An Evaluation of Changes in Selected Limnological Parameters of Grafton Lake, Kejimkujik National Park After Dam Removal

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SUMMARY

During the period between July 1993 and September 1996, the Centre for Wildlife and Conservation Biology of Acadia University carried out studies to assess changes occurring in Grafton Lake, Kejimkujik National Park resulting from removal of the dam. As part of this study, a number of limnological parameters were monitored to determine changes in the basic physical, chemical and biological characteristics of the lake. A number of these same parameters were monitored in 2000 and the results from all years analyzed to determine if any additional changes have occurred since the time of the 1993-1996 studies.

Although some difference appears to exist in the levels of alkalinity, total inorganic carbon and total nitrogen, few changes were observed between 2000 and previous years in the values of most of the limnological parameters monitored.

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1. Introduction

In 1938 the Federal Department of Fisheries constructed a dam on Grafton Brook in order to meet the water requirements for a salmon hatchery. The dam resulted in enlargement of the surface area of Grafton Lake from ca. 200 to 270 km^2. The hatchery ceased operation in 1972 and in the early 1990s the Park Management team of Kejimkujik National Park decided to remove the dam allowing the system to revert to its original physical characteristics. This presented a unique opportunity to study and document the successional changes occurring in the terrestrial and aquatic communities within and around the lake resulting from removal of the dam. During the period July 1993 - September 1996 the Centre for Wildlife and Conservation Biology of Acadia University, in partnership with a number of other agencies, carried out a multidisciplinary study to obtain data on the physical, chemical and biological characteristics of the lake prior to and after removal of the dam. Results of the study indicated some minor changes in the lake's biology as a result of the decreased water depth and surface area, but it was concluded that any changes that may result would likely require a longer period of time before becoming evident (Brylinsky and others, 1995; 1997).

In order to further evaluate if removal of the dam has resulted in significant changes in the limnology of Grafton Lake, a limnological survey was carried out in 2000 and the results from all years of monitoring were compared.

2. Methods

During the period 1993-96, limnological surveys were conducted at two stations in Grafton Lake, one located centrally (#NS01ED0076) and one located along the eastern shore (#NS01ED0116) in the deepest part of the lake (Figure 1). With the exception of 1993, when surveys did not begin until late June, each station was monitored bi-weekly between the months of May and September and water samples were collected from the surface, mid-depth and just above the bottom of the water column. During 2000, only the central station was monitored and this was done on a monthly basis between May and September. In addition, since there was never any indication of water column stratification during 2000, water samples were collected only from the surface.

Compared to the previous surveys, the 2000 survey was limited in terms of the number of parameters monitored. However, the parameters chosen for monitoring in 2000 were those considered to be the most informative with respect to assessing the degree of change in the limnology of the lake. These included: water temperature, Secchi Disk depth, colour, conductivity, alkalinity, pH, total phosphorus, total nitrogen, nitrate,

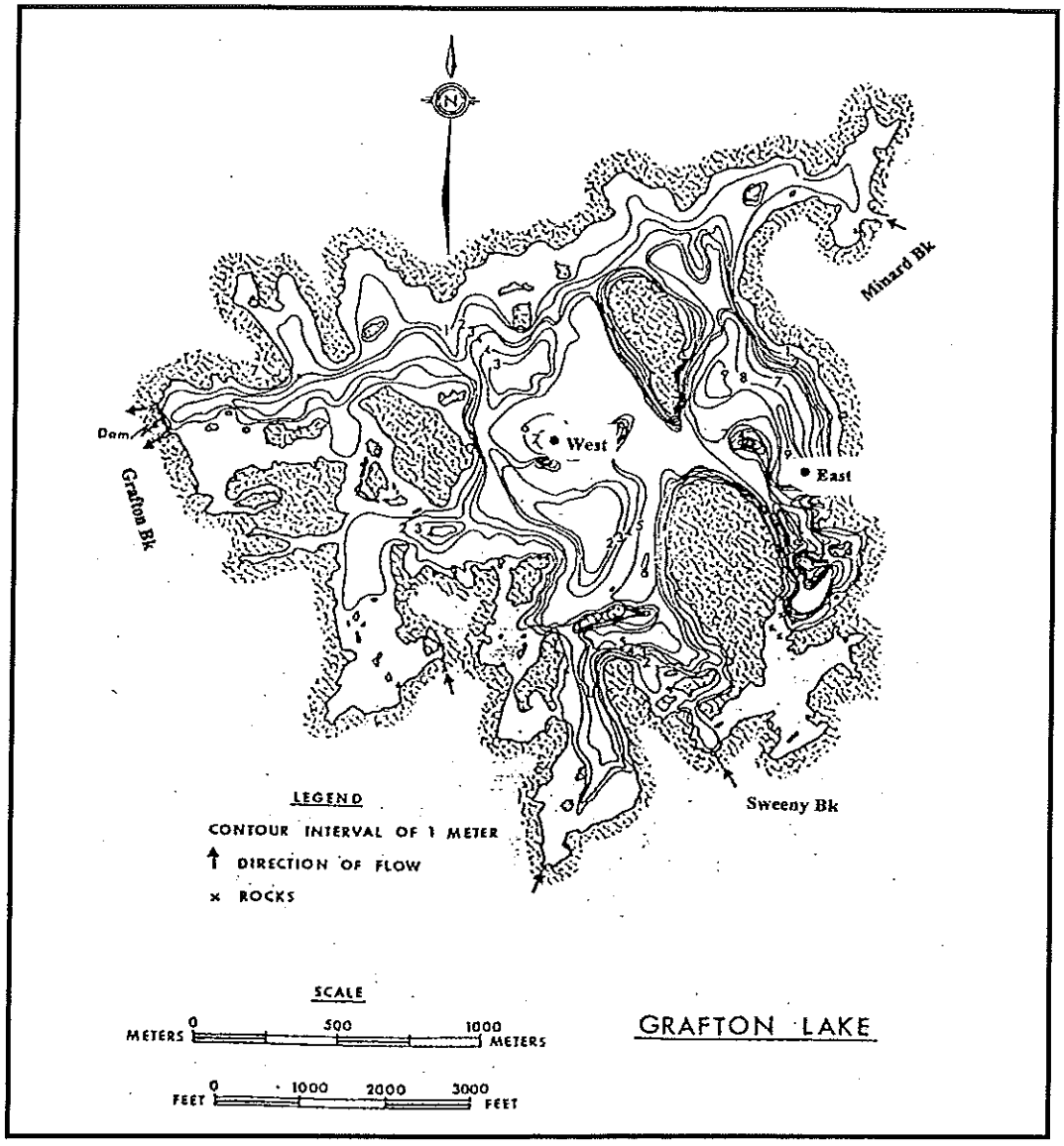

Figure 1. Map of Grafton Lake showing location of limnological sampling stations (modified from Kerekes (1973)).

inorganic ions and chlorophyll *a*. Appendix I contains the complete database for surface water samples for each parameter for all survey years.

Assessing the degree of change that has occurred after removal of the dam largely involved between year comparisons of the mean seasonal values of the parameters monitored. This precluded use of the 1993 data since the survey during that year covered only the period between late June to September whereas the surveys in other years covered the period between May to September. Since most of the parameters monitored can have considerable seasonal variation, it was considered important that comparisons were made only for data that had been collected at similar times.

The procedures used for field sample collection and laboratory analyses were as described in Brylinsky and others (1997).

3. Results

Figures 2, 3 and 4 show the seasonal means for each year for a number of the parameters monitored. The only parameters that appeared to differ significantly in 2000 from previous years are alkalinity, total inorganic carbon and total nitrogen, all of which show a decrease. Alkalinity is a measure of the buffering capacity of the system and is dependent largely on the amount of inorganic carbon available. Although both appear to have decreased, this has not resulted in a decrease in pH suggesting that there is still adequate alkalinity to buffer the system against the effects of acid precipitation. Grafton Lake still remains one of the better systems within the Park with respect to pH levels.

Although the level of total nitrogen appears to have decreased, there is little evidence that this has had any influence on the level of productivity since there has been little change in chlorophyll *a* levels, an indirect measure of phytoplankton biomass. The N:P ratios suggest that phosphorus is still the major limiting factor.*

None of the other limnological parameters measured, including the major cations and anions (Figure 3) exhibited any significant change since removal of the dam.

4. Discussion

Aside from the noted changes in alkalinity, total inorganic carbon and total nitrogen, there appears to have been little change in the basic physical and chemical limnological characteristics of Grafton Lake. The absence of significant changes in most of the parameters monitored may be related to the high flushing rate of Grafton Lake. Prior to removal of the dam, the theoretical flushing rate of Grafton Lake was about six times per year (Kerekes and Swinghammer 1973). Lakes with flushing rates this high generally have chemistries similar to that of the water supply to the lake. The short residence time within the lake does not allow much time for the water chemistry to reach new equilibria or be influenced by biological processes (such as removal of nutrients by photosynthesis) or physical/chemical processes (such as new chemical equilibria caused by differences in temperature, chemical precipitation, etc.). Removal of the dam decreased the volume of Grafton Lake by more than 50 percent, and correspondingly doubled the flushing rate to about 12 times per year, making differences between water inputs to the lake, water within the lake and water exiting from the lake, even less likely.

If the lower alkalinity observed in 2000 is accurate and persists, this may have serious consequences for Grafton Lake. Buffering capacity is an exceptionally important factor for lakes within southwestern Nova Scotia because of the high amounts of acid contained in atmospheric precipitation and the dominance of a geology that has little buffering

* In general, N:P ratios greater than eight (weight:weight basis) are considered to be indicative of phosphorus, as opposed to nitrogen, limitation.

capacity. If the lower alkalinity observed in 2000 is an indication of a trend that leads to a lower pH, this could have a major impact on the biology of the lake. Grafton Lake is one of the few lakes within the Park that has at least some buffering capacity and, although oligotrophic, is one of the more productive lakes within the Park (Kerekes 1975). It is therefore important that this factor be monitored on as frequent a basis as possible to determine if the lower alkalinity observed in 2000 is indicative of a trend or is perhaps simply the result of some unusual conditions that may have occurred in that year.

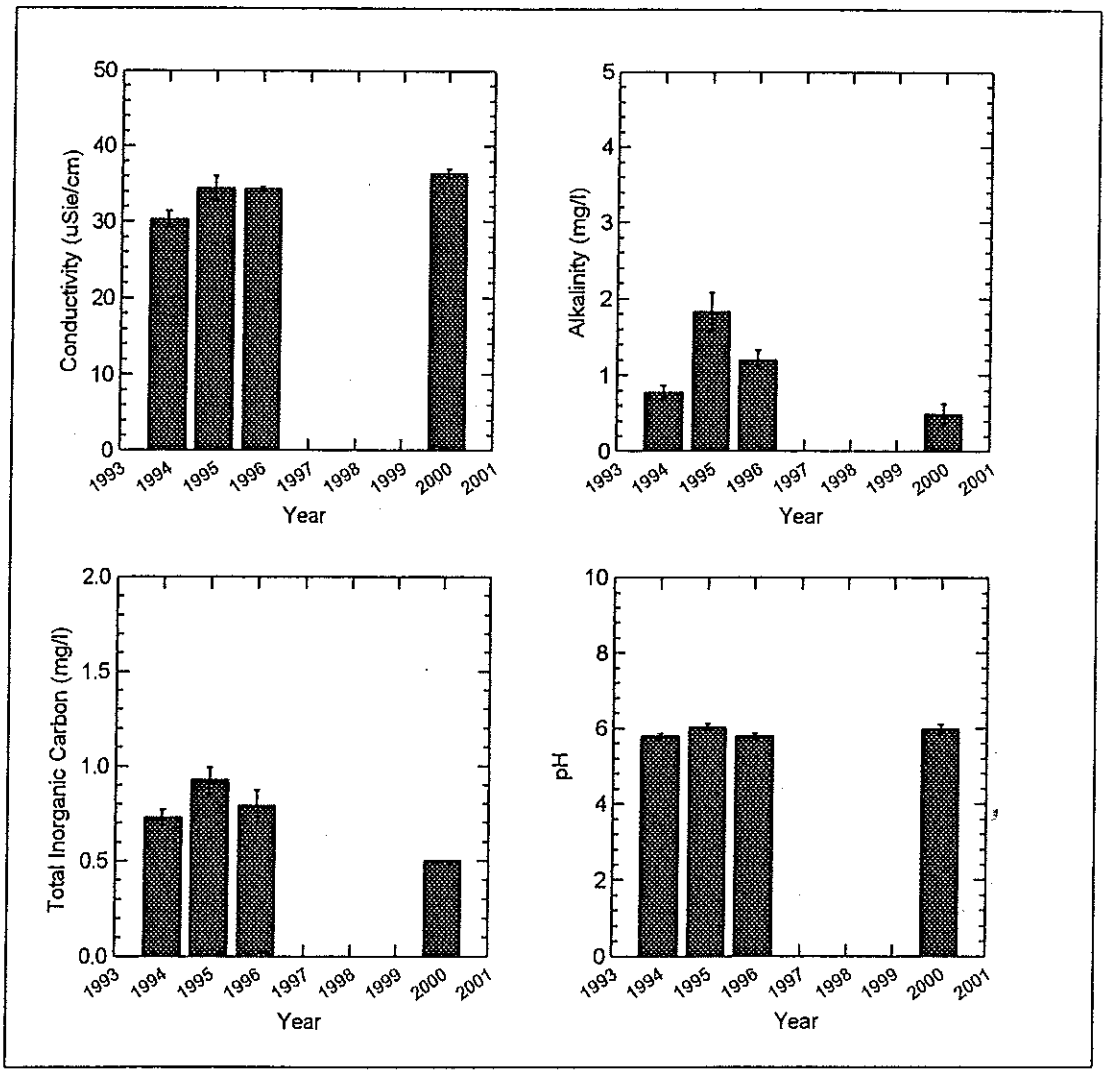

Figure 2. Seasonal averages of variables related to buffering capacity (error bars are one standard error of the mean).

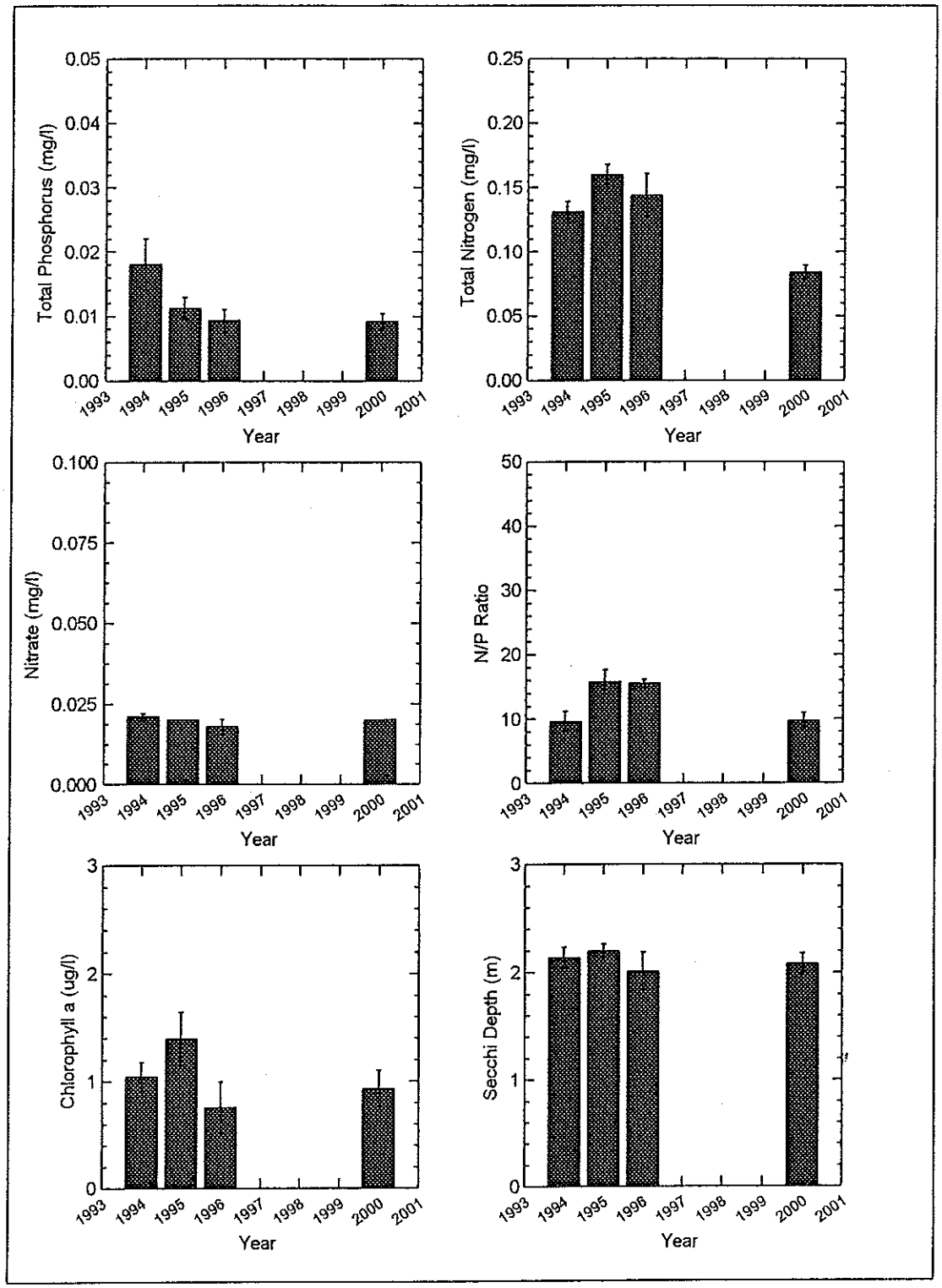

Figure 3. Seasonal averages of variables related to nutrient concentrations and productivity (error bars are one standard error of the mean).

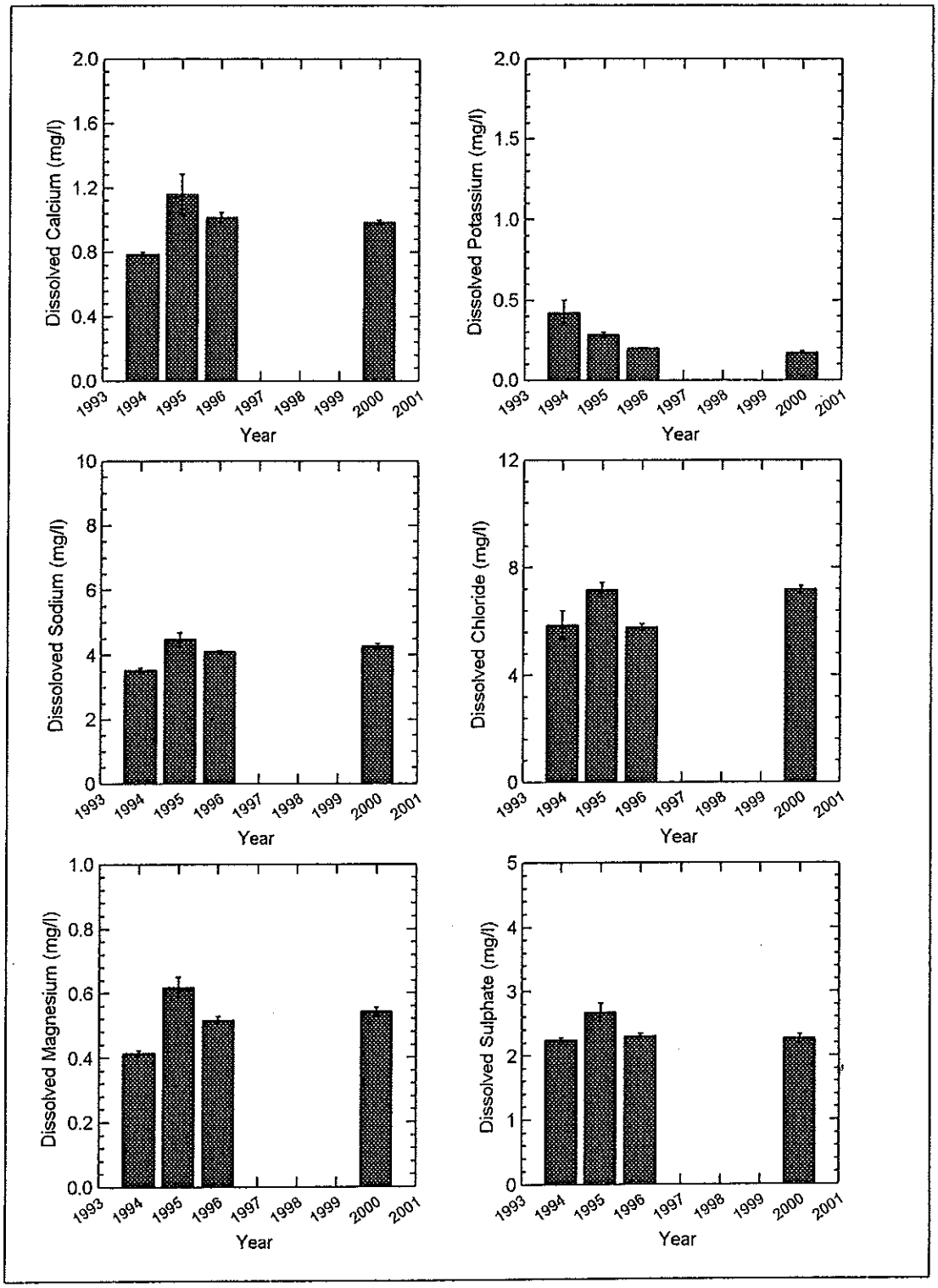

Figure 4. Seasonal averages of major dissolved ions (error bars are one standard error of the mean).

5. Acknowledgements

I would like to thank Paul Olshefsky of Parks Canada for logistic support, Fred Payne for assistance in the field and Dr. Tom Clair of Environment Canada for arranging the chemical analyses of water samples which were carried out by the Environment Canada Laboratory in Moncton, N.B.

6. References

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Appendix I

Database for Limnological Surveys Carried Out at Grafton Lake Between 1993 and 2000

Appendix I. Database for limnological surveys carried out at Grafton Lake between 1993 and 2000.

SITE	DATE	Depth (m)	Color (pt Units)	Conductivity (uSie/cm)	Dissolved Organic Carbon (mg/l)	Dissolved Inorganic Carbon (mg/l)	Alkalinity (mg/l)	pH	Nitrate (mg/l)	Total Phosphate (mg/l)	Total Nitrogen (mg/l)	N:P Ratio	Na+ (mg/l)	Mg+ (mg/l)	K+ (mg/;)	Ca+ (mg/l)	SO4- (mg/l)	Cl- (mg/l)
East	930630	0.0	25	32	4.0	0.7	1.1	5.7	0.01	0.006	0.20	33.33	4.0	0.48	0.29	0.95	2.6	7.6
East	930630	6.0	30	32	4.3	0.5	0.7	5.6	0.01	0.008	0.20	25.00	4.3	0.52	0.24	0.85	2.4	6.9
East	930630	9.0	30	32	3.2	0.5	0.9	5.6	0.03	0.017	0.19	11.18	4.0	0.50	0.27	1.00	2.4	6.5
East	930714	0.0	30	31	4.0	0.5	1.7	5.8	0.02	0.009	0.18	20.00	4.1	0.52	0.26	0.90	2.5	6.6
East	930714	6.0	30	32	4.0	0.5	0.8	5.7	0.01	0.009	0.17	18.89	4.2	0.54	0.34	0.80	2.4	6.5
East	930714	8.5	35	34	3.5	0.5	1.1	5.6	0.02	0.016	0.19	11.88	4.3	0.56	0.56	1.00	3.2	6.7
East	930728	0.0	40	35	3.9	0.5	1.6	6.0	0.01	0.014	0.36	25.71	4.7	0.50	0.41	1.00	2.3	7.5
East	930728	6.5	45	34	3.6	0.5	1.8	5.8	0.02	0.010	0.21	21.00	4.2	0.52	0.31	1.00	2.5	6.7
East	930728	8.5	100	38	3.6	0.5	2.7	5.9	0.02	0.028	0.38	13.57	4.8	1.50	0.34	1.40	5.2	3.4
East	930811	0.0	25	33	3.5	0.6	1.4	5.8	0.01	0.009	0.18	20.00	4.1	0.52	0.25	1.00	1.6	6.7
East	930811	6.0	40	33	3.6	0.7	1.9	5.7	0.02	0.009	0.20	22.22	4.0	0.50	0.24	1.00	2.4	6.6
East	930811	9.0	30	36	3.2	0.9	5.8	6.1	0.01	0.042	0.47	11.19	4.1	0.44	0.30	1.20	1.0	6.6
East	930825	0.0	25	33	3.6	0.5	1.3	6.0	0.01	0.013	0.21	16.15	4.2	0.50	0.28	1.00	2.5	6.9
East	930825	6.5	75	35	4.0	1.0	3.3	6.1	0.02	0.022	0.21	9.55	4.2	0.58	0.25	1.10	2.4	6.4
East	930825	8.0	155	36	4.9	1.0	4.2	6.1	0.01	0.030	0.24	8.00	4.2	0.55	0.28	1.30	2.0	6.3
East	930908	0.0	25	34	3.9	0.5	1.3	6.1	0.01	0.006	0.21	35.00	4.2	0.49	0.24	1.10	2.4	6.8
East	930908	7.0	95	35	3.7	0.7	2.8	5.9	0.01	0.015	0.26	17.33	4.2	0.52	0.25	1.20	2.3	6.6
East	930908	9.0	500	41	5.1	0.7	8.3	6.1	0.01	0.024	0.64	26.67	4.4	0.62	0.36	1.70	0.6	6.7
East	940428	0.0	35	31	5.5	0.9	0.5	5.5	0.02	0.013	0.12	9.23	3.5	0.43	0.79	0.83	2.4	5.6
East	940512	0.0	35	36	5.5	0.5	0.5	5.3	0.02	0.024	0.13	5.42	3.5	0.40	2.50	0.84	2.3	7.2
East	940526	0.0	40	32	6.1	0.5	0.9	5.5	0.02	0.042	0.12	2.86	3.5	0.39	1.10	0.73	2.3	5.7
East	940526	3.0	40	38	6.2	0.7	0.5	5.5	0.03	0.014	0.11	7.86	4.8	0.54	0.60	0.78	2.5	7.8
East	940526	7.0	45	31	6.3	0.5	0.7	5.5	0.02	0.013	0.13	10.00	3.8	0.43	0.59	0.75	2.3	5.7
East	940609	0.0	40	28	0.8	0.8	0.6	5.7	0.02	0.021	0.12	5.71	3.1	0.37	0.22	0.74	2.2	4.7
East	940609	4.5	40	28	0.9	0.9	1.1	5.8	0.02	0.025	0.13	5.20	3.3	0.38	0.25	0.75	2.2	4.9
East	940609	7.0	40	28	0.7	0.7	0.9	5.5	0.02	0.011	0.11	10.00	3.5	0.39	0.24	0.75	2.4	5.0
East	940623	6.0	40	28	0.5	0.5	0.9	5.7	0.03	0.032	0.11	3.44	3.2	0.39	0.23	0.78	2.2	4.7
East	940706	6.0	40	29	0.9	0.9	1.4	5.9	0.02	0.023	0.14	6.09	3.4	0.40	0.32	0.83	2.2	4.9
East	940706	8.0	65	30	0.6	0.6	1.9	5.9	0.02	0.026	0.20	7.69	3.5	0.39	0.25	0.86	2.3	4.9
East	940719	0.0	25	31	5.1	0.6	0.9	5.9	0.02	0.014	0.13	9.29	4.1	0.48	0.35	0.82	2.4	5.0
East	940719	6.0	30	29	5.0	1.2	1.0	5.9	0.02	0.027	0.19	7.04	3.6	0.43	0.27	0.88	1.2	6.2
East	940719	8.0	65	30	5.8	1.6	0.4	5.5	0.02	0.032	0.30	9.38	3.7	0.43	0.29	0.91	2.4	5.0
East	940728	0.0	35	32	0.8	0.8	1.1	5.9	0.02	0.013	0.14	10.77	4.0	0.46	0.41	0.82	2.3	4.9

Appendix I. Database for limnological surveys carried out at Grafton Lake between 1993 and 2000.

East	940728	8.0	60	29	0.7	0.7	1.0	5.6	0.07	0.048	0.18	3.75	3.4	0.38	0.24	0.82	2.3	4.9
East	940804	0.0	20	28	4.9	0.7	1.1	5.9	0.02	0.011	0.14	12.73	3.4	0.44	0.23	0.82	2.1	4.9
East	940804	5.5	30	28	5.1	1.0	1.2	5.9	0.02	0.009	0.16	17.78	3.7	0.44	0.25	0.86	2.1	5.0
East	940804	8.0	65	31	5.7	2.0	2.0	5.9	0.06	0.029	0.22	7.59	3.6	0.44	0.43	0.94	2.2	5.0
East	940816	0.0	25	29	4.8	0.9	1.3	6.0	0.02	0.010	0.14	14.00	3.8	0.44	0.28	0.82	2.2	5.2
East	940816	7.0	75	30	5.6	1.8	0.7	5.5	0.17	0.024	0.24	10.00	3.6	0.44	0.28	0.89	2.2	4.9
East	940816	8.0	110	32	6.5	1.9	2.8	6.0	0.21	0.033	0.31	9.39	3.7	0.51	0.48	1.10	2.0	5.2
East	940831	0.0	25	30	5.0	0.8	1.1	6.0	0.02	0.012	0.14	11.67	3.7	0.45	0.68	0.82	2.1	5.5
East	940831	8.5	175	38	8.5	2.3	4.6	6.3	0.13	0.041	0.40	9.76	4.1	0.62	0.58	1.40	1.6	6.1
East	950505	0.0	20	126	6.0	0.7	3.3	5.6	0.02	0.010	0.27	27.00	23.0	0.52	0.33	0.89	2.9	36.5
East	950525	0.0	30	30	4.9	0.9	1.4	5.6	0.02	0.003	0.16	53.33	4.2	0.47	0.31	0.81	2.6	6.6
East	950607	0.0	30	30	5.5	0.6	1.5	5.6	0.02	0.006	0.19	31.67	3.8	0.48	0.24	0.85	2.6	6.7
East	950607	8.0	40	31	5.2	0.9	1.6	5.5	0.07	0.043	0.26	6.05	4.0	0.51	0.24	0.93	2.7	7.0
East	950621	0.0	45	31	5.4	0.6	1.6	5.8	0.02	0.009	0.15	16.67	3.9	0.52	0.25	0.89	2.5	6.4
East	950621	7.5	50	34	5.3	0.8	2.3	5.9	0.03	0.014	0.14	10.00	4.1	0.58	0.26	1.09	2.6	6.6
East	950706	0.0	45	33	5.5	0.8	2.6	6.2	0.02	0.015	0.15	10.00	4.9	0.56	0.42	1.21	2.4	6.5
East	950706	8.0	60	35	4.4	0.8	2.2	5.6	0.21	0.025	0.31	12.40	3.8	0.59	0.25	1.17	2.7	6.6
East	950719	0.0	40	33	5.7	0.8	1.9	5.8	0.02	0.011	0.16	14.55	4.1	0.55	0.33	0.97	2.4	6.4
East	950719	7.5	95	35	5.1	0.9	2.9	5.6	0.31	0.150	0.43	2.87	4.2	0.59	0.28	1.17	2.5	6.4
East	950803	0.0	35	35	5.1	1.0	2.5	6.0	0.02	0.013	0.14	10.77	4.2	0.61	0.27	1.09	2.6	6.9
East	950803	6.0	35	34	5.0	0.8	1.9	5.9	0.02	0.011	0.16	14.55	4.2	0.54	0.25	0.89	2.5	6.6
East	950803	7.0	45	35	4.4	1.2	2.4	5.6	0.05	0.016	0.22	13.75	4.0	0.56	0.27	1.13	2.7	6.8
East	950816	0.0	35	33	5.2	0.7	2.1	5.9	0.02	0.011	0.15	13.64	4.0	0.54	0.25	0.93	2.5	6.6
East	950816	8.5	75	36	4.5	2.3	3.3	5.7	0.02	0.026	0.25	9.62	4.1	0.58	0.27	1.09	2.6	7.1
East	950830	0.0	35	34	5.2	0.9	2.0	6.0	0.02	0.027	0.16	5.93	4.5	0.58	0.30	1.09	2.6	7.1
East	960502	0.0		37.2	4.6	2.1	0.7	5.4		0.004			4.2	0.52	0.19	1.02	2.5	6.1
East	960517	0.0		43.4	4.5	1.0	0.8	5.6		0.007			6.3	0.69	0.28	1.23	3.5	12.3
East	960603	0.0		34.3	4.9	0.6	0.9	5.8		0.007			4.2	0.49	0.19	0.94	2.1	5.1
East	960614	0.0		35	48.0	1.0	0.7	5.6		0.006			4.2	0.50	0.19	0.88	2.6	6.3
East	960614	7.5		36.2	4.3	2.1	0.7	5.6		0.007			4.2	0.51	0.20	0.96	2.6	6.4
East	960627	0.0		35.4	5.1	1.1	1.3	5.7		0.014			4.3	0.51	0.21	0.94	2.4	6.2
East	960627	7.0		35.8	4.7	0.5	0.7	5.9		0.011			4.3	0.52	0.23	1.03	2.5	6.5
East	960711	0.0	35	35.7	4.9	1.3	1.4	5.8	0.03	0.007	0.16	23.53	4.2	0.52	0.20	1.08	2.4	6.3
East	960725	0.0	40	35.4	5.1	0.7	1.2	5.8	0.04	0.011	0.14	13.21	4.1	0.53	0.20	1.08	2.3	6.2
East	960725	6.0	40	36.9	3.8	1.4	1.1	5.5	0.02	0.010	0.12	11.76	4.3	0.52	0.21	1.07	2.5	6.2
East	960725	7.0	35	36.1	4.3	1.0	1.3	5.9	0.02	0.018	0.12	6.52	4.2	0.54	0.21	1.10	2.5	6.2
East	960808	0.0	30	35.1	5.7	0.5	1.6	6.0	0.02	0.008	0.13	16.05	4.2	0.53	0.18	1.05	2.3	6.2
East	960808	7.5	30	36.1	5.9	1.2	1.4	5.7	0.02	0.011	0.15	13.39	4.2	0.55	0.18	1.08	2.3	6.0
East	960822	0.0	30	35.6	5.7	1.0	1.6	5.8	0.02	0.007	0.13	19.70	4.3	0.56	0.19	0.98	2.2	6.1
East	960822	7.0	35	37.1	0.5	1.2	1.4	5.9	0.22	0.018	0.22	12.02	4.2	0.62	0.22	1.10	2.2	6.3
East	960921	0.0	65	35.2	9.2	0.6	1.6	5.8	0.05	0.012	0.21	17.21	4.0	0.56	0.23	1.09	2.1	5.7
West	930630	0.0	35	32	4.3	0.5	1.2	5.8	0.01	0.007	0.18	25.71	4.3	0.50	0.27	1.00	2.6	7.2
West	930630	4.5	35	33	4.5	0.5	1.0	5.7	0.01	0.012	0.21	17.50	4.4	0.54	0.28	0.90	2.4	6.9
West	930630	5.5	35	32	3.9	0.6	1.2	5.7	0.03	0.012	0.18	15.00	3.8	0.50	0.24	1.00	2.5	12.5

Appendix I. Database for limnological surveys carried out at Grafton Lake between 1993 and 2000.

West	930714	0.0	25	31	3.7	0.5	1.3	5.7	0.01	0.007	0.18	25.71	4.2	0.54	0.25	0.90	2.4	6.7
West	930714	4.0	25	31	4.0	0.5	0.8	5.7	0.02	0.005	0.16	32.00	4.0	0.52	0.24	0.95	2.4	6.5
West	930714	5.5	20	31	3.7	0.7	1.2	5.6	0.01	0.004	0.17	42.50	4.2	0.54	0.25	0.85	2.4	6.7
West	930728	0.0	25	32	3.7	0.5	1.0	5.8	0.01	0.008	0.17	21.25	4.2	0.48	0.33	0.90	2.4	6.5
West	930728	3.0	30	33	4.0	0.6	1.3	5.7	0.01	0.005	0.20	40.00	4.2	0.56	0.27	0.95	2.5	6.7
West	930728	5.0	35	32	4.0	0.5	1.3	5.8	0.01	0.009	0.19	21.11	4.1	0.50	0.30	0.95	2.5	6.7
West	930811	0.0	25	31	3.5	0.6	1.5	6.0	0.01	0.005	0.18	36.00	4.0	0.50	0.24	1.00	2.4	6.8
West	930811	3.0	30	32	3.5	0.5	1.3	5.9	0.01	0.027	0.19	7.04	4.1	0.52	0.27	1.00	2.5	6.8
West	930811	6.0	30	33	3.7	0.6	2.4	5.9	0.02	0.010	0.20	20.00	3.8	0.52	0.23	1.00	2.5	8.0
West	930825	0.0	25	32	3.7	0.5	2.1	6.1	0.01	0.013	0.19	14.62	4.2	0.50	0.23	0.95	2.5	6.8
West	930825	3.5	25	33	3.7	0.5	1.8	6.0	0.01	0.014	0.20	14.29	4.3	0.53	0.24	0.95	2.4	6.5
West	930825	5.5	40	33	3.4	0.5	1.5	6.0	0.01	0.014	0.21	15.00	4.3	0.55	0.22	0.95	2.4	6.4
West	930908	0.0	25	50	3.4	0.5	1.4	6.0	0.01	0.010	0.20	20.00	7.0	0.73	0.44	1.10	3.1	11.9
West	930908	5.0	30	33	3.1	0.5	1.4	6.0	0.02	0.011	0.20	18.18	4.3	0.46	0.44	0.95	2.5	6.8
West	940428	0.0	35	29	5.3	0.9	0.3	5.4	0.02	0.007	0.10	14.29	3.3	0.42	0.37	0.74	2.4	5.1
West	940512	0.0	40	37	5.9	0.5	0.6	5.6	0.03	0.020	0.17	8.50	3.4	0.40	0.28	0.74	2.2	7.1
West	940526	0.0	40	29	6.0	0.8	0.4	5.6	0.02	0.028	0.11	3.93	3.3	0.39	0.51	0.73	2.4	4.9
West	940526	3.5	40	28	6.1	0.5	0.7	5.5	0.02	0.011	0.11	10.00	3.3	0.40	0.30	0.73	2.2	4.8
West	940526	5.0	40	28	6.0	0.5	0.6	5.4	0.02	0.008	0.11	13.75	3.3	0.40	0.23	0.73	2.2	4.7
West	940609		40	30	0.5	0.5	0.4	5.6	0.02	0.011	0.10	9.09	3.5	0.36	0.97	0.74	2.2	9.4
West	940609	0.0	40	30	0.8	0.8	0.6	5.7	0.02	0.015	0.12	8.00	3.5	0.37	0.93	0.75	2.2	9.4
West	940623	0.0	40	28	0.6	0.6	1.0	5.8	0.02	0.047	0.12	2.55	3.3	0.38	0.30	0.78	2.2	5.0
West	940623	4.0	40	30	1.0	1.0	1.4	5.7	0.02	0.010	0.10	10.00	3.6	0.41	0.54	0.85	2.2	5.0
West	940623	6.0	45	29	0.6	0.6	1.2	5.7	0.02	0.014	0.14	10.00	3.2	0.40	0.23	0.86	2.2	4.7
West	940706	0.0	35	28	0.8	0.8	1.0	5.9	0.02	0.010	0.12	12.00	3.5	0.40	0.26	0.82	2.3	4.5
West	940706	5.0	40	29	0.8	0.8	1.0	5.9	0.02	0.070	0.16	2.29	3.5	0.41	0.25	0.85	2.2	4.7
West	940719	0.0	20	28	4.9	0.8	0.8	5.9	0.02	0.024	0.13	5.42	3.6	0.43	0.25	0.82	2.2	4.9
West	940719	5.0	30	28	5.0	1.0	1.3	5.9	0.02	0.017	0.16	9.41	3.6	0.45	0.27	0.88	2.1	4.9
West	940804	0.0	20	36	4.9	0.7	1.0	5.9	0.02	0.038	0.12	3.16	3.8	0.44	2.50	0.85	2.2	7.2
West	940804	4.5	25	29	4.8	0.9	1.0	5.9	0.02	0.012	0.14	11.67	3.7	0.45	0.31	0.85	2.1	5.1
West	940816	0.0	25	29	5.0	0.7	0.9	6.0	0.02	0.007	0.16	22.86	3.8	0.45	0.32	0.82	2.2	5.3
West	940816	5.0	25	28	5.0	0.5	1.1	5.8	0.02	0.009	0.12	13.33	3.7	0.44	0.25	0.82	2.1	5.0
West	940831	0.0	20	29	4.8	0.7	1.1	6.1	0.02	0.010	0.16	16.00	3.7	0.45	0.55	0.82	2.1	5.3
West	950505	0.0	35	36	4.9	0.9	2.3	6.4	0.02	0.014	0.15	10.71	5.0	0.72	0.30	1.44	2.8	8.1
West	950607	0.0	30	35	4.8	0.9	2.2	6.1	0.02	0.007	0.13	18.57	4.3	0.63	0.26	1.25	2.5	6.8
West	950621	0.0	40	33	5.4	1.0	1.5	5.9	0.02	0.010	0.19	19.00	4.5	0.63	0.31	0.95	2.6	7.5
West	950706	0.0	40	30	5.6	0.7	1.2	5.8	0.02	0.008	0.16	20.00	4.0	0.52	0.26	0.93	2.4	6.4
West	950706	4.0	35	30	5.9	0.9	1.2	5.7	0.02	0.010	0.17	17.00	4.0	0.53	0.26	0.93	2.3	6.2
West	950719	0.0	35	44	5.2	1.2	3.1	6.2	0.02	0.017	0.19	11.18	5.6	0.76	0.36	1.83	3.6	8.2
West	950719	4.5	35	32	5.6	0.7	1.2	5.8	0.02	0.008	0.17	21.25	4.0	0.53	0.25	0.97	2.3	6.3
West	950803	0.0	30	31	5.4	1.1	1.3	5.8	0.02	0.007	0.15	21.43	4.1	0.55	0.27	0.97	2.5	6.8
West	950816	0.0	35	32	5.2	0.7	1.4	6.0	0.02	0.009	0.15	16.67	4.1	0.55	0.24	0.89	2.5	6.7
West	950816	4.5	35	32	5.3	0.9	1.5	6.0	0.02	0.011	0.14	12.73	4.2	0.56	0.24	1.01	2.5	6.7
West	950830	0.0	35	34	5.3	0.9	1.6	6.1	0.02	0.018	0.16	8.89	4.2	0.58	0.27	1.01	2.6	6.8

Appendix I. Database for limnological surveys carried out at Grafton Lake between 1993 and 2000.

West	960502	0.0		33.2	4.4	0.5	0.6	5.6		0.023			4.0	0.50	0.19	0.97	2.5	5.2
West	960517	0.0		33.9	4.1	0.9	0.9	5.7		0.005			4.0	0.49	0.19	0.96	2.6	6.0
West	960603	0.0		33.9	4.6	1.0	1.1	5.7		0.006			4.2	0.48	0.20	0.97	2.1	5.1
West	960614			33.5	4.7	1.0	0.9	5.7		0.006			4.0	0.48	0.19	0.90	2.3	5.8
West	960614	0.0		34.2	4.2	1.1	1.1	5.7		0.005			4.1	0.49	0.20	0.98	2.3	5.6
West	960627	0.0		34.8	4.7	1.0	1.1	5.8		0.009			4.2	0.50	0.23	0.96	2.3	6.1
West	960711	0.0	35	34.8	5.3	1.0	0.9	5.6	0.02	0.008	0.14	16.67	4.2	0.51	0.19	0.92	2.3	6.1
West	960725	0.0	30	33.7	4.7	0.5	1.4	6.1	0.02	0.009	0.12	13.79	4.0	0.53	0.19	1.02	2.3	5.9
West	960808	0.0	25	34.5	5.5	0.5	1.7	6.0	0.02	0.008	0.12	15.19	4.2	0.52	0.19	1.07	2.2	6.0
West	960822	0.0	30	35.2	5.6	0.6	1.8	6.1	0.02	0.009	0.14	16.28	4.2	0.56	0.21	1.10	2.2	6.1
West	960921	0.0	55	35	9.0	0.8	1.4	5.6	0.01	0.013	0.20	15.75	4.0	0.58	0.20	1.21	2.2	5.6
West	000526	0.0	39	34.4	4.3	0.5	0.2	5.7	0.02	0.005	0.07	14.00	4.0	0.51	0.15	0.96	2.2	6.9
West	000607	0.0	40	36.6	4.1	0.5	0.2	5.7	0.02	0.010	0.10	10.00	4.2	0.53	0.18	1.01	2.2	7.3
West	000705	0.0	31	36.2	4.3	0.5	0.7	6.1	0.02	0.010	0.09	9.00	4.3	0.54	0.18	1.02	2.2	7.0
West	000815	0.0	20	36.8	3.3	0.5	0.6	6.2	0.02	0.010	0.08	8.00	4.4	0.56	0.18	0.96	2.4	7.4
West	000915	0.0	19	37.6	3.3	0.5	0.7	6.2	0.02	0.011	0.08	7.27	4.4	0.57	0.18	0.97	2.5	7.4