Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2015 Muriel Lake Report

LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:

Beaver River Watershed Alliance

aemera.org

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 Lyle Kortzman, Jeff Hlewka, and Richard Bourgeois for their assistance with sampling Muriel 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.

MURIEL LAKE:

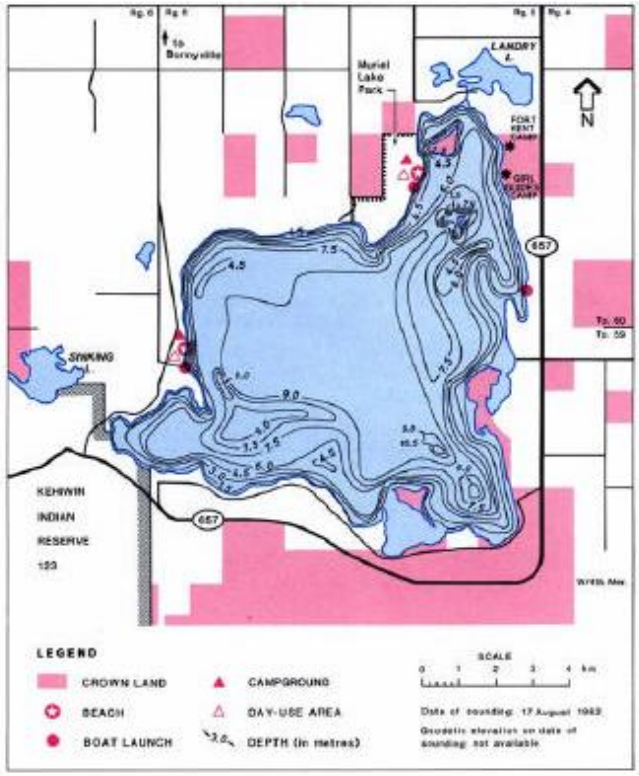

Figure 1 – Bathymetry of Muriel Lake from Mitchell and Prepas 1990.

Muriel Lake is located 13 km south of the town of Bonnyville and 250 km northeast of Edmonton. The first establishment in the area by non-aboriginal peoples was a fur-trading post in 1781 by the North West Company near the present-day hamlet of Beaver Crossing, about 35 km northeast of Muriel Lake. The first settlers came to the Bonnyville area in 1907 and established an economy based on the timber industry. Two sawmills were located at Muriel Lake, one at the northeastern tip and the other on the large island/peninsula on the eastern shore. In the 1920's, a large fire forced the economic base to switch to agriculture.

There are several subdivisions (391 lots) around the lakeshore, mostly on the south and east sides of the lake. Much of the watershed is occupied by the Kehewin Cree Nation Reserve 123, located on 8200 ha of land southwest of the lake. The largest recreational facility on Muriel Lake is Muriel Lake Park, which is operated by the Municipal District of Bonnyville. Northern pike, yellow perch, lake whitefish, and walleye were once prevalent in the lake, however these fish are no longer stocked, and a 2012 netting of the lake performed by Environment and Sustainable Resource Development revealed no sport fishes are present in Muriel Lake; only brook stickleback and longnose suckers were captured in 2012 netting.[1] Low winter dissolved oxygen levels (3.0 mg/L) leaves Muriel Lake at a high risk for fish kills.[1]

Muriel Lake is a large (64.1 km^2) but shallow water body with a relatively small drainage basin, measuring only 4.8 times the size of the lake area. The shorelines consist primarily of steep rocky slopes, but there are also several attractive sandy beaches. Water levels have been monitored since the late 1960's and since then have dropped by as much as 4.5 m.

[1] Latty, D. 2012. Muriel Lake Fall Walleye Index Netting, 2012. Alberta Environment and Sustainable Resource Development. Retrieved on February 21st, 2012 from: http://srd.alberta.ca/FishWildlife/FisheriesManagement/FallWalleyeIndexNetting/Default.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.

Water levels at Muriel Lake have declined steadily over the past 30 years (Figure 2). Since 1980, water levels have dropped from 559.744 m asl to 555.861 m asl, or approximately four meters. Such a decline is thought to be unprecedented at Muriel Lake[2] and has been the topic of recent Alberta Environment studies. Conclusions from these studies, the results of which were presented at a Muriel Lake Basin Management Society annual general meeting, have suggested that Muriel Lake is a net groundwater gaining lake and that declines in water levels are due primarily to changes in climate, including both reduced precipitation and increased temperatures[3,4]. Members of the Muriel Lake Basin Management Society are interested in completing further studies to determine if development activities in the drainage basin have had any effect on lake levels – including altered drainage patterns and water withdrawals.

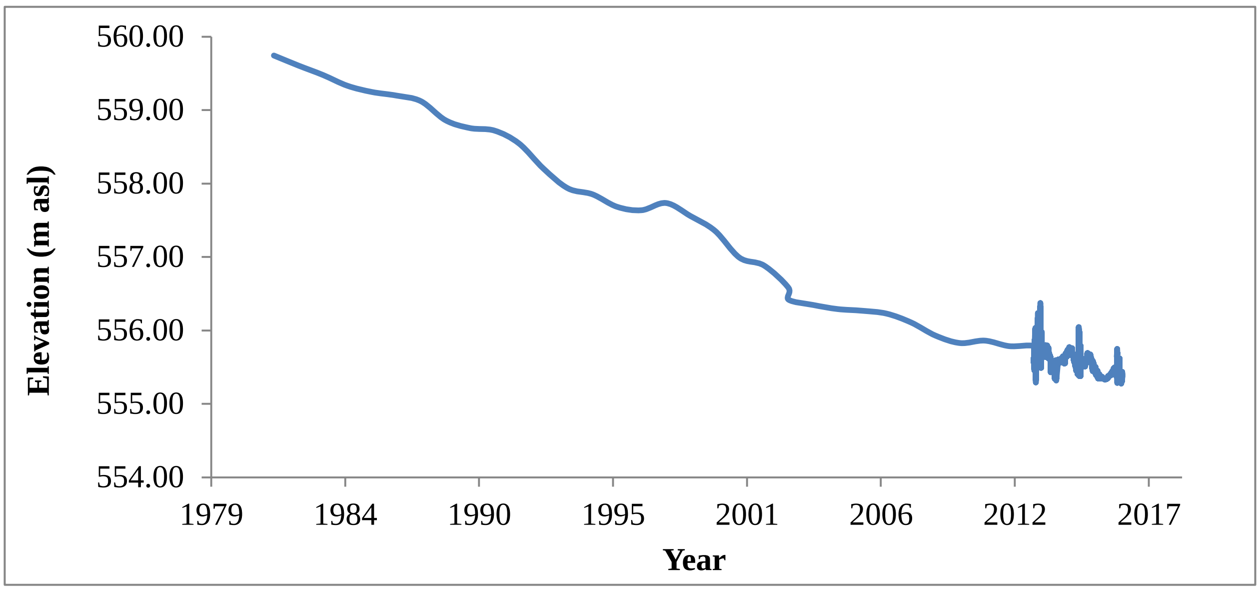

Figure 2 – Historical water levels for Muriel Lake in meters above sea level (m asl) retrieved from Environment Canada (1981-2012 yearly averages; 2012-2016 daily real-time).

[2] Donohue, W. F., 2006. Historical Interpretation of Water Supply to Muriel Lake in the 20th Century. Freshwater Research Ltd.

[3] Welsh, B. July 8th, 2012. Groundwater in the Muriel Lake Watershed. Muriel Lake Basin Management Society Annual General Meeting. Presentation conducted from Bonnyville and District Centennial Centre, Bonnyville, Alberta.

[4] Kerkhoven, E. July 8th, 2012. Muriel Lake Hydrology. Muriel Lake Basin Management Society Annual General Meeting. Presentation conducted from Bonnyville and District Centennial Centre, Bonnyville, Alberta.

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 2015 measured 0.75 m. Maximum Secchi depth observed in 2015 was 1.00 m, while the minimum observed Secchi depth was 0.50 m. 2015's average Secchi depth falls at the low end of the historical variation observed at Muriel Lake (Table 1) – it is likely that the unusually high concentrations of chlorophyll-*a* observed in 2015 impeded water clarity. However, suspended sediments due to wind activity on shallow lakes can also negatively impact water clarity.

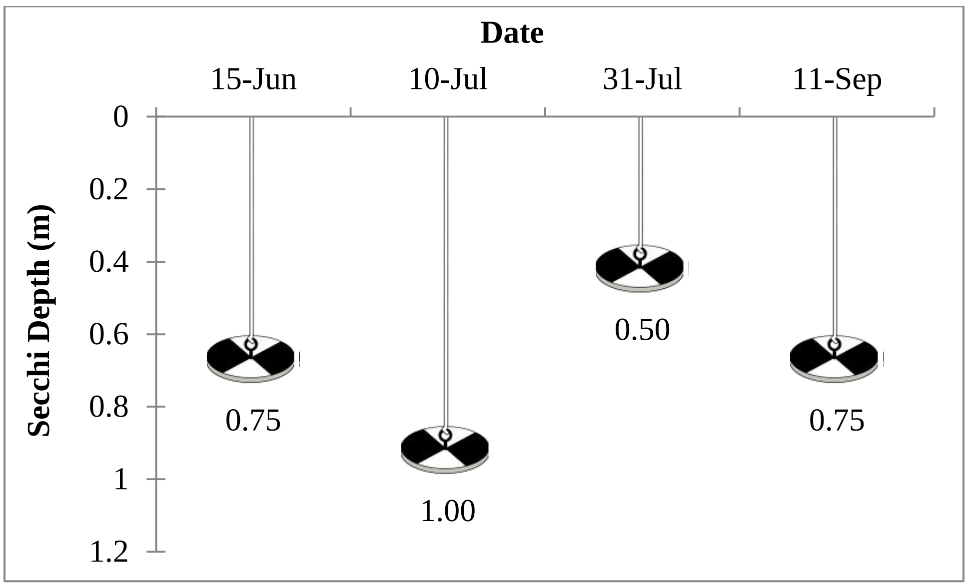

Figure 2 – Secchi disk depth measured four times over the course of the summer in 2015 at Muriel Lake.

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.

Water temperature at Muriel Lake was high in 2015. Surface water temperature measured a maximum of 21.49 °C on July 10th and a minimum of 14.16 °C on September 11th. At the sediment, temperatures were also warm, measuring a maximum of 20.46 °C on July

10th and a minimum of 12.67 °C on September 11th. Because thermal stratification was not observed, the water column remained well mixed throughout the summer.

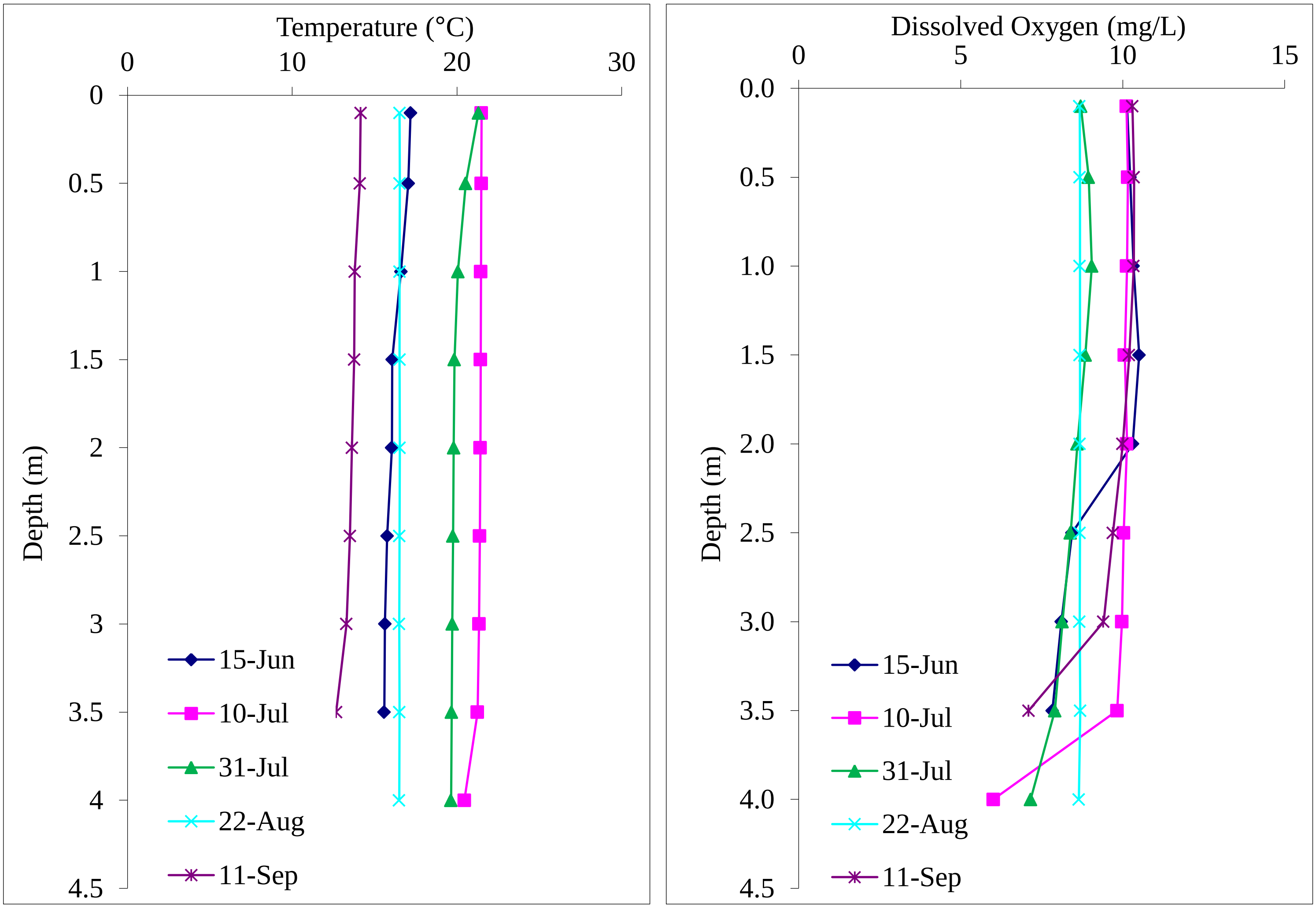

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles measured five times throughout the summer at Muriel Lake.

Because of the lack of thermal stratification, the water column remained well oxygenated in 2015. At the surface, photosynthesis by phytoplankton have the ability to elevate oxygen concentrations. In Muriel Lake, maximum surface dissolved oxygen concentration measured 10.30 mg/L on September 11th. For nearly the entire summer, the water column remained well above the Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life (PAL) of 6.5 mg/L. Anoxia was not observed at the lakebed, which can contribute to nutrient release from the sediments. Decomposition of biomass during the winter months can severely deplete oxygen concentrations and result in stressful environments for fish species.

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 100 µg/L during the summer of 2015 (Table 1). This average falls on the cusp of the eutrophic (30 µg/L - 100 µg/L) and hypereutrophc (>100 µg/L) classifications. Unlike many polymictic lakes, where phosphorus levels increase throughout the course of the summer, the lowest phosphorus concentration in 2015 was measured on September 11th. Nutrient concentrations in 2015 fell on the high end of the historical variation observed at Muriel Lake. Phosphorus levels may have become concentrated with declines in water levels, though the interactions that occur at the sediment-water interface are also important factors in the phosphorus cycle.

Similar to phosphorus, average chlorophyll-*a* concentration in 2015 is the highest concentration observed when compared to historical data (Table 1). Chlorophyll-*a* concentrations were high throughout the summer, measuring a maximum of 39.9 µg/L on July 10th and a minimum of 18.6 µg/L on September 11th. High concentrations of phytoplankton biomass can cause low oxygen concentrations as decomposition occurs at the lake sediments.

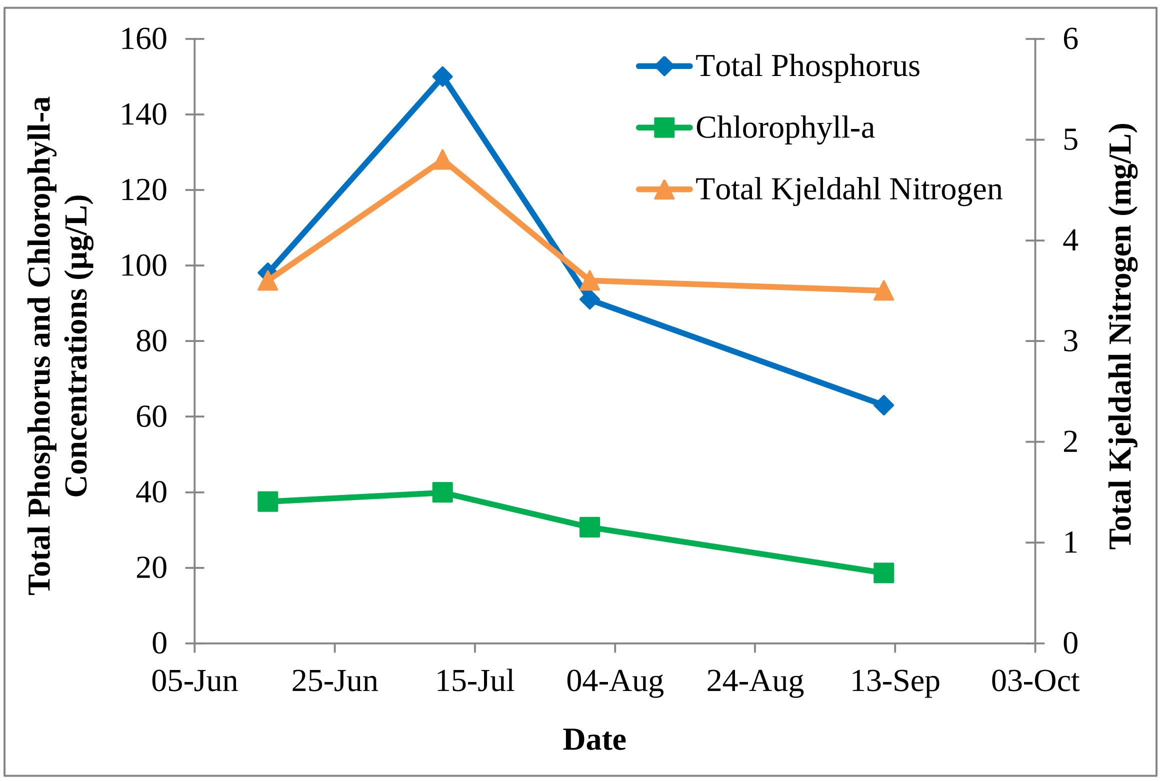

Figure 5 – Average total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L) concentrations measured four times over the course of the summer at Muriel Lake.

Average Total Kjeldahl Nitrogen (TKN) measured 3.9 mg/L in 2015. Some cyanobacteria species have the ability to fix atmospheric nitrogen in their cells which can cause increases in a lake's nitrogen. High concentrations of TKN are frequently observed at lakes throughout the province, and high concentrations have been observed historically at Muriel Lake

Average pH at Muriel Lake measured 9.27, well above neutral (Table 1). Muriel Lake has high alkalinity (1175 mg/L $CaCO_3$) and bicarbonate (873 mg/L) concentrations which help to buffer the lake against changes to pH. Concentrations of alkalinity and bicarbonate appear to have increased when compared to historical values. Similarly, conductivity at Muriel Lake is quite high, measuring 2475 uS/cm, and this high conductance may inhibit the growth of algae/cyanobacteria. Dominant ions in Muriel Lake include sodium (313 mg/L) and magnesium (210 mg/L).

Metals were measured twice at Muriel Lake and all metals sampled for, with the exception of arsenic, fell within the recommended CCME guidelines (Table 2). Arsenic measured an average of 10.7 µg/L, which exceeds the recommended CCME guideline of 5.0 µg/L for the Protection of Aquatic Life; however, lakes in the Beaver River Watershed are known to have elevated levels of arsenic.

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 2015, concentrations of microcystin were high. Muriel Lake exceeded the recreational guideline of 20 µg/L on two of the four sampling trips. Overall, an average microcystin concentration of 16.25 µg/L was recorded – this is the highest average concentration observed at ALMS' lakes in 2015. Caution should be observed when recreating in waters experiencing cyanobacteria blooms.

Date	Microcystin Concentration (µg/L)
15-Jun-15	22.28
10-Jul-15	21.95
31-Jul-15	12.18
11-Sep-15	8.57
Average	**16.24**

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 Muriel Lake.

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

Parameter	**1988**	**1993**	**1997**	**2003**	**2006**	**2009**	**2012**	**2015**
TP (μg/L)	35.7	32.0	41.1	47.5	54.0	64.3	54.2	100
TDP (μg/L)	12.3	17.0	16.0	18.0	21.5	28.7	32.0	21
Chlorophyll-*a* (μg/L)	6.70	/	6.74	9.15	8.49	9.59	4.59	31.7
Secchi depth (m)	2.16	/	1.86	1.13	1.5	1.08	2.86	0.75
TKN (mg/L)	1.5	1.8	2.0	2.5	2.7	3.4	3.1	3.9
NO_2 and NO_3 (μg/L)	1.2	1.0	3.0	2.5	2.5	23.2	3.8	2.5
NH_3 (μg/L)	21.3	111	22.8	20.5	45	26	64.4	56
DOC (mg/L)	26.2	32.5	28.0	/	44.7	47.1	48.1	62
Ca (mg/L)	10.58	7	7.52	5.03	6.02	4.85	5.16	4.2
Mg (mg/L)	97.7	115	126	173	163.5	152.7	154.7	210
Na (mg/L)	117.8	140	160.2	237.5	245	288.7	283.3	313
K (mg/L)	21.3	26.8	30.28	38.65	40.6	53.8	57.97	56
SO_4^{2-} (mg/L)	116.3	143	154.4	239	256.5	332.7	334	398
Cl^- (mg/L)	16.7	/	23.18	34.2	35.7	40.96	41.3	51
CO_3 (mg/L)	70.5	108.0	114.6	209.5	181.0	213.3	154.9	265
HCO_3 (mg/L)	535.04	703	620	746	800	858	962.6	873
pH	9.03	9.15	9.18	9.28	9.24	9.25	9.19	9.27
Conductivity (μS/cm)	1142.8	1350	1354	/	1925	2156.7	2212	2475
Hardness (mg/L)	427.33	491	537.6	725.5	688	640.33	649.7	875
TDS (mg/L)	713.9	853	919.4	1305	1325	1510	1506.7	1725
TSS (mg/L)	5.05	/	6.6	/	/	/	2.66	/
Microcystin (μg/L)	/	/	/	/	0.18	0.22	0.36	16.25
Total Alkalinity (mg/L $CaCO_3$)	556	667	696	961	957	1060	1050	1175

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 Muriel Lake on July 31st and September 11th 2015. Values shown 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)	**2003**	**2006**	**2009**	**2012**	**2015**	**Guidelines**
Aluminum μg/L	34	31.8	20.15	16.485	19.8	100[a]
Antimony μg/L	0.22	0.183	0.1825	0.2265	0.2435	6[e]
Arsenic μg/L	7.6	8.54	9.21	8.72	10.7	5
Barium μg/L	3.9	5.13	3.105	2.88	2.63	1000[e]
Beryllium μg/L	0.07	0.0015	0.0015	0.00625	0.004	100[d,f]
Bismuth μg/L	0.013	0.0032	0.0046	0.00245	0.008	/
Boron μg/L	319	290	325.5	377.5	441	5000[ef]
Cadmium μg/L	0.01	0.0088	0.00365	0.0077	0.006	0.085[b]
Chromium μg/L	0.63	0.696	0.72	0.6335	0.265	/
Cobalt μg/L	0.036	0.23	0.0576	0.0489	0.055	1000[f]
Copper μg/L	1	1.87	1.435	0.995	1.57	4[c]
Iron μg/L	15	26.3	14.585	23.3	20.3	300
Lead μg/L	0.115	0.0944	0.04865	0.0444	0.1005	7[c]
Lithium μg/L	114	132	154	195.5	227.5	2500[g]
Manganese μg/L	2.4	4.26	1.665	2.35	2.77	200[g]
Molybdenum μg/L	1.25	1.49	1.58	1.885	1.995	73[d]
Nickel μg/L	0.08	0.206	0.1315	0.12535	0.1735	150[c]
Selenium μg/L	0.7	1.41	0.759	0.466	0.055	1
Silver μg/L	0.0025	0.0024	0.00575	0.0018	0.0015	0.1
Strontium μg/L	9.9	11	9.405	9.38	5.535	/
Thallium μg/L	0.077	0.0098	0.00155	0.000525	0.00045	0.8
Thorium μg/L	0.015	0.0134	0.00725	0.007825	0.00045	/
Tin μg/L	0.05	0.015	0.015	0.05495	0.076	/
Titanium μg/L	2.7	2.58	2.12	1.211	2.13	/
Uranium μg/L	1.55	1.44	1.595	1.56	1.9	100[e]
Vanadium μg/L	0.9	0.597	0.703	0.578	0.51	100[f,g]
Zinc μg/L	2.8	2.46	1.525	1.42	1.7	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:

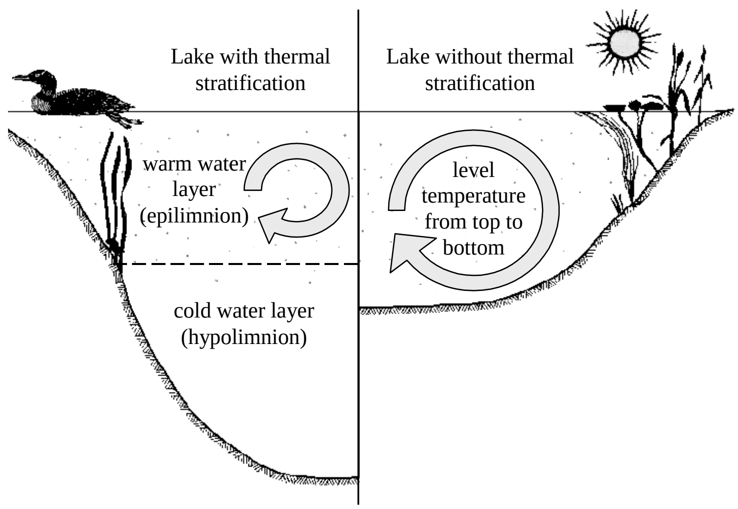

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

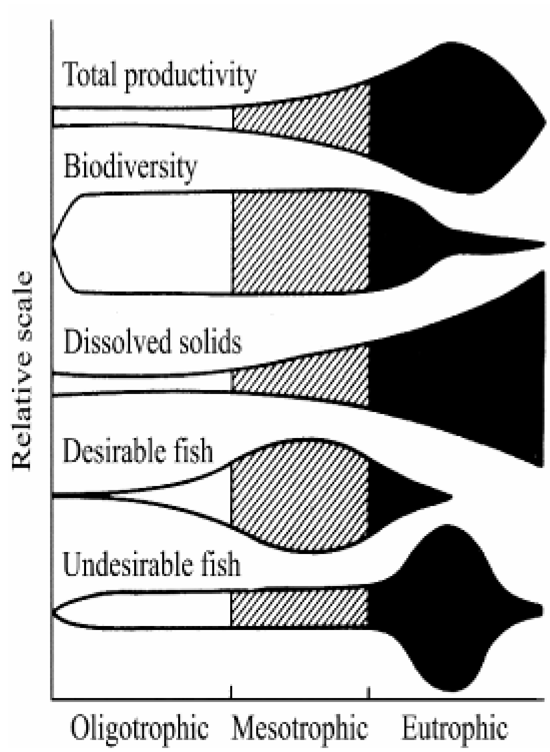

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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