Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2010 Laurier Lake Report

COMPLETED WITH SUPPORT FROM:

Beaver River Watershed Alliance

Government of Alberta

LICA
Lakeland Industry & Community Association

Alberta Lake Management Society's Lakewatch Program

Lakewatch has several important objectives, one of which is to collect and interpret water quality data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. 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. Additional information is available for many lakes that have been included in Lakewatch and readers requiring more information are encouraged to seek those sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Lakewatch Chairs, Al Sosiak and Ron Zurawell. We would like to thank Bev Smith for her efforts in collecting data in 2010. We would also like to thank Bradley Peter and Emily Port who were summer interns with ALMS in 2010. Project Technical Coordinator Jill Anderson was instrumental in planning and organizing the field program. Technologists Shelley Manchur, Mike Bilyk, Brian Jackson, and John Willis were involved in the training aspects of the program. Doreen LeClair and Chris Rickard were responsible for data management. Jill Anderson (Program Manager) was responsible for program administration and planning. Théo Charette, Ron Zurawell (Limnologist, AENV), Lori Neufeld, and Sarah Lord prepared the original report, which was updated for 2010 by Bradley Peter and Arin Dyer. Alberta Environment, the Beaver River Watershed Alliance (BRWA), and the Municipal District of Wainwright were major sponsors of the Lakewatch program.

LAURIER LAKE:

Laurier Lake is one of four beautiful lakes that were left behind 10,000 years ago when glaciers carved a hummocky terrain of kettles, eskers, and lake basins. Archaeological evidence indicates that the area was inhabited 7000 years ago. The first Europeans came through the area in 1754 by way of the nearby North Saskatchewan River.

Figure 1 – Bradley Peter and volunteer Bev Smith at Laurier Lake.

The Whitney Lakes Provincial Park adjacent to Laurier Lake was established in 1982. It boasts a diverse setting of jack pine (*Pinus banksiana),* meadows, aspen (*Populus* spp.), groves, willow (*Salix* spp.), thickets, marshes, fens, and mixed wood forests. As many as 148 bird species have been observed in the park with an excellent viewing point on the west side of Laurier Lake. The land surrounding Laurier Lake includes a mixture of recreational cottage development, cleared agricultural land, and natural deciduous forest. Protected Crown Land makes up the north shore of the lake and the remainder is privately owned.

The lake is enjoyed for recreational activities such as hiking, wildlife viewing, and water-based recreation. Popular activities include: wind surfing, water-skiing, sailing, swimming, and fishing. Yellow perch (*Perca flavescens*), walleye (*Sander vitreus*), and northern pike (*Esox lucius*), are the sport fish of Laurier Lake. Fish stocking occurred in 1953. Sport and forage fish were transferred from Moose Lake to Laurier Lake. The lake has not been managed for commercial or domestic fisheries.

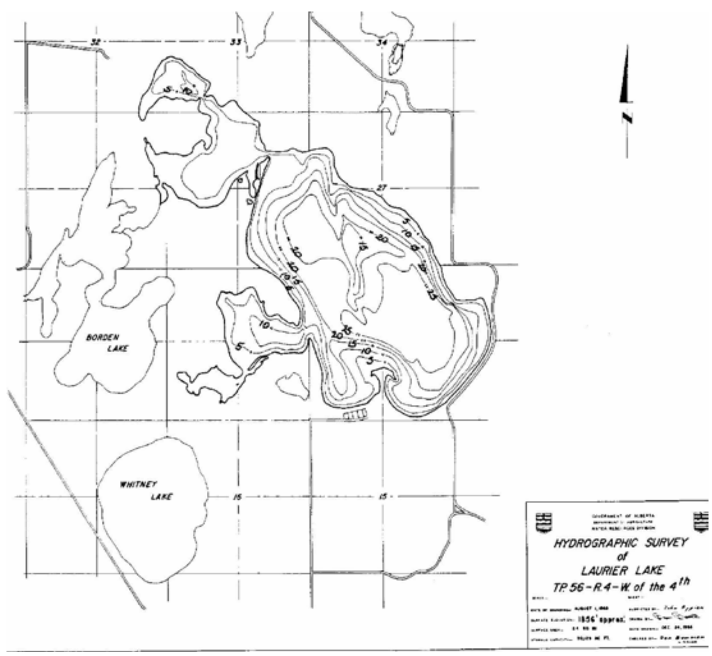

Figure 2 – Bathymetric map of Laurier Lake showing five-foot depth contour intervals.

WATER LEVELS:

Laurier Lake has a surface area of 6.42 km^2, a maximum of depth of approximately 6.0 m (Figure 2), and a drainage basin of 92.0 km^2 (which is shared with Ross, Borden, and Whitney Lakes). One intermittent and three permanent streams feed into Laurier Lake. The outflow, on the northwest end, drains into Borden Lake and subsequently into the North Saskatchewan River. Water levels at Laurier Lake have been monitored since 1968 (Figure 3), with a historical maximum of 567.2 meters above sea level (m asl) being achieved in 1974. Since then, a historical minimum of 564.0 m asl was reached in 2004. While lake levels have shown a general trend towards decline, intermittent wet periods (1997, 2008) have offered short reprieves from water loss.

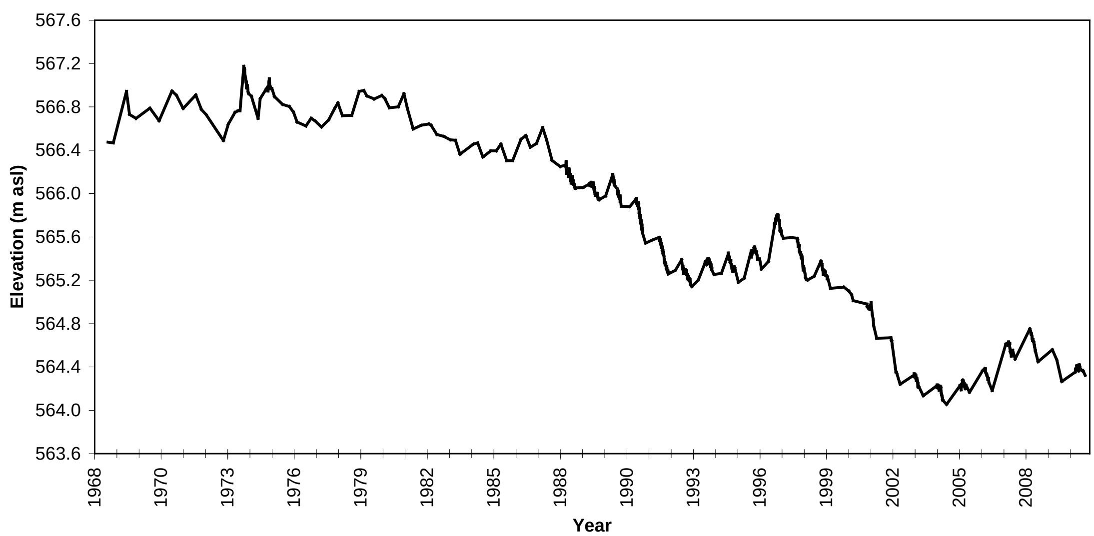

Figure 3 – Historical water levels for Laurier Lake recorded in meters above sea level (m asl) obtained from Alberta Environment.

WATER CLARITY AND SECCHI DEPTH:

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

The average secchi disc depth measured at Laurier Lake in 2011 was 1.80 m, well within the natural variation seen in previous years (Table 1). Secchi disc showed little pattern over the course of the summer, with a seasonal maximum of 2.50 m seen on June 9th and a seasonal minimum of 1.50 m seen on July 7th, August 27th, and September 10th. While algae blooms are common at Laurier Lake, it is likely that suspended sediments play a large role in diminishing water clarity due to the lakes shallow depth, strong winds, and polymictic nature.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Temperature at Laurier Lake changed very little over the course of the summer (Figure 4a). As a polymictic lake, no thermal stratification was observed on any of the sampling dates in 2010. Surface water temperatures ranged from a seasonal minimum of 13.92 °C on June 9th, to a seasonal maximum of 21.07 °C on July 28th. On September 10th, surface water temperature (14.63 °C) was slightly cooler than that seen at the lakebed (14.95 °C).

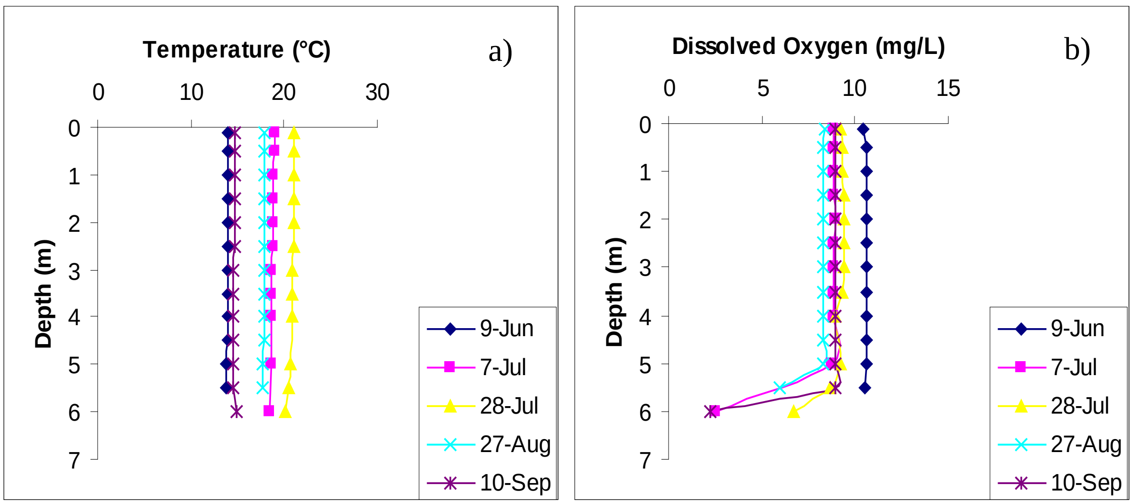

Figure 4 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles measured over the course of the summer in 2010 at Laurier Lake.

Dissolved oxygen at Laurier Lake also changed little over the course of the summer (Figure 4b). A seasonal minimum of 8.35 mg/L was seen on August 27th, and a seasonal maximum of 10.39 mg/L was measured on June 9th. On all sample dates with the exception of June 9th, dissolved oxygen dropped drastically near the lakebed. This is typical of Alberta lakes as decomposition of algae (an oxygen consuming process) occurs at the sediment-lake interface, resulting in reduced oxygen levels at the lakebed. The polymictic nature of the lake, however, helps to maintain high oxygen levels throughout the rest of the water column. The Canadian Council for Ministers of the Environment (CCME) guidelines for the protection of aquatic life recommend 6.5 mg/L dissolved oxygen.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorous, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of *harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.*

Based on average total phosphorous measured in 2010 (37.6 µg/L), Laurier Lake would be considered eutrophic. Throughout the years, the trophic classification of Laurier Lake based on total phosphorous has fluctuated between mesotrophic and eutrophic, with the 2010 average falling on the low-end of the eutrophic classification. Ultimately, total phosphorous changed little throughout the summer, fluctuating between a minimum of 33 µg/L and a maximum of 41 µg/L. Average total Kjeldahl nitrogen in 2010 (2.61 mg/L) fell well within the natural variation seen at Laurier Lake. This level of nitrogen falls in the hypereutrophic, or extremely productive, classification. Nitrogen increased over the course of the summer, measuring 2.17 mg/L on June 9th, and 3.21 mg/L on September 10th. Finally, chlorophyll-*a* concentration at Laurier Lake measured an average of 6.96 µg/L in 2010, falling in the mesotrophic classification, which is slightly lower than the eutrophic 2009 average of 9.13 µg/L. The mild summer in 2010 may have contributed to lower chlorophyll-*a* concentrations compared to previous years. Levels of chlorophyll-*a* seemed to increase throughout the summer along with nutrients, measuring 4.49 µg/L on June 9th and 8.86 µg/L on September 10th. Ultimately, both chlorophyll-*a* and total phosphorous concentrations fell close to the historical average for Laurier Lake (Figure 5).

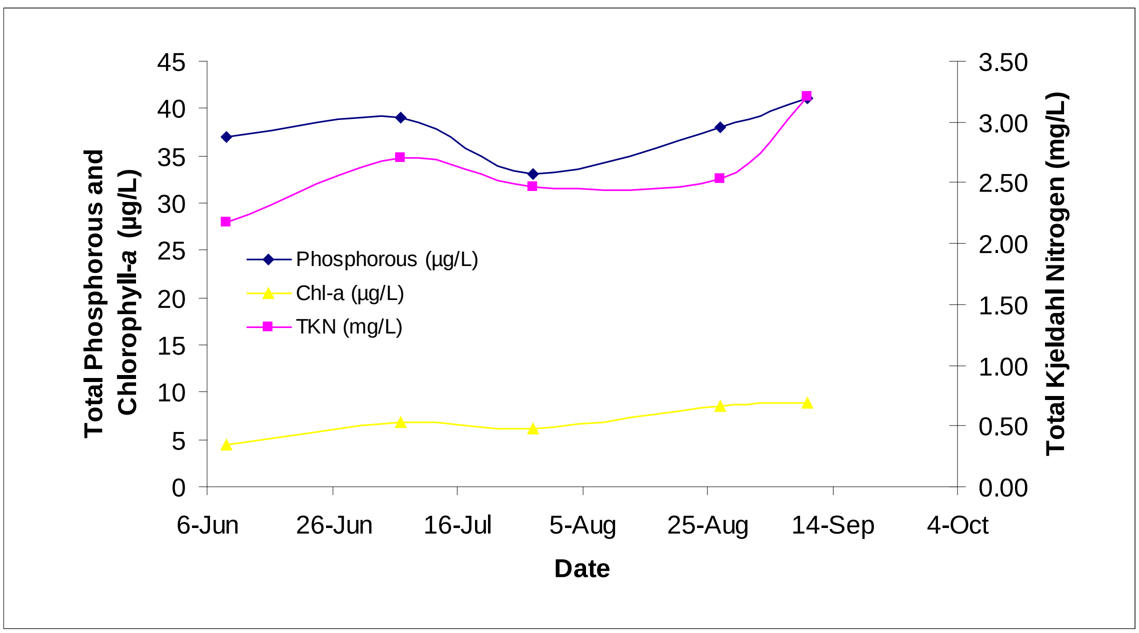

Figure 4 – Total phosphorous (µg/L), chlorophyll-a concentration, and total Kjeldahl nitrogen, measured five times over the course of the summer at Laurier Lake.

Average pH measured at Laurier Lake in 2010 was 9.1, well above neutral (Table 1). Laurier Lake has high hardness, alkalinity, and conductivity. Dominant ions include magnesium, sodium, sulphate, and bicarbonate, which helps to buffer the lake against changes in pH. Since 1978, ion concentrations have been increasing, resulting in higher alkalinity, hardness, and conductivity. Reduced surface water run-off into Laurier Lake in previous decades may have resulted in groundwater sources becoming more important and contributed to the change in the water chemistry of Laurier Lake. Metal concentrations were measured twice over the summer at Laurier Lake, with all concentrations falling well within their respective guidelines (Table 2).

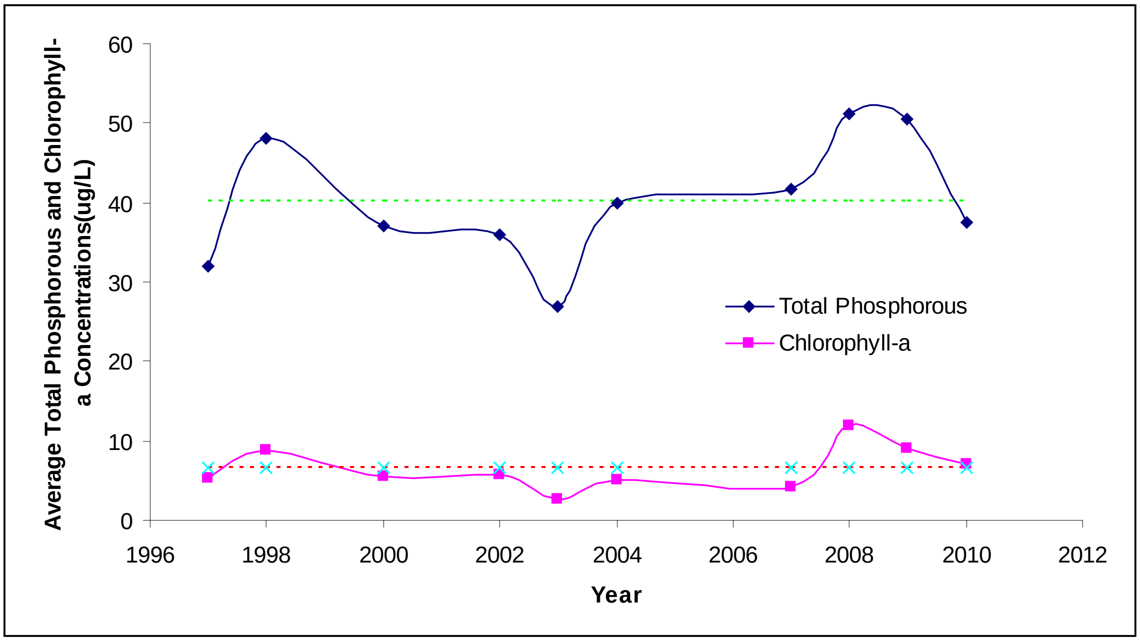

Figure 5 – Historical total phosphorous (µg/L) and chlorophyll-*a* (µg/L) concentration averages for Laurier Lake.

Table 1 – Average secchi depth and water chemistry values for Laurier Lake. Previous years averages are provided for comparison.

Parameter	1978	1980	1987	1997	1998	2000	2002	2003	2004	2007	2008	2009	2010
TP (μg/L)	/	/	/	32	48	37	36	27	40	41.6	51.2	50.5	37.6
TDP (μg/L)	/	/	/	/	/	/	15	15	18	22	18.8	20.5	16.4
Chlorophyll-*a* (μg/L)	/	/	/	5.3	8.9	5.5	5.8	2.6	5	4.3	11.9	9.13	6.96
Secchi depth (m)	/	1.3	1.2	4.6	1.3	1.8	2.5	4.4	3.2	2.4	1.3	2	1.8
TKN (μg/L)	/	/	/	/	/	/	2.5	2.6	2.7	2.2	2.7	2.76	2.614
NO_2 and NO_3 (μg/L)	<50	50	<1	/	/	/	3.8	2.11	7.7	<7	<5	9.6	9.6
NH_3 (μg/L)	/	/	/	/	/	/	23	41	76	46.2	39.2	39.3	33.2
DOC (mg/L)	/	/	/	/	/	/	/	/	/	37.9	37.9	39	37.5
Ca (mg/L)	23	27	19	20	21	13	12	10	10.5	14.6	14.5	12.1	12.2
Mg (mg/L)	48	54	52	73	81	83	99	106	107	/	92.9	88.1	98.6
Na (mg/L)	49	45	59	86	92	98	77	128	129	122.7	120.6	132.3	136
K (mg/L)	14	14	17	24	25	25	26	31	34	32.8	31.9	38	34.5
SO_4^{2-} (mg/L)	36	40	41	62	66	73	94	99	105	111.7	121.3	135.7	148.7
Cl^- (mg/L)	5	6	9	12	13	15	12	18	20	19.5	20.2	21.2	22.7
CO_3 (mg/L)	/	/	/	39	62	66	102	112	84	86	84.7	70	85
HCO_3 (mg/L)	/	/	/	493	468	469	515	522	603	535.7	544.3	582.3	568
pH	/	/	/	8.8	8.9	8	9.2	9.2	9.1	9.1	9	9	9.1
Conductivity (μS/cm)	/	/	/	/	/	/	/	/	/	1163	1197	1246	1257
Hardness (mg/L)	/	/	/	351	387	376	/	463	468	443	419	1257	436
TDS (mg/L)	/	/	/	562	598	602	/	764	/	/	754	758	817
Microcystin (μg/L)	/	/	/	/	/	/	/	/	/	0.41	0.24	0.39	0.17
Total Alkalinity (mg/L $CaCO_3$)	310	329	360	470	488	493	592	615	634	583	588	594	608

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Laurier Lake on July 7th and September 10th 2010. Values shown for 2010 are an average of those dates. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2007**	**2008**	**2010**	**Guidelines**
Aluminum µg/L	29.4	9.69	20.65	100[a]
Antimony µg/L	0.137	0.117	0.131	6[e]
Arsenic µg/L	2.6	3	3.185	5
Barium µg/L	20.2	16.95	17.8	1000[e]
Beryllium µg/L	<0.003	<0.003	0.0015	100[d,f]
Bismuth µg/L	<0.005	0.0051	0.00205	/
Boron µg/L	175.5	182	188.5	5000[e,f]
Cadmium µg/L	0.008	0.0038	0.00425	0.085[b]
Chromium µg/L	0.611	0.56	0.441	/
Cobalt µg/L	0.099	0.058	0.07075	1000[f]
Copper µg/L	0.613	0.555	0.278	4[c]
Iron µg/L	37.1	15.8	16.855	300
Lead µg/L	0.057	0.023	0.0208	7[c]
Lithium µg/L	102.9	100.2	114	2500[g]
Manganese µg/L	5.15	7.97	4.125	200[g]
Molybdenum µg/L	0.661	0.587	0.8645	73[d]
Nickel µg/L	0.275	0.127	0.12845	150[c]
Selenium µg/L	0.547	0.372	0.416	1
Silver µg/L	<0.003	0.0086	0.001425	0.1
Strontium µg/L	84.5	62.9	58.85	/
Thallium µg/L	<0.001	0.0024	0.00115	0.8
Thorium µg/L	<0.01	0.017	0.01245	/
Tin µg/L	<0.06	<0.03	0.015	/
Titanium µg/L	1.24	1.36	1.38	/
Uranium µg/L	0.811	0.808	1.085	100[e]
Vanadium µg/L	0.742	0.512	0.807	100[f,g]
Zinc µg/L	1.53	0.916	0.326	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5; calcium ion concentrations [Ca^{+2}] ≥ 4 mg/L; and dissolved organic carbon concentration [DOC] ≥ 2 mg/L.
[b] Based on water Hardness of 300 mg/L (as $CaCO_3$)
[c] Based on water hardness > 180mg/L (as $CaCO_3$)
[d] CCME interim value.
[e] Based on Canadian Drinking Water Quality guideline values.
[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[g] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.

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:

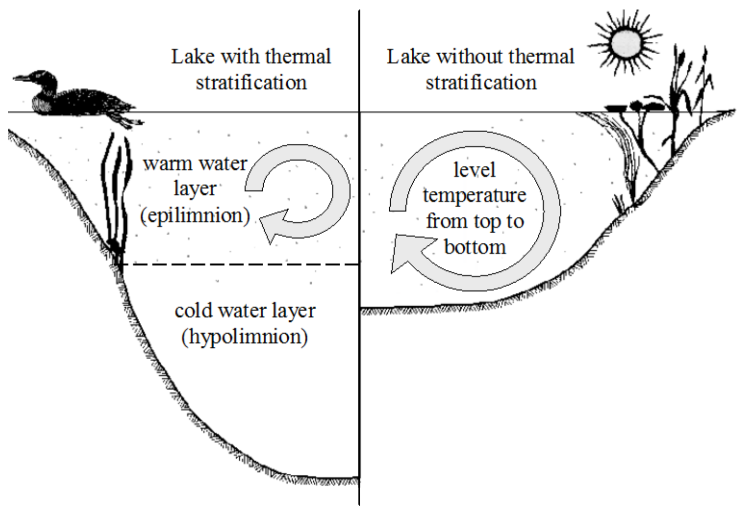

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 (Table 2)**.

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.

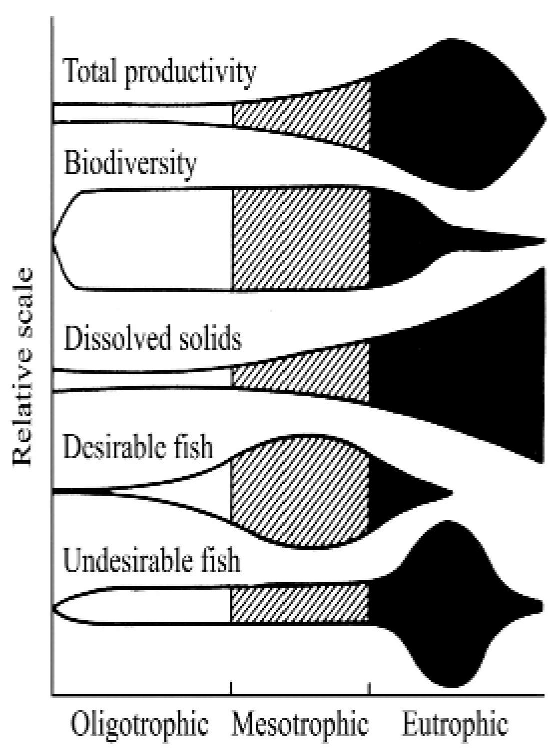

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

Table A - 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.