

Water Quality Summary: Temperature

2023 Barr Lake & Milton Reservoir



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 4 of 8 of a water quality summary series for 2023 calendar year for both reservoirs. The first three summaries focused on pH, Chl-a, and dissolved oxygen; this one discusses water temperature.

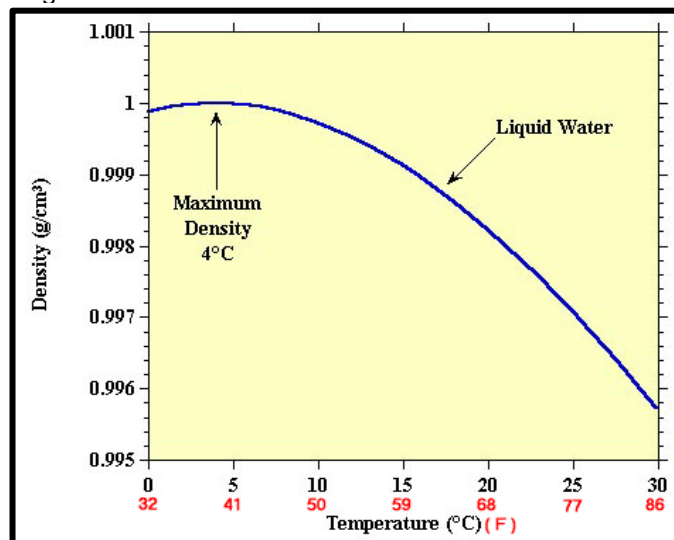
The Big Picture – Eutrophication is the addition of nutrients and sediments to water bodies resulting in algae and plant growth and sedimentation. This natural process occurs over a long geological period - 1,000's of years. Many lakes, reservoirs, ponds, and even estuaries throughout the world experience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

Temperature – A unique property of water is the temperature-density relationship (Figure 1). Water changes density as it changes temperature. Water is heaviest at 4 °C. Any warmer or colder and the water is less dense and float to the surface. This is why ice (0 °C) floats during the winter, and warm water (25 °C) floats during the summer. The bottom water temperature in many deep lakes is around 4 °C year round. Lake temperature is around 4 °C when ice cover comes off in the spring and is fully mixing. This density gradient associated with temperature defines a lake's ecology and mixing regime.

A lake's annual temperature cycle is determined by its local climate and latitude. **Barr Lake** and **Milton Reservoir** are considered *dimictic* when deeper than 7.0 – 8.0 meters by mixing twice a year; once in the spring and again in the fall with thermal stratification occurring during the winter and summer months. If the reservoirs are less than 7.0 – 8.0 meters, they become *polymictic*; mixing multiple times when wind and wave action is strong enough to mix the entire water column.

Thermal stratification is important to understand. It is the layering of water caused by temperature differences. During the summer, the uppermost, warmest layer (epilimnion) is the lightest and well mixed. The middle water is where the temperature transitions to the cooler, bottom water. Each change in temperature forms a layer of non-mixing water (metalimnion). It only takes half of a degree Celsius to form stratification. The bottom layer (hypolimnion) is the coldest and most isolated.

Figure 1.



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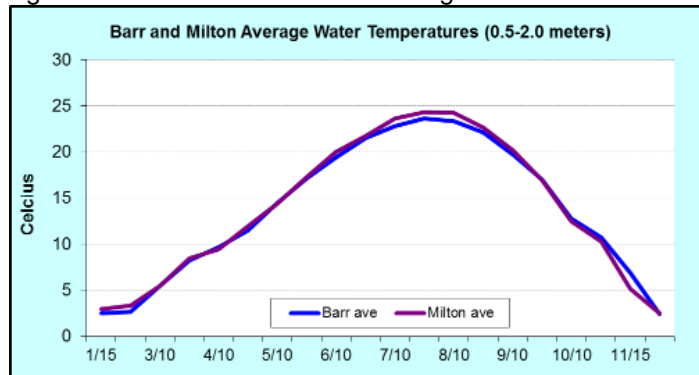


It takes a large amount of energy to change the temperature of water. This is why the unit of energy (calorie) uses water in its definition. A dietary calorie is the amount of energy it takes to heat 1 kilogram of water by 1 °C.

Because of this thermal resistance, lakes tend to have gradual temperature cycles. This is good for aquatic organisms and explains

why they have evolved to have specific temperature ranges for various life stages (e.g., spawning). The annual temperature cycle for both **Barr Lake** and **Milton Reservoir** changes little from year to year (Figure 2). The warmest water occurs during the last week of July and the coldest in December and January.

Figure 2. 2003 – 2023 Annual Average



The temperature standard for warm-water, lakes (deeper than 5 meters) only applies to the top water (0.5 – 2.0 meters). The temperature standard for **Barr Lake** and **Milton Reservoir** is 26.2 °C (chronic) and 29.3 °C (acute) between April and December and 13.1 °C (chronic) and 24.1 °C (acute) between January and March.

Table 1. Barr and Milton Temperature Data for 2023 in degrees Celsius and Fahrenheit.

Month	Temperature (Barr)	Temperature (Milton)
Jan	2.4 (36.3 F)	2.3 (36.2 F)
Feb	3.4 (38.2 F)	3.2 (37.8 F)
Mar	5.1 (41.1 F)	4.2 (39.6 F)
Mar	5.5 (41.9 F)	5.6 (42.1 F)
Apr	11.0 (51.9 F)	11.4 (52.5 F)
Apr	10.8 (51.4 F)	10.8 (51.4 F)
May	15.1 (59.3 F)	16.0 (60.9 F)
May	18.7 (65.6 F)	18.6 (65.5 F)
Jun	18.9 (66.0 F)	19.7 (67.5 F)
Jun	22.8 (73.1 F)	22.6 (72.7 F)
Jul	24.0 (75.1 F)	24.2 (75.6 F)
Jul	25.3 (77.6 F)	24.8 (76.6 F)
Aug	23.2 (73.8 F)	23.2 (73.8 F)
Aug	24.4 (75.9 F)	24.8 (76.7 F)
Sep	20.9 (69.7 F)	21.3 (70.3 F)
Sep	19.5 (67.1 F)	19.1 (66.4 F)
Oct	16.0 (60.9 F)	16.6 (61.9 F)
Oct	13.4 (56.2 F)	13.5 (56.2 F)
Nov	8.8 (47.8 F)	8.2 (46.7 F)
Dec	2.8 (37.1 F)	2.2 (36.0 F)

The acute standard is a daily maximum average, and the chronic standard is the maximum average during the growing season (July 1 – September 30). A lake can exceed these temperatures as long as there is deeper water that meets both DO and temperature standards.

2023 Temperature Data – Temperature data are collected throughout the entire water column in half meter increments during each visit. Temperature data from 0.5 meter to 2.0 meters are averaged for each visit. For 2023, there were 20 temperature averages recorded for each reservoir (Table 1). For **Barr Lake** and **Milton Reservoir**, the temperature standard was achieved.

The growing season average for **Barr Lake** was 22.9 °C and 22.9 °C for **Milton Reservoir**.

Celsius to Fahrenheit = double it and add 32

$$F = (1.8 \times C) + 32$$

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Climate change can have an important effect on lakes, specifically surface water temperatures. Figure 3 shows the comparison of water temperature averages for two different 5-yr periods, 2003-2007 and 2019-2023. The pattern seems to show a cooler March and May and a much warmer summer season from June to the beginning of October. Warmer water in the growing season can have a major impact on the algal community.

Figure 3.

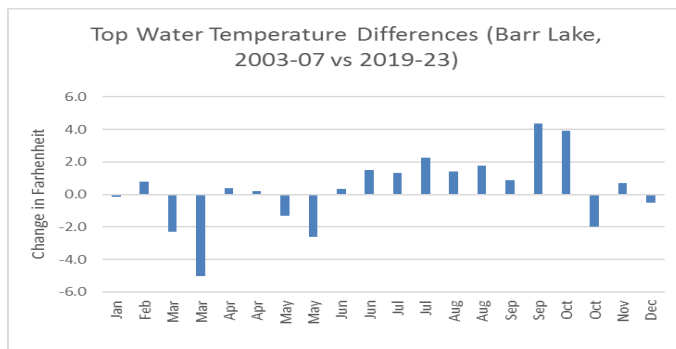


Figure 4.

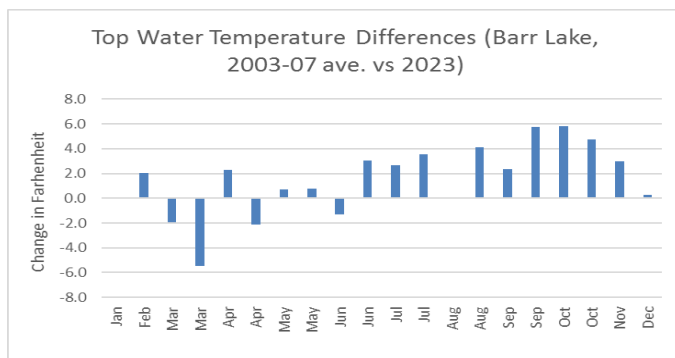


Figure 4 compares the 2023 top water temperature averages with averages from 2003-2007. This graph shows similar patterns to Figure 3. In 2023, March was much cooler while the period between June and December were typically warmer. A cooler than normal spring can encourage more diatom growth. Similarly, warmer water during the peak summer season can trigger warm water loving blue-green algae. Some of the differences

between year to year with water quality in reservoirs can be explained by the unique weather patterns and the resulting changes in water temperatures.

The cooler than normal water in Barr in March matches with the algal growth and elevated chl-a levels (chl-a was 127.0 µg/L on 3/14/23). Then the chl-a level on 9/27/23 was 102.0 µg/L. This occurred during the largest increase in water temperature in 2023 from the 2003-2007 average (6.0 F increase). These are two examples of comparing water quality parameters that are responsive to water temperatures.

Climate change is best described with large observations to see the larger picture. It can be difficult to see a global issue on a 1,800 acre reservoir. Overall trends are difficult to see, but isolated, severe weather can cause local impacts and alter water quality on a short temporal timeframe.