Mailing Address:
Suite #1,
250 Diamond Avenue
Spruce Grove
Alberta
T7X 4C7

Web Site:
www.wwmc.ca

Email:
info@wwmc.ca

Telephone:
(780) 960-8631

Meetings:
2nd Wednesday of each month at the above address

Wabamun Watershed Management Council

Wabamun Lake Water Quality Overview

By Kelly Aldridge, WWMC Member - Seba Beach

Introduction

Each of us has our own ideas of what is "good" or "poor" water quality. It depends on what we want to use the water for. For example, if our primary use of the lake is for swimming, we probably think clear water is the top priority. If we like to fish or watch wildlife, we may be more interested in weed beds and fish habitat, and accept some greener water. If our home is on higher ground, we will likely be more tolerant of high water levels than if it is on lower ground.

Lake water quality also depends on the nature of the lake. Is it a deep lake, or a shallow lake? Is it a rock-bottomed lake, or a mud-bottomed lake? Is it fed by rivers and streams or is the primary source of water from rainfall and runoff? These basic natural characteristics will place limits on the best water quality we can expect from a lake. So what are the characteristics of prairie lakes and Wabamun Lake in particular?

Wabamun Lake is a fairly typical prairie lake. It has a mud bottom. The mud in prairie lakes has concentrations of organic materials, nutrients, minerals, chemicals, etc. The mud can contribute both positively and negatively to the quality of lake water. The lake is shallow, with an average depth of about 5 meters,and a maximum depth of about 11 meters.

Wabamun Lake is fed by a few small streams which flow primarily in springtime, while underground inflow contributes throughout the year. The primary water source is direct precipitation onto the lake and runoff from the watershed. Because there are no major rivers flowing in or out of the lake, the lake has limited flow through. Therefore anything that gets into the lake, such as nutrients or chemicals, tends to stay there and concentrate in the mud. In fact, it takes more than a human lifetime for the lake to completely flush itself.

Fluctuating precipitation is the main reason that Wabamun water levels change from year to year. In recent years TransAlta has contributed significantly to the lake levels via a pipeline from the North Saskatchewan River. The purpose of this pipeline is to replace the water used by TransAlta to operate their mines and power plants on the lake. The water is treated at the TransAlta Water Treatment Plant (WTP) before entering the lake to remove unwanted biological matter. Originally there were two WTPs operating, and by 2007 TransAlta had entirely replaced the historical deficit of water used and ceased operation of one plant. The remaining WTP replaces surface runoff and groundwater that has been diverted from the lake by coal mining activities.

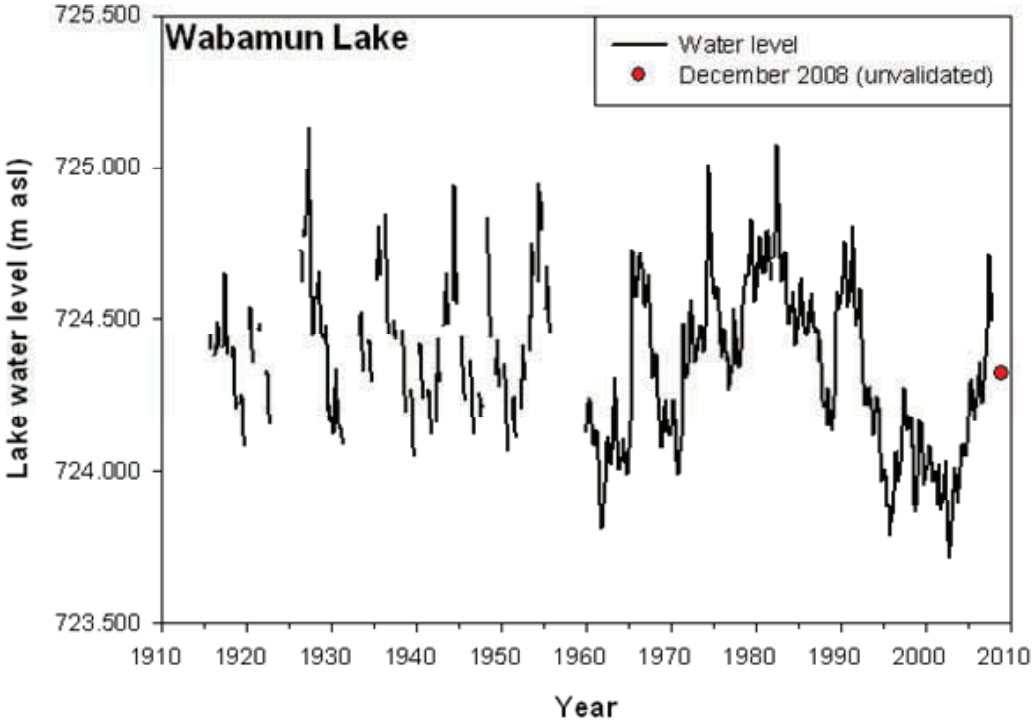

Figure 1: Historical water levels at Wabamun Lake. Data from Water Survey of Canada.

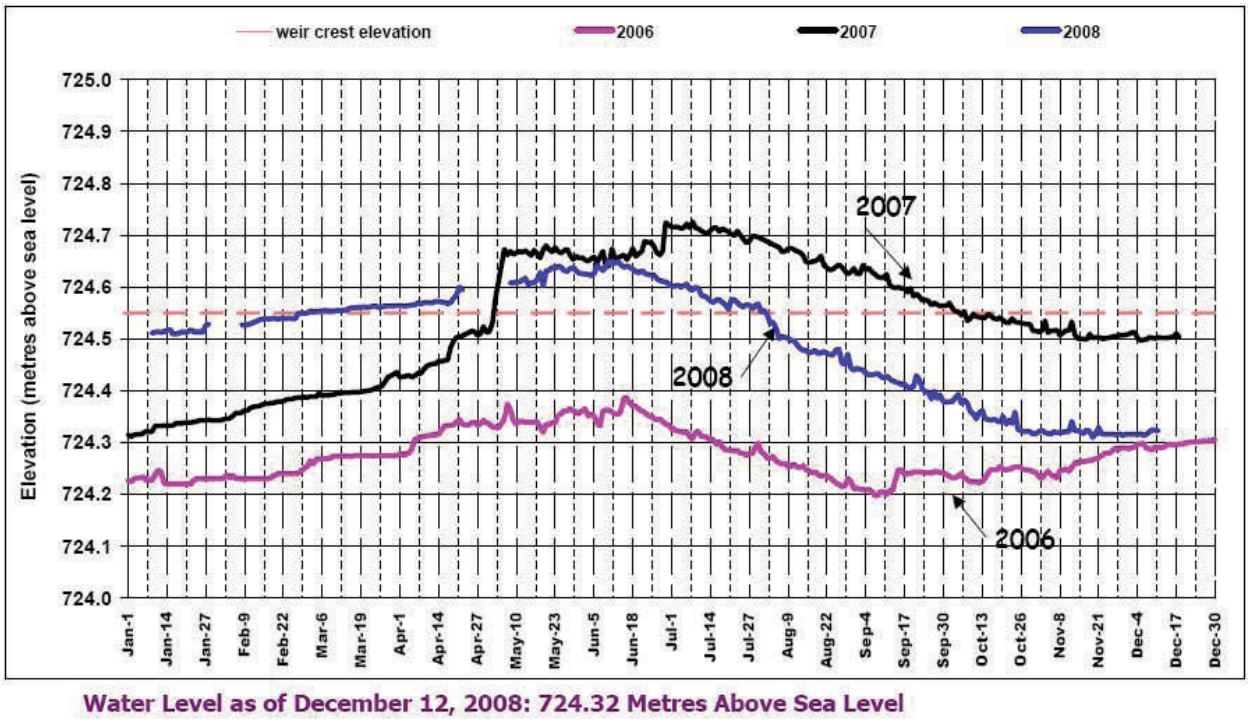

Figure 2: Wabamun Lake water levels from 2006 to 2008. Data from Alberta Environment.

The current water levels can be viewed on the internet at the following address:
http://www.environment.alberta.ca/forecasting/Wabamun.pdf

Measuring water quality

There are many measures of lake water quality. One commonly used measure is based on the overall level of biological productivity in the lake. This is known as the "**trophic status**" of the lake. The trophic status of a lake can range from low productivity (oligotrophic), to moderate productivity (mesotrophic), to high productivity (eutrophic), to very high productivity (hypereutrophic). In general, the higher the productivity of a lake the more algae grows in the water, and the lower the recreational qualities of the lake.

The concentration of chlorophyll-*a* in lake water relates to the amount of algae and other microscopic floating plants, and is commonly used to indicate the trophic status. Phosphorus is the most important nutrient required for plant growth in freshwaters, so it too is usually measured. When there is too much algae, the oxygen levels in the lake can be reduced to levels that will negatively affect fish populations. At the same time, the green water and weeds reduce the recreational potential of the lake. Figure 3 and Figure 4 show the trophic status of Wabamun Lake for chlorophyll-*a* and total phosphorus respectively, and how it compares to other Alberta lakes.

For those of us with limited scientific knowledge, trying to understand the science behind measures of water quality can be daunting. Most of us only want to know, in general terms, how healthy our lake is, and how it compares to other lakes in Alberta. We also need to know whether the water quality is getting better or worse. For those who want to know the details of the scientific measurements and analysis of the water at Lake Wabamun, please see the table on pages 9 and 10.

Water Clarity

Water clarity is an important measure of lake health because plants need light in order to grow. If light can't penetrate the water, leafy plants that help keep the water clear cannot grow. Clear water is a good indicator of general lake health because murky water is usually associated with high levels of nutrients. Wabamun Lake water clarity is near the middle of the range for all Alberta lakes. Although it varies from year to year, there is no trend towards either increasing or decreasing clarity.

Physical Measurements

Physical measurements are measured with a multi-probe instrument and water samples. Together they give a general overview of the suitability of the location for aquatic life and the productivity of the ecosystem.

Water temperature – Water temperature changes with the seasons, and can change drastically with depth in some lakes that 'stratify'. Water is heaviest (most dense) at 4 ºC and sinks to the bottom of lakes, while warmer water and water approaching 0 ºC is lighter (less dense) and rises above the heavier water. Wabamun Lake tends to be uniform in temperature from top to bottom in summer, ranging up to approximately 22ºC at the surface and in shallow water areas. In winter the water below the ice ranges from 0-4 ºC.

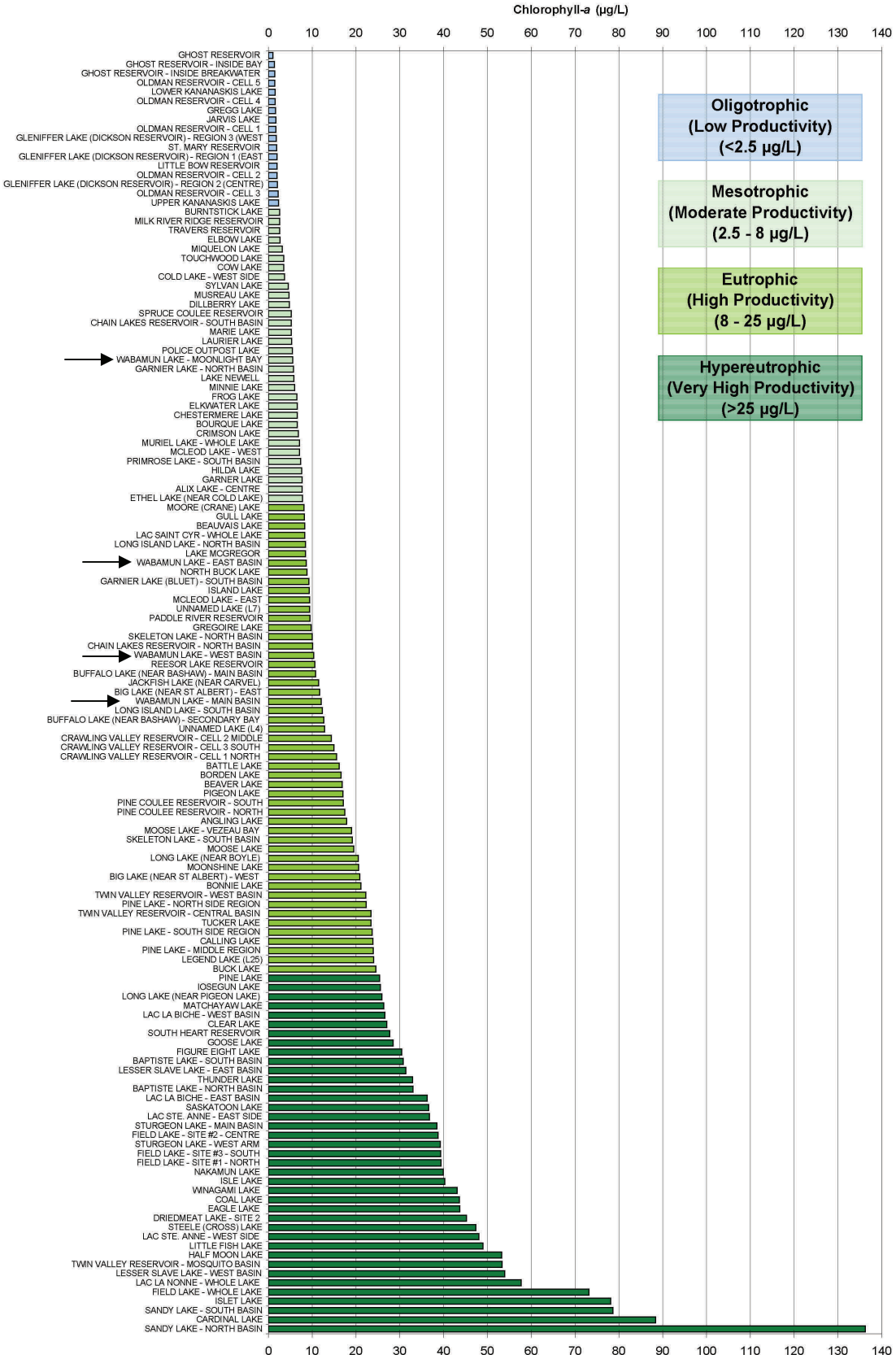

Figure 3. Trophic status of several Alberta lakes (May-September) using chlorophyll-a concentrations. Data from Alberta Environment.

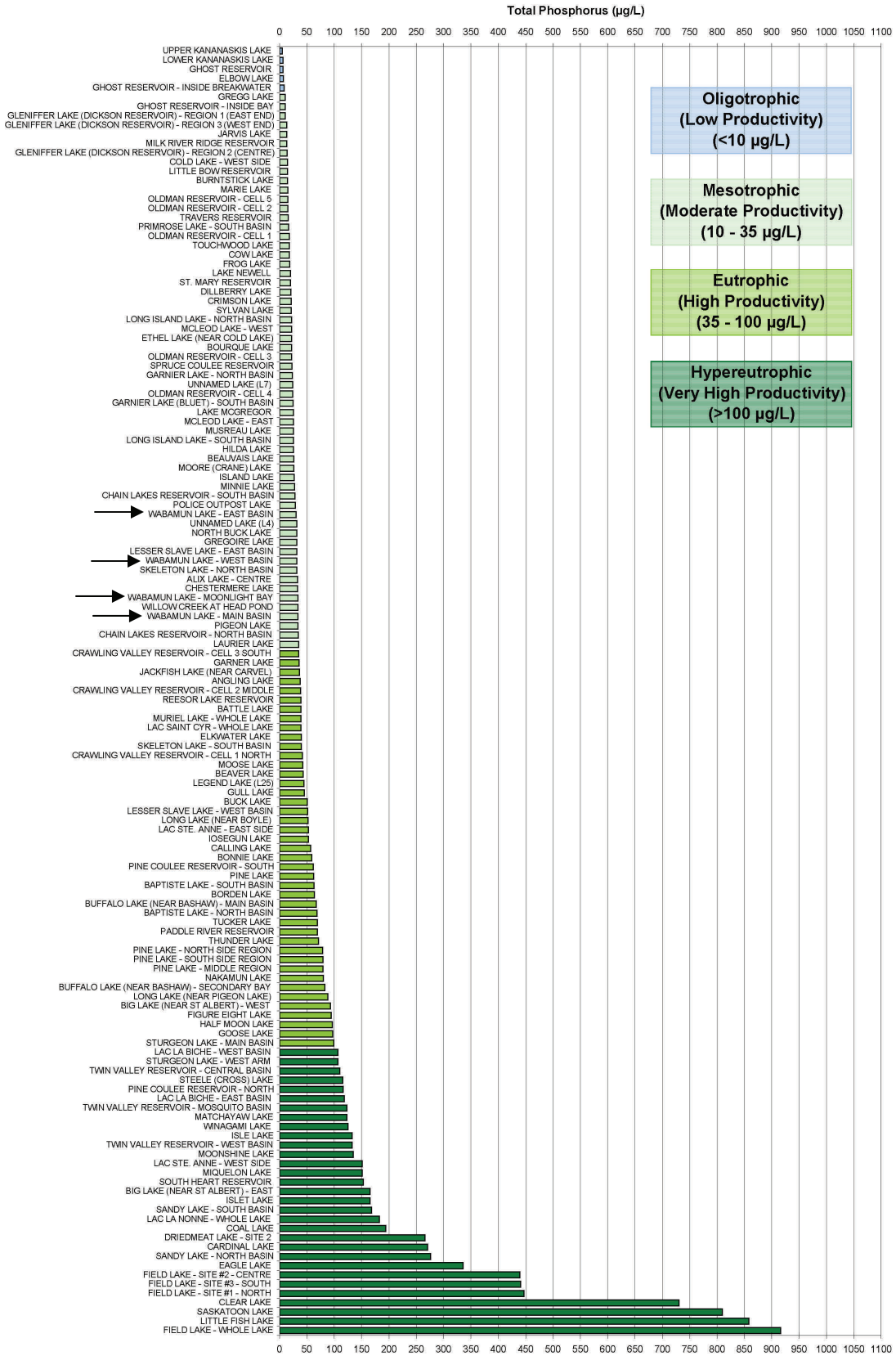

Figure 4: Trophic status of several Alberta lakes (May-September) using total phosphorus concentrations. Data from Alberta Environment.

Dissolved Oxygen – Oxygen dissolves in water, and it is this oxygen that is used by fish and other organisms. If oxygen levels are too low, organisms suffocate. Bacterial decomposition in lake mud, and high algae and other plant production can lower oxygen levels enough to cause large-scale kills of certain organisms. Dissolved oxygen levels in Wabamun Lake are in the normal range for healthy lakes, and are steady. Fish kills are rare.

Redox Potential – This refers to the potential to utilize oxygen. A high redox potential indicates an oxygen-rich environment where in general, organisms use oxygen less than is available. A low redox potential indicates an oxygen poor environment where organisms use oxygen very quickly and above the typical supply. Most Alberta lakes are between 300 and 600 mV. Wabamun Lake has a healthy redox potential, and varies throughout the year in a range of 300 to 700 mV. There is no trend towards either increasing or decreasing redox potential.

Acidity/Alkalinity – The pH of water is the concentration of hydrogen ions in the water. More hydrogen ions indicate a more acidic system. The pH scale is logarithmic, meaning each integer indicates an increase of 10 times. The higher the pH, the more acid-poor or alkaline the water is, whereas a lower pH indicates a more acidic lake. A healthy lake has a pH of 6.5 to 9. Most prairie lakes are at the high end of this range because our soils are generally alkaline. The pH of Wabamun Lake ranges from 8.3 to 8.8 and is slightly increasing.

Alkalinity – This is the capacity of a lake to neutralize strong acid. It is expressed as units of calcium carbonate (CaCO3) in the water. A reading of over 100 mg/L is considered very resistant to acid. The range for Wabamun Lake is 180-220 mg/L. The readings are slightly decreasing. Acid rain is not an issue at Wabamun Lake.

Salinity (saltiness)

Salinity is a measure of the abundance of dissolved ions in the water (ions=charged elements that dissolve in water). Salinity increases over time in a lake if little runoff is received and high evaporation rates occur, since ions are left behind when water evaporates. If salinity gets too high it can negatively affect some organisms. Major ions that contribute to salinity include calcium, magnesium, sodium, carbonate, bicarbonate, sulfate and chloride. Salinity in Wabamun Lake tends to increase as water levels fall, and vice-versa. Recently, inputs of water from the North Saskatchewan River through the Wabamun WTP have been contributing certain ions to the system due to natural differences in the river water compared to Wabamun, as well as contributions from the water treatment process. Total salinity in Wabamun Lake is well below lakes considered 'saline'.

Nutrients

Phosphorus, nitrogen, carbon, and silica are all important nutrients for healthy plant growth. In most lakes, including Wabamun Lake, the growth of algae is controlled primarily by the amount of phosphorus available. The more phosphorus present the greater the algae growth. Nutrients other than phosphorus play a relatively smaller role in algae development. Total phosphorus less than or equal to 0.05 mg/L is considered healthy. Total phosphorus (TP) in Wabamun Lake ranges from 0.025 to 0.045 mg/L. This level is approaching the levels where

algae could become a bigger problem. Excess phosphorus is stored in lake bottom mud, and released slowly into the water. It is estimated that phosphorus stored in Wabamun Lake mud now contributes approximately 35-55% of the total phosphorus added to the water. To reduce the risk of increasing algae growth, it is essential to use phosphate free products in the home and garden, especially if we live close to the lake.

Human Health Concerns

Metals – There are many important metals in freshwater lakes, all of which have different properties and sources. Most metals occur naturally in rock formations while other can be indicative of atmospheric or human influences (runoff, heavy industry, mining). There are national guidelines for safe levels of metals. They are known as the Canadian Council of Environment Ministers - Protection of Aquatic Life guidelines (CCME-PAL). In 1999 tests were conducted for 27 metals in Wabamun Lake, and all were under CCME-PAL guidelines. In 2002 cadmium (2 sites) and selenium were found to be slightly over guidelines. Results for cadmium and selenium after 2002 have been below guidelines. Due to land-use in the watershed (mining, coal burning), Wabamun Lake sediments are higher in metals compared to other lakes in the region. However this has not translated into similar increases in concentrations in the water.

Mercury levels have increased in Wabamun Lake sediments because of local emissions, but again, there is no reliable data to indicate that there are increases of mercury in the water. Mercury levels in most fish in the lake are within human consumption guidelines for occasional consumers. Mercury levels in some very large pike may exceed guidelines and may be of concern if fish are consumed as a routine part of a person's diet. There are currently no mercury related health advisories for consumption of fish from Wabamun Lake. At present the fishery is "catch and release" in an effort to increase fish populations which have fallen due to over fishing.

Disinfection by-products (DBPs) – After chlorination and de-chlorination, treated water can contain several by-products in low concentrations. Long-term accumulation of some of these products may be a concern for ecosystem and human health. The concentrations of DBPs in water from the Wabamun Lake Water Treatment Plant are greatly diluted by the lake, and well below levels that would affect human health.

Polyaromatic hydrocarbons (PAHs) – The burning of coal in power plants has caused significant increases in polyaromatic hydrocarbons in the sediments, but again, we do not see evidence of this in the water. Some of these PAHs are known to cause cancer. Some PAH readings in Wabamun Lake exceeded human health toxicity guidelines just after the CN oil spill but have since reduced below guidelines.

Pesticides – These are mostly man-made chemicals. They are aimed at controlling the growth and proliferation of weeds, insects or other organisms. Little is known about the combined effect of many pesticides on life function, but some are of known concern to human health. Guidelines exist for **2-4-D**

(2,4,Dichlorophenoxyyacetic acid), **MCPA** (4-Chlor-2-methyl phenoxy acetic acid) and several others. There were two detections of 2-4-D and MCPA in 1995, and they were very much below guidelines.

Bacteria – The presence of *E.coli* bacteria indicates human or other warm-blooded animal faecal material. Faecal coliforms are short lived outside of the body, so detection in water indicates relatively 'fresh' sources. Ingestion of certain forms of faecal bacteria can cause sickness and other human health problems. Capital Health has collected water from various beaches around Wabamun Lake for the past 4-5 years. Bacterial analysis was conducted on these samples. In 2008, Alberta Environment collected water from several beaches and inflowing streams throughout the summer. Results from both programs mostly showed levels below guidelines, but some beaches and streams exceeded recreational guidelines. In 2004, Capital Health posted a health advisory at Wabamun Beach due to high bacterial levels. Alberta Environment and Capital Health scientists are working toward identifying the sources of bacteria for sites that have high *E. coli* counts.

See pages 9-10 for specific details of water quality testing at Wabamun Lake.

Details of water quality testing at Wabamun Lake

	Measure	Guidelines and Notes for Healthy Lakes	Wabamun Ranges & Information	Data Range
Water Clarity	**Secchi Disk:** Depth disk visually disappears in water column	**≥ 1.2 m**[A]	**1.5-3.5 m**	1982-2001 Casey, 2003a
	Total Suspended Solids (TSS): Quantity of particles left on filter after filtration	**≤ 10 mg/L increase over background**[B]	**1.5-4.5 mg/L** *6-9 mg/L 1981-86; mine discharge*	
	Light Profiles: Sunlight energy at different depths of water	**No accepted guidelines**	**1600 - <10 µmol/s/m^2** *decreases top to bottom in column*	
	Chlorophyll-*a*: Quantity of algal chlorophyll-*a* pigment (greenness of water)	**No accepted guidelines** *algae amounts (µg/L): Low <2.5; Moderate 2.5-8; High 8-25; Very High 25+*	**5 – 25 µg/L** *decrease of 1-2 µg/L after WTP began in 1998-99*	
Physical Measurements	**Water Temperature:** Temperature of the water	**No accepted guidelines**	**0-4 °C (winter)** **Up to ~22 °C (summer)** *typically uniform top to bottom*	1982-2001 Casey, 2003a
	Dissolved Oxygen (DO): Quantity of oxygen dissolved in water	**≥ 5.0 (1-day mean); ≥ 6.5 (7-day mean)**[B] *anoxia < 1 mg/L*	**~7-10 mg/L (open water)** **~5-7 mg/L (winter)** *low DO near bottom in winter < 3 mg/L*	
	Redox Potential: General ability of water to sustain aerobic life	**No accepted guidelines** *most lakes: 300-600 mV; Highly productive/polluted <<300 Mv*	**300-700 mV** *typically uniform top to bottom, except near sediments*	
	pH: Acidity / alkalinity of water at different depths	**6.5-9**[C] *Acid lakes ~ <6.5*	**8.3 – 8.8**	
	Alkalinity: Capacity to neutralize strong acid	**≤ 20 mg/L as $CaCO_3$**[D] *> 100 mg/L (as $CaCO_3$) very resistant to acid < 100 mg/L susceptible to acidification*	**180-220 mg/L as $CaCO_3$** *can increase with falling water levels*	
Salinity	**Major Ions:** Quantity of common ions in water (i.e. calcium, sulphate, etc.)	**Chloride >860 mg/L**[D]**; all others no accepted guidelines** *can increase with falling water levels*	**Ca 20-28; Mg 10-18; K 7-11; Na 42-70; HCO3 210-260; CO3 0-15; Cl 2-10; SO4 24-45 (all mg/L)**	1982-2001 Casey, 2003a
	Conductivity: Electrical conductivity of the water	**No accepted guidelines**	**~400-500 µS/cm** *can increase with falling water levels*	
	Total Dissolved Solids: Quantity of particles passing through filter after filtration	**No accepted guidelines** *saline lakes > 500 mg/L; freshwater lakes < 500 mg/L*	**~220-300 mg/L** *can increase with falling water levels*	
	Hardness: Quantity of calcium and magnesium in water	**No accepted guidelines** *soft 0-40 mg/L as $CaCO_3$; hard 40 - > 120 as $CaCO_3$*	**~105-135 mg/L as $CaCO_3$**	

Canadian Water Quality Guidelines: [A]Recreational and Aesthetic, 2008; [C]Protection of Aquatic Life, 2008; **Alberta Water Quality Guidelines:** [B]Protection of Aquatic Life, 1999; [E]Recreational and Aesthetic, 1999 **USA Environmental Protection Agency:** [D]Water Quality Standards, 2008

mg/L: milligrams per litre; Dissolved ions: Ca-calcium; Mg-magnesium; K-potassium; Na-sodium; HCO3-bicarbonate; CO3-carbonate; Cl-chloride; SO4-sulphate

WTP – Wabamun Water Treatment Plant: Water has been taken from the North Saskatchewan, treated to drinking water standards and pumped into Wabamun since 1998

Details of water quality testing at Wabamun Lake

	Measure	Guidelines and Notes for Healthy Lakes	Wabamun Ranges & Information	Data Range
Nutrients	**Phosphorus:** Quantity of phosphorus in water (several forms)	**Total Phosphorus ≤ 0.05 mg/L**[B] *TP amounts (mg/L): Low <0.01; Moderate 0.01-0.035; High 0.035-0.1;Very High 0.1+*	**0.025-0.0458 mg/L**	1982-2001 *Casey, 2003a*
	Nitrogen: Quantity of N in water (several forms)	**Total Nitrogen ≤ 1.0 mg/L**[B]	**0.6-1.4 mg/L**	
	Carbon: Quantity of carbon in water (several forms)	**No accepted guidelines**	**DOC 10-15 mg/L**	
	Silica: Quantity of silica in water	**No accepted guidelines**	**~0.5-6 mg/L**	
	Chlorophyll-a: Quantity of algal chlorophyll-a pigment (greenness of water)	**See "Water Clarity" section**	***See "Water Clarity" section**	
Human Health Concerns	**Metals:** Quantity of ~30 different metals in water (several forms)	**SEVERAL** *see http://ceqg-rcqe.ccme.ca/*	*-all metals below CCME-PAL guidelines* *-cadmium (2 sites), selenium (1 site) slightly over guideline*	1996-2001 *Casey, 2003a* 2002 *Anderson, 2003*
	Disinfection By-Products (DBPs): Quantity of potential health concerning organic by-products of water disinfection	**Chloroform ≤ 1.8 µg/L**[C] **Methylene chloride ≤ 98 µg/L**[C] **Carbon tetrachloride ≤ 13.3 µg/L**[C]	**Chloroform 0.6-8.5 µg/L** *in WTP* **Haloacetic acids, aldehydes, chlorate** *below toxicity endpoints*	2003 *Casey, 2003b*
	Organic contaminates/Poly Aromatic Hydrocarbons (PAHs): Quantity of potentially health concerning hydrocarbons	**SEVERAL** *see http://ceqg-rcqe.ccme.ca/*	*-several data sets related to AENV studies, Donahue et al. (2003) and documents related to CN spill* *-some limits exceeded both before and after spill in **sediments*** *-some PAH limits exceeded in **water** just after spill before retreating below guidelines*	**Various** *See Wabamun Lake bibliography*
	Pesticides: Quantity of synthetic chemicals used to inhibit pests, weeds, etc.	**2,4-Dichlorophenoxyacetic acid ≤ 4.0 µg/L**[C] **2-methyl-4-chlorophenoxyacetic acid ≤ 2.6 µg/L**[C]	**2,4-D 0.005-0.014 µg/L** **MCPA 0.0065 µg/L**	2002 *Anderson, 2003* 1995 *Casey, 2003a*
	Bacteria: Quantity of important indicator (faecal) bacteria (i.e. *E. coli*)	**200 CFU/100mL**[E]	*-streams/beaches mostly below recreational guidelines* *-Alberta Health Services has data from 2001+ for public beaches*	-2008 *Study Overview* -2001-2008 *AHS*

Canadian Water Quality Guidelines: [A]Recreational and Aesthetic, 2008; [C]Protection of Aquatic Life, 2008; **Alberta Water Quality Guidelines:** [B]Protection of Aquatic Life, 1999; [E]Recreational and Aesthetic, 1999 **USA Environmental Protection Agency:** [D]Water Quality Standards, 2008

mg/L: milligrams per litre; DOC-dissolved organic carbon

WTP – Wabamun Water Treatment Plant: Water has been taken from the North Saskatchewan, treated to drinking water standards and pumped into Wabamun since 1998

For full references to reports cited, *See Wabamun Lake bibliography*.