Water Quality Summary: Temperature
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 4 of 8 of a water quality summary series for 2020 calendar year for both reservoirs. The first three summaries focused on pH, chlorophyll-a, and dissolved oxygen; this one discusses water temperature.

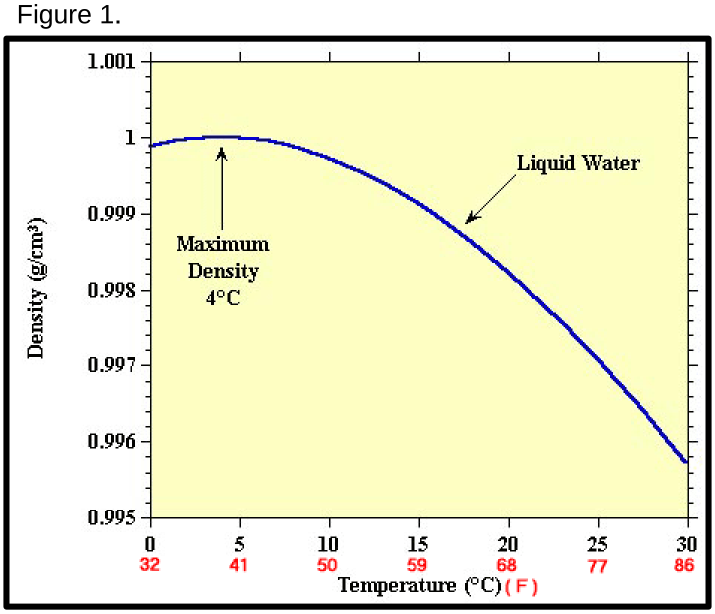
The Big Picture – Eutrophication is the addition of nutrients and sediments to water bodies resulting in algae and plant growth and sedimentation. This natural process occurs over a long, geological period - 1,000's of years. Many lakes, reservoirs, ponds, and even estuaries throughout the world experience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

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 ^{0}C. Any warmer or colder and the water is less dense. This is why ice (0 ^{0}C) floats during the winter and warm water (25 ^{0}C) floats during the summer. The bottom water temperature in many deep lakes is around 4 ^{0}C year round. This density gradient associated with temperature defines a lake's ecology and mixing cycles.

A lake's annual temperature cycle is determined by its local climate and angle to the sun (i.e., 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.

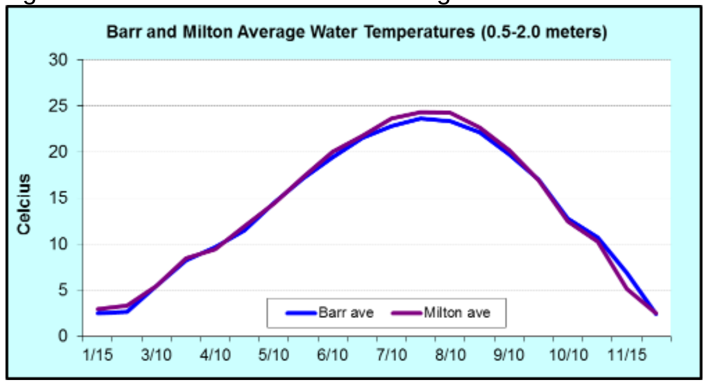
Thermal stratification is important to understand. It is the layering of water caused by temperature differences. During the summer, the uppermost, warmest layer (epilimion) is the lightest and well mixed. The middle water is where the temperature transitions to the cooler bottom water. Each change in 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 is isolated from any other water.

Figure 1.



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 ^{0}C.

Figure 2. 2003 – 2020 Annual Average



Because of this thermal resistance, lakes tend to have very predictable and 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.

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 ^{0}C (chronic) and 29.3 ^{0}C (acute) between April and December and 13.1 ^{0}C (chronic) and 24.1 ^{0}C (acute) between January and March.

Table 1. Barr and Milton Temperature Data for 2020 in degrees Celsius (^{0} F).

Month	Temperature (Barr)	Temperature (Milton)
Jan	1.4 (34.6 F)	2.2 (35.9 F)
Feb	2.8 (37.0 F)	2.6 (36.7 F)
Mar	6.4 (43.6 F)	7.1 (44.8 F)
Mar	-	-
Apr	9.5 (49.1 F)	9.5 (49.0 F)
Apr	14.0 (57.2 F)	15.3 (59.6 F)
May	14.6 (58.3 F)	14.3 (57.7 F)
May	18.8 (65.9 F)	18.3 (65.0 F)
Jun	19.3 (66.7 F)	18.6 (65.5 F)
Jun	20.4 (68.7 F)	20.6 (69.1 F)
Jul	22.2 (72.0 F)	24.0 (75.2 F)
Jul	23.4 (74.0 F)	23.9 (75.0 F)
Aug	23.8 (74.8 F)	24.7 (76.4 F)
Aug	23.2 (73.7 F)	23.7 (74.6 F)
Sep	18.5 (65.4 F)	17.2 (63.0 F)
Sep	19.4 (66.9 F)	19.1 (66.4 F)
Oct	12.9 (55.3 F)	13.0 (55.4 F)
Oct	3.6 (38.5 F)	3.5 (38.2 F)
Nov	7.5 (45.5 F)	6.2 (43.1 F)
Dec	2.7 (36.8 F)	3.6 (38.5 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.

2020 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 2020, there were 19 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 21.7 ^{0}C and 22.1 ^{0}C for **Milton Reservoir**.

Celsius to Fahrenheit = double it and add 32

F = (1.8 x C) + 32

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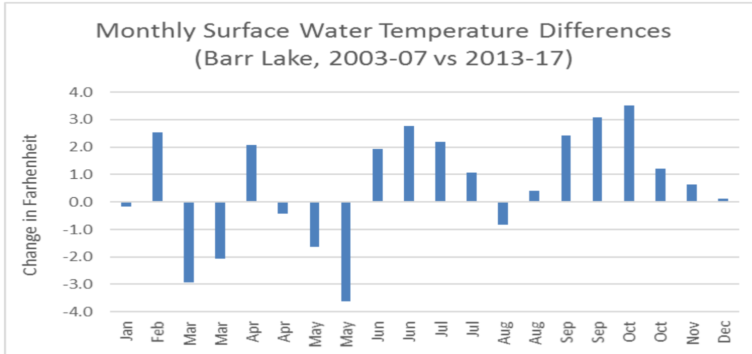
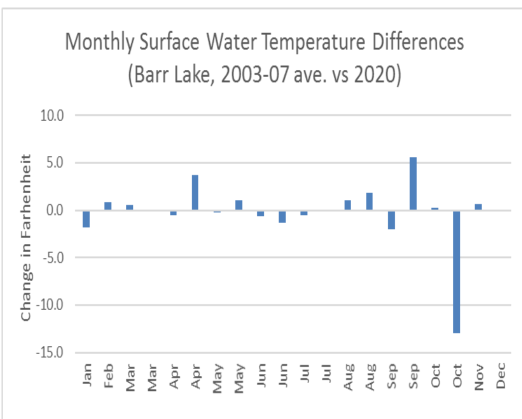
Climate change can have an important effect on lakes, specifically surface water temperatures. Figure 3 shows the comparison of 5-yr surface water temperature averages (0.5-2.0 meters) for Barr Lake. The temperature regime for both Barr and Milton follows a bell curve with coldest waters in the winter and the warmest water in late July to early August.

Figure 3.



The 5-yr span for 2013 to 2017 showed a large increase in water temperatures from June to October when compared to the 5-yr average for 2003 to 2007. The spring temperatures seem to be cooler, especially for early March and late May. These changes in water temperature can possibly trigger algal growth and alter spawning scheduels for fish.

Figure 4.



Climate change doesn't always mean warmer water temperatures. For 2020, there was a major drop in water temperatures in late October when compared to the 2003-2007 average. Late October weather cooled the surface temperatures below the average by over 12.9 ^{0}F. Besides weather, extremely low water depths (just 6 feet of maximum depth) in October contributed to the cooler temperatures. This shows that multiple stresses on a waterbody can have compounding impacts to water quality. Besides the extreme temperatures, the other noteworthy impact from climate change is the speed at which these extremes occur. Late September registered over a 5.0 ^{0}F increase above the average before having the 12.9 ^{0}F in late October. This almost 18 ^{0}F differential in water temperature in a span of four weeks can seriously impact the biological community and ultimately change the chemistry of a reservoir, especially if you add in a major drawdown.

Climate change is best described with global 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.