Water Quality Summary: Alkalinity

2019 Barr Lake & Milton Reservoir

Twenty times a year since 2003, **Barr Lake** and **Milton Reservoir** have been sampled for water quality. These 340 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 2019 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 to water bodies resulting in nuisance algae growth and sedimentation. This natural process usually occurs over a long geological period of time. Many lakes, reservoirs, and even estuaries and bays throughout the world experience "*cultural eutrophication*". This term means that water bodies tend to become more productive and shallower over relatively short periods of time due to increased inputs of nutrients and sediments from human activities. Accelerated aging of lakes causes a quick biological response – severe algae growth. This response then leads to other chemical and physical changes within the water – pH, oxygen, water clarity and color, fish, plants, and aesthetics can all change.

"Bathtub ring" of calcium deposit at Barr Lake

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 in water to 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.

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.

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2019 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 2019, there were 20 alkalinity concentrations recorded for each reservoir (Table 1).

Table 1. Barr Lake and Milton Reservoir 2019 alkalinity data (as $CaCO_3$ mg/L). Bold values exceed the water quality target.

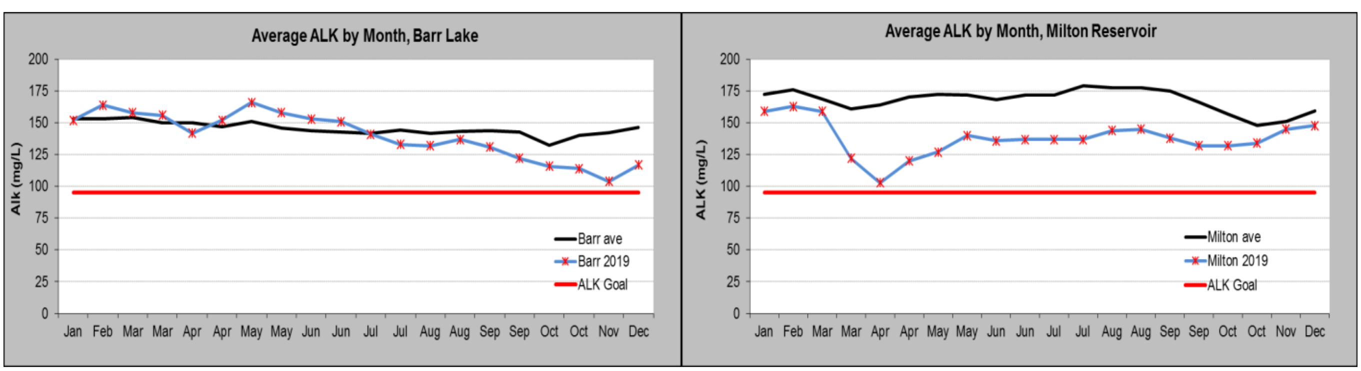
Month	Alk (Barr)	Alk (Milton)
Jan	152	159
Feb	164	163
Mar	158	159
Mar	156	122
Apr	142	103
Apr	152	120
May	166	127
May	158	140
Jun	153	136
Jun	151	137
Jul	**141**	**137**
Jul	**133**	**137**
Aug	**132**	**144**
Aug	**137**	**145**
Sep	**131**	**138**
Sep	**122**	**132**
Oct	116	132
Oct	114	134
Nov	104	145
Dec	117	148

The average alkalinity for **Barr Lake** in 2019 was 140 mg/L and 138 mg/L for **Milton Reservoir**. From sampling event to sampling event, the alkalinity does not change drastically. Barr remained near average for most of the year while Milton experienced bigger deviations from the average.

The growing season (July 1 – September 30) average for **Barr Lake** was 133 mg/L and 139 mg/L for **Milton Reservoir**. The growing season average was slightly lower than the annual average for Barr 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 2019 results for alkalinity. **Barr Lake** had a normal year with a steady decline in alkalinity after August. **Milton Reservoir** typically has about 25 mg/L as $CaCO_3$ more alkalinity than Barr (compare the two average lines). The noticeable fluctuations in April were during times of inflows that may have diluted the alkalinity. The below average alkalinity has occurred for the past few years along with improvements in point source treatments.

Figure 1. 2019 Alkalinity data compared to WQ target and 2003-2019 annual average



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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.