

2001-2002

**BEAR LAKE MONITORING
DATA SUMMARY**

Prepared for:

**BEAR LAKE REGIONAL COMMISSION
Fish Haven, Idaho**

Prepared by:

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INTRODUCTION

Water quality conditions were monitored in a single mid-lake station on Bear Lake during 2001-2002. The purpose of the Bear Lake monitoring program has been to:

- 1) Evaluate current water quality conditions in Bear Lake; and**
- 2) Maintain the current water quality database.**

Data was collected from the middle station of Bear Lake on six dates between July 11, 2001 and June 12, 2002. A map designating the sample location as well as long-term water quality plots are included in Appendix A. Raw data are presented in Appendix B. The following is a summary of the Bear Lake data.

BEAR LAKE WATER QUALITY

Bear Lake was sampled from July 2001 to June 2002. This sampling occurred twice during both summer and winter stratifications, and once in spring and fall turnover. Samples were taken from the middle station (approximately 60 meters in depth) at ten meter intervals.

Surface and bottom total phosphorus (TP) concentrations were less than detection (5 µg/L) in nearly 40 percent of the samples (Figure 1). When results were less than the detection limit, half the value (2.5 µg/L) was used for sample values in this analysis. During the 1999 and 2000 sampling period, the average surface total phosphorus concentrations in Bear Lake ranged from 2.5 to 6.5 µg/liter. Bottom concentrations ranged from 2.5 to 12.8 µg/liter. February 2001 exhibited the highest concentrations throughout the lake, while the end of April brought levels which were less than detection at all depths. This pattern is similar to other years in which winter concentrations of phosphorus tended to be higher than spring levels. However, the 2000-2001 monitoring year results contain slightly lower overall concentrations of phosphorus than the previous year. This may be related to the continued drop in elevation of Bear Lake.

Average surface and bottom orthophosphorous (OP) concentrations were similar during the 2001-2002 monitoring program (Figure 2), ranging from 0.5 to 6.0 µg/liter in the epilimnion and 0.5 to 4 µg/liter in the hypolimnion. Less than detection results (<1 µg/L) accounted for 23 percent of the samples. The highest concentration of OP was observed in June 2002, but only in the epilimnion. December 2001 had the lowest concentrations in which all depths were less than detection.

Surface total inorganic nitrogen (TIN) concentrations have started to stabilize since exhibiting the most dramatic change of any parameter monitored since the spring of 1997 (Figure 3). Concentrations have nearly returned to pre-1997 levels. During spring runoff in 1997, large quantities of total inorganic nitrogen ($\text{NH}_3 + \text{NO}_3 + \text{NO}_2$) were flushed into Bear Lake from the Bear Lake marsh. Levels remained elevated for nearly four years, with nitrate-nitrogen contributing the most (Figure 4). Starting in 2000, nitrate concentrations have almost completely disappeared. Average nitrate-nitrogen decreased dramatically during the 2001-2002 monitoring season. Average surface concentrations ranged from 2.2 µg/liter in June 2001 to a high of 10.8 µg/liter in July 2002. Compared to the historical dataset, this peak was not significant (Figure 5,



top). The highest nitrate concentrations (28-34 µg/liter) were found in the hypolimnion during the summer stratification in 2001.

Average surface ammonia concentrations ranged from 24 to 141 µg/liter (Figure 5, bottom). All samples were above detection levels, compared to 30 percent of the samples below detection in the 2000-2001 monitoring period. Unlike the previous two years, the hypolimnion did not experience generally higher concentrations of ammonia than the epilimnion. Seasonally concentrations peaked in the fall of 2001 and in the summer of 2002. Overall, the average concentrations of ammonia were consistent with past year's concentrations.

Water transparency, measured with a secchi disk, ranged from 7.30 meters on July 11, 2001 to a minimum of 2.05 meters in December 2001 (Figure 6, top). During this monitoring season, the lake had transparencies greater than five meters 40 percent of the time. Chlorophyll-*a* concentrations in the surface waters were highest in July 2001 (0.39 µg/liter) and lowest in December 2001 (0.04 µg/liter). At first glance, this seems inconsistent relative to water transparency. However, because Bear Lake is oligotrophic, the transparency is more related to the abiotic turbidity (CaCO₃) rather than the biology which is expressed as chlorophyll-*a* (Figure 6, bottom).

Average surface and bottom pH levels were similar to the previous monitoring years (1996-2000), ranging from a low of 7.49 and 7.80 (epilimnion and hypolimnion, respectively) to a high of 8.49 pH units and 8.33 pH units (Figure 7). The pH levels reached their lowest levels during the most mixed periods of the lake (September 2001 and April 2002).

Bottom temperatures during the entire monitoring period did not exceed 3.5°C, and the highest temperature in the epilimnion was 20.46°C, recorded on July 11, 2001 (Figure 8). Compared to the data collected since 1996, this monitoring period showed a similar overall temperature of both the hypolimnion and the epilimnion. The lake was stratified during both summer sampling events, and had started the stratification during the second spring turnover sampling event (Figure 9).

Hypolimnetic dissolved oxygen concentrations ranged from 5.11 to 9.72 mg/liter during the monitoring period (Figure 10). Epilimnetic concentrations of dissolved oxygen ranged from 7.12 to 10.28 mg/liter. With the exception of lower concentrations of oxygen in the hypolimnion during the summer sampling events, the year was similar to the last monitoring season (2000-2001). These lower concentrations (6.12 and 5.11 mg/L during July through September sampling events, respectively), correspond to the increase in total inorganic nitrogen, primarily nitrate.



SUMMARY

Plots of the long-term water quality data and a map of the long-term monitoring location are presented in Appendix A. Tables of raw data for Bear Lake are included in Appendix B.

During the 2001-2002 monitoring season, total phosphorus continued the trend toward declining levels, ranging from below detection ($<5 \mu\text{g/L}$) to $13 \mu\text{g/liter}$. The lake averaged $5.9 \mu\text{g/liter}$ for the entire monitoring season. Orthophosphorus remained low as well, ranging from below detection ($<1 \mu\text{g/L}$) to $4 \mu\text{g/liter}$, and averaging $1.7 \mu\text{g/liter}$ for the entire monitoring season. Total inorganic nitrogen continued to decrease throughout 2001 and 2002 and seems to have returned to pre-1997 levels. Most of the decrease in total inorganic nitrogen was due to the reduction of nitrate-nitrogen within the system. An increase in hypolimnetic nitrate levels was observed during summer of 2001, but returned to low levels by the fall sampling..

The system is currently calculated to be phosphorus limited.

RECOMMENDATIONS

1. The revised Bear Lake monitoring program is sensitive in its ability to detect changes in the physical and chemical water quality conditions in Bear Lake and should be continued.
2. Sampling of the marsh sites (Causeway, Lifton, Stewart Dam and the Outlet) was discontinued in July 1998. Additional funding should be found in order that this program can monitor both the lake and marsh sample sites. Annual nutrient loading for Bear lake needs to be determined.
3. During the technical exchange at Bear Lake in the spring of 1998, it was suggested that a detailed hydrologic budget be conducted on the lake. It is recommended that the Bear Lake Regional Commission take the lead on this task and link a nutrient budget to this effort. A detailed nutrient budget is needed for the lake.
4. New environmental studies (Ruzycki et al. 2001) have indicated that stocked lake trout and cutthroat trout are having an impact on the endemic prey species of Bear Lake. Funding should be sought that will allow the existing fisheries data to be entered into an electronic database for subsequent analysis.

REFERENCES

Ruzycki, J.R, W.A. Wurtsbaugh and C. Luecke. 2001. Salmonine Consumption and Competition for Endemic Prey Fishes in Bear Lake, Utah-Idaho. Transactions of the American Fisheries Society 130: 1175-1189.



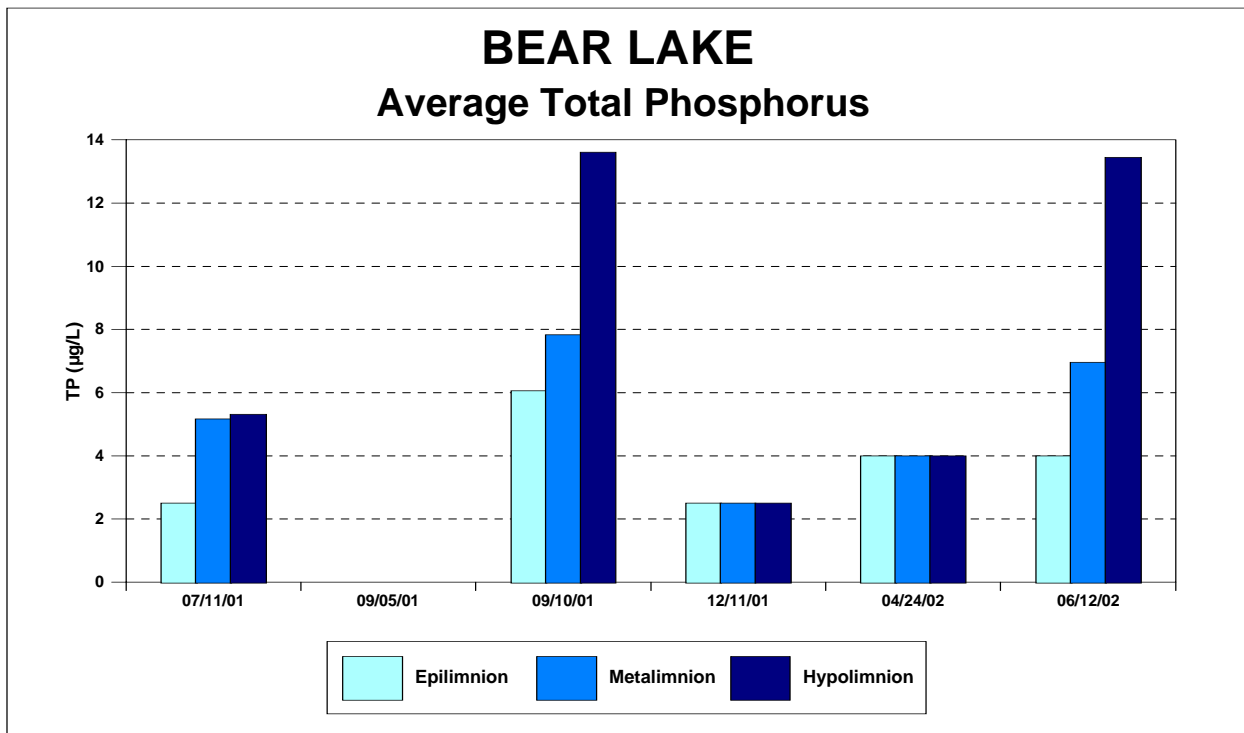
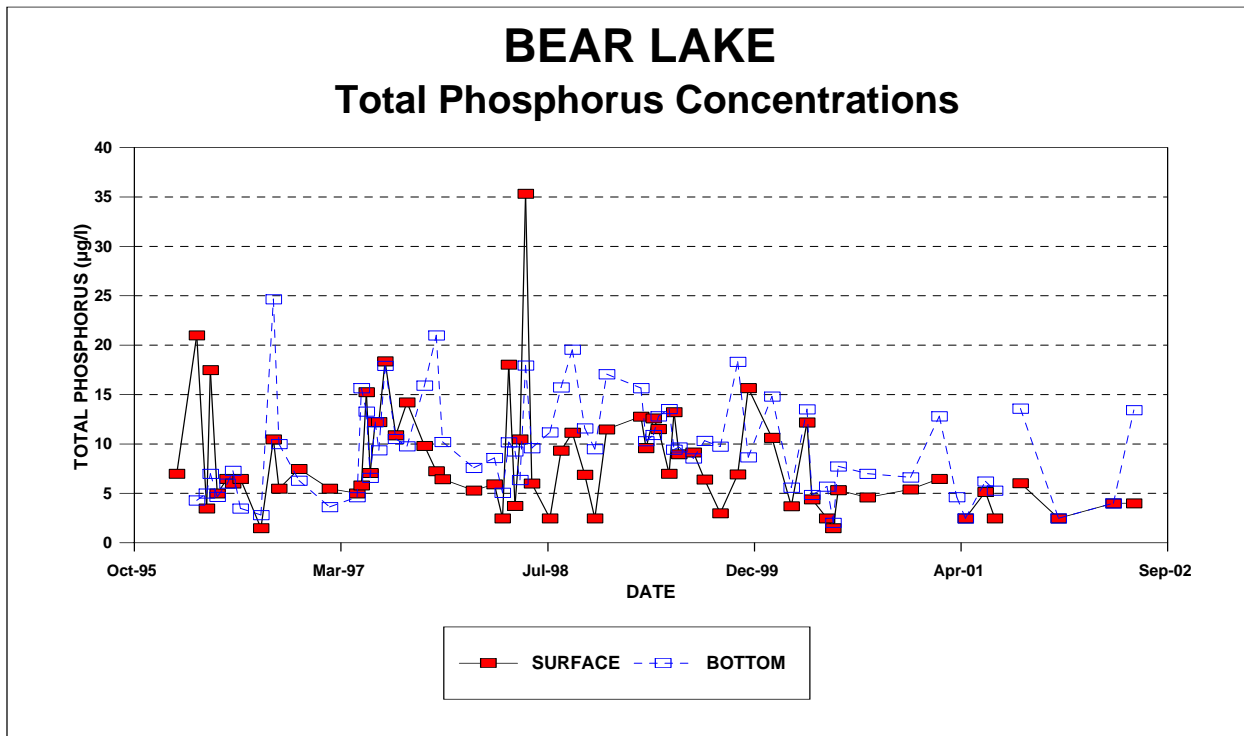


Figure 1. Concentrations of total phosphorus in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).



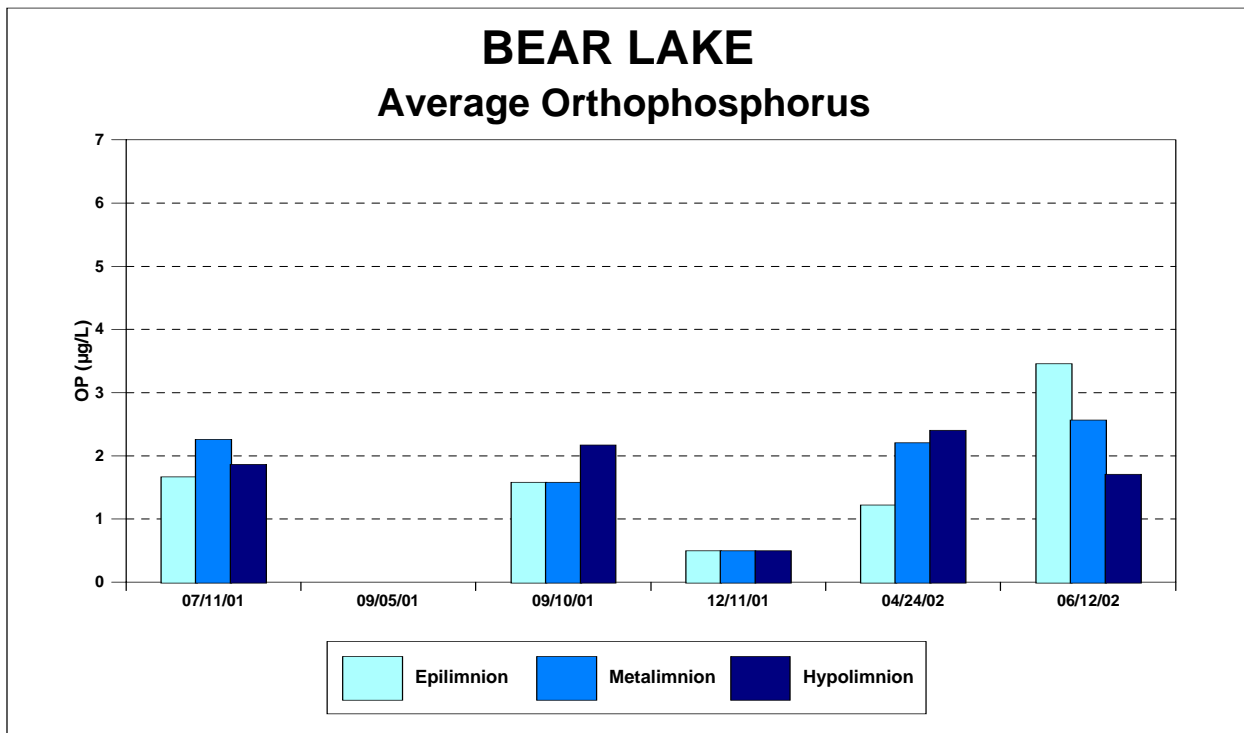
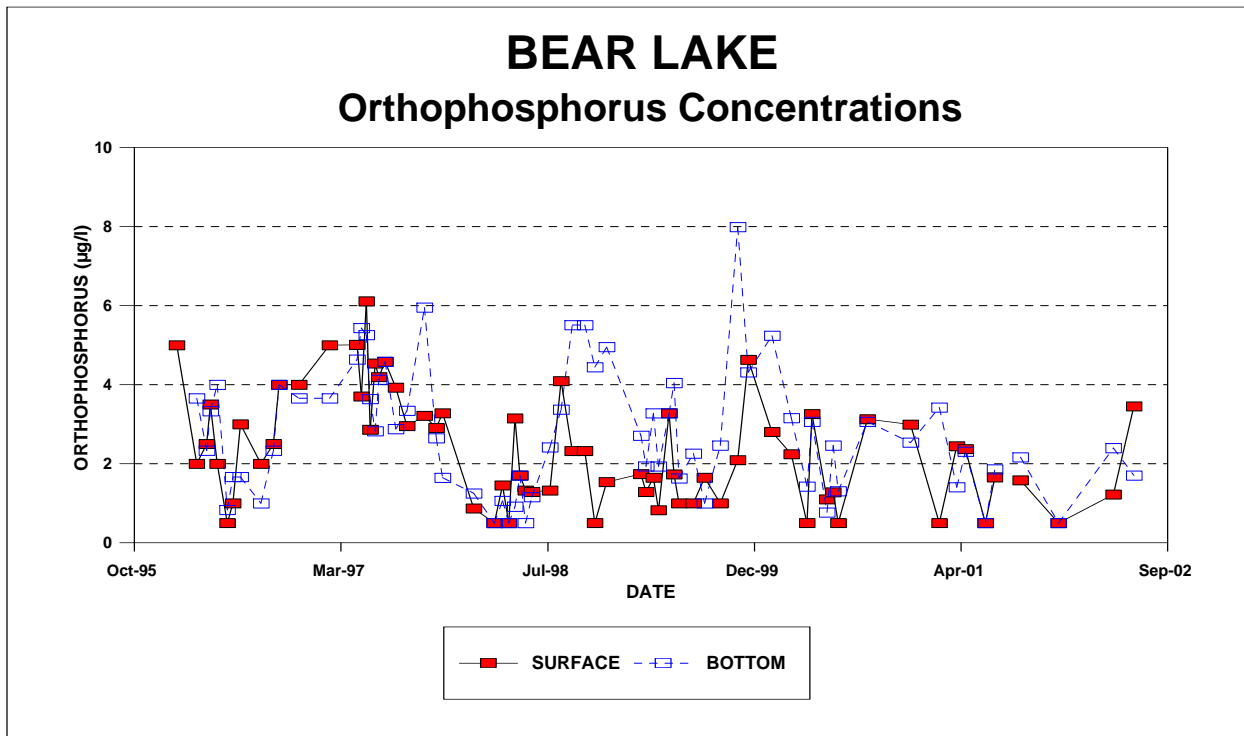


Figure 2. Concentrations of orthophosphorus in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).



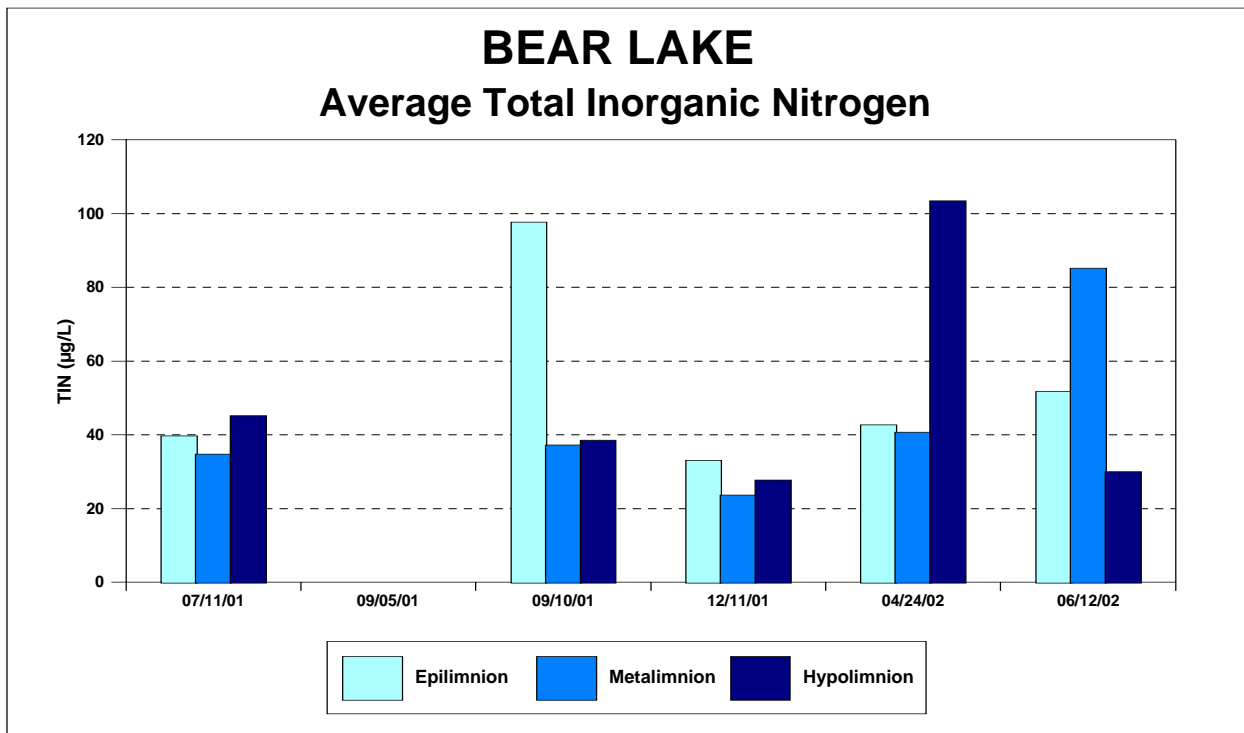
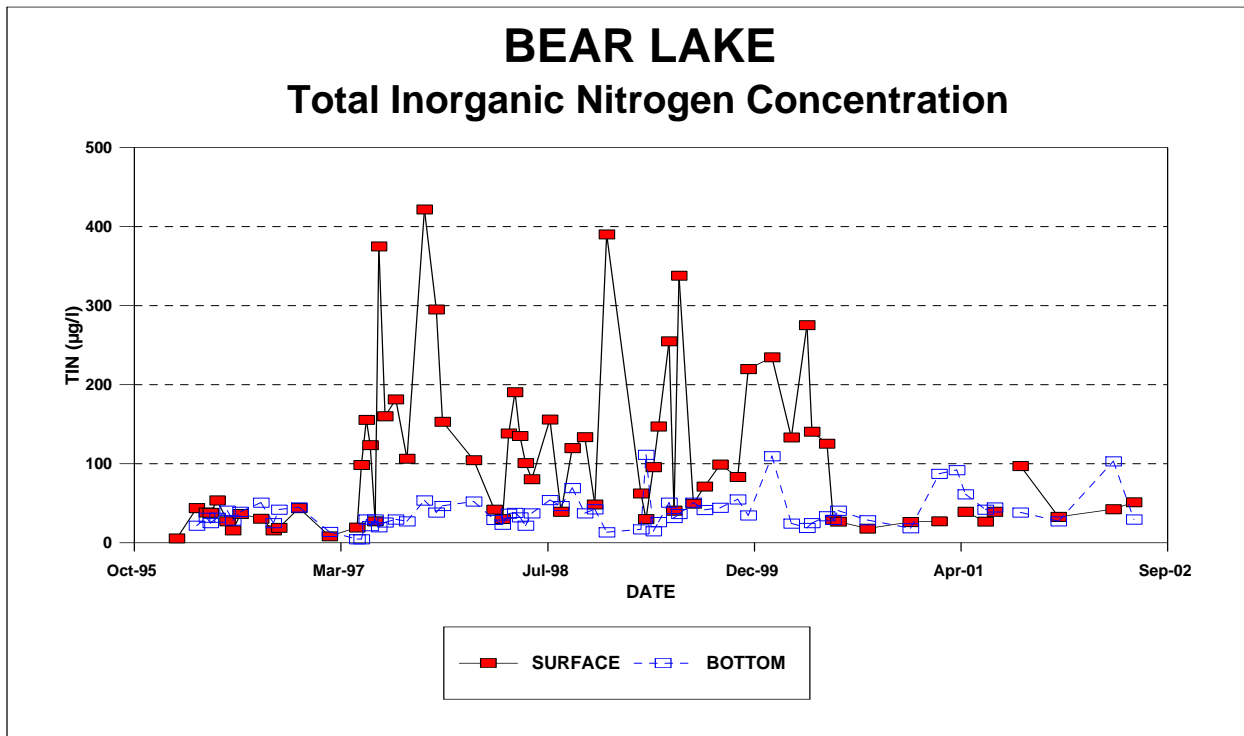


Figure 3. Concentrations of total inorganic nitrogen ($\text{NH}_3+\text{NO}_3+\text{NO}_2$) in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).



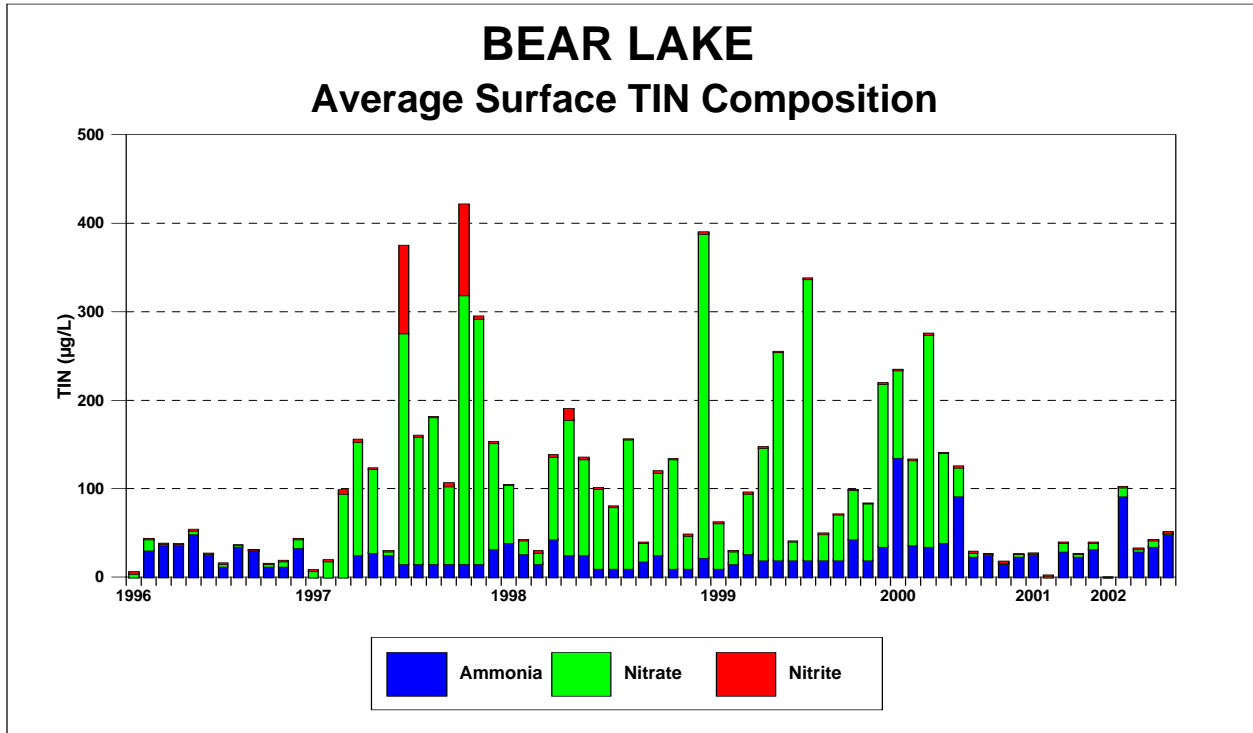


Figure 4. Total inorganic nitrogen composition of the epilimnion in Bear Lake since 1996.



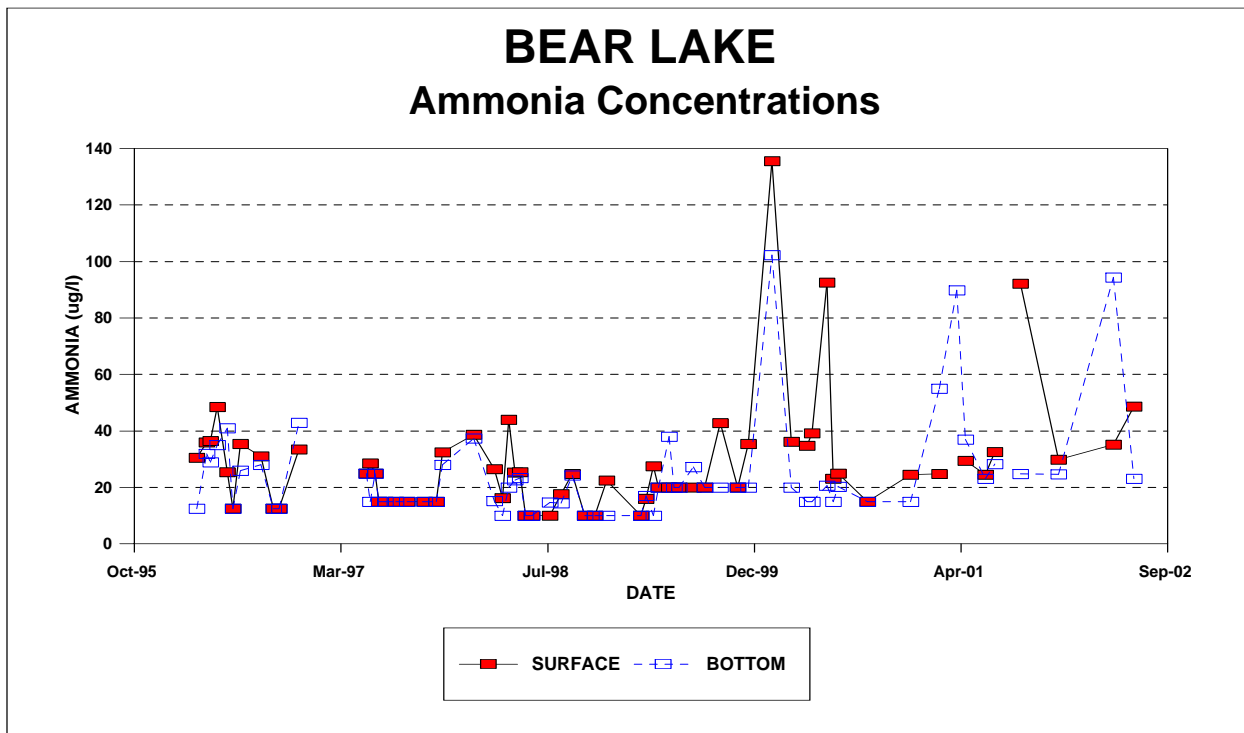
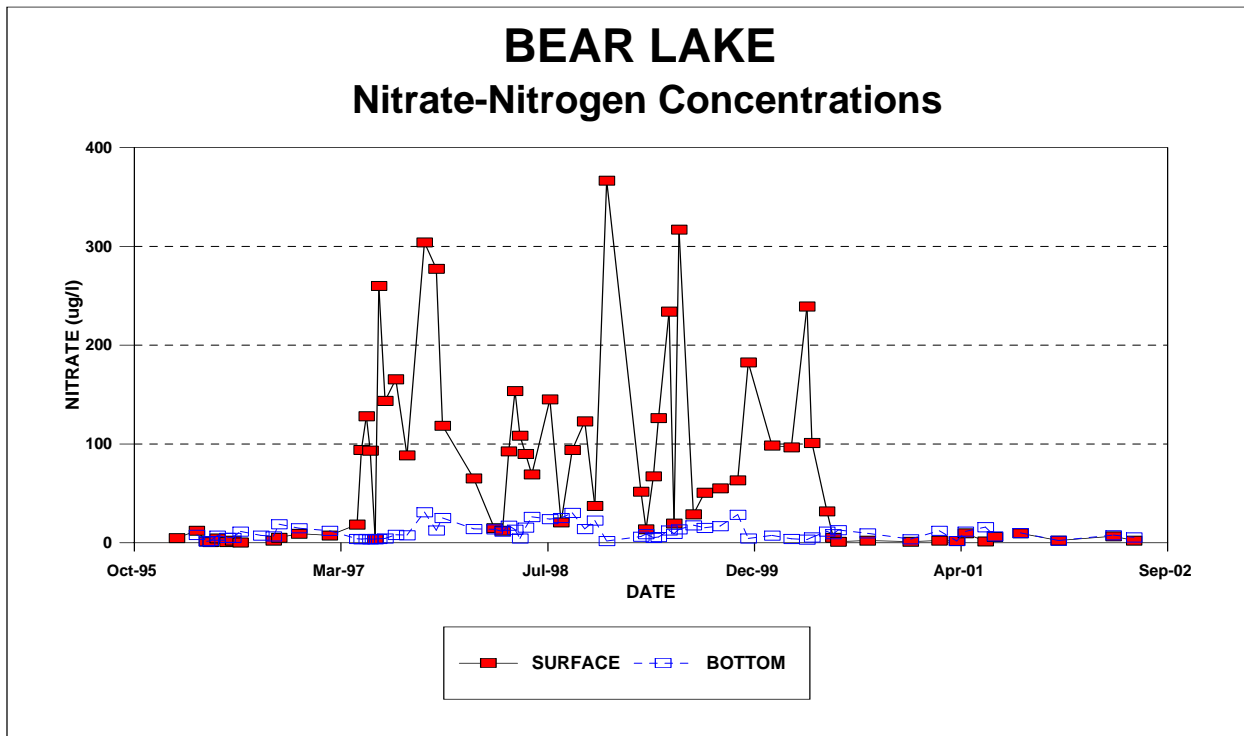


Figure 5. Concentrations of nitrate-nitrogen (above) and ammonia (below) in the surface and bottom waters of Bear Lake since 1996.



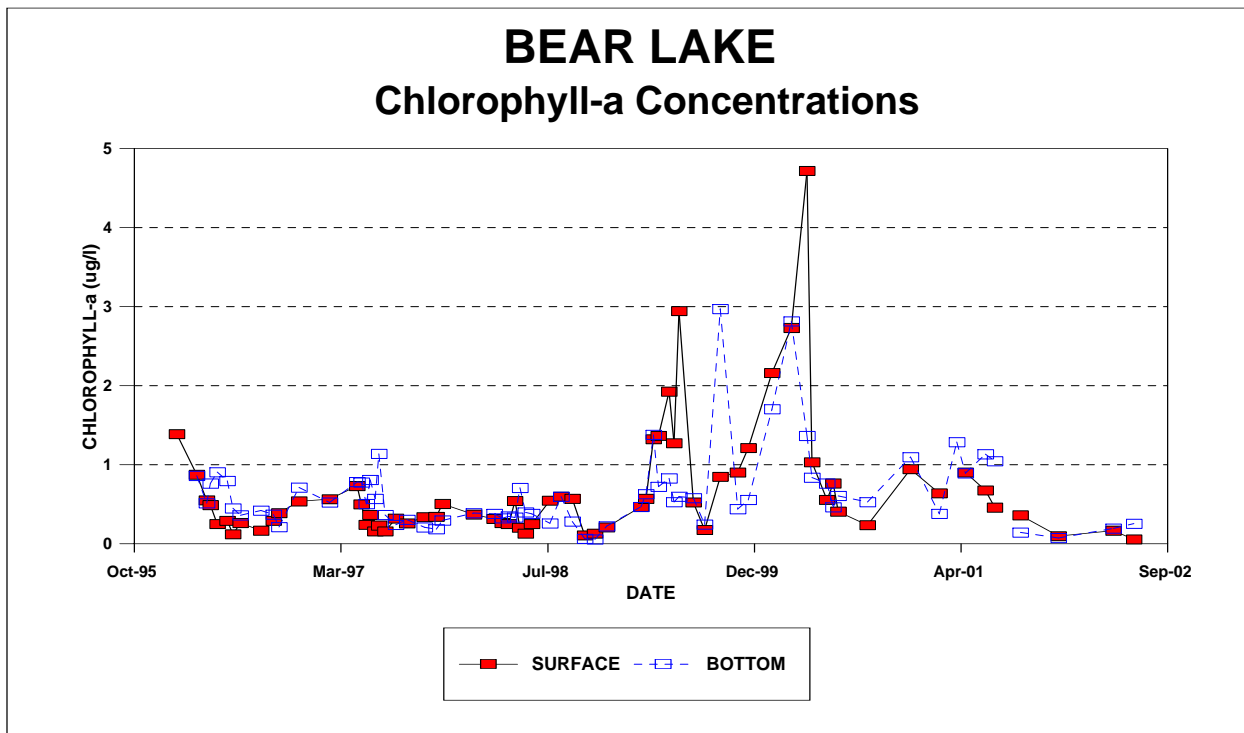
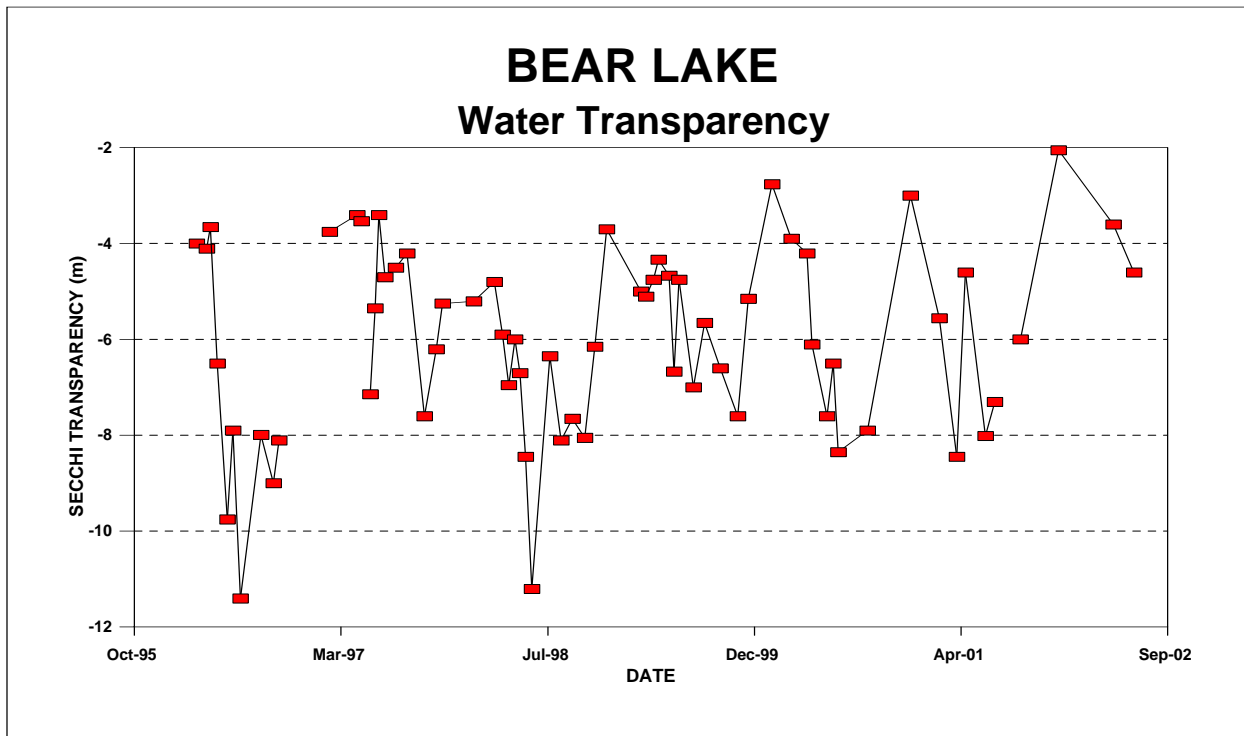


Figure 6. Water transparency (above) and surface and bottom chlorophyll-a concentrations in Bear Lake since 1996.



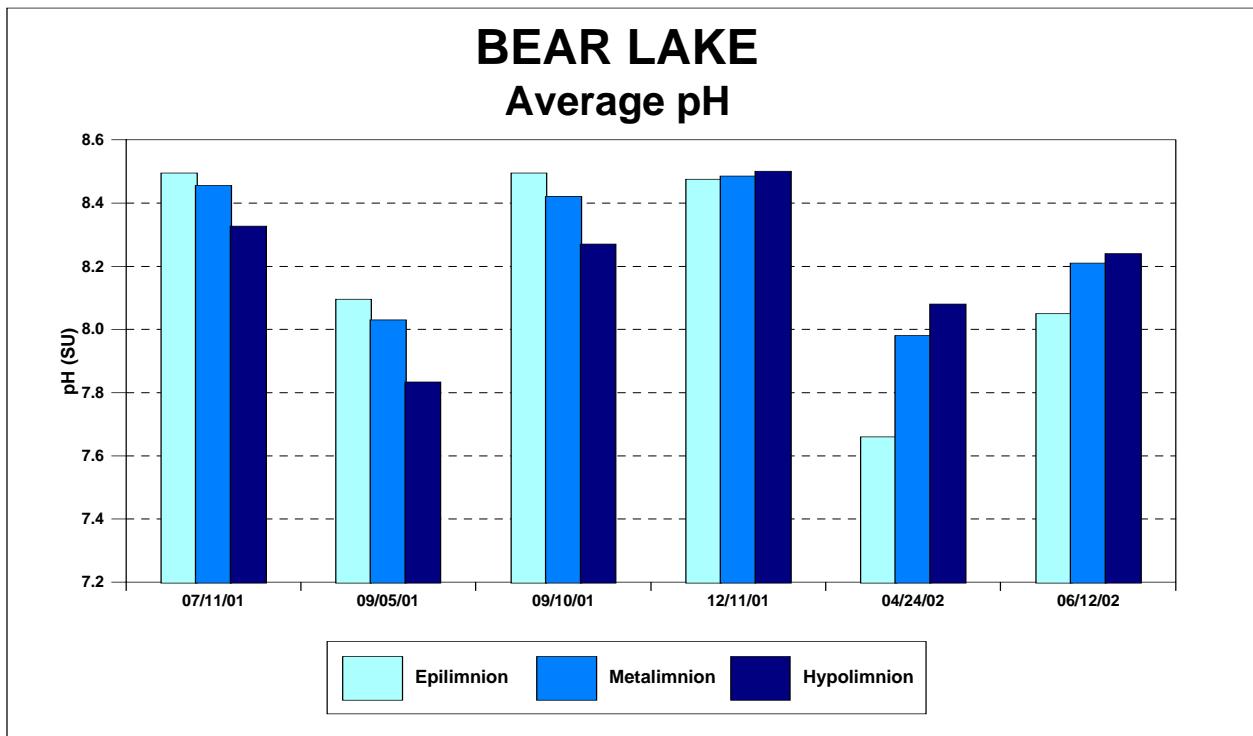
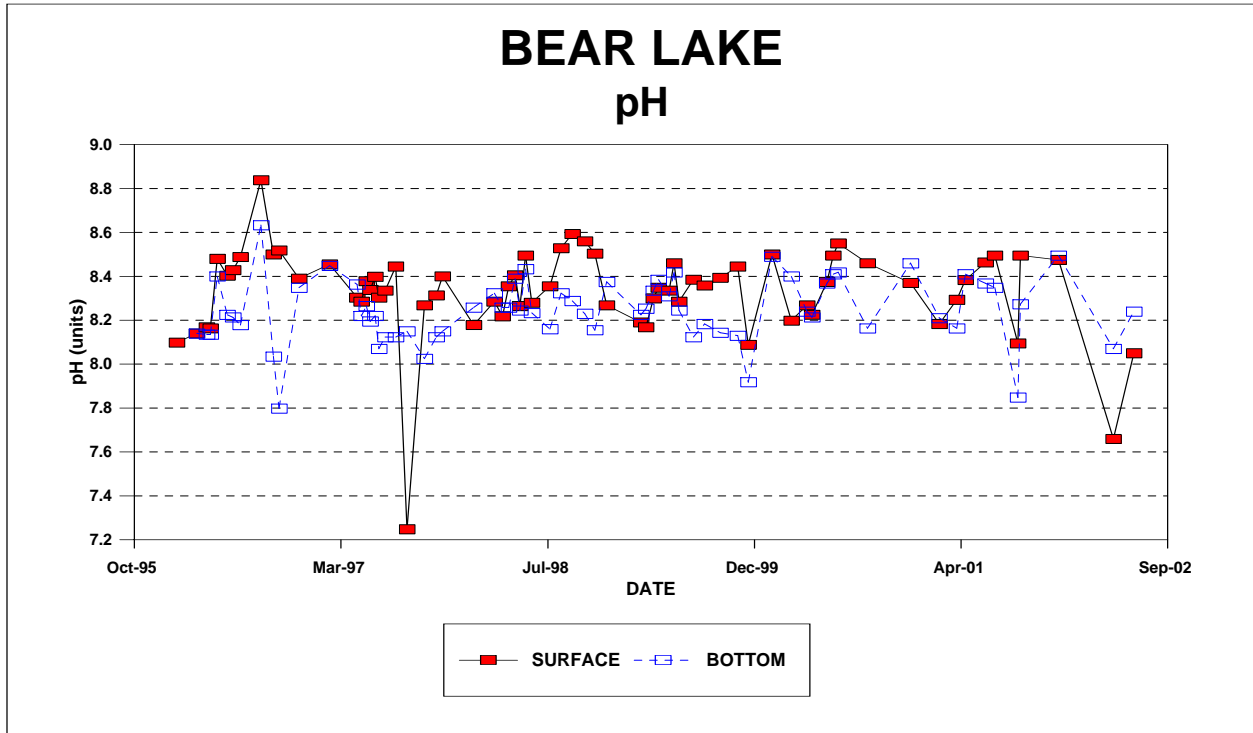


Figure 7. pH levels in the surface and bottom waters of Bear Lake since 1996 (above) and average levels within each layer of the lake for the monitoring period (below).



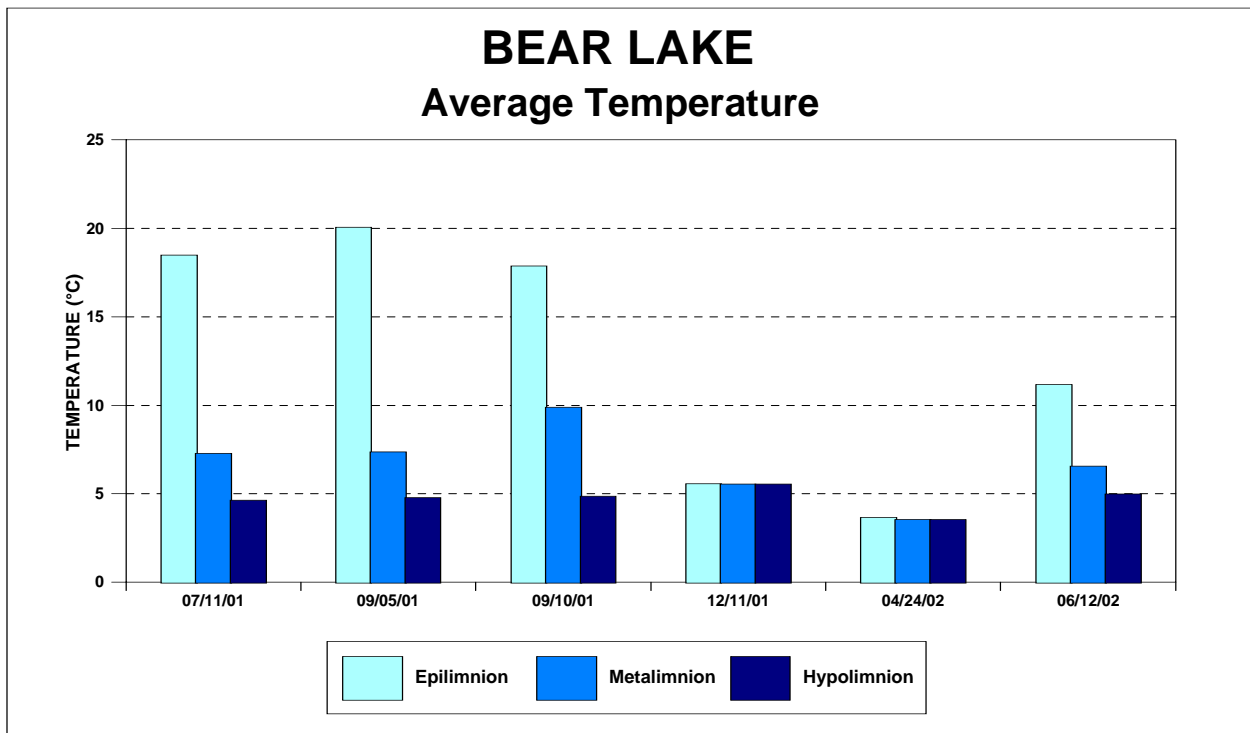
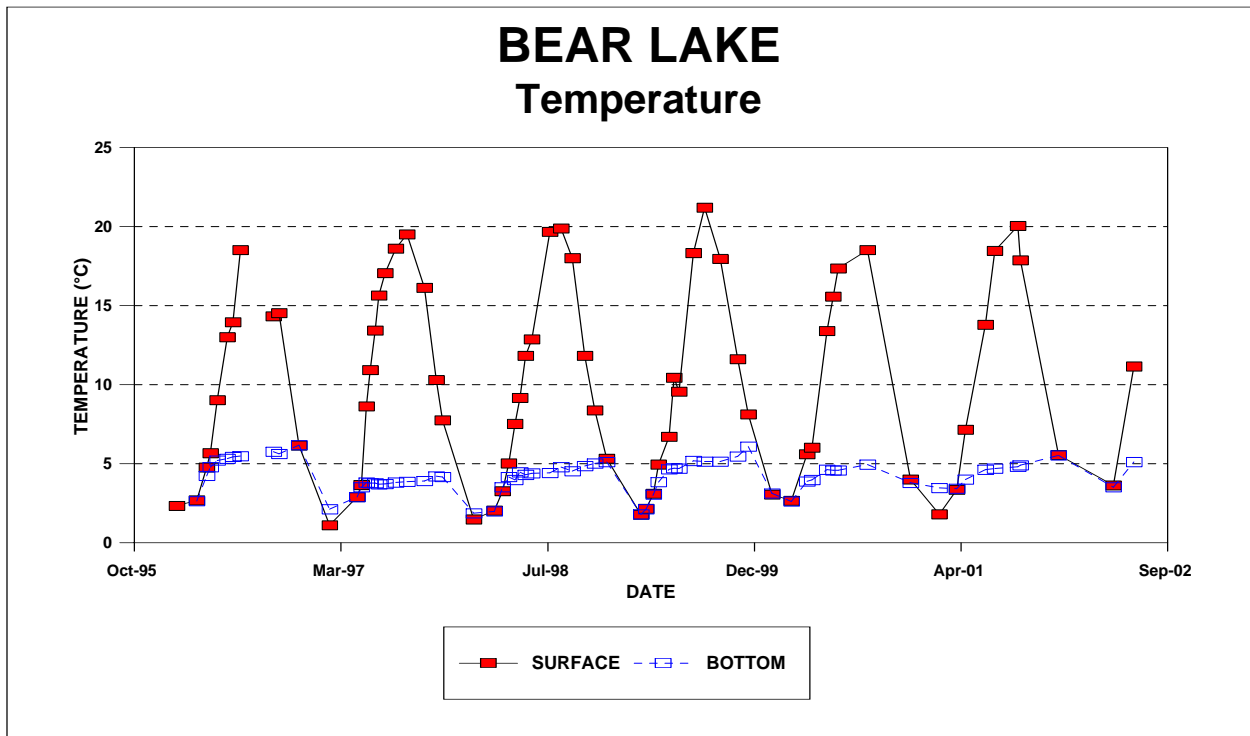


Figure 8. Temperature of the surface and bottom waters of Bear Lake since 1996 (above) and average temperature within each layer of the lake for the monitoring period (below).



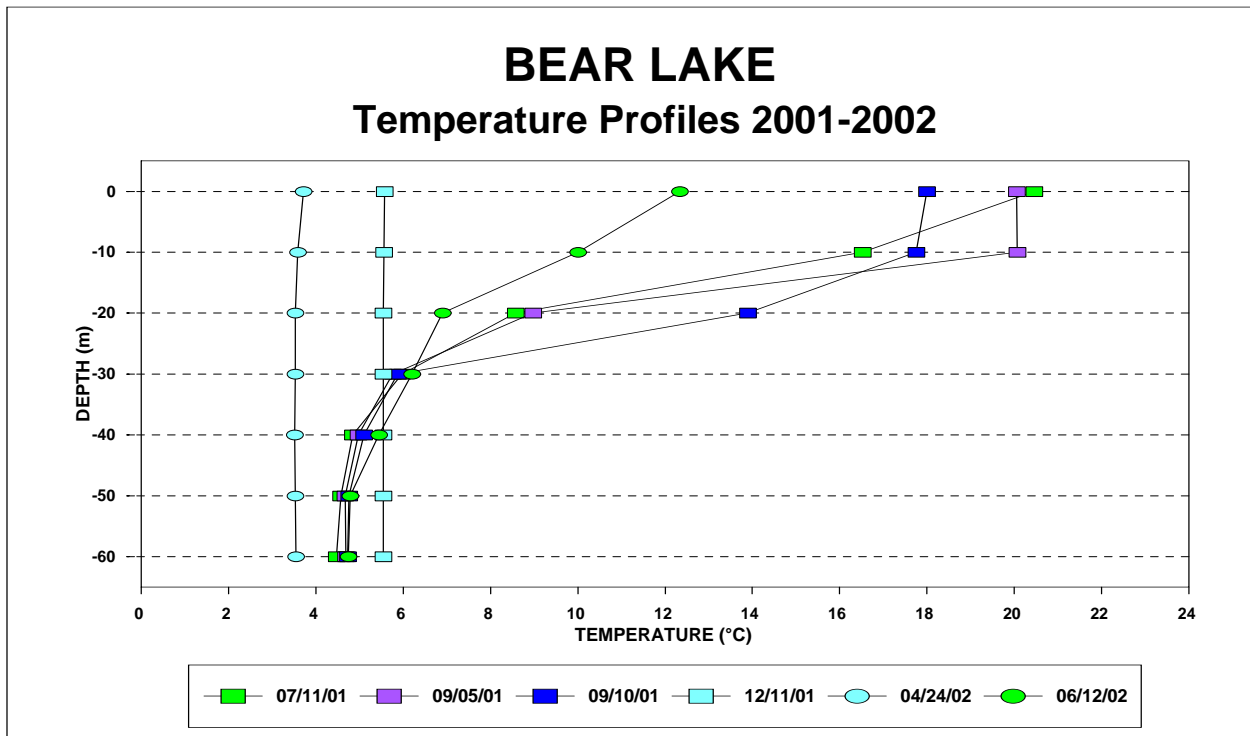


Figure 9. Temperature profiles of Bear Lake for each sampling event during the monitoring period. Green indicates summer stratification, cyan is spring turnover, purple and blue are fall and winter conditions, respectively.



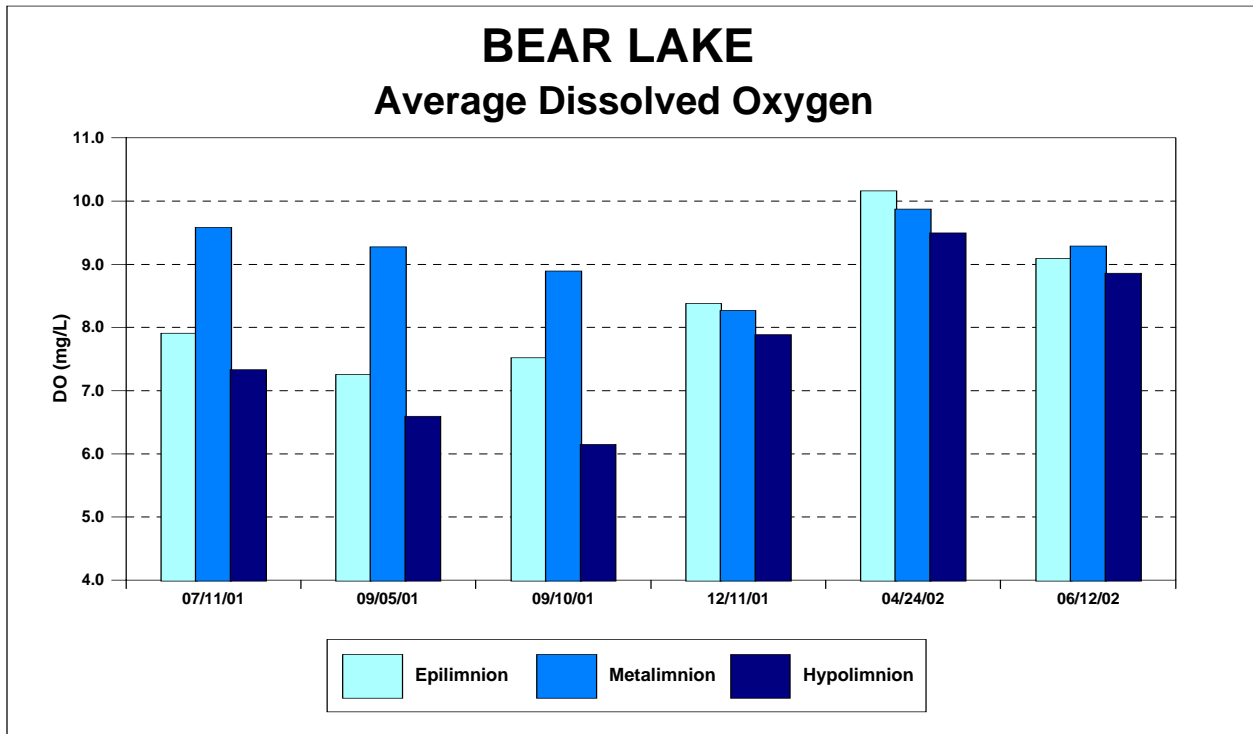
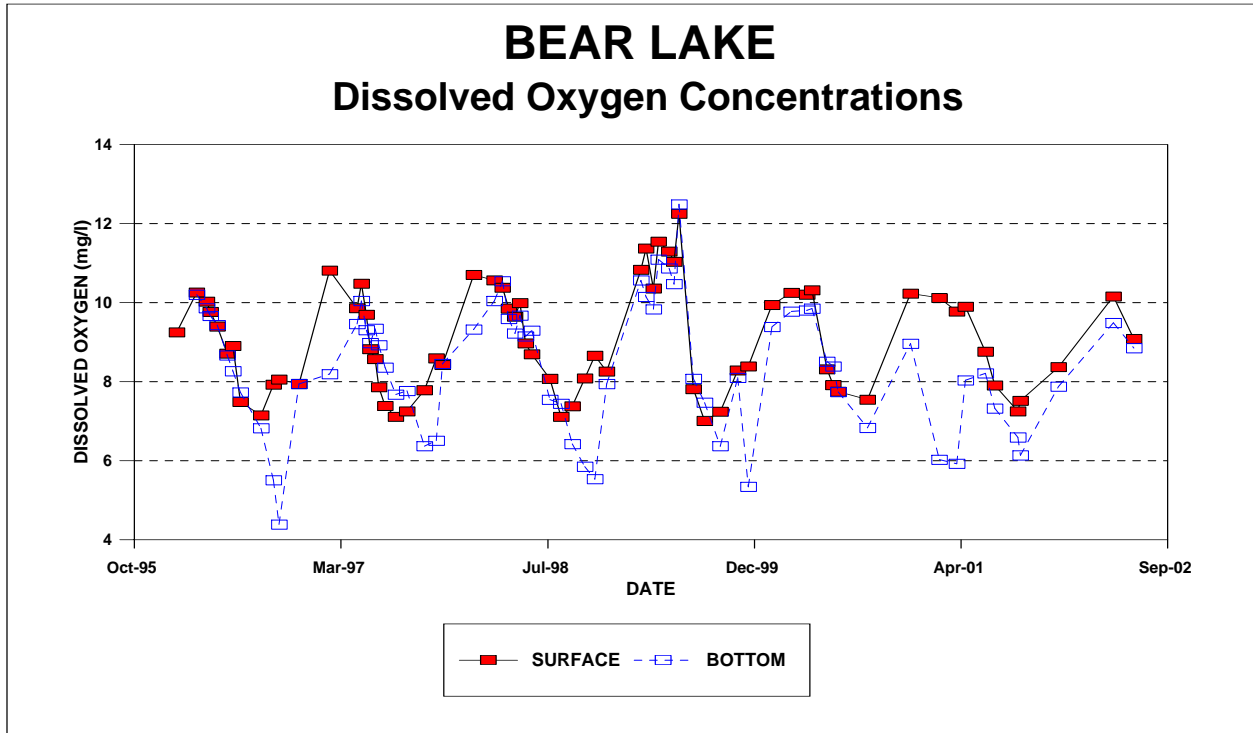


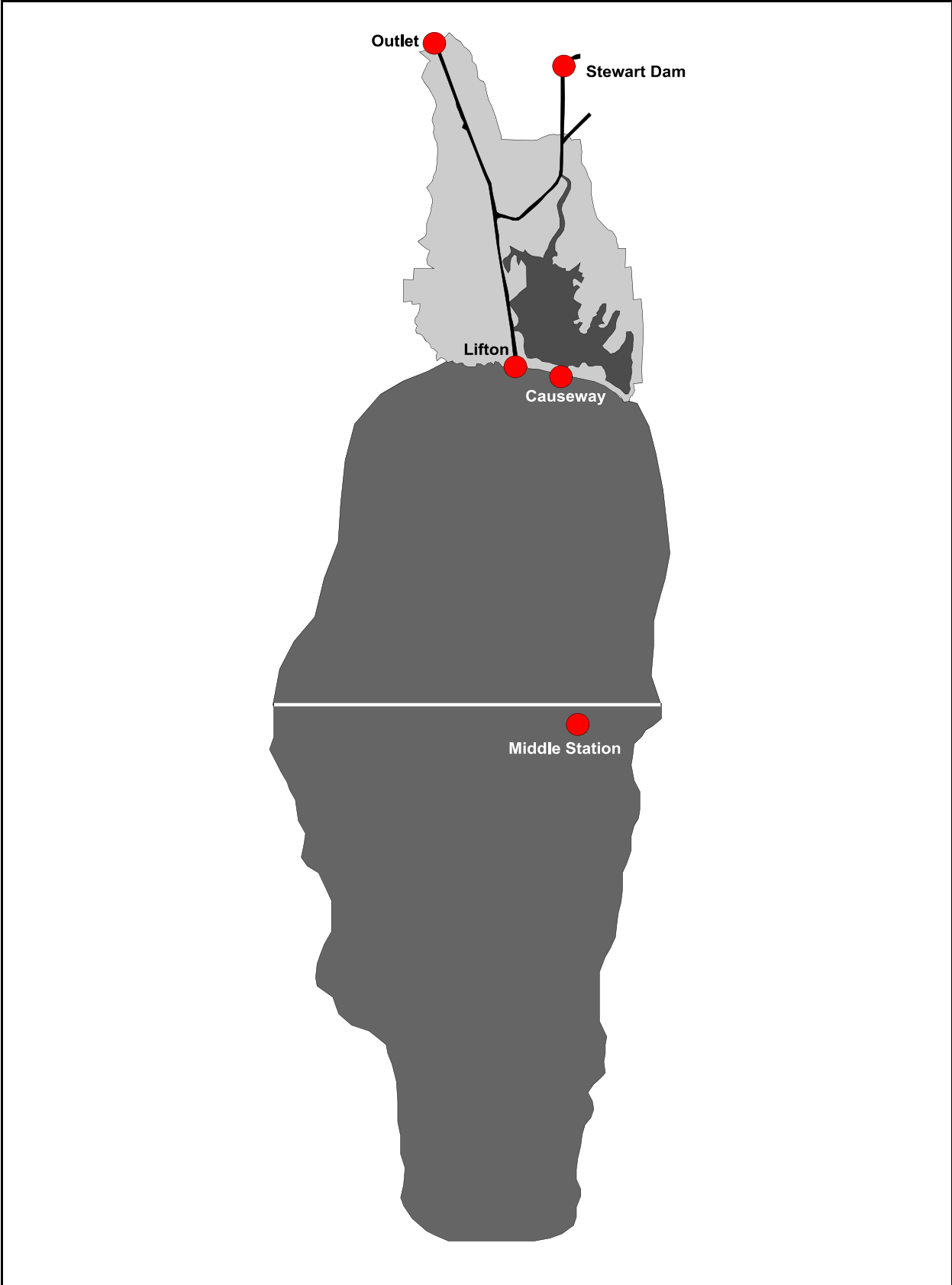
Figure 10. Dissolved oxygen concentrations in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).



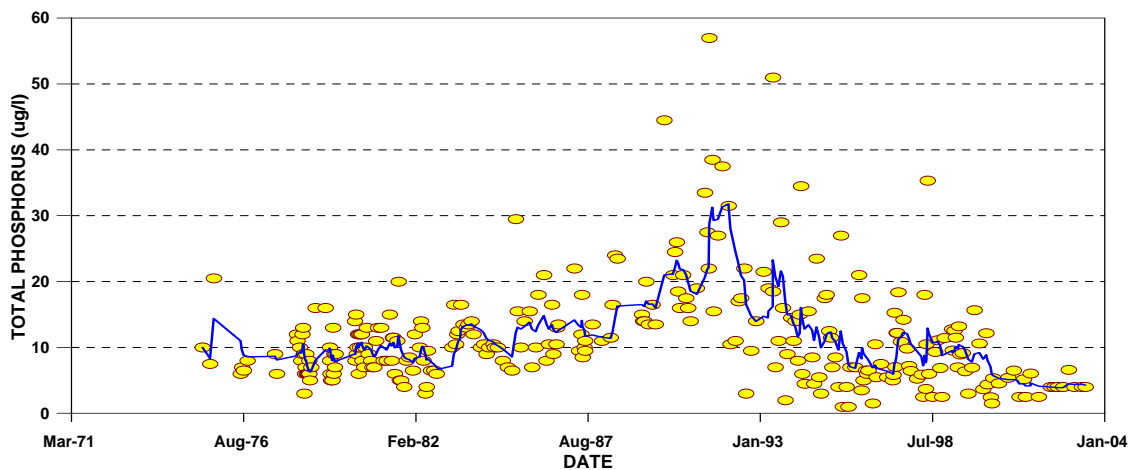
APPENDIX A

Graphs of Long-term Water Quality Data Monitoring Locations

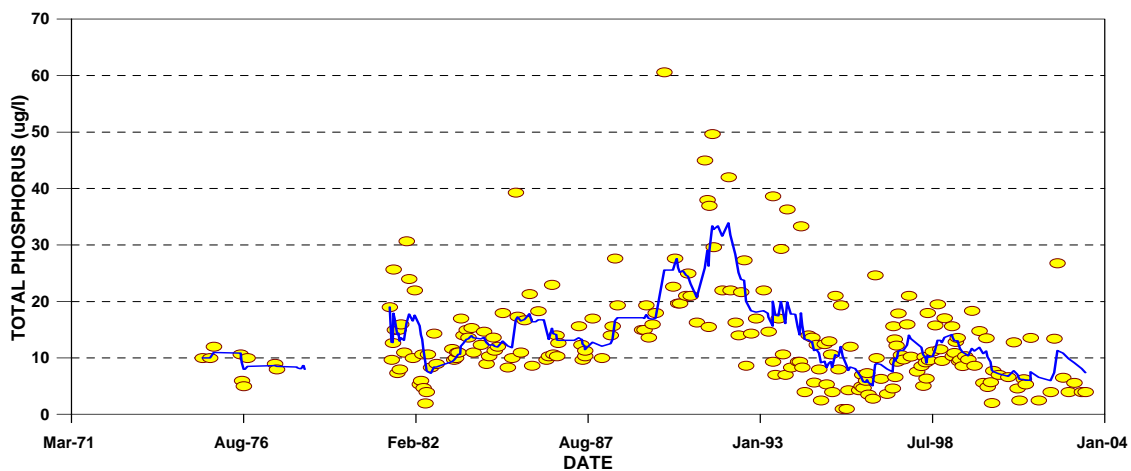




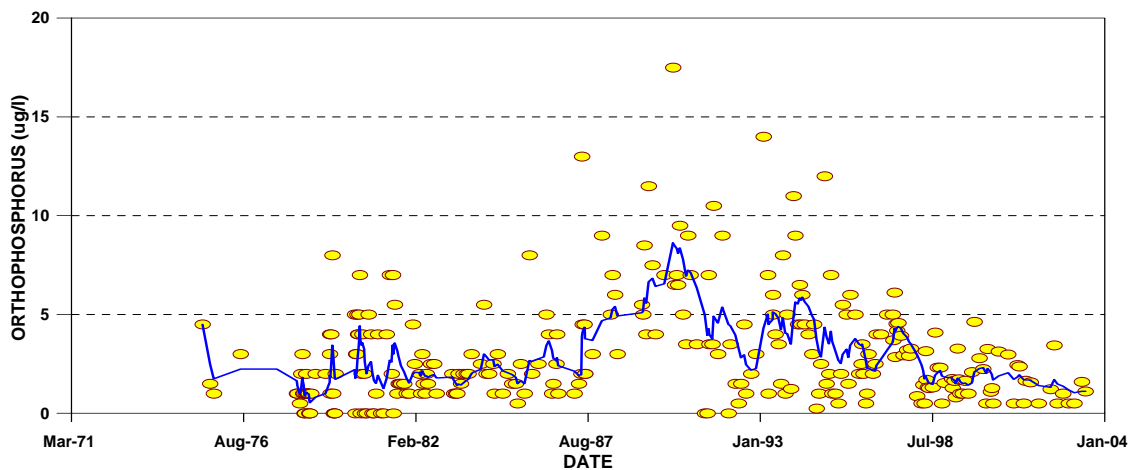
AVERAGE SURFACE CONCENTRATION TOTAL PHOSPHORUS



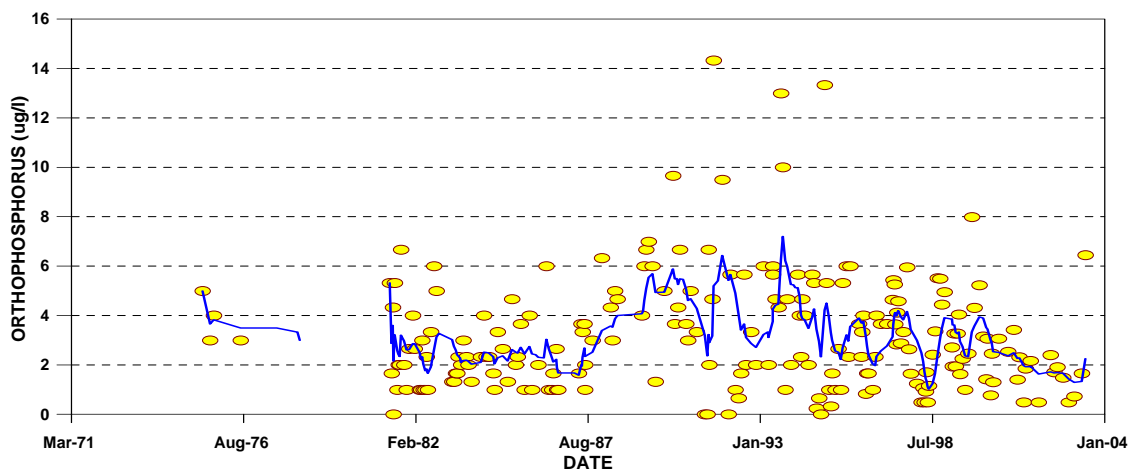
AVERAGE BOTTOM CONCENTRATION TOTAL PHOSPHORUS



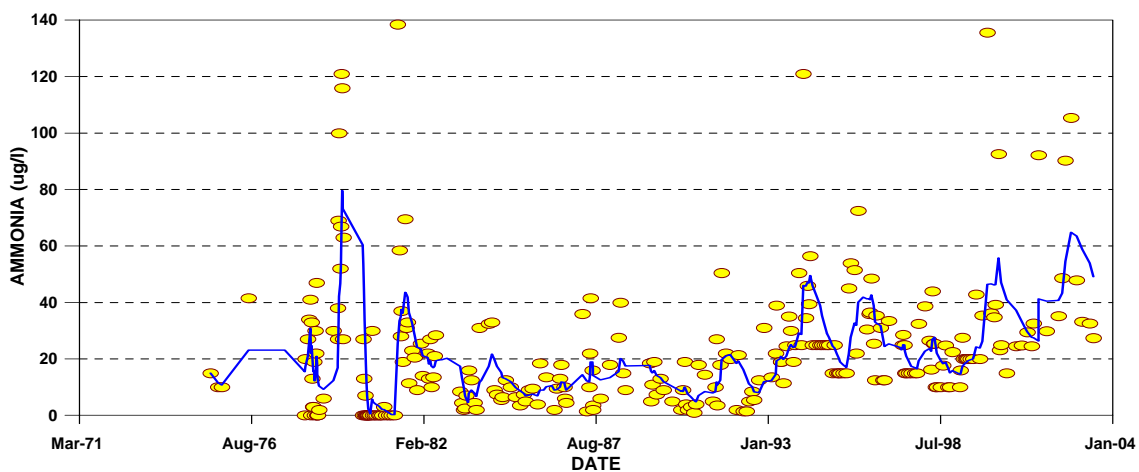
AVERAGE SURFACE CONCENTRATION ORTHOPHOSPHORUS



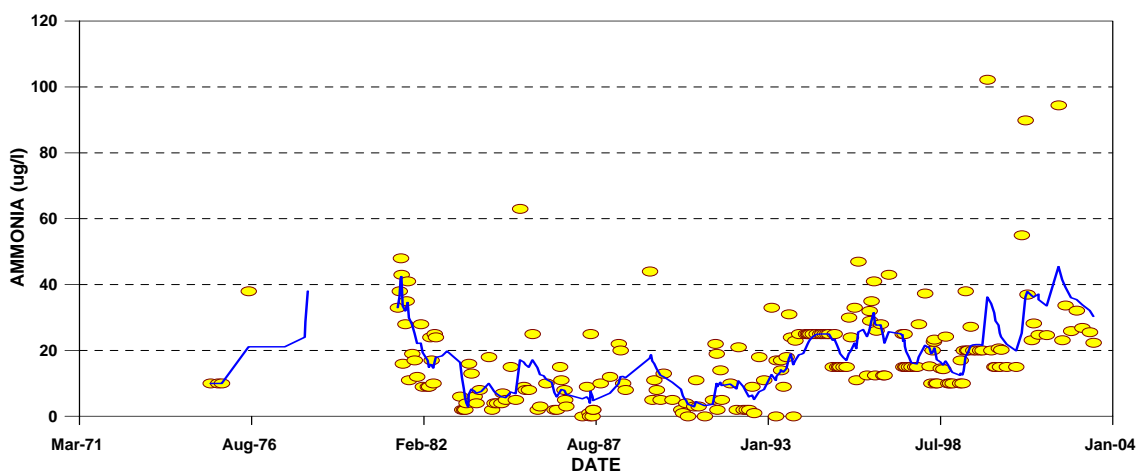
AVERAGE BOTTOM CONCENTRATION ORTHOPHOSPHORUS



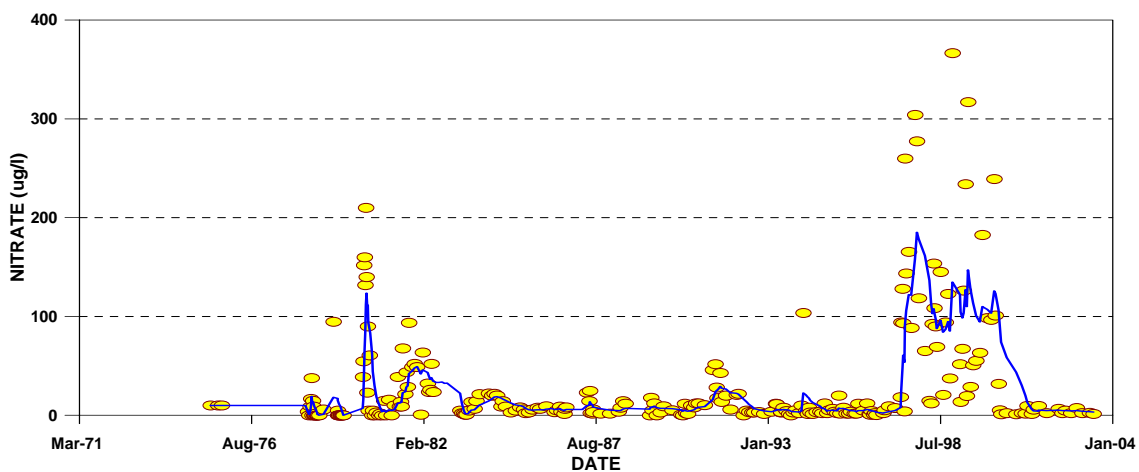
AVERAGE SURFACE CONCENTRATION AMMONIA



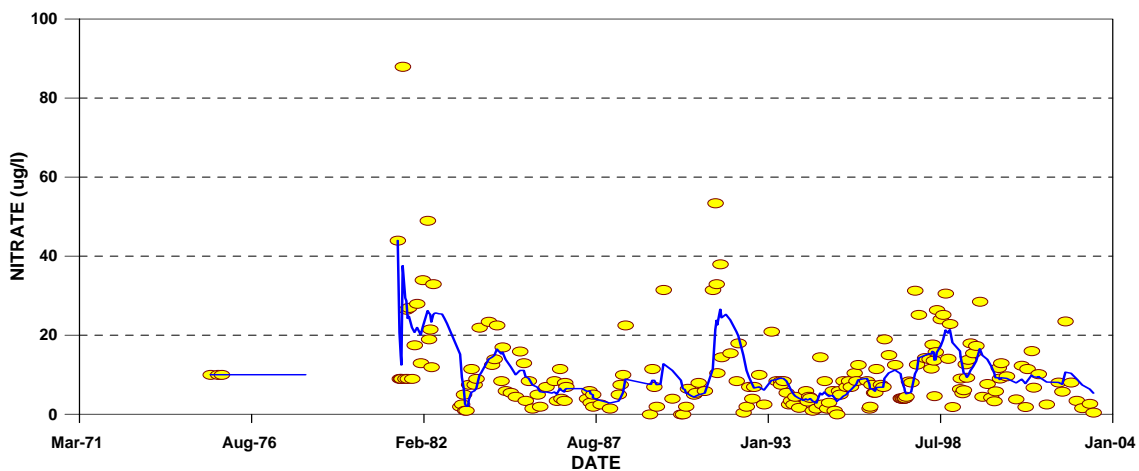
AVERAGE BOTTOM CONCENTRATION AMMONIA



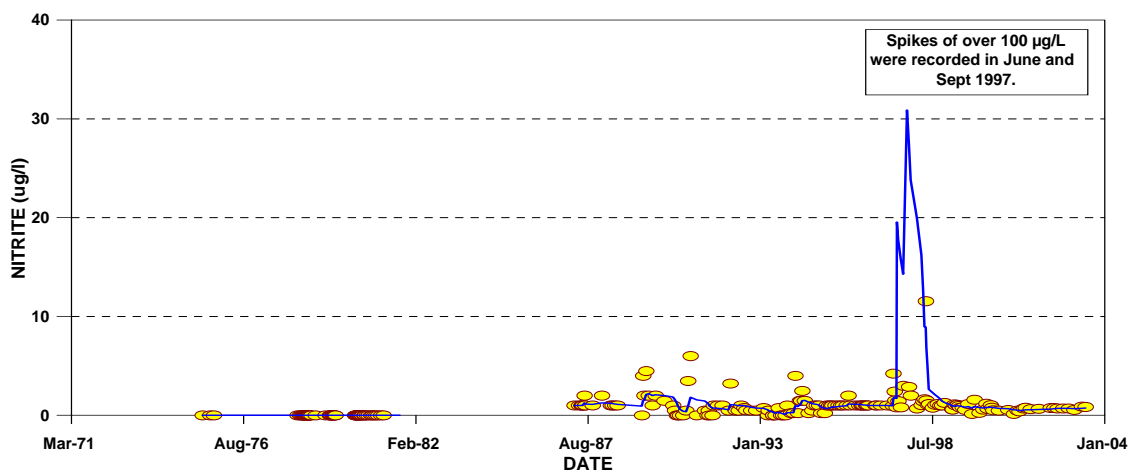
AVERAGE SURFACE CONCENTRATION NITRATE



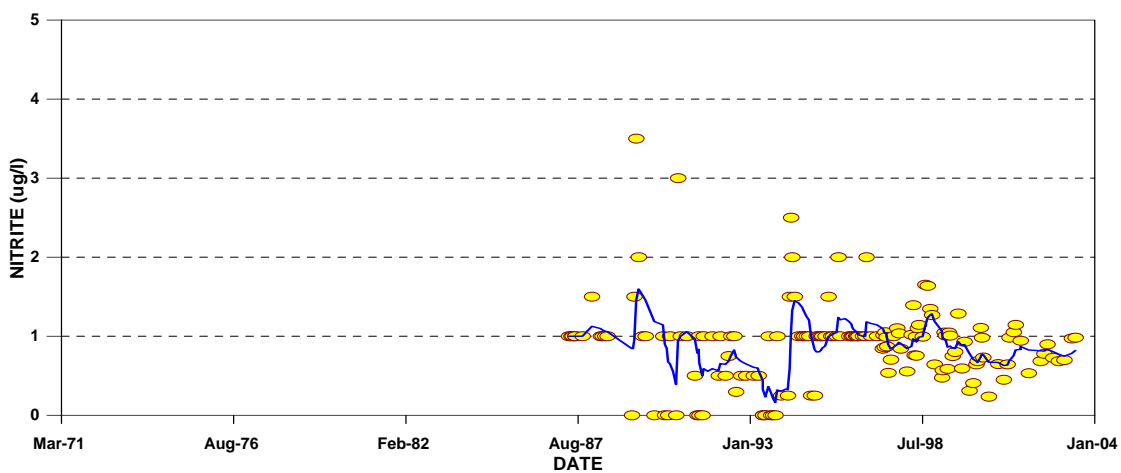
AVERAGE BOTTOM CONCENTRATION NITRATE



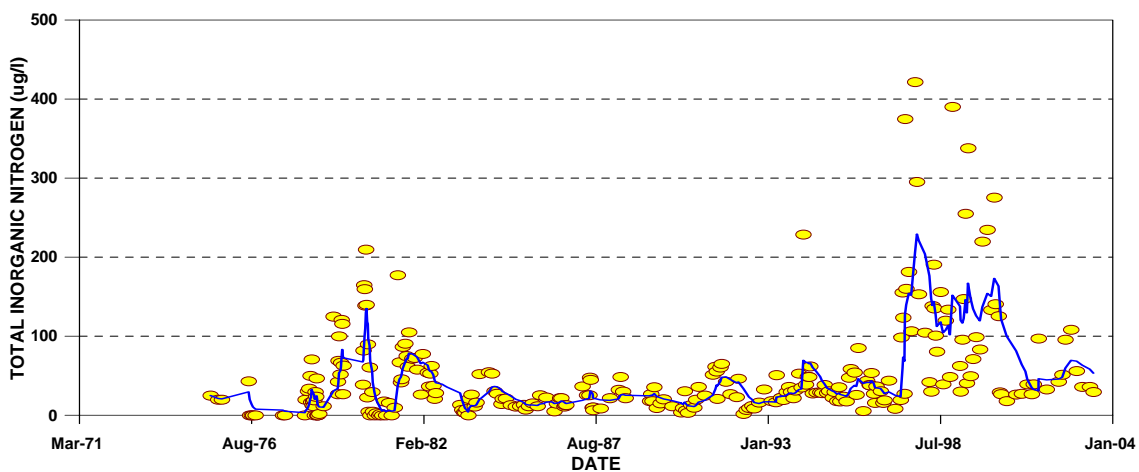
AVERAGE SURFACE CONCENTRATION NITRITE



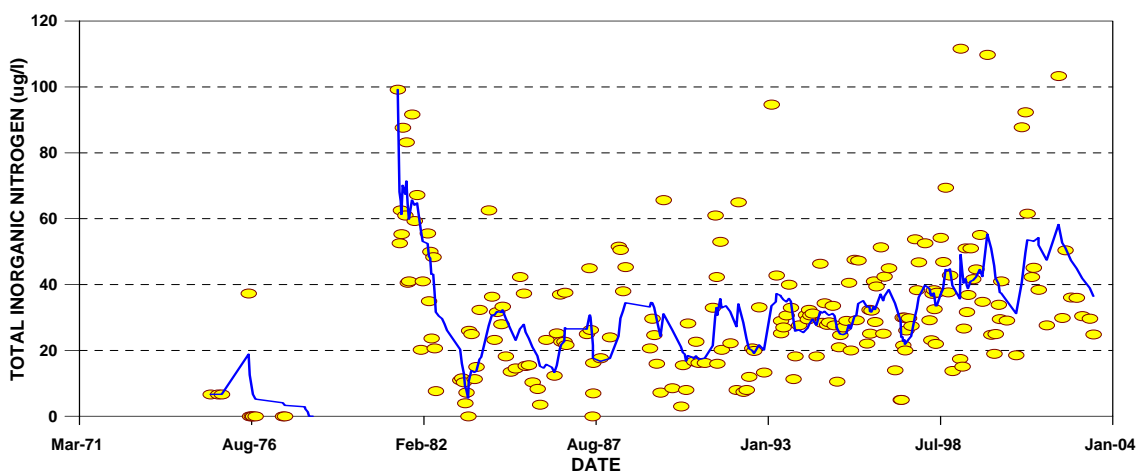
AVERAGE BOTTOM CONCENTRATION NITRITE



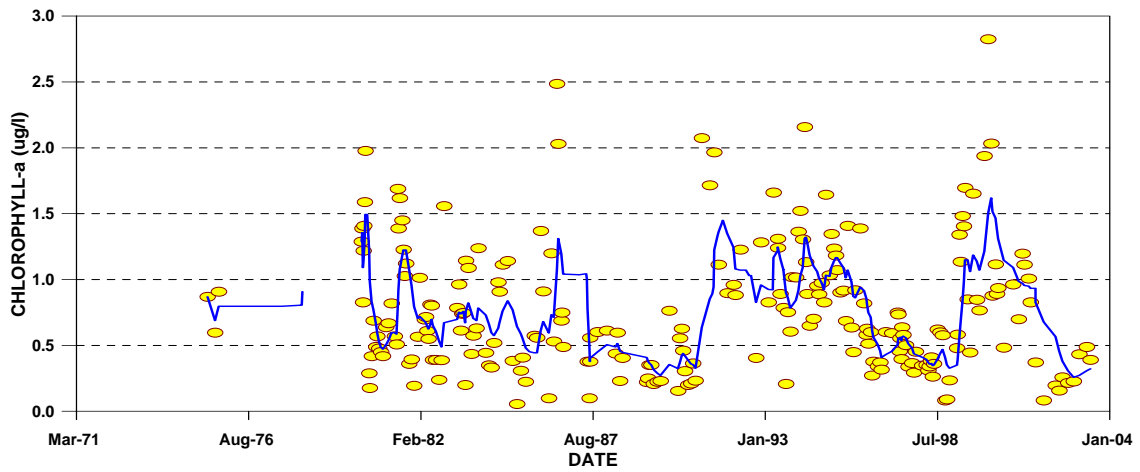
AVERAGE SURFACE CONCENTRATION TOTAL INORGANIC NITROGEN



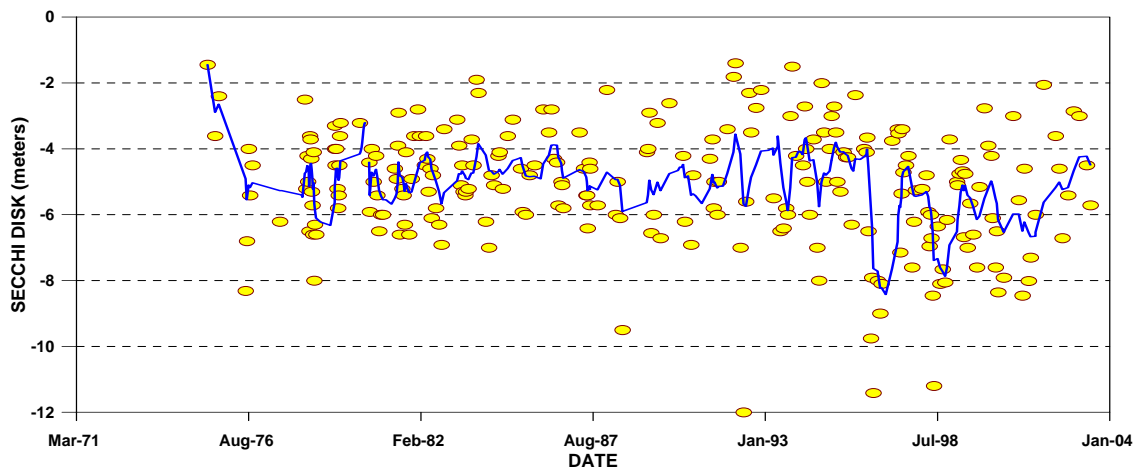
AVERAGE BOTTOM CONCENTRATION TOTAL INORGANIC NITROGEN



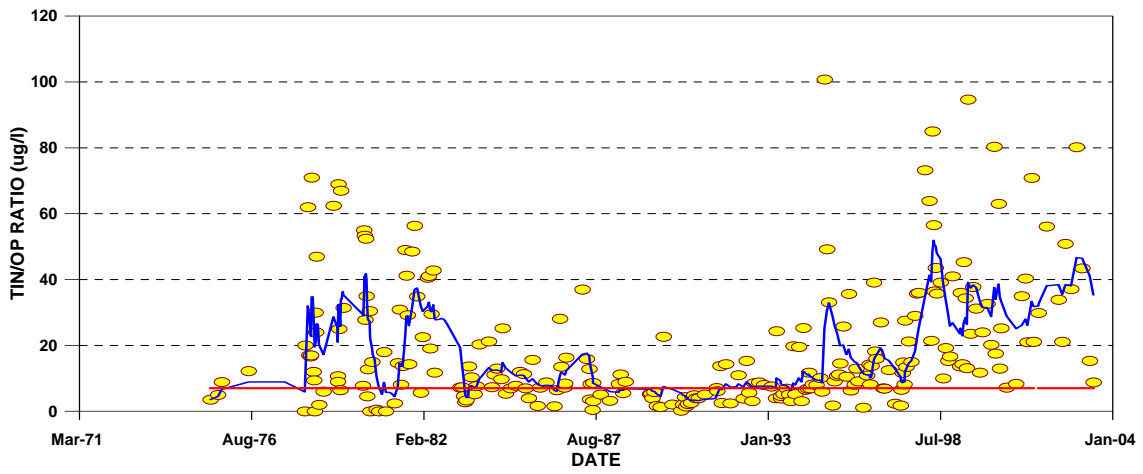
AVERAGE CONCENTRATIONS CHLOROPHYLL-a



AVERAGE WATER TRANSPARENCY SECCHI DISK



BEAR LAKE TIN/OP RATIO



APPENDIX B

Raw Data



| | DEPTH (meters) | | | | | | |
|---------------------------------------|----------------|-------|-------|------|------|------|------|
| | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
| <i>Dissolved Oxygen (mg/L)</i> | | | | | | | |
| 07/11/01 | 7.45 | 8.37 | 9.96 | 9.2 | 8.33 | 7.54 | 6.12 |
| 09/05/01 | 7.12 | 7.39 | 9.5 | 9.05 | 7.5 | 6.95 | 5.33 |
| 09/10/01 | 7.57 | 7.47 | 9.16 | 8.62 | 7 | 6.33 | 5.11 |
| 12/11/01 | 8.39 | 8.36 | 8.3 | 8.23 | 8.17 | 8.22 | 7.26 |
| 04/24/02 | 10.28 | 10.04 | 9.94 | 9.8 | 9.85 | 9.72 | 8.91 |
| 06/12/02 | 8.93 | 9.25 | 9.37 | 9.2 | 9.19 | 8.94 | 8.44 |
| <i>Temperature (°C)</i> | | | | | | | |
| 07/11/01 | 20.46 | 16.53 | 8.57 | 5.97 | 4.85 | 4.57 | 4.47 |
| 09/05/01 | 20.06 | 20.07 | 8.98 | 5.76 | 4.97 | 4.68 | 4.69 |
| 09/10/01 | 17.99 | 17.76 | 13.89 | 5.87 | 5.1 | 4.76 | 4.73 |
| 12/11/01 | 5.57 | 5.56 | 5.55 | 5.55 | 5.55 | 5.55 | 5.55 |
| 04/24/02 | 3.71 | 3.59 | 3.53 | 3.53 | 3.52 | 3.53 | 3.54 |
| 06/12/02 | 12.33 | 10.01 | 6.91 | 6.2 | 5.45 | 4.79 | 4.74 |
| <i>pH (SU)</i> | | | | | | | |
| 07/11/01 | 8.5 | 8.49 | 8.49 | 8.42 | 8.37 | 8.33 | 8.28 |
| 09/05/01 | 8.06 | 8.13 | 8.07 | 7.99 | 7.86 | 7.84 | 7.8 |
| 09/10/01 | 8.49 | 8.5 | 8.47 | 8.37 | 8.28 | 8.27 | 8.26 |
| 12/11/01 | 8.47 | 8.48 | 8.48 | 8.49 | 8.49 | 8.5 | 8.51 |
| 04/24/02 | 7.49 | 7.83 | 7.95 | 8.01 | 8.06 | 8.08 | 8.1 |
| 06/12/02 | 7.95 | 8.15 | 8.19 | 8.23 | 8.24 | 8.24 | 8.24 |
| <i>Conductivity (µmho/cm)</i> | | | | | | | |
| 07/11/01 | 714 | 707 | 697 | 695 | 696 | 698 | 701 |
| 09/05/01 | 714 | 715 | 696 | 695 | 697 | 699 | 703 |
| 09/10/01 | 707 | 708 | 698 | 693 | 695 | 695 | 697 |
| 12/11/01 | 685 | 686 | 687 | 688 | 688 | 688 | 689 |
| 04/24/02 | 682 | 685 | 684 | 685 | 685 | 685 | 685 |
| 06/12/02 | 692 | 689 | 688 | 689 | 689 | 689 | 688 |
| <i>Turbidity (NTU)</i> | | | | | | | |
| 07/11/01 | 0.4 | 0.5 | 0.6 | 1.2 | 0.7 | 0.7 | 4.5 |
| 09/10/01 | 0.8 | 0.7 | 0.8 | 0.9 | 1 | 2.4 | 2.8 |
| 12/11/01 | 2.7 | 2.7 | 2.5 | 3 | 2.5 | 2.7 | 2.6 |
| 04/24/02 | 1 | 1 | 1.5 | 1.4 | 1.6 | 1.5 | 5.3 |
| 06/12/02 | 0.7 | 0.6 | 0.6 | 0.6 | 0.7 | 1 | 1.6 |



| | DEPTH (meters) | | | | | | |
|--|----------------|-----|----|----|----|-----|-----|
| | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
| Secchi (meters) | | | | | | | |
| 07/11/01 | -7.3 | | | | | | |
| 09/10/01 | -6 | | | | | | |
| 12/11/01 | -2.05 | | | | | | |
| 04/24/02 | -3.6 | | | | | | |
| 06/12/02 | -4.6 | | | | | | |
| Total Phosphorus ($\mu\text{g/L}$) | | | | | | | |
| 07/11/01 | <5 | <5 | <5 | 8 | 6 | <5 | 7 |
| 09/10/01 | 5 | 7 | 9 | 7 | 8 | 6 | 27 |
| 12/11/01 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| 04/24/02 | <7 | <7 | <7 | <7 | <7 | <7 | <7 |
| 06/12/02 | 7 | 7 | 10 | 7 | 13 | 8 | 24 |
| Orthophosphorus ($\mu\text{g/L}$) | | | | | | | |
| 07/11/01 | 2 | 1 | 3 | 1 | 1 | 1 | 3 |
| 09/10/01 | 2 | 1 | 1 | 2 | 1 | 2 | 3 |
| 12/11/01 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 04/24/02 | 1 | 1 | 2 | 2 | 1 | 4 | 2 |
| 06/12/02 | 6 | 1 | 1 | 4 | 2 | 1 | 2 |
| Total Suspended Solids (mg/L) | | | | | | | |
| 07/11/01 | <1 | <1 | <1 | <1 | <1 | <1 | 5 |
| 09/10/01 | <1 | <1 | <1 | <1 | <1 | 2 | 30 |
| 12/11/01 | 2 | 3 | 2 | 2 | 1 | 1 | 1 |
| 04/24/02 | 2 | 3 | 2 | 3 | 3 | 3 | 8 |
| 06/12/02 | 2 | <0 | 1 | 1 | 1 | 3 | 4 |
| Ammonia ($\mu\text{g/L}$) | | | | | | | |
| 07/11/01 | 36 | 29 | 27 | 37 | 31 | 28 | 26 |
| 09/10/01 | 43 | 141 | 40 | 25 | 23 | 26 | 25 |
| 12/11/01 | 34 | 25 | 21 | 20 | 20 | 29 | 25 |
| 04/24/02 | 36 | 34 | 29 | 37 | 41 | 121 | 121 |
| 06/12/02 | 73 | 24 | 93 | 73 | 25 | 23 | 21 |



| | DEPTH (meters) | | | | | | |
|--|----------------|------|------|------|------|------|------|
| | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
| <i>Nitrate+Nitrite ($\mu\text{g/L}$)</i> | | | | | | | |
| 07/11/01 | 12 | <5 | <5 | <5 | <5 | 13 | 35 |
| 09/10/01 | 10 | | 9 | | 11 | | 29 |
| 12/11/01 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| 04/24/02 | 8 | 7 | 7 | 8 | 10 | 7 | 9 |
| 06/12/02 | 2 | <1 | <1 | | 5 | 8 | 7 |
| <i>Nitrite ($\mu\text{g/L}$)</i> | | | | | | | |
| 07/11/01 | 0.9 | 0.8 | 0.9 | 0.9 | 1 | 1.3 | 1.4 |
| 09/10/01 | 0.7 | 0.7 | 0.7 | 0.7 | 0.9 | 1 | 0.9 |
| 12/11/01 | 0.8 | 0.6 | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 |
| 04/24/02 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 |
| 06/12/02 | 0.8 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 |
| <i>Chlorophyll-a ($\mu\text{g/L}$)</i> | | | | | | | |
| 07/11/01 | 0.39 | 0.53 | 0.54 | 1.5 | 1.13 | 0.97 | 0.73 |
| 09/10/01 | 0.24 | 0.48 | 0.63 | 0.73 | 0.29 | 0 | 0.24 |
| 12/11/01 | 0.11 | 0.09 | 0.07 | 0.08 | 0.09 | 0.07 | 0.09 |
| 04/24/02 | 0.14 | 0.2 | 0.22 | 0.18 | 0.22 | 0.18 | 0.28 |
| 06/12/02 | 0.04 | 0.07 | 0.14 | 0.2 | 0.39 | 0.12 | 0.16 |

