2023 New Hampshire Precipitation & Temperature Overview

Weather and Water Quality Overview

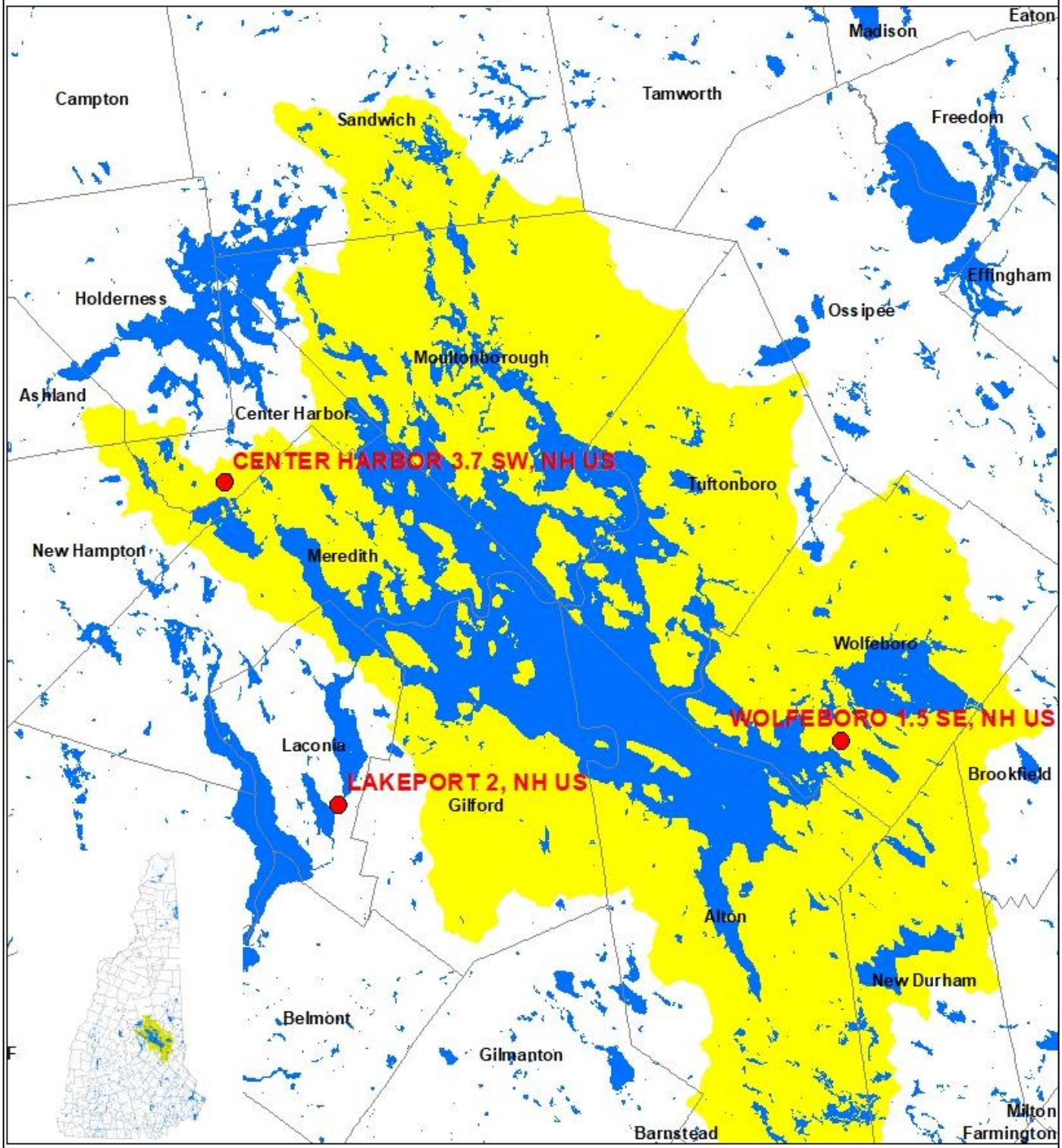
Water quality fluctuations can be dependent upon short and long-term variations in weather conditions including temperature and the quantity of rainfall. Heavy periods of rainfall and associated overland runoff frequently correlate with poorer lake and stream water quality. Heavy runoff events tend to pick up and transport pollutants, such as phosphorus and sediments, into our lakes. Temperature fluctuations can also have water quality implications. The period of spring runoff associated with the melting of winter snowpack, coupled with spring rainfall events, can be influenced by temperature variations. For instance, during warmer winters, precipitation may frequently fall as rain. When the precipitation occurs as snow, the intermittent warm periods may diminish the quantity of snow on the ground through the winter months and result in a mild spring runoff period. On the other hand, a colder winter with significant snowfall may result in an intense spring runoff period as all the snowpack melts during a relatively short period in the early spring time frame.

The forms of microscopic photosynthetic growth, algae and cyanobacteria, undergo seasonal cycles that are associated with temperature differences. Many of the photosynthetic forms are adapted to grow well in warm waters and will also respond to increased nutrient levels. The intensity of storm events is also important, as the ground only has a certain capacity for the water to infiltrate, with the excess water flowing overland.

As you review data from your lake, you may want to consider how the 2023 weather could have impacted your lake. The 2023 weather summary is based on sampling locations located within, and in close proximity to, the Lake Winnipesaukee watershed (Figure 1). The summary provides a glimpse into the 2023 weather conditions that were characteristic of southern New Hampshire. Since weather conditions can be highly variable, even when locations are in close proximity, you may also want to look at data collected more locally. Sources of more local data may include newspaper reports, or monitoring locations operated by the New Hampshire Dam Bureau and the United States Geological Survey and locations reported through the National Oceanic and Atmospheric Administration. When reviewing the 2023 weather conditions, as they relate to your lake's water quality, some points to consider include:

- How do the 2023 measurements compare to the long-term (~30 year) record?
- Are there particular days and/or periods when the conditions were unusually wet or dry?
- How much winter snowpack remained and contributed to the spring runoff period?
- Were there unusually warm or cool periods in 2023?
- Have you identified locations where stormwater management could be improved? Several useful resources to facilitate implementation of stormwater management projects include:
    - University of New Hampshire Stormwater Center
    - Landscaping at the Water's Edge
    - Soak up the Rain New Hampshire

Figure 1. Select Weather Stations in the New Hampshire Lakes Region



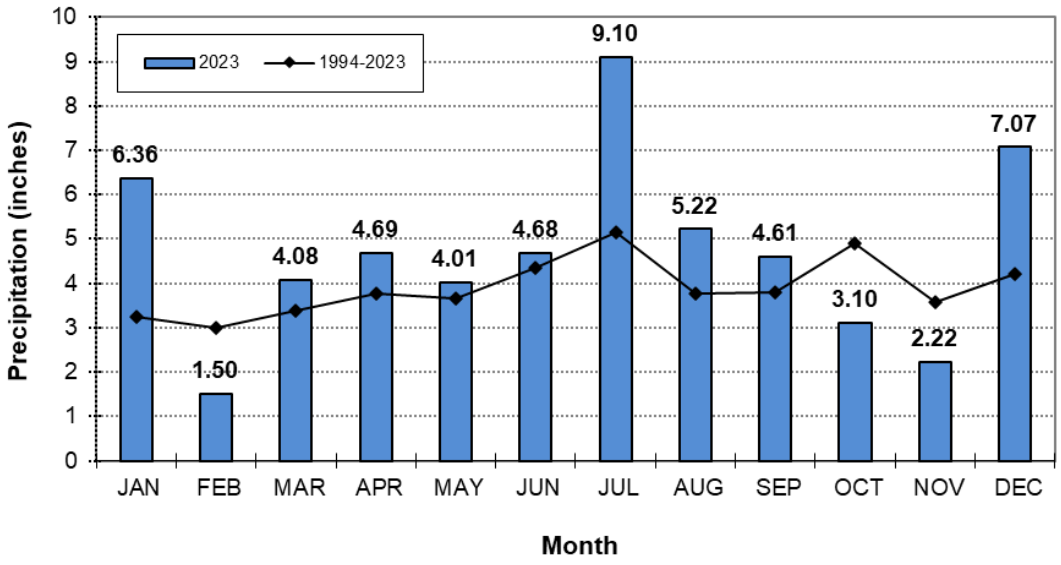
Weather Station	Latitude (dd.dddd)	Longitude (dd.dddd)	Elevation (feet)
Wofeboro 1.5 SE, NH US	43.5732	-71.1894	709
Center Harbor 3.7 SW, NH US	43.6758	-71.5267	769
Lakeport 2, NH US	43.5491	-71.4646	500

This summary highlights 2023 conditions directly measured at three locations in the central New Hampshire Lakes Region (Figure 1). These locations provide insight into the 2023 weather conditions characteristic of southern New Hampshire. However, localized weather variations were common during the 2023 season and might impact more localized lakes differently. *Note: the Lakeport 2 sampling location is used as a representative location to approximate monthly conditions for other Lakes Lay Monitoring Program lakes. The Lakeport 2 station is centrally located, and both temperature and precipitation data have been collected year-round over the past 30 years.*

Monthly Precipitation Totals (2023)

The 2023 annual precipitation (reported as "rainfall" water equivalent) measured 56.64 inches and was approximately four inches above the 30 year (1994-2023) average of 46.84 inches at the Lakeport 2 Climatological Sampling Station, Laconia, New Hampshire. Significantly above average January 2023 precipitation was followed by below average precipitation in February (Figure 2). Above average monthly precipitation subsequently persisted between March and September and was highlighted by elevated July precipitation. Unusually dry conditions characterized October and November. Significantly above average precipitation was documented in December to end the year.

Figure 2: Lakeport 2 Climatological Sampling Station (Laconia, NH)
Monthly Precipitation (1994-2023)



Monthly Snowfall Totals (2023)

The annual 2023 snowfall measured 75.4 inches and was nearly 10 inches above the 30-year average (1994-2023) of 66.0 inches at the Lakeport 2 Climatological Sampling Station in Laconia New Hampshire. Unusually heavy snowfall was documented during the months of January and March while below average monthly snowfall totals were documented during the months of February, April and December (Figure 3). Near normal snowfall was documented in November.

Monthly Temperature Averages (2023)

The annual 2023 average temperature of 34.9° F was nearly six degrees higher than the 30-year average temperature of 29.1° F at the Lakeport 2 Climatological Sampling Station, Laconia, New Hampshire. The year began with an unseasonably high January temperature, with this trend of above average monthly temperatures continuing through April (Figure 4). Below average temperatures characterized May, June, August, and November. Above average temperatures were also documented in July, September, October, and December.

The seasonal variations in temperature and precipitation, coupled with the extreme conditions during certain periods of time, had implications to the timing of runoff periods. The following sections provide additional insight into the winter/spring and summer 2023 conditions.

Figure 3: Lakeport 2 Climatological Sampling Station (Laconia, NH)
Monthly Snowfall (1994-2023)

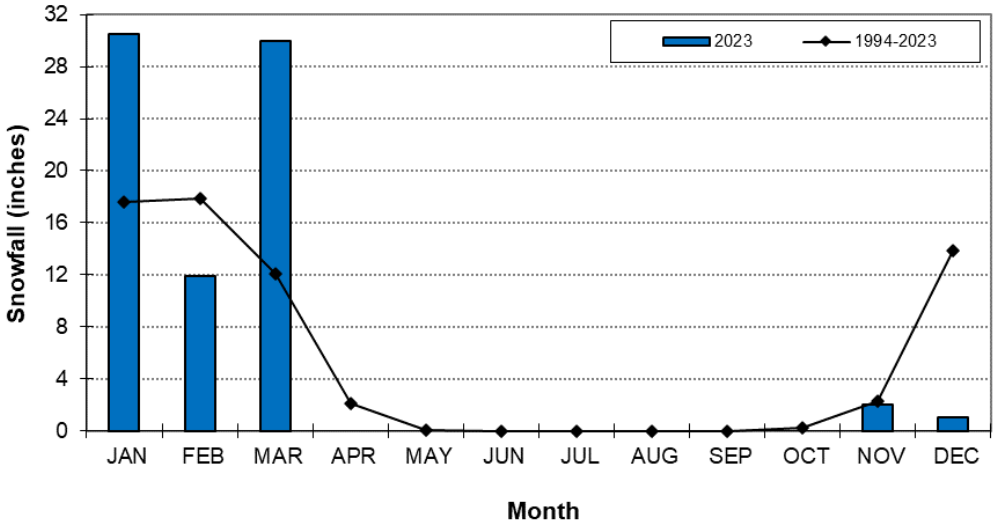
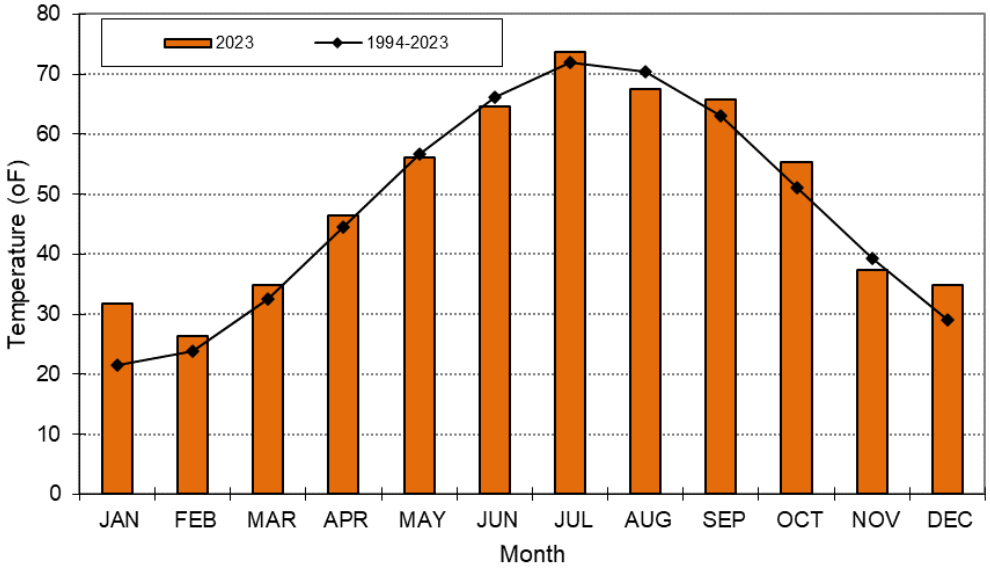
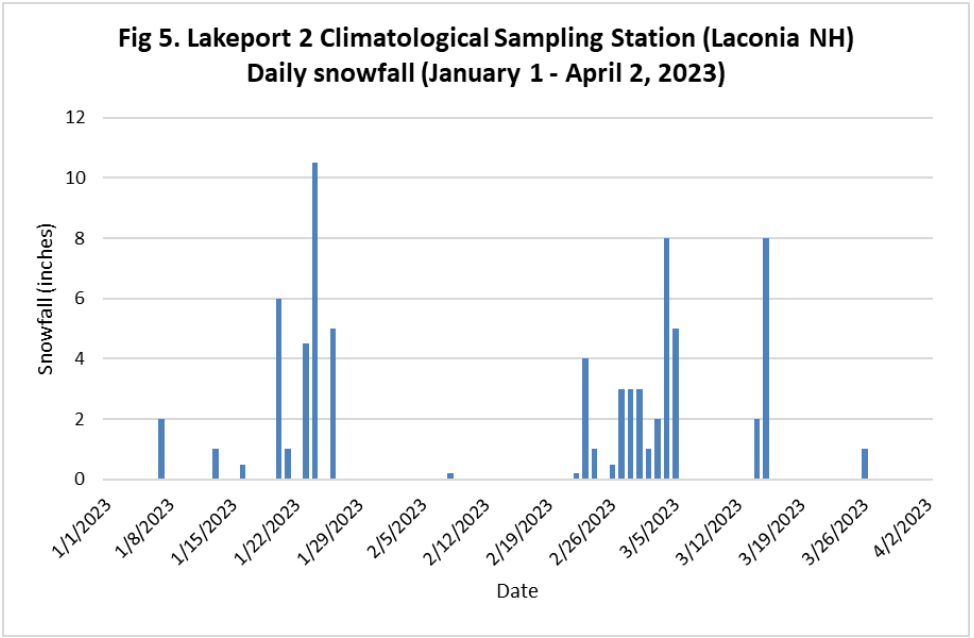


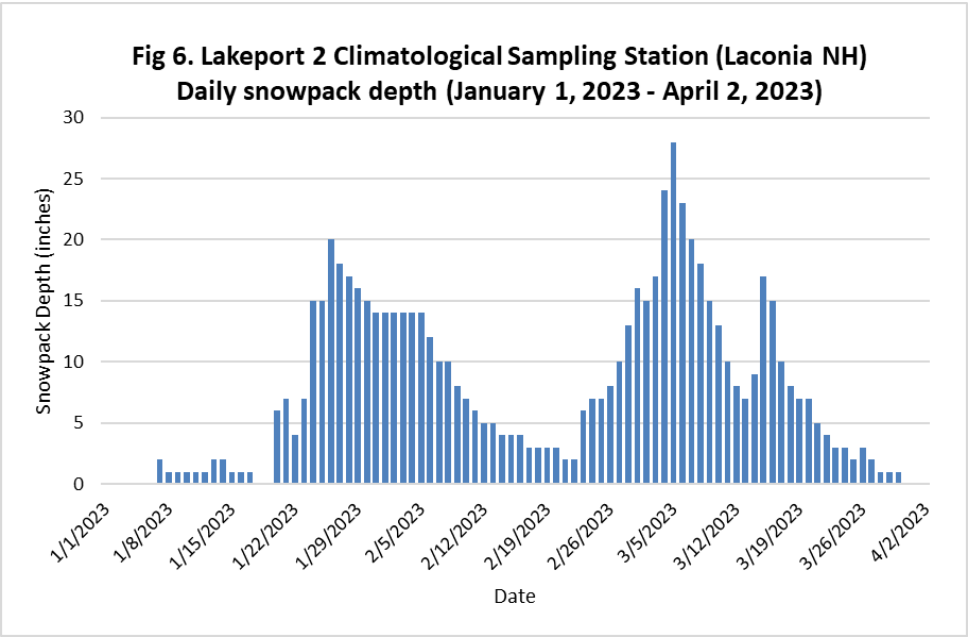
Figure 4: Lakeport 2 Climatological Sampling Station (Laconia, NH)
Monthly Temperature (1994-2023)

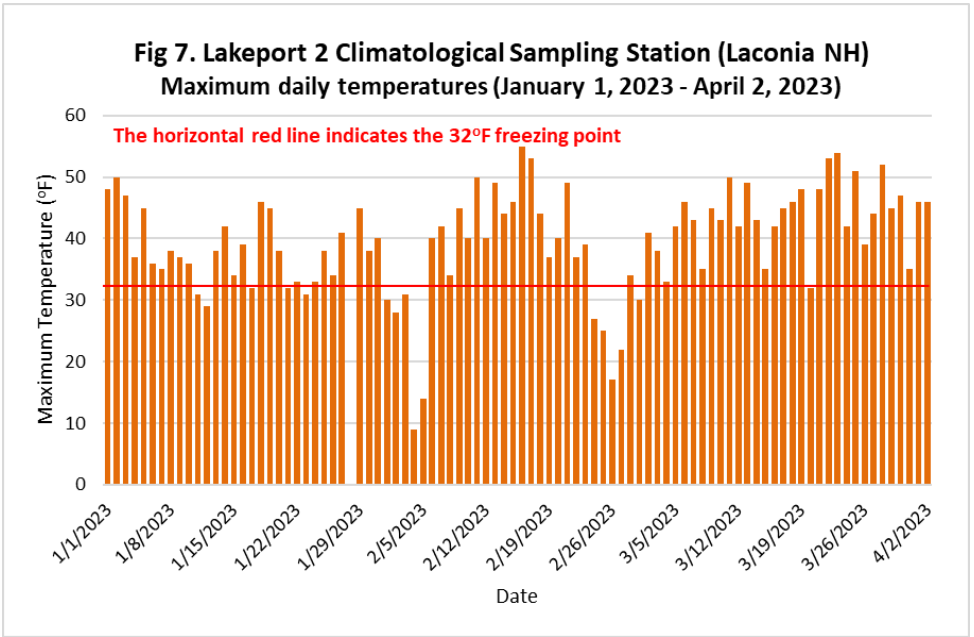


2023 Winter and Spring Runoff Period (Lakeport 2 Climatological Sampling Station, Laconia NH)

Numerous snowfall events of equal to or greater than four inches occurred between January and March (Figure 5) and resulted in periods of deep snowpack. The winter 2023 snowpack reached a peak depth of 28 inches on March 5 (Figure 6). Maximum daytime temperatures between January 1st and April 2nd were highly variable and included intermittent periods of temperatures that were above 32 degrees Fahrenheit (Figure 7). In fact, maximum daytime temperatures during January and February included numerous daytime temperatures that were well above 32° F depicted as the red horizontal line in Figure 7. These warm periods resulted in a rapid melting of the snowpack as exhibited in Figure 6. A warm period in January resulted in the reduction of snowpack to a depth of two inches by February 21st (Figure 6). Several successive snowfall events resulted in the peak winter snowpack depth of 28 inches on March 5th. Elevated maximum daily temperatures melted away the snow cover by March 31st (Figures 6 and 7).







Daily June, July and August 2023 Rainfall Totals: Lakeport 2 (Laconia NH), Wolfeboro 1.5 SE (Wolfeboro NH) and Center Harbor 3.7 (Center Harbor NH) Climatological Stations.

2023 was not only characterized by above average monthly rainfall totals, but was the recipient of numerous more intense, greater than one inch of rainfall over a 24-hour period, rainfall events (Figures 8, 9 and 10). Not only did the rainfall vary among sampling dates, but there was significant variability among sampling locations (Figures 8, 9 and 10) as presented for the three stations located within 20 miles of one another (Figure 1). For instance, the Center Harbor daily precipitation totals were near or more than one-inch multiple times during each of the three months. An intense storm event on July 16 and 17 (reflected in the July 17 data points) dumped approximately 4.8 inches of rain in Wolfeboro while the daily measurements for the storm event totaled approximately 2.3 inches in Laconia and 1.3 inches in Center Harbor. Intense and locally variable storm events can have a profound impact on water quality. These intense storm events can mobilize pollutants, such as phosphorus, into our New Hampshire lakes. Lakes oftentimes respond to these atypically wet periods with decreased water transparency measurements coupled with greener and more "tea" colored water.

Figure 8. Daily New Hampshire Lakes Region Rainfall Variability Among Weather Sampling Locations (June 2023)

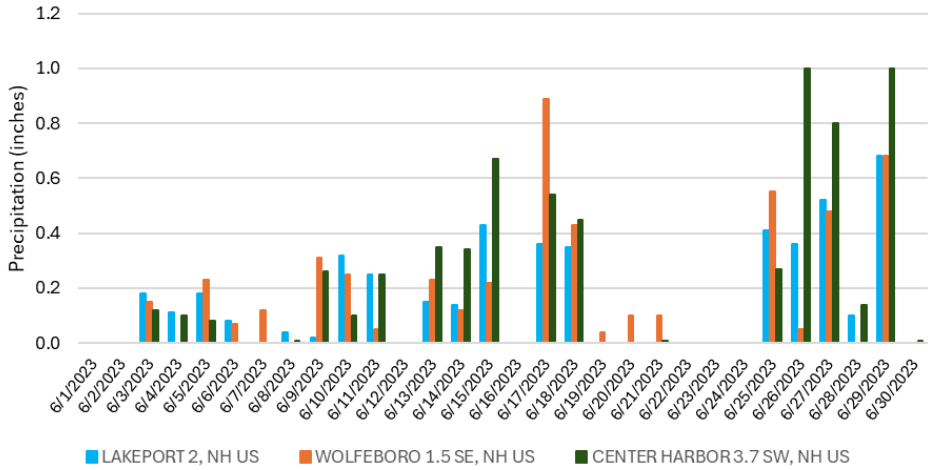


Figure 9. Daily New Hampshire Lakes Region Rainfall Variability Among Weather Sampling Locations (July 2023)

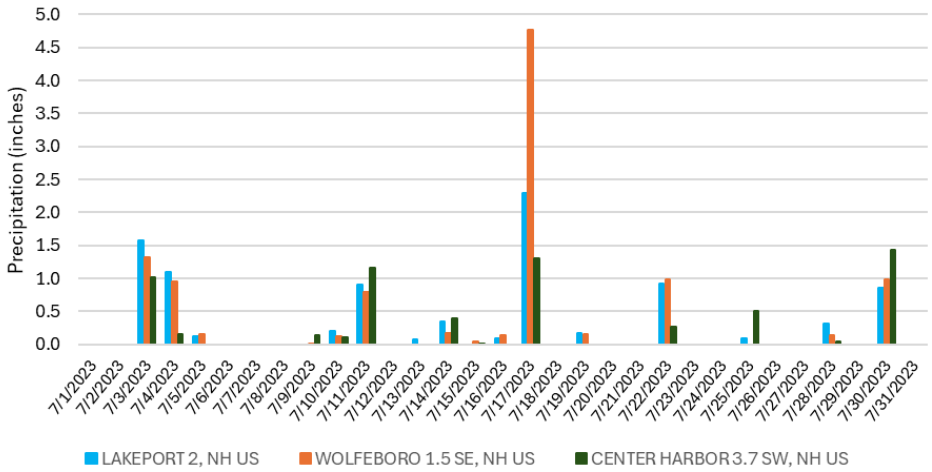
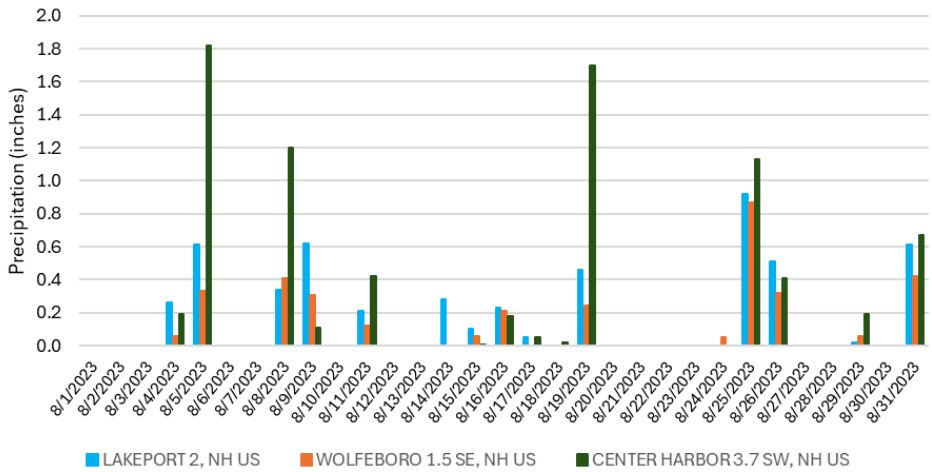


Figure 10. Daily New Hampshire Lakes Region Rainfall Variability Among Weather Sampling Locations (August 2023)



Water Quality Implications:

- **Total Phosphorus** – Phosphorus is frequently flushed into lakes and ponds during or immediately following heavy rainfall periods. Dry periods, on the other hand, tend to limit the amount of phosphorus that enters lakes through channelized (e.g. streams and drainage culverts) and sheet flow (e.g. flows in a thin layer over the ground). Elevated 2023 phosphorus concentrations were documented in many of our New Hampshire lakes and are likely associated with the atypically wet year and associated intense storm events that were characteristic of 2023. *Note: localized, and unusually intense, short-term rainfall events were associated with localized washout and nutrient loading occurrences. Such events can be associated with unusually high total phosphorus and suspended particle levels (reflected in unusually low Secchi Disk transparency and elevated turbidity measurements).*

- **Secchi Disk Transparency** – Water transparency (measured with the Secchi Disk) can be heavily impacted by the amount of algal growth (measured as chlorophyll *a* concentrations), the amount of suspended particles (both organic and inorganic) and the amount of dissolved color compounds, many of which are naturally occurring and are associated with decaying vegetation and surrounding wetland complexes. Generally speaking, wetter periods are associated with reduced water transparencies while dry periods are associated with deeper water visibility.

- **Chlorophyll *a*** (surrogate for algal and cyanobacteria growth) – Algal and cyanobacteria populations can be heavily influenced by water temperatures, the amount of light penetration into the water column, and nutrient concentrations. Thus, there are multiple factors that could influence the chlorophyll content. In general, wet periods are associated with increased algal and cyanobacteria growth that take advantage of nutrients that are flushed into our lakes. On the other hand, dry periods can be associated with lower algal and cyanobacteria levels in our lakes. There is a natural progression of different algal and cyanobacteria forms that occur annually. In general, nuisance algal and cyanobacteria forms flourish in warmer water temperatures that are associated with annual cycles (e.g. warm July and August water temperatures), as well as unusually warm short-term periods, when the water temperatures rapidly increase in a lake's surface waters.

- **Turbidity** – Turbidity, a measure of the scattering of light, is associated with particles in the water. Since wet periods are typically associated with displacement of fine sediments into our lakes, higher turbidity levels are frequently associated with unusually wet periods while lower turbidity levels are frequently associated with dry periods. Algal and cyanobacteria levels, discussed above, can also impact turbidity as their densities increase or decrease.

- **Dissolved "true" Color** – Dissolved color, a byproduct of microbial decomposition of soils and plants, varies among lakes and can vary seasonally. Wet periods, when highly colored water from the surrounding wetlands is flushed into our lakes, tend to be associated with elevated dissolved color concentrations. On the other hand, dissolved color concentrations tend to be lower during dry periods. More "tea" colored lakes tend to have shallower water transparencies relative to New Hampshire Lakes that are uncolored or slightly "tea" colored.

- **Summer Thermal (Temperature) Stratification** – Summer thermal stratification forms in our deeper lakes as the surface water temperatures increase. The timing, degree, and duration of thermal stratification is influenced by numerous factors including the timing of ice out, the ambient air temperatures, surface lake conditions (e.g. calm or windy conditions), how "tea" colored the water is, and the number of bright and sunny days. Thermal stratification and associated surface water temperatures can have implications for how well algae and cyanobacteria grow. Thermal stratification can be associated with the suitability of the lake as a cold-water fishery and can also have implications for chemical and biological variations from the surface to the lake bottom.