Preston McEachern
9637 – 81 Ave.
Edmonton, AB, T6C 0X6
(780) 427-1197
prestonm@telusplanet.net

Lakewatch

Isle Lake

The Alberta Lake Management Society
Volunteer Lake Monitoring Report

> *And you really live by the river? What a jolly life!"*
>
> *"By it and with it and on it and in it," said the Rat. "It's brother and sister to me. What it hasn't got is not worth having, and what it doesn't know is not worth knowing."* *Kenneth Grahame The Wind in the Willows*
>
> *"The world's supply of fresh water is running out. Already one person in five has no access to safe drinking water."* *BBC World Water Crisis Homepage*

A note from the Lakewatch Coordinator

Preston McEachern

Lakewatch has several important objectives, one of which is to document and interpret water quality in Alberta Lakes. Equally important are the objectives of educating lake users about their aquatic environment; enhancing public involvement in lake management; and facilitating a link between aquatic scientists and lake users. The Lakewatch Reports are designed to summarize basic lake data in understandable terms for a lay audience, and are not meant to be a complete synopsis of information about specific lakes. Substantial additional information is generally available on the lakes that have participated in Lakewatch and readers requiring more information are encouraged to seek these sources.

The 2002 Lakewatch Report has undergone a substantial change in format from previous years. I am no longer the author as much as an editor including text and figures from others who have done an excellent job describing lakes throughout Alberta. I have attempted to give due credit to these outstanding people and apologize for blatant plagiarism where it occurs. As editor, feel free to castigate me for errors. I have included easily accessible information that is likely to have been updated in recent years and readers are encouraged to help update these reports by sending new information to me.

I would like to thank all people who share my love for aquatic environments and particularly those who have helped in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that water will not be the limiting factor in the health of our planet.

Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Mike Bilyk, John Willis, Doreen LeClair and Dave Trew from Alberta Environment were instrumental in funding, training people and organizing with Lakewatch data. Comments on this report by Dave Trew were appreciated. Alberta Lake Management Society members and the board of directors helped in many facets of water collection and management. Sophie Lewin and Lucille Kowalchuk were as our summer field coordinators and were an excellent addition to the program. Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred.

Isle Lake

Isle Lake is located in the counties of Lac Ste. Anne and Parkland, 80 km west of the City of Edmonton. The Hamlet of Gainford, established in 1942 is situated on the southwest shore (Mitchell and Prepas 1990). The lake has several islands, hence its name. In 1879, the Hudson Bay Company set up a trading post at nearby Lac Ste. Anne. Settlers began arriving in 1905, as agricultural lands became available (Mitchell and Prepas 1990). Today, several subdivisions are registered along the shoreline and the lake is heavily used for recreation. Favorite recreational activities include swimming, boating and fishing. Sport fish include northern pike, yellow perch, burbot, white suckers and walleye (Mitchell and Prepas 1990). Isle has had a stocking program for Walleye in past years (Mitchell and Prepas 1990). Also, the lake supported active commercial and domestic fisheries in the past, while in the last decade the lake has been managed only as recreation and domestic fisheries (Bodden ASNR, 2002). In view of the fact that the basin lies on geological formations Horseshoe and Paskapoo (Mitchell and Prepas 1990), it contains natural resources such as: an excellent source of groundwater, coal, oil, gas, sand and gravel.

Isle is long and moderately shallow (Fig. 1; maximum depth 7.5 m). Dominant phytoplankton in spring are dinoflagellates (*Peridinium, cinctum*) and diatoms (*Stephanodiscus hantzschia*, and *Asterionella formosa*). During summer, blue-green algae (*Gleotrichia echinulata* and *Aphanizomenon flos-aquae*) are dominant until late fall when, again diatoms, *Stephanodiscus niagarie* dominate the biomass composition (Mitchell and Prepas 1990). Emergent aquatic plants such as; *Scirpus validus, Typha latifolia* and *Carex* sp.are common (Mitchell and Prepas 1990). Submergent plants are found between 1 to 5 m depths and include northern watermilfoil and Richardson pondweed (Mitchell and Prepas 1990). Such aquatic vegetation is important in supporting a healthy fishery by providing, cover, food and spawning beds for fish. However, excessive vegetation provides conflict with recreational use and treatments have been applied to rid of some the vegetation (Mitchell and Prepas 1990).

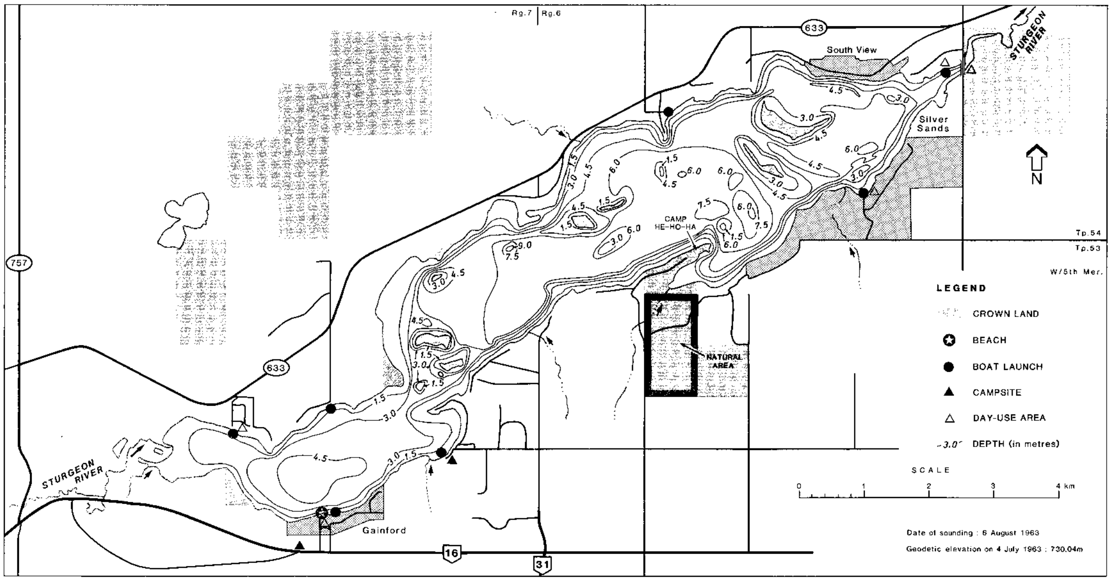


Fig. 1: Bathymetry of Isle Lake. From Mitchell and Prepas 1990.

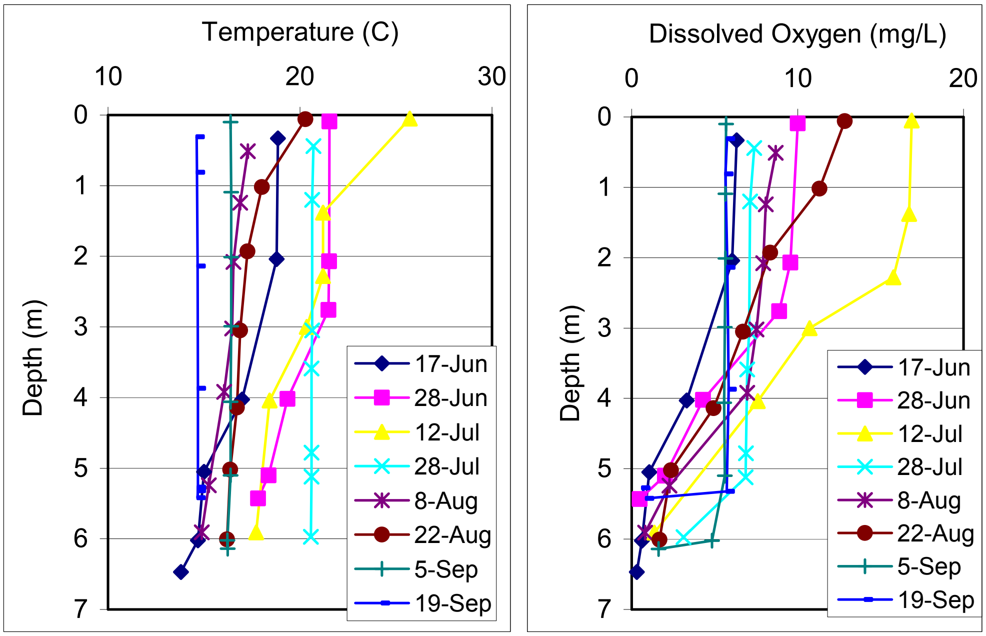
Results

Water Levels

Water levels in Isle Lake have been monitored since at least 1960 (Alberta Environment Monitoring data). From 1960 to 2000, the lowest recorded elevation was 729.2 m in 1968 (Mitchell and Prepas 1990), and the highest was 730.8 m in 1989 (Alberta Environment Monitoring data), a difference of 1.6 m. High water levels were also recorded in July 1997 when the monthly mean elevation was 730.4 m, but dropped 0.83 m the next year and continued to fluctuate until 2000 (Alberta Environment Monitoring data). In 2002, the maximum monthly mean elevation above sea level was 729.9 m and didn't vary much (Alberta Environment Monitoring data).

Water Temperature and Dissolved Oxygen

Thermal stratification formed in mid June and was at its strongest in mid July. Other months saw weak thermal stratification with complete or partial mixing. Oxygen concentrations in spring declined below 2 m due to surface warming. At least one thermal stratification period occurred during each month from June to August where the oxygen concentrations declined below 4 m depth. Throughout summer sampling, oxygen was available to a depth near the sediment where concentrations were low or anoxic. Summerkills of fish have been reported in Isle Lake, indicating that the water column can become oxygen-deficient.



Figs. 2 & 3: Temperature and dissolved oxygen profiles in Isle Lake, summer 2002.

Water Clarity and Secchi Disk Depth

Water clarity is influenced by suspended materials, both living and dead, as well as some coloured dissolved compounds in the water column. During the melting of snow and ice in spring, lake water can become cloudy from silt transported into the lake. Lake water usually clears in late spring but then becomes more turbid with increased algal biomass as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

Isle Lake's water was fairly clear in 2002: Secchi disk depth averaged about 2.1 m. The maximum clarity occurred in June when Secchi disk depth reached 4.0 m. Typical of lakes in Alberta, water clarity decreased over the summer to a minimum clarity of 1.25 m by the end of July. Average water clarity in the summer of 2002 was consistent with historical values (Table 1).

Water chemistry

Because Isle Lake had very high nutrient concentrations and algal biomass compared to lakes throughout Canada, it is considered hypereutrophic (see details on trophic status classification at end of this report). In the Alberta context, Isle Lake is ranked as having high productivity. In 2002, however, algal biomass was low relative to phosphorus and was more characteristic of eutrophic waters in Alberta.

In 2002, both nitrogen and phosphorus concentrations increased to a maximum at the end of July and then decrease

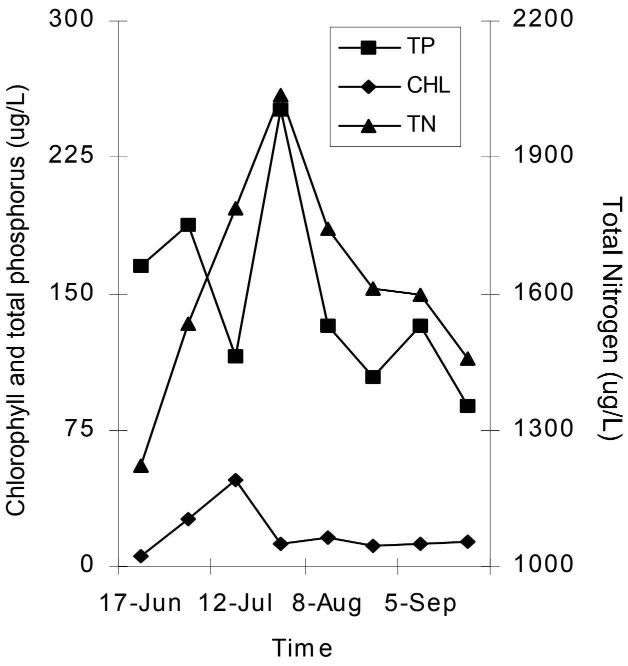


Fig. 4: Total phosphorus (TP), chlorophyll *a* (CHL), and total nitrogen (TN) concentrations in Isle Lake, summer 2002.

Table1: Mean chemical characteristics of Isle Lake during summer 2002 compared to historical values (Mitchell and Prepas 1990, Mitchell 1999).

Parameter	1983/84	1996-98	2002
Total phosphorus (µg/L)	101	198	147
TDP (µg/L)	56	146	95
Chlorophyll *a* (µg/L)	39	48	20
Secchi disk depth (m)	2.0	2.7	2.1
Total nitrogen (µg/L)	1391*	1500	1623
NO$_{2+3}$ (µg/L)	11	-	25
NH$_4$ (µg/L)	108	-	52
Ca (mg/L)	27	30.6	30
Mg (mg/L)	7	8.6	10
Na (mg/L)	18	19	26
K (mg/L)	6	7	9
SO$_4$ (mg/L)	< 8	8	8.9
Cl (mg/L)	3	5	6.6
CO$_3$	< 6	-	6.2
HCO$_3$	163	-	189
Alkalinity (mg/L CaCO$_3$)	143	148	153

Note. TDP = total dissolved phosphorus, NO$_{2+3}$ = nitrate + nitrite, NH$_4$ = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO$_4$ = sulphate, Cl = chloride, CO$_3$ = carbonate, HCO$_3$ = bicarbonate.
* Total kjehldahl nitrogen

over the rest of the summer (Fig. 4). Algal biomass, measured as chlorophyll, displayed a similar pattern. This pattern is typical for Alberta lakes. The source of much of the total phosphorus at the end of summer is the bottom sediments, which typically release phosphorus as the water warms and bacterial activity reduces oxygen levels at the bottom of the lake (Mitchell and Prepas 1990).

By comparing historical data in the early 1980s and late 1990s to 2002, the water quality of Isle Lake has been fairly stable over time. However, phosphorus and nitrogen concentrations seem to be slightly higher recently than in the early 1980s. Sediment cores taken in 1997 also reveal that since 1970, the lake has become more productive (Mitchell 1999). Isle Lake's watershed is about 10 times larger than the lake area, meaning that the chemistry of the lake can be mostly regulated by watershed runoff. Indeed, the lake receives over half of its nutrient concentration of phosphorus from the watershed via the Sturgeon River (Mitchell 1999). Therefore, the lake has the potential to be very sensitive to anthropogenic watershed disturbances.

Isle Lake is well-protected from acidification: its pH of 8.5 is well above that of pure water (i.e., pH 7). Its dominant ion is bicarbonate and calcium, corresponding to the alkaline nature of the water in the area. Mineral ions such as calcium and sulfate are supplied by weathering in the watershed and from groundwater inflows. The lack of change in ion concentrations over time (Table 1) suggests that the relationship between Isle Lake and its hydrology has not changed. Atmospheric deposition of acidifying pollutants from petroleum activities can often be seen in increasing sulfate concentrations. Because sulfate concentrations have not changed much over time, there is no evidence of pollution from atmospheric sources.

A brief introduction to Limnology

Indicators of water quality

Water samples are collected in Lakewatch to determine the chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in Lakewatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of lake productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

Temperature and mixing

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake. As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is often called a **turnover** event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and near 0° C water on the top.

In spring another turnover event occurs when surface waters warm to 4° C. Lakes with this mixing pattern of two stratification periods and two turnover events are called **dimictic** lakes. In shallower lakes, the water column may mix from top to bottom most of the ice-free season with occasional stratification during periods of calm warm conditions. Lakes that mix frequently are termed **polymictic** lakes. In our cold climate, many shallow lakes are **cold monomictic** meaning a thermocline develops every winter, there is one turnover event in spring but the remainder of the ice free season the lake is polymictic.

Dissolved Oxygen

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes that stratify (see temperature above), oxygen that dissolves into the lake at the surface cannot mix downward into the hypolimnion. At the same time oxygen is depleted in the hypolimnion by decomposition. The result is that the hypolimnion of a lake can become **anoxic**, meaning it contains little or no dissolved oxygen. When a lake is frozen, the entire water column can become anoxic because the surface is sealed off from the atmosphere. Winter anoxic conditions can result in a fish-kill which is particularly common during harsh winters with extended ice-cover. Alberta Surface Water Quality Guidelines suggest dissolved oxygen concentrations (in the epilimnion) must not decline below 5 $mg{\bullet}L^{-1}$ and should not average less than 6.5 $mg{\bullet}L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg{\bullet}L^{-1}$ in areas where early life stages of aquatic biota, particularly fish, are present.

General Water Chemistry

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

Phosphorus and Nitrogen

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

Chlorophyll a

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

Secchi Disk Transparency

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

Trophic state

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	Total Nitrogen ($\mu g \bullet L^{-1}$)	Chlorophyll a ($\mu g \bullet L^{-1}$)	Secchi Depth (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 - 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 - 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1

Note: These values are from a detailed study of global lakes reported in Nurnberg 1996. Alberta Environment uses slightly different values for TP and CHL based on those of the OECD reported by Vollenweider (1982). The AENV and OECD cutoffs for TP are 10, 35 and 100; for CHL are 3, 8 and 25. AENV does not have TN or Secchi depth criteria. The corresponding OECD exists for Secchi depth and the cutoffs are 6, 3 and 1.5 m.