Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2014 Upper Therien Lake Report

LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:

Beaver River Watershed Alliance

Alberta Government

LICA
Lakeland Industry & Community Association

Ce projet a été réalisé avec l'appui financier de :
This project was undertaken with the financial support of:

Environnement Canada
Environment Canada

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 the town of St. Paul and Gary Ward for arranging sampling trips in 2014. We would also like to thank Jackson Woren, Brittany Kereliuk, and Kara MacAulay who were summer technicians with ALMS in 2014. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Mike Bilyk was involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Jackson Woren and Bradley Peter. Alberta Environment, the Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), and Environment Canada, were major sponsors of the program.

UPPER THERIEN:

Upper Therien is a small lake that borders the town of St. Paul which is located about 202 km northeast of Edmonton. Its sister lake, Lower Therien, is located 500 m southwest and separated by Range Road 95A. In 1895, Oblate Father Albert Lacombe created two reserves for Metis settlement, and, due to the fertile soils in the area, there was an increase in settlement from Quebec and Ukraine in the early 1900's[1]. The lake used to be called "Manawan Lake North" in 1898, which is Cree for 'eggs'. The lake name was changed in 1905 to Upper and Lower Therien[2]. Upper Therien Lake is located in the Boreal Transition ecoregion of Alberta which is characterized by a mix of forest and farmland. Forested vegetation is comprised of trembling aspen, balsam poplar, and mixed shrubs and herbs[3]. The last time water quality testing was done was in 1981, and in the last few years there has been growing concerns about the quality of the lake with regards to the smell and cyanobacteria blooms[4].

Figure 1 – Shoreline vegetation and cyanobacteria at Upper Therien Lake. Photo by Kara MacAulay.

The lake is small pothole lake that is 3.7 km long and 3.4 km wide at the widest spot. Upper Therien is known to be a shallow lake with a maximum depth of 2.4 m. The Town of St. Paul has a sewage plant that releases treated effluent into the north side of Upper Therien Lake. Two other inflow streams are located in the north east side of Upper Therien Lake.

The lake is primarily used for activities such as canoeing, kayaking, and bird watching. There are no official boat launches on the lake. There is a bird viewing stand on the north side of the lake which will give people the opportunity to view bird species such as the; ruddy turnstone, barrows goldeneye, hooded merganser, great blue heron, black-capped night-herons, American white pelicans, Canadian geese, and other waterfowl[5].

A macrophyte survey was completed by our Invasive Plant Technician at Upper Therien Lake; species collected and identified were hornwort, slender leaved pondweed, and sago pondweed.

---

[1] Carl Betke. 2009. Historic Canada: St. Paul. Available at: http://www.thecanadianencyclopedia.ca/en/article/st-paul/

[2] Merrily K. Aubrey. 2006. Concise Place Names of Alberta. University of Calgary Press Available at: http://www.albertasource.ca/placenames

[3] Ecoregions of Canada. 1995. Available at: http://ecozones.ca/English/region/156.html

[4] St. Paul Journal. News Article. Available at: http://www.spjournal.com/article/20140819/STP0801/308199968/-1/stp/residents-raise-stink-over-lake

[5] AESRD. 2010. Therien Lakes Wildlife. Available at: http://esrd.alberta.ca/recreation-public-use/wildlife-viewing/northeast-lakeland-boreal/therien-lakes.aspx

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. Requests for water quantity monitoring should go through Environment and Sustainable Resource Developments Monitoring and Science division.

In 1974, Upper Therien measured a maximum water quantity of 636.449 meters above sea level (m asl) and has declined steadily over the years to an observable minimum of 634.347 m asl in 2003 (Figure 2). Since 2003, water quality has increased approximately 0.60 m to approximately 635.3 m asl in 2013.

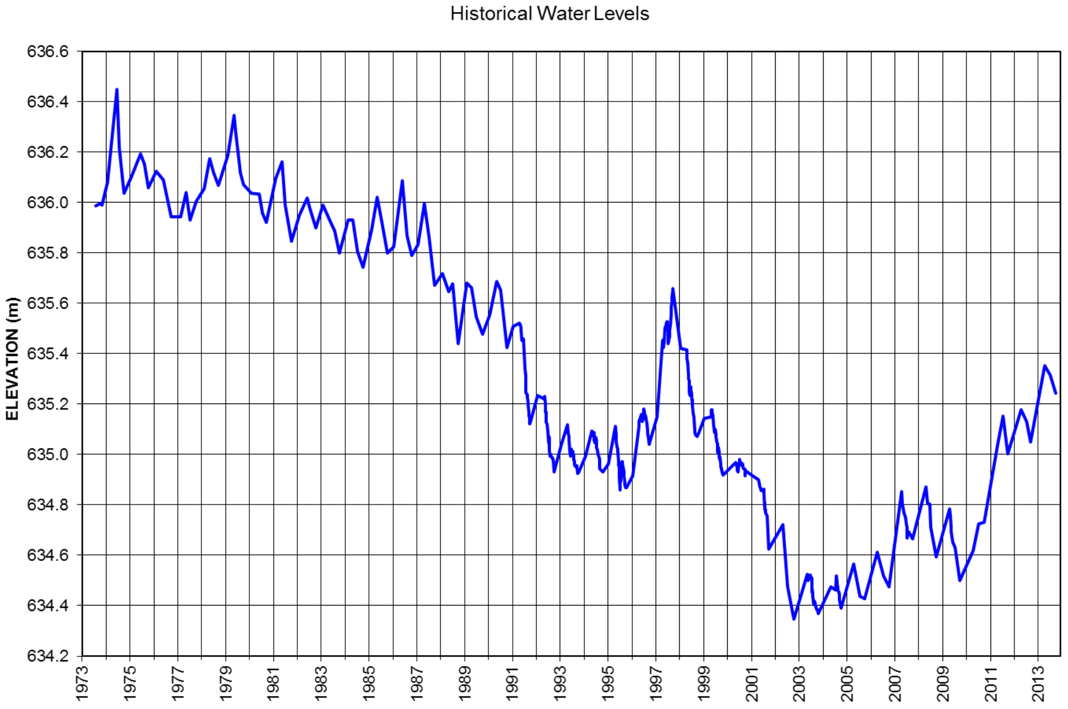


Figure 2 – Historical water levels at Upper Therien Lake measured in meters above sea level (m asl).

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. Two times the Secchi disk depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

Throughout the sampling season, Secchi disk depth did not change dramatically at Upper Therien Lake (Figure 3). On July 8th, Secchi disk depth measured a seasonal minimum of 0.60 m, while on August 27th, Secchi disk depth measured a seasonal maximum of 1.30 m. This decrease in water clarity correlated closely with increases in chlorophyll-*a* concentration, suggesting phytoplankton is the primary factor impeding water clarity at Upper Therien Lake. On average, Secchi disk depth measured 0.84 m in 2014.

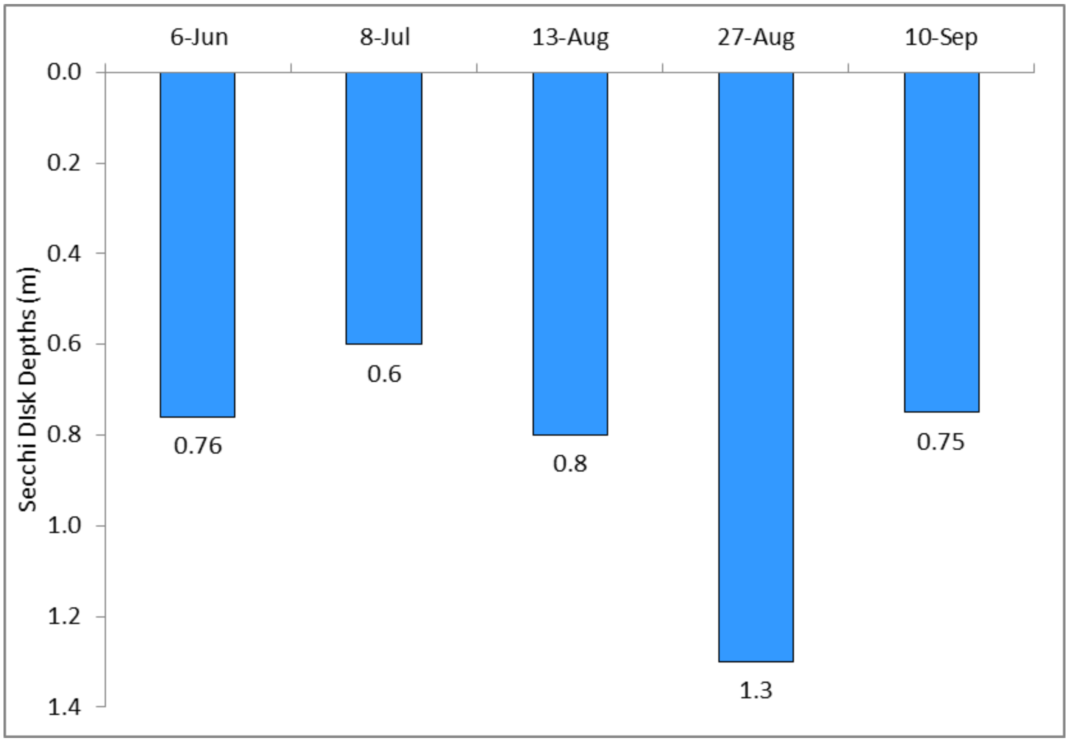


Figure 3 – Secchi disk depths obtained from the profile site on Upper Therien Lake in 2014.

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 temperatures ranged from a minimum of 10.36 °C on September 10th to a maximum of 21.97 °C on August 13th (Figure 4a). Upper Therien remained isothermal, measuring the same temperature throughout the water column, on every trip in 2014. As well, Upper Therien is a polymictic lake, mixing several times a year; however, on hot and calm days, the lake may thermally stratify. The presence/absence of thermal stratification has important implications for nutrient cycling and dissolved oxygen concentrations in Upper Therien Lake.

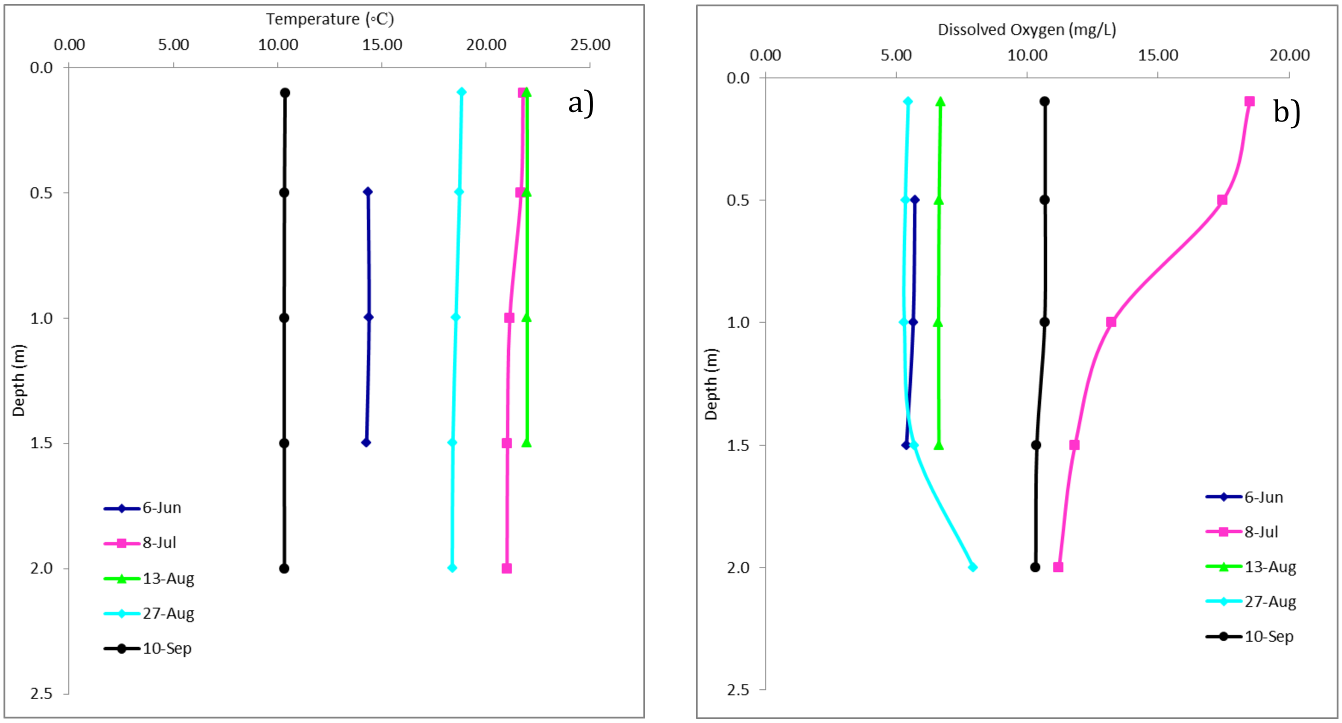


Figure 4 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles from Upper Therien Lake, 2014.

Surface dissolved oxygen concentrations varied greatly at Upper Therien Lake during 2014 (Figure 4b). On June 6th and August 27th, oxygen concentrations at the surface fell below the Canadian Council for Ministers of the Environments (CCME) Guidelines for the Protection of Aquatic Life (PAL) of 6.5 mg/L (measuring 5.71 mg/L and 5.46 mg/L, respectively). Low dissolved oxygen concentrations coupled with warm water temperatures can create a stressful environment for fish. On July 8th, however, dissolved oxygen concentrations were supersaturated at the surface (18.51 mg/L) due to a large phytoplankton bloom.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorus, 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 more complete list of parameters.

Average Total Phosphorus (TP) was extremely high in Upper Therien Lake measuring 1233.6 µg/L in 2014 (Table 1). This value falls well into the hypereutrophic, or extremely nutrient rich, classification. TP concentrations decreased throughout the summer, ranging from a seasonal maximum of 1710 µg/L on June 6th to a seasonal minimum of 838 µg/L on September 10th (Figure 5). High concentrations of phosphorus will promote cyanobacteria blooms which can result in unpleasant odors – lake management should aim to reduce inputs of phosphorus into Upper Therien Lake.

Chlorophyll-*a* concentration measured an average of 113.86 µg/L in 2014 (Table 1). This value falls well into the hypereutrophic, or extremely productive, classification. Throughout the summer, chlorophyll-*a* concentration ranged from a minimum of 5.3 µg/L on June 6th to a maximum of 200 µg/L on July 8th (Figure 5). More data is required to better understand the relationship between nutrients and chlorophyll-*a* concentration at Upper Therien Lake.

Finally, total Kjeldahl nitrogen (TKN) measured an average of 4582 µg/L in 2014 (Table 1). Similar to chlorophyll-*a,* average TKN falls into the hypereutrophic classification. Throughout the summer, TKN ranged from a minimum of 1950 µg/L on August 13th to a maximum of 5970 µg/L on July 8th.

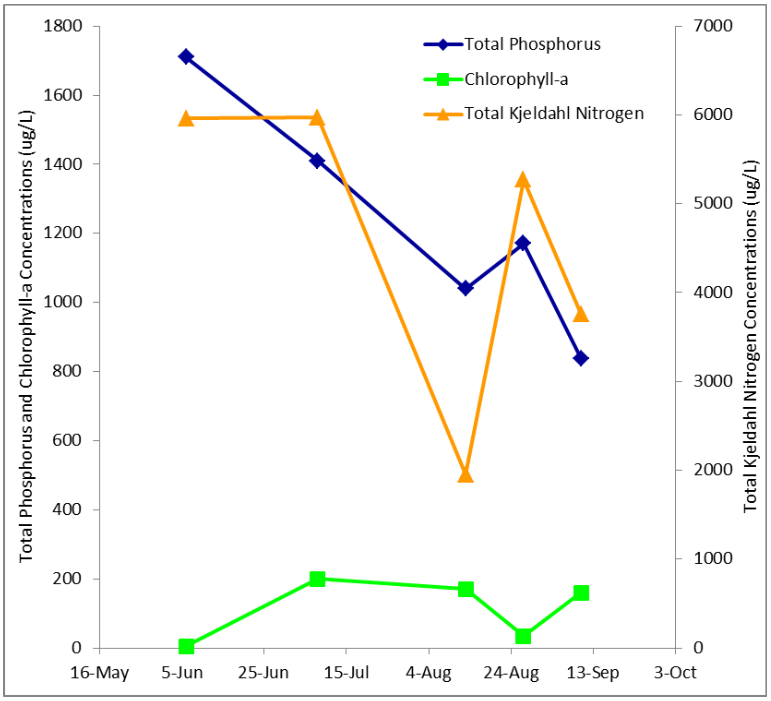


Figure 5 – Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (µg/L) concentrations measured five times over the course of the summer of 2014.

Average pH measured 8.858 in 2014 – this value is well above neutral. Upper Therien Lake has high alkalinity (506 mg/L CaCO3) and bicarbonate (319.2 mg/L HCO_3) concentration which will help to buffer the lake against changes to pH (Table 2). Sulphate (410 mg/L), sodium (286 mg/L), and magnesium (106.67 mg/L) are the dominant ions in Upper Therien, contributing to a high conductivity of 2180 µS/cm. Ion concentrations in Upper Therien Lake likely became more concentrated as water levels declined over the past 40 years (Table 1).

Metals were collected twice at Upper Therien Lake and all concentrations, except selenium and arsenic, fell within their respective guidelines (Table 2). Although the average was below the guideline, Arsenic concentrations exceeded CCME guidelines on August 13th. Further monitoring should seek to evaluate the speciation of the metals and assess lake organisms for bioaccumulation.

MICROCYSTIN:

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, when ingested, can cause severe liver damage. Microcystins are produced by many species of cyanobacteria which are common to Alberta's Lakes, and are thought to be the one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 20 µg/L.

In 2014, concentrations of microcystin reached an observed maximum of 12.33 µg/L on July 8th (Table 1). The average concentration throughout the season was 3.422 µg/L. Field notes suggest that *Aphanizomenon spp.* was the dominant species throughout the open water season in 2014. These are high concentrations of microcystin toxin, and caution should always be taken when recreating in waters experiencing cyanobacteria blooms.

INVASIVE SPECIES:

Quagga and Zebra mussels are invasive species which, if introduced to our lakes, will have significant negative ecological, economical, and recreational impacts. ALMS collects water samples which are analyzed for mussel veligers (juveniles) and monitors substrates for adult mussels. In order to prevent the spread of invasive mussels, always clean, drain, and dry your boat between lakes. To report mussel sightings or mussel-fouled boats, call the confidential Alberta hotline at 1-855-336-BOAT.

In 2014, no zebra or quagga mussels were detected in Upper Therien Lake.

Table 1 – Average Secchi disk depth and water chemistry values for Upper Therien Lake.

Parameter	**2014**
TP (µg/L)	1233.6
TDP (µg/L)	1139.4
Chlorophyll-*a* (µg/L)	113.86
Secchi depth (m)	0.84
TKN (µg/L)	4582
NO_2 and NO_3 (µg/L)	86
NH_3 (µg/L)	729
DOC (mg/L)	58.3
Ca (mg/L)	64.77
Mg (mg/L)	106.67
Na (mg/L)	286
K (mg/L)	90.9
SO_4^{2-} (mg/L)	410
Cl^- (mg/L)	252.67
CO_3 (mg/L)	31.68
HCO_3 (mg/L)	319.2
pH	8.86
Conductivity (µS/cm)	2180
Hardness (mg/L)	235.67
TDS (mg/L)	423.67
Microcystin (µg/L)	3.42
Total Alkalinity (mg/L $CaCO_3$)	506

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

Table 2 - Concentrations of metals measured in Upper Therien Lake on August 13th and September 10th, 2014. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2014**	**Guidelines**
Aluminum µg/L	65.2	100[a]
Antimony µg/L	0.33	6[e]
Arsenic µg/L	4.51	5
Barium µg/L	30.9	1000[e]
Beryllium µg/L	0.004	100[d,f]
Bismuth µg/L	0.0445	/
Boron µg/L	251.5	5000[ef]
Cadmium µg/L	0.0085	0.085[b]
Chromium µg/L	1.65	/
Cobalt µg/L	0.108	1000[f]
Copper µg/L	1.36	4[c]
Iron µg/L	40.925	300
Lead µg/L	0.134	7[c]
Lithium µg/L	105	2500[g]
Manganese µg/L	19.165	200[g]
Molybdenum µg/L	1.84	73[d]
Nickel µg/L	0.699	150[c]
Selenium µg/L	1.72	1
Silver µg/L	0.0055	0.1
Strontium µg/L	415	/
Thallium µg/L	0.0068	0.8
Thorium µg/L	0.5345	/
Tin µg/L	0.2395	/
Titanium µg/L	5.145	/
Uranium µg/L	2.475	100[e]
Vanadium µg/L	1.785	100[f,g]
Zinc µg/L	2.1	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] ≥ 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.

Red text indicates value exceeding guideline.

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:

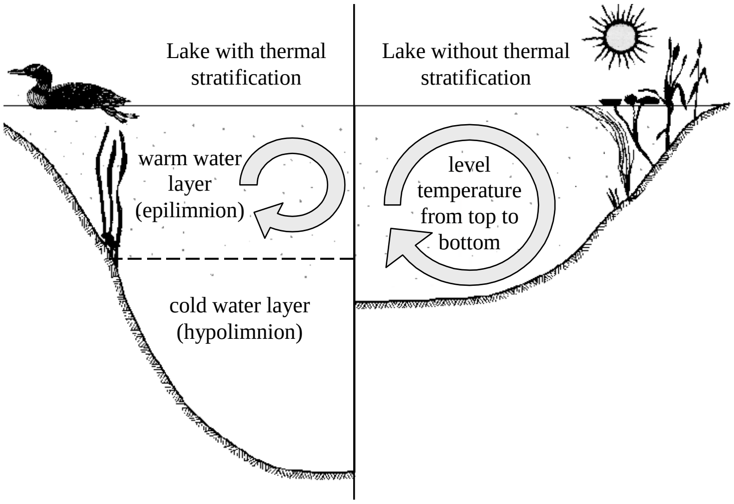


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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:

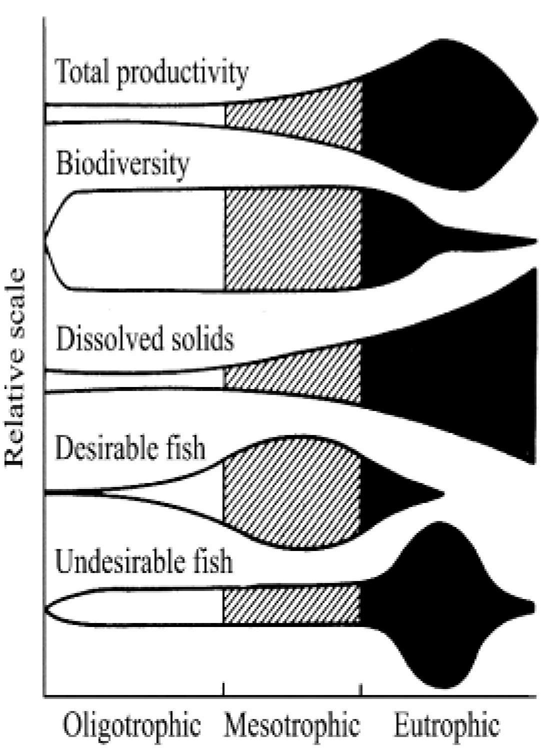
Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity 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.



i

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