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Yahara Lakes Water Quality Monitoring
– Nearshore Monitoring Manual –

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Background

The Program

In 2013, Clean Lakes Alliance launched the Yahara Lakes Monitoring program in response to findings from a 2011 study by Richard Lathrop and Steve Carpenter who identified the importance of monitoring nearshore water quality conditions to safeguard public safety. Working with an array of unique partnerships including Wisconsin Department of Natural Resources, Public Health Madison & Dane County, UW- Madison Center for Limnology, Long Term Ecological Research, 5Nines, Madison College, City of Madison lifeguards, UW Space Science and Engineering Center, and UW Morgridge Center for Public Service, Clean Lakes Alliance is entering the seventh year of implementation.

Clean Lakes Alliance recruits the support of Greater Madison citizens to measure and record various water quality parameters, including clarity, temperature, and various visual observations in the nearshore environment. These roughly 70 volunteers ranging from UW- Madison students to retired community members graciously donate their time on a weekly (and in some cases daily) basis during the summer season. This program wouldn't be possible without the dedication of the volunteers.

In 2016, Clean Lakes Alliance added offshore monitoring to the program to help increase sampling frequency for water clarity and dissolved oxygen and water temperature profiles at depth at the center of each of the Yahara lakes. This program bolsters efforts by the Wisconsin Department of Natural Resources' Citizen Lake Monitoring Network and Long-Term Ecological Research Network.

In 2017, Clean Lakes Alliance deployed 14 continuous temperature data loggers to collect continuous data at various volunteer stations on lakes Mendota, Monona, and Waubesa. The use of these data loggers to supplement volunteer monitoring drastically increases sample size and improves the potential for future lake condition forecasting.

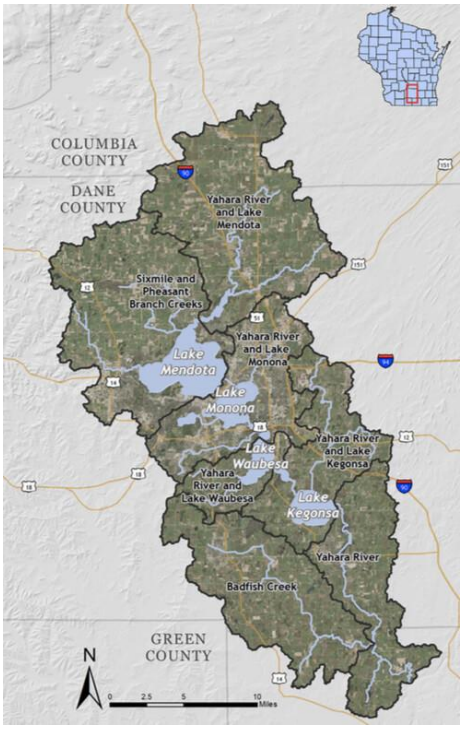
In 2018, Clean Lakes Alliance added a *E. coli* bacteria sampling pilot to test the effectiveness of sampling from various volunteer locations around the watershed because this is one of the primary factors that leads to beach closures. Also, Clean Lakes Alliance received the Wisconsin Citizen-based Monitoring Program of the Year award for the Yahara Lakes monitoring efforts. Successes such as this would not be possible without the support and dedication of our monitors.

In 2019, Clean Lakes Alliance switched to website provider 5Nines to host and improve Lakeforecast.org. A new scrollable map, picture submission, and cyanobacteria text alerts are just some of the features intended to improve user experience.

Since its inception, the program has expanded to include around 70 nearshore sites and 7 offshore sites and collected over 10,600 condition reports.

The Yahara River Watershed

- Watershed size: about 540 square miles
- Total lakes surfaces: 29 square miles
- Total lakes shorelines: 66 miles
- Across 3 counties: Columbia, Dane, and Rock (with 87% of area in Dane)
- Drains to 5 lakes: Mendota, Monona, Wingra (not part of chain), Waubesa, and Kegonsa (Figure 1)
- The watershed begins in the headwaters of the Yahara River in Columbia County and end at the confluence with the Rock River
- All of the five Yahara lakes are lowland drainage lakes
- Water quality in drainage lakes can be highly variable because they are fed by streams, groundwater, precipitation, and runoff



Purpose of the nearshore monitoring

The monitoring of nearshore water quality conditions serves many purposes:

- It **helps researchers** understand the conditions that create damaging algal blooms because it supplements the sampling conducted by other entities, creating a **more robust dataset** for all parties to draw upon.
- It tracks changing beach conditions and the formation and movement of **potentially toxic cyanobacteria and algal blooms**. Knowing where algal blooms are occurring helps inform and **protect the public**.
- It provides information to the **LakeForecast.org website** that combines water quality conditions reported by Clean Lakes Alliance citizen monitors as well as other water condition information such as beach closures to the general public in real-time. This website **helps Yahara lake users choose where they'd like to spend time on the lakes**.
- It informs the Clean Lakes Alliance weekly **Weekend Lake Reports** during the summer on social media which **builds awareness and educates the public** about lake ecosystems and

water quality. These reports include updates on beach closures and where to spend time on the lakes based on conditions reported by monitors and weather conditions.

Our Weekend Lake Reports received over 77,800 views in 2018. Continued efforts are being made to broadcast them on a Madison TV station. To access the weekend lake reports, like Clean Lakes Alliance on Facebook or go to YouTube and search "Weekend Lake Report."

2020 Goals

2020 project goals are to:

- Transition Lakeforecast.org website to new platform that improves user interface and volunteer experience
- Maintain approximately 65 volunteers to provide adequate spatial coverage around the Yahara lakes
- Increase frequency of nearshore monitoring at all public beaches by allowing multiple monitors to participate at the same location
- Deploy thermistors to test water temperature at a 3 ft depth contour at least 18 locations around four Yahara lakes (Mendota, Monona, Waubesa, Kegonsa)
- Continue collaborating with City of Madison to have lifeguards monitor at four of nine lifeguarded beaches *five* times per week
- Perform weekly offshore monitoring of water clarity, temperature, and dissolved oxygen at the deep hole on all five Yahara lakes to increase sampling frequency
- Increase number of *Lake Forecasting Stewards*
- Continue analyzing the impacts of temperature, wind, and rainfall on cyanobacteria bloom formation

Volunteer Training

Additional training or a refresher are not required but can be requested. Volunteers should see the training video on Clean Lakes Alliance's Water Quality Monitoring webpage cleanlakesalliance.org/monitoring/ or on YouTube at youtube.com/watch?v=IGECFKXXha4 for a refresher on the protocols used during the sampling period.

Throughout the year, **Luke Wynn** will provide assistance and support to volunteers. This support includes obtaining and disseminating equipment and supplies (e.g. monitoring equipment and manual), troubleshooting equipment issues, and performing periodic check-ins to answer questions.

Implementation timeline

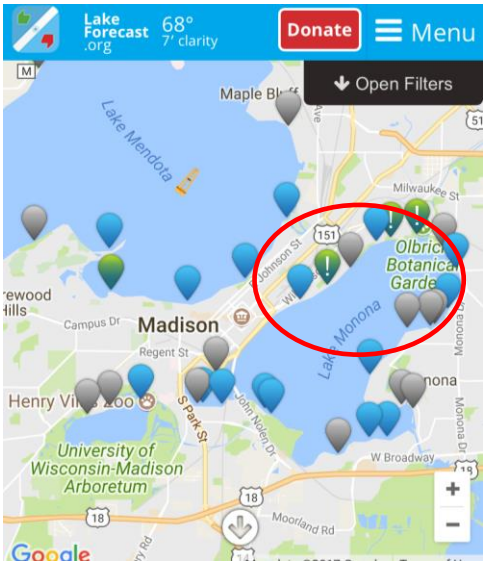
Start of the monitoring season: **May 25th**(volunteers can start earlier if interested)

End of the monitoring season: **September 7th** (volunteers can sample through the end of September if interested)

Sampling frequency: **twice a week** (or more if it is possible)

Recommended date for sampling (if possible): **Thursday mornings** between 7 a.m. and 12 p.m. **and one additional day** - either Tuesday and/or Saturday morning

We are asking all volunteers to sample two times per week or more to help increase the timeliness of information to lake users through LakeForcast.org and the Weekend Lake Report on social media.



Clean Lakes Alliance staff will inform volunteers via email when multiple volunteers and/or Public Health - Madison & Dane County reports a cyanobacteria algal bloom presence. Cyanobacteria bloom reports will be incorporated into LakeForecast.org, displaying the observations with an exclamation point as shown in the picture.

Collecting data

Quantitative parameters to be measured include:

- water temperature and air temperature measured using a digital thermometer (Appendix 1)
- water turbidity (an indicator of clarity) will be determined using a 120cm turbidity tube (Appendix 2)

Qualitative, visual observations (Appendix 3) will be collected for:

- wave intensity
- waterfowl presence
- surface bloom presence
- algal bloom type: monitors are trained to distinguish and report green algae and cyanobacteria algae blooms at their sites (Appendix 5)
- floating plant debris abundance
- bather load (or the number of people in the water)
- visual water clarity

Sample area size: for all visual observations we ask volunteers to concentrate on conditions in the immediate area. More specifically, the sampling area is approximately 50 feet in any direction from where you measure water temperature and turbidity.

Additional data to collect

Microcystins Strip Test

In 2020, Clean Lakes Alliance will work with UW Water Systems & Society Research Group to conduct Microcystins testing. Microcystins are a class of toxins produced by cyanobacteria. The data collected will be used to estimate the quantity of Microcystins in water. We will also use the results to correlate them with visual observation of cyanobacteria blooms. Volunteers who wish to participate will attend a training day and collect a small water sample while they are monitoring. The procedure to conduct the test takes 35min to complete and the data will be submitted through a shared google sheet.

Data submission

Volunteers will record their data on provided data sheets and enter results into the web-based data entry system (Lakeforecast.org).

The Monitor Login button at the bottom of the page will direct you to enter your username and password. Once logged in, select the New Entry button at the top right and follow the prompts to enter your visual and quantitative observations (Appendix 4).

Safety instruction

Clean Lakes Alliance recommends the volunteers to take some safety precautions **during algal blooms events**:

- Do not enter the water and do not perform the measure of water temperature and water turbidity.
- Limit the time breathing nearby water while you are collecting visual information.

It's Blue, It's Green, It's Cyanobacteria

Definition: Cyanobacteria are a group of bacteria that photosynthesize and fix nitrogen
Identification: Looks like blue-green paint across the surface of the water, and noticeably bacteria are disconnected and free-flowing
Dangers: Some species produce cyanotoxins which can be hazardous to health when ingested, touched, or inhaled. Cyanotoxins are usually neurotoxic (affecting the nervous systems) or hepatotoxic (affect the liver).

Symptoms of Cyanobacterial Poisoning:

- In animals:

    - Usually observable as soon as 20 minutes after ingestion
    - Weakness, staggering, difficulty breathing, convulsions, death
- In humans:
    - Microcystin-LR
        - Abdominal pain, headache, sore throat, vomiting/nausea, dry cough, diarrhea, blistering around the mouth, and pneumonia
    - Cylindrospermopsin
        - Fever, headache, vomiting, and bloody diarrhea
    - Anatoxin - a group
        - Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis (which could lead to death)

IF YOU OR OTHERS BELIEVE YOU MAY HAVE CYANOBACTERIAL POISONING, SEEK MEDICAL HELP IMMEDIATELY!

Cyanobacterial Poisoning Prevention Strategies:

- Avoid contact with water known to be contaminated
- Rinse off with clean/fresh water as soon as possible if contact suspected
- Do not ingest lake water
- Keep pets away from water if unsure about water quality

Not all species generate toxins, so stay updated on advisories and closures with Lakeforecast.org!

E. Coli: What you need to know

Definition: *E. coli* refers to a family of bacteria that can live in water, on food, and in the intestines of people and animals

Dangers: When ingested, *E. coli* can make people ill, and in extreme cases cause dehydration and death
Who monitors for it: Public Health - Madison & Dane County conduct water quality checks once a week to look for *E. coli*
What triggers a beach closure: Beach Closures occur when levels of *E. coli* or cyanobacteria are above a threshold (1,000 MPN/100mL or 20 ppb respectively). Closed beaches are tested daily until conditions improve.

Beach closures are posted on the Public Health - Madison & Dane County website, Facebook, and Twitter, in addition to email notifications and signage at the beach.

***E. Coli* Contamination Symptoms:**

- Diarrhea
- Abdominal cramping, pain, or tenderness
- Nausea and vomiting

Strategies to Prevent Contamination:

- Avoid swimming after a heavy rainfall because levels could be elevated
- Do not ingest lake water and wash your hands before eating
- Wash your pet after swimming
- Follow safety alerts and advisories

Annual Project Reporting

At the end of 2020, Clean Lakes Alliance will compile and interpret both individual and aggregated sampling results. These results will be presented to volunteers via mail and in an annual report format. The end-of-year summary for each year can be found on Clean Lakes Alliance's Water Quality Monitoring webpage cleanlakesalliance.org/monitoring/. The information will also be shared with UW-Madison researchers as we continue to work toward developing a predictive model for cyanobacteria algal bloom formation. In addition, Clean Lakes Alliance will inform other water resources organizations of the data collected and facilitate its timely distribution.

How to Support our Monitoring Efforts

Support Financially

If you would like to help support the program in 2020, please consider becoming a *Lake Forecasting Steward* or renewing starting at $135 by going to our website cleanlakesalliance.org/product/lake-forecasting-steward/ or sending a check to Clean Lakes Alliance (150 E. Gilman St., Suite 2600, Madison, WI 53703) with memo "Lake Forecasting Steward." In 2018, 24 of your fellow lake monitors donated to help support this program.

A *Lake Forecasting Steward* donation of $135 contributes to the following:

- $60.25: Turbidity tube for one additional volunteer & monitoring site
- $15.00: Thermometer for one additional volunteer & monitoring site
- $24.75: Office expenses and supplies
- $35.00: 2017 Friend of Clean Lakes donation

Support with Pictures

Receiving pictures from you and your loved ones sampling at your sites will help us to promote and educate the public on the program through social media. Please send your action pictures while handling the material at your site to Clean Lakes Alliance staff. We would also like receiving pretty water scenes and/or algae blooms events pictures.

Contact Information

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Appendix 1

Instructions for Performing Digital Air and Water Temperature Measurements

Equipment/Materials Needed

- Digital Arrow-Shaped Thermometer (either Thermoworks or Fisher Scientific brand)
- Nearshore Water Quality Monitoring Data Sheet

General Rules of Sampling

- Sample air temperature as close to lake sample collection site as possible
- Collect data by removing the probe from the chamber and allowing the temperature reading on the probe to stabilize before recording.
- Pressing the "hold" button freezes the current temperature on screen for easier recording
    - Thermoworks thermometers do not have a "hold" button
- Remember to remove the plastic sheath that covers the temperature probe when sampling.
- You can switch between °C and °F by pressing the [°C/°F] button.
    - This button is located on the back of Thermoworks thermometers

Changing Battery

- You may need to replace the battery periodically during the sample season.
- To replace the battery, remove the screw cover with a small Phillips screwdriver, carefully remove the old battery and replace it with a new battery in the same position as the old battery, and rescrew the cover back on the thermometer.
- LR44 batteries are used in the Thermoworks thermometers and CR2032 batteries are used in the Fisher Scientific thermometers. Batteries can be obtained from a hardware store.

Sampling Methods

Step 1 – Air Temperature Measurement

1. Remove the temperature probe from the probe chamber.
2. Hold the thermometer so that it is shaded by your body
3. Press the [ON/OFF] button.
4. Allow the temperature to stabilize.
5. Record stabilized temperature in °F on water quality monitoring data sheet.

Step 2 – Water Temperature Measurement

1. Sample the surface at location where it is ~3 feet total depth
2. Carefully move to the sampling location, while wading slowly in the water. If collecting samples from your pier, sample as above (3 feet total depth) but disregard the wading.
3. Remove the temperature probe from the probe chamber.
4. Press the [ON/OFF] button.
5. Insert thermometer vertically into the water, submerging the silver probe.
6. Allow the temperature to stabilize.
7. Record stabilized temperature in °F on data sheet.

Step 3 – Enter Data

1. After recording your measurements on the paper form, please enter the data into the online submission form on Lakeforecast.org using your username and password provided by Clean Lakes Alliance.

Appendix 2

Instructions for Performing Turbidity Measurements Using a 120cm Turbidity Tube

Turbidity is a measurement of how cloudy water appears. Turbidity is also a measure of how much light passes through water and is caused by suspended solid particles that scatter light. These particles may be microscopic plankton, stirred up sediment or organic materials, eroded soil, clay, silt, sand, mud, industrial waste, chemical precipitates, or urban runoff.

Equipment/Materials Needed

- 120cm turbidity tube
- Nearshore Water Quality Monitoring Data Sheet

General Rules and Tips of Sampling

- Do not wear sunglasses when sampling
- Record the value when you can first see the white and black disk: the moment you first recognize the contrasting pattern, not necessarily when the pattern is completely visible.
- Keep the tube vertical when taking your reading. It is easy to accidently tilt the tube as you lean over to view the Secchi disk.

Cleaning the Turbidity Tube

- Although Clean Lakes Alliance cleans the tubes between seasons, you may want to periodically clean your tube if it starts collecting algae or other debris that obstructs view of the black and white Secchi disk.
- To clean your tube, it is best to use a long-handled brush that can be pushed to the bottom of the tube. An attached string or broom handle is necessary for easy removal. A small amount of environmentally friendly cleaner can help remove dirt and algae. Rinse well with a garden hose or your indoor sink.

<u>Sampling Methods</u>

Step 1 – Sample Collection

1. Sample at ~3 feet total depth
2. Dip the tube ~6 inches into the water at your sampling site and fill to the top

Step 2 – Turbidity Measurement

1. Take your filled turbidity tube to a shaded spot. If there is no shade around, use your body to block the sun from shining on the tube
2. Look down through the tube toward the target disk on the bottom of the tube.
3. If the disk is visible, record the water level as 120 centimeters
4. If the disk is not visible, slowly release water from the release valve until the disk at the bottom of the tube becomes visible. Record the water level in centimeters (cm).

5. Record all values on water quality monitoring data sheet

Step 3 – Enter Data

1. After recording your measurements on the paper form, please enter the data into the online submission form on Lakeforecast.org (**https://lakeforecast.org/#/login**) using your username and password provided by Clean Lakes Alliance.

Appendix 3

Instructions for Collecting Qualitative Data

Equipment/Materials Needed

- Nearshore Water Quality Monitoring Data Sheet
- Computer or smartphone

Qualitative, Visual Observations

Step 1 – Collect Observations

1. Record all data on the nearshore water quality monitoring data sheet.
    a. Wave intensity on a scale of 1 - 3 (1 = calm to small ripples, 2 = small to moderate chop, 3 = rough water).
    b. Waterfowl presence in the water or at the lake edge, paying particular attention to geese/ducks (1 = none, 2 = some, 3 = a lot).
        i. "Some" signifies between 1 - 10 waterfowl are present.
        ii. "A lot" signifies greater than 10 waterfowl are present.
    c. Algal surface bloom presence (1 = none, 2 = some clear evidence, 3 = strong, extensive presence) within the general vicinity of the sampling area
    d. Algal bloom type (G = green algae, CY = cyanobacteria or BOTH if there is both cyanobacteria and green algae)
    e. Floating, uprooted plant debris abundance (1 = none, 2 = small coverage, 3 = heavy coverage)
    f. Bather load, or the number of people in the water (1 = none, 2 = some, 3 = a lot/crowded).
        i."Some" signifies between 1 - 10 people are in the water
        ii."A lot" signifies greater than 10 people are in the water
    g. Water clarity (Good= can see toes, fair= can barely see toes, murky= cannot see toes

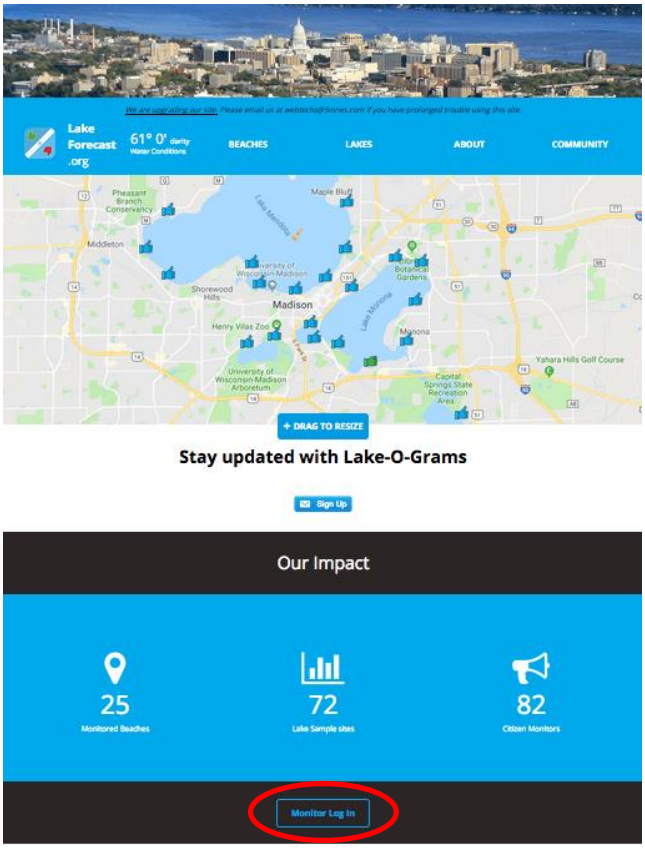
Step 2 – Enter Data

1. After recording your measurements on the paper form, please enter the data into the online submission form on Lakeforecast.org (**https://lakeforecast.org/#/login**) using your username and password provided by Clean Lakes Alliance.

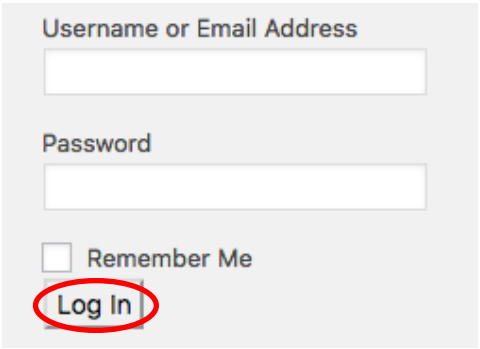
Appendix 4

Instructions for submitting Data on LakeForcast.org

STEP 1: Go to https://lakeforecast.org/#/
Click "Monitor Log In"
OR "Submit Collection" if already logged in



STEP 2: Enter your Username and Password and click "Log In"



STEP 3: Enter date and time
Your site ID code will automatically update

STEP 4: Select the appropriate visual

STEP 5: Continue to select visual observations

Floating Plant Debris (click one)

1

None

2

Some clear evidence

3

Strong extensive evidence

Bather Load (click one)

1

None

2

Some (1-10)

3

A lot/crowded (greater than 10)

Water Clarity (click one)

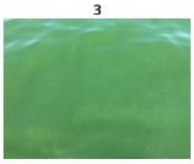
1

Good

2

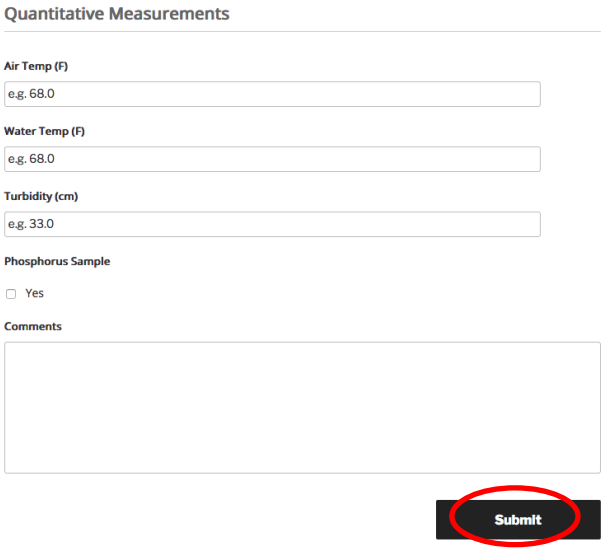
Fair

3



Murky

STEP 6: Enter Quantitative Measurements Click "Submit"



Appendix 5

Green Algae v. Cyanobacteria: Who's who?

	Green Algae	Cyanobacteria
What does it look like?	Long, green filaments that stick together in mats	Microscopic colonies or unconnected bacteria that flows over surfaces and looks like paint
ID Pictures:		
Why is it bad?	In excess, mats can grow too thick and trap oxygen from photosynthesis and float to the lake surface	Toxic and can make people sick
Notable changes	Turns brown when decaying	Turns blue, white, or other bright colors while decaying
Differences between species:	● *Spirogyra* forms long, unbranched filaments ● *Cladophora* feels like wet cotton, has branched filaments, and grows on hard surfaces ● *Pithopora* branches at right angles and is very coarse, with brownish resting cells in the filaments	● *Aphanizomenon* looks like small grass clippings ● *Microcytis* forms nearly microscopic globular colonies ● *Gloetrichia* are spherical and made of a ton of small filaments attached to a common center

Remember!

If it's slimy and in mats, green algae filaments are back!

If it's disconnected and small, that's cyanobacteria's call!

Additional Resources

Invasion of the Invasive Species

Turbidity, Clarity and Total Suspended Solids (TSS)

Understanding your Data: What Affects Water Clarity?

Invasion of the Invasive Species

Definition: Invasive species are plants or animals that are not native to the area they now live. Often, they have been brought or accidentally carried into the new region, and cause trouble for the native species.

Plants

Purple Loosestrife:

- 3-7 feet tall
- Purple flowers from a head spike
- Downy, smooth-edged leaves in pairs
- Stem has ridges

Water Lettuce:

- Floats on the water
- Thick leaves
- Resembles an open head of lettuce

Animals

New Zealand Mudsnails:

- 4-6 mm long
- Light brown shell with 5-6 whorls
- Can close shell to survive out of water for days

Mystery Snails:

- Japanese: 6cm, light to dark olive-green shells, 6-7 whorls, longer and narrow cones
- Chinese: 5cm, light to dark brown shells, 7-8 whorls, wider and shorter cones
- Banded: 4.5cm, yellow or green with a red band, 4-5 whorls, shortest cone
- If seen, do not touch - can carry parasites detrimental to humans

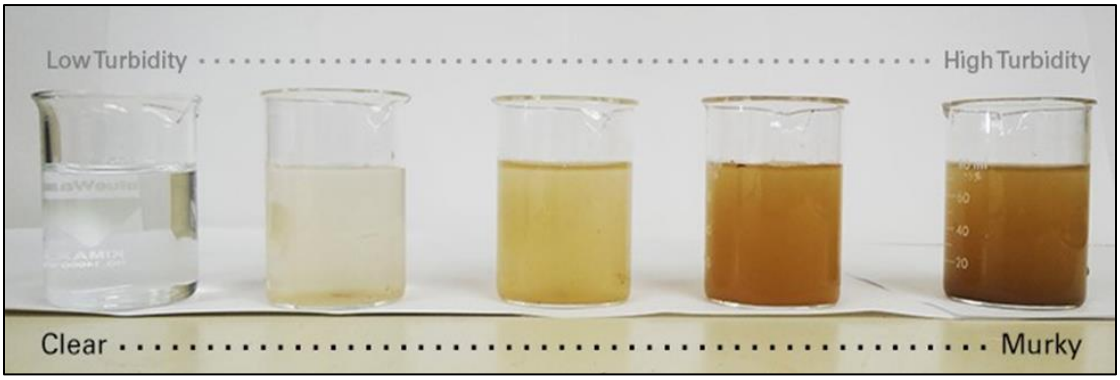
Rusty crayfish:

- 7.5-13cm long from nose to tail
- Smooth claws with black bands on the tips
- When closed, claws have an oval gap
- Claws are generally grayish-green to reddish-brown

If spotted, report date, time, and exact location to the DNR!

Turbidity, Clarity, and Total Suspended Solids

Parameters	Clarity	Turbidity	Total Suspended Solids (TSS)
Definition	How far light can pass through the water column.	Measure of the degree to which water loses its transparency.	Particles that are larger than 2 microns found in the water column.
Comments	Turbidity and clarity are directly related. In fact, turbidity is a measure of water clarity. *High turbidity = Low clarity* *Low turbidity = High clarity*		While TSS affect turbidity, turbidity is not a direct measurement of TSS.
What is measured?	Organic and inorganic suspended solids, like clay, silt, sediment, algae, and bacteria + Dissolved colored materials (smaller than 2 microns)		Organic and inorganic suspended solids + Settleable solids (Solids that are moved along the bottom of a body of water by strong flow)
How is it measured?	<u>Direct measurement</u>: Turbidimeter or Turbidity Sensor <u>Indirect measurement</u>: Secchi disk or Turbidity Tube Indirect methods are quick and inexpensive but are dependent on the visual acuity of the observer		To measure TSS, a water sample is filtered, dried, and weighed.



Understanding Your Data: What Affects Water Clarity?

- **Amount of sunlight available**

The measurement of water clarity using Secchi disk and Turbidity tube is affected by the visual acuity of the observer, cloud cover, sun position, and lake surface state. If the sky is clear and the surface water calm, the Secchi disk will be more visible for the observer (Figure 1).

Figure 1: Monitor taking a Secchi disk reading during ideal weather conditions.

- **Inorganic suspended solids**

In lakes, inorganic sediment such as clay, silt, and sand come from rivers, streams, and land use activities in the watershed. Soil erosion and runoff increase the amount of sediment in the water column (Figure 2). Those solid particles eventually settle down at the bottom of water bodies but seasonal mixing, boat activities, wind generated waves, and certain fish species can stir them up and make the lake appears murky.

Figure 2: Suspended sediments after intense rainfalls in Pheasant Branch Creek.

- **Organic suspended solids**

Algae (small aquatic plant), phytoplankton (microscopic plant), and zooplankton (microscopic animals) are suspended organisms that can affect the water clarity. In particular, cyanobacteria can grow very quickly and impact the entire food web by significantly reducing light penetration, depleting oxygen during die-off, and producing toxin (Figure 3).

Figure 3: Cyanobacteria bloom on Mendota Lake.

- **Dissolved colored solids**

Particles that are smaller than 2 microns are considered as dissolved solids. Some of these dissolved solids gives a color to the water which affect water clarity. For example, lakes near acidic wetlands might be stained brown due to dissolved tannic acid in the water (Figure 4).

Figure 4: Characteristic brown tea color that is the result of dissolved tannic