productivity and lower secchi disc depths. Phosphorus and chlorophyll *a* concentrations are two to three times higher in Cemetery and Norwegian bays than concentrations recorded in the bays of the Upper lake. Of the two bays in the Lower lake, Cemetery Bay has the highest levels of phosphorus and primary productivity. However, the data recorded in Cemetery and Norwegian bays indicates continued improvement of the water quality in the Lower lake.

In review of the trophic indicator data collected in 1992 and 1994, both Norwegian and Cemetery bays are in transition. Since 1992, Cemetery Bay has improved from "Poor" to "Fair" condition. The bay is still considered eutrophic, but has improved from a recreational suitability of "Swimming impaired" to one of "Minor aesthetic impact" and a physical appearance classification of "High algae" to one of "Definite algae."

Norwegian Bay has improved from "Good" to "Very Good" condition. The bay has maintained a mesotrophic classification, but has improved from a recreational suitability of "Minor aesthetic impact" to one between "Beautiful" and "Minor aesthetic impact." The physical appearance classification of Norwegian Bay has improved from "Definite algae" to one between "Some algae" and "Definite algae."

Discussion and statistical analysis of the trends exhibited by the trophic indicators is provided in the following section.

Trends

An important objective of a monitoring program is the detection of changes or trends in water quality. The statistical analysis of trends indicated by the recent two years of water quality data recorded at Beaver Dam Lake involved acquisition and analysis of water quality monitoring data collected in the past by WDNR (personal communication, D. Ryan, 1991) which was compared to the data collected in 1992 and in 1994. A statistical analysis of all the recorded data was performed using the nonparametric Mann-Kendall (Mann, 1945; Kendall, 1975) analysis for trends. Test procedures followed those outlined in Gilbert (1987).

The Mann-Kendall test is useful because missing values are allowed and the data need not conform to any particular distribution. In addition, data reported as less than the detection limit can be used by assigning them a value that is half the detection limit of the analytical procedure. Analysis of trends in total phosphorus concentrations were performed at stations C1, C2, C4 and C5. These stations were selected because historical data from the WDNR lake surveys were available and provide data in addition to the nine months recorded in 1992 and 1994. The results of the analyses are provided in tabular format in Appendix C and in a graphical form in the following discussion.

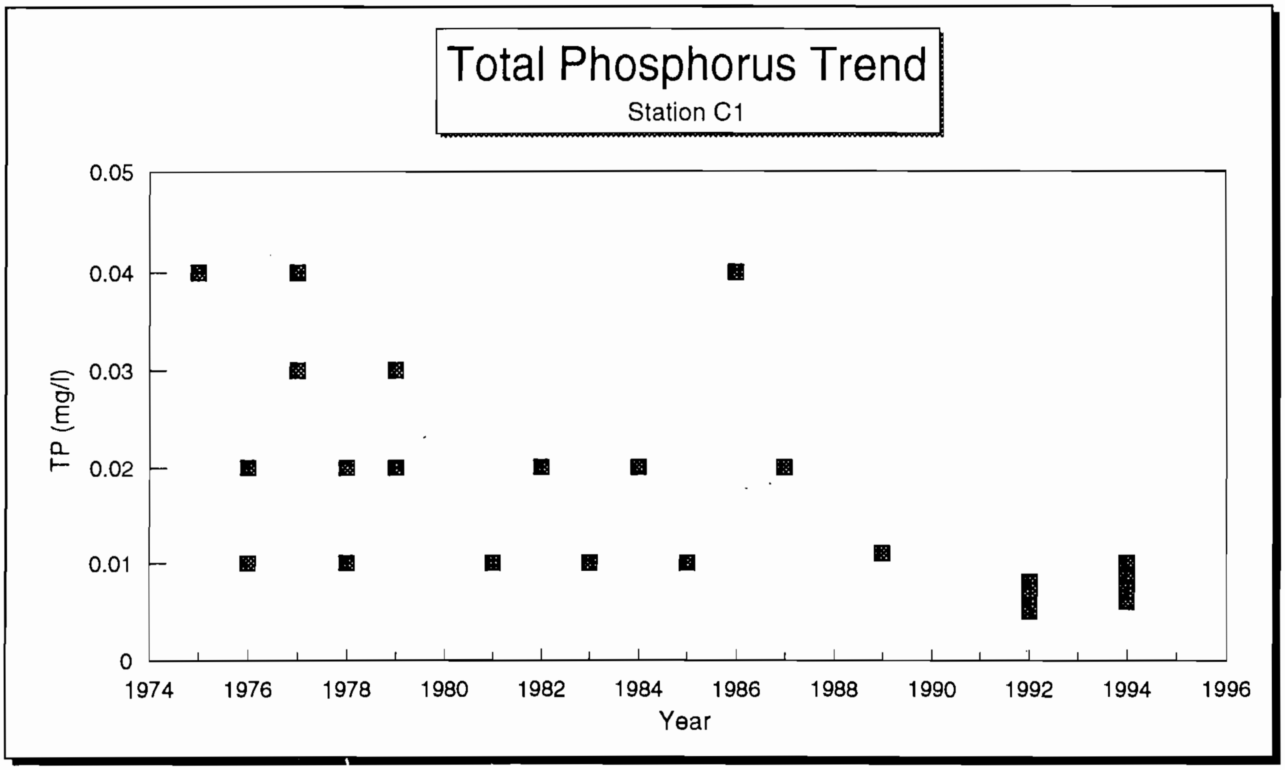
Upper Lake

Two stations, C1 and C2, were analyzed for a trend in total phosphorus in 1992. These stations were analyzed again to include the data collected in 1994. Figures 9 and 10 illustrate the total phosphorus trend recorded in the Upper lake. The upper graph shows the data recorded throughout each year while the lower graph illustrates the individual phosphorus concentrations recorded during the growing season (April - September).

As in 1992, the Mann-Kendall statistical test again showed a downward trend in total phosphorus concentrations at Station C1 and at Station C2. The "S" and "Z" statistics calculated in the analyses indicate even stronger support of the hypothesis that a downward trend is apparent. As discussed in the previous report, although the downward trend of the data is real, the basis for the trend is problematic. Gilbert (1987) states:

> "A change of analytical laboratories or of sampling and/or analytical procedures may occur during a long-term study. Unfortunately, this may cause a shift in the mean or in the variance of the measured values. Such shifts could be incorrectly attributed to changes in the underlying natural or man-induced processes generating the pollution."

A conclusion as to whether or not the Upper lake is in a "steady state" condition or if an actual trend in phosphorus decline is present could not be made after the 1992 sampling season. Even with the addition of the 1994 sampling data, the Mann-Kendall statistics did not



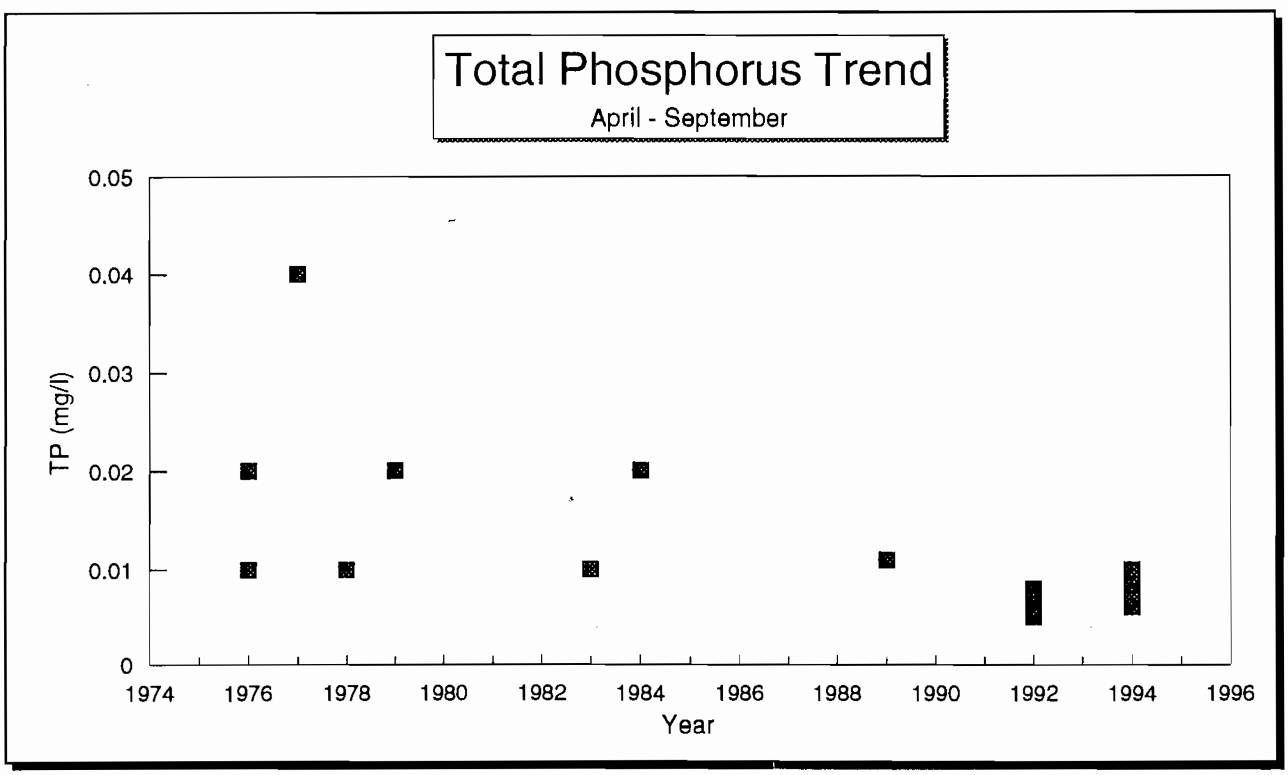
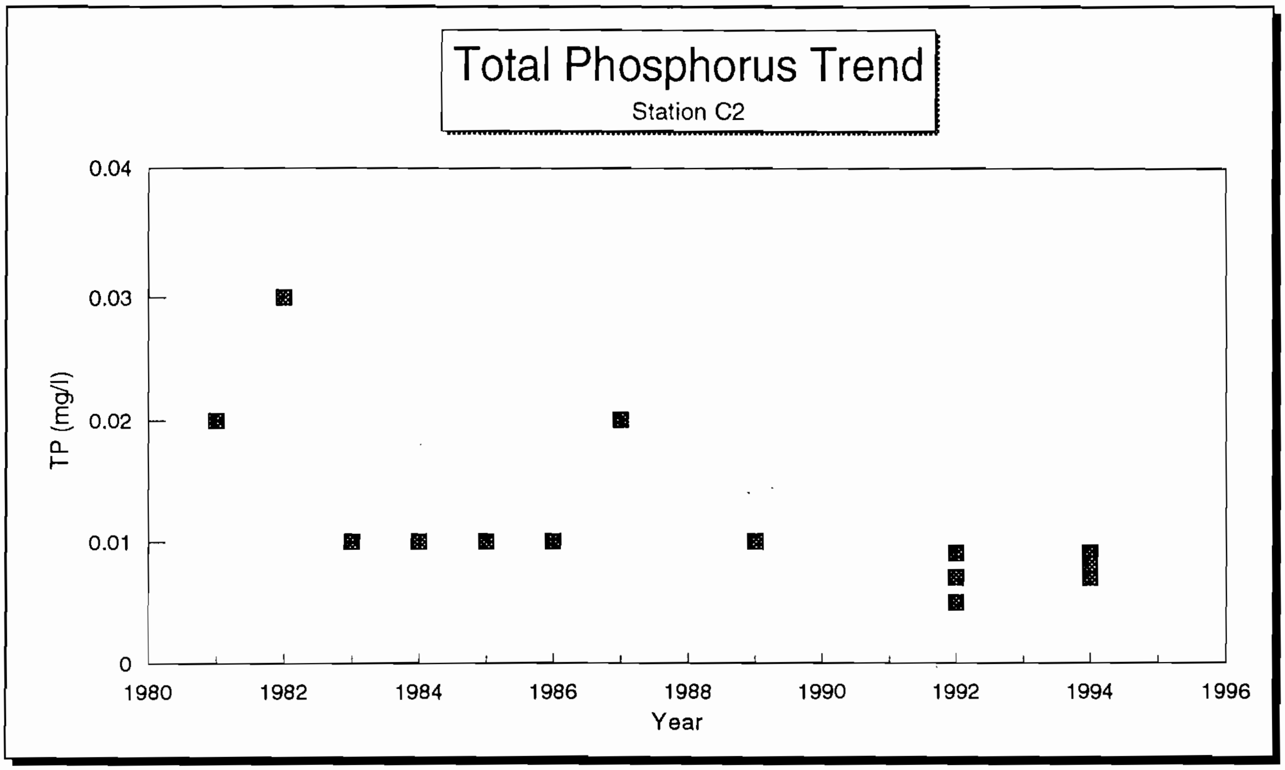


Figure 9
Total Phosphorus Trend at Site C1



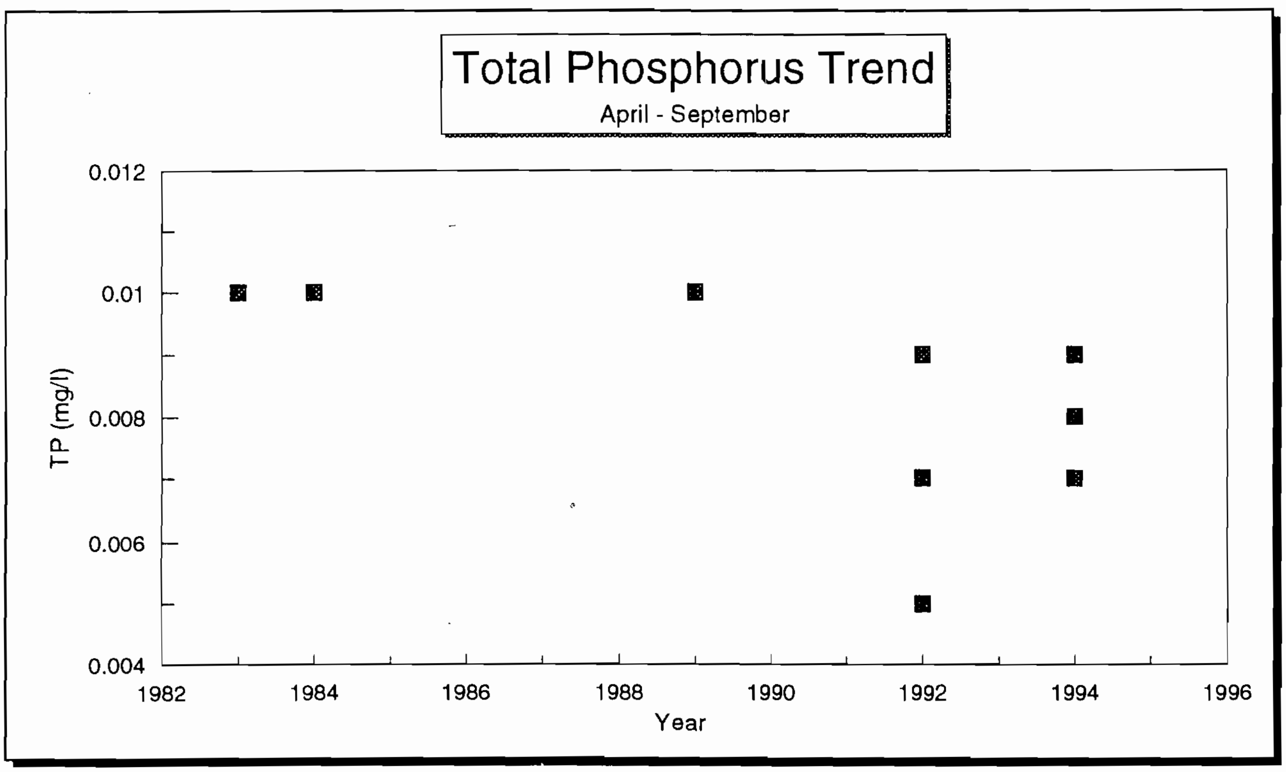


Figure 10
Total Phosphorus Trend at Site C2

increase significantly and a solid trend in phosphorus decline cannot be determined because of the changes in sampling and analytical procedures. Laboratory detection levels for total phosphorus are not likely to change in the near future. Therefore, continued monitoring of Beaver Dam Lake will provide the additional data necessary to make a conclusion as to the trend in total phosphorus concentrations in the Upper lake.

Lower Lake

The same two monitoring stations, C4 (Cemetery Bay) and C5 (Norwegian Bay), were analyzed for a trend in total phosphorus concentration as in 1992. Both of these stations were impacted in the past by the City's municipal wastewater discharge. In reviewing the WDNR data for these basins, it is apparent that the concentration of total phosphorus has declined since the 1970's. Figures 11 and 12 show the trend in total phosphorus concentration in Cemetery Bay and Norwegian Bay, respectively. Again, the upper graph shows the data recorded throughout the year while the lower graph illustrates the individual phosphorus concentrations recorded during the growing season (April - September).

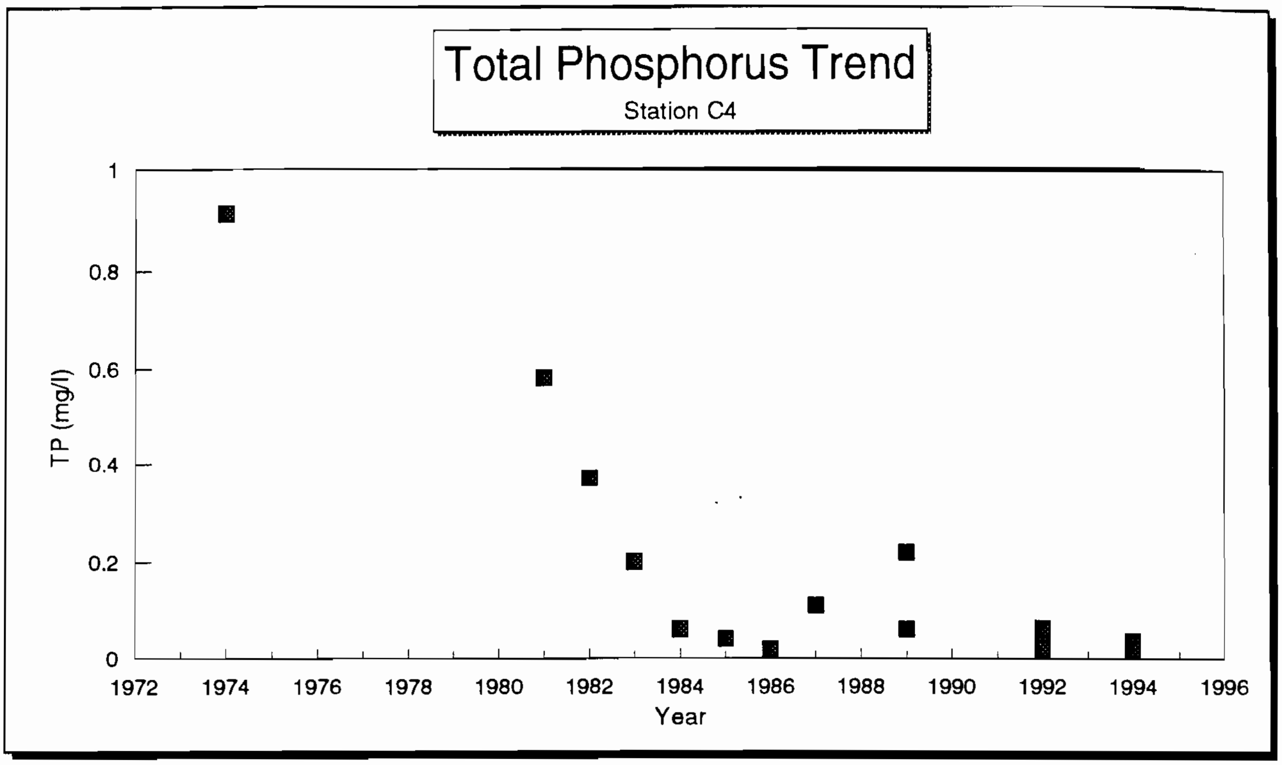
After the addition of the 1994 monitoring data, the Mann-Kendall statistics "S" and "Z" statistics indicate even stronger support of the hypothesis that a downward trend is apparent.

The question of laboratory analytical procedures is not an issue in the Lower lake because none of the recorded total phosphorus concentrations were near or below the analytical detection limits. The phosphorus concentrations in Cemetery and Norwegian bays were order of magnitude greater than those recorded in the Upper Lake most likely due to the historic inflow of the City's wastewater treatment works discharge. Since this discharge was removed in November 1981 (personal communication, Dennis Rockow, 1995) the total phosphorus concentration in Cemetery Bay declined rapidly and the quality of the bay continues to improve today.

Although the improvement of these bays is somewhat substantiated, continued monitoring of the entire lake will allow better estimation of future water quality changes and lake responses to internal and external nutrient loading.

Oxygen Prediction Modelling

One of the hypotheses suggested after the 1992 analysis is that the hypolimnetic oxygen depletion observed in nearly all of the bays of Beaver Dam Lake is due to the lake morphometry and not necessarily the external or internal phosphorus loading. To address this hypothesis, a model for predicting end-of-summer oxygen profiles in stratified lakes was utilized (Molot, et. al., 1992). The model utilizes lake morphometry, total phosphorus concentration and initial oxygen



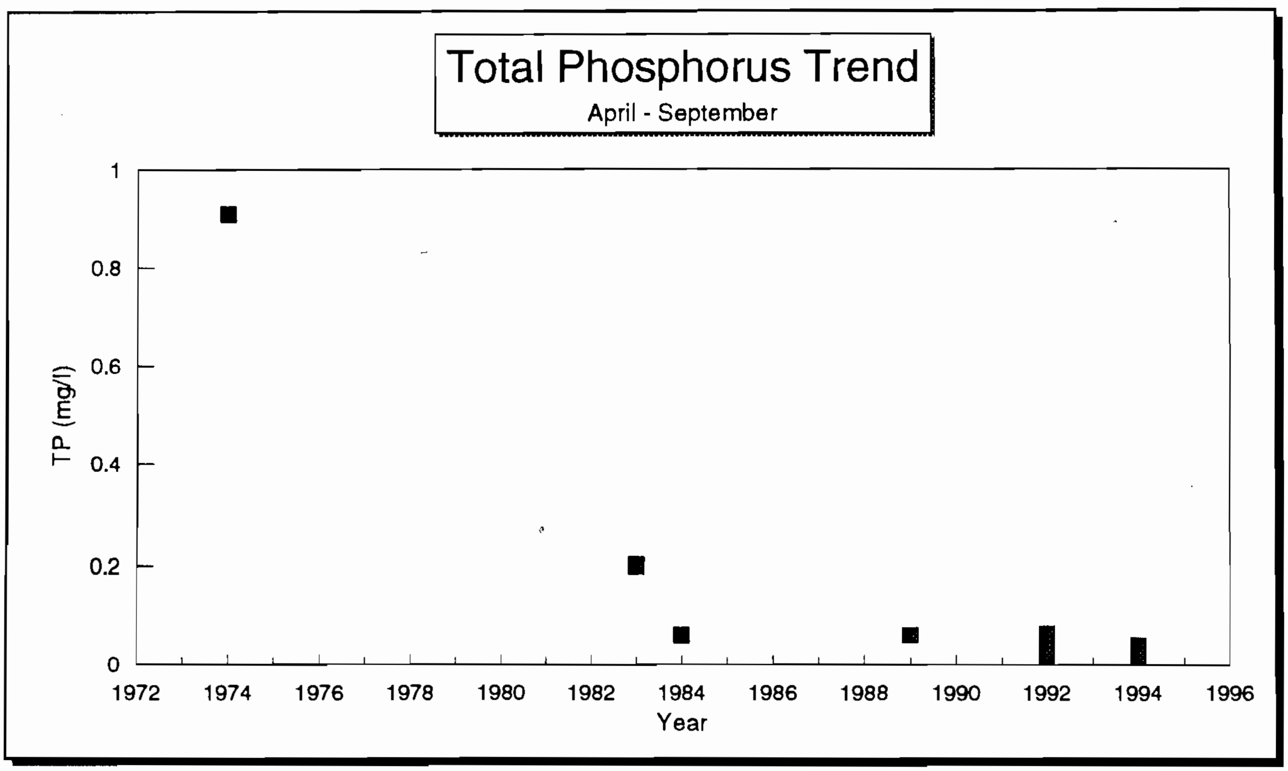
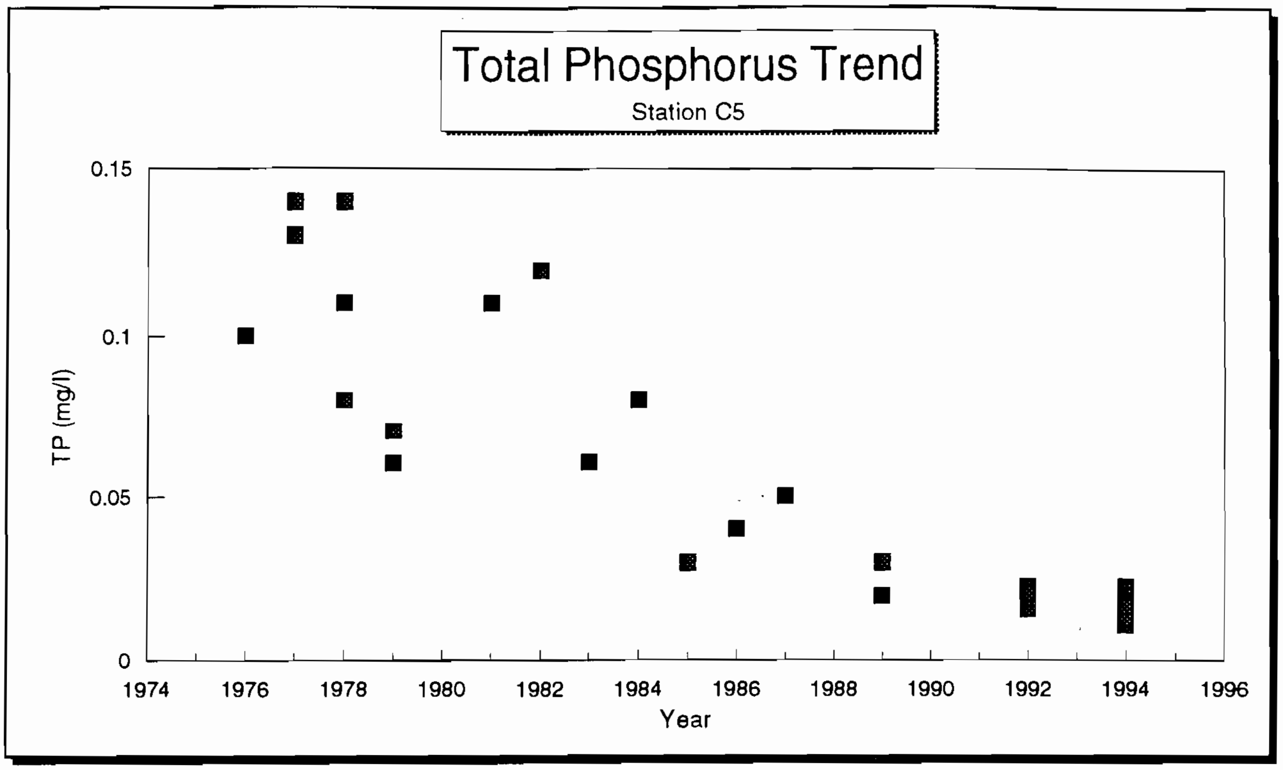


Figure 11
Total Phosphorus Trend at Site C4



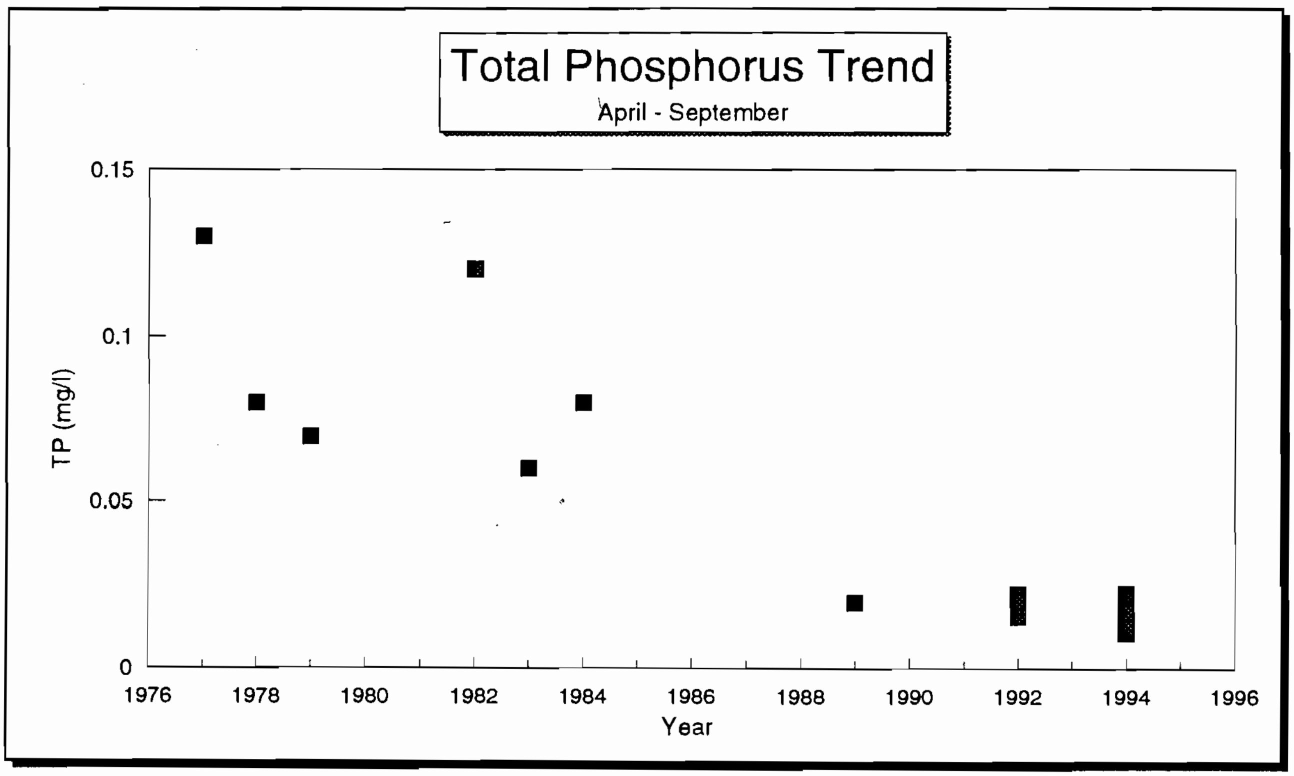


Figure 12
Total Phosphorus Trend at Site C5

concentration at spring turnover to predict mean end-of-summer oxygen profiles in a lake's hypolimnion.

The model was used to predict oxygen concentrations in the hypolimnion of each of the bays of Beaver Dam Lake, except for Cemetery Bay (Station C4) which does not stratify and Library Lake (Station C7) because of its shallow depth. The predicted hypolimnetic oxygen profiles were then compared to the data recorded during August of the 1992 and 1994 sampling seasons.

Upper Lake

The oxygen prediction model was used with the physical and chemical characteristics of each of the basins of the Upper lake to determine if oxygen depletion recorded in the hypolimnion of each basin could be the result of the morphometry of the basin or is the result of internal and/or external nutrient loading. The model was based on lakes similar to the physical and chemical characteristics of the upper Upper portion of Beaver Dam Lake.

At Station C1, the model predicts hypolimnetic oxygen concentrations between 9.6 mg/l at a depth of 13 meters (43 ft.) to a low of 6.2 mg/l at a depth of 23 meters (75 ft.) to 8.8 mg/l at 30 meters (bottom). These predictions are 5 to 9 ppm higher than the oxygen concentrations recorded in August of 1992 and 1994 (Figure 13). Similar results were obtained at stations C2 and C2A (Figures 14 and 15) leading to the conclusion that the morphometry of the lake is not the only factor influencing the oxygen depletion in the upper Upper lake.

The model also predicts the upper level of the hypolimnion should be at a depth of 20 to 23 meters (65 to 75 feet) in contrast to the 10 to 15 meter depths recorded. The model requires the use of the fetch, or maximum distance across the lake, to determine the susceptibility of the basin to wind mixing. The upper Upper portion of Beaver Dam Lake may not be as susceptible as the length of each basin suggests because of steep hills and vegetation protection along the shoreline. This protection from the wind may also allow the development of a stronger epilimnetic barrier and promote the hypolimnetic oxygen depletion.

The model predicts oxygen concentrations from 4.1 mg/l at a depth of 8 meters (26 ft.) to 0.8 mg/l at 14 meters (bottom) of Rabbit Island Bay (Figure 16). The observed values are somewhat lower, but not to the degree observed in the upper Upper lake.

Additional data collection will provide more support of the long-term average conditions used in the model and provide a better basis for estimation of hypolimnetic oxygen depletion as well as a basis for the determination of the trends in the water quality in that area of the lake.

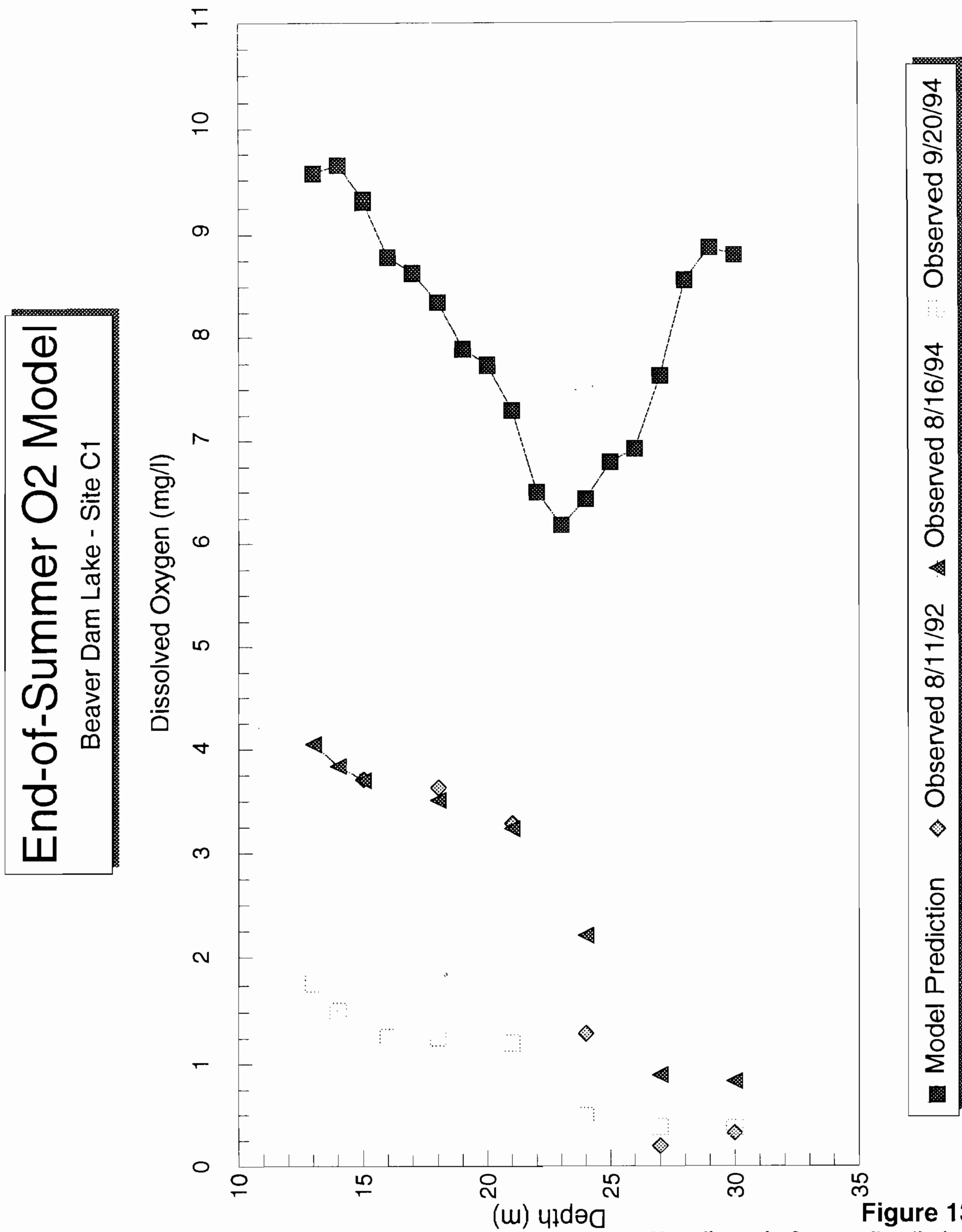


Figure 13
Hypolimnetic Oxygen Prediction
at Station C1

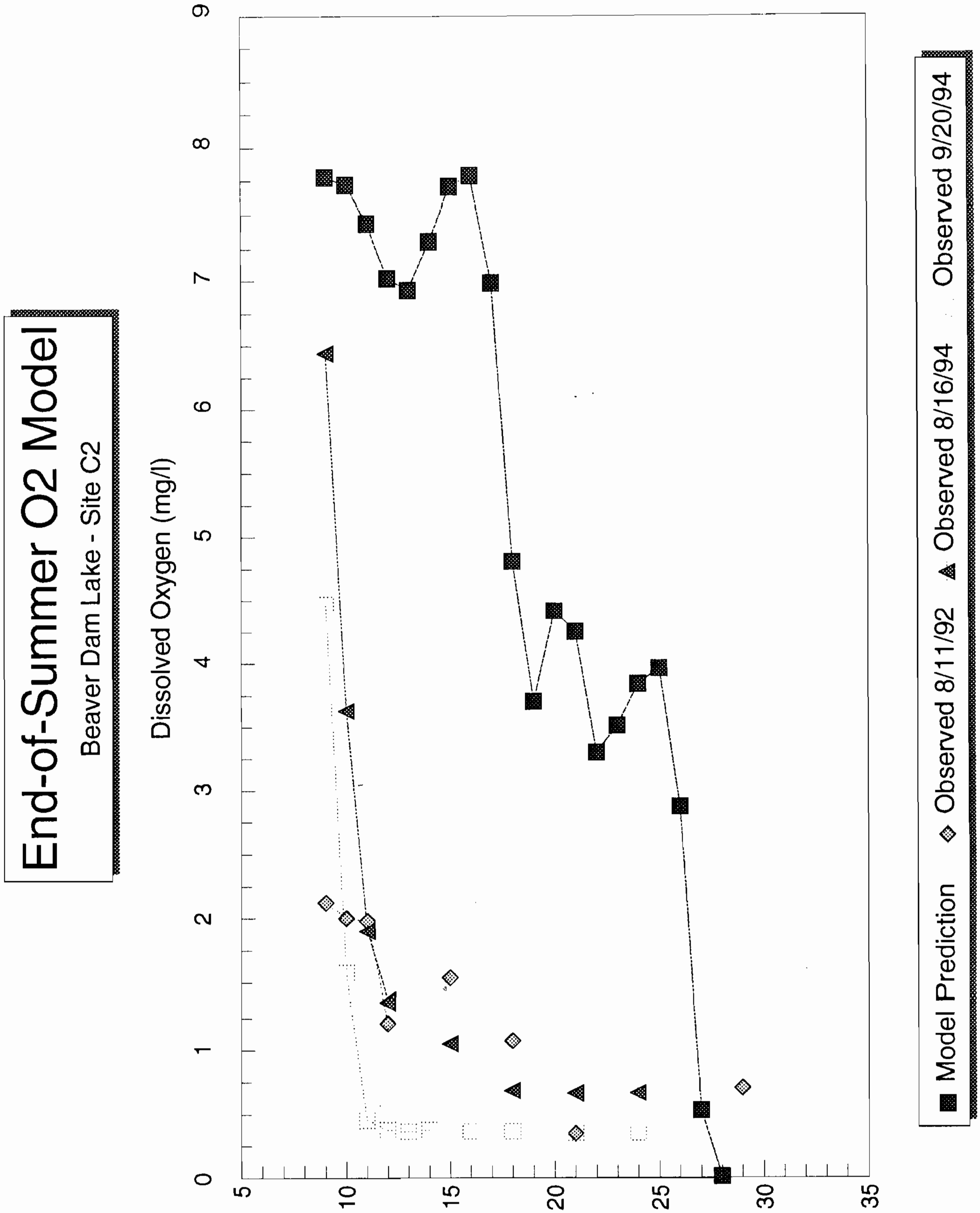


Figure 14
Hypolimnetic Oxygen Prediction at Station C2

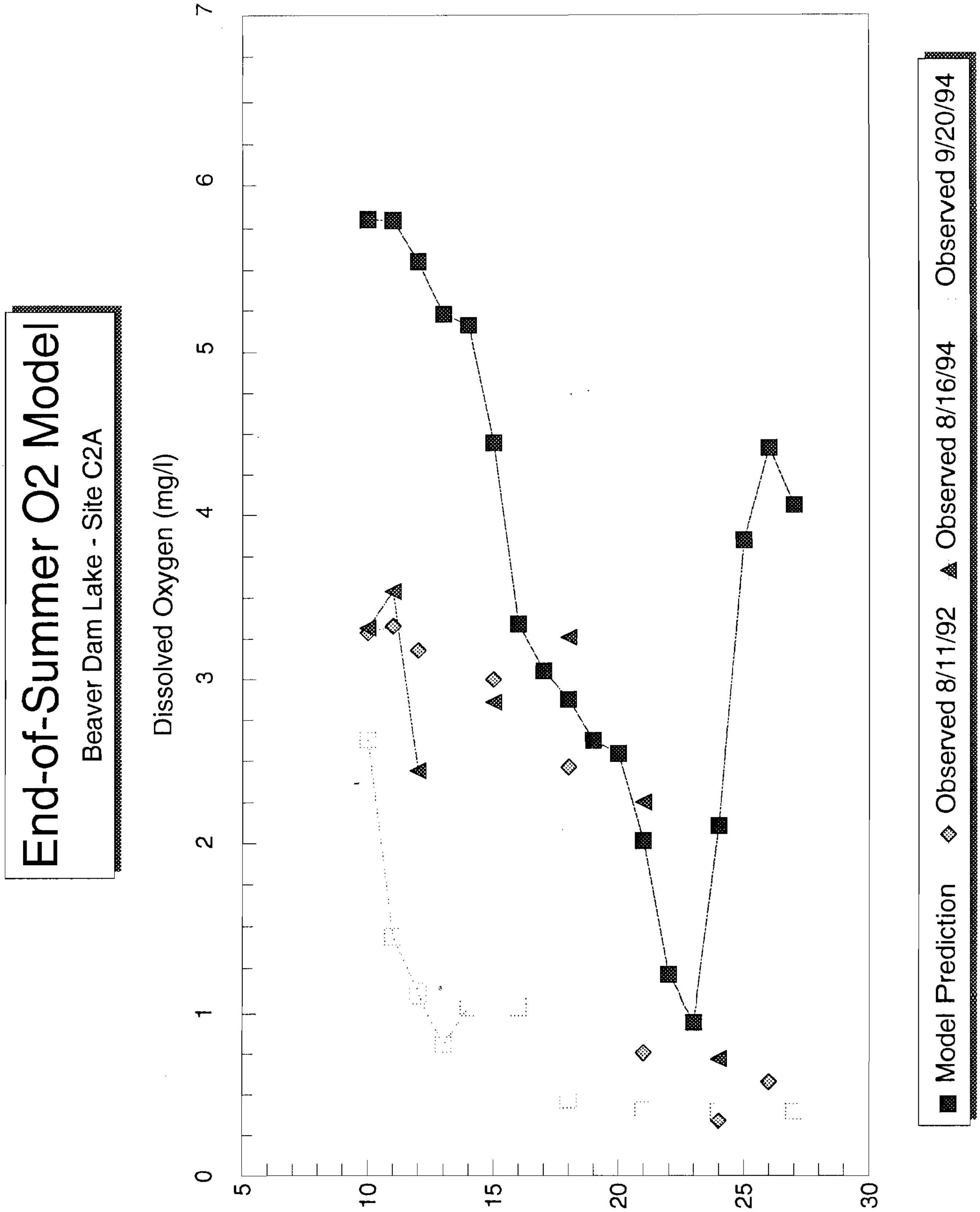


Figure 15
Hypolimnetic Oxygen Prediction
at Station C2A

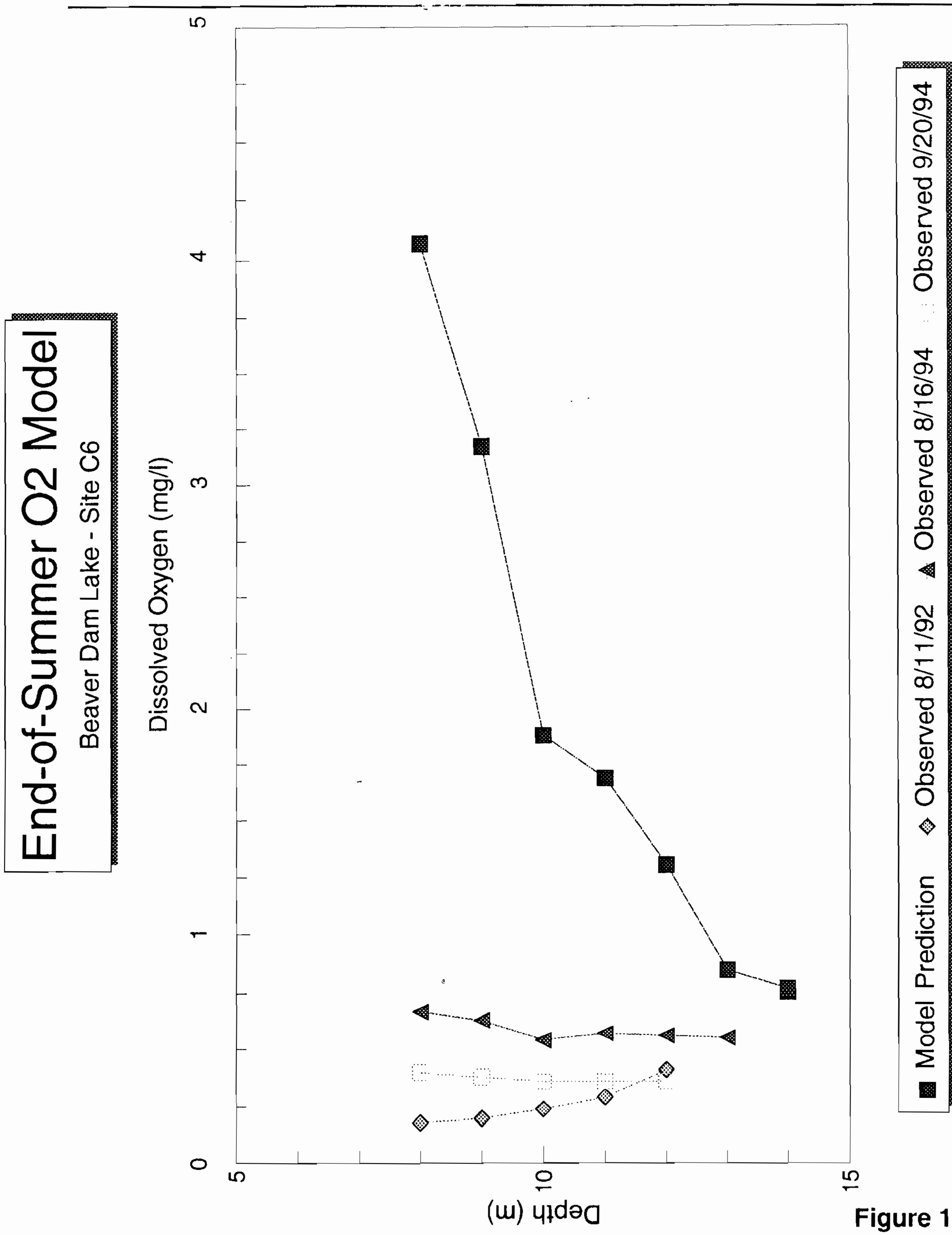


Figure 16
Hypolimnetic Oxygen Prediction
at Station C6

Lower Lake

At Station C5, the model predicts hypolimnetic oxygen concentrations between 6.4 mg/l at a depth of 10 meters (33 ft.) to 0.08 mg/l at 27 meters (bottom). The observed oxygen concentrations are significantly lower than those predicted for the upper layers of the hypolimnion, but oxygen concentrations near the bottom of the basin have not been observed during the past two monitoring seasons to be as low as predicted by the model.

The model prediction is not an accurate representation of actual summer hypolimnetic conditions in Norwegian Bay (Figure 17). For this reason, it is concluded that the oxygen depletion observed in the hypolimnion is not exclusively the result of lake morphometry and is supported by internal and external nutrient loading. This conclusion is supported by the fact that Norwegian Bay is believed to have been impacted by the City of Cumberland wastewater treatment works discharge.

Complete oxygen depletion was recorded in the hypolimnion of Norwegian Bay in August and October of 1977, July 1978, May 1979, and August 1983. Because of the trend of water quality improvement in the bay, complete deoxygenation has not been recorded since then. Additional monitoring will supply the data necessary to quantify the future water quality improvement of the basin.

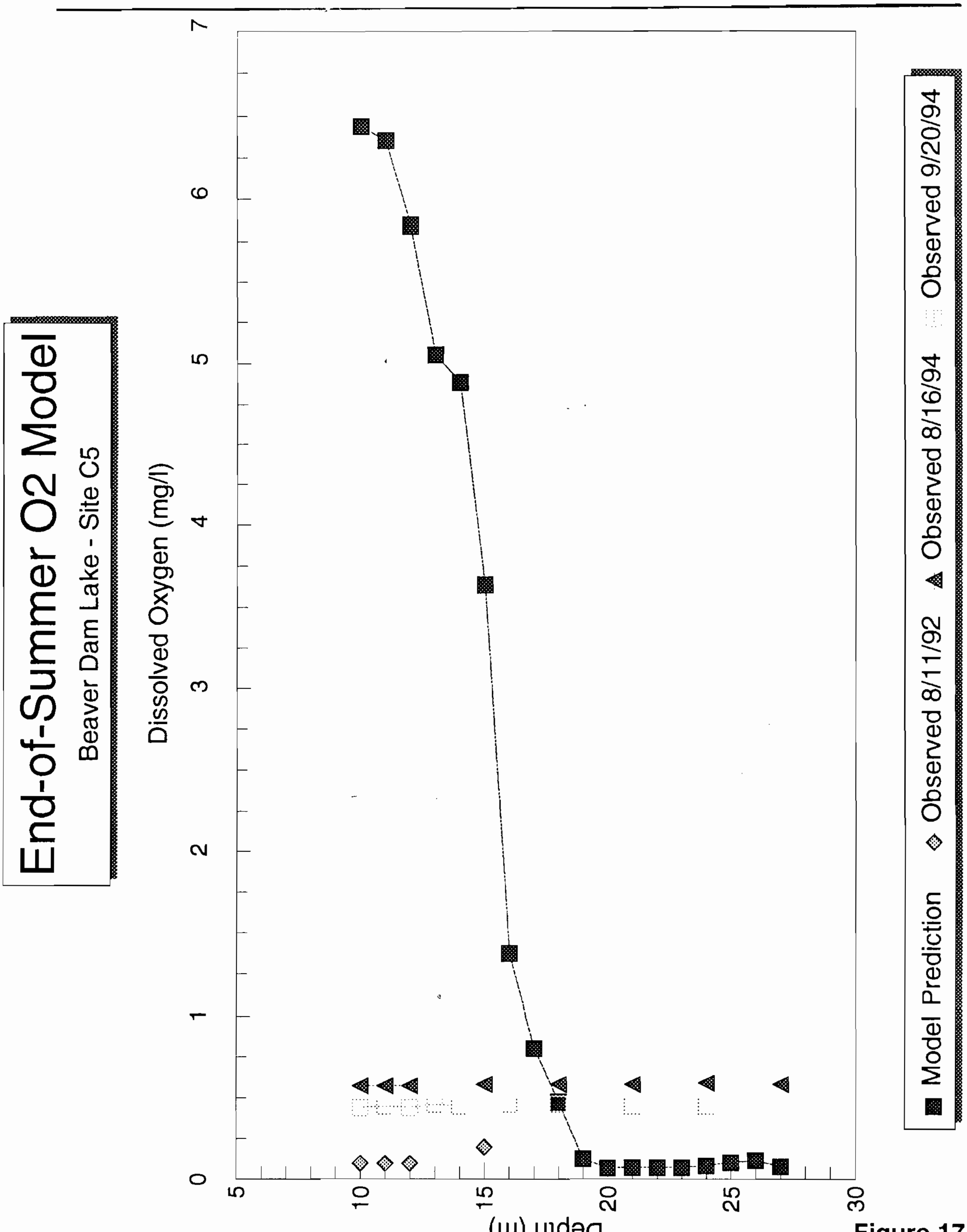


Figure 17
Hypolimnetic Oxygen Prediction
at Station C5

Conclusions and Recommendations

Conclusions

1. Water quality data was acquired from Beaver Dam Lake once each month from May through September, 1994 at seven monitoring stations.

2. Temperature profiles indicate vertical stratification by mid-May in all seven bays except Cemetery Bay because of its shallow depth.

3. Oxygen depletion was observed in the hypolimnion at all stations but was less severe than that recorded by WDNR and by SEH, Inc. in 1992.

4. As in 1992, the trophic state of the upper Upper lake is oligotrophic and is considered in good to very good condition with a recreational suitability of beautiful and a physical appearance of crystal clear.

5. The condition of Rabbit Island Bay appeared to improve slightly since 1992. The bay is still considered mesotrophic with minor aesthetic impact and a physical appearance of some algae.

6. The quality of Library Bay did not change significantly and is considered mesotrophic with a recreational suitability of minor aesthetic impact and a physical appearance of some algae, but contains extensive emergent and submergent weed growth.

7. Cemetery and Norwegian bays continue to exhibit high productivity as a result of the City of Cumberland wastewater treatment works discharge.

8. The water quality of the Lower lake continues to show improvement apparent since the removal of the wastewater treatment works discharge in 1981.

9. Norwegian and Cemetery bays are considered eutrophic, however, the recreational suitability of both bays improved from nearly swimming impaired to minor aesthetic impact and the physical appearance has improved from definite algae to some algae since 1992.

10. The downward trend in total phosphorus in the Upper lake determined in 1992 was strengthened with the addition of the 1994 data, but may still be an artifact of improved laboratory analytical procedures and not actual water quality improvements.

11. The downward trend in total phosphorus concentration in the Lower lake was also strengthened with the addition of the 1994

data and is the result of the diversion of the City of Cumberland's wastewater treatment plant discharge to Cemetery Bay.

12. Oxygen prediction modelling indicates the hypolimnetic oxygen depletion occurring in late summer in the bays of the Upper lake may not be the result of basin morphometry but from internal and/or external nutrient loading.

13. The oxygen prediction modelling confirmed that the Lower lake continues to be influenced by internal nutrient loading from residuals in the bottom sediments from past wastewater treatment works discharge.

Recommendations

1. Water quality and flow monitoring of selected inflows to and within Beaver Dam Lake should be performed to validate and calibrate subsequent lake modeling with BATHTUB.

2. Additional monitoring of the water quality of Beaver Dam Lake should be performed concurrent with the hydraulic monitoring for BATHTUB calibration.

3. The BATHTUB model should be utilized to assess the external loading and internal hydrology of Beaver Dam Lake.

4. The District should apply for an additional WDNR lake planning grant by August 1, 1995.

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Appendix A

Historic, 1992 and 1994 Water Quality Data (Stations C1, C2, C4 and C5)

AVAILABLE HISTORICAL DATA
SAMPLING SITE C1

Temperature (C)

Depth (m)	18-Jul-75	22-Apr-76	15-Jul-76	03-Feb-77	23-Apr-77	27-Jul-78	07-Nov-78	29-Mar-79	16-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	25.28	7.50	24.44	0.00	12.50	22.78	8.33		7.22	8.10	7.00	26.00	4.40		2.10	8.00	6.00	17.03	18.04	21.11	22.53	12.24	23.51	23.24	20.58	20.40
1						23.33		0.28		8.00		25.50		1.00			6.00	16.63	18.04	20.84	22.53	12.24	23.49	23.25	20.56	20.40
2	25.28				11.50			1.67		7.90	7.00	25.20		2.00		8.00	6.00	16.35	18.02	20.70	22.37	12.23	23.40	23.24	20.56	20.38
3				3.33	10.00			2.22		7.80		24.80	4.20		4.00		6.00	16.15	18.01	20.65	22.21	12.20	23.43	23.22	20.53	20.30
4					9.50				6.67	7.80	7.00	24.10		2.70		8.00	6.00	16.05	18.01	20.55	22.14	12.20	22.00	23.22	20.47	20.24
5	21.11		23.33		7.50	22.78				7.80		24.00						15.55	17.87	18.51	22.05	12.18	19.35	22.18	20.27	19.94
6	16.67		20.00			21.11		2.78		7.80	7.00	23.50	4.20	2.80	4.10	8.00	6.00	11.44	14.40	16.87	17.19	12.16	15.23	20.39	20.18	19.66
7	12.22	7.50	15.56		6.50	18.33						18.80						9.53	11.06	14.18	15.05	12.11	13.16	16.21	19.64	19.07
8	11.11		12.78			15.00				7.80	7.00	14.90		2.80		8.00	5.50	8.17	9.23	11.13	12.21	11.97	11.67	12.88	15.06	17.88
9	9.17		10.56		6.00	11.67			6.11	7.80		12.50	4.10		4.60			7.00	8.22	8.87	9.56	9.70	10.08	10.06	11.47	15.25
10	8.06		10.00			10.00				7.80	7.00	10.20		2.80		8.00	5.50	6.51	7.14	7.36	7.88	8.87	8.74	8.49	9.44	10.88
11			8.89			9.44				7.80		9.00						6.37	6.60	6.82	7.14	8.02	7.88	7.89	8.50	9.07
12	7.22				5.50	8.33			5.56	7.80	7.00	8.00	4.10	2.80	4.60	8.00	5.30	6.27	6.42	6.51	6.60	7.47	7.35	7.32	7.78	8.28
13			7.78							7.80													7.11	7.01	7.20	7.78
14		6.50				7.78				7.70	7.00	7.00		2.80		8.00	5.10						6.91	6.91	7.07	7.40
15			7.22										4.00		4.60			5.94	6.14	6.22	6.18	6.46	6.76	6.84	6.96	
16						7.22					7.00	7.00		2.60		7.60	5.10						6.78			7.11
17	6.11	6.00																								
18				3.89							7.00	6.80	4.00	2.80	4.60	6.90	5.10	5.82	6.04	6.12	6.14	6.18	6.48	6.69	6.69	6.96
19							7.78																			
20	5.83		6.67				6.94				7.00	6.50		2.90		6.20	5.10						6.56			
21		5.50							5.00				4.00		4.80			5.71	5.84	6.04	5.99	6.00		6.38	6.38	6.84
22							6.11				7.00	6.00		2.90		5.90	5.00						6.28			
23															4.60											
24				3.89	5.00	6.67					6.00	6.00	4.00	2.90		5.60	5.00	5.48	5.66	5.76	5.76	5.76	6.14	6.07	6.22	6.40
25	5.56	5.00													4.80							5.72				
26							5.56				5.80	5.90		2.90		5.40	5.00						5.92			
27								2.78					3.90		5.80			5.40	5.56	5.61	5.77			6.02	6.09	6.22
28			6.67								6.50	5.90		2.90		5.40	5.00						5.90			
29				3.89	5.00								3.90		6.10									5.99		
30	5.28	4.50	5.56			6.87	5.56		5.00								4.90	5.30	5.49	5.56	5.61		5.89		5.99	6.18

AVAILABLE HISTORICAL DATA
SAMPLING SITE C1

Dissolved Oxygen (mg/L)

Depth (m)	18-Jul-75	22-Apr-76	15-Jul-76	03-Feb-77	23-Apr-77	27-Jul-78	07-Nov-78	29-Mar-79	16-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	8.4	10.2	8.1	12.5	15.0	8.2	9.5		10.6	10.3	8.5	8.4	9.6		8.9	11.0	11.2	10.1	9.6	9.2	9.1	10.42	8.87	8.72	9.18	8.99
1								9.3		10.1		8.5		11.6			11.2	10.1	9.6	9.2	9.1	10.39	8.88	8.66	9.17	9.06
2										10.0	8.5	8.6		11.6		10.4	11.2	10.2	9.6	9.3	9.1	10.39	8.89	8.65	9.15	9.05
3										9.8		8.6	9.4		8.6		11.2	10.2	9.6	9.2	9.2	10.35	8.85	8.66	9.12	9.00
4										9.8	8.5	8.6		10.2		8.9	11.2	10.2	9.6	9.1	9.2	10.33	9.19	8.66	9.10	8.97
5	8.2		8.1							9.7		8.5						9.9	9.4	8.8	9.1	10.31	9.64	8.84	9.04	8.75
6				11.0						9.6	8.5	8.0	9.4	10.2	8.3	8.9	11.2	9.3	8.1	7.8	7.5	10.28	10.40	9.29	9.01	8.50
7			9.8									8.0						8.8	8.2	6.7	6.4	10.27	10.51	10.00	9.17	8.38
8			10.3		13.7	7.4				9.6	8.5	7.6		10.2		8.5	11.0	8.7	7.9	6.1	5.8	10.15	10.38	10.40	9.59	7.98
9	10.8									9.6		7.1	9.4		7.9			8.4	7.7	6.2	4.9	9.85	9.58	9.32	9.85	7.05
10										9.6	8.5	4.9		10.2		6.6	11.0	8.3	7.3	6.0	4.6	9.85	8.79	6.82	8.26	5.83
11			7.9							9.6		4.2						8.2	7.0	5.5	4.1	9.71	7.85	5.98	6.07	3.91
12				10.4						9.6	8.6	2.4	9.3	10.2	7.5	6.1	10.8	8.3	6.9	5.3	4.0	9.49	7.63	5.22	4.51	2.58
13										9.4													7.19	4.93	4.05	1.78
14	7.1									9.3	8.6	2.8		9.1		7.8	10.6						6.97	4.90	3.84	1.52
15		9.2	4.5		13.2	4.1		7.6	9.1				9.2		6.9			8.0	6.7	5.3	3.7	8.95	6.93	4.86	3.70	
16											8.6	2.6		8.5		5.9	10.5						6.91			1.27
17							8.0																			
18	6.5			9.9							8.7	2.4	9.2	8.1	6.6	1.0	10.4	8.0	6.6	5.1	3.6	8.79	7.07	4.89	3.51	1.26
19																										
20							1.0				8.4	2.4		7.9		0.4	10.4						6.91			
21			3.3										9.1		5.9			7.5	6.4	5.0	3.3	8.61		4.81	3.24	1.21
22											7.0	1.9		7.7		0.3	10.3						6.68			
23	5.7				11.4	2.2	0.5								4.9											
24				7.0							0.8	0.6	8.5	6.7		0.3	10.3	6.5	5.3	3.8	1.3	8.23	6.16	2.97	2.21	0.50
25															3.1							8.13				
26								1.9			0.2	0.0		5.6		0.3	10.2						5.02			
27													8.1		2.1			6.0	4.0	1.4	0.2			2.24	0.90	0.39
28											0.2	0.0		3.3		0.3	10.0						4.79			
29					4.5								3.4		1.1									1.44		
30	3.3	7.1	1.4	3.1		1.1	0.5		8.3								9.6	3.0	2.0	0.3	0.3		4.33		0.84	0.38

AVAILABLE HISTORICAL DATA
SAMPLING SITE C1

Surface

Parameter	18-Jul-75	22-Apr-76	15-Jul-76	03-Feb-77	23-Apr-77	27-Jul-78	07-Nov-78	29-Mar-79	16-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84
Secchi (meters)	3.35	3.51	3.51	1.37	4.42	3.35	3.66	6.71	3.51	3.66	3.51	4.72	4.57
Chlorophyll a (ug/L						4					6		2.5
pH	7.8	7.6	7.7	7.5	7.3	7.7	7.5	7.7	7.3	6.9	7.2	8.3	7.2
Color (Pt-Co)													
Chloride (mg/L)	4	3	3	5	4	3	3	2	4	3	3.9		3.9
Alkalinity (mg/L)	58	56	59	71	63	60	65	70	62	70	74		70
Total P (mg/L)	0.04	0.01	0.02	0.03	0.04	0.01	0.02	0.03	0.02	0.01	0.02	0.01	0.02
Dissolved P (mg/L)	0.024	0.003	0.014	0.008	0.014	0.011	0.0025	0.019	0.015	0.002	0.002	0.002	0.002
Total N (mg/L)	0.26	0.51	0.42		0.65	0.60	0.48	0.65	0.93	0.44	0.53		0.53
Inorganic N (mg/L)	0.06	0.16	0.10		0.21	0.09	0.09	0.29	0.33	0.05	0.05		0.14

Bottom

Parameter	18-Jul-75	22-Apr-76	15-Jul-76	03-Feb-77	23-Apr-77	27-Jul-78	07-Nov-78	29-Mar-79	16-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84
pH	7.6	7.5	7.5	7.5	7.4	7.6	7.4	7.6	7.3			6.8	
Color (Pt-Co)													
Chloride (mg/L)	4	3	3	6	4	3	3	2	4				
Alkalinity (mg/L)	84	57	61	75	65	64	68	73	64				
Total P (mg/L)	0.03	0.01	0.04	0.05	0.03	0.02	0.02	0.01	0.005			0.02	
Dissolved P (mg/L)	0.0025	0.003	0.017	0.029	0.030	0.007	0.007	0.0025	0.008			0.005	
Total N (mg/L)	0.42	0.53	0.94		0.38	0.69	0.65	0.67	0.89				
Inorganic N (mg/L)	0.16	0.19	0.28		0.07	0.27	0.29	0.29	0.33				

Surface

Parameter	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
Secchi (meters)			3.6	3.9	3.12	3.66	3.81	3.35	3.66	5.33	4.72	4.42	4.27
Chlorophyll a (ug/L				5	4	4	4	5.11	5.49	1.94	1.94	1.38	2.56
pH	7.9	7.0	7.9	7.7	8.5	8.5	8.5	8.5	7.98			8.39	8.45
Color (Pt-Co)					15	15	10	10					
Chloride (mg/L)	4.0	4.0	3.9	4	4	4	4	6	4.5	4.6	4.6	4.8	4.5
Alkalinity (mg/L)	74	76	78	82	74	76	73	75	77			77	77
Total P (mg/L)	0.01	0.04	0.02	0.011	0.006	0.008	0.005	0.007	0.010	0.008	0.009	0.007	0.010
Dissolved P (mg/L)	0.002	0.006	0.002	0.003	0.001	0.001	0.003	0.001					
Total N (mg/L)	0.54	0.72	0.41	0.47	0.504	0.304	0.404	0.404	0.307	0.407	0.407	0.377	0.367
Inorganic N (mg/L)	0.15	0.13	0.02	0.09	0.011	0.011	0.017	0.006	0.028	0.018	0.017	0.018	0.020

Bottom

Parameter	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
pH	8.0	6.7	7.4	7.5	7.0	7.0	6.8	7.0	7.90			7.36	7.47
Color (Pt-Co)					15	15	15	15					
Chloride (mg/L)	3.9	3.7	3.8	4.1	4	4	4	4	4.3	4.4	4.3	4.3	4.2
Alkalinity (mg/L)	82	88	98	83	78	81	83	85	79			82	84
Total P (mg/L)	0.02	0.02	0.08	0.012	0.016	0.019	0.019	0.017	0.012	0.012	0.015	0.017	0.021
Dissolved P (mg/L)	0.009	0.012	0.049	0.004	0.003	0.006	0.006	0.004					
Total N (mg/L)	0.69	0.64	0.61	0.38	0.611	0.597	0.881	0.709	0.379	0.550	0.685	0.663	0.647
Inorganic N (mg/L)	0.3	0.38	0.3	0.11	0.276	0.368	0.370	0.345	0.140	0.262	0.321	0.345	0.291

AVAILABLE HISTORICAL DATA
SAMPLING SITE C2

Temperature (C)

Depth (m)	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	8.6	7.0	25.9			0.0	7.9	7.2	16.96	18.35	21.29	22.97	11.72	23.57	23.75	20.94	20.73
1	8.0		25.5		1.0				16.87	18.31	21.08	22.99	11.72	23.55	23.75	20.90	20.76
2	8.7	7.0	25.1		2.3		7.9	6.5	16.55	18.26	20.71	22.90	11.61	23.48	23.66	20.80	20.74
3	7.8		24.8			2.5			16.32	18.18	20.64	22.83	11.49	23.41	23.55	21.64	20.59
4	7.8	7.0	24.5		2.6		7.8	6.0	16.10	18.07	20.01	22.80	11.36	23.35	23.17	20.38	20.07
5	7.8		24.0						15.78	17.70	19.03	22.78	10.74	21.11	22.61	20.29	19.96
6	7.8	7.0	23.0		2.6	2.9	7.8	6.0	13.45	17.11	17.70	22.12	10.23	18.01	22.20	20.22	19.72
7	7.7		19.7						11.02	13.03	15.35	18.42	10.08	13.08	17.21	19.98	18.88
8	7.7	7.0	15.5		2.6		7.8	5.9	9.18	10.48	13.68	12.87	9.85	11.85	14.27	16.49	17.94
9	7.7		12.6			3.0			7.88	8.84	10.80	10.02	9.61	10.61	10.84	12.34	15.53
10	7.7	7.0	10.2		2.6		7.8	5.8	7.29	7.70	8.42	8.58	9.14	9.63	9.69	10.57	12.29
11			9.0						8.97	7.19	7.63	7.97	8.09	8.71	8.81	9.25	9.53
12	7.7	7.0	8.3		2.6	3.0	7.8	5.8	6.71	6.94	7.32	7.42	7.63	8.07	8.37	8.48	8.71
13	7.7												7.04	7.84			8.33
14	7.7	7.0	7.8		2.7		7.8	5.8						7.63			8.17
15						3.0			6.51	6.66	6.83	6.86	6.83	7.53	7.73	7.68	
16		7.0	7.3		2.7		7.8	5.7						7.37			7.74
17						3.0								7.27			
18		7.0	7.1		2.5		7.6	5.5	6.38	6.51	6.66	6.71	6.69	7.06	7.27	7.40	7.58
19						3.0											
20		7.0	7.1		2.5		7.4	5.5						6.92			
21						3.0			6.23	6.42	6.51	6.68	6.43		7.12	7.12	7.25
22		7.0	7.1		2.6		6.7	5.4						6.89			
23						3.0							6.40		7.09		
24		7.0	7.1		2.8		6.5	5.4						6.86		7.06	7.18
25								5.4						6.86			
26		7.0	7.1		2.8		6.4							6.83			
27																	
28		6.5															
29									6.23	6.32	6.48	6.51					

AVAILABLE HISTORICAL DATA
SAMPLING SITE C2

Dissolved Oxygen (mg/L)

Depth (m)	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	10.5	9.0	8.5			9.3	9.0	11.0	10.17	9.87	9.46	9.00	10.81	8.86	8.85	9.19	9.03
1	10.2		8.5		11.3				10.17	9.80	9.44	8.98	10.68	8.88	8.80	9.20	9.06
2	10.2	9.0	8.9		10.0		8.6	11.0	10.23	9.77	9.34	8.99	10.58	8.90	8.74	9.15	9.06
3	10.0		8.9			8.5			10.26	9.75	9.26	9.00	10.53	8.88	8.69	9.10	9.03
4	10.0	8.9	8.7		9.8		8.7	11.0	10.11	9.69	9.33	9.00	10.45	8.82	8.70	9.12	9.03
5	9.9		8.5						9.93	9.58	8.87	8.98	10.31	9.09	8.73	9.04	8.83
6	9.9	8.9	7.9		9.8	8.4	9.1	11.0	9.62	9.00	7.92	8.17	10.22	10.02	8.67	8.93	8.59
7	9.8		6.9						8.77	7.80	6.40	6.37	10.16	10.39	9.60	8.83	7.94
8	9.8	8.9	6.7		9.8		9.1	10.7	8.41	7.17	5.41	2.71	10.05	9.70	9.65	8.60	7.23
9	9.8		3.8			7.5			8.15	6.39	4.51	2.12	9.95	8.63	6.45	6.44	4.47
10	9.7	8.9	2.6		9.8		9.1	10.6	8.28	6.22	4.34	2.00	9.64	7.63	5.02	3.63	1.58
11			1.9						8.01	5.82	4.00	1.98	9.34	6.78	3.75	1.90	0.46
12	9.7	8.9	1.7		9.2	7.0	9.1	10.4	7.89	5.88	4.13	1.21	9.13	6.14	3.39	1.37	0.38
13	9.7												8.89	5.72			0.37
14	9.6	8.9	1.4		8.9		9.1	10.4						5.50			0.38
15						5.9			7.96	5.45	3.75	1.54	8.78	5.10	3.12	1.05	
16		8.9	1.3		8.5		9.0	10.4						5.15			0.37
17						4.9								5.04			
18		8.9	0.9		7.4		7.6	10.4	7.78	4.76	2.96	1.07	8.63	4.40	2.16	0.68	0.37
19						3.4											
20		8.9	0.0		5.2		4.3	10.1						3.96			
21						3.2			7.23	4.14	2.14	0.35	8.31		1.67	0.66	0.36
22		8.9	0.0		4.1		0.5	10.1						3.66			
23						1.2							8.15		1.32		
24		8.9	0.0		1.5		0.3	9.9						3.31		0.66	0.36
25								9.7						2.80			
26		8.9	0.0		0.8		0.3							2.28			
27																	
28		6.1															
29									6.63	3.02	1.17	0.70					

AVAILABLE HISTORICAL DATA
SAMPLING SITE C2

Surface

Parameter	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89
Secchi (m)	3.66	3.05	4.11	4.57			4.4	3
Chlorophyll a (ug/L)	6.5	6	2.5	2.5				5
pH	7.4	7.5	8.5	7.1	7.9	7.3	7.9	7.9
Color (Pt-Co)								
Chloride (mg/L)	3	4		4	4.3	4.2	4	4.3
Alkalinity (mg/L)	70	70		66	76	74	78	84
Total P (mg/L)	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.01
Dissolved P (mg/L)	0.002	0.002	0.002	0.002	0.002	0.006	0.002	0.004
Total N (mg/L)	0.401	0.42		0.86	0.52	0.49	0.41	0.45
Inorganic N (mg/L)	0.031	0.07		0.48	0.13	0.1	0.03	0.06

Bottom

Parameter	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89
pH			7.2		7.7	7.2	7.3	7.7
Color (Pt-Co)								
Chloride (mg/L)					4.9	4.1	4.1	4.3
Alkalinity (mg/L)					78	74	82	84
Total P (mg/L)			0.02		0.02	0.02	0.14	0.015
Dissolved P (mg/L)			0.005		0.005	0.009	0.098	0.004
Total N (mg/L)					0.71	0.48	0.81	0.56
Inorganic N (mg/L)					0.35	0.19	0.44	0.09

Surface

Parameter	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
Secchi (m)	2.89	3.66	3.51	2.74	3.66	4.88	4.11	3.81	4.57
Chlorophyll a (ug/L)	4	5	5	5.31	5.71	2.23	2.30	2.16	0.21
pH	8.7	8.6	8.6	8.5	8.01			8.41	8.19
Color (Pt-Co)	15	15	10	10					
Chloride (mg/L)	4	4	4	4	4.6	4.6	4.7	4.3	4.5
Alkalinity (mg/L)	74	75	73	75	77			77	77
Total P (mg/L)	0.007	0.009	0.005	0.009	0.009	0.009	0.009	0.007	0.008
Dissolved P (mg/L)	0.001	0.002	0.002	0.001					
Total N (mg/L)	0.404	0.304	0.404	0.404	0.467	0.307	0.307	0.407	0.457
Inorganic N (mg/L)	0.006	0.010	0.010	0.013	0.080	0.020	0.017	0.012	0.055

Bottom

Parameter	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
pH	7.2	7.0	6.8	7.0	7.91				7.56
Color (Pt-Co)	15	15	20	15					
Chloride (mg/L)	4	4	4	4	4.5	4.8	4.6	4.6	4.8
Alkalinity (mg/L)	74	75	76	77	77				81
Total P (mg/L)	0.014	0.025	0.029	0.045	0.011	0.023	0.018	0.024	0.097
Dissolved P (mg/L)	0.002	0.008	0.014	0.019					
Total N (mg/L)	0.583	0.741	0.706	0.647	0.463	0.555	0.586	0.620	0.527
Inorganic N (mg/L)	0.234	0.329	0.363	0.302	0.161	0.294	0.306	0.291	0.245

AVAILABLE HISTORICAL DATA
SAMPLING SITE C4

Temperature (C)

Depth (m)	01-Aug-74	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	13-Mar-89	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	21.67	8.4	2.7	27.0	7.2	2.3		4.3	0.0	9.3	17.40	17.80	22.15	23.42	17.11	26.05	25.90	21.02	21.11
1		7.8	2.5	26.0		3.7	1.1	4.3	1.0	9.3	17.11	17.77	21.26	23.31	17.08	25.05	24.30	20.20	21.15
1.5				24.2								17.52	21.25	22.81					
2		7.3	2.5	24.0	7.1	3.9	2.2			7.5					17.06	24.81	23.95	19.75	21.02

Dissolved Oxygen (mg/L)

Depth (m)	31-Jul-70	02-Nov-77	07-Nov-78	15-Aug-79	16-Apr-80	19-Mar-81	03-Mar-82	27-Oct-83	12-Mar-85	08-May-85	26-May-88	23-Jun-88	13-Jul-88	10-Aug-88	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	14.8	11.4	13.4	16.1	12.2	11.8		13.2	0.3	11.9	9.1	10.7	9.1	8.8	9.76	8.92	10.35	10.92	9.94
1		11.5	13.4	12.6		9.1	4.9	13.0	0.2	11.9	9.1	10.7	9.1	8.9	9.73	9.70	10.24	10.70	9.89
1.5	13.1			2.8								9.5	9.0	8.0					
2		5.0	13.5	0.8	12.2	8.4	6.1			11.6					9.65	9.42	8.44	10.19	9.68

Surface

Parameter	31-Jul-70	02-Nov-77	07-Nov-78	15-Aug-79	16-Apr-80	19-Mar-81	03-Mar-82	27-Oct-83	12-Mar-85	08-May-85	26-May-88	23-Jun-88	13-Jul-88	10-Aug-88	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
Secchi (m)	0.46	0.58	1.13	0.43	1.22			1.00		1.00	1.37		1.68	0.61	2.13	2.13	1.68	1.68	1.83
Chlorophyll a (ug/L)		60	56	170	22					27	7	39	13	34.3	7.60	7.06	16.30	7.19	4.12
pH	9.6	8.2	8.4	9.9	7.2	7.4	6.9	8.5	6.7	8.2	8.0	8.7	8.6	8.7	7.90				8.14
Color (Pt-Co)											20	20	15	15					
Chloride (mg/L)	20	4	9.4		3.7	5.6	3.9	8.4		4.6	4	4	4	4	4.4	4.4	4.2	4.4	4.2
Alkalinity (mg/L)	62	78	62		40	62	60	68	89	58	51	49	51	52	57				49
Total P (mg/L)	0.91	0.58	0.37	0.20	0.06	0.04	0.02	0.11	0.22	0.06	0.030	0.040	0.021	0.063	0.027	0.034	0.037	0.031	0.021
Dissolved P (mg/L)	0.666	0.34	0.23	0.005	0.002	0.002	0.005	0.005	0.143	0.049	0.002	0.002	0.002	0.001					
Total N (mg/L)	2.448	4.34	1.6		0.93	1.47	0.84	1.61	3.71	1.11	0.604	0.804	0.604	1.104	0.507	0.607	1.107	0.737	0.637
Inorganic N (mg/L)	0.568	1.49	0.19		0.04	0.58	0.29	0.02	1.71	0.02	0.014	0.019	0.016	0.010	0.040	0.023	0.014	0.017	0.020

Bottom

Parameter	31-Jul-70	02-Nov-77	07-Nov-78	15-Aug-79	16-Apr-80	19-Mar-81	03-Mar-82	27-Oct-83	12-Mar-85	08-May-85	26-May-88	23-Jun-88	13-Jul-88	10-Aug-88
pH	9.4										8.0	8.4	8.6	8.6
Chloride (mg/L)	22													
Alkalinity (mg/L)	63													
Total P (mg/L)	0.97													
Dissolved P (mg/L)	0.697													
Total N (mg/L)	2.719													
Inorganic N (mg/L)	0.339													

AVAILABLE HISTORICAL DATA
SAMPLING SITE C5

Temperature (C)

Depth (m)	07-Nov-76	19-Aug-77	17-Oct-77	09-Mar-78	03-May-78	27-Jul-78	29-Mar-79	15-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	05-Mar-86	28-Oct-87	13-Mar-89	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	7.78	18.33	9.17		13.33	22.78		9.44	8.70	5.80	26.20	4.00			6.60	0.30	9.50	17.40	18.18	22.09	22.99	14.70	24.74	24.65	20.61	21.00
1			8.89	0.56	12.78	23.33	0.56	9.72	7.10		26.00		3.00	1.30		1.00		17.36	18.14	21.28	22.96	14.69	24.62	24.49	20.88	20.91
2			8.89	1.67	10.56		2.50		7.00	5.85	23.60	4.00	3.20	2.30	6.60	2.00	7.20	17.08	18.02	21.05	22.88	14.65	24.42	24.12	20.67	20.79
3			8.89	2.22	10.00		2.78	8.89	6.90		23.20		3.30	2.80		2.10		16.74	17.85	20.65	22.88	14.55	24.21	24.05	20.18	20.38
4			8.89	2.22	8.89	22.78			6.90	5.50	22.90	4.00	3.20	2.90	6.60	2.30	6.90	16.35	17.67	18.58	21.02	14.50	22.75	22.93	19.99	19.63
5			8.89	2.22	7.22	21.67		8.33	6.90		20.50		3.20			2.30		15.10	17.36	17.75	18.52	14.40	19.83	22.64	19.89	19.21
6		17.78	8.89	2.22	6.39	18.33		7.78	6.90	5.50	15.80	4.00	3.20	3.00	6.50	2.40	6.80	11.31	13.90	14.60	15.00	12.39	15.28	17.00	19.66	18.46
7		13.89	8.89	2.22	5.58	15.00			6.90		13.20		3.30			2.50		8.89	9.85	12.04	11.33	11.20	12.40	14.32	14.45	16.65
8		8.89	8.89	2.22	5.56	13.33			6.90	5.50	10.90	4.00	3.30	3.00	6.50	2.50	6.20	7.84	7.84	9.61	8.94	9.23	10.47	11.31	11.93	13.92
9		7.22	8.89	2.22	5.56	10.00		7.22	6.80		9.00		32.30			2.60		7.09	7.09	7.51	7.99	8.28	8.95	9.41	9.92	10.54
10		6.39	8.89	2.22	5.56	9.44			6.80	5.50	8.00	4.00		3.00	6.50	2.60	6.10	6.73	6.83	6.99	7.40	7.71	8.22	8.50	8.71	9.25
11			8.89	2.22	5.56	8.89			6.80		7.50		3.30			2.60		6.37	6.69	6.78	6.97	7.32	7.83	7.97	8.30	8.56
12			8.61	2.22	5.56			6.67	6.80	5.50	7.20	4.00		3.00	6.50	2.60	6.00	6.27	6.53	6.73	6.58	7.29	7.69	7.68	7.92	8.28
13		5.56		2.22	5.56	8.33		6.11	6.80				3.30			2.60							7.58			8.06
14				2.22	5.56				6.60	5.20	7.00	4.00		3.00	6.50	2.70	5.00						7.45			7.76
15			8.33	2.22	5.56			5.56				4.00	3.30			2.80		5.85	6.14	6.35	6.65	7.04	7.32	7.33	7.40	
16				2.22	5.56			4.44		5.20	6.80	4.00		3.00	6.50	2.80	5.20						7.20			7.55
17			7.78	2.22	5.00	7.78										2.80							7.17			
18	7.22		6.11	2.22	5.00					5.20	6.80	4.00		3.00	6.50	2.80	4.60	5.62	6.02	6.20		6.86	7.15	7.20	7.20	7.48
19				2.22	5.00			4.17								2.80										
20			5.56	2.22	5.00					5.20		4.00		3.20	6.50	2.80	4.00						7.15			
21			5.56	2.22	5.00							4.00				2.90		5.57	5.92	6.10				7.11	7.20	7.47
22			5.56	2.22	5.00					5.20					6.50	2.90	4.00									
23			5.56	2.22	5.00		3.06							3.20		2.90										
24			5.56	2.78	5.00					5.20					6.40	2.90	3.80		5.86	6.09				7.11	7.14	7.38
25			5.56	2.78	5.00									3.60		3.00										
26	6.67		5.56	2.78	5.00		3.33			5.20					6.30	3.00	3.60									
27			5.56		5.00	6.67		4.17								3.00	3.40								7.12	
28	6.67	5.56			5.00	6.67				5.20			4.10				3.40									

AVAILABLE HISTORICAL DATA
SAMPLING SITE C5

Dissolved Oxygen (mg/L)

Depth (m)	07-Nov-76	19-Aug-77	17-Oct-77	09-Mar-78	03-May-78	27-Jul-78	29-Mar-79	15-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	05-Mar-86	28-Oct-87	13-Mar-89	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	9.1	7.5	7.2		17.4	7.5		13.1	12.4	9.4	13.6	8.9			8.6	5.0	11.6	9.2	10.1	10.5	9.0	9.62	8.76	10.19	9.04	9.68
1				0.9			1.0		12.4		13.4		11.1	2.1		5.1		9.1	10.1	10.7	9.0	9.41	8.74	9.24	8.91	9.64
2									11.9	9.4	5.8	8.9	6.3	5.1	8.2	5.2	11.4	9.0	10.1	10.5	8.9	9.34	8.79	9.30	8.87	9.53
3						6.9	0.9		11.2		3.2		6.2	5.4		5.0		8.6	9.9	9.1	8.9	9.31	8.75	9.23	8.57	8.72
4									10.5	9.2	1.7	8.6	6.2	5.3	8.1	4.4	11.2	8.4	9.5	7.0	7.1	9.26	8.50	8.33	8.74	7.29
5		6.1				1.1	1.3		10.4		0.0		6.1			4.0		6.9	8.0	5.7	0.2	9.20	8.70	7.66	7.86	6.59
6		3.3				0.0			10.3	9.0	0.0	8.6	5.4	5.1	8.0	3.6	10.4	5.8	2.4	0.5	0.1	9.14	6.34	0.96	7.36	5.32
7									10.2		0.0		4.7			3.3		5.3	0.8	0.1	0.1	8.90	5.21	0.64	0.55	1.59
8		0.2							10.3	9.0	0.0	8.5	4.1	4.6	8.0	2.5	9.6	4.8	0.7	0.1	0.1	8.84	4.23	0.88	0.54	0.48
9		0.0				0.0		7.9	10.4		0.0		3.2			1.3		4.7	0.6	0.1	0.1	8.63	4.08	1.04	0.56	0.45
10									10.4	9.1	0.0	8.3		4.0	8.0	0.6	9.4	4.5	0.5	0.1	0.1	8.32	3.96	0.81	0.57	0.44
11							0.9		10.2		0.0		2.2			0.2		4.2	0.3	0.1	0.1	8.16	3.90	0.89	0.57	0.45
12				0.0	6.2				10.1	9.1	0.0	8.3		2.3	8.0	0.2	9.0	4.2	0.3	0.1	0.1	7.93	3.85	0.60	0.57	0.44
13									9.8				0.8			0.2							3.77			0.46
14								0.3	9.8	9.2	0.0	8.2		1.2	8.0	0.2	8.0						3.63			0.45
15												8.2	0.4			0.2		3.2	0.1	0.1	0.2	7.40	3.51	0.57	0.58	
16										9.2	0.0	8.1		0.8	8.0	0.2	5.9						3.26			0.46
17			4.7			0.0										0.2							3.15			
18										9.2	0.0	8.1		0.8	8.0	0.2	2.6	2.2	0.1	0.1		6.95	2.99	0.56	0.58	0.46
19																0.2										
20			0.0							9.2		7.9		0.7	7.7	2.0	0.2						2.75			
21	7.7				3.7							7.0				0.1		1.7	0.1	0.1				0.56	0.58	0.45
22										9.1					7.6	0.1	0.2									
23							0.0							0.7		0.1										
24					2.4					9.1					7.3	0.1	0.1		0.1	0.1				0.56	0.59	0.45
25														0.6		0.1										
26				0.0						9.1					6.8	0.1	0.1									
27			0.0					0.0								0.1	0.1								0.58	
28	0.0	0.0			0.2	0.0				8.8			0.3		6.7		0.1									

AVAILABLE HISTORICAL DATA
SAMPLING SITE C5

Surface

Parameter	07-Nov-76	19-Aug-77	17-Oct-77	09-Mar-78	03-May-78	27-Jul-78	29-Mar-79	15-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	05-Mar-86	28-Oct-87	13-Mar-89
Secchi (meters)	1.07	0.46	1.37	2.90	0.94	0.91	1.83	1.22	0.91	1.68	0.52	2.23			3.1	
Chlorophyll a (ug/L)									65	28	130	15				
pH	7.5	7.5	7.4	7.3	7.2	7.3	7.4	7.0	7.7	7.5	9.9	7.4	7.3	7.0	7.8	6.8
Color (Pt-Co)																
Chloride (mg/L)	6	11	10	11	9	6	5	6	4	5.5		2.1	3.5	3.2	3.3	
Alkalinity (mg/L)	55	51	77	60	54	47	58	53	58	62		40	50	38	46	56
Total P (mg/L)	0.10	0.13	0.14	0.11	0.14	0.08	0.06	0.07	0.11	0.12	0.06	0.08	0.03	0.04	0.05	0.03
Dissolved P (mg/L)	0.073	0.035	0.117	0.085	0.078	0.048	0.035	0.058	0.005	0.050	0.004	0.016	0.005	0.015	0.014	0.020
Total N (mg/L)	1.55	2.28	2.30	2.01	1.57	1.57	1.38	1.69	2.02	1.95		1.29	1.19	1.07	0.91	0.95
Inorganic N (mg/L)	0.72	0.94	1.57	1.24	0.67	0.61	0.67	0.66	0.52	0.93		0.59	0.66	0.34	0.31	0.46

Bottom

Parameter	07-Nov-76	19-Aug-77	17-Oct-77	09-Mar-78	03-May-78	27-Jul-78	29-Mar-79	15-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	05-Mar-86	28-Oct-87	13-Mar-89
pH	7.0	7.1	7.0	7.0	6.7	7.4	7.1	6.9					7.0	6.8	7.5	6.8
Color (Pt-Co)																
Chloride (mg/L)	9	10	10	10	8	8	15	11					4.1	4.0	3.3	
Alkalinity (mg/L)	73	53	95	82	48	43	62	85					94	70	46	
Total P (mg/L)	0.94	0.36	0.63	1.54	0.42	0.42	1.11	0.75					3.0	0.12	0.08	0.27
Dissolved P (mg/L)	0.622	0.330	0.484	0.848	0.424	0.401	0.832	0.613					0.45	0.115	0.031	0.101
Total N (mg/L)	5.25	2.83	5.19	6.05	3.04	2.94	3.41	4.8					8.3	1.21	1.11	1.54
Inorganic N (mg/L)	4.31	1.79	4.23	4.64	2.15	1.47	2.34	3.67					7.6	0.78	0.42	1.4

Surface

Parameter	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
Secchi (meters)	1.7	3.12	2.13	1.37	1.68	5.49	5.33	3.35	2.74	2.59
Chlorophyll a (ug/L)		5	15	28	16.8	1.18	2.92	7.26	4.82	7.39
pH	8.0	8.1	8.7	9.2	8.8	7.82			8.03	8.18
Color (Pt-Co)		30	30	15	15					
Chloride (mg/L)	3.9	4	4	3	4	3.6	3.6	5.8	3.8	3.6
Alkalinity (mg/L)	62	47	47	46	47	51			49	49
Total P (mg/L)	0.02	0.016	0.023	0.019	0.021	0.011	0.013	0.018	0.017	0.023
Dissolved P (mg/L)	0.004	0.003	0.001	0.003	0.001					
Total N (mg/L)	0.82	0.614	0.604	0.804	0.811	0.418	0.507	0.607	0.587	0.687
Inorganic N (mg/L)	0.13	0.066	0.015	0.015	0.029	0.062	0.026	0.015	0.012	0.017

Bottom

Parameter	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
pH	6.9	6.7	6.6	6.3	6.3	7.57			7.00	7.34
Color (Pt-Co)		25	40	20	30					
Chloride (mg/L)	4.5	4	4	3	4	3.7	3.8	3.8	4.0	3.5
Alkalinity (mg/L)	75	51	51	46	51	52			55	56
Total P (mg/L)	0.32	0.081	0.280	0.020	0.193	0.036	0.080	0.188	0.366	0.288
Dissolved P (mg/L)	0.119	0.058	0.171	0.004	0.091					
Total N (mg/L)	2.01	1.100	1.287	0.804	1.267	0.539	0.751	0.981	1.170	1.027
Inorganic N (mg/L)	1.21	0.636	0.757	0.014	0.686	0.256	0.412	0.523	0.615	0.627

Appendix B

1994 Water Quality Data
(All Stations)

1994 SAMPLING DATA
SITE C1

Depth	Temperature (C)					Dissolved Oxygen (mg/L)					pH				
(m)	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	12.24	23.51	23.24	20.58	20.40	10.42	8.87	8.72	9.18	8.99	7.95	8.36	8.50	8.38	8.28
1	12.24	23.49	23.25	20.56	20.40	10.39	8.88	8.66	9.17	9.06	7.98	8.35	8.52	8.38	8.33
2	12.23	23.40	23.24	20.56	20.38	10.39	8.89	8.65	9.15	9.05	8.00	8.37	8.54	8.41	8.34
3	12.20	23.43	23.22	20.53	20.30	10.35	8.85	8.66	9.12	9.00	8.02	8.38	8.55	8.42	8.35
4	12.20	22.00	23.22	20.47	20.24	10.33	9.19	8.66	9.10	8.97	8.03	8.37	8.55	8.43	8.36
5	12.16	19.35	22.18	20.27	19.94	10.31	9.64	8.84	9.04	8.75	8.03	8.28	8.53	8.44	8.31
6	12.16	15.23	20.39	20.18	19.66	10.28	10.40	9.29	9.01	8.50	8.04	7.95	8.39	8.43	8.24
7	12.11	13.16	16.21	19.64	19.07	10.27	10.51	10.00	9.17	8.38	8.03	7.79	8.12	8.36	8.22
8	11.97	11.67	12.88	15.06	17.88	10.15	10.38	10.40	9.59	7.98	8.03	7.66	7.88	7.84	8.13
9	9.70	10.08	10.06	11.47	15.25	9.85	9.58	9.32	9.85	7.05	7.77	7.42	7.51	7.65	7.56
10	8.87	8.74	8.49	9.44	10.88	9.85	8.79	6.82	8.26	5.83	7.67	7.25	7.18	7.41	7.20
11	8.02	7.88	7.89	8.50	9.07	9.71	7.85	5.98	6.07	3.91	7.60	7.11	7.07	7.10	7.03
12	7.47	7.35	7.32	7.78	8.28	9.49	7.63	5.22	4.51	2.58	7.53	7.07	7.02	6.97	6.88
13		7.11	7.01	7.20	7.78		7.19	4.93	4.05	1.78		7.03	6.99	6.93	6.83
14		6.91	6.91	7.07	7.40		6.97	4.90	3.84	1.52		7.01	6.97	6.88	6.81
15	6.46	6.76	6.84	6.96		8.95	6.93	4.86	3.70		7.41	7.00	6.97	6.85	
16		6.78			7.11		6.91			1.27		7.00			6.79
17															
18	6.18	6.48	6.69	6.69	6.96	8.79	7.07	4.89	3.51	1.26	7.38	7.02	6.97	6.82	6.78
19															
20		6.56					6.91					7.01			
21	6.00		6.38	6.38	6.84	8.61		4.81	3.24	1.21	7.36		6.96	6.81	6.77
22		6.28					6.68					6.99			
23															
24	5.76	6.14	6.07	6.22	6.40	8.23	6.16	2.97	2.21	0.50	7.31	6.96	6.89	6.78	6.74
25	5.72					8.13					7.30				
26		5.92					5.02					6.90			
27			6.02	6.09	6.22			2.24	0.90	0.39			6.85	6.74	6.73
28		5.90					4.79					6.89			
29			5.99					1.44					6.83		
30		5.89		5.99	6.18		4.33		0.84	0.38		6.89		6.74	6.74

Parameter	Surface								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)	3.66	5.33	4.72	4.42	4.27	5.33	3.66	4.48	0.62
Chlorophyll a (ug/L)	5.49	1.94	1.94	1.38	2.56	5.49	1.38	2.66	1.64
Chloride (mg/L)	4.5	4.6	4.6	4.8	4.5	4.8	4.5	4.6	0.1
Alkalinity (mg/L)	77			77	77	77	77	77	0
Total P (mg/L)	0.010	0.008	0.009	0.007	0.010	0.010	0.007	0.009	0.001
Total N (mg/L)	0.307	0.407	0.407	0.377	0.367	0.407	0.307	0.373	0.041
Inorganic N (mg/L)	0.028	0.018	0.017	0.018	0.020	0.028	0.017	0.020	0.004

Parameter	Bottom								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)									
Chlorophyll a (ug/L)									
Chloride (mg/L)	4.3	4.4	4.3	4.3	4.2	4.4	4.2	4.3	0.1
Alkalinity (mg/L)	79			82	84	84	79	82	3
Total P (mg/L)	0.012	0.012	0.015	0.017	0.021	0.021	0.012	0.015	0.004
Total N (mg/L)	0.379	0.550	0.685	0.663	0.647	0.685	0.379	0.585	0.126
Inorganic N (mg/L)	0.140	0.262	0.321	0.345	0.291	0.345	0.140	0.272	0.080

NOTES:
Chlorophyll a analyses of 19 July, 16 August and 20 September are approximate
Total Kjeldahl Nitrogen holding time of 16 August exceeded by approximately 5 days
Total Phosphorus holding time of 16 August exceeded between 13 to 16 days
Total Kjeldahl Nitrogen holding time of 20 September exceeded by approximately 16-17 days
Total Phosphorus holding time of 20 September exceeded, results are approximate

1994 SAMPLING DATA
SITE C2

Depth	Temperature (C)					Dissolved Oxygen (mg/L)					pH				
(m)	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	11.72	23.57	23.75	20.94	20.73	10.81	8.86	8.85	9.19	9.03	7.97	8.45	8.60	8.42	8.33
1	11.72	23.55	23.75	20.90	20.76	10.68	8.88	8.80	9.20	9.06	7.98	8.43	8.59	8.44	8.34
2	11.61	23.48	23.66	20.80	20.74	10.58	8.90	8.74	9.15	9.06	8.00	8.45	8.62	8.45	8.37
3	11.49	23.41	23.55	21.64	20.59	10.53	8.88	8.69	9.10	9.03	7.98	8.45	8.61	8.47	8.39
4	11.36	23.35	23.17	20.38	20.07	10.45	8.82	8.70	9.12	9.03	7.96	8.45	8.59	8.49	8.40
5	10.74	21.11	22.61	20.29	19.96	10.31	9.09	8.73	9.04	8.83	7.87	8.35	8.56	8.49	8.37
6	10.23	18.01	22.20	20.22	19.72	10.22	10.02	8.67	8.93	8.59	7.81	8.23	8.57	8.46	8.34
7	10.08	13.08	17.21	19.98	18.88	10.16	10.39	9.60	8.83	7.94	7.79	7.82	8.11	8.43	8.17
8	9.85	11.85	14.27	16.49	17.94	10.05	9.70	9.65	8.60	7.23	7.76	7.60	7.90	7.96	7.96
9	9.61	10.61	10.84	12.34	15.53	9.95	8.63	6.45	6.44	4.47	7.72	7.38	7.27	7.30	7.41
10	9.14	9.63	9.69	10.57	12.29	9.64	7.63	5.02	3.63	1.58	7.66	7.24	7.12	7.10	7.02
11	8.09	8.71	8.81	9.25	9.53	9.34	6.78	3.75	1.90	0.46	7.55	7.12	7.00	6.90	6.88
12	7.63	8.07	8.37	8.48	8.71	9.13	6.14	3.39	1.37	0.38	7.50	7.03	6.95	6.84	6.80
13	7.04	7.84			8.33	8.89	5.72			0.37	7.45	6.99			6.78
14		7.63			8.17		5.50			0.38		6.96			6.77
15	6.83	7.53	7.73	7.68		8.78	5.10	3.12	1.05		7.46	6.93	6.92	6.78	
16		7.37			7.74		5.15			0.37		6.93			6.76
17		7.27					5.04					6.90			
18	6.69	7.06	7.27	7.40	7.58	8.63	4.40	2.16	0.68	0.37	7.40	6.76	6.86	6.75	6.75
19															
20		6.92					3.96					6.85			
21	6.43		7.12	7.12	7.25	8.31		1.67	0.66	0.36	7.36		6.83	6.75	6.73
22		6.89					3.66					6.84			
23	6.40		7.09			8.15		1.32			7.34		6.81		
24		6.86		7.06	7.18		3.31		0.66	0.36		6.83		6.75	6.73
25		6.86					2.80					6.82			
26		6.83					2.28					6.81			

Parameter	Surface								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)	3.66	4.88	4.11	3.81	4.57	4.88	3.66	4.21	0.51
Chlorophyll a (ug/L)	5.71	2.23	2.30	2.16	0.21	5.71	0.21	2.52	1.99
Chloride (mg/L)	4.6	4.6	4.7	4.3	4.5	4.7	4.3	4.5	0.2
Alkalinity (mg/L)	77			77	77	77	77	77	0
Total P (mg/L)	0.009	0.009	0.009	0.007	0.008	0.009	0.007	0.008	0.001
Total N (mg/L)	0.467	0.307	0.307	0.407	0.457	0.467	0.307	0.389	0.078
Inorganic N (mg/L)	0.080	0.020	0.017	0.012	0.055	0.080	0.012	0.037	0.030

Parameter	Bottom								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)									
Chlorophyll a (ug/L)									
Chloride (mg/L)	4.5	4.8	4.6	4.6	4.8	4.8	4.5	4.7	0.1
Alkalinity (mg/L)	77				81	81	77	79	3
Total P (mg/L)	0.011	0.023	0.018	0.024	0.097	0.097	0.011	0.035	0.035
Total N (mg/L)	0.463	0.555	0.586	0.620	0.527	0.620	0.463	0.550	0.060
Inorganic N (mg/L)	0.161	0.294	0.306	0.291	0.245	0.306	0.161	0.259	0.060

NOTES:
Chlorophyll a analyses of 21 June, 19 July, 16 August and 20 September are approximate
Total Kjeldahl Nitrogen holding time of 16 August exceeded by approximately 5 days
Total Phosphorus holding time of 16 August exceeded between 13 to 16 days
Total Kjeldahl Nitrogen holding time of 20 September exceeded by approximately 16-17 days

1994 SAMPLING DATA
SITE C2A

Depth	Temperature (C)					Dissolved Oxygen (mg/L)					pH				
(m)	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	12.79	23.61	23.68	20.52	20.40	10.52	8.81	8.84	9.37	9.30	8.06	8.44	8.62	8.43	8.34
1	12.77	23.53	23.64	20.50	20.40	10.41	8.83	8.74	9.25	9.24	8.07	8.44	8.61	8.46	8.39
2	12.72	23.44	23.59	20.27	20.31	10.35	8.81	8.63	9.28	9.22	8.11	8.45	8.63	8.49	8.42
3	12.66	23.37	23.50	20.10	20.27	10.31	8.81	8.62	9.18	9.19	8.12	8.45	8.65	8.48	8.44
4	12.61	22.67	23.42	20.01	19.94	10.25	8.84	8.62	9.12	8.99	8.14	8.43	8.65	8.50	8.43
5	12.21	19.24	21.11	19.96	19.70	10.15	9.63	8.70	9.02	8.81	8.10	8.33	8.53	8.50	8.35
6	11.13	14.97	18.91	19.70	19.07	11.20	10.85	9.53	8.95	8.65	7.96	8.08	8.53	8.47	8.35
7	10.08	10.87	14.80	17.36	17.82	10.10	10.29	10.27	9.40	7.85	7.83	7.63	8.07	8.18	8.18
8	9.05	9.95	10.75	11.03	15.15	9.81	8.50	9.11	8.65	6.54	7.72	7.44	7.68	7.66	7.54
9	7.70	9.09	8.87	9.33	11.57	9.73	8.62	6.60	5.83	4.95	7.58	7.28	7.20	7.20	7.19
10	6.96	8.35	8.10	8.45	9.15	9.45	8.03	5.70	3.32	2.63	7.50	7.17	7.08	6.98	6.99
11	6.78	7.71	7.42	7.76	8.25	9.17	7.59	5.41	3.54	1.44	7.45	7.10	7.04	6.93	6.88
12	6.61	7.27	6.91	7.37	7.52	9.17	7.37	4.90	2.44	1.11	7.45	7.07	6.98	6.89	6.83
13		6.83			7.09		7.02			0.81		7.03			6.79
14		6.37			6.89		6.71			1.04		6.99			6.77
15	6.20	6.32	6.27	6.46		8.72	6.47	4.97	2.86		7.36	6.97	6.96	6.84	
16		9.14			6.37		6.42			1.04		6.96			6.75
17		6.05					6.34					6.98			
18	5.90	6.02	5.99	6.20	6.17	8.40	6.19	3.86	3.26	0.47	7.30	6.94	6.91	6.82	6.73
19															
20		5.90					5.72					6.92			
21	5.81		5.89	5.97	5.95	8.18		3.00	2.25	0.41	7.28		6.86	6.78	6.72
22		5.81					5.03					6.88			
23															
24	5.74	5.81	5.84	5.84	5.90	7.75	4.11	2.00	0.72	0.40	7.23	6.84	6.82	6.73	6.71
25															
26		5.76					3.35					6.82			
27	5.70				5.82	7.17				0.40	7.19				6.70

Parameter	Surface								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)	3.51	5.03	4.27	3.66	4.11	5.03	3.51	4.11	0.60
Chlorophyll a (ug/L)	4.96	2.58	2.28	2.22	1.81	4.96	1.81	2.77	1.25
Chloride (mg/L)	4.8	4.8	4.8	4.9	4.3	4.9	4.3	4.7	0.2
Alkalinity (mg/L)	77			77	76	77	76	77	1
Total P (mg/L)	0.009	0.008	0.009	0.007	0.009	0.009	0.007	0.008	0.001
Total N (mg/L)	0.324	0.307	0.407	0.427	0.387	0.427	0.307	0.370	0.052
Inorganic N (mg/L)	0.042	0.012	0.018	0.012	0.019	0.042	0.012	0.021	0.012

Parameter	Bottom								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)									
Chlorophyll a (ug/L)									
Chloride (mg/L)					4.9	4.9	4.9	4.9	
Alkalinity (mg/L)					79	79	79	79	
Total P (mg/L)					0.036	0.036	0.036	0.036	
Total N (mg/L)					0.688	0.688	0.688	0.688	
Inorganic N (mg/L)					0.295	0.295	0.295	0.295	

NOTES:
Chlorophyll a analyses of 19 July, 16 August and 20 September are approximate
Total Kjeldahl Nitrogen holding time of 16 August exceeded by approximately 5 days
Total Phosphorus holding time of 16 August exceeded between 13 to 16 days
Total Kjeldahl Nitrogen holding time of 20 September exceeded by approximately 16-17 days

1994 SAMPLING DATA
SITE C4

Depth	Temperature (C)					Dissolved Oxygen (mg/L)					pH				
(m)	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	17.11	26.05	25.90	21.02	21.11	9.76	8.92	10.35	10.92	9.94	8.35	8.97	9.68	9.34	8.36
1	17.08	25.05	24.30	20.20	21.15	9.73	9.70	10.24	10.70	9.89	8.34	9.50	9.70	9.39	8.45
2	17.06	24.81	23.95	19.75	21.02	9.65	9.42	8.44	10.19	9.68	8.37	9.56	9.63	9.39	8.37

Parameter	Surface								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Aug-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)	2.13	2.13	1.68	1.68	1.83	2.13	1.68	1.89	0.23
Chlorophyll a (ug/L)	7.60	7.06	16.30	7.19	4.12	16.30	4.12	8.45	4.60
Chloride (mg/L)	4.4	4.4	4.2	4.4	4.2	4.4	4.2	4.3	0.1
Alkalinity (mg/L)	57				49	57	49	53	6
Total P (mg/L)	0.027	0.034	0.037	0.031	0.021	0.037	0.021	0.030	0.006
Total N (mg/L)	0.507	0.607	1.107	0.737	0.637	1.107	0.507	0.719	0.232
Inorganic N (mg/L)	0.040	0.023	0.014	0.017	0.020	0.040	0.014	0.023	0.010

NOTES:

Chlorophyll a analysis of 20 September is approximate
Total Kjeldahl Nitrogen holding time of 16 August exceeded by approximately 5 days
Total Phosphorus holding time of 16 August exceeded between 13 to 16 days
Total Kjeldahl Nitrogen holding time of 20 September exceeded by approximately 16-17 days

1994 SAMPLING DATA
SITE C5

Depth (m)	Temperature (C)					Dissolved Oxygen (mg/L)					pH				
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	14.70	24.74	24.65	20.61	21.00	9.62	8.76	10.19	9.04	9.68	7.22	8.34	9.25	8.18	8.35
1	14.69	24.62	24.49	20.88	20.91	9.41	8.74	9.24	8.91	9.64	7.70	8.30	8.92	8.21	8.35
2	14.65	24.42	24.12	20.67	20.79	9.34	8.79	9.30	8.87	9.53	7.76	8.34	8.94	8.27	8.37
3	14.55	24.21	24.05	20.18	20.38	9.31	8.75	9.23	8.57	8.72	7.75	8.34	8.94	8.22	7.90
4	14.50	22.75	22.93	19.99	19.63	9.26	8.50	8.33	8.74	7.29	7.76	8.07	8.65	8.13	7.42
5	14.40	19.83	22.64	19.89	19.21	9.20	8.70	7.66	7.86	6.59	7.76	7.83	8.49	7.98	7.35
6	12.39	15.28	17.00	19.66	18.46	9.14	6.34	0.96	7.36	5.32	7.55	6.99	6.72	7.83	7.19
7	11.20	12.40	14.32	14.45	16.65	8.90	5.21	0.64	0.55	1.59	7.43	6.82	6.64	6.73	6.88
8	9.23	10.47	11.31	11.93	13.92	8.84	4.23	0.88	0.54	0.48	7.32	6.70	6.59	6.62	6.69
9	8.28	8.95	9.41	9.92	10.54	8.63	4.08	1.04	0.56	0.45	7.24	6.66	6.57	6.57	6.57
10	7.71	8.22	8.50	8.71	9.25	8.32	3.96	0.81	0.57	0.44	7.16	6.62	6.54	6.54	6.50
11	7.32	7.83	7.97	8.30	8.56	8.16	3.90	0.89	0.57	0.45	7.13	6.61	6.54	6.52	6.47
12	7.29	7.69	7.68	7.92	8.28	7.93	3.85	0.60	0.57	0.44	7.08	6.61	6.52	6.50	6.47
13		7.56			8.06		3.77			0.46		6.61			6.47
14		7.45			7.76		3.63			0.45		6.60			6.45
15	7.04	7.32	7.33	7.40		7.40	3.51	0.57	0.58		7.03	6.59	6.51	6.49	
16		7.20			7.55		3.26			0.46		6.59			6.45
17		7.17					3.15					6.58			
18	6.86	7.15	7.20	7.20	7.48	6.95	2.99	0.56	0.58	0.46	6.98	6.58	6.52	6.47	6.46
19															
20		7.15					2.75					6.55			
21			7.11	7.20	7.47			0.56	0.58	0.45			6.52	6.45	6.45
22															
23															
24			7.11	7.14	7.38			0.56	0.59	0.45			6.52	6.43	6.45
25															
26															
27				7.12					0.58					6.42	

Parameter	Surface								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)	5.49	5.33	3.35	2.74	2.59	5.49	2.59	3.90	1.41
Chlorophyll a (ug/L)	1.18	2.92	7.26	4.82	7.39	7.39	1.18	4.71	2.71
Chloride (mg/L)	3.6	3.6	5.8	3.8	3.6	5.8	3.6	4.1	1.0
Alkalinity (mg/L)	51			49	49	51	49	50	1
Total P (mg/L)	0.011	0.013	0.018	0.017	0.023	0.023	0.011	0.016	0.005
Total N (mg/L)	0.418	0.507	0.607	0.587	0.687	0.687	0.418	0.561	0.103
Inorganic N (mg/L)	0.062	0.026	0.015	0.012	0.017	0.062	0.012	0.026	0.021

Parameter	Bottom								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)									
Chlorophyll a (ug/L)									
Chloride (mg/L)	3.7	3.8	3.8	4.0	3.5	4.0	3.5	3.8	0.2
Alkalinity (mg/L)	52			55	56	56	52	54	2
Total P (mg/L)	0.036	0.080	0.188	0.366	0.288	0.366	0.036	0.192	0.138
Total N (mg/L)	0.539	0.751	0.981	1.170	1.027	1.170	0.539	0.894	0.249
Inorganic N (mg/L)	0.256	0.412	0.523	0.615	0.627	0.627	0.256	0.487	0.155

NOTES:
Chlorophyll a analysis of 17 May is approximate
Total Kjeldahl Nitrogen holding time of 16 August exceeded by approximately 5 days
Total Phosphorus holding time of 16 August exceeded between 13 to 16 days
Total Kjeldahl Nitrogen holding time of 20 September exceeded by approximately 16-17 days

1994 SAMPLING DATA
SITE C6

Depth	Temperature (C)					Dissolved Oxygen (mg/L)					pH				
(m)	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	15.13	24.70	24.15	20.57	20.80	9.88	8.62	9.45	9.01	9.30	8.13	8.43	8.72	8.08	8.31
1	15.08	24.53	24.10	20.48	20.81	9.70	8.72	9.20	8.89	9.31	8.10	8.43	8.76	8.11	8.30
2	15.08	24.31	24.00	20.36	20.73	9.61	8.71	9.03	8.92	9.30	8.11	8.42	8.77	8.16	8.32
3	14.77	24.13	24.04	19.86	20.45	9.56	8.43	9.00	8.50	9.10	8.13	8.37	8.78	8.06	8.31
4	14.07	22.17	24.00	19.72	19.53	9.26	7.65	8.90	8.37	8.38	8.00	7.99	8.79	8.03	8.05
5	13.31	19.03	20.95	19.56	18.77	9.00	6.21	6.30	8.31	7.75	7.88	7.40	7.84	8.00	7.80
6	11.90	14.35	16.10	19.03	17.99	8.74	2.13	1.33	5.90	5.42	7.65	6.89	6.94	7.47	7.45
7	9.40	12.33	13.06	15.35	17.08	7.49	0.99	1.49	4.10	1.77	7.34	6.80	6.88	7.00	7.11
8	8.30	11.34	11.92	11.82	14.54	6.72	0.67	0.58	0.67	0.40	7.22	6.76	6.83	6.75	6.87
9	7.96	9.53	10.48	10.35	11.75	6.05	0.63	0.56	0.63	0.38	7.16	6.75	6.81	6.70	6.73
10	7.60	8.81	9.22	9.51	10.08	4.52	0.61	0.59	0.54	0.36	7.07	6.74	6.81	6.70	6.65
11	7.50	8.35	8.53	8.86	9.40	3.46	0.62	0.58	0.57	0.36	7.01	6.74	6.81	6.69	6.61
12		8.24	8.40	8.63	9.10		0.62	0.57	0.56	0.36		6.75	6.80	6.68	6.59
13		8.09	8.35	8.53			0.61	0.57	0.55			6.76	6.81	6.66	
14		8.07	8.30				0.61	0.56				6.76	6.81		

Parameter	Surface								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)	4.27	4.57	4.11	3.05	3.66	4.57	3.05	3.93	0.59
Chlorophyll a (ug/L)	3.91	5.59	4.19	3.16	3.87	5.59	3.16	4.14	0.89
Chloride (mg/L)	6.5	5.8	5.8	5.7	5.4	6.5	5.4	5.8	0.4
Alkalinity (mg/L)	74			71	70	74	70	72	2
Total P (mg/L)	0.011	0.010	0.014	0.014	0.014	0.014	0.010	0.013	0.002
Total N (mg/L)	0.307	0.307	0.407	0.457	0.367	0.457	0.307	0.369	0.065
Inorganic N (mg/L)	0.029	0.017	0.016	0.012	0.029	0.029	0.012	0.021	0.008

Parameter	Bottom								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)									
Chlorophyll a (ug/L)									
Chloride (mg/L)	6.0	6.2	6.1	6.2	6.1	6.2	6.0	6.1	0.1
Alkalinity (mg/L)	76			83	86	86	76	82	5
Total P (mg/L)	0.040	0.133	0.134	0.093	0.052	0.134	0.040	0.090	0.044
Total N (mg/L)	0.813	1.007	1.418	1.669	1.894	1.894	0.813	1.360	0.449
Inorganic N (mg/L)	0.403	0.654	0.815	1.029	1.284	1.284	0.403	0.837	0.339

NOTES:
Chlorophyll a analysis of 16 August is approximate
Total Kjeldahl Nitrogen holding time of 16 August exceeded by approximately 5 days
Total Phosphorus holding time of 16 August exceeded between 13 to 16 days
Total Kjeldahl Nitrogen holding time of 20 September exceeded by approximately 16-17 days
Total Phosphorus holding time of 20 September exceeded, results are approximate

1994 SAMPLING DATA
SITE C7

Depth (m)	Temperature (C)					Dissolved Oxygen (mg/L)					pH				
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94
0	16.52	24.85	24.44	20.31	20.38	9.16	7.89	8.61	9.22	8.54	7.90	8.08	8.00	7.62	7.47
1	16.44	24.79	24.21	20.15	20.36	9.01	7.39	8.62	9.11	8.43	7.89	7.90	8.10	7.67	7.54
2	16.30	23.40	22.66	19.01	19.20	9.05	6.07	5.48	7.16	7.46	7.92	7.26	7.05	7.13	7.10
3	11.44	18.96	20.80	18.38	17.84	10.40	6.73	6.72	6.50	1.56	7.95	7.18	7.19	7.03	6.75
4	7.56	13.36	16.70	17.28	16.97	8.53	2.15	2.60	2.34	0.40	7.27	6.70	6.82	6.78	6.66
5	6.69	10.00	13.13	15.73	15.57	1.03	0.83	0.65	0.76	0.33	6.67	6.57	6.70	6.57	6.51
6	6.40	8.02	9.28	10.57		0.89	0.59	0.58	0.57		6.57	6.32	6.45	6.32	

Parameter	Surface								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)	3.05	3.81	3.35	3.35	3.05	3.81	3.05	3.32	0.31
Chlorophyll a (ug/L)	4.55	3.67	5.78	5.88	4.83	5.88	3.67	4.94	0.92
Chloride (mg/L)	26.7	18.8	18.7	19.3	16.8	26.7	16.8	20.1	3.8
Alkalinity (mg/L)	63			53	53	63	53	56.3	6
Total P (mg/L)	0.017	0.018	0.020	0.014	0.018	0.020	0.014	0.017	0.002
Total N (mg/L)	0.407	0.407	0.607	0.557	0.617	0.617	0.407	0.519	0.105
Inorganic N (mg/L)	0.017	0.020	0.018	0.012	0.014	0.020	0.012	0.016	0.003

Parameter	Bottom								
	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Maximum	Minimum	Mean	Std. Dev.
Secchi (meters)									
Chlorophyll a (ug/L)									
Chloride (mg/L)	39.6	39.5	36.7	30.1	21.2	39.6	21.2	33.4	7.8
Alkalinity (mg/L)	59			58		59	58	58.5	34
Total P (mg/L)	0.072	0.094	0.131	0.054	0.039	0.131	0.039	0.078	0.036
Total N (mg/L)	1.007	0.807	1.407	0.998	0.727	1.407	0.727	0.989	0.263
Inorganic N (mg/L)	0.017	0.027	0.012	0.013	0.027	0.027	0.012	0.019	0.007

NOTES:

Total Kjeldahl Nitrogen holding time of 16 August exceeded by approximately 5 days
Total Phosphorus holding time of 16 August exceeded between 13 to 16 days
Total Kjeldahl Nitrogen holding time of 20 September exceeded by approximately 16-17 days
Total Phosphorus holding time of 20 September exceeded, results are approximate

Appendix C

Mann-Kendall Trend Analyses

Mann-Kendall Test
Trend Analysis for Station C1

Ho= No Trend
Ha= Downward Trend

Conf. Level 95.0%
alpha= 0.05

Tied Groups

Value	Freq. of Occurrence	
0.01	3	= t1
0.02	6	= t2
0.03	2	= t3
0.04	3	= t4
<0.02	3	= t5
0.007	2	= t6
0.008	2	= t7

S=	-152	Maximum	0.04
VAR[S]=	2016	Minimum	0.005
Z=	-3.36	N =	26
Abs. Z=	3.36		|Z| > 0.6826
Z 1-a/2	0.6826		Ho is rejected

Total P	18-Jul-75	22-Apr-76	15-Jul-76	03-Feb-77	23-Apr-77	27-Jul-78	07-Nov-78	29-Mar-79	16-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86
(mg/L)	0.04	0.01	0.02	0.03	0.04	0.01	0.02	0.03	0.02	0.01	0.02	0.01	0.020	0.010	0.040
		-0.03	-0.02	-0.01	0	-0.03	-0.02	-0.01	-0.02	-0.03	-0.02	-0.03	-0.02	-0.03	0
			0.01	0.02	0.03	0	0.01	0.02	0.01	0	0.01	0	0.01	0	0.03
				0.01	0.02	-0.01	0	0.01	0	-0.01	0	-0.01	0	-0.01	0.02
					0.01	-0.02	-0.01	0	-0.01	-0.02	-0.01	-0.02	-0.01	-0.02	0.01
						-0.03	-0.02	-0.01	-0.02	-0.03	-0.02	-0.03	-0.02	-0.03	0
							0.01	0.02	0.01	0	0.01	0	0.01	0	0.03
								0.01	0	-0.01	0	-0.01	0	-0.01	0.02
									-0.01	-0.02	-0.01	-0.02	-0.01	-0.02	0.01
										-0.01	0	-0.01	0	-0.01	0.02
											0.01	0	0.01	0	0.03
												-0.01	0	-0.01	0.02
													0.01	0	0.03
														-0.01	0.02
															0.03

28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Sum	Sum
0.020	0.011	0.006	0.008	0.005	0.007	0.006	0.008	0.009	0.007	0.010	Positives	Negatives
-0.02	-0.029	-0.034	-0.032	-0.035	-0.033	-0.034	-0.032	-0.031	-0.033	-0.03	0	23
0.01	0.001	-0.004	-0.002	-0.005	-0.003	-0.004	-0.002	-0.001	-0.003	0	11	8
0	-0.009	-0.014	-0.012	-0.015	-0.013	-0.014	-0.012	-0.011	-0.013	-0.01	4	14
-0.01	-0.019	-0.024	-0.022	-0.025	-0.023	-0.024	-0.022	-0.021	-0.023	-0.02	2	19
-0.02	-0.029	-0.034	-0.032	-0.035	-0.033	-0.034	-0.032	-0.031	-0.033	-0.03	0	20
0.01	0.001	-0.004	-0.002	-0.005	-0.003	-0.004	-0.002	-0.001	-0.003	0	8	8
0	-0.009	-0.014	-0.012	-0.015	-0.013	-0.014	-0.012	-0.011	-0.013	-0.01	2	13
-0.01	-0.019	-0.024	-0.022	-0.025	-0.023	-0.024	-0.022	-0.021	-0.023	-0.02	1	17
0	-0.009	-0.014	-0.012	-0.015	-0.013	-0.014	-0.012	-0.011	-0.013	-0.01	1	13
0.01	0.001	-0.004	-0.002	-0.005	-0.003	-0.004	-0.002	-0.001	-0.003	0	5	8
0	-0.009	-0.014	-0.012	-0.015	-0.013	-0.014	-0.012	-0.011	-0.013	-0.01	1	12
0.01	0.001	-0.004	-0.002	-0.005	-0.003	-0.004	-0.002	-0.001	-0.003	0	4	8
0	-0.009	-0.014	-0.012	-0.015	-0.013	-0.014	-0.012	-0.011	-0.013	-0.01	1	11
0.01	0.001	-0.004	-0.002	-0.005	-0.003	-0.004	-0.002	-0.001	-0.003	0	3	8
-0.02	-0.029	-0.034	-0.032	-0.035	-0.033	-0.034	-0.032	-0.031	-0.033	-0.03	0	11
	-0.009	-0.014	-0.012	-0.015	-0.013	-0.014	-0.012	-0.011	-0.013	-0.01	0	10
		-0.005	-0.003	-0.006	-0.004	-0.005	-0.003	-0.002	-0.004	-0.001	0	9
			0.002	-0.001	0.001	0	0.002	0.003	0.001	0.004	6	1
				-0.003	-0.001	-0.002	0	0.001	-0.001	0.002	2	4
					0.002	0.001	0.003	0.004	0.002	0.005	6	0
						-0.001	0.001	0.002	0	0.003	3	1
							0.002	0.003	0.001	0.004	4	0
								0.001	-0.001	0.002	2	1
									-0.002	0.001	1	1
										0.003	1	0
										Totals	68	220
											S= -152	

Mann-Kendall Test
Trend Analysis for Station C2

Ho= No Trend
Ha= Downward Trend

Conf. Level 95.0%
alpha= 0.05

Tied Groups

Value	Freq. of Occurrence	
0.02	2	= t1
<0.02	4	= t2
0.009	5	= t3
0.007	2	= t4

S=	-78	Maximum	0.03
VAR[S]=	562	Minimum	0.005
Z=	-3.25	N =	17
Abs. Z=	3.25		|Z| > 0.6826
Z 1-a/2	0.6826		Ho is rejected

Total P	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Sum	Sum
(mg/L)	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.01	0.007	0.009	0.005	0.009	0.009	0.009	0.009	0.007	0.008	Positives	Negatives
		0.01	-0.01	-0.01	-0.01	-0.01	0	-0.01	-0.013	-0.011	-0.015	-0.011	-0.011	-0.011	-0.011	-0.013	-0.012	1	14
			-0.02	-0.02	-0.02	-0.02	-0.01	-0.02	-0.023	-0.021	-0.025	-0.021	-0.021	-0.021	-0.021	-0.023	-0.022	0	15
				0	0	0	0.01	0	-0.003	-0.001	-0.005	-0.001	-0.001	-0.001	-0.001	-0.003	-0.002	1	9
					0	0	0.01	0	-0.003	-0.001	-0.005	-0.001	-0.001	-0.001	-0.001	-0.003	-0.002	1	9
						0	0.01	0	-0.003	-0.001	-0.005	-0.001	-0.001	-0.001	-0.001	-0.003	-0.002	1	9
							0.01	0	-0.003	-0.001	-0.005	-0.001	-0.001	-0.001	-0.001	-0.003	-0.002	1	9
								-0.01	-0.013	-0.011	-0.015	-0.011	-0.011	-0.011	-0.011	-0.013	-0.012	0	10
									-0.003	-0.001	-0.005	-0.001	-0.001	-0.001	-0.001	-0.003	-0.002	0	9
										0.002	-0.002	0.002	0.002	0.002	0.002	0	0.001	6	1
											-0.004	0	0	0	0	-0.002	-0.001	0	3
												0.004	0.004	0.004	0.004	0.002	0.003	6	0
													0	0	0	-0.002	-0.001	0	2
														0	0	-0.002	-0.001	0	2
															0	-0.002	-0.001	0	2
																-0.002	-0.001	0	2
																	0.001	1	0
																	Totals	18	96

S= -78

Mann-Kendall Test
Trend Analysis for Station C4

Ho= No Trend
Ha= Downward Trend

Conf. Level 95.0%
alpha= 0.05

Tied Groups

Value	Freq. of Occurrence	
0.06	3	= t1
0.04	6	= t2
0.021	2	= t3

S=	-94	Maximum	0.91
VAR[S]=	784	Minimum	0.02
Z=	-3.32	N =	19
Abs. Z=	3.32	|Z| > 0.6826	
Z 1-a/2	0.6826	Ho is rejected	

Total P	01-Aug-74	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87	13-Mar-89	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94
(mg/L)	0.91	0.58	0.37	0.20	0.06	0.04	0.02	0.11	0.22	0.06	0.03	0.04	0.021	0.063	0.027
		-0.33	-0.54	-0.71	-0.85	-0.87	-0.89	-0.8	-0.69	-0.85	-0.88	-0.87	-0.889	-0.847	-0.883
			-0.21	-0.38	-0.52	-0.54	-0.56	-0.47	-0.36	-0.52	-0.55	-0.54	-0.559	-0.517	-0.553
				-0.17	-0.31	-0.33	-0.35	-0.26	-0.15	-0.31	-0.34	-0.33	-0.349	-0.307	-0.343
					-0.14	-0.16	-0.18	-0.09	0.02	-0.14	-0.17	-0.16	-0.179	-0.137	-0.173
						-0.02	-0.04	0.05	0.16	0	-0.03	-0.02	-0.039	0.003	-0.033
							-0.02	0.07	0.18	0.02	-0.01	0	-0.019	0.023	-0.013
								0.09	0.2	0.04	0.01	0.02	0.001	0.043	0.007
									0.11	-0.05	-0.08	-0.07	-0.089	-0.047	-0.083
										-0.16	-0.19	-0.18	-0.199	-0.157	-0.193
											-0.03	-0.02	-0.039	0.003	-0.033
												0.01	-0.009	0.033	-0.003
													-0.019	0.023	-0.013
														0.042	0.006
															-0.036

21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Sum Positives	Sum Negatives
0.034	0.037	0.031	0.021		
-0.876	-0.873	-0.879	-0.889	0	18
-0.546	-0.543	-0.549	-0.559	0	17
-0.336	-0.333	-0.339	-0.349	0	16
-0.166	-0.163	-0.169	-0.179	1	14
-0.026	-0.023	-0.029	-0.039	3	10
-0.006	-0.003	-0.009	-0.019	4	8
0.014	0.017	0.011	0.001	12	0
-0.076	-0.073	-0.079	-0.089	1	10
-0.186	-0.183	-0.189	-0.199	0	10
-0.026	-0.023	-0.029	-0.039	1	8
0.004	0.007	0.001	-0.009	5	3
-0.006	-0.003	-0.009	-0.019	1	6
0.013	0.016	0.01	0	5	0
-0.029	-0.026	-0.032	-0.042	0	5
0.007	0.01	0.004	-0.006	3	1
	0.003	-0.003	-0.013	1	2
		-0.006	-0.016	0	2
			-0.01	0	1
			Totals	37	131
			S= -94		

Mann-Kendall Test
Trend Analysis for Station C5

Ho= No Trend
Ha= Downward Trend

Conf. Level 95.0%
alpha= 0.05

Tied Groups

Value	Freq. of Occurrence	
0.14	2	= t1
0.11	2	= t2
0.08	2	= t3
0.06	2	= t4
0.03	2	= t5

S= -229
VAR[S]= 2053
Z= -5.03
Abs. Z= 5.03
Z 1-a/2 0.6826

Maximum 0.14
Minimum 0.011
N = 26

|Z| > 0.6826
Ho is rejected

Total P	07-Nov-76	19-Aug-77	17-Oct-77	09-Mar-78	03-Mar-78	27-Jul-78	29-Mar-79	15-May-79	03-Nov-81	08-Nov-82	16-Aug-83	17-Apr-84	20-Mar-85	04-Mar-86	28-Oct-87
(mg/L)	0.10	0.13	0.14	0.11	0.14	0.08	0.06	0.07	0.11	0.12	0.06	0.08	0.03	0.04	0.05
		0.03	0.04	0.01	0.04	-0.02	-0.04	-0.03	0.01	0.02	-0.04	-0.02	-0.07	-0.06	-0.05
			0.01	-0.02	0.01	-0.05	-0.07	-0.06	-0.02	-0.01	-0.07	-0.05	-0.1	-0.09	-0.08
				-0.03	0	-0.06	-0.08	-0.07	-0.03	-0.02	-0.08	-0.06	-0.11	-0.1	-0.09
					0.03	-0.03	-0.05	-0.04	0	0.01	-0.05	-0.03	-0.08	-0.07	-0.06
						-0.06	-0.08	-0.07	-0.03	-0.02	-0.08	-0.06	-0.11	-0.1	-0.09
							-0.02	-0.01	0.03	0.04	-0.02	0	-0.05	-0.04	-0.03
								0.01	0.05	0.06	0	0.02	-0.03	-0.02	-0.01
									0.04	0.05	-0.01	0.01	-0.04	-0.03	-0.02
										0.01	-0.05	-0.03	-0.08	-0.07	-0.06
											-0.06	-0.04	-0.09	-0.08	-0.07
												0.02	-0.03	-0.02	-0.01
													-0.05	-0.04	-0.03
														0.01	0.02
															0.01

13-Mar-89	09-May-89	27-May-92	24-Jun-92	14-Jul-92	11-Aug-92	17-May-94	21-Jun-94	19-Jul-94	16-Aug-94	20-Sep-94	Sum Positives	Sum Negatives
0.03	0.02	0.016	0.023	0.019	0.021	0.011	0.013	0.018	0.017	0.023		
-0.07	-0.08	-0.084	-0.077	-0.081	-0.079	-0.089	-0.087	-0.082	-0.083	-0.077	6	19
-0.1	-0.11	-0.114	-0.107	-0.111	-0.109	-0.119	-0.117	-0.112	-0.113	-0.107	2	22
-0.11	-0.12	-0.124	-0.117	-0.121	-0.119	-0.129	-0.127	-0.122	-0.123	-0.117	0	22
-0.08	-0.09	-0.094	-0.087	-0.091	-0.089	-0.099	-0.097	-0.092	-0.093	-0.087	2	19
-0.11	-0.12	-0.124	-0.117	-0.121	-0.119	-0.129	-0.127	-0.122	-0.123	-0.117	0	21
-0.05	-0.06	-0.064	-0.057	-0.061	-0.059	-0.069	-0.067	-0.062	-0.063	-0.057	2	17
-0.03	-0.04	-0.044	-0.037	-0.041	-0.039	-0.049	-0.047	-0.042	-0.043	-0.037	4	14
-0.04	-0.05	-0.054	-0.047	-0.051	-0.049	-0.059	-0.057	-0.052	-0.053	-0.047	3	15
-0.08	-0.09	-0.094	-0.087	-0.091	-0.089	-0.099	-0.097	-0.092	-0.093	-0.087	1	16
-0.09	-0.1	-0.104	-0.097	-0.101	-0.099	-0.109	-0.107	-0.102	-0.103	-0.097	0	16
-0.03	-0.04	-0.044	-0.037	-0.041	-0.039	-0.049	-0.047	-0.042	-0.043	-0.037	1	14
-0.05	-0.06	-0.064	-0.057	-0.061	-0.059	-0.069	-0.067	-0.062	-0.063	-0.057	0	14
0	-0.01	-0.014	-0.007	-0.011	-0.009	-0.019	-0.017	-0.012	-0.013	-0.007	2	10
-0.01	-0.02	-0.024	-0.017	-0.021	-0.019	-0.029	-0.027	-0.022	-0.023	-0.017	1	11
-0.02	-0.03	-0.034	-0.027	-0.031	-0.029	-0.039	-0.037	-0.032	-0.033	-0.027	0	11
	-0.01	-0.014	-0.007	-0.011	-0.009	-0.019	-0.017	-0.012	-0.013	-0.007	0	10
		-0.004	0.003	-0.001	0.001	-0.009	-0.007	-0.002	-0.003	0.003	3	6
			0.007	0.003	0.005	-0.005	-0.003	0.002	0.001	0.007	6	2
				-0.004	-0.002	-0.012	-0.01	-0.005	-0.006	0	0	6
					0.002	-0.008	-0.006	-0.001	-0.002	0.004	2	4
						-0.01	-0.008	-0.003	-0.004	0.002	1	4
							0.002	0.007	0.006	0.012	4	0
								0.005	0.004	0.01	3	0
									-0.001	0.005	1	1
										0.006	1	0
										Totals	45	274

S= -229