Phosphorus and Nitrogen

Nitrogen (N) in the form of nitrates, and phosphorus (P) in the form of phosphates are required by all living organisms. High concentrations of them in lake water, however, may cause the explosive growth of microorganisms that impair water quality greatly and cause eutrophication (see picture below). Primary (point) sources of N and P in lakes are agricultural and residential fertilizers, and waterfowl excrement. N and P concentrations determined in lake water can be compared to Indiana state standards to determine lake health.

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Dissolved orthophosphate (P_o) (as inorganic PO_4^{-3}): >0.045 mg/L or 45 ppb can stimulate algal blooms

Total phosphorus (P_T) concentrations that exceed ~36 ppb (36 μg/L) – eutrophic state

Dissolved inorganic nitrogen (mainly as nitrates): <0.3 mg/L or 300 ppb (higher concentrations are associated with eutrophic lakes)

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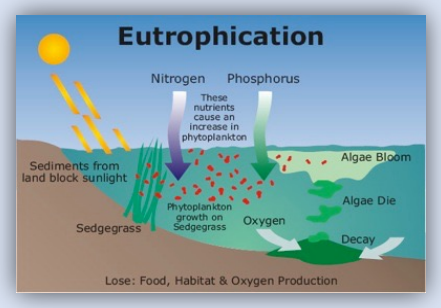
In LP, P_T values are typically <0.02 mg/L. However, water entering LP from Redhead Pond has P_T ranging from 0.04–0.19 mg/L, with some samples containing as much as 0.27 mg/mL. Nitrate concentrations in LP are well below 0.3 mg/L.

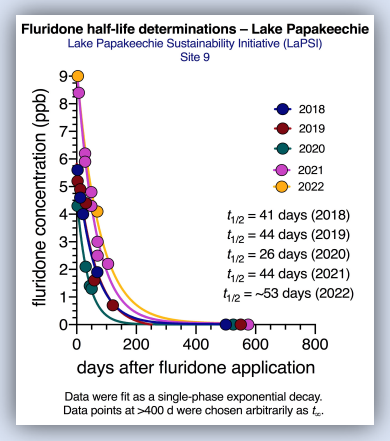


Other Water Quality Parameters

There are additional water quality indicators such as acidity (pH), chlorophyll *a*, photic zone, and conductivity. There are also biological indicators (benthic organisms) that complement chemical and physical indicators and provide further evidence of lake health. In practice, all of these indicators are used collectively to paint a comprehensive picture of lake health.

Herbicide Monitoring: Fluridone

Fluridone is an herbicide that is applied to Lake Papakeechie each spring to control plant growth. Changes in fluridone concentrations as a function of days after application in 2018–2022 are shown below for Site 9. **The average half-life is 42 ± 10 days.** Data were fit to a single exponential decay function to calculate half-lives. These half-lives need to be known to determine herbicide effectiveness. For example, a concentration >4 ppb needs to be maintained for at least 40–50 days for optimal control of curly leaf pondweed.



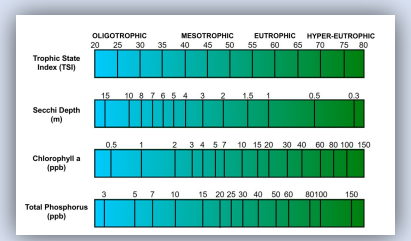
Lake Papakeechie Sustainability Initiative (LaPSI)
Summer 2022

LaPSI WATER TESTING

2023

LaPSI tests for several indicators of water quality and lake health on Lake Papakeechie. An important indicator of general lake health is the Trophic State Index (TSI or Carlson Index). TSI values classify lakes respect to their biological productivity (concentrations of macronutrients) and overall health (ability to support diverse life). Lower TSI values are associated with healthier lakes. TSI values range from <30 to >70, the former associated with oligotrophic lakes and the latter with hyper-eutrophic lakes.

TSI values are calculated from lake turbidity (Secchi), total phosphorus (P_T) and chlorophyll *a* measurements using the three equations shown below. **The TSI for Lake Papakeechie is 46–55 based on turbidity and P_T measurements, which places it in the mesotrophic class. Many lake management efforts aim to prevent or forestall lake eutrophication (i.e., keep TSI values as low as possible).**



TSI from Secchi Depth
TSI = 60 – 14.41 ln SD
(SD = Secchi depth in m)

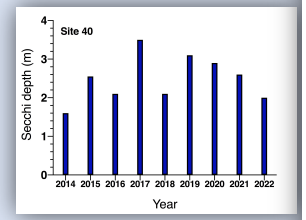
TSI from P_T
TSI = 14.42 ln TP + 4.15
(P_T = total phosphorus concentration in surface water in mg/L)

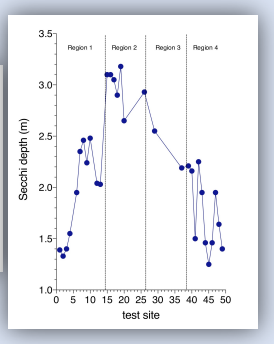
TSI from Chl *a*
TSI = 9.81 ln Chl a + 30.6
(Chl *a* = chlorophyll *a* concentration in mg/L)

Turbidity: Secchi Disc

Turbidity is a measurement of water clarity. Turbidity is affected by the amount of light scattered and absorbed by particles suspended in water. Some particles are biological (algae cells, microscopic organisms, and decomposing soluble organic matter) while others are geological (soil sediment and soluble materials like calcium and iron). Turbidity can be used to determine the Trophic State Index (TSI) of a lake. TSI is a measure of a lake's biological productivity (concentrations of macronutrients) and overall health (ability to support diverse life). Turbidity is determined with a Secchi disc that is lowered into the water until it disappears; that depth is defined as the Secchi depth.

Secchi data collected on Lake Papakeechie at Site 40 during the month of July in 2014–2022 are shown below. **Secchi depths ranged from 5.2 feet (1.6 meters) to 11.5 feet (3.5 meters) over this eight-year period, giving an average value of 2.5 ± 0.6 meters (8.2 ± 2.0 feet).**





Left: Secchi depths at Site 40 from 2014–2022 (mid-summer)
Right: Secchi depths at different locations on LP (Region 2 least turbid)(mid-summer, 2015)

Biological Pathogens: *E. coli* and Blue-Green Algae

When pathogenic bacteria like *E. coli* and some blue-green algae come into contact with humans, discomfort or illness can result. Lakes containing high levels of bacteria and/or their released metabolites cannot be used safely for those human activities that involve significant water contact. *E. coli* contamination is commonly caused by pollution from impaired septic systems. The feces of waterfowl and other wildlife also contribute significant amounts of *E. coli* to some lakes. The state of Indiana has published standards to determine whether a lake is impaired by high levels of bacteria or microcystins released by blue-green algae. **Simple, convenient and rapid tests to measure *E. coli* and microcystin concentrations on Lake Papakeeckie are available.**

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For lake water to meet recreational standards, the geometric mean of 5 samples over a 30-day period is required to be less than 125 CFU/100 mL, with no sample testing higher than 235 CFU/100 mL (CFU = colony forming unit). **Test results on LP since 2012 show very low levels of *E. coli*, although testing along the shoreline where potential contamination is most likely to occur has been limited.**

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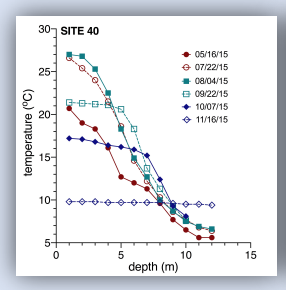
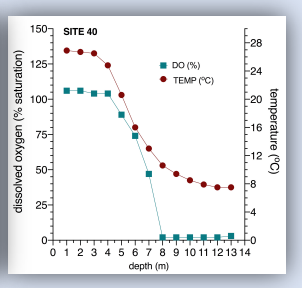
Indiana guidance values for microcyctins:
Low risk: 4 ppb
Moderate risk: 4–20 ppb
High risk: >20 ppb
A test run in 2022 (local algal bloom) showed very little microcystins present in the water.

Dissolved Oxygen and Temperature

Many organisms require oxygen and stable optimal temperatures to live. In lakes, the availability of oxygen dissolved in water and average temperatures determine which organisms can exist and thrive. For example, trout require higher oxygen levels and lower temps than carp. The concentration of dissolved oxygen (DO) can depend significantly on water depth. Warm surface water usually has lower DO than cooler, deeper water. However at a certain depth in a lake oxygen becomes too low to support most life despite the cool temperatures. **The shapes of DO and T vs lake depth plots (see below) can be strong indicators of lake health**. DO and T are measured with a scientific meter by lowering a probe into the water and recording measurements at one foot increments.





Left: Temperature stratification is seasonal as expected for dimictic lakes (Site 40).
Right: DO drops rapidly below ~4 meters. The hypolimnion essentially anoxic at >8 meters. (Site 40, mid-summer, 2015)