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Lakewatch

Chestermere 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. Susan Cassidy was our summer field coordinator and was an excellent addition to the program. Her hard work made it possible for Lakewatch to expand to 17 lakes, more than triple the number in any previous year! Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred.

Figure 1: Chestermere Lake Fire and Rescue boat launching. Photo: Jay White

Chestermere Lake

Chestermere Lake was originally built by the Canadian Pacific Railroad (CPR) as a water balancing reservoir supplying water at 50 cents an acre to CPR land. In the 1940s, CPR offered to forgive mortgages held on their land in return for settlers giving up their water rights. The irrigation system was turned over to the Western Irrigation District which currently owns and operates the structures feeding water to and from Chestermere Lake (Mitchell and Prepas 1990). The drainage basin for the lake is only 7.65 km^2 including the 2.65 km^2 "reservoir" at its maximum capacity.

Chestermere Lake is shallow over most of its depth. During the original survey conducted by the Alberta government, Chestermere Lake was more than 7 m deep (Fig. 2). The deepest areas have accumulated little sediment as maximum depth is still between 5 and 7 m depending on lake water levels (White 2000). Sediment accumulation has been heaviest at the WID canal inflow (south) where as much as 2 m has accumulated (White 2000).

Aquatic weeds are a problem in Chestermere Lake (Figure 1). Weed growth is extensive because of its shallow depth with about 50% of the lakes area shallower than 2 m. The prevailing theory on weed growth is that weeds dominate in shallow lakes that contain relatively clear water. Some shallow lakes have poor water clarity either because of excessive algal growth or because of suspended sediments. These lakes tend to have few weed problems no matter how shallow they are. Among shallow lakes these two states, turbid but weed free versus clear but weed dominated exist as two stable possibilities for the same lake. The current evidence suggests that a lake can be pushed from weed dominated to weed free by a single event causing high suspended sediments. Turbid and

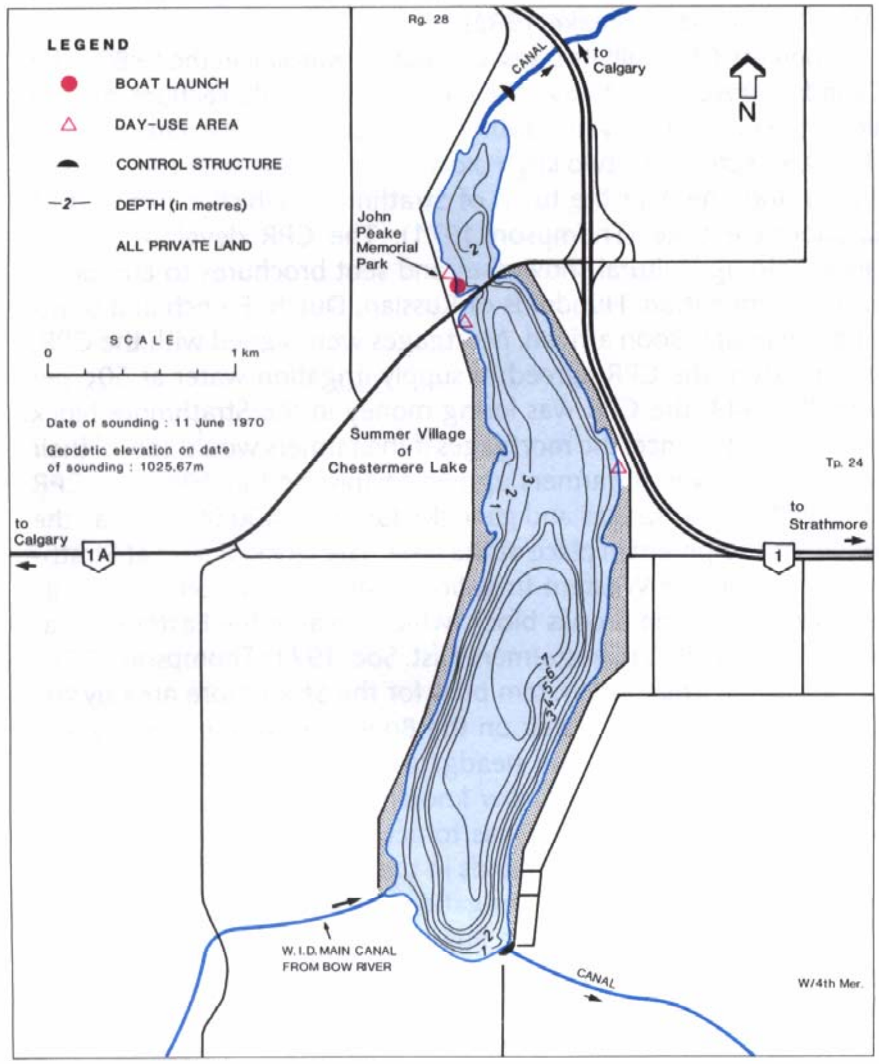


Fig. 2: Bathymetry of Chestermere Lake. From Mitchell and Prepas 2001.

algae-dominated conditions then persist because the stability of both the water column and bottom sediments provided by the rooted plants disappears. Chestermere Lake receives a large volume of water during summer months, enough to replace the entire lake volume in 8 days. Flushing of this magnitude may actually contribute to maintaining water clarity in Chestermere Lake and thus the success of weeds compared to lakes of similar depth in Alberta.

It is important to note that water bodies less than 2 m deep are considered wetlands by Canadian and U.S. classification criteria. This is not to detract from the beauty of Chestermere but simply to acknowledge the reality that a large portion of Chestermere should be dominated by aquatic plants. Chestermere is vital to local recreational use and requires a strong educational drive to increase awareness that a fringe of reeds followed by floating leafed and submerged vegetation may be unavoidable. At the same time depth must be maintained in the lake to provide weed-free areas. Aggressive weed removal by mechanical methods will provide respite from the weeds but will be required on a continuous basis.

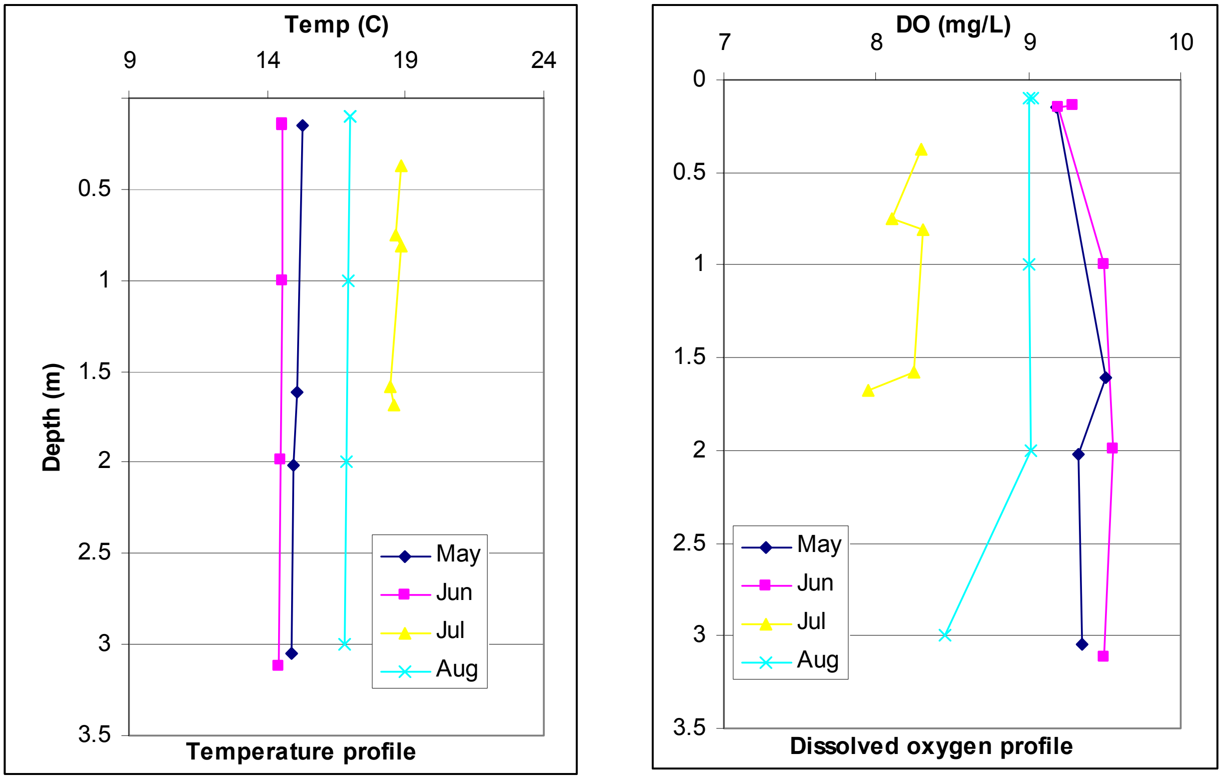


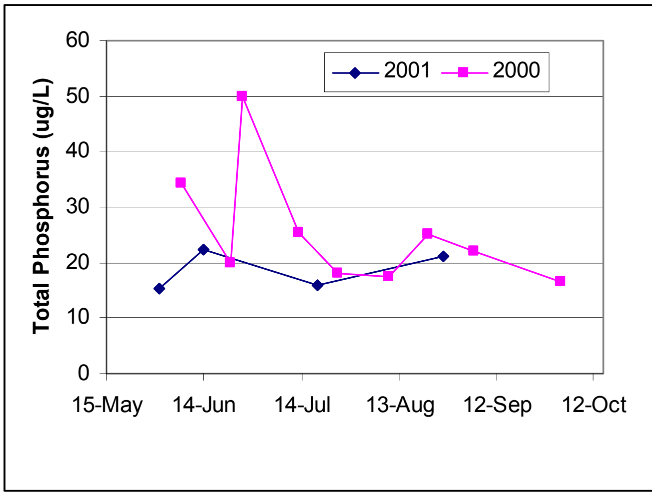
Fig. 3 & 4: Temperature and dissolved oxygen profile of Chestermere Lake, summer 2001.

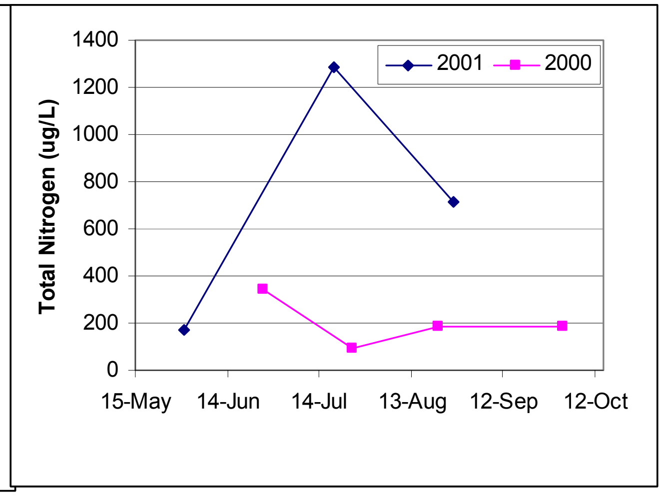
Results

Water temperature and dissolved oxygen

Thermal stratification was not observed in Chestermere Lake in 2000 or 2001. As a result, the water of Chestermere Lake remained well oxygenated. Dissolved oxygen concentrations were typically above 8 $mg \bullet L^{-1}$ during sampling events. As water warms, it holds less dissolved oxygen. Slightly lower dissolved oxygen in July is due to the warmer water conditions.

Photo: Jay White





Figs. 5 & 6: Total phosphorus nitrogen concentrations for Chestermere Lake, summers 2000 and 2001.

Table1: Mean values from summer 2001 samples compared to values from previous summers and those reported in the Atlas of Alberta Lakes for 1983.

Parameter	1983	1999	2000	2001
TP (μg•L^{-1})	36	32	25	19
Chl (μg•L^{-1})	5.5	9	7.6	3.4
Secchi (m)	2.9	2.6		
TKN (μg•L^{-1})	443	335	200	724
TN (μg•L^{-1})	-		229	739
Ca (mg•L^{-1})	35	37	37	37
Mg (mg•L^{-1})	12	15	14	13
Na (mg•L^{-1})	7	15	8	5
K (mg•L^{-1})	1	1	1	1
SO_4^{2-} (mg•L^{-1})	38		43	38
Cl^- (mg•L^{-1})	4	7	5	3
Total Alkalinity (mg•L^{-1} $CaCO_3$)	111		116	110

Water chemistry

Mean total phosphorus concentrations were lower in 2001 than in previous years (Table 1). TP concentrations remained below 22 μg•L^{-1} throughout the summer which was largely consistent with data from 2000. However in years other than 2001, summer TP concentrations demonstrated occasional peaks (e.g. 50 μg/L in 2000) that were not observed in the 2001 data. Total nitrogen concentrations were more than double that of preceding Lakewatch years (Table 1). Elevated total nitrogen concentrations were apparent in Chestermere Lake from July through August samples in 2001. The average nitrogen : phosphorus ratio was 43 compared to 11 and 9 in 1999 and 2000, respectively. Algal chlorophyll concentrations remained relatively stable through the summer between 3 and 4 μg•L^{-1} (Table 1). These low chlorophyll concentrations were close to oligotrophic, the most desirable but a rare condition for Alberta lakes.

Ion concentrations were similar to previous years (Table 1). Both sodium and chloride were thought to be a problem in 1999 likely due to road salt and urban runoff. However, concentrations of both declined in 2000 and continued to decline in 2001 (Table 1). The decline likely represents reduced salt runoff from urban roads in 2000 and 2001 or enhanced dilution by diversions from the Bow River.

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		< 3	
Mesotrophic	10 - 35		3 - 8	
Eutrophic	35 - 100		8 - 25	
Hypereutrophic	> 100		> 25	