

Barr Lake and Milton Reservoir's water quality has been sampled twenty times a year since 2003. These 420 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 2023 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 unnaturally accelerated aging of lakes causes a biological response – algae growth that usually leads to blue-green algal scums. This biological response then triggers chemical and physical changes within the water – pH, oxygen, water clarity and color, fish, water safety, plants, and aesthetics.

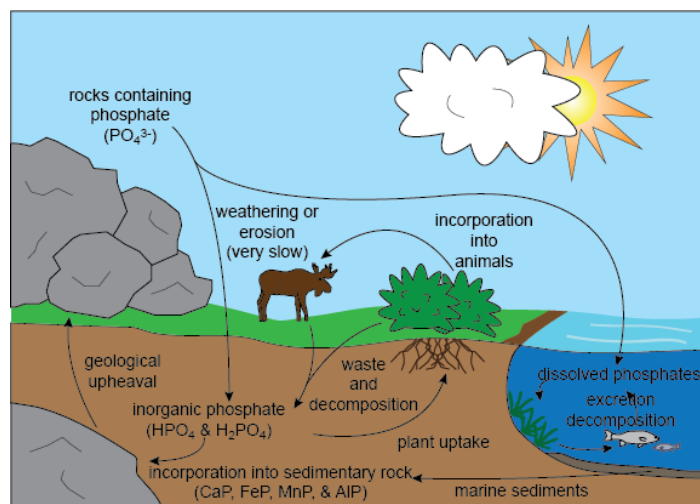
Phosphorus – Phosphorus is an element that is required by all living organisms. Phosphorus can be attached to soils (inorganic), dissolved in water (organic or inorganic), or be in the form of biomass (organic) (Figure 1). Phosphorus cannot be a gas. The most common form of phosphorus is the oxidized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

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

Phosphorus is a key nutrient that usually determines how much algae can grow in freshwater. Concentrations are expressed in units of micrograms per liter ($\mu\text{g/L}$) or parts per billion (ppb). The two forms commonly analyzed are TP and SRP. TP concentrations below 10 $\mu\text{g/L}$ are considered low and values greater than 20 to 50 $\mu\text{g/L}$ 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, odors, cyanotoxins, 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) during the growing season (July 1 – September 30). The Colorado updated TP standard for warm-water lakes is 0.047 µg/L. This is a growing season average.

2023 Phosphorus Data – Phosphorus data were collected one meter from the surface and from the lake bottom during each visit. For 2023, 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 2023 epilimnion phosphorus data (µg/L). Bold values exceed the water quality standard. Both reservoirs were sampled.

| Barr Lake (µg/L) | | | Milton Reservoir (µg/L) | | |
|------------------|------------|-----|-------------------------|------------|-----|
| Month | TP | SRP | Month | TP | SRP |
| Jan | 380 | 180 | Jan | 300 | 130 |
| Feb | 370 | 310 | Feb | 380 | 230 |
| Mar | 370 | 20 | Mar | 330 | 100 |
| Mar | 270 | 120 | Mar | 260 | <10 |
| Apr | 220 | 130 | Apr | 270 | 30 |
| Apr | 290 | 210 | Apr | 150 | <10 |
| May | 270 | 230 | May | 110 | 50 |
| May | 320 | 190 | May | 150 | 120 |
| Jun | 220 | 190 | Jun | 180 | 130 |
| Jun | 200 | 150 | Jun | 150 | 90 |
| Jul | 160 | 80 | Jul | 70 | 30 |
| Jul | 230 | 130 | Jul | 140 | <10 |
| Aug | 280 | 190 | Aug | 120 | 50 |
| Aug | 230 | 150 | Aug | 250 | <10 |
| Sep | 180 | 100 | Sep | 150 | 20 |
| Sep | 160 | <10 | Sep | 130 | 20 |
| Oct | 110 | <10 | Oct | 110 | 20 |
| Oct | 110 | <10 | Oct | 150 | <10 |
| Nov | 100 | 10 | Nov | 120 | <10 |
| Dec | 160 | 30 | Dec | 120 | <10 |

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

Example:
1 second in 32 years

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.

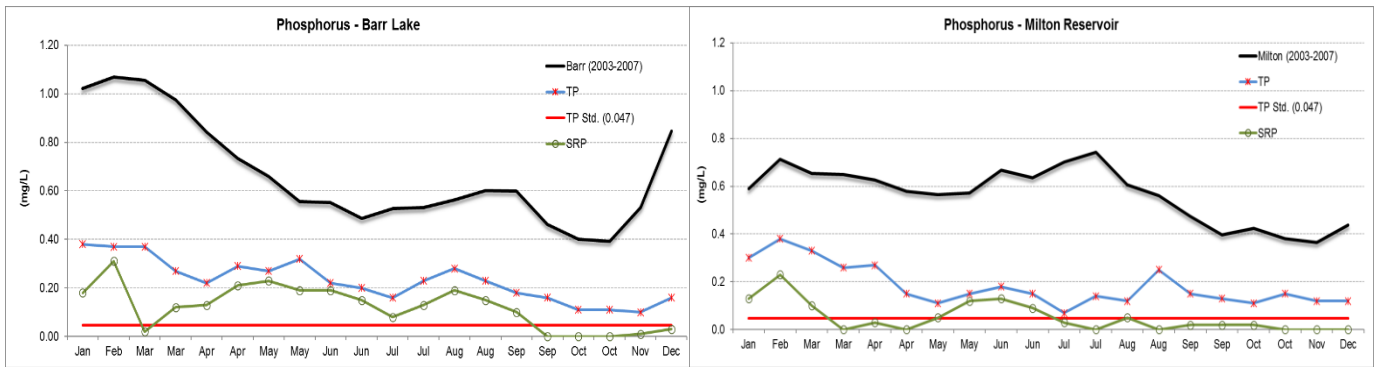
*SRP cannot be greater than TP, analytical error

The average TP for **Barr Lake** in 2023 was 232 µg/L and 182 µg/L for **Milton Reservoir**. Milton, for the 9th 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 except for the winter refill period. Historically, the winter-time refill is when most of the phosphorus enters each reservoir. Barr did experience a noticeable increase in TP in June, October, and November/December. The winter refill showed a gradual decline in TP until April. Inflows to Barr ended by mid-June and did not occur again until the end of September. Overall, TP in both reservoirs did not show any major issues and was below average.

The growing season average for **Barr Lake** was 207 µg/L and 143 µg/L for **Milton Reservoir**. Typically, the growing season average is lower than the annual average. Both reservoirs had a steady decline in TP through all of 2023. There was a slight increase in August due to inflows and possibly some internal loading.

Figure 2 shows the annual TP cycles, TP target, and 2023 data for both lakes. **Barr Lake** TP was below average for all of 2023. **Milton Reservoir** had some of the lowest TP values, especially SRP.

Figure 2. 2023 Phosphorus data compared to WQ targets and 2003-2007 annual average.



Internal Loading – Another way that phosphorus can enter lakes is from lake sediments. 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.

