Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2015 Pinehurst Lake Report

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Beaver River Watershed Alliance

aemera.org

LICA Lakeland Industry & Community Association

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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.

Data in this report is still in the validation process.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Lac la Biche County – specifically Megan Franchuk and summer staff Brayden and Jordan - as well as Tom Hannan, for their assistance with collecting water quality data in 2015 We would also like to thank Laticia McDonald, Ageleky Bouzetos, and Mohamad Youssef who were summer technicians with ALMS in 2015. Executive Director 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 Bradley Peter and Alicia Kennedy. The Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), the Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA), and Environment Canada, were major sponsors of the program.

PINEHURST LAKE:

Figure 1 - Pinehurst Lake. Photo by Nicole Meyers.

Pinehurst Lake is located 20 km south of Lac La Biche and 245 km northeast of Edmonton, in the Lakeland Provincial Recreation Area just east of the Lakeland Provincial Park. The name Pinehurst is derived from the jack pine tree and from the English word "hurst", which means "a wooded hillock". This term refers to the long ridge that runs along the northwest shore of the lake. At one time, jack pine may have grown along the ridge, but forest fires have removed most of this species[1].

Pinehurst Lake has a water surface area of 40.7 km^2, a mean depth of 12 m and a maximum depth of 21.3 m. It has a relatively complex shoreline with several bays and two islands just offshore. The bays at the east end of the lake are very shallow (less than 6-m deep) and the bottom of the basin slopes gently. The bay at the north end is somewhat deeper (less than 12-m deep) and its sides slope more steeply. A large area in the center of the basin is quite level, and ranges in depth from 18 m to 21.3 m.[2]

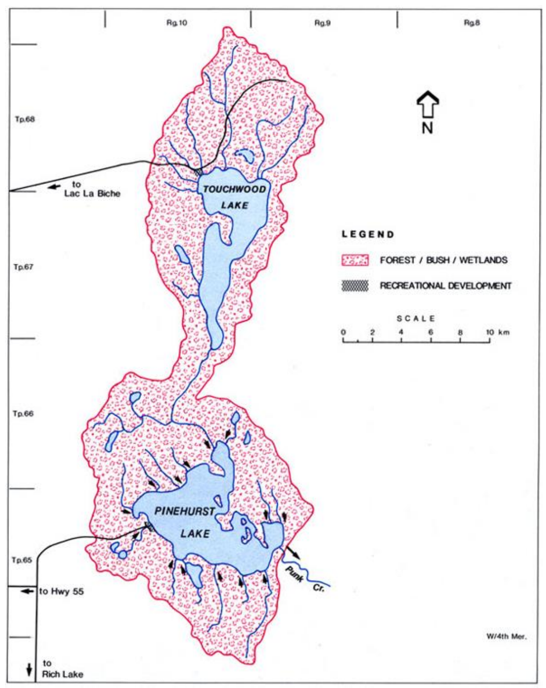

Figure 2 - Pinehurst Lake and its watershed.

The lake has a watershed that is approximately 7 times its size, 285 km^2, and includes Touchwood Lake and its watershed (Fig 1). A large permanent stream drains Touchwood into Pinehurst. Pinehurst drains by Punk Creek into the Sand River, a tributary in the Beaver River basin. The Watershed is almost completely forested and is representative of the central mixed natural subregion with aspen dominant in early seral stages and white spruce increasing with forest age. Black

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[1] Chipeniuk, R.C. 1975. Lakes of the Lac la Biche District. R.C. Chipeniuk, Lac La Biche.
[2] University of Alberta. 2005. Atlas of Alberta Lakes. University of Alberta Press. Available at: http://sunsite.ualberta.ca/Projects/Alberta-Lakes/

spruce and tamarack on extensive peatlands and sedge bogs are common in this watershed. Recreational development includes an Alberta Provincial Park campsite accessible by road on the western shore and boat-in only, privately owned cabin rentals on the eastern shore.

Pinehurst Lake is a favourite destination for local anglers but restrictive sport fishing regulations have been implemented at the lake to improve the health of the fish populations. Snug Cove (Mud Bay) has been closed to fishing and the remainder of the lake walleye may only be fished with a Special Fish Harvest License. Pike and perch may be fished in limited numbers and sizes.[3] Commercial fishing has not occurred since the seventies.

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 Alberta Environment and Parks Environmental Monitoring and Science division..

Currently no long term water quantity data exists for Pinehurst Lake.

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 in Pinehurst Lake measured 2.45 m in 2015 (Table 1). This average is comparable to the average value of 2.68 m measured in 2013. Throughout the summer water clarity fluctuated between a maximum of 3.50 m on June 24th to a minimum of 1.75 m on both July 24th and August 7th. Secchi disk depth appeared unaffected by changes in chlorophyll-*a* concentration – suggesting phytoplankton blooms are not likely impacting water clarity.

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[3] Government of Alberta. 2013. Guide to Sportfishing Regulations. Available at: http://www.albertaregulations.ca/fishingregs/nb1.html.

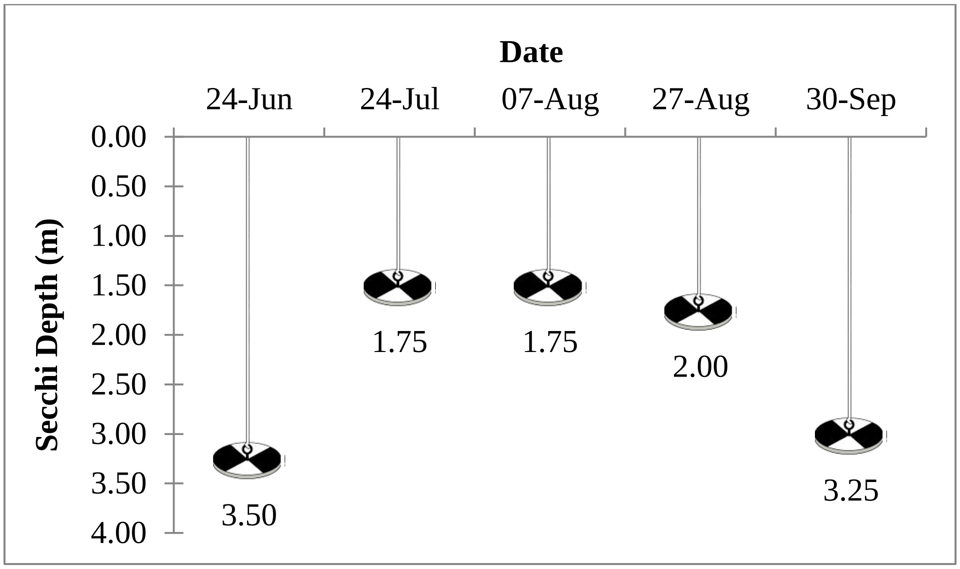

Figure 3 – Secchi disk depths measured five times over the course of the summer at Pinehurst Lake, 2015.

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 were cool in 2015 at Pinehurst Lake – a maximum surface water temperature of 19.64 °C was observed on July 21st and a minimum surface water temperature of 11.96 °C was observed on September 30th (Figure 4a). Thermal stratification was observed on each trip to Pinehurst Lake – however, by September 30th, there was evidence of a weakening of the thermocline which suggests Pinehurst Lake me be susceptible to mixing at least once throughout the year. Thermal stratification, which is not unusual in a lake as deep as Pinehurst, has important implications for the dissolved oxygen concentrations in the lake.

Dissolved oxygen concentrations were typical of a deep, stratified lake (Figure 4b). Pinehurst was well oxygenated at the surface, measuring over 9.00 mg/L on each sampling trip. On June 24th, the surface waters of Pinehurst Lake appeared super-satured, measuring 11.29 mg/L. This coincided with the season's peak chlorophyll-*a* concentration, suggesting photosynthetic activity was responsible for the elevated dissolved oxygen concentrations. Due to thermal stratification, oxygen concentrations regularly proceeded towards anoxia with the exception of June 24th. The presence of oxygen below the thermocline on June 24th suggests the lake may have been well mixed in the spring. In addition, on June 24th, a spike in oxygen concentration observed at 5.50 m is suggestive of a metalimnetic bloom – a dense population of phytoplankton which sits partway down the water column. The decomposition of cyanobacteria/algae on the lakebed, as well as separation by the thermocline from atmospheric oxygen, contribute to the decline in oxygen below the thermocline. A lack of oxygen near the lakebed likely promotes the release of phosphorus from the sediments which would be distributed throughout the water column when stratification breaks down.

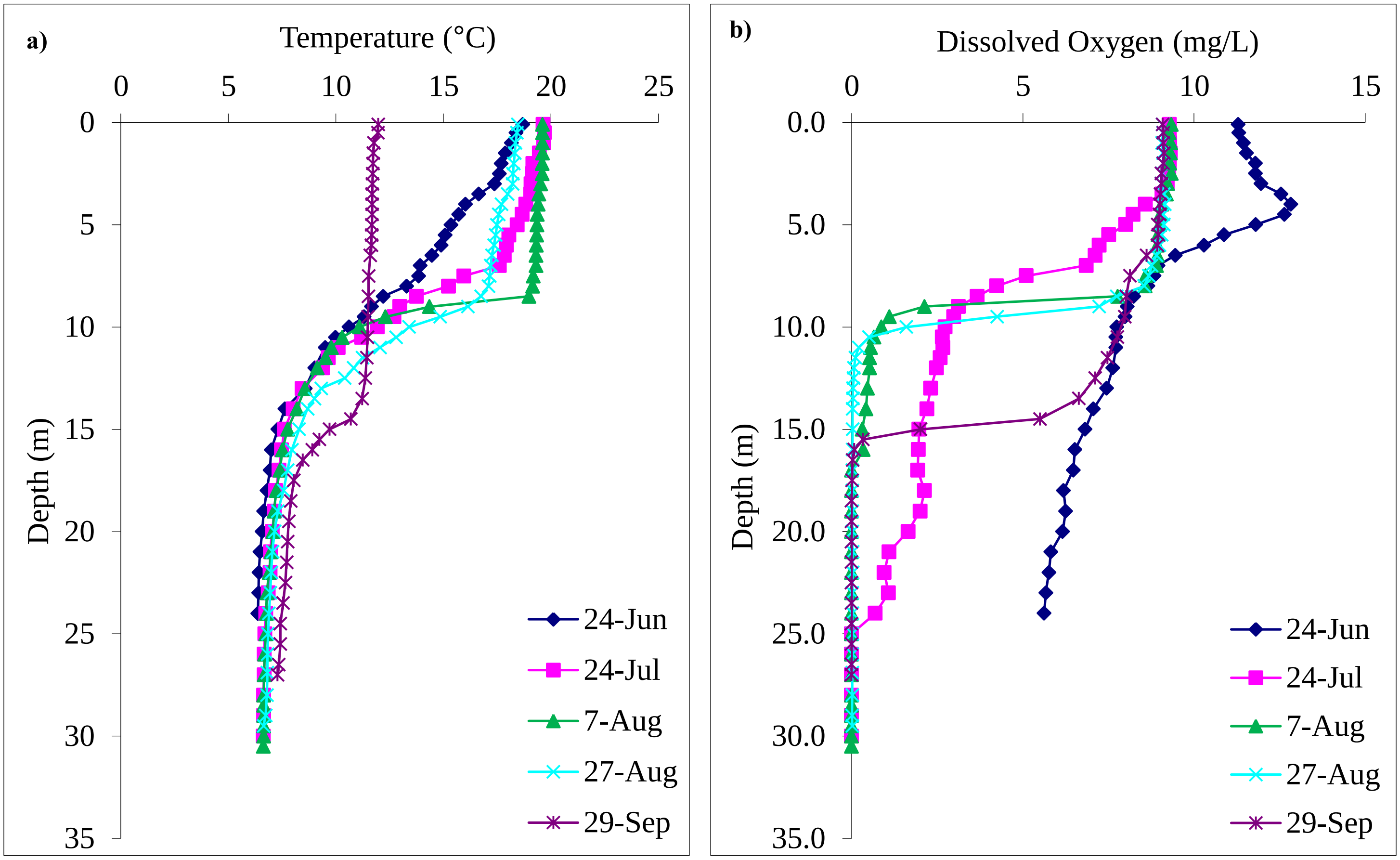

Figure 4 – Temperature (°C) and dissolved oxygen (mg/L) profiles for Pinehurst Lake measured five times throughout the course of the summer of 2015.

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 2 for a complete list of parameters.

Average total phosphorus measured 16 µg/L in 2015 – this value falls into the mesotrophic, or moderately productive, classification (Table 1). This is the lowest TP concentration observed historically at Pinehurst Lake (Table 1). A maximum TP concentration of 20 µg/L was observed on September 30th and a minimum concentration of 13 ug/L was observed on August 27th.

Similar to TP concentration, average total Kjeldahl nitrogen (TKN) concentration in 2015 (0.89 mg/L) was the lowest concentration observed historically. TKN fluctuated between a maximum of 1.10 mg/L on June 24th to a minimum of 0.82 mg/L on July 24th.

Finally, average chlorophyll-*a* concentration measured 7.2 µg/L in 2015. This average falls well within the historical variation observed at Pine Lake and lands in the mesotrophic, or moderately productive, classification. The average chlorophyll-*a* concentration was highly influenced by a seasonal maximum of 17.2 ug/L observed on June 24th. Field observations suggest the lake may have undergone a 'whiting' event, in which tiny phytoplankton bloom partway through the water column, causing the precipitation of calcium and a resulting glacial colour. This whiting event may explain the high concentration of chlorophyll-*a* in late June as well as the spike in dissolved oxygen concentration. A minimum concentration of chlorophyll-*a* was observed on August 27th, measuring only 3.2 ug/L.

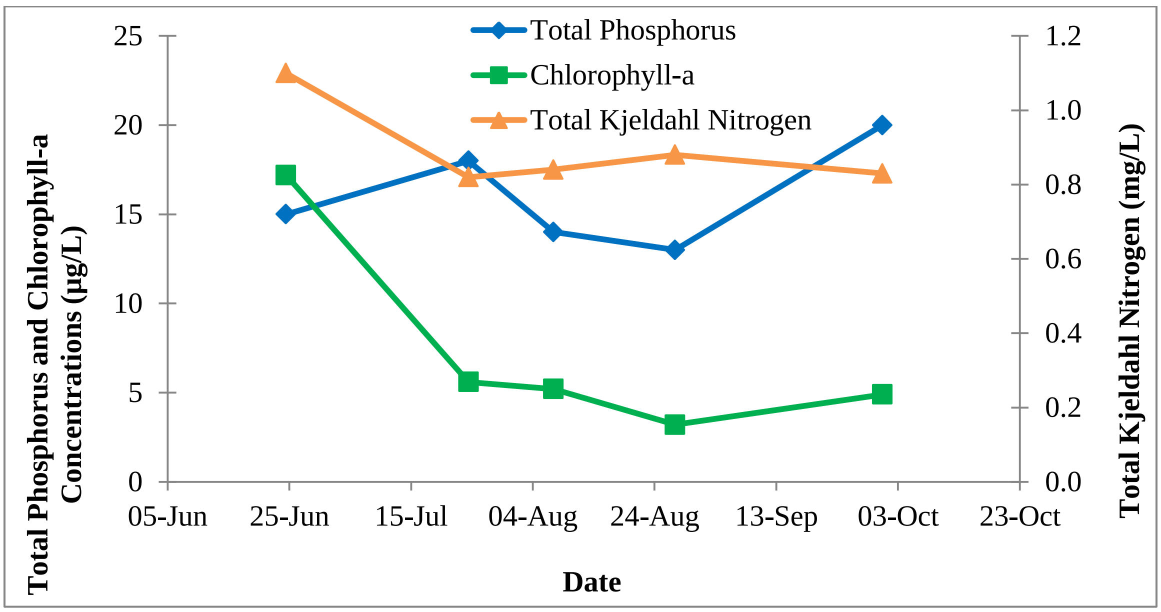

Figure 5 - Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (µg/L) concentrations measured three times over the course of the summer of 2013.

Average pH in Pinehurst Lake measured 8.59, well above neutral. Pinehurst Lake is well buffered against changes to pH due to its moderate alkalinity (154 mg/L $CaCO_3$) and bicarbonate concentration (176 HCO_3; Table 1). Conductivity in Pinehurst Lake is low (286 µS/cm) with dominant contributing ions as calcium (28 mg/L) and magnesium (16 mg/L). Compared to 1986, concentrations of ions and conductivity appear to have increased – this may reflect a reduction in water levels or a simple accumulation over time.

Metals were sampled for twice throughout the summer and all concentrations fell within their respective guidelines (Table 2).

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 2015, no zebra or quagga mussels were detected in Pinehurst Lake.

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.

All concentrations of microcystin fell below the minimum detection limit of 0.1 ug/L. While microcystins were not detected, caution should still be observed when recreating around cyanobacteria as skin irritation and exposure to additional toxins is still a risk.

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

Parameter	**1986**	**2013**	**2015**
TP (µg/L)	46	27	16
TDP (µg/L)	9.83	14.4	7.2
Chlorophyll-*a* (µg/L)	14.58	4.968	7.2
Secchi depth (m)	/	2.68	2.45
TKN (mg/L)	1.21	0.95	0.89
NO_2 and NO_3 (µg/L)	1.58	2.5	2.5
NH_3 (µg/L)	15.83	37.8	25
DOC (mg/L)	13	13	13
Ca (mg/L)	32	32	28
Mg (mg/L)	12.83	17.4333	16
Na (mg/L)	8.17	10.5	11
K (mg/L)	3.8	4.46667	4.7
SO_4^{2-} (mg/L)	2.5	4.5	2.4
Cl^- (mg/L)	0.5	1.33333	0.5
CO_3 (mg/L)	6.76	8.7	6.7
HCO_3 (mg/L)	169.638	178.8	176
pH	8.53333	8.394	8.59
Conductivity (µS/cm)	280	302.4	286
Hardness (mg/L)	132.5	150.667	136
TDS (mg/L)	152.035	166	154
Microcystin (µg/L)	/	/	<0.1
Total Alkalinity (mg/L $CaCO_3$)	148.833	160.6	154

Note: TP = total phosphorus, TDP = total dissolved phosphorus, 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 Pinehurst Lake on August 7th and September 30th 2015. Values shown for 2015 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)	**2013**	**2015**	**Guidelines**
Aluminum µg/L	12.65	7.2	100[a]
Antimony µg/L	0.01345	0.02	6[e]
Arsenic µg/L	0.6475	0.606	5
Barium µg/L	39.25	38.5	1000[e]
Beryllium µg/L	0.0057	0.004	100[d,f]
Bismuth µg/L	0.0005	0.005	/
Boron µg/L	43.05	43.4	5000[ef]
Cadmium µg/L	0.001	0.001	0.085[b]
Chromium µg/L	0.293	0.07	/
Cobalt µg/L	0.00855	0.003	1000[f]
Copper µg/L	0.26825	0.23	4[c]
Iron µg/L	25.6	7.2	300
Lead µg/L	0.01735	0.035	7[c]
Lithium µg/L	15.05	13.6	2500[g]
Manganese µg/L	11.4	20.6	200[g]
Molybdenum µg/L	0.01685	0.024	73[d]
Nickel µg/L	0.0025	0.004	150[c]
Selenium µg/L	0.05	0.05	1
Silver µg/L	0.0166	0.001	0.1
Strontium µg/L	139	135	/
Thallium µg/L	0.00015	0.001	0.8
Thorium µg/L	0.00015	0.010025	/
Tin µg/L	0.05295	0.021	/
Titanium µg/L	0.3165	0.60	/
Uranium µg/L	0.0606	0.062	100[e]
Vanadium µg/L	0.117	0.10	100[f,g]
Zinc µg/L	0.4625	0.4	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:

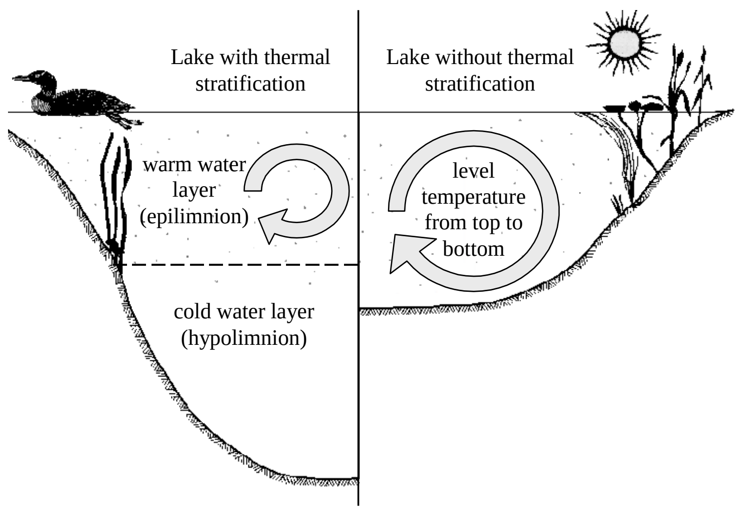

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

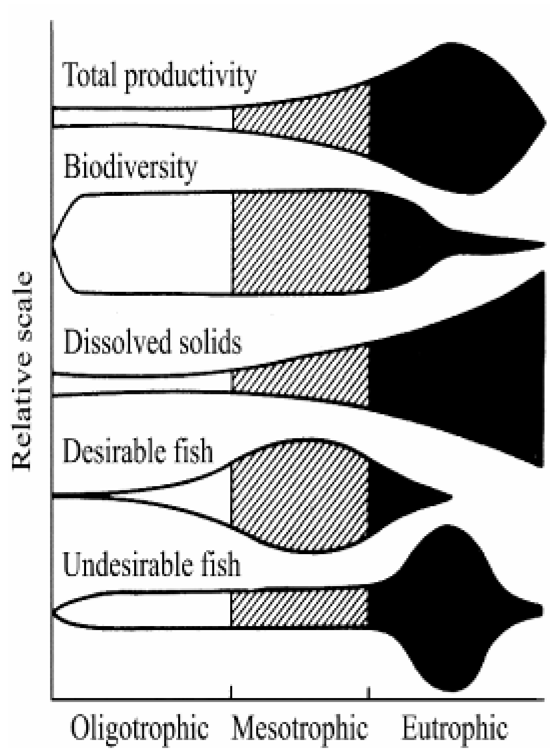

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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