THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2013 Mayatan Lake Report

COMPLETED WITH SUPPORT FROM:

Alberta Government

Alberta Lake Management Society's LakeWatch Program

LakeWatch has several important objectives, one of which is to collect and interpret water quality data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. LakeWatch Reports are designed to summarize basic lake data in understandable terms for a lay audience and are not meant to be a complete synopsis of information about specific lakes. Additional information is available for many lakes that have been included in LakeWatch and readers requiring more information are encouraged to seek those sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the LakeWatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank everyone from the Mayatan Lake Management Association who assisted us with sampling, including: Tara Doell and Alvin & Sandy Steinke. We would also like to thank Jared Ellenor, Nicole Meyers, and Elynne Murray who were summer technicians with ALMS in 2013. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Chris Ware and Sarah Hustins were involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Bradley Peter and Arin Dyer. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the program.

MAYATAN LAKE:

Mayatan Lake is a small lake located 68 km west of the City of Edmonton in the North Saskatchewan River watershed. Mayatan Lake is comprised of two basins joined by a narrow water channel. The west basin is deep, measuring up to 26.5 m, while the eastern basin is shallow, measuring 7.0 m (Figure 1). On average, Mayatan Lake is 5.7 m deep. In 2011, data collected was compiled from both basins. However, as the two basins are dramatically different, in 2012 and 2013 they were sampled separately on the same days to provide greater precision. This report presents the results from both basins.

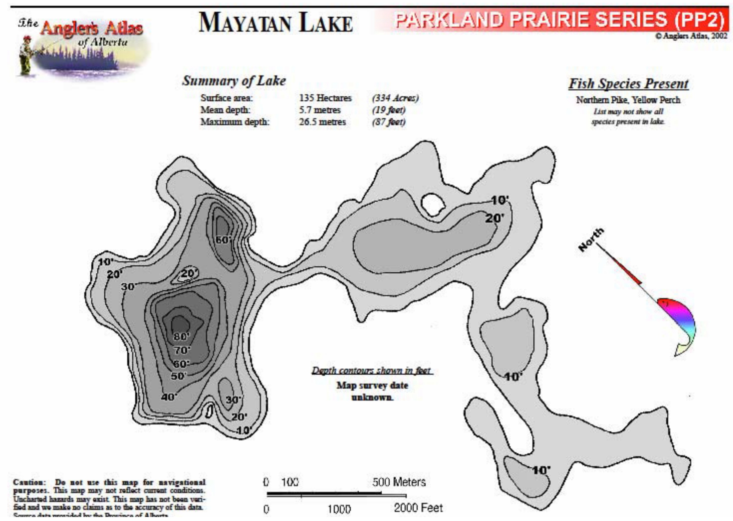

Figure 1 – Bathymetric chart of Mayatan Lake obtained from the Anglers Atlas (http://www.anglersatlas.com/lakes/8412).

According to the 2011 State of the Watershed Report released by the North Saskatchewan Watershed Alliance, Mayatan Lake has a small drainage basin (effective: 4.23 km^2; gross: 13.6 km^2) compared to the lake's surface area (1.38 km^2). This results in an effective drainage basin:surface area ratio of 3.06 km^2. While a small drainage basin:surface area ratio will help to minimize the nutrients entering the lake from the watershed, there is also no outlet channel at the lake, suggesting there is nearly no flushing, and therefore nutrients entering the lake remain there for long periods of time.

After an appeal hearing in November of 2012 with Parkland County, a decision was made to deny the development of a 200 stall RV resort campground on the southeast side of Mayatan Lake.

The 2011 State of the Watershed Report for Mayatan Lake contains more in depth descriptions of the area's land use, climate, topography, geology, and biology. This report can be viewed at http://www.nswa.ab.ca/resources/nswa_publications.

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.

Currently no long term water quantity data exists for Mayatan Lake. The State of the Watershed Report estimates no net input or output from precipitation, runoff, and evaporation. Ground water input likely plays a large role in maintaining water levels at Mayatan 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.

East Basin: Average Secchi disk depth in 2013 was poor at 1.59 m (Table 1). This value changed greatly throughout the summer, measuring a minimum of 0.80 m on September 29th versus a maximum of 3.80 m on June 23rd. Secchi disk depth decreased greatly with a spike in chlorophyll-*a* concentration, confirming that algae/cyanobacteria play a large role in impeding water clarity in the East Basin of Mayatan Lake. Data collected in 2012 showed that Total Suspended Solids (TSS) likely also play a role in impeding water clarity as they measured as high as 19.2 mg/L in 2012. As the East Basin is shallow, it is likely that wind and boating activity stir bottom sediments into the water column, decreasing water clarity.

West Basin: In contrast to the East Basin, average Secchi disk depth measured 4.51 m in the West Basin of Mayatan Lake (Table 1). This value ranged between a maximum of 5.25 m on August 25th and a minimum of 4.00 m on July 28th and September 29th. In 2013, concentrations of algae/cyanobacteria in the West Basin were low. Similarly, in 2012 average TSS in the West Basin was 9 times less than the average in the East Basin. The depth of the west basin limits the amount of bottom sediment that is stirred into the water column.

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.

East Basin: Throughout the summer, surface water temperature ranged from a minimum of 12.05 °C on September 29th to a maximum of 20.82 °C on August 25th (Figure 2a). Thermal stratification was observed on the first four sampling trips – by late September, however, the east basin began to turn-over as water temperatures became uniform throughout the water column. The presence of thermal stratification has important implications for dissolved oxygen concentrations.

West Basin: Surface water temperatures in the west basin were very similar to those observed in the east basin (Figure 2b). Thermal stratification in the west basin was much stronger than that observed in the east basin, with a thermocline beginning as early as 3.5 m. On each sampling trip, water temperatures measured around 5.00 °C for almost half of the water column. Because stratification was strong even in late September, it is possible that the west basin of the lake remains stratified all year long with no turn-over events. This pattern of temperature is common in lakes that are small and deep.

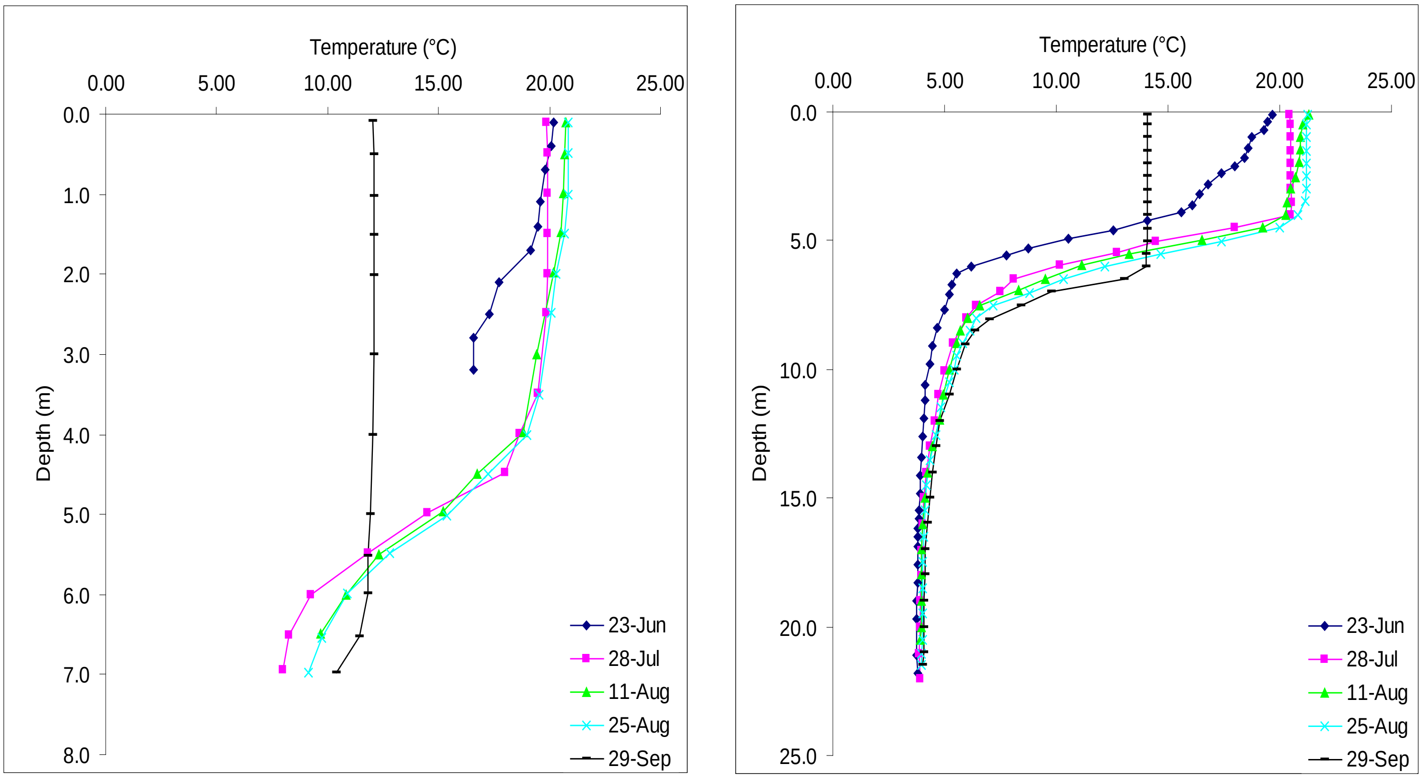

Figure 2 – Temperature (°C) profiles for the a) east and b) west basins of Mayatan Lake measured five times throughout the summer of 2013.

East Basin: Dissolved oxygen concentrations were poor in the east basin of Mayatan Lake (Figure 3a). While dissolved oxygen proceeded towards anoxia on each sampling trip, on both July 28th and September 29th the entire water column fell below the Canadian Council for Ministers of the Environment (CCME) guideline for the Protection of Aquatic Life of 6.5 mg/L. Thermal stratification separates surface waters from deeper waters, restricting the mixing of atmospheric dissolved oxygen to deep waters. In addition, the decomposition of organic matter (ex. algae/cyanobacteria) on the lakebed, an oxygen consuming process, acts to drive down dissolved oxygen concentrations. Low levels of dissolved oxygen near the lakebed may also promote the release of phosphorus from the sediments. When the water column becomes mixed, these released nutrients become available to cyanobacteria/algae near the surface. On June 23rd, August 11th, and August 25th, dissolved oxygen concentrations were high at the surface, likely due to cyanobacteria performing oxygen-producing photosynthesis.

West Basin: The west basin remained well oxygenated above the thermocline (Figure 3b). Below the thermocline, however, there were dramatic reductions in dissolved oxygen concentrations, with concentrations consistently proceeding to anoxia between 5.00 and 6.00 m. As with temperature, this pattern is typical of lakes that are small and deep. On June 23rd a spike in dissolved oxygen concentrations was observed at ~4.50 m. This is likely oxygen produced from the photosynthesis of a metalimnetic bloom of cyanobacteria/algae – a bloom that sits on top of the thermocline. On September 29th, the surface water dissolved oxygen concentrations measured only 6.89 mg/L – a deepening and weakening of the thermocline likely caused this decline.

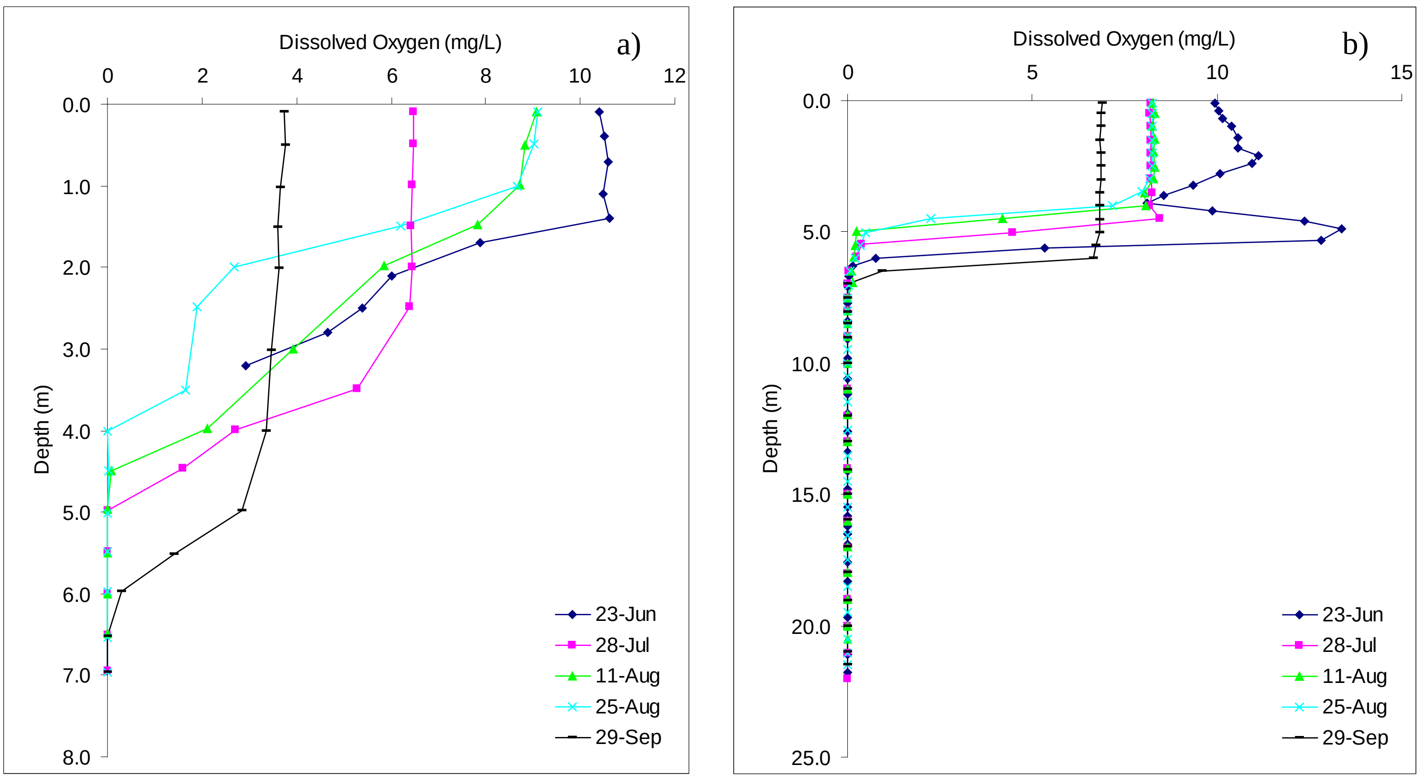

Figure 3 – Dissolved oxygen concentration (mg/L) profiles for the a) east and b) west basins of Mayatan Lake measured five times throughout the summer of 2013.

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.

East Basin: Average total phosphorus (TP) concentration measured during the summer of 2012 was 99.2 µg/L (Table 2). This value falls well into the eutrophic, or nutrient rich, classification, and just borders the cut-off for a hypereutrophic classification of 100 µg/L.

A large spike in TP was observed on June 23rd – this is possibly due to nutrient contributions from run-off as well as an accumulation of nutrients released into from the sediments throughout the winter. Total Kjeldahl nitrogen (TKN) levels were similarly high, measuring an average of 2264 µg/L, which falls well into the hypereutrophic classification. Finally, chlorophyll-*a* levels, an indication of algae/cyanobacteria biomass, measured an average of 19.69 µg/L, which falls into the eutrophic, nutrient rich, classification (Figure 4; Table 1). As is typical at most lakes in the province, chlorophyll-*a* concentration peaked in mid-summer when surface water temperatures were highest. This average is reduced in comparison to the 2012 average, possibly due to reduced water temperatures; in 2013, maximum surface water temperature was approximately four degrees lower than in 2012.

Figure 4 – Decaying cyanobacterial scum on the surface of the East Basin of Mayatan Lake. Photo by Jared Ellenor, 2013.

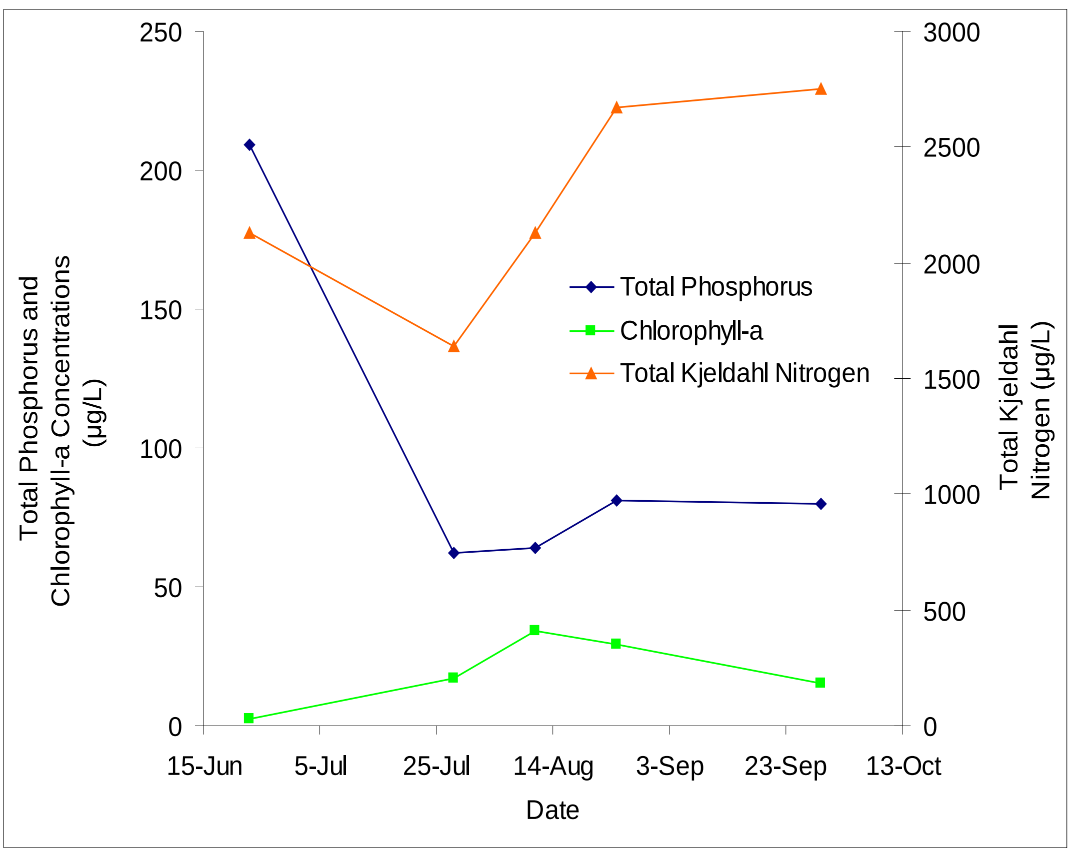

Figure 5 – Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L) concentrations measured five times over the course of the summer of 2013.

West Basin: Average TP measured 30.4 µg/L during the summer of 2013, less than a third the concentration in the east basin (Table 2). This value falls into the eutrophic classification, lying just on the cusp between mesotrophic and eutrophic. Similar to the east basin, TKN fell into the hypereutrophic classification, measuring 1424 µg/L. Finally, chlorophyll-*a* concentrations were significantly reduced in the west basin compared to the east basin. The west basin measured an average of 4.59µg/L, with a maximum of 7.28 µg/L on June 23rd and a minimum of 1.96 µg/L on September 29th; an average value of 4.59 µg/L falls into the mesotrophic, or moderately productive, classification.

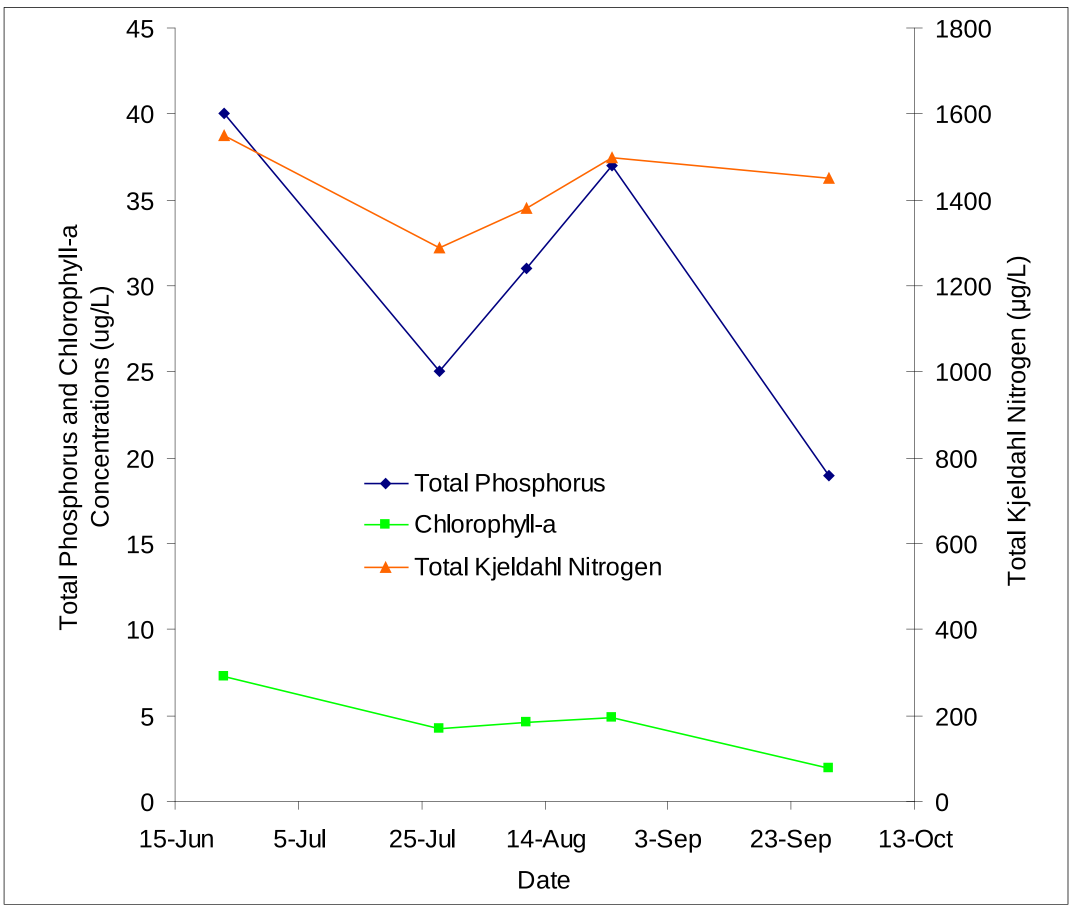

Figure 6 – Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L) concentrations measured five times over the course of the summer of 2013.

Metals were sampled for twice throughout the summer. In the East Basin, average aluminum concentration fell above the recommended guideline of 100 µg/L; however, because the lake is so shallow, sediments in the water column likely contaminated the results (Table 3)

In 2013, microcystin concentrations were higher in the East Basin than the West Basin (Table 2). In the East Basin, average microcystin concentration measured 2.32 µg/L while in the West Basin microcystin concentration measured 0.07 µg/L. While these averages are below the recommended recreational guidelines of 20 µg/L, concentrations from individual dates are important as these toxins can pose a health risk to wildlife and humans. Maximum concentration observed in the East Basin was 6.36 µg/L while maximum concentration in the West Basin measured 0.12 µg/L (Table 1). As these values are the result of a 10-point lake composite, it is possible that one of these composite sites have exceeded the recreational guidelines, thus caution should be exercised when recreating on lakes with cyanobacteria blooms.

Table 1 – Microcystin concentrations (µg/L) measured at Mayatan Lake during the summer of 2013. Values represent samples taken as 10-point composites from each basin.

	Microcystin (µg/L)	
Date	**East Basin**	**West Basin**
23-Jun	0.17	0.07
28-Jul	1.76	0.08
11-Aug	6.36	0.05
25-Aug	0.75	0.05
29-Sep	2.57	0.12

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 2013, no zebra or quagga mussels were detected in Mayatan Lake.

Figure 5 – Technician Jared Ellenor examining a substrate for adult mussels. East Basin of Mayatan Lake, 2013.

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

	Both Basins	**East Basin**		**West Basin**	
Parameter	**2011**	**2012**	**2013**	**2012**	**2013**
TP (µg/L)	30.8	88.2	99.2	35.4	30.4
TDP (µg/L)	12.5	28.4	27.2	16	14
Chlorophyll-*a* (µg/L)	4.70	34.80	19.69	6.18	4.59
Secchi depth (m)	4.3	1.3	1.59	4.5	4.51
TKN (µg/L)	1488	2946	2264	1424	1434
NO_2 and NO_3 (µg/L)	3	7.1	9.3	3.9	2.5
NH_3 (µg/L)	34	329	277.6	30	60.6
DOC (mg/L)	16.1	23.3	23.67	15.8	18.27
Ca (mg/L)	35.4	46.0	52	36.9	39.1
Mg (mg/L)	67.2	62.9	64.9	63.1	65.9
Na (mg/L)	21.2	21.6	21	21.7	22.4
K (mg/L)	23.7	27.1	31.2	24.1	26.7
SO_4^{2-} (mg/L)	185	233	229	186.7	179.7
Cl^- (mg/L)	2.2	2.97	3	2.3	2.77
CO_3 (mg/L)	8.8	2.2	8	6.7	4.8
HCO_3 (mg/L)	244.6	254.0	243.8	256.8	265
pH	8.57	8.23	8.382	8.454	8.368
Conductivity (µS/cm)	746.8	826.6	854.8	744.2	784.8
Hardness (mg/L)	365	522	397	470.3	369.3
TDS (mg/L)	464	374	530	352	473
Microcystin (µg/L)	0.0648	4.95	2.32	0.067	0.07
Total Alkalinity (mg/L $CaCO_3$)	215.0	211.2	210.8	222	225.2

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 3 - Concentrations of metals measured in Mayatan Lake on August 11th and September 29th 2013. Values shown for 2013 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.

	East Basin		**West Basin**		
Metals (Total Recoverable)	**2012**	**2013**	**2012**	**2013**	**Guidelines**
Aluminum µg/L	43.95	102.2	7.695	27.9	100[a]
Antimony µg/L	0.204	0.1755	0.10315	0.0994	6[e]
Arsenic µg/L	4.5	3.565	2.48	2.45	5
Barium µg/L	70	57.2	98.25	119.5	1000[e]
Beryllium µg/L	0.0157	0.0015	0.00885	0.00545	100[d,f]
Bismuth µg/L	0.0005	0.0029	0.0005	0.0005	/
Boron µg/L	108.5	100.75	110.5	108.5	5000[ef]
Cadmium µg/L	0.0205	0.00295	0.01715	0.0018	0.085[b]
Chromium µg/L	0.172	0.6215	0.1795	0.538	/
Cobalt µg/L	0.08095	0.09345	0.0469	0.0757	1000[f]
Copper µg/L	0.7685	0.7635	1.5895	0.7255	4[c]
Iron µg/L	7.62	59.35	1.6	32.8	300
Lead µg/L	0.07635	0.07485	0.10355	0.02265	7[c]
Lithium µg/L	104.5	108	108.5	114.5	2500[g]
Manganese µg/L	96.05	64.6	120.15	104.3	200[g]
Molybdenum µg/L	0.1965	0.2675	0.1044	0.109	73[d]
Nickel µg/L	0.0025	0.4345	0.00725	0.4225	150[c]
Selenium µg/L	0.05	0.05	0.05	0.05	1
Silver µg/L	0.00025	0.0131	0.000725	0.0116	0.1
Strontium µg/L	377.5	514.5	278	364	/
Thallium µg/L	0.00085	0.00135	0.00065	0.000475	0.8
Thorium µg/L	0.00015	0.011	0.00015	0.003275	/
Tin µg/L	0.03115	0.0232	0.0675	0.0278	/
Titanium µg/L	1.55	3.48	0.4015	1.075	/
Uranium µg/L	0.453	0.578	0.36	0.384	100[e]
Vanadium µg/L	0.6525	0.742	0.401	0.3705	100[f,g]
Zinc µg/L	1.285	1.089	1.495	1.1215	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.
Values in red exceed their recommended 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:

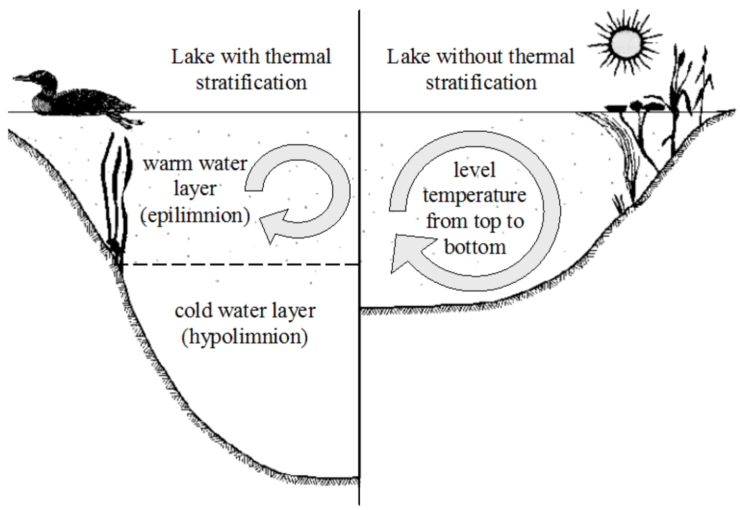

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

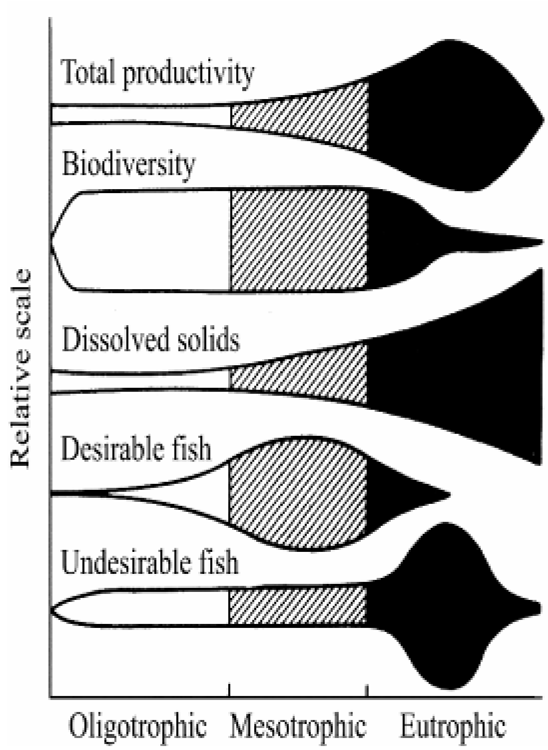

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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