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# Lake Water Nutrient Chemistry and Chlorophyll *a* in Pasqua, Echo, Mission, Katepwa, Crooked and Round Lakes on the Qu'Appelle River, Saskatchewan

R.J. Allan and M. Roy



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NATIONAL WATER RESEARCH INSTITUTE  
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## Abstract

Between June 1977 and June 1978, the National Water Research Institute, Western and Northern Region, conducted a systematic water sampling and analysis program of the hypertrophic Fishing Lakes (Pasqua, Echo, Mission and Katepwa), Crooked and Round lakes (hereafter referred to as the Qu'Appelle Valley lakes), in the Qu'Appelle River basin of the central Prairies. Lake water vertical, horizontal and downstream variations in different chemical parameters and phytoplankton algal biomass (chlorophyll *a*) were determined during one complete annual cycle. Lake profiling of these shallow, hypertrophic lakes provides basic information required for understanding a variety of limnological processes, such as lake water nutrient-phytoplankton biomass interactions, sediment-water nutrient interactions, oxygen depletion rates, under-ice nutrient regeneration and lake water mixing. The first objective was to provide a systematic data base of value in resolving the extent of such key processes. A plant to remove phosphorus from Regina sewage was operating at high efficiency by January 1977. The sampling was initiated in June 1977, with the objective of providing a year of systematic data after the plant had come on-stream. If the same sampling program were carried out in a future year of identical hydrodynamic conditions, an analysis of the effect of phosphorus loading reductions on lake chemistry and phytoplankton biomass might be made.

## Résumé

Entre juin 1977 et 1978, l'Institut national de recherche sur les eaux, région de l'Ouest et du Nord, a dirigé un programme systématique d'échantillonnage et d'analyse des eaux en voie d'eutrophisation, soit les lacs Fishing (Pasqua, Echo, Mission et Katepwa), Crooked et Round du bassin de la rivière Qu'Appelle dans les Prairies centrales. Divers paramètres chimiques indicateurs de variations verticales, horizontales et de la qualité des eaux à des points de prélèvement en aval, ainsi que la biomasse de phytoplancton (chlorophylle *a*) ont été déterminés pendant un cycle annuel complet. Les profils lacustres fournissent les données de base nécessaires pour comprendre plusieurs processus limnologiques observés dans de tels lacs, y compris les interactions entre les substances nutritives et la biomasse phytoplanctonique, les interactions entre les sédiments et les substances nutritives, les taux de déperdition d'oxygène, la régénération des substances nutritives sous la glace et le mélange des eaux de ces lacs eutrophes peu profonds des Prairies. Le premier objectif était d'établir une base systématique de données valables afin de déterminer l'étendue de ces processus clés. Dès janvier 1977, une usine destinée à éliminer le phosphore des eaux usées de Régina fonctionnait très efficacement. L'échantillonnage scientifique, entrepris en juin 1977, avait pour but de recueillir des données systématiques pendant la première année d'exploitation de l'usine. À une date ultérieure, le même programme d'échantillonnage effectué au cours d'une année où les conditions hydrodynamiques sont similaires permettrait de déterminer l'effet de la réduction de la charge de phosphore sur les processus chimiques des lacs et la biomasse phytoplanctonique.

# Lake Water Nutrient Chemistry and Chlorophyll a in Pasqua, Echo, Mission, Katepwa, Crooked and Round Lakes on the Qu'Appelle River, Saskatchewan

R.J. Allan and M. Roy

## INTRODUCTION

The Fishing Lakes (Pasqua, Echo, Mission and Katepwa) are part of a recreation corridor in southern Saskatchewan (Fig. 1). They serve the population centres of Regina, Moose Jaw, Saskatoon and Yorkton. Expenditures by the federal-provincial Qu'Appelle River Basin Implementation Board are aimed at improving the valley as a tourist and recreational area. The development plan for the Fishing Lakes area will improve the area aesthetically. The full potential of this unique Prairie setting, however, may not be realized if the public continues to associate the Fishing Lakes with blue-green algal scums during late July and early August, the peak recreational period. The Qu'Appelle Implementation Board has recognized this, and considerable sums are being expended to reduce phosphorus input to the lakes, a procedure expected to prevent worsening of algal biomass problems. Schemes include tertiary phosphorus removal from Regina sewage, tertiary sewage treatment at Moose Jaw, measures to reduce agricultural nutrient runoff and, recently, a proposal for phosphorus removal from effluents of small local communities such as Fort Qu'Appelle.

Early scientific publications on Prairie lakes deal mainly with general limnology. In particular, Rawson and Moore (1944) and Hammer (1964, 1970, 1972) of the University of Saskatchewan have made major contributions to the data base. More recently, Barica (1975) greatly expanded understanding of limnological processes in eutrophic Prairie sloughs. A review of the general limnology of Prairie lakes is forthcoming (Barica, 1979). This general data base on Prairie lakes is, however, much less than that which exists, for example, for the Laurentian Great Lakes, the Wisconsin lakes near Madison or the Alpine lakes of Europe, where much of the Western world's predictive limnology has been concentrated and developed.

The detailed, systematic, multi-parameter sampling required to construct predictive nutrient-loading/productivity models of the type developed elsewhere by Vollenweider (1968, 1975, 1976), Dillon and Rigler (1974),

Schindler (1977), Lee *et al.* (1978) and others has not been carried out for Prairie lakes. Nevertheless, the National Water Research Institute has recently applied to Prairie lakes the existing predictive models relating lake phytoplankton biomass to nutrient concentrations and loadings (Allen and Kenney, 1978; Cross, 1978). These models were developed for systems outside the Prairie region and have had to be applied to an insufficient Prairie lake data base, collected largely for purposes other than research. These pre-1977 nutrient/chlorophyll *a* data were accumulated since 1970 by the Water Pollution Control Branch, Saskatchewan Department of the Environment, and the Water Quality Branch, Environment Canada. Further interpretation and modelling will require several more years of data collection. There is a need for several years of systematic data gathering because of the extreme natural variations in annual nutrient loading in the Prairie hydrodynamic system.

The National Water Research Institute, Western and Northern Region (N.W.R.I.-W.N.R.) has initiated several other studies on the Qu'Appelle Valley lakes. A sediment-phosphorus form analysis program was aimed at understanding internal loading and estimating changes in historical loading of phosphorus (Allan and Williams, 1978; Allan *et al.*, 1980). In 1976, N.W.R.I.-W.N.R. initiated a program of benthic fauna identification in the Fishing Lakes, Crooked and Round Lakes. Sampling has continued on a reduced basis in 1977, 1978 and 1979. Analysis of these data reveals the extreme trophic level reached by these lakes (Warwick, 1979a). In addition, benthic samples collected over the last three decades have been provided by the Saskatchewan Department of Fisheries and are being analyzed to reveal recent trends. In 1979, N.W.R.I.-W.N.R. initiated a complex, detailed paleolimnology-paleoecology program for Pasqua Lake (Warwick, 1979b). A contract let by N.W.R.I.-W.N.R. to the Saskatchewan Research Council resulted in a report on local, cottage and groundwater phosphorus inputs to the Fishing Lakes (Lakshman, 1979). A very preliminary assessment of bacterial biomass in the Fishing Lakes, Crooked and Round lakes was carried out by N.W.R.I.-Burlington (Dutka, 1977).

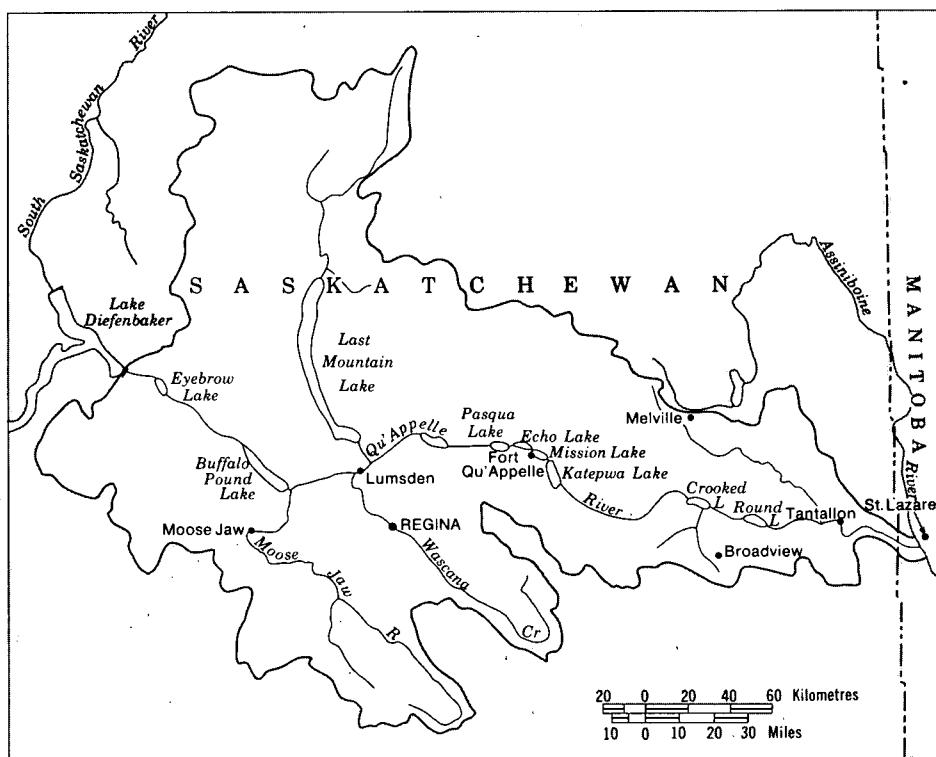


Figure 1. Qu'Appelle River basin.

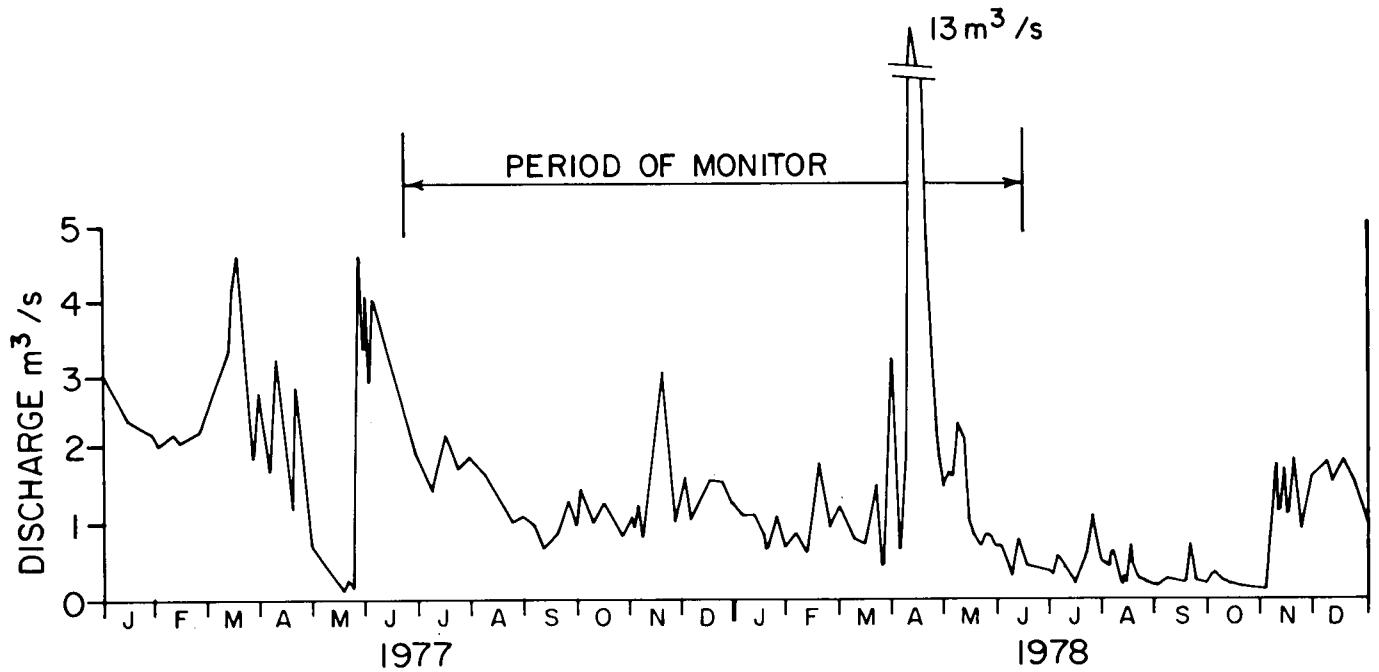


Figure 2. Hydrodynamic conditions during the sampling period; data for the Qu'Appelle River below Loon Creek, above Pasqua Lake inlet.

The objectives of the one-year systematic lake nutrient and algal biomass (chlorophyll *a*) profiling of the six lakes were to provide:

- (1) a systematic data base of value in resolving the extent of key limnological processes in shallow, hypertrophic lakes, including lake water nutrient-phytoplankton biomass interactions and cycles; sediment-water nutrient interactions; oxygen depletion rates; under-ice nutrient regeneration and lake water mixing and
- (2) a one-year systematic sampling, after 95% efficient phosphorus removal from Regina's effluents had been initiated, for comparison at some future date with the results for a year with identical hydrodynamic characteristics (Fig. 2). The aim would be to compare mean annual and mean summer total phosphorus, spring total phosphorus and chlorophyll *a* of the two sampling periods and thus assess the effects of phosphorus reduction schemes on chlorophyll *a*.

## METHODS

### Sample Collection

A 1300-km round trip was made biweekly or monthly by road from Winnipeg. Samples were collected at designated stations (Fig. 3) in a Van Dorn 2-L water sampler.

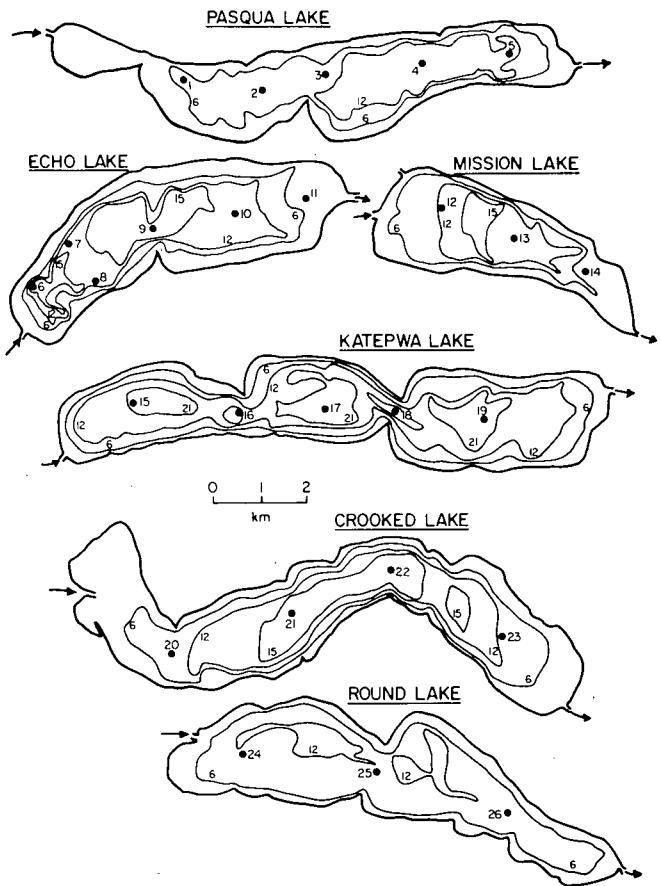


Figure 3. Location of lake water profile sites.

### *Sample Preservation*

Following collection, the samples were immediately placed in coolers. Magnesium carbonate suspension (0.1 to 0.2 mL) was added to the chlorophyll samples on collection. Samples were taken to a field laboratory established at the Fish Culture Station on Echo Lake, from June to September 1977, and to the Water Quality Branch Laboratory in Regina, from November 1977 to June 1978. Water samples and particulate nitrogen filters were shipped by Air Express on the night of collection to the Water Quality Branch Laboratory in Calgary. The chlorophyll *a* filters were frozen and shipped frozen the next day. Ice packs were placed along with the chlorophyll *a* petri dishes in a cooler. Early problems in synchronizing air shipments and pickups in Calgary were quickly resolved and none of the data are considered suspect on the basis of time between collection and analysis.

### *Analytical Methods*

Temperature, conductivity, pH and dissolved oxygen were measured in the field. A Hydrolab Surveyor model 6D was used from June until September 1977. From November 1977 until June 1978, temperature and conductivity were measured by YSI model 54, pH by Accumet Portable pH meter, and dissolved oxygen by the Winkler method.

Nutrient parameters and chlorophyll *a* were determined by the standard procedures of the Water Quality Branch. For the particulate nitrogen and chlorophyll *a* analyses, specially prepared filters were used prior to each sample collection period. The parameters measured were total phosphorus (TP), soluble reactive phosphorus (SRP), particulate nitrogen (part.-N), total dissolved nitrogen (TDN), nitrate-nitrite nitrogen ( $\text{NO}_3 + \text{NO}_2\text{-N}$ ), ammonia ( $\text{NH}_3\text{-N}$ ) and chlorophyll *a* (chloro. *a*). For details, the reader should consult the NAQUADAT Dictionary (Environment Canada, 1979). Brief summaries of analytical procedures follow.

For TP, the sample is manually digested with a sulphuric acid-persulphate mixture. Phosphorus in solution is then determined colorimetrically by the molybdenum blue method (NAQUADAT No. 15406). For SRP there is no digestion. The original sample is analyzed by the molybdenum blue method for phosphate (NAQUADAT No. 15256). For particulate nitrogen, the sample is filtered immediately on collection through a pre-ignited Whatman GF/C filter. The residue is analyzed using a Hewlett-Packard model 185 CHN Analyzer (NAQUADAT No. 07902). For TDN, the sample is analyzed by ultraviolet (UV) digestion, followed by colorimetric analysis on an

AutoAnalyzer (NAQUADAT No. 07651). Nitrate-nitrite nitrogen is also determined by AutoAnalyzer using an azo dye after the sample has passed through a column of Cu-Cd filings (NAQUADAT No. 07110). Ammonia is determined using a specific ion meter (NAQUADAT No. 07506). For chlorophyll *a* analyses, the filtered residues are extracted with acetone for spectrophotometric determinations at specified wavelengths. The chlorophyll *a* values are calculated by SCOR/UNESCO equations (NAQUADAT No. 06711).

Because of the distance between the sampling sites (Regina area) and the laboratory (Calgary) and because the analyses had to be integrated into the regular work load of the Water Quality Laboratories, time between collection and analysis varied. Samples were not filtered for SRP in the field but immediately on arrival in Calgary. Recent results (V. Chacko, personal communication) for samples of Red River water stored unfiltered for up to 21 days before analysis indicate that there is little significant difference in SRP over this time period. Thus, the data presented here for SRP are probably valid but should be viewed with some caution. Samples were filtered in the field for particulate nitrogen. Analyses for  $\text{NH}_3\text{-N}$  in Calgary are probably not affected by shipment time because of the generally high concentrations.

Initial difficulty was encountered with chlorophyll *a* analysis. The values appeared to be too low for predicted results. Some samples were stored frozen for considerable periods of time before they could be analyzed in Calgary and decomposition of chlorophyll *a* to pheophytin was considered possible. An appropriate recalculation showed that this was not a problem. A check of the photometric accuracy of the spectrometer using calibrated filters revealed a fault in the absorbance range selector switch which had led to a 50% reduction in readout above a certain point. Only the highest values were affected. A correction was applied and the results obtained are those presented here. Although the mean values are still less than would be predicted by existing models, the results are considered to be correct in terms of the sample density and analytical methodology used.

### *Isopleth Diagrams*

To construct the annual isopleth diagrams for each lake for each parameter, the data value at each point was calculated as follows. On a certain date, e.g. August 2, 1977, for a particular parameter, e.g. conductivity, there could be up to five readings for a depth of 0.5 m. These five readings were added and averaged to produce a single reading for that particular depth on that date. If there

was only one reading at a certain depth, it was used on the profile. Thus, a single reading at each depth for each sampling period was obtained.

## RESULTS AND DISCUSSION

This report presents the complete data base collected from June 1977 to June 1978. Other agencies operating in the Qu'Appelle River basin will be able to use these data if more detailed or more extensive monitoring programs are planned. In some cases, the results for the six lakes are repetitive and only an example would be required in a journal publication. In other cases, there are subtle differences between the six lakes that show that each is a different and complicated limnological system. The aim of the following discussion is to highlight the features of the data base that help to resolve some of the questions relating to limnological processes operating in hypertrophic lakes and that provide some insight into possible changes in the lakes following phosphorus loading reductions.

The raw data are presented in the Appendix (Tables A-1 to A-12). Isopleth diagrams have been constructed to show annual variations in the parameters measured (Figs. 4 to 16). These depth-time diagrams are particularly useful in limnology because they aggregate hundreds of data points taken at different depths and times into an annual picture that indicates the seasonal dynamics of the physical, chemical and biological properties of the lake. In spite of the large numbers of samples collected over the years in the Qu'Appelle River system, these are the first diagrams of this type published on these lakes. Dissolved oxygen variations in the six lakes are also presented in diagram form (Figs. 17 to 22). A final set of diagrams compares chlorophyll *a*, particulate nitrogen, dissolved oxygen, ammonia and soluble reactive phosphorus at specific stations (Fig. 3) within each lake (Figs. 23 to 30). It must be clearly understood that the following discussion, although perhaps generally applicable, only applies specifically to the monitoring period.

### Temperature

During spring (May and June), water temperatures in all of the lakes rose rapidly, usually exceeding 18°C by late June (Fig. 4). Although the lakes showed an initial tendency to begin stratification, this was only achieved, and at an incipient stage, during July in Katepwa, the deepest lake. The other five shallower lakes were continually mixed during the summer period. Maximum summer temperatures exceeded 21°C in Round Lake, the shallowest

lake. Manpower problems prevented sample collection in September and October. Thus the autumn cooling rates of the lakes are interpolated for these months, as is the case for the other parameters discussed below. During the winter, inverse stratification is set up. The lakes mix in spring and fall and are inversely stratified under-ice. They fall into the large but unclassified group of shallow, non-summer stratified, northern temperate region lakes.

### Dissolved Oxygen

The dissolved oxygen (D.O.) isopleths show that the lakes do not mix in the spring in terms of this parameter and that low dissolved oxygen levels formed under the winter ice extend into the summer months (Fig. 5). During the open water period the surface water of all the lakes is oxygen saturated or supersaturated. The temporary, late winter-early summer dissolved oxygen meromixis (<4 mg/L D.O.) existed in all of the lakes except Round, the shallowest. In Katepwa, which partially thermally stratified, the D.O. values of <4 mg/L persisted until fall overturn. In Pasqua, Echo, Mission and Crooked lakes (Figs. 17, 18, 19 and 21, respectively), the effect occurred until late July and early August. Dissolved oxygen of <4 mg/L was not found in Round Lake (Fig. 22), and surprisingly, because Round is the shallowest lake, D.O. was also high throughout the winter months. It would appear that organic decomposition during the winter months was sufficient to reduce dissolved oxygen concentrations to <4 mg/L in all of the lakes except Round. During the spring and early summer, thermal mixing (Fig. 4) was apparently insufficient to overwhelm the effect of dissolved oxygen reduction by bacterial activity at the sediment-water interface or layer of deepest water. The argument that this D.O. stratification was temporary during the open water period and coincided with calm periods is not valid because no significant temperature stratification was recorded. This situation may not, however, occur every year. Although it was the case in both 1977 and 1978, both years had minimal spring runoff (Fig. 2). In 1978, the spring peak discharge of 13 m<sup>3</sup>/s was more than an order of magnitude less than the peak value of 163 m<sup>3</sup>/s recorded in the 1974 flood year.

### Conductivity

Conductivity is the highest in the fall and declines to a minimum in midwinter. Fall values increase with water depth and may be partly related to decomposition of sedimenting organic material or groundwater inflow. The high late summer values could be related partially to evaporation. Conductivity values for June 1977 were

higher than those of June 1978 in Echo, Katepwa and Round lakes and may be partly related to dilution by spring runoff. Spring snowmelt flushing of salts from reservoirs on Prairie streams has been described elsewhere (Allan and Richards, 1978). By the same analogy, some of the increase in conductivity during the summer may be related to greater loading owing to increased salt concentrations during summer in Prairie streams. Were it not for such effects, a summer decline in conductivity might be expected in such productive lakes. The high conductivities in these lakes, the slightly higher conductivities of the deeper waters of these lakes, and the lower dissolved oxygen concentrations which extend through the spring thermal mixing before being displaced in the late summer (Figs. 17 to 21) may be taken to imply an incipient type of lake meromixis.

#### pH

The pH of all of the lakes was high throughout the year (Fig. 7). The pH changes generally correspond to changes in conductivity. Lower pH values in the deeper water in late winter (Fig. 7) are associated with bacterial decomposition of organics and related lower dissolved oxygen levels and regeneration of nutrients. The maximum surface water pH values in the summer period are related to photosynthesis and associated reductions in  $\text{CO}_2$  content. The highest midsummer values of greater than pH 9 occurred in Round Lake (Fig. 7).

#### Total Phosphorus

Mean annual and post-spring total phosphorus concentrations and total phosphorus loadings to the Qu'Appelle Valley lakes are all excessive (Allan and Kenney, 1978; Cross, 1978). In terms of total phosphorus concentrations, the lakes are hypertrophic and possibly have the highest values recorded for temperate zone lakes of similar dimensions. The highest values of total phosphorus are in midsummer (Fig. 8), and the maximum value recorded in 1977-1978 was  $5200 \text{ mg/m}^3$  in Pasqua Lake. Values decline in the fall. Under winter-ice conditions there is regeneration of phosphorus, apparently from the bottom sediments. Concentrations rise to over  $750 \text{ mg/m}^3$  deep in Echo Lake (Fig. 8) in contrast with immediate under-ice concentrations of  $400 \text{ mg/m}^3$ . During the late winter of 1979, even more extreme conditions of up to  $1300 \text{ mg/m}^3$  TP were recorded in the deepest water of Pasqua Lake (Warwick, 1979b). The high deep-water concentrations were apparently not affected by spring thermal mixing in 1977 and 1978 and were carried over, as were the lower D.O. values, to midsummer and late summer.

This late winter internal release of phosphorus has significant implications in terms of (1) summer algal production following late summer mixing and (2) time of recovery of the lake following reduction of external phosphorus loads. The effect was seen in all of the lakes that had bottom water D.O. values of  $<4 \text{ mg/L}$ . The exception was Round Lake.

For the period 1970 to 1976, mean  $\pm 1$  standard deviation (S.D.) total phosphorus concentrations in Pasqua, Echo, Mission, Katepwa, Round and Crooked lakes were  $647 \pm 372$  ( $n = 369$ ),  $556 \pm 206$  ( $n = 279$ ),  $516 \pm 196$  ( $n = 156$ ),  $531 \pm 270$  ( $n = 281$ ),  $275 \pm 172$  ( $n = 172$ ) and  $235 \pm 161$  ( $n = 101$ )  $\text{mg/m}^3$ , respectively.<sup>1</sup> For 1977 and 1978, the earliest open water sampling gave values of 573, 460 (393 in 1978), 531, 383 (547 in 1978), 439 and 295 (321 in 1978)  $\text{mg/m}^3$  TP, respectively, for these six lakes. There are, of course, distinct and significant differences between mid-July, midwinter, surface and bottom total phosphorus concentrations (Fig. 8). As seen with changes in conductivity, spring runoff in 1977 and 1978 primarily diluted lake water phosphorus concentrations. The very small 1978 runoff which occurred in late April may also have been responsible for the reduction of under-ice TP values of over  $400 \text{ mg/m}^3$  to  $370 \text{ mg/m}^3$  in Echo Lake (Fig. 8). The base spring (late winter) value of TP in the four Fishing Lakes in 1977 and 1978 was 400 to  $500 \text{ mg/m}^3$ . The corresponding value for Round Lake and possibly also Crooked Lake could be 300 to  $400 \text{ mg/m}^3$ , based on the limited data of these two years.

Phosphorus loading reduction has been implemented in the Qu'Appelle River basin. Chemical tertiary removal of phosphorus at Regina and proposed effluent-irrigation at Moose Jaw, redesign of feedlots and other schemes are aimed at phosphorus loading reductions. These reductions are expected to reduce phosphorus concentrations in the Fishing Lakes, which in turn, it is hoped, will reduce mean summer algal (phytoplankton) biomass in the lakes or cause species shifts away from blue-green algae. Nutrient-productivity relations are described later in the discussion of chlorophyll *a*. In terms of changes in phosphorus concentrations, it can be seen that in Echo

<sup>1</sup> Mean total phosphorus, nitrogen, chlorophyll *a* and annual discharge and their standard deviations were calculated by Dr. R.A. Vollenweider, N.W.R.I., Burlington, from the raw data in a report by Cross (1978), for inclusion in an Organization for Economic Cooperation and Development (OECD) report on Eutrophication of Canadian Lakes. Cross had extracted and summarized data from files of the Water Pollution Control Branch, Saskatchewan Department of the Environment, and from those of the Water Quality and Water Survey of Canada Branches of the Inland Waters Directorate, Environment Canada.

Lake (Fig. 8), for example, in June 1977 surface water total phosphorus levels were  $450 \text{ mg/m}^3$  and in June 1978,  $372 \text{ mg/m}^3$ . Note, however, that the deeper water in June 1977 had  $580 \text{ mg/m}^3$  TP, and in 1978, the value at the same depth was over  $800 \text{ mg/m}^3$ . Presumably, when mixing of this lower layer took place in the summer of 1978, the surface Echo Lake TP value would have increased.

Flushing action is a major factor to be considered in predicting summer total phosphorus concentrations in these lakes. In 1977, there was no real spring flush or runoff. Two maximum discharge events in March and early June were only  $5 \text{ m}^3/\text{s}$  maximum (Fig. 2). The 1978 spring runoff peak was  $13 \text{ m}^3/\text{s}$ . The 1974 flood spring discharge was  $163 \text{ m}^3/\text{s}$ . The effects of spring flushing events are critical to interpretation of phosphorus concentrations and effective phosphorus loading to the contiguous four-lake Fishing Lake chain (Allan and Kenney, 1978). A large spring runoff, such as that which occurred in 1974, exceeds the volume of water in all four lakes, whereas a small spring runoff may simply shift water out of Pasqua Lake into Echo and on to the others in a domino effect. Because of mixing processes the true residence time is difficult to calculate, but it is likely that more than one and possibly up to five lake volumes of river water are required to flush any one lake (B.C. Kenney, N.W.R.I.—W.N.R., personal communication). In lower flow years, the river water may not mix with the deeper oxygen deficient and salt- and nutrient-enriched water in the lakes. A considerable discharge may be necessary to break up the winter stratification. Neither of the 1977 and 1978 runoffs appeared to do this (Figs. 5, 17, 18, 19, 20). In terms of predicting the final early summer total phosphorus concentrations and thus summer phytoplankton biomass, the critical parameters are: the degree of under-ice phosphorus regeneration; the size and efficiency of the spring runoff to replace the first ( $115 \times 10^6 \text{ m}^3$ ) lake volume, first and second ( $229 \times 10^6 \text{ m}^3$ ), first three ( $295 \times 10^6 \text{ m}^3$ ) or all four of the contiguous lakes ( $522 \times 10^6 \text{ m}^3$ ); and the relative pre-runoff lake and runoff river phosphorus concentrations. It is extremely important to remember that in flood years, these four contiguous lakes virtually represent four basins of one large lake.

The total discharge to Pasqua Lake in 1970 was equal to 100% of its volume plus 100% of the volume of Echo Lake, 100% of the volume of Mission Lake and 4% of the volume of Katepwa Lake. In 1971, it was equal to 100% of Pasqua Lake plus 94% of the volume of Echo Lake. In 1972, it was equal to 100% of Pasqua Lake plus 2% of the volume of Echo Lake. In 1973, it was equal to 62% of Pasqua Lake. In 1974, it was equal to 100% of Pasqua Lake plus 100% of the volumes of Echo, Mission and Katepwa

lakes plus an excess of 25% of the total volume of the four lakes combined. In 1975, it was equal to 100% of Pasqua Lake plus 100% of the volumes of Echo and Mission lakes plus 78% of the volume of Katepwa Lake. In 1976, it was equal to 100% of Pasqua Lake plus 100% of the volumes of Echo, Mission and Katepwa lakes plus an excess of 17% of the total volume of the four lakes combined. On this basis, disregarding the complications of mixing and density layering, all four lakes would only have been flushed in 1974 and 1976 during the seventies. During other years, the effect would have been to exchange the water of the upper lakes (mainly Pasqua and Echo) with river water while transmitting Pasqua and Echo Lake water downstream to the lower lakes. In low flow years, winter regeneration of phosphorus has a significant effect on summer total phosphorus. In high spring runoff years (1974, 1975, 1976), total phosphorus in the chain of four lakes is more truly controlled by upstream loadings from the Qu'Appelle River. In medium runoff years, the progressive downstream domino effect will determine which lakes begin the summer with the highest phosphorus concentrations.

The mean flow of  $2 \text{ m}^3/\text{s}$  between late February and late July 1977 amounted to 22% of the volume of only Pasqua Lake. In 1978, the peak runoff (there was a distinct spring peak of  $13 \text{ m}^3/\text{s}$ ) was equal to  $1 \times 10^6 \text{ m}^3/\text{day}$  or less than 1% of the volume of Pasqua. The mean peak runoff of 1978, about 1.5 months, was sufficient to replace only 11% of the volume of Pasqua Lake alone. In essence, during both 1977 and 1978, the spring runoff period only served to shift Pasqua Lake water of high phosphorus content farther downstream into Echo and thus into Mission Lake. In the flood year of 1974, a volume of water equal to ten times the volume of Mission Lake was discharged to Katepwa Lake. In terms of Mission Lake flushing, however, 35% of this water could have originated in Pasqua and Echo lakes. At the other extreme, in the 1977 drought year, the spring runoff would only have transferred 22% of "Pasqua"<sup>2</sup> water to Echo Lake and 22% of "Echo"<sup>2</sup> water to Mission Lake.

Because of differing degrees of under-ice internal nutrient regeneration and the complexities of hydrodynamics upstream and in the contiguous Fishing Lakes, it is clear that (1) only comparison of long-term means is valid for assessing trends in TP concentrations in these lakes and (2) each year is unique for each lake in terms of

<sup>2</sup> The water transferred would have consisted of a mixture of Qu'Appelle River and Pasqua Lake water, depending on the particular mixing processes, chemocline stability and other unquantified parameters of each spring.

eventual early summer total lake water phosphorus and thus possibly summer algal biomass production.

### *Soluble Reactive Phosphorus*

Soluble reactive phosphorus concentrations are extreme throughout the year (Fig. 9). With four exceptions, SRP values were in the hundreds of milligrams per cubic metre even during the summer. It showed a deep-water under-ice increase in Echo and Katepwa lakes but not in Round Lake. Under-ice SRP was as high as 1200 mg/m<sup>3</sup> in the deeper parts of Pasqua Lake in late winter of 1979 (Warwick, 1979b). One very interesting period is the time of first sampling in 1977. The SRP content of Pasqua Lake (Fig. 9) was less than 100 mg/m<sup>3</sup> in late June. Perhaps this was related to the 22% replacement of Pasqua Lake water by snowmelt, although it also could be related to some internal algal production during mid-June, such as a bloom of diatoms at the inflow end of Pasqua Lake. If the high SRP values recorded are correct, then there is a vast excess of bioavailable phosphorus in all of the lakes throughout the year. However, as noted in the section on "Methods," these values should be viewed with some caution.

### *Total Nitrogen*

The total nitrogen concentrations in all six lakes (Fig. 10) are similar to those found in other lakes on the Qu'Appelle and other Prairie rivers (Allan and Kenney, 1978). Maximum values of total nitrogen (highest value was 5440 mg/m<sup>3</sup>) were associated with under-ice release of ammonia (Fig. 14) from bottom sediments during the late winter. In 1977, June total nitrogen in Pasqua Lake exceeded 2000 mg/m<sup>3</sup>. At the same time NO<sub>3</sub> + NO<sub>2</sub>-N was also high, probably due to spring runoff. Total nitrogen declined into the summer months and showed a July-August minimum during the open water period. In general, the lakes have higher surface nitrogen than deep water nitrogen in the summer months. Mean annual nitrogen values<sup>3</sup> during the seven-year period from 1970 to 1976 inclusive for Pasqua, Echo, Mission, Katepwa, Crooked and Round lakes were 2994 ± 1976 (n = 370), 1989 ± 780 (n = 278), 1801 ± 691 (n = 155), 1880 ± 999 (n = 280), 1827 ± 1031 (n = 172) and 1586 ± 773 (n = 101) mg/m<sup>3</sup>, respectively. The figures for total nitrogen for 1977 and 1978, with very few exceptions, are less than the mean values for all of the

<sup>3</sup>See footnote 1.

lakes. This is especially so for Crooked and Round lakes, although only summer values are given for the former. Both 1977 and 1978 were relatively low flow years, and as shown, spring runoff contributed only 22% and 11% of the volume of Pasqua Lake alone.

### *Particulate Nitrogen*

The distribution of particulate nitrogen (Fig. 11) is closely related to the distribution of chlorophyll *a* (Figs. 16, 23 to 30). During the summer particulate nitrogen exceeds 1000 mg/m<sup>3</sup> in Echo, Katepwa and Round lakes. The values in Pasqua Lake do not reach 750 mg/m<sup>3</sup>. Maximum values in Pasqua Lake appear later than in the other lakes, in late August and early September, which is also the period when NO<sub>3</sub> + NO<sub>2</sub>-N in Pasqua Lake rapidly falls to its lowest concentrations (Fig. 13, Table A-1). Under-ice, the particulate nitrogen component is rapidly reduced to a minimum, especially in the surface waters. The particulate nitrogen decreases mirror increases in NO<sub>3</sub> + NO<sub>2</sub>-N. There is a good correlation between particulate nitrogen and chlorophyll *a* for values of up to 600 mg/m<sup>3</sup> and 50 mg/m<sup>3</sup>, respectively. Above these, the relationship breaks down. This general correlation can be seen in the profiles (Figs. 23 to 30).

### *Total Dissolved Nitrogen*

Maximum values (Fig. 12) are found deep in the lakes in late winter and are partly associated with conversion of particulate nitrogen to nitrate in the water column (Fig. 13) and with ammonia generation (Fig. 14). Late July and August is a period of the lowest dissolved nitrogen content. High values in Pasqua in June are most likely related to regeneration during the winter of 1976 to 1977. By far the greatest component of the TDN is dissolved organic nitrogen.

### *Nitrate-Nitrite Nitrogen*

Nitrate forms a small fraction of total nitrogen. Nitrate was higher in Pasqua Lake in June, July and August, but not in any of the other lakes. This may be related to 1976-77 under-ice nitrification in the upper water column as seen in Echo and Katepwa, and to a much lesser extent, Round Lake. The high nitrate in Pasqua Lake during late June and July 1977 may also be related to runoff. The 1977 effect in Pasqua Lake was not detected in Echo Lake. Nitrate reached lowest values of less than

10 mg/m<sup>3</sup> by June 1977 in Mission, Katepwa and Round lakes, and by July 1977, in Crooked Lake. Minimum concentrations in Pasqua Lake did not occur until late August. These reductions are related to algal assimilation and denitrification. Under-ice nitrate production (Fig. 13) mirrored reduction in particulate nitrogen (Fig. 11). Nitrate exceeded 200 mg/m<sup>3</sup> in Echo Lake and 400 mg/m<sup>3</sup> in Katepwa Lake. This relationship could be fortuitous. One other possible source of nitrate is from groundwater which could enter the lakes beneath the ice through the lake bottom or by lateral springs. Nevertheless, the under-ice accumulation of nitrate (Fig. 13) in the upper water column along with ammonia (Fig. 14) and phosphate (Fig. 9) accumulation in the deeper waters provides a late winter pool of bioavailable nutrients.

The input of nitrogen from the Qu'Appelle River is significant. The Qu'Appelle River above Pasqua Lake has had extreme total nitrogen concentrations (maximum of 13 250 mg/m<sup>3</sup> TN between 1970 and 1976 inclusive). In a flood year such as 1974, TN concentration in the spring runoff fell as low as 900 mg/m<sup>3</sup>. On the other hand, in a drought year such as 1977, TN concentrations over the spring period remained between 3140 and 6500 mg/m<sup>3</sup>. Thus the total nitrogen available for summer biomass production is again a complex function of the interaction of the spring flushing, mixing, and internal regeneration components. This is especially critical in terms of nitrate nitrogen, which may play a role in determining algal species composition in phosphorus-enriched Prairie lakes.

#### *Ammonia Nitrogen*

Under-ice late winter ammonia production in Prairie sloughs is well documented by Barica (1975). Both Echo and Katepwa lakes showed a late winter accumulation of ammonia by decomposition in the deeper water or from bottom sediments. The effect was the greatest in Echo Lake. No under-ice accumulation of ammonia was seen in Round Lake. There were high under-ice dissolved oxygen levels in the lake throughout the winter (Fig. 22). The winter release of ammonia, as in the case of phosphorus, is carried over into the early and midsummer months (Fig. 14). Periods of higher nutrient concentrations in the deeper waters of the lakes (Figs. 8 to 14) can be compared with cross sections of dissolved oxygen distribution (Figs. 17 to 22). The volume of the lakes with D.O. values of <4 mg/L has been shaded for emphasis. The distribution of ammonia and in some cases SRP (Figs. 23 to 30) appears to be related to the presence of a D.O. concentration of <4 mg/L. The effects of D.O. values of <4 mg/L are best seen by comparison of Crooked and Round lakes (Figs. 29

and 30, respectively). In the summer of 1977, ammonia in Crooked Lake was 600 mg/m<sup>3</sup>, while the D.O. values of <4 mg/L persisted. During the same period in Round Lake, when D.O. values exceeded 4 mg/L, ammonia concentrations were <200 mg/m<sup>3</sup>. Another example in Pasqua Lake shows that when D.O. rises above 4 mg/L (Fig. 24c, 2/8/77; Fig. 17), there is an immediate sharp decline in ammonia at depth. Within 15 days thereafter (Fig. 24c, 17/8/77), ammonia in the surface water had declined to 100 mg/m<sup>3</sup>, while chlorophyll *a* and particulate nitrogen had climbed to 417 mg/m<sup>3</sup> and 1200 mg/m<sup>3</sup>, respectively. There is only a small amount of regeneration in the deeper parts of the lakes. On the other hand, the nutrients are in bioavailable forms and this must be taken into account when measuring the impact. After mixing, their total concentrations in the water column may actually decline (Fig. 23, 31/8/77) due to rapid algal biomass production. Daily or even hourly sampling may be necessary to detect this process of injection following storm events.

#### *Total Nitrogen to Total Phosphorus Ratios*

Low nitrogen to phosphorus ratios are commonly related to nitrogen limitation. The diagrams and equations normally used relating mean summer algal biomass (as measured by chlorophyll *a* content) to spring, mean summer or mean annual total phosphorus are not considered valid for lakes with total nitrogen to phosphorus ratios of less than 15 (Dillon and Rigler, 1974) or, in more recent experiments, less than 5 (Schindler, 1977). In 1977 and 1978, with two sample exceptions, TN/TP ratios in all six lakes were lower than 5 (Fig. 15). During the critical midsummer and late summer months, TN/TP ratios fell to less than 2 and situations where the total phosphorus exceeded the total nitrogen were found in all of the lakes. Values throughout the winter ranged from 2 to 4, with a slight rise at the end of the winter owing perhaps to a relatively greater accumulation of nitrogen (Fig. 12) than phosphorus (Fig. 9) from sediment and seston nutrient release processes. The highest TN/TP ratios occurred in late June. Values exceeded 4 in Pasqua, Mission and Katepwa lakes at that time and may have been a combination of regeneration and winter inflow.

In February of 1974 and 1977, total nitrogen in the Qu'Appelle River above Pasqua Lake rose to over 13 000 mg/m<sup>3</sup> and 8000 mg/m<sup>3</sup>, respectively. The corresponding total phosphorus values were 2000 and 400 mg/m<sup>3</sup>, respectively. Thus in February 1974 the TN/TP ratio was low (6.5), whereas in February 1977 it was high (20). Winter flow, however, was minimal. The extreme variation in TN and TP in the Pasqua inflow can again be seen in the spring runoff. In 1974, a flood year, runoff

had TN and TP concentrations of some 800 and 100 mg/m<sup>3</sup>, respectively. The 1977 drought year had concentrations of 3600 to 7500 mg/m<sup>3</sup> TN and 500 to 1000 mg/m<sup>3</sup> TP at the same sample time (there was no distinct spring peak). The extent of winter and spring inflow had a significant effect not only on eventual nutrient levels but also on the TN/TP ratios found in the lakes the following summer. Between 1970 and 1976 inclusive, TN/TP ratios  $\pm 1$  S.D. were  $4.63 \pm 3.96$  ( $n = 370$ ),  $3.58 \pm 1.98$  ( $n = 278$ ),  $3.49 \pm 1.88$  ( $n = 155$ ),  $3.54 \pm 2.60$  ( $n = 280$ ),  $6.64 \pm 5.60$  ( $n = 172$ ) and  $6.75 \pm 5.67$  ( $n = 101$ ) for Pasqua, Echo, Mission, Katepwa, Crooked and Round lakes, respectively.<sup>4</sup> As noted by Cross (1978), the low TN/TP ratios in the Fishing Lakes in contrast with those in Crooked and Round lakes indicate a greater possibility of nitrogen limitation in the former. For most of 1977 and 1978, TN/TP ratios in the lakes were less than these seven-year means. The highest TN/TP ratios recorded were from 20 (Katepwa Lake) up to 46 (Crooked Lake). Most of these were under-ice during the winter and were probably due to nitrogen regeneration or high nitrogen concentrations in inflowing streams. Occasional high TN/TP ratios ( $>10$ ) did occur in the open water period during 1970 to 1976 but apparently not in 1977 and 1978.

#### *Chlorophyll a*

The phosphorus loading reduction schemes implemented in the Qu'Appelle Basin are aimed at reducing phosphorus concentrations in the Fishing Lakes. When this reduction in phosphorus loading results in a reduction in lake total phosphorus concentrations, it has been shown to reverse eutrophication of originally oligotrophic lakes and bays (Edmondson, 1972; Dillon *et al.*, 1978). In these examples, the reductions in total phosphorus were from 65 mg/m<sup>3</sup> and 50 mg/m<sup>3</sup>, respectively, to just less than 20 mg/m<sup>3</sup>. It has also been demonstrated that additions of phosphorus (along with sufficient nitrogen to maintain an N/P ratio of about 15) result in eutrophication of oligotrophic lakes (Schindler *et al.*, 1973). In this case, total phosphorus was artificially elevated from 5 mg/m<sup>3</sup> to 70 mg/m<sup>3</sup>. The addition of phosphorus and nitrogen to the eutrophic Bay of Quinte also produced increases in phytoplankton biomass (Lean and Charlton, 1976). In this case, TP increased from 38 mg/m<sup>3</sup> to 150 mg/m<sup>3</sup>, closer to but still well below the concentrations found in the Fishing Lakes (Fig. 8). Phosphorus additions alone have only been shown to cause phytoplankton biomass increases which could be accounted for by natural annual variations (Lean and Charlton, 1976), including the relative area of the lake bottom in contact with epilimnetic water (Fee, 1979). In combination, these results clearly demonstrate that given adequate TN/TP ratios ( $>5$ ),

increases in phosphorus (up to 150 mg/m<sup>3</sup>) result in proportional increases in mean summer algal biomass and that reduction of phosphorus to  $<20$  mg/m<sup>3</sup> reverts the lakes to a non-eutrophic state. Still unknown about the Fishing Lakes are: (1) the proportionality of the relationship or how much of a reduction in chlorophyll a will occur for a particular reduction in total phosphorus and (2) whether concentrations can be lowered to levels where improvements become clearly visible to laymen (Allan, 1980).

Models relating phosphorus levels in lakes to mean summer algal biomass form two groups. The first deals with estimating spring phosphorus or mean annual total phosphorus from phosphorus loading. Determining phosphorus loading involves quantifying several components, such as external loading from rivers, internal loading from groundwater, sediment regeneration, sedimentation and airborne fallout. For the Fishing Lakes, attempts to predict lake concentrations from various loading equations always produce values less than those actually measured (Allan and Kenney, 1978; Cross, 1978). This anomaly is probably related to a combination of factors including the complex hydrodynamic system with dramatic short-interval (one year) variations from floods to droughts; intermittent summer and winter internal loading; and the difficulty of sampling to determine total load in high runoff years. The lower predicted values may thus be an artifact of the data base rather than a fault in the logic used to derive the loading formulae. Normally, the concentrations derived from these loading equations could then be used to predict mean annual chlorophyll a values.

A direct approach to productivity modelling involves the use of actual lake water concentrations of phosphorus, nitrogen and chlorophyll a. When these models are applied to the Fishing Lakes, actual mean summer chlorophyll a values are usually much less than the concentrations predicted from the total phosphorus concentrations (Allan and Kenney, 1978; Cross, 1978). Proportionality does exist over the long term from 1970 to 1976. The highest mean total phosphorus and mean chlorophyll a concentrations for that time period occurred in the same lakes. There may be a unique phytoplankton biomass/phosphorus proportionality at the extreme phosphorus concentrations in these lakes or phytoplankton biomass may not be proportional to phosphorus in lakes with very low TN/TP ratios ( $<5$ ) (Schindler, 1977). It may be that factors other than total phosphorus affect summer algal biomass in the Fishing Lakes, and could include:

- (1) nitrogen deficiency, as evidenced by the low TN/TP ratios (Allan and Kenney, 1978; Cross, 1978) and presence of nitrogen-fixing blue-green algae;

<sup>4</sup>See footnote 1.

- (2) light limitation because of organic content of the water, wind-resuspended bottom sediment (Hammer, 1970) or self-shading due to the algae themselves during calm periods;
- (3) competition with bacteria, e.g., Dutka (1977) reported extreme summer bacterial counts in all six lakes;
- (4) difficulty in measuring mean chlorophyll *a* because of analytical methodology or because of natural chlorophyll *a* variations in algae (Nicholls and Dillon, 1978); and
- (5) difficulty in measuring mean chlorophyll *a* content because of in-lake distribution.

All of these possibilities have merit. If they apply to varying degrees, then their quantification is necessary before models are developed to predict the effects of phosphorus reductions from the existing high concentrations presently found in the Fishing Lakes.

Present estimates are that 33% of the phosphorus loaded to the Fishing Lakes comes from upstream urban point sources and therefore can be reduced (Cross, 1978). Peters (1973) estimated that 50% of the phosphorus generated in the total Qu'Appelle Basin came from Regina and Moose Jaw effluents. Reductions of 33% or 50% would still leave total phosphorus concentrations far in excess of those necessary for attaining a eutrophic state (20 to 50 mg/m<sup>3</sup>). Prairie mainstem lakes with no urban sources of phosphorus are subject to dense summer algal blooms of nitrogen-fixing algae. Historical observations indicate that eutrophic conditions existed in Prairie lakes prior to expansion of agriculture and general settlement of the Prairies. Sediment phosphorus forms can be interpreted to support an argument for pre-settlement eutrophic conditions (Allan *et al.*, 1980). Lake Washington and Gravenhurst Bay were returned to their natural oligotrophic state by total phosphorus reductions of 65 to 20 mg/m<sup>3</sup>. The lowering of TP in the Fishing Lakes to 20 mg/m<sup>3</sup> is unlikely. A return to their natural eutrophic state is environmentally desirable and could be statistically established over a period of years. However, to the recreational layman, who mainly sees near-shore effects, the visual appearance of the lake on any particular day may not be sufficiently different in terms of phytoplankton biomass (algal blooms) to convince him of long-term improvements. The relationship between extreme phosphorus concentrations and phytoplankton biomass is basically the extreme perturbation of the latter (Tables A-1 to A-6) (maxima can be very high compared with mean values).

Mean chlorophyll *a* in Pasqua, Echo, Mission, Katepwa, Crooked and Round lakes from 1970 to 1976 inclusive was 25.5 ±33.8 (n = 162), 33.6 ±50.5 (n = 139), 26.0 ±37.0

(n = 64), 21.2 ±46.0 (n = 100), 15.3 ±24.0 (n = 71) and 9.3 ±9.4 (n = 31), respectively.<sup>5</sup> These values are high because sampling was biased toward the open water period. When compared with the mean 1970 to 1976 TP concentrations, a proportional relationship does exist. However, the significant fact is the large standard deviation which exceeds the mean in all cases except Round Lake, and this could be related to the smaller number of Round Lake samples. These means can be compared with values in the six lakes during 1977 and 1978 (Fig. 16). Sampling eutrophic or hypertrophic lakes for estimates of mean chlorophyll *a* is not a simple matter and predictions based on a few samples or on mean values alone are of limited value. The cost of dense sampling and analysis at short time intervals can be very high. On the other hand, such data are essential for accurate modelling and also for understanding the processes controlling algal production in these lakes. Usually when hypertrophic lakes have been sampled, the approach has been necessarily objective. A few fixed stations are visited at regular intervals.

Subjective sampling in Rock Lake, Manitoba, a lake with dimensions similar to Round Lake, revealed variations in chlorophyll *a* content of 8 to 80 to 480 mg/m<sup>3</sup> in different parts of the lake on the same morning. Furthermore, the visual appearance of the lake to the layman was not markedly better at 80 than at 480 mg/m<sup>3</sup>. As long as these variations are distributed in the field of vision from the lakeshore, the eye synthesizes a total impression. Algal species composition, the mixing effects of high winds, and the washing ashore of algal scums all contribute to changes in lake appearance in short time periods. This type of variation is seen in the lake profiles (Figs. 23 to 30). For example, on August 17, 1978, chlorophyll *a* in the top 2 m of the west basin of Pasqua Lake was about 35 mg/m<sup>3</sup> (Fig. 23), a mean value which would have looked terrible, while in the east basin chlorophyll *a* was 120 to 417 mg/m<sup>3</sup> (Fig. 24), a value so offensive that it has to be seen to be appreciated.

The total phosphorus levels in the lakes in 1977 and 1978 should have produced considerably higher chlorophyll *a* means, if the proportionality is based on existing correlations. Use of mean summer rather than mean annual chlorophyll *a* raises the means as does the use of only 0 to 1.5-m depth open-water chlorophyll *a*, i.e., to the normal Secchi depths (see Tables A-7 to A-12). Using mean summer chlorophyll *a* from 0 to 1.5-m depths results in means of 50, 43, 39, 40, 175 and 41 mg/m<sup>3</sup> for Pasqua, Echo, Mission, Katepwa, Crooked and Round lakes, respectively. The reason for the Crooked Lake value of 175 mg/m<sup>3</sup> is evident in the chlorophyll *a* results. It is a function of the extreme surface concentration of 718 mg/m<sup>3</sup> at station 4

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<sup>5</sup>See footnote 1.

on August 3, 1977 (Table A-5). With chlorophyll *a* concentrations of 90 and 480 mg/m<sup>3</sup> in the top 3 m of Crooked Lake, the visual appearance of the lake in terms of algal biomass would have been about as poor as could be imagined. There is then a potential for extreme phytoplankton biomass levels to occur in these lakes. It is the extreme values with which we should be concerned, rather than or at least in combination with the mean concentrations. Round Lake also had dense algal growth in August and the contrast between the west and east ends of the lake was even greater (1 versus 230 mg/m<sup>3</sup>) (Table A-6). In nearly all cases, the east end of the lake had higher chlorophyll *a* concentrations. River inflow is from west to east, but this has minimal effect on algal drift relative to that of the prevailing winds, which are also from the west.

## CONCLUSIONS

No one year can be called typical of the Prairie hydrodynamic system. Spring runoff from the Qu'Appelle River to the Fishing Lake chain can vary from no flow to dramatic floods, with discharges exceeding the total volume of all four lakes ( $521 \times 10^6$  m<sup>3</sup>) in a few weeks. There are many variations between these extremes. Thus, because of the tremendous control exerted by discharge on (1) external riverborne nutrient loading, (2) flushing of the lakes and (3) spring shifting of water masses downstream from one lake to the next, any valid comparisons of the system must be made between years of almost identical discharge conditions. The corollary is that one or two years of information on the lakes only indicate conditions operating during that particular discharge period. This study, conducted in 1977 and 1978, represents extreme low flow conditions. During 1977 there was actual concern over the degree and extent of drought conditions in the southern Prairies.

Systematic sampling of the density, frequency and time span required in the Qu'Appelle Basin has been focused on the river and not the lakes. No systematic monitoring of the Qu'Appelle Valley lakes had been carried out in such a way that annual isopleth diagrams of the type presented here could be constructed. As mentioned initially, this basic limnological information is essential for resolution of controlling processes and quantification of those operating in particular lakes. Now, such information at least exists for extreme low flow conditions. Possibly an even more extensive program should be conducted in a major flood year. Sampling of river inflows and outflows should also be carried out simultaneously. This was beyond our logistical capability in 1977 and 1978. Sampling would have to be initiated on the basis of a flood forecast and might be impractical during the peak of the flood. This would cause problems with loading estimates. One option for assessing

long-term effects of phosphorus loading reductions would be to conduct lake plus river monitoring for several successive years, for example, eight years is quoted in the Gravenhurst Bay situation in Ontario. A less extensive method would be to wait until a very low runoff year is forecast and conduct a sampling program identical with that reported here.

The data obtained in this one-year monitoring period during low flow conditions revealed the following main points:

- (1) The lakes showed late spring tendencies to develop thermal stratification but were otherwise essentially isothermal during the open-water period.
- (2) Only the deepest lake, Katepwa, developed incipient thermal stratification and only for the early summer period.
- (3) Inverse stratification was set up during the winter in all of the lakes.
- (4) During the summer, dissolved oxygen was high in the surface waters of all of the lakes.
- (5) During the winter, dissolved oxygen in all of the lakes, except Round Lake, formed a chemical stratification with values falling below 4 mg/L in the deepest water in the late winter.
- (6) The late winter chemical stratification was not disrupted during the spring of 1977 and 1978, and D.O. values of <4 mg/L extended well into the summer months.
- (7) The low D.O. conditions were accompanied by higher conductivities and pH values.
- (8) Maximum pH values occurred in the surface water in the summer months.
- (9) Total phosphorus concentrations were still extremely high in both 1977 and 1978, in spite of the high efficiency of removal of phosphorus at Regina from January 1977. However, because of low flow conditions, the flushing effect in the Fishing Lakes was minimal in both years. The net result was that the lakes operated essentially as closed systems.
- (10) Regeneration of phosphorus from sediments built up under-ice during the late winter with concentrations in the deepest water rising to over 750 mg/m<sup>3</sup>.
- (11) The under-ice regeneration of phosphorus was carried over to late summer as part of the chemical stratification.
- (12) Total phosphorus was highest in midsummer and the maximum value recorded was 5200 mg/m<sup>3</sup>.
- (13) The late winter, deep water, high nutrient concentrations, with the exception of Round Lake, were carried on into the late summer months.
- (14) Soluble reactive phosphorus concentrations were extremely high throughout the year, even at times of greatest phytoplankton biomass.

- (15) Total nitrogen concentrations were high (1000 to 1500 mg/m<sup>3</sup> in the early summer) but in the same range as found in other mainstem Prairie lakes.
- (16) Particulate nitrogen was proportional to chlorophyll *a*, at least up to values of 600 mg/m<sup>3</sup> and 50 mg/m<sup>3</sup>, respectively.
- (17) The highest values (>1000 mg/m<sup>3</sup>) of summer particulate nitrogen were recorded in Mission and Crooked lakes.
- (18) Maximum values of total dissolved nitrogen occurred in the deep water in late winter and corresponded to high ammonia concentrations.
- (19) Nitrate nitrogen was produced in the upper water column during the winter.
- (20) Higher nitrate values in Pasqua Lake in the early summer of these low flow years may be partly due to input from the Qu'Appelle River.
- (21) Ammonia accumulated in the deeper water during the late winter and is associated with D.O. values of <4 mg/L and higher phosphorus concentrations, conductivity and pH.
- (22) Total nitrogen to phosphorus ratios were extremely low throughout both years and during summer months TP exceeded TN.
- (23) Higher TN/TP ratios appear related to higher nitrogen content in river inflow.
- (24) Mean chlorophyll *a* results (39 to 175 mg/m<sup>3</sup>) were sufficient to account for extreme visible eutrophication in terms of mean summer phytoplankton biomass.
- (25) Chlorophyll *a* concentrations varied dramatically within short periods (two weeks or less) at any one site and also at the same time at different sites in the same lake.
- (26) Mean annual chlorophyll *a* values over the long term (1970-1976) are proportional to mean annual total phosphorus. Mean summer chlorophyll *a* values in 1977, even the mean in the top 1.5 m, were less than would be predicted from existing chlorophyll *a*/total phosphorus correlations (with the exception of Crooked Lake, 175 mg/m<sup>3</sup>). The long-term and 1977 relationships are such that large decreases in mean total phosphorus will be required to effect decreases in mean chlorophyll *a*.
- (27) Because of the extreme variability in phytoplankton density (chlorophyll *a* can vary from 1 to over 230 mg/m<sup>3</sup> when bloom and scum conditions exist in parts of the same lake), much intensified sampling or new techniques may be required to estimate accurately true mean summer chlorophyll *a* for use in nutrient-biomass modelling of hypertrophic lakes.
- (28) Late summer breakdown of chemical stratification releases available nitrogen to the euphotic zone where it appears to be rapidly used in phytoplankton biomass production.
- (29) Because of (a) the rapid disappearance of nitrate in the early summer, (b) the rapid disappearance of ammonia following late summer breakdown of the chemical stratification, (c) the extremely low summer TN/TP ratios, and (d) the high SRP content throughout the summer, nitrogen is presently the element in most critical supply in the Fishing Lakes.
- (30) Lowering of phosphorus concentrations will create more normal eutrophic conditions in the lakes. An increase in TN/TP ratios may shift the algal species composition from blue-green to less noxious varieties.
- (31) The extremely high total phosphorus concentrations in the Fishing Lakes provide a continuous potential for production of extreme phytoplankton biomass concentrations, and extreme chlorophyll *a* concentrations can be reached on occasion. Lowering of phosphorus concentrations will lower the perturbations (difference between mean summer and maximum summer chlorophyll *a*) in phytoplankton biomass. In lakes with dimensions such as those studied here, however, physical factors (onshore winds) may produce near-shore conditions which are visually similar at quite different maximum open water chlorophyll *a* concentrations.
- (32) Present extreme phytoplankton production, at least in these drought years, appears related to short-term events, such as storms which break down summer chemoclines and mix deep water nitrogen into the euphotic zone.
- (33) Under flood conditions, the Fishing Lakes will operate differently, perhaps in a mode predictable by mean annual or probably more predictable by spring runoff phosphorus loading.
- (34) Intermediate runoff years will operate somewhere between the conditions described here and those of a flood year. Prediction for each lake in the contiguous Fishing Lake chain will depend on the domino effect whereby spring runoff river water first mixes with Pasqua Lake water before being transferred to Echo, Mission and, lastly, Katepwa Lake.

#### ACKNOWLEDGMENTS

M. Roy took part in the sampling program for the entire year. He was assisted at various intervals by summer students, term employees and other staff members of N.W.R.I.-W.N.R., and at other times by staff of the Water Quality Branch, I.W.D.-W.N.R., Regina. All sampling trips were a two-man operation, and gaps in the data arose when an assistant was unavailable. The samples were analyzed by the Calgary Laboratory of the Water Quality Branch, I.W.D.-W.N.R., under the direction of M. Forbes and then R. Sampson. We are extremely grateful to the laboratory for accommodating these samples in

its work load; for the very professional interest taken in recommending and advising on sample preservation techniques; and for resolving analytical difficulties related to the extreme concentrations of many of the parameters measured in this study. Although N.W.R.I.—W.N.R. assigned man months to Calgary as compensation for analytical costs which would have been in the range of \$15 000, this did not compensate for the total effort put into the study by the Calgary Laboratory. The most expensive analysis was for chlorophyll *a*, which has implications in terms of some of the conclusions of this study. We are also grateful to H. Weiss of the University of Manitoba graphics section, who drafted the diagrams, and to K. Hoeppner, who typed the manuscript.

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## **Figures 4 to 30**

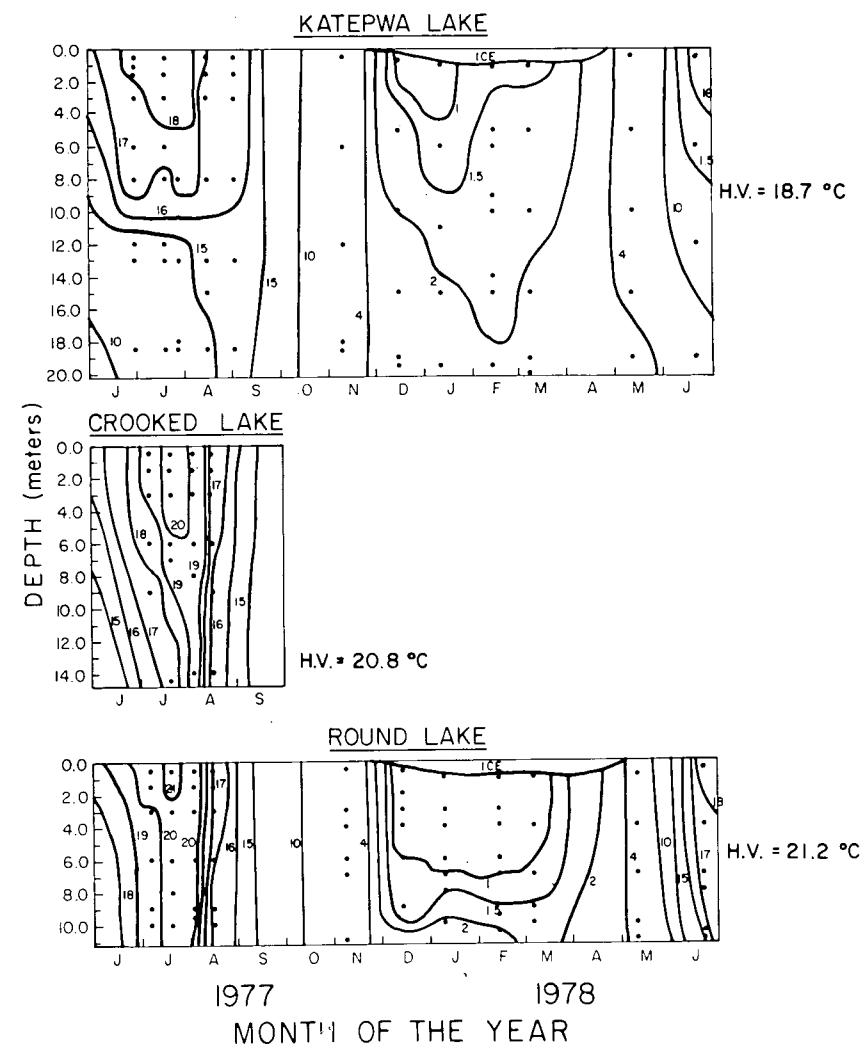
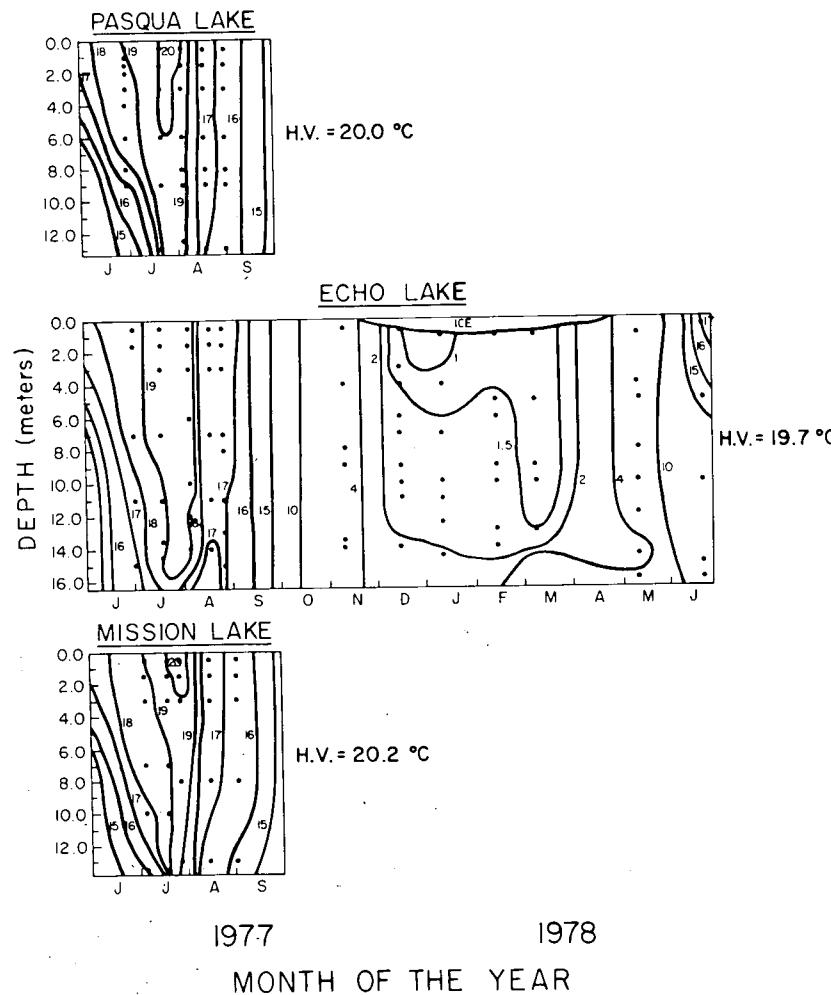


Figure 4. Temperature °C, Qu'Appelle Valley lakes (H.V. = highest value recorded).

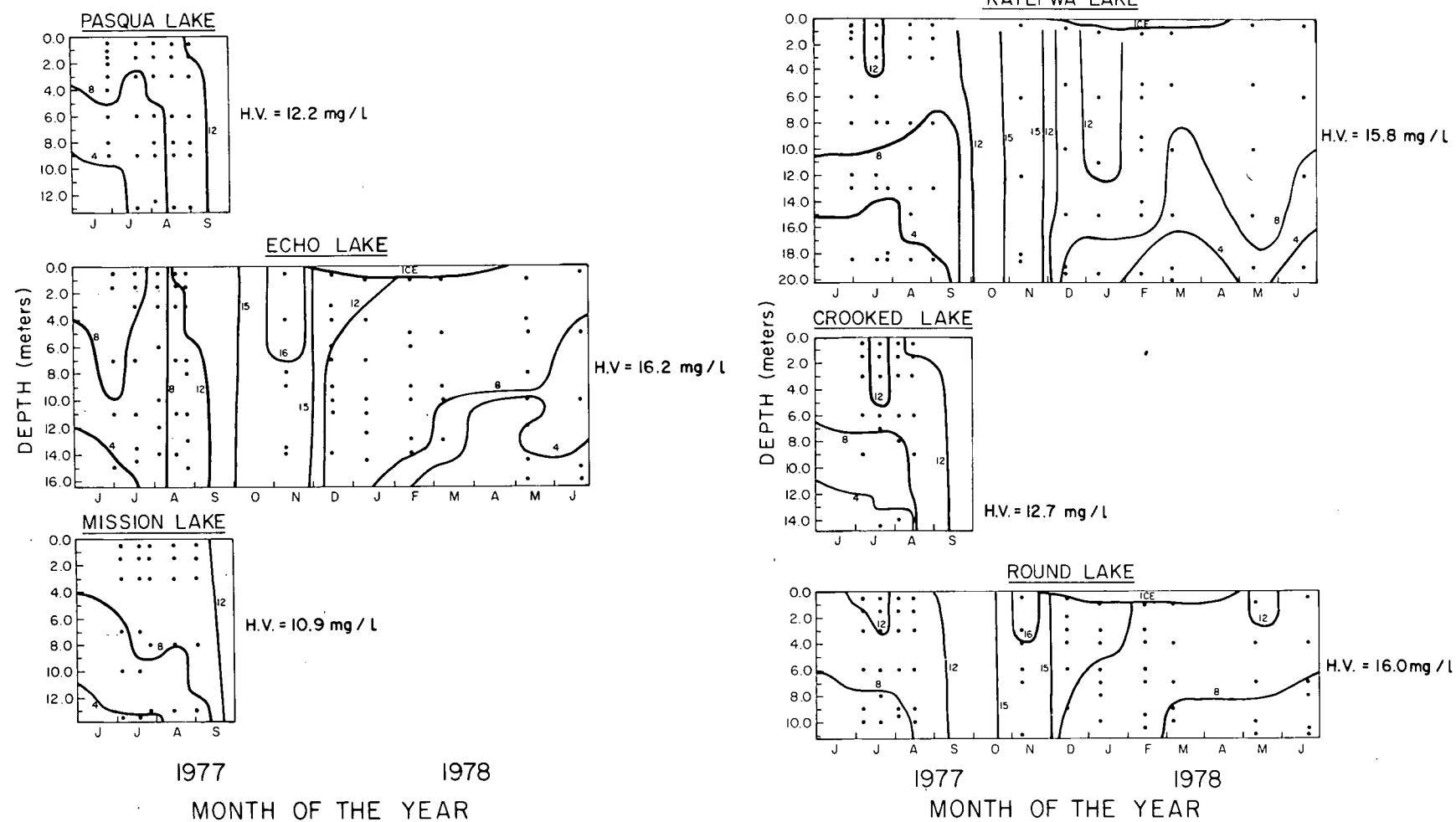
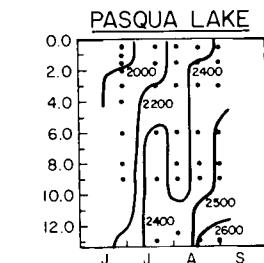
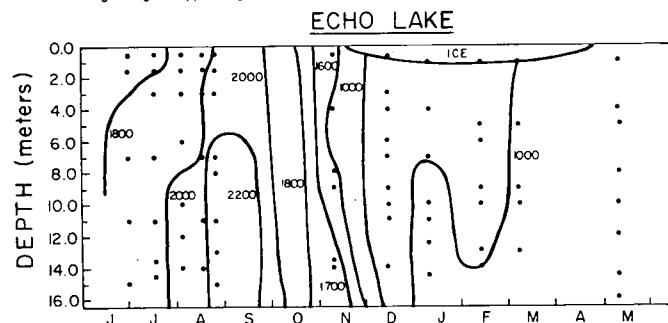


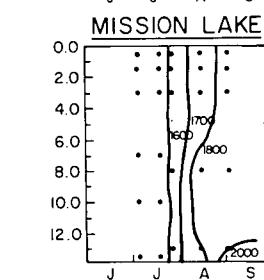
Figure 5. Dissolved oxygen (mg/L), Qu'Appelle Valley lakes (H.V. = highest value recorded).



H.V. = 2,600  $\mu\text{mhos}$



H.V. = 2,300  $\mu\text{mhos}$

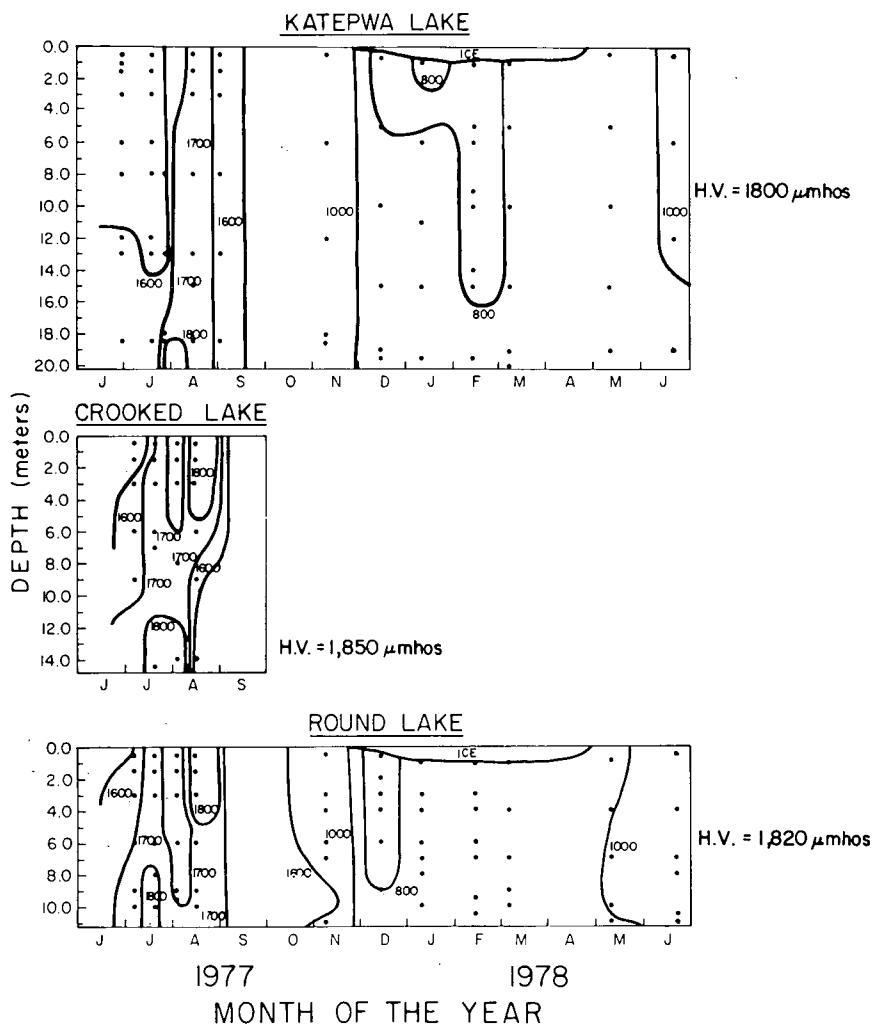


H.V. = 2,000  $\mu\text{mhos}$

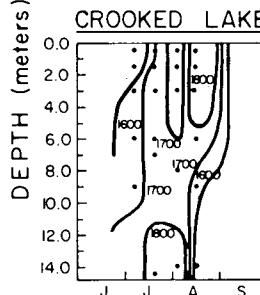
1977

1978

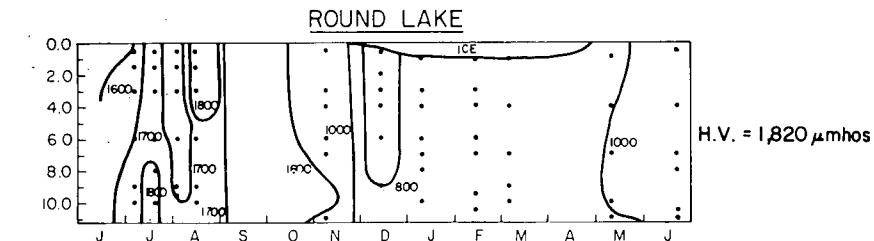
MONTH OF THE YEAR



H.V. = 1800  $\mu\text{mhos}$



H.V. = 1,850  $\mu\text{mhos}$



H.V. = 1,820  $\mu\text{mhos}$

1977

1978

MONTH OF THE YEAR

Figure 6. Conductivity ( $\mu\text{mhos}$ ), Qu'Appelle Valley lakes (H.V. = highest value recorded).

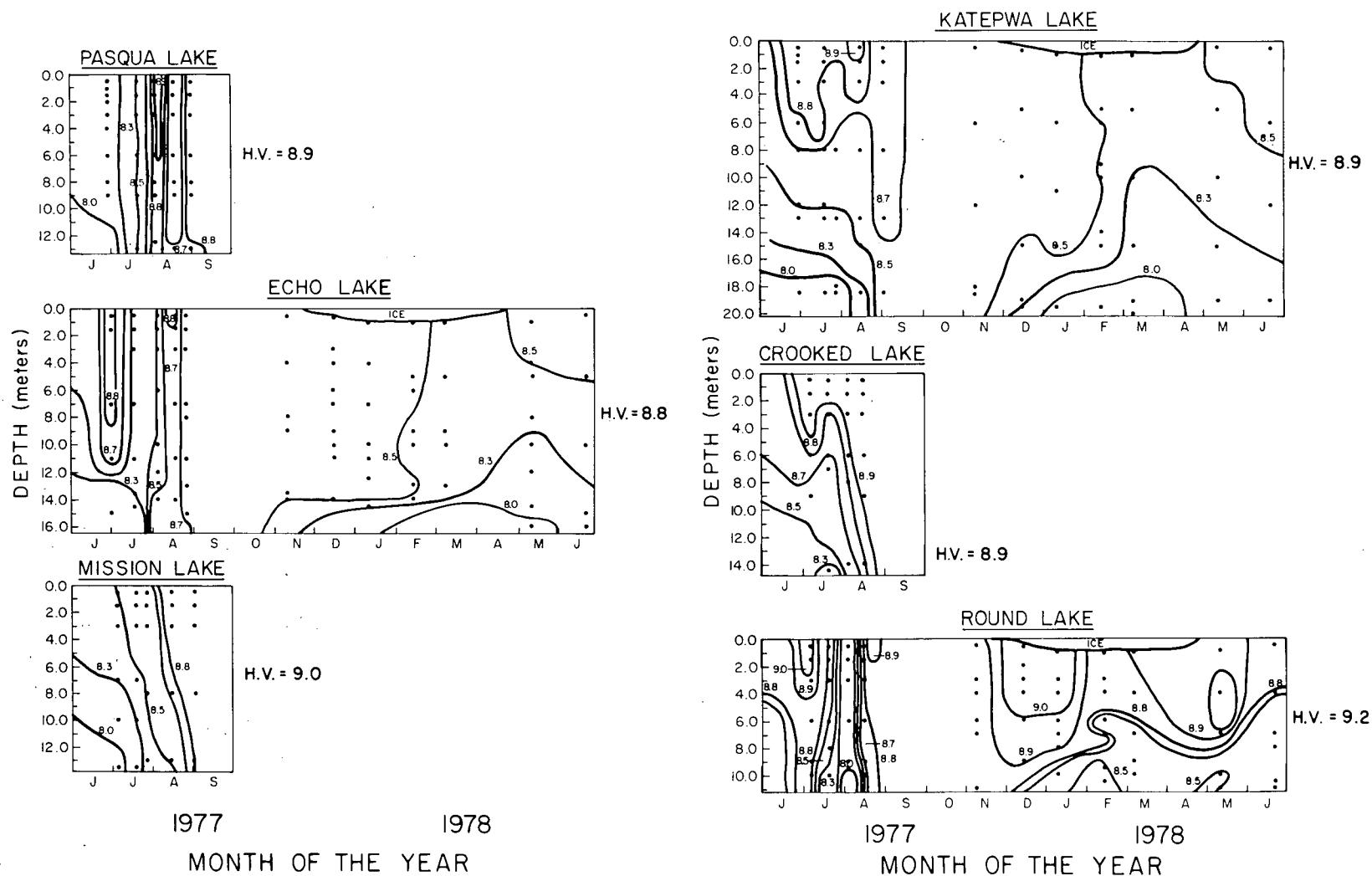


Figure 7. pH, Qu'Appelle Valley lakes (H.V. = highest value recorded).

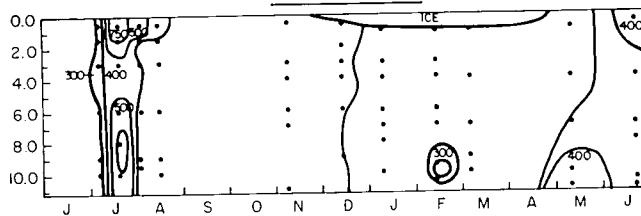
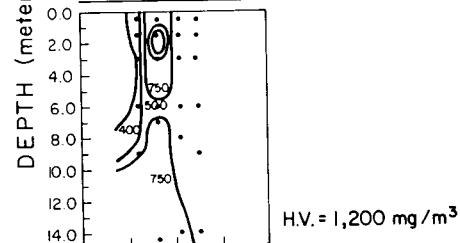
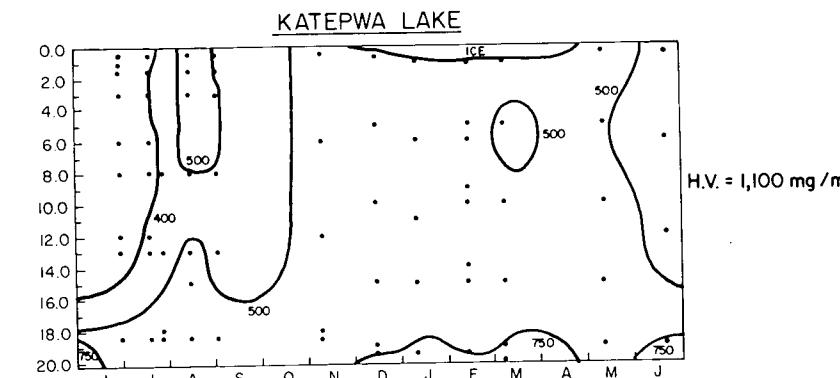
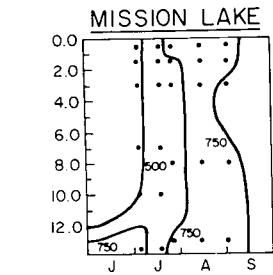
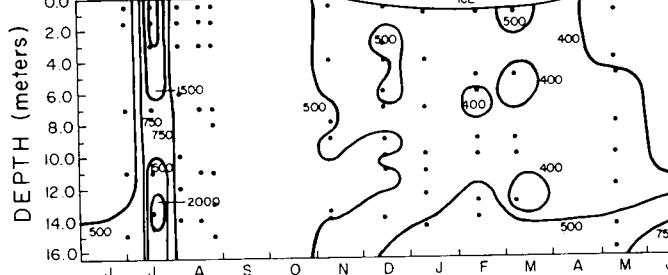
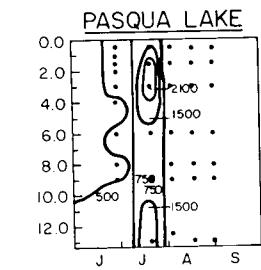


Figure 8. Total phosphorus (mg/m<sup>3</sup>), Qu'Appelle Valley lakes (H.V. = highest value recorded).

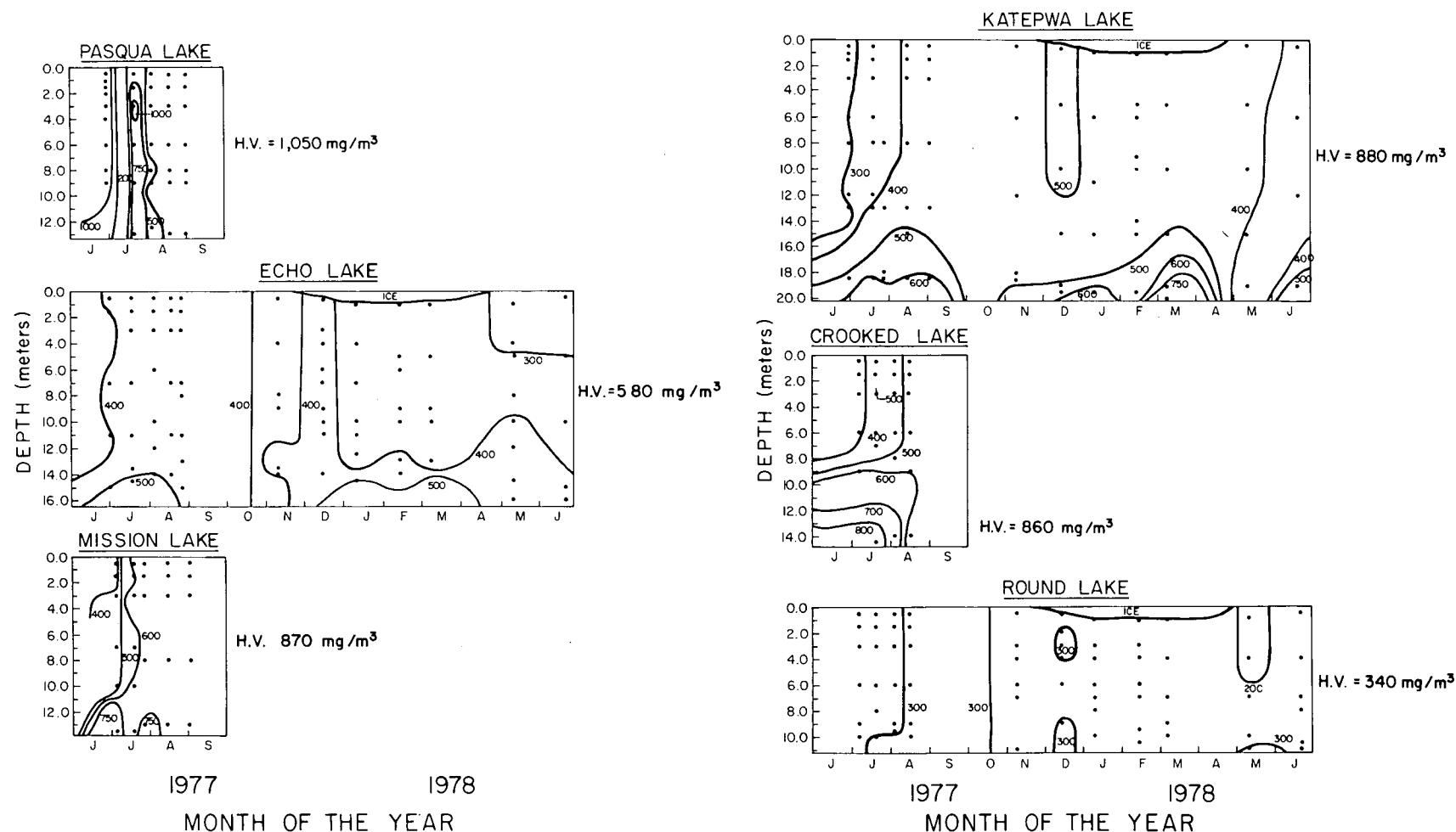
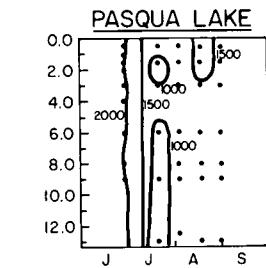
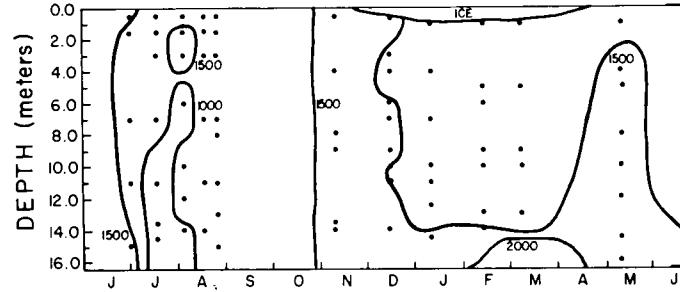


Figure 9. Soluble reactive phosphorus (mg/m<sup>3</sup>), Qu'Appelle Valley lakes (H.V. = highest value recorded).

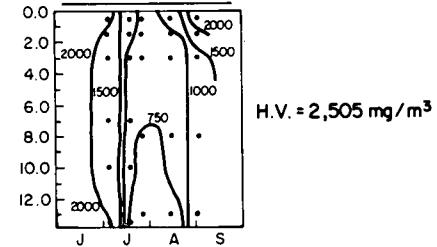


J J A S

ECHO LAKE



MISSION LAKE

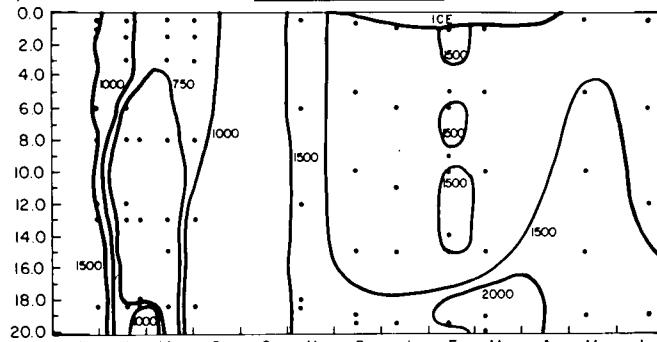


1977

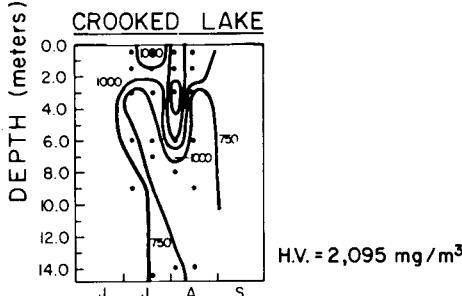
1978

MONTH OF THE YEAR

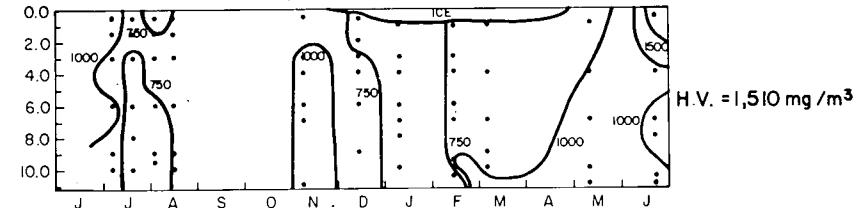
KATEPWA LAKE



CROOKED LAKE



ROUND LAKE



1977

1978

MONTH OF THE YEAR

Figure 10. Total nitrogen (mg/m<sup>3</sup>), Qu'Appelle Valley lakes (H.V. = highest value recorded).

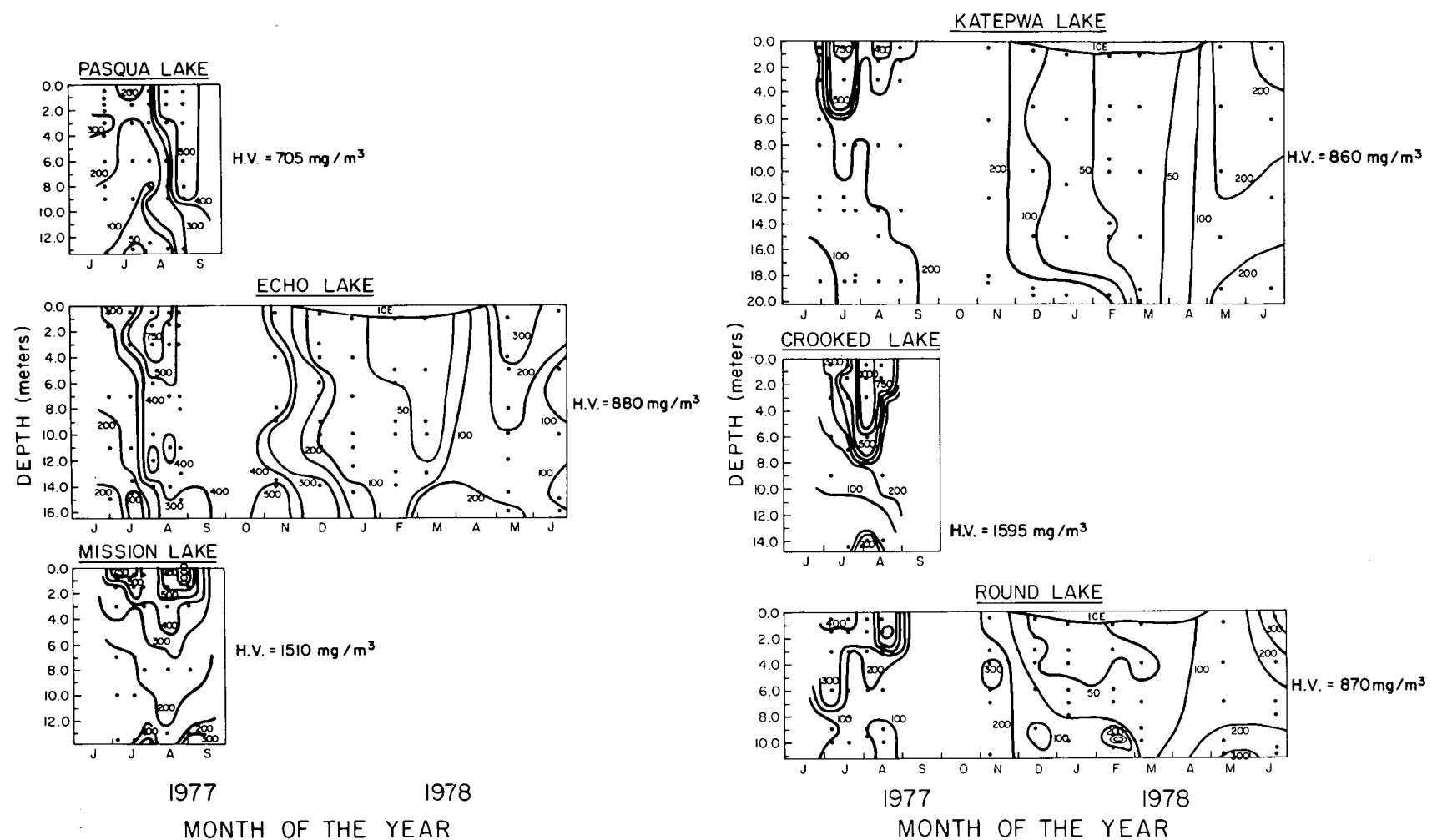


Figure 11. Particulate nitrogen (mg/m<sup>3</sup>), Qu'Appelle Valley lakes (H.V. = highest value recorded).

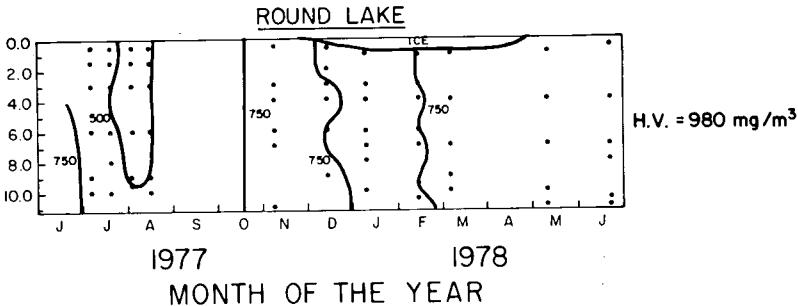
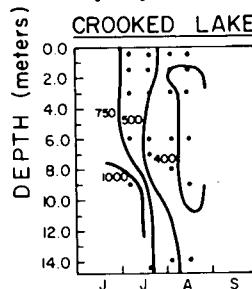
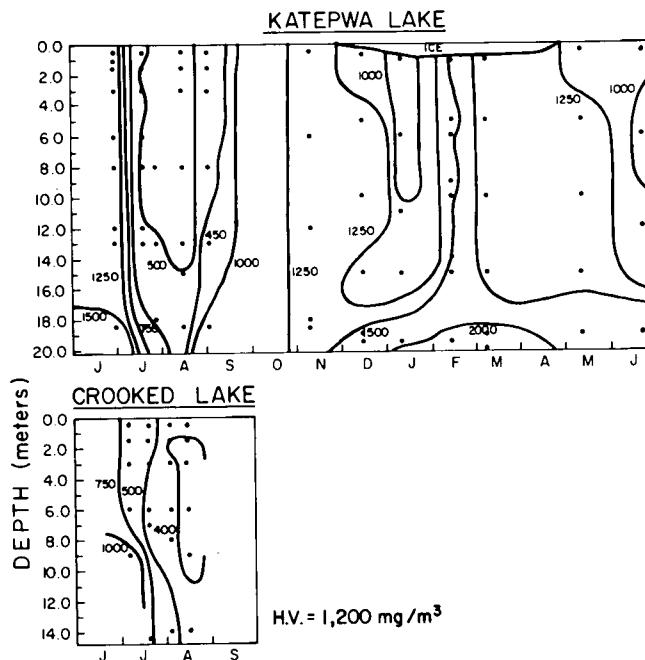
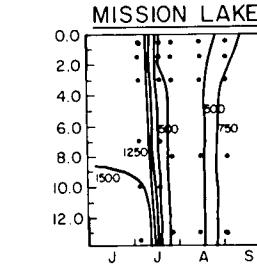
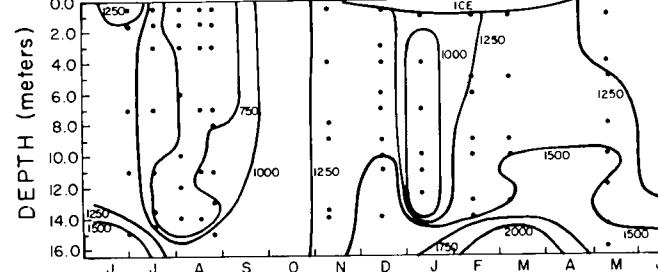
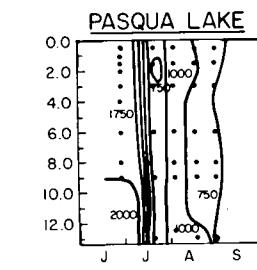


Figure 12. Total dissolved nitrogen (mg/m<sup>3</sup>), Qu'Appelle Valley lakes (H.V. = highest value recorded).

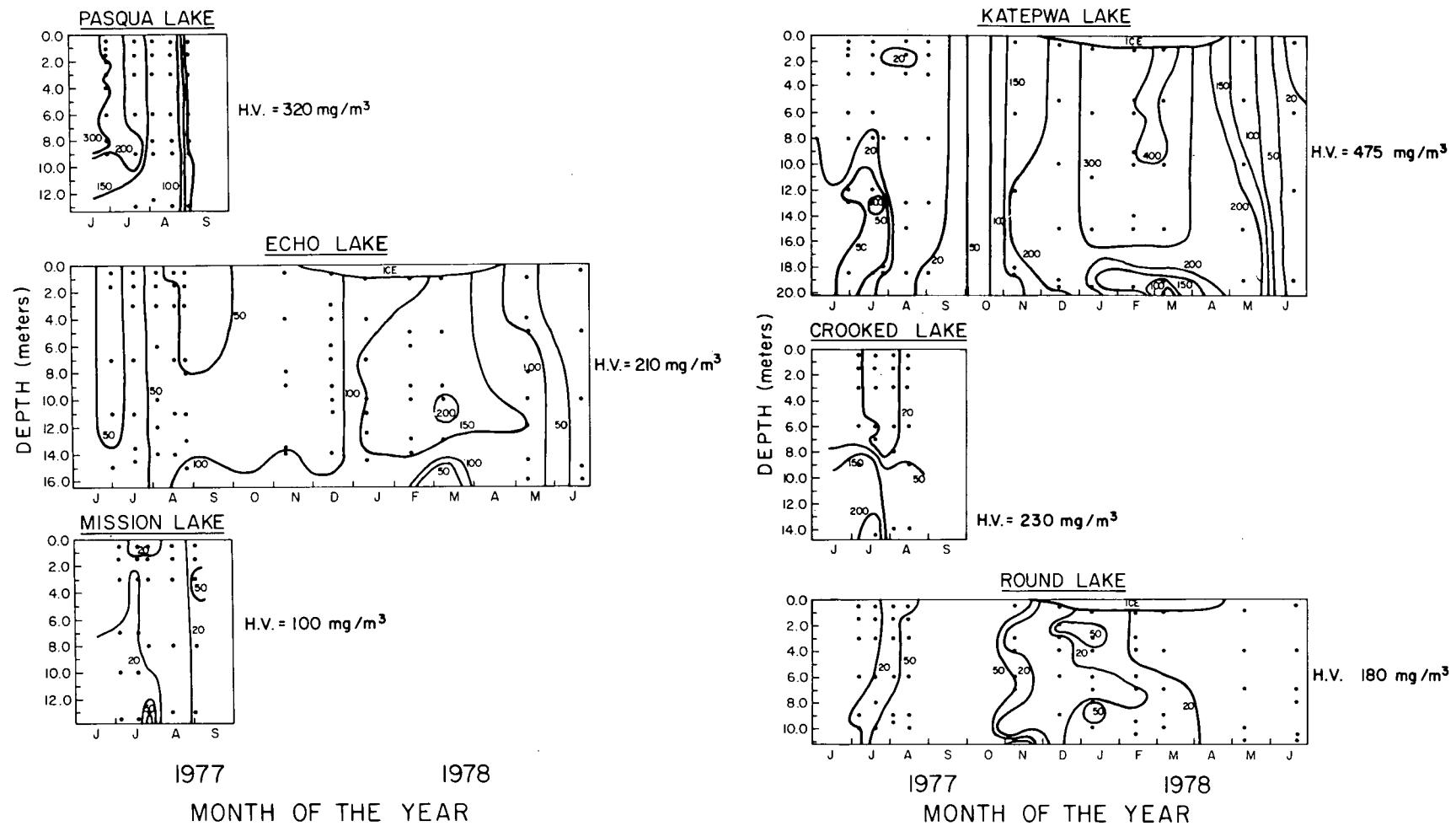
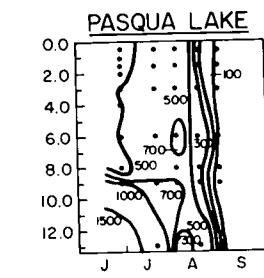
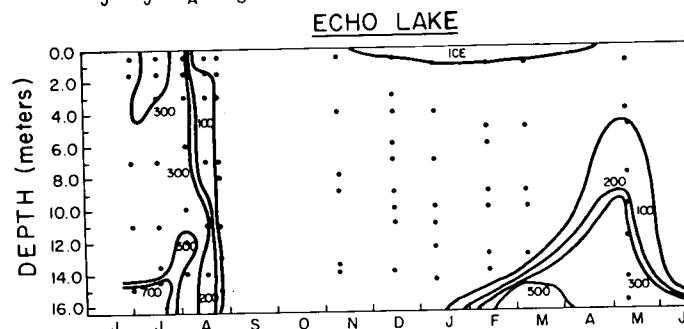


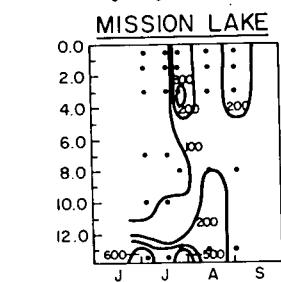
Figure 13. Nitrate + nitrite (mg/m<sup>3</sup>), Qu'Appelle Valley lakes (H.V. = highest value recorded).



H.V. =  $1800 \text{ mg/m}^3$



H.V. =  $750 \text{ mg/m}^3$

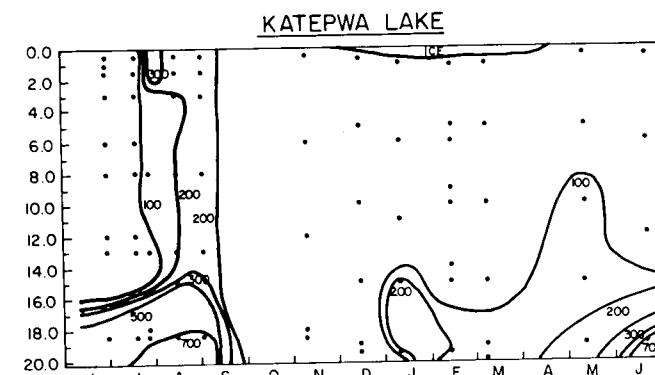


H.V. =  $600 \text{ mg/m}^3$

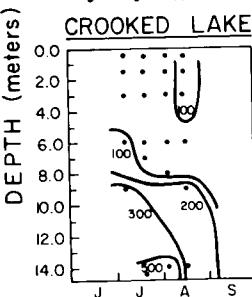
1977

1978

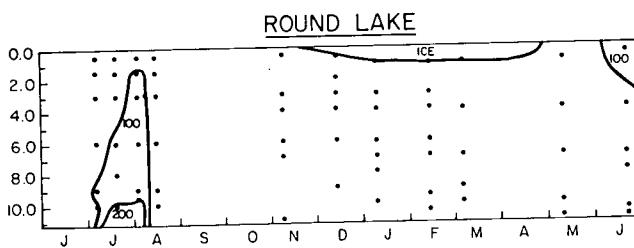
MONTH OF THE YEAR



H.V. =  $885 \text{ mg/m}^3$



H.V. =  $500 \text{ mg/m}^3$



H.V. =  $200 \text{ mg/m}^3$

1977

1978

MONTH OF THE YEAR

Figure 14. Ammonia ( $\text{mg/m}^3$ ), Qu'Appelle Valley lakes (H.V. = highest value recorded).

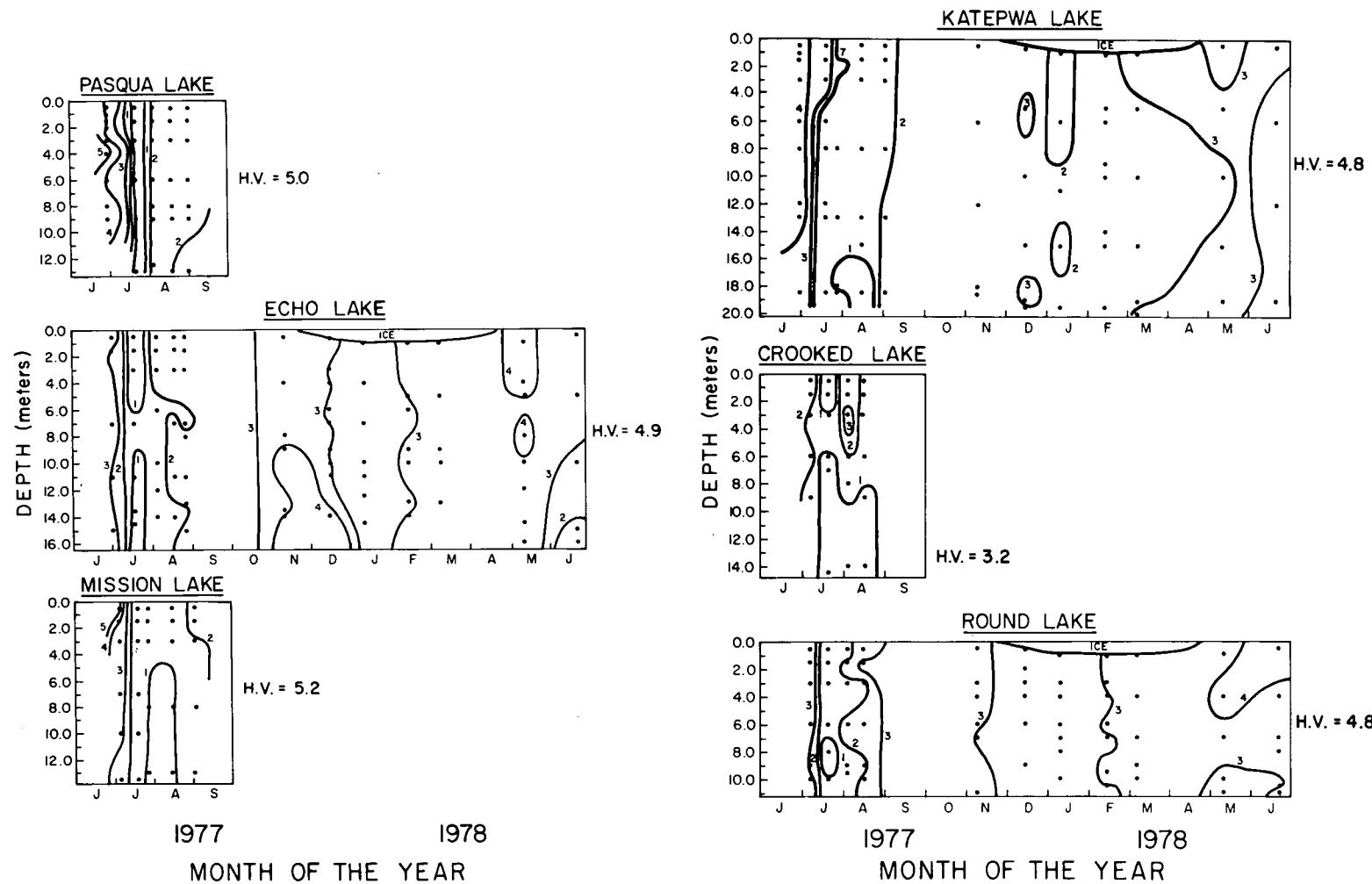
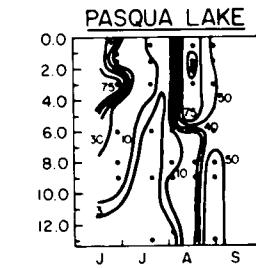
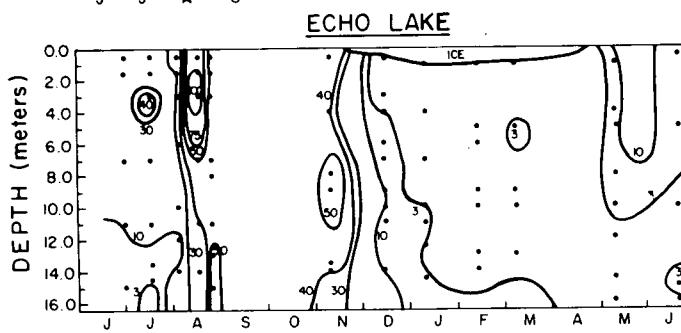


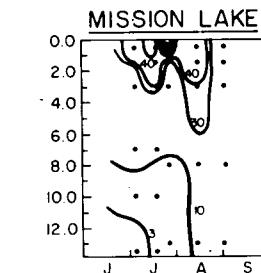
Figure 15. Total nitrogen/total phosphorus, Qu'Appelle Valley lakes (H.V. = highest value recorded).



H.V. = 276 mg/m<sup>3</sup>



H.V. = 110 mg/m<sup>3</sup>

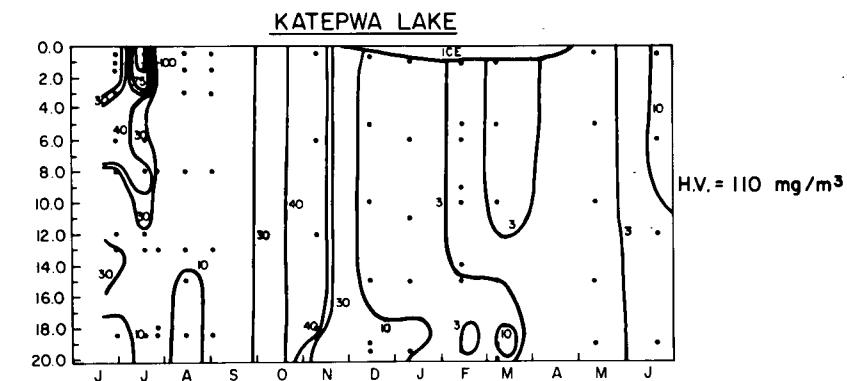


H.V. = 48 mg/m<sup>3</sup>

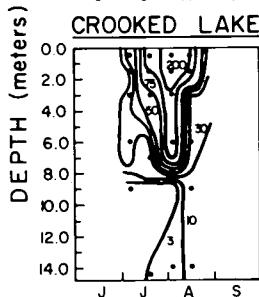
1977

1978

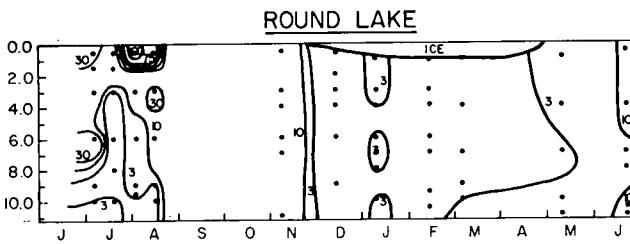
MONTH OF THE YEAR



H.V. = 110 mg/m<sup>3</sup>



H.V. = 383 mg/m<sup>3</sup>



H.V. = 115 mg/m<sup>3</sup>

1977 1978

MONTH OF THE YEAR

Figure 16. Chlorophyll *a* ( $\text{mg}/\text{m}^3$ ), Qu'Appelle Valley lakes (H.V. = highest value recorded).

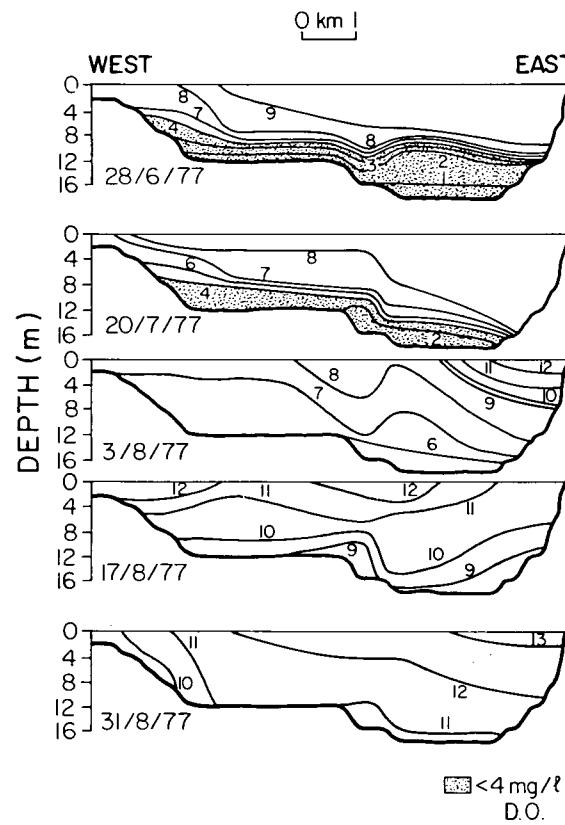


Figure 17. Pasqua Lake, dissolved oxygen (mg/L).

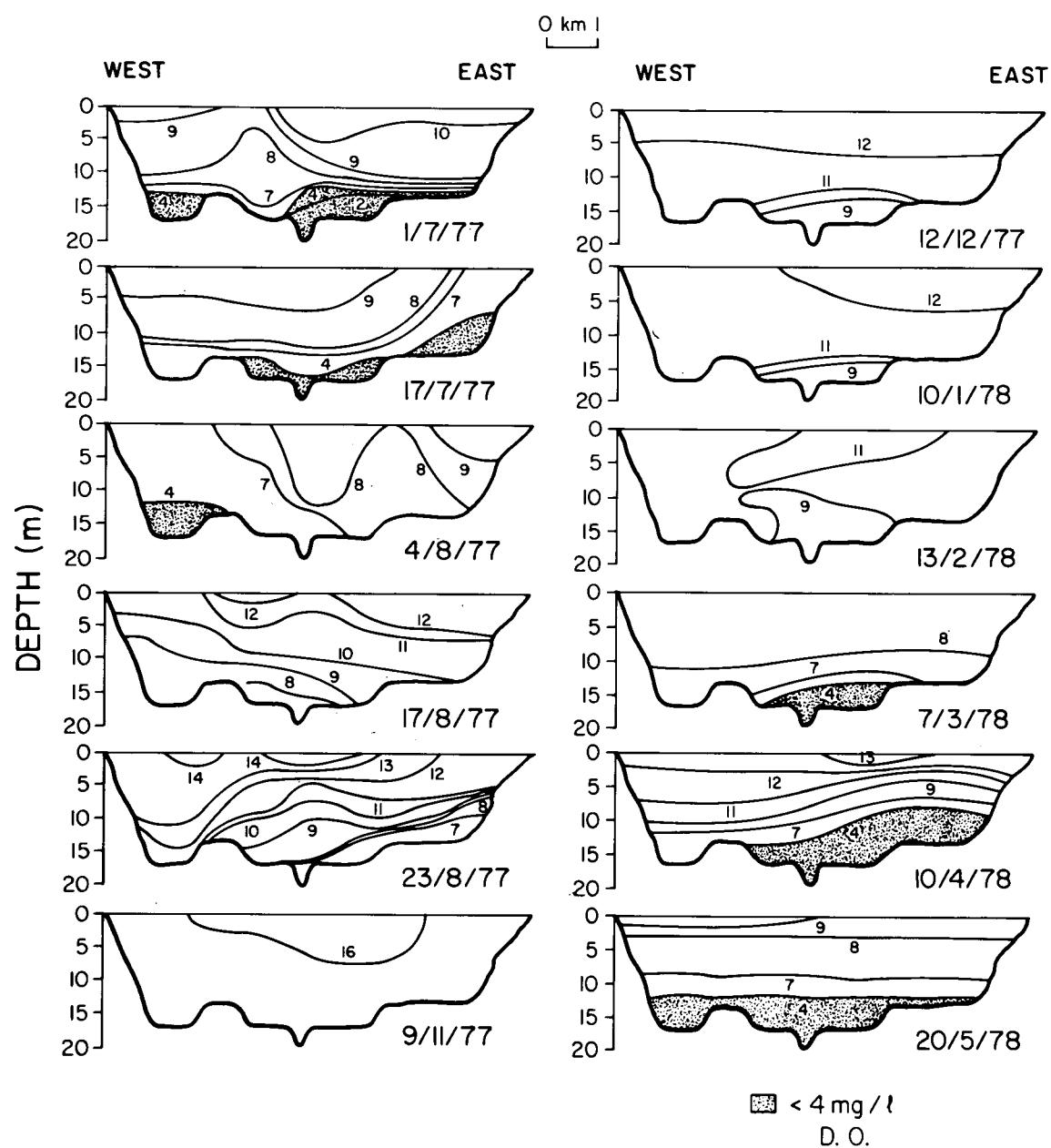


Figure 18. Echo Lake, dissolved oxygen (mg/L).

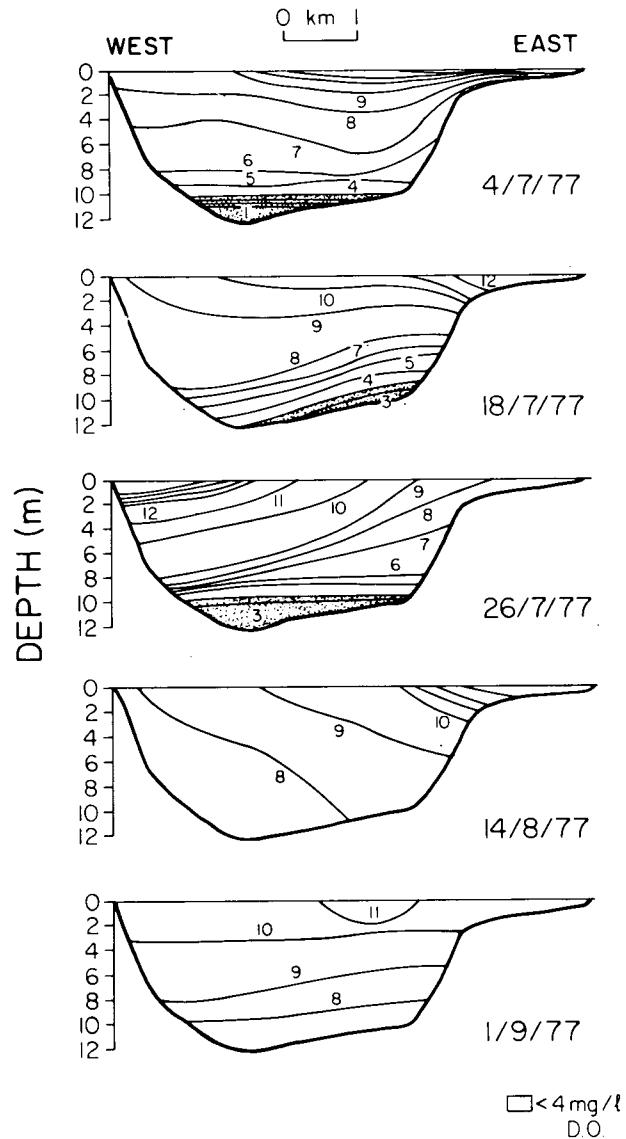


Figure 19. Mission Lake, dissolved oxygen (mg/L).

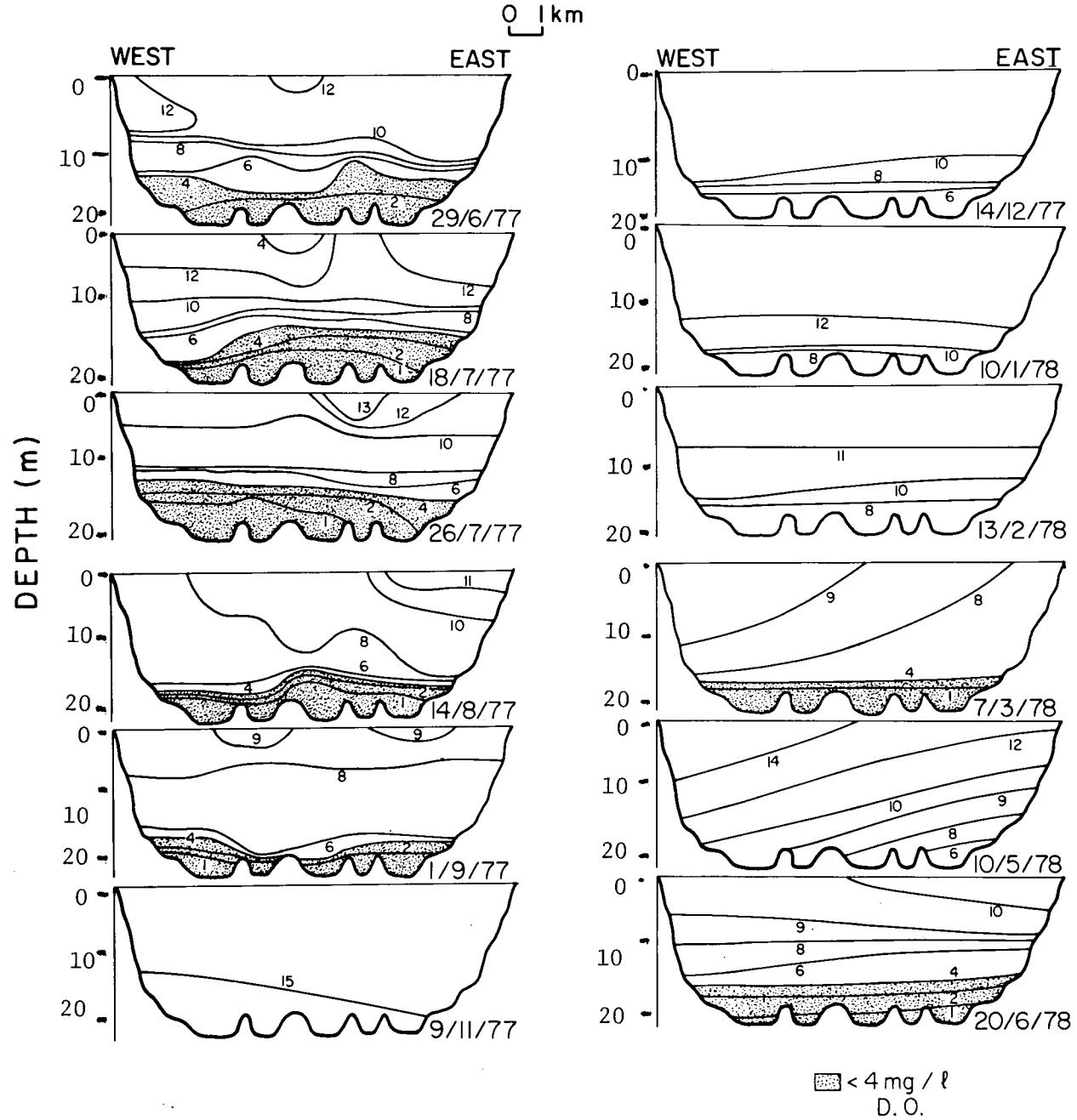


Figure 20. Katepwa Lake, dissolved oxygen (mg/L).

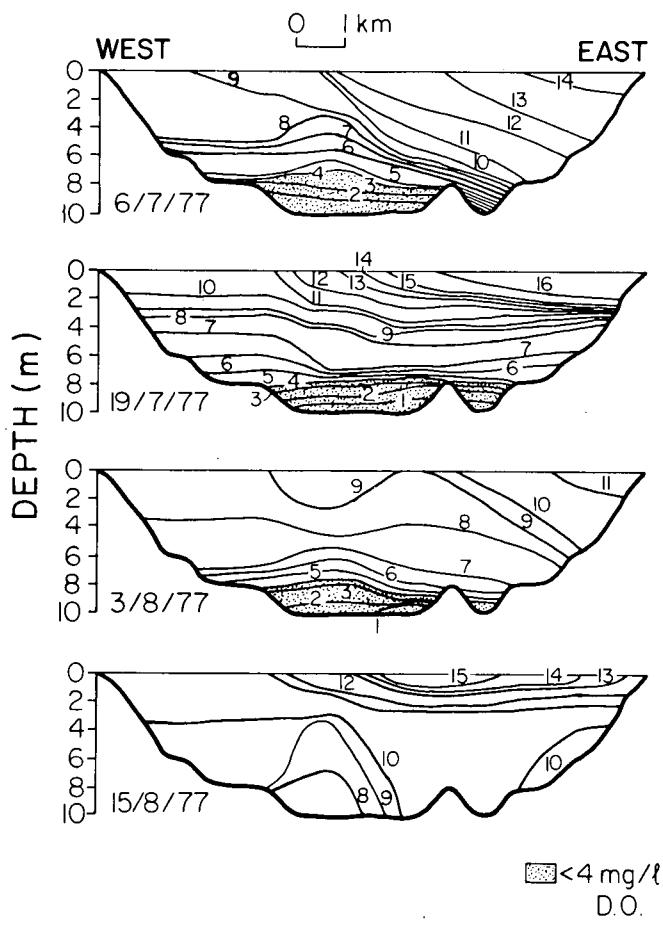


Figure 21. Crooked Lake, dissolved oxygen (mg/L).

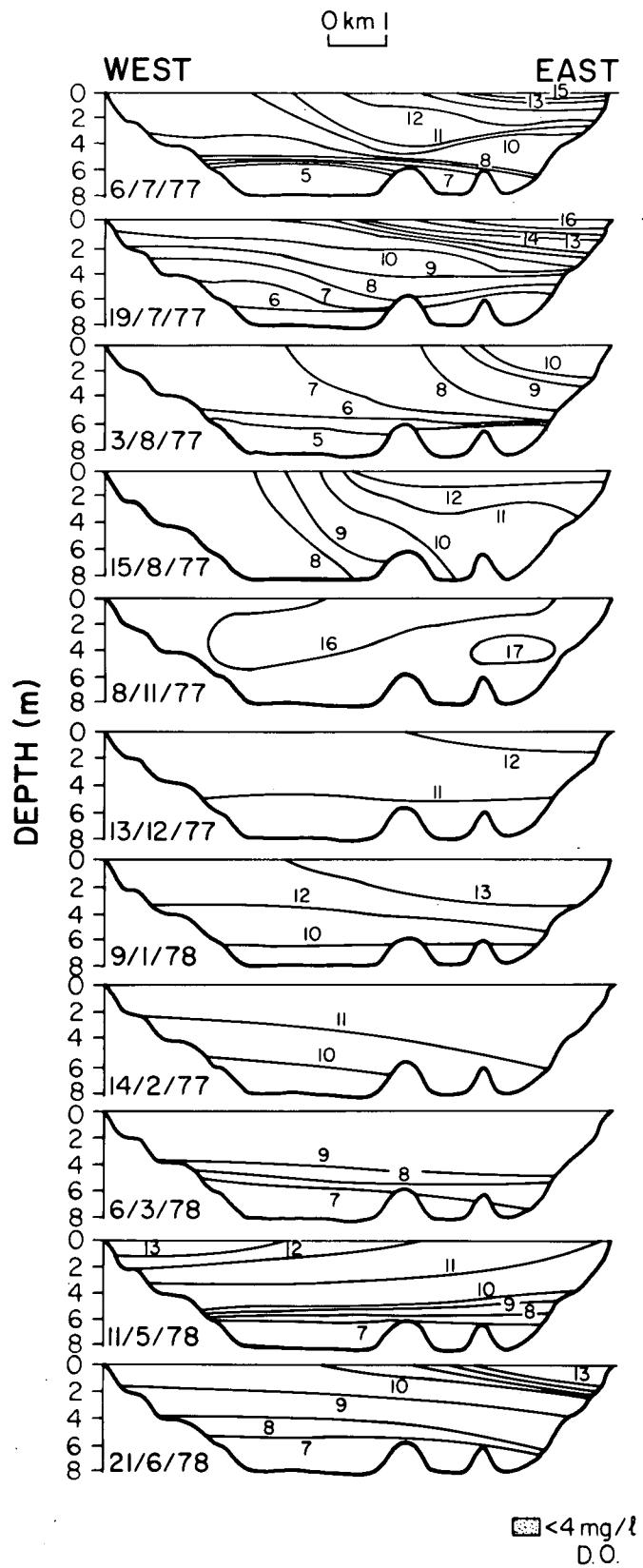


Figure 22. Round Lake, dissolved oxygen (mg/L).

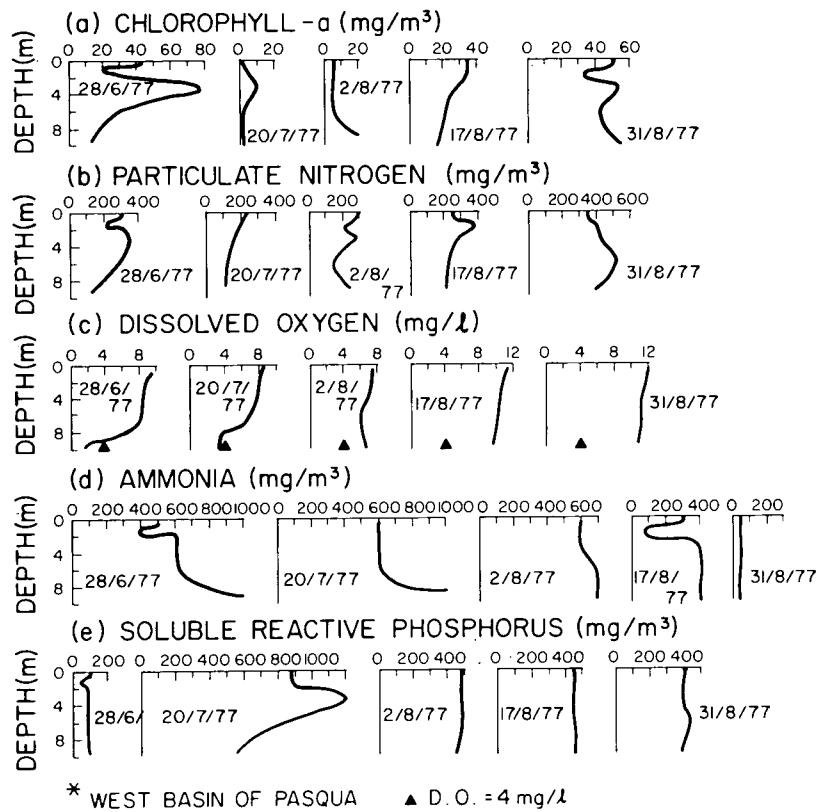


Figure 23. Pasqua Lake (Station 2)\*.

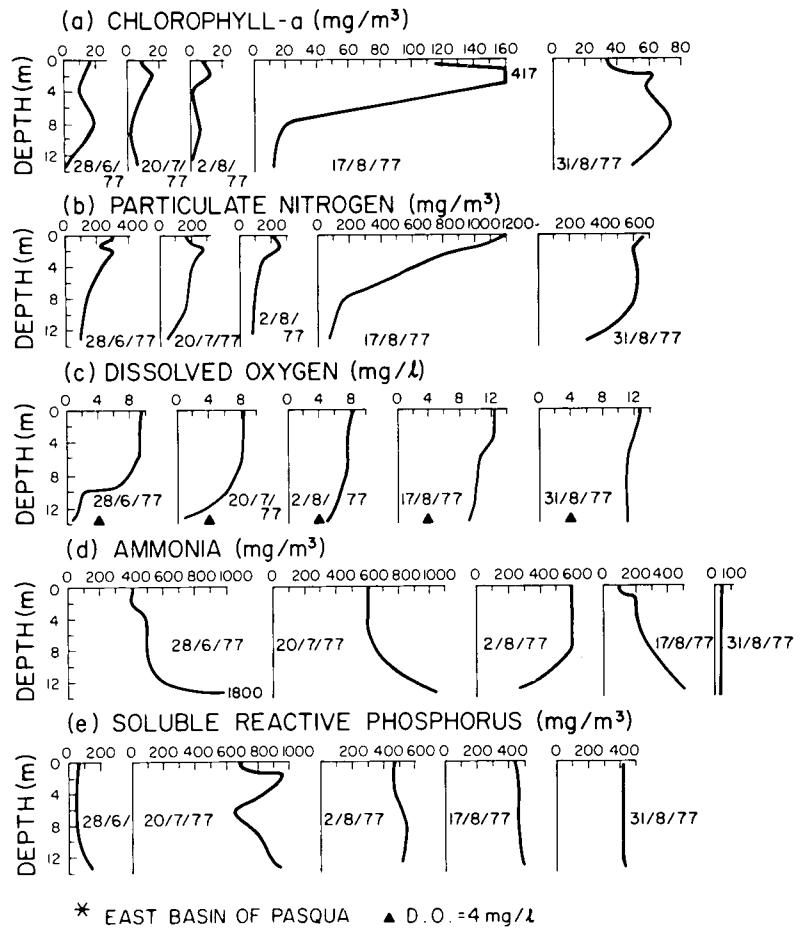


Figure 24. Pasqua Lake (Station 4)\*.

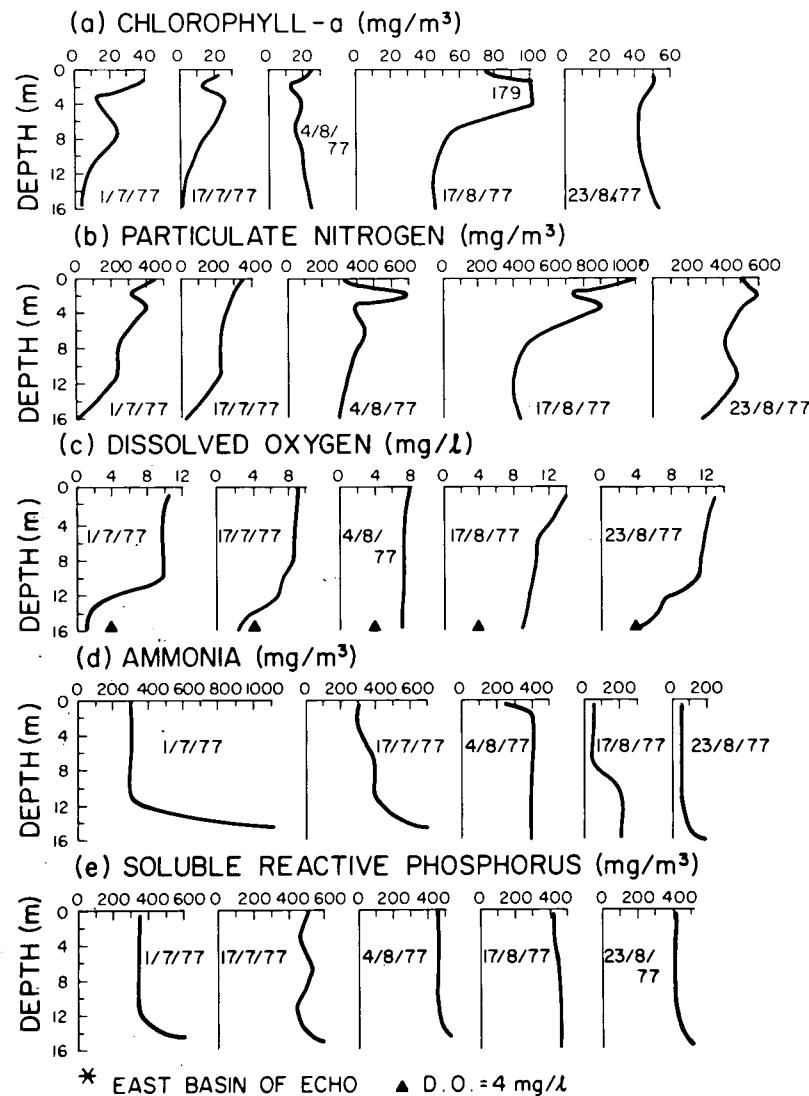
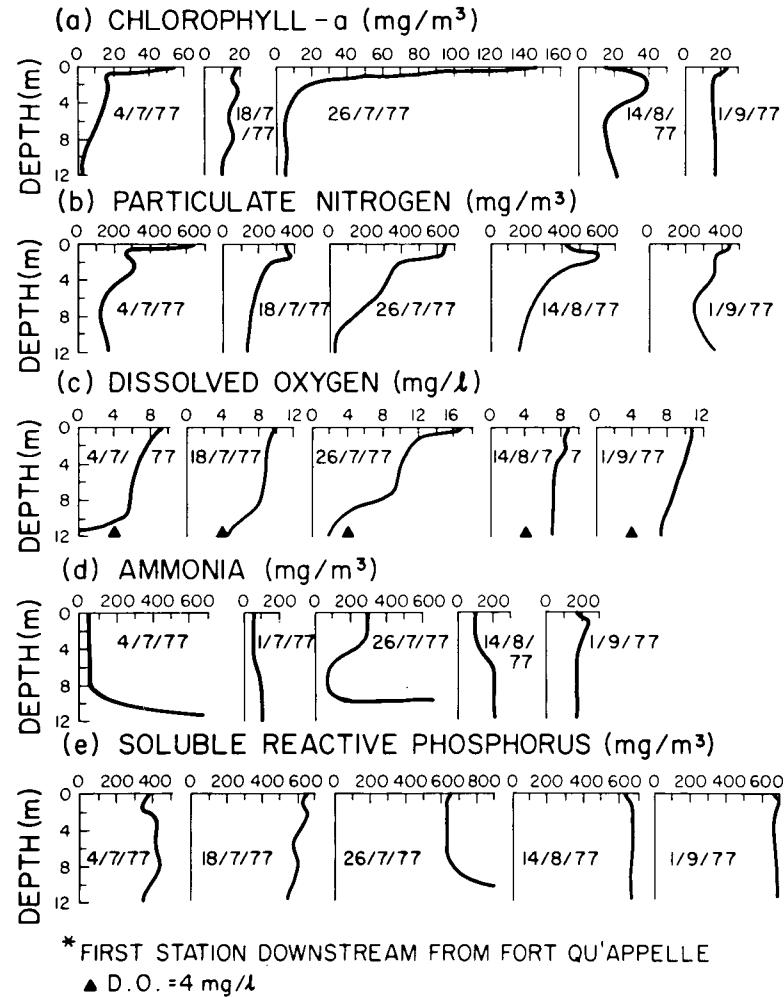


Figure 25. Echo Lake (Station 10)\*.



\* FIRST STATION DOWNSTREAM FROM FORT QU'APPELLE  
▲ D.O. = 4 mg/l

Figure 26. Mission Lake (Station 12)\*.

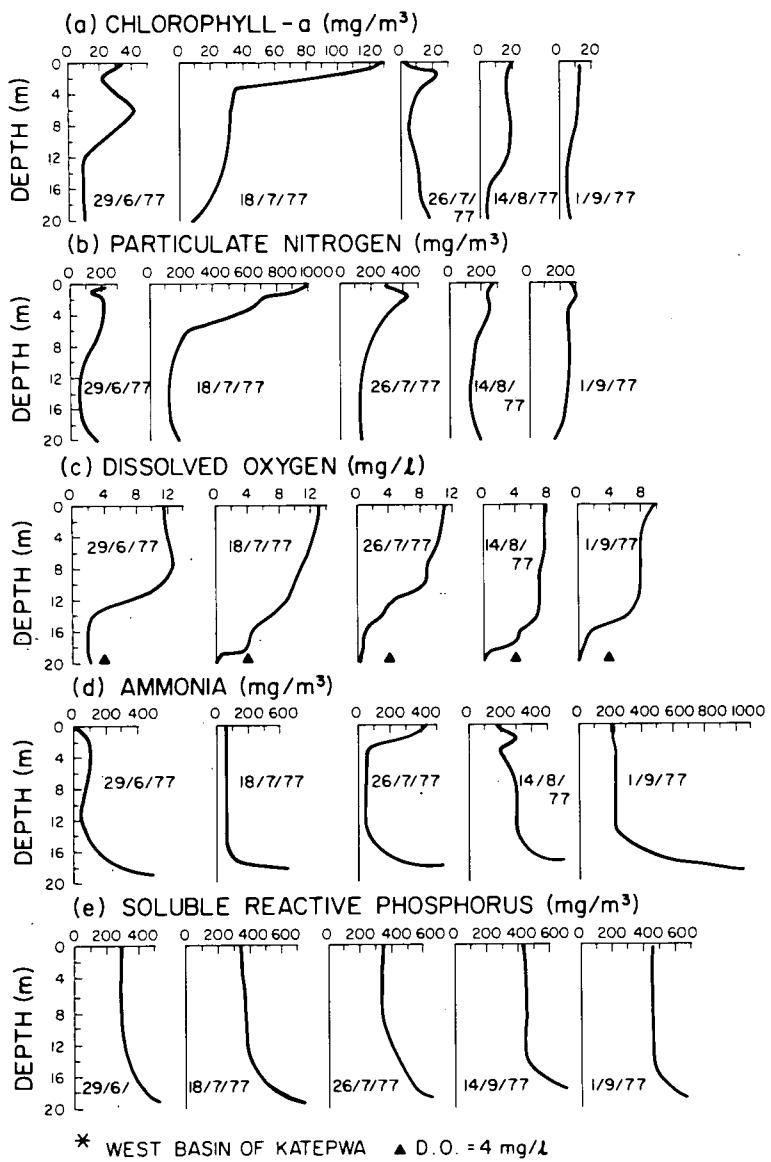


Figure 27. Katepwa Lake (Station 15)\*.

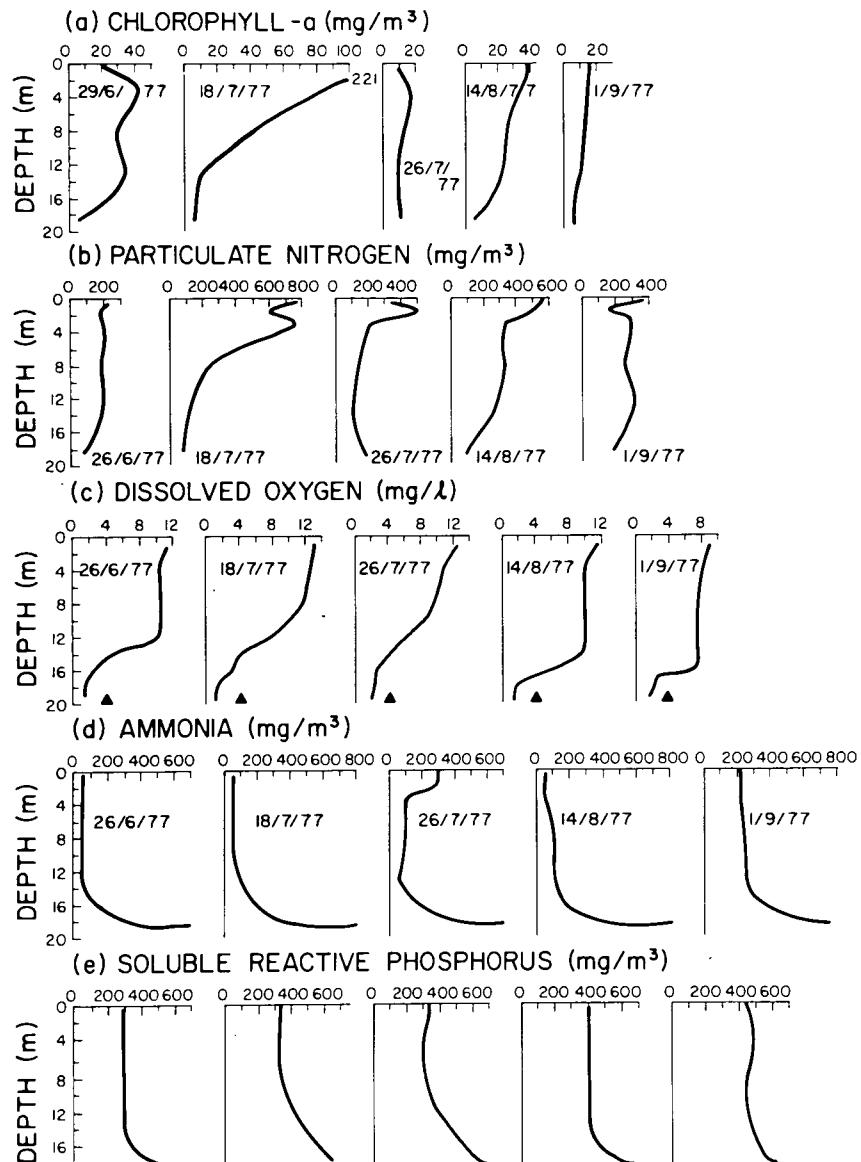
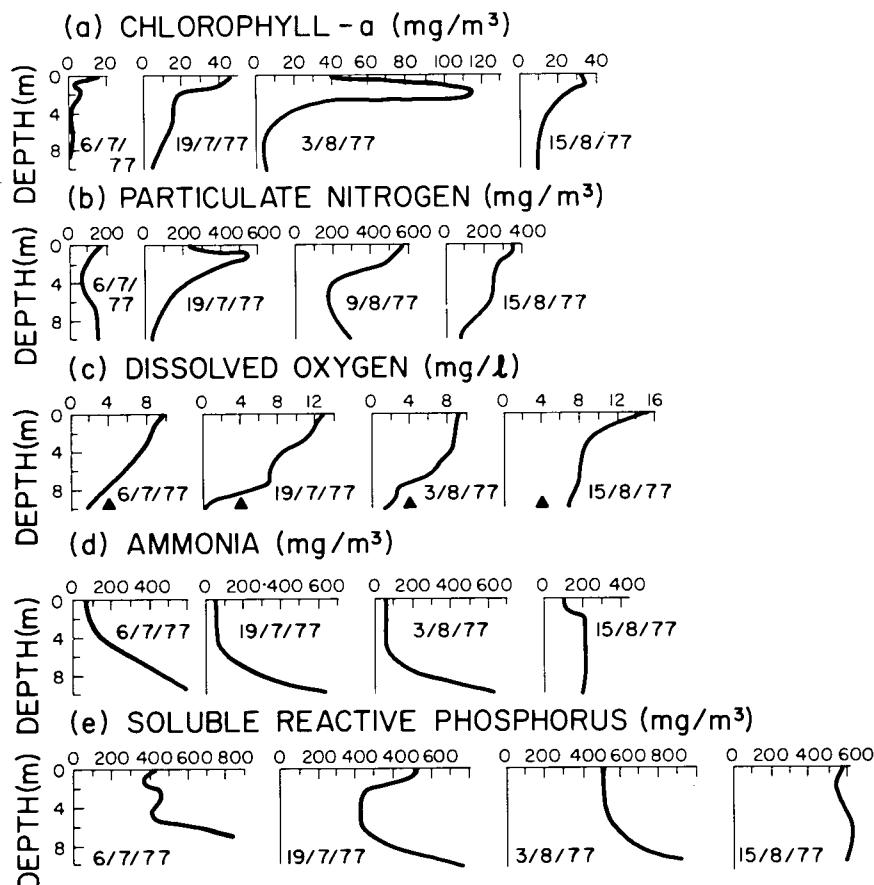
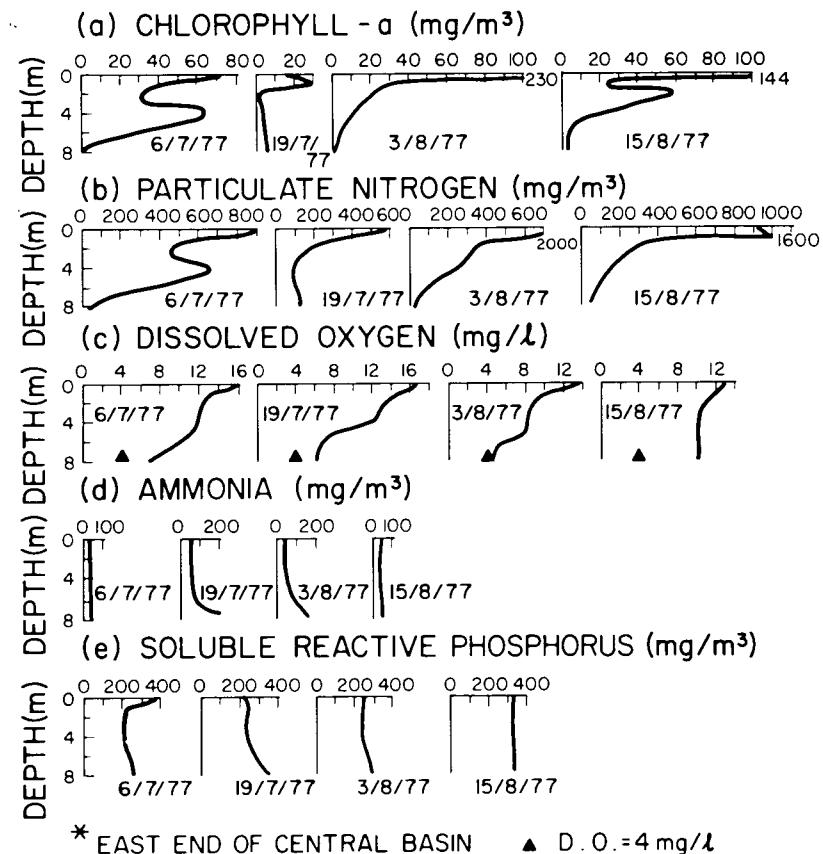


Figure 28. Katepwa Lake (Station 19)\*.



\* CENTRAL STATION IN CROOKED LAKE.  $\Delta \text{D.O.} = 4 \text{ mg/l}$

Figure 29. Crooked Lake (Station 21)\*.



\* EAST END OF CENTRAL BASIN  $\Delta \text{D.O.} = 4 \text{ mg/l}$

Figure 30. Round Lake (Station 26)\*.

## **Appendix**

## **Appendix**

The following tables contain the raw data used in the construction of the diagrams presented in this report. In Figure 3, the sample sites are numbered consecutively. In the tables, each lake is numbered separately from site 1 in the west to higher numbers eastward. Thus Mission Lake station 3 in the tables is site 14 in Figure 3 or Round

Lake station 2 in the tables is site 25 in Figure 3, etc. Tables A-1 to A-6 concern nutrient chemistry and chlorophyll *a* in Pasqua, Echo, Mission, Katepwa, Crooked and Round lakes, respectively. Tables A-7 to A-12 contain basic physical and chemical data for Pasqua, Echo, Mission, Katepwa, Crooked and Round lakes, respectively.

Table A-1. Nutrient Chemistry and Chlorophyll *a*, Pasqua Lake

Station	Date	Depth	PHOSPHORUS		NITROGEN				Chloro-a
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	NH <sub>3</sub>	
		m				mg/m <sup>3</sup>			
2	28/6/77	0.5	480	80	290	1800	280	500	42
		1.0	460	50	210	1800	280	400	22
		1.5	520	83	290	1800	280	600	29
		3.0	520	87	350	1900	260	600	77
		6.0	610	93	290	1800	250	600	29
		9.0	510	93	130	2000	160	1000	16
4	28/6/77	0.5	800	61	290	1700	300	400	--
		1.0	900	65	230	1700	310	400	--
		2.0	550	65	300	1700	310	400	13
		4.0	410	67	230	1800	320	500	10
		8.0	450	68	150	1800	310	500	19
		13.0	670	130	100	--	<10	1800	<1
2	20/7/77	0.5	100	--	210	700	170	600	3
		1.5	1200	890	190	700	170	600	6
		3.0	9400	1200	170	800	170	600	10
		6.0	910	860	120	700	170	600	<1
		8.5	980	600	110	800	280	1000	<1
4	20/7/77	0.5	1500	700	170	1000	170	600	10
		1.5	3100	970	370	600	170	600	16
		3.0	1000	900	220	900	170	600	13
		6.0	1100	650	180	800	170	600	6
		9.0	820	800	170	700	170	700	3
		13.0	1750	925	50	900	90	1050	6
2	2/8/77	0.5	530	490	270	1000	130	600	6
		1.5	570	490	210	1000	100	600	6
		3.0	540	490	280	1000	110	600	6
		6.0	540	490	140	1000	120	700	6
		8.5	560	470	220	1100	120	700	19
4	2/8/77	0.5	540	470	240	1000	130	600	10
		1.5	540	470	260	1000	110	600	13
		3.0	540	470	140	1000	140	600	<1
		8.0	550	540	90	1000	140	600	6
		12.5	540	510	80	1100	110	300	<1
2	17/8/77	0.5	540	450	260	900	120	300	35
		1.5	540	450	380	1000	120	<100	35
		3.0	520	450	270	1000	120	400	29
		6.0	520	450	220	900	120	400	22
		9.0	520	450	210	900	130	400	19
4	17/8/77	0.5	630	450	1150	950	100	100	119
		1.5	600	460	940	1000	100	200	417
		3.0	580	470	700	900	110	200	154
		8.0	510	470	160	900	120	300	19
		13.0	530	490	70	1000	120	500	13
2	31/8/77	0.5	500	400	350	800	20	<100	50
		1.5	510	400	400	900	20	<100	35
		3.0	510	400	420	800	20	<100	54
		6.0	510	440	520	800	40	<100	42
		9.0	520	400	390	800	30	<100	51
4	31/8/77	0.5	550	420	660	800	<10	<100	35
		1.5	560	420	600	800	<10	<100	61
		3.0	540	420	620	700	<10	<100	58
		8.0	560	420	610	800	10	<100	74
		13.0	510	430	300	700	20	<100	51

**Table A-2. Nutrient Chemistry and Chlorophyll *a*, Echo Lake**

Station	Date	Depth	PHOSPHORUS		NITROGEN			Chloro-a	
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>		
		m	-----	-----	mg/m <sup>3</sup>	-----	-----	-----	
3	01/07/77	0.5	480	470	260	1100	60	400	19
		1.5	470	450	190	1100	60	400	13
		3.0	470	440	150	1100	60	300	13
		7.0	480	470	230	1200	60	400	19
		11.0	470	440	140	1200	70	400	--
		15.0	410	400	350	1200	70	400	--
5	01/07/77	0.5	420	350	390	1600	60	300	--
		1.5	420	350	320	1000	70	300	38
		3.0	420	350	400	1000	70	300	13
		7.0	410	350	250	1100	60	300	26
		11.0	420	350	240	1000	70	300	10
		14.5	650	600	90	1800	<10	1100	6
3	17/7/77	0.5	2800	400	450	800	40	200	35
		1.5	1600	440	570	900	40	200	26
		3.0	1700	450	--	900	40	300	70
		7.0	1100	450	290	900	40	200	35
		11.0	2600	450	270	600	40	300	29
		13.5	3700	450	160	700	40	400	6
5	17/7/77	0.5	2150	500	320	700	40	300	21
		1.5	2800	480	--	--	40	300	13
		3.0	--	460	--	--	40	300	26
		7.0	440	540	220	600	40	400	16
		11.0	520	440	220	700	40	400	6
		14.5	1700	520	100	--	30	700	3
3	4/8/77	0.5	590	500	1000	500	60	500	35
		1.5	570	500	930	700	50	500	29
		3.0	560	480	1100	800	60	500	32
		6.0	570	480	430	300	60	500	29
		10.0	570	480	500	600	50	500	22
		12.0	560	480	500	600	60	500	16
5	4/8/77	0.5	550	460	370	650	50	250	24
		1.5	530	470	690	700	50	400	13
		3.0	550	470	390	700	60	400	19
		6.0	570	470	430	600	60	400	16
		10.0	540	470	360	700	60	400	19
		14.0	510	500	320	500	60	400	22
3	17/8/77	0.5	550	430	770	--	70	<100	80
		1.5	540	440	680	600	90	200	54
		3.0	550	450	430	700	80	200	42
		7.0	540	440	460	800	90	200	42
		11.0	560	480	240	1100	80	400	29
		14.0	520	460	400	700	100	300	26
5	17/8/77	0.5	570	420	990	600	20	<100	78
		1.5	560	430	740	600	30	<100	154
		3.0	570	430	900	700	50	<100	179
		7.0	520	450	480	600	70	<100	54
		11.0	520	460	410	600	80	200	45
		14.0	540	460	420	600	70	200	45
3	23/8/77	0.5	470	420	420	600	50	<100	45
		1.5	550	430	370	600	50	<100	48
		3.0	480	430	450	600	50	<100	51
		8.0	530	440	470	800	60	<100	45
		13.0	540	440	410	700	70	100	51
5	23/8/77	0.5	530	420	540	700	15	<100	51
		1.5	540	430	590	700	10	<100	51
		3.0	530	430	520	700	10	<100	45
		7.0	520	420	410	600	20	<100	42
		11.0	540	430	480	800	50	<100	45
		15.0	600	490	330	1100	120	100	51
3	9/11/77	0.5	500	360	290	1260	80	<100	37
		4.0	500	360	440	1300	70	<100	43
		8.0	500	360	490	1280	80	<100	53
		14.0	500	300	570	1260	140	<100	37

Table A-2. (cont.)

Station	Date	Depth	PHOSPHORUS		NITROGEN				Chloro-a
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	NH <sub>3</sub>	
		m	-----	-----	mg/m <sup>3</sup>	-----	-----	-----	-----
5	9/11/77	0.5	400	400	250	1300	80	<100	48
		4.0	400	400	420	1400	80	<100	37
		9.0	400	400	280	1340	80	<100	32
		13.5	400	400	480	1380	90	<100	48
3	14/12/77	0.5	400	400	40	1440	70	<100	<1
		3.0	600	400	60	1400	50	<100	<1
		6.0	600	400	290	1400	60	<100	3
		9.0	600	400	100	1420	60	<100	10
		11.0	500	400	130	1720	60	<100	3
5	14/12/77	0.5	400	400	70	1520	100	<100	--
		4.0	400	400	90	1320	60	<100	3
		7.0	400	400	150	1380	60	<100	6
		10.0	400	400	70	1400	60	<100	6
		14.0	400	400	300	1680	60	<100	10
3	10/1/78	1.0	480	380	60	1100	140	<100	<1
		4.0	460	370	60	1100	140	<100	3
		7.0	--	--	70	1100	160	<100	3
		10.0	480	370	70	960	150	<100	3
		12.5	460	360	70	1000	160	<100	<1
5	10/1/78	1.0	440	380	70	1000	140	<100	3
		4.0	460	380	70	880	140	<100	<1
		7.0	460	380	60	860	150	<100	<1
		11.0	440	370	60	1000	160	<100	3
		14.5	600	500	160	1500	110	<100	3
3	13/2/78	1.0	400	370	60	1100	150	<100	<1
		5.0	410	380	40	1200	160	<100	<1
		9.0	440	380	90	1400	160	<100	2
		13.0	760	470	60	1300	150	<100	2
5	13/2/78	1.0	420	380	30	1400	140	<100	2
		6.0	880	370	50	1400	140	<100	<1
		10.0	430	370	60	1400	150	<100	<1
		14.0	530	470	90	1800	150	<100	<1
3	7/3/78	1.0	420	390	50	--	140	<100	<1
		5.0	350	350	50	1300	160	<100	2
		9.0	410	370	50	1200	150	<100	<1
		13.0	410	350	60	1300	150	<100	2
5	7/3/78	1.0	620	390	40	1600	190	<100	2
		5.0	400	390	40	1500	200	<100	3
		10.0	440	380	50	1500	210	<100	2
		15.0	680	530	240	5200	40	300	6
3	10/5/78	0.1	380	270	400	1300	70	<100	1
		4.0	390	280	360	1200	80	<100	1
		8.0	400	310	310	1400	110	140	1
		12.0	470	410	160	1400	150	350	<1
		16.0	510	420	210	1500	140	430	1
5	10/5/78	0.1	360	250	320	960	40	<100	19
		5.0	410	330	250	1300	120	160	11
		10.0	490	430	100	1500	140	450	4
		14.5	520	440	110	1500	140	490	2
3	20/6/78	0.1	370	290	200	1600	20	<100	8
		5.0	370	300	110	1200	20	<100	14
		10.0	380	320	120	1500	30	<100	<1
		16.0	920	440	180	1500	10	500	<1
5	20/6/78	0.1	380	300	240	910	20	<100	6
		5.0	360	300	80	920	20	<100	<1
		10.0	410	350	100	610	30	<100	3
		14.5	820	420	60	1500	20	<100	7

Table A-3. Nutrient Chemistry and Chlorophyll *a*, Mission Lake

Station	Date	Depth	PHOSPHORUS		NITROGEN				Chloro-a
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	NH <sub>3</sub>	
		m	mg/m <sup>3</sup>						
1	04/07/77	0.5	440	370	510	1400	<10	<100	35
		1.5	460	320	260	1300	<10	<100	16
		3.0	460	410	300	1300	<10	<100	16
		7.0	460	410	140	1400	20	<100	13
		10.0	500	440	130	1500	20	100	6
		13.5	890	360	170	1900	20	600	<1
3	04/07/77	0.5	530	380	1700	1400	<10	<100	58
		1.5	510	380	530	1300	10	<100	26
1	18/07/77	0.5	640	630	360	500	10	<100	19
		1.5	620	610	390	500	10	<100	16
		3.0	680	660	220	600	20	<100	19
		7.0	590	580	200	600	20	<100	13
		10.0	600	600	160	600	30	100	16
		13.5	590	540	130	500	30	100	10
3	18/07/77	0.5	690	600	1100	500	50	<100	54
		1.5	650	570	620	500	<10	<100	77
1	26/07/77	0.5	800	640	640	500	10	300	128
		1.5	760	630	630	500	<10	300	45
		3.0	710	640	390	500	<10	300	13
		8.0	700	640	240	500	<10	<100	6
		12.5	940	870	40	500	100	500	5
		0.5	740	710	170	500	30	200	3
		1.5	700	700	180	600	10	200	3
1	14/08/77	0.5	780	670	460	500	<10	100	29
		1.5	790	680	600	500	<10	100	38
		3.0	790	680	460	500	<10	100	38
		8.0	770	680	290	500	<10	200	13
		13.0	770	680	180	500	<10	200	19
3	14/08/77	0.5	800	660	1090	450	<10	<100	64
		1.5	800	660	500	400	<10	<100	51
1	01/09/77	0.5	740	670	440	620	40	180	22
		1.5	800	680	370	750	30	240	16
		3.0	725	670	370	770	50	210	16
		8.0	780	680	250	780	30	180	
		13.0	780	680	320	790	30	180	19
3	01/09/77	0.5	890	640	2600	620	<10	260	--
		1.5	820	650	1700	650	<10	280	--

**Table A-4. Nutrient Chemistry and Chlorophyll *a*, Katepwa Lake**

Station	Date	Depth	PHOSPHORUS		NITROGEN			Chloro-a
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	
	m		mg/m <sup>3</sup>					
1	29/06/77	0.5	320	290	220	1300	<10	<100
		1.0	330	290	140	1400	<10	<100
		1.5	340	290	200	1300	<10	100
		6.0	340	300	170	1300	<10	100
		12.0	360	320	60	1400	70	<100
		18.5	560	490	100	1700	120	350
5	29/06/77	0.5	340	290	220	1300	10	<100
		1.5	340	290	180	1300	10	<100
		3.0	340	290	200	1400	10	<100
		8.0	330	290	180	1400	10	<100
		13.0	350	290	180	1400	20	<100
		18.5	650	600	70	1900	30	700
1	18/07/77	0.5	380	340	950	600	<10	<100
		1.5	400	340	710	500	<10	<100
		3.0	400	340	650	700	<10	<100
		6.0	390	370	230	500	<10	<100
		12.0	410	390	120	600	60	<100
		18.5	680	620	130	700	20	<100
5	18/07/77	0.5	370	330	770	500	<10	<100
		1.5	400	330	600	500	<10	<100
		3.0	400	330	750	500	10	<100
		8.0	390	350	230	500	20	<100
		13.0	450	450	120	600	140	100
		18.5	740	700	80	800	30	800
1	26/07/77	0.5	410	340	290	500	10	400
		1.5	400	340	440	500	10	300
		3.0	510	340	330	500	10	<100
		8.0	410	340	180	500	10	<100
		13.0	470	420	140	600	120	<100
		18.0	810	590	130	600	30	400
5	26/07/77	0.5	550	340	340	500	10	300
		1.5	390	340	500	500	30	300
		3.0	400	310	210	500	20	100
		8.0	400	310	130	600	120	100
		13.0	510	430	100	600	120	<100
		18.5	790	700	170	900	10	700
1	14/08/77	0.5	520	440	250	500	10	200
		1.5	550	430	230	500	80	300
		3.0	540	450	250	500	10	200
		8.0	540	460	150	600	20	300
		13.0	540	450	120	600	10	300
		15.0	620	530	--	700	10	500
5	14/08/77	0.5	500	400	560	500	10	<100
		1.5	490	400	530	500	10	<100
		3.0	500	400	350	500	10	<100
		8.0	450	400	340	400	10	100
		13.0	480	400	270	400	10	100
		18.5	740	660	100	500	<10	800
1	01/09/77	0.5	510	460	280	640	10	220
		1.5	520	470	300	690	10	210
		3.0	520	470	260	670	10	220
		8.0	500	470	270	650	10	220
		13.0	520	470	240	710	<10	220
		18.5	700	660	200	1115	<10	1050
5	01/09/77	0.5	460	460	360	600	<10	220
		1.5	470	470	160	700	<10	230
		3.0	480	480	290	700	<10	230
		8.0	460	460	250	700	<10	250
		13.0	470	470	300	800	<10	260
		18.5	610	610	180	1200	80	720
1	09/11/77	0.5	600	400	380	1320	220	<100
		6.0	500	400	480	1320	180	<100
		12.0	700	400	240	1320	180	<100
		18.0	700	400	220	1380	180	<100

Table A-4. (cont.)

Station	Date	Depth m	PHOSPHORUS		NITROGEN				Chloro-a
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	NH <sub>3</sub>	
5	09/11/77	0.5	700	500	200	1340	140	<100	32
		6.0	700	500	310	1360	150	<100	37
		12.0	700	500	180	1340	240	<100	43
		18.5	600	500	190	1320	140	<100	21
1	14/12/77	0.5	500	500	120	780	300	<100	16
		5.0	500	500	90	1360	300	<100	10
		10.0	500	500	90	1240	200	<100	10
		15.0	500	460	90	1260	200	<100	10
		19.5	1000	600	180	1760	200	<100	13
2	14/12/77	0.5	500	500	110	1500	200	<100	<1
		5.0	500	500	90	1440	200	<100	6
		10.0	500	500	130	1360	200	<100	6
		15.0	500	400	110	1000	200	<100	3
		19.0	500	500	150	1760	200	<100	29
1	10/01/78	1.0	470	460	80	1000	370	<100	6
		6.0	520	480	80	1000	370	<100	6
		11.0	540	480	80	1200	370	<100	10
		15.0	520	480	90	1000	380	<100	10
		19.5	800	700	300	1400	300	<100	6
5	10/01/78	1.0	660	480	60	960	270	190	13
		6.0	560	480	70	920	270	180	--
		11.0	540	500	70	920	260	<100	6
		15.0	780	460	90	840	240	300	6
		19.0	--	680	370	1560	110	760	13
1	13/02/78	1.0	640	490	50	1900	320	<100	3
		6.0	520	460	50	1600	330	<100	2
		10.0	540	460	40	1500	340	<100	2
		15.0	540	460	50	1400	340	<100	5
		19.5	830	--	140	980	170	<100	5
2	13/02/78	1.0	520	490	50	1400	400	<100	3
		5.0	520	490	50	1400	400	<100	2
		9.0	510	490	40	1300	400	<100	2
		14.0	580	460	60	1500	390	<100	2
		19.0	620	510	230	4600	40	200	2
1	07/03/78	1.0	500	470	40	1500	350	<100	5
		5.0	450	450	40	1400	360	<100	5
		10.0	730	480	<10	1400	360	<100	5
		15.0	490	480	50	1300	360	<100	3
		20.0	800	780	10	2600	30	<100	3
5	07/03/78	1.0	500	410	50	1400	400	<100	2
		5.0	520	460	<10	1400	420	<100	2
		10.0	500	480	50	1400	420	<100	2
		15.0	560	560	50	1500	420	<100	3
		18.9	1100	880	30	2800	30	100	13
1	10/05/78	0.1	480	380	340	1100	110	<100	2
		5.0	470	380	370	1200	110	<100	2
		10.0	480	370	250	1200	150	<100	2
		15.0	500	230	230	1500	220	<100	3
		18.8	490	240	320	1400	230	<100	1
5	10/05/78	0.1	660	540	220	1200	130	<100	2
		5.0	530	440	160	1300	180	<100	2
		10.0	650	470	220	1400	210	110	2
		15.0	580	500	120	1400	260	150	1
		19.0	630	540	130	1600	220	310	1
1	20/06/78	0.1	430	370	150	1400	10	<100	15
		6.0	440	350	160	930	10	<100	17
		12.0	450	370	100	920	20	<100	8
		19.0	680	540	160	1700	20	600	3
5	20/06/78	0.1	450	350	190	900	10	<100	14
		6.0	440	350	320	840	70	<100	17
		12.0	480	410	160	1500	30	<100	6
		19.0	900	580	260	1600	30	800	11

**Table A-5. Nutrient Chemistry and Chlorophyll *a*, Crooked Lake**

Station	Date	Depth	PHOSPHORUS			NITROGEN			
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	NH <sub>3</sub>	Chloro-a
		m	- - - - -	- - - - -	- - - - -	mg/m <sup>3</sup>	- - - - -	- - - - -	- - - - -
2	06/07/77	0.5	410	400	150	800	40	<100	10
		1.5	390	370	110	800	40	<100	3
		3.0	470	450	90	700	40	<100	6
		6.0	420	400	70	800	80	150	<1
		9.0	750	650	110	1200	160	310	<1
		11.5	--	--	--	--	--	--	--
4	06/07/77	0.5	390	360	510	700	<10	<100	80
		1.5	420	370	470	700	<10	<100	51
		3.0	310	300	470	200	10	<100	70
		6.0	390	320	330	700	<10	<100	67
2	19/07/77	0.5	--	--	290	600	<10	<100	45
		1.5	3200	690	590	500	<10	<100	42
		3.0	860	450	420	500	<10	<100	13
		7.0	900	440	140	500	10	<100	16
		14.5	1200	860	60	800	230	500	6
4	19/07/77	0.5	910	470	--	500	<10	<100	237
		1.5	1150	480	--	600	<10	<100	150
		3.0	700	410	--	500	<10	<100	109
		6.0	670	460	190	500	20	<100	13
2	03/08/77	0.5	590	500	550	400	30	<100	48
		1.5	590	500	520	400	30	<100	103
		3.0	590	500	490	500	30	<100	115
		8.0	590	520	170	500	40	<100	3
		14.0	860	780	290	600	80	500	6
4	03/08/77	0.5	800	430	2500	500	<10	<100	718
		1.5	720	450	2000	400	<10	<100	461
		3.0	700	470	2500	500	<10	<100	256
		6.0	610	500	690	500	10	<100	128
2	15/08/77	0.5	670	570	350	500	50	100	32
		1.5	680	580	350	400	50	100	35
		3.0	660	590	270	400	50	200	26
		9.0	660	600	230	400	60	200	10
		14.0	660	590	90	500	50	200	10
4	15/08/77	0.5	760	550	1350	400	10	<100	430
		1.5	710	550	1200	300	10	<100	256
		3.0	730	570	210	300	40	<100	38
		5.5	620	570	300	400	30	<100	35

**Table A-6. Nutrient Chemistry and Chlorophyll *a*, Round Lake**

Station	Date	Depth m	PHOSPHORUS		NITROGEN				Chloro-a
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	NH <sub>3</sub>	
mg/m <sup>3</sup>									
1	06/07/77	0.5	280	260	115	650	15	<100	6
		1.5	290	290	130	700	10	<100	<1
		3.0	320	280	110	700	10	<100	6
		6.0	290	270	110	700	10	<100	<1
		9.0	290	280	80	700	30	110	<1
3	06/07/77	0.5	320	310	850	700	<10	120	64
		1.5	300	210	630	600	<10	<100	45
		3.0	320	210	490	600	<10	<100	32
		6.0	290	270	670	600	<10	<100	61
		10.0	250	250	190	600	10	<100	6
1	19/07/77	0.5	665	260	275	500	10	<100	18
		1.5	420	250	210	500	10	<100	13
		3.0	440	250	210	500	10	<100	3
		6.0	500	260	100	500	20	100	<1
		8.0	760	270	100	600	40	100	<1
3	19/07/77	0.5	1100	230	530	600	10	<100	19
		1.5	600	250	480	600	10	<100	29
		3.0	550	240	190	500	10	<100	<1
		6.0	530	240	100	600	20	<100	3
		10.0	700	320	120	600	50	200	6
1	03/08/77	0.5	370	275	180	500	45	<100	1
		1.5	350	280	140	500	40	100	6
		3.0	390	290	180	500	50	200	3
		6.0	340	290	110	500	50	200	<1
		9.5	360	300	160	500	90	200	3
3	03/08/77	0.5	680	240	200	500	<10	<100	230
		1.5	400	250	610	400	<10	<100	32
		3.0	510	250	360	500	30	<100	22
		6.0	350	240	280	500	30	<100	13
		9.0	350	280	60	500	60	<100	6
1	15/08/77	0.5	360	330	110	400	80	<100	6
		1.5	360	320	150	600	100	<100	6
		3.0	380	340	120	600	90	<100	3
		6.0	380	340	80	700	80	<100	3
		10.0	360	340	100	700	80	<100	<1
3	15/08/77	0.5	460	305	975	600	<10	<100	144
		1.5	370	320	1600	500	<10	<100	26
		3.0	400	320	300	500	<10	<100	58
		6.0	380	320	180	600	20	<100	26
		9.0	360	320	100	600	20	<100	3
1	08/11/77	0.5	320	220	200	780	80	<100	--
		4.0	340	220	330	790	30	<100	--
		7.0	370	220	210	800	50	<100	--
		11.0	330	220	250	800	180	<100	--
3	08/11/77	0.5	320	210	170	790	40	<100	--
		3.0	320	280	260	780	<10	<100	--
		6.0	320	210	210	810	50	<100	--
		9.5	320	210	210	770	10	<100	--
1	13/12/77	0.5	360	300	80	700	<10	<100	3
		3.0	300	300	60	760	<10	<100	<1
		6.0	320	260	50	760	<10	<100	3
		9.0	300	300	50	780	10	<100	<1

Table A-6. (cont.)

Station	Date	Depth	PHOSPHORUS		NITROGEN				Chloro-a
			TP	SRP	PART-N	TDN	NO <sub>3</sub> +NO <sub>2</sub>	NH <sub>3</sub>	
		m	- - - - -	- - - - -	mg/m <sup>3</sup>	- - - - -	- - - - -	- - - - -	- - - - -
3	13/12/77	0.5	360	240	<10	680	<10	<100	<1
		2.0	320	320	50	640	60	<100	<1
		3.5	340	240	50	760	10	<100	<1
		6.0	280	250	70	680	10	<100	<1
1	09/01/78	1.0	260	240	50	600	20	<100	3
		3.0	250	240	50	580	70	<100	3
		6.0	260	240	80	520	10	<100	3
		8.0	300	--	120	600	90	<100	<1
3	09/01/78	1.0	260	260	40	580	40	<100	6
		4.0	260	260	40	560	20	<100	<1
		7.0	260	260	70	580	10	<100	3
		10.0	240	220	140	460	20	<100	3
1	14/02/78	1.0	280	230	40	940	15	<100	<1
		3.0	280	230	40	820	15	<100	<1
		6.0	280	230	60	800	20	<100	<1
		9.5	400	240	530	980	30	<100	<1
3	14/02/78	1.0	270	230	70	740	10	<100	<1
		4.0	270	230	50	720	10	<100	<1
		7.0	270	230	70	680	10	<100	<1
		10.5	270	230	100	620	20	<100	<1
1	06/03/78	1.0	260	240	60	840	10	<100	2
		4.0	260	240	60	920	20	<100	2
		7.0	280	250	40	880	30	<100	<1
		9.0	280	260	50	810	30	<100	2
3	06/03/78	1.0	260	230	50	940	10	<100	2
		4.0	260	230	40	860	10	<100	<1
		7.0	260	230	30	940	10	<100	3
		10.0	270	220	90	860	20	<100	8
1	11/05/78	0.1	250	190	140	850	<10	<100	2
		4.0	260	200	150	820	<10	<100	4
		7.0	320	--	160	840	<10	<100	2
		10.0	500	220	290	900	<10	<100	8
3	11/05/78	0.1	270	210	170	830	<10	<100	7
		4.0	210	--	160	870	10	<100	6
		7.0	330	260	150	870	<10	<100	2
		11.0	430	320	350	900	<10	<100	4
1	21/06/78	0.1	310	250	250	760	<10	<100	11
		4.0	310	250	210	770	<10	<100	8
		7.0	310	250	150	790	<10	<100	8
		10.5	360	250	260	760	<10	<100	19
3	21/06/78	0.1	680	230	2900	840	<10	200	--
		4.0	290	230	270	800	<10	<100	14
		8.0	300	240	170	790	<10	<100	8
		11.0	320	250	220	780	10	<100	11

**Table A-7. Basic Physical and Chemical Data, Pasqua Lake**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos		m
1 Total Depth=5.8m	28/06/77	1.0	19.0	7.8	2000	8.5	0.4
		2.0	18.5	7.8	2000	8.4	
		3.0	18.5	7.7	2000	8.4	
		4.0	18.5	7.5	2000	8.3	
		5.0	18.0	6.7	2100	8.2	
		5.8	17.5	3.4	2100	8.0	
2 Total Depth=9.6m		1.0	18.5	9.4	2000	8.4	1.3
		2.0	18.0	9.4	2100	8.3	
		3.0	18.0	8.8	2100	8.3	
		4.0	18.0	8.6	2100	8.3	
		5.0	18.0	8.6	2100	8.3	
		6.0	18.0	8.5	2100	8.3	
		7.0	17.5	7.9	2100	8.3	
		8.0	17.5	7.1	2100	8.3	
		9.0	18.0	2.5	2100	8.3	
		9.6	17.0	1.8	2100	8.1	
3 Total Depth=11.9m		1.0	19.0	9.2	2000	8.1	1.6
		2.0	19.0	9.3	2100	8.2	
		3.0	19.0	9.3	2100	8.2	
		4.0	19.0	9.3	2100	8.2	
		5.0	18.5	9.3	2100	8.2	
		6.0	18.5	8.5	2100	8.2	
		7.0	18.0	8.5	2100	8.2	
		8.0	18.0	8.4	2100	8.2	
		9.0	17.5	7.4	2100	8.2	
		10.0	17.0	6.6	2100	8.2	
		11.0	17.0	2.1	2100	8.1	
		11.9	17.0	1.5	2100	7.9	
		1.0	19.0	9.4	2100	8.1	1.6
		2.0	18.7	9.4	2200	8.2	
		3.0	18.5	9.5	2200	8.3	
4 Total Depth=13.4m		4.0	18.5	9.4	2200	8.3	
		5.0	18.5	9.2	2200	8.3	
		6.0	18.5	9.2	2200	8.3	
		7.0	18.5	9.0	2200	8.3	
		8.0	16.5	6.5	2200	8.3	
		9.0	16.5	6.5	2200	8.3	
		10.0	16.0	2.0	2200	8.0	
		11.0	16.0	2.0	2200	7.9	
		12.0	15.5	1.7	2200	7.9	
		13.0	15.5	1.6	2200	7.8	
		13.4	15.5	1.0	2200	7.8	

**Table A-7. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos		m
1 Total Depth=5.5m	20/07/77	1.0	20.0	8.2	2000	8.4	1.1
		2.0	20.0	8.0	2100	8.3	
		3.0	20.0	6.9	2200	8.3	
		4.0	20.0	6.8	2200	8.2	
		5.0	20.0	4.9	2250	8.2	
		1.0	20.0	8.3	2150	8.5	1.6
2 Total Depth=9.5m		2.0	20.0	7.9	2150	8.5	
		3.0	20.0	7.8	2150	8.5	
		4.0	20.0	7.8	2200	8.4	
		5.0	20.0	7.6	2250	8.4	
		6.0	19.5	7.5	2300	8.5	
		7.0	19.5	6.0	2300	8.5	
		8.0	19.5	3.5	2300	8.5	
		9.0	19.5	3.5	2300	8.5	
		1.0	20.0	8.2	2300	8.4	1.6
		2.0	20.0	7.9	2400	8.4	
3 Total Depth=11.8m		3.0	20.0	7.8	2400	8.4	
		4.0	20.0	7.7	2500	8.4	
		5.0	19.5	7.6	2500	8.4	
		6.0	19.5	7.6	2500	8.4	
		7.0	19.0	7.5	2500	8.4	
		8.0	19.0	4.6	2500	8.4	
		9.0	19.0	3.8	2500	8.4	
		10.0	19.0	1.5	2500	8.2	
		11.0	19.0	0.8	2500	8.1	
		11.5	19.0	0.6	2500	8.0	
		1.0	20.0	8.3	2100	8.6	1.5
		2.0	20.0	8.2	2200	8.6	
4 Total Depth=13.5m		3.0	20.0	8.1	2300	8.6	
		4.0	20.0	8.1	2300	8.6	
		5.0	20.0	8.0	2300	8.6	
		6.0	20.0	8.0	2300	8.6	
		7.0	20.0	8.0	2300	8.6	
		8.0	19.5	7.9	2300	8.6	
		9.0	19.5	7.8	2300	8.6	
		10.0	19.5	6.2	2300	8.6	
		11.0	19.0	6.1	2300	8.6	
		12.0	19.0	3.6	2300	8.6	
		13.0	19.0	1.2	2350	8.5	
		1.0	20.5	8.9	2100	8.5	1.6
		2.0	20.5	8.8	2100	8.5	
5 Total Depth=12.9m		3.0	20.5	8.8	2100	8.5	
		4.0	20.5	8.6	2300	8.5	
		5.0	20.5	8.6	2400	8.5	
		6.0	20.5	8.6	2500	8.5	
		7.0	20.5	8.5	2500	8.5	
		8.0	20.0	8.5	2500	8.5	
		9.0	20.0	8.5	2500	8.5	
		10.0	20.0	8.7	2500	8.5	
		11.0	20.0	8.6	2500	8.5	
		12.0	20.0	8.6	2500	8.5	
		12.5	20.0	8.0	2500	8.5	

**Table A-7. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
			m	°C	mg/l	μmhos	m
1	02/08/77	1.0	19.5	7.1	2100	8.6	1.2
		2.0	19.0	7.0	2000	8.6	
		3.0	19.0	6.9	2000	8.6	
		4.0	19.0	6.8	2100	8.6	
		5.0	19.0	6.8	2100	8.6	
2		1.0	20.0	7.5	2250	9.0	1.3
		2.0	19.7	7.2	2300	9.0	
		3.0	19.7	7.0	2300	9.0	
		4.0	19.7	6.8	2300	9.0	
		5.0	19.5	6.4	2300	8.9	
		6.0	19.5	6.0	2300	8.9	
		7.0	19.5	6.4	2300	8.8	
		8.0	19.5	6.5	2300	8.7	
		9.0	19.5	6.5	2300	8.6	
		10.0	19.5	6.5	2300	8.6	
3		1.0	20.0	8.6	2300	9.1	
		2.0	20.0	8.5	2300	9.1	
		3.0	20.0	8.3	2300	9.1	
		4.0	19.7	8.1	2300	9.1	
		5.0	19.7	8.0	2300	9.1	
		6.0	19.7	8.6	2300	9.1	
		7.0	19.7	8.9	2300	9.0	
		8.0	19.7	8.8	2350	9.0	
		9.0	19.7	8.7	2350	9.0	
		10.0	19.7	7.2	2400	9.0	
		11.0	19.7	5.9	2400	9.0	
		11.5	19.7	5.1	2400	9.0	
		12.0	19.7	5.1	2400	9.0	
4		1.0	20.0	8.0	2350	8.7	1.8
		2.0	20.0	7.9	2300	8.7	
		3.0	20.0	7.8	2350	8.7	
		4.0	20.0	7.8	2350	8.9	
		5.0	20.0	7.9	2350	8.8	
		6.0	20.0	7.8	2350	8.8	
		7.0	20.0	7.0	2350	8.7	
		8.0	20.0	7.0	2400	8.7	
		9.0	20.0	6.9	2400	8.7	
		10.0	20.0	6.5	2400	8.7	
		11.0	20.0	6.2	2400	8.7	
		12.0	19.7	6.0	2400	8.7	
		13.0	19.7	5.4	2400	8.7	
5		1.0	20.5	12.0	2450	9.0	0.7
		2.0	20.5	11.2	2500	9.0	
		3.0	20.0	11.2	2500	8.9	
		4.0	20.0	10.4	2500	8.9	
		5.0	20.0	10.2	2500	8.8	
		6.0	20.0	8.3	2500	8.9	
		7.0	20.0	8.2	2500	8.9	
		8.0	20.0	8.1	2500	8.9	
		9.0	20.0	8.1	2500	8.9	
		10.0	20.0	8.0	2500	8.9	
		11.0	20.0	7.9	2500	8.9	
		12.0	20.0	7.7	2500	8.9	
		12.5	20.0	6.1	2500	8.9	

**Table A-7. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos	m	
1	17/08/77	1.0	17.0	12.4	2400	8.6	1.4
		2.0	16.7	12.2	2400	8.6	
		3.0	16.7	12.0	2400	8.5	
		4.0	16.7	11.8	2400	8.5	
		5.0	16.7	11.7	2400	8.4	
2		1.0	17.5	11.4	2400	8.6	1.5
		2.0	17.3	11.2	2400	8.6	
		3.0	17.3	10.6	2350	8.6	
		4.0	17.3	10.6	2400	8.5	
		5.0	17.0	10.2	2350	8.5	
		6.0	17.0	10.2	2350	8.5	
		7.0	17.0	10.1	2350	8.5	
		8.0	17.0	10.0	2350	8.5	
		9.0	17.0	9.7	2400	8.5	
		10.0	17.0	9.6	2400	8.5	
3		1.0	17.7	12.0	2350	8.7	1.3
		2.0	17.7	12.0	2350	8.7	
		3.0	17.7	11.9	2350	8.7	
		4.0	17.7	11.8	2350	8.7	
		5.0	17.5	11.6	2350	8.7	
		6.0	17.5	11.0	2400	8.7	
		7.0	17.3	10.1	2400	8.7	
		8.0	17.0	9.8	2400	8.7	
		9.0	17.0	8.8	2400	8.6	
		10.0	17.0	8.6	2400	8.6	
4		1.0	17.7	12.4	2400	8.8	1.2
		2.0	17.5	12.3	2450	8.8	
		3.0	17.5	12.2	2500	8.8	
		4.0	17.5	11.8	2500	8.8	
		5.0	17.5	10.6	2500	8.8	
		6.0	17.5	10.4	2550	8.8	
		7.0	17.5	10.3	2550	8.8	
		8.0	17.5	10.3	2600	8.8	
		9.0	17.4	10.2	2600	8.8	
		10.0	17.3	10.1	2600	8.7	
5		1.0	17.7	10.8	2400	8.5	2.0
		2.0	17.7	10.7	2400	8.5	
		3.0	17.5	10.7	2450	8.5	
		4.0	17.5	10.6	2450	8.5	
		5.0	17.5	10.4	2450	8.5	
		6.0	17.5	10.1	2450	8.5	
		7.0	17.5	9.6	2500	8.4	
		8.0	17.5	9.4	2500	8.5	
		9.0	17.3	9.3	2500	8.5	
		10.0	17.3	9.2	2500	8.4	
Total		11.0	17.3	8.8	2550	8.4	
		12.0	17.3	8.3	2550	8.4	
		12.5	17.3	8.3	2550	8.4	

**Table A-7. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos		m
1 Total Depth=5.7m	31/08/77	1.0	16.5	10.4	2000	8.8	0.9
		2.0	16.5	10.3	2050	8.7	
		3.0	16.5	10.2	2050	8.7	
		4.0	16.5	9.6	2100	8.7	
		5.0	16.5	9.6	2100	8.8	
2		1.0	16.5	12.0	2600	8.8	
		2.0	16.5	11.9	2650	8.8	
		3.0	16.5	11.4	2650	8.8	
		4.0	16.5	11.3	2700	8.8	
		5.0	16.5	11.5	2700	8.8	
		6.0	16.3	11.4	2700	8.8	
		7.0	16.3	11.4	2700	8.8	
		8.0	16.0	11.3	2700	8.8	
		9.0	16.0	11.2	2700	8.8	
		10.0					
3 Total Depth=11.8m		1.0	16.7	12.8	2450	8.8	1.0
		2.0	16.7	12.7	2450	8.8	
		3.0	16.7	12.2	2450	8.8	
		4.0	16.5	12.0	2450	8.8	
		5.0	16.5	11.8	2400	8.8	
		6.0	16.5	11.5	2400	8.8	
		7.0	16.5	11.4	2400	8.8	
		8.0	16.3	11.3	2400	8.8	
		9.0	16.3	11.2	2400	8.8	
		10.0	16.3	11.0	2400	8.8	
		11.0	16.3	10.8	2350	8.8	
		11.5	16.3	10.7	2350	8.8	
4 Total Depth=13.4m		1.0	17.0	12.6	2650	8.9	0.9
		2.0	17.0	12.4	2650	8.9	
		3.0	17.0	12.2	2650	8.9	
		4.0	17.0	12.0	2700	8.9	
		5.0	16.7	11.8	2700	8.9	
		6.0	16.7	11.5	2700	8.9	
		7.0	16.7	11.4	2700	8.9	
		8.0	16.5	11.3	2700	8.9	
		9.0	16.5	11.2	2750	8.8	
		10.0	16.5	11.2	2750	8.8	
		11.0	16.5	11.1	2750	8.8	
		12.0	16.5	11.1	2750	8.7	
		13.0	16.5	2750	11.0	8.6	
5 Total Depth=13.7m		1.0	17.0	13.4	2400	8.9	0.6
		2.0	17.0	12.8	2400	8.9	
		3.0	17.0	12.5	2400	8.9	
		4.0	17.0	12.4	2400	8.9	
		5.0	17.0	12.3	2400	8.9	
		6.0	17.0	12.3	2400	8.9	
		7.0	16.7	12.2	2400	8.8	
		8.0	16.7	12.1	2400	8.8	
		9.0	16.7	12.0	2450	8.8	
		10.0	16.7	12.0	2450	8.8	
		11.0	16.7	11.9	2450	8.7	
		12.0	16.7	11.9	2450	8.7	
		13.0	16.7	11.8	2450	8.7	

**Table A-8.** Basic Physical and Chemical Data, Echo Lake

Station	Date	Depth m	Temp. °C	D.O. mg/l	Cond. μmhos	pH	Secchi m
1	01/07/77	1.0	18.2	9.1	1750	8.8	2.0
		2.0	18.0	8.7	1780	8.8	
Total		3.0	18.0	8.6	1800	8.8	
Depth=12.7m		4.0	18.0	8.6	1800	8.8	
		5.0	17.8	8.3	1800	8.8	
		6.0	17.8	8.1	1800	8.8	
		7.0	17.8	8.0	1800	8.8	
		8.0	17.8	8.1	1800	8.8	
		9.0	17.8	8.1	1800	8.8	
		10.0	17.8	8.1	1800	8.8	
		11.0	17.7	8.2	1800	8.8	
		12.0	17.5	8.3	1800	8.6	
		12.5	17.5	7.4	1800	8.6	
2		1.0	18.0	9.0	1800	8.9	1.7
		2.0	18.0	8.9	1800	8.9	
Total		3.0	18.0	8.8	1800	8.9	
Depth=15.8m		4.0	18.0	8.8	1820	8.9	
		5.0	18.0	8.8	1820	8.8	
		6.0	19.0	8.8	1820	8.8	
		7.0	18.0	8.6	1820	8.8	
		8.0	18.0	8.4	1820	8.8	
		9.0	18.0	7.9	1820	8.7	
		10.0	18.0	7.5	1820	8.6	
		11.0	18.0	6.9	1820	8.6	
		12.0	17.7	6.7	1820	8.7	
		13.0	17.6	6.0	1820	8.5	
		14.0	16.6	2.7	1820	8.4	
		15.0	16.2	2.7	1820	8.3	
		15.5	16.2	2.8	1820	8.3	
3		1.0	18.0	8.4	1800	8.6	2.4
		2.0	18.0	8.4	1820	8.6	
Total		3.0	18.0	8.0	1820	8.7	
Depth=15.7m		4.0	18.0	7.9	1850	8.7	
		5.0	18.0	7.8	1850	8.7	
		6.0	18.0	7.7	1880	8.7	
		7.0	18.0	7.6	1900	8.7	
		8.0	18.0	7.6	1900	8.7	
		9.0	18.0	7.6	1900	8.7	
		10.0	18.0	7.7	1900	8.7	
		11.0	18.0	7.7	1900	8.7	
		12.0	18.0	7.7	1900	8.7	
		13.0	18.0	7.7	1900	8.7	
		14.0	17.7	7.7	1900	8.8	
		15.0	17.7	7.4	1900	8.8	
		15.5	17.7	6.3	1900	8.8	
4		1.0	18.2	10.2	1700	8.8	1.2
		2.0	18.2	10.2	1700	8.8	
Total		3.0	18.2	10.1	1750	8.8	
Depth=16.7m		4.0	18.2	9.8	1780	8.8	
		5.0	18.2	9.8	1800	8.8	
		6.0	18.0	9.8	1820	8.8	
		7.0	17.8	8.9	1850	8.7	
		8.0	17.7	8.6	1850	8.7	
		9.0	17.7	8.5	1850	8.6	
		10.0	17.5	7.6	1850	8.6	
		11.0	17.4	5.5	1850	8.6	
		12.0	17.3	4.7	1820	8.5	
		13.0	17.2	3.7	1820	8.4	
		14.0	17.0	3.7	1820	8.4	
		15.0	16.7	1.8	1800	8.4	
		16.0	16.5	1.7	1800	8.4	
		16.5	16.5	1.3	1800	8.4	
5		1.0	18.5	10.2	1720	8.7	1.5
		2.0	18.5	10.0	1750	8.8	
Total		3.0	18.5	9.7	1800	8.8	
Depth=15.0m		4.0	18.5	9.7	1800	8.8	
		5.0	18.5	9.7	1820	8.7	
		6.0	18.5	9.6	1820	8.7	
		7.0	18.5	9.6	1850	8.7	
		8.0	18.4	9.6	1850	8.7	
		9.0	18.4	9.6	1850	8.7	
		10.0	18.2	9.6	1820	8.7	
		11.0	18.0	9.6	1820	8.7	
		12.0	17.5	4.3	1820	8.4	
		13.0	16.2	1.4	1820	8.3	
		14.0	16.2	1.4	1800	8.3	
		15.0	16.2	1.4	1800	8.2	
6		1.0	18.7	9.9	1800	9.0	1.3
		2.0	19.0	9.8	1800	9.0	
Total		3.0	18.8	10.0	1800	8.9	
Depth=10.3m		4.0	18.8	9.9	1800	8.9	
		5.0	18.8	9.8	1800	8.8	
		6.0	18.8	9.9	2000	8.8	
		7.0	18.7	9.9	2050	8.8	
		8.0	18.7	9.9	2080	8.7	
		9.0	18.7	9.8	2080	8.7	
		10.0	18.7	9.8	2150	8.7	

**Table A-8.** (cont.)

Station	Date	Depth	Temp.	D.O.		Cond.	pH	Secchi
				m	°C	mg/l	µmhos	m
1 Total Depth=9.6m	17/07/77	1.0	20.5	9.3	1900	8.4	1.1	
		2.0	20.0	9.2	1900	8.3		
		3.0	20.0	9.1	1900	8.3		
		4.0	20.0	8.7	1900	8.3		
		5.0	20.0	8.6	1900	8.3		
		6.0	20.0	8.5	1900	8.3		
		7.0	20.0	8.5	1900	8.3		
		8.0	20.0	8.6	1900	8.4		
		9.0	20.0	8.6	1900	8.4		
2 Total Depth=14.9m	17/07/77	1.0	20.0	9.5	1800	8.3	1.4	
		2.0	20.0	9.1	1800	8.3		
		3.0	20.0	9.0	1850	8.3		
		4.0	20.0	9.0	1900	8.3		
		5.0	20.0	8.6	1900	8.3		
		6.0	19.5	8.5	1900	8.3		
		7.0	19.5	8.6	1900	8.3		
		8.0	19.5	8.5	1950	8.3		
		9.0	19.5	8.4	1950	8.3		
		10.0	19.5	8.2	1900	8.3		
		11.0	19.5	8.1	1900	8.3		
		12.0	19.5	7.8	1900	8.3		
		13.0	19.5	7.2	1900	8.3		
		14.0	19.0	6.0	1850	8.2		
		14.5	19.0	4.6	1800	8.2		
3 Total Depth=14.1m	17/07/77	1.0	20.0	9.2	1800	8.5	1.4	
		2.0	20.0	9.2	1850	8.5		
		3.0	20.0	8.5	1900	8.5		
		4.0	20.0	8.4	1900	8.5		
		5.0	19.8	8.4	1900	8.5		
		6.0	19.8	8.4	1925	8.5		
		7.0	19.5	8.3	1925	8.5		
		8.0	19.5	8.2	1900	8.5		
		9.0	19.5	8.2	1900	8.5		
		10.0	19.0	7.5	1900	8.5		
		11.0	19.0	7.3	1900	8.5		
		12.0	19.0	7.3	1900	8.5		
		13.0	19.0	6.4	1900	8.4		
		14.0	19.0	2.5	1925	8.3		
4 Total Depth=18.5m	17/07/77	1.0	19.5	9.2	1800	8.2	1.8	
		2.0	19.5	9.0	1800	8.2		
		3.0	19.5	9.0	1800	8.2		
		4.0	19.0	9.0	1800	8.2		
		5.0	19.0	9.0	1850	8.2		
		6.0	19.0	8.9	1900	8.2		
		7.0	19.0	8.9	1900	8.2		
		8.0	19.0	8.9	1900	8.2		
		9.0	19.0	8.9	1900	8.2		
		10.0	19.0	8.5	1900	8.2		
		11.0	19.0	8.5	1900	8.2		
		12.0	19.0	8.5	1900	8.2		
		13.0	19.0	8.2	1900	8.2		
		14.0	18.5	6.2	1900	8.2		
		15.0	18.0	5.1	1900	8.2		
		16.0	18.0	4.0	1900	8.2		
5 Total Depth=15.2m	17/07/77	1.0	18.0	4.0	1900	8.1		
		2.0	18.0	2.4	1900	8.1		
		3.0	19.5	9.1	1700	8.4	1.8	
		4.0	19.5	8.8	1750	8.4		
		5.0	19.5	8.7	1750	8.4		
		6.0	19.0	8.6	1750	8.4		
		7.0	19.0	8.5	1750	8.4		
		8.0	19.0	8.4	1750	8.5		
		9.0	19.0	7.8	1800	8.5		
		10.0	19.0	7.3	1800	8.5		
6 Total Depth=7.9m	17/07/77	1.0	19.0	4.4	1700	8.9	1.8	
		2.0	19.0	4.4	1700	8.9		
		3.0	19.0	4.4	1700	8.9		
		4.0	18.5	4.3	1700	8.9		
		5.0	18.5	4.2	1700	8.9		
		6.0	18.0	3.8	1700	8.9		
		7.0	18.0	2.2	1750	8.9		
		7.5	18.0	0.5	1750	8.9		

**Table A-8. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
1	04/08/77	1.0	19.3	6.5	2000	8.4	1.7
		2.0	19.3	6.4	2000	8.4	
Total		3.0	19.3	6.4	2000	8.4	
Depth=12.3m		4.0	19.3	6.3	2000	8.4	
		5.0	19.0	6.2	2000	8.4	
		6.0	19.0	6.2	2000	8.4	
		7.0	19.0	6.2	2100	8.4	
		8.0	19.0	6.1	2100	8.4	
		9.0	19.0	6.1	2100	8.4	
		10.0	19.0	6.1	2100	8.4	
		11.0	19.0	6.1	2100	8.4	
		12.0	18.7	6.1	2100	8.5	
2		1.0	19.3	6.9	2000	8.7	1.0
		2.0	19.3	6.7	2000	8.7	
Total		3.0	19.3	6.6	2000	8.6	
Depth=15.0m		4.0	19.3	6.5	2000	8.6	
		5.0	19.3	6.5	2000	8.6	
		6.0	19.3	6.4	2000	8.6	
		7.0	19.3	6.3	2000	8.6	
		8.0	19.3	6.2	2000	8.6	
		9.0	19.3	6.2	2000	8.6	
		10.0	19.3	6.1	2000	8.6	
		11.0	19.3	5.1	2000	8.6	
		12.0	19.0	3.6	2000	8.6	
		13.0	19.0	3.6	2000	8.6	
		14.0	19.0	3.5	2000	8.6	
		15.0	19.0	3.5	2000	8.6	
3		1.0	19.0	7.6	2000	8.5	0.8
		2.0	19.0	7.4	2000	8.5	
Total		3.0	19.0	7.3	2000	8.5	
Depth=14.0		4.0	19.0	7.1	2000	8.5	
		5.0	19.0	7.0	2000	8.5	
		6.0	19.0	6.8	2050	8.6	
		7.0	19.0	6.8	2050	8.6	
		8.0	19.0	6.8	2050	8.7	
		9.0	19.0	6.7	2100	8.7	
		10.0	19.0	6.7	2100	8.7	
		11.0	19.0	6.7	2100	8.7	
		12.0	19.0	6.6	2100	8.7	
		13.0	18.7	6.7	2100	8.8	
		14.0	18.5	6.7	2100	8.8	
4		1.0	19.7	8.8	1950	8.5	1.5
		2.0	19.7	8.7	2000	8.7	
Total		3.0	19.7	8.6	2000	8.5	
Depth=19.5		4.0	19.5	8.5	2000	8.5	
		5.0	19.3	8.5	2000	8.5	
		6.0	19.3	8.4	2050	8.5	
		7.0	19.3	8.4	2050	8.5	
		8.0	19.0	8.2	2050	8.5	
		9.0	19.0	8.2	2050	8.5	
		10.0	19.0	8.2	2050	8.6	
		11.0	19.0	7.0	2100	8.6	
		12.0	19.0	7.0	2100	8.6	
		13.0	19.5	6.8	2100	8.6	
		14.0	19.5	6.8	2100	8.6	
		15.0	19.5	6.8	2100	8.6	
5		1.0	20.0	8.0	2000	8.5	1.1
		2.0	20.0	7.7	2000	8.5	
Total		3.0	19.7	7.7	2000	8.5	
Depth=14.6m		4.0	19.7	7.6	2000	8.5	
		5.0	19.5	7.6	2000	8.5	
		6.0	19.5	7.5	2000	8.5	
		7.0	19.3	7.4	2000	8.5	
		8.0	19.3	7.4	2100	8.5	
		9.0	19.3	7.4	2100	8.6	
		10.0	19.3	7.4	2100	8.6	
		11.0	19.0	7.3	2100	8.6	
		12.0	19.0	7.3	2100	8.7	
		13.0	19.0	7.3	2100	8.7	
		14.0	19.0	7.3	2100	8.7	
6		1.0	20.0	9.1	1900	8.3	1.0
		2.0	20.0	9.0	1850	8.3	
Total		3.0	20.0	9.0	1800	8.3	
Depth=9.5m		4.0	19.7	9.0	1800	8.3	
		5.0	19.7	9.0	1800	8.2	
		6.0	19.7	9.0	1800	8.1	
		7.0	19.5	8.9	1800	8.1	
		8.0	19.5	8.9	1800	8.1	
		9.0	19.5	8.8	1800	8.0	

**Table A-8. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
1	17/08/77	1.0	17.0	10.2	2250	8.8	1.7
		2.0	17.0	10.1	2250	8.8	
Total		3.0	17.0	10.0	2250	8.8	
Depth=14.0m		4.0	17.0	9.5	2250	8.8	
		5.0	17.0	9.1	2250	8.8	
		6.0	17.0	8.8	2250	8.7	
		7.0	17.0	8.7	2250	8.7	
		8.0	17.0	8.6	2250	8.7	
		9.0	17.0	8.5	2250	8.7	
		10.0	17.0	8.4	2300	8.7	
		11.0	17.0	8.4	2300	8.7	
		12.0	16.7	8.6	2300	8.7	
		13.0	16.7	8.5	2300	8.7	
		14.0	16.7	8.4	2300	8.7	
2		1.0	17.3	10.8	2050	8.6	1.5
		2.0	17.3	10.7	2000	8.6	
Total		3.0	17.0	10.2	2000	8.6	
Depth=15.2m		4.0	17.0	10.0	2000	8.6	
		5.0	17.0	9.5	2000	8.6	
		6.0	17.0	9.3	2050	8.6	
		7.0	17.0	9.3	2050	8.6	
		8.0	17.0	9.2	2050	8.6	
		9.0	16.7	9.1	2050	8.6	
		10.0	16.7	9.0	2050	8.6	
		11.0	16.7	9.0	2050	8.6	
		12.0	16.7	8.9	2050	8.6	
		13.0	16.7	8.9	2100	8.6	
		14.0	16.7	8.9	2100	8.6	
		15.0	16.7	9.0	2100	8.6	
3		1.0	17.3	13.8	2000	8.7	1.2
		2.0	17.3	12.0	2100	8.7	
Total		3.0	17.3	11.6	2100	8.7	
Depth=14.5m		4.0	17.3	11.2	2100	8.7	
		5.0	17.3	11.0	2100	8.7	
		6.0	17.3	10.8	2100	8.7	
		7.0	17.3	10.7	2150	8.7	
		8.0	17.0	10.7	2150	8.7	
		9.0	17.0	10.0	2150	8.7	
		10.0	17.0	10.0	2200	8.7	
		11.0	16.7	8.2	2200	8.7	
		12.0	16.7	7.4	2200	8.7	
		13.0	16.7	7.4	2200	8.7	
		14.0	16.7	7.9	2150	8.7	
4		1.0	17.5	11.4	1900	8.7	1.1
		2.0	17.5	11.0	1950	8.7	
Total		3.0	17.3	10.8	1950	8.7	
Depth=19.7m		4.0	17.3	10.7	2000	8.7	
		5.0	17.3	10.7	2000	8.7	
		6.0	17.0	10.6	2000	8.6	
		7.0	17.0	10.4	2000	8.6	
		8.0	17.0	10.2	2000	8.6	
		9.0	17.0	10.0	2000	8.6	
		10.0	17.0	9.6	2000	8.6	
		11.0	17.0	9.3	2000	8.6	
		12.0	17.0	9.3	2000	8.6	
		13.0	17.0	9.2	2000	8.6	
		14.0	17.0	8.7	2000	8.6	
		15.0	17.0	8.1	2000	8.6	
		16.0	17.0	7.4	2050	8.7	
		17.0	16.7	7.2	2050	8.8	
		18.0	16.7	7.2	2050	8.8	
		19.0	16.7	7.1	2050	8.8	
5		1.0	18.0	14.0	2050	8.9	1.3
		2.0	18.0	12.8	2050	8.9	
Total		3.0	18.0	12.4	2050	8.9	
Depth=14.5m		4.0	18.0	12.0	2050	8.9	
		5.0	17.5	11.2	2100	8.8	
		6.0	17.5	10.6	2100	8.8	
		7.0	17.5	10.4	2100	8.8	
		8.0	17.5	10.4	2100	8.8	
		9.0	17.5	10.3	2100	8.8	
		10.0	17.5	10.2	2150	8.7	
		11.0	17.5	10.0	2150	8.7	
		12.0	17.5	10.0	2200	8.7	
		13.0	17.5	10.0	2200	8.7	
		14.0	17.5	9.8	2200	8.7	
6		1.0	17.7	13.4	1700	8.8	1.2
		2.0	17.7	13.2	1650	8.7	
Total		3.0	17.7	12.8	1650	8.7	
Depth=9.6m		4.0	17.5	12.4	1700	8.7	
		5.0	17.3	12.2	1700	8.8	
		6.0	17.3	11.2	1750	8.8	
		7.0	17.3	10.8	1750	8.8	
		8.0	17.3	10.4	1800	8.7	
		9.0	17.5	10.3	1800	8.7	

**Table A-8. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
			m	°C	mg/l	µmhos	m
1 Total Depth=12.3m	23/08/77	1.0	17.5	13.8	2400	8.3	1.6
		2.0	17.5	13.6	2400	8.3	
		3.0	17.5	13.6	2450	8.3	
		4.0	17.5	13.6	2450	8.3	
		5.0	17.5	13.6	2450	8.3	
		6.0	17.5	13.6	2500	8.3	
		7.0	17.5	13.6	2500	8.3	
		8.0	17.5	13.6	2500	8.3	
		9.0	17.0	13.6	2500	8.3	
		10.0	17.0	13.0	2500	8.4	
		11.0	17.0	13.2	2500	8.4	
		12.0	17.0	12.0	2500	8.4	
		13.0					
2 Total Depth=14.9m	23/08/77	1.0	17.5	14.0	2300	8.7	1.2
		2.0	17.5	14.0	2300	8.6	
		3.0	17.5	14.0	2350	8.6	
		4.0	17.5	13.8	2350	8.6	
		5.0	17.5	13.4	2350	8.6	
		6.0	17.5	13.4	2400	8.6	
		7.0	17.5	13.4	2400	8.6	
		8.0	17.5	13.2	2400	8.6	
		9.0	17.5	13.0	2400	8.6	
		10.0	17.0	13.0	2400	8.6	
		11.0	17.0	13.0	2400	8.6	
		12.0	17.0	12.8	2400	8.6	
		13.0	17.0	12.6	2400	8.6	
		14.0	17.0	12.2	2400	8.6	
		14.5	17.0	11.6	2400	8.6	
3 Total Depth=13.6m	23/08/77	1.0	17.5	13.2	2050	8.6	1.5
		2.0	17.5	13.2	2100	8.6	
		3.0	17.0	13.0	2100	8.6	
		4.0	17.0	13.0	2200	8.6	
		5.0	17.0	12.0	2200	8.6	
		6.0	17.0	11.6	2200	8.6	
		7.0	17.0	11.6	2200	8.6	
		8.0	17.0	11.4	2200	8.6	
		9.0	17.0	11.2	2200	8.6	
		10.0	17.0	10.0	2200	8.6	
		11.0	17.0	9.5	2200	8.6	
		12.0	17.0	9.5	2200	8.6	
		13.0	17.0	9.5	2200	8.6	
		14.0					
4 Total Depth=19.5m	23/08/77	1.0	17.5	14.8	2100	8.9	0.9
		2.0	17.5	14.0	2100	8.9	
		3.0	17.5	13.8	2100	8.9	
		4.0	17.5	10.8	2100	8.8	
		5.0	17.5	10.2	2100	8.8	
		6.0	17.5	10.1	2100	8.8	
		7.0	17.5	10.0	2100	8.8	
		8.0	17.0	9.5	2150	8.8	
		9.0	17.0	9.5	2150	8.8	
		10.0	17.0	9.0	2200	8.8	
		11.0	17.0	8.8	2200	8.8	
		12.0	17.0	8.6	2200	8.8	
		13.0	17.0	8.6	2200	8.8	
		14.0	17.0	8.6	2200	8.8	
		15.0	17.0	8.4	2200	8.7	
		16.0	17.0	8.4	2200	8.7	
		17.0	17.0	7.8	2200	8.7	
		18.0	17.0	7.1	2200	8.7	
		19.0	17.0	7.1	2200	8.7	
5 Total Depth=15.3m	23/08/77	1.0	18.0	13.0	2050	8.6	1.3
		2.0	17.5	12.8	2050	8.6	
		3.0	17.5	12.8	2100	8.6	
		4.0	17.5	12.2	2100	8.6	
		5.0	17.5	12.2	2200	8.6	
		6.0	17.5	12.0	2200	8.6	
		7.0	17.5	12.0	2200	8.6	
		8.0	17.5	11.3	2200	8.6	
		9.0	17.5	11.3	2200	8.5	
		10.0	17.0	11.2	2200	8.5	
		11.0	17.0	11.0	2200	8.5	
		12.0	17.0	7.4	2200	8.5	
		13.0	17.0	6.8	2200	8.5	
		14.0	17.0	6.3	2200	8.5	
		15.0	17.0	4.9	2200	8.5	
6 Total Depth=10.3m	23/08/77	1.0	18.0	11.3	2000	8.3	1.1
		2.0	18.0	11.2	2000	8.3	
		3.0	18.0	11.3	2000	8.3	
		4.0	17.5	11.1	2000	8.3	
		5.0	17.5	11.1	2000	8.4	
		6.0	17.5	11.0	2050	8.4	
		7.0	17.5	7.1	2100	8.4	
		8.0	17.5	5.0	2100	8.4	
		9.0	17.5	4.8	2100	8.3	
		10.0	17.5	3.8	2100	8.3	

**Table A-8. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
3 Total Depth=14.2m	09/11/77	1.0	5.6	16.2	1620	8.4	2.6
		2.0	5.6	1680	8.4		
		3.0	5.6	1700	8.4		
		4.0	5.5	15.9	1600	8.5	
		5.0	5.5	1620	8.5		
		6.0	5.5	1620	8.5		
		7.0	5.5	1680	8.5		
		8.0	5.5	15.7	1700	8.5	
		9.0	5.5	1700	8.5		
		10.0	5.5	1700	8.5		
		11.0	5.5	1700	8.5		
		12.0	5.5	1720	8.5		
		13.0	5.5	1720	8.5		
		14.0	5.3	15.8	1720	8.5	
5 Total Depth=14.1m	14/12/77	1.0	5.5	16.2	1600	8.6	2.7
		2.0	5.5	1600	8.6		
		3.0	5.5	1500	8.6		
		4.0	5.5	16.1	1500	8.5	
		5.0	5.3	1500	8.5		
		6.0	5.2	1600	8.5		
		7.0	5.0	1600	8.5		
		8.0	5.0	1650	8.6		
		9.0	5.0	1680	8.6		
		10.0	5.0	1700	8.6		
		11.0	5.0	1700	8.6		
		12.0	5.0	1700	8.6		
		13.0	5.0	1720	8.6		
		13.5	5.2	15.5	1720	8.6	
3 Total Depth=11.2m	14/12/77	0.5	1.0	12.1	950	8.7	2.9
		1.0	1.2	970			
		2.0	1.3	970			
		3.0	1.6	12.2	970	8.7	
		4.0	1.7	970			
		5.0	1.8	980			
		6.0	1.8	11.7	980	8.6	
		7.0	1.8	980			
		8.0	1.8	980			
		9.0	1.8	11.7	980	8.6	
		10.0	1.8	11.4	970	8.6	
		11.0	1.8	980			
		12.0	1.8	980			
		13.0	1.8	980			
		14.0	2.1	9.1	980	8.5	

**Table A-8. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
3	10/01/78	1.0	1.0	11.9	990	8.6	3.0
		2.0	1.2		990		
Total		3.0	1.3		990		
Depth=12.9m		4.0	1.4	11.8	1000	8.7	
		5.0	1.5		1000		
Ice Depth		6.0	1.6		1000		
0.8m		7.0	1.7	11.4	1000	8.5	
		8.0	1.7		1000		
		9.0	1.7		1000		
		10.0	1.7	11.7	1000	8.7	
		11.0	1.7		1000		
		12.0	1.7		1000		
		12.5	1.8	11.4	1000	8.6	
5		1.0	0.6	12.5	990	8.6	2.7
		2.0	1.1		990		
Total		3.0	1.2		990		
Depth=14.9m		4.0	1.2	12.5	990	8.6	
		5.0	1.5		990		
Ice Depth		6.0	1.7		990		
0.9m		7.0	1.7	11.9	1000	8.7	
		8.0	1.7		1000		
		9.0	1.8		1000		
		10.0	1.8		1000		
		11.0	1.8	11.4	1000	8.6	
		12.0	2.0		1000		
		13.0	2.0		1010		
		14.0	2.5		1020		
		14.5	2.9	8.8	1020	8.3	

**Table A-8. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH
		m	°C	mg/l	µmhos	
3	07/03/78	1.0	1.0	8.7	1000	8.3
		2.0	1.1		1000	
Total		3.0	1.1		1000	
Depth=13.0m		4.0	1.2		1000	
		5.0	1.2	8.1	1010	8.4
Ice Depth		6.0	1.2		1010	
1.0m		7.0	1.2		1010	
		8.0	1.2		1010	
		9.0	1.2	8.3	1010	8.4
		10.0	1.1		1010	
		11.0	1.0		1020	
		12.0	1.0		1020	
		13.0	1.0	7.6	1020	8.4
5		1.0	1.2	8.4	1000	8.5
		2.0	1.2		1000	
Total		3.0	1.2		1000	
Depth=13.0m		4.0	1.4		1000	
		5.0	1.5	8.3	1000	8.4
Ice Depth		6.0	1.5		1000	
1.0m		7.0	1.5		1000	
		8.0	1.5		1000	
		9.0	1.6		1020	
		10.0	1.7	7.1	1020	8.4
		11.0	1.7		1020	
		12.0	1.8		1020	
		13.0	2.0		1020	
		14.0	2.7		1030	
		15.0	5.1	0.0	1560	7.3
3	10/05/78	1.0	7.7	12.2	1100	8.5
		2.0	7.7		1100	
Total		3.0	7.4		1100	
Depth=16.2m		4.0	7.2	11.6	1100	8.5
		5.0	7.0		1100	
		6.0	6.8		1090	
		7.0	6.8		1090	
		8.0	6.4	10.1	1090	8.4
		9.0	6.2		1080	
		10.0	6.2		1080	
		11.0	6.0		1080	
		12.0	6.0	4.9	1080	8.1
		13.0	4.2		1080	
		14.0	4.2		1080	
		15.0	4.2		1080	
		16.0	4.2	3.4	1080	8.0
5		1.0	8.0	13.6	1100	8.7
		2.0	8.0		1100	
Total		3.0	7.8		1100	
Depth=14.6m		4.0	6.7		1100	
		5.0	5.8	9.1	1080	8.4
		6.0	5.3		1080	
		7.0	4.7		1080	
		8.0	4.2		1080	
		9.0	4.2		1080	
		10.0	4.2	3.1	1080	8.1
		11.0	3.8		1080	
		12.0	3.8		1080	
		13.0	4.0		1080	
		14.0	4.0		1080	
		14.5	3.8	3.6	1050	8.1

**Table A-8. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH
			m	°C	mg/l	μmhos
3 Total Depth=15.0m	20/06/78	surface	17.0	9.7	1470	8.5
		1.0	17.0		1450	
		2.0	16.2		1420	
		3.0	15.5		1400	
		4.0	15.5		1400	
		5.0	15.5	7.5	1400	8.4
		6.0	15.5		1400	
		7.0	15.2		1400	
		8.0	15.0		1380	
		9.0	15.0		1380	
		10.0	13.8	4.9	1350	8.4
		11.0	13.8		1330	
		12.0	13.8		1330	
		13.0	13.0		1320	
5 Total Depth=16.5m	20/06/78	14.0	12.8		1300	
		15.0	12.2	1.5	1280	8.2
		surface	17.0	8.9	1420	8.5
		1.0	16.8		1420	
		2.0	16.8		1420	
		3.0	16.0		1400	
		4.0	16.0		1400	
		5.0	15.8	7.7	1400	8.5
		6.0	15.8		1400	
		7.0	15.8		1400	
		8.0	15.5		1400	
		9.0	15.5		1380	
		10.0	15.2	6.9	1380	8.4
		11.0	14.8		1360	
		12.0	14.6		1350	
		13.0	14.2		1330	
		14.0	13.0		1330	
		15.0	13.0		1320	
		16.0	12.0	1.3	1300	8.2

**Table A-9. Basic Physical and Chemical Data, Mission Lake**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
1	04/07/77	1.0	19.0	8.6	1320	8.4	1.3
		2.0	19.0	8.0	1400	8.3	
Total		3.0	19.0	7.9	1500	8.3	
Depth=13.8m		4.0	18.5	7.7	1500	8.3	
		5.0	18.5	7.0	1500	8.3	
		6.0	18.5	6.7	1500	8.2	
		7.0	18.5	6.6	1500	8.2	
		8.0	17.5	6.5	1550	8.2	
		9.0	17.5	6.1	1550	8.1	
		10.0	17.5	5.9	1550	8.1	
		11.0	17.0	5.7	1580	8.1	
		12.0	16.5	4.8	1550	8.1	
		13.0	16.0	0.4	1500	8.0	
		13.5	16.0	0.4	1500	7.8	
2		1.0	19.0	11.4	1580	8.5	1.8
		2.0	18.5	10.8	1600	8.5	
Total		3.0	18.0	8.5	1600	8.5	
Depth=12.0m		4.0	18.0	7.3	1600	8.4	
		5.0	18.0	7.2	1600	8.3	
		6.0	18.0	7.2	1600	8.3	
		7.0	18.0	7.1	1600	8.3	
		8.0	18.0	7.0	1550	8.3	
		9.0	18.0	7.0	1550	8.3	
		10.0	18.0	6.8	1580	8.2	
		11.0	17.8	6.1	1580	8.2	
		12.0	17.5	4.2	1600	8.2	
3		1.0	19.0	12.4	1400	8.5	0.6
Total		2.0	19.0	6.3	1400	8.3	
Depth=2.0m							

**Table A-9. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
1	26/07/77	1.0	20.3	15.2	1700	8.6	1.0
		2.0	20.2	12.0	1700	8.6	
Total		3.0	20.0	11.1	1700	8.6	
Depth=13.6m		4.0	20.0	10.4	1700	8.6	
		5.0	20.0	10.0	1700	8.6	
		6.0	19.7	9.5	1700	8.5	
		7.0	19.7	9.3	1750	8.5	
		8.0	19.5	9.2	1750	8.5	
		9.0	19.3	8.3	1750	8.5	
		10.0	19.3	8.0	1800	8.6	
		11.0	19.0	4.6	1750	8.6	
		12.0	19.0	4.0	1750	8.4	
		13.0	19.0	2.9	1750	8.4	
2		1.0	20.0	9.5	1750	8.8	1.7
		2.0	20.0	9.4	1750	8.5	
Total		3.0	19.8	9.0	1750	8.5	
Depth=12.4m		4.0	19.8	8.4	1750	8.4	
		5.0	19.8	7.9	1800	8.4	
		6.0	19.7	7.2	1850	8.4	
		7.0	19.7	7.0	1850	8.4	
		8.0	19.5	7.0	1850	8.4	
		9.0	19.5	6.9	1850	8.4	
		10.0	19.3	6.0	1850	8.4	
		11.0	19.3	4.4	1850	8.3	
		12.0	19.3	2.3	1850	8.2	
3		1.0	20.3	8.0	1650	8.3	1.6
Total		2.0	20.3	7.9	1600	8.3	
Depth=2.2m							

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
1	14/08/77	1.0	17.5	8.8	1650	8.8	1.2
		2.0	17.5	8.7	1700	8.8	
Total		3.0	17.5	8.6	1700	8.8	
Depth=13.6m		4.0	17.5	8.0	1700	8.8	
		5.0	17.5	7.8	1750	8.8	
		6.0	17.5	7.7	1750	8.7	
		7.0	17.5	7.6	1750	8.7	
		8.0	17.5	7.6	1750	8.7	
		9.0	17.5	7.5	1750	8.7	
		10.0	17.3	7.4	1750	8.7	
		11.0	17.0	7.4	1750	8.6	
		12.0	17.0	7.4	1750	8.6	
		13.0	16.3	7.4	1750	8.5	
2		1.0	17.5	9.4	1750	8.9	1.3
		2.0	17.5	9.3	1750	8.8	
Total		3.0	17.5	9.3	1750	8.8	
Depth=12.4m		4.0	17.0	9.1	1750	8.8	
		5.0	17.0	9.0	1800	8.7	
		6.0	17.0	8.7	1800	8.7	
		7.0	17.0	8.6	1850	8.7	
		8.0	17.0	8.5	1850	8.7	
		9.0	16.7	8.5	1850	8.7	
		10.0	16.7	8.5	1850	8.6	
		11.0	16.7	8.4	1850	8.6	
		12.0	16.5	8.4	1850	8.6	
3		1.0	17.7	13.0	1800	8.8	1.0
Total		2.0	17.5	12.6	1800	8.8	
Depth=2.1m							

**Table A-9. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
							m
1 Total Depth=14.0m	01/09/77	1.0	16.3	10.4	1800	9.0	1.1
		2.0	16.3	10.4	1850	9.0	
	Depth=14.0m	3.0	16.3	10.2	1850	9.0	
		4.0	16.3	10.1	1900	9.0	
		5.0	16.0	10.1	1900	9.0	
		6.0	16.0	10.0	1900	9.0	
		7.0	16.0	9.5	1900	9.0	
		8.0	16.0	9.2	1950	9.0	
		9.0	16.0	9.0	1950	9.0	
		10.0	16.0	8.4	1950	9.0	
		11.0	15.7	8.0	1950	9.0	
		12.0	15.7	7.6	1950	9.0	
		13.0	15.7	7.5	1950	9.0	
		13.5	15.7	7.3	2000	9.0	
2 Total Depth=12.0m	1.0	16.3	11.2	1800	8.5	1.0	
		2.0	16.5	10.8	1800	8.5	
	Depth=12.0m	3.0	16.5	10.0	1850	8.5	
		4.0	16.5	9.6	1850	8.6	
		5.0	16.5	9.6	1850	8.6	
		6.0	16.5	9.1	1850	8.6	
		7.0	16.5	8.9	1850	8.6	
		8.0	16.3	8.9	1900	8.6	
		9.0	16.3	8.3	1900	8.6	
		10.0	16.3	8.0	1950	8.6	
		11.0	16.0	7.1	1950	8.6	
		12.0	16.0	7.1	1950	8.6	
3 Total Depth=2.1m	1.0	16.5	10.1	1800	8.8	0.7	
	2.0	16.5	10.1	1800	8.8		

**Table A-10. Basic Physical and Chemical Data, Katepwa Lake****Table A-10. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
			m	°C	mg/l	μmhos	m
1 Total Depth=19.5m	29/06/77	1.0	18.0	11.6	1500	9.0	1.5
		2.0	18.0	11.8	1500	9.0	
	Depth=19.5m	3.0	18.0	11.6	1500	9.0	
		4.0	18.0	12.0	1500	9.0	
		5.0	18.0	12.6	1500	9.0	
		6.0	18.5	12.4	1500	8.9	
		7.0	18.5	12.4	1500	8.9	
		8.0	18.5	12.4	1500	8.9	
		9.0	18.0	12.0	1500	8.8	
		10.0	17.5	6.1	1500	8.6	
		11.0	16.0	6.1	1500	8.5	
		12.0	15.0	6.3	1500	8.5	
		13.0	14.5	5.0	1500	8.1	
		14.0	13.5	2.1	1500	8.0	
		15.0	12.5	2.0	1500	8.0	
		16.0	12.0	2.0	1500	8.0	
		17.0	11.5	2.0	1500	8.0	
		18.0	11.5	2.0	1500	7.9	
		19.0	11.5	2.1	1600	7.9	
2 Total Depth=19.5m	18/07/77	1.0	18.0	11.7	1450	8.8	1.5
		2.0	18.0	11.6	1450	8.8	
	Depth=19.5m	3.0	17.5	11.3	1450	8.8	
		4.0	17.5	11.3	1500	8.8	
		5.0	17.5	11.3	1500	8.8	
		6.0	17.5	11.2	1500	8.7	
		7.0	17.5	11.1	1500	8.7	
		8.0	17.0	11.1	1500	8.7	
		9.0	17.0	10.7	1550	8.7	
		10.0	14.5	7.3	1600	8.6	
		11.0	14.0	6.6	1600	8.5	
		12.0	13.5	5.1	1600	8.4	
		13.0	13.0	5.1	1650	8.4	
		14.0	12.5	4.8	1650	8.3	
		15.0	12.0	4.5	1650	8.3	
		16.0	12.0	3.3	1650	8.2	
		17.0	11.5	2.9	1650	8.1	
		18.0	11.5	2.2	1650	8.1	
		19.0	11.5	1.2	1700	8.1	
3 Total Depth=19.1m	18/07/77	1.0	18.5	12.1	1500	8.7	1.6
		2.0	18.0	12.0	1500	8.7	
	Depth=19.1m	3.0	18.0	11.8	1500	8.7	
		4.0	18.0	11.8	1550	8.7	
		5.0	18.0	11.8	1600	8.7	
		6.0	18.0	11.7	1700	8.7	
		7.0	18.0	11.7	1700	8.7	
		8.0	18.0	11.6	1700	8.7	
		9.0	18.0	11.5	1700	8.7	
		10.0	17.5	11.4	1700	8.7	
		11.0	17.5	11.4	1750	8.8	
		12.0	17.0	10.8	1750	8.8	
		13.0	15.0	8.8	1750	8.7	
		14.0	14.5	6.4	1750	8.5	
		15.0	11.0	4.6	1750	8.4	
		16.0	11.0	2.4	1750	8.2	
		17.0	11.0	1.5	1750	8.1	
		18.0	11.0	1.3	1750	8.1	
		19.0	11.0	1.3	1750	8.1	
4 Total Depth=19.0m	18/07/77	1.0	18.0	11.4	1550	8.4	1.6
		2.0	18.0	11.8	1550	8.4	
	Depth=19.0m	3.0	17.8	11.7	1550	8.4	
		4.0	17.7	11.6	1550	8.4	
		5.0	17.5	11.6	1550	8.4	
		6.0	17.2	11.5	1600	8.4	
		7.0	17.0	11.1	1600	8.4	
		8.0	16.8	10.9	1600	8.4	
		9.0	16.0	9.7	1650	8.4	
		10.0	15.0	8.9	1650	8.4	
		11.0	12.5	7.8	1700	8.3	
		12.0	12.5	4.0	1700	8.1	
		13.0	12.2	3.8	1700	8.0	
		14.0	12.0	3.6	1700	8.0	
		15.0	11.7	3.4	1700	7.9	
		16.0	11.5	2.7	1650	7.9	
		17.0	11.2	2.3	1650	7.9	
		18.0	11.0	2.0	1650	7.9	
		19.0	11.0	1.3	1650	7.9	
5 Total Depth=19.0m	18/07/77	1.0	18.0	11.2	1550	9.1	1.9
		2.0	17.8	11.1	1550	9.1	
	Depth=19.0m	3.0	17.6	10.8	1500	9.0	
		4.0	17.6	10.2	1500	9.0	
		5.0	17.6	10.4	1550	9.0	
		6.0	17.5	10.3	1580	9.0	
		7.0	17.5	10.4	1600	8.8	
		8.0	17.5	10.5	1600	8.9	
		9.0	17.4	10.4	1650	8.8	
		10.0	17.0	10.5	1680	8.8	
		11.0	17.0	10.1	1700	8.7	
		12.0	16.5	10.1	1720	8.7	
		13.0	15.5	9.3	1720	8.6	
		14.0	13.5	4.5	1700	8.5	
		15.0	11.6	2.9	1700	8.3	
		16.0	11.4	2.3	1700	8.0	
		17.0	11.0	1.9	1700	8.0	
		18.0	11.0	1.5	1700	7.9	
		19.0	11.0	1.5	1700	7.8	

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos	m	
1 Total Depth=18.8m	18/07/77	1.0	18.5	12.8	1400	8.7	1.0
		2.0	18.5	12.6	1400	8.7	
	Depth=18.8m	3.0	18.0	12.2	1450	8.6	
		4.0	18.0	12.2	1450	8.6	
		5.0	17.5	12.1	1450	8.6	
		6.0	17.5	11.0	1450	8.6	
		7.0	16.5	10.8	1450	8.5	
		8.0	16.5	10.6	1450	8.5	
		9.0	15.5	10.6	1450	8.5	
		10.0	14.5	10.2	1450	8.5	
		11.0	14.5	10.0	1450	8.4	
		12.0	13.5	9.0	1450	8.3	
		13.0	13.0	8.3	1450	8.2	
		14.0	13.0	6.5	1450	8.0	
		15.0	12.5	5.0	1450	7.7	
		16.0	12.5	4.5	1450	7.7	
		17.0	12.5	4.4	1450	7.6	
		18.0	12.0	4.1	1450	8.0	
		18.5	12.5	0.8	1550	7.8	
2 Total Depth=19.5m	18/07/77	1.0	18.5	13.2	1450	8.6	0.9
		2.0	18.5	13.0	1450	8.6	
	Depth=19.5m	3.0	18.5	12.8	1450	8.6	
		4.0	18.0	12.6	1500	8.6	
		5.0	18.0	12.0	1500	8.6	
		6.0	17.5	11.2	1500	8.6	
		7.0	17.0	11.0	1500	8.5	
		8.0	17.0	10.8	1450	8.5	
		9.0	16.0	10.0	1450	8.5	
		10.0	15.5	9.0	1450	8.5	
		11.0	15.0	7.5	1450	8.5	
		12.0	14.5	5.9	1450	8.3	
		13.0	14.0	4.3	1450	8.2	
		14.0	14.0	3.0	1450	8.3	
		15.0	12.5	2.5	1450	8.0	
		16.0	12.0	1.5	1600	8.0	
		17.0	12.0	1.0	1500	7.8	
		18.0	12.0	0.8	1500	7.7	
		19.0	12.0	0.7	1500	7.6	
3 Total Depth=19.1m	18/07/77	1.0	19.0	14.0	1500	8.7	
		2.0	19.0	14.0	1500	8.7	
	Depth=19.1m	3.0	18.5	13.0	1550	8.7	
		4.0	18.0	12.8	1550	8.7	
		5.0	17.5	12.4	1550	8.7	
		6.0	17.5	12.2	1550	9.0	
		7.0	17.5	12.0	1550	9.0	
		8.0	17.0	12.2	1550	8.9	
		9.0	16.5	12.2	1600	8.9	
		10.0	15.5	12.0	1600	8.8	
		11.0	15.0	8.0	1650	8.7	
		12.0	13.5	7.4	1650	8.4	
		13.0	13.0	4.4	1650	8.4	
		14.0	13.0	3.6	1650	8.3	
		15.0	13.0	1.8	1650	8.3	
		16.0	12.5	1.2	1650	8.1	
		17.0	13.0	1.1	1650	7.9	
		18.0	13.0	0.9	1650	7.9	
		19.0	13.0	0.8	1650	7.8	
4 Total Depth=19.0m							

Table A-10. (cont.)

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
			m	°C	mg/l	μmhos	m
1 Total Depth=18.9m	26/07/77	1.0	19.0	10.8	1650	8.5	1.5
		2.0	19.0	10.8	1650	8.4	
		3.0	19.0	10.6	1650	8.4	
		4.0	19.0	10.4	1650	8.4	
		5.0	18.5	9.4	1650	8.4	
		6.0	18.5	9.3	1650	8.4	
		7.0	18.3	9.2	1650	8.4	
		8.0	18.0	8.7	1650	8.4	
		9.0	17.5	8.7	1650	8.4	
		10.0	16.5	8.6	1700	8.4	
		11.0	16.0	8.3	1700	8.4	
		12.0	15.0	4.5	1700	8.2	
		13.0	14.5	3.5	1750	8.2	
		14.0	13.5	3.0	1750	7.9	
		15.0	13.3	1.9	1750	7.7	
		16.0	13.0	1.2	1750	7.5	
		17.0	12.5	0.8	1750	7.5	
		18.0	12.5	0.5	1750	7.5	
		18.5	12.5	0.4	1750	7.3	
2 Total Depth=19.4	1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0	1.0	19.0	10.6	1700	8.6	1.4
		2.0	19.0	10.4	1700	8.6	
		3.0	19.0	10.4	1700	8.5	
		4.0	18.5	10.2	1700	8.4	
		5.0	18.5	10.0	1750	8.4	
		6.0	18.5	9.3	1750	8.5	
		7.0	18.5	9.1	1750	8.4	
		8.0	18.0	8.7	1750	8.4	
		9.0	17.5	8.4	1750	8.4	
		10.0	17.0	7.2	1750	8.3	
		11.0	15.5	6.5	1750	8.0	
		12.0	15.0	5.0	1750	7.8	
		13.0	14.5	4.6	1750	8.2	
		14.0	13.5	1.2	1750	7.9	
		15.0	13.5	0.9	1750	7.9	
		16.0	12.5	0.9	1800	7.9	
		17.0	12.5	0.8	1800	7.8	
		18.0	12.5	0.5	1800	7.8	
		19.0	12.5	0.4	1800	7.8	
3 Total Depth=18.5m	1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 18.5	1.0	18.5	10.2	1700	9.1	1.8
		2.0	18.5	10.2	1700	9.1	
		3.0	18.5	10.0	1700	9.1	
		4.0	18.5	9.0	1700	9.1	
		5.0	17.5	9.0	1750	9.1	
		6.0	17.0	8.8	1750	9.1	
		7.0	16.5	8.7	1750	9.0	
		8.0	16.5	8.6	1750	9.0	
		9.0	16.5	8.2	1800	9.0	
		10.0	15.5	7.3	1800	9.0	
		11.0	15.0	6.2	1800	8.9	
		12.0	14.5	4.9	1800	8.8	
		13.0	13.5	3.4	1800	8.6	
		14.0	13.0	2.4	1800	8.4	
		15.0	12.5	1.7	1800	8.4	
		16.0	12.5	1.0	1800	8.2	
		17.0	12.0	0.8	1800	8.0	
		18.0	12.5	0.5	1800	7.8	
		18.5	12.5	0.4	1800	7.7	
4 Total Depth=19.0	1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 18.5	1.0	18.5	13.0	1700	8.9	1.3
		2.0	18.5	13.0	1700	8.9	
		3.0	18.5	13.0	1750	8.8	
		4.0	18.3	12.2	1750	8.8	
		5.0	17.8	11.2	1800	8.8	
		6.0	17.3	10.0	1800	8.8	
		7.0	17.0	9.3	1800	8.8	
		8.0	16.5	9.0	1800	8.7	
		9.0	15.5	8.9	1800	8.7	
		10.0	15.0	8.5	1850	8.7	
		11.0	14.0	7.7	1850	8.7	
		12.0	14.0	7.3	1850	8.7	
		13.0	13.5	5.5	1850	8.6	
		14.0	13.0	2.2	1850	8.4	
		15.0	12.5	1.8	1850	8.3	
		16.0	12.5	1.2	1850	8.3	
		17.0	12.5	1.8	1850	8.1	
		18.0	12.5	1.6	1850	8.0	
		18.5	12.5	1.6	1850	7.8	
5 Total Depth=19.4m	1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0	1.0	18.5	12.2	1600	8.7	1.5
		2.0	18.5	11.8	1600	8.6	
		3.0	18.5	11.4	1650	8.6	
		4.0	18.5	10.6	1650	8.6	
		5.0	18.3	10.2	1650	8.6	
		6.0	18.0	10.0	1650	8.7	
		7.0	18.0	9.9	1650	8.7	
		8.0	17.5	9.5	1650	8.7	
		9.0	16.0	8.8	1650	8.7	
		10.0	15.5	8.5	1650	8.6	
		11.0	15.0	8.0	1650	8.5	
		12.0	14.5	6.0	1650	8.5	
		13.0	13.5	6.0	1650	8.4	
		14.0	12.5	4.2	1650	8.3	
		15.0	12.0	4.7	1650	8.2	
		16.0	12.0	2.5	1650	8.0	
		17.0	12.0	2.7	1650	7.8	
		18.0	12.0	2.2	1650	7.7	
		19.0	12.0	2.0	1650	7.7	
5 Total Depth=19.2m	1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0	1.0	17.7	11.8	1650	probe	1.4
		2.0	17.5	11.4	1650	mal-	
		3.0	17.0	10.6	1650	function	
		4.0	16.7	10.0	1650		
		5.0	16.7	10.0	1650		
		6.0	16.7	8.1	1750		
		7.0	16.7	8.0	1800		
		8.0	16.7	7.7	1800		
		9.0	16.7	7.7	1800		
		10.0	16.5	7.7	1800		
		11.0	16.5	7.7	1800		
		12.0	16.5	7.6	1800		
		13.0	16.0	7.6	1800		
		14.0	16.0	7.6	1800		
		15.0	15.0	7.6	1800		
		16.0	14.7	7.6	1800		
		17.0	14.5	1.1	1800		
		18.0	14.3	0.9	1800		
		19.0	14.3	0.6	1800		

Table A-10. (cont.)

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos		m
1 Total Depth=18.9m	14/08/77	1.0	16.3	7.9	1700	8.6	1.8
		2.0	16.3	7.8	1700	8.6	
		3.0	16.3	7.8	1700	8.5	
		4.0	16.3	7.7	1700	8.5	
		5.0	16.0	7.5	1700	8.4	
		6.0	16.0	7.4	1700	8.4	
		7.0	16.0	7.2	1700	8.5	
		8.0	16.0	7.1	1700	8.5	
		9.0	15.7	7.1	1700	8.5	
		10.0	15.7	7.0	1700	8.5	
		11.0	15.7	7.0	1700	8.4	
		12.0	15.6	7.0	1700	8.4	
		13.0	15.5	7.0	1700	8.4	
		14.0	15.3	6.8	1700	8.4	
		15.0	15.0	6.7	1700	8.4	
		16.0	14.5	4.3	1700	8.3	
		17.0	14.3	4.2	1750	8.3	
		18.0	14.0	0.9	1750	8.3	
		18.5	14.0	0.8	1750	8.3	
2 Total Depth=19.4m	2 Total Depth=19.4m	1.0	16.5	8.7	1700	9.0	1.5
		2.0	16.5	8.6	1750	9.0	
		3.0	16.5	8.4	1750	8.9	
		4.0	16.5	8.3	1750	8.9	
		5.0	16.5	8.1	1750	8.9	
		6.0	16.3	8.0	1750	8.9	
		7.0	16.3	7.9	1750	8.9	
		8.0	16.3	7.8	1750	8.9	
		9.0	16.3	7.6	1750	8.9	
		10.0	16.0	7.6	1750	8.9	
		11.0	15.5	7.5	1750	8.9	
		12.0	15.5	7.6	1800	9.0	
		13.0	15.5	7.6	1800	9.0	
		14.0	15.3	4.1	1800	8.7	
		15.0	15.0	4.0	1800	8.6	
		16.0	14.7	3.8</td			

**Table A-10. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
1 Total Depth=19.0m	01/09/77	1.0	16.5	8.7	1600	8.5	1.2
		2.0	16.5	8.4	1600	8.5	
		3.0	16.5	8.2	1600	8.5	
		4.0	16.5	8.0	1600	8.5	
		5.0	16.5	7.9	1600	8.5	
		6.0	16.5	7.9	1600	8.5	
		7.0	16.5	7.9	1600	8.5	
		8.0	16.5	7.9	1600	8.5	
		9.0	16.3	8.0	1600	8.5	
		10.0	16.3	7.9	1600	8.5	
		11.0	16.0	7.9	1600	8.5	
		12.0	16.0	7.7	1600	8.5	
		13.0	16.0	7.4	1600	8.5	
		14.0	15.7	6.2	1600	8.5	
		15.0	15.7	4.5	1600	8.5	
		16.0	15.7	1.5	1600	8.5	
		17.0	15.7	1.4	1600	8.4	
		18.0	15.7	1.0	1600	8.4	
		18.5	15.7	0.8	1600	8.4	
2 Total Depth=19.5m	1.0	16.3	9.4	1600	8.6	1.6	
		2.0	16.3	9.2	1600	8.6	
		3.0	16.3	9.0	1650	8.5	
		4.0	16.3	7.9	1650	8.5	
		5.0	16.3	7.7	1650	8.5	
		6.0	16.3	7.7	1650	8.5	
		7.0	16.3	7.6	1650	8.5	
		8.0	16.0	7.6	1650	8.5	
		9.0	16.0	7.6	1700	8.5	
		10.0	15.7	7.6	1700	8.5	
		11.0	15.7	7.6	1700	8.5	
		12.0	15.7	7.7	1700	8.5	
		13.0	15.7	8.0	1750	8.5	
		14.0	15.7	7.7	1750	8.5	
		15.0	15.7	7.7	1750	8.5	
		16.0	15.7	7.7	1750	8.5	
		17.0	15.7	7.7	1750	8.6	
		18.0	15.7	7.2	1750	8.6	
		19.0	15.7	1.2	1750	8.6	
3 Total Depth=19.1m	1.0	16.5	8.7	1600	8.8	1.5	
		2.0	16.5	8.6	1650	8.8	
		3.0	16.5	8.5	1650	8.8	
		4.0	16.5	8.2	1650	8.8	
		5.0	16.5	8.0	1650	8.8	
		6.0	16.3	7.7	1650	8.8	
		7.0	16.0	7.6	1650	8.8	
		8.0	16.0	7.5	1650	8.8	
		9.0	16.0	7.5	1700	8.8	
		10.0	16.0	7.5	1700	8.8	
		11.0	16.0	7.6	1700	8.8	
		12.0	16.0	7.7	1700	8.8	
		13.0	16.0	7.7	1700	8.8	
		14.0	16.0	7.6	1700	8.8	
		15.0	15.7	7.5	1700	8.8	
		16.0	15.5	7.4	1750	8.8	
		17.0	15.5	6.0	1750	8.8	
		18.0	15.5	5.8	1750	8.8	
		18.5	15.5	1.0	1750	8.8	
4 Total Depth=19.3m	1.0	16.5	8.9	1650	8.8	1.5	
		2.0	16.5	8.8	1650	8.8	
		3.0	16.3	8.8	1650	8.8	
		4.0	16.3	8.5	1650	8.8	
		5.0	16.3	8.2	1650	8.8	
		6.0	16.3	7.9	1650	8.8	
		7.0	16.0	7.4	1600	8.8	
		8.0	16.0	7.2	1600	8.8	
		9.0	16.0	7.2	1600	8.8	
		10.0	16.0	7.4	1600	8.8	
		11.0	16.0	7.4	1600	8.8	
		12.0	15.7	7.2	1650	8.8	
		13.0	15.7	7.0	1650	8.8	
		14.0	15.5	6.5	1700	8.8	
		15.0	15.3	6.0	1700	8.8	
		16.0	15.3	5.7	1700	8.8	
		17.0	15.3	3.6	1700	8.8	
		18.0	15.0	3.6	1700	8.8	
		19.0	15.0	1.6	1700	8.8	
5 Total Depth=19.3	1.0	16.0	9.0	1750	9.0	1.4	
		2.0	16.0	8.8	1700	9.0	
		3.0	16.0	8.6	1650	9.0	
		4.0	16.0	8.2	1650	8.9	
		5.0	16.0	7.9	1650	8.9	
		6.0	16.0	7.7	1700	8.9	
		7.0	16.0	7.6	1700	8.9	
		8.0	16.0	7.4	1700	8.9	
		9.0	16.0	7.6	1700	8.9	
		10.0	16.0	7.5	1700	8.9	
		11.0	15.7	7.5	1700	9.0	
		12.0	15.7	7.4	1700	9.0	
		13.0	15.7	7.4	1700	9.0	
		14.0	15.5	7.4	1700	9.0	
		15.0	15.0	7.3	1700	9.0	
		16.0	14.7	7.2	1700	9.0	
		17.0	14.7	2.3	1700	9.0	
		18.0	14.5	2.2	1650	9.0	
		19.0	14.5	1.9	1650	8.5	

**Table A-10. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	µmhos		m
1 Total Depth=18.3m	09/11/77	1.0	7.4	15.6	1400	8.4	2.0
		2.0	7.4		1420	8.4	
		3.0	7.4		1500	8.4	
		4.0	7.4		1520	8.4	
		5.0	7.4		1600	8.4	
		6.0	7.4	15.5	1600	8.4	
		7.0	7.3		1650	8.4	
		8.0	7.3		1650	8.4	
		9.0	7.3		1680	8.4	
		10.0	7.3		1680	8.4	
		11.0	7.3		1700	8.4	
		12.0	7.3	15.0	1700	8.4	
		13.0	7.5		1700	8.4	
		14.0	7.5		1720	8.4	
		15.0	7.5		1720	8.4	
		16.0	7.5		1720	8.4	
		17.0	7.5		1720	8.4	
		18.0	7.5	15.0	1720	8.4	
5 Total Depth=19.5m	14/12/77	1.0	6.8	15.9	1320	8.5	2.1
		2.0	6.8		1350	8.5	
		3.0	6.8		1320	8.5	
		4.0	6.8		1380	8.5	
		5.0	6.8		1400	8.5	
		6.0	6.8	15.8	1400	8.5	
		7.0	6.8		1380	8.5	
		8.0	6.8		1300	8.5	
		9.0	6.8		1300	8.5	
		10.0	6.8		1300	8.5	
		11.0	6.8		1300	8.5	
		12.0	7.0		1320	8.5	
		13.0	7.0		1350	8.5	
		14.0	7.0		1350	8.5	
		15.0	7.0		1400	8.5	
		16.0	7.0		1400	8.5	
		17.0	7.0		1400	8.5	
		18.0	7.2	15.3	1320	8.5	

**Table A-10. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos		m
1	10/01/78	1.0	1.0	12.2	820	8.5	2.5
		2.0	1.2		820		
Total		3.0	1.3		820		
Depth=19.8m		4.0	1.3		820		
		5.0	1.3		820		
Ice depth 0.8m		6.0	1.4	12.0	820	8.6	
		7.0	1.5		820		
		8.0	1.7		820		
		9.0	1.8		820		
		10.0	1.9		820		
		11.0	1.9	12.1	820	8.6	
		12.0	1.9		820		
		13.0	1.9		820		
		14.0	1.9		820		
		15.0	1.9	11.8	820	8.5	
		19.5	3.0	7.6	820	8.0	
5		1.0	0.2	12.4	820	8.6	2.6
		2.0	1.0		830		
Total		3.0	1.0		820		
Depth=19.3m		4.0	1.0		820		
		5.0	1.2		830		
Ice depth 0.8m		6.0	1.2	12.6	820	8.6	
		7.0	1.5		820		
		8.0	1.5		820		
		9.0	1.7		830		
		10.0	1.8		830		
		11.0	1.8	12.6	830	8.6	
		12.0	2.0		850		
		13.0	2.0		850		
		14.0	2.1		840		
		15.0	2.2	10.8	840	8.4	
		19.0	2.7		820	8.0	
1	13/02/78	1.0	1.7	11.5	800	8.4	2.6
		2.0	1.8		800		
Total		3.0	1.8		800		
Depth=20.0m		4.0	1.8		800		
		5.0	1.8		800		
Ice depth 1.0m		6.0	1.8	11.7	800	8.5	
		7.0	1.8		800		
		8.0	1.8		800		
		9.0	1.8		800		
		10.0	1.8	10.9	800	8.5	
		11.0	1.8		800		
		12.0	1.8		800		
		13.0	1.8		800		
		14.0	1.8		800		
		15.0	1.8	11.0	800	8.4	
		16.0					
		17.0					
		18.0					
		19.0					
		19.5	3.0	6.8	850	7.9	
5		1.0	1.3	10.5	790	8.4	2.7
		2.0	1.5		790		
Total		3.0	1.5		790		
Depth=19.2m		4.0	1.6		790		
		5.0	1.8	11.3	780	8.4	
Ice depth 1.0m		6.0	1.8		790		
		7.0	1.8		790		
		8.0	1.8		790		
		9.0	1.8	10.4	800	8.4	
		10.0	1.8		800		
		11.0	1.8		800		
		12.0	1.8		800		
		13.0	1.9		800		
		14.0	1.9	10.0	800	8.3	
		15.0	2.0		800		
		16.0					
		17.0					
		18.0					
		19.0	3.8	0.0	820	7.8	

**Table A-10. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH
		m	°C	mg/l	μmhos	
1	07/03/78	1.0	1.5	9.5	810	8.4
		2.0	1.7		820	
Total		3.0	1.7		820	
Depth=20.1m		4.0	1.7		820	
		5.0	1.7	9.3	820	8.4
Ice depth 1.0m		6.0	1.7		820	
		7.0	1.8		820	
		8.0	1.8		820	
		9.0	1.8		820	
		10.0	1.8	9.0	820	8.4
		11.0	1.8		820	
		12.0	1.8		820	
		13.0	1.8		820	
		14.0	1.8		820	
		15.0	1.8	8.5	820	8.3
5		1.0	1.3	8.2	810	8.3
		2.0	1.3		820	
Total		3.0	1.6		820	
Depth=18.9m		4.0	1.6		820	
		5.0	1.8	7.7	820	8.3
Ice depth 1.0m		6.0	1.8		820	
		7.0	1.9		820	
		8.0	2.0		820	
		9.0	2.0		820	
		10.0	2.0	6.7	820	8.2
		11.0	2.0		830	
		12.0	2.0		830	
		13.0	2.1		830	
		14.0	2.6		830	
		15.0	2.8	4.4	830	8.1
		16.0				
		17.0	2.8		840	
		18.0	3.0		870	
		18.9	3.6	0.0	880	7.6

**Table A-10. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.		pH	
					m	°C	mg/l	µmhos
1 Total Depth=19.0m	10/05/78	1.0	6.7	13.8	820	8.5		
		2.0	6.6		820			
		3.0	6.6		820			
		4.0	6.5		820			
		5.0	6.5	14.1	820	8.5		
		6.0	6.3		820			
		7.0	6.2		820			
		8.0	6.2		820			
		9.0	6.2		820			
		10.0	6.0	13.5	820	8.5		
		11.0	5.7		820			
		12.0	5.2		820			
		13.0	4.9		820			
		14.0	4.8		820			
		15.0	4.2	10.3	820	8.3		
		18.8	4.0	9.4	880	8.2		
5 Total Depth=19.1m	10/05/78	1.0	6.0	12.7	860	8.4		
		2.0	6.0		860			
		3.0	6.0		850			
		4.0	5.8		850			
		5.0	5.2	10.9	850	8.3		
		6.0	5.1		850			
		7.0	5.0		850			
		8.0	4.9		850			
		9.0	4.9		850			
		10.0	4.8	9.0	850	8.2		
		11.0	4.8		850			
		12.0	4.7		850			
		13.0	4.4		850			
		14.0	4.2		850			
		15.0	4.2	7.8	860	8.1		
		19.0	3.8	5.2	880	8.0		

**Table A-10. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH
		m	°C	mg/l	µmhos	
1 Total Depth=19.5m	20/06/78	surface	15.6	9.7	1100	8.5
		1.0	15.5		1080	
		2.0	15.0		1080	
		3.0	15.0		1070	
		4.0	14.8		1070	
		5.0	14.8		1070	
		6.0	14.8	8.9	1070	8.5
		7.0	14.8		1070	
		8.0	14.8		1070	
		9.0	14.8		1070	
		10.0	14.5		1070	
		11.0	13.8		1070	
		12.0	13.2	7.7	1030	8.4
		13.0	13.0		1030	
		14.0	11.0		1000	
		15.0	9.8		940	
		19.0	9.7	1.2	950	8.1
5 Total Depth=19.3m	20/06/78	surface	17.0	10.6	1140	8.6
		1.0	16.5		1120	
		2.0	16.0		1120	
		3.0	16.0		1120	
		4.0	16.0		1120	
		5.0	16.0		1120	
		6.0	15.8	9.4	1120	8.6
		7.0	15.8		1120	
		8.0	15.8		1120	
		9.0	15.8		1120	
		10.0	15.8		1120	
		11.0	14.2		1080	
		12.0	12.4	5.1	1020	8.4
		13.0	11.2		1000	
		14.0	10.2		980	
		15.0	9.8		960	
		19.0	9.0	0.6	980	8.1

**Table A-11. Basic Physical and Chemical Data, Crooked Lake**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos		m
1	06/07/77	1.0	19.0	9.0	1500	8.8	1.3
		2.0	18.5	8.9	1500	8.8	
Total		3.0	18.5	8.8	1550	8.7	
Depth=12.8m		4.0	18.5	8.7	1550	8.7	
		5.0	18.5	8.7	1550	8.7	
		6.0	18.0	8.5	1550	8.7	
		7.0	18.0	7.5	1600	8.7	
		8.0	18.0	6.6	1600	8.6	
		9.0	17.5	5.5	1600	8.5	
		10.0	17.0	5.3	1650	8.5	
		11.0	17.0	5.1	1650	8.4	
		12.0	17.5	2.5	1700	8.3	
		12.5	17.5	2.4	1700	8.4	
2		1.0	19.0	9.4	1650	8.9	2.1
		2.0	19.0	9.0	1700	8.9	
Total		3.0	18.5	9.2	1700	8.9	
Depth=12.2m		4.0	18.5	9.0	1700	8.9	
		5.0	18.5	7.9	1750	8.8	
		6.0	18.5	7.6	1750	8.8	
		7.0	18.0	7.0	1750	8.7	
		8.0	17.5	6.6	1750	8.7	
		9.0	17.5	5.6	1800	8.7	
		10.0	17.5	4.5	1800	8.6	
		11.0	17.0	3.8	1850	8.5	
		12.0	17.0	3.5	1850	8.5	
3		1.0	19.5	12.2	1550	9.1	1.3
		2.0	19.0	12.0	1550	9.1	
Total		3.0	19.0	12.0	1600	9.1	
Depth=15.5		4.0	18.5	11.8	1600	9.1	
		5.0	18.5	11.6	1600	9.0	
		6.0	18.5	11.6	1600	9.0	
		7.0	18.0	11.6	1600	9.0	
		8.0	17.5	10.4	1600	8.9	
		9.0	17.5	7.0	1650	8.8	
		10.0	17.0	6.5	1700	8.7	
		11.0	17.0	6.0	1700	8.7	
		12.0	16.5	5.5	1700	8.7	
		13.0	16.5	3.0	1700	8.6	
		14.0	16.5	2.0	1750	8.5	
		15.0	16.5	1.5	1750	8.4	
4		1.0	20.5	14.2	1600	8.8	1.2
		2.0	20.5	14.0	1600	8.8	
Total		3.0	20.5	14.0	1600	8.8	
Depth=6.9m		4.0	20.5	14.0	1650	8.8	
		5.0	20.5	13.8	1650	8.6	
		6.0	20.5	13.8	1650	8.6	
		6.5	20.5	13.6	1650	8.6	

**Table A-11. (cont.)**

Station	Date	Depth	Temp	D.O.	Cond.	pH	Secchi
		m	°C	mg/l	μmhos		m
1	19/07/77	1.0	20.5	10.8	1500	8.6	0.9
		2.0	20.0	10.0	1600	8.6	
Total		3.0	19.5	9.2	1650	8.6	
Depth=10.5m		4.0	19.5	8.1	1650	8.6	
		5.0	19.5	7.8	1700	8.6	
		6.0	19.5	7.7	1700	8.4	
		7.0	19.5	7.5	1750	8.4	
		8.0	19.5	7.6	1750	8.5	
		9.0	19.5	6.0	1750	8.5	
		10.0	19.5	4.8	1800	8.5	
2		1.0	20.5	12.8	1700	8.8	1.1
		2.0	20.5	12.2	1700	8.7	
Total		3.0	20.5	11.8	1750	8.7	
Depth=15.2m		4.0	20.0	11.6	1750	8.7	
		5.0	20.0	8.5	1750	8.7	
		6.0	19.5	8.2	1750	8.7	
		7.0	19.5	7.9	1800	8.6	
		8.0	19.5	7.6	1800	8.6	
		9.0	19.5	7.6	1800	8.5	
		10.0	19.0	7.4	1800	8.6	
		11.0	19.0	7.2	1800	8.5	
		12.0	18.0	4.9	1800	8.5	
		13.0	17.5	2.6	1800	8.3	
		14.0	17.5	1.1	1800	8.1	
		15.0	17.5	0.8	1800	8.1	
3		1.0	20.8	15.2	1800	9.1	0.9
		2.0	20.5	14.3	1800	9.0	
Total		3.0	20.5	13.0	1850	9.0	
Depth=15.5m		4.0	20.0	12.4	1900	9.0	
		5.0	20.0	11.4	1900	9.0	
		6.0	19.5	10.5	1900	9.0	
		7.0	19.0	8.5	1900	8.9	
		8.0	18.5	8.2	1900	8.9	
		9.0	18.5	7.9	1900	8.9	
		10.0	18.0	7.8	1900	8.8	
		11.0	18.0	5.8	1900	8.8	
		12.0	17.5	3.4	1900	8.6	
		13.0	17.5	1.9	1900	8.5	
		14.0	17.5	1.2	1900	8.5	
		15.0	17.5	0.8	1900	8.4	
4		1.0	21.5	16.2	1800	9.1	0.3
		2.0	21.0	16.2	1800	9.1	
Total		3.0	21.0	16.0	1800	9.0	
Depth=6.5m		4.0	20.5	14.2	1800	9.0	
		5.0	20.5	9.0	1800	8.9	
		6.0	20.5	7.6	1800	8.8	

**Table A-11. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
			m	°C	μmhos	m	m
1 Total Depth=10.8m	03/08/77	1.0	19.7	8.6	1650	8.8	1.0
		2.0	19.7	8.4	1650	8.8	
		3.0	19.7	8.2	1650	8.8	
		4.0	19.7	8.0	1650	8.8	
		5.0	19.7	7.8	1650	8.8	
		6.0	19.7	7.8	1650	8.8	
		7.0	19.7	7.7	1650	8.8	
		8.0	19.7	7.6	1650	8.8	
		9.0	19.7	7.3	1650	8.7	
		10.0	19.5	7.2	1650	8.7	
		10.5	19.5	7.2	1650	8.7	
2 Total Depth=14.6m	03/08/77	1.0	20.3	9.4	1700	8.7	1.4
		2.0	20.3	9.3	1700	8.7	
		3.0	20.0	9.1	1700	8.6	
		4.0	20.0	8.9	1750	8.6	
		5.0	20.0	8.7	1750	8.6	
		6.0	20.0	8.5	1750	8.6	
		7.0	20.0	8.2	1750	8.6	
		8.0	19.7	7.2	1800	8.6	
		9.0	19.5	6.9	1800	8.6	
		10.0	19.3	5.1	1800	8.5	
		11.0	19.3	4.0	1800	8.5	
		12.0	19.3	2.8	1800	8.5	
		13.0	19.3	2.7	1850	8.4	
		14.0	19.3	1.9	1850	8.4	
3 Total Depth=15.8	03/08/77	1.0	20.0	8.7	1700	9.0	1.3
		2.0	20.0	8.6	1700	9.0	
		3.0	20.0	8.2	1700	9.0	
		4.0	20.0	8.1	1700	9.0	
		5.0	19.7	7.9	1700	9.0	
		6.0	19.7	7.8	1750	9.0	
		7.0	19.7	7.8	1750	9.0	
		8.0	19.7	7.6	1750	9.0	
		9.0	19.5	7.6	1750	9.0	
		10.0	19.5	7.6	1750	9.0	
		11.0	19.3	6.7	1800	9.0	
		12.0	19.3	6.6	1800	9.0	
		13.0	19.0	5.0	1800	9.0	
		14.0	19.0	4.0	1800	9.0	
4 Total Depth=6.2m	03/08/77	1.0	19.7	11.0	1650	9.2	0.3
		2.0	19.7	11.0	1650	9.2	
		3.0	19.7	10.8	1650	9.2	
		4.0	19.7	10.6	1650	9.2	
		5.0	19.7	10.0	1650	9.2	
		6.0	19.7	10.0	1650	9.2	

**Table A-11. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
			m	°C	μmhos	m	m
1 Total Depth=10.7m	15/08/77	1.0	17.5	10.9	1550	probe	0.7
		2.0	17.5	10.6	1450	mal-	
		3.0	17.3	10.0	1450	function	
		4.0	17.3	9.6	1500		
		5.0	17.0	9.5	1500		
		6.0	17.0	9.4	1500		
		7.0	17.3	9.0	1450		
		8.0	17.0	8.8	1500		
		9.0	17.0	9.2	1500		
		10.0	17.0	9.2	1450		
2 Total Depth=14.9m	15/08/77	1.0	17.0	11.2	1600	"	0.9
		2.0	17.0	10.8	1600		
		3.0	17.0	10.0	1600		
		4.0	16.7	8.5	1550		
		5.0	16.7	8.3	1550		
		6.0	16.5	8.2	1550		
		7.0	16.5	8.1	1550		
		8.0	16.5	8.1	1550		
		9.0	16.5	8.0	1550		
		10.0	16.5	7.9	1550		
		11.0	16.5	7.9	1550		
		12.0	15.7	7.8	1500		
		13.0	15.7	7.7	1500		
		14.0	15.7	7.5	1450		
		14.5	15.7	7.4	1400		
3 Total Depth=16.0	13/08/77	1.0	17.7	15.2	2100	"	1.0
		2.0	17.7	14.8	2100		
		3.0	17.5	12.6	2100		
		4.0	17.3	11.2	2050		
		5.0	17.3	11.0	1900		
		6.0	17.3	10.8	1850		
		7.0	17.3	10.8	1800		
		8.0	17.0	10.6	1800		
		9.0	17.0	10.6	1800		
		10.0	17.0	11.0	1800		
		11.0	17.0	10.6	1750		
		12.0	17.0	10.6	1750		
		13.0	17.0	11.2	1700		
		14.0	17.0	11.1	1700		
4 Total Depth=6.0m	13/08/77	1.0	16.5	11.0	1700		
		2.0	18.0	13.6	2050	"	0.6
		3.0	17.7	11.1	2050		
		4.0	17.7	10.8	2000		
		5.0	17.7	9.5	1950		
		5.5	17.7	9.5	1950		

**Table A-12. Basic Physical and Chemical Data, Round Lake**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
			m	°C	µmhos	m	m
1 Total Depth=9.5m	06/07/77	1.0	19.5	9.5	1550	8.7	1.3
		2.0	19.5	9.4	1600	8.7	
		3.0	19.3	9.3	1600	8.7	
		4.0	19.3	9.1	1600	8.7	
		5.0	19.3	8.9	1600	8.7	
		6.0	19.0	8.7	1600	8.7	
		7.0	19.0	8.6	1650	8.7	
		8.0	19.0	7.8	1650	8.7	
		9.0	19.0	4.5	1650	8.7	
2 Total Depth=11.0m	1.0	20.0	12.2	1700	9.1	1.4	
		2.0	20.0	11.6	1700	9.1	
		3.0	19.7	11.5	1750	9.0	
		4.0	19.5	11.0	1800	9.0	
		5.0	19.5	11.0	1800	9.0	
		6.0	19.3	10.6	1850	8.9	
		7.0	19.0	10.2	1850	8.9	
		8.0	19.0	9.1	1850	8.9	
		9.0	19.0	6.5	1900	8.9	
		10.0	19.0	4.5	1900	8.7	
3 Total Depth=10.4m	1.0	21.0	15.0	1550	9.1	1.0	
		2.0	20.7	13.0	1550	9.1	
		3.0	20.5	12.8	1550	9.0	
		4.0	20.5	12.2	1600	9.0	
		5.0	20.5	12.0	1600	9.0	
		6.0	20.0	12.0	1650	9.0	
		7.0	20.0	12.0	1600	9.0	
		8.0	20.0	11.0	1600	8.9	
		9.0	20.0	10.0	1600	8.9	
		10.0	20.0	8.0	1600	8.9	

**Table A-12. (cont.)**

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi
		m	°C	µmhos	m	m	m
1 Total Depth=8.5m	19/07/77	1.0	20.5	10.4	1650	8.8	1.5
		2.0	20.5	10.2	1650	8.8	
		3.0	20.5	9.5	1800	8.8	
		4.0	20.5	8.6	1800	8.8	
		5.0	20.5	8.3	1800	8.8	
		6.0	20.5	7.8	1800	8.6	
		7.0	20.5	6.9	1800	8.6	
		8.0	20.5	6.5	1800	8.6	
2 Total Depth=10.9m	1.0	21.0	15.0	1650	8.8	0.7	
		2.0	21.0	14.4	1650	8.8	
		3.0	20.5	12.8	1700	8.8	
		4.0	20.5	12.8	1750	8.6	
		5.0	20.5	9.8	1650	8.6	
		6.0	20.5	9.0	1650	8.6	
		7.0	20.5	8.6	1650	8.6	
		8.0	20.5	8.3	1700	8.6	
		9.0	20.5	7.9	1750	8.5	
		10.0	20.5	5.9	1800	8.4	
3 Total Depth=10.5m	1.0	22.0	16.0	1800	8.8	1.3	
		2.0	21.5	14.8	1800	8.8	
		3.0	21.5	13.6	1800	8.8	
		4.0	21.0	13.6	1850	8.8	
		5.0	20.5	13.2	1850	8.9	
		6.0	20.5	12.2	1900	8.9	
		7.0	20.5	8.9	1900	8.8	
		8.0	20.0	7.5	1900	8.6	
		9.0	20.0	6.6	1900	8.5	
		10.0	20.0	6.1	1850	8.4	
1 Total Depth=9.9m	1.0	20.0	6.7	1650	8.2	1.6	
		2.0	20.0	6.6	1650	8.1	
		3.0	20.0	6.5	1700	8.1	
		4.0	20.0	6.3	1700	8.1	
		5.0	20.0	6.2	1700	8.1	
		6.0	20.0	6.1	1700	8.0	
		7.0	20.0	7.0	1750	8.0	
		8.0	20.0	6.9	1750	8.0	
		9.0	20.0	5.8	1750	8.0	
		9.5	20.0	5.6	1750	8.0	
2 Total Depth=10.9m	1.0	20.3	7.5	1600	8.4	2.4	
		2.0	20.3	7.3	1600	8.4	
		3.0	20.0	7.3	1600	8.4	
		4.0	20.0	7.4	1600	8.4	
		5.0	20.0	7.4	1600	8.4	
		6.0	20.0	7.4	1650	8.4	
		7.0	20.0	7.2	1650	8.5	
		8.0	20.0	7.0	1650	8.4	
		9.0	20.0	6.8	1650	8.4	
		10.0	19.7	5.5	1650	8.3	
3 Total Depth=9.5m	1.0	20.5	12.8	1650	8.1	0.4	
		2.0	20.3	10.2	1650	8.1	
		3.0	20.3	9.0	1650	8.1	
		4.0	20.3	8.6	1650	8.1	
		5.0	20.0	8.4	1650	8.1	
		6.0	20.0	8.2	1650	8.1	
		7.0	20.0	8.1	1650	8.1	
		8.0	20.0	8.0	1650	8.1	
		9.0	20.0	5.7	1650	8.0	

Table A-12. (cont.)

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi		
								m	°C
1 Total Depth=10.5m	13/08/77	1.0	17.5	7.8	1700	8.8	2.4		
		2.0	17.5	7.6	1700	8.8			
		3.0	17.5	7.6	1700	8.8			
		4.0	17.0	7.6	1750	8.8			
		5.0	17.0	7.5	1750	8.7			
		6.0	17.0	7.5	1750	8.7			
		7.0	17.0	7.5	1750	8.7			
		8.0	17.0	7.5	1750	8.7			
		9.0	16.7	7.5	1750	8.7			
		10.0	16.7	7.4	1750	8.8			
2 Total Depth=10.8m	13/08/77	1.0	17.3	12.0	1800	8.9	1.7		
		2.0	17.3	11.0	1800	8.9			
		3.0	17.3	10.4	1800	8.8			
		4.0	17.0	10.4	1800	8.8			
		5.0	17.0	10.4	1800	8.8			
		6.0	17.0	9.4	1800	8.8			
		7.0	17.0	9.2	1800	8.8			
		8.0	17.0	9.1	1800	8.7			
		9.0	17.0	9.1	1750	8.7			
		10.0	17.0	8.8	1750	8.6			
		10.5	17.0	8.5	1750	8.6			
3 Total Depth=9.6m	13/08/77	1.0	17.5	12.2	1950	8.9	0.5		
		2.0	17.5	12.2	1950	8.8			
		3.0	17.3	11.8	1900	8.7			
		4.0	17.3	10.9	1850	8.7			
		5.0	17.3	10.6	1800	8.7			
		6.0	17.0	10.6	1800	8.7			
		7.0	17.0	10.6	1800	8.6			
		8.0	17.0	10.4	1800	8.6			
		9.0	17.0	10.4	1800	8.5			
		9.0	17.0	10.4	1800	8.5			

Table A-12. (cont.)

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi		
								m	°C
1 Total Depth=9.1m	13/12/77	0.5	0.2	12.7	790	9.1	2.6		
		1.0	0.6		790				
		2.0	0.8		790				
		3.0	0.8	12.7	790	9.1			
		4.0	0.8		790				
		5.0	0.8		790				
		6.0	1.0	12.2	800	9.0			
		7.0	1.0		800				
		8.0	1.1		800				
		9.0	1.1	11.4	800	8.9			
		9.1	1.1		800				
3 Total Depth=6.5m	13/12/77	0.5	0.2	12.7	720	9.0	2.7		
		1.0	0.5		770				
		2.0	0.7	13.2	770	9.0			
		3.0	1.0		770				
		3.5		12.5		9.1			
		4.0	1.0		770				
		5.0	1.0		780				
		6.0	1.0	12.2	780	8.9			
		6.5	2.0		780				

Table A-12. (cont.)

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi		
								m	°C
1 Total Depth=8.3m	09/01/78	1.0	0.0	12.8	860	8.9	2.6		
		2.0	0.0		860				
		3.0	0.5	12.5	870	8.9			
		4.0	1.0		870				
		5.0	1.1		880				
		6.0	1.2	11.8	880	8.9			
		7.0	1.5		880				
		8.0	1.7	11.1	890	8.8			
3 Total Depth=10.4m	09/01/78	1.0	-0.2	13.1	850	9.0	2.7		
		2.0	0.0		850				
		3.0	0.0		850				
		4.0	0.1	13.2	860	9.0			
		5.0	0.2		860				
		6.0	0.5		870				
		7.0	0.8	12.6	870	8.9			
		8.0	1.0		870				
		9.0	1.6		880				
		10.0	2.3	10.5	920	8.7			

Station	Date	Depth	Temp.	D.O.	Cond.	pH	Secchi		
								m	°C
1 Total Depth=9.6m	14/02/78	1.0	-0.2	11.5	870	8.8	2.6		
		2.0	+0.1		870				
		3.0	0.2	11.8	880	8.7			
		4.0	0.7		880				
		5.0	0.8		880				
		6.0	1.0	10.6	880	8.6			
		7.0	1.0		880				
		8.0	1.0		890				
		9.0	1.6		900				
		9.5	1.8	9.3	890	8.5			
3 Total Depth=10.8m	14/02/78	1.0	0.0	11.5	860	8.8	2.7		
		2.0	0.2		870				
		3.0	0.2		870				
		4.0	0.2	11.5	870	8.7			
		5.0	0.5		880				
		6.0	0.7		880				
		7.0	1.0	11.2	880	8.8			
		8.0	1.0		880				
		9.0	1.5		900				
		10.0	2.0		920				
		10.5	2.0	10.6	920	8.5			

**Table A-12. (cont.)**

<u>Station</u>	<u>Date</u>	<u>Depth</u>	<u>Temp.</u>	<u>D.O.</u>	<u>Cond.</u>	<u>pH</u>
		m	°C		µmhos	
1	06/03/78	1.0	0.8	9.9	870	8.8
		2.0	0.8		870	
Total		3.0	0.8		870	
Depth=9.1m		4.0	1.0	9.5	870	8.7
		5.0	1.2		880	
Ice Depth=1.1m		6.0	1.2		880	
		7.0	1.7	8.0	880	8.7
		8.0	2.0		880	
		9.0	2.2	6.9	900	8.7
3		1.0	0.2	9.9	870	8.9
		2.0	0.7		880	
		3.0	0.7		880	
		4.0	0.7	9.8	880	8.9
		5.0	0.7		880	
		6.0	0.7		880	
		7.0	1.0	9.3	880	8.7
		8.0	1.0		900	
		9.0	1.0		900	
		10.0	1.7	7.7	900	8.7
1	11/05/78	1.0	9.8	13.1	1010	8.9
		2.0	9.8		1010	
Total		3.0	9.8		1020	
Depth=10.2m		4.0	9.8	11.0	1020	9.0
		5.0	9.8		1020	
		6.0	9.8		1020	
		7.0	9.2	10.7	1020	8.7
		8.0	6.3		1020	
		9.0	5.8		1020	
		10.0	5.8	6.5	1020	8.5
3		1.0	9.8	11.3	980	8.9
		2.0	9.8		980	
Total		3.0	9.8		980	
Depth=11.2m		4.0	9.6	10.4	980	9.3
		5.0	9.6		980	
		6.0	8.0		990	
		7.0	7.8	8.8	990	9.1
		8.0	6.8		990	
		9.0	6.2		990	
		10.0	6.0		980	
		11.0	6.0	6.7	980	8.8

**Table A-12. (cont.)**

<u>Station</u>	<u>Date</u>	<u>Depth</u>	<u>Temp.</u>	<u>D.O.</u>	<u>Cond.</u>	<u>pH</u>
		m	°C		µmhos	
1	21/06/78	surface	17.8	9.1	1200	8.7
		1.0	17.8		1190	
Total		2.0	17.6		1190	
Depth=10.8m		3.0	17.2		1170	
		4.0	17.2	8.6	1170	8.7
		5.0	17.0		1170	
		6.0	16.8		1170	
		7.0	16.8	7.8	1170	8.6
		8.0	16.8		1170	
		9.0	16.8		1170	
		10.0	16.8		1170	
		10.5	16.7	6.3	1170	8.6
3		surface	19.8	13.7	1240	8.8
		1.0	19.4		1240	
		2.0	19.0		1230	
		3.0	18.2		1220	
		4.0	18.0	9.8	1200	8.7
		5.0	18.0		1200	
		6.0	17.8		1200	
		7.0	17.5		1180	
		8.0	17.2	7.2	1180	8.8
		9.0	17.0		1180	
		10.0	17.0		1180	
		11.0	17.0	6.0	1140	8.7
		11.3	17.0		1140	