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Water Quality Summary: Nitrogen

2020 Barr Lake & Milton Reservoir

BARR MILTON Watershed Association

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 6 of 8 of a water quality summary series for 2020 calendar year for both reservoirs. The first five summaries focused on pH, Chl-a, dissolved oxygen, temperature, and phosphorus. This summary covers nitrogen (N).

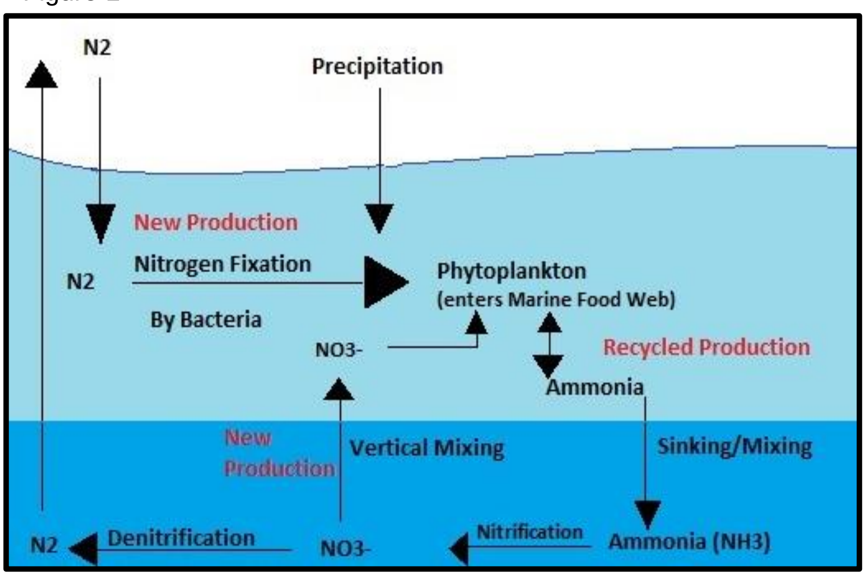
The Big Picture – Eutrophication is the addition of nutrients and sediments to water bodies resulting in algae and plant growth and sedimentation. This natural process occurs over a long, geological period - 1,000's of years. Many lakes, reservoirs, ponds, and even estuaries throughout the world experience "*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.

Nitrogen – N is an element that is required by all living organisms and comes in many forms. N is the most abundant element in the atmosphere, comprising 78%. Typically, saltwater is nitrogen limited while freshwater is phosphorus limited. Under the right conditions, N can also be the limiting nutrient for freshwater lakes.

In water, N can occur in three forms: dissolved N gas, inorganic N, and organic N (Figure 1). Some cyanobacteria can use dissolved N gas while other plants use inorganic N. Nitrogen fixation by cyanobacteria is one reason why they grow so well; they are capable of fixing (assimilating) the dissolved N gas when there are no other forms of N in the water. Nitrogen limited waters then promote these N-fixing bacteria.

Organic N is the nitrogen that is in living, dead, or decomposing plants and animals. Examples of organic N are proteins, amino acids, and some humic compounds.

Figure 1



The two main forms of inorganic N are ammonia (NH_3) and nitrate (NO_3^-). NH_3 is preferred by plants. This form of N takes the least amount of energy to assimilate. NH_3 is released from decomposing organic N and ammonification of NO_3^- by bacteria when dissolved oxygen is not present. NH_3 is the most reactive form of N and can adhere to sediment particles. NH_3 in water is present primarily as ammonium (NH_4^+). Ammonia is toxic to aquatic organisms but NH_4^+ is not. Water temperature and pH determines the ratio of NH_3 and NH_4^+in the water.

Nitrification is the biological conversion of organic and inorganic N from a reduced state to a more oxidized state. NO_3^- is the next inorganic compound that plants use and is the most common inorganic form in lakes. NO_3^- can convert to NH_3 by ammonification or convert to dissolved N gas that will dissipate into the atmosphere. NO_3^- does not bind to soil but can leach into groundwater. Nitrite (NO_2^-) is the slightly reduced form of NO_3^- but is not as common.

Total nitrogen (TN) is the summation of all N in the water (organic, inorganic, particulate, and dissolved). Total Kjeldahl Nitrogen (TKN) is the measurement of organic N, NH_3, and NH_4^+. To calculate TN, nitrate and nitrite need to be added to TKN. Total inorganic N (TIN) is the summation of NH_4^+, NH_3, NO_3^-, and NO_2^-; this is what's readily available for plants. TN concentration over 10 mg/L in freshwater is considered high in general terms.

A TN standard has been established for **Barr Lake** and **Milton Reservoir** at 0.91 mg/L. This is the interim nutrient criteria value for warm water lakes and will be applied state wide in 2027. The ammonia standard for lakes is based on water temperature and pH. There are different ammonia standards. There are chronic and acute values for two different seasons, early life stages absent (September through March) and early life stages present (April through August). These standards are further applied to cold and warm waters to protect salmonids. Barr and Milton are warm water so the salmonid values do not apply.

2020 Nitrogen Data – Nitrogen data are collected from one-meter below the surface and one meter from the lake bottom during each visit. For 2020, there were 16 nitrogen sampling events for each reservoir. Only epilimnion (1-m) data are shown in Table 1.

Table 1. Barr Lake and Milton Reservoir 2020 epilimnion nitrogen data (mg/L). Bold values exceed the interim nutrient criteria value.

	Barr Lake (mg/L)					Milton Reservoir (mg/L)				
Month	NH_3	NO_{3+2}	TKN	TN	TN:TP	NH_3	NO_{3+2}	TKN	TN	TN:TP
Jan	<0.05	0.62	2.5	3.12	8.7	<0.05	4.02	1.8	5.82	20.8
Feb	<0.05	0.39	2.2	2.59	7.8	<0.05	0.29	2.2	2.49	8.6
Mar	0.30	0.52	2.2	2.72	7.4	<0.05		1.9	2.36	6.9
Mar	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Apr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Apr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
May	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
May	0.40	0.07	1.5	1.57	7.1	<0.05	<0.02	1.8	1.80	9.5
Jun	0.53	0.33	1.6	1.93	7.4	<0.05	0.02	1.8	1.82	7.3
Jun	0.36	0.26	2.0	2.26	5.6	<0.05	<0.02	1.7	1.70	7.1
Jul	0.08	0.02	2.0	**2.02**	5.6	0.09	<0.02	1.4	**1.40**	5.8
Jul	0.08	0.03	1.6	**1.63**	3.9	<0.05	0.04	1.5	**1.54**	5.5
Aug	0.12	0.07	3.3	**3.37**	6.9	0.07	0.03	2.3	**2.33**	7.5
Aug	0.09	0.05	2.0	**2.05**	4.7	<0.05	0.03	1.9	**1.93**	8.0
Sep	<0.05	<0.02	2.9	**2.90**	7.4	<0.05	0.10	2.7	**2.80**	8.5
Sep	<0.05	0.03	3.2	**3.23**	7.0	<0.05	0.03	2.1	**2.13**	12.5
Oct	0.30	0.10	4.1	4.20	8.8	<0.05	0.06	2.9	2.96	10.2
Oct	<0.05	0.45	3.5	3.95	9.6	<0.05	0.08	2.5	2.58	10.8
Nov	0.19	1.96	2.9	4.84	13.8	<0.05	0.04	2.8	2.84	10.1
Dec	0.16	2.14	2.2	4.34	14.5	0.16	0.04	2.7	2.74	11.4

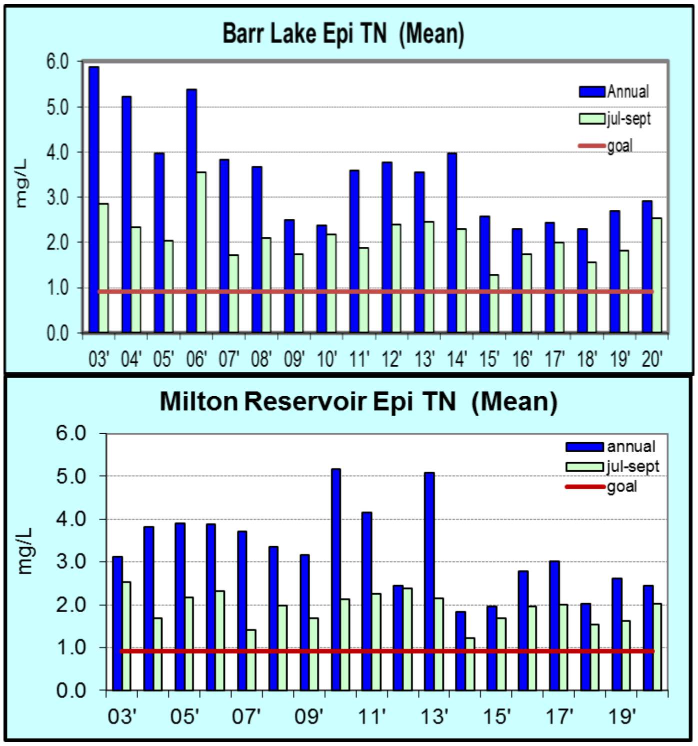
The average TN for **Barr Lake** in 2020 was 2.92 mg/L and 2.45 mg/L for **Milton Reservoir**. TN tends to decrease through the growing season for both reservoirs until they begin to refill in the fall/winter. TKN increased the most in the late summer and fall for both reservoirs. Again, TKN is comprised of organic N and ammonia. For Barr and Milton, TKN increases are driven by the increase in organic N (i.e., algae growth). Ammonia is close to detection limits when TKN increases.

The growing season (July 1 – September 30) average TN for **Barr Lake** was 2.53 mg/L and 2.02 mg/L for **Milton Reservoir**. Typically, the growing season average is lower than the annual average because of the winter fill period and uptake, settling, and releasing of N during the summer.

The ammonia standard was met for both Barr Lake and Milton Reservoir in 2020 with no exceedances. TKN in Barr spiked during the major drawdown period.

Figure 2 shows the annual and growing season averages since 2003. There is an overall downward trend in the annual average TN since 2003. **Milton Reservoir** has slightly less TN on average than **Barr Lake.** There is a noticeable decline in TN for both reservoirs since 2014.

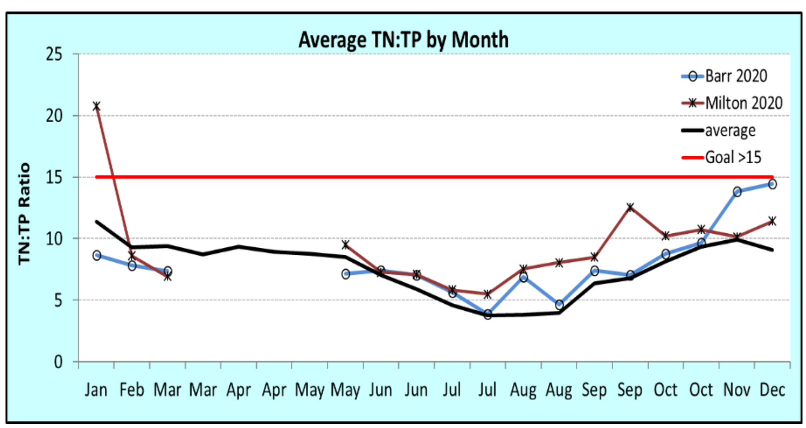
Figure 2



TN:TP Ratio – In a complex reservoir system, there are multiple factors acting at once to influence algal growth. Both phosphorus and nitrogen are equally important. Other factors such as sunlight, water temperature, and even carbon and silica play an important role.

N is much harder to control since cyanobacteria can assimilate the dissolved N gas that comes from an endless source, the atmosphere. Phosphorus, on the other hand, is more controllable and less abundant. For these reasons, it is more desirable to have a phosphorus limited reservoir.

Figure 3. 2020 TN:TP ratio compared to 2003-2020 annual average



A TN:TP ratio greater than 20 is a desirable ratio that would indicate a phosphorus limited system. Cyanobacteria blooms can be reduced when the ratio is kept high. Figure 3 shows the TN:TP ratio for 2020 for both reservoirs. **Barr's** ratio did not reach 15 or higher all year. **Milton's** ratio went above 10 six times. Both reservoirs were not phosphorus limited for most of the year. Even though concentrations might be lower, it is important to understand that the ratio of N and P is just as critical as their individual concentrations.