BENEATH THE SURFACE

DATA SUMMARY | **14** LAKES, **3** SUMMERS, **1** COUNTY

USE THIS **2021 REPORT** TO INVESTIGATE AND CLARIFY THE COMPLEX RELATIONSHIPS BETWEEN LAND, WATER AND LIVING ORGANISMS IN KOSCIUSKO COUNTY.

LILLY CENTER FOR LAKES & STREAMS | GRACE COLLEGE

Dr. Nate Bosch
Director

You probably love your lake and want to preserve it for future generations – so does our team!

Beneath the Surface will equip you with information that will give your family, organization or agency the ability to care for the lakes. A special thank you to **The Papers** and the **Renda family** for making this publication possible!

The Lilly Center launched back in 2007. We believe that a countywide lakes culture needs countywide research, education and collaboration, so our team crafts original content for those in kindergarten through retirement. Due to the Lilly Center's work, the lakes in Kosciusko County are some of the best-studied in the state of Indiana.

We have a library of valuable data that shows patterns and trends in the health of our lakes, which in turn reveals specific management steps. **That's part of the design of this report.** After looking at the data, we encourage you to follow the action steps on page 24 and share it with others. A digital copy can be found at: **lakes.grace.edu/bts**

We invite you to dive Beneath the Surface with us!

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MISSION & VISION

The Lilly Center for Lakes & Streams uses research, education and collaboration to make the lakes and streams of Kosciusko County clean, healthy, safe and beautiful.

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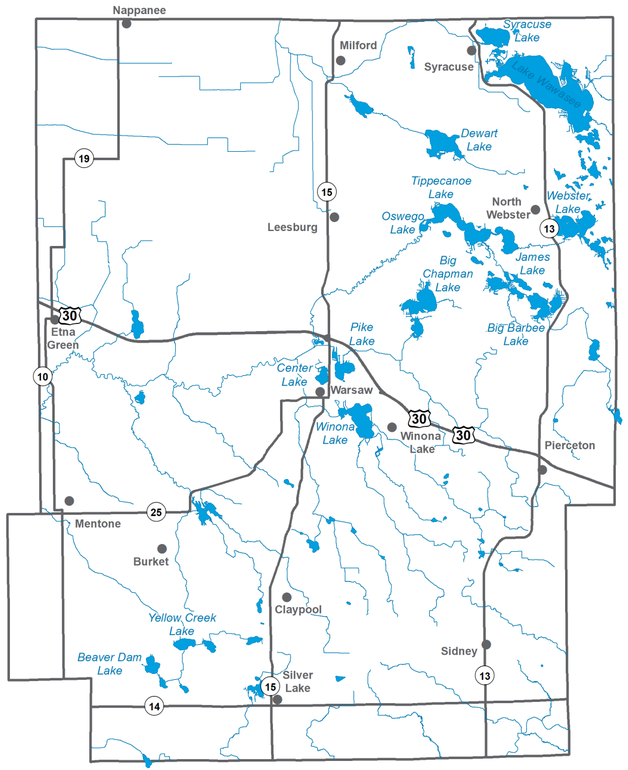
LILLY CENTER FOR LAKES & STREAMS | GRACE COLLEGE



How should you use this report?

We want you to understand this data and use it to make the best decisions for your local lakes and their watersheds. That is what this report helps you do: **investigate and clarify the complex relationships between land, water and living organisms**.

What is *Beneath the Surface?*

Beneath the Surface is a condensed form of the data Lilly Center staff and students gathered on 14 lakes during the summers of 2019-21. Reviewing several years of data helps us accurately compare and contrast data points and catch any changes that may have occurred.

How do we conduct lake research?

Every week from the beginning of June through the second week of August, the Lilly Center research team samples 12 all-sport lakes of Kosciusko County (since 2012), Center and Pike lakes, and seven public swimming beaches (since 2018).

Lakes are sampled at the deepest point in order to get a full vertical profile of the lake's temperature, dissolved oxygen, pH and conductivity. Nutrient samples are collected from one meter above the bottom and one meter below the surface to observe both layers of lake water in the summer.

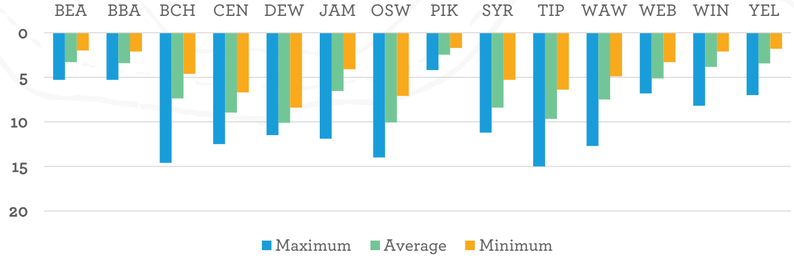
At all 14 lakes, we take **microcystin** (blue-green algae toxin) samples from the top six feet of open water, as well as the top three feet at seven public beaches. Measurements and notes are also recorded on atmospheric conditions, past and present weather, resident observations and recent management work.

WATER CLARITY

Have you noticed that you assess **water clarity** when you look off of a pier into the lake or down at your toes while swimming? You take note of whether or not you can see the bottom, or if sinking things disappear into murky depths. The Lilly Center quantifies water clarity using a black-and-white circle called a Secchi disk. Water clarity is reduced by the "stuff" suspended in the water – usually soil particles and algae. A deep Secchi disk reading, represented by a longer bar on the graph below, means clearer water. Clearer water is a sign of less algae and sediment in your lake!

2021 Summer Water Clarity

Organized alphabetically; measured by Secchi disk depth in feet



This Secchi disk graph shows the maximum, average and minimum depths we could see into each lake across all 11 of our weekly measurements during the summer of 2021. The average of all summer **2021** clarity readings was **6.4 ft**, barely greater than **2020's** overall average of **6.3 ft**. But not every week or lake was the same as last year! Take a look at the individual lake pages, starting on page 12, for more in-depth water clarity comparisons across the past three years.

LAKE ABBREVIATIONS

These abbreviations will be used throughout Beneath the Surface.

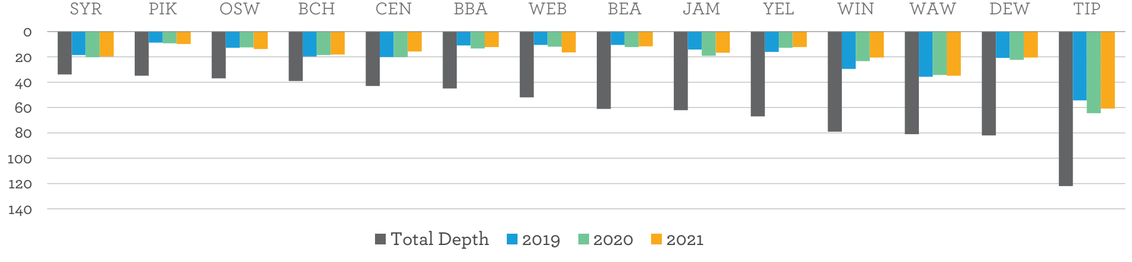
Beaver Dam..... BEA	Dewart..... DEW	Syracuse..... SYR	Winona..... WIN
Big Barbee..... BBA	James ..... JAM	Tippecanoe..... TIP	Yellow Creek..... YEL
Big Chapman..... BCH	Oswego..... OSW	Wawasee..... WAW	
Center..... CEN	Pike..... PIK	Webster..... WEB	

DISSOLVED OXYGEN

We are not the only ones interested in water quality; fish rely on healthy lakes, too. One threat to Kosciusko County fish is a lack of **dissolved oxygen** in the summer. As microbes, fish and other organisms live and "breathe" in the cool, deep water (**hypolimnion**), the dissolved oxygen content can diminish to zero, forcing fish into the much-warmer upper layer (**epilimnion**). The stark contrast in water temperature from top to bottom creates these epilimnion and hypolimnion layers, a boundary that dissolved oxygen and some other molecules cannot pass through until autumn cools the top water again. That is when water moves freely from top to bottom, replenishing dissolved oxygen throughout the lake. By **reducing the amount of material** decomposing at the bottom of a lake, we can hopefully slow the use of dissolved oxygen and reclaim deeper, cooler water habitat for fish during the summer.

Depth of Fish Habitat

Depths where dissolved oxygen > 2.0 mg/L; summer averages by year, organized by max depth, measured in feet



The lakes in this graph are organized from shallowest to deepest at their deepest point (gray bars show total depth). The longer the colored bars in this graph, the deeper the oxygen, the more habitat there is for fish! At bare minimum, **fish require at least 2.0 mg/L of oxygen** in the water to survive, so the colored bars represent where dissolved oxygen was measured greater than or equal to 2.0 mg/L. Many species of fish, however, need three or more times that amount to thrive and produce healthy offspring, and many rely on colder temperatures than can be found in the oxygenated upper layer of lake water in the summer.

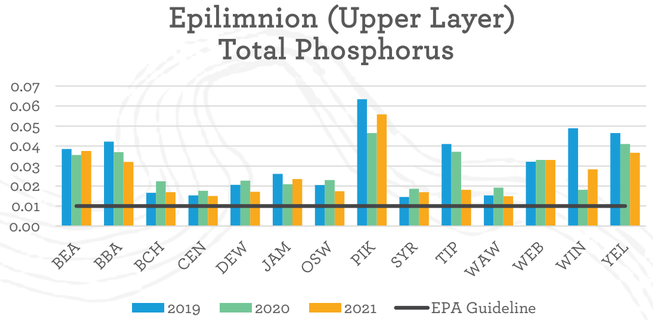
TOTAL PHOSPHORUS, TOTAL NITROGEN

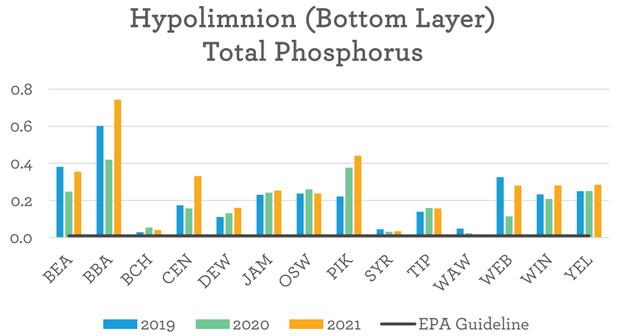
These four graphs show two nutrients (**phosphorus** and **nitrogen**) in two layers of lake water: the epilimnion and the hypolimnion, defined on the previous page. In order to get a full picture of lake nutrient levels, we sample both layers.

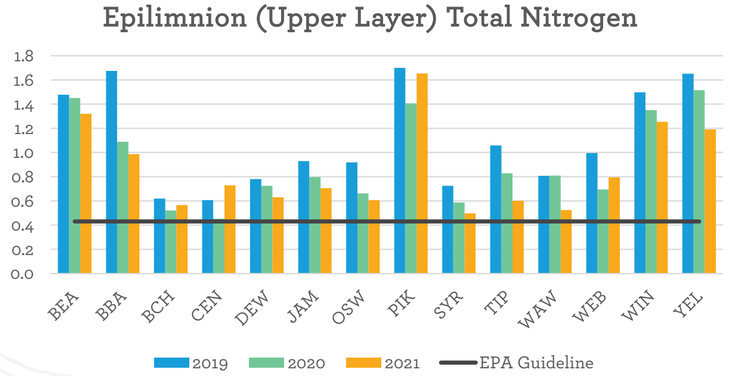
Phosphorus and nitrogen are nutrients that directly influence lake health. They are chemical elements necessary to support aquatic life, starting with the rooted plants (weeds) and phytoplankton (algae) that make up the base of the food chain.

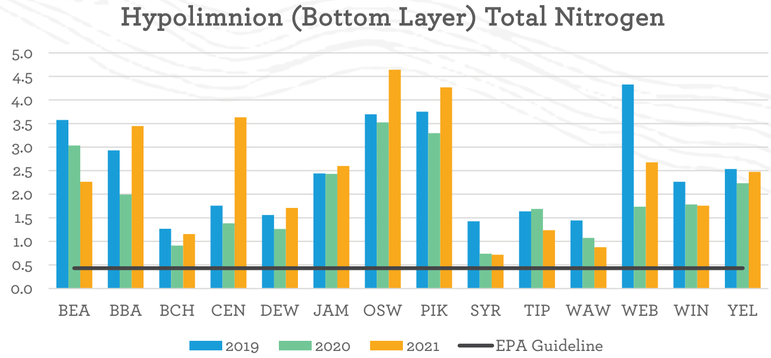
Nutrients have a positive, healthy connotation for people. Just as eating too much or the wrong foods can be bad for human health, **too much phosphorus and nitrogen can damage our lakes and their aquatic residents**.

The gray line on each of the nutrient graphs marks the Environmental Protection Agency's (EPA) calculation of the nutrient content of high-quality lakes in our area. It is a low bar compared to our results; in this graph, a shorter bar is more beneficial. According to our data from the past three years, all 14 lakes we sample need **fewer nutrients** to increase water clarity and the depth of fish habitats.









Note that the scales on these graphs are different, highlighting the fact that there are typically more nutrients in the hypolimnion than epilimnion in our lakes. That indicates that nutrients are not only coming from inflowing streams, but the lake bottom itself, too. (This is called "nutrient loading".)

You can also see that Big Chapman, Syracuse and Wawasee lakes have relatively low total phosphorus concentrations in their hypolimnion layer, indicating less nutrient loading from the sediments in these lakes at their deepest point.

The EPA guideline for total phosphorus is **0.010 mg P/L**. The average total phosphorus across all 2021 epilimnion samples was **0.029 mg P/L**, while the hypolimnion was **0.259 mg P/L**. The EPA total nitrogen guideline is **0.43 mg N/L**. The 2021 overall average total nitrogen was **0.861 mg N/L** in the epilimnion and **2.390 mg N/L** in the hypolimnion. **94%** (185 of 196) of 2021 samples were above the EPA guideline for total nitrogen, and **100%** (196 of 196) were above the total phosphorus guideline.

BLUE-GREEN ALGAE

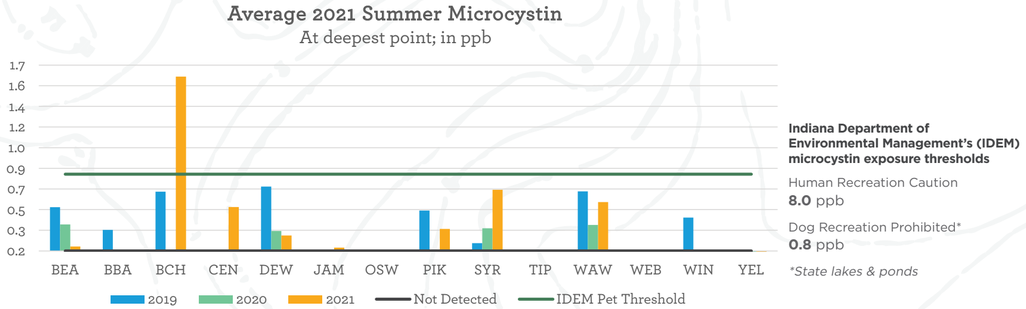
Most of our time spent investigating our lakes does not take place on the water at all, but in a lab! A team of trained undergraduate students, lead by Grace College professor Dr. Joseph Frentzel, have spent the summer of 2021 identifying and counting thousands of individual algae cells.

Out of all water samples assessed so far, 53.8% of cells have been blue-green algae (BGA) rather than green algae or other cells, and 71% of the BGA genera, or groups, found in our lakes are capable of producing toxin. 12.6% of our summer microcystin samples exceeded IDEM's pet recreation threshold.

Average percent of algae population that is BGA

Summer microcystin samples over the dog threshold (0.8)

Percent of identified BGA species that can produce toxins



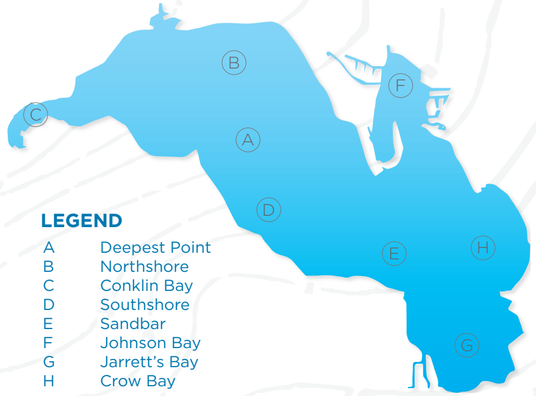
Blue-green algae are a photosynthesizing, increasingly-prevalent, potentially toxin-producing family of bacteria natural to freshwater. **Not every species of BGA creates toxins, and the toxin-producing species do not always produce toxin.** Though BGA are abundant in our lakes, data from the past four years shows that **microcystin toxin averages at or near levels of concern for pets** (0.8 ppb). While our BGA are capable of producing higher levels, typical levels do not approach the IDEM's guideline for human health concern (8.0 ppb; four times higher than this graph's scale) for our lakes.

Did you recieve our weekly microcystin update emails this summer? These data are just a taste of what we discovered while sampling. Stay in the loop when you follow this QR code and sign up for our curated, lake-focused monthly e-newsletter.

SPATIAL VARIABILITY STUDY

If you are a Kosciusko County native (especially in the town of Syracuse), you are likely aware that Wawasee is the largest natural lake in Indiana. With nearly five square miles of surface area, multiple bays, and all kinds of recreation taking place across the lake, Wawasee is a diverse waterbody. **These characteristics may have an impact on microcystin toxin levels.** To investigate, the Lilly Center started a spatial variability study in 2021 that continues into into 2022.

This study asked two questions, "Do microcystin levels vary across Lake Wawasee?" and "If so, is the variation driven by weather or other lake conditions?" We sampled **eight sites** (shown below) weekly for **seven weeks**. We collected data on toxin levels, water chemistry, and wind speed and direction. Below is a glimpse at our ongoing work with this data.



LEGEND

A Deepest Point
B Northshore
C Conklin Bay
D Southshore
E Sandbar
F Johnson Bay
G Jarrett's Bay
H Crow Bay

WHAT WE NOTICED

Microcystin concentrations varied across our sampling sites. We observed the greatest difference on July 6: Crow Bay had the highest concentration at 4.0 ppb, while Conklin Bay had the smallest at 0.4 ppb.

Jarrett's Bay and the Sandbar also had concentrations similar to Crow Bay that day (3.8 ppb), and Johnson Bay, the north shore, and the south shore had half as much toxin (1.7 to 1.0 ppb). Wind was breezy (average of 7 knots) mostly from the west. Some algae or other material may have been gathering on the eastern side of the lake, encouraging algae growth and potentially toxin production.

Thanks to the support of two generous Lake Wawasee families, the Finches and the Herdrichs, the Lilly Center was able to sample these seven additional sites on Lake Wawasee. This is just one example of the complex story these data help us piece together! More in-depth analysis and discussion on spatial toxin variability is on its way in a report by spring 2022.

LILLY CENTER PARTNERS

We work with each of these organizations to analyze or provide relevant data. We also co-host events, speak at presentations and collaborate on other activities within the county's watersheds. It is a privilege to work with dozens of individuals and businesses, including many more not on this list!

LAKE ASSOCIATIONS

Consider becoming a member of your local lake association to participate in the work that is already being done to protect your lake.

BARBEE LAKES PROPERTY OWNERS ASSOCIATION
North Webster, IN | barbeelakes.org

BEAVER DAM & LOON LAKE CONSERVATION CLUB
Claypool, IN

CENTER LAKE CONSERVATION ASSOCIATION
Warsaw, IN

CHAPMAN LAKES CONSERVATION ASSOCIATION
Warsaw, IN | chapmanlake.com

DEWART LAKE PROTECTIVE ASSOCIATION
Syracuse, IN | dewartlake.org

LAKE TIPPECANOE PROPERTY OWNERS ASSOCIATION
Leesburg, IN | ltpo.org

PIKE LAKE ASSOCIATION
Warsaw, IN

WAWASEE PROPERTY OWNERS ASSOCIATION
Syracuse, IN | wawaseepoa.org

WEBSTER LAKE CONSERVATION ASSOCIATION
North Webster, IN | lakewebster.net

WINONA LAKE PRESERVATION ASSOCIATION
Winona Lake, IN | winonalakepreservation.com

SYRACUSE LAKE ASSOCIATION
Syracuse, IN

YELLOW CREEK LAKE CONSERVATION CLUB
Claypool, IN

GOVERNMENTAL & CONSERVATION ORGANIZATIONS

Searching for an expert on local environmental efforts or ongoing statewide projects? Reach out to one of these organizations!

CITY OF WARSAW STORMWATER UTILITY
Warsaw, IN | warsaw.in.gov/301/stormwater-utility

U.S. ENVIRONMENTAL PROTECTION AGENCY
epa.gov

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Indianapolis, IN | in.gov/idem

INDIANA DEPARTMENT OF NATURAL RESOURCES
Indianapolis, IN | in.gov/dnr

KOSCIUSKO COUNTY CONVENTION, RECREATION AND VISITORS COMMISSION
Warsaw, IN

KOSCIUSKO COUNTY SOIL AND WATER CONSERVATION DISTRICT
Warsaw, IN | kosciuskoswcd.org

THE WATERSHED FOUNDATION
North Webster, IN | watershedfoundation.org

WAWASEE AREA CONSERVANCY FOUNDATION
Syracuse, IN | wacf.com

GRACE COLLEGE

Winona Lake, IN | grace.edu

The Lilly Center was founded and is based at Grace College. Over the years, our connection with the Department of Science and Mathematics has proven exceedingly valuable; the Lilly Center's research would be incomplete without the expert insights of the department's professors. The Lilly Center also works closely with the School of Education and other departments on campus, drawing from a seemingly endless supply of resources and knowledge.

K21 HEALTH FOUNDATION

Warsaw, IN | k21foundation.org

Several years ago, K21 Health Foundation provided the intitial funding for the Lilly Center's cyanobacteria (blue-green algae) research. They share our vision for healthy communities around healthy waterways and continue to provide invaluable support. Most recently, they invested over $230,000 into the Lilly Center's research. Their support also provided new lab equipment for in-house water testing and toxin analysis, and will provide resources for continued development and proactive measures to protect public health.

&wawasee &syracuse

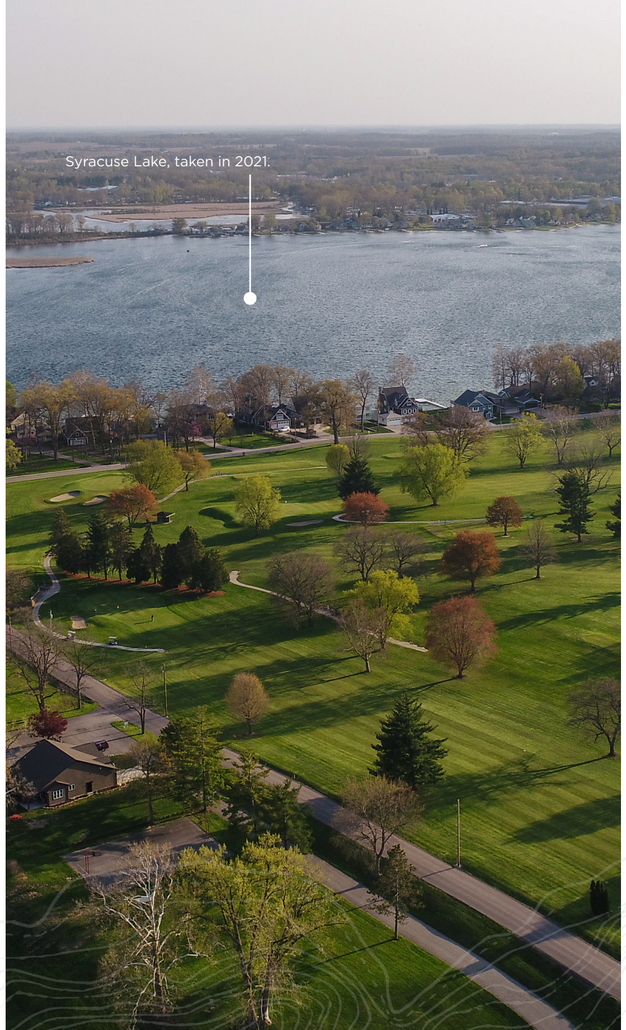
Tucked into the northeast corner of Kosciusko County, Wawasee and Syracuse lakes share a channel and acres of wetlands. Wawasee is Indiana's largest natural lake, with a surface area of over 3,000 acres and a watershed reaching well into Noble County.

WAW

Surface area	3,006 acres
Max. depth	81 ft
Avg. depth	22 ft
Watershed	24,448 acres

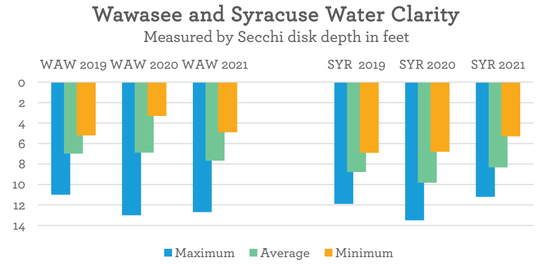
SYR

Surface area	411 acres
Max. depth	34 ft
Avg. depth	13 ft
Watershed	24,498 acres



Syracuse Lake, taken in 2021.

WATER CLARITY



Average and minimum water clarity was deeper in Wawasee this past year compared to last. Syracuse, on the other hand, had slightly reduced water clarity, illustrated by shorter bars on 2021 compared to 2019 and 2020. These two lakes have similar maximums, averages, and minimums overall, which may be expected given that Wawasee flows into Syracuse Lake. However, on a week to week basis, they have differed by 6 feet or more on occasion. Both handle water quality changes differently based on their shape, depth, surrounding hydrology, and even their algae communities.

MICROCYSTIN (MC)

Wawasee saw microcystin levels more similar to '19 than '20, and Syracuse was slightly higher than both previous years in average and maximum. In 2021, Hoy's and the community center beaches had four and five samples above the pet recreation guideline of 0.8 ppb, respectively. (For more information on these health guidelines, see page 8!) Syracuse's deepest point had four samples over, while Wawasee open water had three. All three Syracuse sites had these higher MC results in the first half of the summer, while Wawasee's MC was higher in the second half.

Sampling Location		2019	2020	2021
Wawasee Open Water	max.	1.5	0.7	1.3
	avg.	0.7	0.4	0.6
Syracuse Open Water	max.	0.6	0.8	2.0
	avg.	0.2	0.3	0.7
Syracuse Community Center Beach	max.	0.6	1.0	1.8
	avg.	0.2	0.4	0.7
Syracuse Hoy's Beach	max.	0.7	0.9	1.9
	avg.	0.2	0.4	0.6

** Measured in parts per billion (ppb)*
nd - no toxin detected

DID YOU KNOW?

Two long-standing Lake Wawasee families, the Herdrichs and the Griffiths, generously funded a year-long monthly sampling effort on the lake to see what is going on under the surface in the off-season. We confirmed that no matter what time of year you are admiring your lake, there is always something happening under the surface! Even in the cold stillness of winter, lakes undergo change that can impact the whole rest of the year. Read the full study here: **lakes.grace.edu/original-research**.

LIMIT of FISH HABITAT

WAW 34.9 ft
SYR 19.7 ft

WATER CLARITY

WAW 7.3 ft
SYR 8.3 ft

AVERAGE TEMPERATURE

WAW 76.2 ˚F
SYR 77.3 ˚F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2021 RESEARCH

dewart & webster

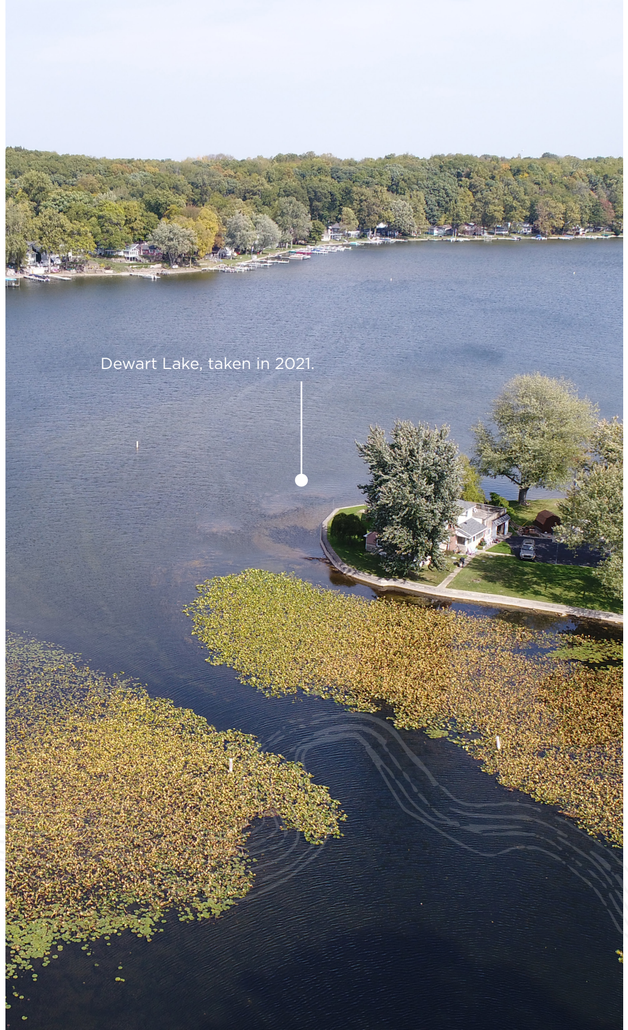
Although Dewart and Webster have few comparable aspects, they are among the county's deepest lakes (Dewart) and most influential for the Tippecanoe River's journey through Kosciusko County (Webster). Both lakes also have islands!

DEW

Surface area	554 acres
Max. depth	82 ft
Avg. depth	16 ft
Watershed	5,059 acres

WEB

Surface area	653 acres
Max. depth	52 ft
Avg. depth	12.5 ft
Watershed	31,459 acres



Dewart Lake, taken in 2021.

MICROCYSTIN (MC)

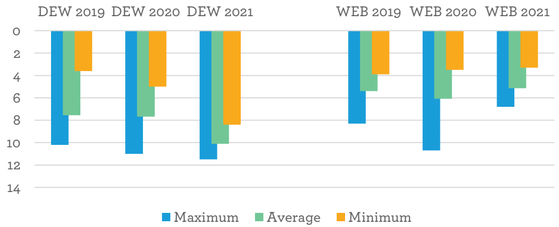
Microcystin toxin levels were slightly higher in Dewart Lake this year compared to '20, though lower than '19. While one result approached 0.8 ppb, IDEM's threshold for pet health (pg. 8), no results exceeded it. In Webster Lake, microcystin was present again this summer after 2020's lack of detections. This year's levels were low and did not approach IDEM's pet threshold. No matter your lake's watershed size or other unique characteristics, there are some tried-and-true methods that everyone in the watershed can do to help their lake thrive. Check them out on pages 24-25.

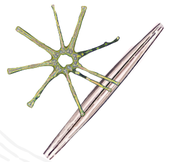
Sampling Location		2019	2020	2021
Webster Open Water	max.	0.3	nd	0.4
	avg.	0.1	nd	0.2
Webster Beach	max.	0.8	nd	0.3
	avg.	0.2	nd	0.2
Dewart	max.	1.3	0.6	0.7
	avg.	0.7	0.3	0.3

** Measured in parts per billion (ppb)*
nd - no toxin detected

Dewart and Webster Water Clarity

Measured by Secchi disk depth in feet





DID YOU KNOW?

The diversity and quantity of diatoms found in Webster Lake has surprised us! Our lab found all sorts of different glass-housed microorganisms, including some that were several millimeters long. That is really big for something that is normally microscopic!

WATER CLARITY

Dewart Lake is surrounded by a smaller-than-average watershed. This is a characteristic that can help lakes receive less nutrient than those that drain larger areas of land. This summer, like the two previous, Dewart contained lower-than-average nutrient levels and slightly-above-average water clarity. And this year, like the past two, Dewart experienced typical water clarity compared to our other lakes, with a maximum of 11.5 ft of visibility and a minimum of 8.4 ft. Dewart's clarity in 2021 surpassed its clarity in both previous years.

Webster Lake is highly variable when it comes to nutrients and water clarity. It receives water drained from a large area of land, which means rain (or a lack of it) has an even larger impact compared to those with small watersheds. This summer, Webster experienced fewer deep visibility readings, though the average and the minimum clarity measurements are similar to those in '19 and '20.

LIMIT of FISH HABITAT
DEW 20.6 ft
WEB 16.4

WATER CLARITY
DEW 10.2 ft
WEB 5.1 ft

AVERAGE TEMPERATURE
DEW 77.6 °F
WEB 77.6 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2021 RESEARCH

james tippecanoe & oswego

A truly unique and beautiful feature of Indiana, the Tippecanoe River feeds into and flows from the Tippecanoe lakes chain. James (Little Tippy), Tippecanoe and Oswego lakes are directly connected, so their health and water quality are, too.

JAM

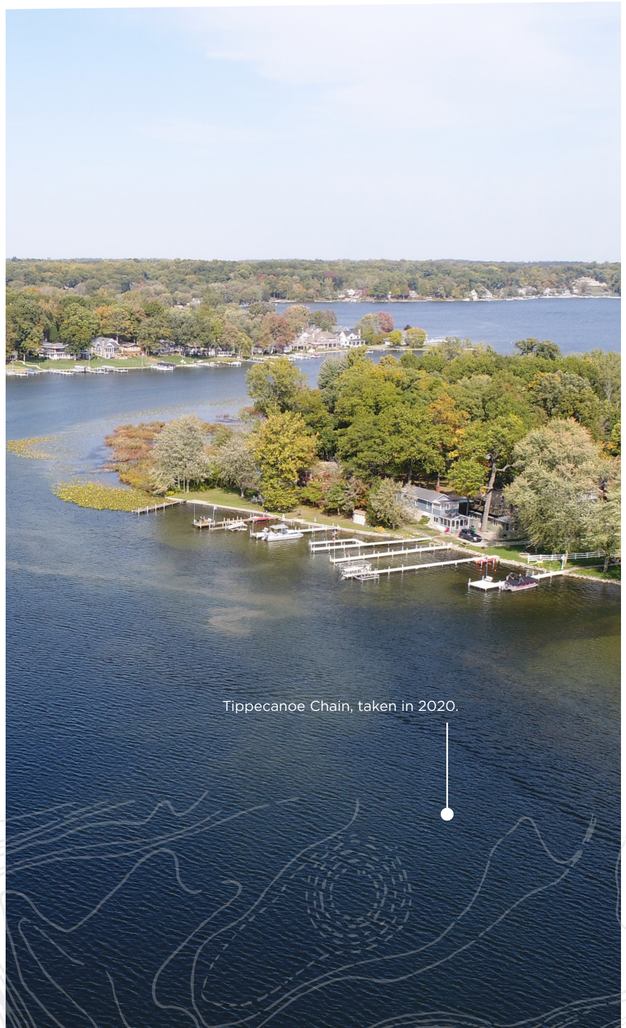
Surface area	278 acres
Max. depth	62 ft
Avg. depth	27 ft
Watershed	35,776 acres

TIP

Surface area	876 acres
Max. depth	122 ft
Avg. depth	37 ft
Watershed	72,847 acres

OSW

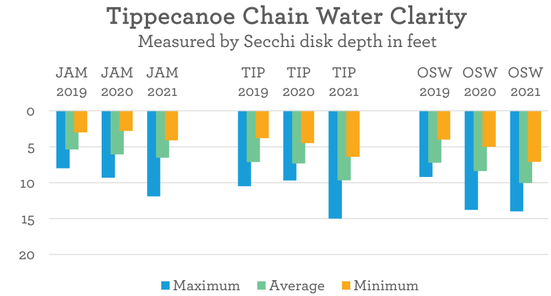
Surface area	78 acres
Max. depth	37 ft
Avg. depth	13.7 ft
Watershed	72,847 acres



Tippecanoe Chain, taken in 2020.

WATER CLARITY

The lakes of the Tippecanoe chain — James (Little Tippy), Tippecanoe and Oswego — all experienced higher water clarity in 2021 than the previous two summers. Tippecanoe achieved the clearest 2021 Secchi disk reading of all of our lakes this year at 15.0 ft of clarity. It may be tempting to hypothesize that this is caused by Tippecanoe's state-record depth, but that is not the case! For example, last year's record clarity reading is held by Center Lake at 15.6 ft with a deepest point of only 43 ft. Water clarity has more to do with runoff, sediment resuspension, and algae activity than total depth; though a deep total depth can help a lake like Tippecanoe process nutrients better over time. See pages 6-7 to learn more about the Tippecanoe chain's nutrient levels.



MICROCYSTIN (MC)

Processing nutrients — or, more importantly, keeping nutrients out of the lake in the first place — is of particular importance to limit green and blue-green algae populations. Blue-green algae are those responsible for producing microcystin toxin. 2020 was a low-to-no microcystin year for the Tippecanoe chain and our other lakes, but this year saw a slight increase, with toxin levels similar to 2019. None of these results approached IDEM's pet recreation threshold of 0.8 ppb. See page 8 for more information!

Sampling Location		2019	2020	2021
James (Little Tippy)	max.	0.3	nd	0.5
	avg.	0.1	nd	0.2
Tippecanoe	max.	0.2	nd	0.2
	avg.	0.1	nd	0.1
Oswego	max.	0.3	nd	0.2
	avg.	0.1	nd	0.1

** Measured in parts per billion (ppb)*
nd - no toxin detected

Clubshell mussels

DID YOU KNOW?

The Tippecanoe River, which flows through the Tippecanoe, Oswego and James lakes, has long been known for its diversity of native mussels and clams. Native mussels and clams contribute significantly to the health of the lakes and play an important role in the food web by eating native microscopic creatures and being eaten by fish and other aquatic wildlife. Losing them would mean losing a vital part of the river's ecosystem!

LIMIT of FISH HABITAT

JAM	16.7 ft
TIP	60.8 ft
OSW	13.7 ft

WATER CLARITY

JAM	6.4 ft
TIP	9.5 ft
OSW	10.0 ft

AVERAGE TEMPERATURE

JAM	77.4 °F
TIP	77.3 °F
OSW	77.6 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2021 RESEARCH

& big barbee big chapman

Big Barbee and Big Chapman are both the largest basins of their respective lake chains. Both of these lakes and their chains were a part of the Lilly Center's DNR-funded sewer impact study, completed in 2021. You can read the full report on our website: lakes.grace.edu.

BBA

Surface area	311 acres
Max. depth	45 ft
Avg. depth	15.6 ft
Watershed	28,737 acres

BCH

Surface area	504 acres
Max. depth	39 ft
Avg. depth	12.5 ft
Watershed	4,500 acres

Big Barbee Lake, taken in 2021.

MICROCYSTIN (MC)

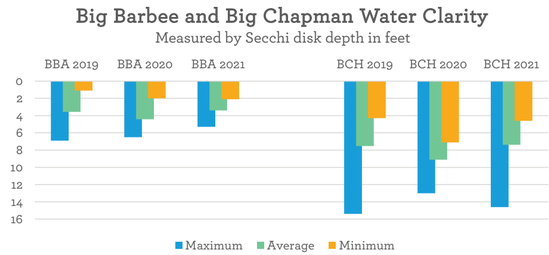
Algae activity is related to microcystin toxin levels, though the relationship is not as obvious as you would think. Some lakes can have large algae populations but minimal toxin, while a neighboring lake can be dealing with higher toxin levels with only occasional blooms or lower apparent algae activity. Big Chapman's weekly toxin results averaged higher than the past two years and higher than Big Barbee this year, in spite of seemingly better water clarity and nutrient levels. The Lilly Center and researchers around the world are working to understand what triggers toxin production in algae populations and why these unexpected differences exist. For more information on this topic, turn to page 8.

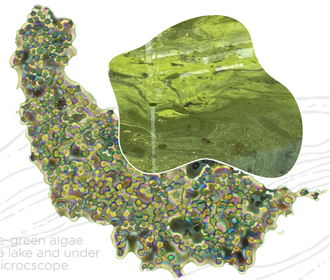
Sampling Location		2019	2020	2021
Big Barbee	max.	1.0	nd	0.2
	avg.	0.3	nd	0.1
Big Chapman	max.	1.6	0.3	3.8
	avg.	0.7	0.1	1.6

** Measured in parts per billion (ppb)*
nd - no toxin detected

WATER CLARITY

Big Barbee and Big Chapman can be compared and contrasted with each other this year for some interesting observations. While Big Barbee has lower water clarity compared to other county lakes (which makes sense given the large size of its watershed), the clarity is more consistent throughout the summer than on Big Chapman. There is a gap between the maximum and average clarity readings from Big Chapman, especially in 2019 and 2021. Big Chapman typically has high water clarity in the early season that falls in the summer with increased algae.





Blue-green algae on a lake and under a microscope

DID YOU KNOW?

Several blue-green algae blooms were reported on Big Chapman this summer, and the majority of those blooms were found in the channels around Big Chapman instead of the open water. Any excess fertilizer or nutrients on property around the lake will get washed into the water when it rains, but since most of the channels have limited water movement, nutrients build up in the shallow water and create the perfect setting for a toxic blue-green algae bloom.

LIMIT of FISH HABITAT

BBA 13.7 ft
BBC 11.9 ft

WATER CLARITY

BBA 3.3 ft
BBC 7.2 ft

AVERAGE TEMPERATURE

BBA 77.7 °F
BBC 78.2 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2021 RESEARCH

center pike & winona

Center, Pike and Winona lakes can be found within a 3-mile radius of each other. These lakes are the most-visited lakes within Warsaw and Winona Lake. They are freely accessible for public swimming, fishing and boating.

CEN

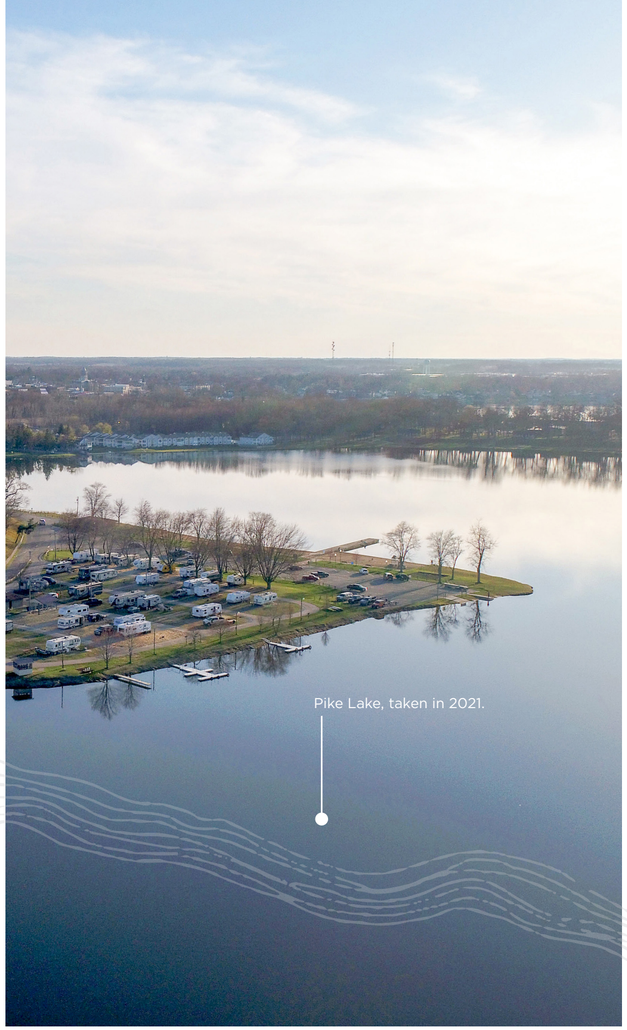
Surface area	120 acres
Max. depth	43 ft
Watershed	9,611 acres

PIK

Surface area	228 acres
Max. depth	35 ft
Avg. depth	14 ft
Watershed	23,405 acres

WIN

Surface area	571 acres
Max. depth	79 ft
Avg. depth	30 ft
Watershed	18,730 acres



Pike Lake, taken in 2021.

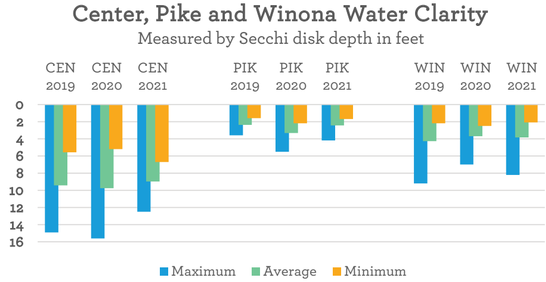
MICROCYSTIN (MC)

Center experienced higher toxin levels in 2021 than either Pike or Winona. Winona's deepest point was the only site in which no microcystin was detected all summer, and the swimming beach only had a low level of microcystin detected on one occasion. Pike contained moderate microcystin in comparison, but all results were still below IDEM's pet threshold.

These data suggest there are more factors contributing to algae activity and toxin production than simply nutrients and water clarity. The Lilly Center has begun an investigation into how different algal species might be driving the differences between our neighboring lakes. We are counting and identifying algal cells present on each of our sampling days. See page 8 for more information on toxin thresholds and blue-green algae work.

Sampling Location		2019	2020	2021
Center Open Water	max.	0.3	nd	2.5
	avg.	0.1	nd	0.5
Center Beach	max.	0.2	nd	1.7
	avg.	0.1	nd	0.4
Pike Open Water	max.	0.9	0.5	0.6
	avg.	0.5	0.1	0.3
Pike Beach	max.	0.8	0.2	0.6
	avg.	0.4	0.1	0.3
Winona Open Water	max.	1.7	nd	nd
	avg.	0.4	nd	nd
Winona Beach	max.	2.3	nd	0.2
	avg.	0.5	nd	0.1

** Measured in parts per billion (ppb)*
nd - no toxin detected



WATER CLARITY

Secchi disk readings show Center with consistently deeper water clarity, then Winona, then Pike. These results parallel nutrient results (pages 6-7) for each of these lakes. More nutrients means more "stuff" in the water which reduces clarity: sediment from streams, the lake bottom, etc. Water clarity (and microcystin levels) on these three Warsaw-area lakes illustrate the complex and mysterious relationship between lake conditions, algae populations and toxin production!

DID YOU KNOW?

Natural shorelines are very important for a healthy lake. Native plants provide habitats for fish, waterfowl and other aquatic creatures. Their roots help prevent erosion and dampen the effects of waves and wakes. They even absorb or buffer some extra nutrients that might get washed in through runoff, which helps stop algae blooms! Some local lakes (like Pike and Winona) have taken huge strides in restoring native plants to areas around the lakes.

LIMIT of FISH HABITAT

CEN	15.8 ft
PIK	9.8 ft
WIN	20.6 ft

WATER CLARITY

CEN	9.1 ft
PIK	2.4 ft
WIN	3.7 ft

AVERAGE TEMPERATURE

CEN	77.2 °F
PIK	76.1 °F
WIN	76.3 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2021 RESEARCH

& beaver dam yellow creek

Beaver Dam and Yellow Creek lakes are separated from the rest of the lakes the center samples, located in the southwest corner of the county. But these two lakes provide a unique way to measure and compare the impact of zebra mussel, cyanobacteria and algae populations for lakes throughout the county.

BEA

Surface area	155 acres
Max. depth	61 ft
Avg. depth	15.6 ft
Watershed	1,266 acres

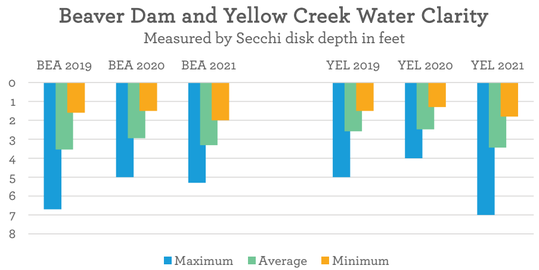
YEL

Surface area	155 acres
Max. depth	67 ft
Avg. depth	31.6 ft
Watershed	2,160 acres

Beaver Dam Lake, taken in 2020.

WATER CLARITY

Water clarity in Beaver Dam this summer was similar to the past two summers, though it was a slightly better summer for clarity on Yellow Creek. Both of these lakes' maximum Secchi disk readings were taken on the first sampling day, in late May. Water temperatures were still cool at that point, so algae populations hadn't hit their growth spurt. But once these lakes warm, algae activity soars, reducing water clarity. And these two lakes, like others in our county, have enough phosphorus and nitrogen nutrient present for them to eat and multiply when the temperature is right. (See pages 6-7 for that data!)



MICROCYSTIN (MC)

Microcystin toxin levels in Beaver Dam were lower compared to the previous two years, both on average and the maximum amount detected. This year, levels on Beaver Dam never exceeded IDEM's pet health threshold. Meanwhile, Yellow Creek increased (compared to no detections of microcystin at all in 2020.) However, in 2021, microcystin was only detected on two instances at low concentrations.

Sampling Location		2019	2020	2021
Beaver Dam	max.	1.2	1.2	0.6
	avg.	0.5	0.4	0.2
Yellow Creek	max.	0.3	nd	0.2
	avg.	0.1	nd	0.1

** Measured in parts per billion (ppb)*
nd - no toxin detected

These two lakes are similar to one another in ways that are particularly helpful to Lilly Center research; there are parallels in their morphology, or shape, and locations. Both have small watersheds and surface areas, are geographically close and have similar maximum depths. Each similarity helps us identify the most influential factors in algae populations and toxin production, especially when these two "twin" lakes differ in our data!

DID YOU KNOW?

This summer, we placed a few zebra mussel samplers on Beaver Dam and Yellow Creek lakes in order to monitor them for zebra mussels. We based it on our county-wide zebra mussel survey conducted in 2019 — during which we found no mussels on Beaver Dam or Yellow Creek. Fortunately, once again, we found no evidence of the invasive bivalves on either lake!

LIMIT of FISH HABITAT

BEA 11.6 ft
YEL 12.2 ft

WATER CLARITY

BEA 3.3 ft
YEL 3.4 ft

AVERAGE TEMPERATURE

BEA 78.6 °F
YEL 77.9 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2021 RESEARCH

BEST PRACTICES TO TRY AT HOME

Searching for a way to apply best practices and experience your lake in a new way? Visit the Lilly Center's Facebook page (**@centerforlakes**) or **lakes.grace.edu/events** to see what events we have on our community event calendar!

LAKE-SAFE BUILDING AND LANDSCAPING

As you move soil, whether to install new landscaping or add onto your home, keep the soil away from the shoreline. If it rains while the work is still in process, loose soil will wash into the lake, leading to more nutrients in the water.

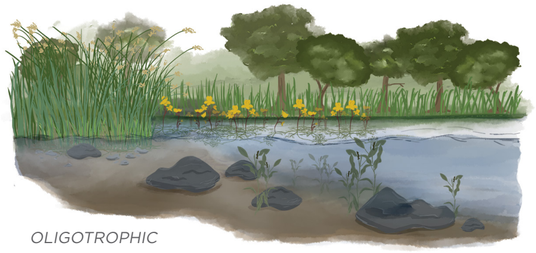
USE NATIVE PLANTS ON YOUR SHORELINE

Try native plants in your landscaping, especially along the shores of lakes and streams. Roots absorb nutrients from rain and groundwater. Look back at pages 6-7 to see current phosphorus and nitrogen levels in the 14 lakes the Lilly Center samples!

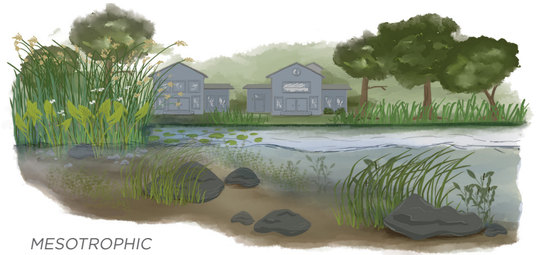
DON'T PUT YARD WASTE IN YOUR LAKE

Collect your leaves, branches and grass clippings for removal according to your local guidelines. Also, be sure not to sweep them into the street and cause them to clog storm drains. As the leaves decompose, they release extra nutrients that algae and plants can use to flourish.

Having the information is one thing; how can you act on what you have learned? At the Lilly Center, we make sure every research project we do has a local application. Often, the lessons learned on one lake will apply to several others. **Consider joining your lake association (page 10) to help with the efforts happening on your own shoreline!**



OLIGOTROPHIC



MESOTROPHIC

EUTROPHIC

DID YOU KNOW THAT YOUR LAKE IS AGING?

Lake aging is a natural process, but our actions can speed it up or slow it down.

Decaying organic materials (like leaves, fish and aquatic plants) naturally accumulate at the bottom of our lakes. As they decompose, the materials release nutrients — more about those on pages 6-7. Excess nutrients are the culprit behind excess weeds and algae, which ultimately lead to *more* sediment that slowly fill in the lake.

An **oligotrophic lake** is typically a young lake ecosystem that tends to have clearer water, minimal plant growth, less mucky sediment at the bottom, and fewer large consumers like fish.

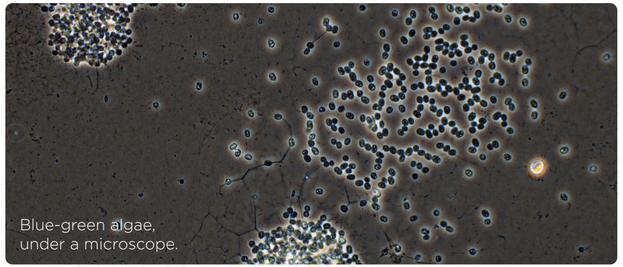
A **mesotrophic lake** is typically a middle-aged lake ecosystem that is fed more nutrients and has greater plant production. Sediment accumulates on the bottom, which makes the lake shallower and warmer overall.

A **eutrophic lake** is typically an old lake ecosystem that often holds shallow, murky water. The shallow water is warmed more easily by the sun and produces more plants and algae. The lake is in the process of filling in with sediment and will eventually become a wetland.

Follow the suggestions on page 24 (and on our website, lakes.grace.edu) to help slow down eutrophication in your lake!

LILLY CENTER PROJECTS

These current and ongoing research projects are part of the Lilly Center's mission to help you make informed decisions for your lake's future. You can read blog posts and studies about each of these and other research projects on our website: **lakes.grace.edu**



Blue-green algae, under a microscope.

ALGAE COUNTING & IDENTIFICATION

After the research team brings back water samples from local lakes, the samples are taken to our in-house lab. The algae team uses the samples to make microscope slides. Then they identify, count and document what they find! That information is used in our research. We are particularly interested in blue-green algae and the microcystin toxin it produces but have found countless cool microscopic organisms that help tell the story of our lakes! **Algae counting and identification tell us which species of blue-green algae are thriving at what times of the summer.** Learn more on page 8.

STREAM LOADS & LAKE BUDGETS

We are currently studying the nutrient loads of local streams and how much nutrient they contribute to lakes. There are many opportunities for **external loading**! That happens when nutrients enter a body of water from the land around it, including stormwater runoff from properties, fallen branches and leaves, yard waste, etc. External loading sources are ones we can help limit so our lakes do not get too many nutrients! Identifying which sources contribute the most nutrient allows us to target those areas for good management.

E. COLI TESTING

This summer, with support from the Luminous Fund and a special piece of equipment from The Watershed Foundation, we added *E. coli* testing to our beach sampling biweekly stream sampling schedule for Winona, the Tippecanoe chain, and Wawasee and Syracuse. *E. coli* is a type of bacteria that belongs in the intestines of healthy humans and warm-blooded animals. If it enters waterways via sewage or animal waste, however, it can cause illness. Over time, the data we gather will help us identify water quality issues or ways to improve those lakes — much like we did on Center and Pike lakes in 2013. More on that at **lakes.grace.edu/original-research**!

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LILLY CENTER FOR
LAKES
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OUR MISSION & VISION

The Lilly Center for Lakes & Streams conducts research, provides resources, engages and educates residents, and collaborates with local organizations to make the lakes and streams of Kosciusko County clean, healthy, safe and beautiful.

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