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Oxygen
15.999

Water Quality Summary: Dissolved Oxygen

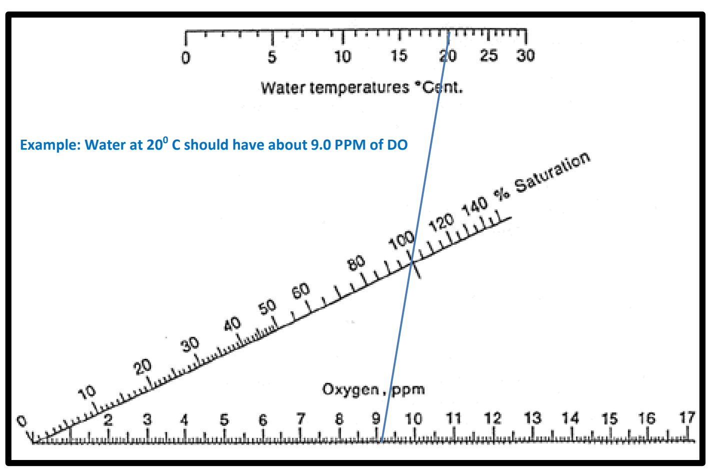
2020 Barr Lake & Milton Reservoir

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 3 of 8 of a water quality summary series for 2020 calendar year for both reservoirs. The first two summaries focused on pH and Chlorophyll-a; this one discusses dissolved oxygen (DO).

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.

DO – Oxygen is one of the most fundamental parameters of lakes. All aquatic organisms, from fish to microscopic bacteria, need oxygen. DO is the measurement of how much oxygen gas is dissolved in water. The two mechanisms that control oxygen dissolution are diffusion from the atmosphere and photosynthesis. DO concentrations are typically expressed in units of milligrams per liter (mg/L) or parts per million (ppm). Concentrations below 1 mg/L are considered anoxic – void of oxygen and allowing internal loading of ammonia and dissolved phosphorus from the sediments.

Water temperature, pressure (atmospheric and hydrostatic), and the amount of dissolved salts determine the solubility of oxygen. The colder the water the more oxygen it can hold. At 32° F, one liter of water can hold about 14 mg of oxygen. The same liter of water at 80° F can hold about 8 mg – *lakes during the summer have less DO*. The higher the pressure, the less likely bubbles will form so it holds the oxygen in solution better – *lakes at higher elevation have less DO*. Water with more dissolved salts has less room for oxygen molecules – *lakes in drier areas have less DO*. At a given temperature, pressure, and salt content, there is a limited amount of DO that water can keep soluble. This is the 100% DO level. Percent DO saturation (%DO) is another way of looking at oxygen.



Quick Saturation Chart – draw a straight line from a water temperature to a DO concentration. The %DO is where the line crosses the % saturation line (note: this nonogram is for sea level).

DO or %DO can change quickly and exhibit large differences between the top, middle, and bottom water in some productive lakes. Algae and wave action occur near the surface allowing for %DO to be 100% or more when in equilibrium. If it is >100%, it is often because of additional oxygen from photosynthesis. At the bottom of a lake there is no photosynthesis and the water is not in contact with the atmosphere, but at the same time it is colder and there is more hydrostatic pressure. Bottom water DO can be less than 100% due to decomposition and chemical reactions. Fish are able to avoid low DO areas and swim to where there is an acceptable amount. This is why the DO water quality standard for Colorado lakes (deeper than 5 meters) only applies to the top water (0.5 – 2.0 meters). The DO standard for **Barr Lake** and **Milton Reservoir** is 5.0 mg/L or higher at all times. Milton met the DO standard but Barr did not for 2020.

2020 DO Data – DO profile data are collected throughout the entire water column in half meter increments during each visit. DO data from 0.5 to 2.0 meters are averaged for the top water. For 2020, there were 19 DO averages recorded for each reservoir (Table 1). For **Barr Lake**, there were three concentrations below the standard and only one below the standard for **Milton Reservoir**. Both reservoirs typically see a decrease in DO in the spring after the diatom bloom.

Table 1. Barr Lake and Milton Reservoir DO data for 2020 (mg/L and %). Bold values exceed water quality target.

Month	DO (Barr)	DO (Milton)
Jan	17.0 (147%)	16.5 (145%)
Feb	19.9 (178%)	16.2 (143%)
Mar	11.6 (113%)	18.4 (181%)
Mar	NA	NA
Apr	10.4 (111%)	10.4 (109%)
Apr	10.3 (130%)	6.0 (71%)
May	6.7 (80.9%)	10.7 (125%)
May	7.9 (103%)	10.5 (133%)
Jun	6.0 (79%)	9.2 (120%)
Jun	9.1 (121%)	7.8 (104%)
Jul	7.6 (106%)	6.5 (93%)
Jul	6.7 (95%)	8.8 (125%)
Aug	**4.9 (99%)**	8.1 (162%)
Aug	**1.8 (26%)**	6.3 (90%)
Sep	**4.0 (50%)**	5.9 (72%)
Sep	9.9 (130%)	11.5 (148%)
Oct	6.7 (77%)	7.4 (83%)
Oct	15.7 (142%)	12.6 (112%)
Nov	9.9 (100%)	8.8 (86%)
Dec	15.1 (134%)	10.8 (97%)

Because of year-round algal growth, both reservoirs tend to have sufficient DO – 11 of the 19 averages in 2020 were over 100% DO for both **Barr Lake** and 12 out of 19 for **Milton Reservoir**. Barr had low oxygen in August and early September when the reservoir volume was significantly decreased during the peak blue-green algae season. No inflows, low water levels, peak water temperatures, and high decomposition all added up to extremely low DO levels for over a month.

For both reservoirs, DO is a direct relation to Chl-a from algal growth. The higher the growth, the higher the DO. Diatoms during the cooler seasons clearly create DO conditions well above 100%. Summer growth leads to quick highs and lows for DO.

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The growing season (July 1 – September 30) average for **Barr Lake** was 5.83 mg/L and 7.84 mg/L for **Milton Reservoir**. In general, there is plenty of oxygen except for isolated situations when consumption is faster than supply or there is a major drawdown.

Figure 1. 2020 DO data compared to water quality standard and 2003-2020 annual average.

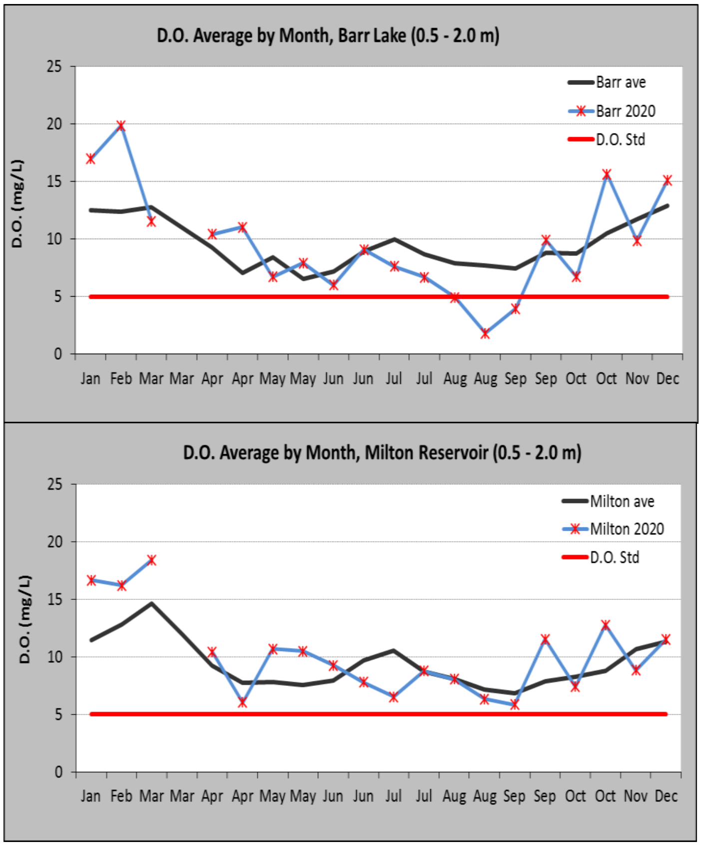

Figure 1 shows the average annual cycle of DO along with 2020 data for both reservoirs. **Barr Lake** followed the annual pattern of highs and lows. **Milton Reservoir** had a typical DO year as well with higher than average values in the winter and fall.

Oxygen Deficit Rate – Figure 2 shows the average DO for each level in Barr Lake (top, middle, and bottom). The Oxygen Deficit Rate (ODR) is the slope of the line when DO declines. It tells you how many milligrams of oxygen are being consumed over a given period of time per unit area. The ODR for **Barr Lake** from March to June 2020 was 657 mg of DO/m^2-day. The oxygen consumption rate is the ODR applied to the sediment area of the bottom water (the bottom 2 meters). The consumption rate was 4,131 Kg of oxygen per day. This information is useful when considering in-lake aeration systems.

The reservoir is fully mixing when all three DO lines are the same. As soon as the bottom water is not mixing, respiration starts to consume the DO. When there is an increase in top water DO, this is caused either by photosynthesis or wave action. When middle and bottom water DO increases, this is usually caused by wind mixing or algal growth in shallow conditions.

Figure 2