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THE APPLICATION OF NUTRIENT LOADING-PRODUCTION
MODELS TO THE QU'APPELLE VALLEY LAKES

by

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for

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Inland Waters Directorate
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FOREWORD

This report is part of an ongoing research programme on hypertrophic, mainstem lakes of interprovincial and international Prairie river basins. The program includes modeling of nutrient loading and nutrient balances; nutrient-productivity modeling; sediment-water interactions; sediment geochemistry; toxic substance pathways; eutrophication and contamination history; physical controls on eutrophication; and hypertrophic lake rehabilitation experiments (National Water Research Institute, Report of Research Activities-1978, N.W.R.I.-W.N.R.-PR-78-3).

Earlier publications (Allan and Kenney, 1977; Allan and Williams, 1978) proposed that in the Fishing Lakes: (1) lake water phosphorus level is buffered internally by release of non-apatite inorganic phosphorus from bottom sediments; and (2) at present phosphorus levels, mean summer phytoplankton biomass is not phosphorus limited and might be nitrogen limited. This report substantiates these proposals by a more comprehensive analysis of the water quality data base for the entire Qu'Appelle River Basin and by additional reasoning from that employed earlier.

Phosphorus export values, calculated for streams in the basin, indicate that phosphorus loading to Pasqua Lake consists of a natural component (30%), a Prairie-agricultural component (37%) and a municipal component (33%). Removing the municipal component will lower phosphorus concentration in the Fishing Lakes but spring total phosphorus levels will remain at eutrophic levels. Reduction of phosphorus will shift the total nitrogen to phosphorus ratio and may actually increase summer phytoplankton biomass.

Phosphorus loading from airborne and groundwater sources is estimated. The latter is not adequately measured to date but could be a significant part of the internal loading component.

It must be noted that the report is not based on a rigorously collected research data base but on information collected by agencies responsible for monitoring water quality and quantity.

The report advocates detailed surveillance of the effects of nutrient removal on summer phytoplankton biomass in the Qu'Appelle Lakes. With 1977 activation of a treatment plant to remove phosphorus from Regina sewage, the historical data base cannot be reproduced. The report also notes a need for expanded research to resolve gaps in our knowledge of Prairie lake responses to manipulation of nutrient loads.

Some of this report will appear in journal publications. Meanwhile, it is released on a limited basis so that the raw data, basic calculations and proposals are available to interested parties.

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1. INTRODUCTION

1.A BACKGROUND

In 1970-71 the Qu'Appelle Basin Study was carried out to prepare "a comprehensive Framework Plan to develop and manage the water and related land resources of the basin for social betterment and economic growth". A portion of the information collected to meet this purpose included an investigation of water quality, with respect to nutrients. The lakes within the basin are highly productive as exhibited by the noxious algal blooms and recommendations were made to control or reduce nutrient inputs from municipal, industrial, agricultural and recreational sources in an attempt to retard the rate of lake eutrophication.

Some measures have been taken to follow the recommendations from this Study and reduce the nutrient inputs. These include the installation of a third treatment plant to process the waste effluent from Regina by reducing phosphorus and algae before it is discharged into Wascana Creek and the subsidizing of farmers to change feedlot practices or fertilizer applications.

Since the study period a network of water quality monitoring stations has been established by the Saskatchewan Department of the Environment. The data collected from these stations provide an ongoing record of water quality in the Qu'Appelle Basin, but they can also be used to help evaluate the applicability of nutrient loading-production models to Prairie lakes. Allan and Kenney (1977) carried out a preliminary investigation using the data set from the Fishing Lakes. However a more thorough investigation of both the original data and the application of these data to nutrient loading-production models is warranted.

The anticipated direct effect of reducing nutrient loading on lake eutrophication in the Qu'Appelle was based on early models relating nutrient loading to production. They were being developed to quantify the effects on a lake of making specific changes to the nutrient loading stress, thus providing a useful predictive tool for lake and watershed management.

One of the early models developed by Sakamoto (1966), in Japanese lakes showed a correlation between both the concentration of phosphorus and the concentration of nitrogen in the lake and the average summer chlorophyll content of the lake. This empirical model which quantifies the relationship between a lake nutrient and lake production was further tested

and confirmed by Dillon and Rigler (1974b) for phosphorus in southern Ontario lakes and using literature values in North American lakes. If this relationship holds for Prairie lakes and if the lake phosphorus concentration is known, the greenness of the lake can be calculated. Therefore if any changes in lake and watershed management are made resulting in a change in lake phosphorus concentration, the corresponding change in lake production can be predicted.

Models have been developed relating lake phosphorus concentration to phosphorus loading, lake phosphorus retention coefficient, flushing rate and mean depth of the lake (Vollenweider, 1969, 1975; Dillon and Rigler, 1974a). Any changes in drainage basin management which affect these factors will in turn affect the lake phosphorus concentration. Again, if this model can be applied to Prairie lakes, management has a useful predictive tool, and when used in conjunction with Sakamoto's model predictions of changing lake production can be made. Vollenweider (1976a) developed a predictive model which combines these two models to predict lake chlorophyll concentration directly from phosphorus loading, water loading and lake mean depth.

Further work in this area of empirical limnology has developed models relating phosphorus export to geology and land use (Dillon and Kirchner, 1975a), and relating lake retention of phosphorus to areal water load (Dillon and Kirchner, 1975b). In addition Vollenweider (1976b) has developed a method of quantifying internal loading and Schindler (1976) has investigated the concept of limiting nutrient using changing N:P ratios.

These models can be used to predict changes in the lake system on a quantitative rather than a qualitative basis and as such are a valuable management tool. However to be useful in the Prairies they must be shown to be applicable. Therefore the historical data collected from the Ou'Appelle Valley will be used to test these models.

1.B OBJECTIVES

The purpose of this study is to determine the applicability of these nutrient loading-production models to the Fishing Lakes; Pasqua, Echo, Mission and Katepwa; and the lower lakes; Crooked and Round; in the Qu'Appelle Valley, Saskatchewan, using historical data of water supply and water quality.

A yearly water budget for the six lakes will be calculated taking into consideration river inputs and outputs, precipitation, evaporation and groundwater, where data are available. In conjunction with the available water quality data, this will form the basis of calculations of a phosphorus budget for each lake and will be attempted for the years 1970-76. The calculations of phosphorus export and loading will be compared with estimates derived from considerations of geology and land use (Dillon and Kirchner, 1975a), and the calculated retention of phosphorus in the lakes will be compared with estimates from a model relating areal water loading to phosphorus retention (Dillon and Kirchner, 1975b).

Historical data from the lakes of phosphorus concentration and chlorophyll a concentration will be evaluated and compared with relevant models (Sakamoto, 1966; Dillon and Rigler, 1974a) and models relating phosphorus loading to lake phosphorus concentration will be tested on these lakes (Dillon and Rigler, 1974b). Other models (Schindler, 1976; Vollenweider, 1976b) will be used to evaluate these Prairie lakes. Finally, an attempt will be made to characterize these lakes with respect to lake phosphorus and chlorophyll concentrations under anticipated natural and reduced loading conditions.

2. METHODS

2.A. HYDROLOGY

2.A.1 Location and Morphometry

The Qu'Appelle Basin in southern Saskatchewan is drained by the Qu'Appelle River and its tributaries. The river locations where water quality and quantity will be investigated are shown in Fig. 2A1, as are the six lakes which provide data for lake budgets. A discussion of the chemical and physical aspects of the drainage basin and some of the lakes is given in Hammer (1971).

The lakes are shallow with mean depths ranging from 5.8 m in Pasqua to 14.1 m in Katepwa and they seldom stratify for extended periods in the summer. The effective drainage areas upstream of the lakes are large relative to the lake areas (Table 2A1). Details of lake morphometry are given in Table AA1.

2.A.2 Water Quantity Data

Water in the Prairies is a precious resource and hence its quantity and movement are monitored closely. Environment Canada routinely collects data from the Qu'Appelle Valley area; hydrological data by Water Survey of Canada and meteorological data by Atmospheric Environment Service. Both of these agencies have been operating for many years and the data they collect is accurate and reliable, providing a firm basis for calculations of water budgets for lakes.

2.A.3 Water Budgets

The water budget of a lake can be calculated from the equation;

$$\text{input} + \text{precipitation} - \text{evaporation} \\ - \text{lake storage change} + \text{groundwater} = \text{output}.$$

All of these parameters except groundwater have been measured or can be closely approximated for the six Qu'Appelle lakes. The groundwater flow will be included within the calculation of miscellaneous drainage input from areas with unmeasured streams and from areas draining directly into the lake.

2.A.3.a Inputs and Outputs

Water Survey of Canada monitors the Qu'Appelle River system

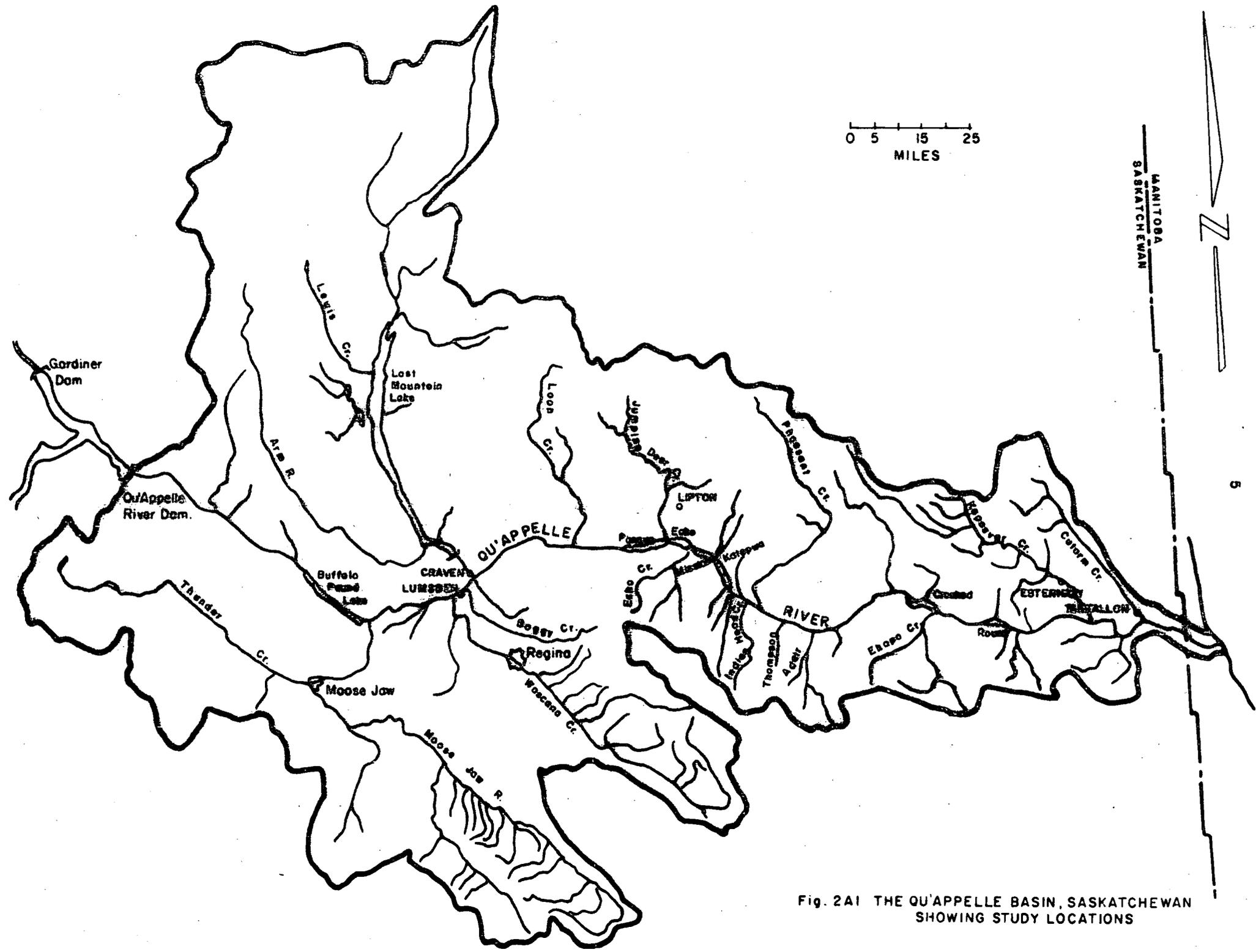


Fig. 2A1 THE QU'APPELLE BASIN, SASKATCHEWAN
SHOWING STUDY LOCATIONS

Table 2A1
Lake and Drainage Basin Morphometry

Lake	Surface Area (A_o) km^2	Effective Drainage Area (A_d) km^2	Mean Depth (z) m	Volume $\times 10^6$ m^3	$\frac{A_d}{A_o}$
Pasqua	19.9	11004.9	5.8	114.7	553
Echo	12.5	11584.2	9.1	114.1	927
Mission	7.6	11792.9	8.7	66.2	1552
Katepwa	16.1	12038.9	14.1	226.6	748
Crooked	14.8	14411.5	8.3	123.5	974
Round	11.0	15337.3	8.1	88.8	1385

(Table AA2) and the Qu'Appelle Basin Study (Water Quality Branch, 1971a) carried out in 1970-71 provided hydrological data at both the input and output of each of the six lakes. However the lakes are not monitored routinely at these locations, and some calculations were required to extend the measured data to these locations for the rest of the study period. The discharge at the input or output from a lake was calculated from the nearest discharge station with adjustments for precipitation, evaporation, change in lake storage and discharge from miscellaneous drainage. The equations used for calculating discharge at each location needed for lake budgets is given in Table 2A2.

Discharge can be expressed in two ways which facilitate comparisons between lakes. Flushing rate, ρ , is the discharge volume per unit time divided by the lake volume or the number of times a volume of water equivalent to the lake volume is replaced. Areal water load, q_s , is the discharge volume per unit time divided by the lake area and is directly analogous to phosphorus loading.

2.A.3.b Precipitation and Evaporation

Atmospheric Environment Service maintains a network of meteorological stations in the Qu'Appelle drainage area monitoring precipitation and a smaller number of these stations also measure evaporation (Table AA4). Precipitation on the lakes was calculated by averaging arithmetically the monthly precipitation depth from the surrounding stations as given in the Monthly Record of Meteorological Observations (Canada, 1970-76). The data from the following stations were used to calculate precipitation to the four Fishing Lakes: Balcarres, Cupar, Dysart, Edgeley, Fort Qu'Appelle, Indian Head CDA, Indian Head Forestry, Lipton. Precipitation to Crooked and Round Lakes was calculated from the following stations: Bangor, Broadview, Grenfell, Melville, Whitewood.

Evaporation is only measured during the summer months and measurements at Indian Head Forestry were applied to the four Fishing Lakes and at Broadview to Crooked and Round Lakes. Evaporation for the months with no measurements had to be estimated. Vowinckel (1967) determined that on average the May to October evaporation was 88% of the annual evaporation. This information was used to calculate annual evaporation from the average measured summer evaporation and the average monthly evaporation was calculated using these data and published maps of Canada with isolines of

Table 2A2

Calculation of Discharge in cfs at each Location for Lake Budgets

Location	Discharge Calculation
Pasqua input	Qu'Appelle River below Loon Creek (05JK007) Jan. and Feb. 1970 - use average values 71-77.
Jumping Deer Creek input to Pasqua	Jumping Deer Creek near Lipton (05JK004) lag all data 1 day, if daily discharge > 10cfs, x 1.45
Pasqua output, Echo input	Pasqua input + 206.6(precip. - evap.) - 2.479 x 10 ³ x (lake level change) + 0.3547(misc.) Jan. and Feb. 1970 use average values 71-77.
Echo output, Mission input	[Echo input + Mission output + 50.87(precip. - evap.) - 124.6(12.5 x lake level change Echo - 7.6 x lake level change Katepwa) + 0.087(misc.)] / 2
Mission output, Katepwa input	Katepwa output - 67.13(precip. - evap.) + 2.006 x 10 ³ x (lake level change) - 0.287(misc.)
Katepwa output	Qu'Appelle River at outlet Katepwa Lake (05JL007)
Crooked input	Qu'Appelle River at Hyde (05JM013) Jan., Feb., Nov. and Dec. 1973-77 use Katepwa output + 1.131
Crooked output	Crooked input + 153.6(precip. - evap.) - 1843.7 x (lake level change) + a(misc.) 70-71, a=0.361; 72-74, a=0.273; 75-77, a=0.196
Round input	1.041(Crooked output) - 0.620
Round output	70-71, Qu'Appelle River at Tantallon (05JM003) - 0.40 x (misc.) - Kaposvar Creek near Esterhazy (05JM012) 72-74, Qu'Appelle River at Tantallon (05JM003) - 0.41(misc.) 75-77, Qu'Appelle River near Welby (05JM001) - Cutarm Creek near Spy Hill (05JM015) - 0.576(misc.)

precipitation and evaporation in inches

lake level change in feet

misc. is miscellaneous drainage discharge calculated for Fishing Lakes or
Lower Lakes.

average monthly evaporation (Bruce and Weisman, 1967). Table 2A3 gives values of monthly evaporation which were assigned when no measurement were available.

To calculate volume of water contributed by precipitation or removed by evaporation, the depth is multiplied by the surface area of the lakes as given in Table 2A1.

2.A.3.c Lake Storage Change

Water Survey monitors changes in lake level on only four of the six lakes (Table AA3). However the level of Pasqua Lake is controlled by the level of Echo Lake and the level of Mission Lake is controlled by the level of Katepwa Lake and any changes in lake level were applied accordingly. In cases where no measurements were available on a particular date the data were interpolated linearly. The volume of water involved in lake storage change was calculated by multiplying change in lake level by lake area.

2.A.3.d Miscellaneous Drainage

The major flows of water into and out of the lake have been determined, however a significant contribution to the water budget is made by both direct runoff into the lake and groundwater flow. For the purposes of the water budget used in calculations of phosphorus budgets these two factors were calculated together as a miscellaneous drainage flow. Later an attempt was made to separate these factors so that a consideration of groundwater flow might be made. The discharge from miscellaneous drainage for the six lakes was dealt with in two groups; the four Fishing Lakes and the two lower lakes.

The water budget for the Fishing Lakes was calculated by volume on an annual and monthly basis as follows:

Qu'Appelle River below Loon Creek - Qu'Appelle River at outlet of Katepwa Lake + 1.45 x Jumping Deer Creek near Lipton + precipitation - evaporation - lake storage change = miscellaneous drainage.

The annual miscellaneous drainage volume was divided on a monthly basis relative to the monthly Pasqua inflow as a percentage of the annual Pasqua inflow. To determine miscellaneous drainage for each individual lake the total miscellaneous drainage was divided according to relative lake areas.

A number of different equations were used to calculate

Table 2A3

Monthly Evaporation Assigned for
Months with no Data Measurements

Month	Fishing Lakes		Lower Lakes	
	in	cm	in	cm
January	0.0	0.0	0.0	0.0
February	0.2	0.5	0.2	0.5
March	0.4	1.0	0.4	1.0
April	1.7	4.3	1.6	4.1
May	4.1	10.4	4.5	11.4
June	5.5	14.0	4.7	11.9
July	5.8	14.7	5.6	14.2
August	4.8	12.2	4.0	10.2
September	2.9	7.4	2.5	6.4
October	2.5	6.4	2.1	5.3
November	0.9	2.3	0.8	2.0
December	0.2	0.5	0.2	0.5
Annual	29.0	73.7	26.7	67.8

miscellaneous drainage for Crooked and Round Lakes because of changes in Water Survey data collected. These equations are:

for 1970-71, Qu'Appelle River at Hyde - Qu'Appelle River at Tantallon

- Ekapo Creek near Marieval - Kaposvar Creek near Esterhazy + precipitation - evaporation - lake storage change = miscellaneous drainage;

for 1972-74, Qu'Appelle River at Hyde - Qu'Appelle River at Tantallon

- Ekapo Creek near Marieval + precipitation - evaporation - lake storage change = miscellaneous drainage;

for 1975-77, Qu'Appelle River at Hyde - Qu'Appelle River near Welby - Cutarm Creek near Spy Hill + precipitation - evaporation - lake storage change = miscellaneous drainage.

The annual miscellaneous drainage volume was divided into monthly volumes on the same percentage basis as the Qu'Appelle River at Hyde and these monthly volumes were divided according to the ratio of miscellaneous drainage upstream of the lake outflow to total miscellaneous drainage.

Example calculations are shown in Table 2A4:

2.A.4 Groundwater

Groundwater flow is not negligible in the area (Rey, 1970) but the groundwater factor, included in the miscellaneous drainage volume can only be very roughly approximated. Assuming that the depth of runoff from the miscellaneous area was equal to that from a measured Qu'Appelle River station, the discharge volume was calculated for the miscellaneous area and the volume of groundwater contribution was calculated by difference. This calculation was made in two groups; the four Fishing Lakes and the two lower lakes.

Table 2A4
Example Calculations of Miscellaneous Drainage

1. Jan. misc. vol. in Lower Lakes	$= \frac{\text{Jan. Qu'Appelle River at Hyde}}{\text{Annual Qu'Appelle River at Hyde}}$	\times annual misc. vol.
2. Pasqua misc. area	$= \frac{19.9}{56.1}$	\times misc. area of Fishing Lakes
3. Crooked misc. area 1975-77	Hyde to Marieval	= 410.0 km ²
	Marieval to Round output	= 475.9 km ²
	1970-71 Round output to Tantallon	= 248.7 km ²
	1972-74 Round output to Tantallon	= 616.5 km ²
	1975-77 Round output to Welby	= 1204.4 km ²
	$= \frac{410.0}{2090.3}$	\times misc. area of Lower Lakes

2.B CHEMISTRY

2.B.1 Water Quality Data2.B.1.a River

The water sampling and analysis were carried out by two different government agencies, the Federal Department of Environment, Water Quality Branch (WQB) and the Saskatchewan Department of Environment, Water Pollution Control Branch (WPCB). All the data from WQB were available using its computerized data retrieval system, NAQUADAT and from WPCB using copies of lab results sheets supplied by the data officer. Total phosphorus and total nitrogen were of primary interest as well as nitrogen to phosphorus ratios, and these data were tabulated for locations relevant to this study (Tables AB2, AB3, AB4).

The data were carefully examined before they were used, in order to eliminate the more questionable concentration values and a useful tool in finding suspicious values was the N:P ratio. When these ratios were examined for a single location any ratio markedly different from other ratios suggested that one of the values was incorrect. The most obvious errors of a misplaced decimal were reflected in a 10-fold difference in ratio and these were corrected. Other possible errors were less easily corrected.

One type of error results from the NAQUADAT computer calculation of total nitrogen by the addition of TKN and dissolved NO_3 & NO_2 . The detection limit of TKN was 0.5 mg/l while the detection limit of NO_3 & NO_2 was 0.005 mg/l. Although this did not occur often, when a TKN value of less than 0.5 mg/l was registered it was taken as 0 and added to the NO_3 & NO_2 data. This resulted in an invalid underestimate of total nitrogen and generally an obvious underestimate of N:P.

On other occasions, though the N:P ratio was questionable, neither the nitrogen nor phosphorus data were obviously in error. Since they could not be verified and might result from a natural fluctuation, the data were used unchanged in calculations of phosphorus budgets. This conservative method was used so that as much data as possible were available for further calculations.

Since the data were collected by two different agencies it is important to establish their comparability. The analytical methods, outlined in Table AB1, differ only slightly and would be expected to give comparable results. In order to test this comparability, data collected at

the same location on the same day were examined. This exact duplication occurred infrequently but there was a certain amount of overlapping data collection to enable comparisons (Table 2B1).

The only dates when samples were taken for phosphorus analysis by both agencies in approximately the same location in the study area were 24/7/72 and 28/8/72. Both the Federal and Provincial governments sampled on the Qu'Appelle River upstream of Pasqua Lake; WQB at two locations and WPCB at one location. In both cases the phosphorus concentration found by WPCB was between the two concentrations found by WQB. On the few occasions when samples were taken at the same location within a month of each other, the results are inconclusive. At times the phosphorus concentrations were very close, but at other times there was a wide discrepancy between values. Since this was also characteristic of values within one data set, it may well reflect fluctuations due to time, location and normal river variability.

In conclusion, neither data set is superior and it must be assumed for these purposes that the measured phosphorus concentrations are accurate and representative if phosphorus budgets calculated from these data are to be useful. The infrequency of data available however necessitated very large extrapolations, and therefore the precision of resulting calculations is questionable.

2.B.1.b Lake

Most of the lake water data were collected by WPCB, but some additional data for 1970 and 1971 were available from Cullimore and Johnson (1971). As with the river data these data (Table AB5) were examined to try to eliminate spurious values. In many cases there was no clearcut evidence for accepting one value rather than another, so often two seemingly incongruous concentration values were used. In the case of chlorophyll a concentrations, the measurements were so infrequent that only the extremely high measurements which probably represent surface scum were eliminated. The inconsistency and infrequency of the lake data make this the weakest area of the study and when any conclusions are drawn from these data this must be considered.

2.B.2 Lake Concentrations of Nutrients and Chlorophyll

Samples were taken by WPCB at various stations and depths in each lake and occasionally composite samples were taken. Since no consistent

Table 2B1

Comparison of Phosphorus Concentration Data in mg/m^3
 Collected by WQB and WPCB on the Qu'Appelle River

Location	Date	[P] mg/m^3		
		WPCB	WQB	
Pasqua input	19/ 8/70		652	
	2/ 9/70	554		
	24/ 9/70		848	
	24/ 7/72	248	538	
			183	
	28/ 8/72	600	730	
			522	
			860	
		11/ 9/72		
		13/ 9/72	685	
Pasqua output	21/ 8/73	776		
	27/ 8/73		730	
Echo output	2/ 5/72		390	
	18/ 5/72	91		
	17/ 8/73	456		
	27/ 8/73		670	
	14/11/73		400	
	5/12/73	639		
	20/ 8/70		456	
Katepwa output	2/ 9/70	424		
	24/ 9/70		480	
	22/ 8/73		365	
	27/ 8/73	660		
	14/11/73		463	
	4/12/73	350		
	22/ 7/74	215		
	1/ 8/74		530	
	15/ 8/74	232		
	13/10/76	555		
	28/10/76		550	
	9/11/76	496		
	11/ 1/77	418		
	20/ 1/77		480	
29/ 8/72	121			
Crooked input	12/ 9/72		250	
	29/ 8/72	225		
Crooked output	12/ 9/72		440	
	29/ 8/72	20		
Round output	12/ 9/72		160	
	22/ 7/74	91		
	26/ 7/74		340	
	20/ 8/74	183		
	23/ 9/74	385		
	2/10/74		370	
	16/ 7/75		365	
	6/ 8/75	450		
	8/ 1/76	640		
	22/ 1/76		420	

pattern of sampling was established, all measurements of total nitrogen, total phosphorus and chlorophyll a concentration were averaged arithmetically to obtain average monthly concentrations for each lake for as many months as possible. In some cases only one sample was used as representative of the monthly concentration and although this is a poor assumption, in order to deal with these data, such assumptions had to be made. An average year was calculated for each lake by averaging the monthly concentrations and from this a theoretical "average Prairie year" was calculated by averaging the monthly concentrations for all six lakes. This may allow some generalizations to be made about the changes of concentration over one year, which cannot be distinguished from the scattering of basic data.

2.C PHOSPHORUS BUDGETS AND MODELS

The phosphorus budgets for the lakes were calculated for both a calendar year and a June to May year. The June-May year, ending with the spring flood may be expected to more closely affect the conditions in the lake in the following summer. In addition average phosphorus budget data were calculated for each lake from the seven years of data, and these data were averaged again to give a theoretical "average Prairie year". The phosphorus budgets for a lake are calculated by integrating the appropriate phosphorus concentrations with the water budgets. This involves the basic determinations of phosphorus inputs, outputs and retention, by difference.

2.C.1 Monthly Phosphorus Supply

The calculation of phosphorus supply passing a specific location was made for as many months as possible. With more frequent sampling during spring and early summer, the phosphorus concentration on a sampling date was multiplied by the volume of water discharged during the time period from halfway to the previous and subsequent sampling dates. During the remainder of the year only one sample was taken in a month and this phosphorus concentration was taken to represent the monthly value and multiplied by the monthly discharge. In some cases values from two surrounding months were averaged to give a phosphorus concentration for this missing month.

When all the available data were used to calculate monthly phosphorus supply at each location a method was developed to estimate the monthly phosphorus supply for the months when no sampling was done. A regression line was calculated between monthly discharge in cfs and monthly supply in kg, and its regression equation was used to calculate monthly supply from measured mean monthly discharge. For each input and output a separate regression line was calculated for the spring data (April + May) and for the other 10 months (Table 2C1). Phosphorus supply data at Round Lake input were only available for 1970-71, but these data were highly correlated with Crooked Lake output data and the regression equation was used to calculate all subsequent Round Lake input data.

2.C.2 Phosphorus Loading and Export

Phosphorus loading is the total supply of phosphorus expressed per unit area of lake surface. For each lake only the loading from the

Table 2C1

Regression Equations for Calculation of Monthly
Phosphorus Supply from Mean Monthly Discharge

Location	Regression Equation	Correlation Coefficient
Pasqua input	$y = 0.0188x + 4.27$ (June-March)	0.69
	$y = 0.0104x + 8.02$ (April-May)	0.57
Pasqua output, Echo input	$y = 0.0152x + 4.77$ (June-March)	0.64
	$y = 0.0146x + 8.03$ (April-May)	0.61
Echo output, Mission input	$y = 0.0187x + 3.84$ (June-March)	0.74
	$y = 0.0149x + 7.13$ (April-May)	0.69
Mission output, Katepwa input	$y = 0.0211x + 3.59$ (June-March)	0.84
	$y = 0.0136x + 7.20$ (April-May)	0.72
Katepwa output	$y = 0.0242x + 2.44$ (June-March)	0.90
	$y = 0.0141x + 8.54$ (April-May)	0.68
Crooked input	$y = 0.0226x + 1.74$ (June-March)	0.85
	$y = 0.0349x - 1.74$ (April-May)	0.94
Crooked output	$y = 0.0221x + 0.20$ (June-March)	0.84
	$y = 0.0282x - 3.01$ (April-May)	0.93
Round input	$y = 1.0461(\text{Crooked output}) + 0.202$	0.96
Round output	$y = 0.0205x - 0.44$ (June-March)	0.91
	$y = 0.0075x + 4.96$ (April-May)	0.74
Jumping Deer Creek	$y = 0.0180x - 0.03$	0.79

y = monthly supply ($\times 10^3$ kg)
 x = monthly mean discharge (cfs)

measured streams was available, therefore a minimum terrestrial loading value was obtainable. Although this represents a major portion of the loading, inputs from the atmosphere, groundwater and direct runoff were omitted, and this must be recognized when these loading values are used in model computations.

Export is an expression of the amount of a substance leaving a drainage area per unit of area and when the contribution of a nutrient is expressed this way the relative importance of different areas as nutrient sources can be compared. This concept works well in an area where the topographic boundaries of a drainage area are well defined and the water within the boundary flows towards an outflow point of the basin. However it is less clearly applicable to the Prairies with low topographic relief and evaporation exceeding precipitation. Often precipitation falling at the extreme distances from the water course will not reach that water course and in times of low precipitation areas of internal drainage exist. In this case the topographic definition of drainage area is insufficient, but defines the maximum area which will be contributing water and nutrients in a very wet year. In fact the contributing drainage area could differ greatly depending on meteorological events. Therefore an effective drainage area has been defined which is "that portion of a drainage basin which might be expected to entirely contribute runoff to the main stream during a period of low precipitation, say, the one in two-year flood. This area excludes marsh and slough areas and other natural or artificial storage areas which would prevent runoff from reaching the main stream in an average year" (Water Quality Branch, 1971b).

Standard maps of topographic or gross drainage area and effective drainage area are being prepared for the Prairie region by the Prairie Farm Rehabilitation Administration (PFRA) and their preliminary figures are used in this report wherever possible (PFRA, 1977). In cases of small drainage areas which were not defined separately by PFRA, the drainage area was taken from a previous publication by Saskatchewan Water Resources Commission (1971). The gross and effective drainage areas are given in Table 2C2.

In order to standardize results all export values are expressed per unit of effective drainage area. This means that during wet years the calculated export will be too high and during dry years the calculated export will be too low. That is, the range of export values for one stream

Table 2C2
Gross and Effective Drainage Areas
used in Export Calculations

Location Basin	Drainage Area (km ²)	
	Gross	Effective
Jumping Deer Creek	2429.8	247.1
Lewis Creek	572.4	129.5
Echo Creek	619.3	119.1
Sandy Beach Creek	377.0	72.5
Arm River	1908.8	600.9
Indian Head Creek	326.3	188.0
Pheasant Creek	1150.0	344.5
Thompson Creek	227.9	42.7
Adair Creek	393.7	60.9
Ekapo Creek	1095.6	435.1
Kaposvar Creek	1704.2	287.5
Boggy Creek	401.4	308.2
Cutarm Creek	766.6	398.9
Loon Creek	1898.5	380.7
Qu'Appelle River		
Pasqua input	36534.5	11004.9
Echo input	39177.6	11584.2
Mission input	39930.9	11792.9
Katepwa input	40012.4	12038.9
Crooked input	45136.7	14411.5
Round input	47152.9	15337.3
above Wascana Cr.	13626.0	5190.4
at Lumsden	18228.4	6897.2
below Craven	33646.7	10362.6
Buffalo Pound in	2626.3	862.5
above Moose Jaw	5244.8	2820.5
below Moose Jaw	9228.2	3449.9
above Regina	3126.1	1077.4
below Regina	4602.4	1706.8

will be extreme, but the average value over several years should be useful for comparisons.

Export was calculated at locations along the Qu'Appelle River, using data calculated for phosphorus budgets. However water quality and quantity data were available for many other locations on tributary streams within the Qu'Appelle Basin (Table AA2, AB3, AB4). These data were integrated in the same way as the phosphorus budget supply data to calculate export from various sub-basins within the Qu'Appelle Basin.

2.C.3 Lake Nutrients and Production

A number of equations relating phosphorus loading, lake phosphorus concentration and chlorophyll a concentration were tested to determine their applicability to data from these lakes.

The concentration of phosphorus in lake water can be calculated from the equation by Dillon and Rigler (1974a);

$$[P] = \frac{L(1-R)}{\bar{z}\rho}$$

where $[P]$ is spring lake concentration of total phosphorus in mg/m^3 , L is phosphorus loading in $\text{mg}/\text{m}^2/\text{yr}$, R is the retention coefficient of phosphorus, \bar{z} is mean depth of the lake in m and ρ is flushing rate in yr^{-1} . The concentration of phosphorus in the lake water predicted from the lake budget data was compared with the measured spring (April-June) concentration of phosphorus in the lake water.

Chlorophyll concentration is a measure of the standing crop of phytoplankton, an indicator of lake eutrophication. The measured summer (July-September) concentration of chlorophyll a in each lake was compared with both the concentration of total phosphorus and the concentration of total nitrogen in the spring lake water to determine if there was a correlation between lake nutrients and lake production as found by Sakamoto (1966). The chlorophyll a concentration predicted from the equation;

$$[\text{chl a}] = 0.367 \left(\frac{L}{q_s (1 + \sqrt{\bar{z}/q_s})} \right)^{0.91}$$

where $[\text{chl a}]$ is the mean summer chlorophyll a concentration in the lake water in mg/m^3 , L is phosphorus loading in $\text{mg}/\text{m}^2/\text{yr}$, q_s is the areal water loading in m/yr and \bar{z} is mean depth in m (Vollenweider, 1976a) was compared with the measured chlorophyll a concentration.

2.C.4 Phosphorus Retention and Internal Loading

The internal loading of phosphorus from the sediments, identified as a possibly important nutrient source to these lakes (Allan and Williams, 1978), was investigated using calculations of phosphorus retention and change in lake phosphorus concentration. The phosphorus retention coefficient is calculated by difference from the lake budget data as input minus output divided by input and it indicates the gross retention of phosphorus within the lake. This can be compared with the retention coefficient calculated from the equation by Dillon and Kirchner (1975b);

$$R = 13.2 / (13.2 + q_s)$$

where R is the retention coefficient of phosphorus and q_s is the areal water loading in m/yr. When the change of lake water phosphorus concentration is taken into account a net retention of phosphorus or flux to the sediments can be calculated (Vollenweider, 1976b). Total phosphorus content of the lake water was calculated for each available month by multiplying phosphorus concentration by lake volume and the sediment flux for each time period was calculated by the following equations;

$$P_{\text{lake}} + P_{\text{retention}} = P_{\text{expected}}$$

$$P_{\text{expected}} - P_{\text{actual}} = P_{\text{sediment}}$$

where P is the phosphorus content in kg and the subscripts lake, retention and sediment apply to one month and expected and actual apply to the next measured month. P_{sediment} is the net sediment flux with negative representing net flux and loading to the lake.

2.C.5 Nitrogen:Phosphorus Ratio

Changes in the ratio between nitrogen and phosphorus in the input and output waters of the lake indicate the relative use of these nutrients within the lake and have been used by Schindler (1976) to assess the limitation of these two nutrients on the lake production. The N:P ratio was calculated for all the data at the input and output to each lake. These ratios were averaged arithmetically to give an annual ratio for each lake and these annual ratios were averaged for the study period. Unequal frequency of sampling of different seasons and different years was not taken into consideration in the average ratio calculations, but the ratios are comparable because they contain similar biases.

3. RESULTS

3.A HYDROLOGY

3.A.1 Water Budgets

The flow of water through the lakes is extremely variable from year to year. There is almost a ten-fold difference between discharges in 1973 and 1974 (Table 3A1), but in general the flushing rate in these lakes is high. The average flushing rate for all the lakes is 3.5/yr but it ranges from 0.31/yr in 1973 for the deepest lake, Katepwa, to 10.06/yr for the smallest lake, Mission in 1974.

The areal water load is generally high averaging 29.6 m/yr and ranging from 3.6 m/yr to 87.6 m/yr for all the lakes. The spring flood in April and May caused by the melting of snow exhibits much of this variability, representing from 11% to 58%, and averaging 35% of the annual flow. In years of low winter precipitation, such as 1973, this peak of discharge can be almost non-existent. The variability from year to year is reflected in the Water Survey data collected from 1970 to 1977 at Qu'Appelle River below Loon Creek (Fig. 3A1).

3.A.2 Groundwater

The accuracy of the measurement of the water budget for the lakes is limited for a number of reasons, but these limitations are not of major importance when the water budget is used in the calculation of phosphorus budgets. They are of more importance when used to calculate the movement of groundwater to and from the lake system because the small errors introduced at each step accumulate and are reflected in the final calculated value. As a rough approximation however, these data may be of value when the following factors about the calculations are considered.

First, any measurement of discharge has an inherent degree of error, however small. Second, the stations for the measurements of discharge are not at precisely the inflow or outflow of the lake and hence small errors may occur in extrapolations to these locations. Third, the inputs of some stations are measured only seasonally and the months from November to February are extrapolated in these cases from stations upstream and downstream. Fourth, measurements and estimates for small streams and direct runoff are of necessity approximations, although they contribute only a small percentage of the water flow through the system. Fifth, the

Table 3A1

Water Budgets

Lake	Calendar	Q	ρ	q_s	June-May	Q	ρ	q_s
	Year	$\times 10^6 \text{ m}^3$	yr^{-1}	m yr^{-1}	Year	$\times 10^6 \text{ m}^3$	yr^{-1}	m yr^{-1}
Pasqua	1970	305.6	2.66	15.4	70-71	326.4	2.85	16.4
	1971	221.8	1.93	11.1	71-72	128.2	1.12	6.4
	1972	116.8	1.02	5.9	72-73	79.8	0.70	4.0
	1973	71.3	0.62	3.6	73-74	281.6	2.46	14.1
	1974	649.3	5.66	32.6	74-75	616.2	5.37	31.0
	1975	473.5	4.13	23.8	75-76	515.3	4.49	25.9
	1976	491.2	4.28	24.7	76-77	277.4	2.42	13.0
Echo	1970	308.0	2.70	24.6	70-71	345.3	3.03	27.6
	1971	223.7	1.96	17.9	71-72	127.4	1.12	10.2
	1972	116.5	1.02	9.3	72-73	76.0	0.67	6.1
	1973	68.5	0.60	5.5	73-74	273.8	2.40	21.9
	1974	660.0	5.78	52.8	74-75	643.2	5.64	51.4
	1975	488.6	4.28	39.1	75-76	530.6	4.65	42.2
	1976	503.1	4.41	40.2	76-77	280.8	2.46	22.5
Mission	1970	319.8	4.83	42.1	70-71	359.9	5.44	47.4
	1971	230.5	3.48	30.3	71-72	129.2	1.95	17.0
	1972	115.5	1.75	15.2	72-73	72.4	1.09	9.5
	1973	69.0	1.04	9.1	73-74	270.2	4.08	35.6
	1974	665.6	10.06	87.6	74-75	663.4	10.03	87.3
	1975	496.4	7.50	65.3	75-76	537.8	8.13	70.8
	1976	510.2	7.71	67.1	76-77	275.8	4.17	36.3
Katepwa	1970	317.6	1.40	19.7	70-71	370.9	1.64	23.0
	1971	236.0	1.04	14.7	71-72	132.6	0.58	8.2
	1972	113.5	0.50	7.0	72-73	70.4	0.31	4.4
	1973	70.2	0.31	4.4	73-74	264.8	1.17	16.4
	1974	677.5	2.99	42.1	74-75	683.0	3.01	42.4
	1975	513.0	2.26	31.9	75-76	556.2	2.45	34.5
	1976	525.0	2.32	32.6	76-77	288.0	1.27	17.9
Crooked	1970	360.2	2.92	24.3	70-71	423.1	3.43	28.6
	1971	277.8	2.25	18.8	71-72	174.8	1.42	11.8
	1972	145.8	1.18	9.8	72-73	76.5	0.62	5.2
	1973	75.1	0.61	5.1	73-74	316.4	2.56	21.4
	1974	734.1	5.94	49.6	74-75	739.7	5.99	50.0
	1975	575.4	4.66	38.9	75-76	670.9	5.43	45.3
	1976	658.6	5.33	44.5	76-77	320.8	2.60	21.7
Round	1970	389.6	4.39	35.4	70-71	442.4	4.98	40.2
	1971	294.4	3.32	26.8	71-72	217.2	2.45	19.7
	1972	153.4	1.73	13.9	72-73	79.8	0.90	7.2
	1973	76.1	0.86	6.9	73-74	294.7	3.32	26.8
	1974	758.5	8.54	69.0	74-75	814.1	9.17	74.0
	1975	633.9	7.14	57.6	75-76	757.3	8.53	68.8
	1976	724.0	8.16	65.8	76-77	320.5	3.61	29.1

Q is lake outflow discharge

ρ is flushing rate

q_s is areal water load

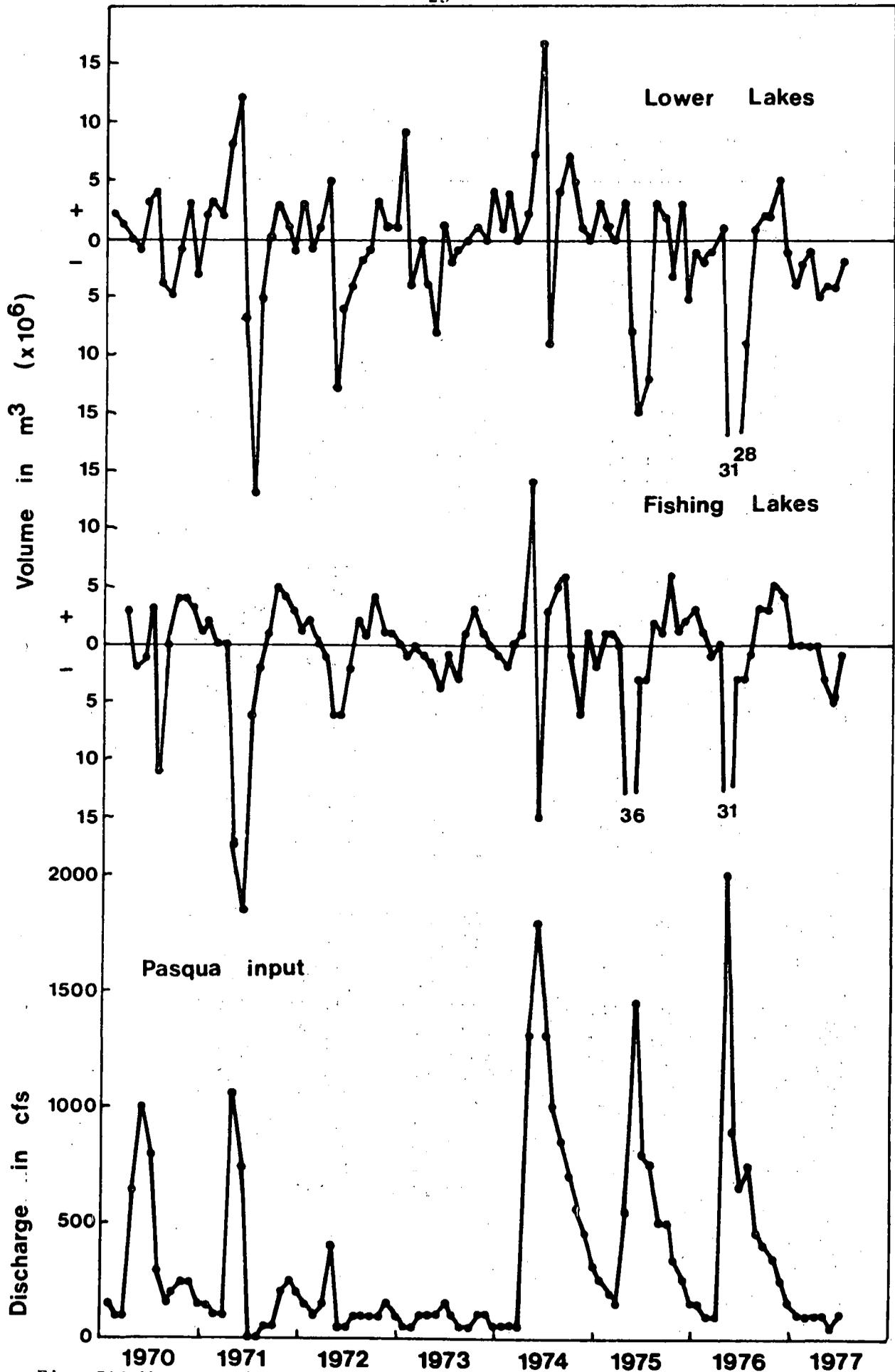


Fig. 3A1 Mean monthly discharge at Pasqua input and monthly volume of groundwater movement in the Fishing and lower lakes

extrapolation of meteorological station data to the lakes may be in error because of the localized nature of Prairie storms, but the good coverage of this area by stations helps reduce this source of error. Sixth, as the water level rises and falls the area of the lake changes, since the sides are not vertical, and this is not considered in calculations of volume changes with changing lake level. Therefore a large number of small sources of error results in an error in the final calculation of the groundwater parameter in the water budget. This error is likely to be larger on the short term of monthly calculations, however on the longer term of a year, some of the errors will cancel each other and hence the estimate for the year is more reliable.

The groundwater movement relative to the two groups of lakes, as calculated by difference, shows both addition to and removal from the lake system on a monthly and on a yearly basis (Table 3A2). Although no pattern is clearly established on a monthly basis the movement of groundwater shows a slight trend towards mirroring the main river inflow (Fig. 3A1). That is, water enters the lakes from groundwater during the spring flood and fluctuates the remainder of the year. The groundwater movement on a yearly basis shows contribution to the lakes in all but three cases; 1970 and 1974 for the Fishing Lakes and 1974 for the lower lakes, and only this last one is substantial at $52.7 \times 10^6 \text{ m}^3$.

Table 3A2

Calculated Volume ($\times 10^6 \text{ m}^3$) of Miscellaneous Drainage and Groundwater

Date	Fishing Lakes			Lower Lakes		
	Misc. for P budget	Misc.	Groundwater	Misc. for P budget	Misc.	Groundwater
1970						
Jan.				+0.877	0.745	+1.622
Feb.				-0.056	0.623	+0.567
Mar.	+1.785	0.748	+2.533	-1.031	0.616	-0.415
Apr.	-6.570	4.605	-1.965	-4.646	3.956	-0.690
May	-8.760	7.317	-1.443	-3.107	5.960	+2.853
Jun.	-3.083	5.789	+2.706	-2.334	5.878	+3.544
Jul.	-13.598	2.337	-11.261	-8.220	3.811	-4.409
Aug.	-1.052	1.129	+0.077	-6.966	1.651	-5.315
Sep.	+2.579	1.365	+3.944	-1.848	0.742	-1.106
Oct.	+1.640	1.912	+3.552	+1.157	1.569	+2.726
Nov.	+1.099	1.849	+2.948	-4.790	1.423	-3.367
Dec.	-0.518	1.127	+0.609	+0.358	1.195	+1.553
Total	-26.478	28.178	+1.700	-30.606	28.169	-2.437
1971						
Jan.	+0.713	0.966	+1.679	+2.028	0.948	+2.976
Feb.	-0.837	0.709	-0.128	+1.282	0.668	+1.950
Mar.	-0.439	0.865	+0.426	+6.283	1.299	+7.582
Apr.	-23.991	7.469	-16.522	+4.750	7.331	+12.081
May	-26.910	3.821	-23.089	-13.979	6.520	-7.459
Jun.	-6.631	0.138	-6.493	-23.534	1.561	-21.973
Jul.	-2.305	0.053	-2.252	-4.957	0.351	-4.606
Aug.	+0.717	0.373	+1.090	-0.490	0.116	-0.374
Sep.	+4.408	0.363	+4.771	+3.240	0.122	+3.362
Oct.	+2.355	1.590	+3.945	+0.112	0.856	+0.968
Nov.	+1.316	1.918	+3.234	-2.042	0.985	-1.057
Dec.	-1.121	1.629	+0.508	+1.604	1.205	+2.809
Total	-52.725	19.894	-32.831	-25.703	21.962	-3.741
1972						
Jan.	+0.437	1.180	+1.617	-2.283	1.089	-1.194
Feb.	-0.248	0.732	+0.484	-0.498	1.113	+0.615
Mar.	-2.164	1.021	-1.143	+1.794	3.098	+4.892
Apr.	-8.657	2.940	-5.717	-17.555	4.162	-13.393
May	-6.599	0.525	-6.074	-8.426	1.979	-6.447
Jun.	-2.693	0.357	-2.336	-4.092	0.183	-3.909
Jul.	+1.045	0.649	+1.694	-2.221	0.055	-2.166
Aug.	+0.204	0.822	+1.026	-1.380	0.417	-0.963
Sep.	+3.677	0.640	+4.317	+2.796	0.508	+3.304
Oct.	+1.632	0.797	+2.429	+0.233	0.623	+0.856
Nov.	+1.547	0.952	+2.499	+0.138	0.947	+1.085
Dec.	-0.252	0.616	+0.364	+7.154	1.431	+8.585
Total	-12.071	11.231	-0.840	-24.340	15.605	-8.735

Table 3A2 cont'd

Date	Fishing Lakes			Lower Lakes		
	Misc. for P budget	Misc.	Groundwater	Misc. for P budget	Misc.	Groundwater
1973						
Jan.	-1.854	0.450	-1.404	-5.226	0.771	-4.455
Feb.	-0.857	0.412	-0.445	-0.966	0.552	-0.414
Mar.	-1.680	0.726	-0.954	-5.282	1.038	-4.244
Apr.	-3.089	0.753	-2.336	-8.519	0.790	-7.729
May	-4.670	0.740	-3.930	+0.590	0.794	+1.384
Jun.	-1.663	0.940	-0.723	-3.084	0.831	-2.253
Jul.	-3.552	0.577	-2.975	-1.953	1.113	-0.840
Aug.	+0.588	0.519	+1.107	-0.589	0.335	-0.254
Sen.	+2.434	0.377	+2.811	+1.078	0.271	+1.349
Oct.	-0.114	0.770	+0.656	+0.048	0.192	+0.240
Nov.	-0.433	0.588	+0.155	+3.363	0.805	+4.168
Dec.	-1.910	0.499	-1.411	+0.380	0.981	+1.361
Total	-16.800	7.351	-9.449	-20.160	8.473	-11.687
1974						
Jan.	-2.641	0.476	-2.165	+2.644	0.974	+3.618
Feb.	-0.128	0.368	+0.240	-0.473	0.658	+0.185
Mar.	+0.829	0.287	+1.116	+1.591	0.670	+2.261
Apr.	+4.270	9.264	+13.534	+3.118	9.201	+12.319
May	-28.259	13.333	-14.926	+2.032	19.665	+21.697
Jun.	-6.412	9.415	+3.003	-22.017	12.995	-9.022
Jul.	-2.587	7.362	+4.775	-4.509	8.979	+4.470
Aug.	-0.789	6.292	+5.503	+0.034	7.141	+7.175
Sep.	-6.553	5.092	-1.461	-1.258	6.136	+4.878
Oct.	-10.141	3.901	-6.240	-3.739	5.162	+1.423
Nov.	-2.143	3.113	+0.970	-3.285	3.616	+0.331
Dec.	-4.421	2.194	-2.227	+0.300	3.052	+3.352
Total	-58.975	61.097	+2.122	-25.562	78.249	+52.687
1975						
Jan.	-0.622	1.944	+1.322	-2.268	3.300	+1.032
Feb.	-0.801	1.392	+0.591	-2.832	2.365	-0.467
Mar.	-1.032	1.277	+0.245	+0.190	2.467	+2.657
Apr.	-39.910	4.091	-35.819	-19.580	12.051	-7.529
May	-13.417	10.842	-2.575	-37.289	21.951	-15.338
Jun.	-8.381	5.571	-2.810	-23.745	12.147	-11.598
Jul.	-3.698	5.386	+1.688	-4.782	7.924	+3.142
Aug.	-2.555	3.616	+1.061	-3.369	5.536	+2.167
Sep.	+2.324	3.504	+5.828	-8.023	5.025	-2.998
Oct.	-1.358	2.528	+1.170	-1.721	4.764	+3.043
Nov.	+0.132	1.780	+1.912	-7.839	2.911	-4.928
Dec.	+1.564	1.234	+2.798	-3.161	2.174	-0.987
Total	-67.754	43.165	-24.589	-114.419	82.615	-31.804

Table 3A2 cont'd

Date	Fishing Lakes			Lower Lakes		
	Misc. for P budget	Misc.	Groundwater	Misc. for P budget	Misc.	Groundwater
1976						
Jan.	-0.237	1.048	+0.811	-3.310	1.779	-1.531
Feb.	-1.454	0.737	-0.717	-2.613	1.502	-1.111
Mar.	-0.638	0.892	+0.254	-1.333	2.063	+0.730
Apr.	-45.598	14.129	-31.469	-63.387	31.937	-31.450
May	-9.272	6.683	-2.589	-46.587	17.908	-28.679
Jun.	-7.433	4.729	-2.704	-21.464	12.406	-9.058
Jul.	-6.029	5.135	-0.894	-7.203	8.654	+1.451
Aug.	-0.536	3.441	+2.905	-4.116	5.753	+1.637
Sep.	+0.004	2.882	+2.886	-1.641	3.865	+2.224
Oct.	+2.656	2.589	+5.245	+0.719	3.791	+4.510
Nov.	+2.112	1.873	+3.985	-3.902	2.717	-1.185
Dec.	-0.634	1.032	+0.398	-6.097	2.087	-4.010
Total	-67.059	45.170	-21.889	-160.934	94.462	-66.472
1977						
Jan.	-0.549	0.600	+0.051	-3.340	1.345	-1.995
Feb.	-0.719	0.547	-0.172	-2.108	0.894	-1.214
Mar.	-0.457	0.792	+0.335	-5.941	1.221	-4.720
Apr.	-3.783	0.544	-3.239	-5.436	1.613	-3.823
May	-5.710	0.282	-5.428	-5.457	1.326	-4.131
Jun.	-1.899	0.709	-1.190	-2.559	0.735	-1.824
Total	-13.117	3.474	-9.643	-24.841	7.134	-17.707

positive groundwater represents addition to the groundwater supply
i.e. removal from the lake system

3.B. CHEMISTRY

3.B.1 River

It is difficult to compare the level of phosphorus concentration in the rivers between years because the sampling is so infrequent. The small streams are sampled for a limited time period during the spring and there is a downward trend in phosphorus concentration through April as demonstrated by Jumping Deer Creek (Fig. 3B1). For the Qu'Appelle River the only obvious comparisons can be made during the spring when more samples were taken. The level of phosphorus concentration in the Qu'Appelle River at the input to Pasqua Lake (Fig. 3B2) illustrates the lower phosphorus concentrations measured in the high flow year of 1974 than in the low flow year of 1973, and the generally lower concentrations in the spring.

3.B.2 Lake

The changing water quality of the lakes as monitored through the pattern of changing concentrations of nitrogen, phosphorus and chlorophyll gives an indication of changes in lake eutrophication. The concentration of phosphorus in the lake water follows a similar trend through the years for all the lakes, with increasing concentrations from about 1974 to the present (Fig. 3B3). Although the data were very scarce in 1970 and 1971 these values tend to be approximately the same as the higher values in 1977. Crooked and Round Lakes demonstrate these changes in lake phosphorus concentration most markedly with low values of 100 mg/m^3 in 1974 rising to 500 and 350 mg/m^3 respectively in 1977.

The generalized pattern of phosphorus concentration change throughout an "average Prairie year" shows two peaks of lake water phosphorus concentration occurring over winter and summer at about 500 mg/m^3 dropping in April and November to about 250 mg/m^3 (Fig. 3B4).

The pattern of nitrogen concentration in the lakes over the years is one of peaks of nitrogen concentration imposed on a fairly level base concentration (Fig. 3B3). These peaks occur in different seasons in different years, not immediately suggesting any consistent seasonal pattern. The basic level of nitrogen concentration is higher for the upstream than the downstream lakes, being 2.5 mg/l for Pasqua Lake and 1.5 mg/l for Round Lake and the fluctuations of nitrogen concentration are largest in Pasqua Lake, the first lake in the series.

The monthly concentration of nitrogen in the "average Prairie

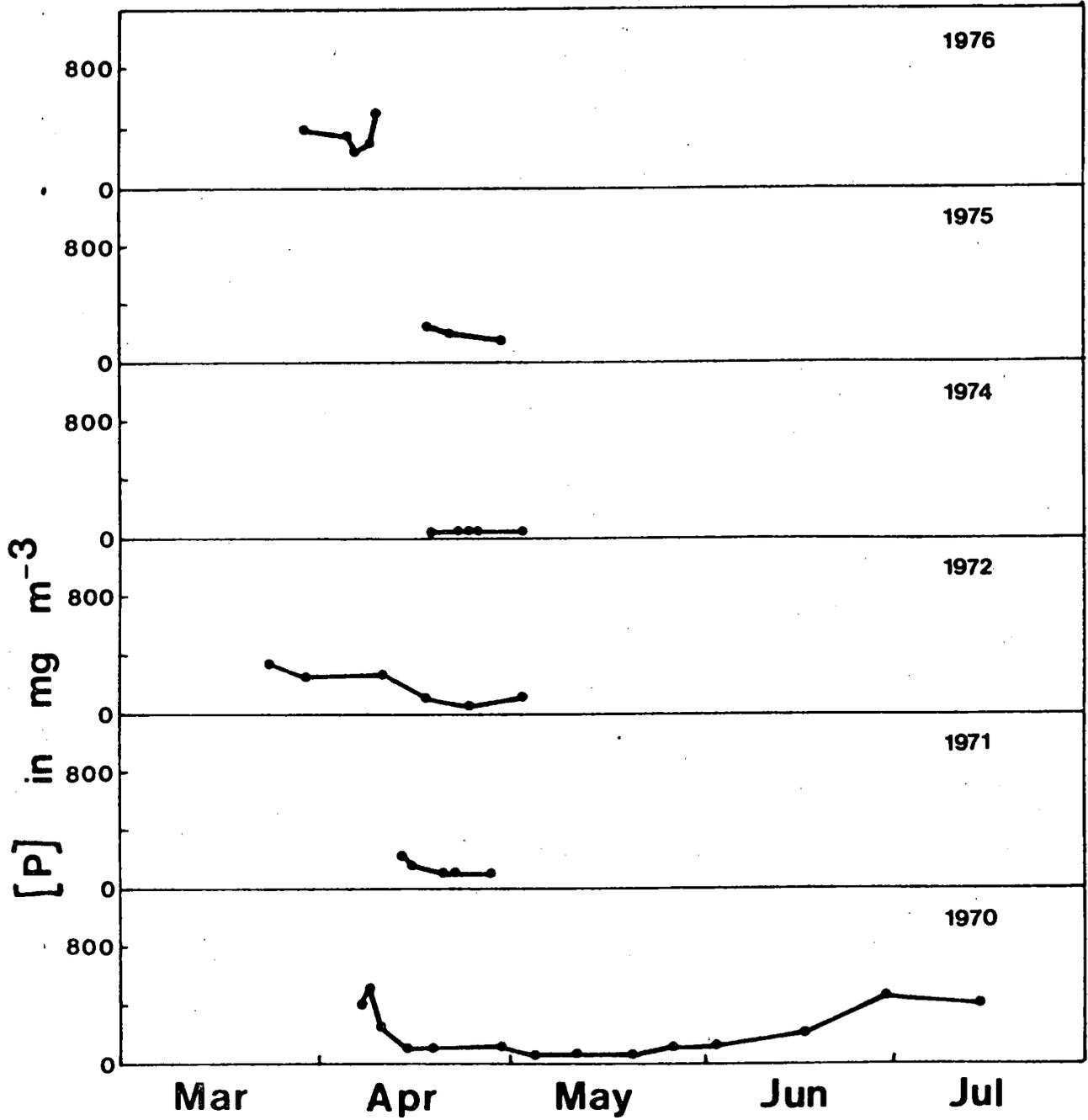


Fig. 3B1 Concentration of total phosphorus in Jumping Deer Creek

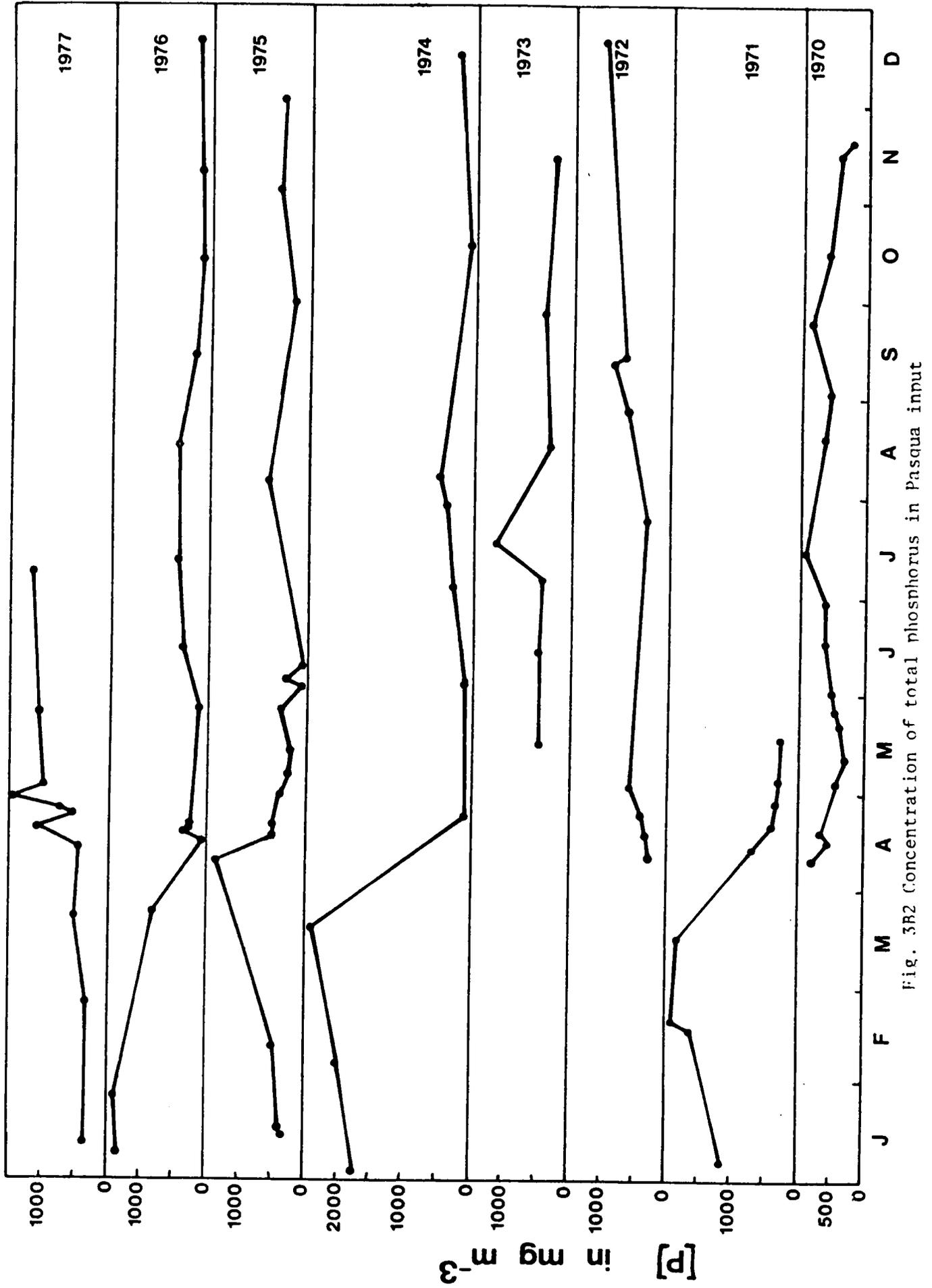


Fig. 3B2 Concentration of total phosphorus in Pasqua input

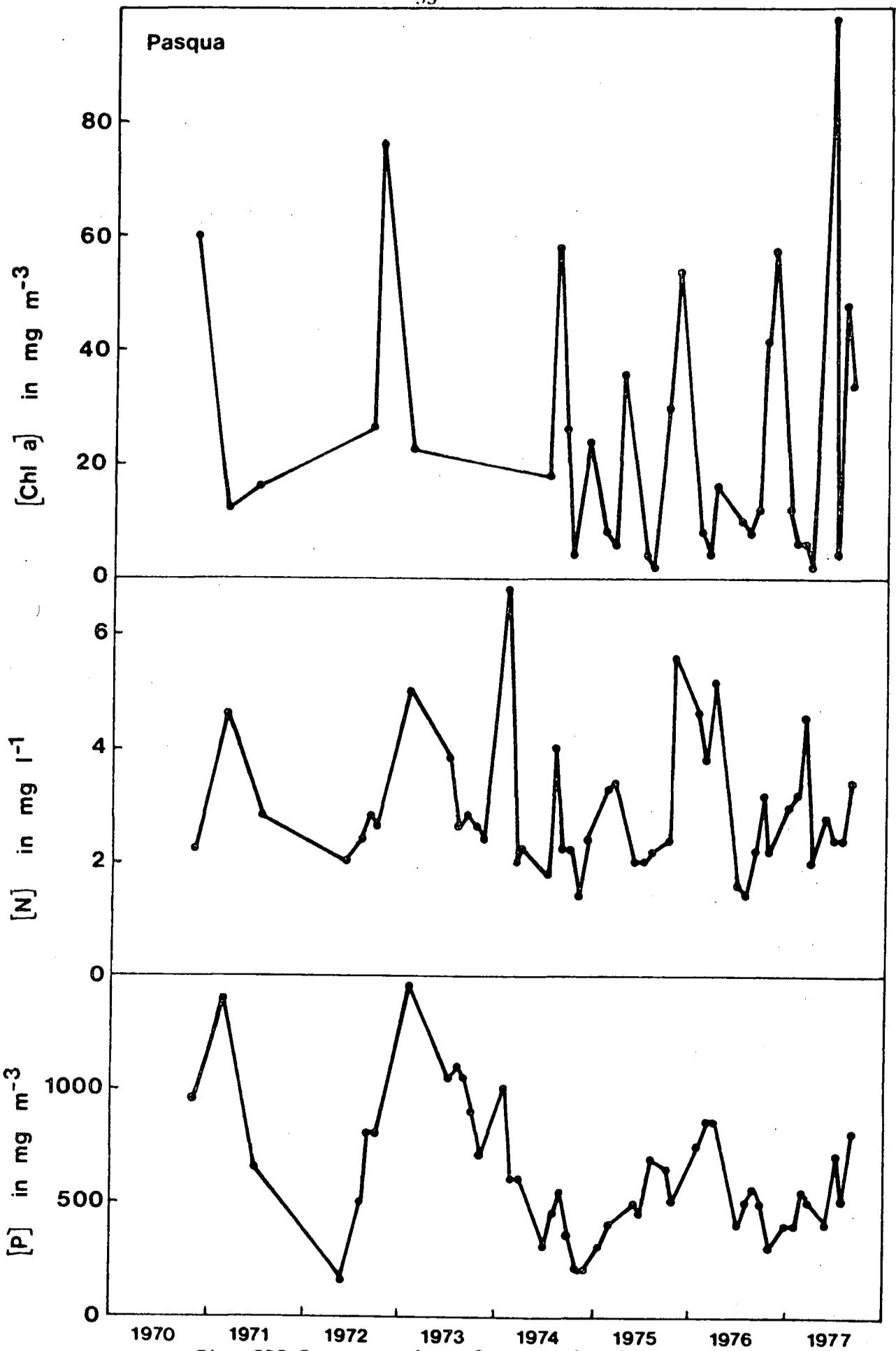


Fig. 3B3 Concentration of total phosphorus, total nitrogen and chlorophyll a in the six lakes

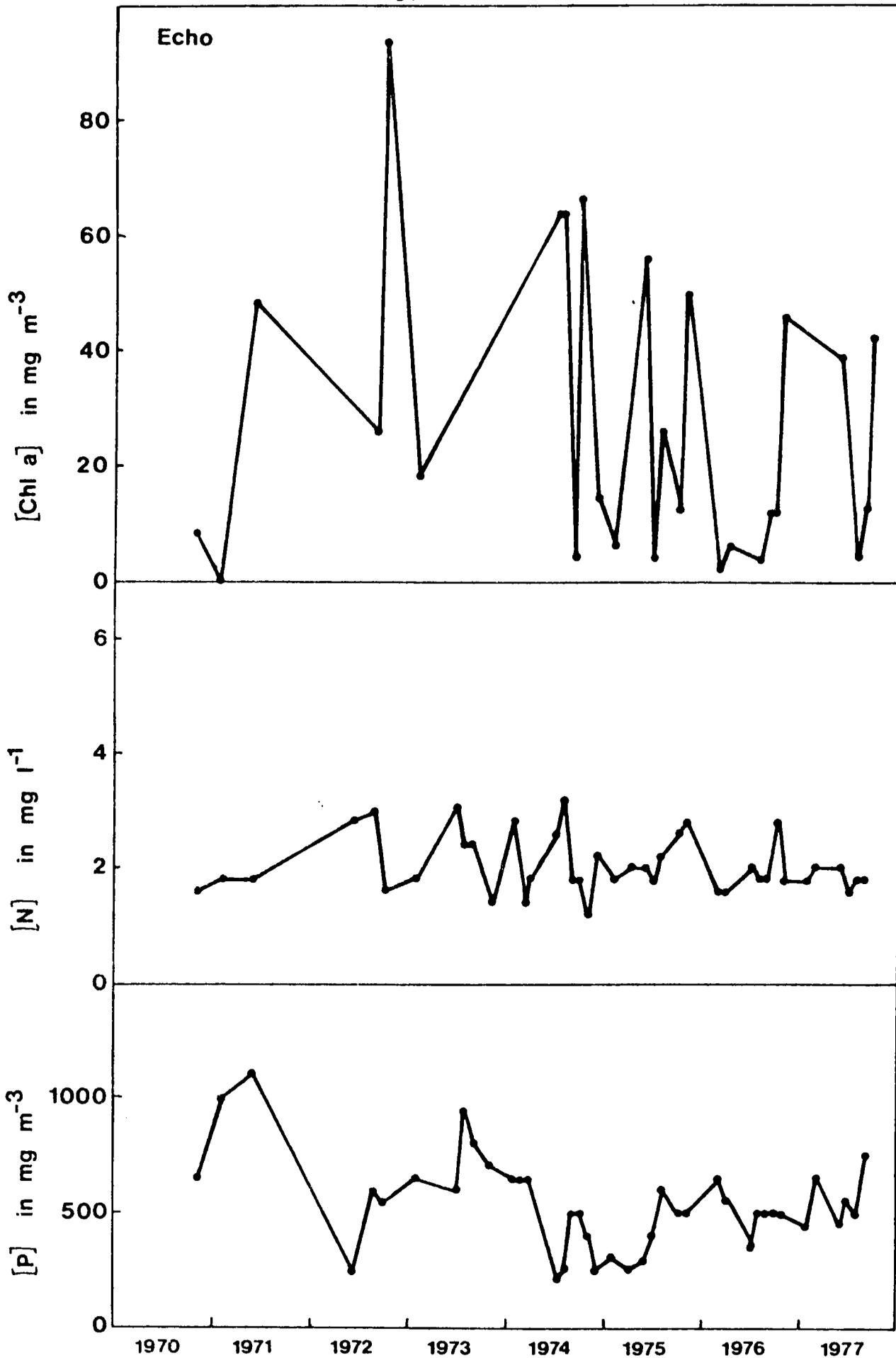


Fig. 3B3 cont'd

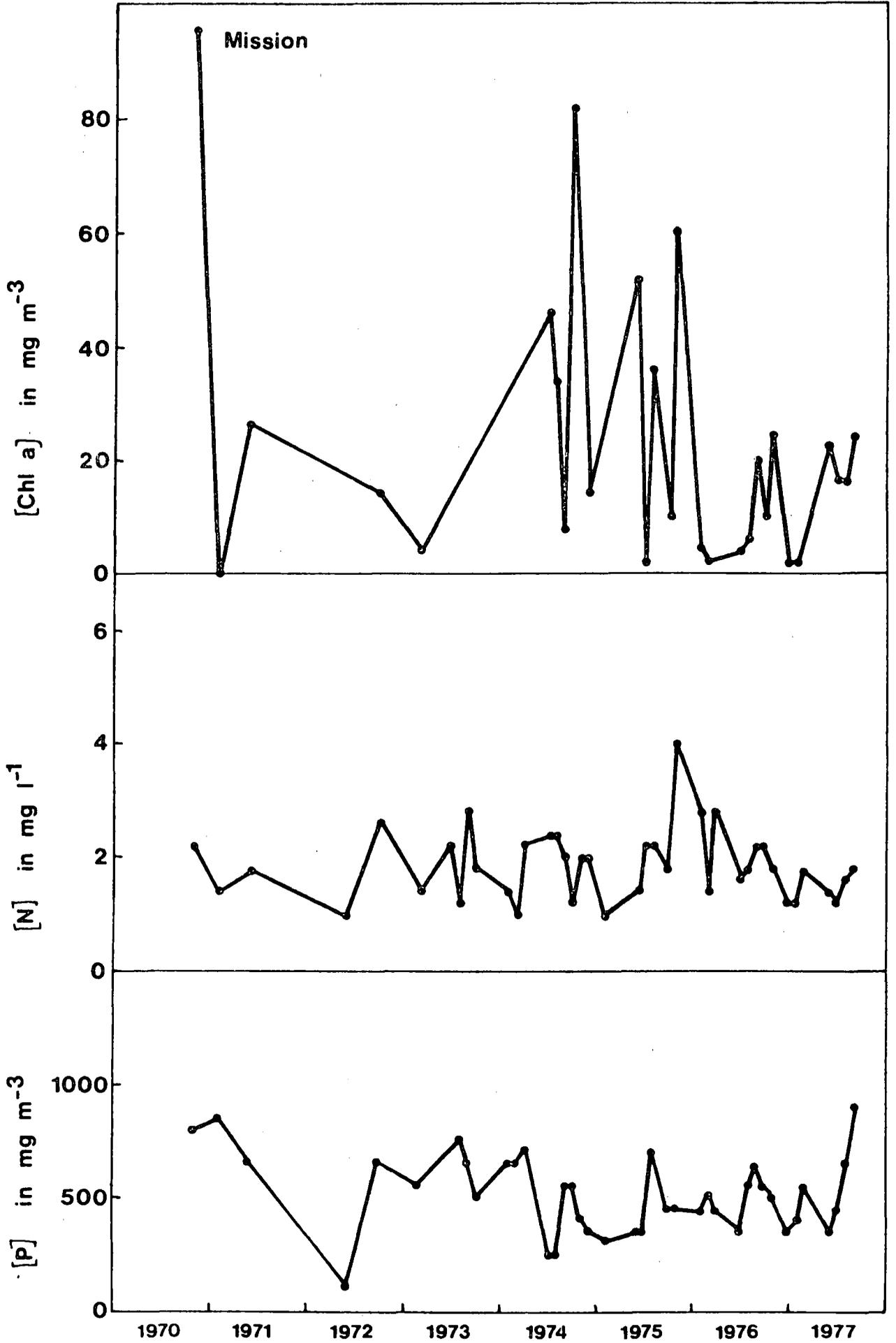


Fig. 3B3 cont'd

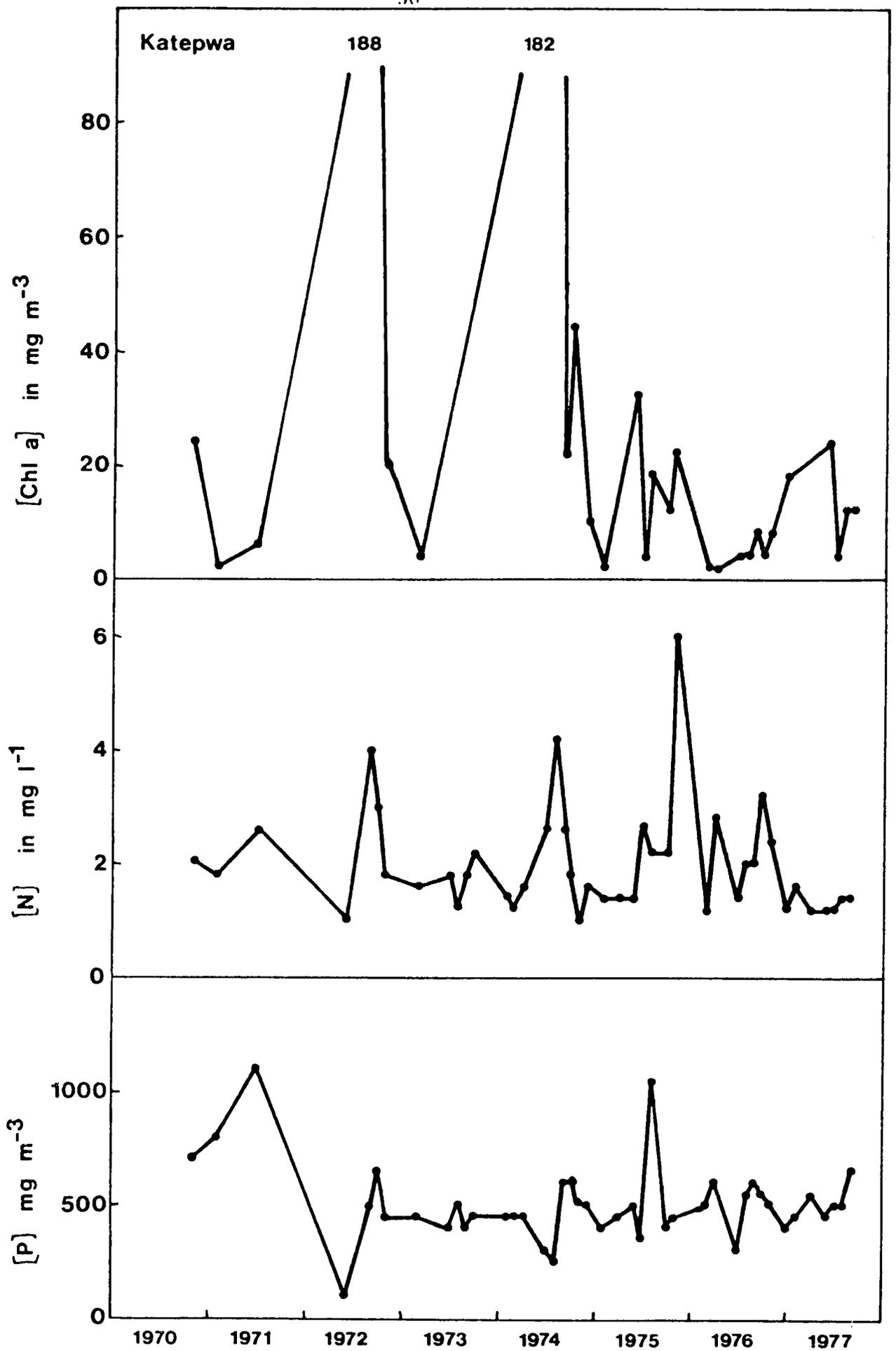


Fig. 3B3 cont'd

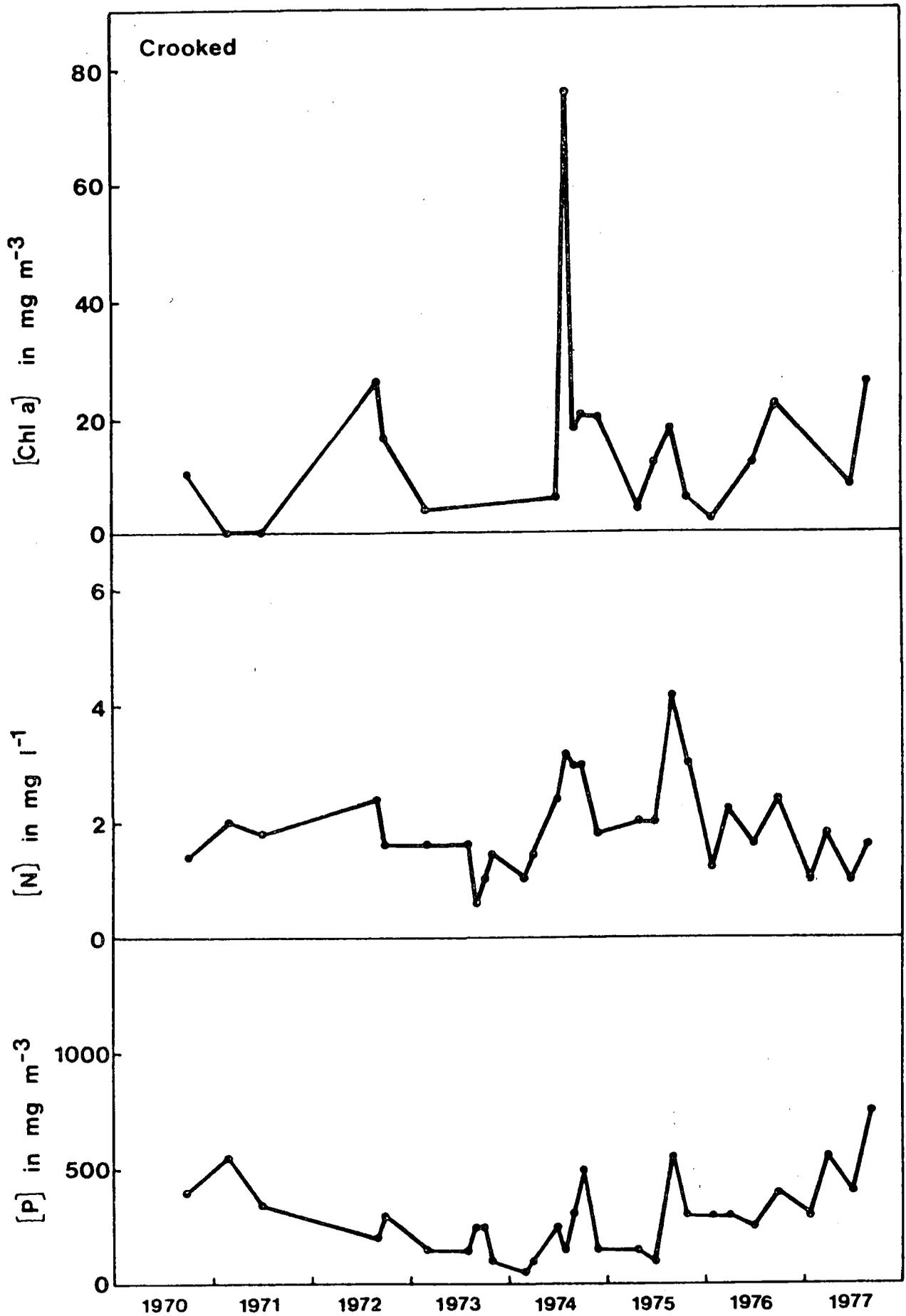


Fig. 3B3 cont'd

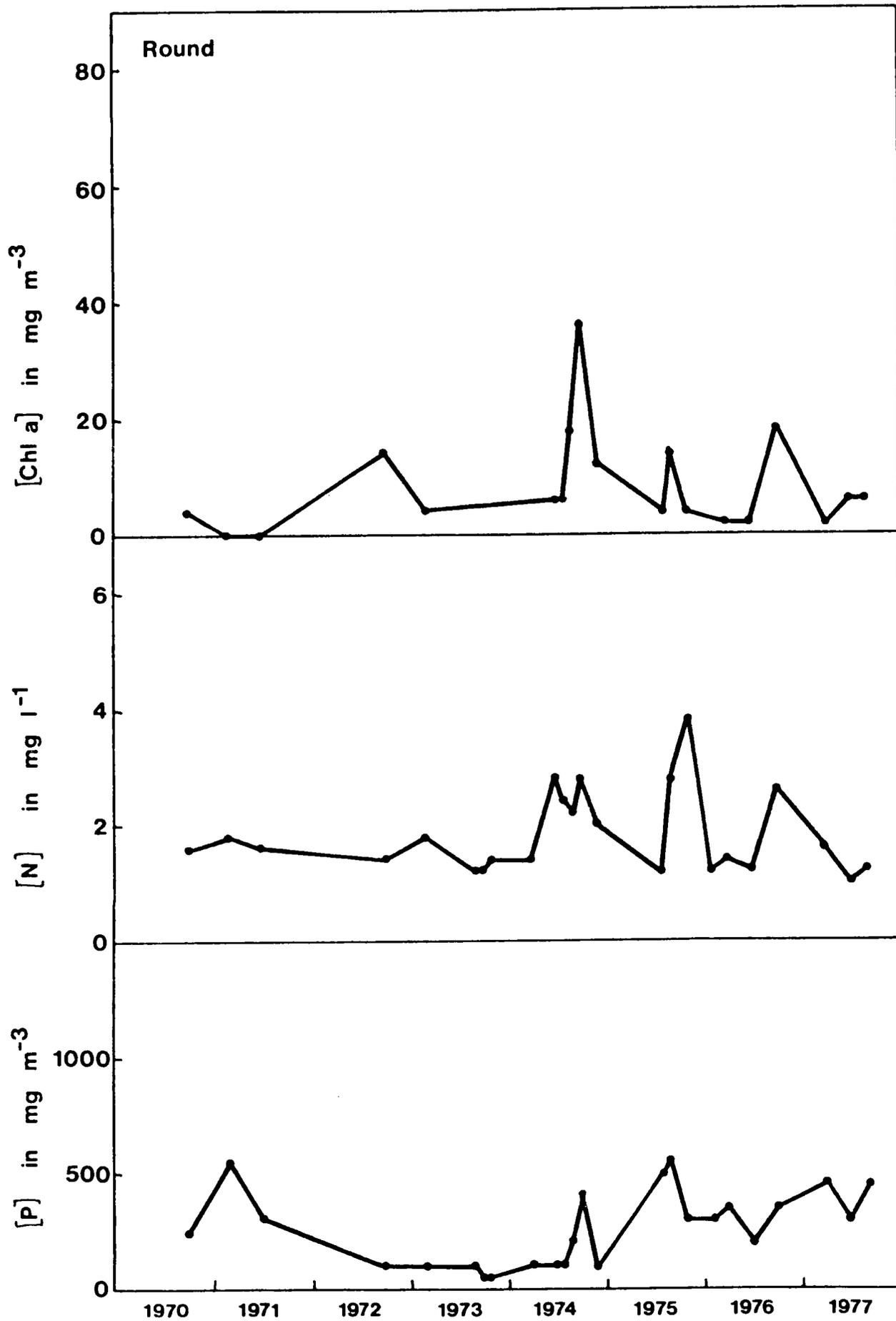


Fig. 3B3 cont'd

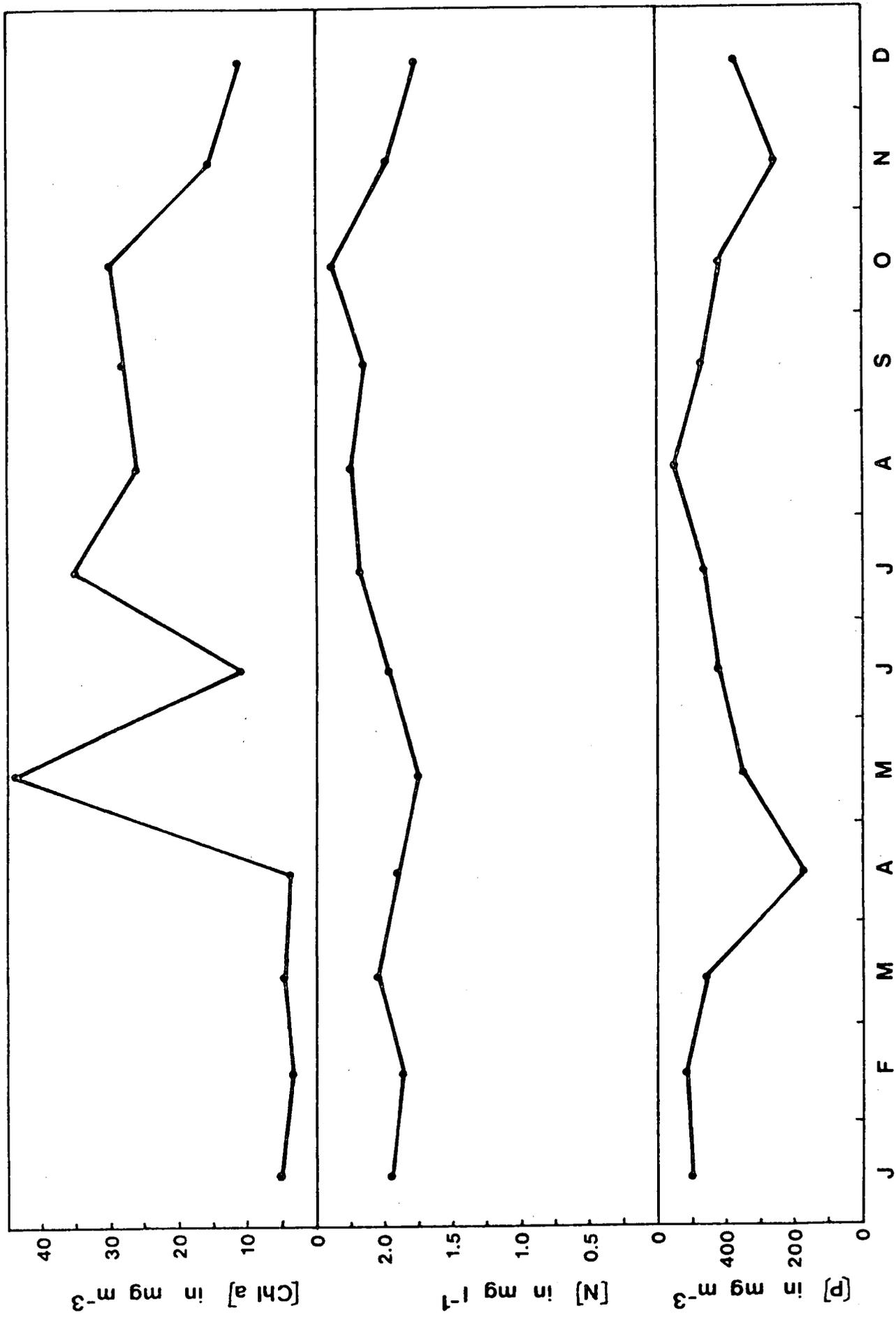


Fig. 3B4 Concentration of total phosphorus, total nitrogen and chlorophyll a calculated for an "average Prairie year"

year" indicates a small peak of 2.0 mg/l in March, dropping to 1.75 mg/l in May with a large broad peak rising to 2.4 mg/l in October and falling to 1.8 mg/l in December (Fig. 3B4).

The chlorophyll data are so infrequent and fluctuate so greatly that no trends can be distinguished over the study period (Fig. 3B4). When the monthly data are pooled in the calculation of an "average Prairie year" a pattern of chlorophyll concentration emerges. Low concentrations of 5 mg/m^3 occur January through April followed by a rise to 45 mg/m^3 in May and a drop in June to 10 mg/m^3 . July shows another peak at 35 mg/m^3 , with a relatively constant 27 mg/m^3 from August to October and a decrease through the rest of the year (Fig. 3B4). Due to the infrequency of data and the extreme fluctuations between concentrations, a single measurement in a month may affect this pattern significantly. For example, the average concentration in April is calculated from only three samples from Crooked Lake in 1975.

3.C PHOSPHORUS BUDGETS AND MODELS

3.C.1 Phosphorus Loading and Export

The phosphorus budgets for each lake were calculated on the basis of a calendar year and a June-May year (Table 3C1) and the phosphorus loading values represent only the terrestrial loading to the lake. The phosphorus loading from the main stream inputs is high and variable between years with as much as a 13-fold difference for Round Lake between 1973 and 1976 with 1.77 g/m^2 and 22.63 g/m^2 respectively. The average annual loading ranged from 6.5 g/m^2 for Pasqua to 18.6 g/m^2 for Mission averaging 11.3 g/m^2 with somewhat lower values on the June-May basis averaging 10.6 g/m^2 .

The range of export values calculated for the Qu'Appelle River is exaggerated because of the method of expression in terms of the effective drainage area. The lowest export for the lower Qu'Appelle River was 1.3 mg/m^2 measured in 1973 at the input to Round Lake and the highest export was 20.0 mg/m^2 , measured in 1976 at the input to Crooked Lake. However the average values for the study period ranged from 11.6 mg/m^2 for Pasqua Lake input to 8.9 mg/m^2 for Round Lake input and the average of these exports, 11.0 mg/m^2 , represents a realistic export value for the lower Qu'Appelle River.

The export values from the Upper Valley (Table 3C2) demonstrate the effects of urban contributions from Moose Jaw and Regina. Moose Jaw River export increases from 21.6 mg/m^2 above Moose Jaw to 29.0 mg/m^2 below Moose Jaw, and Wascana Creek export increases to 137.4 mg/m^2 below Regina. The drainage area to Buffalo Pound Lake averages an export of 13.5 mg/m^2 , similar to the other lakes, while Wascana Creek increases the Qu'Appelle River export from 21.8 mg/m^2 to 30.6 mg/m^2 . This export is reduced to 16.1 mg/m^2 below Craven and further to 11.6 mg/m^2 at the input to Pasqua Lake.

Phosphorus loading was correlated with areal water load and phosphorus export was correlated with lake discharge on the basis of both a calendar year ($r=0.86$, $r=0.79$) and on the basis of a June-May year ($r=0.88$, $r=0.82$). The monthly export values for the Qu'Appelle River (Fig. 3C1) show a trend of higher values during the spring flood and early summer. The high export during spring coincides with the peaks of flow discharge and the secondary peak of export in the summer coincides with increases in phosphorus concentration.

A study of the smaller streams indicates that a wide range of

Table 3C1

Phosphorus Budgets

Lake	Year	Input $\times 10^3$ kg	Output $\times 10^3$ kg	Retention $\times 10^3$ kg	Retention Coeff.	Loading $\text{g m}^{-2} \text{yr}^{-1}$	Qu'Appelle Export mg m^{-2}	
Pasqua	1970	176.51	212.19	-35.68	-0.20	8.87	15.97	
	1971	133.01	130.85	+2.16	+0.02	6.68	12.01	
	1972	71.56	82.94	-11.38	-0.16	3.60	6.46	
	1973	52.68	60.39	-7.71	-0.15	2.65	4.79	
	1974	155.18	143.13	+12.04	+0.08	7.80	14.08	
	1975	163.76	128.69	+35.06	+0.21	8.23	14.76	
	1976	147.44	183.39	-35.95	-0.24	7.41	13.14	
	70-71	183.68	192.75	-9.07	-0.05	9.23	16.61	
	71-72	80.20	82.02	-1.82	-0.02	4.03	7.24	
	72-73	66.20	74.73	-8.53	-0.13	3.33	6.01	
	73-74	71.79	79.36	-7.57	-0.10	3.61	6.51	
	74-75	190.33	155.84	+34.49	+0.18	9.56	17.18	
	75-76	149.02	133.82	+15.20	+0.10	7.49	13.35	
	76-77	93.22	131.70	-38.48	-0.41	4.68	8.41	
	Echo	1970	212.19	192.09	+20.10	+0.09	16.98	18.32
		1971	130.85	140.11	-9.26	-0.07	10.47	11.30
1972		82.94	73.13	+9.80	+0.12	6.64	7.15	
1973		60.39	47.81	+12.58	+0.21	4.83	5.21	
1974		143.13	173.82	-30.69	-0.21	11.45	12.36	
1975		128.69	133.15	-4.46	-0.03	10.30	11.11	
1976		183.39	177.75	+5.64	+0.03	14.67	15.83	
70-71		192.75	214.55	-21.80	-0.11	15.42	16.63	
71-72		82.02	76.18	+5.84	+0.07	6.56	7.08	
72-73		74.73	63.47	+11.26	+0.15	5.98	6.45	
73-74		79.36	69.31	+10.05	+0.13	6.35	6.84	
74-75		155.84	186.32	-30.48	-0.20	12.47	13.45	
75-76		133.82	153.49	-19.67	-0.15	10.70	11.56	
76-77		131.70	115.88	+15.82	+0.12	10.54	11.37	
Mission		1970	202.42	184.51	+17.91	+0.09	26.63	16.29
		1971	146.37	125.38	+20.99	+0.14	19.26	11.88
	1972	76.79	71.80	+4.99	+0.06	10.10	6.20	
	1973	50.20	55.90	-5.70	-0.11	6.60	4.05	
	1974	182.51	180.14	+2.37	+0.01	24.01	14.74	
	1975	139.81	173.85	-34.04	-0.24	18.40	11.29	
	1976	186.64	167.49	+19.15	+0.10	24.56	15.07	
	70-71	220.81	193.62	+27.19	+0.12	29.05	18.19	
	71-72	79.84	76.00	+3.84	+0.05	10.50	6.46	
	72-73	65.86	64.63	+1.23	+0.02	8.66	5.37	
	73-74	78.00	81.14	-3.14	-0.04	10.26	5.90	
	74-75	192.98	202.43	-9.45	-0.05	25.39	15.79	
	75-76	162.38	159.10	+3.28	+0.02	21.36	13.01	
	76-77	117.88	125.74	-7.86	-0.07	15.51	9.82	

Table 3C1 cont'd

Lake	Year	Input $\times 10^3$ kg	Output $\times 10^3$ kg	Retention $\times 10^3$ kg	Retention Coeff.	Loading $\text{g m}^{-2} \text{yr}^{-1}$	Qu'Appelle Export mg m^{-2}
Katepwa	1970	184.51	154.10	+30.41	+0.16	11.46	15.33
	1971	125.38	122.35	+3.03	+0.02	7.79	10.41
	1972	71.80	63.25	+8.55	+0.12	4.46	5.96
	1973	55.90	47.51	+8.39	+0.15	3.47	4.64
	1974	180.14	188.15	-8.01	-0.04	11.19	14.96
	1975	173.85	209.53	-35.68	-0.20	10.80	14.44
	1976	167.49	195.39	-27.90	-0.17	10.40	13.91
	70-71	193.62	180.45	+13.17	+0.07	12.03	16.08
	71-72	76.00	70.97	+5.03	+0.07	4.72	6.31
	72-73	64.63	59.30	+5.33	+0.08	4.01	5.37
	73-74	81.14	47.17	+33.97	+0.42	5.04	6.73
	74-75	202.43	255.97	-53.54	-0.26	12.57	16.81
	75-76	159.10	196.36	-37.26	-0.23	9.88	13.22
	76-77	125.74	129.48	-3.74	-0.03	7.81	10.44
	Crooked	1970	145.96	93.40	+52.56	+0.36	9.86
1971		111.70	81.94	+29.75	+0.27	7.55	7.75
1972		67.15	44.49	+22.66	+0.34	4.54	4.66
1973		24.45	16.71	+7.75	+0.32	1.65	1.70
1974		262.69	211.13	+51.56	+0.20	17.75	18.23
1975		227.09	212.43	+14.66	+0.06	15.34	15.76
1976		288.30	235.61	+52.69	+0.18	19.48	20.00
70-71		170.36	114.30	+26.06	+0.33	11.51	11.82
71-72		77.64	52.78	+24.59	+0.32	5.24	5.39
72-73		31.21	21.51	+9.70	+0.31	2.11	2.16
73-74		157.95	98.66	+59.28	+0.38	10.67	10.96
74-75		236.95	215.62	+21.33	+0.09	16.01	16.44
75-76		283.04	263.03	+20.01	+0.07	19.12	19.64
76-77		134.31	107.01	+27.30	+0.20	9.08	9.32
Round		1970	100.13	81.98	+18.15	+0.18	9.10
	1971	85.07	53.41	+31.66	+0.37	7.73	5.55
	1972	52.02	32.76	+19.27	+0.37	4.73	3.39
	1973	19.50	19.90	-0.41	-0.02	1.77	1.27
	1974	223.28	170.08	+53.20	+0.24	20.30	14.56
	1975	224.64	171.52	+53.12	+0.24	20.42	14.65
	1976	248.89	136.08	+112.81	+0.45	22.63	16.23
	70-71	120.88	93.42	+27.46	+0.23	10.99	7.88
	71-72	60.70	40.71	+19.99	+0.33	5.52	3.96
	72-73	24.52	23.60	+0.92	+0.04	2.23	1.60
	73-74	105.63	45.08	+60.55	+0.57	9.60	6.89
	74-75	227.98	181.95	+46.02	+0.20	20.72	14.86
	75-76	277.57	175.25	+102.32	+0.37	25.23	18.10
	76-77	114.36	88.00	+26.37	+0.23	10.40	7.46

Table 3C2

Phosphorus Export from Locations in the Upper Qu'Appelle Valley

Location	Year	Export mg/m ²	Year	Export mg/m ²
Buffalo Pound Lake Input	1970	16.92	1974	24.49
	1971	9.08	1975	4.69
	1972	13.68	1976	9.86
	1973	15.66		
Moose Jaw River above Moose Jaw	1970	30.92	1974	37.97
	1971	22.38	1975	22.89
	1972	4.19	1976	31.86
	1973	0.92		
Moose Jaw River below Moose Jaw	1970	32.05	1974	52.21
	1971	29.65	1975	29.62
	1972	8.48	1976	43.33
	1973	7.98		
Qu'Appelle River above Wascana Creek	1970	24.59	1974	46.01
	1971	12.62	1975	24.36
	1972	8.23	1976	33.44
	1973	3.15		
Wascana Creek above Regina	1970	10.51	1972	3.36
	1971	24.05	1973	0.32
Wascana Creek below Regina	1970	63.15	1974	209.32
	1971	97.81	1975	288.35
	1972	57.31	1976	176.60
	1973	69.01		
Qu'Appelle River at Lumsden	1970	38.22	1974	25.05
	1971	39.62	1975	32.77
	1972	21.94	1976	35.94
	1973	20.49		
Qu'Appelle River below Craven	1970	17.60	1974	16.76
	1971	13.52	1975	16.40
	1972	10.93	1976	27.16
	1973	10.34		

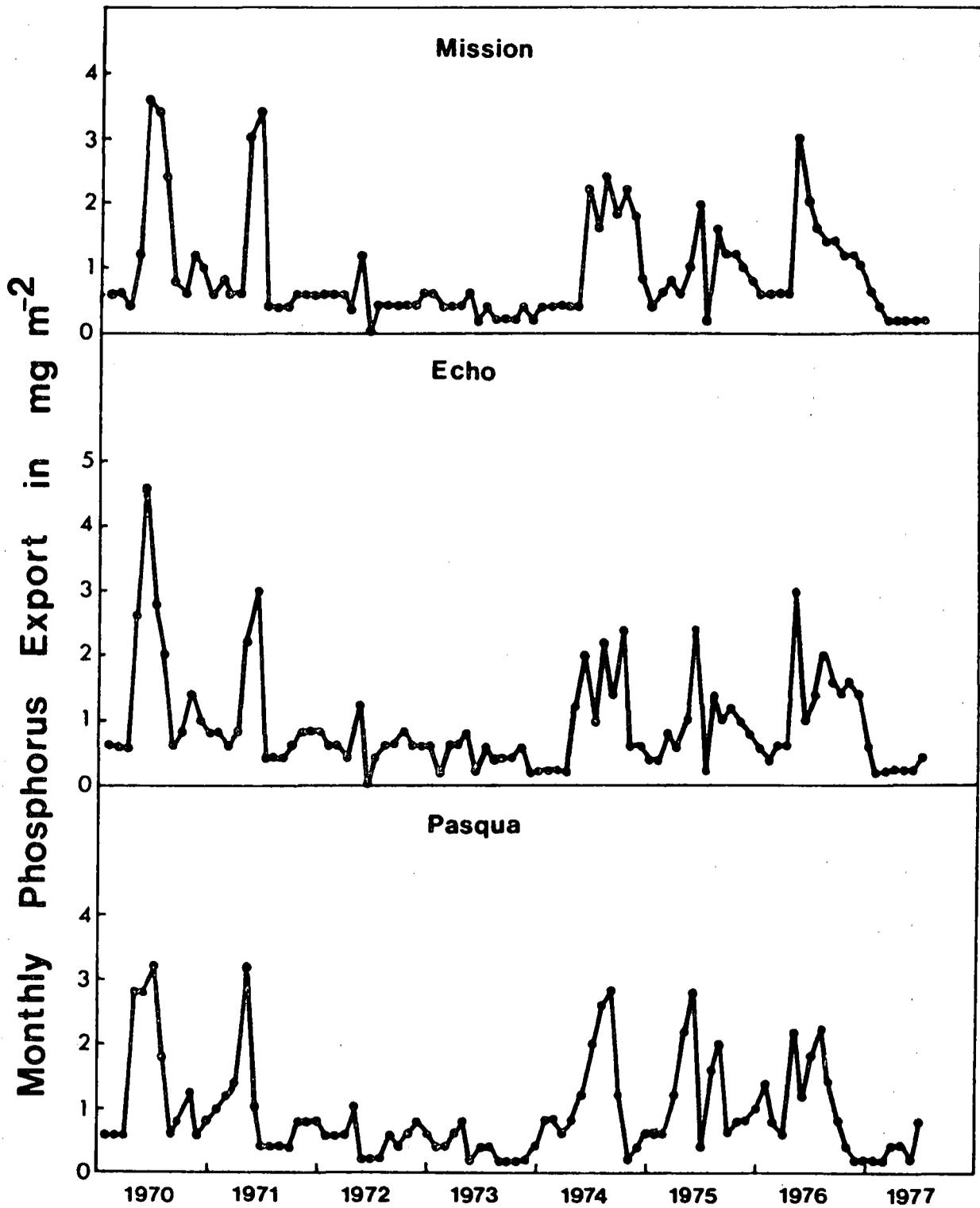


Fig. 3C1 Monthly Export from the Ou'Appelle River at the Input to Each Lake

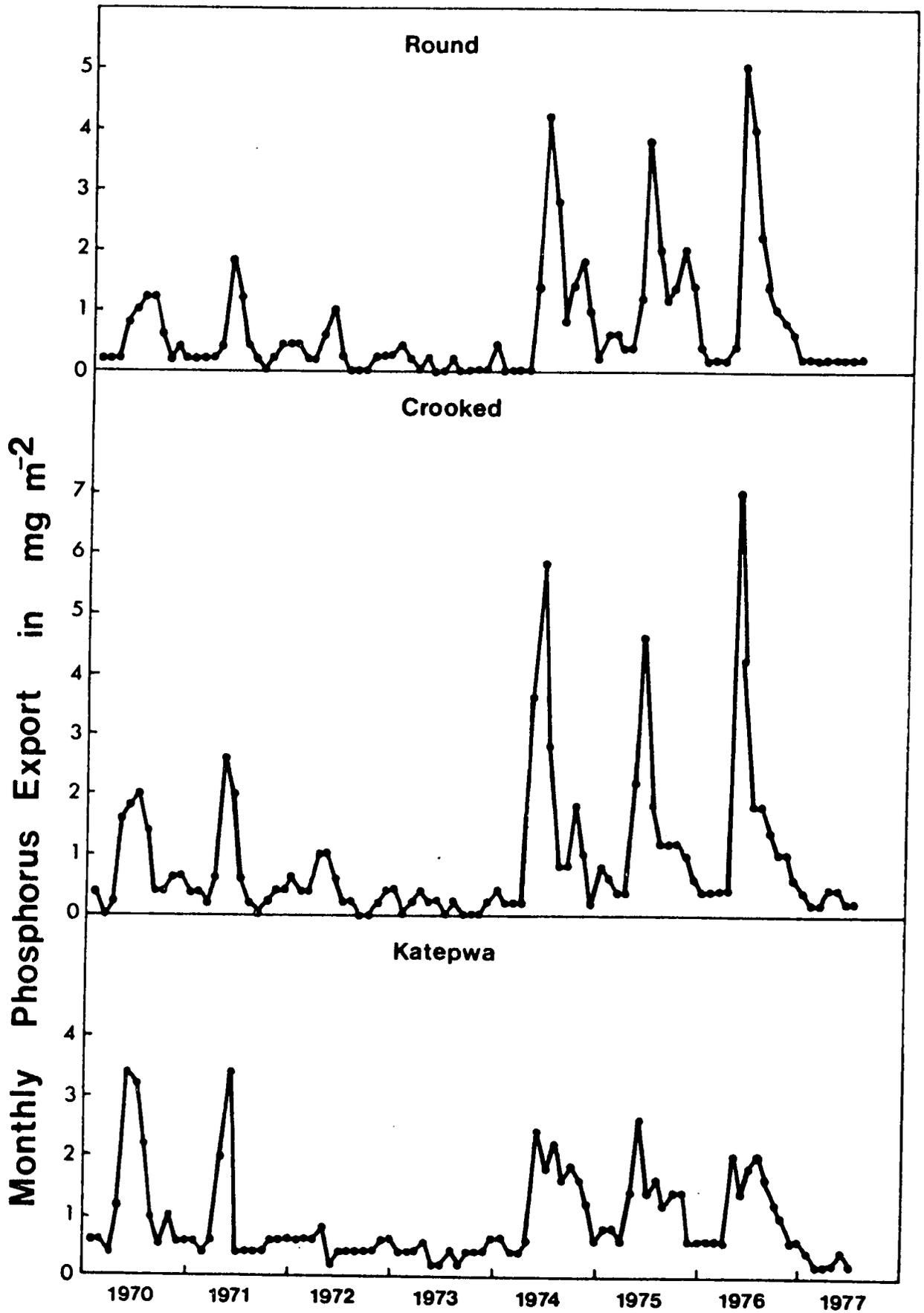


Fig. 3C1 cont'd

export values can be determined for one stream depending on the conditions for a particular year (Table 3C3), though it must be remembered that these export values are also affected by the use of a static contributing drainage area. Jumping Deer Creek has a negligible export during 1973, a year of very little snowmelt, while during 1976 the export is 11.62 mg/m^2 . In addition to the variability of exports calculated for one stream, a comparison between two streams in the same year again shows a wide variability of export values. For example, Echo Creek in 1970 has an export of 86.78 mg/m^2 while Kaposvar Creek of about twice the effective drainage area has an export of only 4.94 mg/m^2 in the same year and the volume of discharge for Echo Creek is about seven times that for Kaposvar in 1970.

The spring snowmelt, for these purposes defined as April + May, is an important time of export, contributing up to 100% of the export from small streams and a significant portion of the export of the main Qu'Appelle River. The average spring export for the lower Qu'Appelle River is 3.3 mg/m^2 or 30% of the annual export. The median spring value for the small streams is 7.5 mg/m^2 (Table 3C4).

3.C.2 Lake Nutrients and Production

The predicted lake phosphorus concentrations from the equation by Dillon and Rigler (1974a) were poorly correlated on a yearly basis with the measured spring values ($r=0.49$). However when the six average lake values were used correlations of $r=0.89$ and $r=0.86$ were found using calendar year data and June-May year data respectively (Table 3C5). The following equations can be used to predict average spring phosphorus concentration for these lakewaters;

$$[P] = 1.463 \frac{L(1-R)}{z\rho} - 145.515 \text{ for a calendar year}$$

$$\text{and } [P] = 1.506 \frac{L(1-R)}{z\rho} - 149.484 \text{ for a June-May year.}$$

The correlations between both spring phosphorus and summer chlorophyll a, and spring nitrogen and summer chlorophyll a using the yearly lake data (Table 3C6) were poor ($r=-0.40$, $r=0.10$) and they were not improved by using the average lake values ($r=0.26$, $r=0.06$). The correlation between measured summer chlorophyll a concentration and that predicted by Vollenweider's (1976a) equation was poor even when lake averages were used ($r=-0.06$) (Table 3C5).

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Phosphorus Export from Small Streams in the Qu'Appelle Basin

Drainage Basin	Year	Export mg m ⁻²	Drainage Basin	Year	Export mg m ⁻²
Jumping Deer Creek	1970	3.25	Cutarm Creek	1970	4.66
	1971	3.56		1971	2.80
	1972	1.87		1972	2.02
	1974	0.83		1973	0.06
	1975	5.30		1974	2.37
	1976	11.62		1975	0.29
Indian Head Creek	1970	16.79	Pheasant Creek	1976	0.23
	1971	12.29		1970	5.62
	1972	2.60		1971	10.36
	1974	3.66		1972	4.48
	1975	31.32		1975	20.71
	1976	9.10		1976	26.62
Lewis Creek	1970	7.60	Thompson Creek	1970	26.63
	1971	1.66		1971	14.13
Echo Creek	1970	86.78	Adair Creek	1970	33.00
	1971	52.55		1971	28.21
Sandy Beach Creek	1970	7.79	Kaposvar Creek	1970	4.94
	1971	8.06		1971	3.92
Arm River	1970	7.68	Ekapo Creek	1970	4.74
	1971	2.43		1971	3.61
	1972	0.30		1972	4.68
Loon Creek	1970	3.58	Boggy Creek	1975	18.32
	1971	10.45		1974	20.02

Table 3C4

Spring Snowmelt (April+May) Export

Location	Year	Export mg/m ²	Location	Year	Export mg/m ²
Pasqua input	1970	5.48	Echo input	1970	7.18
	1971	4.18		1971	5.21
	1972	1.25		1972	1.32
	1973	1.12		1973	1.04
	1974	2.14		1974	3.18
	1975	4.99		1975	3.32
	1976	3.33		1976	3.97
	1977	0.59		1977	0.28
Mission input	1970	4.79	Katepwa input	1970	4.71
	1971	6.30		1971	5.48
	1972	1.16		1972	1.16
	1973	0.79		1973	0.92
	1974	2.51		1974	2.93
	1975	2.97		1975	3.96
	1976	5.00		1976	3.34
	1977	0.46		1977	0.74
Crooked input	1970	3.40	Round input	1970	1.85
	1971	4.45		1971	2.96
	1972	1.56		1972	1.20
	1973	0.24		1973	0
	1974	9.31		1974	5.72
	1975	6.76		1975	5.05
	1976	11.06		1976	8.99
	1977	0.67		1977	0.41
Jumping Deer Creek	1970	2.63	Indian Head Creek	1970	16.69
	1971	3.56		1971	12.28
	1972	1.15		1972	0.78
	1974	0.74		1974	3.65
	1975	5.28		1975	31.32
	1976	8.51		1976	7.45
Pheasant Creek	1970	5.56	Cutarm Creek	1970	4.11
	1971	10.20		1971	2.20
	1972	3.39		1972	1.89
	1975	20.55		1974	2.28
	1976	23.23		1975	0.03
Lewis Creek	1970	7.60	Adair Creek	1970	33.00
	1971	1.65		1971	28.21
Echo Creek	1970	84.84	Kaposvar Creek	1970	4.77
	1971	52.54		1971	2.95
Sandy Beach Creek	1970	7.79	Loon Creek	1970	3.58
	1971	8.06		1971	10.45
Thompson Creek	1970	26.63	Ekapo Creek	1970	4.60
	1971	14.13		1971	3.60
Arm River	1970	6.19	Boggy Creek	1972	1.93
	1971	2.29		1975	18.23
	1972	0.15		1974	20.02

Table 3C5
 Comparison Between Measured and Predicted Concentrations;
 Spring Phosphorus from $L(1-R)/\bar{z}\rho$ and Summer
 Chlorophyll a from $0.367(L/q_s(1+\sqrt{\bar{z}/q_s}))^{0.91}$

Lake	Spring Phosphorus			Summer Chlorophyll	
	Pred. Cal. yr mg/m ³	June-May mg/m ³	Meas. mg/m ³	Pred. mg/m ³	Meas. mg/m ³
Pasqua	407	395	462	54.5	30.0
Echo	391	375	485	56.2	28.6
Mission	405	394	396	62.8	22.3
Katepwa	380	374	430	49.0	43.7
Crooked	301	306	218	57.2	38.3
Round	232	228	233	49.1	11.4

Table 3C6

Lake Concentrations of Nitrogen and Phosphorus
in Spring and Chlorophyll a in Summer

Date	Lake	[P] mg/m ³	[N] mg/l	[Chl a] mg/m ³	Lake	[P] mg/m ³	[N] mg/l	[Chl a] mg/m ³
	Pasqua				Echo			
1971		628	2.72			1092	1.75	
1972		126	2.05	75.5		232	2.80	85.2
1973		1031	3.76			663	2.97	
1974		276	1.85	28.9		221	2.60	44.7
1975		470	2.06	13.0		365	1.85	12.0
1976		400	1.44	20.9		348	1.95	9.2
1977		462	2.68	41.2		517	1.81	26.5
	Mission				Katepwa			
1971		652	1.73			1112	2.60	
1972		96	0.75	10.4		117	0.90	188.9
1973		698	2.14			395	1.84	
1974		252	2.32	41.2		311	2.58	83.7
1975		331	1.82	23.2		435	1.86	13.2
1976		450	1.63	10.0		314	1.34	5.4
1977		400	1.32	19.5		480	1.25	10.4
	Crooked				Round			
1970				10.3				3.4
1971		350	1.72			320	1.56	
1972				20.7				
1974		266	2.39	36.9		82	2.83	20.4
1975		139	1.98	20.4				5.3
1976		249	1.61	22.7		222	1.13	17.5
1977		338	1.00	26.3		307	1.07	5.2
Average								
	Pasqua	462	2.36	30.0				
	Echo	485	2.15	28.6				
	Mission	396	1.62	22.3				
	Katepwa	430	1.57	43.7				
	Crooked	218	1.83	38.3				
	Round	233	1.65	11.4				

When the average measured concentrations are compared with the data in Sakamoto (1966), the measured chlorophyll is considerably lower on both the nitrogen vs chlorophyll and phosphorus vs chlorophyll graphs (Fig. 3C2). Similarly predictions of chlorophyll a concentration made directly from phosphorus budget values (Vollenweider, 1976a) give overestimates relative to those measured (Fig. 3C2). Allan and Kenney (1977) in preliminary studies found that Vollenweider's loading equation accurately predicts average summer chlorophyll within the 99% confidence limits, while the lake phosphorus concentration data overestimated measured values. However they point out that the range of chlorophyll a concentrations predicted at these high loadings is large enough to have dramatic effects on the greenness of the lakes.

3.C.3 Phosphorus Retention and Internal Loading

The phosphorus retention coefficient was positive in some years and negative in others for the Fishing Lakes indicating both net gain and net loss of phosphorus in the lake in different years. The lower lakes, Crooked and Round, had a consistently positive retention, except for one negative retention in 1973 of -0.02 in Round Lake (Table 3C1).

Predictions of phosphorus retention in lakes based solely on the areal water load (Kirchner and Dillon, 1975; Chapra, 1975; Dillon and Kirchner, 1975b) provide only for positive values, and the correlations between measured and calculated retention coefficients were poor using the yearly data and the average lake data ($r=-0.01$, $r=-0.50$). Table 3C7 gives the measured and calculated retention coefficients from the average lake data and it appears that the predictions for Crooked and Round Lake are much closer than those for the Fishing Lakes.

A rough estimate for internal loading can be made under the assumption that the phosphorus retention calculated from areal loading of water is accurate, and that the difference between this calculated value and the measured value represents an internal loading coefficient. In that case internal loading values of 3.0 to 4.1 $\text{g/m}^2/\text{yr}$ are calculated on average for the 4 Fishing Lakes (Table 3C7). This corresponds to an annual average of 8.2 to 11.2 $\text{mg/m}^2/\text{day}$, comparable to the values found by Allan and Williams (1978) for rates of winter phosphorus regeneration in the lakes.

Throughout the year all of the lakes show time periods of flux to

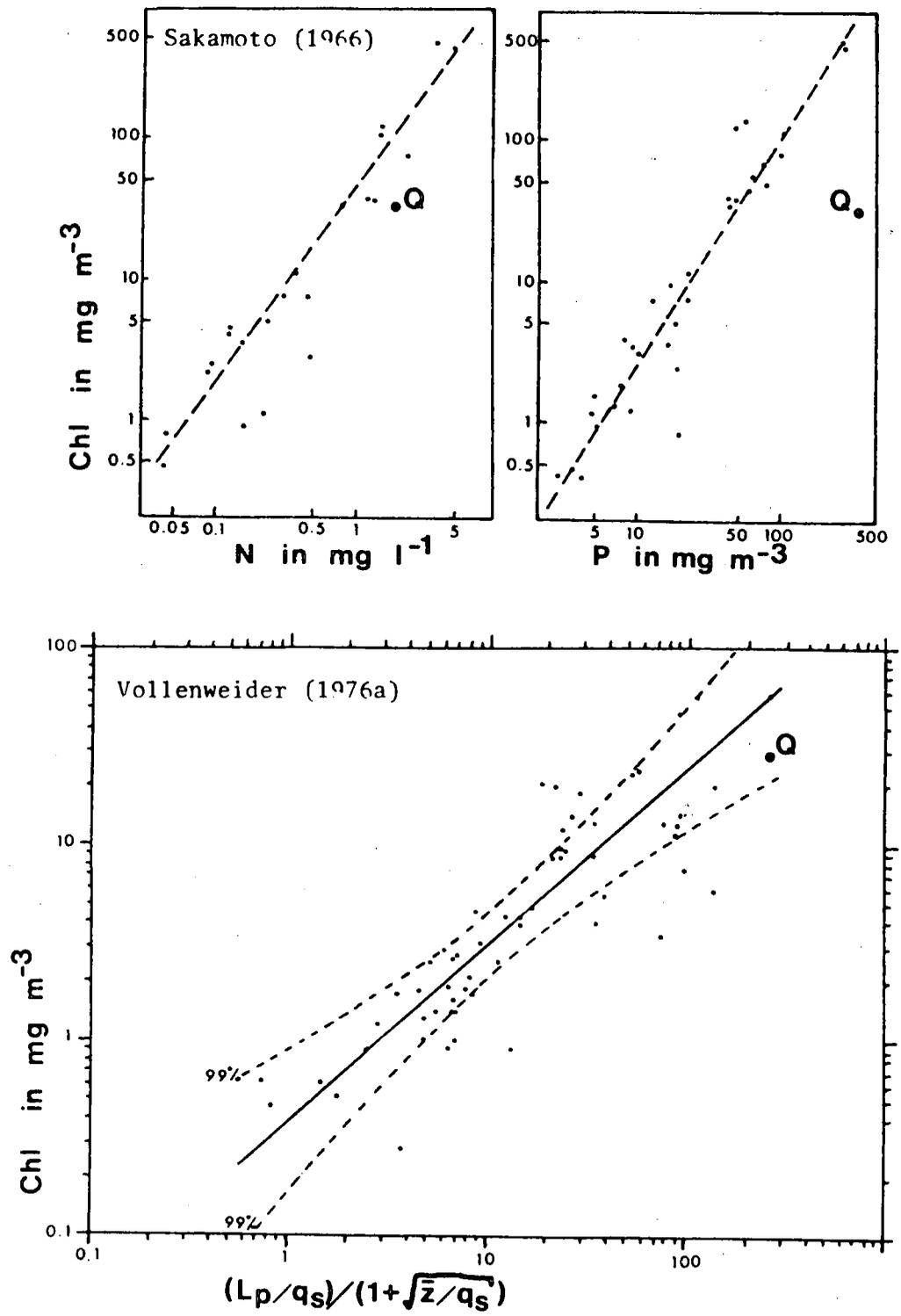


Fig. 3C2 The Average Ouzanne Lakes Data on Graphs by Sakamoto (1966) and Vollenweider (1976a)

Table 3C7
 Comparison Between Measured and Predicted Phosphorus Retention Coefficient
 from $13.2/(13.2+q_s)$ and the Calculated Internal Phosphorus Loading

Lake	Coefficients			Phosphorus Loading		
	Retention Pred.	Meas.	Internal Loading	External g/m ² /yr	Internal g/m ² /yr	mg/m ² /day
Pasqua	0.44	-0.06	0.50	6.46	3.23	8.8
Echo	0.33	0.02	0.31	10.76	3.34	9.2
Mission	0.23	0.01	0.22	18.51	4.07	11.2
Katepwa	0.38	0.03	0.35	8.51	2.98	8.2
Crooked	0.33	0.25	0.07	10.88	0.76	2.1
Round	0.25	0.26	-0.01	12.38	-0.12	

and from the sediments of phosphorus (Table 3C8). Many months of data for phosphorus content of the lake water are missing, but there is an indication of a possible seasonal flux with flux from the sediments in May, June and July, flux to the sediments in August, September and October, flux from the sediments in November, December and January and finally flux to the sediments in February, March and April.

The phosphorus retention coefficient and the sediment flux are affected by the use of terrestrial phosphorus loading to represent total phosphorus loading. If the measured input represents a low value, but the measured output is accurate, the calculation of phosphorus retained in the lake and sediments would be low and even incorrectly negative. Thus the calculated sediment flux represents a value biased toward flux from the sediments and any interpretation of results must be made with this fact in mind.

3.C.4 Nitrogen:Phosphorus Ratio

The N:P ratio in the Fishing Lakes on average decreases from input to output from 8.6 at Pasqua input to 6.0 at Katepwa output, with Echo and Mission Lakes showing the largest decreases (Table 3C9). Studying the ratio change in individual years, Pasqua, Echo and Mission Lakes all register drops in ratio from input to output in six of the eight years, while Katepwa Lake registers a rise in N:P ratio in five years. The ratio of N:P in general is higher in the Fishing Lakes from 1974-76 but lower again in 1977.

The N:P ratio in Crooked and Round Lakes shows a trend of change through the lakes opposite to the Fishing Lakes. The average ratio increases from 6.4 at Crooked input to 14.3 at Round output. In Crooked Lake the ratio increases in seven of the eight years, while Round Lake, with only three years of directly comparable ratios, shows an increase in each year. The years of higher ratios in general for these lower lakes were 1973 and 1974.

In summary, the Fishing Lakes and lower lakes appear to be different on the basis of the change in N:P ratio from input to output waters, with Katepwa Lake almost an intermediate case showing the ratio changes of the Fishing Lakes on average but those of the lower lakes when individual years are considered.

Table 3C8

Phosphorus Retention and Sediment Flux in the Lakes

Date	Retention	Sed. Flux	Retention	Sed. Flux	Retention	Sed. Flux
	$\times 10^3$ kg					
	Pasqua		Echo		Mission	
1972						
Jan	-0.26		+0.26		-0.13	
Feb	-0.49		+0.27		-0.14	
Mar	+1.56		-0.31		-0.38	
Apr	-3.44	+53.71	+1.31	+103.34	+4.13	+39.62
May	+2.21		+0.30		-0.70	
Jun	-3.24	-43.92	+0.97		+0.01	
Jul	-3.44	-39.78	+1.00	-40.02	+0.60	
Aug	-0.99	-0.42	+0.72	+7.67	+0.38	-37.46
Sep	-4.78		+4.22		+0.70	
Oct	+0.61		+0.84		+0.39	
Nov	+0.87		+0.05		+0.28	
Dec	+0.02	-75.73	+0.17	-8.85	-0.14	
1973						
Jan	+2.36		-0.86		-1.71	+8.10
Feb	-0.36		+0.65		-0.02	
Mar	+0.11		+0.86		+0.00	
Apr	+0.07		+1.08		+1.01	
May	+0.24	+49.57	+1.55	+11.14	-0.27	-9.84
Jun	-2.43	-10.48	+2.90	-35.74	+0.97	-3.12
Jul	-0.90	+2.55	+2.32	+20.10	-1.19	+6.80
Aug	-2.47	+19.38	+2.60		-1.17	+7.01
Sep	-1.87	+20.44	+1.33	+14.19	-1.83	
Oct	-3.40		+2.80		-1.43	
Nov	-1.11		-0.34		-0.37	
Dec	+2.06	-36.26	-2.32	+2.53	-0.70	-12.51
1974						
Jan	+5.99	+48.77	-1.87	+0.07	-1.18	-2.44
Feb	+5.51	+7.93	-2.62	-0.34	-0.03	-1.35
Mar	+4.26		-2.40		+0.16	
Apr	-3.68		+8.72		+2.72	
May	-9.52	+26.82	-1.28	+51.90	+0.11	+31.11
Jun	+9.25	-9.27	-6.39	-7.88	-3.52	-2.27
Jul	+2.85	-7.38	-4.02	-32.40	+2.90	-17.03
Aug	+14.64	+35.23	-3.53	-3.99	+0.40	+0.60
Sep	-11.03	+8.05	-0.22	+7.31	+4.41	+13.05
Oct	-5.68	-8.55	-12.63	+4.81	+2.29	+6.19
Nov	-1.44		-4.22		-3.61	
Dec	+0.90	-9.28	-0.22	-5.35	-2.29	-2.87

Table 3C8 cont'd

Date	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg
1975						
Jan	+3.62	-9.49	-2.68		-3.55	
Feb	-0.92		-0.03	-1.23	-0.32	
Mar	+4.63		+0.08		-0.23	
Apr	+13.87	+7.69	+0.32	-5.87	-2.53	-9.00
May	+3.82	+6.47	+3.70	-7.02	-3.42	-3.29
Jun	+2.04	-25.45	-0.16	-19.88	-14.88	-39.23
Jul	+1.53		-2.08		-1.16	
Aug	+10.25	+18.57	-0.77	+5.50	-0.80	+13.80
Sep	-5.79	+13.07	-0.38	+0.99	-4.13	-2.08
Oct	-2.31		-0.72		-4.97	
Nov	-0.75		+0.06		+1.20	
Dec	+5.08	-29.15	-1.16		+0.74	-4.09
1976						
Jan	+10.43	-1.76	-1.92	-21.75	+0.04	-4.38
Feb	+1.56	+3.06	+0.23	+15.73	-0.26	+3.04
Mar	+0.29		+0.29		-0.15	
Apr	-8.95		+0.62		+15.10	
May	+1.83	+43.65	-13.68	+7.41	+12.54	+35.87
Jun	+3.87	-10.27	-1.10	-16.04	-3.48	-15.82
Jul	+0.07	-4.42	+6.21	+1.65	-6.84	-15.62
Aug	-3.11	+2.30	+2.82	+3.85	-2.71	+3.50
Sep	-8.61	+15.99	+2.14	+0.66	-0.53	+4.88
Oct	-14.23		+4.51		+2.04	
Nov	-13.95	-37.03	+5.08		+3.02	+14.23
Dec	-5.14	-6.98	+0.44	+18.81	+0.38	-2.19
1977						
Jan	-1.07	-18.20	-0.82	-22.26	-0.19	-9.10
Feb	-0.44	+7.26	-0.72		+0.60	
Mar	+0.96		-0.47		+1.33	
Apr	+1.72	+10.27	-0.96	+17.69	+0.11	+14.25
May	+1.46	-33.04	-1.30	-13.84	-1.58	-9.50
Jun	+4.49	+30.94	+0.79	+11.05	+0.16	-11.72

Table 308 cont'd

Date	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg
	Katepwa		Crooked		Round	
1972						
Jan	+0.16		+2.11		+1.93	
Feb	+0.43		+1.92		+2.87	
Mar	-0.49		+6.32		+5.22	
Apr	+0.69	+231.97	+5.67		-1.28	
May	-1.54		+2.65		+0.40	
Jun	+1.41		+1.62		-0.14	
Jul	+1.65	-82.92	+1.65	+46.57	-0.45	
Aug	+1.47	-35.53	-0.34	-12.89	+0.98	+38.28
Sep	+2.34	+43.88	-2.15		+2.86	
Oct	+0.98		+1.16		+0.99	
Nov	+1.01		+1.73		+1.55	
Dec	+0.44		+0.32		+3.44	
1973						
Jan	+0.60	+12.11	-2.59	+18.65	+1.50	+12.74
Feb	+2.69		+2.40		-0.44	
Mar	+0.76		+2.49		+0.30	
Apr	-1.52		+1.75		-5.25	
May	-6.51	+3.14	+1.66		-5.31	
Jun	+0.10	-28.28	-1.25	+5.82	+1.77	
Jul	+1.32	+34.24	+1.20	-10.86	-0.50	-8.00
Aug	+1.20	-17.19	+0.14	+1.99	+0.08	+2.21
Sep	+3.25		+0.66	+14.19	+1.03	-0.84
Oct	+3.60		-0.23		+0.39	
Nov	+0.78		-1.28		+5.65	
Dec	+2.12	+11.56	+4.10		+0.37	
1974						
Jan	+2.26	+0.68	+2.73	+12.70	+0.47	
Feb	+2.85	+8.75	+3.41	-0.53	+0.18	+5.64
Mar	+2.86		+3.43		-0.34	
Apr	+3.40		+29.73		+6.36	
May	+10.24	+43.28	+17.96	+29.84	+45.07	+51.71
Jun	-1.97	+8.70	-0.51	+14.50	-1.52	-0.90
Jul	-3.11	-81.42	+1.22	-17.35	-7.21	-19.40
Aug	-1.78	+1.17	-8.61	-33.09	+8.64	-7.91
Sep	-5.40	+16.84	-0.44		+4.83	
Oct	-15.05	-13.46	+0.45	+45.15	-5.91	+24.55
Nov	-2.08		+0.92		-0.22	
Dec	-0.23	+18.80	+1.28		+2.84	

Table 3C8 cont'd

Date	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg	Retention $\times 10^3$ kg	Sed. Flux $\times 10^3$ kg
1975						
Jan	-0.26		+1.15		-0.61	
Feb	-0.05	-12.11	+0.97		+1.28	
Mar	+0.24		+1.03	-0.43	+1.75	
Apr	-5.91	-22.24	+14.38		+6.77	
May	-17.94	+22.01	+9.48	+32.47	+35.39	
Jun	-16.26	-180.38	-1.27		-5.09	+4.83
Jul	+1.95		+1.49	-54.64	-2.72	-5.21
Aug	+0.94	+156.34	-2.52		+5.22	
Sep	+4.41	-6.71	-11.01	+19.06	+10.29	+34.64
Oct	+4.74		-4.06		+5.72	
Nov	-1.49		+3.08		-3.88	
Dec	-6.05		+1.92	+0.21	-0.99	+2.01
1976						
Jan	-8.74	-29.47	+1.91		-3.10	
Feb	+0.41	-17.53	+1.06	-0.11	+0.84	-5.82
Mar	+0.33		+1.41		+1.73	
Apr	-2.15		+27.45		+47.82	
May	-15.36	+47.97	+0.54	+37.64	+46.50	+106.28
Jun	-0.48	-53.14	-7.34		+8.91	
Jul	+0.46	-15.89	+7.03		+4.95	
Aug	+0.57	+19.19	+3.47	-17.75	+6.08	+10.60
Sep	+0.80	+7.83	+3.11		+5.10	
Oct	-1.13		+4.22		+0.36	
Nov	-1.93	+17.38	+6.64		-3.79	
Dec	-0.68	-5.45	+3.19	+31.43	-2.58	
1977						
Jan	-0.28		+0.71		-0.40	
Feb	-0.41	-31.11	-0.42	-32.43	+1.77	-9.69
Mar	-0.70		+2.69		+1.35	
Apr	-0.04	+26.50	+4.06		+1.32	
May	+0.08	-13.54	-0.07	+29.93	+3.30	+17.63
Jun	+0.54	+7.35	-0.38		+0.73	

Table 3C9
N:P Ratios at Lake Inputs and Outputs

Location	1970	1971	1972	1973	1974	1975	1976	1977	Average
Pasqua input	4.1	4.9	7.3	6.2	13.2	10.2	13.3	9.8	8.6
Pasqua output, Echo input	3.3	3.7	4.3	3.6	16.0	20.3	11.3	5.9	8.6
Echo output, Mission input	3.2	2.9	5.3	4.1	14.2	17.8	9.2	3.4	7.5
Mission output, Katepwa input	3.0	3.1	3.4	2.4	13.7	9.8	11.7	2.8	6.2
Katepwa output	3.3	3.5	3.9	4.8	16.7	4.8	7.9	2.8	6.0
Crooked input	3.9	3.7	6.0	16.7	6.7	6.6	4.4	3.5	6.4
Crooked output	6.1	4.6	5.7	18.1	33.5	8.5	6.9	4.0	10.9
Round input	5.9	4.9	5.3						
Round output	6.3	5.6	14.5	38.6	33.8	4.9	7.0	3.8	14.3

4. DISCUSSION

4.A HYDROLOGY

4.A.1 Water Budgets

The water budget data are basic to the phosphorus budget calculations used in the development of empirical models for lakes, but the Prairie region experiences such a wide variability of water flow from year to year that this factor makes predictions difficult. When predictions are made for the Prairie region based on average water budget data, modification due to hydrological fluctuations from this average must be considered and any predictions will be qualified by the effects of these fluctuations. Therefore quantitative predictions may be too imprecise to be of any more significant value than qualitative predictions on a yearly basis and they may be more valuable for defining long term averages.

4.A.2 Groundwater

The calculation of groundwater from the water budget gives only the net movement to and from the lake system and in some cases both lake input and output may be occurring. However some tentative statements can be made about groundwater movement from these calculations. Both net monthly input and output to the lake have been calculated, with the largest movement during the spring, but on a yearly basis contribution to the lake system of groundwater is the typical net movement. The large flux in the spring must be considered with caution, since large volumes of water are being used in the calculations and this large flux may be merely an artifact of the calculation method. The groundwater movement in this region is being studied by the Saskatchewan Research Council and their findings can be used to evaluate these preliminary results.

Phosphorus movement via groundwater was not considered in the phosphorus budgets, but earlier studies (Water Quality Branch, 1971b) suggested that aquifers in the region receive nutrients from the Ou'Appelle River, as a possible explanation for the net loss of nutrients in nutrient balance calculations. The value of being able to measure the groundwater component of the water budget becomes apparent if it involves a significant flow through of water and significant concentrations of phosphorus which must be considered for accurate phosphorus budget calculations.

4.B. PHOSPHORUS LOADING

The terrestrial phosphorus loading to these Prairie lakes represents some of the highest values recorded in the world (Allan and Kenney, 1977). One reason for this is the extremely high ratios of catchment to lake surface area. Using the effective drainage area, a more conservative estimate of contributing drainage area than the gross drainage area, these ratios range from 553 to 1552. Even with low phosphorus export the large drainage area would rapidly increase the total supply to the lake.

The phosphorus loading calculated in this study is exclusively terrestrial loading and therefore the high correlation between phosphorus loading and areal water loading and between phosphorus export and discharge volume are hardly surprising, but it does emphasize the very strong dependence on the water budget of any considerations of phosphorus loading. The other sources of external phosphorus loading from the miscellaneous drainage area, atmosphere and groundwater should be considered to determine the extent of their effect on the phosphorus loading from this study.

The miscellaneous drainage area represents from 1% to 3% of the total drainage area for each lake. Using the average terrestrial loading to the lake of $11.3 \text{ g/m}^2/\text{yr}$ and assuming that this drainage area contributes a proportional loading, this represents an additional average loading of $0.1 \text{ g/m}^2/\text{yr}$ to $0.3 \text{ g/m}^2/\text{yr}$. The miscellaneous drainage area includes the development around the lake and the relationship between its contribution to the phosphorus loading may not be as easily related to the contribution of more remote developments as this simple estimate. Lakshman (pers. comm.) is presently studying the contribution of cottages to the phosphorus loading of the Fishing Lakes and his findings will be useful in evaluating this estimate.

The aeolian loading of phosphorus to lakes in North America ranges from $8 \text{ mg/m}^2/\text{yr}$ to $102 \text{ mg/m}^2/\text{yr}$ (Uttormark, Chapin and Green, 1974), while Caiazza (1976) found a value of $159 \text{ mg/m}^2/\text{yr}$ at a site near Edmonton. The percentage contribution of aeolian loading is higher in lakes with smaller ratios of drainage area to lake surface area and in one study in southern Ontario contributed from 4% to 86% of the phosphorus loading (Scheider, 1974). Because these lakes have such a large relative drainage area the significance of aeolian loading would be expected to be small. In fact if a value for aeolian loading of $100 \text{ mg/m}^2/\text{yr}$ is applied to these lakes, it represents only 0.9% of the average terrestrial phosphorus

loading to the lakes. Measurements of nutrients in precipitation are being made at nearby Wyngard by Canada Centre for Inland Waters, Applied Research Division and these results can be used to establish the level of aeolian loading in this area and to determine whether this estimate is realistic. This component of the total phosphorus loading becomes more significant if terrestrial loading of phosphorus is reduced.

Groundwater phosphorus loading values of $23 \text{ mg/m}^2/\text{yr}$ to $120 \text{ mg/m}^2/\text{yr}$ are reported by Uttormark et al (1974). Once again if these loadings are applicable they are insignificant relative to the measured terrestrial loading, but measurement within this area would be necessary to establish this.

The measured terrestrial loading from the main river accounts for an estimated 95% of the average annual external phosphorus loading using values of 0.3, 0.1, and $0.1 \text{ g/m}^2/\text{yr}$ for phosphorus loading from miscellaneous drainage, the atmosphere and groundwater, respectively. Due to the fluctuations measured in terrestrial loading over the study period, this contribution of $0.5 \text{ g/m}^2/\text{yr}$ could range from 2% to 26% of the total phosphorus loading. The study of these factors will establish whether they provide significant adjustments to the measurements of phosphorus loading used in this study, and hence the predictions made using these values.

4.C PHOSPHORUS EXPORT

Determinations of phosphorus export are useful for management purposes in identifying watersheds which contribute large amounts of phosphorus. The range of average export for small streams in the Qu'Appelle Basin was from 1.78 mg/m^2 for Cutarm Creek to 69.66 mg/m^2 for Echo Creek (Table 3C3). This quickly identifies Echo Creek drainage area as a larger relative contributor of phosphorus and if a reduction of phosphorus is desired, work to reduce the export within this basin would probably have a more significant effect than in the Cutarm Creek basin.

The small streams represent drainage areas with no municipal sewage and the export results from agricultural and feedlot operations. Moose Jaw River and Wascana Creek contribute 99% of the municipal sewage phosphorus in the Qu'Appelle Basin (Water Quality Branch, 1971c) and their high export values of 29.0 mg/m^2 and 137.4 mg/m^2 respectively reflect the importance of municipal sources of phosphorus. The reduction of export from 30.6 mg/m^2 at the Qu'Appelle River at Lumsden to 12.5 mg/m^2 at the input to Pasqua Lake, demonstrates the diluting effect of integration with lower export watersheds, and possibly indicates removal of nutrients along the length of the river.

Phosphorus export is also useful in developing phosphorus budgets for lakes. Patalas (1972) proposed a general formula for predicting phosphorus loadings to lakes which included an export coefficient representative of the land drainage, and studies have been conducted to try to define a scheme of typical phosphorus export values which would be applicable.

The geology and land use of the watershed seem to be critical factors to be considered (Dillon and Kirchner, 1975a) and although average exports have been calculated, the classifications are very general, including a wide range of values. For example, the export from agricultural land given in Uttormark, Chapin and Green (1974) ranges from 10 to 100 mg/m^2 averaging 30 mg/m^2 , while they cite studies which give exports ranging from 3 mg/m^2 to 230 mg/m^2 .

The average phosphorus export from the lower Qu'Appelle River, 11.0 mg/m^2 , represents an integration of many small sub-basin exports, each produced by a unique combination of geology and land use. However the wide range of values for phosphorus export measured in this study area illustrates the difficulty of calculating phosphorus loading to a lake from

the export coefficient. In fact it might be expected that to predict phosphorus loading to a lake within a small watershed from export requires a close identification of watershed characteristics of geology and land use whereas a similar prediction for a lake with a large watershed may be considerably easier with the natural integration of Prairie export values and hence reliability of an average export value.

4.D LAKE NUTRIENTS AND PRODUCTION

4.D.1 Phosphorus, Nitrogen and Chlorophyll Concentrations

The equation $[P] = 1.463L(1-R)/\bar{z}\rho - 145.515$ can be used to calculate the spring phosphorus concentration in these Prairie lakes on an overall basis at these loading levels. The possible underestimate of phosphorus loading by $0.5 \text{ g/m}^2/\text{yr}$ will have little effect on the recalculation of phosphorus concentration because the retention coefficient used in the equation predicting lake phosphorus concentration to modify the phosphorus loading is itself dependent on the loading determination. Any error in phosphorus supply will be balanced by a complementary error in the phosphorus retention and the predicted lake concentration will be relatively unaffected.

The decision to reduce the phosphorus from Regina sewage was based on the results anticipated from the early models relating phosphorus loading, lake phosphorus and chlorophyll concentrations. These early relationships do not appear to work well for these lakes. In fact, Vollenweider (1976a) did not expect this relationship to hold for lakes with a high phosphorus load, since production level is not solely controlled by phosphorus and Dillon and Rigler (1974b) and Sakamoto (1966) restrict the application of their models to lakes with lake water N:P ratios of greater than 12, a condition which these lakes do not satisfy.

The poor correlations between both spring lake nutrients and the summer chlorophyll concentration suggest that some other factor is controlling lake production. Cullimore and Johnson (1971) working on these lakes determined that nitrogen was a very critical factor controlling the algal growth and Allan and Kenney (1977) suggest turbidity and light limitation as well as nitrogen limitation as possible factors limiting algal growth. This other factor or factors seem to be reducing the chlorophyll a concentration in these Prairie lakes below levels predicted by phosphorus and nitrogen concentration. However any conclusions drawn from the lake data are of necessity tentative due to the infrequency of sampling and consequently large extrapolations. Indeed the chlorophyll data are extremely questionable. The method of chlorophyll analysis with poor preservation between sampling and analysis suggest that these samples may in fact be underestimates. In order to clarify this situation a more complete study of these lakes is necessary.

4.D.2 The Effects of Hydrology

Hydrological conditions play a major role in the variability of lake conditions. The decrease of phosphorus concentration within the lakes from 1970 to 1974 followed by the increase to 1977 probably represents a variability imposed on the state of lake eutrophication by the variability of the hydrological condition rather than a real trend in lake eutrophication. Although high phosphorus loading occurs during 1974, a year of high water flow, the measured river water and lake phosphorus concentration are low. Allan and Kenney (1977) found an hyperbolic relationship between phosphorus concentration and instantaneous discharge at the input to Pasqua Lake and they point out that a large spring inflow will lower the phosphorus concentration of the lake water. The expected relationship between river and lake phosphorus concentration is apparent within the predictive equation for lake phosphorus concentration. $L/Z\rho$ is the same as L/q_s , the phosphorus loading divided by the areal water loading, and represents an integrated average concentration of the lake sources of phosphorus.

The lower lakes registered a much more marked change in phosphorus concentration during the study period than the Fishing Lakes and the reason for this may be found by returning to the equation used to predict lake phosphorus concentration. The only other component used to adjust the prediction from L/q_s is R , the retention coefficient. Thus, the differences between the Fishing Lakes and the lower lakes may be affected by this factor. In fact on an annual basis the Fishing Lakes register many large negative retention coefficients, while the lower lakes register positive phosphorus retention in most years. Hence the Fishing Lakes, with their net internal phosphorus loading, are less regulated by external loading and maintain a more constant lake phosphorus concentration, despite the variability of the hydrological conditions.

4.D.3 Nutrient Limitation and Internal Phosphorus Loading

An evaluation of these lakes based on the changes of N:P ratio between input and output waters (Schindler, 1976) again indicates this difference between the two groups of lakes. The Fishing Lakes generally show an average decrease in N:P ratio between the input and the output indicating the predominant limiting nutrient to be nitrogen, while the lower lakes show the opposite change, indicating phosphorus limitation to

algal growth. Schindler determined that phosphorus was more likely to be the lake nutrient limiting algal growth because of the possibility of self regulation of the other two major nutrients, carbon and nitrogen. Any shortages of these elements in the lake may be readily affected by exchange directly with the atmosphere, whereas phosphorus has no such mechanism.

The lower lakes, which exhibit phosphorus limitation, also exhibit net phosphorus retention in the lake sediment and the assessment according to Schindler seems to be applicable. The Fishing Lakes, however, exhibit nitrogen limitation, and this may result from a mechanism to reduce any shortages of phosphorus supply in the lake, internal phosphorus loading. This hypothesis is further supported when the data of N:P ratio change on a yearly basis are examined. The Fishing Lakes do not consistently register a decrease of N:P ratio in every lake in every year (Table 3C9) and often when an increase in N:P ratio is calculated from input to output of a lake, indicating phosphorus limitation, a larger positive retention coefficient is also calculated (Table 3C1). That is the supply of phosphorus from the sediments is less available in that year.

The flux of phosphorus between the sediments and the lake water may provide an explanation for the difference between the phosphorus limitation and nitrogen limitation of these lakes. In fact the lower lakes may represent an earlier stage of development in the eutrophication of the Fishing Lakes. The study of these lakes provides a unique opportunity for trying to develop models for this highly eutrophic situation, which is outside the scope of most existing models.

4.E PREDICTING PHOSPHORUS LOADING AND LAKE CONDITIONS

4.E.1 Natural Loading

It may be possible to estimate natural loading of phosphorus if the components of artificial phosphorus loading can be removed from the terrestrial loading in this study. The atmospheric and miscellaneous drainage loading not measured in this study are both to a large extent loadings from artificial sources, and hence can be disregarded. The cottages and small towns certainly provide artificial supplies of nutrients and the amount of phosphorus in the atmosphere is almost certainly increased by inputs from civilization, both industry and agriculture. The direct effect of inputs from Moose Jaw River and Wascana Creek is to increase the export of the Qu'Appelle River. To evaluate their effect downstream is more difficult since the phosphorus export drops from 30.6 mg/m² at Lumsden to 11.6 mg/m² at the input to Pasqua Lake.

The Qu'Appelle River exports on average 11.3 mg/m² to the six lakes and the small streams which have agricultural, but no municipal sewage, export 7.5 mg/m². Therefore it is fairly reasonable to attribute the difference, 3.8 mg/m², to urban influence, and the elimination of this source might reduce the phosphorus loading to the lake by about one third.

Prairie rivers contribute much of their runoff in the snow melt season and depending on agricultural practices the runoff from some of the smaller streams may represent a relatively natural phosphorus export. In addition, the Qu'Appelle River phosphorus export during April and May might be used to approximate the natural export. This is a first approximation only, increased by the additional urban and agricultural factories but decreased by the omission of the natural export during the remainder of the year. Therefore a natural phosphorus export of 3.3 mg/m² may be a reasonable estimate, and agricultural practices may be responsible for one third of the total loading. Allan and Williams (1978) studied the sediment cores from the Fishing Lakes and their data suggest that historical loadings were about 40% of present levels, thus substantiating this estimate (Allan, pers. comm.).

In conclusion the natural export from the Qu'Appelle River might be considered to be about one third of the present export and thus the average natural loading for the lakes would range from 2.2 g/m²/yr for Pasqua Lake to 6.2 g/m²/yr for Mission Lake.

These estimated phosphorus loadings are still extremely high but

their effect on the lake must be considered, and a number of estimates of the natural lake phosphorus concentration are possible (Table 4E1). Firstly when the equation derived from this study is applied to the lakes with the estimated natural loading it does not extrapolate well to these lower loading values, giving a negative lake phosphorus concentration for Round Lake. Secondly the drop in spring lake water concentration may be directly proportional to the decrease in loading to one third the present concentration predicting levels of 73 to 162 mg/m^3 . Thirdly at these lower levels of phosphorus loading, the Fishing Lakes may be phosphorus limited with positive phosphorus retention more like the lower lakes. Therefore, using the equation by Dillon and Kirchner (1975b) to calculate retention, this would result in predictions of 72 to 105 mg/m^3 for the lake phosphorus concentration. Finally if the retention remained the same for these lakes predictions of 77 to 135 mg/m^3 would be calculated. In all cases substantially lower lake phosphorus concentrations are predicted for the lakes under the predicted natural phosphorus loading conditions.

A second consideration deals with the relationship between phosphorus and chlorophyll. This relationship is not well defined in these lakes but two possible situations will be discussed assuming the highest estimate of average spring phosphorus concentration, 124 mg/m^3 . Firstly, at these reduced levels the N:P ratio in the lake water will increase and the phosphorus will become a more important controlling factor in determining the algal growth. Chlorophyll a concentrations will more closely approximate those predicted by Dillon and Rigler and Vollenweider, with the fluctuations imposed by Prairie hydrology taken into consideration. Using Vollenweider's equation a chlorophyll concentration of 38 mg/m^3 is calculated and using Sakamoto's line a chlorophyll concentration of approximately 150 mg/m^3 is found. Earlier calculation of chlorophyll a using Vollenweider's equation fell within his 99% confidence limits, therefore his estimate may be more accurate under this condition and a small increase in chlorophyll a concentration might be expected under natural loading conditions. Secondly, the factors which are controlling the algal growth under these conditions of high loading will continue to act at lower levels of phosphorus loading and the chlorophyll a concentration will be relatively unaffected by the lower phosphorus concentration alone.

Table 4E1

Predictions of Spring Phosphorus Concentrations of Lake
Water under Natural and Reduced Loading Conditions

Lake	P Loading g/m ² /yr	Spring Phosphorus Concentration mg/m ³			
		1	2	3	4
	Natural				
Pasqua	2.15	52.7	154	72	135
Echo	3.59	45.6	162	80	131
Mission	6.17	52.0	132	105	135
Katepwa	2.84	40.1	143	81	127
Crooked	3.63	1.2	73	90	99
Round	4.13	-32.4	78	78	77
average	3.75		124	86	117
	Reduced				
Pasqua	4.31	252	308	143	272
Echo	7.17	236	323	178	261
Mission	12.34	253	264	210	270
Katepwa	5.67	225	287	162	253
Crooked	7.25	148	145	170	200
Round	8.25	80	155	156	154
average	7.50	190	247	171	235

1 - from equation $[P] = 1.463L(1-R)/\bar{z}\rho - 145.515$ using R from P budget

2 - 2/3 of present concentration for reduced loading, 1/3 for natural loading

3 - from equation $[P] = L(1-R)/\bar{z}\rho$ using R from $13.2/(13.2+q_s)$

4 - from equation $[P] = L(1-R)/\bar{z}\rho$ using R from P budget

4.F.2 Reduced Loading

One of the early steps to improve the water quality of the Qu'Appelle Lakes was the removal of phosphorus from municipal sewage. Cullimore and Johnson (1971) identify Regina as the source of 44% of the phosphorus in Pasqua Lake, so this would be expected to have a large effect in reducing phosphorus loading. Using the previously calculated values, the contribution from municipal sources is approximately one third of the present phosphorus loading and the anticipated changes in lake phosphorus concentration caused by this reduction can be calculated using the same considerations as for natural phosphorus conditions (Table 4E1).

Schindler (1976) stated that any recoveries of this type of highly eutrophied lake would be slow because of the changing nutrient interactions between sediment and lake water, and Allan and Williams (1978) predicted that the Fishing Lakes would show a gradual decline in sediment phosphorus regeneration rate following removal of external, cultural phosphorus load. Therefore any improvement in lake phosphorus concentration may be expected to occur gradually.

As with the natural loading situation it is not possible to predict the changes in chlorophyll concentration from this study, although the prediction from Vollenweider's equation would be 71 mg/m^3 , an increase in chlorophyll concentration. There is no significant correlation between the lake nutrients, phosphorus and nitrogen and chlorophyll but further study of the lakes is required to verify this since the lake chlorophyll data were so unreliable.

5. SUMMARY AND CONCLUSIONS

1. The water quantity data collected routinely by Water Survey of Canada provide a reliable basis for calculations of a water budget for these lakes. However the natural hydrological variability reduces the precision with which predictions can be made.
2. The water quality data collected routinely by the Saskatchewan Water Pollution Control Branch with a few additional samples by the Federal Water Quality Branch are not necessarily unreliable, but are certainly insufficient for thorough studies of this kind. The sampling is too infrequent on the rivers but the real fault lies with the lake data. The lakes are poorly sampled and infrequently sampled and the validity of the data is suspect, especially the chlorophyll data, with the questionable handling between sampling and analysis. The data base cannot be reasonably used to make statements about lake models with any degree of certainty, although some suggested statements are made using average values.
3. The groundwater component of the water budget was not measured separately but calculations suggest there is a net input of water to the water budget of these lakes from groundwater.
4. The large area of land drainage relative to lake surface of these Prairie Lakes ensures a high phosphorus loading. The terrestrial loading accounts for approximately 95% of the average annual phosphorus loading to the lakes. The aeolian, miscellaneous drainage and groundwater phosphorus loadings should be investigated to confirm this estimate.
5. The average phosphorus export from the effective drainage area of a large Prairie area is estimated as $11.0 \text{ mg/m}^2/\text{yr}$, however the wide range of exports depending on geology and land use must be considered in making phosphorus loading estimates from this value.
6. Predictions of lake phosphorus concentration can be made from the equation $[P] = 1.463 L(1-R)/\bar{z}\rho - 145.515$ at these loading levels.
7. The predictions of chlorophyll a concentration are consistently low from the models using lake phosphorus concentrations, lake nitrogen concentrations and lake budget parameters. Other controlling factors may include nitrogen, turbidity and light limitation, however, the chlorophyll data themselves may be low due to poor sample preservation. In order to clarify this situation, a more complete study of these lakes is necessary.
8. Changes in lake phosphorus concentration are strongly affected by

hydrological variability and this effect is moderated by the internal flux of phosphorus between the lake water and sediments.

9. Based on changing N:P ratios between input and output waters for these lakes, the Fishing Lakes show nitrogen limitation while Crooked and Round Lakes show phosphorus limitation. The flux of phosphorus between the sediments and the lake water may provide an explanation for the difference between these groups of lakes.

10. The annual average value of internal phosphorus loading for the Fishing Lakes is estimated to be 8.2 to 11.2 mg/m²/day.

11. Average natural phosphorus loading is estimated to range from 2.2 g/m²/yr for Pasqua Lake to 6.2 g/m²/yr for Mission Lake, approximately one third of the present loading. The estimated average spring phosphorus concentration is 109 mg/m³.

12. Under reduced loading conditions of about two thirds of the present loading the estimated average spring phosphorus concentration is 213 mg/m³.

13. Crooked and Round Lakes may represent an earlier stage of development in the eutrophication of the Fishing Lakes. The study of these lakes provides a unique opportunity for trying to develop models for this highly eutrophic situation, which is outside the scope of most existing models.

14. The water quality data were insufficient to reach any firm conclusions. Therefore a thorough lake budget study is recommended with particular emphasis placed on the collection of reliable lake data. This study should concentrate on a few lakes which are monitored routinely for water quantity data. Such a recommendation has gone forward to the Qu'Appelle Implementation Board.

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APPENDICES

TABLE AA1
LAKE MORPHOMETRY

LAKE	CONTOUR m	AREA km ²	STRATUM m	VOLUME x 10 ⁶ m ³	VOLUME %
PASQUA	0	19.9	0- 3	45.18	39.4
	3	10.27	3- 6	28.17	24.6
	6	8.25	6- 9	22.22	19.4
	9	6.37	9-12	14.94	13.0
	12	3.57	12-14	3.38	2.9
	14	1.10	14-15	0.67	0.6
	15	0.03	15-	0.10	0.1
ECHO	0	12.5	0- 3	33.30	29.2
	3	9.42	3- 6	26.27	23.0
	6	7.84	6- 9	22.07	19.3
	9	6.66	9-12	18.46	16.2
	12	5.47	12-15	11.42	10.0
	15	2.26	15-18	2.53	2.2
	18	0.02	18-21	0.04	0.0
21	0.01	21-	0.01	0.0	
MISSION	0	7.6	0- 3	20.71	31.3
	3	6.02	3- 6	16.63	25.1
	6	4.91	6- 9	13.56	20.5
	9	4.00	9-12	10.05	15.2
	12	2.64	12-15	4.59	6.9
15	0.61	15-	0.62	0.9	
KATEPWA	0	16.1	0- 3	46.04	20.3
	3	14.13	3- 6	41.04	18.1
	6	12.81	6- 9	37.09	16.4
	9	11.54	9-12	33.20	14.6
	12	10.26	12-15	29.05	12.8
	15	8.82	15-18	23.99	10.6
	18	6.96	18-21	14.40	6.4
	21	2.80	21-23	1.76	0.8
23	0.11	23-	0.06	0.0	
CROOKED	0	14.8	0- 3	38.14	30.9
	3	10.36	3- 6	29.14	23.6
	6	8.78	6- 9	24.20	19.6
	9	7.13	9-12	18.91	15.3
	12	5.32	12-15	10.95	8.9
15	2.11	15-	2.14	1.7	
ROUND	0	11.0	0- 3	30.62	34.5
	3	9.12	3- 6	25.87	29.1
	6	7.87	6- 9	20.83	23.5
	9	5.85	9-12	10.11	11.4
	12	1.32	12-	1.34	1.5

Table AA2

Water Survey of Canada Discharge Stations

Name	Station #
Moose Jaw River above Thunder Creek	05JE001
Moose Jaw River near Burdick	05JE006
Qu'Appelle River near Lumsden	05JF001
Wascana Creek near Lumsden	05JF005
Wascana Creek near Richardson	05JF009
Qu'Appelle River above Buffalo Pound Lake	05JG004
Qu'Appelle River below Moose Jaw River	05JG007
Arm River near Bethune	05JH001
Lewis Creek near Imperial	05JH005
Qu'Appelle River below Craven Dam	05JK002
Jumping Deer Creek near Lipton	05JK004
Qu'Appelle River below Loon Creek	05JK007
Qu'Appelle River at outlet Katepwa Lake	05JL001
Indian Head Creek near Indian Head	05JL002
Pheasant Creek near Abernethy	05JL005
Qu'Appelle River near Welby	05JM001
Qu'Appelle River at Tantallon	05JM003
Ekapo Creek near Marieval	05JM010
Kaposvar Creek near Esterhazy	05JM012
Qu'Appelle River at Hyde	05JM013
Cutarm Creek near Spy Hill	05JM015

Table AA3

Water Survey of Canada Lake Level Stations

<u>Name</u>	<u>Station #</u>
Echo Lake at Fish Hatchery	05JK005
Katepwa Lake at outlet weir	05JL004
Crooked Lake at Grayson	05JM006
Round Lake near Whitewood	05JM007

TABLE AA4
 PRECIPITATION AND EVAPORATION IN INCHES USED
 IN THE CALCULATION OF WATER BUDGETS

DATE	FISHING LAKES		LOWER LAKES	
	PRECIP	EVAP	PRECIP	EVAP
1970				
JAN	0.73	0.0	0.66	0.0
FEB	0.94	0.2	1.08	0.2
MAR	1.01	0.4	1.33	0.4
APR	2.43	1.7	2.88	1.6
MAY	2.42	3.42	2.22	4.5
JUN	2.33	6.35	1.62	4.7
JUL	2.81	5.61	4.00	5.6
AUG	1.03	6.68	0.68	4.0
SEP	2.25	3.26	2.45	2.5
OCT	2.52	2.5	2.64	2.1
NOV	0.97	0.9	0.92	0.8
DEC	1.11	0.2	1.25	0.2
ANNUAL	20.55	31.22	21.73	26.6
1971				
JAN	1.06	0.0	1.02	0.0
FEB	0.26	0.2	0.21	0.2
MAR	1.00	0.4	0.79	0.4
APR	0.68	1.7	0.82	1.6
MAY	0.42	6.14	0.36	4.5
JUN	4.32	5.09	5.58	4.7
JUL	2.16	4.98	2.39	5.6
AUG	0.58	4.99	0.83	4.0
SEP	0.34	3.20	1.30	2.5
OCT	1.72	2.5	2.40	2.1
NOV	0.36	0.9	0.65	0.8
DEC	0.64	0.2	0.80	0.2
ANNUAL	13.54	30.30	17.15	26.6

TABLE AA4 CONT'D

		FISHING LAKES		LOWER LAKES	
DATE	PRECIP	EVAP	PRECIP	EVAP	
1972					
JAN	1.12	0.0	1.35	0.0	
FEB JAN	0.97	0.2	1.20	0.2	0.0
MAR FEB	0.56	0.4	0.94	0.4	0.2
APR MAR	0.74	1.7	0.54	1.6	0.4
MAY APR	2.39	4.6	1.42	4.9	1.6
JUN MAY	1.83	5.0	1.47	6.8	4.9
JUL JUN	2.21	5.2	2.08	6.0	6.8
AUG JUL	0.48	4.8	1.07	5.6	6.0
SEP AUG	1.09	2.6	1.10	2.5	5.6
OCT SEP	0.60	2.5	0.65	2.1	2.5
NOV OCT	0.54	0.9	0.68	0.2	2.1
DEC NOV	0.77	0.2	0.76	0.2	0.8
ANNUAL	13.30	29.16	13.26	31.2	0.2
ANNUAL	13.30	29.16	13.26	31.2	0.2
1973					
JAN	0.10	0.0	0.07	0.0	
FEB JAN	0.50	0.2	0.51	0.2	0.0
MAR FEB	0.50	0.4	0.51	0.4	0.2
APR MAR	0.66	1.7	0.69	1.5	0.4
MAY APR	2.98	4.0	1.60	4.5	1.6
JUN MAY	4.42	5.4	1.96	6.2	4.5
JUL JUN	1.92	5.8	2.12	7.2	6.2
AUG JUL	1.80	4.2	2.34	6.2	7.2
SEP AUG	1.99	3.1	3.68	3.4	6.2
OCT SEP	0.44	2.5	0.31	2.1	3.4
NOV OCT	0.79	0.9	0.75	0.2	2.1
DEC NOV	1.55	0.2	0.25	0.2	0.8
ANNUAL	19.81	29.19	19.90	33.1	0.2
ANNUAL	19.81	29.19	19.90	33.07	0.2

TABLE AA4 CONT'D

DATE	FISHING LAKES		LOWER LAKES	
	PRECIP	EVAP	PRECIP	EVAP
1974				
JAN	1.61	0.0	1.49	0.0
FEB	0.68	0.2	0.46	0.2
MAR	1.07	0.4	1.23	0.4
APR	0.72	1.7	1.02	1.6
MAY	4.37	3.68	3.94	4.5
JUN	1.25	6.00	1.46	6.92
JUL	2.48	6.22	1.38	7.54
AUG	4.67	3.43	4.33	4.55
SEP	1.20	2.44	1.37	3.04
OCT	0.59	2.5	0.52	2.1
NOV	0.06	0.9	0.12	0.8
DEC	0.69	0.2	0.94	0.2
ANNUAL	19.39	27.67	18.26	31.85
1975				
JAN	0.89	0.0	0.83	0.0
FEB	0.69	0.2	0.81	0.2
MAR	0.88	0.4	1.17	0.4
APR	3.68	1.7	3.93	1.6
MAY	0.26	3.82	0.50	4.5
JUN	2.94	4.36	3.34	5.53
JUL	0.92	6.77	0.70	7.59
AUG	2.96	3.96	3.69	4.89
SEP	2.64	2.46	3.46	2.99
OCT	0.49	2.5	0.56	2.1
NOV	0.40	0.9	0.53	0.8
DEC	1.26	0.2	1.27	0.2
ANNUAL	18.01	27.27	20.79	30.80

TABLE AA4 CONT'D

DATE	FISHING LAKES		LOWER LAKES	
	PRECIP	EVAP	PRECIP	EVAP
1976				
JAN	0.80	0.0	1.59	0.0
FEB	1.27	0.2	1.38	0.2
MAR	2.03	0.4	1.69	0.4
APR	0.96	1.7	1.20	1.6
MAY	2.17	4.80	1.16	4.5
JUN	6.88	4.66	5.06	5.65
JUL	1.59	5.37	1.17	6.94
AUG	0.88	4.64	1.34	5.66
SEP	0.15	3.18	0.14	4.19
OCT	0.08	2.5	0.20	2.1
NOV	0.12	0.9	0.14	0.8
DEC	0.99	0.2	1.28	0.2
ANNUAL	17.92	28.55	16.35	32.24
1977				
JAN	0.29	0.0	0.15	0.0
FEB	0.15	0.2	0.46	0.2
MAR	0.42	0.4	1.02	0.4
APR	0.50	1.7	0.48	1.6
MAY	3.94	4.55	4.26	5.39
JUN	2.01	5.04	3.10	5.41

Table AB1

Analytical Methods

1. Federal Department of Environment, Water Quality Branch.

NAOHADAT #	Description
15413	<p><u>Total Phosphorus</u> - Colourimetry on an autoanalyzer with ammonium molybdate and SnCl_2. H_2SO_4 and $\text{K}_2\text{S}_2\text{O}_8$ solns. are added to an aliquot of the shaken sample, which is then autoclaved 30 min at 121 deg. C. Then, if turbid the sample is passed through a 0.45μ membrane filter. The filtrate is mixed with a premixed soln. of $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$ and SnCl_2. The resulting molybdenum blue colour is measured spectrophotometrically at 660 mμ, and compared with those of identically prepd. PO_4 ion solns. and reagent blanks. Interferences: Hg concn. at 1 mg/l, As. The detection limit is 5 $\mu\text{g/l}$.</p>
15406	<p><u>Total Phosphorus</u> - commencing 1/5/74 - Colourimetry on an autoanalyzer with ammonium molybdate, ascorbic acid, and potassium antimonyl tartrate. $\text{K}_2\text{S}_2\text{O}_8$ and H_2SO_4 soln. are added to a sample, which is then autoclaved 30 min at 121 deg. C. If turbid, the treated aliquot is passed through a 0.45μ membrane filter. A filtrate aliquot is then mixed with a reagent soln., contg. H_2SO_4, $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$, potassium antimonyl tartrate, and ascorbic acid. The resulting colour is measured spectrophotometrically at 880 mμ, and compared with those of identically prepd. PO_4 ion solns. Interference: high Fe concns. The detection limit is 3 $\mu\text{g/l}$.</p>
07105	<p><u>Dissolved NO_3 & NO_2</u> - Colourimetry on an autoanalyzer. The sample, after filtration through a 0.45μ membrane filter, is reduced by Cd. The resulting nitrite is determined with sulphanilic acid and 1-naphthylamine.</p>
07106	<p><u>Dissolved NO_3 & NO_2</u> - commencing 15/6/72 - Colourimetry on an autoanalyzer. If turbid, the sample is passed through a 0.45μ membrane filter. An aliquot of the sample is mixed with a disodium EDTA (disodium dihydrogen ethylenediamine tetraacetate) soln. and passed through a column of Cd filings. A sulphanilamide soln. then a N-1-naphthylethylenediamine dihydrochloride soln. are added to the sample to form an azo dye. The intensity of the dye is measured spectrophotometrically at 550 mμ, and compared with those of std. NO_3 and NO_2 ion solns. The detection limit is 1 $\mu\text{g/l}$.</p>
07110	<p><u>Dissolved NO_3 & NO_2</u> - commencing 19/10/76 - Colourimetry on an autoanalyzer. If turbid, the sample is passed through a 0.45μ membrane filter. An aliquot of the sample is mixed with an $\text{NH}_4\text{Cl-NH}_4\text{OH}$ buffer soln. (pH = 8.5), and passed through a column of Cu-Cd filings. A soln. of sulphanilamide, N-1-naphthylethylenediamine dihydrochloride and H_3PO_4, is added to the sample to form an azo dye. The intensity of the dye is measured spectrophotometrically at 550 mμ, and compared with std. solns. of NO_3 and NO_2 ions. The detection limit is 0.01 mg/l.</p>

Table AB1 cont'd

NAQUADAT #	Description
07001	<p><u>Total Kjeldahl Nitrogen</u> - The shaken sample is digested with concd. H_2SO_4, in the presence of $HgSO_4$ and K_2SO_4 to give NH_4HSO_4. The soln. is then made alk., the NH_3 distd., and collected in an H_3BO_3 soln. The distillate is then titrated with 0.02N H_2SO_4. 'N' point' indicator is used. The effective detection limit is 0.5 mg/l.</p>
<p>2. Saskatchewan Department of Environment, Water Pollution Control Branch</p>	
<p><u>Samples</u> - Except where stated, samples are collected in one gallon plastic containers with no preservative. Sample volumes are assuming 100 per cent sample.</p>	
<p><u>Total Phosphorus</u> - H_2SO_4 and $K_2S_2O_8$ solutions are added to an aliquot of the shaken sample, which is autoclaved 30 minutes at 121°C. Then, mixed with a premixed solution of $(NH_4)_6Mo_7O_{24}$, and $SnCl_2$ at 30°C. The resulting molybdenum blue colour is measured spectrophotometrically at 650 nm. Sample volume - 50 ml.</p>	
<p><u>Total Phosphorus</u> - commencing 4/4/77 - Technicon Auto Analyzer II. Detection limit - 0.01 mg/l. Samples are digested using a Technicon BD-40 Block Digestor and assayed using a Technicon Auto Analyzer II Continuous Flow Analytical System. The determination of phosphorus is based on the colourimetric method in which a blue colour is formed by the reaction of phosphate, molybdate ion and antimony ion followed by reduction with ascorbic acid at an acidic pH. The phosphomolybdenum complex is read at 660 nm. Sample volume - Minimum 25 ml. Detection limit - 0.02 mg/l.</p>	
07109	<p><u>Dissolved NO_3 & NO_2</u> - Colourimetry on an autoanalyzer. The sample, after filtration through a 0.45 μ membrane filter, is reduced by hydrazine sulphate. The resulting nitrite is determined with sulphanilamide and N-1-naphthylethylenediamine dihydrochloride. Sample volume - 10 ml.</p>
07001	<p><u>Total Kjeldahl Nitrogen</u> - as above. Detection limit - 0.3 mg/l. Sample volume - 50 ml.</p>
<p><u>Total Kjeldahl Nitrogen</u> - commencing 1/11/76 - Samples are digested using a Technicon BD-40 Block Digestor and assayed using a Technicon Auto Analyzer II Continuous Flow Analytical System. The determination is based on a colourimetric method in which an emerald-green colour is formed by the reaction of ammonia, sodium nitroprusside, sodium salicylate and sodium hypochlorite (chlorine source) in a buffered alkaline medium at a pH of 12.8-13.0. The ammonia-salicylate complex is read at 660 nm. Sample volume - Minimum 25 ml.</p>	

Table AB1 cont'd

NAQUADAT #	Description
	<p><u>Chlorophyll</u> - The sample is filtered on a 0.45 μm membrane filter. The filter is placed in a volume of 9:1 v/v acetone and distilled water mixture, capped, and kept in a dark place for 20 hours. Chlorophyll a, b, and c are calculated from the optical densities readings of the extract measured at 750, 665, 745 and 630 nm. Detection limit - 1 ppb. Sample volume - 250 ml.</p>

TABLE AB2

CONCENTRATIONS OF TOTAL PHOSPHORUS AND TOTAL NITROGEN
AND N:P RATIO DATA USED IN THE CALCULATION OF LAKE BUDGETS

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
PASQUA INPUT				JUMPING DEER INPUT			
1970				1970			
10/ 4	815	4.28	5.2	7/ 4	424	1.41	3.3
15/ 4	554	2.34	4.2	8/ 4	619	1.40	2.3
18/ 4	652	2.48	3.8	10/ 4	267	1.56	5.8
4/ 5	456			14/ 4	114	1.12	9.8
12/ 5	310	1.30	4.2	18/ 4	111	1.10	9.9
21/ 5	391	1.00	2.6	29/ 4	78	0.90	11.5
26/ 5	456	1.00	2.2	4/ 5	72	1.50	20.8
1/ 6	489	1.00	2.0	11/ 5	65	1.12	17.2
16/ 6	619	1.10	1.8	20/ 5	62	1.11	17.9
29/ 6	619	1.00	1.6	26/ 5	88	0.91	10.3
15/ 7	913	2.40	2.6	2/ 6	78	1.01	12.9
19/ 8	652	4.70	7.2	16/ 6	179	1.32	7.4
2/ 9	554			29/ 6	456	1.83	4.0
24/ 9	848	4.20	5.0	4/ 7	391	1.43	3.6
15/10	619	3.12	5.0	1971			
15/11	391	2.92	7.5	13/ 4	186	1.89	10.2
19/11	254	1.55	6.1	15/ 4	166	1.18	7.1
1971				20/ 4	108	1.31	12.1
6/ 1	1170	6.50	5.6	22/ 4	114	1.00	8.8
16/ 2	1630	8.21	5.0	27/ 4	88	0.92	10.4
19/ 2	1890	3.30	1.7	1972			
16/ 3	1830	9.09	5.0	23/ 3	360	2.49	6.9
13/ 4	717	3.65	5.1	29/ 3	270	1.88	7.0
20/ 4	391	2.23	5.7	10/ 4	260	1.35	5.2
27/ 4	326	1.67	5.1	17/ 4	110	1.12	10.2
5/ 5	284	1.60	5.6	24/ 4	59	1.10	18.6
17/ 5	274	1.46	5.3	2/ 5	93	1.35	14.5
1972				1974			
10/ 4	290	2.52	8.7	18/ 4	49	3.61	73.7
17/ 4	350	3.41	9.7	22/ 4	29	3.51	121.0
24/ 4	420	3.61*	8.6	24/ 4	59	3.26	55.2
2/ 5	600	3.09	5.2	25/ 4	29	2.30	79.3
24/ 7	377	3.69	9.8	2/ 5	29	2.17	74.8
28/ 8	646	4.90	7.6	1975			
11/ 9	860	3.64	4.2	17/ 4	274	3.0	10.9
13/ 9	685	3.2	4.7	21/ 4	209	2.8	13.4
20/12	1040	1.11	7.0	29/ 4	163	3.2	19.6
1973				1976			
16/ 5	427	2.82	6.6	29/ 3	398	1.75	4.4
14/ 6	494	4.05	8.2	5/ 4	346	1.85	5.4
6/ 7	456	6.62	1.4	6/ 4	222	2.35	10.6
17/ 7	1170	3.20	2.7	8/ 4	320	3.28	10.2
16/ 8	358	2.80	7.8	9/ 4	496	3.25	6.6

TABLE AB2 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
				PASQUA OUTPUT, ECHO INPUT			
26/ 9	434	2.85	6.6	1970			
14/11	320	3.22	10.1	10/ 4	522		
1974				14/ 4	978	3.32	3.4
3/ 1	1740	10.15	5.8	18/ 4	1240	4.27	3.4
6/ 2	2000	11.2	5.6	29/ 4	848	2.27	2.7
19/ 3	2440	13.25	5.4	4/ 5	554	1.87	3.4
22/ 4	98	4.07	41.5	11/ 5	1110	3.00	2.7
3/ 6	111	0.90	8.1	20/ 5	652	2.24	3.4
3/ 7	320	3.86	12.1	26/ 5	554	2.03	3.7
29/ 7	417	1.7	4.1	2/ 6	522	1.59	3.0
7/ 8	483	2.4	5.0	16/ 6	554	1.42	2.6
17/10	59	1.85	31.4	29/ 6	619	1.24	2.0
16/12	244	2.93	13.1	14/ 7	619	1.64	2.6
1975				20/ 8	685	2.01	2.9
14/ 1	359	3.6	10.0	14/10	815	4.64	5.7
16/ 1	398	3.72	9.3	19/11	554	3.10	5.6
11/ 2	522	4.85	9.3	7/12	750	2.32	3.1
9/ 4	1370	5.7	4.2	1971			
17/ 4	483	4.1	8.5	13/ 1	848	1.92	2.3
21/ 4	483	4.2	8.7	10/ 2	782	2.09	2.7
29/ 4	417	3.6	8.6	15/ 3	593	1.97	3.3
5/ 5	235	3.6	15.3	16/ 3	1010	2.27	2.2
13/ 5	261	1.5	5.7	13/ 4	489	2.14	4.4
26/ 5	342	1.9	5.6	20/ 4	554	2.62	4.7
2/ 6	75	1.7	22.7	27/ 4	685	2.59	3.8
4/ 6	300	1.72	6.3	5/ 5	456	2.07	4.5
9/ 6	52	1.9	36.5	17/ 5	685	3.48	5.1
5/ 8	616	2.4	3.9	1972			
30/ 9	196	2.26	11.5	23/ 3	490	1.98	4.0
3/11	456	4.5	9.9	29/ 3	380	1.61	4.2
2/12	398	2.9	7.3	10/ 4	790	3.18	4.0
1976				17/ 4	360	2.31	6.4
8/ 1	1330	5.7	4.3	24/ 4	530	2.47	4.7
26/ 1	1390	6.72	4.8	2/ 5	510	2.60	5.1
24/ 3	785	6.81	8.7	11/ 9	1100	2.15	2.0
15/ 4	69	2.78	40.3	1973			
17/ 4	334	1.49	4.5	25/ 1	554*	2.46	4.4
19/ 4	300	2.62	8.7	16/ 5	880	2.9	3.3
21/ 4	274	1.49	5.4	19/ 6	815	3.12	3.8
26/ 5	82	2.6	31.7	27/ 6	864	3.32	3.8
14/ 6	418	1.72	4.1	25/ 7	1120	2.45	2.2
12/ 7	451	1.3	2.9	21/ 8	776	3.05	3.9
16/ 8	464	2.9	6.2	27/ 8	730	2.33	3.2
13/ 9	274	4.10	15.0	10/10	832	1.84	2.2
13/10	173	3.38	19.5	14/11	390	2.04	5.2
9/11	126	2.53	20.1				
20/12	210	5.05	24.0				

TABLE A82 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
1977				1974			
11/ 1	359	7.11	19.8	16/ 1	522	2.25	4.3
24/ 2	368	8.75	23.8	11/ 2	548	2.07	3.8
22/ 3	484	6.38	13.2	18/ 3	567	2.14	3.8
13/ 4	440	3.44	7.8	16/ 4	209	1.95	9.3
19/ 4	1100	4.61	4.2	22/ 4	81	3.74	46.2
22/ 4	550	7.13	13.0	24/ 4	267	5.31	19.9
25/ 4	750	6.38	8.5	26/ 4	232	6.69	28.8
28/ 4	1500	7.25	4.8	29/ 4	117	3.35	28.6
2/ 5	1000	6.5	6.5	1/ 5	215	3.57	16.6
25/ 5	1100	3.55	3.2	8/ 5	199	3.60	18.1
7/ 7	1170	3.14	2.7	13/ 5	111	2.25	20.3
ECHO OUTPUT, MISSION INPUT				15/ 5	75	2.75	36.7
1970				17/ 5	117	2.22	19.0
8/ 4	522	1.47	2.8	24/ 5	150	1.79	11.9
14/ 4	587	1.49	2.5	28/ 5	130	2.81	21.6
18/ 4	587	1.61	2.7	31/ 5	85	2.07	24.4
28/ 4	685	2.02	2.9	7/ 6	85	1.17	13.8
4/ 5	489	1.68	3.4	14/ 6	98	1.01	10.3
11/ 5	619	1.69	2.7	28/ 6	173	5.21	30.1
20/ 5	587	1.77	3.0	8/ 7	417	1.77	4.2
26/ 5	587	1.78	3.0	15/ 7	489	1.77	3.6
2/ 6	652	1.78	2.7	22/ 7	147	1.70	11.6
16/ 6	587	1.52	2.6	15/ 8	241	1.80	7.5
29/ 6	652	1.46	2.2	16/ 9	450	2.60	5.8
14/ 7	652	1.85	2.8	21/10	183	0.97	5.3
20/ 8	619	2.20	3.6	16/12	176	1.9	10.8
24/ 9	652	2.14	3.3	1975			
14/10	717	6.16	8.6	21/ 1	169	3.38	20.0
17/11	554	1.80	3.2	17/ 4	300	3.0	10.0
2/12	587	1.52	2.6	21/ 4	450	4.1	9.1
1971				29/ 4	346	3.6	10.4
12/ 1	750	1.83	2.4	5/ 5	235	3.1	13.2
10/ 2	913	1.91	2.1	13/ 5	205	1.5	7.3
10/ 3	750	2.45	3.3	26/ 5	293	2.2	5.8
15/ 3	541	0.84	1.6	2/ 6	23	1.7	73.9
13/ 4	750	1.97	2.6	9/ 6	42	1.9	45.2
20/ 4	587	1.97	3.4	3/11	398	3.1	7.8
27/ 4	587	1.95	3.3	1976			
5/ 5	554	1.80	3.2	8/ 1	346		
17/ 5	522	2.14	4.1	5/ 4	484	2.45	5.1
1972				6/ 4	496	2.94	5.9
23/ 3	460	1.59	3.4	13/ 4	150	3.54	23.5
10/ 4	680	1.49	2.2	15/ 4	82	1.76	21.8
17/ 4	500	2.26	4.5	17/ 4	628	2.94	4.7
24/ 4	440	2.01	4.6	19/ 4	300	2.02	6.7
2/ 5	390	1.90	4.9	21/ 4	398	3.29	8.3
18/ 5	91	1.38	15.2	23/ 4	173	2.62	15.1
11/ 9	680	1.63	2.4	29/ 4	131	3.44	26.2

TABLE A82 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
1973							
25/ 1	603	1.94	3.2	27/ 5	111	1.2	10.8
16/ 5	652	1.65	1.9	14/ 6	300	5.22	17.4
19/ 6	548	1.67	3.5	12/ 7	418	0.9	2.2
17/ 8	456	3.74	8.2	13/ 9	568	4.41	7.8
27/ 8	670	2.6	3.9	19/11	732	2.14	2.9
14/11	400	1.64	4.1	1977			
5/12	639	2.48	3.9	11/ 1	386	2.10	5.4
1974				22/ 3	386	2.44	6.3
8/ 1	639	2.21	3.4	13/ 4	270	4.14	15.3
16/ 4	121	1.43	11.8	19/ 4	250	1.20	4.8
22/ 4	209	2.38	11.4	22/ 4	380	2.94	7.7
24/ 4	75	3.56	47.5	25/ 4	500	2.00	4.0
26/ 4	104	2.61	25.1	28/ 4	550	3.55	6.4
29/ 4	121	3.42	28.3	2/ 5	510	2.14	4.2
8/ 5	147	2.94	20.0	25/ 5	800*	2.04	0.2
13/ 5	147	1.91	12.7	5/ 7	500	2.44	4.9
15/ 5	121	1.76	14.8	MISSION OUTPUT, KATEPWA INPUT			
17/ 5	147	1.72	11.7	1970			
24/ 5	173	2.09	12.1	15/ 4	489	1.88	3.8
28/ 5	147	2.87	19.5	18/ 4	522	1.59	3.0
31/ 5	199	2.87	14.4	28/ 4	554	1.70	3.1
7/ 6	121	2.80	16.4	4/ 5	489	1.33	2.7
14/ 6	160	1.77	11.1	11/ 5	554	1.61	2.9
28/ 6	225	2.11	9.4	20/ 5	522	1.37	2.6
8/ 7	587	1.19	2.0	26/ 5	554	1.40	2.5
22/ 7	160	2.00	12.5	2/ 6	554	1.50	2.7
15/ 8	293	1.10	3.8	16/ 6	554	1.40	2.5
17/ 9	430	1.57	3.6	29/ 6	619	1.23	2.0
22/10	417	2.74	6.6	14/ 7	619	1.60	2.6
16/12	163	2.2	13.5	20/ 8	717	2.70	3.8
1975				24/ 9	685	2.13	3.1
21/ 1	274	2.65	9.7	14/10	619	2.98	4.8
21/ 4	293	2.2	7.5	17/11	424	1.24	2.9
28/ 4	300	2.8	9.3	1971			
5/ 5	209	2.4	11.5	16/ 2	554	1.67	3.0
14/ 5	244	3.2	13.1	10/ 3	587	1.76	3.0
26/ 5	163	1.8	11.0	15/ 3	496	0.46	0.9
2/ 6	75	1.7	22.7	13/ 4	391	1.99	5.1
9/ 6	29	1.9	65.5	20/ 4	456	1.49	3.3
3/11	385	3.8	9.9	27/ 4	522	1.63	3.1
1976				5/ 5	522	1.49	2.8
8/ 1	496	2.0	4.0	17/ 5	456	1.55	3.4
6/ 4	516	2.02	3.9	1972			
13/ 4	173	2.27	13.1	23/ 3	490	1.40	2.8
15/ 4	105	2.34	22.3	29/ 3	410	2.08	5.1
17/ 4	484	1.75	3.6	10/ 4	490	1.52	3.1
19/ 4	432	1.97	4.6	17/ 4	370	1.31	3.5
21/ 4	398	2.87	7.2	24/ 4	370	1.61	4.4
23/ 4	137	2.25	16.4	2/ 5	470	1.53	3.2
				11/ 9	850	1.47	1.7

TABLE A82 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
29/ 4	131	3.88	29.6	1973			
27/ 5	368	2.97	8.1	16/ 5	717	1.87	2.6
15/ 6	300	1.38	4.6	19/ 6	463	1.57	3.4
12/ 7	300	1.47	4.9	27/ 8	721	0.53	0.7
13/ 9	556	1.95	3.6	14/11	460	1.37	3.0
4/11	516	1.68	3.2	1974			
1977				16/ 4	121	1.15	9.5
11/ 1	450	1.62	3.6	22/ 4	183	3.26	17.8
22/ 3	561	1.75	3.1	24/ 4	685	3.21	4.7
13/ 4	460	1.32	2.9	26/ 4	111	2.91	26.2
19/ 4	640	1.30	2.0	29/ 4	104	2.62	25.2
22/ 4	580	2.27	3.9	1/ 5	258	2.57	10.0
25/ 4	510	1.80	3.5	8/ 5	183	2.55	13.9
28/ 4	600	2.08	3.5	13/ 5	130	1.65	12.7
2/ 5	530	2.74	5.2	15/ 5	160	1.95	12.2
25/ 5	750	1.51	2.0	17/ 5	98	2.27	23.2
5/ 7	560	2.42	4.3	24/ 5	147	1.42	9.7
	KATEPWA OUTPUT			28/ 5	147	2.30	15.6
1970				31/ 5	160	2.63	16.4
24/ 2	443	1.48	3.3	7/ 6	147	1.54	10.5
8/ 4	489	1.35	2.8	14/ 6	258	2.37	9.2
15/ 4	619	1.79	2.9	28/ 6	199	1.81	9.1
18/ 4	587	1.27	2.2	8/ 7	450	1.47	3.3
24/ 4	848	1.35	1.6	22/ 7	225	2.8	12.4
28/ 4	489	1.40	2.9	15/ 8	293	7.67	26.2
4/ 5	359	1.16	3.2	16/12	228	1.5	6.6
6/ 5	554	2.14	3.9	1975			
11/ 5	424	1.76	4.2	21/ 4	385	3.0	7.8
20/ 5	456	1.41	3.1	29/ 4	274	2.3	8.4
26/ 5	391	1.54	3.9	24/ 6	241	3.3	13.7
2/ 6	456	1.60	3.5	3/ 9	515	2.2	4.3
16/ 6	456	1.50	3.3	16/10	548	7.1	13.0
29/ 6	554	1.31	2.4	3/11	346	4.0	11.6
11/ 7	424	1.50	3.5	1976			
20/ 8	456	2.61	5.7	8/ 1	496	1.9	3.8
2/ 9	424			14/ 4	85	1.97	23.2
24/ 9	489	2.51	5.1	19/ 4	398	1.88	4.7
14/10	554	2.24	4.0	21/ 4	450	2.87	6.4
23/10	587	2.15	3.7	23/ 4	150	2.18	14.5
2/12	522	1.48	2.8	26/ 4	105	4.35	31.9
29/12	650*	0.99	1.5	28/ 4	199	2.47	12.4
1971				30/ 4	216	4.07	18.8
6/ 1	554	4.02	7.2	27/ 5	105	2.67	25.4
10/ 2	554	1.79	3.2	15/ 6	346	1.01	2.9
23/ 2	554	1.23	2.2	12/ 7	418	0.92	2.2
10/ 3	652	2.49	3.8	13/ 9	602	2.05	3.4
15/ 3	505	0.91	1.8	9/11	418	1.27	3.0
13/ 4	456	1.64	3.6				

TABLE A82 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
17/ 4	424	1.39	3.3	1977			
20/ 4	456	1.52	3.3	11/ 1	484	1.24	2.6
23/ 4	443	1.36	3.1	22/ 3	386	1.72	4.4
27/ 4	424	1.23	2.9	25/ 5	800*	0.85	1.1
3/ 5	293	1.31	4.5	5/ 7	590	1.72	2.9
5/ 5	522	1.46	2.8		CROOKED INPUT		
1972				1970			
23/ 3	520	1.88	3.6	17/ 2	156	1.30	8.3
10/ 4	480	1.63	3.4	9/ 4	554	2.84	4.2
17/ 4	300	1.52	5.1	13/ 4	424	1.95	4.6
24/ 4	370	1.42	3.8	23/ 4	424	1.54	3.6
2/ 5	520	1.74	3.3	28/ 4	489	1.55	3.2
11/ 9	500	2.04	4.1	4/ 5	424	1.28	3.0
1973				11/ 5	326	1.62	5.0
7/ 2	424	1.15	2.7	19/ 5	391	0.6	0.2
19/ 6	512	1.82	11.3	20/ 5	319	1.10	3.4
22/ 8	365	1.2	4.2	25/ 5	359	1.30	3.6
27/ 8	660*	1.59	2.4	1/ 6	287	1.59	5.5
27/ 9	463	1.1	2.4	15/ 6	456	1.30	2.8
14/11	350	1.58	4.5	28/ 6	456	1.42	3.1
4/12	398	2.29	5.8	14/ 7	456	1.21	2.6
1974				17/ 8	375	2.20	5.9
8/ 1	385	1.45	3.8	19/ 8	290	1.90	6.6
19/ 3	385	1.91	5.0	24/ 9	717	1.81	2.5
16/ 4	117	1.22	10.4	14/10	424	1.40	3.3
22/ 4	121	2.45	20.2	12/11	652	1.60	2.4
24/ 4	75	1.90	42.7	17/11	424	1.76	4.2
26/ 4	91	2.74	30.1	2/12	456	1.67	3.7
29/ 4	82	2.23	27.2	1971			
2/ 5	91	2.25	24.7	12/ 1	522	1.82	3.5
8/ 5	82	2.27	24.9	15/ 2	489	1.33	2.7
13/ 5	104	1.65	15.9	9/ 3	554	1.75	3.2
15/ 5	104	1.91	18.4	17/ 3	430	1.07	2.5
17/ 5	104	1.54	14.8	12/ 4	424	2.35	5.5
24/ 5	137	1.95	14.2	20/ 4	359	1.67	4.6
28/ 5	147	10.28	69.9	26/ 4	359	1.38	3.8
31/ 5	121	1.77	14.6	4/ 5	326	1.20	3.7
7/ 6	166	2.8	16.9	17/ 5	359	1.10	3.1
14/ 6	209	2.07	9.9	25/ 8	404		
28/ 6	293	1.17	4.0	9/12	522	2.21	4.2
8/ 7	417	1.75	4.2	1972			
22/ 7	215	1.7	7.9	15/ 2	560	1.12	2.0
1/ 8	530	1.80	3.4	29/ 3	480	2.19	4.6
15/ 8	232	1.84	7.9	10/ 4	340	1.79	5.3
10/10	620	1.45	2.3	14/ 4	620	1.60	2.6
16/12	228	1.5	6.6	17/ 4	280		
				24/ 4	340	1.74	5.1
				2/ 5	440	1.94	4.4
				29/ 8	121	2.10	17.4
				12/ 9	250	1.70	6.8

TABLE A82 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
1975				1973			
21/ 4	535	2.2	4.1	26/ 1	40	1.69	42.2
25/ 4	639	0.6	0.9	19/ 6	173	1.52	8.8
29/ 4	333	2.3	6.9	8/ 8	199	0.6	3.0
9/ 6	440	1.34	3.0	19/ 9	75	1.1	14.7
16/ 7	300	1.21	4.0	17/10	75	1.1	14.7
4/ 9	365	2.7	7.4	1974			
3/11	398	3.0	7.5	7/ 1	417	1.76	4.2
1976				30/ 4	600*	1.38	2.3
8/ 1	1100	2.0	1.8	22/ 7	147	1.7	11.6
14/ 4	92	1.65	17.9	20/ 8	173	2.05	11.8
19/ 4	398	1.24	3.1	23/ 9	463	2.4	5.2
21/ 4	432	1.54	3.6	5/11	117	0.6	5.1
23/ 4	150	1.52	10.1	1975			
26/ 4	248	4.22	17.0	11/ 4	535	1.5	2.8
28/ 4	199	2.64	13.3	16/ 4	417	2.8	6.7
30/ 4	147	3.52	23.9	29/ 4	346	2.7	7.8
27/ 5	433	2.3	5.3	6/ 8	463	2.8	6.0
15/ 6	334	1.27	3.8	4/ 9	496	1.1	2.2
23/ 7	400	0.90	2.2	6/11	450	6.1	13.6
13/ 9	568	2.05	3.6	3/12	375	2.6	6.9
13/10	555	3.01	5.4	1976			
28/10	550	2.08	3.8	8/ 1	386	2.0	5.2
9/11	496	1.87	3.8	27/ 1	484	1.15	2.4
1977				26/ 5	498	3.05	6.1
11/ 1	418	1.48	3.5	16/ 6	297	1.17	3.9
20/ 1	480	1.27	2.6	14/ 7	450	1.77	3.9
22/ 3	418	1.45	3.5	15/ 9	550	2.6	4.7
25/ 5	750	0.87	1.2	8/11	496	2.12	4.3
5/ 7	410	1.22	3.0	1977			
	CROOKED OUTPUT			18/ 1	398	1.32	3.3
1970				15/ 3	628	2.05	3.3
9/ 2	359	1.76	4.9	25/ 5	440	1.3	3.0
9/ 4	186	1.39	7.5	5/ 7	570	2.52	4.4
13/ 4	391	1.33	3.4		ROUND OUTPUT		
23/ 4	313	1.64	5.2	1970			
28/ 4	245	0.88	3.6	15/ 1	153	1.47	9.6
4/ 5	261	1.20	4.6	17/ 2	137	1.02	7.4
11/ 5	232	1.35	5.8	14/ 3	111	1.01	9.1
20/ 5	212	1.23	5.8	10/ 4	199	1.47	7.4
25/ 5	228	1.10	4.8	14/ 4	218	1.02	4.7
1/ 6	196	1.10	5.6	16/ 4	228	1.28	5.6
15/ 6	231	1.30	5.6	23/ 4	316	1.57	5.0
28/ 6	254			28/ 4	235	2.12	9.0
14/ 7	261	1.40	5.4	5/ 5	170	1.10	6.5
19/ 8	326	2.01	6.2	12/ 5	215	1.39	6.5
24/ 9	391	1.93	4.9	14/ 5	245	0.33	1.3
14/10	271	1.06	3.9	19/ 5	176	1.20	6.8
17/11	205	1.59	7.8	1/ 6	160	1.00	6.2
2/12	212	4.12	19.4	15/ 6	165	1.50	6.1

TABLE A82 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
1971				25/ 6	179	1.09	6.1
12/ 1	287	1.69	5.9	28/ 6	222	1.01	4.5
9/ 3	391	1.53	3.9	13/ 7	251	1.20	4.8
17/ 3	303	0.95	3.1	14/ 7	235	0.91	3.9
12/ 4	424	1.83	4.3	15/ 8	277	2.16	7.8
20/ 4	277	1.23	4.4	19/ 8	248	2.01	8.1
26/ 4	251	1.31	5.2	23/ 9	261	1.63	6.2
4/ 5	287	1.40	4.9	13/10	225	1.25	5.6
19/ 5	212	1.10	5.2	16/11	209	1.37	6.6
1972				1/12	225	1.67	7.4
5/ 4	110	1.52	13.8	15/12	238	1.42	6.0
17/ 4	280	1.65	5.9	1971			
24/ 4	290	1.50	5.2	11/ 1	222	1.32	5.9
2/ 5	490*	1.01	2.1	8/ 2	225	1.47	6.5
29/ 8	225	0.6	2.7	16/ 2	222*	1.12	5.0
12/ 9	440	2.04	4.6	8/ 3	267	1.43	5.4
1973				16/ 3	189	0.90	4.8
21/ 2	150	1.67	11.1	12/ 4	313	1.48	4.7
11/ 7	75	2.1	28.0	14/ 4	287	1.20	4.2
8/ 8	137	0.3	2.2	19/ 4	264	1.48	5.6
19/ 9	293	1.1	3.8	26/ 4	202	1.23	6.1
17/10	98	1.1	11.2	4/ 5	215	1.20	5.6
4/12	33	1.72	52.1	19/ 5	134	1.01	7.5
1974				17/ 6	114	0.77	6.8
7/ 1	104	3.7	35.6	17/ 8	186		
6/ 2	52	0.92	17.7	16/10	183		
8/ 3	20	1.87	93.5	18/12	170	0.70	4.1
22/ 7	130	4.0	30.8	1972			
23/ 9	450	2.4	5.3	14/ 2	120	0.87	7.2
5/11	82	1.5	18.3	16/ 3	150	0.89	5.9
1975				5/ 4	250	1.42	5.7
11/ 4	385	1.4	3.6	11/ 4	400	1.77	4.4
29/ 4	274	3.4	12.4	17/ 4	230	1.42	6.2
6/ 8	515	4.2	8.2	24/ 4	300	1.40	4.7
4/ 9	783	1.1	1.4	2/ 5	190	1.33	7.0
6/11	241	3.1	12.9	29/ 8	20	1.5	75.0
3/12	212	2.6	12.3	12/ 9	160		
1976				1973			
8/ 1	222	2.0	9.0	26/ 1	111	1.85	16.7
27/ 1	262	1.1	4.2	19/ 6	130	1.55	11.9
26/ 5	433	3.8	8.8	11/ 7	160	1.8	11.2
14/ 7	294	0.9	3.1	8/ 8	160	0.97	6.1
15/ 9	464	2.35	5.1	19/ 9	36	0.9	25.0
8/11	118	1.3	11.0	17/10	52	0.6	11.5
1977				4/12	23	0.43*	18.8
18/ 1	262	1.82	6.9	1974			
15/ 3	596	1.64	2.8	7/ 1	104	1.49*	14.3
25/ 5	480	0.8	1.7	6/ 2	52	0.95	18.3
5/ 7	530	2.52	4.8	8/ 3	100*	0.69	69.0

TABLE A82 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
	ROUND INPUT			30/ 4	300*	1.45	4.8
1970				22/ 7	91	3.4	37.4
10/ 4	277	1.93	7.0	26/ 7	340	1.83	5.4
13/ 4	326			20/ 8	183	3.2	17.5
23/ 4	232	1.62	7.0	23/ 9	385	2.1	5.4
28/ 4	264	1.06	4.0	2/10	370	1.33	3.6
4/ 5	212	1.10	5.2	5/11	85		
12/ 5	222	1.46	6.6	1975			
19/ 5	176	1.30	7.4	29/ 1	360	1.30	3.6
25/ 5	215	1.10	5.1	18/ 6	320	1.10	3.4
1/ 6	183	1.00	5.5	16/ 7	365	1.32	3.6
15/ 6	267	1.30	4.9	6/ 8	450	2.8	6.2
28/ 6	526	1.19	3.6	4/ 9	496	2.1	4.2
14/ 7	319	1.5	4.7	6/11	320	1.9	5.9
19/ 8	306	1.93	6.3	3/12	261	2.0	7.7
24/ 9	424	3.10	7.3	1976			
13/10	248	1.46	5.9	8/ 1	640	1.4	2.2
17/11	192	1.28	6.7	22/ 1	420	1.52	3.6
2/12	267	1.94	7.3	26/ 1	235*	1.26	5.4
1971				26/ 5	92	2.0	21.7
12/ 1	287	1.50	5.2	16/ 6	262	2.05	7.8
9/ 2	359			14/ 7	236	2.6	11.0
9/ 3	391	1.86	4.8	6/ 8	270	1.20	4.4
12/ 4	456	1.75	3.8	15/ 9	346	2.6	7.5
20/ 4	251	1.35	5.4	19/10	340	0.92	2.7
26/ 4	245	1.12	4.6	8/11	294	1.0	3.4
4/ 5	258	1.30	5.0	1977			
19/ 5	173	0.91	5.3	19/ 1	301	0.83	2.8
1972				23/ 3	210	1.17	5.6
5/ 4	310	2.10	6.8	25/ 5	300	0.7	2.3
11/ 4	620	2.06	3.3	5/ 7	490	2.22	4.5
17/ 4	260	1.43	5.5				
24/ 4	260	1.44	5.5				
2/ 5	260	1.45	5.6				

* DENOTES CONCENTRATION VALUES WHICH HAVE BEEN CORRECTED

TABLE AB3

TOTAL PHOSPHORUS CONCENTRATION USED IN THE
CALCULATION OF PHOSPHORUS EXPORT FROM SMALL STREAMS

DATE	P mg/m ³	DATE	P mg/m ³	DATE	P mg/m ³	DATE	P mg/m ³
CUTARM		INDIAN HEAD		PHEASANT		ARM	
1970		1970		1970		1970	
10/ 4	489	7/ 4	815	9/ 4	424	7/ 4	326
14/ 4	192	8/ 4	848	11/ 4	359	8/ 4	326
23/ 4	293	11/ 4	522	17/ 4	293	9/ 4	391
27/ 4	130	15/ 4	457	28/ 4	163	13/ 4	271
5/ 5	104	23/ 4	391	4/ 5	391	18/ 4	199
12/ 5	62	28/ 4	391	20/ 5	134	27/ 4	127
19/ 5	49	4/ 5	489	26/ 5	130	5/ 5	143
26/ 5	42	11/ 5	277	2/ 6	134	12/ 5	101
1/ 6	68	20/ 5	176	16/ 6	218	20/ 5	108
15/ 6	114	26/ 5	183	17/11	245	27/ 5	95
28/ 6	111	2/ 6	326	1971		1/ 6	95
13/ 7	98	16/ 6	652	13/ 4	424	2/ 6	85
19/ 8	85	13/ 7	251	15/ 4	359	17/ 6	95
23/ 9	65	1971		20/ 4	254	2/ 7	36
13/10	72	13/ 4	424	22/ 4	277	14/ 7	68
16/11	39	15/ 4	489	27/ 4	225	18/ 8	101
1/12	59	20/ 4	391	5/ 5	147	22/ 9	75
1971		22/ 4	323	19/ 5	127	20/10	85
12/4	241	27/ 4	254	1972		12/11	68
15/ 4	391	1972		23/ 3	490	10/12	124
19/ 4	215	29/ 3	440	29/ 3	350	1971	
22/ 4	78	10/ 4	430	10/ 4	370	14/ 1	306
26/ 4	114	1974		17/ 4	220	3/ 2	554
4/ 5	64	22/ 4	68	24/ 4	150	1/ 4	114
1972		2/ 5	82	2/ 5	210	13/ 4	228
17/ 4	220	9/ 5	65	1975		19/ 4	179
24/ 4	120	1975		16/ 4	398	22/ 4	228
1973		16/ 4	600	20/ 4	261	28/ 4	130
21/ 3	36	21/ 4	587	24/ 4	515	3/ 5	108
22/ 3	49	24/ 4	385	8/ 5	104	18/ 5	95
23/10	20	25/ 4	320	1976		1972	
1974		8/ 5	417	5/ 4	588	17/ 4	140
22/ 1	85	1976		6/ 4	216	26/ 4	95
20/ 2	65	15/ 4	105	8/ 4	399	EKARO	
15/ 4	267	19/ 4	320	10/ 4	392	1970	
17/ 4	104	21/ 4	432	12/ 4	196	9/ 4	424
22/ 4	68	23/ 4	121	14/ 4	260	13/ 4	209
24/ 4	65	27/ 4	262	26/ 4	140	23/ 4	108
28/ 4	29	LOON		ECHO		28/ 4	108
1/ 5	10	1970		1970		4/ 5	163
7/ 5	3	7/ 4	587	7/ 4	946	11/ 5	78
13/ 5	3	8/ 4	685	8/ 4	1170	20/ 5	49

TABLE AHS CONT'D

DATE	P mg/m ³	DATE	P mg/m ³	DATE	P mg/m ³	DATE	P mg/m ³
21/ 5	52	10/ 4	424	9/ 4	554	25/ 5	59
27/ 5	23	15/ 4	424	14/ 4	359	1/ 6	62
4/ 6	49	18/ 4	424	18/ 4	323	15/ 6	95
4/ 9	20	4/ 5	233	28/ 4	261	28/ 6	95
18/ 9	82	12/ 5	150	4/ 5	750	14/ 7	75
11/12	75	21/ 5	134	11/ 5	228	1971	
1975		26/ 5	189	20/ 5	325	12/ 4	277
17/ 1	65	1/ 6	163	26/ 5	192	15/ 4	205
21/ 3	104	1971		2/ 6	212	20/ 4	117
25/ 6	49	13/ 4	424	16/ 6	456	22/ 4	88
15/ 8	29	15/ 4	408	1971		26/ 4	65
25/ 9	49	20/ 4	293	13/ 4	489	4/ 5	52
24/10	20	22/ 4	326	20/ 4	245	1972	
1976		27/ 4	264	22/ 4	232	5/ 4	350
8/ 1	242	5/ 5	218	27/ 4	228	10/ 4	350
19/ 2	20	17/ 5	215	5/ 5	192	17/ 4	100
18/ 6	42	1972		17/ 5	215	24/ 4	46
8/ 7	42	29/ 3	350	1972		2/ 5	270
15/ 9	52	10/ 4	360	23/ 3	550	1975	
1977		17/ 4	280	29/ 3	390	16/ 4	222
19/ 1	52	25/ 4	180	10/ 4	310	17/ 4	450
23/ 3	150	2/ 5	790	17/ 4	110	22/ 4	346
15/ 6	160	KAPOSVAR		2/ 5	200	25/ 4	222
25/ 8	160	1970		LEWIS		6/ 5	160
ADAIR		10/ 4	848	1970		10/ 5	85
1970		14/ 4	619	12/ 4	284	THOMPSON	
8/ 4	554	23/ 4	783	14/ 4	288	1970	
9/ 4	652	27/ 4	522	16/ 4	222	7/ 4	685
11/ 4	456	5/ 5	284	21/ 4	222	8/ 4	619
17/ 4	225	12/ 5	202	10/ 5	192	9/ 4	750
23/ 4	241	19/ 5	189	14/ 7	68	10/ 4	456
28/ 4	222	25/ 5	199	1971		4/ 5	267
4/ 5	424	1/ 6	205	19/ 4	254	26/ 5	212
11/ 5	150	1971		22/ 4	222	2/ 6	183
20/ 5	98	12/ 4	750	28/ 4	108	1971	
26/ 5	134	15/ 4	652	5/ 5	101	13/ 4	326
2/ 6	134	19/ 4	619	19/ 5	95	15/ 4	245
1971		22/ 4	391	SANDY BEACH		20/ 4	192
13/ 4	300	26/ 4	277	1970		22/ 4	166
15/ 4	254	4/ 5	127	7/ 4	1210	27/ 4	114
20/ 4	179	19/ 5	121	8/ 4	815	HOGGY	
22/ 4	166	1972		11/ 4	913	1974	
27/ 4	114	5/ 4	290	4/ 5	750	19/ 4	463
5/ 5	91	11/ 4	380	1971			
17/ 5	49	17/ 4	310	13/ 4	554		
		24/ 4	200	15/ 4	685		
		2/ 5	170	20/ 4	619		
				22/ 4	554		

TABLE A84

CONCENTRATIONS OF TOTAL PHOSPHORUS, TOTAL NITROGEN AND
NITROGEN:PHOSPHORUS RATIOS IN THE UPPER QU'APPELLE RIVER BASIN

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
QU'APPELLE RIVER AT QU'APPELLE DAM							
1970				/ 4	100	1.12	11.2
29/ 1	101	1.87	18.5	2/ 5	400	1.13	2.8
1/ 2	20	1.61	80.5	2/ 8	15	0.87	58.0
25/ 2	36	0.10**	2.8	16/ 8	36	0.41	11.4
25/ 3	228	1.74	7.6	1973			
7/ 4	108*	0.95	8.8	10/ 4	42	1.83	43.6
27/ 4	121	0.60	5.0	15/ 5	65	1.13	17.4
25/ 5	130	0.71	5.5	31/ 5	29	1.06	36.6
23/ 6	196	0.91	4.6	5/ 7	35	0.72	20.6
27/ 7	59	1.27	21.5	25/ 7	6	0.97	161.7
25/ 8	130	0.51	3.9	15/ 8	7	0.26**	37.1
29/ 9	163	0.51	3.1	30/ 8	6	0.58	96.7
22/10	150	0.01**	0.1	31/ 8	5		
27/10	218	1.54	7.1	11/10	42	0.41	9.8
24/11	20	0.16**	8.0	31/10	10	0.69	69.0
25/11	33	0.22**	6.7	8/11	23	0.68	29.6
15/12	13			1974			
1971				8/ 1	10	0.80	80.0
4/ 1	33	0.21**	6.4	30/ 1	6	0.22**	36.7
18/ 1	7	0.19**	27.1	18/ 4	67	3.14	46.9
25/ 2	49	0.22**	4.5	25/11	52	0.6	11.5
1/ 3	23	0.23**	10.0	1975			
4/ 3	39	0.16**	4.1	21/ 1	10	1.54	154.0
25/ 3	114	0.80	7.0	11/ 2	3	1.2	400.0
13/ 4	137	1.09	8.0	2/ 6	16	1.1	68.8
20/ 4	173	0.69	4.0	7/ 8	23	2.4	104.3
26/ 4	166	0.78	4.7	4/11	20	3.5	175.0
28/ 4	170	1.03	6.1	1/12	39	2.6	66.7
5/ 5	179	1.20	6.7	1976			
19/ 5	29	0.08**	2.8	5/ 1	10	0.9	90.0
25/ 5	88	0.13**	1.5	22/ 3	274	3.07	11.2
25/ 6	150			25/ 5	433	1.7	3.9
25/ 7	59			14/ 9	20	1.51	75.5
21/ 8	20			8/11	23	0.11**	4.8
25/11	16			1977			
29/12	16	0.33**	20.6	12/ 1	23	0.21	9.1
1972				21/ 3	72	0.61	8.5
28/ 1	13	0.30**	23.1	24/ 8	40	0.27	6.8
25/ 2	11	0.24**	21.8	4/ 7	120	0.47	3.9
QU'APPELLE RIVER ABOVE WASCANA CREEK							
1970				4/ 8	144	1.05	7.3
16/ 2	231	1.80	7.8	21/11	734	4.98	6.8
9/ 4	587	2.98	5.1	28/11	147	3.74	25.4
13/ 4	522	2.64	5.1	1973			

TABLE AB4 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
18/ 4	587	2.52	4.3	14/ 2	880	4.0	4.5
27/ 4	424	1.63	3.8	8/ 3	913	4.55	5.0
4/ 5	783	2.67	3.4	14/ 5	104	0.67	6.4
11/ 5	587	2.08	3.5	13/ 6	137	2.12	15.5
15/ 5	326	1.31	4.0	4/ 7	225	1.34	6.0
19/ 5	456	1.58	3.5	16/ 7	117	1.2	10.2
25/ 5	456	1.62	3.6	14/ 8	75	0.9	12.0
3/ 6	456	1.45	3.2	28/ 8	60	0.80	13.3
15/ 6	456	1.88	4.1	5/ 9	85	1.06	12.5
1/ 7	945	3.12	3.3	12/10	104	0.69	6.6
16/ 7	489	1.90	3.9	13/11	270	2.20	8.1
16/ 8	473	1.55	3.3	1974			
17/ 8	359	1.90	5.3	2/ 1	799	7.7	9.6
21/ 9	169	1.65*	9.8	20/ 1	400	2.80	7.0
20/10	209	1.30	6.2	6/ 2	424	3.10	7.3
9/11	163	1.40	8.6	4/ 3	799	4.89	6.1
16/11	293	1.60	5.5	2/ 7	346	3.83	11.1
9/12	652			29/ 7	183	1.7	9.3
15/12	750	2.50	3.3	7/ 8	274	3.01	11.0
1971				9/ 9	267	2.9	10.9
14/ 1	1385	7.90	5.7	25/ 9	98	3.5	35.7
2/ 2	1010	5.99	5.9	17/10	121	2.9	24.0
15/ 2	1300	6.50	5.0	4/12	121	4.7	38.8
18/ 2	254	2.20	8.7	1975			
2/ 3	1990	12.41	6.2	13/ 1	391	4.7	12.0
/ 4	490	2.56	5.2	10/ 2	587	4.5	7.7
12/ 4	587	2.52	4.3	8/ 4	685	5.4	7.9
15/ 4	717	4.10	5.7	4/ 6	587	4.6	7.8
20/ 4	359	1.89	5.3	8/ 7	864	4.4	5.1
22/ 4	391	1.83	4.7	5/ 8	274	1.8	6.6
26/ 4	297	1.51	5.1	3/ 9	209	1.8	8.6
3/ 5	456	2.25	4.9	30/ 9	183	3.9	21.3
15/ 5	326	1.82	5.6	3/11	98	3.4	34.7
18/ 5	326	2.56	7.8	2/12	1140	8.7	7.6
13/10	266			1976			
1/11	238			6/ 1	1420	8.0	5.6
15/11	411			26/ 1	1480	6.77	4.6
15/12	489			23/ 3	1500	12.52	8.3
1972				26/ 5	690*	3.2	4.6
17/ 1	509	1.25	2.4	14/ 6	375	2.6	6.9
15/ 2	380	3.00	7.9	13/ 7	568	3.2	5.6
16/ 3	840	2.10	2.5	16/ 8	398	2.0	5.0
22/ 3	850	6.80	8.0	13/ 9	300	2.97	9.9
29/ 3	1600	10.13	6.3	13/10	366	3.08	8.4
4/ 4	840	6.90	8.2	9/11	965	7.32	7.6
12/ 4	590	7.04	11.9	20/12	150	3.52	23.5
17/ 4	430	4.34	10.1	1977			
4/ 5	560	3.56	6.4	10/ 1	483	9.12	18.9

TABLE A84 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
16/ 5	192	2.8	14.6	15/ 2	850	8.88	10.4
13/ 7	59	1.03	17.4	21/ 3	1340	10.59	7.9
19/ 7	75	1.22	16.3	25/ 5	800	2.34	2.9
3/ 8	87	1.10	12.6	6/ 7	450	2.42	5.4
QUIAPPELLE RIVER AT LUMSDEN							
1970				1974			
9/ 4	717	3.99	5.6	2/ 1	2320	13.8	5.9
12/ 4	815	3.44	4.2	20/ 1	2100	13.16	6.3
15/ 4	619	3.07	5.0	6/ 2	2610	15.36	5.9
18/ 4	815	2.84	3.5	4/ 3	3750	14.29	3.8
27/ 4	456	2.15	4.7	20/ 4	241	9.24	38.3
4/ 5	978	2.23	2.3	22/ 4	340	3.32	9.8
11/ 5	587	1.57	2.7	24/ 4	130	4.03	33.6
19/ 5	489	1.80	3.7	25/ 4	104	3.78	36.3
25/ 5	554	2.06	3.7	3/ 6	274	1.40	5.1
3/ 6	522	2.02	3.9	18/ 6	385	2.43	6.3
15/ 6	652	3.04	4.7	24/ 6	313	5.02	16.0
1/ 7	1500	4.30	2.9	2/ 7	320	6.05	18.9
16/ 7	848	3.21	3.8	3/ 7	293	5.18	17.7
17/ 8	1500	4.70	3.1	10/ 7	587	8.14	13.9
21/ 9	7830	18.50	2.4	16/ 7	489	8.37	17.1
20/10	3460	14.25	4.1	23/ 7	199	7.14	35.9
9/11	420	1.52	3.6	24/ 7	913	4.02	4.4
9/12	1790	8.63	4.8	30/ 7	232	3.26	14.0
1971				6/ 8	199	6.99	35.1
7/ 1	3550	19.07	5.4	7/ 8	104*	5.79	55.7
2/ 2	4370	19.48	4.4	19/ 8	232	3.28	14.1
18/ 2	3260	11.50	3.5	27/ 8	111	3.77	34.0
2/ 3	4630	43.08	9.3	3/ 9	104	4.52	43.5
15/ 3	1700	17.00	10.0	9/ 9	756	3.25	4.3
12/ 4	1300	3.93	3.0	11/ 9	137	3.00	21.9
19/ 4	913	3.06	3.4	18/ 9	241	5.40	22.4
26/ 4	424	2.16	5.1	23/ 9	835	12.62	15.1
3/ 5	489	2.69	5.5	30/ 9	489	10.9	22.3
18/ 5	587	3.39	5.8	8/10	832	7.66	9.2
1972				17/10	815	6.46	7.9
22/ 3	1500	8.55	5.7	6/11	401	15.6	3.9
29/ 3	490	4.25	8.7	21/11	750	6.2	8.3
4/ 4	490	5.49	11.2	16/12	1260	13.6	10.8
12/ 4	510	5.68	11.1	1975			
17/ 4	520	5.17	9.9	13/ 1	2410	16.2	6.7
26/ 4	1000	7.23	7.2	10/ 2	2840	18.2	6.4
4/ 5	1500	9.00	6.0	8/ 4	2610	15.3	5.9
16/ 5	1110	7.6	6.8	28/ 4	496	5.3	10.7
8/ 6	1830	16.46	9.0	4/ 6	346	4.4	12.7
13/ 7	443	3.04	6.9	5/ 8	1300	4.0	3.1
3/ 8	3100	19.90	6.4	3/ 9	1660	6.6	4.0
25/ 9	5790	24.29	4.2	30/ 9	1830	13.0	7.1

TABLE AB4 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
21/11	1210	6.72	5.6	3/11	430	4.5	10.5
28/11	3910	14.22	3.6	2/12	3000	18.2	6.1
5/12	2930	13.4	4.6	26/ 1	3680	17.14	4.6
1973				23/ 3	2050	15.47	7.5
14/ 2	3200	17.16	5.4	26/ 5	645	3.95	6.1
8/ 3	2840	12.90	4.5	14/ 6	630*	3.40	5.7
2/ 5	1500	6.13	4.1	12/ 7	294	1.7	5.8
14/ 5	978	3.33	3.4	16/ 8	450	2.62	5.8
13/ 6	1420	6.32	4.4	13/ 9	1420	9.00	6.3
4/ 7	2480	12.30	5.0	13/10	666	4.83	7.2
16/ 7	1000	3.86	3.9	9/11	855	12.06	14.1
14/ 8	1370	4.49	3.3	20/12	464	14.18	30.6
28/ 8	1800			1977			
5/ 9	1290	4.63	3.6	10/ 1	835	16.47	19.7
12/10	2930	9.05	3.1	15/ 2	1110	18.52	16.7
7/11	370	4.51	12.2	21/ 3	1160	20.68	17.8
13/11	610	4.50	7.4	25/ 5	1300	5.50	4.2
				6/ 7	790	4.19	5.3
				QU'APPELLE RIVER BELOW CRAVEN			
1970				1974			
10/ 4	978	4.70	4.8	2/ 1	2580	13.8	5.3
15/ 4	685	3.41	5.0	20/ 1	1400	10.14	7.2
18/ 4	717	3.07	4.3	6/ 2	2610	14.67	5.6
21/ 4	652	3.00	4.6	4/ 3	4010	12.89	3.2
27/ 4	489	1.95	4.0	22/ 4	400	3.59	9.0
4/ 5	880	3.27	3.7	3/ 6	85	1.38	16.2
11/ 5	587	1.67	2.8	18/ 6	244	2.6	10.6
19/ 5	522	1.92	3.7	24/ 6	81	2.3	28.4
25/ 5	522	2.26	4.3	2/ 7	147	2.37	16.1
3/ 6	522	1.78	3.4	3/ 7	173	3.81	22.0
15/ 6	489	2.21	4.5	10/ 7	137	2.35	17.2
1/ 7	978	3.23	3.3	16/ 7	150	2.07	13.8
16/ 7	782	2.47	3.2	23/ 7	183	4.0	21.8
17/ 8	652	2.30	3.5	29/ 7	274	1.72	6.3
21/ 9	365*	4.55	12.5	30/ 7	91	0.97	10.6
15/10	456	2.88	6.3	6/ 8	130	2.40	18.5
9/12	186	2.01	10.8	7/ 8	261*	1.52	5.8
1971				19/ 8	104	2.97	28.6
7/ 1	1240	6.58	5.3	27/ 8	121	4.34	35.9
2/ 2	261	1.68	6.4	3/ 9	65	2.4	36.9
19/ 2	245	2.00	8.2	11/ 9	59	1.80	30.5
22/ 2	2280	13.60	6.0	18/ 9	49	1.50	30.6
3/ 3	456	3.07	6.7	23/ 9	137	2.17	15.8
18/ 3	1790	19.60	10.9	30/ 9	82	1.80	22.0
10/ 4	613	3.80	6.2	8/10	124	2.60	21.0
12/ 4	652	4.19	6.4	17/10	98	1.50	15.3
19/ 4	522	2.19	4.2	6/11	65	1.2	18.5
26/ 4	359	1.97	5.5	21/11	20	1.2	60.0

TABLE A84 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
6/ 5	424	2.40	5.7	16/12	111	1.5	13.5
18/ 5	489			1975			
14/ 6	1080	6.40	5.9	13/ 1	365*	1.8	4.9
14/ 7	1340			10/ 2	124	2.9	23.4
16/ 8	1560			8/ 4	130	1.7	13.1
15/ 9	978			28/ 4	483	3.8	7.9
15/10	639			4/ 6	261	2.2	8.4
15/11	629			8/ 7	320*	3.1	9.7
15/12	782			5/ 8	587	2.4	4.1
1972				3/ 9	750	4.3	5.7
17/ 1	1040	6.20	6.0	30/ 9	665	7.0	10.5
15/ 2	1720	7.70	4.5	3/11	417	5.2	12.5
15/ 3	2200	8.20	3.7	2/12	913	8.4	9.2
29/ 3	490	2.45	5.0	1976			
12/ 4	510	4.98	9.8	6/ 1	3680	17.2	4.7
17/ 4	490	5.49	11.2	26/ 1	1480	7.42	5.0
26/ 4	900	5.85	6.5	23/ 3	1880	12.47	6.6
4/ 5	1100	7.40	6.7	26/ 5	483	3.15	6.5
19/ 7	587	3.03	5.2	14/ 6	1150	4.85	4.2
3/ 8	1500	7.30	4.9	12/ 7	236	2.00	8.5
21/11	913	4.86	5.3	16/ 8	334	2.35	7.0
5/12	2930	13.46	4.6	13/ 9	346	7.44	21.5
1973				13/10	833	5.79	7.0
8/ 3	3780	18.31	4.8	9/11	800	7.75	9.7
2/ 5	880	3.61	4.1	20/12	432	13.08	30.3
14/ 5	535	3.3	6.2	1977			
17/ 5	417	1.74	4.2	10/ 1	865	15.54	18.0
13/ 6	1040	6.06	5.8	15/ 2	820	14.41	17.6
6/ 7	3100	8.8	2.8	21/ 3	995	17.72	17.8
16/ 7	978	2.99	3.0	25/ 5	470	3.52	7.5
14/ 8	1160	4.53	3.9	6/ 7	580	3.25	5.6
28/ 8	1300	11.20	8.6				
26/ 9	1240	7.24	5.8				
1970				MOOSE JAW RIVER ABOVE MOOSE JAW AT HWY #2			
5/ 4	424	2.04	4.8	10/ 4	260	2.40	9.2
9/ 4	652	2.84	4.4	18/ 4	220	1.73	7.9
13/ 4	554	3.13	5.6	26/ 4	160	1.52	9.5
18/ 4	750	2.10	2.8	2/ 5	150	1.53	10.2
27/ 4	456	1.30	2.8	27/ 8	120	1.83	15.2
5/ 5	652	1.34	2.1	28/ 8	70	2.03	11.9
12/ 5	489	1.37	2.8	29/ 8	110	1.79	16.3
20/ 5	391	1.59	4.1	30/ 8	120	2.04	17.0
27/ 5	456	1.34	2.9	15/10	95	1.73	18.2
2/ 6	489	2.63	5.4	16/10	91	1.70	18.7
17/ 6	456	1.40	3.1	17/10	77	1.32	17.1
2/ 7	254	1.50	5.9	18/10	80	1.58	19.8
14/ 7	326	1.22	3.7	1973			
				7/ 1	410	2.64	6.4

TABLE AH4 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
27/ 4	391	2.00	5.1	15/ 7	640	1.75	2.7
3/ 5	456	2.54	5.6	14/ 8	620	7.1	11.4
17/ 5	231	3.71	16.1	14/10	2580	17.9	6.9
1972				15/12	5800	28.1	4.8
21/ 3	650	4.88	7.5	1976			
23/ 3	620	4.90	7.9	23/ 1	4500	25.02	5.6
28/ 3	560	3.09	5.5	10/ 5	620	5.08	8.2
3/ 4	460			26/ 7	460	3.10	6.7
4/ 4	460	3.27	7.1	5/10	1730	8.76	5.1
6/ 4	530	3.78	7.1	20/10	3000	25.50	8.5
10/ 4	460	1.57	3.4	1977			
18/ 4	520	3.87	7.4	7/ 1	6300	32.75	5.2
26/ 4	520	4.16	8.0	9/ 2	7530	45.27	6.0
2/ 5	940	5.64	6.0	12/ 7	2250	8.18	3.6
				6/ 8	2250	10.61	4.7
WASCANA CREEK NEAR RICHARDSON							
1970				1971			
5/ 4	685	2.32	3.4	12/ 4	522	3.01	5.8
10/ 4	522	2.67	5.1	15/ 4	424	2.06	4.8
13/ 4	424	2.41	5.7	19/ 4	489	3.19	6.5
18/ 4	489	2.08	4.3	22/ 4	522	2.56	4.9
28/ 4	316	1.80	5.7	26/ 4	319	1.87	5.9
4/ 5	587	2.02	3.4	3/ 5	313	2.00	6.4
11/ 5	176	1.41	8.0	18/ 5	202	1.35	6.7
19/ 5	277	1.20	4.3	1972			
25/ 5	280	1.40	5.0	22/ 3	1200	6.34	5.3
3/ 6	121	0.90	7.4	29/ 3	450	3.61	8.0
15/ 6	326	1.20	3.7	4/ 4	450	3.49	7.8
1/ 7	391	1.50	3.8	9/ 4	200	1.62	8.1
17/ 8	685	2.50	3.6	12/ 4	350	4.01	11.4
21/ 9	192	1.27	6.6	17/ 4	200	1.82	9.1
22/10	169	0.70	4.1	26/ 4	200	1.62	8.1
9/11	72	1.20	16.7	1973			
				4/ 7	111	1.57	14.1
WASCANA CREEK ABOVE QU'APPELLE RIVER							
1970				12/10	6680	22.43	3.4
7/ 4	1470	6.17	4.2	13/11	4100	31.10	7.6
8/ 4	978	4.98	5.1	1974			
9/ 4	1240	5.52	4.4	2/ 1	7500	40.2	5.4
13/ 4	554	4.58	8.3	20/ 1	5500	39.03	7.1
18/ 4	815	4.15	5.1	6/ 2	6680	40.2	6.0
28/ 4	913	4.21	4.6	4/ 3	7500	32.75	4.4
4/ 5	1010	2.71	2.7	24/ 6	522	6.5	12.4
11/ 5	717	3.28	4.6	2/ 7	456	10.43	22.9
19/ 5	1340	5.31	4.0	10/ 7	326*	16.45	50.5
25/ 5	2020	7.04	3.5	16/ 7	652	15.32	23.5
3/ 6	913	4.26	4.7	23/ 7	685	12.14	17.7
15/ 6	2180	8.42	3.9	29/ 7	1630	9.86	6.0

TABLE AB4 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
1/ 7	2220	5.10	2.3	30/ 7	456	6.52	14.3
16/ 7	2380	7.31	3.1	1/ 8	2800	8.30	3.0
17/ 8	1890	5.80	3.1	6/ 8	1300	9.70	7.5
20/10	5220	25.76	4.9	7/ 8	235	10.42	44.3
9/11	2800	9.30	3.3	19/ 8	241	5.04	20.9
9/12	7140	34.67	4.8	27/ 8	166	5.09	30.7
1971				3/ 9	147	6.70	45.6
7/ 1	9580	41.00	4.3	9/ 9	652	4.63	7.1
2/ 2	13500	57.51	4.3	11/ 9	267	6.96	26.1
2/ 3	9290	22.60	2.4	18/ 9	241	7.08	29.4
12/ 4	1140	5.71	5.0	23/ 9	3680	19.02	5.2
20/ 4	880	3.41	3.9	25/ 9	2930	18.42	6.3
22/ 4	522	3.31	6.3	30/ 9	3420	16.87	4.9
26/ 4	619	3.24	5.2	8/10	1560	10.87	7.0
3/ 5	652	4.23	6.5	11/10	1800	10.20	5.7
18/ 5	2410	14.60	6.1	17/10	1400	6.07	4.3
1972				6/11	603	20.7	34.3
12/ 1	1076*	4.72*	4.4	21/11	3330	20.0	6.0
22/ 3	1830	12.10	6.6	4/12	3910	28.9	7.4
29/ 3	1700	11.31	6.6	1975			
4/ 4	1100	9.50	8.6	13/ 1	6200	34.3	5.5
12/ 4	630	6.30	10.0	31/ 1	6400	47.09	7.4
17/ 4	810	5.83	7.2	10/ 2	7110	36.	5.1
26/ 4	1300	7.90	6.1	8/ 4	6030	32.	5.3
4/ 5	1900	13.70	7.2	4/ 6	368	4.5	12.2
16/ 5	1830	5.1	2.8	9/ 6	1100	10.60	9.6
8/ 6	5220	19.68	3.8	8/ 7	799	4.9	6.1
13/ 7	4890	20.6	4.2	15/ 7	1200	7.20	6.0
19/ 7	3750	12.17	3.2	5/ 8	2440	10.0	4.1
17/ 8	7145	22.35	3.1	3/ 9	2610	10.2	3.9
18/ 8	6455	22.2	3.4	1976			
25/ 9	6200	27.29	4.4	6/ 1	7350	35.	4.8
21/11	6850	31.16	4.5	23/ 1	7500	32.41	4.3
28/11	7340	35.72	4.9	26/ 1	7350	33.	4.5
1973				23/ 3	2130	15.47	7.3
14/ 2	8640	38.0	4.4	14/ 6	862	4.36	5.1
8/ 3	7830	40.0	5.1	22/ 7	390	6.20	15.9
16/ 3	4890	25.0	5.1	27/10	2250	18.70	8.3
14/ 5	4340	20.7	4.8	9/11	915	11.03	12.05
13/ 6	4170	19.77	4.7	1977			
4/ 7	5380	24.5	4.6	15/ 1	1400	37.10	26.5
16/ 7	1790	7.09	4.0	15/ 2	2050	36.59	17.8
7/ 8	3910	13.71	3.5	21/ 3	735	28.47	38.7
28/ 8	4000	34.00	8.5	24/ 5	1000	6.47	6.5
5/ 9	5870	14.43	2.4	6/ 7	1100	6.99	6.4
				6/ 9	700	10.27	14.7

TABLE AH4 CONT'D

DATE	P mg/m ³	N mg/l	N:P	DATE	P mg/m ³	N mg/l	N:P
BUFFALO POUND INPUT							
1970				2/ 5	110	2.31	21.0
9/ 4	456	2.37	5.2	6/11	49	0.60	12.2
13/ 4	489	1.97	4.0	18/12	16	1.08	67.5
18/ 4	489	2.01	4.1	1973			
27/ 4	277	1.40	5.1	9/ 1	29	0.53	18.3
5/ 5	245	1.50	6.1	4/ 6	378	2.28	6.0
10/ 5	147	1.30	8.8	5/ 7	117	0.62	5.3
20/ 5	130	1.20	9.2	14/ 8	111	0.92	8.3
27/ 5	88	1.30	14.7	15/ 8	82	0.30	3.6
2/ 6	68	0.90	13.2	30/ 8	36	0.34	8.9
17/ 6	212	1.80	8.5	11/10	68	0.62	9.1
2/ 7	245	1.20	4.9	31/10	16	1.10	68.8
14/ 7	176	1.60	9.1	1974			
22/ 9	169	1.20	7.1	30/ 1	82	0.85	10.4
22/10	153	0.61	4.0	1/ 2	456	6.30	13.6
12/11	65	2.27	34.9	25/11	16	1.8	112.5
15/12	29	0.16	5.5	1975			
1971				21/ 1	10	1.75	175
5/ 1	29	1.10	37.9	2/ 6	16	1.9	119
3/ 2	23	0.71	30.9	7/ 8	117	0.5	4.3
1/ 3	26	0.76	29.2	7/10	29	1.5	51.7
13/ 4	316	2.47	7.8	4/11	20	1.2	51.7
15/ 4	359	2.07	5.8	1/12	92	2.0	47.6
20/ 4	222	0.85	3.8	1976			
22/ 4	228	1.72	7.5	5/ 1	150	1.8	12.0
28/ 4	150	1.30	8.7	22/ 3	484	4.53	9.4
5/ 5	179	1.70	9.5	25/ 5	65	3.2	49.2
19/ 5	95	1.60	16.8	14/ 9	59	1.2	20.3
1972				1977			
23/ 3	460	2.89	6.3	12/ 1	3	0.81	270
13/ 4	120	0.76	6.3	24/ 5	90	0.20	2.2
26/ 4	280	3.73	13.3				

* DENOTES CONCENTRATION VALUES WHICH HAVE BEEN CORRECTED

** DENOTES CONCENTRATION VALUE CALCULATED WHEN TKN IS BELOW THE DETECTION LIMIT

TABLE A85

CONCENTRATIONS OF TOTAL PHOSPHORUS, TOTAL NITROGEN
AND CHLOROPHYLL A AND N:P RATIOS IN THE LAKES

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
PASQUA LAKE					
1970					
6/10	T	910	3.16	3.5	147
	H	930	3.26	3.5	170
	T	920	1.96	2.1	28
	H	920	1.71	1.8	21
	T	950	1.95	2.0	35
	H	920	1.64	1.8	15
	T	950	2.19	2.3	92
	B	970	2.11	2.2	30
	T	910	2.06	2.3	58
	B	930	1.99	2.1	11
1971					
15/ 2	T	2410	9.92	4.1	41
	T	1080	3.12	2.9	0.5
	B	1430	5.02	3.5	6
	T	1080	4.03	3.7	ND
	B	1750	6.77	3.9	6
	T	1100	3.38	3.1	3
	B	1180	3.06	2.6	22
	T	1070	2.10	2.0	1
	B	1580	3.23	2.0	3.5
7/ 6	T	620	2.64	4.2	14
	T	750	3.14	4.2	2
	B	530	2.92	5.5	21.5
	T	790	2.76	3.5	31
	B	710	3.13	4.4	35
	T	500	2.47	4.9	2.5
	B	490	2.66	5.4	20.5
	T	350	2.17	6.2	1
	B	910	2.60	2.8	15
1972					
19/ 5	T	121	1.86	15.4	
	T	147	1.64	11.1	
	T	111	2.66	24.0	
24/ 7	T	499	2.45	4.9	
28/ 8	T	815	2.87	3.5	26.1
6/ 9	T	619	1.96	3.2	31.8
	M	619	1.66	2.7	204.6
	H	619	2.26	3.6	107.5
7/ 9	T	1160	6.06	5.2	97.0
	M	1040	2.58	2.5	3.8
	B	913	2.76	3.0	
8/ 9	T	1010	2.15	2.1	8.4

TABLE AHS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
14/ 9 1975	M	489	2.12	4.3	
18/ 1	M	1990	11.09	5.6	32.6
	M	1990	9.80	4.9	29.0
	M	2120	2.85	1.3	11.2
	M	1830	6.96	3.8	19.6
25/ 1	T	750	2.18	2.9	
	H	1160	2.42	2.1	
	T	799	2.03	2.5	17.8
	H	913	2.65	2.9	17.8
27/ 6	T	450	3.99	8.9	
	H	1240	4.27	3.4	
	T	1160	3.41	2.9	
	H	1240	3.71	3.0	
	T	1160	4.38	3.8	
	H	1210	5.00	4.1	
	T	1120	3.62	3.2	
	M	1040	3.94	3.8	
	H	1040	3.94	3.8	
	T	1160	2.76	2.4	
	M	476	3.02	6.3	
	H	1080	3.06	2.8	
25/ 7	T	1290	1.99	1.5	
	T	1080	3.03	2.8	
	H	1040	3.00	2.9	
	T	1010	2.48	2.4	
	H	1120	2.82	2.5	
	T	913	3.17	3.5	
	M	1080	1.52	1.4	
	H	1160	2.54	2.2	
	T	962	2.61	2.7	
	M	1340	2.03	1.5	
	H	1080	2.29	2.1	
21/ 8	M	1600	3.97	2.5	
	T	1080	2.54	2.4	
	H	1160	4.29	2.7	
	T	978	2.81	2.9	
	M	1080	2.47	2.3	
	H	1120	3.09	2.8	
	T	995	1.01	1.0	
	M	1080	2.21	2.0	
	H	1080	2.51	2.3	
	T	1120	2.47	2.1	
	M	636	2.17	2.2	
	H	913	4.29	3.4	
26/ 9	T	880	2.69	3.0	
9/10	T	587	2.99	5.1	
	H	522	2.99	5.7	

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	T	489	2.97	6.1	
	H	456	2.97	6.5	
	T	587	2.41	4.1	
	M	734	2.39	3.5	
	H	685	2.39	3.5	
	T	832	2.11	2.5	
	M	832	2.39	2.9	
	B	832	1.79	2.2	
	T	750	1.81	2.4	
	M	864	2.11	2.4	
	B	750	2.09	2.8	
1974					
17/ 1	T	1660	10.64	6.4	
	T	2320	19.82	8.5	
	B	1600	9.22	5.7	
	T	554	2.25	4.1	
	M	554	1.83*	3.3	
	B	554	2.17*	3.9	
	T	489	1.72*	3.5	
	M	489	2.20	4.5	
11/ 2	H	603	2.18	3.6	
	T	587	1.98	3.4	
	M	567	2.03	3.6	
	B	685	2.28	3.3	
	T	538	1.93	3.6	
	M	535	1.70	3.2	
	B	734	1.93	2.6	
18/ 3	T	535	2.12	4.0	
	M	587	2.14	3.6	
	B	639	2.39	3.7	
18/ 6	T	267	2.00	7.5	19
	M	267	1.47	5.5	15
	B	277	1.67	6.0	20
	T	251	2.30	9.2	20
	M	267	1.40	5.2	22
	B	359	1.70	4.7	20
	T	267	3.10	11.6	2.3
	M	267	1.86	7.0	11
	B	303	1.90	6.3	7
	T	251	1.47	5.9	14
	M	244	2.71	11.1	9.3
	B	244	1.01	4.1	16
	T	251	1.60	6.4	47
	M	251	1.81	7.2	20
	B	375	1.79	4.8	33
15/ 7	T	293	3.8	10.8	21
	C	489	4.1	7.1	21
	C	522	6.2	11.0	133

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	C	391	3.0	6.1	
	C	489	3.0	4.8	
7/ 8	T	417	2.10	5.0	21
	T	463	2.60	5.6	33
12/ 8		483	2.40	5.0	44
		538	2.10	3.9	23
		567	2.10	3.7	42
		483	2.30	4.8	9
		734	2.37	3.2	6
16/ 9		241	2.10	8.7	3
		293	1.80	6.1	3
		333	2.90	8.7	
		417	1.85	4.4	
		450	2.15	4.8	
21/10		82	2.90	3.5	
		59	0.60	10.2	
		209	0.60	2.9	
		261	0.95	3.6	
		293	1.85	6.3	
12/11	M	290*	2.1	7.2	20
	M	230*	3.5	15.2	25
	M	130	1.8	13.8	25
	C	170	2.4	14.2	
	C	209	2.1	10.0	
1975					
16/ 1	T	463	4.64	10.0	19
	T	365	4.34	11.9	3
21/ 1	M	346	3.52	10.2	11
	M	333	3.67	11.0	2.4
	C	59	1.98	33.6	
	C	209	2.00	9.6	
	C	196	1.68	8.6	
24/ 2	M	548	4.7	8.6	2.9
	M	567	4.7	8.3	11.1
	M	300	2.8	9.3	4.8
	C	293	2.5	8.5	
	C	274	2.5	9.1	
21/ 5	T	926	2.2	2.4	
	H	528	1.4	2.6	
	C	580	1.4	2.4	32.7
	T	737	2.0	2.7	
	H	528	2.3	4.4	
	C	515	1.2	2.3	38.5
	T	515	2.2	4.3	
	M	365	2.9	6.8	
	H	404	2.6	5.4	
	C	417	1.4	3.4	33.8
	T	496	2.7	5.4	

TABLE ABS (CONT'D)

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	M	443	2.5	5.6	
	B	359	2.6	7.2	
	C	417	1.7	4.1	38.5
	T	274	2.2	8.0	
	M	346	2.1	6.1	
	B	463	2.3	5.0	
23/ 6	C	359	1.7	4.7	-3.3
	C	626	2.2	3.5	6.6
	C	417	1.7	4.1	2.3
	M	567	1.9	3.4	2.3
	C	398	2.6	4.7	7.0
	M	365	1.9	4.7	4.9
	C	398	1.7	4.3	4.2
	H	463	3.6	7.8	4.2
	M	417	1.7	4.3	
	C	430	1.7	4.0	0
	M	365	1.4	3.6	
16/ 7	H	567	1.9	3.4	
	C	880	2.7	3.1	0
	C	538	3.1*	5.8	2.3
	M	946	3.0	3.2	0
	B	783	1.4	1.8	
	C	600	1.8	3.0	0
	T	600	2.1	3.5	0
	B	633	1.8	2.8	
	C	515	1.5	2.9	0
	T	626	1.5	2.4	2.3
	M	770	1.8	2.3	
2/ 9	B	783	3.6	4.6	
	H	734	6.5	8.9	42.6
	M	434	2.4	5.5	36.6
	C	499	2.1	4.2	32.7
	C	799	1.8	2.2	28.8
	T	646	2.1	3.2	18.6
	M	603	1.5	2.5	
	B	734	2.4	3.3	
	C	668	2.1	3.1	12.4
	T	620	2.4	3.9	6.3
	M	646	1.5	2.3	
15/10	B	646	1.1	1.7	
	C	274	6.1	22.3	47.5
	C	717	8.3	11.6	121
	C	496	6.4	12.9	55.2
	T	430	5.41	12.6	
	B	346	5.28	15.0	
	C	463	6.3	13.6	26.6
	C	430	5.7	13.2	17.7
	T	515	4.8	9.3	

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	M	665	3.4	5.1	
	B	417	3.3	7.9	
1976					
19/ 1	C	1130	6.47	5.7	4.2
	C	1240	7.72	6.2	29.5
	C	1570	8.57	5.4	2.3
	C	1130	8.27	7.3	4.2
	C	628	4.10	6.5	1.9
	C	536	3.18	5.9	1.9
	T	450	3.48	7.7	
	M	516	2.88	5.6	
	B	464	4.08	8.8	
	C	432	2.84	6.6	13.1
	T	516	2.54	4.9	
	M	464	2.58	5.6	
	B	628	3.44	5.5	
19/ 2	C	1290	7.00	5.4	1.9
	C	1670	6.91	4.1	10.5
	C	1340	7.21	5.4	1.9
	C	1470	7.54	5.1	10.5
	C	516	2.28	4.4	3.8
	C	602	2.30	3.8	2.3
	T	758	2.10	2.8	
	M	568	2.40	4.2	
	B	732	3.11	4.2	
	C	568	2.24	3.9	1.9
	T	496	2.28	4.6	
	M	496	2.28	4.6	
	B	568	2.28	4.0	
15/ 3	C	1550	8.37	5.4	28.8
	C	1080	8.65	8.0	0
	C	563	2.42	4.3	0
	C	645	3.15	4.9	2.3
	T	563	1.75	3.1	
	M	710	3.25	4.6	
	B	670	6.08	9.1	
	C	898	6.45	7.2	0
	T	670	5.65	8.4	
	M	1080	5.55	5.1	
	B	800	6.08	7.6	
14/ 6	C	398	1.27	3.2	6.6
	C	386	1.47	3.8	18.7
	C	366	1.47	4.0	
	C	386	1.47	3.8	
	T	334	1.47	4.4	
	M	320	1.42	4.4	
	B	536	2.02	3.8	
	C	464	1.42	3.1	4.2

TABLE ABS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	T	274	1.22	4.4	
	M	300	1.22	4.1	
	H	640	1.42	2.2	
28/ 7	C	666	2.00	3.0	4.2
	C	568	1.72	3.0	4.2
	M	484	1.20	2.5	15.2
	M	464	1.20	2.6	6.1
	M	432	0.90	2.1	6.1
17/ 8	C	516	2.30	4.4	24.9
	C	536	2.00	3.7	4.7
	T	496	2.00	4.0	
	M	496	2.00	4.0	
	B	588	2.00	3.4	
	C	758	2.30	3.0	8.4
	T	550	2.00	3.6	
	M	536	2.30	4.3	
	B	580	3.20	5.5	
20/ 9	C	516	3.27	6.3	4.7
	M	450	4.30	9.6	66.0
	M	464	4.30	9.3	82.8
	C	536	3.25	6.0	17.7
	T	516	2.05	3.9	
	M	536	2.65	4.8	
	B	588	2.65	4.4	
12/10	M	105	2.60	24.8	109.7
	M	98	2.60	26.5	93.4
	C	484	1.75	3.6	13.5
	C	516	1.81	3.5	11.2
20/12	M	320	5.69	17.8	37.4
	M	294	5.29	18.0	18.7
	M	242	5.12	21.2	12.6
	M	418	2.35	5.6	8.2
	M	366	2.35	6.4	5.3
	C	418	2.60	6.2	5.3
	T	398	1.88	4.7	
	M	568	2.05	3.6	
	B	432	2.05	5.2	
	C	366	2.12	5.8	2.9
	T	386	2.05	5.3	
	M	386	2.15	5.6	
	B	320	2.42	7.6	
1977					
19/ 1	T	366	7.04	19.2	11.2
	T	334	6.74	20.2	8.9
	M	418	2.52	6.0	2.3
	C	602	2.45	4.1	ND
	T	386	2.25	5.8	
	M	398	2.35	5.9	

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	H	366	2.25	6.1	
	C	398	2.85	7.2	2.3
	T	366	2.00	5.5	
	M	366	2.45	6.7	
	H	334	3.05	9.1	
23/ 2	C	523	2.65	5.1	ND
	T	523	2.58	4.9	
	M	563	3.35	6.0	
	H	368	2.92	7.9	
	C	498	2.91	5.8	ND
	T	540	2.62	4.8	
	M	523	2.68	5.1	
	H	523	3.07	5.9	
		498	5.47	11.0	
		433	8.15	18.8	6.5
		563	8.11	14.4	
		965	11.09	11.5	
21/ 3	C	588	1.50	2.6	ND
	T	464	1.39	3.0	
	M	450	1.47	3.3	
	H	450	1.59	3.5	
	C	536	1.91	3.6	1.9
	T	432	1.57	3.6	
	M	484	1.70	3.5	
	H	432	1.75	4.1	
	T	450	5.37	11.9	
17/ 5	C	390	3.34	8.6	92.0
	C	390	2.72	7.0	87.8
	M	450*	2.61	5.8	114
6/ 6	C	400	2.17	2.9	2.3
	T	340	2.24	6.6	
	M	580	2.34	4.0	
	H	480	2.65	5.5	
		400	2.17	2.9	1.9
		1100	2.20	1.0	
		1600	2.37	1.5	8.9
		1200	3.77	3.1	
		560	2.55	4.6	
		440	2.27	5.2	
4/ 7	C	420	2.45	5.8	17.3
		420	2.40	5.7	17.7
		640	2.70	4.2	110
	H	450	2.38		
15/ 8	C	680	1.94	2.8	28.5
	C	860	2.11	2.4	30.4
	T	920	3.11	3.4	43.3

TABLE AHS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
ECHO LAKE					
1970					
8/10	T	760	1.49	2.0	6
	R	750	1.41	1.9	2.5
	T	760	1.50	2.0	14
	R	760	1.68	2.2	11
1971					
21/ 1	T	990	1.71	1.7	ND
	R	980	1.69	1.7	ND
	T	1000	1.85	1.8	ND
	R	970	1.61	1.6	ND
26/ 5	T	1170	1.48	1.3	79.5
	R	880	1.65	1.9	78.5
	T	1560	1.78	1.1	18.5
	R	760	2.10	2.8	16.5
1972					
18/ 5	T	117	1.80	15.4	
	T	346	3.79	11.0	
26/ 8	T	603			
	T	13000	173	13.3	5781
6/ 9	T	391	1.52	3.9	69.2
	M	391	1.50	3.8	124.3
	B	391	1.22	3.1	76.7
7/ 9	T	913	1.22	1.3	0
	M	603	2.12	3.5	195.3
	R	587	2.12	3.6	8.4
	T	603	2.12	3.5	2.8
	M	587	1.85	2.7	2.8
	R	554	1.52	3.2	6.6
8/ 9	T	401	0.40	1.0	365.8
1973					
25/ 1	T	652	1.71	2.6	17.8
	R	603	1.94	3.2	17.8
	T	734	1.41	1.9	17.8
	R	750	1.76	2.3	17.8
	T	603	1.44	2.4	17.8
	R	652	2.76	4.2	17.8
27/ 6	T	802	2.77	3.4	
	M	587	2.75	4.7	
	R	548	3.65	6.7	
	T	626	2.15	3.4	
	M	515	3.07	6.0	
	R	567	3.97	7.0	
	T	600	3.67	6.1	
	M	600	3.05	5.1	
	R	756	2.47	3.3	
25/ 7	T	365	2.17	5.9	
	M	913	5.18	5.7	

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl: a mg/m ³
	T	750	2.48	3.3	
	M	962	2.17	2.2	
	B	1660	3.01	1.8	
	T	799	1.89	2.4	
	M	913	1.87	2.0	
	B	864	2.05	2.5	
	T	832	1.85	2.2	
	M	799	2.48	3.1	
	B	864	1.55	1.8	
21/ 8	T	734	1.59	2.2	
	T	717	2.17	3.0	
	B	756	3.37	4.4	
	T	717	1.50	2.1	
	M	717	2.12	3.0	
	B	756	3.02	4.0	
	T	1040	2.47	2.4	
	B	799	2.47	3.1	
10/10	T	685	1.26	1.8	
	T	652	1.26	1.9	
	M	685	1.28	1.9	
	H	734	1.28	1.7	
	T	685	1.30	1.9	
	M	799	1.28	1.6	
	B	603	1.28	2.1	
	T	652	1.28	2.0	
	M	652	1.60	2.4	
	B	750	1.58	2.1	
1974					
17/ 1	T	567	2.20	3.9	
	M	626	2.07*	3.3	
	B	887	7.86	8.9	
	T	665	2.23	3.3	
	M	756	2.23	2.9	
	B	730	5.10	7.0	
21/ 4	T	587	1.28	2.2	
	M	603	1.58	2.6	
	B	603	1.30	2.2	
11/ 2	T	587	1.38	2.4	
	M	587	1.10	1.9	
	B	734	1.36	1.8	
	T	603	1.36	2.2	
	M	652	1.38	2.1	
	B	832	1.33	1.6	
	T	600	1.36	2.3	
	M	620	1.64	2.6	
	B	652	1.36	2.1	
18/ 3	T	626	1.73	2.7	
	M	626	1.70	2.2	

TABLE AHS CONT'D

DATE	SAMPLF DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	H	717	1.68	2.4	
	T	626	1.68	2.8	
	M	626	1.38	2.7	
19/ 3	H	691	1.64	2.3	
	T	646	2.60	4.0	
	M	646	1.70	2.6	
19/ 6	H	668	1.68	2.5	
	T	173	1.53	8.8	15
	M	225	1.79	8.0	36
	H	209	5.19	24.8	248
	T	365	2.00	5.5	22
	M	241	2.39	9.9	31
	H	192	2.93	15.3	91
	T	160	2.00	12.5	15
	M	121	2.69	22.2	46
16/ 7	H	300	2.89	9.6	68.8
	C	225	2.87	12.8	32.7
	C	192	4.30	22.4	158
	C	284	2.67	9.4	3.1
12/ 8		483	1.61	3.3	4.7
		483	2.47	5.1	3.2
		483	1.57	8.2	3.1
17/ 9		515	1.91	3.7	50.1
		463	1.31	2.8	63.0
		483	1.87	3.9	84.1
21/10		430	1.55	3.6	
		417	1.15	2.8	
		417	1.17	2.8	
12/11	C	300	1.81	6.3	13.8
	M	235	2.40	10.2	11
1975					
21/ 1	C	274	1.70	6.2	6.2
	C	293	1.70	5.8	7.0
	C	261	1.70	6.5	3.3
2/ 3	C	261	1.9	7.3	
	C	293	1.9	6.5	
	C	235	1.9	8.1	
22/ 5	T	235	2.0	8.5	68.3
	M	274	1.8	6.6	
	H	290	1.8	6.2	
	C	261	1.8	6.9	60.7
	T	271	1.8	6.6	43.8
	M	290	2.0	6.0	
	H	310	2.4	7.7	
	C	287	1.9	6.6	60.1
	T	408	2.2	5.4	52.0
	M	408	2.0	4.9	
	H	398	2.0	5.0	
	C	382	2.1	5.5	46.1

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³	
23/ 6	C	365	1.1	3.0	6.6	
	M	333	0.8	2.4		
	H	587	2.8	4.8	2.3	
	C	346	2.2	6.4		
	M	300	1.7	5.7		
	H	430	2.2	5.1		
	16/ 7	C	320	1.4	4.4	0
		M	626	1.4	2.2	
		H	398	1.9	4.8	25.6
		C	913	2.4	2.6	
T		515	3.0	5.8		
M		626	1.8	2.9		
17/ 7		H	587	2.2	3.7	0
		C	515	1.8	3.5	
		T	496	3.0	6.0	11.2
		M	913	1.8	2.0	
	H	626	2.1	3.4		
	C	450	2.4	5.3		
	3/ 9	T	385	1.2	3.1	10.8
		M	365	2.3	6.3	
		H	626	2.2	3.5	13.1
		C	496	2.1	4.2	
T		515	3.2	6.2		
M		385	2.7	7.0		
15/10		H	515	2.6	5.0	10.7
		C	515	2.3	4.5	
		T	515	2.3	4.5	10.7
		M	587	4.1	7.1	
	H	496	3.3	6.6		
	C	515	2.7	5.2		
	1976 10/ 2	T	567	2.4	4.2	50.9
		M	535	0.9	1.7	
		H	535	2.1	3.9	50.9
		C	463	2.2	4.8	
C		515	3.7	7.2		
T		496	1.9	3.8		
1976 10/ 2		M	515	3.1	6.0	2.3
		H	515	1.9	3.7	
		C	515	3.7	7.2	4.2
		C	758	1.40	1.8	
	T	516	1.45	2.8		
	M	516	1.75	3.4		
	1976 10/ 2	H	628	1.75	2.8	4.2
		C	692	1.45	2.1	
T		888	1.75	2.0	2.4	
M		602	1.45	2.4		
1976 10/ 2	H	516	1.70	3.4		

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³	
15/ 3	C	550	1.75	3.2	1.9	
	M	804	1.75	2.2		
	H	804	2.00	2.5		
	C	483	1.55	3.2	0	
	T	456	1.55	3.4		
	M	483	1.72	3.6		
	H	523	1.54	2.9		
	C	605	1.65	2.7	-0.2	
	T	483	1.65	3.4		
	M	483	1.67	3.4		
	H	605	1.54	2.5		
	C	563	1.58	2.8	6.5	
14/ 6	T	483	1.67	3.4		
	M	523	1.72	3.3		
	H	605	1.27	2.1		
	C	320	2.07	6.5		
	T	262	0.67	2.6		
	M	274	1.51	5.5		
	H	386	1.77	4.6		
	C	398	2.67	6.7		
	T	300	1.77	5.9		
	M	366	1.77	4.8		
	H	432	2.37	5.5		
	C	418	3.27	7.8		
28/ 7	T	366	1.47	4.0		
	M	294	1.72	5.8		
	H	366	2.37	6.5		
	C	464	2.02	4.4	4.2	
	C	464	1.40	3.0	4.2	
	C	464	2.00	4.3	1.9	
	T	432	1.70	3.9		
	M	516	1.72	3.3		
	H	536	2.02	3.8		
	C	496	1.80	3.6	8.4	
	T	464	1.40	3.0		
	17/ 8	M	450	1.40	3.1	
H		588	1.40	2.4		
C		536	2.30	4.3	15.0	
T		484	1.40	2.9		
M		484	1.40	2.9		
H		628	2.30	3.7		
C		536	1.40	2.6	13.1	
T		516	3.20	6.2		
M		496	2.60	5.2		
H		550	2.00	3.6		
20/ 9		C	484	2.32	4.8	4.7
		C	550	2.92	5.3	11.2
	C	496	2.87	5.8	20.0	

TABLE AHS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³	
12/10	C	516	1.84	3.6	46.6	
	C	516	1.88	3.6	44.3	
	C	536	1.60	3.0	46.6	
1977						
19/ 1	C	418	1.55	3.7	ND	
	T	418	1.25	3.0		
	M	386	1.40	3.6		
	H	432	2.05	4.7		
	C	432	1.70	3.9	ND	
	T	484	2.55	5.3		
	M	418	1.65	3.9		
	H	550	2.45	4.4		
	C	450	1.75	3.9	ND	
	T	418	1.45	3.5		
	M	464	1.45	3.1		
	H	484	1.48	3.1		
	21/ 2	C	602	1.92	3.2	ND
		T	640	2.05	3.2	
M		640	1.87	2.9		
H		758	2.05	2.7		
C		588	1.98	3.4	ND	
T		640	1.98	3.1		
M		550	1.98	3.6		
H		536	1.94	3.6		
C		758	2.22	2.8	ND	
T		640	1.98	3.1		
M		666	1.94	2.9		
H		588	2.22	3.8		
17/ 5		C	460	1.98	4.3	39.2
		C	460	2.14	4.6	36.9
	C	460	1.84	4.0	39.7	
6/ 6		520	1.51	2.9	4.7	
	T	480	1.64	3.4		
	M	510	1.64	3.2		
	H	540	1.71	3.2		
		520	1.64	3.2	4.2	
		800	1.64	2.0		
		520	1.64	3.2	2.3	
		800	1.61	2.0		
		480	1.64	3.4		
	4/ 7	C	450	1.67	3.7	11.2
C		560	1.87	3.3	8.9	
C		470	1.77	3.8	15.4	
T		450	1.77	3.9		
15/ 8	T	460	1.77	3.8		
	C	660	1.87	2.8	28.4	
	C	640	1.87	2.9	37.8	
	C	880	1.87	2.1	57.4	

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
MISSION LAKE					
1970					
8/10	T	1000	4.10	4.1	254
	H	800	2.19	2.7	103
	T	710	1.33	1.9	15
	B	700	1.42	2.0	12
1971					
21/ 1	T	950	1.65	1.7	ND
	H	790	1.33	1.7	-1
	T	780	1.40	1.8	ND
	H	790	1.40	1.8	ND
28/ 5	T	660	1.42	2.2	23.5
	B	700	1.76	2.5	22
	T	610	1.92	3.1	43.5
	H	640	1.82	2.8	15
1972					
19/ 5	T	75	1.50	20.0	
	T	121	0.90	7.4	
	T	91	0.60	6.6	
11/ 9	T	554	3.30	6.0	10.4
	M	554	2.25	4.1	
	H	766	3.27	4.3	
	T	864	2.17	2.5	
	H	603	2.15	3.6	
1973					
6/ 2	T	489	0.97	2.0	3.0
	M	522	2.17	4.2	3.0
	H	587	1.36	2.3	6.4
	T	522	1.31	2.5	3.0
	M	587	0.99	1.7	3.0
	H	652	0.74	1.1	5.2
	M	522	1.87	3.6	3.0
	H	424	1.55	3.6	3.0
28/ 6	T	750	2.72	3.6	
	H	734	2.19	3.0	
	T	548	1.82	3.3	
	M	734	2.12	2.9	
	B	734	2.40	3.3	
	T	685	1.62	2.4	
26/ 7	T	665	0.90	1.4	
	M	665	1.20	1.8	
	H	962	1.22	1.3	
		750	1.80	2.4	
22/ 8	M	665	2.81	4.2	
	T	626	3.05	4.9	
	H	626	2.45	3.9	
27/ 9	T	274	1.82	6.6	
	M	639	2.41	3.8	

TABLE ABS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	B	346	1.81	5.2	
	M	802	1.40	1.7	
1974					
21/ 1	T	685	1.19	1.7	
	M	603	1.49	2.5	
	B	652	1.26	1.9	
	T	603	1.49	2.5	
	B	652	1.49	2.3	
13/ 2	T	626	1.04	1.7	
	M	668	1.06	1.6	
	H	750	1.08	1.4	
	T	600	1.06	1.8	
	B	646	0.99	1.5	
19/ 3	T	620	1.79	2.9	
	M	685	3.65	5.3	
	H	734	1.88	2.6	
	T	668	1.79	2.7	
	B	685	1.75	2.6	
19/ 6	T	215	2.60	12.1	40
	M	258	1.70	6.6	42
	H	313	2.73	8.7	55
	T	241	2.02	8.4	37
	M	274	2.60	9.5	55
	B	209	2.30	11.0	46
15/ 7	C	225	2.07	9.2	34.6
	C	241	2.67	11.1	32.7
13/ 8	C	522	2.21	4.2	2.7
	C	548	1.97	3.6	14.9
17/ 9		515	1.20	2.3	88.8
		548	1.20	2.2	73.5
22/10	C	385	1.91	5.0	
	C	417	1.91	4.6	
13/11	C	346	2.0	5.8	20.4
	C	333	1.7	5.1	4.2
	T	346	2.3	6.6	8.4
1975					
23/ 1	C	293	1.4	4.8	
	C	300	0.78	2.6	
22/ 5	T	320	1.1	3.4	65.9
	M	359	1.1	3.1	
	B	261	1.8	6.9	
	C	287	1.8	6.3	37.9
	T	388	1.4	3.6	
	M	310	1.4	4.5	
	B	339	1.4	4.1	
	C	388	1.4	3.6	
24/ 6	C	320	1.9	6.0	2.3
	M	300	2.8	9.3	

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	H	365	2.2	6.0	
	C	293	1.4	4.8	2.3
	M	320	2.2	6.9	
	H	385	2.8	7.3	
17/ 7	C	1174	1.8	1.5	34.5
	T	365	1.5	4.1	
	M	398	1.9	4.8	
	B	1109	3.7	3.3	
	C	450	1.8	4.0	37.2
3/ 9	C	515	1.6	3.1	10.7
	T	515	1.9	3.7	
	M	496	1.6	3.2	
	B	496	1.9	3.8	
	C	333	2.2	6.6	10.7
16/10	C	430	5.2	12.1	57.4
	C	450	2.9	6.4	62.0
1976					
20/ 1	C	464	2.54	5.5	0
	T	432	2.81	6.5	
	M	418	2.81	6.7	
	H	432	2.84	6.6	
	C	536	2.54	4.7	4.2
10/ 2	C	482	1.40	2.9	2.3
	T	432	1.70	3.9	
	M	640	1.40	2.2	
	T	464	2.00	4.3	
	B	598	1.40	2.3	
16/ 3	C	450	2.74	6.1	0
	C	496	2.74	5.5	0
15/ 6	C	334	1.67	5.0	4.2
	C	450	1.40	3.1	1.9
	T	320	1.77	5.5	
	M	334	1.51	4.5	
	B	294	1.78	6.1	
29/ 7	C	550	2.11	3.8	4.2
	M	516	1.40	2.7	8.0
18/ 8	C	640	2.18	3.4	6.5
	M	692	2.07	3.0	34.1
22/ 9	C	550	2.00	13.1	3.6
	C	588	2.30	8.9	
		578	2.00	8.9	3.5
13/10	C	496	1.88	3.8	26.6
	C	484	1.88	3.9	21.9
21/12	C	334	1.14	3.4	1.9
	T	366	1.04	2.8	
	M	334	1.04	3.1	
	B	386	1.54	4.0	
	M	334	1.04	3.1	1.9

TABLE ABS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
1977					
17/ 1	C	346	1.04	3.0	2.3
	T	418	1.08	2.6	
	M	386	0.98	2.5	
	R	366	1.47	4.0	
	C	432	1.17	2.7	ND
18/ 2	C	432	1.68	3.9	ND
	T	666	1.78	2.7	
	M	516	1.68	3.3	
	H	496	1.68	4.4	
	M	516	1.98	3.8	ND
18/ 5	C	350	1.45	4.1	19.6
	C	330	1.37	4.2	23.8
7/ 6		490	1.20	2.4	11.9
		440	1.30	3.0	
		450	1.20	2.7	
5/ 7	C	650	1.52	2.3	16.9
		650	1.52	2.3	14.0
	T	620	1.80	2.9	
16/ 8	C	900	1.50	1.7	6.6
	C	870	2.20	2.5	40.5

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
KATEPWA LAKE					
1970					
5/10	T	700	2.08	3.0	23
	B	700	1.98	2.8	15.5
	T	710	2.29	3.2	33
	H	710	2.19	3.1	21
	T	720	2.11	2.9	26.5
	B	700	2.07	2.9	13.5
	T	710	2.07	2.9	30.5
	B	700	1.97	2.8	16
	T	700	1.70	2.4	35
	H	710	1.66	2.3	22.5
1971					
24/ 1	T	880	1.85	2.1	19
	B	850	1.77	2.1	ND
	T	840	1.91	2.3	ND
	H	810	1.66	2.0	ND
	T	830	1.70	2.0	ND
	B	790	1.70	2.2	ND
	T	790	1.82	2.3	ND
	B	760	1.63	2.1	ND
	T	760	1.82	2.4	ND
	B	800	1.95	2.4	ND
4/ 6	T	910			23
	B	1890	2.23	1.2	18.5
	T	790	2.25	2.8	5.5
	B	780	2.89	3.7	8.5
	T	630	2.24	3.6	4
	B	2140	2.67	1.2	6
	T	1240	2.77	2.2	14
	B	600	2.97	5.0	7
	T	760	3.14	4.1	4
	B	1380	2.21	1.6	8
1972					
19/ 5	T	121	0.90	7.4	
	T	68	0.90	13.2	
	T	150	0.90	6.0	
	T	130	0.90	9.2	
28/ 8	T	489	4.09	8.4	188.9
8/ 9	T	652	2.97	3.0	
2/10	M	554	1.29	2.3	25.2
	B	408	1.57	3.8	16.8
	T	522	1.31	2.5	29.9
	M	554	1.61	2.9	16.8
	B	489	1.59	3.2	16.8
	T	554	3.55	6.4	20.6
	M	342	2.17	6.3	13.1
	B	342	1.57	4.6	16.8

TABLE AHS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
1973					
7/ 2	T	424	1.15	2.7	3.0
	M	424	1.45	3.4	3.0
	B	424	2.8	6.6	4.5
	T	391	1.15	2.9	3.0
	M	489	1.47	3.0	3.0
	B	424	1.43	3.4	3.0
28/ 6	T	398	1.82	4.6	
	M	346	1.85	5.3	
	B	417	1.62	3.9	
	T	150	2.12	14.1	
	M	463	2.40	5.2	
	B	463	2.42	5.2	
	T	365	1.62	4.4	
	M	385	1.37	3.6	
	B	567	1.32	2.3	
26/ 7	T	515	0.90	1.7	
	M	515	0.60	1.2	
	B	587	0.90	1.5	
	T	515	1.50	2.9	
	M	483	1.50	3.1	
	B	515	1.20	2.3	
	T	483	1.80	3.7	
	M	515	1.20	2.3	
	B	548	1.28	2.3	
22/ 8	T	417	2.70	6.5	
	M	450	2.12	4.7	
	B	450	1.87	4.2	
	T	333	1.80	5.4	
	M	333	1.82	5.6	
	B	326	1.82	5.5	
	T	333	1.80	5.4	
	M	346	1.22	3.5	
	B	385	1.52	3.9	
27/ 9	T	463	1.47	3.2	
	M	430	1.40	3.2	
	B	483	4.67	9.7	
	T	430	4.30	10.0	
	M	535	2.00	3.7	
	B	430	1.40	3.2	
	T	450	2.30	5.1	
	M	430	1.11	2.6	
	B	450	1.40	3.1	
1974					
21/ 1	T	424	1.46	3.4	
	M	408	1.46	3.6	
	B	424	1.15	2.7	
	T	424	1.35	3.2	

TABLE AHS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	M	603	1.42	2.4	
	B	489	1.35	2.8	
	T	375	1.15	3.1	
	M	473	1.33	2.8	
	B	408	1.17	2.9	
13/ 2	T	417	1.19	2.8	
	M	417	1.24	3.0	
	B	470	1.19	2.5	
	T	515	1.22	2.4	
	M	430	1.26	2.9	
	B	483	1.24	2.6	
19/ 3	T	440	1.61	3.6	
	M	417	1.61	3.9	
	B	430	1.61	3.7	
19/ 6	T	274	2.30	8.4	
	M	333	1.77	5.3	
	B	378	5.53	14.6	
	T	320	1.70	5.3	
	M	320	2.11	6.6	
	B	274	2.41	8.8	
	T	258	2.30	8.9	
	M	320	2.37	7.4	
	B	320	2.71	8.5	
16/ 7	C	346	6.20	17.9	419.9
	C	232	4.50	19.5	108.5
	C	215	1.70	7.9	16.6
15/ 8		603	2.01	3.3	15.4
		685	2.67	3.9	22.6
		538	2.90	5.4	36.6
17/ 9		587	1.59	2.7	34.2
		600	1.61	2.7	43.4
		600	2.21	3.7	56.2
22/10	C	483	1.31	2.7	
	C	522	1.31	2.5	
	C	489	0.41	8.4	
13/11	C	535	1.94	3.6	8.2
	C	496	1.61	3.2	14.9
	C	548	1.91	3.5	9.4
	T	385	1.12	2.6	8.4
1975					
23/ 1	C	398	1.08	2.7	3.1
	C	398	1.38	3.5	1.6
5/ 3	C	450	1.1	2.4	
	C	450	1.1	2.4	
22/ 5	T	447	1.2	2.7	38.5
	M	388	1.1	2.8	
	B	479	1.4	2.7	
	C	417	0.9	2.2	33.3

TABLE AB5 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	T	499	1.4	2.8	32.7
	M	606	1.4	2.3	
	H	479	2.1	4.4	
	C	538	1.1	2.0	24.5
	T	600	1.1	1.8	
	M	587	1.1	1.9	
	B	639	0.9	1.4	
	C	600	1.1	1.8	
24/ 6	C	293	2.2	7.5	0
	M	293	3.9	13.3	
	H	483	3.9	8.1	
	C	326	2.5	7.7	2.3
	M	293	1.4	4.8	
	B	365	1.1	3.0	
	C	365	2.8	7.7	4.2
	M	320	2.2	6.9	
	B	385	2.5	6.5	
17/ 7	C	730	1.9	2.6	7.0
	T	1300	1.8	13.8	
	M	1110	1.8	1.6	
	B	717	2.3	3.2	
	C	1300	2.0	1.5	43.4
	T	913	2.7	3.0	0
	M	2220	2.3	1.0	
	B	2090	3.3	1.6	
	C	887	2.2	2.5	4.7
	T	548	3.0	5.5	
	M	450	1.7	3.8	
	B	535	1.7	3.2	
3/ 9	C	365	2.2	6.0	10.7
	T	333	1.5	4.5	17.3
	M	346	2.2	6.4	
	B	417	1.5	3.6	
	C	463	2.4	5.2	21.5
	T	333	0.9	2.7	6.5
	M	398	0.9	2.3	
	B	639	7.1	11.1	
	C	378	2.6	6.9	8.9
	T	346	2.8	8.1	10.7
	M	320	1.5	4.7	
	B	385	1.4	3.6	
16/10	C	430	6.9	16.0	11.2
	C	483	7.8	16.1	37.4
	C	417	3.0	7.2	15.4
1976					
10/ 2	C	464	1.04	2.2	2.3
	T	602	1.04	1.7	
	M	398	1.04	2.6	
	B	536	1.04	1.9	

TABLE AHS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
16/ 3	C	432	1.04	2.4	2.3
	T	432	1.38	3.2	
	M	398	1.34	3.4	
	B	916	1.34	1.5	
	C	1420	3.48	2.4	0
	T	464	4.34	9.4	
	M	464	2.84	6.1	
	H	450	2.88	6.4	
	C	496	2.88	5.8	
	T	568	2.24	3.9	
15/ 6	B	496	2.26	4.6	2.3
	C	450	2.00	4.4	
	C	366	1.47	4.0	
	T	300	0.97	3.2	
	M	300	1.21	4.0	
	H	334	1.85	5.5	
	C	418	1.51	3.6	
	T	320	0.97	3.0	
	M	274	1.17	4.3	
	H	262	1.30	5.0	
28/ 7	C	418	1.51	3.6	4.6
	T	300	0.97	3.2	
	M	236	0.95	4.0	1.9
	B	242	2.14	8.8	
	C	464	1.47	3.2	
	T	418	2.37	5.7	
	M	536	1.54	2.9	
	H	568	1.77	3.1	
	C	496	2.11	4.2	
	T	732	1.72	2.3	
M	464	1.51	3.2		
B	784	3.67	4.7		
18/ 8	C	450	1.47	3.3	3.8
	C	602	2.37	3.9	
	T	602	2.37	3.9	6.5
	M	568	1.81	3.2	
	H	692	2.11	3.0	
	C	550	2.07	3.8	
	T	536	2.07	3.9	
	M	640	1.81	2.8	
	H	718	1.77	2.5	
	C	568	1.51	2.6	
T	496	2.37	4.8		
M	602	2.37	3.9		
22/ 9	H	836	2.37	2.8	4.2
	C	536	2.30	4.3	
	C	536	3.80	7.1	
	C	536	3.50	6.5	

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³	
13/10	C	484	2.74	5.7	11.2	
	C	516	2.14	4.1	7.0	
	C	516	2.48	4.8	6.6	
21/12	C	366	1.28	3.5	21.9	
	C	464	1.18	2.5	13.0	
1977						
17/ 1	C	386	1.25	3.2	ND	
	T	346	1.31	3.8		
	M	568	1.15	2.0		
	H	346	1.54	4.4		
	C	450	1.00	2.2	ND	
	T	550	1.20	2.2		
	M	398	1.20	3.0		
	H	588	1.15	2.0		
	C	398	1.12	2.8	ND	
	T	398	1.27	3.2		
	M	568	5.65	9.9		
	H	232	1.35	5.8		
	1/ 3	C	568	1.25	2.2	ND
		T	628	1.22	1.9	
M		666	1.25	1.9		
H		568	1.27	2.2		
C		588	1.32	2.2	ND	
T		862	1.47	1.7		
M		536	1.22	2.3		
H		484	1.32	2.7		
2/ 3	C	433	1.32	3.0	ND	
	T	483	1.24	2.6		
	M	580	1.24	2.1		
	H	453	1.34	3.0		
18/ 5	C	410	1.27	3.1	24.3	
	C	430	1.07	2.5	23.8	
	C	500	1.31	2.2	26.1	
7/ 6		600	1.30	2.2	2.9	
		480	1.10	2.3		
		480	1.20	2.5	4.2	
		490	1.50	3.1	4.2	
		450	1.27	2.8	11.6	
5/ 7	C	490	1.51	3.1	14.0	
	C	510	1.57	3.1	11.1	
	T	460	1.42	3.1		
	T	440	1.42	3.2		
	T	530	1.42	2.7		
	T	530	1.42	2.7		
16/ 8	C	1000	1.32	1.3	15.0	
	T	500	1.32	2.6		
	C	600	1.52	2.5	10.8	
	T	540	1.52	2.8		
	C	580	1.52	2.6	ND	
	T	570	1.42	2.4		

TABLE AHS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
CROOKED LAKE					
1970					
30/ 9	T	480	1.43	3.0	18.5
	B	490	1.66	3.4	23
	T	420	1.39	3.3	ND
	B	330	1.29	3.9	ND
	T	400	1.58	4.0	15
	B	410	1.34	3.3	5.5
1971					
17/ 2	T	650	1.96	3.0	2
	B	640	1.95	3.0	1
	T	620	1.69	2.7	ND
	B	430	1.80	4.2	0
	T	610	1.78	2.9	ND
	B	420	2.79	6.6	0
4/ 6	T	280	1.98	7.1	ND
	B	350	1.75	5.0	ND
	T	300	1.60	5.3	ND
	B	360	1.73	4.8	ND
	T	260	1.73	6.6	ND
	B	550	1.50	2.7	ND
1972					
29/ 8	T	160	2.45	15.3	29.0
	B	241	2.22	9.2	23.4
12/ 9	T	267	1.85	6.9	3.8
	M	241	1.57	6.5	40.2
	B	192	1.87	9.7	8.4
	T	456	2.19	4.8	8.4
	M	424	1.22	2.9	
	B	232	1.27	5.5	
1973					
21/ 2	T	147	0.71	4.8	4.5
	M	121	1.04	8.6	4.5
	B	75	1.47	19.6	4.5
	T	173	1.76	10.2	4.5
	M	150	2.94	19.6	4.5
	B	160	1.08	6.8	4.5
17/ 7	T	258	1.22	4.7	
	B	111	0.97	8.7	
	T	293	1.50	5.1	
	M	75	1.90	25.3	
	B	68	1.20	17.6	
	T	82	2.10	25.6	
	B	147	1.90	12.9	
8/ 8	T	166	0.30	1.8	
	M	150	0.60	4.0	
	B	515	0.67	1.3	
	T	147	0.90	6.1	

TABLE ABS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³	
19/ 9	M	137	0.39	2.8		
	H	548	0.90	1.6		
	T	137	0.60	4.4		
	M	117	0.60	5.1		
	H	293	0.62	2.1		
	T	91	1.47	16.2		
	M	75	1.12	14.9		
	H	300	0.62	2.1		
	T	320	0.92	2.9		
	M	300	1.12	3.7		
23/10	H	300	1.12	3.7		
	T	85	1.40	16.5		
	M	75	1.10	14.7		
	B	104	1.40	13.5		
	T	137	1.10	8.0		
	M	130	1.12	8.6		
	B	111	1.42	12.8		
	T	104	0.97	9.3		
	M	232	1.12	4.8		
	H	111	1.12	10.1		
1974 20/ 2	T	36	1.29	35.8		
	M	42	1.29	30.7		
	H	42	1.04	24.8		
	T	42	1.04	22.4		
	M	33	1.04	28.5		
	H	241	1.64	6.8		
	T	23	0.90	39.1		
	M	49	0.92	18.8		
	B	42	0.64	15.2		
	T	68	1.29	19.0		
20/ 3	M	75	1.61	21.5		
	B	85	1.68	19.8		
	T	85	1.29	15.2		
	M	85	1.38	16.2		
	B	160	1.70	10.6		
	T	346	3.70	10.7	13	
	M	274	2.35	8.6	4.6	
	B	300	2.30	7.7	6.5	
	T	346	2.80	8.1		
	M	320	2.60	8.1	4.6	
24/ 6	B	117	3.40	29.0	6.9	
	T	241	1.70	7.0	4.1	
	M	241	0.90	3.7	4.1	
	B	209	1.77	8.5	5.8	
	22/ 7		160	2.32	14.5	11.3
			111	2.80	25.2	22.6
			160	4.50	28.1	194.1

TABLE ABS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³	
20/ 8	C	300	2.71	9.0	19.4	
	C	284	2.95	10.4	1.9	
	C	300	3.50	11.7	25.4	
23/ 9		450	2.47	5.5	18.5	
		548	2.90	5.3	25.8	
		483	3.80	7.9	12.8	
5/11	C	166	1.50	9.0	20.7	
	C	111	1.80	16.2	25.7	
	C	104	2.10	20.2	14.0	
1975						
11/ 4	C	183	2.0	10.9	2.2	
	C	192	1.7	8.8	4.4	
	C	147	2.0	13.6	3.6	
10/ 6	C	196	2.2	11.2	4.7	
	T	98	1.9	19.4	8.9	
	M	72	1.4	19.4	0	
	H	117	1.7	14.5	4.7	
	C	170	2.5	14.7	2.3	
	T	65	2.8	43.1	19.6	
	M	65	1.4	21.5	17.3	
	H	65	1.4	21.5	ND	
	C	170	1.9	11.2	21.9	
	T	65	3.0	46.1	13.5	
	H	65	2.5	38.5	17.7	
	6/ 8	C	483	4.7	24.3	8.1
C		548	3.2	5.8	27.9	
T		587	4.0	6.8	9.3	
M		515	7.0	13.6		
H		691	5.3	7.7		
C		515	4.4	8.5	7.0	
T		450	4.6	10.2	49.9	
M		535	2.2	4.1		
H		626	2.0	3.2		
20/10		C	274	3.0	10.9	7.0
		C	261	3.0	11.5	4.7
		C	320	3.0	9.4	7.0
1976						
27/ 1	C	300	1.10	3.7	ND	
	C	294	1.10	3.7	2.3	
	T	294	1.10	3.7		
	M	262	1.10	4.2		
	H	294	1.10	3.7		
	C	236	1.08	4.6	2.3	
	T	262	1.08	4.1		
	M	242	1.10	4.5		
	H	432	1.10	2.5		
	10/ 3	C	346	1.54	4.4	ND
T		334	1.54	4.6		

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
	M	386	1.54	4.0	
	H	300	1.54	5.1	
	C	320	1.54	4.8	ND
	T	300	1.24	4.1	
	M	274	4.27	15.6	
	B	300	4.54	15.1	
	C	294	3.37	11.5	ND
	T	464	1.27	2.7	
	M	236	1.57	6.6	
	B	242	1.34	5.5	
16/ 6	C	294	2.14	7.3	14.8
	C	242	1.47	6.1	
	T	236	1.40	5.9	
	M	236	1.27	5.4	
	B	262	2.14	8.2	
	C	236	2.35	10.0	7.8
	T	236	1.40	5.9	
	M	236	1.15	4.9	
	B	262	1.21	4.6	
21/ 9	C	398	5.20	13.1	28.5
	C	398	1.40	3.5	21.9
	C	450	2.30	5.1	17.7
	T	418	1.70	4.1	
	M	418	2.00	4.8	
	H	432	1.70	3.9	
1977					
18/ 1	C	346	0.94	2.7	ND
	M	300	1.11	3.7	ND
	C	262	1.22	4.6	ND
15/ 3		536	2.09	3.9	ND
		568	1.77	3.1	ND
	C	602	1.67	2.8	ND
8/ 6		380	0.90	2.4	6.5
		370	1.20	3.2	6.5
		380	0.90	2.4	8.9
17/ 8	C	760	1.35	1.8	10.7
	C	730	1.74	2.4	17.3
	C	770	1.95	2.5	50.8

TABLE A85 CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
ROUND LAKE					
1970					
30/ 9	T	270	1.28	4.7	1.5
	B	260	2.15	8.3	10
	T	280	1.23	4.4	2
	B	240	1.33	5.5	ND
1971					
17/ 2	T	540	1.91	3.5	ND
	B	600	1.59	2.6	2
	T	560	1.60	2.8	ND
	B	570	1.68	2.9	0
14/ 6	T	370	1.47	4.0	ND
	B	350	1.64	4.7	ND
	T	340	1.88	5.5	ND
	B	220	1.23	5.6	ND
1972					
12/ 9	T	91	2.17	23.8	
	M	121	2.10	17.4	
	B	121	0.65	5.4	
	T	111	1.20	10.8	
	M	121	1.25	10.3	
	B	150	1.50	10.0	
1973					
21/ 2	T	98	2.27	23.2	
	M	85	0.62	7.3	
	B	85	0.44	5.2	
	T	111	1.92	17.3	
	M	85	0.99	11.5	
	B	91	3.98	43.7	
8/ 8	T	75	1.80	24.0	
	M	65	0.60	9.2	
	B	75	0.90	12.0	
	T	104	1.82	17.3	
	M	42	0.60	14.3	
	B	98	0.90	9.2	
19/ 9	T	91	0.99	10.9	
	M	36	0.99	27.5	
	B	52	0.97	18.6	
	T	52	1.42	27.3	
	M	42	1.15	27.4	
	B	42	1.17	27.8	
23/10	T	68	0.92	13.5	
	M	75	0.95	12.7	
	B	65	0.92	14.2	
	T	75	0.95	12.7	
	M	68	2.65	39.0	
	B	85	1.45	17.1	

TABLE A85 CONT'D

DATE	SAMPLF DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
1974					
20/ 3	T	147	1.89	12.8	
	M	65	1.55	23.8	
	B	65	1.68	25.8	
	T	121	1.27	10.5	
	M	49	1.25	25.5	
	B	85	1.31	15.4	
24/ 6	T	91	2.80	30.8	12.8
	M	68	2.80	41.2	
	B	75	2.35	31.3	7.9
	T	91	2.80	30.8	4.2
	M	85	3.40	40.0	4.1
22/ 7		82	2.30	28.0	4.6
		68	2.30	33.8	9.0
20/ 8	C	225	2.21	9.8	27.9
	C	199	2.17	10.9	8.0
23/ 9	C	398	3.80	9.5	34.0
	C	398	1.80	4.5	39.0
5/11	C	98	2.1	21.4	11.7
	C	121	0.9	7.4	12.3
1975					
2/ 7	C	554	1.9	3.4	4.2
	M	496	1.4	2.8	
	B	463	1.1	2.4	
	C	385	1.1	2.8	2.3
	M	417	1.1	2.6	
	B	665	1.1	1.6	
6/ 8	C	483	2.1	4.3	14.9
	C	567	3.6	6.3	ND
20/10	C	300	4.8	16.0	4.7
	C	320	2.7	8.4	4.7
1976					
27/ 1	C	320	1.10	3.4	0.0
	T	274	1.10	4.0	
	M	294	1.10	3.7	
	B	300	1.10	3.7	
	C	294	1.10	3.7	0.0
	T	274	1.10	4.0	
	M	320	1.10	3.4	
	B	300	1.10	3.7	
10/ 3	C	398	1.84	4.6	ND
	T	450	1.52	3.4	
	M	300	1.22	4.1	
	B	300	1.28	4.3	
	C	294	1.24	4.2	2.3
	T	294	1.24	4.2	
	M	366	1.24	3.4	
	B	294	1.24	4.2	

TABLE ABS CONT'D

DATE	SAMPLE DEPTH	P mg/m ³	N mg/l	N:P	Chl a mg/m ³
16/ 6	C	196	1.45	7.4	1.9
	T	236	0.92	3.9	
	M	196	1.15	5.9	
	H	210	0.95	4.5	
	C	274	1.17	4.3	
21/ 9	C	334	2.00	6.0	15.4
	C	320	3.20	10.0	19.6
1977					
15/ 3		432	1.58	3.6	2.3
		450	1.55	3.4	2.3
18/ 6		310	1.15	3.7	6.6
		300	1.00	3.3	
		310	1.05	3.4	
		440	1.27	2.9	
17/ 8		440	1.27	2.9	1.9
	C	430	1.30	3.0	8.4

* DENOTES CONCENTRATION VALUES WHICH HAVE BEEN CORRECTED
 ND MEANS NONE DETECTED
 C MEANS COMPOSITE
 T MEANS TOP
 M MEANS MIDDLE
 B MEANS BOTTOM

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