THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2011 Half Moon Lake Report

COMPLETED WITH SUPPORT FROM:

Government

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 Jason Kropp for arranging the sampling of Half Moon 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. The 2012 report was prepared 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.

HALF MOON LAKE:

Half Moon Lake is a small lake east of the City of Edmonton in the County of Strathcona. Half Moon Lake lies in the North Saskatchewan River basin, within in the Moist Mixedwood Subregion of the Boreal Mixedwood Ecoregion, thus the watershed is dominated by trembling aspen (*Populus tremuloides*) and balsam poplar (*Populus balsamifera*)[1].

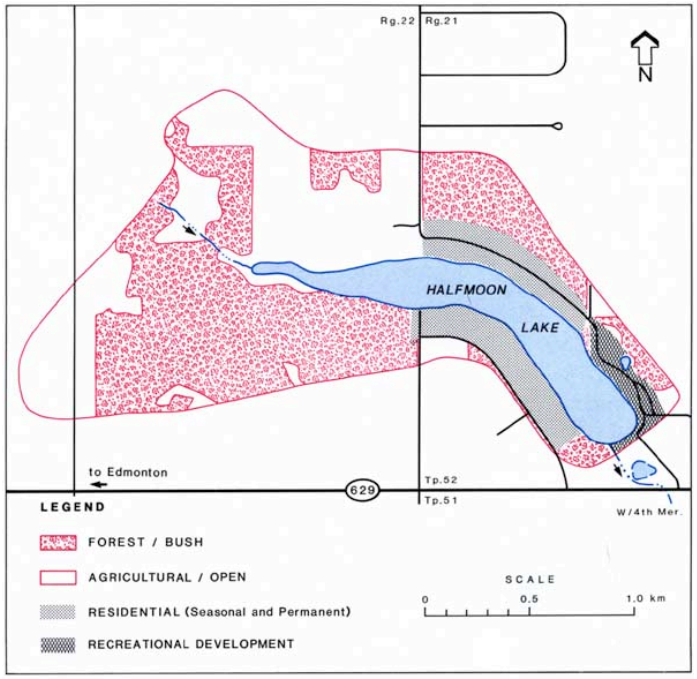

Figure 1 – Drainage basin of Half Moon Lake (Mitchell and Prepas 1990).

Half Moon Lake, named for its shape, is small, with a surface area of only 0.41 km^2 and a maximum depth of 8.5 m. The drainage basin is also small, measuring only 2.43 km^2, resulting in a drainage basin to surface area ratio of 6:1 (Figure 1). Due to this small ratio, surface runoff contributes little to Half Moon Lake's water levels, and only one intermittent stream flows into the lake from the north.

Development in Half Moon Lake's watershed includes residential units on the East and West shores, and one resort, the Half Moon Lake Resort, on the South shore, which includes 90 campsites. There are plans for extensive development at the resort, such as a baseball diamond, tennis courts, community centre, recycling centre, conference centre, and more[2]. Improper waste disposal discovered in 2011 led to a short closure of the resort. Since then, the resort has updated its sewage management practices and is back open for business. It is unknown whether this improper waste disposal had implications for Half Moon Lake's water quality. Despite the lakes popularity as a recreational

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[1] Strong, W.L. and K.R. Leggat. 1981. Ecoregions of Alberta. Alta. En. Nat. Resour., Resour. Eval. Plan. Div., Edmonton.

[2] Half Moon Lake Resort Future Development Sketches. 2012. (Artist renditions of proposed developments and modifications to the Half Moon Lake Resort area.) Retrieved from http://halfmoonlakeresort.ca/camp/wp-content/uploads/2012/05/hmlr-future-development.pdf

destination, sport fishing is absent as sport fish are unable to survive in the lake's low dissolved oxygen concentrations[3].

Half Moon Lake has been subject to several in-lake treatments for the control of nuisance algal/cyanobacterial blooms including herbicides and the addition of lime[3].

WATER LEVELS:

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.

Currently no water level data exists for Half Moon Lake. Requests for water level monitoring should go through Environment and Sustainable Resource Development's Monitoring and Science Division.

WATER CLARITY & 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 Half Moon Lake in 2011 was low, measuring 1.33 m. This measurement falls into the eutrophic, or nutrient rich, classification. Throughout the summer, Secchi disk depth ranged from a maximum of 2.5 m in June to a minimum of 0.8 m in August. It is common in Alberta for Secchi disk depth to decline throughout the summer as increased temperatures and nutrient concentrations result in greater amounts of algae/cyanobacteria.

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.

Temperatures throughout the water column at Half Moon Lake were generally high (Figure 2a). Thermal stratification was observed on June 22nd between 4.5-7.0 m and on August 5th between 5.0-6.0 m. The establishment of thermal stratification may contribute

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[3] Mitchell, P and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Available at: http://sunsite.ualberta.ca/Projects/Alberta-Lakes/

to the depletion of oxygen in the deeper parts of the lake. Surface water temperatures ranged from a minimum of 17.99 °C on June 22nd to 21.08 °C on August 5th. At the lakebed, temperatures were as high as 16.77 °C. High temperatures and low dissolved oxygen concentrations are unfavorable conditions for fish.

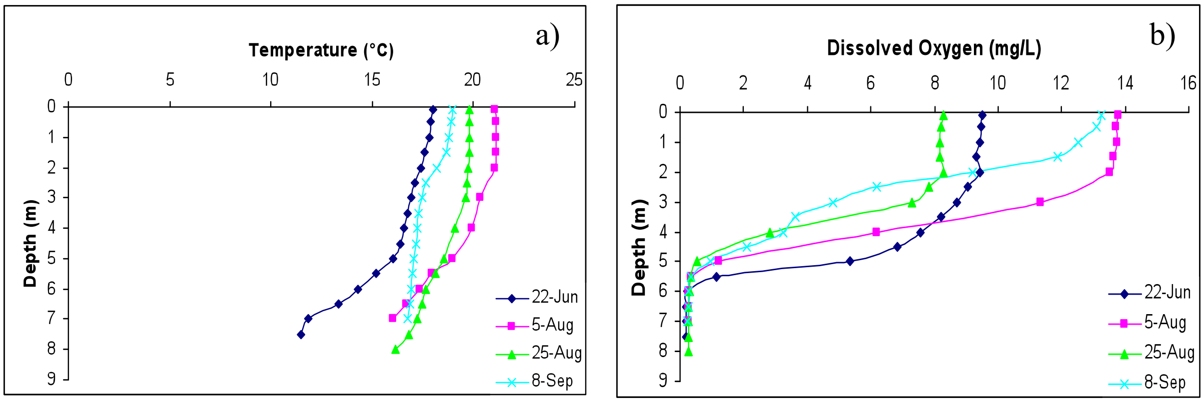

Figure 2 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles measured four times over the course of the summer at Half Moon Lake.

Despite the absence of stratification after August 5th, dissolved oxygen concentrations remained extremely low throughout the summer (Figure 2b). On each sampling trip, approximately half of the total water column fell below the Canadian Council for Ministers of the Environment guidelines for the Protection of Aquatic life of 6.5 mg/L. Low dissolved oxygen concentrations are likely a result of the decomposition of algae/cyanobacteria on the lakebed, which is an oxygen consuming process. These low oxygen levels at the lakebed may also contribute to the release of phosphorous from the sediments.

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.

Average Total Phosphorous (TP) measured at Half Moon Lake in 2011 was 111 µg/L, which falls into the hyper-eutrophic, or extremely productive, classification (Table 1). Due to persistent anoxia and a small drainage basin size, it is likely that internal loading of phosphorous from the lake sediments contributes greatly to the amount of phosphorous in the lake. Throughout the summer, TP concentration ranged from a minimum of 49 µg/L on June 22nd to a maximum of 176 µg/L on September 8th (Figure 3).

In 1989, 58 tonnes of calcium carbonate and 49 tonnes of calcium hydroxide were added to the lake in effort to reduce the amounts of available phosphorous and algae/cyanobacteria biomass[4]. In 1989, after positive results from the first additions, an extra 139 tonnes of calcium hydroxide was added to the lake. While immediate results were positive, additions of calcium hydroxide have not been maintained, and data collected in 2011 suggests TP and algae/cyanobacteria levels are no longer suppressed.

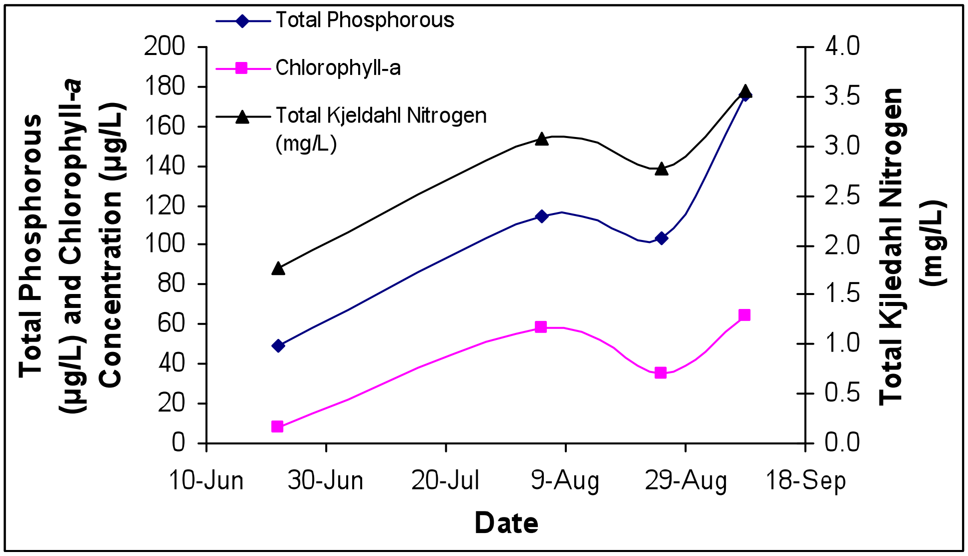

Figure 3 – Total phosphorous (µg/L), total Kjeldahl nitrogen (mg/L), and chlorophyll-*a* (µg/L) concentrations measured during the summer of 2011 at Half Moon Lake.

Similar to TP, average Total Kjeldahl Nitrogen (TKN) also fell into the hyper-eutrophic classification, measuring 2793 µg/L in 2011. TKN fluctuated throughout the summer, measuring a minimum of 1760 µg/L on June 22nd and a maximum of 3550 µg/L on September 8th.

Finally, average chlorophyll-*a* concentration in 2011 was 41.42 µg/L. As with TP and TKN, chlorophyll-*a* falls into the hyper-eutrophic classification. Chlorophyll-*a* concentration ranged from a minimum of 7.59 µg/L on June 22nd to a maximum of 64.6 µg/L on September 8th. This peak in chlorophyll-*a* concentration coincided with the highest measured TP and TKN values. In the past, algal community composition at Half Moon Lake has been dominated by cyanobacteria[3]. Microcystin levels, a cyanobacterial toxin, were high (Table 2), however not high enough to exceed the Guidelines for Canadian Recreational Water Quality of (20 ug/L).

Average pH measured at Half Moon Lake was 8.74, which is well above neutral. pH levels are typically high throughout Alberta, and Half Moon Lake is well buffered against

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4 Prepas, J. and Babin, J. 1990. Final Report on the 1989 Lime Treatment of Halfmoon Lake. Retrieved from: http://environment.gov.ab.ca/info/library/8316.pdf

pH changes due to its moderately-high alkalinity (175 mg/L $CaCO_3$) and bicarbonate concentration (195.75 mg/L HCO_3). Concentrations of other ions were low, with sodium (35 mg/L) and calcium (21.8 mg/L) representing the dominant ions. More data is required at Half Moon Lake to identify trends in its water quality.

Table 1 – Average Secchi disk depth and water chemistry values measured at Half Moon Lake. Data from previous years are shown for comparison.

Parameter	1982[a]	1987[a]	2011
TP (µg/L)	124	99	111
TDP (µg/L)	/	27	29.3
Chlorophyll-*a* (µg/L)	50.2	63.8	41.4
Secchi depth (m)	1.3	0.8	1.33
TKN (µg/L)	3111	2180	2793
NO_2 and NO_3 (µg/L)	44	9	4.13
NH_3 (µg/L)	/	/	40.5
DOC (mg/L)	/	/	21.8
Ca (mg/L)	/	19	21.8
Mg (mg/L)	/	10	17
Na (mg/L)	/	18	35
K (mg/L)	/	12	15.1
SO_4^{2-} (mg/L)	/	<5	2.67
Cl^- (mg/L)	/	8	19.87
CO_3 (mg/L)	/	18	8.75
HCO_3 (mg/L)	/	133	195.75
pH	/	8.8-9.4	8.74
Conductivity (µS/cm)	/	287	697
Hardness (mg/L)	/	90	124
TDS (mg/L)	/	156	224
Microcystin (µg/L)	/	/	2.07
Total Alkalinity (mg/L $CaCO_3$)	/	139	175

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. 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. / = absence of data.
[a]Prepas and Babin 1990.

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:

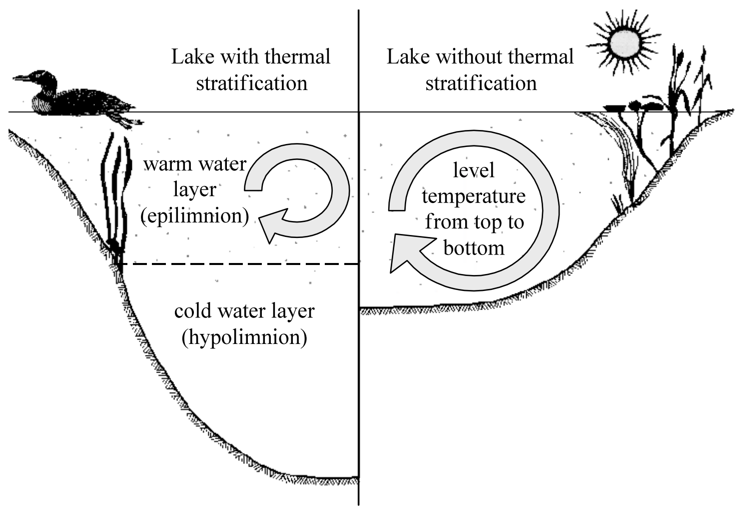

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

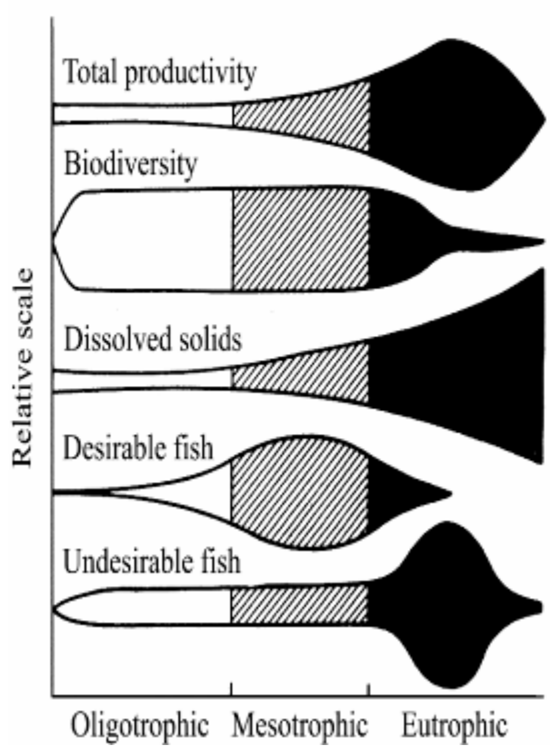

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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

Trophic state	Total Phosphorus (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