Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2013 Middle Chain 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 Michael Clark for his assistance with sampling in 2013. 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.

MIDDLE CHAIN LAKE: (42-24-W4)

Middle Chain Lake is the middle section of three water bodies in the Buffalo Sub-Watershed collectively known as Chain Lakes. The northern-most lake is called Berdine, or Upper Chain, Lake; the middle lake is Middle Chain Lake; and the third, or southern-most water body, is called Magee, or Lower Chain, Lake. The Chain Lakes are connected by the north branch of Parlby Creek and ultimately drain into Mirror Bay to the South East, then to Buffalo Lake, and finally into the Red Deer River via Tail Creek. They are located just east of Ponoka and south of Highway 53 in the County of Ponoka.

Figure 1 – Middle Chain Lake in August, 2013. Photo by Jared Ellenor.

The lakes lie incised in a steep valley carved by an ice-marginal meltwater channel during the Pleistocene.[1] Maximum depth is ~ 5m. Because of the steep valley and lake bed, the marsh edge is generally narrow and discontinuous; however, because of two alluvial fans, Upper Chain Lake hosts fairly good marsh habitat. The lakes have a small collective surface area (~1.63 km^2)[2] though a watershed which is large relative to the size of the lakes, draining an area of 79.5 km^2.

Middle Chain Lake is situated in the central parkland natural sub-region of Alberta, within the Battle River basin, and is surrounded by prime agricultural land. In 2011, concerns over a proposal for a confined feeding operation (CFO) next to Upper Chain Lake prompted residents to form the Friends of the Chain Lakes Society to initiate water-quality data collection through the LakeWatch program. The CFO next to the lake was later denied, though many CFO's are present within Chain Lakes' watershed boundary. Several new residential developments have recently been approved for the lakes and a watershed management plan was created by the County of Ponoka in 2012 to manage future development.

Sport fishing is limited to large (>63 cm) northern pike.

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[1] Battle River and Red Deer Regional Planning Commissions. 1974. A study of the recreational potential of Chain Lakes. Wetaskiwin, Alberta.

[2] Ponoka County. 2012. Chain Lakes Watershed Management Plan. Retrieved from: www.ponokacounty.com.

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.

Secchi disk depths were poor in Middle Chain Lake in 2013 (Figure 2; Table 2). Secchi disk depths ranged from a maximum of 3.25 m on June 28th to a minimum of 0.45 m on September 20th. On average, Secchi disk depth measured 1.47 m. Middle Chain Lake experiences dense phytoplankton blooms which act as the greatest impediment to water clarity. Given the shallow depths of Middle Chain Lake, it is also possible that wind energy stirs bottom sediments into the water column, reducing water clarity.

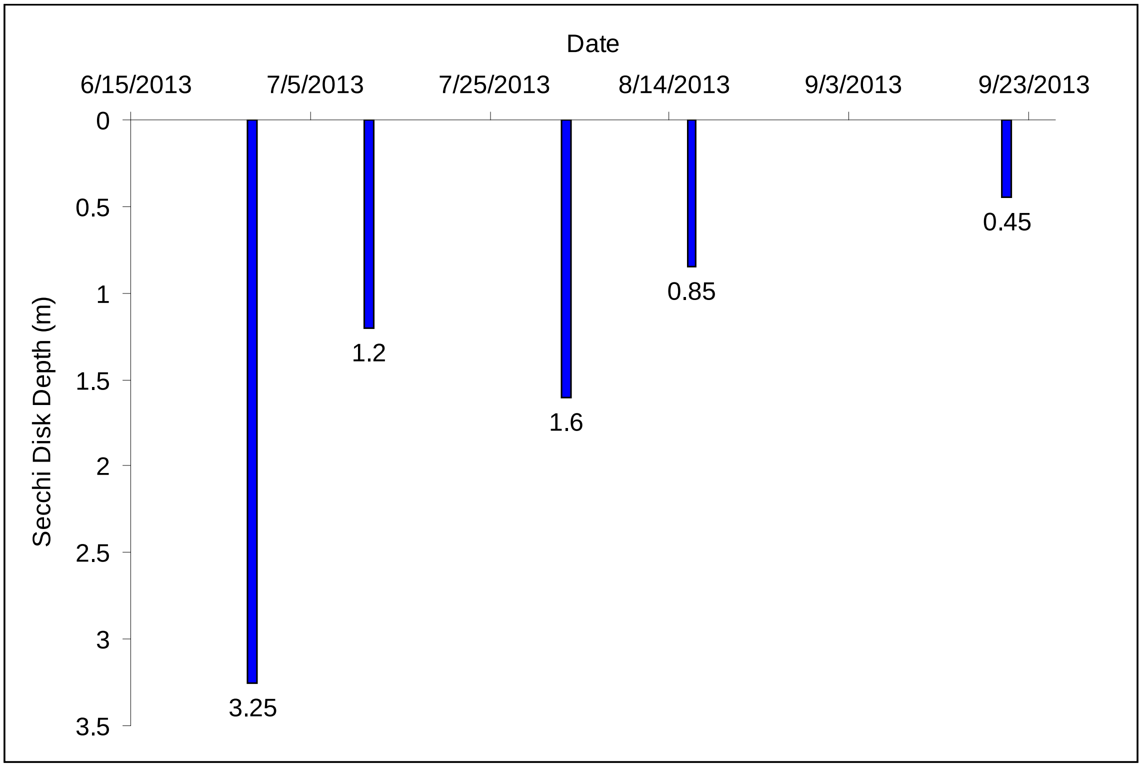

Figure 2 – Secchi disk depth values measured in from June-September in 2013 at Middle Chain Lake.

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.*

Thermal stratification was observed on only one occasion during the summer of 2013 (Figure 3a). On August 16th, weak stratification was present between 2.00 and 3.50 m. The presence of thermal stratification may have important implications for the release of phosphorus from the lake sediments and the concentrations of oxygen present in deeper waters. It is likely that Middle Chain Lake is polymictic, stratifying on calm, hot days, and mixing on windy days. Throughout the summer, surface water temperature ranged from a minimum of 16.66 °C on September 20th to a maximum of 22.97 °C on June 28th.

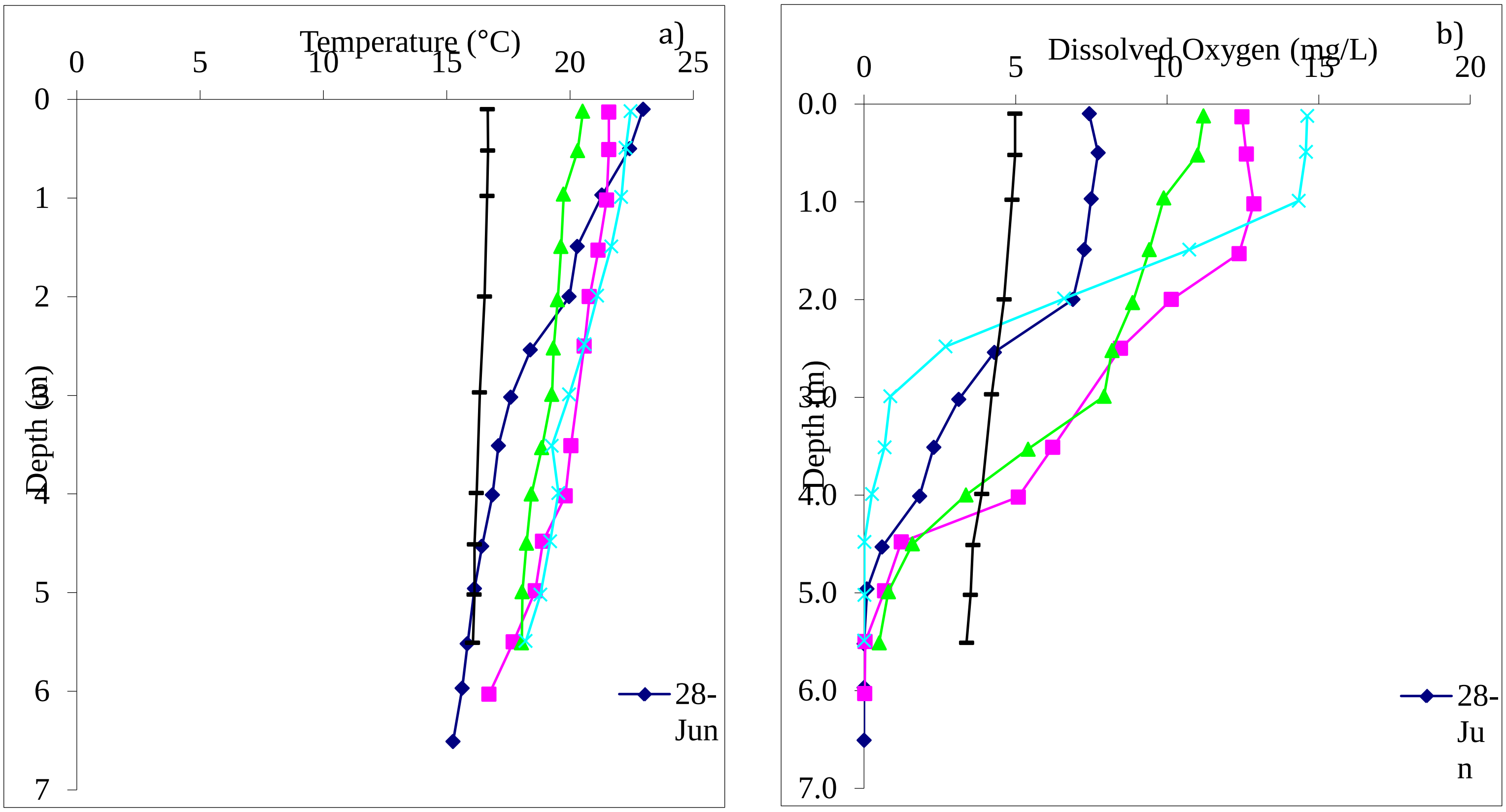

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Middle Chain Lake measured five times over the course of the summer of 2013.

Dissolved oxygen concentrations varied greatly throughout the summer at Middle Chain Lake (Figure 3b). Dissolved oxygen concentrations fell below the Canadian Council for Ministers of the Environment (CCME) guideline of 6.5 mg/L for the Protection of Aquatic Life (PAL) for the entire length of the water column on September 20th. On the other four sampling trips the surface was well oxygenated, likely due to photosynthesis by phytoplankton. On each trip, however, dissolved oxygen concentrations ultimately proceeded towards anoxia with depth. This was most marked on August 16th when the lake had weak thermal stratification which prevents the mixing of oxygen-rich surface waters with deeper waters.

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.

Like its northern neighbour Upper Chain Lake, Middle Chain Lake has extremely high nutrient concentrations (Table 2). In 2013, average TP concentration measured 260.6 μg/L – this average falls well into the hypereutrophic, or extremely productive, classification. Concentrations were high throughout the summer, ranging from a minimum of 191 μg/L on August 2nd to a maximum of 380 μg/L on September 20th (Figure 4). Dissolved forms of phosphorus, which represent phosphorus available for plant/cyanobacteria growth, were also extremely high, averaging 186.4 μg/L in 2013. Nutrient values are substantially higher in 2013 than samples collected in 2001.

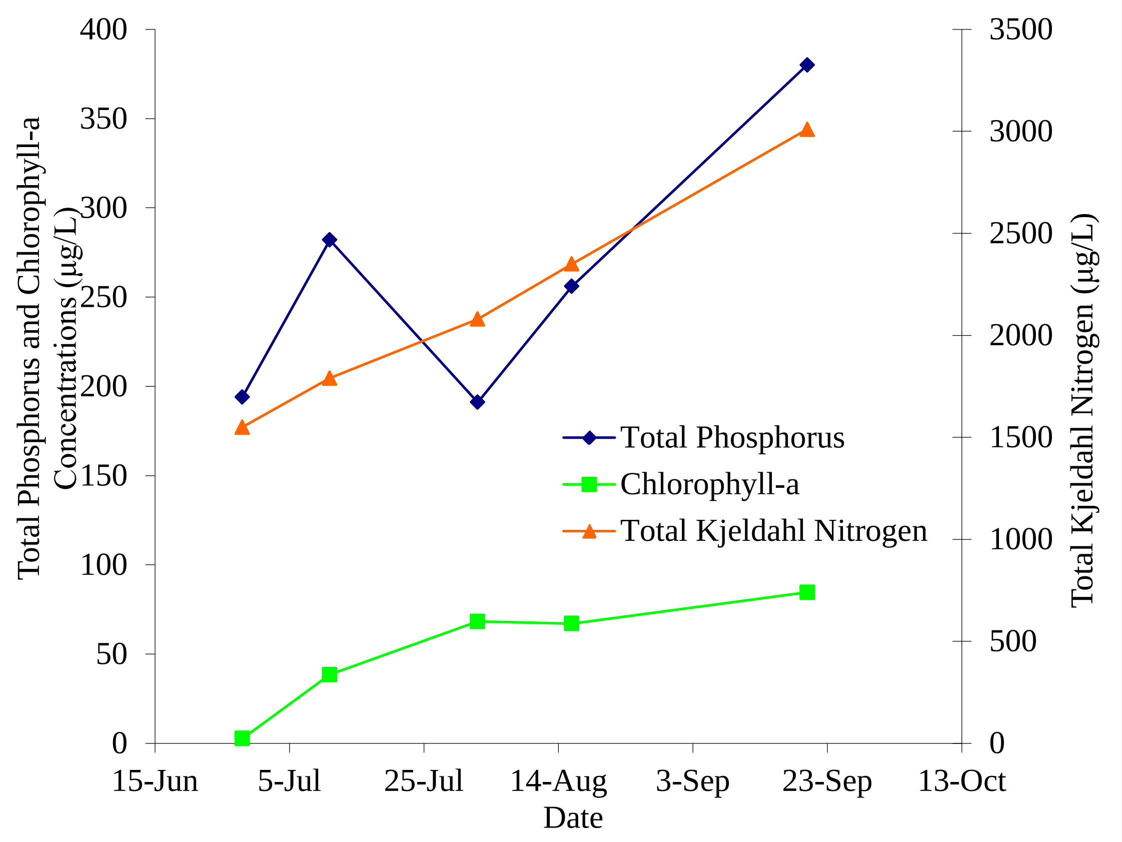

Figure 4 – Total phosphorus (μg/L), chlorophyll-*a* (μg/L), and Total Kjeldahl Nitrogen (μg/L) measured five times over the course of the summer of 2013 at Middle Chain Lake.

Figure 5 – A cyanobacteria surface scum near the shores of Middle Chain Lake. Photo by Jared Ellenor, 2013.

Given its high TP concentrations, it is not surprising that Middle Chain Lake experiences large amounts of phytoplankton (Figure 5). Chlorophyll-*a* concentration, an indirect indicator of phytoplankton, measured an average of 52.21 μg/L in 2013, falling into the hypereutrophic classification (Table 2). This concentration does not seem unusual for Middle Chain Lake, as chlorophyll-*a* samples collected in 2001 measured an average of 66 μg/L. Chlorophyll-*a* concentration increased steadily throughout the summer, measuring 2.63 μg/L on June 28th and 84.6 μg/L on September 20th (Figure 6). Visual observations of the cyanobacteria blooms suggest the cyanobacteria community is dominated by species from the genera *Anabaena* or *Microcystis* and *Aphanizomenon* (Figure 6, 7).

Finally, total Kjeldahl nitrogen (TKN) measured an average of 2156 μg/L in 2013 (Table 2). Again, this value falls into the hypereutrophic classification. Throughout the summer, TKN ranged from a minimum of 1550 μg/L on June 28th to a maximum of 3010 μg/L on September 20th (Figure 4).

Figure 6 – Clumps of cyanobacteria in the water and decaying cyanobacteria on a log revealing its characteristic blue-green colour. Photo by Jared Ellenor, 2013.

Figure 7 – A water strider climbing across *Aphanizomenon* sp. in Middle Chain Lake. Note the distinguishing grass-clipping shape of *Aphanizomenon* spp. Photo by Jared Ellenor, 2013.

Average pH in Middle Chain Lake was 8.57 – well above neutral (Table 2). Middle Chain Lake has high alkalinity (240.2 mg/L $CaCO_3$) and bicarbonate (271.2 mg/L HCO_3) concentration which help to buffer the lake against changes to pH. Conductivity is not particularly high (495.8 uS/cm), with sodium (47.5 mg/L) and calcium (36.9 mg/L) representing the dominant ions in the lake.

Microcystin concentration averaged 6.00 µg/L in 2013 (Table 1). A maximum concentration of 12.20 µg/L was observed on September 20th. As these values represent averages across the whole lake, it is possible that microcystin concentrations exceed the recreational guidelines of 20 µg/L at specific locations.

Table 1 – Microcystin concentrations (µg/L) measured at Middle Chain Lake during the summer of 2013. Values represent samples taken as whole-lake composites.

Date	Microcystin (µg/L)
28-Jun	0.25
11-Jul	8.19
2-Aug	8.07
16-Aug	1.31
20-Sep	12.20

Metals were sampled for twice in Middle Chain Lake (Table 3). Concentrations of aluminum and iron were high, indicating the possibility of lake sediments in the water samples – in a shallow like, it is likely that sediments are naturally suspended throughout the water column. Other than aluminum and iron, all metals fell within their respective guidelines.

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 Middle Chain Lake.

Table 2 – Average Secchi disk depth and water chemistry values for Chain Lakes. Previous year averages from all basins are provided for comparison.

	Historical		**Recent**	
	Lower	**Middle**	**Upper**	**Middle**
Parameter	**2001**	**2001**	**2011**	**2013**
TP (μg/L)	112	105	345	260.6
TDP (μg/L)	41	40	266	186.4
Chlorophyll-*a* (μg/L)	51	66	94.9	52.206
Secchi depth (m)	1.6	2.1	1.18	1.47
TKN (μg/L)	1600	1547	2090	2156
NO_2 and NO_3 (μg/L)	9	9	20.4	6.7
NH_3 (μg/L)	91	27	220	108
DOC (mg/L)	/	/	17.7	17.3
Ca (mg/L)	25	35	38.8	36.9
Mg (mg/L)	20	21	15.5	16.8
Na (mg/L)	62	68	39.5	47.5
K (mg/L)	5	5	9.3	9
SO_4^{2-} (mg/L)	15	20	7.5	16
Cl^- (mg/L)	3	3	7.73	7.43
CO_3 (mg/L)	/	/	2.13	10.6
HCO_3 (mg/L)	/	/	287.25	271.2
pH	9	8	8.23	8.57
Conductivity (μS/cm)	519	567	479	495.8
Hardness (mg/L)	/	/	157	161.3
TDS (mg/L)	/	/	256	278.7
Microcystin (μg/L)	/	/	0.24	6.00
Total Alkalinity (mg/L $CaCO_3$)	272	299	239	240.2

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 Middle Chain Lake on August 2nd and September 20th 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.

Metals (Total Recoverable)	**2013**	**Guidelines**
Aluminum µg/L	192.05	100[a]
Antimony µg/L	0.0682	6[e]
Arsenic µg/L	1.375	5
Barium µg/L	49.95	1000[e]
Beryllium µg/L	0.01005	100[d,f]
Bismuth µg/L	0.0023	/
Boron µg/L	67.05	5000[ef]
Cadmium µg/L	0.0041	0.085[b]
Chromium µg/L	0.5295	/
Cobalt µg/L	0.1635	1000[f]
Copper µg/L	0.5145	4[c]
Iron µg/L	164.05	300
Lead µg/L	0.10185	7[c]
Lithium µg/L	22.5	2500[g]
Manganese µg/L	69.75	200[g]
Molybdenum µg/L	0.727	73[d]
Nickel µg/L	0.8385	150[c]
Selenium µg/L	0.1655	1
Silver µg/L	0.02175	0.1
Strontium µg/L	367	/
Thallium µg/L	0.0023	0.8
Thorium µg/L	0.01685	/
Tin µg/L	0.015	/
Titanium µg/L	5.3	/
Uranium µg/L	0.7645	100[e]
Vanadium µg/L	1.0755	100[f,g]
Zinc µg/L	1.2195	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 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:

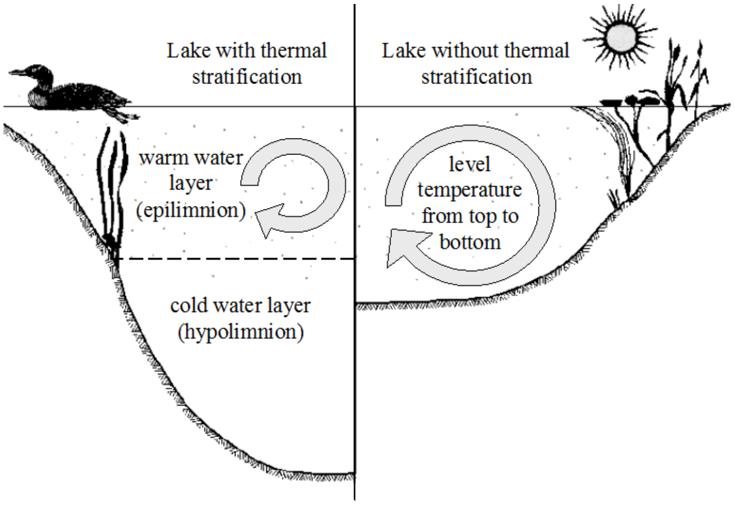

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

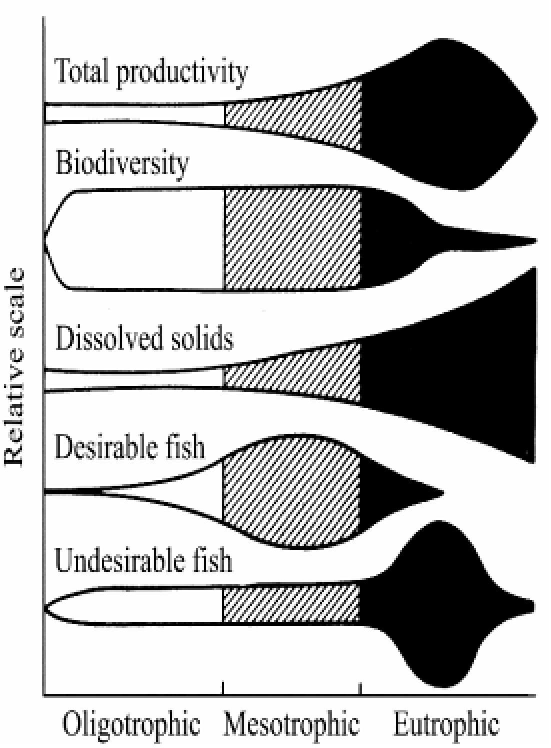

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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