Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2015 Minnie Lake Report

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Beaver River
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.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Gary & Nadine Kissel for their assistance with sampling Minnie Lake 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.

MINNIE LAKE:

Figure 1 – Minnie Lake, Alberta. Photo by Pauline Pozsonyi, 2011.

Minnie Lake (Figure 1) is a small lake located west of Bonnyville and north-east of Glendon within the Beaver River Watershed. The lake is 2 km long and 0.6 km wide, with a surface area of 0.84 km^2. Mean depth is 8.3 m and maximum depth is 21.45 m, though water levels have decreased since these values were calculated.

The shoreline of the lake hosts two municipal campsites, private cabins and recreational properties, agricultural land, and boreal forest.

Minnie Lake is spring-fed by the Beverly channel aquifer and surface runoff from precipitation. In 2006-2007 the lake experienced a winterkill, which decimated stocks of northern pike and yellow perch that previously supported a recreational fishery. Fish populations have not recovered to date.

Figure 2 – Bathymetric map of Minnie Lake, Alberta (Trew 1986). Each contour represents 1 m elevation.

In 2008, Canadian Natural Resources Ltd. had planned to drill 15 wells on 8 well pads less than 1.5 km from the lake, in addition to one well pad already present. Local residents expressed concern about the effects of drilling and other oil extraction activities on water quality in the lake and its aquifer, especially as one of the proposed wells would be directionally drilled to pump oil from directly underneath the lake. The Save Minnie Lake Committee was formed in 2008 after discussions with CNR representatives provided insufficient answers for community members. The Municipal District of Bonnyville has since rescinded the development approval permit for the well pad that would have allowed directional drilling.

Minnie Lake is known to have a very unique change in water colour during the course of the open water season (Figure 3). This is known as 'whiting events' and occurs when tiny organisms called picoplankton photosynthesize and increase the pH around their body, causing calcium carbonate to precipitate and create a bright blue/green colour[1]. This event is benign and typically occurs at the height of picoplankton biomass, but may or may not occur every year. Similar events have been observed at Crane Lake, Hanmore Lake, and Marie Lake.

Figure 3 - Lake whitening event at Minnie Lake on July 14th. Photo taken by Kara MacAulay

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.

Water levels at Minnie Lake have continued to decline since measurements began in 1981 (Figure 4). In 1981, water levels were at a historical maximum of 554.5 meters above sea level (m asl). In 1986, the Minnie Lake Stabilization Plan was drawn up in response to water level declines observed in the early 1980's. The decline was attributed to a combination of drought (which reduced aquifer replenishment by surface runoff) and municipal withdrawals by the village of Glendon, which had been withdrawing water directly from Minnie Lake since 1964. The plan suggested that a halt in municipal withdrawals be combined with a one-time addition of water (of approximately 10% of total water volume in Minnie Lake) from other sources to raise water level back to the desired level of 554.5 m asl. In 2013, however, water levels reached a new historical minimum of 551.174 m asl, three meters lower than in 1981.

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[1] Dittrich, M., Obst, M. 2004. Are picoplankton responsible for calcite precipitation in lakes? *Ambio.* Dec; 33(8): 559-564.

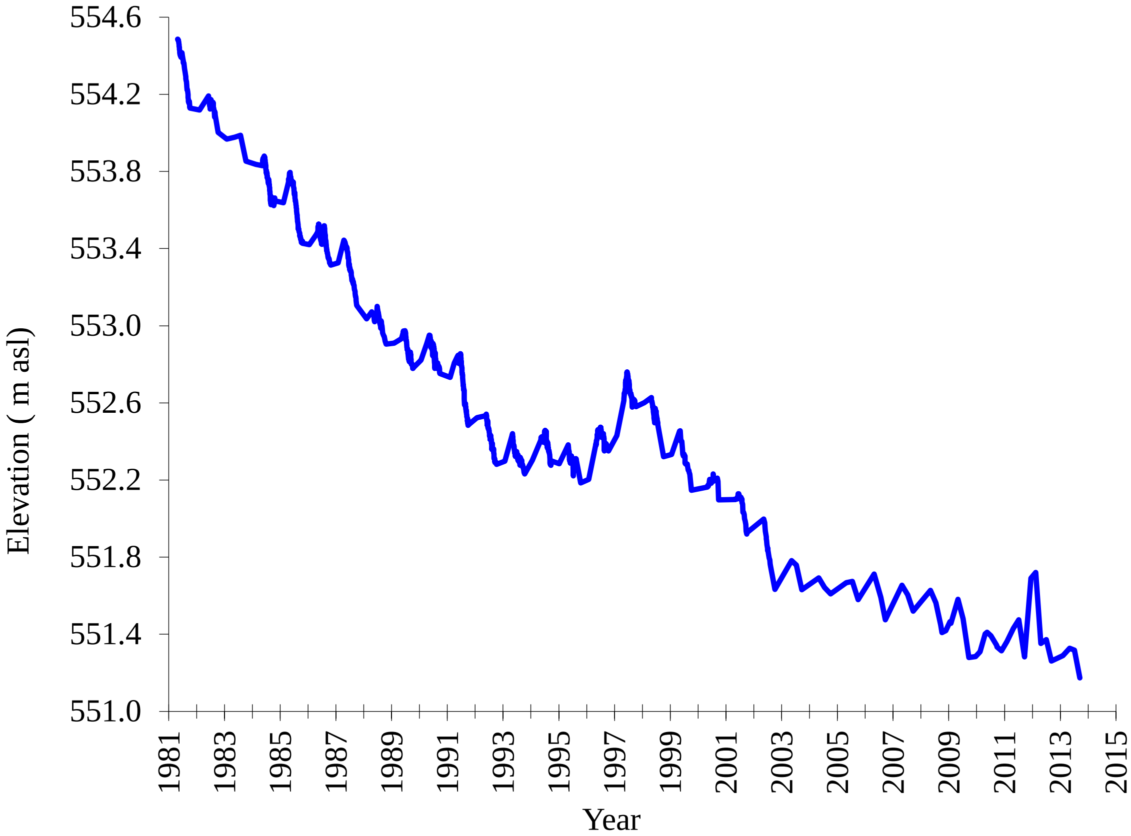

Figure 4 – Average monthly water levels measured in meters above sea level (m asl) retrieved from Alberta Environment and Parks.

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.

In 2015, Secchi disk depth measured an average of 2.55 m (Table 2). This value falls well within the historical variation observed at Minnie Lake. Throughout the summer, Secchi disk depth ranged from a minimum of 1.75 m on September 8th and a maximum of 3.75 m observed on August 4th (Figure 3). Secchi disk depth was also high in August of 2014 – water clarity at Minnie Lake is likely a combination of factors including ambient environmental conditions and the lake whiting phenomemon.

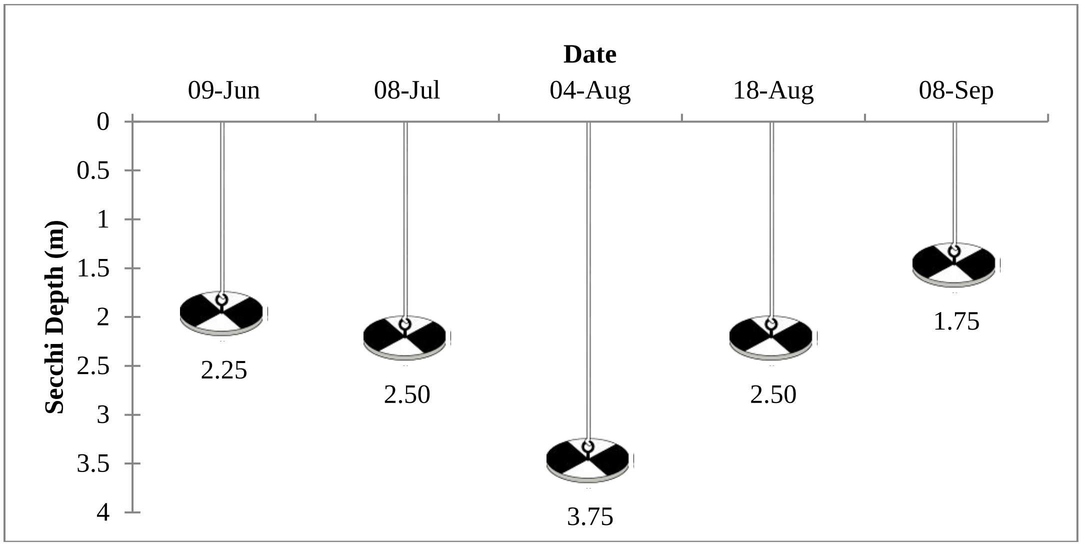

Figure 3 – Secchi depth values measured five times over the course of the summer at Minnie Lake in 2015.

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.

In 2015, Minnie Lake experienced strong thermal stratification which separates surface waters from bottom waters. This stratification was present as early as 3.5 m on June 9th and remained strong on September 9th (Figure 4). Throughout the summer surface temperatures ranged from a minimum of 18.37 °C on June 9th and a maximum of 21.15 °C on July 8th. Below the thermocline, temperatures regularly proceeded towards approximately 4 °C.

In 2015, dissolved oxygen concentrations were high above the thermocline, regularly measuring above the Canadian Council for Ministers of the Environment guidelines for the Protection of Aquatic Life of 6.5 mg/L (Figure 4). Below the thermocline, dissolved oxygen concentrations dropped dramatically, consistently proceeding towards anoxia on each sampling trip. This is expected of a lake stratified as strongly as Minnie Lake. Unlike in 2014, no spikes in dissolved oxygen were detected above the thermocline which is indicative of the lake whiting events often observed at Minnie Lake. Decreased oxygen levels in the hypolimnion are due to a combination of factors including the decomposition of organic matter on the lakebed, which is an oxygen consuming process, and the separation from surface waters by the thermocline.

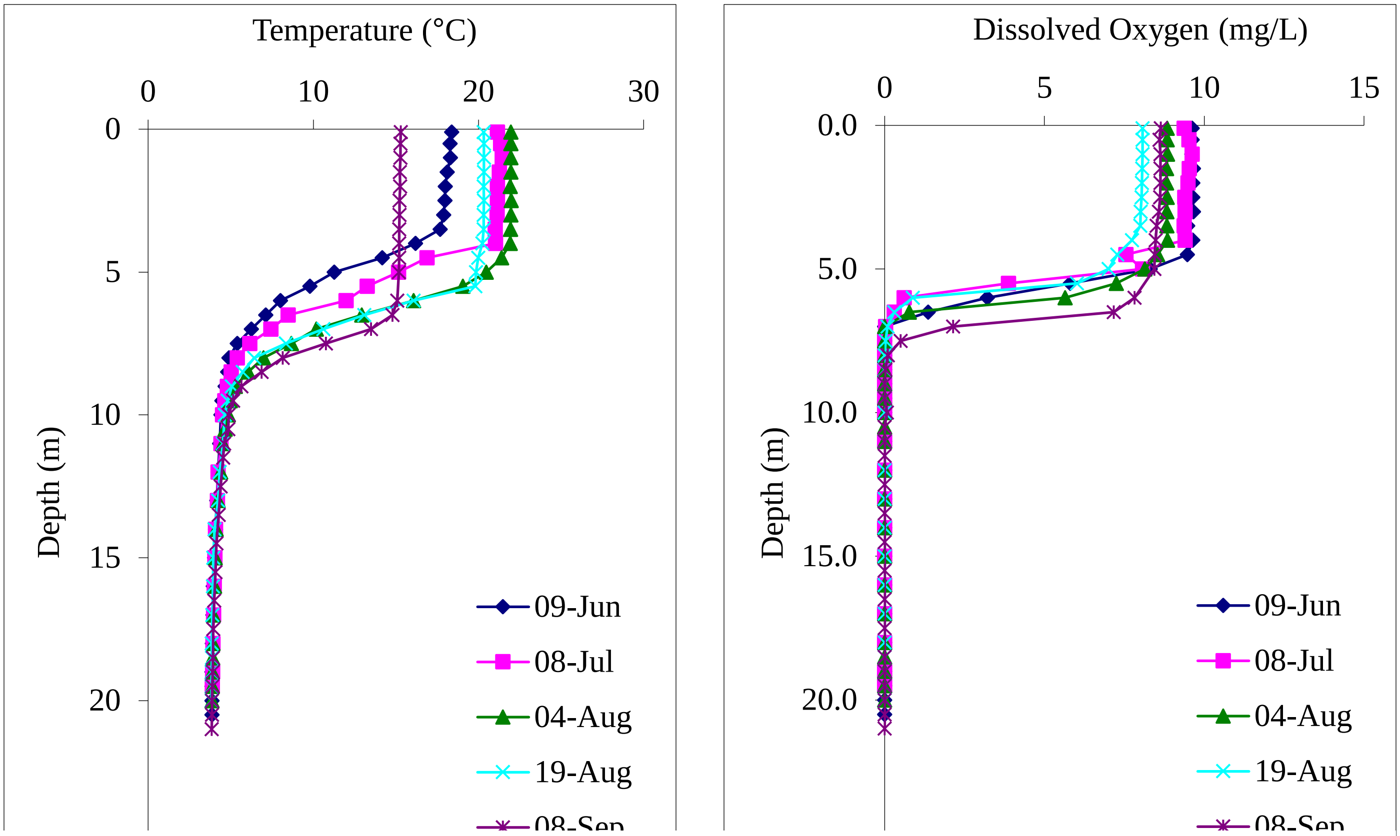

Figure 4 – a) temperature (°C) and b) dissolved oxygen (mg/L) profiles for Minnie Lake measured five times over the course of the summer of 2015.

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 1 for a complete list of parameters.

Average total phosphorus (TP) measured 24 µg/L in 2015 (Table 2). This value falls into the mesotrophic, or moderately productive, trophic classification. An average of 24 µg/L falls on the low end of the historical variation observed at Minnie Lake (Table 2). Throughout the summer, TP changed very little, measuring a maximum of 26 µg/L on August 4th and a minimum of 23 µg/L on September 8th.

Average chlorophyll-*a* concentration measured an average of 4.8 µg/L in 2015 (Table 2). This average falls into the mesotrophic, or moderately productive, classification. An average of 4.8 µg/L falls on the low end of the historical variation observed at Minnie Lake (Table 2).

Finally, total Kjeldahl nitrogen concentration measured an average of 1.5 mg/L in 2015 (Table 2). This value falls well within the historical variation previously observed at Minnie Lake.

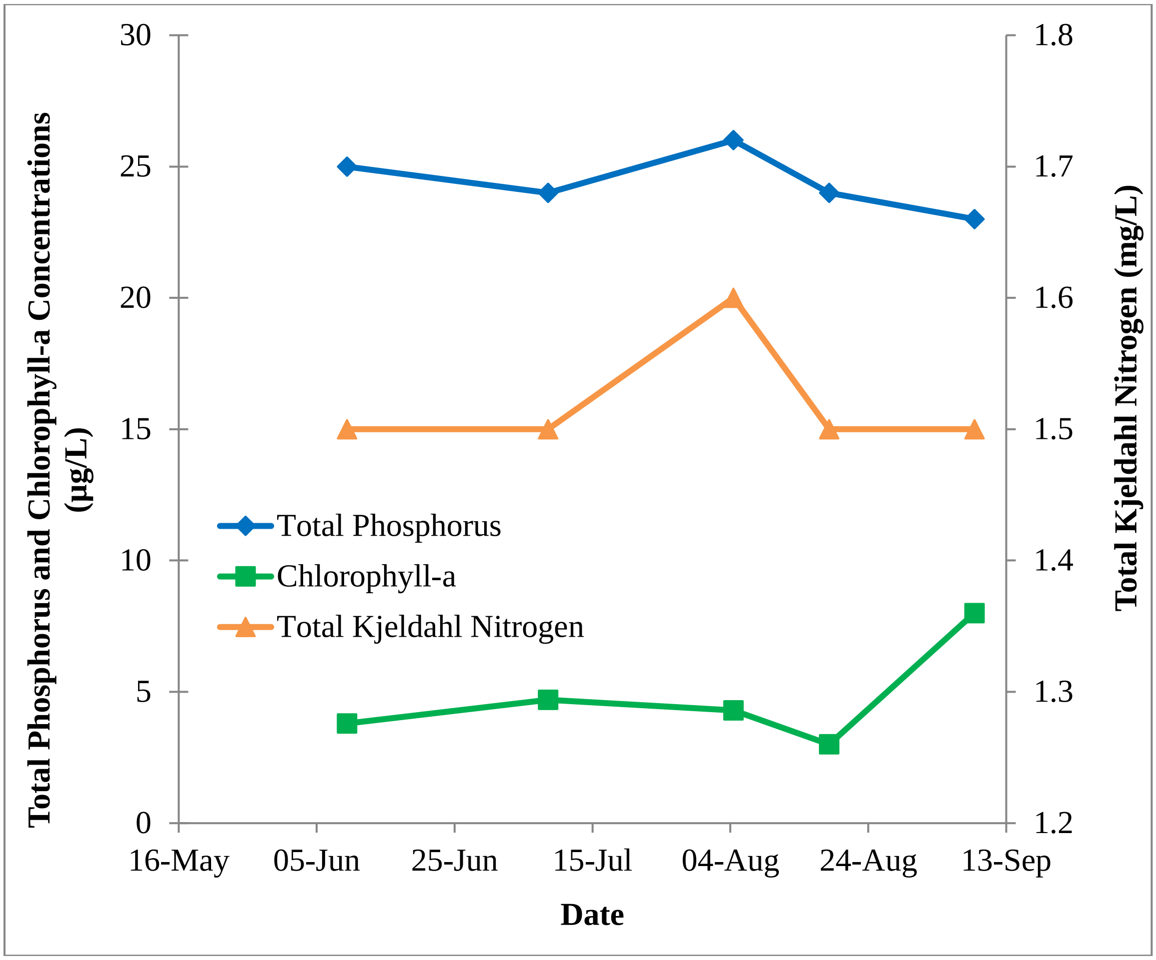

Figure 5 – Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and chlorophyll-*a* concentration measured five times over the course of the summer at Minnie Lake.

Average pH measured 8.82 in 2015 – this value is well above neutral and Minnie Lake is well buffered against changes to pH due to its high alkalinity (370 mg/L $CaCO_3$) and bicarbonate (376 mg/L HCO_3) concentration (Table 2). Minnie Lake has high conductivity (1400 uS/cm) and water hardness (660 $CaCO_3$) - dominant contributing ions include sulphate (440 mg/L), magnesium (144 mg/L), and sodium (96 mg/L).

Metals were measured twice at Minnie Lake and all concentrations measured with the exception of arsenic (10.36 µg/L) fell within their respective guidelines (Table 3). High arsenic concentrations in surface waters in the Beaver River Watershed are not uncommon due to the region's geology, and Minnie Lake has consistently shown results which exceed the Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life. Quality control samples have been collected by ALMS to ensure the accuracy of the arsenic values.

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.

Microcystin concentrations in Minnie Lake fellow below the laboratory's detection limit (<0.1 µg/L) on each trip with the exception of July 8th when a concentration of 0.15 µg/L was detected. All cyanobacteria blooms should be treated with caution when recreating in Alberta's lakes.

Table 1 – Microcystin concentrations measured at Minnie Lake in 2015.

Date	Microcystin Concentration (µg/L)
09-Jun-15	>0.1
08-Jul-15	0.15
04-Aug-15	<0.1
18-Aug-15	<0.1
08-Sep-15	<0.1

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 invasive zebra or quagga mussels were detected in Minnie Lake.

Table 2 - Average Secchi disk depth and water chemistry values for Minnie Lake. Previous years averages are provided for comparison.

Parameter	**1978**	**1979**	**1985**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
TP (µg/L)	/	/	21	40	42.25	38.8	52.4	44.75	32.2	33.75	24
TDP (µg/L)	/	/	11	23.8	22.5	27	25.6	22	21.2	24.25	11
Chlorophyll-*a* (µg/L)	/	/	6	5.26	4.03	3.44	5.16	6.42	3.02	4.1*	4.8
Secchi depth (m)	/	/	/	4.5	2.19	4.7	3.85	3.81	3.32	3.67	2.55
TKN (mg/L)	/	/	1.2	1.5	1.5	1.6	1.8	1.7	1.6	1.5	1.5
NO_2 and NO_3 (µg/L)	/	/	6	21	7.625	12.1	13.9	11.38	2.5	38	2.5
NH_3 (µg/L)	/	/	50	6.2	35.75	99.2	35	42.25	23.6	50.2	31
DOC (mg/L)	/	/	13.2	18.27	19.5	19.6	19	19.4	22.03	17.7	18
Ca (mg/L)	29	30	19.4	26.6	25.73	21.8	25.6	24.2	22.93	22.67	26
Mg (mg/L)	90	87	91	120.3	121.3	123.3	131.3	121	143.67	124	144
Na (mg/L)	62	61	68	94.23	96.6	97.2	95.8	95.63	98.9	103.33	96
K (mg/L)	11.7	9.4	13.1	23.3	19.07	18.57	18.5	19.87	21.03	20.17	20
SO_4^{2-} (mg/L)	223	211	197	398.7	421	408.67	400	450.7	391	433.33	440
Cl^- (mg/L)	3	3	4.4	7.13	6.93	7.47	7.3	7.6	6.8	7.5	8.0
CO_3 (mg/L)	/	/	21	25.67	31.33	23	29	28	44.8	37.94	37
HCO_3 (mg/L)	340	398	368	408.3	389.67	412	393.4	398	358.6	424.6	376
pH	8.9	8.6	8.6-8.9	8.627	8.8	8.65	8.77	8.73	8.88	8.78	8.82
Conductivity (µS/cm)	922	981	992	1340	1323.3	1370	1350	1367.5	1418	1360	1400
Hardness (mg/L)	442	435	422	561.67	563.67	562.3	605	558.3	648.67	567	660
TDS (mg/L)	614	611	595	897.3	914	902.67	902	943.3	906	948.3333333	962
Microcystin (µg/L)	/	/	/	0.1275	0.1125	0.076	0.11	0.135	0.088	0.076	0.07
Total Alkalinity (mg/L $CaCO_3$)	324	316	338	378.3	371.67	376	371.2	373	369	352	370

Note: TP = total phosphorous, TDP = total dissolved phosphorous, 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, TSS = total suspended solids. A forward slash (/) indicates an absence of data.

*This value has been corrected to 4.1 ug/L as of April 11 2019

Table 3 - Average concentrations of metals measured in Minnie Lake on August 4th and September 8st 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)	**2008**	**2009**	**2010**	**2011**	**2013**	**2014**	**2015**	**Guidelines**
Aluminum µg/L	13.7	13	14.26	14.84	22.55	17.4	9.95	100[a]
Antimony µg/L	0.382	0.375	0.392	0.3725	0.3685	0.349	0.3985	6[e]
Arsenic µg/L	9.15	9.33	9.56	9.07	9.83	9.875	10.36	5
Barium µg/L	20.6	18.7	18.5	18.25	12.65	12.35	14.9	1000[e]
Beryllium µg/L	<0.003	<0.003	0.005	0.0015	0.0057	0.004	0.004	100[d,f]
Bismuth µg/L	0.0073	0.0057	0.00385	0.0005	0.00795	0.0005	0.0005	/
Boron µg/L	162	205.5	159.5	204.5	186.5	185	185	5000[ef]
Cadmium µg/L	0.0124	0.0187	0.01725	0.01385	0.0036	0.001865	0.002	0.085[b]
Chromium µg/L	0.494	0.394	0.169	0.2575	0.3065	0.292	0.125	/
Cobalt µg/L	0.111	0.092	0.0972	0.07485	0.09775	0.0687	0.0875	1000[f]
Copper µg/L	0.332	2.09	0.6815	1.0825	1.3	0.9025	1.665	4[c]
Iron µg/L	10.9	43.6	16.1	8.9	29.3	16.85	13.1	300
Lead µg/L	0.0274	0.0544	0.0851	0.03275	0.0617	0.01115	0.029	7[c]
Lithium µg/L	74.1	101.5	84.05	106.5	93.95	92.95	89.3	2500[g]
Manganese µg/L	8.61	6.36	5.905	15.75	4.515	6.78	7.38	200[g]
Molybdenum µg/L	0.799	0.727	0.746	0.735	0.6685	0.5695	0.6185	73[d]
Nickel µg/L	0.271	0.665	0.3805	0.15125	0.5225	0.3475	0.3825	150[c]
Selenium µg/L	0.2	0.292	0.232	0.228	0.089	0.123	0.085	1
Silver µg/L	0.0022	0.0082	0.0029	0.00025	0.01125	0.001	0.001	0.1
Strontium µg/L	74	69.7	55	73.25	49.7	58.7	76	/
Thallium µg/L	0.0026	0.0029	0.00555	0.000275	0.0015	0.00085	0.00045	0.8
Thorium µg/L	0.0628	0.00215	0.01825	0.01015	0.0321	0.011375	0.002225	/
Tin µg/L	0.0308	<0.03	0.015	0.015	0.015	0.00825	0.0135	/
Titanium µg/L	0.667	0.691	1.0995	0.686	1.1145	0.685	0.875	/
Uranium µg/L	2.3	2.08	2.16	2.14	2.1	2.165	2.26	100[e]
Vanadium µg/L	1.31	1.22	1.165	1.06	1.035	1.04	1.265	100[f,g]
Zinc µg/L	1.58	1.34	1.165	1.48	1.465	1.58	1.55	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:

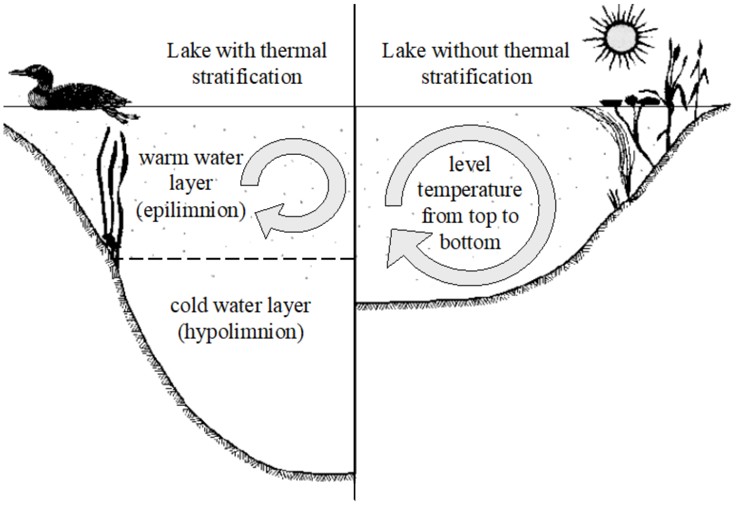

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

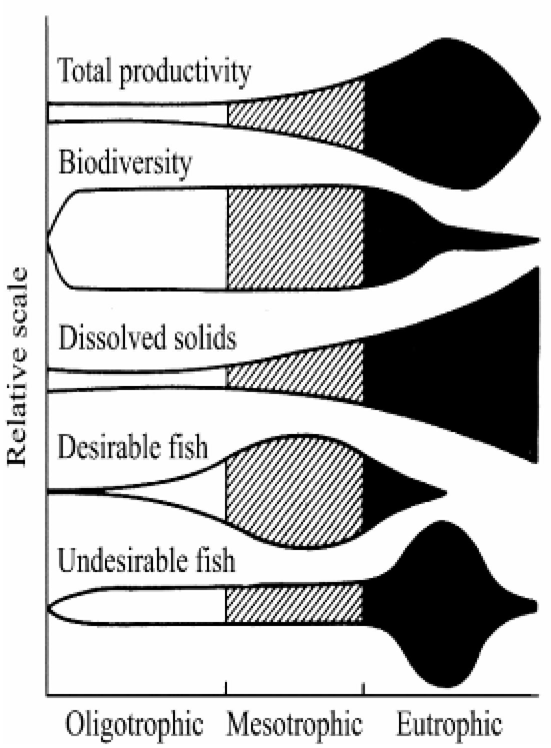

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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

Trophic state	Total Phosphorus (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