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Water Quality Summary: Phosphorus

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 5 of 8 of a water quality summary series for 2019 calendar year for both reservoirs. The first four summaries focused on pH, chl-a, dissolved oxygen, and water temperature; this one discusses phosphorus.

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.

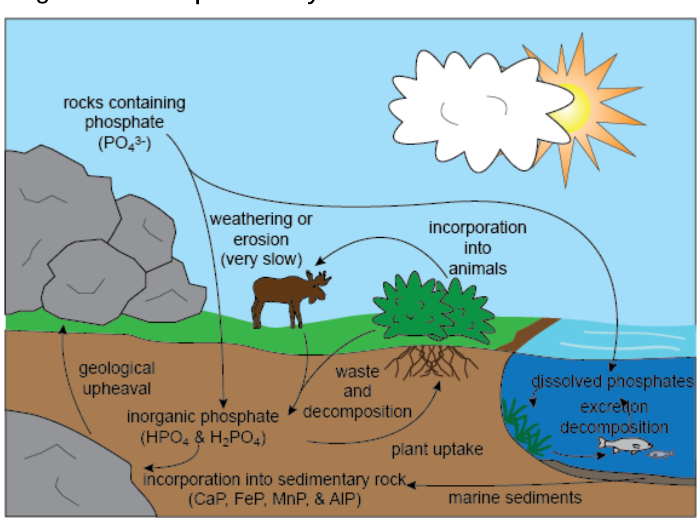
***Phosphorus* –** Phosphorus is a chemical element that is required by all living organisms. Phosphorus can be attached to soils (inorganic), dissolved in water (organic or inorganic), or be in the form of biomass (organic) (Figure 1). Phosphorus cannot be a gas. The most common form of phosphorus is the oxidized state, *phosphate* (PO_4^{-3}). Phosphates exist in three forms: orthophosphate, polyphosphate, and organically-bound phosphate. Orthophosphate is the compound that is available for algae/plant uptake.

Total phosphorus (TP) is the analysis that sums all of the phosphorus forms in a water sample (organic, inorganic, particulate, and dissolved). Soluble Reactive Phosphorus (SRP) or orthophosphate is the analysis that includes the soluble, inorganic phosphates.

Phosphorus is a key nutrient that determines how much algae can grow in a lake. Concentrations are typically expressed in units of micrograms per liter (µg/L) or parts per billion (ppb). The two forms commonly analyzed are TP and SRP. Concentrations below 10 µg/L are considered low and values greater than 20 - 50 µg/L are considered high in general terms.

Excessive nutrient inputs are the main cause of *cultural eutrophication*. Too many nutrients

Figure 1. Phosphorus cycle



lead to aesthetic issues, odor problems, cyanotoxins, large dissolved oxygen fluctuations, and lower water clarity. The TP goal that has been determined for **Barr Lake** and **Milton Reservoir** is 100 µg/L or less in the epilimnion (top mixing water, about three meters deep) during the growing season (July 1 – September 30).

***2019 Phosphorus Data* –** Phosphorus data were collected from the one-meter depth and one meter from the bottom depth during each visit. For 2019, there were 40 phosphorus samples analyzed for each reservoir. Only top water data are shown in Table 1.

Table 1. Barr Lake and Milton Reservoir 2019 epilimnion phosphorus data (µg/L). Bold values exceed water quality target. Both reservoirs were sampled.

Barr Lake (µg/L)			Milton Reservoir (µg/L)		
Month	**TP**	**SRP**	**Month**	**TP**	**SRP**
Jan	380	590*	**Jan**	690	640
Feb	520	320	**Feb**	520	350
Mar	540	480	**Mar**	510	290
Mar	580	360	**Mar**	520	130
Apr	480	230	**Apr**	310	30
Apr	410	380	**Apr**	320	120
May	490	440	**May**	380	330
May	470	410	**May**	400	370
Jun	410	350	**Jun**	380	340
Jun	390	370	**Jun**	410	380
Jul	**390**	360	**Jul**	**400**	370
Jul	**510**	320	**Jul**	**430**	380
Aug	**350**	290	**Aug**	**340**	220
Aug	**260**	170	**Aug**	**250**	130
Sep	**190**	50	**Sep**	**110**	40
Sep	**150**	210	**Sep**	**170**	50
Oct	180	<10	**Oct**	100	20
Oct	200	10	**Oct**	110	<10
Nov	230	20	**Nov**	460	280
Dec	300	-	**Dec**	380	-

*SRP cannot be greater than TP, analytical error

Units - microgram

µg/L or Parts Per Billion (ppb) is a really small concentration

Example:
1 drop in 2 tanker trucks

State defined "Growing Season" for Colorado Lakes and Reservoirs: this is the peak time for recreational use, irrigation, and when a waterbody is most productive.

The average TP for **Barr Lake** in 2019 was 372 µg/L and 360 µg/L for **Milton Reservoir**. Coming off of Milton's lowest annual TP average in 2019, the reservoir continues to try to get below 100 µg/L. The winter refill creates an annual challenge. Historically, the winter time refill is when the majority of the phosphorus enters the reservoirs. Barr also saw a noticeable increase in TP in late July after 154 days of thermal stratification (92 of which had no oxygen at the bottom) ended. TP at the bottom of Barr peaked for the year at 720 µg/L on 07/09/20 and then the water column fully mixed by the end of July allowing for the spike in TP. Inflow volumes were minor during July and could not have increased the epi TP by 120 µg/L in two weeks' time.

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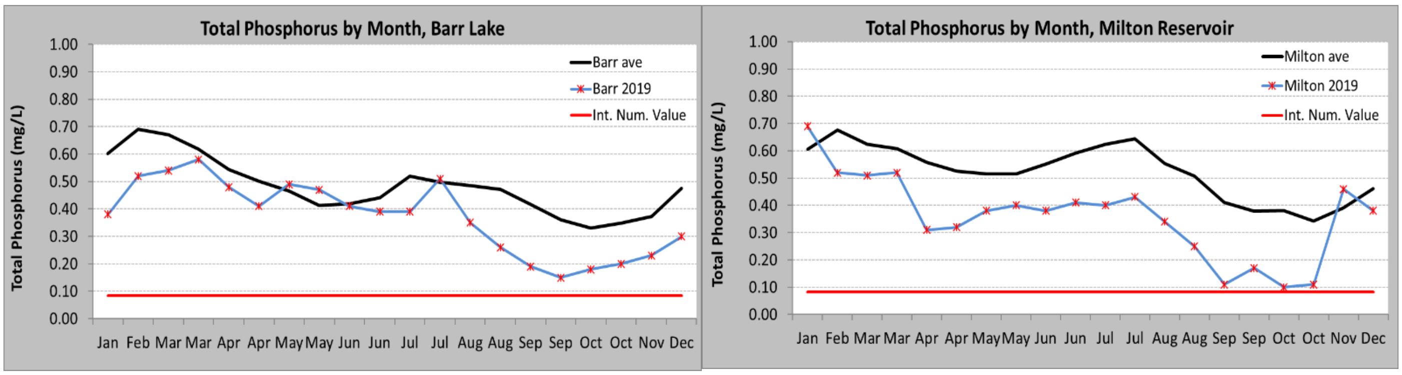
The growing season average for **Barr Lake** was 308 µg/L and 283 µg/L for **Milton Reservoir**. Typically, the growing season average is lower than the annual average.

Figure 2 shows the annual TP cycles, TP target, and 2019 data for both lakes. **Barr Lake** TP was close to average for the first half of the year. The Burlington Pumps have not operated since February 10, 2012. **Milton Reservoir** followed the average trend where TP is highest in January, slowly drops all year long, with a small increase during the July and then a major increase in November when the refill begins.

Figure 2. 2019 Phosphorus data compared to WQ targets and 2003-2019 annual average



Internal Loading – Another way that phosphorus can enter lakes is from the lake sediment. This typically occurs when the bottom of a lake is anoxic (void of oxygen). No dissolved oxygen allows for a chain reaction to occur that results in a release of dissolved phosphorus from the sediments. This can happen during the winter or spring when the reservoirs are deeper than 7 meters. The other cause for internal loading is from sediments being physically stirred. This happens when the reservoirs are shallow in the late summer and winds can re-suspend sediments. Carp and other bottom feeders can also stir up the sediments. Carp are known to dig up to a foot in the sediments to get food. This is called "*bioturbation"* – when aquatic animals disturb the sediments.