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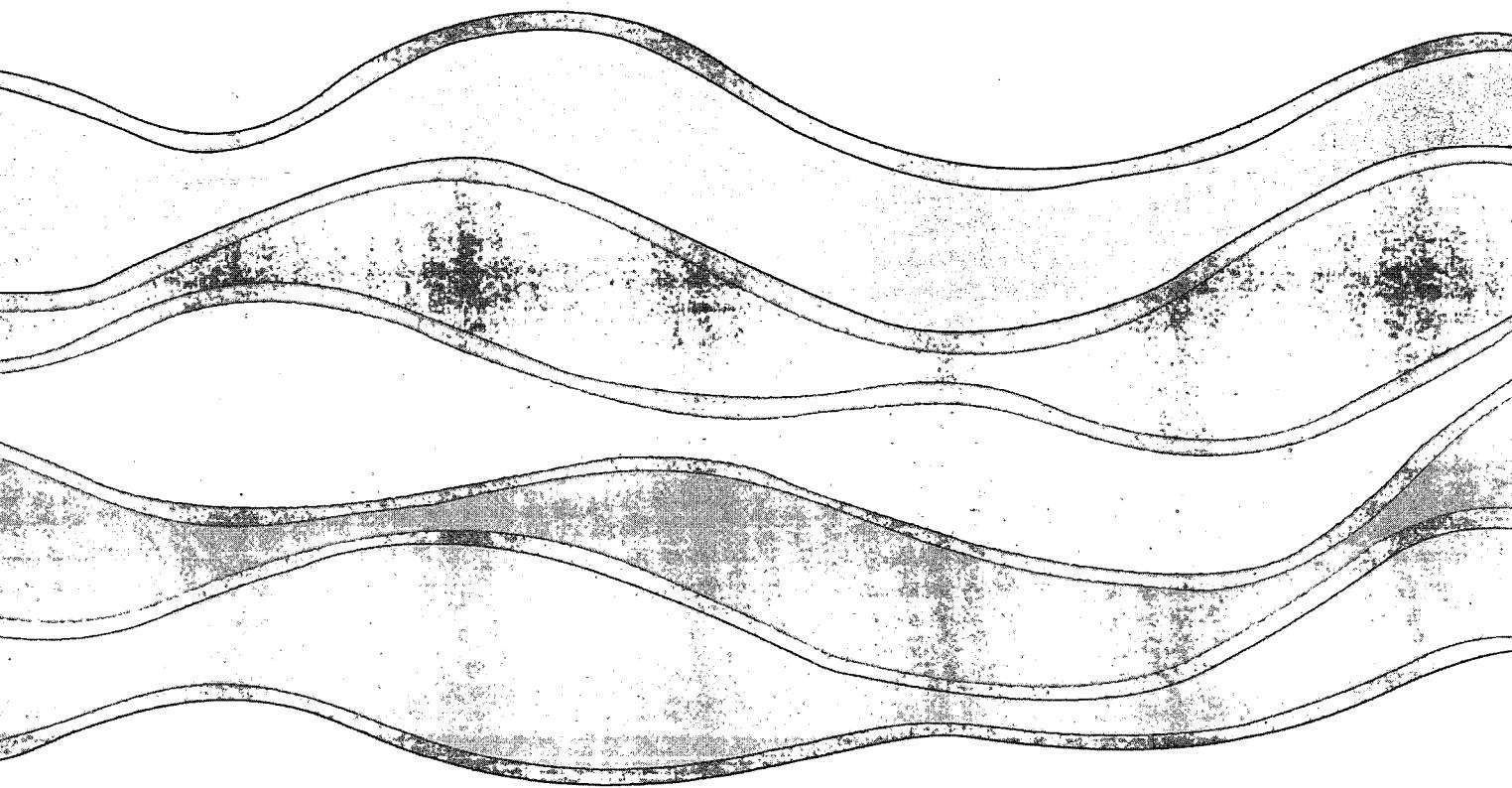
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NUTRIENT FLUXES ACROSS THE
SEDIMENT-WATER INTERFACE OF
PENETANG BAY, SEVERN SOUND

C. Vieira and F. Rosa

NWRI Contribution No. 92-63

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**NUTRIENT FLUXES ACROSS THE SEDIMENT-WATER INTERFACE OF
PENETANG BAY, SEVERN SOUND**

C. Vieira and F. Rosa

**Lakes Research Branch
National Water Research Institute
Burlington, Ontario L7R 4A6**

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MANAGEMENT PERSPECTIVE

This report on the role of bottom sediments as sources of phosphorus and nitrogen in Penetang Bay was prepared for the Severn Sound Remedial Action Plan. Penetang Bay is one of four areas in Severn Sound, in the south-eastern portion of Georgian Bay, Ontario which has been most affected by nutrient inputs from STP's. In order to determine the factors involved in remediating the eutrophication of this Bay, an internal nutrient loading estimate was required. The goal of this study was to obtain an internal loading estimate of soluble reactive phosphorus for the Bay, and to evaluate whether an oxygen depletion problem was noted during the transient summer stratification period, or under ice cover in the winter.

The results of this study show that the sediments are a source of phosphorus and are contributing approximately 31% of the total phosphorus load to the water column. The concentration of dissolved oxygen in the bottom waters remained above 3.0 mg/L over the study period. Anoxic conditions were never encountered, and thus an oxygen depletion problem is not apparent in Penetang Bay.

SOMMAIRE À L'INTENTION DE LA DIRECTION

Le présent rapport sur le rôle des sédiments de fond comme sources de phosphore et d'azote dans la baie Penetang a été préparé pour le Plan d'assainissement du Severn Sound. La baie Penetang est un des quatre secteurs du Severn Sound, dans la partie sud-est de la baie Georgienne, en Ontario, qui a été le plus touché par des apports de matières nutritives de l'usine de traitement des eaux usées. Afin de déterminer les facteurs en jeu en vue de corriger l'eutrophisation de cette baie, la charge interne de substances nutritives devait être évaluée. La présente étude visait à obtenir une estimation de la charge interne de phosphore réactif soluble dans les eaux de la Baie, et à déterminer s'il existait un problème d'épuisement d'oxygène pendant la période de stratification estivale transitoire, ou sous la glace en hiver.

Les résultats de la présente étude montrent que les sédiments sont une source de phosphore et fournissent environ 31 % du phosphore total à la colonne d'eau. La concentration d'oxygène dissous dans les eaux de fond demeurait supérieure à 3,0 mg/L au cours de la période de à l'étude. On n'a jamais relevé de conditions d'anoxie, et par conséquent il n'est pas évident qu'il existe un problème d'épuisement d'oxygène dans la baie Penetang.

ABSTRACT

Nutrient fluxes across the sediment water interface were measured at two sites in Penetang Bay and at one control site using dialysis chambers (peepers). Penetang Bay is located in Severn Sound, in the south-eastern portion of Georgian Bay, Lake Huron, Ontario. Use of the most representative ammonia and soluble reactive phosphorus data yielded a conservative estimate of the internal loading of these nutrients. The sediments of Penetang Bay act as a source of nutrients to the overlying water. Thus molecular diffusion is responsible for an internal load of 751 and 3078 kg/yr for SRP and NH₃, respectively. External inputs (1663 kg/yr) contribute the remainder of the phosphorus load to the bay. The internal load of SRP represents 31% of the total loading to Penetang Bay. These results are further supported by an examination of the water chemistry data for the Bay and surrounding area, which showed that soluble reactive phosphorus, total phosphorus, and ammonia have consistently higher concentrations near the surface waters, rather than in the bottom waters, as would be expected if the internal loads were the major contributing factor. Oxygen depletion was not noted in the water column to any great extent, though a decrease was noted at Station P2 during a brief period in the summer.

RÉSUMÉ

Des échanges de substances nutritives au niveau de l'interface sédiment eau ont été mesurés à deux endroits dans la baie Penetang et à un endroit témoin au moyen de cellules de dialyse. La baie Penetang est située dans le Severn Sound, dans le secteur sud-est de la baie Georgienne, dans le lac Huron (Ontario). L'utilisation des données les plus caractéristiques sur l'ammoniac et le phosphore réactif soluble a permis une estimation prudente de la charge interne de ces matières nutritives. Les sédiments de la baie Penetang agissent comme sources de matières nutritives pour la couche d'eau supérieure. La diffusion moléculaire est donc responsable d'une charge interne de phosphore réactif soluble et de NH_3 , respectivement de 751 et de 3 078 kg par année. Des apports externes (1 663 kg/année) fournit le reste de la charge de phosphore dans la baie. La charge interne de phosphore réactif soluble représente 31 % de la charge totale dans la baie Penetang. Ces résultats sont appuyés en outre par un examen des propriétés chimiques de l'eau de la baie et de la région avoisinante, qui a montré que les concentrations de phosphore réactif soluble, de phosphore total, et d'ammoniac sont uniformément plus élevées près des eaux superficielles que dans les eaux du fond, comme on s'y attendrait si les charges internes étaient le principal facteur responsable. On n'a pas signalé d'épuisement d'oxygène de grande importance dans la colonne d'eau, bien qu'une diminution ait été observée à la station P2 pendant une brève période en été.

INTRODUCTION

Penetang Bay is located in Severn Sound, in the south-eastern portion of Georgian Bay, Ontario. The area has been designated by the International Joint Commission as an Area of Concern within the Great Lakes System. The Bay shows evidence of noticeably impaired water quality, having a significant algae problem, declining fish populations and elevated concentrations of nutrients. In view of this, a Remedial Action Plan (RAP) has been implemented for the area.

The RAP Committee, in the process of information gathering, defined areas where further research would help make an accurate environmental assessment to achieve their goal of having swimmable waters virtually everywhere in the Sound. In calculating a nutrient budget for the area, it was noted that an internal loading estimate was required in order to later establish appropriate loading requirements from controllable sources, as well as determining whether an oxygen depletion occurred during summer stratification or under ice in winter, and whether it contributed to eutrophication of the Bay. Minimizing these sources would lead to the control of nuisance algal growth, ameliorate fish rehabilitation, and improve recreational usage of the area.

Penetang Bay receives inputs from two Water Pollution Control Plants (WPCPs). In order to provide an estimate of the internal loads, sites in Penetang Bay were selected. Interstitial (pore) water samplers (dialysis chambers or peepers) were used to measure sediment pore water profiles over a one year study period - from June 1988 to August 1989. Water quality data for lake water were also collected from various sites in the Sound. Peepers were deployed at two locations in Penetang Bay and at a reference station off the south-east shores of Beausoleil Island. Samples were collected in the summer of 1988 and in the winter and summer of 1989. A third site at a northerly point (P3) in the Bay was sampled in July 1988 and August 1989. These peepers (P3) were tampered with and dislodged in 1988,

and the surface marker buoy was removed by boaters in 1989 so that the data for this site were lost for both years.

METHODS

Figure 1 and Figure 2 show collection sites for Water Quality data and pore water data, respectively.

The methods used for peeper assembly, deployment and retrieval are described in Rosa *et al.* (1992). The single and double peeper used (Figure 3), have a 1-cm resolution and were constructed after Hesslein (1976). Samples syringed from the double peelers were combined for adjacent cells and analyzed as one sample. Single peeper samples were syringed and analyzed individually. During deployment, the peelers were inserted so that between 20-25 cells remained above the sediment water interface, and the remaining 34-50 cells were below sediment interface, as visually observed by the divers. All peelers were allowed to equilibrate in the sediments for a period of two weeks. For winter, peeper retrieval was modified in the following way: upon removal from the sediment, peelers were wrapped in Saran wrap to minimize exposure to air and stored in a N₂-purged chamber until they were sampled approximately 4 hours later for Station P2, and 3 hours later for Station P1. The water samples froze thoroughly after removal from the water (air temperatures were -30°F). They were kept frozen, and subsequently thawed at room temperature, and placed in an N₂ - purged chamber while samples were syringed from the peelers. Samples were diluted using an automatic diluter and phosphorus-free double distilled water as the dilutant. They were later analyzed by the National Water Quality Laboratory (NWQL) at the National Water Research Institute (NWRI) using an autoanalyzer and following standard analytical methods, according to the Analytical Methods Manual (1974).

Routine surveillance cruises (10) were also carried out. One litre of water was collected from discrete depths (bottom minus 1 m, mid-depth or at 5 m intervals, and 1m below the surface). Samples were kept in a cooler on ice and filtered within 24 hours for nutrient analysis and chlorophyll a. Total phosphorus samples were left unfiltered and preserved with 1 ml of 30% H₂SO₄/100 ml of sample. An electronic bathythermograph was used for temperature determinations. pH was measured using a digital Orion meter, and dissolved oxygen (DO) using a YSI Orion meter. In the summer the DO meter was calibrated against titrated samples using the Winkler technique. In the winter, dissolved oxygen was measured using the Winkler technique in order to minimize effects of extreme cold temperature on probe performance.

The method used for calculating flux rates are based on Fick's law of diffusion as described in Carignan and Rosa (1990). The following is the equation selected in calculating flux rates for this report:

$$J = -P \times D_t \times \frac{dc}{dx} \quad (1)$$

where D_t = the apparent diffusion random mixing coefficient which takes into account molecular diffusion, bioturbation, wave action, benthic activities in the sediment and other random mixing mechanisms; $D_t = 9.8 (\pm 2.0) \times 10^{-6} \text{ cm}^2/\text{s}$ for NH₃ and $D_t = 3.6 (\pm 1.1) \times 10^{-6} \text{ cm}^2/\text{s}$ for SRP (Krom and Berner, 1980)

P = porosity = .90 (estimated porosity; Carignan and Rosa, 1992) and $\frac{dc}{dx}$ = observed concentration gradient a few cm below the sediment-water interface (see below).

RESULTS

The results from the surveillance cruises are summarized in Appendix 1. Data for ammonia, nitrite, nitrate + nitrite, soluble reactive phosphorus, total phosphorus, pH, temperature, dissolved oxygen and chlorophyll *a* are summarized in table format.

Pore water profiles for Stations B1, P1 and P2 are shown graphically in Figures 4a, 4b, 4c and 4d for ammonia and soluble reactive phosphorus, respectively. The sediment-water interface reported by divers (visual inspection of the divers upon retrieval) corresponded to the ferric-hydroxide staining on the dialysis paper. This observation confirmed the locations used in selecting where the actual interface or depth zero (see pore water profiles - Fig. 4). A summary of the concentration gradients derived from these graphs are provided in Table 1 along with a statistical analysis comparing regressions performed on the concentration gradients using both 7 and 11 data points.

Using the concentration gradient from Table 1, the method for flux calculation, using Equation 1, for Station B1A is shown below:



$$\begin{aligned} J &= -.90 \times (9.8 \times 10^{-6} \text{ cm}^2/\text{s}) \times .0888 \text{ ug/cm}^3 \cdot \text{cm} \\ &= -.782 \times 10^{-6} \text{ ug/cm}^2 \cdot \text{s} \end{aligned}$$



$$\begin{aligned} J &= -.90 \times (3.6 \times 10^{-6} \text{ cm}^2/\text{s}) \times .0889 \text{ ug/cm}^3 \cdot \text{cm} \\ &= -2.88 \times 10^{-7} \text{ ug/cm}^2 \cdot \text{s} \end{aligned}$$

The results of the remaining flux calculations for other peepers were also performed as shown above, and are reported in Table 2.

Where replicate measurements were available, the flux for ammonia and SRP replicates were averaged for the n=7 data set. For Station P2, winter SRP, the average was taken for the n=11 data since these were more statistically significant (see Table 1). The NH₃ flux calculation for Station B1, using replicate measurements from B1A and B1B concentration gradients, would be averaged as follows:

$$\begin{aligned} & ((-.782 \times 10^{-6} \text{ ug/cm}^2 \cdot \text{s}) + (-.902 \times 10^{-6} \text{ ug/cm}^2 \cdot \text{s})) / 2 \\ & = -.842 \times 10^{-6} \text{ ug/cm}^2 \cdot \text{s} \times (8.64 \times 10^5) = -.73 \text{ mg/m}^2 \cdot \text{d} \end{aligned}$$

The flux rates for ammonia and SRP are given in Table 3.

DISCUSSION

Monitoring of Lake Water Chemistry

The results of the lake water monitoring are presented in Figure 5 and Appendix 1, and will be discussed only as it pertains to Penetang Bay site P1, and the reference station (B1). The remaining data are provided in table form only as background and additional information in Appendix 1.

Data for station P1 shows that in 1988 between June and July, there was a significant increase (estimated from mean values over the vertical profile) of NH₃ and SRP in the water column (from approximately 9 ug/l to 60 ug/l NH₃), and then a subsequent decline to 15 ug/l in August and September. SRP increased from approximately 1.3 ug/l to 2.2 ug/l between June and early August, then decreased to 0.5 ug/l in September.

In February 1989, the concentrations of for NH₃ and SRP were significantly higher in surface water (approximately three times higher for NH₃, and twice as high for SRP) than in the rest of the water column. Data for July and August 1989 show similar increases during late July and decreases for August and September for both NH₃ and SRP.

Dissolved oxygen concentrations are typically high for the Sound, and there is no evidence of an oxygen depletion problem either during the summer or during the winter when the bays are ice-covered. A transient stratification period is noted during the summer of 1989, especially near P2, but oxygen levels did not decrease below 3.0 mg/l (except at Stations M2, M3, PM3 in June 1988 and at M5 in August 1989) in the water column. pH values typically range from 8-9 in the summer and were about 7.5 during the fall and winter months. Winter water temperatures averaged between 0.5-1.0, but the accuracy of the electronic bathythermograph (EBT) under the severely cold air temperatures should take into account some degree of error (especially since the EBT was alternately icing over, freezing and thawing in the air). Similar trends for oxygen, pH and temperature were observed in the general chemistry of P2 and P3 (Appendix 1), and on average, the two stations had somewhat lower concentrations of ammonia and SRP than P1.

In 1988, Station B1 showed a 2-fold decrease in both NH₃ and SRP between July and August (from 55 ug/l to 20 ug/l for NH₃, and 1.8 to 0.9 ug/l for SRP). A similar decrease between July and early August, was not observed in 1989.

Generally, the summer concentration of NH₃ and SRP at the stations in Penetang Bay and the reference station B1 are not significantly different. The water chemistry profiles show that concentrations of nutrients are higher towards the surface of the Bay (e.g. Station P1 in Figure 5) and that the concentrations at the control station, B1, are similar to that of P1 and P2 (Appendix 1). One possible explanation for this similarity is that the bay has a short residence time (69 days), and

large inputs of nutrients entering the bay are adsorbed onto particulates and removed before settling due to high lateral transport out of the bay and low sedimentation inside the bay. On the contrary, the higher concentrations at B1 may be due to higher sedimentation rates of organic material (see explanation below). Pore water concentration gradients are affected by sediment compositions. The pore water profiles for phosphorus and ammonia are generally similar for the three sites (P1, P2 and B1) monitored in 1988. This is unexpected since site B1 was chosen as the control site. B1 is at a site where more pristine conditions should exist than the rest of the Sound. Sites P1 and P2 were expected to have much greater concentrations of suspended sediments due to the localized inputs from the Water Pollution Control Plants. There appears to be a decreasing trend in concentration values from the south to the north end of Penetang Bay. This is probably attributable to flushing and water movement, since most of the loading from WPCPs may be confined to the southern half of the bay. This effect has been previously noted for total phosphorus and SRP, mean total nitrogen and chlorophyll a (MOE *et al.*, 1988). This increase in SRP and NH₃ in the water column could be attributed to internal diffusive loading. Similarly, this increase could be attributed to an event of anoxic regeneration, where SRP and oxyhydroxides are released from sediments under lower redox potential conditions. If either of these processes were occurring, the nutrient concentrations would be higher closer to the bottom than the surface waters. On the contrary, most of the concentration increases are mainly evident in the surface waters (1 m depth), Figure 5. Thus, this concentration increase from June to July must be due either to external loading sources resulting from fluctuations in the degree of treatment provided to the effluents and variations in operational practices at the sewage treatment plant and not from internal (diffusive) loading from the sediments.

The concentration decreases from summer to fall may be due to a decrease in external loadings. The increase in summer loadings could be due to the increased population attracted by the sporting and recreational summer activities in the area.

Winter data for Penetang Bay shows a distinct zonation of nutrients within the water column, with highest concentrations of NH₃ and SRP accumulating within the top 1 m under the ice. (Ice cover was approximately 45-80 cm in most areas in the bay.) This zonation could be attributable to circulation restrictions in the water column resulting from the ice cover in the winter.

In addition, high SRP and total phosphorus concentrations in surface waters, together with high summer water temperatures are responsible for the algal blooms (a concern identified by the RAP committee as crucial in remediation of the Sound) that are often manifested in the bay during August and September.

Pore Water Results

In order to predict the exchange of an element between the sediments and water, each of the chemical, biological and physical factors that influence exchange must be accounted for. In this report, only differences of porewater along their concentration gradients are considered to be the main mechanism. It is also recognized that physical mixing (resuspension) in shallow areas can contribute to internal loading (both soluble and particulate nutrient species). The bay is shallow (mean depth is approximately 4.71 m). This process would mostly contribute to the resuspension of particulates (i.e. particulate phosphorus) and not soluble species (i.e. SRP). For the purpose of calculating the internal loadings to the Bay, only diffusive loadings through molecular diffusion are calculated based on Equation 1. Thus, these loadings (internal) would only be a rough estimate, since resuspension and bioturbation are not taken into consideration (no data available). Also, microbial degradation of freshly sedimented organic matter may contribute to the dissolved SRP load.

Statistical analysis of the depth intervals over which the flux rates and regressions were calculated are provided in Table 1. The correlation coefficients for the data calculated over seven data points as opposed to eleven data points (5 and 9 degrees of freedom, respectively) show that the NH₃ results (n=7) were significant at 5% levels and were not significant at 1% for February 1989 (P2A) and August 1989 (P2). For n=11, February 1989 (P2A) and August 1989 (P2) were not significant at either the 5% or 1% levels.

The SRP correlation (n=7) is not significant at 5% or 1% levels for P2A (July 1988 and February 1989). As well, P2B (July 1988) and P1 (Aug. 1989) are not significant at 1% levels. For all stations and times (n=11), only one-half of the correlations are not significant at either 5 or 1% levels.

Thus, the smaller data set, according to the correlation analysis (Snedecor and Cochran, 1967), is deemed to be appropriate for establishing trends and more clearly defines the nutrient fluxes occurring just below the sediment-water interface. This zone can be defined as the zone of enhanced diffusion occurring within the 6 cells below the interface, in most cases, in this study.

For the reference station B1, the replicate peepers B1A and B1B (July 1988), have an average diffusion of $.73 \times 10^{-9}$ mg/m².d for NH₃ and $.27 \times 10^{-10}$ mg/m².d for SRP.

Differences between summer NH₃ and SRP values between 1988 and 1989 for all stations might be partially accounted for in terms of timing. There is a one-week difference between peeper deployment and retrieval in 1988 and 1989. In addition, the water quality data demonstrate that peak concentrations for ammonia and SRP occurred earlier in 1988 than in 1989. If these concentrations are indicative of sediment-water interactions and potential releases of nutrients, then the difference in timing and/or slight seasonal differences may account for some of the variations

observed. This may be especially true if intermittent anoxia may have occurred at the sediment water interface, releasing large amounts of nutrients, although our water quality data has not shown these processes.

It should also be noted that Penetang Bay is a relatively small bay (approximately 3.7 km² in area). In the summer, between 1700-1800 of the boat slips in the bay are occupied. A launching ramp exists near Station P1, and the frequent traffic in this area could potentially supply a great deal of sediment mixing. Station P2 is also not far away from a marina and would also be within range of a great deal of boat traffic that could result in a fair amount of sediment mixing and resuspension.

The relationship between dissolved oxygen, ammonia and SRP should also be considered. During the summer, at the sediment-water interface, there may be an increased demand for oxygen with increasing temperatures. During quiescent periods, low oxygen concentration at the sediment-water interface may lead to anoxia in the first few centimetres above the sediment, and a subsequent release of high levels of both ammonia and SRP may occur.

The benthic composition of the sediment is another important constituent that could play a role in release of nutrients in the sediment, and at or near the interface. In areas where resuspension may occur at rapid rates, and particularly with fine grained sediments (except for near the sewage outfalls, Penetang Bay has silty/sandy bottom sediment), the release of remineralized fractions of nitrogen and phosphorus may occur within the sediment column if burial occurred rapidly, or near the interface. The biological and chemical processes occurring within the sediments could effect the timing and magnitude of the net flux of NH₃ and SRP, and could in part account for the apparent seasonality of the effects seen (Val Klump and Martens, 1981). Carignan and Rosa (1992) also noted that variations in benthos abundance and different species (burrowing varieties) may also contribute to differences in flux rates expected. In order to more clearly define the contributing

role of the benthos in the transport of nutrients into the water column, benthic quantification and characterization for corresponding cores for the peepers should be done in future experiments.

Flux Calculations for Penetang Bay

Control Station B1

$$J = -PD_t \frac{dc}{dx}$$

NH₃ (B1A)

$$\begin{aligned} J &= -.90 \times (9.8 \times 10^{-6} \text{ cm}^2/\text{s}) \times .0888 \text{ ug/cm}^3 \cdot \text{cm} \\ &= -7.82 \times 10^{-7} \text{ ug/cm}^2 \cdot \text{s} \end{aligned}$$

SRP (B1A)

$$\begin{aligned} J &= -.90 \times (3.6 \times 10^{-6} \text{ cm}^2/\text{s}) \times .0889 \text{ ug/cm}^3 \cdot \text{cm} \\ &= -2.88 \times 10^{-7} \text{ ug/cm}^2 \cdot \text{s.} \end{aligned}$$

Note: For explanation, see Methods, page 5; Units conversion: 1 mg/l = 1 ug/cm³.

Individual Flux (J) for each station, for each peeper, as a replicate, and for each season are reported in Table 2. All replicate flux rates were averaged and are reported in Table 3. A negative (-) flux indicates that the particular nutrient is diffusing from the sediments into the overlying water. This will result in some type of internal load, which is estimated below.

Based on the results presented in Table 3, the summer fluxes and winter fluxes were averaged for the study year (see Table 3A). Based on the results from

Table 3A, the winter flux rates are much lower (less than 25%) than the summer rates for P1, and practically negligible (less than 2%) for station P2. Since the summer flux rates for station P2 are so variable between the two years (Table 3), especially for SRP (coefficient of variation is 1.3), the mean flux rates for station P1, which are much more consistent, (coefficient of variation = .41) between the two years, will be used to calculate the internal loading for the Bay. (Note: Station P2 will be reconsidered below.)

Summer Internal Load (P1)

Thus the internal loadings for Penetang Bay based on two years of summer data from station P1, and assuming that P1 is representative of the whole Bay are as follows:

The bay has a surface area of 3.7 km^2 , and a bottom area of 2.9 km^2 .

Thus based on the bottom area, the internal load of NH_3 to the bay is:

$$\begin{aligned} 4.6 \text{ mg/m}^2 \cdot \text{d} \times (2.9 \times 10^6 \text{ m}^2) &= 13.3 \times 10^6 \text{ mg/d} \\ &= 13.3 \text{ kg/d or } 2394 \text{ kg/season. (Season = 180 days.)} \end{aligned}$$

For SRP, the loading based on similar calculations is $1.14 \text{ mg/m}^2 \cdot \text{d} = 3.3 \text{ kg/d or } 595 \text{ kg/season.}$

Winter Internal Load (P1)

The winter flux for P1 is 26 and 28 % (from Table 3A) of the summer flux.. For this reason, the winter internal load is calculated separately from the summer (assuming 180 days)

$$\begin{aligned}
 & \text{NH}_3 \\
 & -1.31 \text{ mg/m}^2.\text{d} \times (2.9 \times 10^6 \text{ m}^2) \\
 & = 3.8 \text{ kg/d or } 684 \text{ kg/season.}
 \end{aligned}$$

$$\begin{aligned}
 & \text{SRP} \\
 & -.3 \text{ mg/m}^2.\text{d} \times (2.9 \times 10^6 \text{ m}^2) \\
 & = .87 \text{ kg/d or } 157 \text{ kg/season.}
 \end{aligned}$$

Summing the winter and summer internal loads:

	Winter(1989)		Summer		Annual
NH ₃ :	684 kg	+	2394 kg	=	3078 kg/yr.
SRP:	157 kg	+	594 kg	=	751 kg/yr.

Comparing the Internal Phosphorus Load, as Calculated, to the External Load, in Penetang Bay

Before any comparison is attempted here, we must differentiate between the different types of phosphorus forms we are dealing with in the comparison.

The phosphorus calculated as the internal load (751 kg/yr) is all SRP. The external P load comprises of many phosphorus forms, soluble inorganic, organic and particulate P. First then, we should try and assess the external SRP load to the Bay and in the water column.

In 1988, 900 to 1200 kg of phosphorus entered the Bay from the two WPCPs. The effluent from WPCPs is known to be greater than 80% SRP. Thus the SRP external load from the two WPCPs to the Bay is between 720 to 960 kg/yr. During the same year, the total load to the Bay was estimated at 1663 kg. Thus, approximately 613 kg of total phosphorus entered the bay from other sources. On average, for the Great Lakes Basin, the percentage of SRP of the total phosphorus, is approximately 20%. Thus, approximately 123 kg of SRP entered the Bay from other sources. Total SRP load to the bay is $1050 + 123 = 1173$ kg/yr. The contributions from internal loading (751 kg) is approximately 64% of the total SRP external load to the bay and 45% of the total phosphorus external load. The above results are considered very conservative estimates, based on the information available, and by using the lower flux rates for P1.

Based on the 1988 external P load (1663 kg), the internal load calculated in this study (751 kg) would increase the total load to the bay to 2414 kg. This amounts to a 31% increase to the annual P load to Penetang Bay.

If the average SRP flux for stations P1 and P2 were used (4.8 mg/m².d), then the P internal load would be 3162 kg/yr. This would amount to a 290% increase to the 1988 external load. The latter calculation was carried out to demonstrate the fluctuations one can expect in different data interpretations. The results for P2 are doubtful, and should not be taken into account. Even if the high concentrations for P2 were correct (Appendix 2), the most probable explanation would be that this location was a very localized and small area of deposition of very nutrient rich effluent loadings, and that this site was sampled by chance, and probably makes up

a very small portion of the nearshore area heavily affected by the WPCP. The concentrations found in this local area are typical of a waste lagoon depositional area. Thus, this area would not be representative of the Bay, but could exemplify certain local effects.

Since external load for NH₃ is not available (usually not reported), a similar calculation as for SRP is not possible.

CONCLUSIONS

Using the results of the most representative data obtained, a conservative estimate of the internal loading of SRP from the sediments for Penetang Bay is 751 kg/yr. External inputs (1663 kg/yr) contribute the remainder of the load to the Bay. This assertion is supported by examination of the water chemistry data, which showed that soluble reactive phosphorus, total phosphorus, and ammonia had consistently higher concentrations nearest to the surface waters, rather than at the bottom waters, as would be expected if the internal loads were the major contributing factor. Based on our calculations, the internal SRP load contributes 31% to the total load to Penetang Bay.

For future studies in Penetang Bay, the authors recommend using more replicates per site (approximately 5) to ensure the accuracy and reproducibility of data. Additional sites within the southern portion of the Bay and along a transect away from the WPCPs (inshore-offshore gradient) should be selected to determine whether the deposition is consistent throughout the Bay, and to provide a more precise loading calculation if differences do occur as a result of flushing and hydrodynamic effects. A survey of the benthic community should be made in order to determine the role of benthos in sediment resuspension. More frequent sampling

for determination of water chemistry is also recommended to detect short-term changes.

The amount of pore water phosphorus as an internal source, through molecular diffusion, in the Bay has been assessed in this study. Because of the heterogeneity of the sediments, seasonal variability and the low reproducibility of replicate measurements, additional sites should be monitored for a more representative estimate, as mentioned above.

If a simple three component (input-output) model should be used to establish a phosphorus budget for the bay, then additional research in particle dynamics and net downward flux of particulates should be conducted. This work must be able to evaluate phosphorus removal from the water column as net downward phosphorus flux. Other research into phosphorus transformation through adsorption-desorption reactions would be helpful in understanding phosphorus dynamics in the sediments and in the water column of Penetang Bay.

If the necessity arises to establish historical loadings to Penetang Bay, then we recommend the approach used by Johnson and Nicholls (1989) in Lake Simcoe. Penetang Bay may be studied as part of Severn Sound as Cook Bay was studied as part of Lake Simcoe.

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TABLE 2: Diffusive flux calculations for NH₃ and SRP

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**CONCENTRATION/DEPTH GRADIENTS CALCULATED
FROM MEASURED PROFILES**
(ug/cm³.cm)
TABLE 1

NH3 STATION	DATE	Constant n=7	Constant n=11	R Squared n=7	R Squared n=11
B1A	July 88	0.08877	0.09542	0.919	0.957
B1B	July 88	0.10233	0.14516	0.945	0.879
P1	July 88	0.37607	0.29277	0.967	0.950
P1A	Feb. 89	0.20209	0.16870	0.987	0.967
P1B	Feb. 89	0.14143	0.14815	0.970	0.988
P1	Aug. 89	0.82370	0.46180	0.942	0.735
P2A	July 88	4.65120	4.28720	0.973	0.978
P2B	July 88	2.86614	3.24850	0.981	0.984
P2A	Feb. 89	0.15686	0.07065	*0.828	**0.560
P2B	Feb. 89	0.04971	0.02749	0.962	0.780
P2	Aug. 89	6.84852	7.66058	*0.798	**0.255
SRP DATA STATION	DATE	Constant n=7	Constant n=11	R Squared n=7	R Squared n=11
B1A	July 88	0.08890	0.10230	0.929	0.957
B1B	July 88	0.10322	0.13953	0.902	*0.734
P1	July 88	0.27395	0.24401	0.928	0.908
P1A	Feb. 89	0.11847	0.09982	0.968	0.963
P1B	Feb. 89	0.09514	0.08367	0.991	0.988
P1	Aug. 89	0.54446	0.22560	*0.838	**0.492
P2A	July 88	0.23713	0.20048	**0.636	*0.693
P2B	July 88	0.32900	0.16034	*0.795	**0.589
P2A	Feb. 89	29.80420	0.01371	**0.587	*0.659
P2B	Feb. 89	0.02151	0.01547	0.942	0.918
P2	Aug. 89	5.66573	8.58664	0.909	*0.692

NB:

B1, P1 AND P2 REFER TO STUDY SITES;
 A AND B REFER TO REPLICATE MEASUREMENTS.
 * NOT SIGNIFICANT AT 1% LEVELS

FLUX CALCULATIONS FOR NH₃ AND SRP
TABLE 2

NH ₃ DATA STATION	DATE	FLUX (n=7) x10 ⁻⁶ (ug/cm ² .s) Reg. on 6	FLUX (n=11) x10 ⁻⁶ (ug/cm ² .s) Reg. on 10
B1A	July 88	0.782	0.841
B1B	July 88	0.902	1.280
P1	July 88	3.316	2.582
P1A	Feb. 89	1.782	1.487
P1B	Feb. 89	1.247	1.306
P1	Aug. 89	7.265	4.073
P2A	July 88	41.023	37.813
P2B	July 88	25.279	28.651
P2A	Feb. 89	1.383	0.623
P2B	Feb. 89	0.438	0.242
P2	Aug. 89	60.403	67.566
SRP DATA STATION	DATE	FLUX (n=7) x10 ⁻⁷ (ug/cm ² .s) Reg. on 6	FLUX (n=11) x10 ⁻⁷ (ug/cm ² .s) Reg. on 10
B1A	July 88	2.88	3.31
B1B	July 88	3.34	4.52
P1	July 88	8.87	7.9
P1A	Feb. 89	3.83	3.23
P1B	Feb. 89	3.08	2.71
P1	Aug. 89	17.64	7.30
P2A	July 88	7.68	6.49
P2B	July 88	10.65	5.19
P2A	Feb. 89	965.65	0.44
P2B	Feb. 89	0.69	0.50
P2	Aug. 89	183.56	278.20

DIFFUSIVE FLUX FOR NH₃ AND SRP
TABLE 3

STATION	DATE	NH ₃ (FLUX) (mg/m ² .d)	SRP (FLUX) (mg/m ² .d)
B1	July 88	-0.73	-0.27
P1	July 88	-2.90	-0.77
P1	Feb. 89	-1.31	-0.30
P1	Aug. 89	-6.30	-1.50
P2	July 88	-33.15	-0.79
P2	Feb. 89	-0.79	*-.04
P2	Aug. 89	-52.20	-15.90

* Number of observations = 11;
 All other values, n=7.

MEAN SEASONAL DIFFUSIVE FLUX (mg/m².d) AND S.D.

TABLE 3A

STATION	SUMMER FLUX		WINTER FLUX	
	SRP	NH ₃	SRP	NH ₃
B1	-0.27	-0.73	ND	ND
P1	-1.14 ±0.52	-4.6 ±2.4	-0.30	-1.31
P2	-8.4 ±10.7	-40.4 ±16.7	-0.04	-0.79

ND = No Data

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FIGURE 3: Pore-water sampler

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FIGURES 4c & 4d: NH₃ and SRP, pore-water profiles for August 1989

FIGURE 5: Water column, nutrients and temperature concentrations

FIGURE 1. WATER QUALITY MONITORING STATIONS

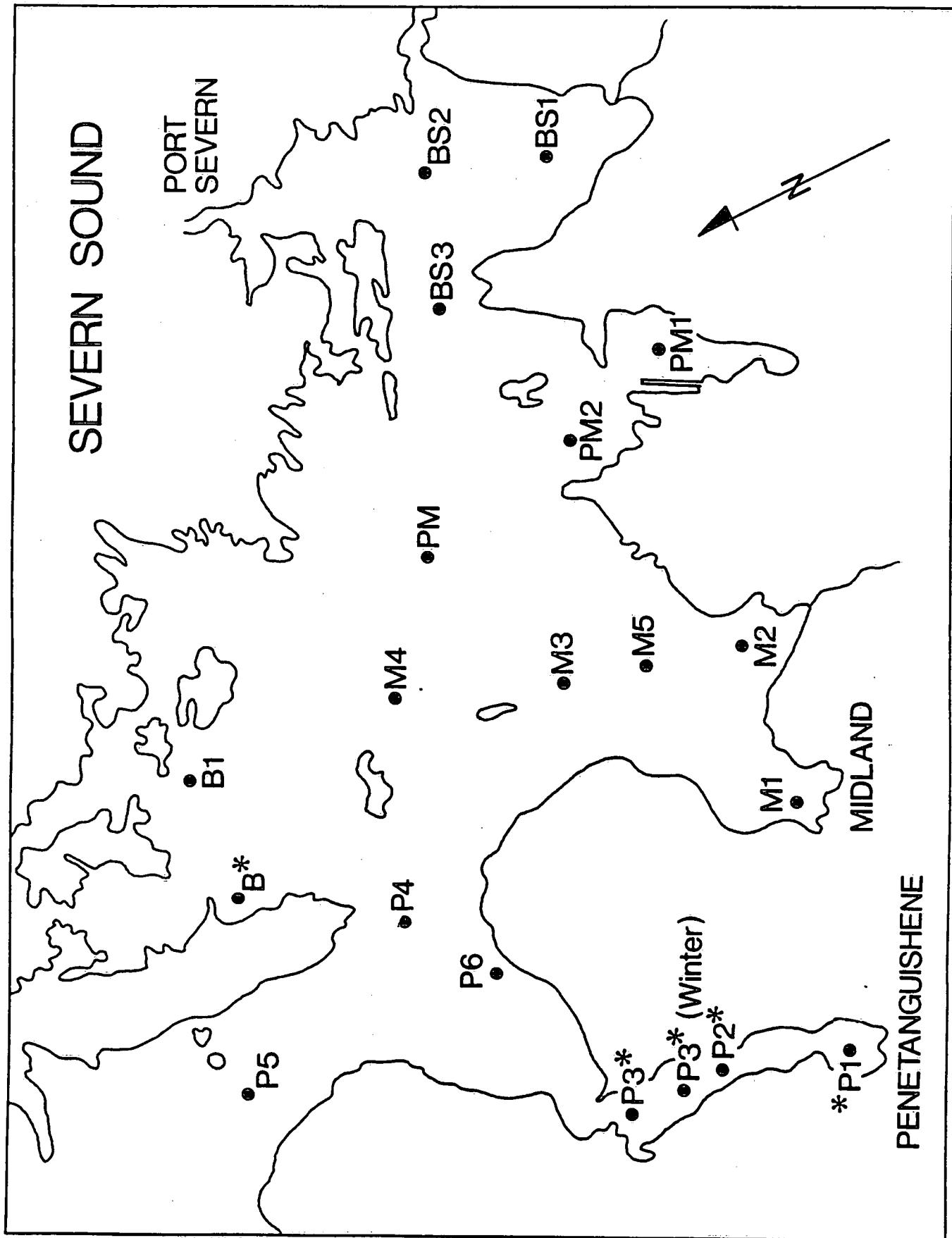


FIGURE 2. PEEPER STATIONS AND WPCPs -
PENETANG BAY

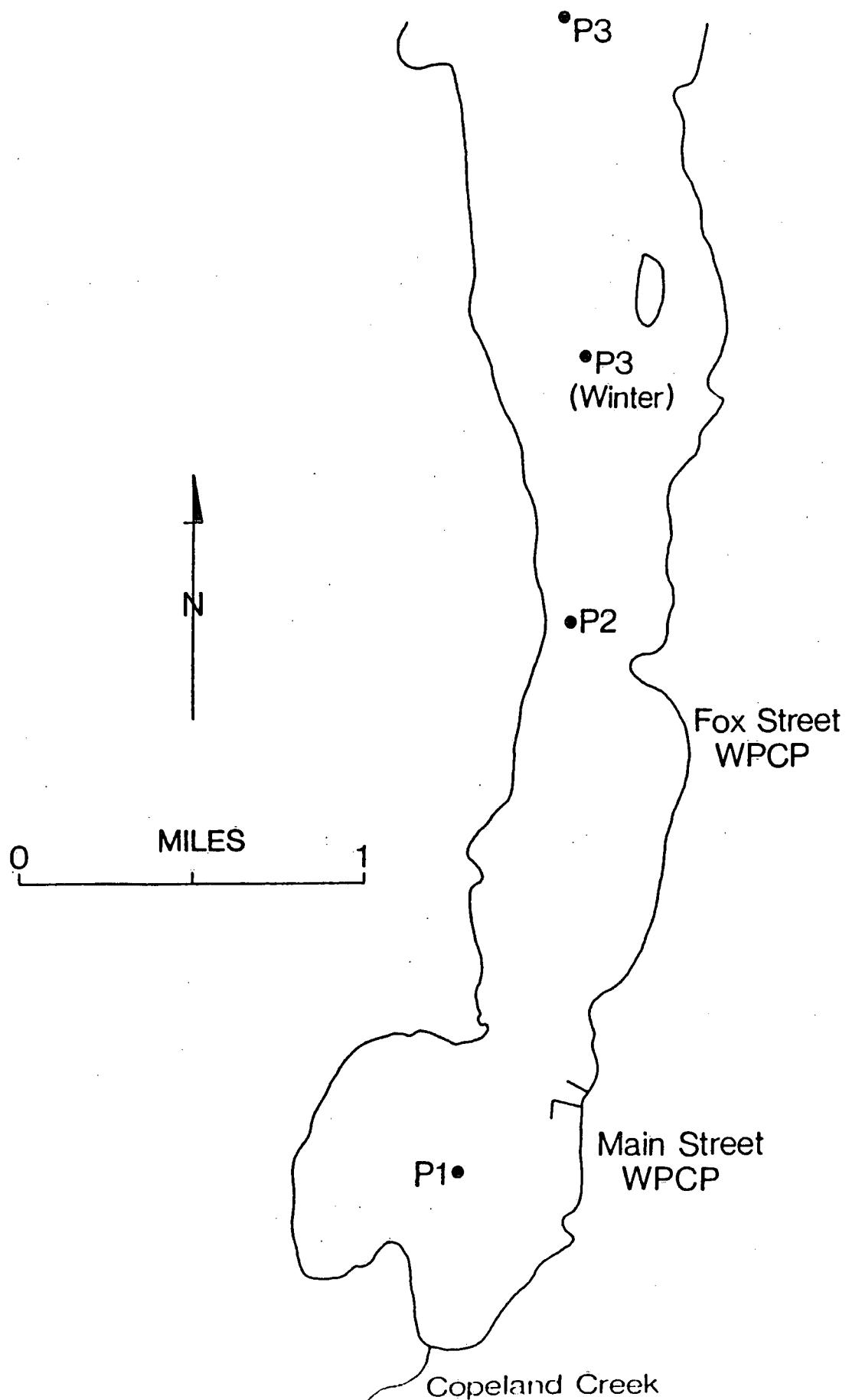
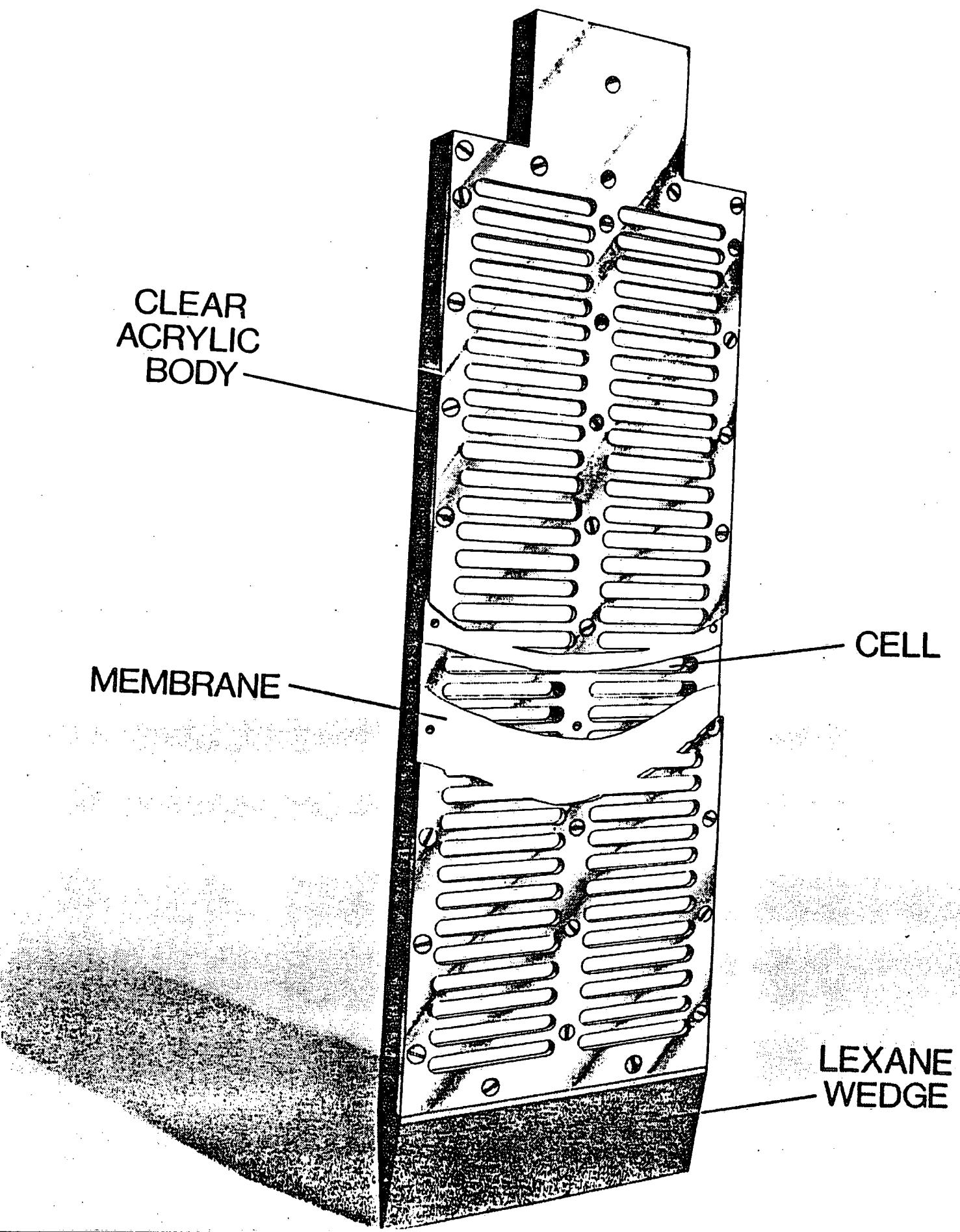
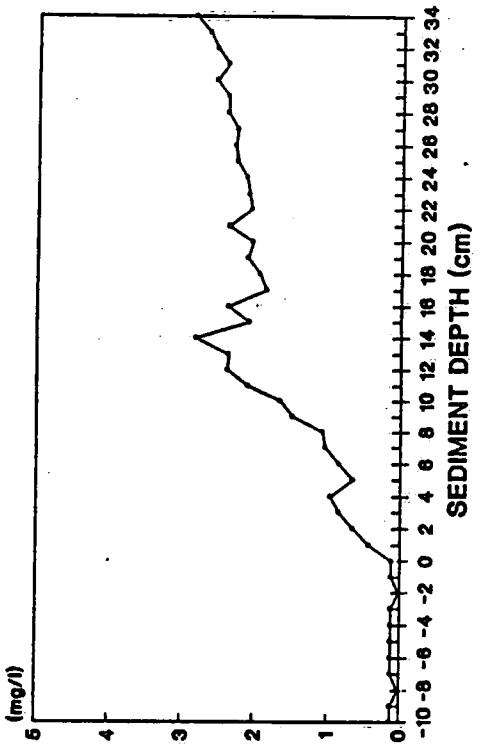


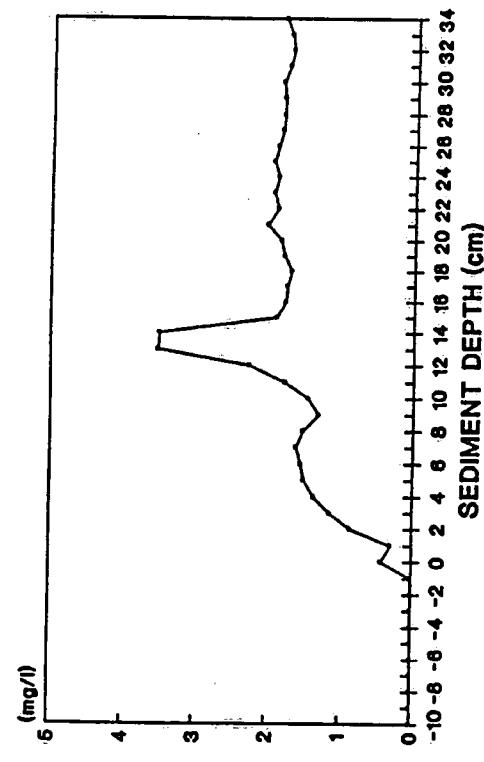
FIGURE 3. PORE WATER SAMPLER



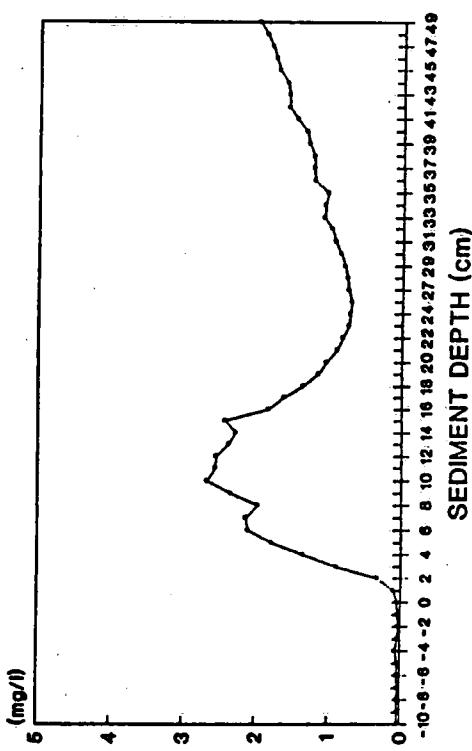
B1A - NH₃
July 1988



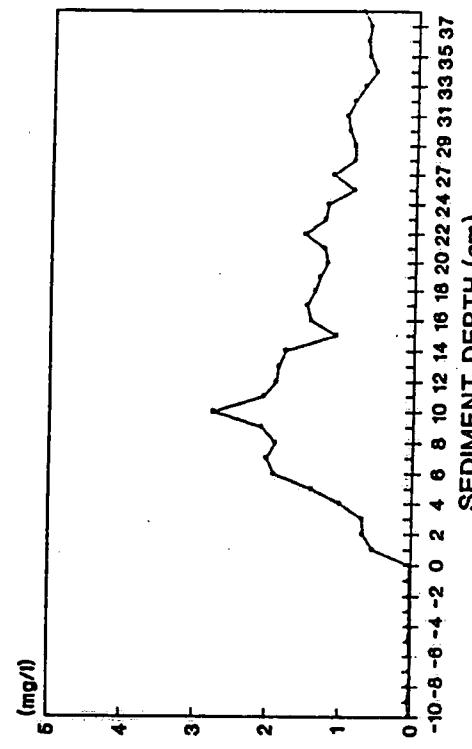
B1A - SRP
July 1988



P1A - NH₃
July 1988



P1A - SRP
July 1988



P1A - NH₃
August 1989

P1A - SRP
August 1989

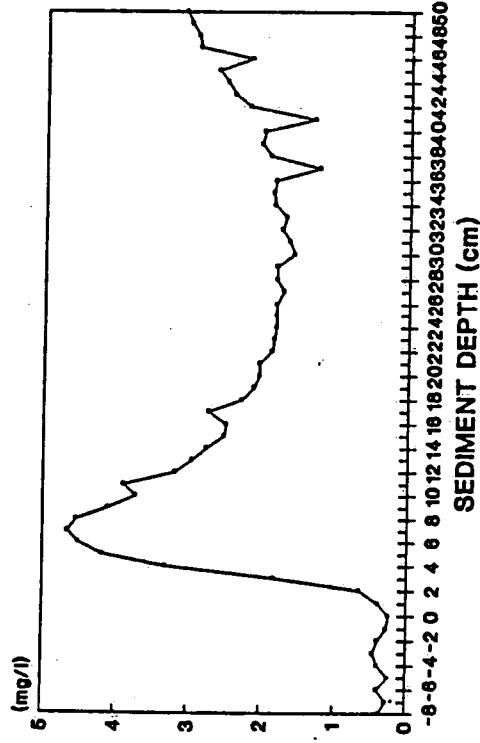


FIGURE 4C

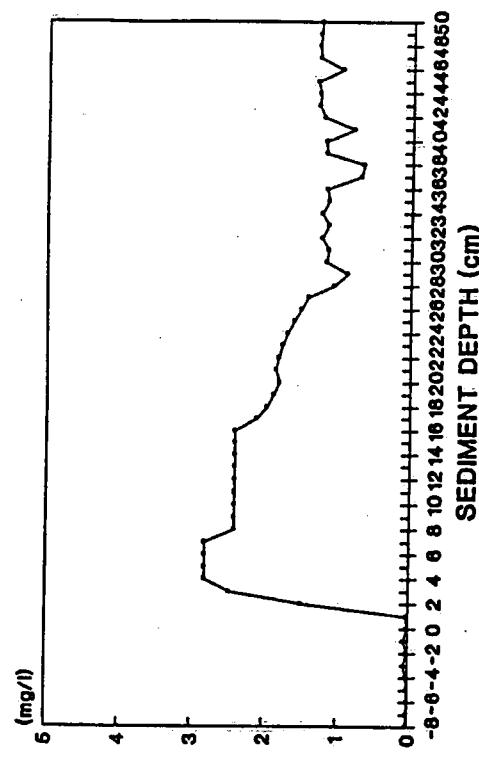


FIGURE 4C

P1A - SRP
August 1989

FIGURE 4D

Station P2A-NH₃
August 1989

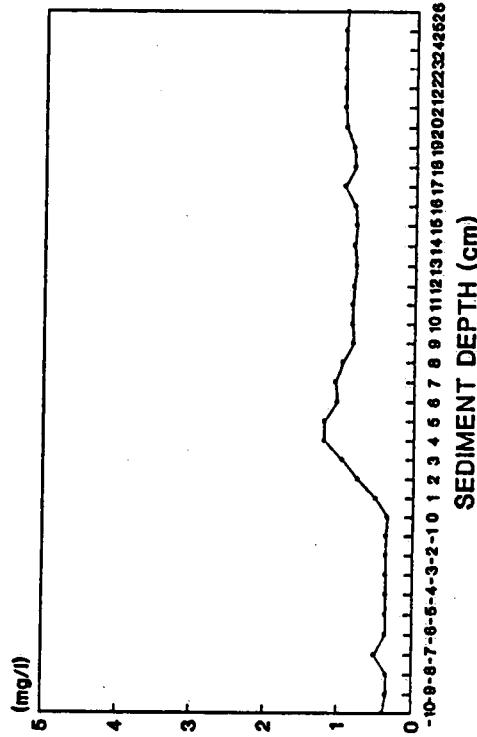


FIGURE 4D

Station P2A-SRP
August 1989

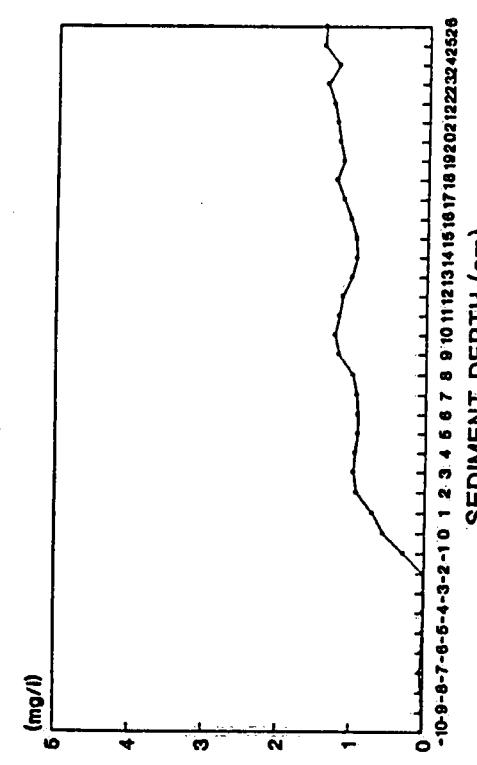


FIGURE 4D

Station P2A-SRP
August 1989

AMMONIA
(mg/l)

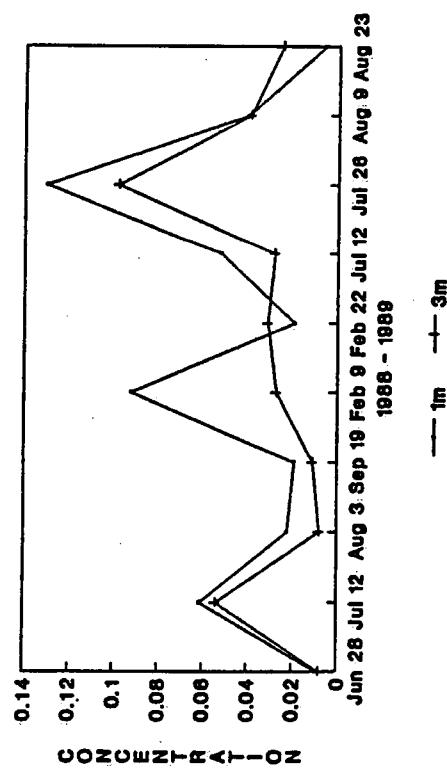
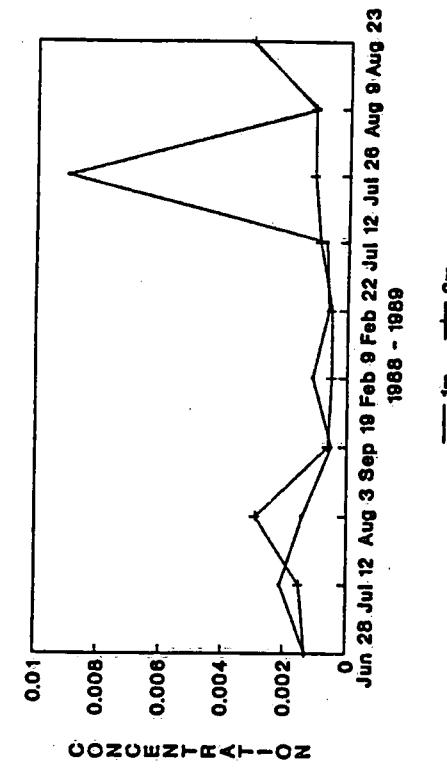
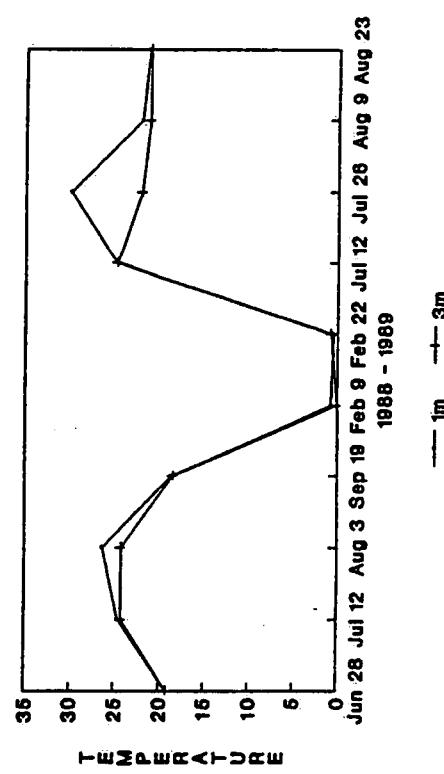


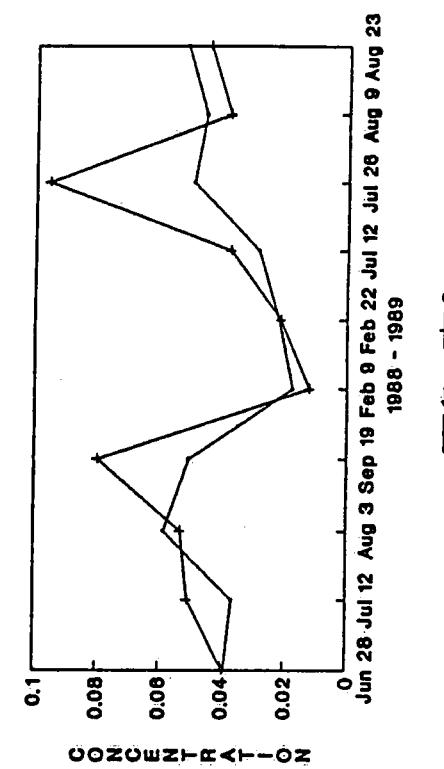
FIGURE 5 SOLUBLE REACTIVE PHOSPHORUS
(mg/l)



Temperature
(Degrees Celcius)



TOTAL PHOSPHORUS
(mg/l)



APPENDIX 1

APPENDIX I
CONCENTRATION OF WATER QUALITY PARAMETERS

STATION B1

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
12-Jul-88	1	0.061	0.004	0.015	0.0021	0.0386	0.387	2.1	13.0	22.5	8.4
	5.5	0.054	0.003	L.001	0.0015	0.0507	0.354	2.7	11.5	22.2	8.4
03-Aug-88	1	0.013	0.002	0.022	0.0009	0.0126	0.245	3.9	14.1	22.3	8.3
	5	0.026	0.002	0.025	0.0009	0.0123	0.277	3.1	13.4	22.0	8.2
12-Jul-89	1	0.014	0.002	0.055	0.0004	0.0174	0.204	4.3	n/a	23.0	8.4
	6	0.032	0.002	0.067	0.0004	0.0111	0.223	4.3	n/a	22.8	8.3
08-Aug-89	1	0.016	0.008	0.037	L.0005	0.0103	0.165	5.7	6.5	22.1	9.3
	5.5	0.029	0.008	0.039	0.0005	0.0132	0.205	4.2	6.3	22.2	9.3
22-Aug-89	1	0.040	0.017	L.01	0.0060	0.0146	0.172	3.5	5.2	23.4	8.6
	5	0.059	0.015	L.01	0.0059	0.0084	0.186	3.6	5.0	23.0	8.5

*On Aug. 8, 1989, a severe thunderstorm occurred.

STATION BS1

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
27-Jun-88	1	0.007	0.005	0.022	0.0013	0.0229	0.351	4.1	7.3	19.9	8.38
	3	0.006	0.006	0.041	0.0013	0.0188	0.373	4.3	5.5	19.9	8.37
12-Jul-88	1	0.016	0.002	0.011	0.0011	0.0169	0.353	3.5	13.6	26.1	9.21
	3	0.053	0.003	0.030	0.0025	0.0232	0.488	4.2	12.9	26.1	9.23
12-Jul-89	1	0.027	L.001	L.011	0.0029	0.0126	0.299	0.6	n/a	24.3	8.84
	2.5	0.033	L.001	L.011	0.0038	0.0139	0.230	5.3	n/a	25.4	8.93
27-Jul-89	1	0.015	0.002	0.012	0.0003	0.0143	0.201	6.1	9.0	26.8	9.62
	2	0.020	0.002	0.021	0.0005	0.0155	0.240	3.6	9.0	26.9	9.67
08-Aug-89	1	L.005	0.005	L.01	0.0010	0.0185	0.194	3.3	6.7	19.8	0.74
	3	0.012	0.003	L.01	L.0005	0.0180	0.203	7.1	6.4	20.1	9.17
22-Aug-89	1	0.055	0.011	L.01	0.0067	0.0113	0.265	3.3	5.6	21.8	8.52
	2.5	0.011	0.007	L.01	0.0056	0.0112	0.213	3.6	5.8	21.9	9.04

APPENDIX 1-CONTINUED

STATION BS2

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
27-Jun-88	1	0.006	0.003	0.035	0.0014	0.0184	0.36	4.6	9.8	19.7	8.97
	3	0.006	0.005	0.020	0.0018	0.0183	0.373	4.2	8.2	19.6	8.47
12-Jul-88	1	0.007	0.002	0.013	0.0008	0.0183	0.329	3.8	11.5	25.9	8.76
	4	0.057	0.002	0.013	0.0008	0.0176	0.357	2.7	10.6	25.9	8.74
12-Jul-89	1	0.016	L.001	L.011	0.0018	0.0148	0.191	6.8	n/a	25.2	8.27
	2.5	0.032	L.001	L.011	0.0030	0.0163	0.214	6.0	n/a	25.0	8.28
27-Jul-89	1	0.019	L.001	0.015	0.0005	0.0124	0.218	2.3	6.3	26.7	8.77
	3	0.011	0.002	L.011	0.0008	0.0117	0.208	0.7	6.3	26.7	8.68
08-Aug-89	1	L.005	0.005	L.01	0.0010	0.0185	0.184	2.8	6.4	21.5	9.32
	3	0.012	0.003	L.01	L.005	0.0190	0.203	3.5	6.4	21.9	9.4
22-Aug-89	1	0.035	0.006	L.01	0.0044	0.0153	0.218	4.7	5.2	22.1	8.46
	3	0.038	0.012	L.01	0.0066	0.0130	0.211	4.1	5.3	22.2	8.27

STATION BS3

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
27-Jun-88	1	0.022	0.003	0.033	0.0014	0.0154	0.365	3.0	6.8	19.5	8.37
	3	0.006	0.003	0.087	0.0016	0.0142	0.368	3.1	4.2	19.0	8.35
12-Jul-88	1	0.015	0.002	0.015	0.0008	0.0152	0.308	3.6	12.5	25.5	8.59
	4	0.053	0.003	0.019	0.0007	0.0133	0.329	3.7	11.4	25.5	8.58
12-Jul-89	1	0.017	L.001	L.011	0.0012	0.0138	0.191	3.5	n/a	24.6	8.38
	4	0.027	L.001	L.011	0.0017	0.0139	0.211	3.5	n/a	24.4	8.26
27-Jul-89	1	0.021	0.002	0.016	0.0006	0.0119	0.219	3.6	6.5	25.9	8.63
	3.5	0.023	L.001	L.011	0.0005	0.0123	0.201	3.0	6.5	25.9	8.64
08-Aug-89	1	0.041	0.003	0.013	0.0007	0.0130	0.209	2.0	6.4	21.6	9.52
	3	0.025	0.002	0.013	0.0007	0.0128	0.204	4.1	6.4	21.6	9.17
22-Aug-89	1	0.024	0.009	L.01	0.0058	0.0132	0.210	4.3	5.1	22.2	7.88
	3	0.057	0.011	L.01	0.0054	0.0121	0.227	4.8	5.1	22.2	8.97

APPENDIX 1 - CONTINUED

Station PM1

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
27-Jun-88	1.00	0.017	0.003	0.044	0.0012	0.0181	0.381	3.5	8.9	19.2	8.34
	4.00	0.017	0.004	0.108	0.0012	0.0192	0.438	4.4	7.4	19.1	8.33
11-Jul-88	1.00	0.025	0.003	0.026	0.0012	0.0167	0.405	3.5	12.4	26.5	8.49
	4.50	0.017	0.002	0.019	0.0011	0.0128	0.274	3.3	11.8	25.6	8.62
12-Jul-88	1.00	0.047	L.001	L.011	0.0025	0.0166	0.237	6.4	n/a	24.9	8.07
	5.00	0.039	L.001	L.011	0.0083	0.0178	0.235	4.9	n/a	24.5	7.63
27-Jul-88	1.00	0.015	L.001	L.011	0.0004	0.0122	0.188	3.8	6.7	28.3	8.74
	4.00	0.037	0.002	0.017	0.0004	0.0242	0.214	5.1	5.2	26.5	7.82
08-Aug-88	1.00	0.022	0.005	0.012	0.0012	0.0051	0.198	7.2	6.4	21.9	9.30
	4.00	L.005	0.005	0.013	0.0008	0.0292	0.165	6.4	6.4	22.9	9.21
22-Aug-88	1.00	0.023	0.013	0.012	0.0021	0.0180	0.173	4.3	5.1	22.8	8.85
	3.00	0.007	0.011	L.01	0.0053	0.0184	0.148	5.1	5.2	22.4	8.86

Station PM2

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
27-Jun-88	1.00	0.007	0.003	0.040	0.0009	0.0154	0.325	4.5	11.3	19.4	8.33
	5.00	0.008	0.003	0.033	0.0009	0.0174	0.329	4.4	8.4	19.4	8.31
11-Jul-88	1.00	0.011	0.003	0.011	0.0004	0.0119	0.273	3.2	11.7	25.5	8.59
	4.00	0.012	0.003	0.017	0.0003	0.0138	0.281	3.1	11.1	25.5	8.59
12-Jul-88	1.00	0.015	0.002	L.011	0.0013	0.0144	0.205	4.7	n/a	24.1	8.02
	5.00	0.037	0.002	L.011	0.0025	0.0153	0.231	3.5	n/a	24.2	8.04
27-Jul-88	1.00	0.013	0.001	L.011	0.0004	0.0126	0.188	4.1	6.8	27.9	8.71
	5.00	0.015	L.001	0.014	0.0003	0.0101	0.167	4.8	6.8	27.3	8.71
08-Aug-88	1.00	0.012	0.005	0.013	0.0005	0.0164	0.183	4.3	6.0	22.9	9.26
	5.00	0.013	0.005	0.013	0.0006	0.0143	0.172	4.3	5.8	22.5	9.21
22-Aug-88	1.00	0.014	0.014	L.01	0.0066	0.0103	0.154	4.3	5.2	22.5	8.68
	5.00	0.043	0.012	L.01	0.0051	0.0125	0.174	6.3	5.0	22.3	8.67
	6.50	0.032	0.012	L.01	0.0068	0.0125	0.177	6.4	5.0	22.3	8.57

Station PM3

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1.00	0.300	0.005	0.083	0.0010	0.0131	0.373	4.5	8.1	19.3	8.86
	5.00	0.012	0.004	0.084	0.0010	0.0102	0.307	3.3	2.2	19.1	8.85
	9.00	0.009	0.004	0.074	0.0009	0.0106	0.325	3.5	1.5	18.4	8.85
11-Jul-88	1.00	0.017	0.003	0.022	0.0003	0.0139	0.308	2.9	12.7	25.2	8.61
	5.00	0.011	0.003	0.084	0.0003	0.0118	0.345	3.5	11.8	25.2	8.59
	10.00	0.021	0.003	0.052	0.0008	0.0159	0.305	4.4	8.8	18.1	7.71
12-Jul-88	1.00	0.059	0.002	0.059	0.0006	0.0102	0.254	6.2	n/a	22.5	8.05
	5.00	0.095	0.006	0.058	0.0005	0.0100	0.309	4.1	n/a	22.6	8.35
	8.50	0.040	0.003	0.060	0.0005	0.0213	0.224	5.0	n/a	22.4	8.03
08-Aug-88	1.00	0.012	0.005	0.013	L.0005	0.0139	0.162	3.0	6.0	22.0	9.16
	5.00	0.012	0.008	0.013	L.0005	0.0116	0.161	n/a	5.9	22.9	9.19
	8.00	0.012	0.006	0.019	L.0005	0.0133	0.160	5.0	5.9	22.9	9.20
22-Aug-88	1.00	0.021	0.023	L.01	0.0047	0.0158	0.167	7.1	5.1	22.5	8.59
	5.00	0.036	0.016	L.01	0.0061	0.0271	0.200	2.9	5.0	22.5	8.67
	8.00	0.070	0.017	L.01	0.0060	0.0133	0.183	4.4	4.9	22.8	8.55

APPENDIX 1--CONTINUED

STATION M1

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1	0.012	0.004	0.085	0.0009	0.0166	0.326	3.3	11.5	19.0	8.74
	5	0.018	0.004	0.083	0.0008	0.0121	0.331	3.9	11.2	19.0	8.72
	10	0.065	0.005	0.129	0.0009	0.0134	0.402	3.8	9.8	19.0	8.53
13-Jul-88	1	0.016	0.003	0.035	0.0004	0.0150	0.306	2.1	13.4	24.7	8.32
	5	0.021	0.004	0.044	0.0004	0.0102	0.309	2.6	13.5	24.1	8.27
	9	0.021	0.005	0.046	0.0004	0.0142	0.300	3.0	12.0	19.0	8.06
04-Aug-88	1	0.021	0.003	0.013	0.0005	0.0121	0.217	2.6	13.0	25.2	8.65
	5	0.013	0.003	0.017	0.0004	0.0158	0.207	3.2	11.4	24.5	8.55
	7	0.018	0.004	0.026	0.0004	0.0127	0.245	2.9	11.6	24.4	8.47
13-Jul-89	1	0.022	0.004	0.063	0.0004	0.0115	0.260	2.3	n/a	23.8	8.14
	5.5	0.027	0.004	0.084	0.0003	0.0129	0.255	0.7	n/a	23.6	8.01
27-Jul-89	1	0.031	0.001	0.012	L.0002	0.0109	0.203	4.3	7.3	27.5	8.80
	5	0.026	0.002	L.011	0.0004	0.0098	0.184	5.1	7.3	26.9	8.77
	7	0.071	0.006	0.187	0.0005	0.0157	0.351	5.2	7.3	22.0	7.47
09-Aug-89	1	0.060	0.005	0.037	0.0013	0.0167	0.218	4.4	5.6	23.0	8.54
	5	0.014	0.008	0.011	0.0009	0.0165	0.158	3.9	5.6	23.1	8.54
	7	0.030	0.005	0.012	0.0008	0.0190	0.182	3.9	5.5	23.0	8.40
22-Aug-89	1	0.007	0.014	0.023	0.0040	0.0141	0.165	7.9	5.1	22.9	8.22
	5	0.018	0.006	0.021	0.0021	0.0138	0.168	6.3	5.0	22.8	8.30
	7	0.037	0.019	0.023	0.0051	0.0126	0.189	6.0	4.9	22.5	8.24

STATION M2

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1	0.006	0.003	0.060	0.0008	0.0141	0.296	2.4	12.8	19.5	8.84
	5	0.009	0.003	0.056	0.0009	0.0122	0.315	4.2	4.5	19.5	8.83
	9.5	0.007	0.003	0.056	0.0009	0.0139	0.309	3.6	5.7	19.5	8.83
13-Jul-88	1	0.014	0.004	0.033	0.0009	0.0118	0.291	2.4	13.2	24.6	8.17
	5	0.031	0.004	0.053	0.0003	0.0134	0.334	3.8	12.8	24.0	8.07
	12	0.074	0.006	0.097	0.0009	0.0147	0.411	2.6	6.2	17.1	7.20
13-Jul-89	1	0.055	0.004	0.053	0.0007	0.0118	0.309	5.5	n/a	23.4	8.17
	5	0.019	0.003	0.048	0.0008	0.0144	0.257	5.7	n/a	23.0	8.03
	11	0.066	0.004	0.185	0.0005	0.0131	0.384	4.4	n/a	27.5	7.04
27-Jul-89	1	0.021	0.001	0.012	L.0002	0.0092	0.174	6.5	7.0	26.9	8.67
	5	0.019	0.000	0.017	0.0003	0.0095	0.174	5.2	7.2	27.1	8.75
	10	0.115	0.005	0.178	0.0005	0.0156	0.363	3.7	3.4	21.0	7.33
09-Aug-89	1	0.021	0.005	0.012	0.0007	0.0171	0.190	5.1	5.3	23.0	8.37
	5	0.010	0.005	0.012	0.0011	0.0163	0.172	6.0	5.2	23.0	8.38
	8	0.060	0.007	0.012	0.0018	0.0235	0.231	3.9	4.7	23.5	8.28
22-Aug-89	1	0.049	0.015	0.020	0.0029	0.0213	0.218	8.9	5.22	22.5	8.49
	5	0.046	0.005	0.020	0.0032	0.0200	0.208	5.6	4.88	22.5	8.34
	10	0.086	0.019	0.104	0.0038	0.0162	0.288	4.3	2.68	22.0	7.80

APPENDIX 1-CONTINUED

STATION M3

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1	0.011	0.003	0.065	0.0009	0.0133	0.320	2.8	2.2	19.3	8.79
	5	0.020	0.003	0.079	0.0012	0.0138	0.359	2.9	0.8	19.3	8.78
	10	0.009	0.003	0.074	0.0010	0.0116	0.351	2.9	0.8	19.3	8.77
	14	0.013	0.003	0.067	0.0021	0.0139	0.310	3.1	1.3	19.3	8.76
13-Jul-88	1	0.190	0.003	0.034	0.0012	0.0252	0.302	3.0	13.2	24.5	8.73
	5	0.053	0.003	0.062	0.0011	0.0111	0.374	3.6	12.3	23.7	8.62
	10	0.015	0.003	0.064	0.0007	0.0130	0.321	5.1	10.6	20.8	7.89
	14.5	0.029	0.004	0.128	0.0009	0.0119	0.369	3.2	8.4	16.8	7.50
04-Aug-88	1	0.028	0.002	0.028	0.0005	0.0145	0.235	3.9	13.2	26.3	8.89
	5	0.039	0.001	0.040	0.0004	0.0132	0.268	5.9	11.4	25.7	8.83
	11	0.027	0.044	0.154	0.0005	0.0126	0.356	4.5	4.3	19.0	7.68
13-Jul-89	1	0.021	0.004	0.069	0.0038	0.0087	0.244	4.3	n/a	22.8	8.38
	5	0.026	0.004	0.069	0.0013	0.0103	0.367	6.4	n/a	21.7	8.29
	12.5	0.043	0.004	0.204	0.0005	0.0155	0.255	5.0	n/a	16.4	7.44
27-Jul-89	1	0.023	L.001	L.011	0.0003	0.0096	0.167	5.8	7.1	27.0	8.72
	5	0.020	0.001	0.014	0.0003	0.0089	0.166	5.2	7.1	27.0	8.78
	11.5	0.052	0.005	0.210	0.0004	0.0095	0.348	4.4	4.0	21.0	7.45
08-Aug-89	1	0.028	0.007	0.010	L.0005	0.0146	0.192	4.6	5.6	23.0	8.73
	5	0.020	0.004	0.012	0.0007	0.0156	0.178	5.1	5.6	23.0	8.63
	10	0.020	0.007	0.012	L.0005	0.0175	0.184	3.1	5.4	23.0	8.59
22-Aug-89	1	0.025	0.016	L.01	0.0045	0.0190	0.183	5.6	5.3	22.1	8.44
	5	0.035	0.014	L.01	0.0057	0.0164	0.178	5.0	5.0	22.5	8.36
	11	0.034	0.016	0.021	0.0047	0.0076	0.203	4.0	4.7	22.1	8.14

STATION M4

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
13-Jul-88	1	0.018	0.003	0.043	0.0017	0.0218	0.345	2.1	12.8	24.1	8.56
	5	0.020	0.003	0.056	0.0009	0.0108	0.312	3.2	11.2	23.6	8.56
	9	0.013	0.003	0.086	0.0006	0.0171	0.353	3.0	8.4	22.9	8.48
04-Aug-88	1	0.025	0.003	0.024	0.0003	0.0130	0.257	4.2	13.2	26.4	8.59
	5	0.021	0.001	0.020	0.0003	0.0167	0.257	6.1	12.0	24.4	8.48
	8	0.020	0.009	0.072	L.0003	0.0129	0.261	5.1	8.1	22.8	7.86
12-Jul-89	1	0.023	0.002	0.057	0.0005	0.0143	0.220	4.1	n/a	22.7	8.58
	5	0.018	0.002	0.056	0.0005	0.0108	0.203	4.3	n/a	22.4	8.52
	8.5	0.056	0.002	0.118	0.0005	0.0175	0.282	5.0	n/a	20.6	7.64
08-Aug-89	1	0.014	0.010	0.013	n/a	0.0155	0.203	3.6	5.5	23.0	9.16
	5	0.011	0.005	0.013	0.0008	0.0187	0.168	3.5	5.5	22.9	9.19
	8	0.011	0.006	0.013	0.0013	0.0148	0.150	4.4	5.5	23.0	9.20
22-Aug-89	1	0.016	0.017	0.017	0.0047	0.0121	0.187	4.4	5.2	22.5	8.34
	5	0.160	0.014	0.022	0.0110	0.0163	0.307	4.1	5.0	22.5	8.33
	7.5	0.024	0.016	0.020	0.0035	0.0104	0.165	4.3	4.9	22.2	8.29

APPENDIX 1—CONTINUED

STATION M5

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1	0.005	0.004	0.067	0.0009	0.0142	0.321	2.6	11.0	19.4	8.4
	5	0.012	0.004	0.098	0.0009	0.0182	0.362	n/a	4.3	19.1	8.75
	11	0.300	0.003	0.122	0.0010	0.0112	0.364	2.7	2.9	18.1	8.83
13-Jul-88	1	0.047	0.004	0.044	0.0011	0.0141	0.394	3.1	13.5	24.6	8.54
	5	0.024	0.003	0.035	0.0009	0.0169	0.318	2.8	13.4	24.0	8.57
	12.5	0.062	0.004	0.085	0.0008	0.0175	0.353	2.9	12.6	17.0	7.16
13-Jul-89	1	0.035	0.003	0.061	0.0004	0.0100	0.304	4.4	n/a	23.4	8.07
	5	0.022	0.003	0.060	0.0005	0.0116	0.230	5.2	n/a	23.3	8.01
	10.5	0.084	0.004	0.097	0.0010	0.0110	0.323	5.7	n/a	22.1	7.51
27-Jul-89	1	0.018	0.002	0.012	0.0004	0.0099	0.187	5.8	7.1	27.0	8.62
	5	0.046	0.001	0.014	0.0004	0.0093	0.183	3.9	7.1	27.0	8.76
	10	0.052	0.004	0.192	0.0004	0.0111	0.334	4.3	4.5	20.3	7.54
09-Aug-89	1	0.071	0.005	0.012	0.0005	0.0191	0.234	5.8	5.6	23.0	8.6
	5	0.045	0.007	0.010	0.0008	0.0138	0.198	5.0	5.5	22.8	8.53
	8	0.029	0.004	0.012	0.0014	0.0187	0.197	5.8	5.4	22.9	8.45
22-Aug-89	1	0.020	0.017	L.01	0.0027	0.0170	0.157	6.7	5.2	22.5	8.37
	5	0.015	0.005	L.01	0.0050	0.0209	0.186	7.8	5.1	22.5	8.39
	8.5	0.019	0.017	L.01	0.0062	0.0139	0.152	2.0	4.8	22.1	8.27

STATION P1

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1	0.009	0.003	0.023	0.0013	0.0388	0.284	2.6	12.7	19.2	9.12
	3.5	0.008	0.003	0.011	0.0013	0.0393	0.265	11.8	11.6	19.1	9.11
12-Jul-88	1	0.081	0.004	0.015	0.0021	0.0368	0.387	7.6	13.8	24.6	8.77
	3	0.054	0.003	0.011	0.0015	0.0507	0.354	9.5	12.8	24.2	8.58
03-Aug-88	1	0.022	0.001	0.154	0.0014	0.0585	0.448	10.1	11.8	26.3	8.75
	2.5	0.008	0.002	0.021	0.0029	0.0530	0.298	6.3	8.6	24.2	7.88
19-Sep-88	1	0.019	0.004	0.034	0.0005	0.0505	n/a	n/a	n/a	18.6	8.44
	3	0.011	0.003	0.030	0.0006	0.0787	n/a	n/a	n/a	18.4	8.03
09-Feb-89	1	0.092	n/a	0.255	0.0011	0.0175	0.474	n/a	13.4	0.8	n/a
	2	0.036	n/a	0.200	0.0006	0.0100	0.434	n/a	12.8	0.8	7.59
	3	0.027	n/a	0.285	0.0005	0.0120	0.469	n/a	12.1	0.1	7.73
	3.5	0.027	n/a	0.200	0.0006	0.0118	0.471	n/a	12.8	1.0	7.49
	4	0.018	n/a	0.221	0.0006	0.0107	0.454	n/a	10.2	1.0	7.72
22-Feb-89	1	0.019	n/a	0.188	0.0006	0.0220	0.394	7.2	12.6	0.5	8.07
	2	0.029	n/a	0.188	0.0006	0.0307	0.428	6.7	14.6	0.5	8.10
	2.5	0.035	n/a	0.200	0.0007	0.0208	0.463	7.8	14.1	0.8	8.09
	3	0.031	n/a	0.191	0.0005	0.0212	0.439	7.8	13.7	0.8	8.09
12-Jul-89	1	0.052	L.001	0.021	0.0007	0.0286	0.233	9.5	8.8	24.8	8.82
	3	0.028	L.001	0.023	0.0009	0.0378	0.207	5.8	8.8	24.7	8.77
28-Jul-89	1	0.130	L.001	0.019	0.0090	0.0496	0.393	19.2	8.6	29.9	9.40
	2.5	0.098	0.002	0.041	0.0016	0.0957	0.362	17.5	7.5	30.5	7.19
09-Aug-89	1	0.040	0.004	L.01	0.0009	0.0457	0.185	15.4	7.6	22.0	9.27
	3	0.039	0.004	L.01	0.0011	0.0380	0.192	15.3	7.6	22.0	9.21
23-Aug-89	1	0.006	0.015	L.01	0.0032	0.0519	0.152	15.4	5.4	21.3	8.69
	2.5	0.025	0.017	L.01	0.0031	0.0446	0.150	15.8	4.9	21.1	8.72

APPENDIX 1 - CONTINUED

STATION P2

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1.00	0.030	0.01	0.043	0.0009	0.0183	0.311	9.8	12.2	19.1	n/a
	4.00	0.022	0.01	0.050	0.0014	0.0201	0.303	6.0	12.0	18.5	n/a
	7.50	0.028	0.00	0.139	0.0022	0.0120	0.387	4.1	9.6	16.9	n/a
12-Jul-88	1.00	0.018	0.00	0.011	0.0011	0.0183	0.294	5.4	13.2	25.3	8.79
	5.00	0.017	0.00	0.028	0.0008	0.0178	0.298	6.7	12.4	25.2	8.69
	7.00	0.043	0.00	0.037	0.0010	0.0302	0.323	10.5	7.8	19.1	7.88
03-Aug-88	1.00	0.008	0.00	0.020	0.0010	0.0250	0.286	9.8	15.2	25.8	8.48
	6.00	0.019	0.00	0.032	0.0011	0.0182	0.258	5.9	8.0	23.2	7.56
19-Sep-88	1.00	0.051	0.00	0.106	0.0005	0.0391	n/a	n/a	n/a	18.8	7.88
	4.50	0.024	0.00	0.013	0.0007	0.0332	n/a	n/a	n/a	18.5	7.95
09-Feb-89	1.00	0.010	n/a	0.194	0.0008	0.0100	0.434	n/a	11.3	0.5	n/a
	2.00	0.012	n/a	0.236	0.0007	0.0120	0.469	n/a	10.7	0.5	7.35
	3.00	0.012	n/a	0.236	0.0005	0.0118	0.471	n/a	12.7	0.5	7.93
	4.00	0.011	n/a	0.222	0.0005	0.0107	0.454	n/a	12.2	1.0	7.53
	5.00	0.012	n/a	0.219	0.0005	0.0118	0.470	n/a	12.4	1.0	n/a
	6.00	0.011	n/a	0.196	L.0003	0.0110	0.427	n/a	13.0	1.0	7.55
	7.00	0.009	n/a	0.182	L.0003	0.0094	0.384	n/a	13.2	1.0	7.64
	7.50	0.014	n/a	0.240	0.0006	0.0138	0.477	n/a	5.4	1.0	n/a
22-Feb-89	1.00	0.011	n/a	0.299	0.0006	0.0152	0.521	2.8	13.8	0.8	6.79
	2.00	0.033	n/a	0.183	0.0003	0.0096	0.407	3.5	13.7	0.8	7.56
	3.00	0.031	n/a	0.175	0.0003	0.0094	0.420	2.0	12.7	0.8	7.71
	4.00	0.028	n/a	0.180	0.0003	0.0087	0.382	2.8	13.8	1.0	7.81
	5.00	0.035	n/a	0.209	L.0003	0.0139	0.435	1.3	13.9	1.0	7.81
	6.00	0.042	n/a	0.180	L.0003	0.0088	0.441	2.3	14.0	1.0	7.81
	6.50	0.060	n/a	0.303	0.0046	0.0179	0.525	1.6	11.9	1.0	7.74
13-Jul-89	1.00	0.035	0.00	0.021	0.0008	0.0208	0.191	8.2	n/a	24.3	8.55
	5.00	0.031	0.00	0.024	0.0008	0.0222	0.217	11.0	n/a	23.5	8.32
	7.00	0.053	0.00	0.083	0.0008	0.0238	0.296	8.2	n/a	22.2	7.54
26-Jul-89	1.00	0.052	0.00	L.011	0.0090	0.0496	0.393	19.2	5.8	30.5	9.17
	5.00	0.020	0.00	L.011	0.0018	0.0957	0.362	17.5	3.7	26.5	8.66
	7.00	0.040	0.00	0.082	0.0007	0.0214	0.260	6.9	3.0	24.0	7.61
09-Aug-89	1.00	0.009	0.01	L.01	0.0010	0.0286	0.162	12.6	6.5	23.0	9.11
	6.00	0.059	0.00	L.01	0.0011	0.0317	0.220	19.0	5.7	22.9	8.67
23-Aug-89	1.00	0.03	0.02	0.08	0.00	0.02	0.23	13.9	5.1	21.2	8.27
	6.00	0.07	0.02	0.05	0.01	0.03	0.260	12.1	3.1	21.0	7.86

APPENDIX 1 - CONTINUED

STATION P3

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1.00	0.017	0.005	0.085	0.0012	0.0137	0.316	4.30	11.6	18.70	8.91
	5.00	0.009	0.005	0.081	0.0009	0.0189	0.296	5.60	11.6	18.60	8.93
	10.00	0.022	0.003	0.127	0.0011	0.0098	0.347	4.30	10.5	17.40	8.52
	14.50	0.027	0.003	0.138	0.0011	0.0105	0.348	6.50	10.2	24.00	8.39
12-Jul-88	1.00	0.012	0.003	0.058	0.0006	0.0098	0.288	5.60	13.5	23.0	8.7
	5.00	0.013	0.003	0.032	0.0007	0.0180	0.288	5.60	13.4	18.5	8.7
	10.00	0.037	0.003	0.058	0.0008	0.0142	0.321	6.40	11.2	17.2	8.4
	13.50	0.049	0.004	0.071	0.0008	0.0167	0.300	7.60	11.0	17.1	8.1
03-Aug-88	1.00	0.010	0.002	0.016	0.0007	0.0170	0.230	6.00	15.3	25.8	8.73
	6.00	0.028	0.004	0.038	0.0006	0.0138	0.239	4.30	10.8	23.0	7.34
09-Feb-89	1.00	0.010	n/a	0.185	L.0003	0.0102	0.435	n/a	13.8	0.8	n/a
	2.00	0.012	n/a	0.183	0.0003	0.0115	0.375	n/a	6.8	0.8	7.45
	3.00	0.010	n/a	0.197	0.0004	0.0100	0.422	n/a	11.9	0.8	n/a
	4.00	0.010	n/a	0.184	L.0003	0.0103	0.397	n/a	13.8	1.0	7.28
	5.00	0.013	n/a	0.189	0.0007	0.0129	0.390	n/a	13.0	1.0	7.19
	6.00	0.013	n/a	0.346	0.0010	0.0127	0.687	n/a	12.9	1.0	7.25
23-Feb-89	1.00	0.016	n/a	0.209	L.0003	0.0157	0.546	n/a	5.3	1.0	7.21
	2.00	0.012	n/a	0.186	0.0003	0.0119	0.434	2.80	8.6	0.5	7.75
	3.00	0.009	n/a	0.191	0.0003	0.0092	0.433	3.00	8.6	0.5	7.76
	4.00	0.008	n/a	0.174	0.0004	0.0088	0.417	3.60	8.5	0.8	7.79
	5.00	0.010	n/a	0.180	0.0004	0.0098	0.404	2.30	8.2	0.8	7.80
	5.50	0.011	n/a	0.208	L.0003	0.0105	0.440	1.60	8.5	1.0	7.81
12-Jul-89	1.00	0.010	n/a	0.192	L.0003	0.0096	0.408	1.20	8.4	1.0	7.82
	2.00	0.021	0.003	0.070	0.0006	0.0135	0.269	4.10	n/a	22.8	8.57
	5.00	0.054	0.004	0.219	L.0003	0.0170	0.209	5.00	n/a	20.3	7.78
	10.00	0.049	0.004	0.115	0.0006	0.0145	0.313	8.10	n/a	16.8	7.69
26-Jul-89	1.00	0.050	0.004	0.200	0.0006	0.0181	0.360	7.40	n/a	n/a	n/a
	5.00	0.024	0.001	L.011	0.0006	0.0191	0.203	5.30	5.8	28.0	8.99
	7.00	0.019	0.002	0.018	0.0006	0.0130	0.197	7.60	4.8	24.9	8.69
09-Aug-89	1.00	0.059	0.002	0.035	0.0006	0.0179	0.244	9.70	3.4	22.9	7.89
	5.00	0.079	0.007	0.013	0.0008	0.0170	0.248	9.50	5.8	21.2	8.53
	10.00	0.018	0.005	0.012	L.0005	0.0189	0.192	8.40	5.7	22.0	8.68
	13.50	0.048	0.009	0.016	0.0007	0.0157	0.210	6.80	5.5	22.5	8.64
23-Aug-89	1.00	0.098	0.008	0.038	0.0014	0.0195	0.281	7.30	3.5	22.3	8.59
	5.00	0.03	0.02	0.04	0.00	0.02	0.19	11.10	5.1	21.1	8.53
	11.00	0.23	0.02	0.08	0.01	0.02	0.38	11.10	4.9	21.2	8.47

APPENDIX 1—CONTINUED

STATION P4

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
13-Jul-88	1	0.012	0.004	0.118	L.0003	0.0075	0.327	3.3	13.0	21.1	8.13
	5	0.010	0.003	0.119	0.0004	0.0103	0.309	2.4	12.0	21.0	8.31
	10	0.014	0.003	0.093	0.0004	0.0116	0.324	3.1	10.0	19.8	7.76
	15	0.020	0.003	0.173	0.0003	0.0079	0.342	3.2	8.3	19.0	7.64
26-Jul-88	1	0.031	0.004	0.071	0.0008	0.0078	0.262	4.8	6.2	27.0	8.73
	5	0.030	0.002	0.053	0.0006	0.0080	0.260	6.0	5.5	26.5	8.78
	10	0.024	0.003	0.213	0.0008	0.0081	0.373	4.3	5.1	19.0	8.03
	12	0.029	0.003	0.224	0.0009	0.0199	0.371	3.5	4.0	16.5	7.46

STATION P5

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
13-Jul-88	1	0.014	0.003	0.147	0.0003	0.0081	0.237	2.5	11.4	19.7	8.32
	5	0.010	0.003	0.147	L.0003	0.0087	0.330	1.9	9.8	19.7	8.32
	10	0.013	0.003	0.109	0.0003	0.0113	0.307	3.8	8.1	19.2	7.83
	15	0.020	0.004	0.225	L.0003	0.0130	0.396	1.9	7.6	18.8	7.95
04-Aug-88	1	0.013	0.003	0.131	0.0005	0.0059	0.293	3.1	13.2	19.0	8.01
	5	0.011	0.004	0.203	0.0004	0.0043	0.339	2.5	13.4	18.8	8.01
	10	0.019	0.003	0.201	0.0003	0.0057	0.339	2.6	13.7	18.8	10.00
	15	0.104	0.016	0.220	0.0004	0.0080	0.519	2.9	9.9	18.0	7.31
	22	0.047	0.003	0.245	0.0005	0.0078	0.439	2.0	n/a	n/a	7.50
12-Jul-89	1	0.014	0.002	0.055	0.0004	0.0174	0.204	4.3	11.4	22.5	8.29
	5	0.032	0.002	0.067	0.0004	0.0111	0.223	4.3	11.3	21.8	8.23
	10	0.017	0.003	0.107	0.0004	0.0087	0.237	3.6	10.7	19.2	7.62
	15.5	0.019	0.003	0.124	0.0004	0.0077	0.269	5.0	8.9	15.2	7.48
26-Jul-89	1	0.024	0.003	0.114	0.0007	0.0068	0.295	2.5	5.4	27.0	8.67
	5	0.015	0.002	0.105	0.0005	0.0063	0.251	3.6	5.1	25.5	8.72
	10	0.063	0.004	0.187	0.0005	0.0068	0.407	3.0	4.4	19.5	7.74
	20	0.047	0.004	0.247	0.0005	0.0080	0.380	3.3	4.7	14.2	7.75
	23	0.047	0.005	0.261	0.0005	0.0065	0.399	2.7	n/a	13.9	7.79
22-Aug-89	1	0.130	0.018	0.114	0.0051	0.0098	0.375	6.1	5.3	21.0	7.94
	5	0.020	0.007	0.090	0.0032	0.0097	0.221	5.0	5.1	21.0	8.24
	10	0.051	0.014	0.099	0.0029	0.0104	0.266	5.0	5.1	21.0	8.32
	15	0.012	0.014	0.111	0.0039	0.0086	0.238	3.3	5.1	20.5	8.17
	20	0.029	0.013	0.267	0.0047	0.0068	0.357	2.7	n/a	17.0	7.64

APPENDIX 1 - CONTINUED

STATION P6

Date	Depth m	NH3 mg/l	NO2 mg/l	NO3NO2 mg/l	SRP mg/l	TP mg/l	TFN mg/l	CHLA-UNC ug/l	D.O. mg/l	Temp. deg.C	pH
28-Jun-88	1	0.017	0.003	0.119	0.0011	0.0108	0.348	4.3	10.3	18.3	8.78
	5	0.013	0.005	0.121	0.0011	0.0093	0.335	3.3	10.8	18.3	8.79
	10	0.012	0.003	0.119	0.0008	0.0115	0.341	n/a	10.8	18.2	8.76
12-Jul-88	1	0.017	0.003	0.092	0.0008	0.0123	0.368	4.5	13.8	24.2	8.88
	5	0.008	0.003	0.058	0.0008	0.0115	0.280	2.9	12.1	23.7	8.65
	10	0.018	0.004	0.058	0.0006	0.0138	0.300	5.1	9.8	17.0	8.02
	15	0.046	0.004	0.136	0.0005	0.0087	0.360	3.8	7.8	16.4	8.07
04-Aug-88	1	0.030	0.002	0.030	0.0003	0.0121	0.221	4.1	13.2	25.9	8.63
	5	0.018	0.003	0.055	0.0003	0.0109	0.245	2.5	10.4	24.4	8.26
	10	0.034	0.005	0.135	0.0004	0.0081	0.322	3.5	10.3	22.2	7.9
	16	0.066	0.015	0.209	0.0004	0.0087	0.419	2.5	8.7	20.0	7.55
19-Sep-88	1	L.005	0.003	0.019	0.0005	0.0240	n/a	n/a	n/a	18.5	8.53
	5	L.005	0.002	0.008	0.0005	0.0216	n/a	n/a	n/a	18.3	8.34
	10	L.005	0.001	0.008	0.0005	0.0180	n/a	n/a	n/a	18.1	8.13
	15	L.005	0.001	0.011	0.0005	0.0315	n/a	n/a	n/a	18.1	8.01
13-Jul-89	1	0.017	0.004	0.104	0.0005	0.0114	0.287	4.3	n/a	22.8	8.32
	5	0.018	0.003	0.101	0.0003	0.0087	0.249	2.0	n/a	22.2	8.42
	10	0.031	0.004	0.126	0.0010	0.0086	0.302	5.1	n/a	19.8	7.96
	16	0.035	0.003	0.225	0.0005	0.0139	0.361	5.3	n/a	15.7	7.57
26-Jul-89	1	0.045	0.002	0.019	0.0006	0.0116	0.217	5.5	5.8	27.4	8.89
	5	0.024	0.002	0.033	0.0004	0.0095	0.222	5.0	4.9	27.0	8.89
	10	0.052	0.004	0.220	0.0008	0.0067	0.381	3.5	4.2	18.5	7.81
	13.5	0.086	0.004	0.238	0.0005	0.0087	0.466	2.0	4.1	15.3	7.53
09-Aug-89	1	0.038	0.004	0.061	0.0012	0.0165	0.257	5.6	5.8	22.0	8.52
	5	0.040	0.004	0.059	0.0018	0.0121	0.262	4.8	7.9	22.0	8.56
	10	0.048	0.008	0.061	0.0017	0.0126	0.256	4.8	5.9	22.0	8.56
	15	0.048	0.011	0.158	0.0005	0.0088	0.307	4.0	4.3	18.1	7.66
22-Aug-89	1	0.029	0.013	0.084	0.0028	0.0010	0.230	4.7	5.1	20.9	8.28
	5	0.039	0.014	0.091	0.0036	0.0110	0.244	4.2	5.0	21.1	8.35
	10	0.020	0.014	0.067	0.0037	0.0118	0.217	3.1	5.0	21.2	8.36
	15	0.038	0.016	0.076	0.0045	0.0101	0.231	4.2	4.7	21.2	8.36

APPENDIX 2

APPENDIX 2
PEEPER CONCENTRATIONS FOR NH3 AND SRP

Station B1A**July 1988**

Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-25	0.120	0.0441
2	-24	0.120	0.0444
3	-23	0.020	0.0147
4	-22	0.120	0.0392
5	-21	0.120	0.0147
6	-20	0.020	0.0098
7	-19	0.020	0.0098
8	-18	0.360	0.0098
9	-17	0.120	0.0098
10	-16	0.120	0.0588
11	-15	0.120	0.0098
12	-14	0.020	0.0097
13	-13	0.312	0.0097
14	-12	0.120	0.0097
15	-11	0.120	0.0097
16	-10	0.120	0.0097
17	-9	0.120	0.0097
18	-8	0.020	0.0097
19	-7	0.120	0.0097
20	-6	0.120	0.0097
21	-5	0.120	0.0097
22	-4	0.120	0.0097
23	-3	0.120	0.0097
24	-2	0.020	0.0097
25	-1	0.120	0.0097
26	0	0.120	0.4171
27	1	0.420	0.2877
28	2	0.647	0.8503
29	3	0.841	1.1381
30	4	0.960	1.3612
31	5	0.647	1.4970
32	6	0.841	1.5390
33	7	1.035	1.6037
34	8	1.067	1.5132
35	9	1.487	1.3062
36	10	1.649	1.4517
37	11	2.102	1.7622
38	12	2.376	2.2544
39	13	2.360	3.5244
40	14	2.813	3.5046
41	15	2.079	1.8810
42	16	2.360	1.7620
43	17	1.843	1.7423
44	18	1.940	1.6929
45	19	2.103	1.7893
46	20	2.037	1.8414
47	21	2.360	2.0196
48	22	2.063	1.8810
49	23	2.102	1.9404
50	24	2.134	1.8810
51	25	2.263	1.9503
52	26	2.296	1.8909
53	27	2.263	1.8414
54	28	2.393	1.8216
55	29	2.393	1.8216
56	30	2.554	1.8414
57	31	2.393	1.7523
58	32	2.554	1.7127
59	33	2.651	1.7350
60	34	2.845	1.8216

Station B1B**July 1988**

Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-24	0.224	0.0020
2	-23	0.044	0.0020
3	-22	0.224	0.0020
4	-21	0.092	0.0020
5	-20	0.080	0.0072
6	-19	0.060	0.0028
7	-18	0.056	0.0020
8	-17	0.020	0.0020
9	-16	0.020	0.0020
10	-15	0.132	0.0020
11	-14	0.020	0.0020
12	-13	0.245	0.0098
13	-12	0.245	0.0245
14	-11	0.245	0.0245
15	-10	0.392	0.0294
16	-9	0.245	0.0098
17	-8	0.245	0.0098
18	-7	0.393	0.0245
19	-6	0.539	0.0098
20	-5	0.245	0.0098
21	-4	0.245	0.0098
22	-3	0.245	0.0098
23	-2	0.393	0.0098
24	-1	0.245	0.0441
25	0	0.245	0.0098
26	1	0.393	0.3234
27	2	0.833	1.0486
28	3	2.254	2.6950
29	4	1.029	1.7787
30	5	1.764	2.6950
31	6	2.695	2.5823
32	7	2.793	2.5774
33	8	1.862	2.5774
34	9	1.911	2.6950
35	10	3.185	2.6950
36	11	2.205	2.4500
37	12	2.205	2.6950
38	13	2.254	2.6950
39	14	2.205	2.6950
40	15	2.254	2.6950
41	16	2.450	2.6950
42	17	2.695	2.6950
43	18	2.891	2.6950
44	19	3.283	2.6950
45	20	3.626	2.6950
46	21	3.626	2.6950
47	22	3.626	2.4206
48	23	3.626	2.2932
49	24	3.626	2.5210
50	25	3.626	2.0727
51	26	2.695	1.9747
52	27	2.352	2.1413
53	28	2.695	2.3226
54	29	2.205	1.9159

APPENDIX 2-CONTINUED

Station P1A

February 1989			
Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-10	0.162	0.2263
2	-9	0.162	0.0743
3	-8	0.162	0.0452
4	-7	0.162	0.0388
5	-6	0.162	0.0323
6	-5	0.162	0.0485
7	-4	0.162	0.0355
8	-3	0.162	0.0194
9	-2	0.162	0.0258
10	-1	0.162	0.0420
11	0	0.162	0.0679
12	1	0.259	0.0291
13	2	0.485	0.1325
14	3	0.776	0.1616
15	4	0.938	0.3298
16	5	1.067	0.4009
17	6	1.358	0.6046
18	7	1.067	0.7404
19	8	1.455	0.7889
20	9	1.649	0.7889
21	10	1.681	0.6305
22	11	1.681	0.6596
23	12	1.681	0.9732
24	13	1.681	0.9247
25	14	1.681	0.7760
26	15	1.681	0.6596
27	16	1.616	0.7727
28	17	1.681	0.8924
29	18	1.552	0.8988
30	19	1.422	1.1025
31	20	1.293	1.1058
32	21	1.261	1.1510
33	22	1.132	1.2028
34	23	1.093	1.1960
35	24	1.067	1.1478
36	25	1.035	1.1640
37	26	1.035	1.2380
38	27	1.067	1.0734
39	28	1.067	1.0767
40	29	1.067	1.2513
41	30	0.937	0.9926
42	31	1.067	0.9344
43	32	1.067	0.7954
44	33	1.067	0.7501
45	34	1.067	0.6499
46	35	1.067	0.6208
47	36	1.067	0.6337
48	37	1.099	0.6272
49	38	1.132	0.5238
50	39	1.164	0.5496
51	40	1.520	0.7857
52	41	1.229	0.5917
53	42	1.293	0.5593
54	43	1.326	0.5238
55	44	1.520	0.4882
56	45	1.520	0.5044
57	46	1.520	0.4947
58	47	1.520	0.5820
59	48	1.520	0.3459
60	49	1.584	0.0252

Station P1B

February 1989			
Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-8	0.144	0.0288
2	-7	0.168	0.0120
3	-6	0.168	0.0120
4	-5	0.120	0.0120
5	-4	0.120	0.0120
6	-3	0.360	0.0120
7	-2	0.144	0.0120
8	-1	0.120	0.0120
9	0	0.120	0.0120
10	1	0.192	0.2880
11	2	0.432	0.0456
12	3	0.384	0.0264
13	4	0.408	0.0168
14	5	0.600	0.0888
15	6	0.840	0.1776
16	7	0.936	0.2712
17	8	1.104	0.4152
18	9	1.320	0.4632
19	10	1.332	0.5760
20	11	1.560	0.6072
21	12	1.536	0.7152
22	13	1.416	0.5928
23	14	1.560	0.6120
24	15	1.608	0.7344
25	16	1.584	1.0368
26	17	1.632	1.0536
27	18	1.536	0.8520
28	19	1.320	0.8640
29	20	1.320	0.8328
30	21	1.320	0.8304
31	22	1.320	0.8496
32	23	1.320	0.7512
33	24	1.320	0.7584
34	25	1.320	0.9624
35	26	1.320	1.0776
36	27	1.320	0.7896
37	28	1.320	0.5184
38	29	1.320	0.4920
39	30	1.176	0.4992
40	31	1.128	0.3744
41	32	1.152	0.3528
42	33	1.104	0.3984
43	34	1.152	0.3576
44	35	1.128	0.3744
45	36	1.248	0.3504
46	37	1.272	0.2088
47	38	1.272	0.2136
48	39	1.320	0.2088
49	40	1.416	0.2136
50	41	1.488	0.2592
51	42	1.536	0.2784
52	43	1.536	0.2592
53	44	1.728	0.2760
54	45	1.728	0.2544
55	46	1.824	0.2616
56	47	2.040	0.2664
57	48	1.944	0.2784
58	49	1.752	0.2616
59	50	1.824	0.2448
60	51	2.160	0.3696

APPENDIX 2-CONTINUED

Station P2A

July 1988

Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-18	0.490	0.1960
2	-17	0.490	0.2156
3	-16	0.490	0.2254
4	-15	0.539	0.1862
5	-14	0.539	0.2058
6	-13	0.490	0.2058
7	-12	0.686	0.2989
8	-11	0.637	0.3038
9	-10	0.637	0.2940
10	-9	0.686	0.2695
11	-8	0.686	0.2597
12	-7	0.700	0.2891
16	-6	0.891	0.2997
18	-5	0.970	0.3104
19	-4	1.099	0.3589
20	-3	1.035	0.3492
21	-2	1.358	0.3977
22	-1	1.358	0.4009
23	0	1.358	0.3880
24	1	2.005	0.5432
25	2	9.183	1.7780
26	3	14.324	1.7780
27	4	19.303	1.7780
28	5	25.058	1.7780
29	6	26.028	1.7780
30	7	29.100	1.7780
31	8	31.581	3.1970
32	9	37.818	2.5443
33	10	46.332	2.3463
34	11	54.549	2.0889
35	12	67.815	1.7721
36	13	68.508	1.8591
37	14	88.407	1.2220
38	15	106.920	0.7986
39	16	101.970	0.6046
40	17	82.071	0.5690
41	18	>100.000	0.2231
42	19	>100.000	0.1875
43	20	>100.000	0.0808
44	21	>100.000	0.1649
45	22	>100.000	0.1649
46	23	>100.000	0.2198
47	24	>100.000	0.4300
48	25	>100.000	0.2328
49	26	>100.000	0.3136
50	27	>100.000	0.4332
51	28	>100.000	0.2813
52	29	>100.000	0.4914
53	30	>100.000	0.9473
54	31	>100.000	1.0346
55	32	>100.000	1.2060
56	33	>100.000	1.2480
57	34	>100.000	1.7460
58	35	>100.000	1.8042
59	36	>100.000	1.7072
60	37	>100.000	>1.778

Station P2B

July 1988

Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-21	0.637	0.2069
2	-20	0.637	0.2295
3	-19	0.637	0.2263
4	-18	0.735	0.2877
5	-17	1.176	0.2974
6	-16	0.686	0.2554
7	-15	0.735	0.2586
8	-14	0.833	0.2328
9	-13	0.776	0.2069
10	-12	0.905	0.3039
11	-11	1.078	0.3039
12	-10	0.833	0.3007
13	-9	1.078	0.3395
14	-8	0.905	0.2683
15	-7	1.028	0.3459
16	-6	1.390	0.4106
17	-5	1.358	0.3654
18	-4	1.681	0.3848
19	-3	1.176	0.3136
20	-2	1.617	0.4116
21	-1	1.274	0.3675
22	0	2.548	0.6223
23	1	7.306	1.6513
24	2	10.388	2.2932
25	3	12.838	2.5137
26	4	14.945	2.6558
27	5	17.003	2.7244
28	6	21.315	2.8567
29	7	23.814	2.8126
30	8	27.734	2.8714
31	9	32.472	2.8518
32	10	37.686	2.6829
33	11	41.778	2.0580
34	12	45.717	1.3365
35	13	44.946	1.3279
36	14	>53.900	0.8330
37	15	>53.900	0.7399
38	16	>53.900	0.3870
39	17	>53.900	0.1715
40	18	>53.900	0.0343
41	19	>53.900	0.0490
42	20	>53.900	0.0392
43	21	>53.900	0.0098
44	22	>53.900	0.0245
45	23	>53.900	0.0637
46	24	>53.900	0.0294
47	25	>53.900	0.0686
48	26	>53.900	0.2940
49	27	>53.900	0.8232
50	28	>53.900	0.1862
51	29	>53.900	0.1862
52	30	>53.900	0.2254
53	31	>53.900	0.4018
54	32	>53.900	0.4459

APPENDIX 2-CONTINUED

Station P2A

		February 1989	
Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-12	0.162	0.0226
2	-11	0.323	0.0808
3	-10	0.162	0.0194
4	-9	0.162	0.0194
5	-8	0.162	0.0162
6	-7	0.162	0.0162
7	-6	0.162	0.0162
8	-5	0.323	0.0452
9	-4	0.162	0.0162
10	-3	0.162	0.0170
11	-2	0.162	0.0162
12	-1	0.162	0.0162
13	0	0.162	0.0162
14	1	0.323	0.0162
15	2	0.323	0.0162
16	3	0.841	0.0162
17	4	0.420	0.0162
18	5	0.711	0.0162
19	6	0.420	0.0162
20	7	1.128	0.0408
21	8	1.056	0.1080
22	9	1.152	0.1104
23	10	1.056	0.1776
24	11	1.152	0.2088
25	12	1.152	0.1584
26	13	1.128	0.1584
27	14	1.104	0.1200
28	15	1.104	0.1152
29	16	1.104	0.1056
30	17	1.176	0.1152
31	18	1.104	0.1416
32	19	1.104	0.1392
33	20	1.104	0.1128
34	21	1.104	0.1224
35	22	1.104	0.1152
36	23	1.224	0.2304
37	24	1.152	0.1464
38	25	1.152	0.1392
39	26	1.152	0.1200
40	27	1.152	0.1416
41	28	1.200	0.1392
42	29	1.320	0.1416
43	30	1.320	0.1392
44	31	1.392	0.1776
45	32	0.490	0.0466
46	33	1.344	0.1200
47	34	1.992	0.1512
48	35	1.368	0.1344
49	36	1.536	0.1128
50	37	1.752	0.1392
51	38	1.536	0.1296
52	39	1.512	0.1128
53	40	1.536	0.0864
54	41	1.536	0.0864
55	42	1.536	0.1152
56	43	1.608	0.2064
57	44	1.536	0.2184
58	45	1.536	0.1896
59	46	1.728	0.2064
60	47	0.744	0.0312

Station P2B

		February 1989	
Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-13	0.744	0.0312
2	-12	0.744	0.0120
3	-11	0.816	0.0144
4	-10	0.888	0.0120
5	-9	0.816	0.0120
6	-8	0.768	0.0120
7	-7	0.744	0.0120
8	-6	0.264	0.1176
9	-5	0.120	0.0240
10	-4	0.120	0.0120
11	-3	0.120	0.0120
12	-2	0.120	0.0120
13	-1	0.120	0.0120
14	0	0.120	0.0120
15	1	0.888	0.0120
16	2	0.192	0.0552
17	3	0.432	0.0120
18	4	0.648	0.0288
19	5	0.264	0.0336
20	6	0.288	0.0264
21	7	0.408	0.0528
22	8	0.360	0.1056
23	9	0.408	0.1176
24	10	0.408	0.1824
25	11	0.408	0.2184
26	12	0.408	0.1536
27	13	0.408	0.1296
28	14	0.384	0.1296
29	15	0.384	0.1152
30	16	0.456	0.1320
31	17	0.384	0.1560
32	18	0.384	0.1560
33	19	0.384	0.1032
34	20	0.384	0.1584
35	21	0.360	0.1368
36	22	0.360	0.1320
37	23	0.384	0.1584
38	24	0.360	0.1824
39	25	0.360	0.1296
40	26	0.624	0.1584
41	27	0.624	0.1632
42	28	0.648	0.1608
43	29	0.840	0.1608
44	30	0.840	0.1560
45	31	0.696	0.1488
46	32	0.816	0.1464
47	33	0.816	0.1416
48	34	0.864	0.1368
49	35	0.816	0.1344
50	36	0.888	0.1104
51	37	1.032	0.1272
52	38	1.032	0.1488
53	39	0.888	0.1128
54	40	1.032	0.0888
55	41	1.008	0.0840
56	42	1.008	0.1344
57	43	1.224	0.2088
58	44	1.008	0.2088
59	45	1.224	0.2352
60	46	1.224	0.1488

APPENDIX 2-CONTINUED

Station P2

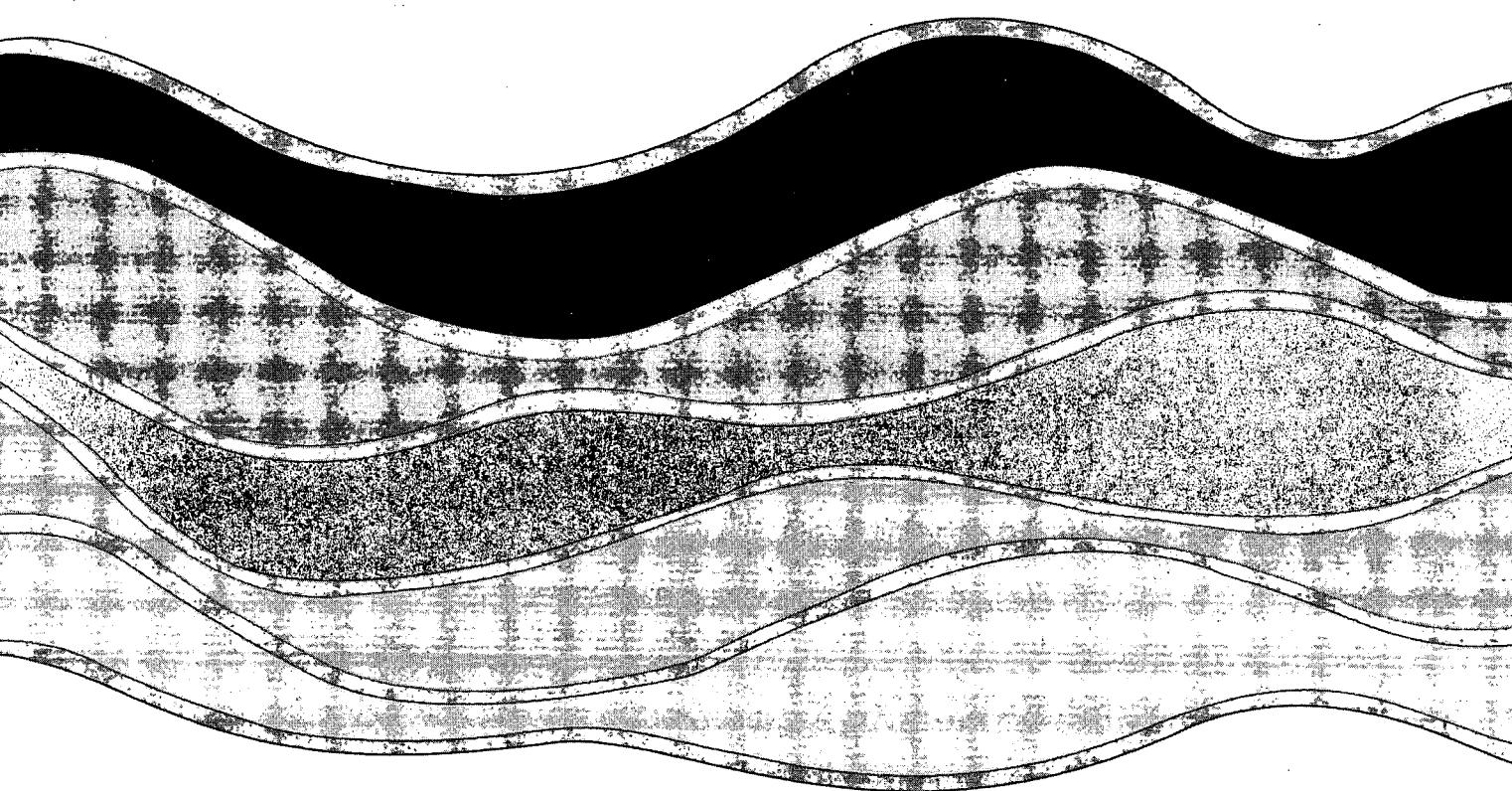
August 1989

Cell	Cell	NH3(mg/l)	SRP(mg/l)
1	-13	0.380	0.0120
2	-12	0.384	0.0182
3	-11	0.384	0.0120
4	-10	0.384	0.0168
5	-9	0.336	0.0240
6	-8	0.336	0.0312
7	-7	0.504	0.0480
8	-6	0.380	0.0264
9	-5	0.380	0.0240
10	-4	0.380	0.0120
11	-3	0.380	0.0120
12	-2	0.380	0.0240
13	-1	0.380	0.2856
14	0	0.336	0.5544
15	1	0.504	0.7008
16	2	0.744	0.9192
17	3	0.960	0.9648
18	4	1.200	0.9480
19	5	1.200	0.9144
20	6	1.032	0.9120
21	7	1.056	0.9288
22	8	0.960	0.9792
23	9	0.816	1.1784
24	10	0.840	1.2312
25	11	0.840	1.1784
26	12	0.816	1.1304
27	13	0.792	1.0104
28	14	0.816	0.9456
29	15	0.792	0.9528
30	16	0.816	1.0296
31	17	0.960	1.1256
32	18	0.816	1.2312
33	19	0.840	1.1400
34	20	0.936	1.1804
35	21	0.960	1.2312
36	22	0.960	1.2768
37	23	0.960	1.3608
38	24	0.960	1.2096
39	25	0.960	1.4064
40	26	0.936	1.3992
41	27	0.936	1.5672
42	28	0.936	1.2096
43	29	0.984	1.1664
44	30	0.960	1.0416
45	31	0.960	1.0224
46	32	0.960	0.9744
47	33	1.104	0.9576
48	34	0.960	0.9624
49	35	1.368	0.9312
50	36	1.080	0.9312
51	37	1.104	0.8496
52	38	1.104	0.8712
53	39	1.752	0.9312
54	40	1.320	0.9024
55	41	1.296	0.8496
56	42	1.344	0.8664
57	43	1.368	0.8568
58	44	1.368	0.8184
59	45	1.896	0.8640
60	46	1.488	0.8136
61	47	4.992	0.9528
62	48	1.536	0.9624
63	49	1.680	0.8496
64	50	1.488	0.8088
65	51	1.488	0.9480
66	52	1.512	0.9072
67	53	1.580	0.9216
68	54	1.680	1.0128
69	55	1.776	0.0192
70	56	0.528	0.0264

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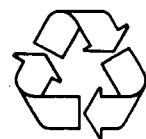


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