2016 Water Quality Summary Series – Alkalinity

Since 2003, water quality scientists have observed and sampled Barr Lake and Milton Reservoir twenty times a year for a variety of water quality parameters. These 240 trips to both reservoirs have produced an abundance of data and information. This is Part 8 of a continuing series summarizing the 2016 water quality data.

The Big Picture – 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 impacts in the watershed. Eutrophication is a natural process, but it generally occurs over a much longer geological period. This 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 column – pH, oxygen, water clarity, water color, and aesthetics.


"Bathtub ring" of calcium deposit at Barr Lake

Alkalinity – This is the measurement of how much acid water can neutralize (buffers the effects of acid and keeps 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 $CaCO_3$ because 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 controlled by rocks, soils, and salts. Decomposition and the lack of dissolved oxygen can also increase alkalinity. Industrial waste and wastewater can also be sources of alkalinity. Reservoirs with high alkalinity and high 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 closer to 8.0. This will allow room for pH to increase when there is algal productivity.

Alkalinity can be lowered chemically by adding more H^+ ions. This can be done by keeping the water aerated allowing for H^+ production. Alkalinity can also be reduced by dilution of water with less alkalinity. Rain and fast moving storm water are typically lower in alkalinity because of water moving rapidly through the watershed without time to dissolved calcium carbonate. Advanced treatment of wastewater will also lower alkalinity because of biological activity in the treatment process.

2016 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 2016, there were 20 alkalinity concentrations recorded for each reservoir (Table 1).

Table 1. Barr Lake and Milton Reservoir 2016 alkalinity data (as $CaCO_3$ mg/L). Bold values exceed the water quality target.

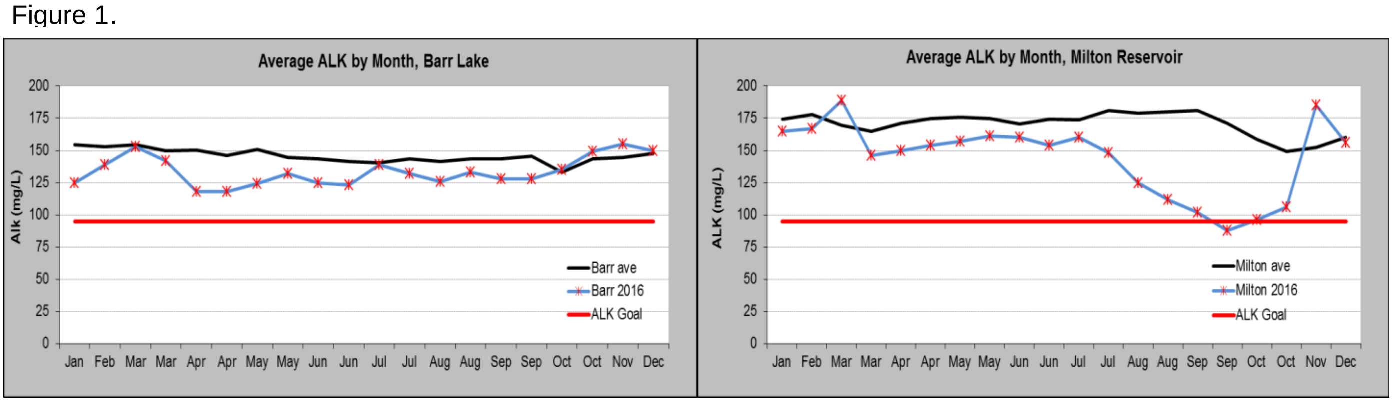
Month	Alk (Barr)	Alk (Milton)
Jan	125	165
Feb	139	167
Mar	153	189
Mar	142	146
Apr	118	150
Apr	118	154
May	124	157
May	132	161
Jun	125	160
Jun	123	154
Jul	**139**	**160**
Jul	**132**	**148**
Aug	**126**	**125**
Aug	**133**	**112**
Sep	**128**	**102**
Sep	**128**	**88**
Oct	135	96
Oct	149	106
Nov	155	185
Dec	150	156

The average alkalinity for **Barr Lake** in 2016 was 134 mg/L and 144 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 while Milton experienced a big decrease in alkalinity during the drawdown.

The growing season (July – September) average for **Barr Lake** was 131 mg/L and 123 mg/L for **Milton Reservoir**. The growing season average was slightly lower than the annual average for both reservoirs indicating that algae productivity was not so high. Typically, primary productivity will increase pH, which also increases alkalinity.

Figure 1 shows the annual cycle, goal, and 2016 results for alkalinity. **Barr Lake** had below normal values for alkalinity until October. Precipitation was above normal March through May and may have caused this dilution. **Milton Reservoir** typically has about 25 mg/L as $CaCO_3$ more alkalinity than Barr (compare the two average lines). The drawdown at Milton altered alkalinity from August to early November.

Figure 1.



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 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.