PRAIRIE CROSSING: SANCTUARY POND

YEAR END REPORT 2006

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SECTION NO. I: INTRODUCTION

During the past 9 years Integrated Lakes Management has monitored water quality data on Sanctuary Pond (formerly referred to as the Upper Pond), presented the results of that monitoring in the form of a year-end report, and made management recommendations based on that data. This year's management report follows last year's report which acknowledges the Environmental Management Plan prepared by the Prairie Crossing Homeowners Association. The year-end report addresses the results of the task items that apply only to Sanctuary Pond. By addressing the efficacy of those task items the Homeowners Association and the Liberty Prairie Foundation can adjust their management plan as appropriate.

Aquatic ecosystems are driven by five major categories of influence: energy sources, biological interactions, water movement, habitat, and water quality. In the past ILM has addressed some of those influences in our water quality report. This year's report is intended to recognize the systems character of lakes and ponds and to comment on discernable influences in the five major categories.

Summaries of results and interpretations are given in the main report. Methods and data concerning the detail of the monitoring that was carried out are incorporated into a series of appendices.

Density of the rooted aquatic plants (7/25/06).

SECTION NO. II: SUMMARY AND RECOMMENDATIONS

Sanctuary Pond was created in 1995. ILM has performed water quality monitoring and selected management of the pond since 1998. This report summarizes Year 2006 water quality sampling, algal and zooplankton collections, and sediment sampling. Water quality data for the past nine years of data collection are reported for purposes of comparison. Entries are organized to reflect the Environmental Management Plan (EMP) of the Prairie Crossing Homeowners Association (PCHA) and the systems character of pond management.

A. EMP Task Items that apply to Sanctuary Pond

1. Sanctuary Pond Monitoring and Management: Sanctuary Pond was monitored seven times across the season for a suite of water quality parameters and biological data. This marks the ninth year of collecting data.

2. Eurasian Water Milfoil (EWM) Control: Coverage by EWM was very extensive this year. An aquatic plant survey conducted by ILM on August 25th (see "Plant and Eurasian Watermilfoil Weevil Survey at Sanctuary Pond at Prairie Crossing 8/25/06"), and a teaching workshop conducted on September 16th showed that EWM weevils were present in the pond, but in extremely low numbers. A total of three thousand EWM weevils had been released in 2002 and 2003, but appear to have not taken well, which may be attributed to the large population of Endangered and Threatened (E/T) minnows in the pond. The weevils may still be able to increase in population to have an effect on the EWM, but after 4 years it is not very likely. ILM recommends that some spot herbicide treatments be done especially near the staff gage where fish surveys occur. Treatments in this area would likely yield more accurate survey results.

3. Zebra Mussel Monitoring: ILM does assessments of zooplankton populations through Waters Edge Scientific. To date no veligers have been discovered. ILM takes special precautions including dedicated sampling gear to insure that zebra mussels are not transmitted to Lake Leopold or Sanctuary Pond through our activities.

4. Goose Control: Dogs are used to chase Canada geese from the site during different seasons. ILM performs egg oiling to destroy future populations of Canada geese that might imprint to the site, and our goose control permits are updated annually. No Canada goose nests have been identified at Sanctuary Pond. The nesting island in Lake Leopold has been the primary goose nesting area at Prairie Crossing.

B. Aquatic Systems Status

1. Biological Interactions

Sanctuary Pond was established as a sanctuary for four species of E/T fish in 2000. ILM has confirmed the presence of five E/T species (including the accidental introduction of pugnose shiners). Two sampling sessions were performed in 2006. The results indicated that blackchin shiners (*Notropis heterodon*) were the most numerous species, with banded killifish (*Fundulus diaphanus*) second. Blacknose shiners (*Notropis heterolepis*) and Iowa darters (*Etheostoma exile*) were present in smaller numbers. Overall trends show that fish populations have increased with time and relative abundances are fairly stable.

Although EWM is the dominant species in the pond, coontail is a close second. Coontail occurs in areas that had once been dominated by chara. Once the EWM populations have decreased, coontail may take over as the dominant species. There is no natural control for coontail and herbicides would need to be applied in mid summer when other plant species are actively growing. In the future the sediment curtain may be used for partial herbicide treatments. To date, curlyleaf pondweed has not been observed in Sanctuary Pond, although it is one of the dominant species in Lake Leopold.

Blue green algae populations were much lower in 2006 than in 2005 (see "Annual average blue-green algae" chart). This was likely due to the wet summer that was experienced in 2006, versus the drought year of 2005. Light amounts of blue-green algae are normal for ponds as long as it does not reach bloom proportions. The relative algal biovolume for blue-green algae (Cyanophyte) has varied from 15 – 50%, with an average of about 30%.

2. Water Movement

The hydraulic retention time of Sanctuary Pond has not been calculated, but it is probably quite long due to its location at the top of the watershed. Hydraulic and nutrient budgets will be calculated later this season. Long retention times, such as seen at Lake Leopold, may lead to the accumulation of nutrients and other pollutants. Rainfall for 2006 was slightly above average, and a recovery from the 2005 drought occurred during the winter of 05-06.

3. Water Quality

Water quality parameters fell within the range of previous years' results, and nutrients continue to remain fairly low. Even though the pond is relatively shallow (~ 8.5 ft), it weakly stratifies in the summer causing nutrient loading back into the water column from anoxic bottom sediments.

4. Habitat

Rooted aquatic plant populations significantly dominate the ecology of the pond. Although predator fish are not present, they would have difficulty foraging for food due to the heavy plant growth. Habitat within the pond would improve significantly if the aquatic weeds could be removed in several areas to provide more diversity. A sand or gravel base in sections of the pond would improve fish habitat. Also, the pond is heavily dominated by the E/T fish species that were introduced in 2000. No other fish species have been observed in the pond during ILM's fish surveys. This means that the ecology of the pond is unbalanced by design in order to protect the E/T fish. Over time it may become balanced if predator fish are introduced into the pond. Left alone, the population may correct itself through a massive dieback threatening the loss of all of the E/T fish. Some research and discussions with the IDNR should be held to determine if the pond should be left as is or allowed to have a more diverse ecology.

A buffer zone of native plants is present around the entire perimeter of the pond, which helps to reduce shoreline erosion and provide habitat for various shoreline species. Bullfrogs are very dominant in the pond and many tadpoles are collected during the fish surveys.

5. Energy Relationships

Aquatic plants can be classified as free floating algae (phytoplankton), attached algae (periphyton), submerged aquatic plants, emergent aquatic plants and floating aquatic plants. Primary productivity refers to the amount of biomass created by photosynthetic organisms across a defined amount of time, generally a year or a growing season. Trophic State Indices (TSIs) are an indirect method of measuring the amount of organic material generated during key stages in the growing season. Sanctuary Pond's TSIs have been the same for the past three years. It should be noted that TSIs only represent the productivity of planktonic algae and do not represent the entire productivity of the pond (i.e. including rooted-aquatic plants and periphyton). In-depth mapping and assessment of the relative biomass of the plant communities would help define the overall productivity of the pond. Based on the TSI for Sanctuary Pond, the productivity of the pond is mesotrophic and appears to be remaining at this level over time (see TSI chart in appendix).

C. Summary

- The extensive rooted aquatic plants in the pond, particularly EWM and coontail (*Ceratophyllum demersum*), are problems that need to be addressed.
- Lack of predation in the pond could be a huge issue for the survival of the E/T fish.

D. Recommendations

Sanctuary pond is maturing and the natural eutrophication process should be slowed down. We can help by:

- EWM and coontail growth continue to be very extensive. Milfoil control with weevils has not been successful and even if it was coontail, would probably take over the areas where EWM had been reduced. The only practical method to control coontail is with aquatic herbicides. Herbicide usage in the pond has not occurred to date and according to Glen Kruse at the IDNR, an incidental take permit for partial treatments should not be required as long as dissolved oxygen sags do not occur.
  - ILM recommends that discussions be held with Liberty Prairie staff regarding the use of herbicides in the pond for spot treatments and its benefits.

- An aquatic plant survey should be conducted annually to notice changes in the plant community and to determine if the milfoil weevils are surviving.

- Diversify the pond bottom with small areas of sand, gravel or rocks Removal of the weeds and installing a liner would be needed to prevent the material from sinking. This would improve aquatic habitat as well as provide an area adequate for aquatic study and surveys.

- Research the implications of installing other fish species into the pond to provide more diversity. Glen Kruse believes that allowing the pond to have a more balanced system would probably improve the hardiness of the E/T fish. He suggested that we write up a fish stocking plan and submit it to him at the IDNR. An incidental take permit may not be required for this activity, but it needs to be reviewed.
  - Once a plan has been developed and approved, ILM can stock the species as needed.
  - ILM can develop a plan that will measure the success of our recommendations that are implemented for the fisheries.

- Continue to conduct fish surveys at least twice per year to gage the population shifts. However, to be more effective, ILM will need to remove some of the aquatic plants prior to subsequent surveys.

- The horses pictured on the front of this report are located on the east side of the pond. Runoff from this area appears to be filtered by only a short buffer zone before the nutrients enter the pond. Most of the farm drains away from the pond, but this area appears to drain towards it.
  - Maintaining a healthy watershed that drains into the pond should be a priority. This would include herbiciding exotic species and controlling pollutants that could enter the pond.

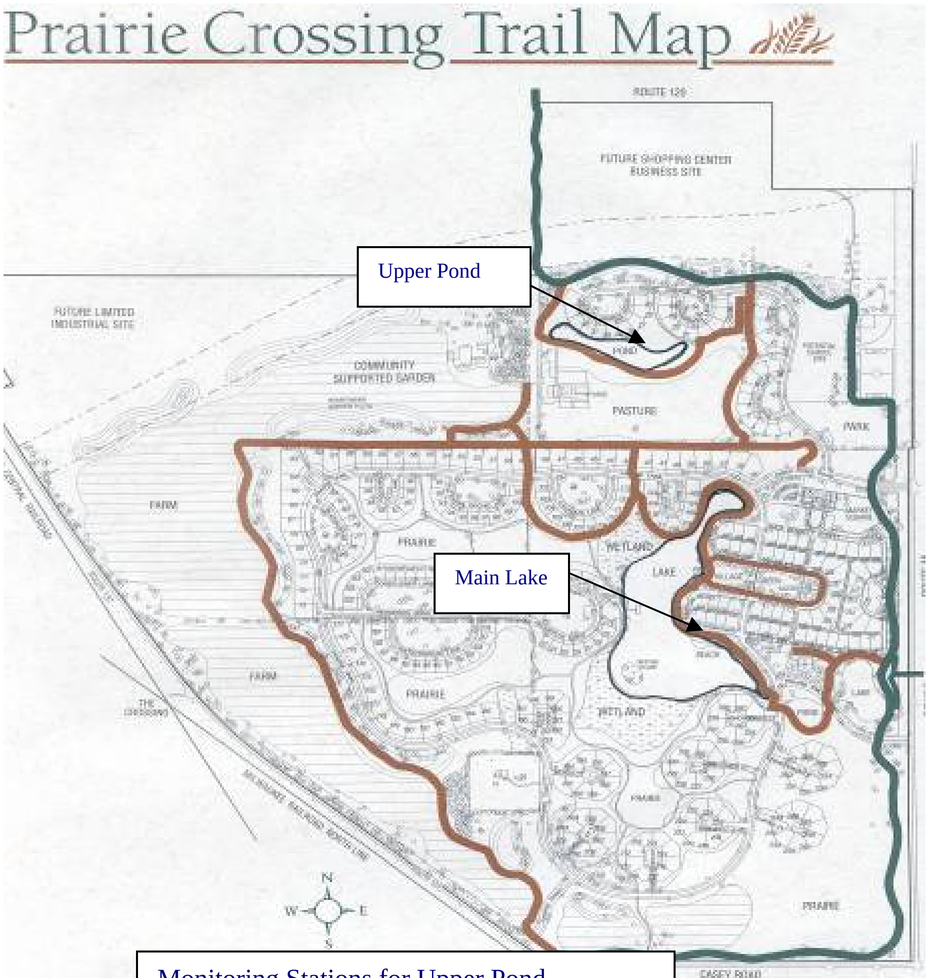
- Continue water quality monitoring on a monthly basis from April through October. Although major changes are not occurring currently in the pond, general trends can be determined and help continue the database of information already available for this pond.

- Chloride concentrations in the pond have increased substantially during the last two years. The heavy rains from the spring/summer of 2006 have not washed out the high concentrations observed during the drought of 2005. Chloride monitoring should continue in the future, and alternatives for salt application should be developed.

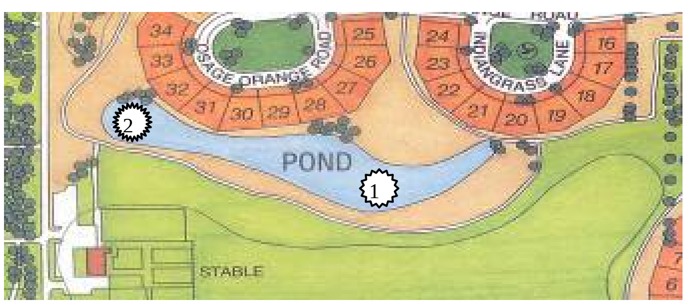
Density of the Eurasian watermilfoil (7/25/06)

White water lilies in bloom (7/25/06)

Prairie Crossing Site Map and Upper Pond Monitoring Stations



Monitoring Stations for Upper Pond



SECTION NO. III: DATA ANALYSIS AND INTERPRETATION

A. Introduction

This year-end report for Sanctuary Pond includes field observations and biological and chemical testing results for the ninth year of water quality monitoring. ILM created a secondary refuge for E/T fish species at Sanctuary Pond in the fall of 1998. The IDNR has required water quality monitoring on a monthly basis during the growing season and monitoring of the fish several times per year. The results of the fisheries survey occurs in a separate report.

Field monitoring and sample collection are undertaken at two stations in Sanctuary Pond, a central station and one on the west side of the pond. Seven site visits were made during the Year 2006 monitoring season from April through October. Field testing and a traditional suite of chemical diagnostics for lakes were taken during each visit. Field testing included: dissolved oxygen and temperature profiles, alkalinity, pH, secchi depth, conductivity, chloride, plankton tows and narrative field observations. Chemical monitoring parameters included nutrients (total & ortho phosphorus and Kjeldahl, nitrate-nitrite, and ammonia nitrogen); suspended solids (total and volatile); algae (chlorophyll *a* and phytoplankton analysis), and chloride, Water samples were also analyzed for relative abundance and relative biomass of zooplankton.

B. Water Quality Results

- **Chlorophyll *a*, TSVS, and Seasonal Algae Shifts**

During 2006 chlorophyll *a* values were somewhat higher (20 ug/l) due to one abnormally high reading on 8/25, when a minor algal bloom occurred. This corresponded with a lower secchi reading that day.

Blue-green algae was only present during June, July and August this year. In June it was dominant and represented about 44% of the algae present, although the total amount of algae that month was fairly low (see "2006 – Sanctuary Pond Blue-green Algae vs. Total Algae" chart). Blue-green algal blooms create a green surface scum that limits light penetration. The dominant blue-green algal forms were different each month (June – *Pseudanabaena*, July – *Merismopedia*, August – *Lyngbya*). The dominant forms that typically cause algal blooms *Oscillatoria* &, *Microcystis* were present, but in very low concentrations.

Chlorophyll *a* Concentrations 2006– Sanctuary Pond

	4/13/06	5/17/06	6/21/06	7/25/06	8/25/06	9/27/06	10/26/06	2006 Avg.
Chlorophyll *a* (µg/l)	5.4	2.5	3.6	2.9	20.0	4.3	4.6	6.2

Annual Average Chlorophyll *a* Concentrations– Sanctuary Pond

	1998	1999	2000	2001	2002	2003	2004	2005	2006
Mean (µg/l)	2.1	3.6	5.5	4.2	24.5*	10.4	6.7**	5.9	6.2

Colored boxes identify a shift in analytic laboratories. Prior to 2004 Northern Lakes Laboratory performed tests. In 2004 Environmental Monitoring and Technologies did analytic testing through mid 2005, when Northern Lakes was again used.
*This value was skewed by an uncharacteristically high value in August 2002.
** Non-detectable levels of Chlorophyll a values were not included in average because method detection limits were higher than in previous years

- **Chloride Concentration**

The average chloride concentration in Sanctuary Pond decreased somewhat from 2005, but still remained higher than previous years (2001 – 2004). The high concentrations experienced in 2005 (131.4 mg/l) were due to the drought concentrating chloride in the pond, and lower levels observed in 2006 (117.3 mg/l) were due to dilution from normal rainfall events. The main source of chloride is road salt that began being applied during the winter of 2000-2001. The pond has a long retention time and chloride entering the lake as road salt sometimes becomes diluted from spring and summer rains, if the rainfall is plentiful. Studies have suggested that chloride influences on aquatic ecosystems are identifiable when concentrations exceed 250 mg/l.

Chloride Concentrations in 2006 – Sanctuary Pond								
	4/13/06	5/17/06	6/21/06	7/25/06	8/25/06	9/27/06	10/26/06	2006 Avg.
Chloride (mg/l) Site 1 Analytic Lab.	110	91	120	130	130	130	110	117
Chloride (mg/l) Site 1 Field Probe	160	180	160	140	140	160	160	157

Annual Average Chloride Concentrations – Sanctuary Pond									
`	1998	1999	2000	2001	2002	2003	2004	2005	2006
Mean (mg/l)	11.5	10.7	11.1	83.0	74.3	74.3	84.8	131.4	117.3
Std. Dev.	4.0	2.2	2.0	8.2	3.3	4.3	23.7	14.7	14.7

Colored boxes identify a shift in analytic laboratories. See Chlorophyll a chart for more information.

- **Conductivity**

Conductivity measures the ability of the water to carry an electrical current, which in turn is dependent on the number of soluble ions present. The larger the number of ions in the water, the higher the conductivity. Chloride is typically the most common ion in water systems, so increases in chloride should cause increases in conductivity. Changes in conductivity that do not involve chlorides imply that other types of chemical loading are taking place. Conductivity values for 2006 correspond to the chloride concentrations discussed above, where 2005 was high due to drought, and 2006 is lower due to increased rainfall, but the concentration is still elevated from levels observed during 2001 - 2004.

Annual Average Conductivity Concentrations – Sanctuary Pond									
	1998	1999	2000	2001	2002	2003	2004	2005	2006
Mean (umhos)	355	378	340	528	545	516	502	805.9	783
Std. Dev.	50.9	84.2	43.2	78.9	88.9	99.5	56.0	82.2	81.7

Colored boxes identify a shift in analytic laboratories. See Chlorophyll a chart for more information.

- **Water Clarity (Secchi Depth), Total Suspended Solids, and Turbidity**

Water clarity, as measured with a Secchi disk, is one of the more significant water quality parameters since it can have a direct bearing on the expressed productivity (how much algae or how many plants are created in a growing season). It can vary dramatically depending on the amount of rooted aquatic plant growth, recent wave action and other factors. Water clarity has increased every year since 1998. This increase in clarity is probably due to the extensive aquatic weed population and low algae growth. Average water clarity was 6.4 ft., which is almost to the bottom of the pond! Maximum water clarity was 7.7 feet. Water clarity is also related to the depth to which plants or algae can grow or the photic zone. In general the photic zone is approximately twice the secchi depth. For Sanctuary Pond this means that light is sufficient to grow plants or algae across the full depth of the lake.

Total suspended solids (TSS) is determined by filtering a water sample under standard conditions and weighing the residue that is left. Organic and inorganic suspended particles contribute to the TSS value and they influence water clarity. TSS can vary dramatically especially during the dormant season when wave action can disturb the lake bottom. Therefore secchi clarity and TSS values are inversely correlated with one another. The average total suspended solids (TSS) concentration for 2006 was 1.1 mg/l, somewhat less than in past years.

Water Clarity 2006 – Sanctuary Pond							
	4/13/06	5/17/06	6/21/06	7/25/06	8/25/06	9/27/06	10/26/06
Secchi depth (ft)	5.5	7.5	7.5	5.4	4.2	7.7	7.0
TSS (mg/l)	ND	1	2	2	1	ND	2

Annual Average Water Clarity – Sanctuary Pond									
`	1998	1999	2000	2001	2002	2003	2004	2005	2006
Secchi depth (ft)	3.6	3.6	3.9	4.9	5.1	3.4	5.2	5.5	6.4
TSS (mg/l)	9.7	9.3	6.8	1.5	4.0	5.5	2.9	3.2	1.1

Colored boxes identify a shift in analytic laboratories. See Chlorophyll a chart for more information.

- **Total Phosphorus and Orthophosphorus**

The average total phosphorous concentration was slightly higher this year (0.031 mg/l) than last year (0.029 mg/l). The values have fluctuated between 0.02 and 0.04 over the nine-year sampling period with no trend confirmed. Impacts of shading, dilution and nutrient uptake by aquatic plants will be reflected in total phosphorus values. Both total and orthophosphorus were measured during each monthly sampling event, so the average concentrations are an average of seven months, unlike previous years when the average may only reflect four months of data collection.

Total phosphorus was also tested one foot from the bottom during the summer months when the pond bottom was anoxic in order to determine if the sediment was releasing phosphorus. Although some minor differences were observed from the surface sample, the deep samples did not show significantly higher phosphorus concentrations. The average was 0.032 mg/l with a range of 0.022 – 0.40 mg/l.

Orthophosphorus values have stayed quite low, and are not likely to be significant unless substantial aquatic plant control is effected, which would release phosphorus when the dying plants decompose.

Phosphorus Concentrations 2006– Sanctuary Pond								
	4/13/06	5/17/06	6/21/06	7/25/06	8/25/06	9/27/06	10/26/06	2006 Avg.
Total phosphorus (mg/l)	0.025	0.044	0.025	0.032	0.025	0.031	0.032	0.031
Orthophosphorus (mg/l)	ND	0.025	ND	ND	0.015	ND	ND	0.006

Annual Phosphorus Concentrations – Sanctuary Pond									
	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total phosphorus (mg/l)	0.039	0.039	0.033	0.025	0.036	0.033	0.020	0.029	0.031
Orthophosphorus (mg/l)	0.010	0.006	0.013	0.004	ND	0.002	<0.010	0.010	0.006

Colored boxes identify a shift in analytic laboratories. See Chlorophyll a chart for more information.

- **Nitrate/Nitrite, Kjeldahl Nitrogen, and Ammonia Nitrogen**

Nitrogen concentrations were very low in 2006. These low values may be attributable to water column uptake by algae and/or rooted aquatic plants. During the growing season nitrogen is actively used by plants and algae and is released into the water when they die in the fall.

Annual average Kjeldahl nitrogen (TKN) has decreased from the last few years. TKN represents the amount of "organic" nitrogen contained by algae and organic detritus in the water column. The nitrogen to phosphorus (N:P) ratio was 25.5 for 2006 indicating that Sanctuary Pond is phosphorus limited. Although the N:P ratio has varied from 18 – 47, they have always indicated that the pond is phosphorus limited. Ratios below 10:1 are regarded as nitrogen limited.

Average Annual Nutrient Concentrations – Sanctuary Pond									
	1998	1999	2000	2001	2002	2003	2004	2005	2006
Avg. TKN (mg/l)	0.70	0.76	0.77	0.82	0.77	0.98	0.94	1.2	0.79
Ammonia nitrogen (mg/l)	0.11	0.16	0.01	0.03	0.04	ND	ND	0.10	ND
Nitrate/Nitrate (mg/l)	0.11	0.11	ND	0.02	ND	ND	ND	0.03	ND
N:P Ratio	17.95	19.49	23.33	32.80	21.39	29.69	47.00	41.38	25.5

Colored boxes identify a shift in analytic laboratories. See Chlorophyll a chart for more information.

Ammonia nitrogen and nitrate/nitrite concentrations have remained below detection limits for many years. These low values may be attributable to water column uptake by algae and/or rooted aquatic plants.

- **Dissolved Oxygen/Temperature Profiles**

Ponds are not considered to be stratified unless there is at least a three degree Centigrade difference between the surface water and the bottom. Temperatures at Sanctuary Pond were homogeneous or very weakly stratified for most of the year. Only July showed a difference in temperature greater than 3^{o}C.

Dissolved oxygen values ranged from 5.1 mg/l (August) to 11.5 mg/l (May) at the surface. At the bottom of the pond, dissolved oxygen became very low during the summer months. The range in dissolved oxygen at the bottom of the pond ranged from 0.3 mg/l in august to 9.5 mg/l in April. Values below 2 mg/l at the water-sediment boundary will result in the release of nutrients from bottom sediments. Values above 5.0 mg/l are preferred by most aquatic fauna.

- **Chemical Oxygen Demand**

Chemical Oxygen Demand (COD) was not tested in 2006 as requested by client. COD represents the amount of oxidizable organic and inorganic materials present in the water column. It is a general measurement of the amount of organic material present, especially when values of inorganic nitrogen are low, such as in Sanctuary Pond. COD values greater than 30 mg/l are considered high, which indicates oxygen depletion.

Annual Average COD Concentrations – Sanctuary Pond								
	1998	1999	2000	2001	2002	2003	2004	2005
Mean (mg/l)	27	24	26	23	30	28	26.5	30.5

Colored boxes identify a shift in analytic laboratories. See Chlorophyll a chart for more information.

- **Carlson Trophic State Index**

Carlson's Trophic State Index (TSI) is a quick way to determine the health of a pond using water clarity, total phosphorus, and chlorophyll *a* concentrations. The index indirectly measures the relative planktonic algae across the growing season but does not measure the productivity of rooted aquatic plants. The TSI was the same as last year but decreased somewhat from previous years (51 mesotrophic).

Carlson Trophic State Index – Sanctuary Pond									
	1998	1999	2000	2001	2002	2003	2004	2005	2006
TSI	53	54	55	51	53	56	51	51	51
Class	Meso/ Eutrophic	Meso/ Eutrophic	Eutrophic	Meso/ Eutrophic	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic

Colored boxes identify a shift in analytic laboratories. See Chlorophyll a chart for more information.

C. Algal and Zooplankton Populations

The dominant forms of algae change across the season. Chrysophytes (brown algae) were dominant in April and May, blue-greens (Cyanophytes) were dominant in June and August, while Dinoflagelates were dominant in July. Cryptophytes were dominant in September and October. There was no blue-green algae detected in the pond in April and May.

Blue-green algal forms did not reach bloom proportions. The dominant blue-green algal forms were *Pseudanabaena* in June, *Merismopedia* in July, and *Lyngbya* in August. Blue-green algae peaked in June this year.

Zooplankton sampling indicated that rotifers were the most common species present in 2006. Copepods were dominant in August, with rotifers dominant during the other sampling periods. The average number per liter of zooplankton observed was higher compared to previous years. Zooplankton biomass can be expected to fluctuate and favor species that are not predated upon by the E/T fish. Rotifers do not appear to be a preferred food and these have been the dominant zooplankton observed.

D. Sediment Sampling

In 2005 Donna Sefton, a locally well known limnologist, visited Sanctuary Pond and reviewed the historic water quality data. One of her recommendations was to study the nutrients in the sediment and to also look at other parameters in relation to their contribution to nuisance aquatic plant growth, specifically EWM in the pond. ILM contacted Steve McComas of Blue Water Science, who has been studying the sediment chemistries required for curly leaf pondweed (CLP) and EWM and their capacity to form dense populations. This year ILM collected shallow sediment samples from 2 main sites, each of which consisted of composite sediment samples. The results are shown in the appendix. Based on these results, it appears that conditions are very favorable for EWM growth and not for CLP. Overall the nutrient concentration of the sediment is fairly low. This was a bit surprising due to the heavy aquatic plant growth that occurs in the pond.

Steve McComas has also developed a density characterization for EWM which is included in the appendix of this report. According to his determinations, EWM would fit in the heavy nuisance growth characteristics given the density of this plant at Sanctuary Pond.

Recreational use of the pond (7/25/06)

APPENDIX

Description of Monitoring Parameters

DESCRIPTION OF MONITORING PARAMETERS

Field Monitoring

Dissolved oxygen (D.O.) *is needed for aquatic life to survive. A healthy environment for fish has D.O. concentration above 5 mg/L. Below 5 mg/L, fish become stressed. When the D.O. reaches 3 mg/L, fish may begin to die. Dissolved oxygen varies depending day/night cycles, the amount of direct sunlight, and the temperature. D.O. drops at night and is highest on sunny days. D.O. is also much higher in cool water in the spring and fall, than during the summer. The Illinois State standard for D.O. is 5 mg/L at all times, and should not fall below 6 mg/L during at least 16 hours out of any 24 hour period (IEPA Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter 1: Pollution Control Board, State of Illinois Rules and Regulations, 1993).*

pH *Some changes in pH occurs naturally and is related to the amount of algal growth in the lake. Most lakes in this area have a pH of greater than 7 and often in the 8 range. pH measures the acidity and alkalinity of the water. A pH of 7.0 is neutral, below 7 is acidic and above 7 is alkaline. The pH scale is logarithmic, so a pH change of 1 unit is very significant.*

Alkalinity *measures the buffering capacity of the lake. Normal alkalinity for this region is about 90-250 mg/L.*

Secchi *indicates the clarity of the lake water. A high secchi depth indicates that the water is quite clear and free of algae and/or suspended sediments*. *A low secchi depth of less than 3 feet indicates that the water is very turbid. Turbidity could be due to either planktonic algae or suspended sediments*.

Chemical Analysis

Biological Oxygen Demand (BOD) *is an indirect measurement of organic loading. This test measures the amount of oxygen removed from the water column during a specified time period (5 days). The BOD is calculated from the difference between the initial and the final dissolved oxygen levels. Oxygen is removed from the water by biochemical degradation of organic matter (carbonaceous demand) and oxidation of inorganic matter such as sulfides, and ferrous iron ("Standard Methods for the examination of water and wastewater, 1989, 17th ed.). Natural, unpolluted waters have a BOD less than or equal to 5 mg/L. Sewage treatment plants have to reduce the BOD levels to the extent listed in their discharge permits. Treated wastewater normally has a BOD between 8 and 150 mg/L ("The monitor's handbook," 1992 by the LaMotte Company).*

Chemical oxygen demand (COD) *represents the amount of oxygen needed to oxidize all inorganic and organic material present in the sample. A strong chemical oxidizer is added to the sample to oxidize the inorganic material. The higher the COD level, the higher the potential for dissolved oxygen depletion. COD readings between 20 - 30 mg/L indicate "moderate organic enrichment." Measurements above 30 mg/L have a high magnitude of organic material. ("Clean lakes program, Phase I diagnostic/feasibility study of McCullom Lake," Northeastern Illinois Planning Commission, 1992).*

Chloride *is usually tested in lake waters as an indicator of human activity. Natural waters away from human influence usually have chloride measurements below 20 mg/L. Sources of chloride include agricultural chemicals, human and animal wastes, and road salt.*

Conductivity *measures the water's ability to conduct an electrical current, and is influenced by the amount of dissolved ions in the water. Conductivity levels vary dramatically from site to site. Distilled water has essentially no conductivity, while seawater is about 50,000 μmhos/l. Typical streams have a conductivity ranging from 150 to 3000 μmhos/l.*

Nitrogen *in a lake usually depends on local land use. High levels of nitrogen are found in runoff from agricultural areas where fertilizer and animal waste occur and from lawns that have been fertilized.*

Waterfowl waste products also contribute nitrogen to the lake. Nitrogen also enters the water naturally from atmospheric deposition during thunderstorms.

Nitrogen has several different forms that are important for lake studies. Ammonium (NH_4+) occurs from human and animal waste products and decomposing organic matter. Kjeldahl nitrogen includes organic nitrogen plus ammonium. Organic nitrogen is nitrogen that occurs in living organisms. All inorganic forms of nitrogen, nitrate (NO_3-) nitrite (NO_2-), and ammonium (NH_4+) can be used as food for aquatic plants and algae. Total nitrogen is the sum of nitrate, nitrite, and Kjeldahl nitrogen (Shaw et al.). Although nitrogen may enter the lake in one form, microorganisms in the sediment and water can change nitrogen to a different form. Some of the nitrogen within the lake may eventually leave the lake by entering the atmosphere as nitrogen gas, flowing out the outlet, or becoming part of the sediments (Wetzel, 1983, Limnology, 2nd ed. Saunders College Publishing: Philadelphia, Pennsylvania).

The general use water quality standard for ammonia nitrogen in Illinois is based on the temperature and pH of the water. The maximum allowable ammonia nitrogen concentration is 0.1 mg/L when the water is above 80°F and pH is 9.0 for chronic conditions (IEPA, Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter 1: Pollution Control Board, State of Illinois Rules and Regulations, 1998). Higher levels of ammonia nitrogen are acceptable when the water has a lower pH and/or when it is cooler. High concentrations of ammonia are potentially toxic to fish life. Lake water concentrations of inorganic nitrogen above 0.3 mg/L can be sufficient to promote algae blooms (Forest Preserve District of DuPage County, 1993, "Phase I Diagnostic - Feasibility study of Herrick Lake, DuPage County, Illinois").

Nitrogen levels change throughout the season depending on plant uptake. Typically nitrogen is higher in the spring and fall when plants are not actively taking up nutrients, and the lake is thoroughly mixed. Also, nitrogen re-enters the upper reaches of the water column during the spring and fall turnover, when the nitrogen rich bottom layer of water is mixed with the surface layer.

Total nitrogen is the sum of Kjeldahl nitrogen plus nitrate/nitrite. The N:P ratio is helpful to determine if the lake is nitrogen or phosphorus limited. Lakes with a ratio above 10:1 have phosphorus as the limiting nutrient controlling the amount of plant growth. Lakes below the 10:1 ratio have nitrogen as the limiting nutrient.

There is the potential for an algal bloom when the inorganic nitrogen (nitrate/nitrite + ammonia) is above 0.3 mg/L (as N).

Total phosphorus (P) *has been the nutrient most often measured in lakes. Phosphorus is the nutrient that stimulates plant growth in most lakes. Total phosphorus represents a sum of all of the different forms of phosphorus in the water column, both dissolved and particulate. Total P includes orthophosphorus, phosphorus contained within organisms and, phosphorus attached to sediments. Orthophosphorus is the dissolved inorganic form of phosphorus that can be used easily by plants. Organisms such as algae contain small amounts of phosphorus that are released when the organism dies. Only very small amounts of phosphorus are needed to stimulate aquatic plant growth.*

The standard for total P is 0.05 mg/L, which is a guideline for natural waters. Urban and rural lakes usually have a much higher total phosphorus level than 0.05 mg/L. Although the state exceedence standard is 0.05 mg/L for natural water (IEPA Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter 1: Pollution Control Board, State of Illinois Rules and Regulations, 1993), many lakes are well above that level because of nutrient loading in stormwater runoff.

Orthophosphorus *is the dissolved inorganic form of phosphorus that can be immediately used by plants. Levels of ortho P above 0.005 mg/L frequently cause algae blooms. Wastewater, agricultural and urban runoff are major sources of orthophosphorus and particulate phosphorus to lakes and streams. Orthophosphorus is the main form of phosphorus found in domestic wastewater (Garmen, G. D., G. B. Good, and L. M. Hinsman, 1986, Phosphorus: a summary of information regarding lake water quality, IEPA/WPC/86-010, Planning Section Division of Water Pollution Control, Illinois Environmental Protection Agency: Springfield, Illinois.)*

Total suspended solids (TSS) *consists of all "filterable" solids present in the water column, and includes both inorganic and organic solids. It is determined from the amount of material collected on a filter.*

Total suspended volatile solids (TSVS) *includes all the organic material, such as algae and invertebrates, in the water column that can be measured by drying the water sample at high enough temperatures to burn off the sample residue.*

Total solids (TS) *are the sum of total suspended solids (TSS) and total dissolved solids (TDS).*

Turbidity is measured in NTUs (Nephelometric Turbidity Units) and determines the extent of water coloration and suspended particles. Turbidity measurements > 20 NTUs are considered very turbid and may cause impacts to the aquatic biota

Chlorophyll *a*, *which is present in plants and algae, is the primary green pigment necessary for photosynthesis to occur. Measuring the amount of chlorophyll a in the water gives a rough indication of the amount of algae present in the lake. The pheophytin a, and trichromomatic chlorophyll a, b, and c represent different pigments that occur in algae. Pheophytin a, in particular, is a degradation product of chlorophyll a that interferes with its analysis. Therefore, corrected chlorophyll a represents the amount of algae present in the lake after adjusting for the presence of pheophytin a.*

Trophic State Index

The trophic state index is useful to determine long-term changes. Since some of the indices of the trophic state index change throughout the season, the TSI is not very effective at determining trophic state from only a single site visit, but is much better if at least 4 – 6 visits throughout the season are made and averages calculated.

Field Methods

FIELD METHODS FOR WATER QUALITY TESTING

FIELD MONITORING:

Water clarity is measured using a 20-cm secchi disk, a black-and-white painted metal disk attached to a cord which is marked at one-foot intervals. The disk is lowered into the water to the point at which the painted divisions are no longer visible. This depth is recorded as the secchi depth, which is an indicator of the amount of water clarity. At least two readings are taken at every sample site.

Dissolved oxygen (DO) is measured using a Hydrolab Quanta Water Quality Monitoring System, a digital multiprobe meter which gives readouts of temperature, dissolved oxygen, pH, and conductivity concentrations. The meter is calibrated at ILM against a solubility table for oxygen in water at various temperatures. The meter is calibrated based on temperature and barometric pressure. Calibrated is typically only needed once per day. To operate the meter, Quanta Transmitter is lowered into the water at one-foot depth intervals and measurements recorded. The Quanta is routinely compared with DO analyses using a HACH kit (model OX-2P). If the differential is greater than 1 mg/l, the readings are regarded as invalid and both the meter and HACH tests are redone.

Water temperature is recorded using the Hydrolab Quanta Water Quality Monitoring System, as well as with a backup non-mercury thermometer.

pH measurements are taken using the Hydrolab Quanta Water Quality Monitoring System and a back up test is done with a LaMotte model HA analog pH meter. Both meters are standardized before use in the field by inserting the probe into buffer solutions of pH 7.0 and 10.0, and calibrating the meter to the appropriate pH. PH buffers are chosen to be slightly above and below the expected pH encountered in the field. The meter is set to the appropriate water temperature for each site, the probe inserted into the water column, and the pH reading then recorded for each foot of depth.

Conductivity measurements are taken in the field using the Hydrolab Quanta Water Quality Monitoring System. The meter uses a two-point calibration, distilled water and 500 umhos/cm. Conductivity is read per foot of water depth.

Chloride measures the amount of salt in the water. A Hach Model 8-P, 5-400 mg/l test kit is used for field analysis. Frequently laboratory backup is also employed. Both high range 0 – 400 mg/l and low range 0-100 mg/l can be used. The method utilized involves titrating silver nitrate into the mixing bottle until a color change is noted. The amount of chloride is then calculated from the number of drops added.

Alkalinity is measured using a HACH model AL-DT with digital titrator. A sulfuric acid titration cartridge is attached to the titrator body. A 100-ml water sample is collected and placed in a glass flask. Phenolphthalein indicator is added to the sample and swirled to mix. Bromcresol green-methyl red indicator is then added to the sample and mixed. Using the digital titrator, the sample is titrated with the sulfuric acid standard solution to a light pink color, and the concentration of alkalinity recorded from the digital reading. Periodically the kit results are graded against a known standard solution provided by the manufacturer.

A **plankton tow** from Wildlife Supply Company, Wildco 48 C60, is used for specimen collection. The plankton tow is comprised of mesh netting with a weighted chamber and rope attachment. The plankton tow is thrown several feet from the boat and pulled through the water at a depth of one to two feet. The clamp attachment on the outlet hose is released and the water poured from the collection chamber into the specimen bottle, which is then reviewed under a microscope back at ILM. The tow is cleaned between sampling sites with a solution of Chlorox. Chlorox residual is rinsed off with distilled water.

CHEMICAL TESTING:

Water samples for laboratory analysis are collected using Wildlife Supply Company's Wildco model 1930-G62 beta bottle. The bottle is lowered into the water column to the appropriate depth (2 feet for all sites except the deep sample taken at 10 feet). When the weighted metal attachment is dropped along the rope from the surface, the collection chamber's doors are released and the water sample is thus captured and retrieved. To avoid contamination, the beta bottle is periodically cleaned with a solution of liquid Alconox and rinsed with tap water. Prior to specimen collection, the bottle is rinsed with lake water at the site.

All samples are placed on ice in the field immediately after collection. Several tests can be conducted from each sample bottle. Bottles used for collection are clean bottles provided by Northern Lakes Service. A 1-liter unpreserved bottle is collected and tested for chloride, total suspended solids, and conductivity. A 250-ml bottle preserved with sulfuric acid is collected from the lake and tested for the nitrogen series and total phosphorus. A separate 1-liter unpreserved bottle is collected for chlorophyll *a* testing. Following any additional preparation required for each sample, the samples are placed on ice and shipped overnight to Northern Lakes Service in Crandon, Wisconsin for laboratory analysis.

Ammonia nitrogen samples are placed in 250-ml plastic containers with sulfuric acid preservative. The samples are maintained at a temperature of approximately 4 ° C upon collection and during shipment.

Biological oxygen demand (BOD) samples are normally collected at a 2-ft depth, and during lake stratification, about 3 feet above the lake bottom. The samples are placed in an unpreserved 1-liter container and are stored on ice upon collection and during shipment.

Chemical oxygen demand (COD) is also collected at a 2-ft depth and may also be collected near the lake bottom. Samples are placed in a 250-ml plastic container with sulfuric acid preservative. Samples are then placed on ice after collection and during shipment.

Chloride samples are placed in 250-ml plastic containers with no preservative.

Chlorophyll *a* samples are composites taken from 2, 4, and 6-foot depths when the lake is stratified. When the lake is well mixed, chlorophyll *a* samples are collected only at a 2-foot depth. The samples are placed in 1-liter plastic bottles with no preservatives. The samples are maintained at a temperature of approximately 4 ° C upon collection and during shipment.

Conductivity samples are placed in plastic containers with no preservative agents. Although this measurement is taken in the field using a conductivity meter, it is standard practice to submit a sample for laboratory analysis as a back up.

Nitrate and nitrite samples are placed in 250-ml plastic containers with sulfuric acid preservative and are maintained at a temperature of approximately 4 ° C upon collection and during shipment.

Total Kjeldahl nitrogen samples are placed in 250-ml plastic containers with sulfuric acid preservative. The samples are maintained at a temperature of approximately 4 ° C upon collection and during shipment.

Orthophosphorus samples are filtered using Millipore 0.45 um nitrocellulose filters and then placed into 250-ml plastic containers with no preservative agent. The samples are maintained at a temperature of approximately 4 deg. C upon collection and during shipment.

Total phosphorus samples are placed into 250-ml plastic containers with sulfuric acid preservative. The samples are maintained at a temperature of approximately 4 deg. C upon collection and during shipment.

TSS (total suspended solids) **and TSVS** (total suspended volatile solids) samples are placed in 250-ml plastic containers with no preservatives. The samples are maintained at a temperature of approximately 4 ° C upon collection and during shipment.

Algae samples are collected using a 250-ml plastic bottle that contains 1% Lugols iodine. Sample depth is at 2-ft when the lake is well mixed, and is a composite sample a 2, 4, and 6-ft when the lake is stratified. Samples are sent to Water's Edge for analysis.

Zooplankton samples are also collected at 2-ft when the lake is mixed and 2, 4, and 6-ft when the lake is stratified. A total of 2 liters of water are collected and sieved through the bottom portion of a plankton tow. The resulting 20 – 40 mls represent a concentrated sample. Samples are preserved in 70% ethyl alcohol and are sent to Water's Edge for analysis.

Water Quality Results

Sanctuary Pond at Prairie Crossing

2006 Trophic State Index

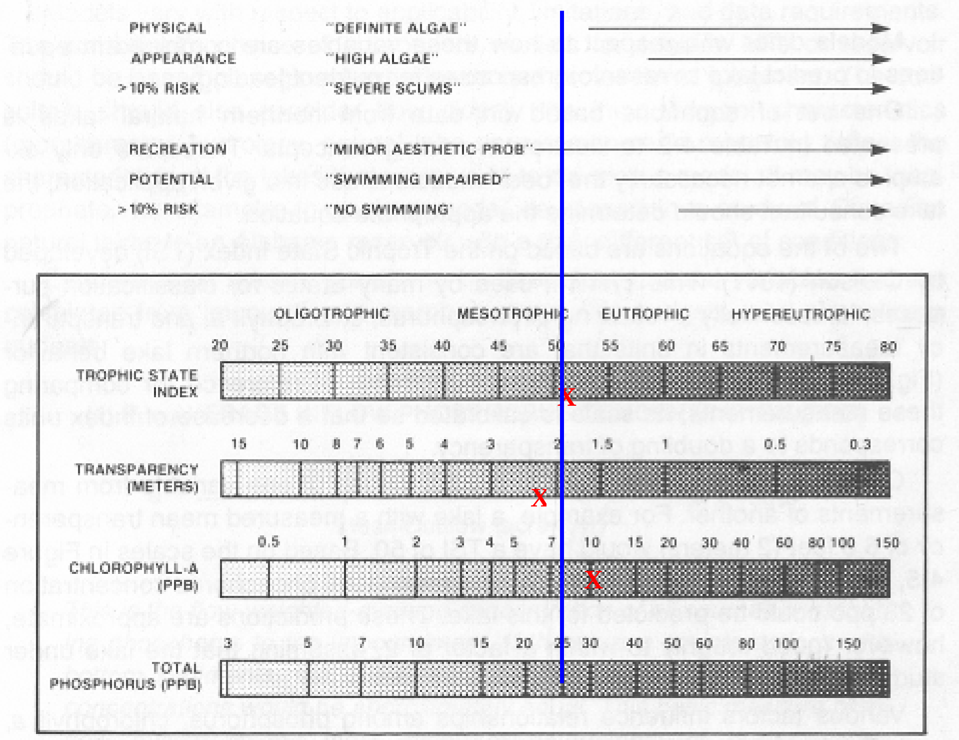


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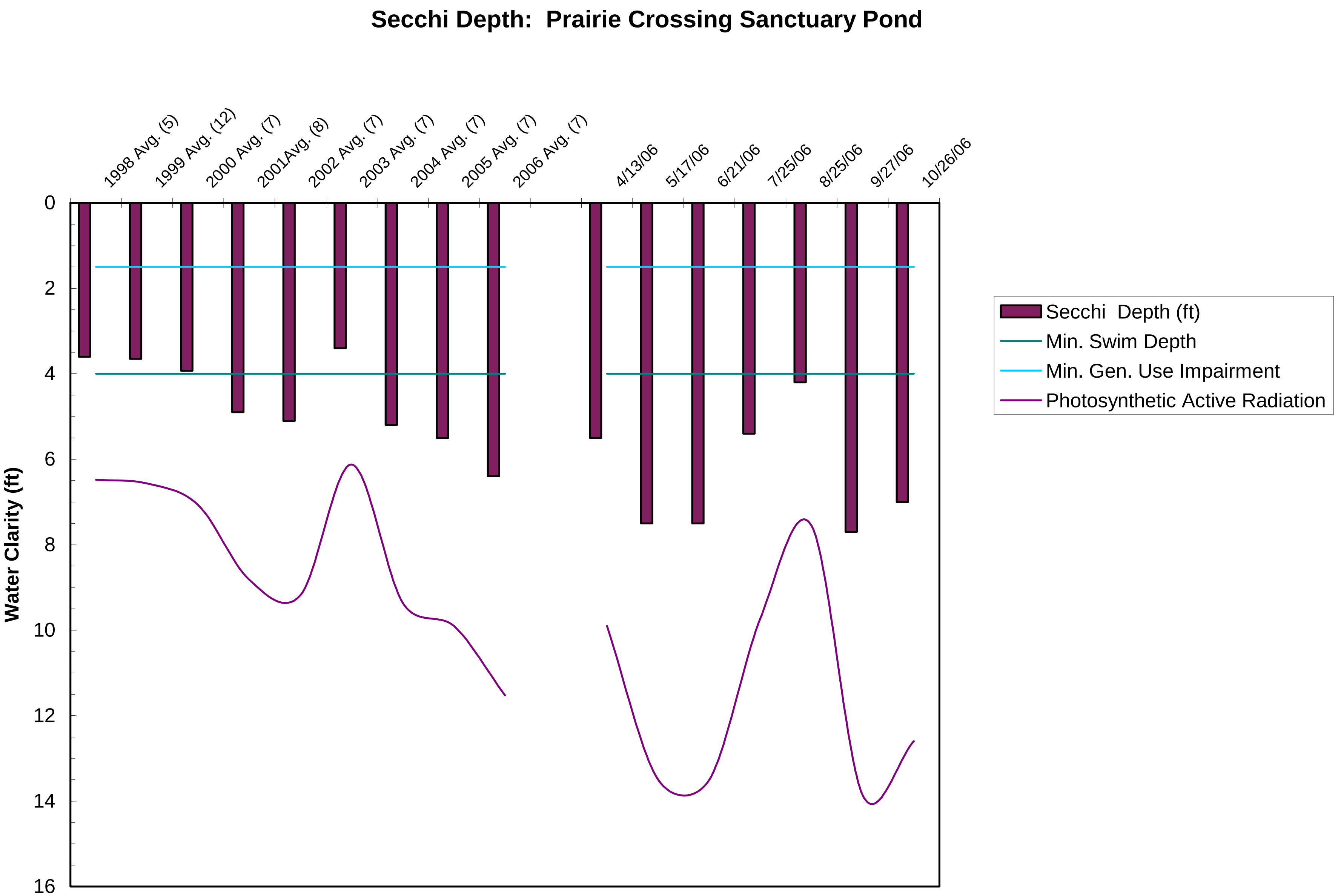
Figure 4-5.—Carlson's Trophic State Index related to perceived nuisance conditions (Heiskary and Walker, 1987). Length of arrows indicate range over which a greater than 10 percent probability exists that users will perceive a problem.


Secchi Depth: Prairie Crossing Sanctuary Pond
1998 Avg. (5)
1999 Avg. (12)
2000 Avg. (7)
2001Avg. (8)
2002 Avg. (7)
2003 Avg. (7)
2004 Avg. (7)
2005 Avg. (7)
2006 Avg. (7)
4/13/06
5/17/06
6/21/06
7/25/06
8/25/06
9/27/06
10/26/06
Water Clarity (ft)
0
2
4
6
8
10
12
14
16
Secchi Depth (ft)
Min. Swim Depth
Min. Gen. Use Impairment
Photosynthetic Active Radiation

Chemical analysis of Sanctuary (Upper) Pond at Prairie Crossing

Site 1 Location: Center of pond

(Samples collected at a 2-foot depth)

Values are mg/l unless otherwise noted

	BOD 5-Day	C.O.D	Chloride as CL	Conduct. umhos	Ammonia as N Nitrogen	Nitrate/ Nitrite Nitrogen	Kjeldahl Nitrogen	Phos. Dis. as P	Phos. Total	Tot. Susp. Solids	Total Susp. Volatile Solids	Total Solids	Turbidity NTU	Chlorophyll *a* (ug/L)	Fecal Coliform colonies/ 100 ml
Standard*	***5***	***30***	500	NA	15/0.01**	NA	NA	***0.01***	0.05	***15****	NA	NA	NA	***20***	200
Avg. 1998	ND	27	11.5	355	0.11	0.11	0.70	0.010	0.039	9.7	1.5	320	NA	2.1	NA
Avg. 1999	0.25	24	10.7	378	0.16	0.11	0.76	0.006	0.039	9.3	5.4	260	NA	3.6	NA
Avg. 2000	ND	26	11.1	340	0.01	ND	0.77	0.013	0.033	6.8	5.5	278	NA	5.5	NA
Avg. 2001	1.75	23	83.0	528	0.03	0.02	0.82	0.004	0.025	1.5	ND	377	NA	4.2	NA
Avg. 2002	0.5	30	74.3	545	0.05	ND	0.77	ND	0.036	4.0	2	383	2.6	24.5	20.5
Avg. 2003	ND	28	74.3	516	ND	ND	0.98	0.002	0.033	5.5	ND	365	2.7	10.4	6
Avg. 2004	6	27	84.8	508	0.00	<0.05/<0.25	0.94	<0.01	0.020	2.9	24	433	1.87	6.7*	NA
Avg. 2005	NA	31	131.4	NA	0.10	< 0.03	1.20	0.010	0.029	3.2	2.8	NA	NA	5.9	NA
4/13/06	NA	NA	110	NA	ND	ND	0.76	ND	0.025	ND	ND	NA	NA	5.4	NA
5/17/06	NA	NA	91	NA	NA	NA	NA	0.025	0.044	1.0	ND	NA	NA	2.5	NA
6/21/06	NA	NA	120	NA	ND	ND	0.69	ND	0.025	2.0	ND	NA	NA	3.6	NA
7/25/06	NA	NA	130	669	ND	ND	0.76	ND	0.032	2.0	ND	NA	NA	2.9	NA
8/25/06	NA	NA	130	NA	ND	ND	0.94	0.015	0.025	1.0	ND	NA	NA	20.0	NA
9/27/06	NA	NA	130	NA	NA	NA	NA	ND	0.031	ND	ND	NA	NA	4.3	NA
10/26/06	NA	NA	110	NA	NA	NA	NA	ND	0.032	2.0	ND	NA	NA	4.6	NA
Avg. 2006	NA	NA	117	NA	NA/ND	NA/ND	0.79	0.006	0.031	1.1	ND	NA	NA	6.2	NA

* IL Standards (Title 35, Subtitle C Water Pollution, IEPA 1998 ***or typical limnological recommended concentrations*** (Yellow) = concentrations above State Standards or Recommended Maximum Concentration

** Ammonia nitrogen is dependent on pH and temperature. At pH 9 & temp 80 °C, std = 0.1 mg/l. At pH 7 and 65 ° temp and below std = 15 mg/l

*** Dredging standard for return water

ND = Not detectable values, NA = data not available

* Not detectable values for Chlorophyll a were not included in average because method detection limits were higher than in previous years

Site 2 Location: West side of pond

(Samples collected at a 2-foot depth)

Values are mg/l

	Phos. Dis. as P	Phos. Total	Tot. Susp. Solids
Avg. 1999	NA	0.034	NA
Avg. 2000	0.010	0.032	8.3
Avg. 2001	0.010	0.030	1.7
Avg. 2002	ND	0.039	5.3
Avg. 2003	0.008	0.033	3.5
Avg. 2004	Samples not collected at this location		
Avg. 2005	Samples not collected at this location		
Avg. 2006	Samples not collected at this location		

Site 1 Location: Deep Sample

(Sample collected 2 feet off bottom)

Values are mg/l

	Ammonia as N Nitrogen	Nitrate/ Nitrite Nitrogen	Phos. Total	COD
Avg. 1999	0.05	ND	0.249	22.5
Avg. 2000	0.02	ND	0.035	NA
Avg. 2001	0.04	ND	0.033	27.5
Avg. 2002	0.04	ND	0.128	42.3
Avg. 2003	ND	ND	0.044	29.5
Avg. 2004	Samples not collected at this location			
Avg. 2005	Samples not collected at this location			
8/11/06			0.035	
8/25/06	NA	NA	0.040	NA
9/27/06	NA	NA	0.022	NA
Avg. 2006	NA	NA	0.032	NA

Water Level - Gage readings

Avg. 2005	1.01 ft	
4/13/06	1.78	
5/17/06	1.76	
6/21/06	1.4	
7/25/06	1.09	
8/25/06	0.92	
9/27/06	1.25	
10/26/06	NA	
Avg. 2006	1.37	ft

Field testing of Sanctuary (Upper) Pond at Prairie Crossing

Site 1 Location: Center of pond

	DO Surface (mg/l)	DO Bottom (mg/l)	Depth (ft)	pH	Secchi (ft)	Temp Surface (*C)	Temp Bottom (*C)	Alkalinity (mg/l)	Conduct. Field (umhos)	Chloride (mg/l)	IEPA Color	Susp. Sed.	Algae	Weeds	Odor
Standard*	5.0	5.0	NA	6.5 - 9	***1.5 / 4***	NA	NA	NA	NA	500					
Avg. 1998	9.4	6.7	8.1	8.4	3.6	15.1	13.9	144	300	NA					
Avg. 1999	9.5	8.3	8.4	7.8	3.6	13.0	12.2	158	245	NA					
Avg. 2000	9.4	4.2	8.3	8.6	3.9	19.8	16.0	135	278	NA					
Avg. 2001	10.7	7.2	8.3	8.6	4.9	15.1	14.3	111	578	NA					
Avg. 2002	9.7	7.9	8.1	9.0	5.1	18.2	15.2	123	572	95					
Avg. 2003	9.2	4.3	8.0	8.7	3.4	18.7	15.5	136	578	123					
Avg. 2004	8.8	4.8	8.3	8.7	5.2	18.4	15.9	115	616	120					
Avg. 2005	8.2	5.4	7.9	8.5	5.5	20.6	17.6	118	806	154					
4/13/06	10.1	9.5	7.5	8.3	5.5	14.9	13.0	130	898	160	greenish yel.	none	none	none	none
5/17/06	11.5	8.2	8.6	8.3	7.5	16.2	13.3	NA	839	180	yellowish	none	minimal	moderate	none
6/21/06	9.6	3.7	8.0	9.2	7.5	23.6	20.9	53	744	160	yellowish	none	minimal	moderate	none
7/25/06	9.2	0.7	8.5	9.7	5.4	26.8	21.0	58	637	140	yellowish	none	slight	moderate	none
8/25/06	5.1	0.3	8.0	8.8	4.2	23.9	21.6	120	770	140	yellowish	none	slight	moderate	none
9/27/06	7.8	2.0	8.5	7.6	7.7	16.2	15.9	160	809	160	yellowish	none	slight	moderate	none
10/26/06	10.2	9.2	7.5	8.6	7.0	7.1	7.1	140	786	160	yellowish	none	none	none	none
Avg. 2006	9.1	4.8	8.1	8.6	6.4	18.4	16.1	110	783	157					

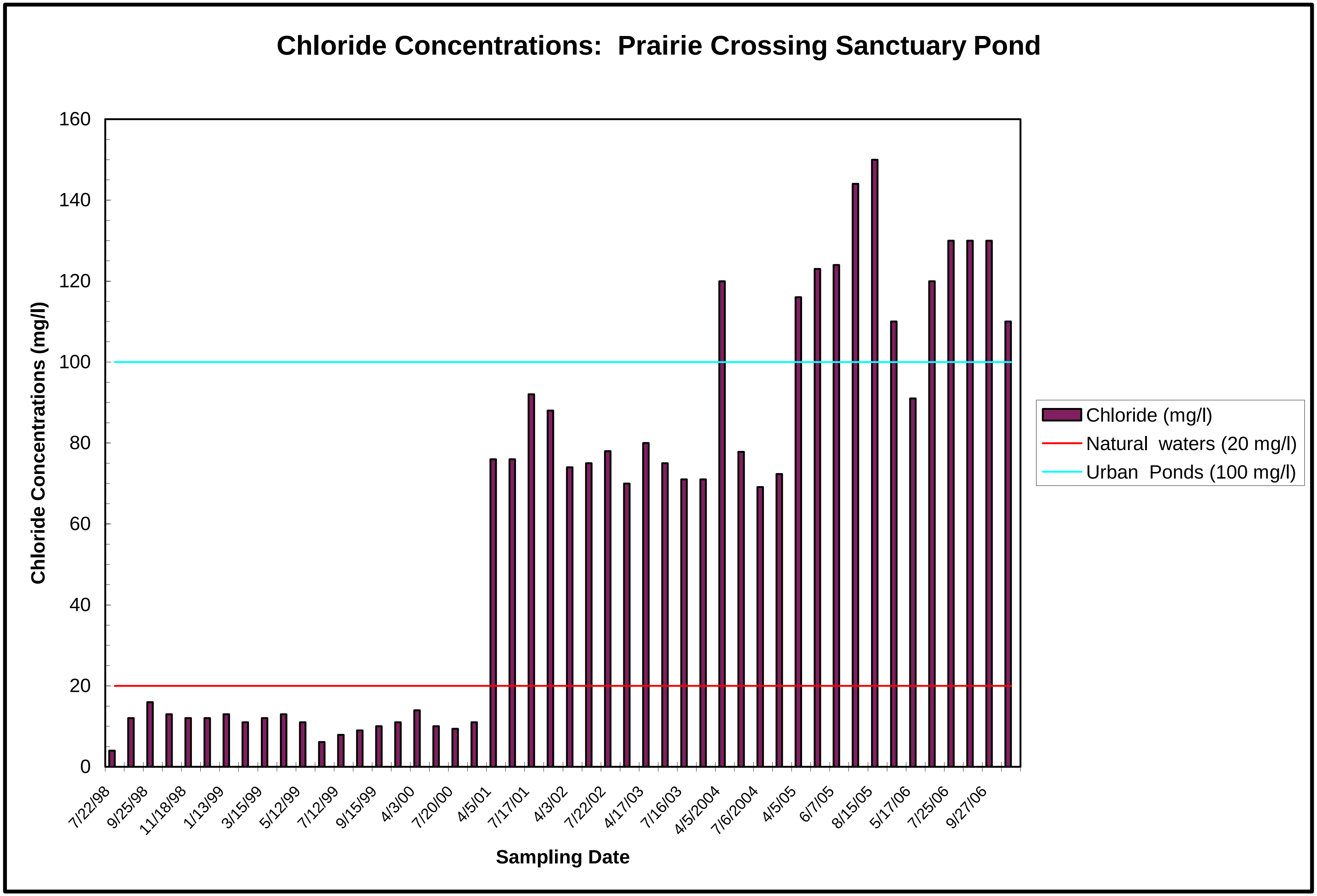
Site 2 Location: West side of pond

	DO Surface (mg/l)	DO Bottom (mg/l)	Depth (ft)	pH	Secchi (ft)	Temp °C Surface (*C)	Temp °C Bottom (*C)	Alkalinity (mg/l)	Conduct. Field (umhos)	Chloride (mg/l)	IEPA Color	Susp. Sed.	Algae	Weeds	Odor
Standard*	5.0	5.0	NA	6.5 - 9	***1.5 / 4***	NA	NA	NA	NA	500					
Avg. 1998	9.8	9.3	6.8	7.9	2.1	7.6	7.5	171	NA	NA					
Avg. 1999	9.0	6.1	8.4	7.7	3.2	13.3	12.2	NA	257.1	NA					
Avg. 2000	9.8	3.3	8.4	8.5	3.8	20.4	16.2	NA	277.2	NA					
Avg. 2001	10.1	7.4	8.0	8.7	5.1	15.3	13.9	174	565.9	NA					
Avg. 2002	10.5	6.6	8.1	9.0	5.0	18.8	14.0	175	562.0	97.5					
Avg. 2003	9.1	1.4	7.8	8.8	3.2	19.2	14.7	121	575.8	116.7					
Avg. 2004	9.0	5.3	8.0	9.0	5.0	20.6	16.2	98	583	NA					
Avg. 2005	9.0	3.7	7.3	8.8	4.7	20.9	17.0	58	799	160					
4/13/06	10.2	8.3	9.0	8.3	5.0	15.3	12.6	NA	899	NA	greenish	none	none	none	none
5/17/06	11.6	9.8	8.0	8.4	6.5	15.6	13.5	NA	841	NA	yellowish	none	minimal	moderate	none
6/21/06	9.4	1.3	8.8	9.2	6.8	24.2	19.8	NA	740	NA	yellowish	none	minimal	moderate	none
7/25/06	9.3	0.4	8.0	9.5	6.2	28.8	20.8	68	641	NA	yellowish	none	moderate	moderate	none
8/25/06	5.7	0.3	8.0	8.8	4.5	25.1	20.1	NA	769	NA	yellowish	none	moderate	moderate	none
9/27/06	8.1	3.4	8.1	7.9	7.5	16.3	15.6	NA	802	NA	yellowish	none	slight	moderate	none
10/26/06	10.5	8.8	7.5	8.7	7.0	7.2	7.2	NA	792	NA	yellowish	none	none	moderate	none
Avg. 2006	9.3	4.6	8.2	8.7	6.2	18.9	15.7	68	783	NA					

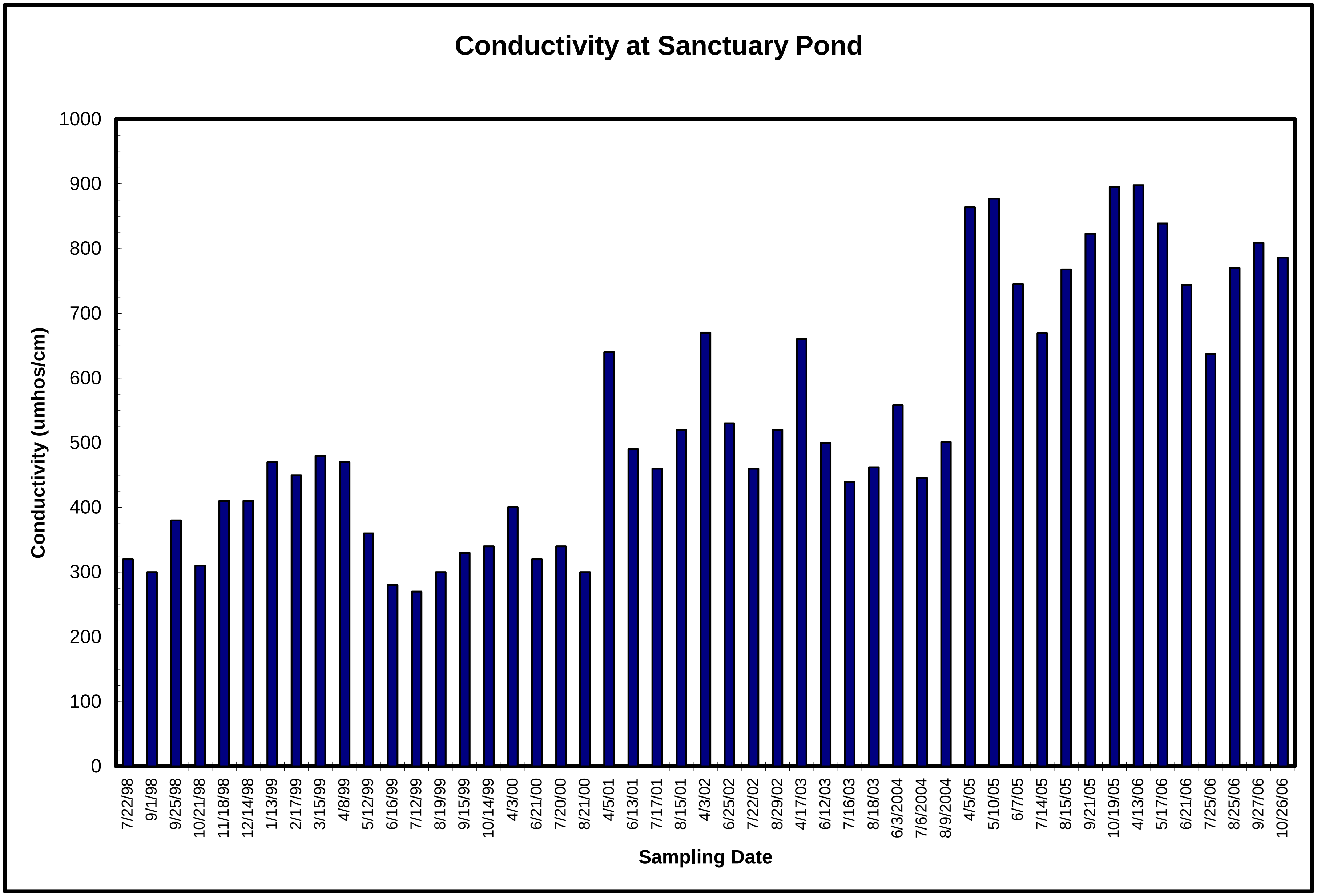
*IL Standards (Title 35, Subtitle C Water Pollution, IEPA 1998) ***or typical limnological recommended concentrations***

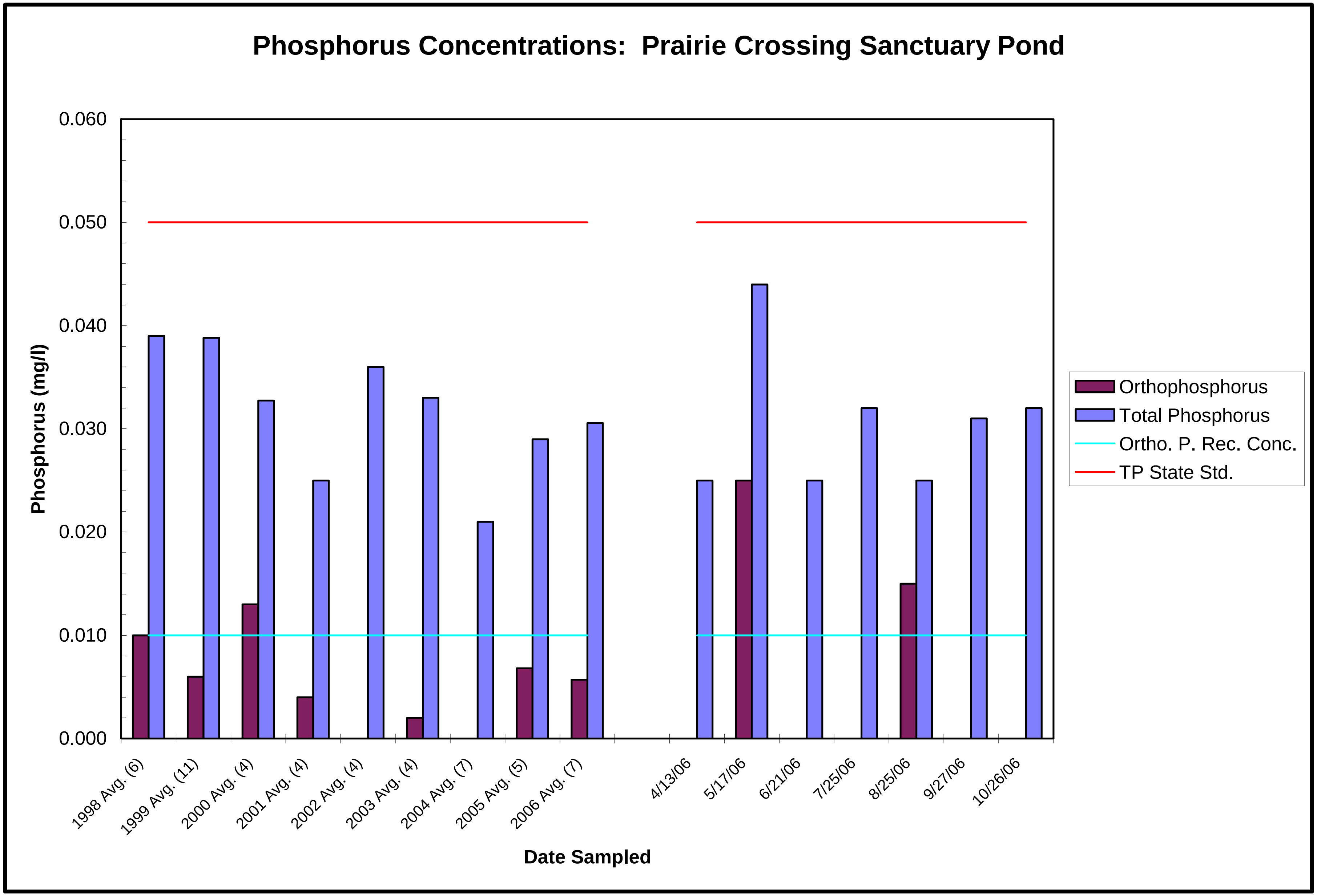
* Secchi depth reading limited by bottom plant growth

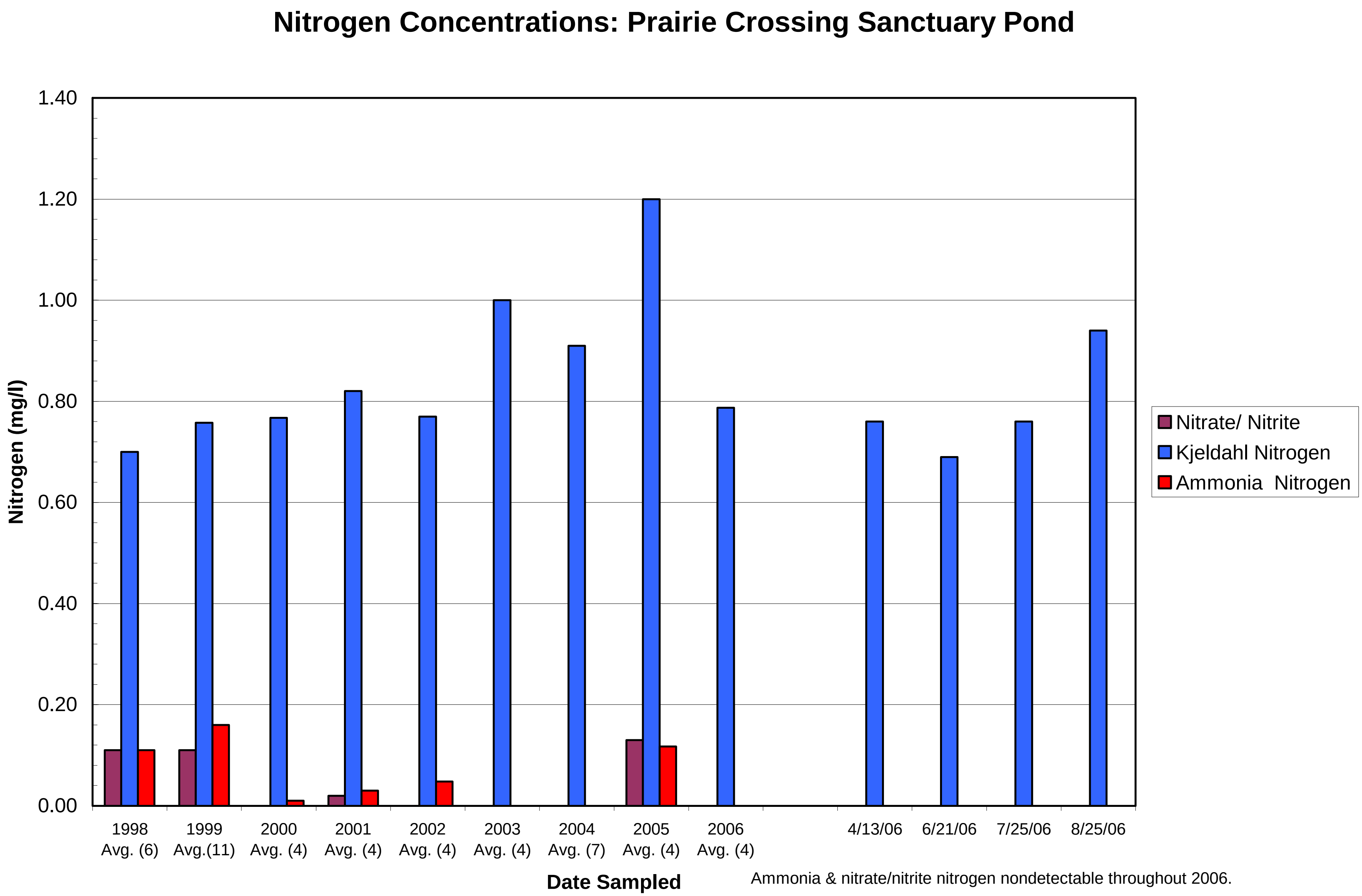
(Yellow) = concentrations above State Standards or Recommended Maximum Concentration



Chloride Concentrations: Prairie Crossing Sanctuary Pond
Chloride Concentrations (mg/l)
160
140
120
100
80
60
40
20
0
7/22/98
9/25/98
11/18/98
1/13/99
3/15/99
5/12/99
7/12/99
9/15/99
4/3/00
7/20/00
4/5/01
7/17/01
4/3/02
7/22/02
4/17/03
7/16/03
4/5/2004
7/6/2004
4/5/05
6/7/05
8/15/05
5/17/06
7/25/06
9/27/06
Sampling Date
Chloride (mg/l)
Natural waters (20 mg/l)
Urban Ponds (100 mg/l)


Conductivity at Sanctuary Pond
Conductivity (umhos/cm)
Sampling Date
0
100
200
300
400
500
600
700
800
900
1000
7/22/98
9/1/98
9/25/98
10/21/98
11/18/98
12/14/98
1/13/99
2/17/99
3/15/99
4/8/99
5/12/99
6/16/99
7/12/99
8/19/99
9/15/99
10/14/99
4/3/00
6/21/00
7/20/00
8/21/00
4/5/01
6/13/01
7/17/01
8/15/01
4/3/02
6/25/02
7/22/02
8/29/02
4/17/03
6/12/03
7/16/03
8/18/03
6/3/2004
7/6/2004
8/9/2004
4/5/05
5/10/05
6/7/05
7/14/05
8/15/05
9/21/05
10/19/05
4/13/06
5/17/06
6/21/06
7/25/06
8/25/06
9/27/06
10/26/06


Phosphorus Concentrations: Prairie Crossing Sanctuary Pond
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Phosphorus (mg/l)
1998 Avg. (6)
1999 Avg. (11)
2000 Avg. (4)
2001 Avg. (4)
2002 Avg. (4)
2003 Avg. (4)
2004 Avg. (7)
2005 Avg. (5)
2006 Avg. (7)
4/13/06
5/17/06
6/21/06
7/25/06
8/25/06
9/27/06
10/26/06
Date Sampled
Orthophosphorus
Total Phosphorus
Ortho. P. Rec. Conc.
TP State Std.


Nitrogen Concentrations: Prairie Crossing Sanctuary Pond
Nitrogen (mg/l)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1998 Avg. (6)
1999 Avg.(11)
2000 Avg. (4)
2001 Avg. (4)
2002 Avg. (4)
2003 Avg. (4)
2004 Avg. (7)
2005 Avg. (4)
2006 Avg. (4)
4/13/06
6/21/06
7/25/06
8/25/06
Date Sampled
Nitrate/ Nitrite
Kjeldahl Nitrogen
Ammonia Nitrogen
Ammonia & nitrate/nitrite nitrogen nondetectable throughout 2006.

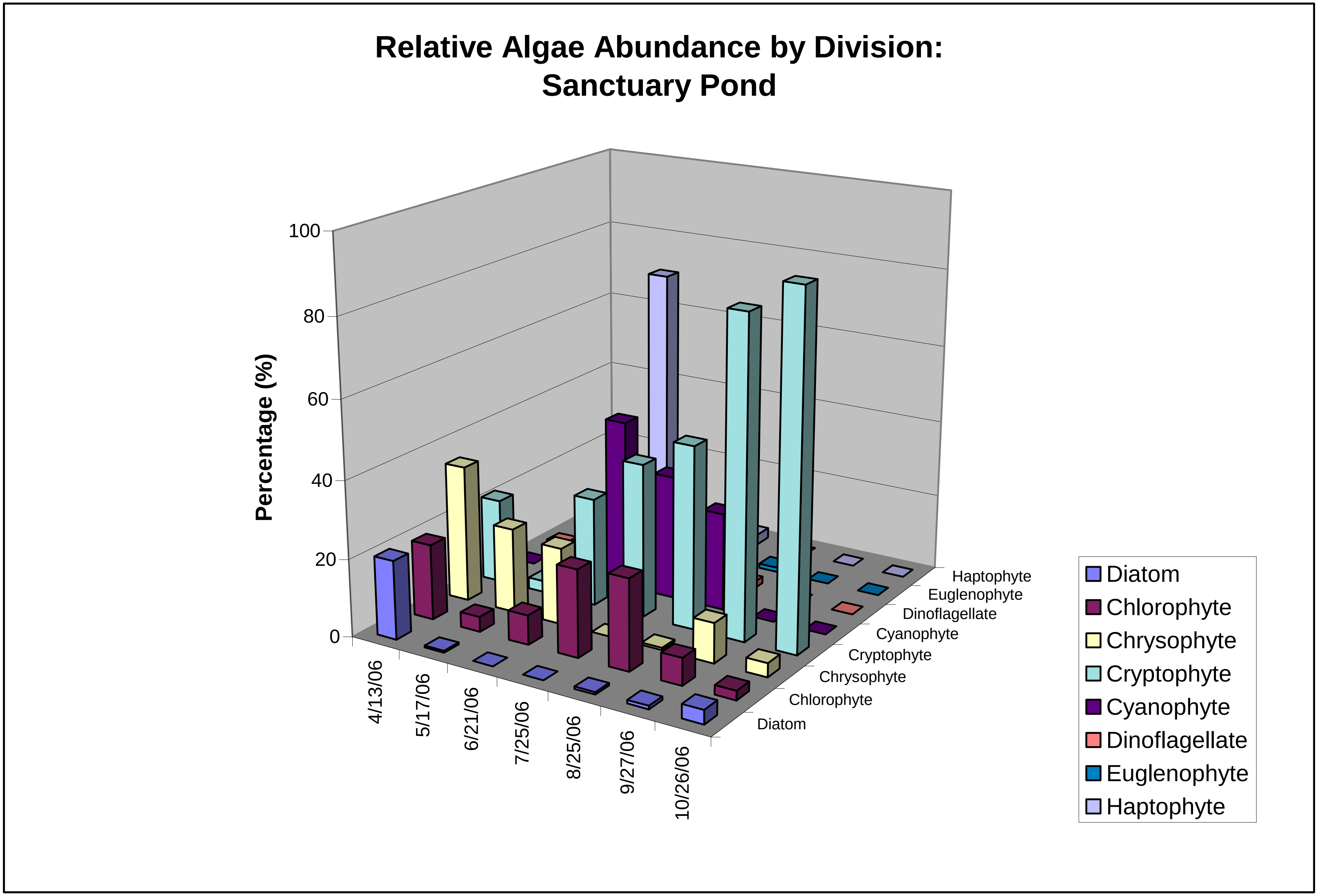
Biological Sampling

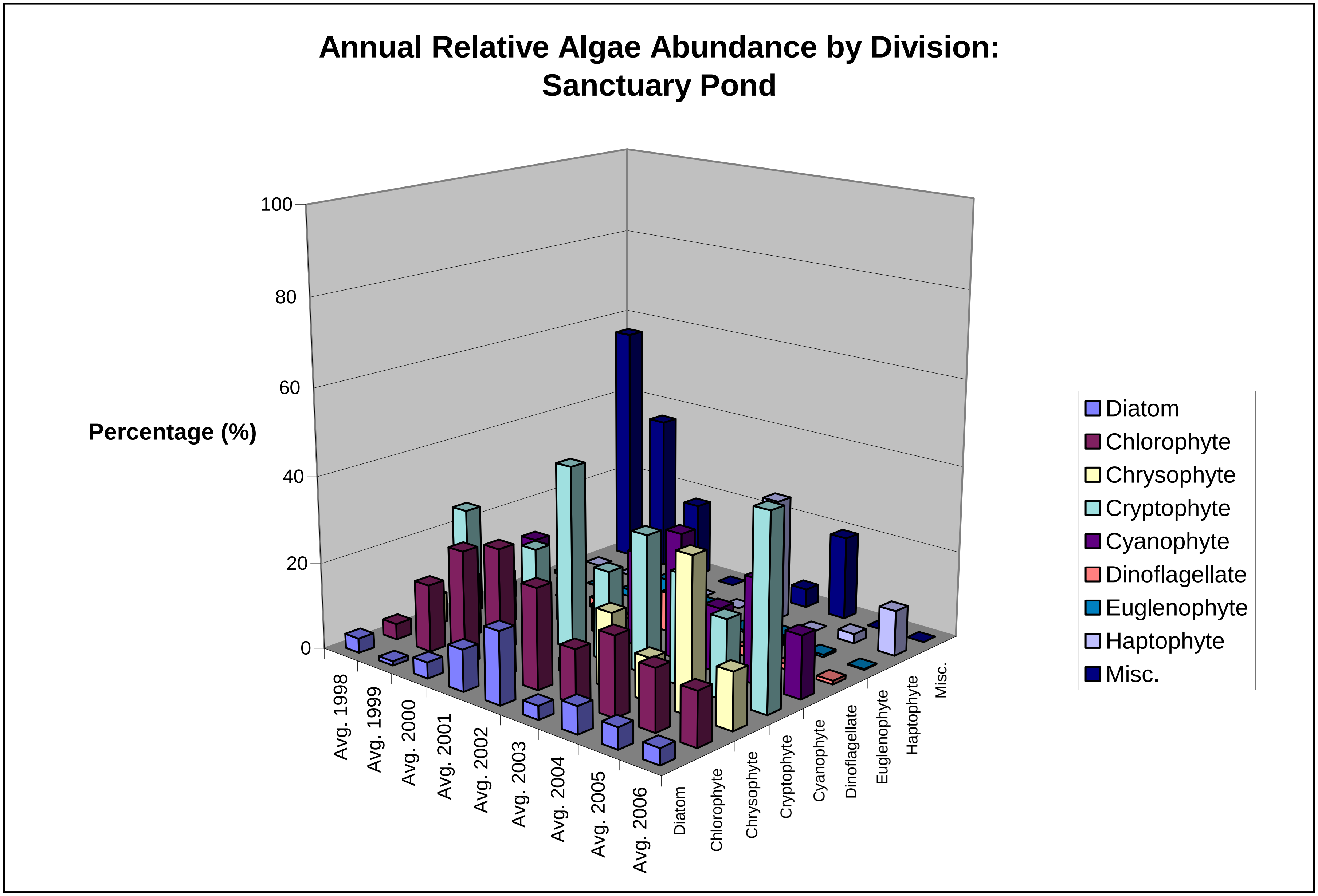
Relative Algal Abundance (%) for Sanctuary Pond 2006

	4/13/06	5/17/06	6/21/06	7/25/06	8/25/06	9/27/06	10/26/06	Average
Diatom	20.3	0.5	0.0	0.0	0.6	0.9	3.6	3.7
Chlorophyte	19.5	3.9	7.6	22.5	23.4	7.0	2.4	12.3
Chrysophyte	**35.2**	21.8	19.8	0.0	0.6	10.3	3.6	13.0
Cryptophyte	21.9	2.9	27.9	**39.6**	**47.0**	**82.0**	**90.3**	**44.5**
Cyanophyte	0.0	0.0	**43.7**	**32.0**	25.2	0.0	0.0	14.4
Dinoflagellate	0.8	0.0	0.4	2.8	1.8	0.0	0.0	0.8
Euglenophyte	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.2
Misc.	2.3	1.0	0.0	0.0	0.0	0.0	0.0	0.5
Haptophyte	0.0	**70.0**	0.4	2.8	0.0	0.0	0.0	10.5

Relative Algal Abundance (%) Yearly Averages

	Avg. 1998	Avg. 1999	Avg. 2000	Avg. 2001	Avg. 2002	Avg. 2003	Avg. 2004	Avg. 2005	Avg. 2006
Diatom	3.4	1.0	3.7	9.6	16.6	3.1	6.2	4.9	3.7
Chlorophyte	3.6	15.5	**26.0**	29.1	**23.1**	12.3	18.3	14.2	12.3
Chrysophyte	7.0	14.0	17.1	1.7	2.9	17.2	10.0	**35.3**	13.0
Cryptophyte	24.9	11.9	20.7	**42.3**	**20.8**	**31.7**	**25.4**	18.3	**44.5**
Cyanophyte	3.7	17.6	10.0	6.6	**21.8**	**29.2**	14.8	24.0	14.4
Dinoflagellate	0.0	0.1	2.4	1.0	9.2	0.5	2.2	1.2	0.8
Euglenophyte	0.8	0.2	1.7	7.0	3.6	0.5	2.3	0.5	0.2
Haptophyte	0.0	0.0	0.0	0.0	0.0	28.5	0.0	2.2	10.5
Misc.	**56.4**	**36.4**	17.5	0.0	2.0	4.3	19.4	0.0	0.0


Relative Algae Abundance by Division:
Sanctuary Pond
Percentage (%)
100
80
60
40
20
0
4/13/06
5/17/06
6/21/06
7/25/06
8/25/06
9/27/06
10/26/06
Diatom
Chlorophyte
Chrysophyte
Cryptophyte
Cyanophyte
Dinoflagellate
Euglenophyte
Haptophyte



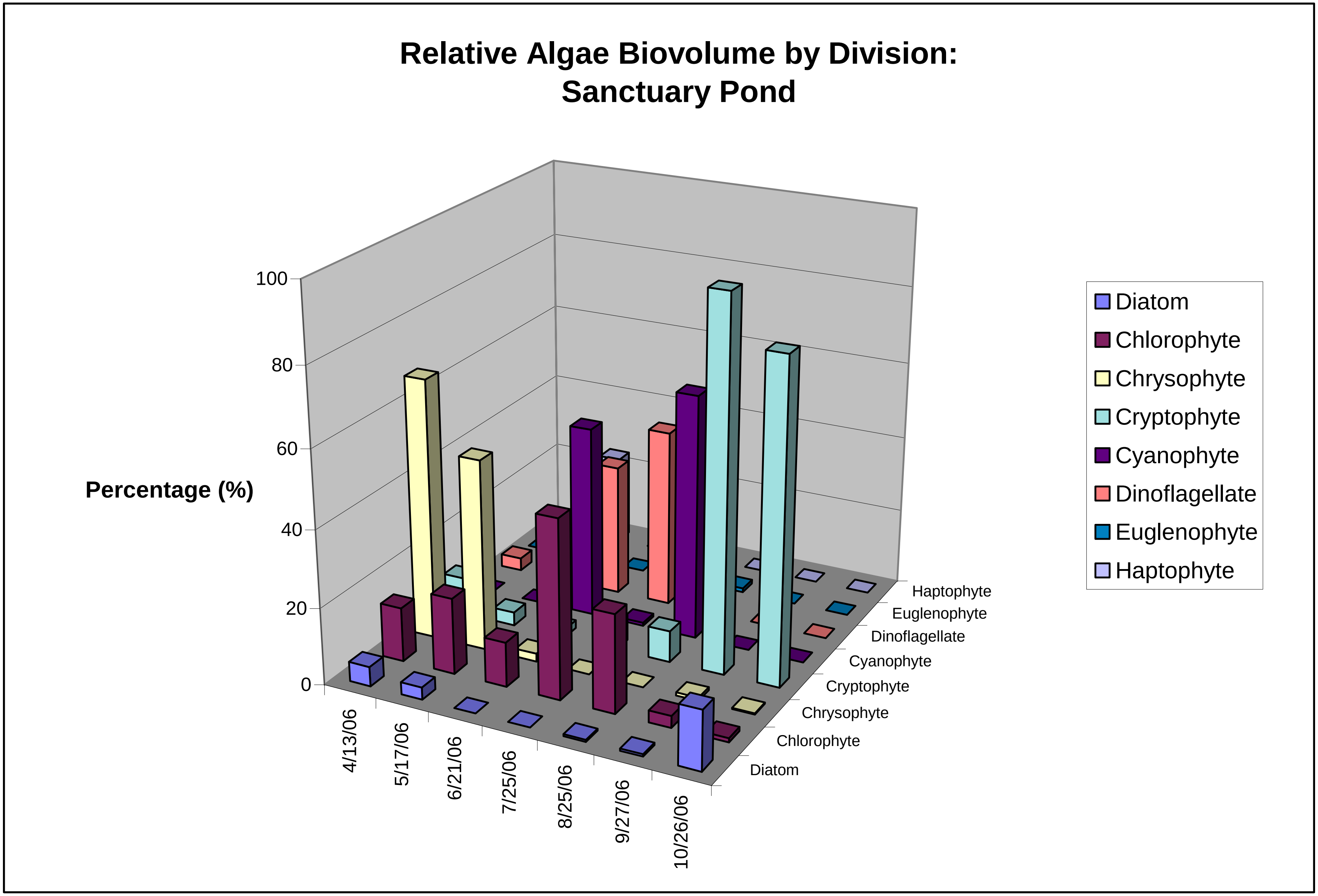
Annual Relative Algae Abundance by Division:
Sanctuary Pond
Percentage (%)
100
80
60
40
20
0
Avg. 1998
Avg. 1999
Avg. 2000
Avg. 2001
Avg. 2002
Avg. 2003
Avg. 2004
Avg. 2005
Avg. 2006
Diatom
Chlorophyte
Chrysophyte
Cryptophyte
Cyanophyte
Dinoflagellate
Euglenophyte
Haptophyte
Misc.

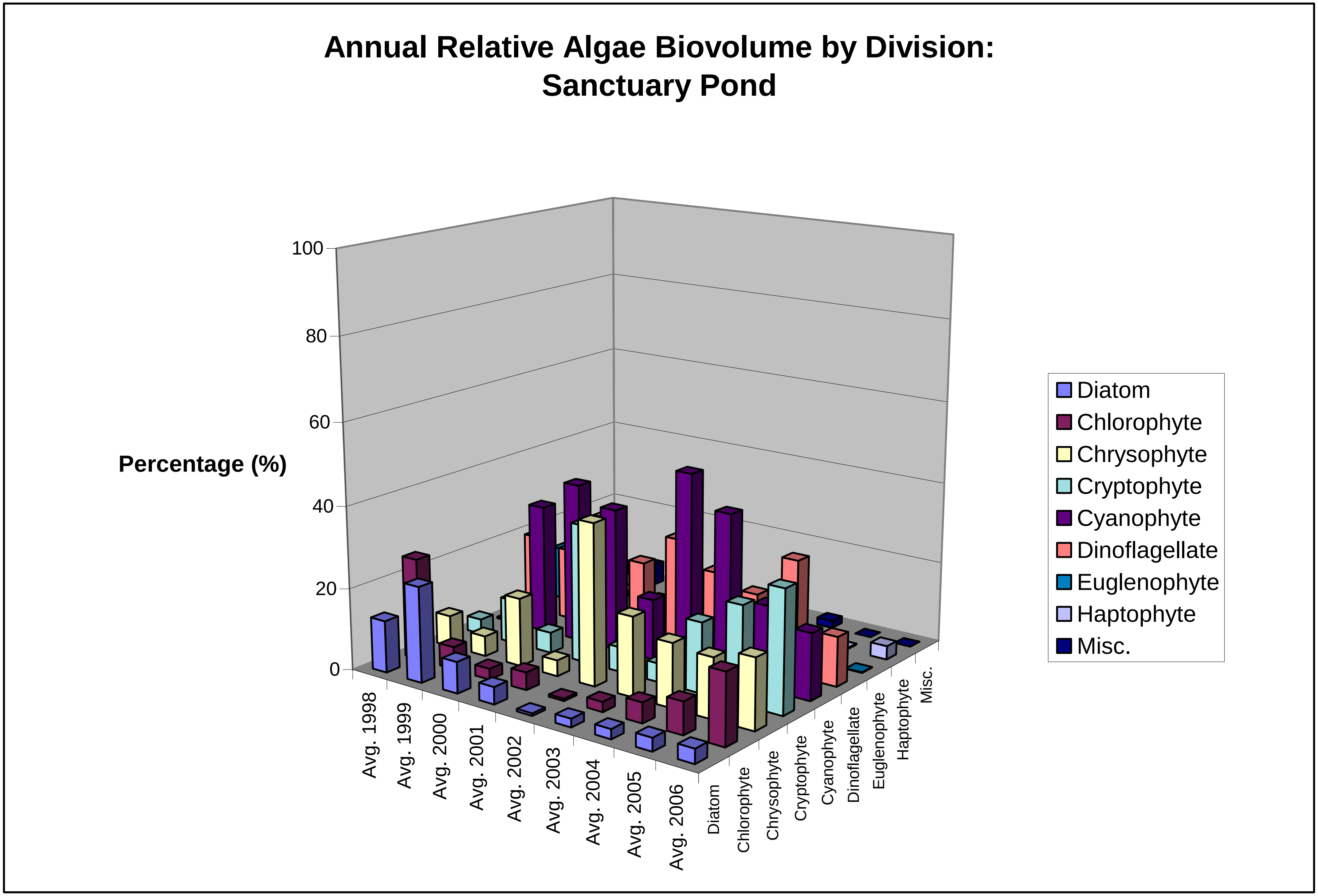
Relative Algal Biovolume (%) for Sanctuary Pond 2006

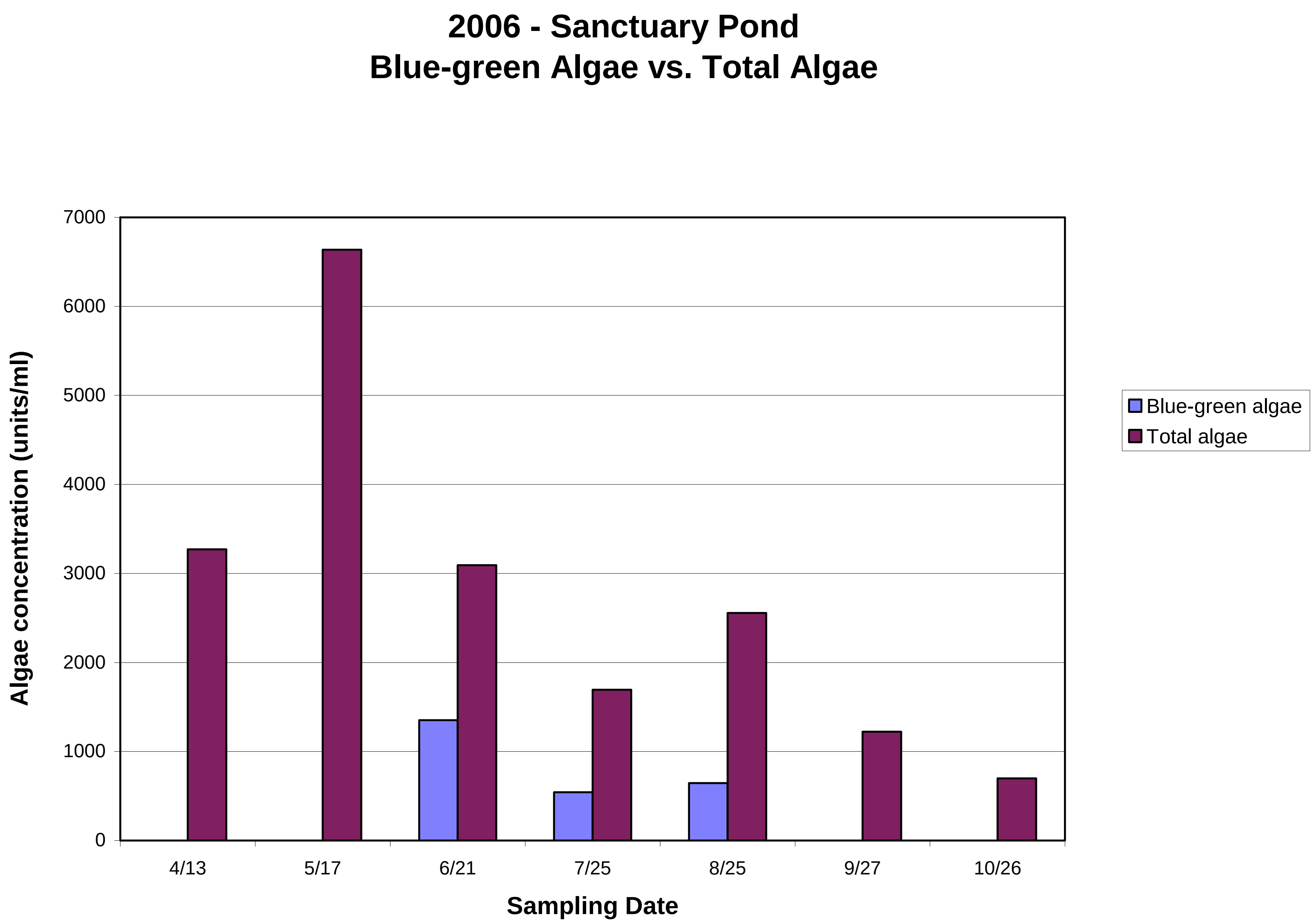
	4/13/06	5/17/06	6/21/06	7/25/06	8/25/06	9/27/06	10/26/06	Average
Diatom	5.1	3.2	0.0	0.0	0.5	0.6	15.4	3.5
Chlorophyte	14.1	19.8	11.6	**46.2**	25.5	3.1	1.1	17.3
Chrysophyte	**67.4**	**49.6**	2.1	0.0	0.0	0.8	0.3	17.2
Cryptophyte	9.8	3.5	2.1	6.8	8.2	**95.6**	**83.2**	**29.9**
Cyanophyte	0.0	0.0	**49.8**	0.8	**63.5**	0.0	0.0	16.3
Dinoflagellate	3.4	0.0	**34.3**	**46.3**	1.1	0.0	0.0	12.2
Euglenophyte	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.2
Haptophyte	0.0	23.5	0.1	0.1	0.0	0.0	0.0	3.4

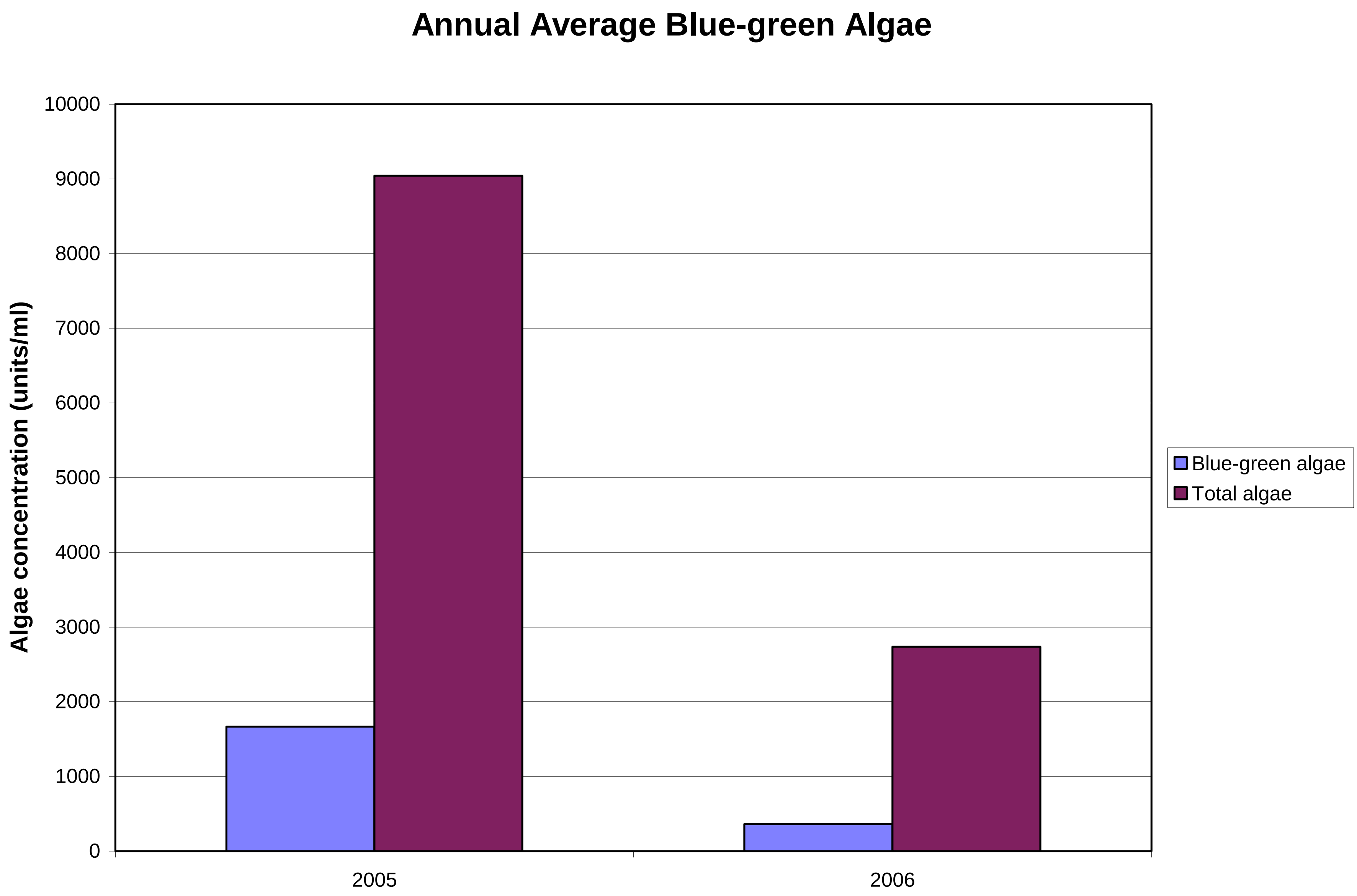
Relative Algal Biovolume (%) Yearly Averages

	Avg. 1998	Avg. 1999	Avg. 2000	Avg. 2001	Avg. 2002	Avg. 2003	Avg. 2004	Avg. 2005	Avg. 2006
Diatom	12.7	23.4	7.7	4.2	0.6	2.1	2.4	3.2	3.5
Chlorophyte	**24.9**	5.5	2.7	4.3	0.5	2.5	5.0	7.9	17.3
Chrysophyte	7.7	5.0	16.8	3.9	**39.4**	19.4	15.6	14.7	17.2
Cryptophyte	3.7	10.8	5.1	**33.9**	6.1	4.6	17.2	**23.7**	**29.9**
Cyanophyte	0.4	**31.8**	**39.3**	**35.0**	14.9	**47.8**	**40.1**	**20.3**	16.3
Dinoflagellate	19.4	17.8	28.5	19.0	27.0	20.9	17.8	**28.3**	12.2
Euglenophyte	13.2	4.4	0.0	0.4	11.6	0.9	0.1	1.6	0.2
Haptophyte	0.8	1.3	1.0	0.1	0.0	1.7	1.8	0.3	3.4
Misc.	3.4	5.4	0.0	0.0	0.1	0.2	1.8	0.0	0.0


Relative Algae Biovolume by Division:
Sanctuary Pond
Percentage (%)
100
80
60
40
20
0
4/13/06
5/17/06
6/21/06
7/25/06
8/25/06
9/27/06
10/26/06
Haptophyte
Euglenophyte
Dinoflagellate
Cyanophyte
Cryptophyte
Chrysophyte
Chlorophyte
Diatom
Diatom
Chlorophyte
Chrysophyte
Cryptophyte
Cyanophyte
Dinoflagellate
Euglenophyte
Haptophyte


Annual Relative Algae Biovolume by Division:
Sanctuary Pond
Percentage (%)
0
20
40
60
80
100
Avg. 1998
Avg. 1999
Avg. 2000
Avg. 2001
Avg. 2002
Avg. 2003
Avg. 2004
Avg. 2005
Avg. 2006
Diatom
Chlorophyte
Chrysophyte
Cryptophyte
Cyanophyte
Dinoflagellate
Euglenophyte
Haptophyte
Misc.


2006 - Sanctuary Pond
Blue-green Algae vs. Total Algae
7000
6000
5000
4000
3000
2000
1000
0
Algae concentration (units/ml)
4/13
5/17
6/21
7/25
8/25
9/27
10/26
Sampling Date
Blue-green algae
Total algae

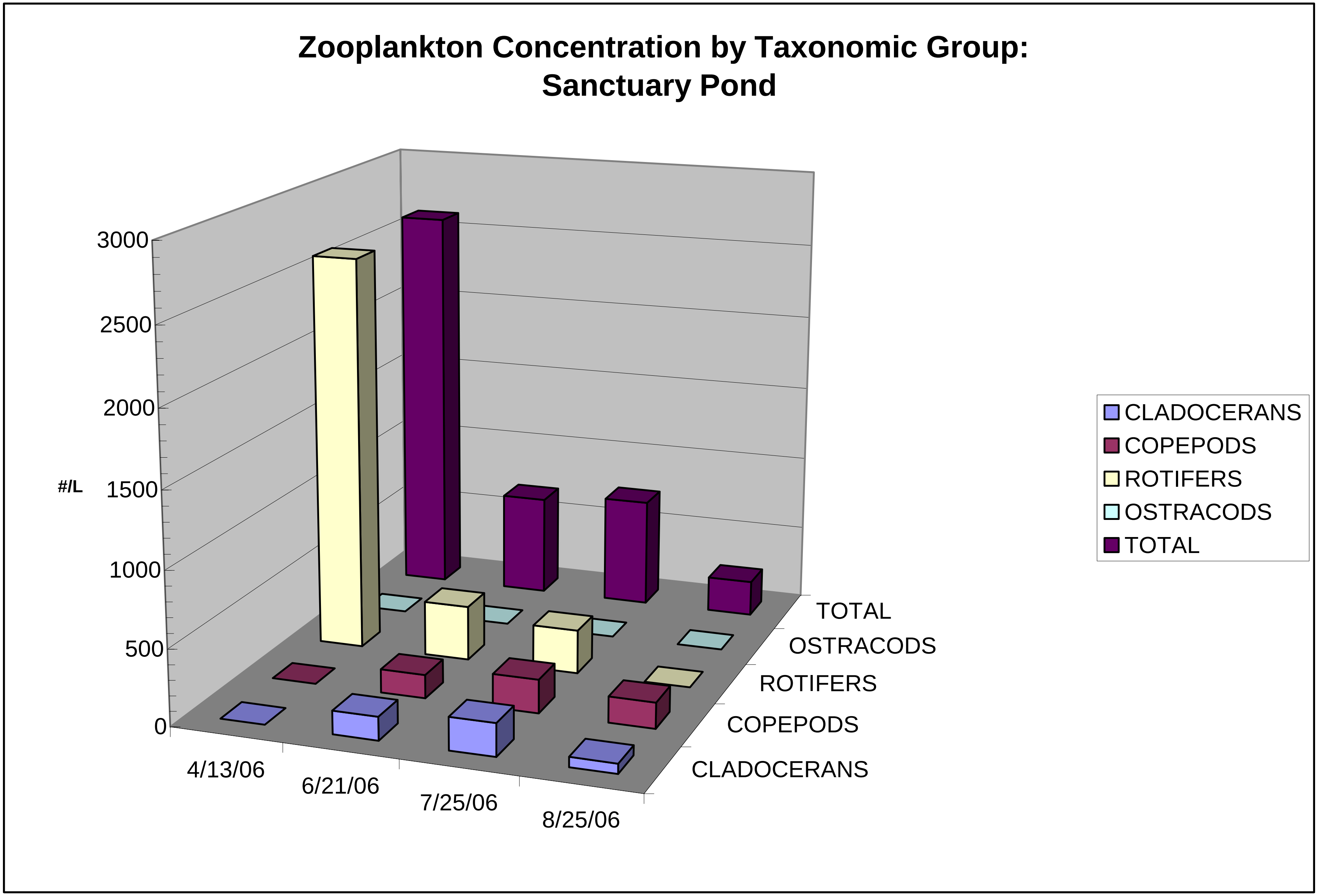

Annual Average Blue-green Algae
Algae concentration (units/ml)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2005
2006
Blue-green algae
Total algae

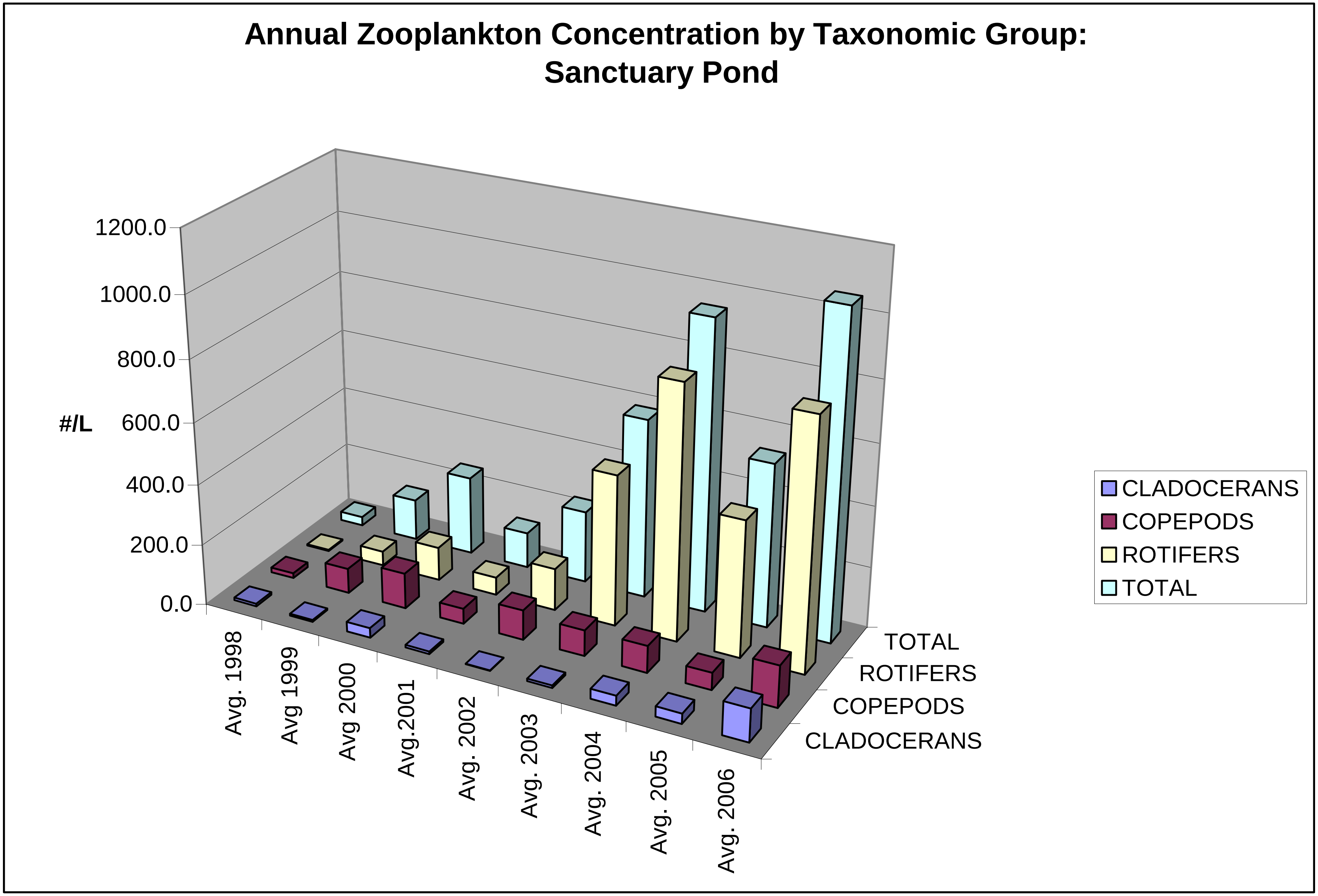
Zooplankton Concentration (#/L) in Sanctuary Pond 2006

	4/13/06	6/21/06	7/25/06	8/25/06	Average
CLADOCERANS	0.5	153.0	213.5	64.5	107.9
COPEPODS	0.0	155.5	221.0	169.5	136.5
ROTIFERS	2610.0	362.5	290.0	0.0	815.6
OSTRACODS	0.0	0.0	0.0	0.0	0.0
TOTAL	2610.5	671.0	724.5	234.0	1060.0

Zooplankton Concentration (#/L) Yearly Averages

	Avg. 1998	Avg 1999	Avg 2000	Avg.2001	Avg. 2002	Avg. 2003	Avg. 2004	Avg. 2005	Avg. 2006
CLADOCERANS	8.8	5.8	32.2	8.5	1.5	8.4	32.5	33.5	107.9
COPEPODS	16.7	82.5	117.0	50.5	97.5	85.4	88.6	56.63	136.5
ROTIFERS	3.9	47.6	110.6	58.4	138.7	494.3	828.1	446.3	815.6
TOTAL	29.4	136.0	259.8	117.4	237.7	588.0	949.2	536.4	1060.0


Zooplankton Concentration by Taxonomic Group:
Sanctuary Pond
#/L
0
500
1000
1500
2000
2500
3000
4/13/06
6/21/06
7/25/06
8/25/06
CLADOCERANS
COPEPODS
ROTIFERS
OSTRACODS
TOTAL
CLADOCERANS
COPEPODS
ROTIFERS
OSTRACODS
TOTAL

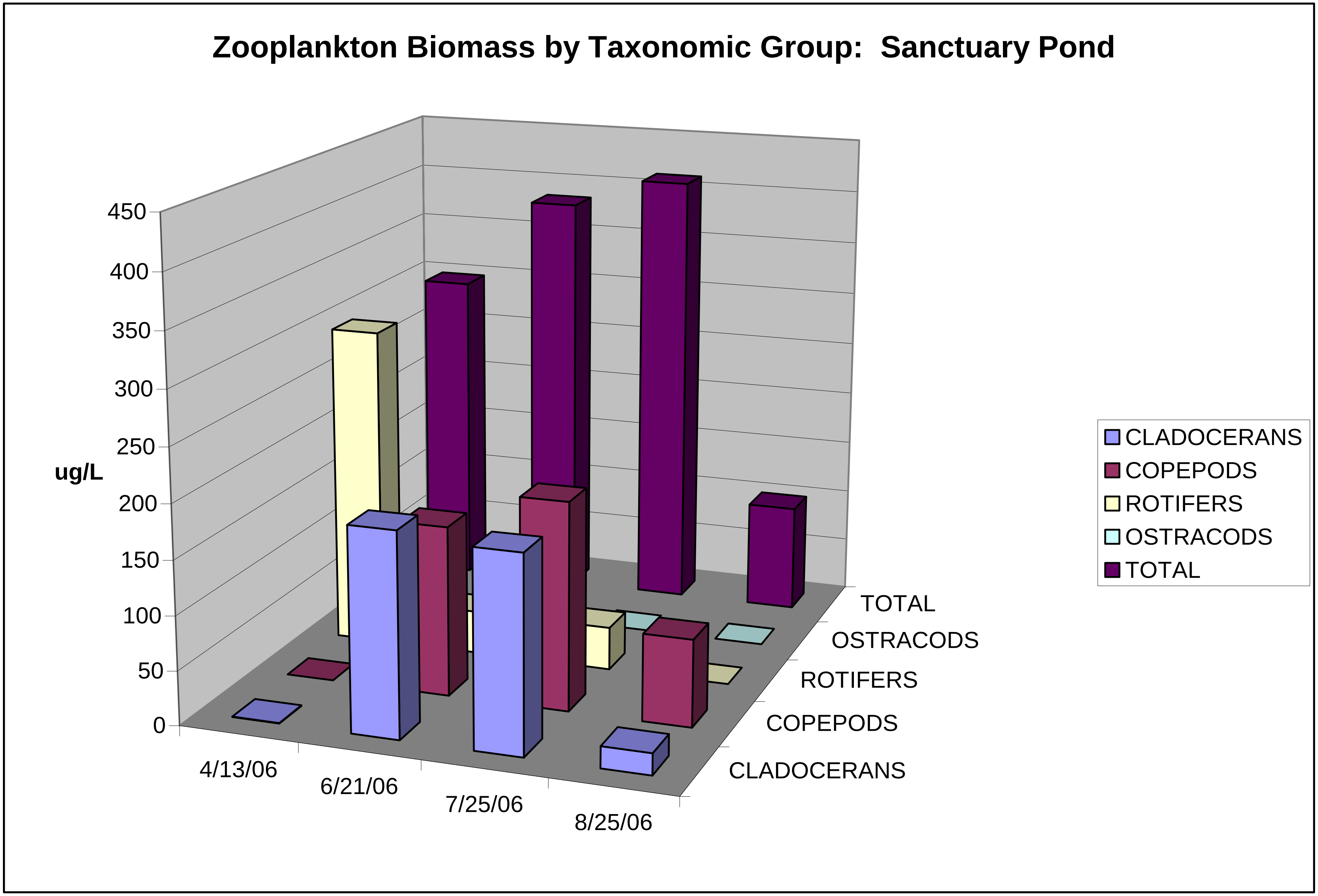

Annual Zooplankton Concentration by Taxonomic Group:
Sanctuary Pond
#/L
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Avg. 1998
Avg 1999
Avg 2000
Avg.2001
Avg. 2002
Avg. 2003
Avg. 2004
Avg. 2005
Avg. 2006
TOTAL
ROTIFERS
COPEPODS
CLADOCERANS
CLADOCERANS
COPEPODS
ROTIFERS
TOTAL

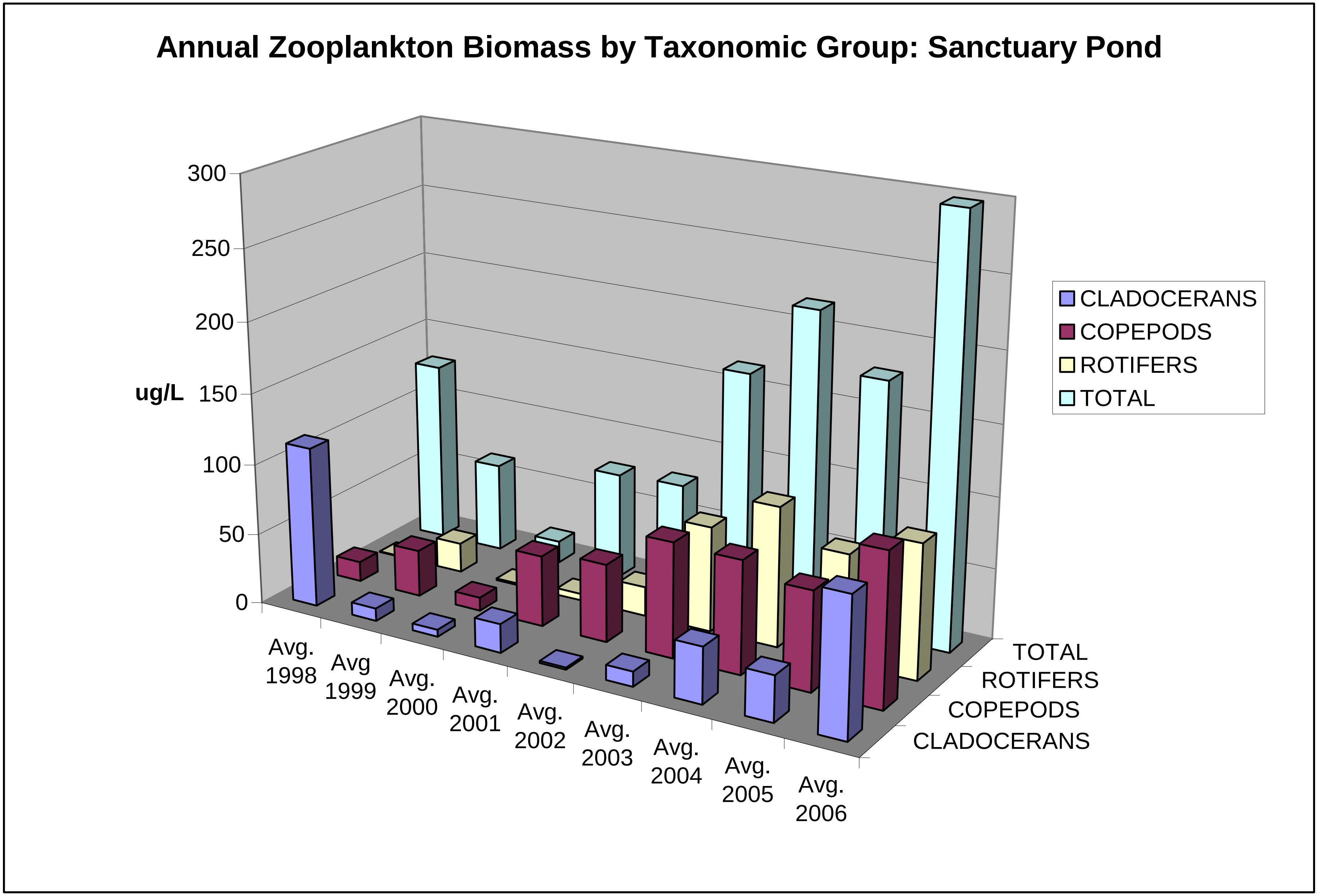
Zooplankton Biomass (µg/L) for Sanctuary Pond 2006

	4/13/06	6/21/06	7/25/06	8/25/06	Average
CLADOCERANS	0.5	187.3	180.3	19.7	97.0
COPEPODS	0.0	156.8	191.5	80.3	107.2
ROTIFERS	297.3	39.9	39.9	0.0	94.3
OSTRACODS	0.0	0.0	0.0	0.0	0.0
TOTAL	297.8	384.0	411.7	100.0	298.4

Zooplankton Biomass (µg/L) Yearly Averages

	Avg. 1998	Avg 1999	Avg. 2000	Avg. 2001	Avg. 2002	Avg. 2003	Avg. 2004	Avg. 2005	Avg. 2006
CLADOCERANS	113.4	9.0	5.0	20.3	1.4	10.6	39.5	32.2	97.0
COPEPODS	14.2	33.0	9.6	50.2	54.9	81.1	79.5	69.8	107.2
ROTIFERS	0.6	21.0	1.1	4.8	20.8	74.3	98.6	76.4	94.3
TOTAL	128.2	62.9	15.7	75.3	77.1	165.9	217.6	178.4	298.4


Zooplankton Biomass by Taxonomic Group: Sanctuary Pond
ug/L
450
400
350
300
250
200
150
100
50
0
4/13/06
6/21/06
7/25/06
8/25/06
TOTAL
OSTRACODS
ROTIFERS
COPEPODS
CLADOCERANS
CLADOCERANS
COPEPODS
ROTIFERS
OSTRACODS
TOTAL



Annual Zooplankton Biomass by Taxonomic Group: Sanctuary Pond
ug/L
300
250
200
150
100
50
0
Avg. 1998
Avg 1999
Avg. 2000
Avg. 2001
Avg. 2002
Avg. 2003
Avg. 2004
Avg. 2005
Avg. 2006
TOTAL
ROTIFERS
COPEPODS
CLADOCERANS

Sediment Sampling

Sanctuary Pond at Prairie Crossing Sediment Samples

Collected 8/11/06

	Low	Normal	Elevated	Highly Elevated	Site 1 East	Site 2 West
pH	< 7	7 - 8.5	8.5 - 9.5	> 9.5	7.02	7.08
Organic Carbon (% dry)	< 20%**	20 - 59%	>'50% - 75%	> 75%	5.2	6.6
Bulk density					NA	NA
Percent Moisture					69.6	76.2
Total phosphorus (mg/kg)	< 394*	394 < 1,115*	1,115 < 2,179*	> 2,179*	266	345
Iron (mg/kg dry)	< 16,000*	16,000 - 37,000*	37,000 < 56,000*	> 56,000*	40,000	33,300
Manganese (mg/kg dry)]	< 500*	500 - 1,700*	1,700 < 5,500*	> 5,500*	483	416
Fe:Mn ratio	< 6**	6 - 10	> 10		83	80
Nitrate N (ppm)***	< 9	10 - 19	20 - 39	> 40	2	3
Bray 1 Phosphorus (ppm)***	< 19	20 - 29	30 - 49	> 50	2	2
exchangeable ammonia N***					NA	NA

** IEPA (1996) Sediment Classification for Illinois Inland Lakes*

**Steve McComas - Blue Water Science study:

Factors favoring EWM
- High Fe:Mn ratio
- exchangeable ammonia N > 10 ppm
- organic matter < 20%

Factors favoring CLP
- Low Fe:Mn ratio
- pH > 7.7
- organic matter > 20%

Dense mat forming colonies require these conditions more than open canopy colonies

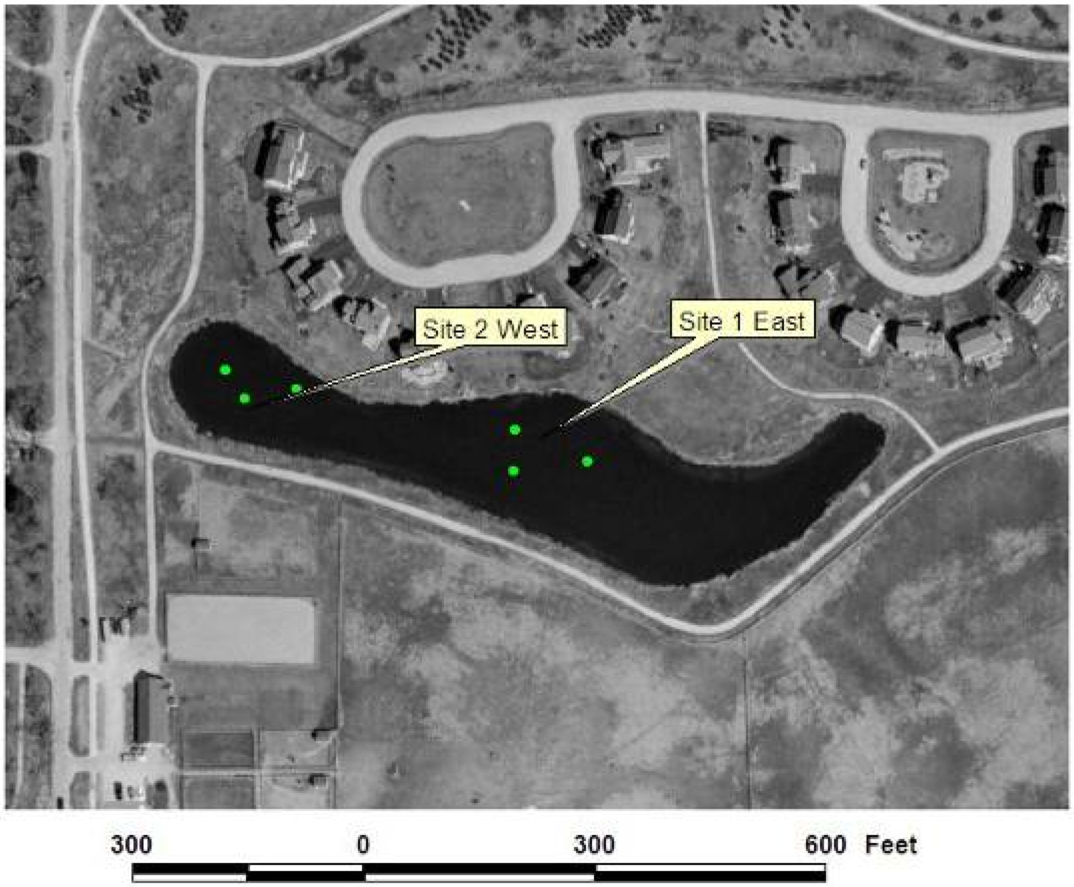
Usually EWM and CLP are not dominant for a long term in the same area in water > 6 feet. EWM or CLP may be dominant for a few years but if nitrogen is low the EWM will dieback. If the organic matter is low the CLP may dieback after a few years.

If get 30 - 40 sunfish/trap - then too high of a density to maintain EWM weevils - may get too much predation.

*** Soil test ratings (A & L Great Lakes Laboratories)

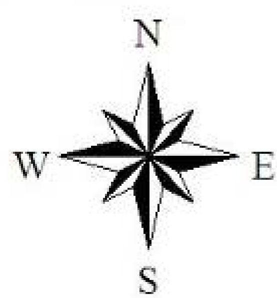
***Have lab use a KCl extract - standard soil test

Sanctuary Pond
Sediment Sampling Locations
8/11/06



Sediment locations are approximate . Each group of 3 sites represent 1 composite sample.

ILM
Integrated Lakes Management, Inc.
Lake and Pond Management
Restoration • Consulting



• Sp sed locations.shp

Eurasian Watermilfoil Growth Characteristics
(source: Steve McComas, Blue Water Science, unpublished)

Non-Nuisance Conditions

Plants rarely reach the surface.

Navigation and recreational activities generally are not hindered.

Stem density: 0 - 40 stems/m^2
Biomass: 0 - 51 g-dry wt/m^2

Light Nuisance Conditions

Broken surface canopy conditions. However, stems are usually unbranched.

Navigation and recreational activities may be hindered.

Lake users may opt for control.

Stem density: 35 - 100 stems/m^2
Biomass: 30 - 90 g-dry wt/m^2

Heavy Nuisance Conditions

Solid or near solid surface canopy conditions. Stems typically are branched near the surface.

Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

Stem density: 250\+ stems/m^2
Biomass: >285 g-dry wt/m^2