Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2011 Hilda Lake Report

COMPLETED WITH SUPPORT FROM:

Beaver River Watershed Alliance

Alberta Government

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. We would like to thank volunteer Dean Schneider for his assistance with sampling Hilda Lake in 2011. We would also like to thank Jessica Davis and Pauline Pozsonyi who were summer interns with ALMS in 2011. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Shelley Manchur and Brian Jackson were involved in the training aspects of the program. Doreen LeClair, Chris Rickard, and Lisa Reinbolt were responsible for data management. Théo Charette, Ron Zurawell, Lori Neufeld, and Sarah Lord prepared the original report, which was updated for 2011 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.

HILDA LAKE:

Figure 1 –Hilda Lake. Photo by Pauline Pozsonyi 2011

Hilda Lake is a small lake (3.62 km^2) located in the Beaver River Basin near Cold Lake, in the MD of Bonnyville. It is fed by Crane (Moore) Lake upstream and drains into Ethel Lake downstream, eventually feeding the Beaver River, which then winds through Saskatchewan ultimately to Hudson Bay. The lake is accessed via Highway 897 connecting to a municipal road off the southeastern shore of the lake.

Hilda Lake is situated in rolling land characteristic of the low boreal mixedwood. The lake supports some sport fish species, including northern pike (*Esox lucius*), walleye (*Sander vitreus*), and to a lesser extent yellow perch (*Perca flavescens*) and burbot (*Lota lota*). Lake whitefish (*Coregonus clupeaformis*) and white suckers (*Catostoum commersonii*) are also present. Good to excellent permanent wetland habitat surrounds part of the lake as well as shorelines suitable for recreation.[1] In 2006 the health of the riparian area was evaluated by aerial survey with 78% of the area healthy, 13% moderately impaired, and 9% highly impaired[1].

Much of the watershed is crown land, with two campsites and two multi-lot rural subdivisions. In-situ oil sand operations within the Hilda Lake watershed will likely be the main human development in the future.

WATER QUANTITY:

There are many factors influencing water quantity. Some of these factors include the size of the lakes drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake.

The drainage basin of Hilda Lake is small (37.2 km^2) and surface run-off is low, with most of the total annual inflow coming from direct rainfall. Areas of muskeg probably intercept the movement of surface water to the lake. Analysis of the lake water in the early 1980's suggested that groundwater plays an important role in lake inputs. Water levels have fluctuated between a minimum of 546.08 meters above sea level (m asl) in 1995 to a maximum of 547.43 m asl in 2011 (Figure 2). Overall, this is a change of ~1.4 m, suggesting that the water quantity at Hilda Lake is stable.

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[1] Walker Environmental. 2006. Shoreline Health and Integrity Assessment Project. Retrieved from: http://www.lica.ca/attachments/065_Presentation%202006%20LICA%20Lakes%20Project.pdf

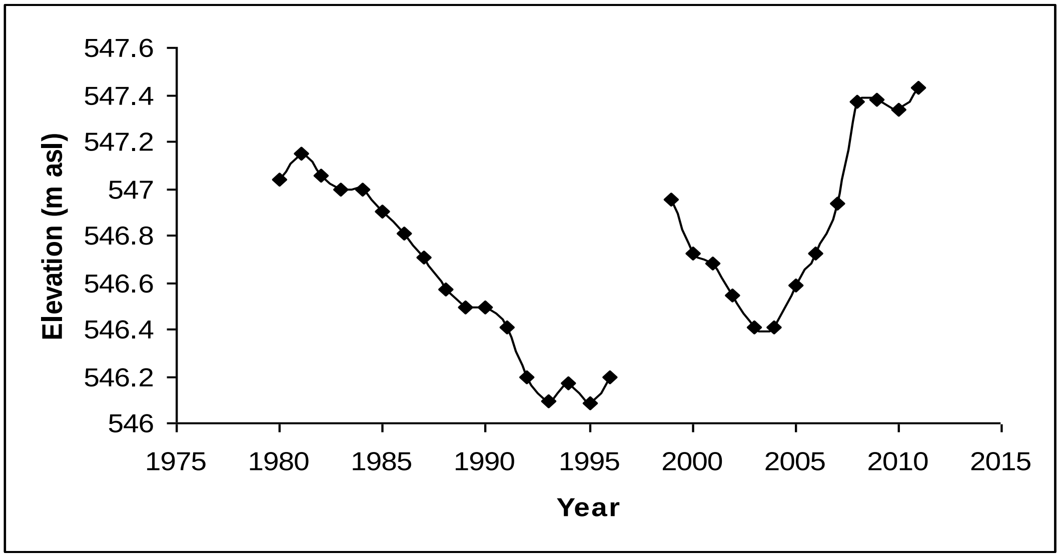

Figure 2 – Water quantity at Hilda Lake measured from 1980-2011. Measurements were obtained from both Environment Canada and Alberta Environment.

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.

Average Secchi disk depth at Hilda Lake in 2011 measured 3.42 m (Table 1). A value of 3.42 m suggests water transparency that is much better compared to previous years (Table 1). Multiplying the average Secchi disk depth by two provides the euphotic depth: the depth to which enough light remains for photosynthesis. This suggests that, on average, there was enough light available for photosynthesis down to 6.84 m, or approximately one-half of the water column. Secchi disk depth ranged from 3.25 m on June 29th and July 29th, to 3.75 m on August 26th.

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.

Surface water temperature measured at Hilda Lake was high and changed very little between samples (Figure 3a). Temperature ranged from 19.39 °C on June 29th to 21.12°C on July 29th. Thermal stratification was observed on each trip, often beginning at ~4.0-6.0 m. From there, temperatures quickly declined to ~5.0 °C at the lakebed. The presence of thermal stratification contributes to the decline of oxygen observed in the hypolimnion. Stratification is present in most of Alberta's lakes, though factors including landscape position, small surface area (3.62 km^2) and depth (max. 14 m) may contribute to the water column never completely mixing throughout the deepest parts of the lake.

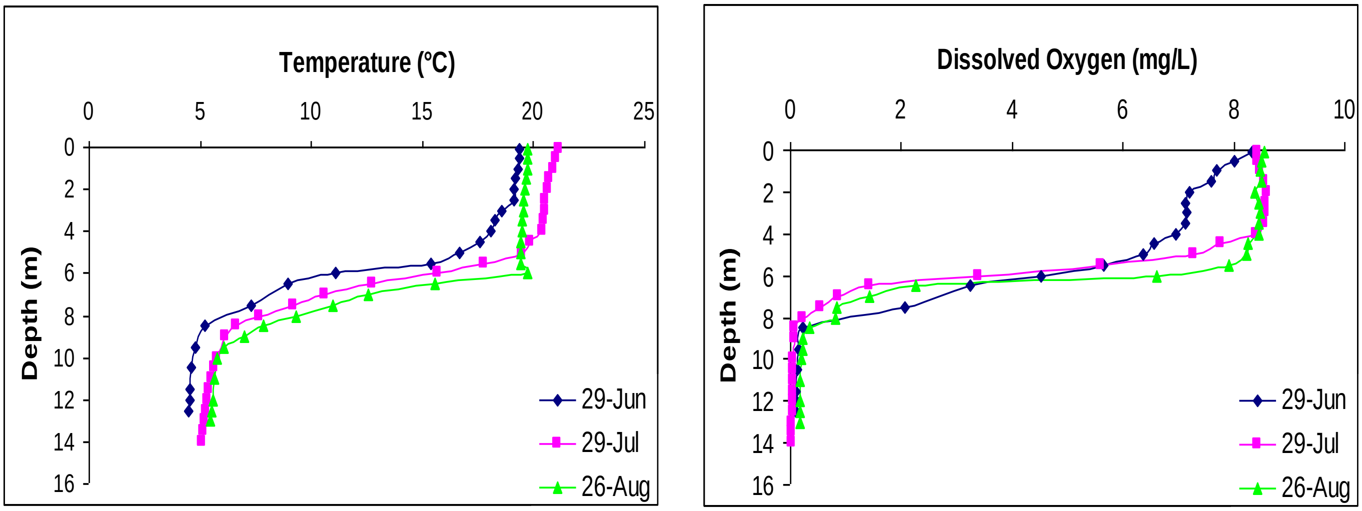

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Hilda Lake measured three times during the summer of 2011.

Dissolved oxygen in Hilda Lake followed a pattern similar to the temperature profile (Figure 3b). While at the surface dissolved oxygen remained well above the Canadian Council for Ministers of the Environment guideline of 6.5 mg/L for the Protection of Aquatic Life, below the thermocline dissolved oxygen declined rapidly to anoxia. Oxygen depletion below the thermocline is a result of separation from atmospheric oxygen as well as decomposition of algae/cyanobacteria near the lakebed which is an oxygen consuming process.

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 algae/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Tables 1 and 2 for a complete list of parameters.

Average Total Phosphorous (TP) measured at Hilda Lake in 2011 was 20.0 µg/L, which falls into the mesotrophic, or moderately productive, classification (Table 1). TP ranged from 17 µg/L on June 29th to 24 µg/L on August 26th (Figure 5). Compared to previous years, an average of 20.0 µg/L is well within the natural historical variation measured at Hilda Lake.

Total Kjeldahl Nitrogen (TKN) measured 1333 µg/L in 2011, which falls into the hypereutrophic, or extremely productive, classification. Since the first measurement in 1980, TKN has changed very little and has a historical average of 1.32 µg/L. Throughout the summer TKN ranged from 1.25 µg/L on July 29th to 1.38 µg/L on June 29th.

Finally, average chlorophyll-*a* concentration (an indirect measure of algal biomass), measured 6.14 µg/L, which falls into the mesotrophic classification. Algae/cyanobacteria are likely limited in their population sizes by the amount of phosphorous in Hilda Lake, which suggests efforts to mitigate external sources of phosphorous entering the lake are extremely important. Chlorophyll-*a* concentration ranged from 2.78 µg/L on June 29th to 12.8 µg/L on August 26th.

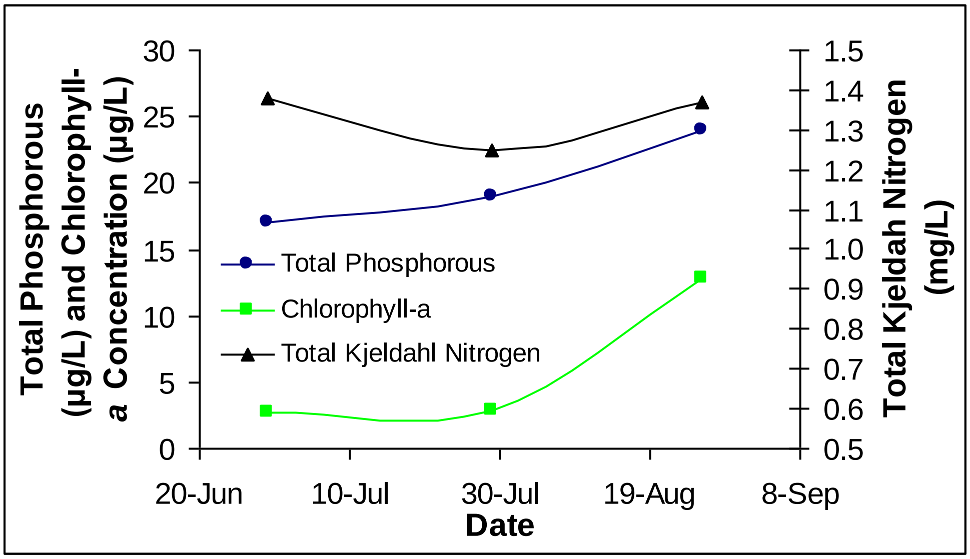

Figure 4 – Total phosphorous (µg/L), chlorophyll-a concentration, and total Kjeldahl nitrogen, measured five times over the course of the summer at Hilda Lake.

Average pH measured at Hilda Lake was 8.86 in 2011. This value is well above neutral, and is likely due to high alkalinity (433 mg/L $CaCO_3$) and bicarbonate (461 mg/L HCO_3) concentrations will help to buffer the lake against changes to pH. Other dominant ions in the lake include sodium (112.5 mg/L) and magnesium (54 mg/L).

Metals were measured once at Hilda Lake, and all values fell within their respective guidelines (Table 2).

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

Parameter	**1980**	**1981**	**2004**	**2005**	**2006**	**2007**	**2011**
TP (µg/L)	/	26	29	19	20	23	20
TDP (µg/L)	/	13	6.8	6.5	10.6	7.5	12
Chlorophyll-*a* (µg/L)	10	7.2	4.8	3.6	3	3.81	6.14
Secchi depth (m)	2.6	2.4	2.8	2.75	2.75	2.2	3.42
TKN (µg/L)	1400	1200	1400	1300	1300	1300	1333
NO_2 and NO_3 (µg/L)	6.4	5.8	3.1	11.7	14	<5	3.33
NH_3 (µg/L)	52	65	14	17	18	17.8	18.7
DOC (mg/L)	16	18	21	/	/	22.3	20.6
Ca (mg/L)	19	20	16	16	18	19	18.35
Mg (mg/L)	38	37	55	53	52	/	54
Na (mg/L)	77	72	116	114	116	110.7	112.5
K (mg/L)	6.9	7	10	9.9	10	10.2	9.85
SO_4^{2-} (mg/L)	17	20	38	35	37	34.3	25
Cl^- (mg/L)	22	21	34	32	32	32.5	31.75
CO_3 (mg/L)	/	/	47	42	41	34.7	33.7
HCO_3 (mg/L)	/	/	444	441	445	456	461
pH	8.6	8.4	9	8.9	8.9	8.9	8.86
Conductivity (µS/cm)	671	666	892	883	883	871	880
Hardness (mg/L)	/	/	/	258	260	277	268
TDS (mg/L)	419	433	535	518	526	521	513
Microcystin (µg/L)	/	/	/	0.12	0.079	0.14	0.087
Total Alkalinity (mg/L $CaCO_3$)	325	328	442	431	433	431	433

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 Hilda Lake on July 29th 2011. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**1981**	**2004**	**2005**	**2006**	**2007**	**2011**	**Guidelines**
Aluminum µg/L	35	12	5.055	10.975	9.6	5.01	100[a]
Antimony µg/L	/	0.049	0.045	0.041	0.044	0.0355	6[e]
Arsenic µg/L	/	2.3	2.21	1.95	2.13	2.28	5
Barium µg/L	/	21	20.75	21.3	21.6	23.8	1000[e]
Beryllium µg/L	<1	0.0013	<0.003	<0.003	0.004	0.0015	100[d,f]
Bismuth µg/L	/	0.0013	0.00475	0.02	0.002	0.0005	/
Boron µg/L	/	265	250.5	278.5	219.5	258	5000[ef]
Cadmium µg/L	<1	0.026	0.0028	0.005	0.008	0.0023	0.085[b]
Chromium µg/L	/	0.61	0.3365	0.3395	0.342	0.282	/
Cobalt µg/L	<1	0.023	0.014	0.029	0.034	0.0123	1000[f]
Copper µg/L	0.75	0.46	0.265	0.322	1.48	0.212	4[c]
Iron µg/L	33	6.2	3.4	8.93	25.3	5.71	300
Lead µg/L	5.5	0.125	0.059	0.055	0.111	0.0157	7[c]
Lithium µg/L	/	65	65.35	68.65	53.8	64.5	2500[g]
Manganese µg/L	10	3.8	6.935	6.64	10.23	5.83	200[g]
Molybdenum µg/L	/	0.7	0.647	0.668	0.608	0.476	73[d]
Nickel µg/L	<10	0.0025	<0.005	<0.005	0.056	0.0025	150[c]
Selenium µg/L	/	0.21	0.24	0.37	0.578	0.435	1
Silver µg/L	<1	0.00025	0.00245	0.0031	<0.0005	0.00025	0.1
Strontium µg/L	/	109	104	106	105.5	106	/
Thallium µg/L	/	0.0021	0.01335	0.00735	0.002	0.00015	0.8
Thorium µg/L	/	0.0103	0.1455	0.0088	0.011	0.003	/
Tin µg/L	/	0.058	0.04	<0.03	0.041	0.015	/
Titanium µg/L	/	0.67	0.697	0.882	0.974	0.711	/
Uranium µg/L	/	0.168	0.176	0.176	0.177	0.159	100[e]
Vanadium µg/L	0.5	0.363	0.272	0.27	0.21	0.178	100[f,g]
Zinc µg/L	7.5	7.3	1.55	1.04	0.959	0.454	30

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5; calcium ion concentrations $[Ca^{+2}] \geq 4$ mg/L; and dissolved organic carbon concentration $[DOC] \geq 2$ 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:

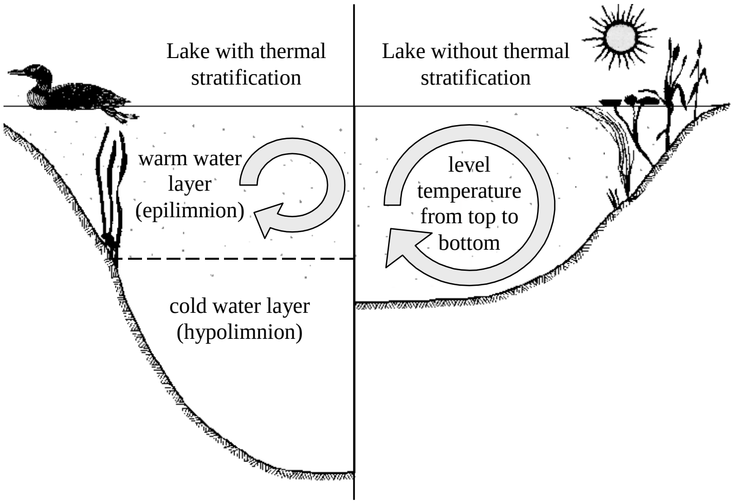

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 $\mathrm{mg{\bullet}L^{-1}}$ and should not average less than 6.5 $\mathrm{mg{\bullet}L^{-1}}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $\mathrm{mg{\bullet}L^{-1}}$ 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.

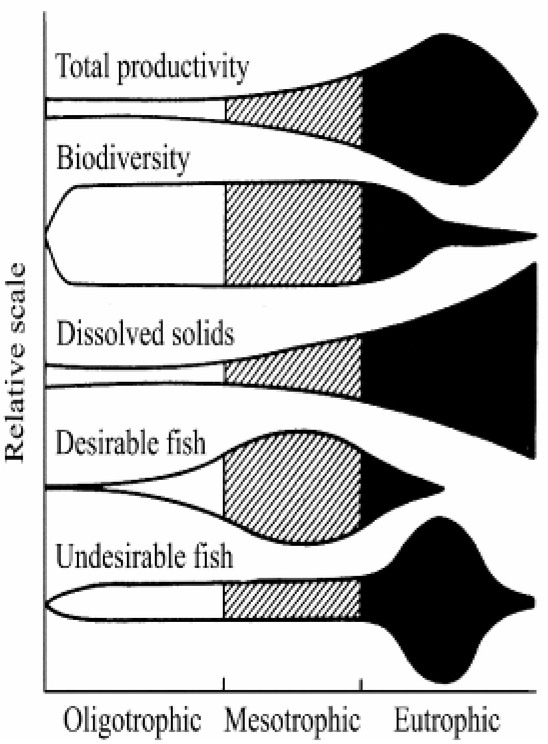

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Table A - Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus (µg•L^{-1})	Total Nitrogen (µg•L^{-1})	Chlorophyll a (µg•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