

LAKE WATER QUALITY MONITORING



METHODS

The following parameters are tested at each lake:

- Dissolved Oxygen (DO);
- Turbidity;
- Conductivity;
- Temperature;
- Salinity;
- Total Phosphorus (TP);
- Transparency (Secchi Disk);
- Chlorophyll-a (Cl-a);
- pH.

Lakes are sampled every two weeks from May to September. Monitoring is conducted by boat at the deepest area of the lake. These sites are located using a portable depth finder. pH, conductivity, turbidity, DO, salinity and temperature were measured using the Horiba Water Checker® U-10 multi-probe at a depth of one meter. Water samples are collected with a Kemmerer sampler from a depth of one meter, to be analyzed by an independent laboratory (Braun Intertec) for chlorophyll-a and total phosphorus. The laboratory provides sample bottles, complete with preservative (H₂SO₄), for TP analysis and a bottle covered in aluminum foil for the Chlorophyll-a sample. These water samples are kept on ice and delivered to the laboratory within 24 hours. Weather and lake conditions are noted during each monitoring event.

Transparency is measured using a secchi disk. The disk is lowered over the shaded side of the boat until it disappears and is then pulled up to the point where it reappears again. The midpoint between these two depths is the secchi disk measurement.

To evaluate the lake, results are compared to other lakes in the region and past readings at the lake. Comparisons to other lakes are based on the Metropolitan Council's lake quality grading system and the Carlson's Trophic State Index for the North Central Hardwood Forest ecoregion. Historical data for each lake are obtained from the U.S. EPA's national water quality database, STORET, via the Minnesota Pollution Control Agency, for historical comparisons.

QUESTIONS AND ANSWERS

This section is intended to answer basic questions about the Anoka Conservation District's methodology for monitoring lake water quality and interpreting the data.

Q- What do the parameters that you test mean?

A-

pH- This test measures if the lake water is basic or acidic. A pH reading of greater than 7 signifies that the lake is basic and a reading of less than 7 means the lake is acidic. Many fish and other aquatic organisms need a pH in the range of 6.5 to 9.0 in order to be viable. Eutrophic lakes are often pH basic (pH = >7). The pH of a lake will fluctuate daily and seasonally due to algal photosynthesis, runoff, and other factors.

Conductivity- This is a measure of the amount of dissolved minerals in the lake. Although every lake has a certain amount of dissolved matter, high conductivity readings may indicate additional inputs from sources such as stormwater, agricultural runoff, or from failing septic systems.

Dissolved Oxygen (DO)- Dissolved oxygen is essential to the metabolism of all aquatic organisms. The lower the DO concentration, the less likely a lake will support a wide range of organisms. Sources of dissolved oxygen include the atmosphere, aeration from stream inflow, and submerged plants in the lake creating oxygen through photosynthesis. Dissolved oxygen is consumed by the organisms in the lake and by the decomposition process that occurs at the bottom of the lake. During the winter, the ice can restrict the supply of oxygen to the lake (limited aeration and dark conditions under snow-covered ice limiting photosynthesis) and the decomposition of matter may consume the oxygen creating very low DO concentrations that may result in a large die off of fish or a "winter kill." Extremely low DO concentrations occurring in the bottom sediments can also trigger a chemical reaction that causes phosphorus to be released from the sediment into the water column. Elevated phosphorus levels can lead to excessive algal and plant growth that can be detrimental to water quality.

Salinity- This parameter measures the amount of dissolved salts in the water. Dissolved salts in a lake are not naturally occurring. High salinity measurements may be the result of inputs from other sources such as failing septic systems, spring runoff from roads, and farm field runoff.

Temperature- Fish species are sensitive to water temperature. Lake trout and salmon prefer temperatures between 46°F-56°F, while bass and panfish will withstand temperatures of 76°F or greater. Temperature also affects the amount of dissolved oxygen that the water can hold in solution. At warmer temperatures, oxygen is readily released to the atmosphere and dissolved oxygen concentrations fall.

Secchi Disk- The secchi disk is a device used to measure transparency or clarity of the lake. Transparency is directly related to the amount of algae and suspended solids in the water column. A secchi disk is a white and black disk attached to the end of a rope that is marked off in 6-inch intervals. The disk is lowered over the shaded side of the boat until it disappears and then pulled up to the point where it reappears again. The midpoint between these two points is the secchi disk measurement. Shallow measurements typically indicate large algae and/or suspended solids concentrations.

Total Phosphorus (TP)- Phosphorus is an essential nutrient that limits and stimulates growth of algae. A single pound of phosphorus can result in 500 pounds of algal growth. Large amounts of algae reduce water clarity, deplete dissolved oxygen levels from algae decay which impact fish populations, and degrade aesthetics for recreation. Ideally, Total Phosphorus should be below 50 µg/l. Sources of phosphorus include runoff from agricultural land, runoff from lakeshore properties carrying fertilizer and untreated human waste from failing septic systems, pet wastes, and stormwater runoff. The lake itself can also be a source of phosphorus. High levels of total phosphorus contained in the bottom sediments of lakes can be released when the sediment is disturbed. In shallow lakes, recreational activities such as power boating stir up the sediment and resuspend the nutrients in the water. Carp stir up the bottom sediment when they forage on the roots of aquatic plants. Dissolved oxygen also has a role in controlling the release of phosphorus from the sediment. When the bottom sediments become oxygen depleted phosphorus can

be released into the water through a chemical reaction.

Chlorophyll-a (Cl-a)- Chlorophyll-a is the inorganic portion of all green plants that absorbs the light needed for photosynthesis. This parameter is used to evaluate the concentration of algae in the water column. It does not provide a measure of large plants (macrophytes) or filamentous algae.

Q- Lakes are often compared to the “ecoregion.” What does this mean?

A- We compare our lakes to conditions in other lakes in the same ecoregion. The U.S. Environmental Protection Agency mapped regions of the U.S based on soils, landform, potential natural vegetation, and land use. These regions are referred to as ecoregions. Minnesota has seven ecoregions; Anoka County is in the North Central Hardwood Forest ecoregion. Reference lakes, deemed to be representative and minimally impacted by man (e.g., no point source wastewater discharges, no large urban areas in the watershed, etc.), were sampled in each ecoregion to establish a standard range for water quality. These data established a range of summertime mean values for each of the water quality parameters.

Q- What is the lake quality report card system and how is it used?

A- The Metropolitan Council developed the lake water quality report card in 1989. In the same way that a teacher would grade students on a “curve,” the lake grading system compares one lake to other lakes in the region. The grading system is based on summertime (May to September) mean values for chlorophyll-a, total phosphorus and secchi disk. Importantly, the comparison is relative to other lakes in the region – a lake that gets an “A” in the Twin Cities Metro might only get a “C” in northern Minnesota.

Lakes receiving an overall A grade have exceptional water quality and no recreational impairment; B lakes have good water quality and some recreational impairment; C lakes have average water quality and are recreationally impaired; D lakes have very poor water quality with severe recreational impairment and F lakes have extremely poor water quality and do not support recreational activity.

Lake grading system table:

Grade	Percentile	TP (µg/l)	Cl-a (µg/l)	Secchi Disk (m)
A	< 10	<23	<10	>3.0
B	10 - 30	23 – 32	10 - 20	2.2 - 3.0
C	30 – 70	32 – 68	20 – 48	1.2 – 2.2
D	70 – 90	68 – 152	48 – 77	0.7 – 1.2
F	> 90	> 152	> 77	< 0.7

Q- What do the lake physical condition and recreational suitability numbers mean?

A- The Minnesota Pollution Control Agency has established a subjective ranking system that ACD staff use during each lake visit. It is based purely upon the observer’s perceptions. These physical and recreational rankings are listed with other results for each lake.

Lake physical and recreational conditions ranking system

Physical Condition	Rank	Interpretation
	1	crystal clear
	2	some algae
	3	definite algae
	4	high algae
	5	severe bloom
Recreational Suitability		
	1	beautiful
	2	minimal problems
	3	swimming impaired
	4	no swimming / boating ok
	5	no swimming or boating

Q- At what concentrations do total phosphorus and chlorophyll-a become a problem in lake water?

A- Lakes in the North Central Hardwood Forests have a certain criteria set for both total phosphorus and chlorophyll-a. For total phosphorus, the

concentration for safe drinking water is set at < 30 µg/l, with the level for primary contact, recreation and aesthetics set at < 40 µg/l. For chlorophyll-a, the average concentrations range from 5 to 22 µg/l, with maximums ranging from 7 to 37 µg/l. Once these set limits have been reached or exceeded, noticeable and excessive plant and algae growth will be observed.

Q- What does the “trophic state” of a lake mean?

A- Lakes fall into four basic categories, called trophic states, based on lake productivity and clarity.

1. Oligotrophic- In these lakes plant nutrients (total phosphorus and nitrogen) are very limited and dissolved oxygen concentrations are high throughout the lake. These lakes are usually not preferred by sport fisherman because they lack the plants required by game fish. Oligotrophic lakes are the deepest, cleanest and clearest of all lakes.

2. Mesotrophic- In these lakes, plant nutrients are available in limited quantities allowing for some plant growth and dissolved oxygen is in abundance. These lakes are still considered clean and relatively clear. Fishing in these lakes is usually good due to increased plant life.

3. Eutrophic- In these lakes, the water is rich in minerals and nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content when it decays and may cause the extirpation of other organisms. These lakes are less clean and clear, but fishing is usually good for panfish and bass. Algae blooms in the “dog days of summer” are commonplace for these lakes, with clearer conditions occurring in early spring and late fall.

4. Hypereutrophic- In these lakes plant nutrients are over abundant and dissolved oxygen frequently falls to levels almost too low to support aquatic life. These lakes are the poorest quality and have very poor transparency. Even in the spring and fall when some lakes have improved transparency, these lakes will retain the algal levels that impede clarity. Fishing in these lakes is usually limited to stunted panfish and roughfish.

Q- How do lakes change throughout the year and how does this affect water quality?

A-Water temperature is very important to the function of lakes. Lakes undergo seasonal changes that can influence water quality conditions. Because

many Anoka County lakes are shallow (< 20 ft), some of the seasonal changes that are typical for deep lakes do not occur. The following discussion does not apply to these shallow lakes.

In the summer after the lake has warmed, deep lakes typically will be divided into three layers (stratified) based on the water's temperature and density; the well-mixed upper layer (epilimnion); the middle transition layer (metalimnion); and the cool, deep bottom layer (hypolimnion). The hypolimnion is usually depleted of oxygen because of decomposition of organic matter, the lack of photosynthesis, and because there is no contact with the surface where gas exchange with air can occur. Nutrients attached to sediment or decomposing organic material also fall into the hypolimnion where they are temporarily or permanently lost from the system. This is one reason deep lakes are usually not as nutrient rich and do not experience algae problems like shallow lakes.

In the autumn, the water near the surface eventually cools to the same temperature as the water at the bottom of the lake. When the water is of uniform temperature from top to bottom, it is easily mixed by the wind. This mixes nutrients that were formerly trapped at the bottom and may cause an autumn algal bloom. If the algal bloom is too severe, it could be detrimental to the lake during the winter when the lake is covered with ice. These algae will decay consuming dissolved oxygen, already impaired due to ice over, which may lead to a winter kill. This situation is typically observed in shallow eutrophic and/or hypereutrophic lakes.

In winter an inverse thermal stratification sets up. Ice is less dense than water and therefore floats. The coldest water is nearest the surface. Water has a maximum density at 4° C, and that water is found at the bottom. The reversal of the temperature layers in spring and fall is called "turning over."

In spring, the lake "turns over" with the warmer water rising to the top and the colder sinking to the bottom. When this occurs nutrients needed for plant growth (total phosphorus and nitrogen) are distributed throughout the lake from the bottom. As solar radiation slowly warms the deeper lakes during the spring and summer, the lake starts to stratify into the three layers again, this time with the warmest water on top.

Q- What factors contribute to poor water quality in our lakes?

A- There are many reasons why lakes become nutrient overloaded and perceived as undesirable for fishing and recreation. One of the reasons a lake becomes eutrophic is due to failing or improperly installed septic systems. Since the majority of the soils surrounding Anoka County lakes are sandy, effluent from a failing or improperly installed septic systems may easily leach into the lake without being properly treated. When untreated effluent reaches the lake, high levels of phosphorus, nitrogen, and fecal coliform bacteria enter the lake. The phosphorus and nitrogen cause excessive plant and algae growth, while the fecal coliform bacteria pose a health risk at high concentrations. Septic systems should be inspected every year, with the holding tank being pumped every one to three years, depending on use.

Agricultural runoff is another cause of eutrophication. Agriculture runoff ranges from feedlot runoff to farm field runoff. When feedlots are allowed to drain to a stream that enters a lake, or when a field is adjacent to a lake or a stream, high levels of phosphorus and nitrogen can be introduced to the lake causing excessive plant and algae growth. Feedlots should be designed to contain the animal waste on site until the waste can be properly applied and incorporated into the soil in a timely matter to prevent runoff. Farmers also should have their soil analyzed to determine the amount of fertilizer or manure needed for optimum crop growth; otherwise the excess phosphorus may end up in the lake. Buffer strips (grass strips \geq 30 ft. wide located between field or feedlot and a waterbody) are an effective method of preventing nutrients from entering the lake or stream.

Over fertilized lawns are another source of phosphorus in lakes. Many lakeshore homeowners prefer manicured green lawns. These homeowners apply fertilizer at least once a year. Unfortunately, most people do not understand how much, if any, fertilizer needs to be applied, which typically results in excess fertilizer being carried into the lake after storm events or during spring runoff. Lake plants and algae take up the extra fertilizer and grow excessively. Like the farmer, lake homeowners should have their soil analyzed to determine which nutrients and how much fertilizer is needed to achieve a green lawn. Native plant buffer strips at

the lakeshore also are an effective means of preventing nutrients from reaching the lake.

Powerboats also play a role in the lake water quality equation. The use of high-powered boats on relatively shallow lakes (<10ft) will stir up bottom sediments. The sediment contains high levels of phosphorus that become re-suspended in the water column and available for algae production.

Large populations of roughfish, such as carp, in shallow lakes also contribute to the re-suspension of phosphorus by feeding on the roots of aquatic vegetation. This action stirs up the bottom sediments and reduces the aquatic plants that stabilize the lake bottom.

One last source of nutrients is those that are naturally. Typically this phosphorus is chemically bound to sediments, but it may be released by low dissolved oxygen or certain hydrologic conditions. Sediment disturbance by boats, roughfish, or wind also make this phosphorus more accessible to algae in the lake.

Q – What analyses are used for trend analysis?

A- When at least 5 years of monitoring data are present, an analysis is conducted to detect water quality trends using a Multivariate Analysis of Variance (MANOVA). MANOVA tests the vector response of correlated response variables (secchi depth, total phosphorus, and chlorophyll-a) while maintaining the probability of making a type I error (rejecting a true null hypothesis) at $\alpha = 0.05$. Testing each response variable separately would increase the chance of making a type I error. When viewing the results, pay attention to the “p” value. If it is less than or equal to 0.05, there is a significant trend. Viewing the graph reveals the trend’s direction.