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Water Quality Summary: Phosphorus

2020 Barr Lake & Milton Reservoir

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 5 of 8 of a water quality summary series for 2020 calendar year for both reservoirs. The first four summaries focused on pH, chl-a, dissolved oxygen, and water temperature; this one discusses phosphorus.

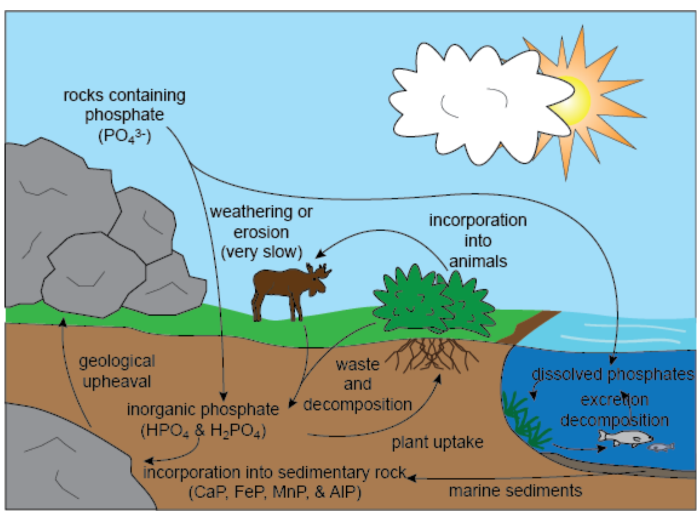
The Big Picture – Eutrophication is the addition of nutrients and sediments to water bodies resulting in algae and plant growth and sedimentation. This natural process occurs over a long, geological period - 1,000's of years. Many lakes, reservoirs, ponds, and even estuaries throughout the world experience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

***Phosphorus* –** Phosphorus is an 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 sum of all 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 usually determines how much algae can grow in fresh water. Concentrations are expressed in units of micrograms per liter (µg/L) or parts per billion (ppb). The two forms commonly analyzed are TP and SRP. TP concentrations below 10 µg/L are considered low and values greater than 20 - 50 µg/L are considered high in general terms.

Figure 1. Phosphorus cycle



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

2020 Phosphorus Data – Phosphorus data were collected one meter from the surface and from the lake bottom during each visit. For 2020, there were 32 phosphorus samples analyzed for each reservoir. Only top water data are shown in Table 1.

Table 1. Barr Lake and Milton Reservoir 2020 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	360	80	**Jan**	280	160
Feb	330	220	**Feb**	290	110
Mar	370	270	**Mar**	340	400*
Mar	NA	NA	**Mar**	NA	NA
Apr	NA	NA	**Apr**	NA	NA
Apr	NA	NA	**Apr**	NA	NA
May	NA	NA	**May**	NA	NA
May	220	160	**May**	190	710*
Jun	260	210	**Jun**	250	170
Jun	320	230	**Jun**	240	70
Jul	**360**	1,030*	**Jul**	**240**	220
Jul	**420**	360	**Jul**	**280**	160
Aug	**490**	610*	**Aug**	**310**	100
Aug	**440**	220	**Aug**	**240**	50
Sep	**390**	50	**Sep**	**330**	30
Sep	**460**	10	**Sep**	**170**	<10
Oct	480	60	**Oct**	290	10
Oct	410	70	**Oct**	240	10
Nov	350	40	**Nov**	280	20
Dec	300	90	**Dec**	240	<10

*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 2020 was 373 µg/L and 265 µg/L for **Milton Reservoir**. Milton, for the 6th year in a row, continues to have below average TP levels for the entire year. It was noticeable that Milton's TP stayed relatively steady for the year with no major trends. The winter refill can create an annual challenge. Historically, the winter-time refill is when the majority of the phosphorus enters each reservoir. Barr did experience a noticeable increase in TP through the summer after the last inflows stopped on 06/10/20. This summer TP increase is considered internal loading. Internal loading can come from low oxygen levels and or resuspension from water mixing and bioturbation from carp activity. Overall, TP in both reservoirs did not show any major issues or spikes.

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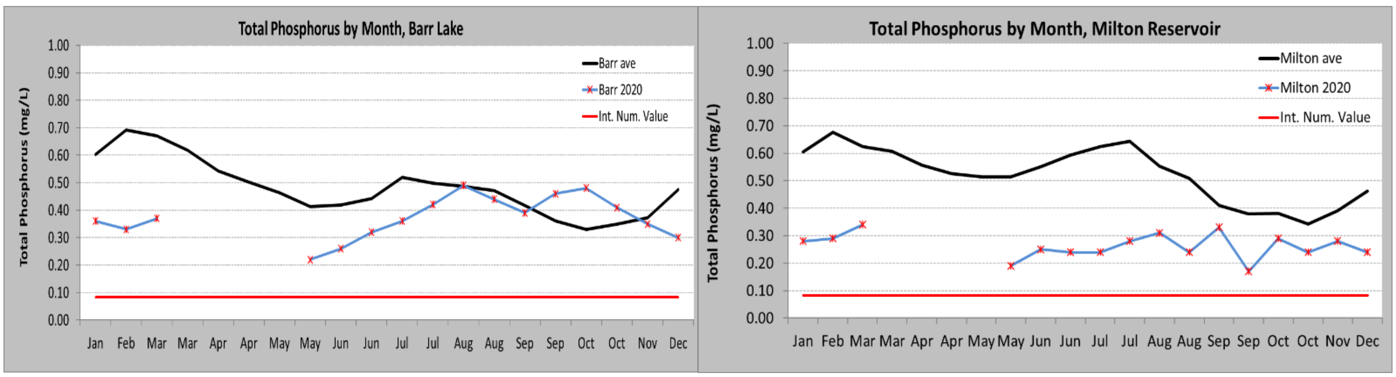
The growing season average for **Barr Lake** was 427 µg/L and 262 µg/L for **Milton Reservoir**. Typically, the growing season average is lower than the annual average. Barr's average was higher during the growing season because of higher levels from internal loading.

Figure 2 shows the annual TP cycles, TP target, and 2020 data for both lakes. **Barr Lake** TP was below to average for the first half of the year. The Burlington Pumps have not operated since February 10, 2012. **Milton Reservoir** did not follow the annual cycle of TP. The range of TP was 170 to 340 µg/L in Milton with no major peaks of TP. The winter time levels are dependent on inflows from the S. Platte River and what the TP concentrations are during diversions.

Figure 2. 2020 Phosphorus data compared to WQ targets and 2003-2020 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.