Twenty times a year since 2003, **Barr Lake** and **Milton Reservoir** have been sampled for water quality. These 360 trips to both reservoirs have produced an abundance of data and information. This is Part 8 of 8 of a water quality summary series for 2020 calendar year for both reservoirs. The first seven summaries focused on pH, Chl-a, dissolved oxygen, water temperature, phosphorus, nitrogen, and water clarity; this one discusses alkalinity.

The Big Picture – Eutrophication is the addition of nutrients and sediments to water bodies resulting in algae and plant growth and sedimentation. This natural process occurs over a long, geological period - 1,000's of years. Many lakes, reservoirs, ponds, and even estuaries throughout the world experience "*cultural eutrophication*". This term means that water bodies become more productive and shallower much quicker (months to years) due to increased inputs of nutrients and sediments from human activities. This unnatural, accelerated aging of lakes causes an obvious biological response – algae growth that usually leads to blue-green algal scums. This biological response then leads to chemical and physical changes within the water – pH, oxygen, water clarity and color, fish, water safety, plants, and aesthetics can all impact the health of the water.

Alkalinity – It is the measure of water's ability to resist pH changes (buffers the effects of strong acids and bases to keep pH steady). Alkalinity is the sum of negatively charged compounds (bases) in the water. The majority of these compounds come from weathered rock or calcium carbonate ($CaCO_3$). Calcium carbonate then dissolves into bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}). Alkalinity is measured as $CaCO_3$ under the assumption that all of the alkalinity is in carbonate or bicarbonate form. Bicarbonate has one negative charge and neutralizes one positive hydrogen (H^+) while carbonate has two negative charges and can neutralize two hydrogen ions.

"Bathtub ring" of calcium deposit at Barr Lake

Alkalinity is influenced by rocks, soils, and salts. Decomposition and the lack of dissolved oxygen can also increase alkalinity. Treated industrial and municipal wastewater can be sources of alkalinity in order to maintain effective biological activity and pH control. Reservoirs with high alkalinity and pH precipitate calcium. This is how the "bathtub ring" is formed on reservoir dams. The water quality goal for alkalinity from the phased pH/DO TMDL is 95 mg/L during the growing season. A lower alkalinity will lower the background pH, allowing room for pH increases caused by algal productivity.

Alkalinity can be lowered chemically by adding more H^+ ions. This can be accomplished by keeping the water aerated allowing for H^+ production. Alkalinity can also be reduced by dilution of water with less alkaline water. Rain and storm water are typically lower in alkalinity because of less contact time with rocks.

Water Quality Summary: Alkalinity

2020 Barr Lake & Milton Reservoir

2020 Alkalinity Data – Alkalinity data were collected from the one-meter depth during each visit. Samples were analyzed in a laboratory by titrating with a strong acid to see how many H^+ ions could be neutralized. For 2020, there were 16 alkalinity concentrations recorded for each reservoir (Table 1).

Table 1. Barr Lake and Milton Reservoir 2020 alkalinity data (as $CaCO_3$ mg/L). Bold values exceed the water quality target.

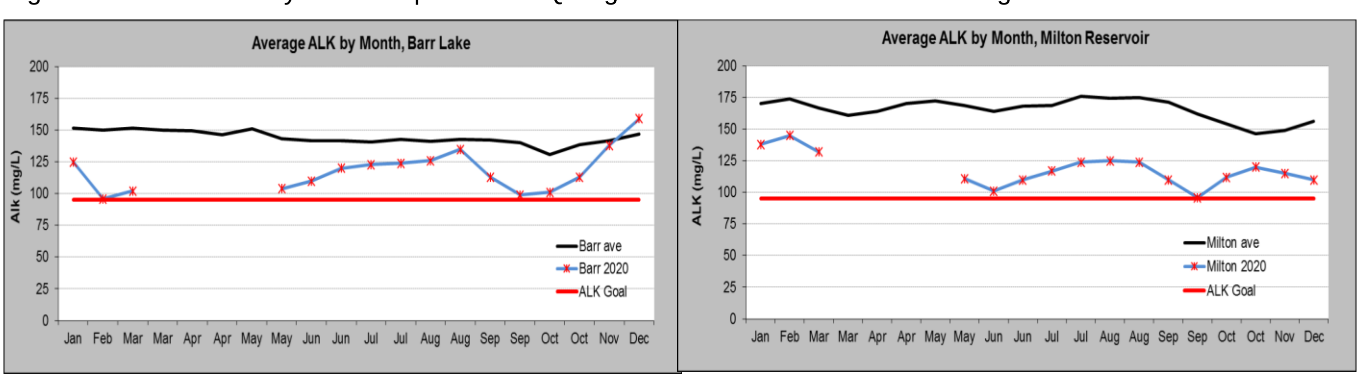
Month	Alk (Barr)	Alk (Milton)
Jan	125	138
Feb	96	145
Mar	102	132
Mar	NA	NA
Apr	NA	NA
Apr	NA	NA
May	NA	NA
May	104	111
Jun	110	101
Jun	120	110
Jul	**123**	**117**
Jul	**124**	**124**
Aug	**126**	**125**
Aug	**135**	**124**
Sep	**113**	**110**
Sep	**99**	**96**
Oct	101	112
Oct	113	120
Nov	138	115
Dec	159	110

The average alkalinity for **Barr Lake** in 2020 was 118 mg/L and 118 mg/L for **Milton Reservoir**. From sampling event to sampling event, the alkalinity does not change drastically. Barr remained below average for most of the year until the refill started. Milton had very little changes in alkalinity with a slight overall decline.

The growing season (July 1 – September 30) average for **Barr Lake** was 120 mg/L and 116 mg/L for **Milton Reservoir**. The growing season average was slightly lower than the annual average for Milton indicating that algae productivity was higher outside of the summer growing season. Typically, primary productivity will increase pH, which also increases alkalinity.

Figure 1 shows the annual cycle, goal, and 2020 results for alkalinity. **Barr Lake's** drawdown allowed for a drop in alkalinity and then a sharp increase from the inflows. **Milton Reservoir** typically has about 25 mg/L as $CaCO_3$ more alkalinity than Barr (compare the two average lines). This year, Milton had lower alkalinity than Barr on nine occasions. The below average alkalinity has occurred for the past few years along with improvements in point source treatments.

Figure 1. 2020 Alkalinity data compared to WQ target and 2003-20120annual average



Water Quality Summary: Alkalinity

2020 Barr Lake & Milton Reservoir

Aquatic Chemistry – pH and alkalinity are important water quality parameters to understand. They both deal with positive hydrogens (acids) and negative oxides (bases). pH is the measurement of the concentration of H^+ ions, and alkalinity is the measurement of mostly HCO_3^-, CO_3^{2-}, and OH^-. As pH goes up, there is less H^+ (negative compounds attach to them) and more negatively charged compounds. From Figure 2 below, if reservoir water has a pH of just over 8.0, then most of the alkalinity is in the form of HCO_3^-. The higher the pH, the greater the buffering capacity because carbonate has a negative charge of 2. When bicarbonate is in large quantities, calcium will bond with it and precipitate out, forming the whitish bathtub ring along the dam (also called marl).

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

(Carbon dioxide) *(Carboic acid)*

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

(Bicarbonate)

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

(Carbonate)

$$Ca^{2+} + CO_3^{2-} \rightleftharpoons CaCO_3$$

(Calcium carbonate)

Figure 2.