BENEATH THE SURFACE

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

USE THIS **2022 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

Heirlooms are items of great value, often passed down from parent to child. The 100+ lakes in our county are gems, contributing to the economic and recreational value of Kosciusko County.

Beneath the Surface will equip you with the information that will give your family, organization, or agency the ability to look after these heirlooms. Special thanks to the **Renda family** for making this publication possible!

Fifteen years ago, three visionaries dreamed of a research center that would change our understanding of our lakes. Suzie Light, Frank Levinson, and Dr. Ron Manahan understood the responsibility of ensuring water quality for generations to come. Due to the Lilly Center's work, our lakes are among the best-studied lakes in Indiana. We have a library of valuable data that shows patterns and trends in the health of our lakes, which in turn reveal **specific management steps.** After looking at the data, we encourage you to follow the action steps on **page 28** and then share them 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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RESEARCH

LAKE DATA

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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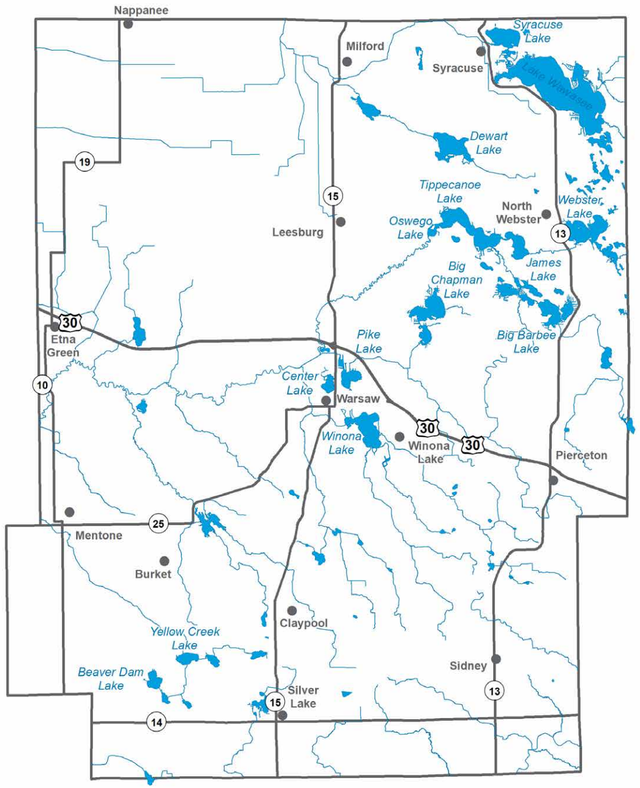


What is *Beneath the Surface?*

Beneath the Surface is a condensed form of the data Lilly Center staff and students gathered on 14 lakes during the summers of 2020-22. Reviewing several years of data helps us accurately compare and contrast data points and recognize any potential changes that may have occurred.

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**.

How do we conduct lake research?

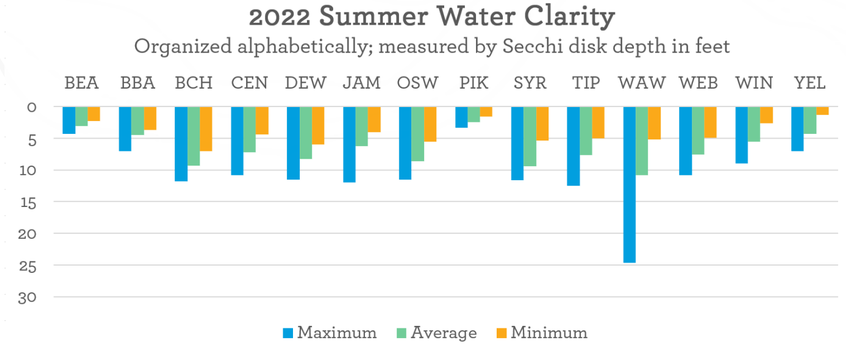
Every week, from the beginning of June through the middle of August, the Lilly Center research team samples 12 all-sport lakes of Kosciusko County (since 2012), Center and Pike lakes, and seven public swimming beaches (since 2018).

Lakes are sampled at the deepest point of the lake 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 distinct 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. See **page 8** for more information on blue-green algae!

WATER CLARITY

Water clarity is a measure of how far down light penetrates through the water column. Measuring water clarity is the first step in assessing the health of a lake. A clear lake is generally a healthy lake, but murky water is a sign that something may be wrong - such as too much sediment, pollution, or an overgrowth of algae. Once the clarity of the water is assessed, it is important to conduct more tests to find out what is affecting the lake's water. Water clarity is measured with a tool called a Secchi disk. A Secchi disk is a frisbee-sized disk that is painted with a black and white pattern. The disk is attached to a rope and lowered into the lake until the black and white pattern is no longer visually distinct. The depth of the disk is recorded as a measure of the water's clarity



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 2022. A deep Secchi disk reading, represented by a longer bar on the graph, means clearer water. Overall water clarity at all 14 lakes has improved slightly in the last few years. In **2022,** Secchi depth readings averaged **6.8 ft** compared to **6.4 ft** in **2021** and **6.3 ft** in **2020**. Water clarity varies from lake to lake and even week to week. Turn to page 16 to begin looking at how individual lakes compare to previous years.

LAKE ABBREVIATIONS

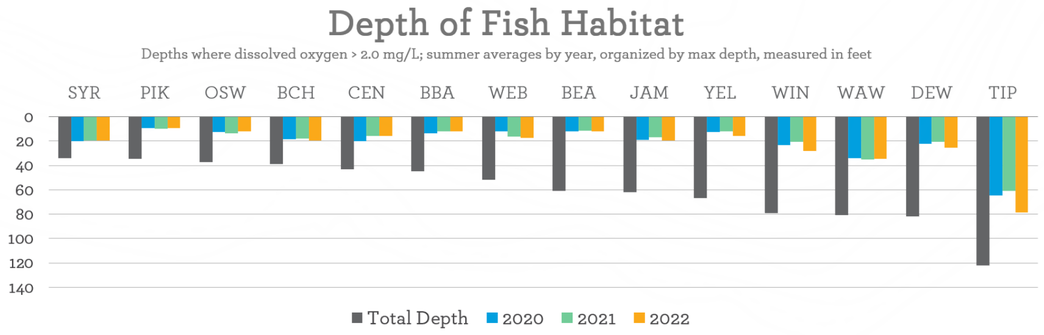
These abbreviations will be used throughout Beneath the Surface.

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

DISSOLVED OXYGEN

Dissolved oxygen is gaseous oxygen in the water and available to aquatic organisms for respiration. It is a major factor that determines where organisms can survive in an aquatic ecosystem. During the summer, many lakes become layered based on temperature - a process called stratification. The bottom layer, or **hypolimnion**, is often depleted of oxygen thanks to chemical reactions that occur when dead plants decay on the bottom of the lake. Since this layer does not mix with the upper layer, or **epilimnion**, it is not able to replenish its oxygen through the mixing of lake waters.

Oxygen from the air cannot reach the hypolimnion to replenish the cool bottom layer of water. Only fish that can live in the warm water near the surface get the oxygen they need. As water temperatures climb in the summer, it becomes difficult for fish to escape the heat because they are limited by the lack of oxygen in the cooler water below. The result is a very narrow layer of water with the appropriate temperature and dissolved oxygen levels for fish to survive. Reducing the amount of material decomposing at the bottom of the lake will slow the use of oxygen and make room in the lake for fish to inhabit in the summer.



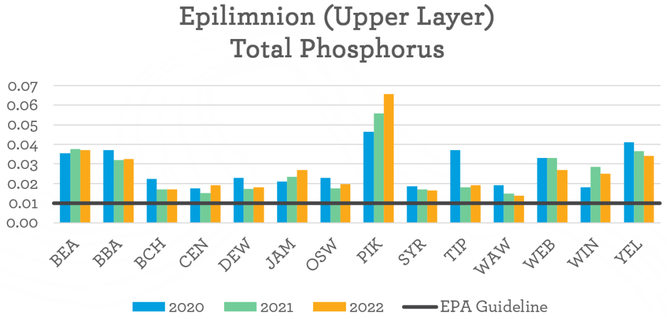
The lakes in this graph are organized from shallowest to deepest at their deepest point (gray bars show total depth). The longer the colored bars in this graph, the deeper the oxygen, the more habitat there is for fish! At bare minimum, **fish require at least 2.0 mg/L of oxygen** in the water to survive, 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 that cannot be found in the oxygenated upper layer of lake water in the summer.

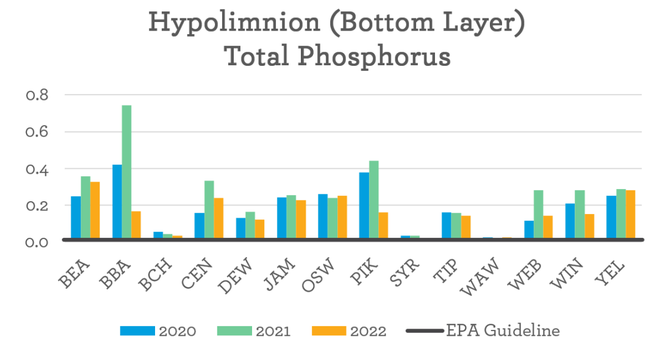
TOTAL PHOSPHORUS, TOTAL NITROGEN

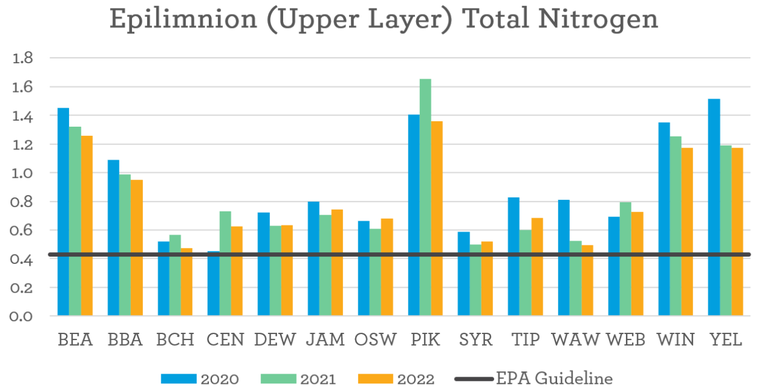
Nutrients have a positive, healthy connotation for people. But when excess nutrients enter a lake in the form of fertilizers, human and animal waste, or even yard waste, **they do damage to our lakes and their aquatic residents.** Two of the most important nutrients we study are **phosphorus** and **nitrogen**. They are chemical elements necessary to support aquatic life, starting with the rooted plants (weeds) and phytoplankton (algae) that make up the foundation of the food chain.

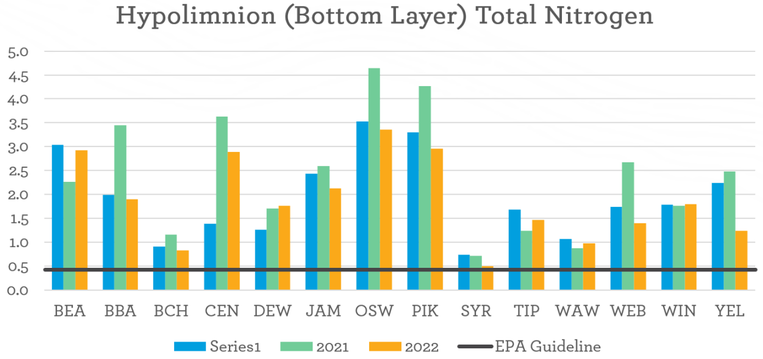
These four graphs show nitrogen and phosphorus levels at our 14 study lakes. In order to get a more accurate picture of nutrient concentrations in the lakes, water samples are taken from the epilimnion (the upper layer of water in a lake) and hypolimnion (the lower layer of water). The dark horizontal lines on each graph represent the Environmental Protection Agency's (EPA) guideline for nitrogen and phosphorus levels.

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.









Phosphorus levels in Kosciusko County lakes are above federal guidelines. The average total phosphorus level in the epilimnion, across all 14 study lakes in **2022** was **0.03 mg P/L,** three times the EPA guideline for phosphorus. Phosphorus levels in the hypolimnion were even higher and averaged **0.16 mg P/L.** As has been the case over the years, Pike, Beaver Dam, and Yellow Creek continue to be the most nutrient-rich lakes followed closely by Big Barbee and Webster.

Similarly, Pike, Beaver Dam, Yellow Creek, and Big Barbee show levels of nitrogen in the epilimnion well above the EPA standard of **0.43 mg N/L.** Winona Lake also has very high levels of total nitrogen (**1.8 mg N/L**). On average, total nitrogen levels in **2022** were **0.83 mg N/L.** This is double the EPA guidelines. It is interesting to note that despite moderate concentrations of phosphorus and nitrogen in the epilimnion, Center Lake and Oswego Lake show high levels of nitrogen in the hypolimnion. This indicates high nutrient loading from the bottom sediments in these lakes.

BLUE-GREEN ALGAE

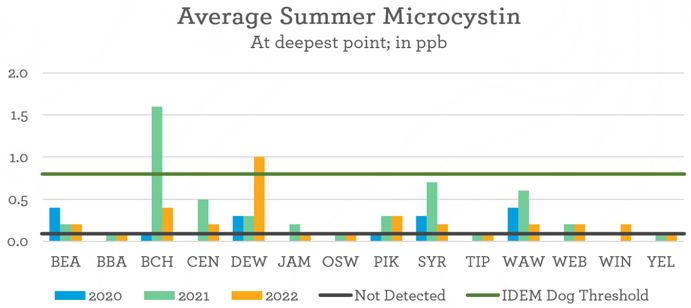
One of the key components to understanding microcystin production is identifying different species of cyanobacteria and green algae. Several students supervised by Dr. Joe Frentzel count species of algae and bacteria in our lab!

Out of all water samples assessed so far, 41.8% of cells are 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. Summer microcystin samples exceeded IDEM's dog recreation threshold 6.7% of the time.

Average percent of algae population that is BGA to date

Summer microcystin samples over the dog threshold (0.8)

Percent of identified BGA species that can produce toxins



Indiana Department of Environmental Management's (IDEM) microcystin exposure thresholds

Human Recreation Caution
8.0 ppb

Dog Recreation Prohibited*
0.8 ppb

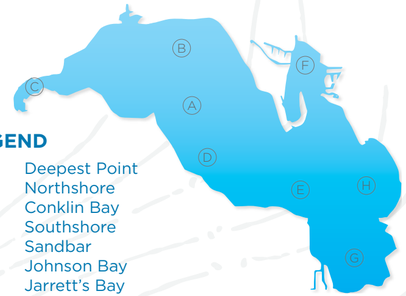
**State lakes & ponds*

Blue-green algae (cyanobacteria) is a type of bacteria that photosynthesizes as plants and green algae do. While BGA is a natural part of lake ecosystems, it has drawn scientists' attention due to the toxins produced by some species. Cyanobacteria toxins, such as microcystin, can cause rashes, sickness, and organ damage in humans, and can be fatal to dogs. Linking the composition of the algae and cyanobacteria populations to the other parameters the Lilly Center measures could **help us better understand why and how microcystin toxins are produced in 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 weekly microcystin updates.

SPATIAL VARIABILITY STUDY

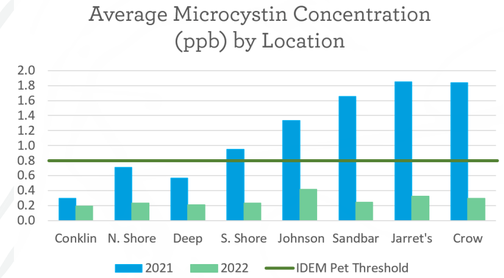
In the summer of 2021, the Lilly Center set out to answer two questions, "Do the microcystin levels vary across Lake Wawasee?" and "If so, is the variation driven by weather or other lake conditions?" We began by sampling seven additional sites in July of 2021. Each site was then sampled all summer in 2022.



LEGEND

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

Last summer, there was evidence of differences in microcystin concentrations due to locations within the lake. The graph below shows that average microcystin levels were substantially higher as sampling locations moved west to east. Microcystin toxin levels were much lower in Lake Wawasee at all sampling locations in 2022 than in 2021.



WHAT WE NOTICED

We hypothesized that wind direction and speed could lead to higher levels of microcystin on the east side of the lake due to prevailing westerly winds. The wind speeds in 2021 when microcystin levels were high averaged 4.5 knots with an average maximum speed of 5.9 knots. However, in 2022 average wind speeds were similar at 4.4 knots, though the average maximum wind speed was higher at 7.5 knots. Wind direction was similar during both 2021 and 2022. **It appears that wind speed and direction had less impact on the spatial variability in microcystin levels** likely due to lower microcystin overall in 2022.

Stay tuned next year for more on this study!

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. The additional data from this study provides insight about potential management steps on other lakes as well.

LAKE WAWASEE RESEARCH BUOY

The spatial variability study on page 9 is an important piece in demystifying blue-green algae production on Lake Wawasee. But what if there was a way to look at the lake between samplings, a way that could show us patterns that we may not have seen otherwise?

A research buoy is a piece of the puzzle to making our county's lakes healthier. After a year of collaboration, research, fundraising, and construction, Lake Wawasee's first research buoy entered the water. **The buoy itself** was made in collaboration with the Department of Engineering at Grace College. **The sensory array** beneath the buoy, the part that gathers the data, is a specialized piece of monitoring equipment similar to the one used for routine lake sampling. It collects several hundred data points each day, measuring parameters like pH, conductivity, and dissolved oxygen every 15 minutes. The buoy is also able to track different algae types through a process called fluorescence.

Department of Engineering students pose with a research buoy protype.

Lilly Center staff and boat captain Jeff Herdrich look on as engineering students attach the flag to the buoy.

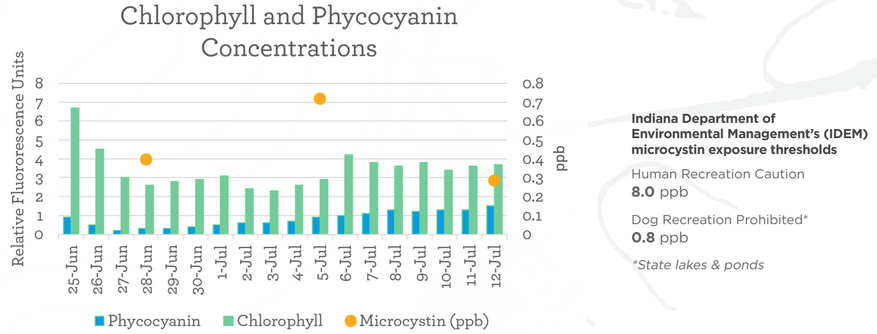
The research buoy floats in Lake Wawasee's Crow Bay for the first time in 2022!

What have we learned since the buoy went into the water earlier this summer? The short answer is: **it's complicated!** Gathering enough data to create a comprehensive understanding of something as complex as Lake Wawasee takes years, even decades. However, the information collected from the buoy will help us create a "temporal profile" of Lake Wawasee as it changes over time.

Take a look at the next page for our initial thoughts on the data we collected this summer.

One interesting feature of the buoy is its ability to use fluorescence to measure algae levels without the time-intensive, but more accurate, process of collecting samples and using a microscope. Thanks to this new technology, we are able to see the **real-time changes** in the relative abundance of two types of algae: green algae and and toxin-producing blue-green algae.

Data collected from the buoy since its launch on June 25th through mid-July shows how the concentration of these different types of algae changed over time. The concentration of **chlorophyll**, indicative of green algae, was initially high, dropped after a couple days, and then remained relatively constant. Blue-green algae pigment, **phycocyanin**, was also high initially and then decreased substantially. However, phycocyanin levels steadily increased over the next 16 days. It would be reasonable to assume that microcystin samples would have a positive relationship with phycocyanin levels. As phycocyanin concentrations increase (meaning the concentration of toxin producing algae is increasing) so would microcystin levels. **That is not necessarily what we saw**.



Indiana Department of Environmental Management's (IDEM) microcystin exposure thresholds

Human Recreation Caution
8.0 ppb

Dog Recreation Prohibited*
0.8 ppb

**State lakes & ponds*

Microcystin samples were collected from Lake Wawasee on June 28, July 5, and July 12. On July 12, the microcystin concentration was lowest **(0.284 ppb)** when the phycocyanin levels were highest. The highest microcystin level **(0.719 ppb)** was observed on July 5 at intermediate concentrations of phycocyanin. The intermediate microcystin measurement **(0.396)** was recorded when phycocyanin was at nearly its lowest point on June 28. More data with more variation over time will add to our understanding. This preliminary data points to the necessity of species-specific identification and enumeration in our lab. Stay tuned next year as we continue to gather data with a new-and-improved research buoy!

The research buoy was inspired by conversations with Alex Levinson and Alan Tehan. It was financially supported by the Levinson family and installed thanks to the help of the Herdrich family, especially Jeff and Bob. Their help and support is key to providing quality data and deepening our understanding of our lakes, all in pursuit of a safe place to live and play.

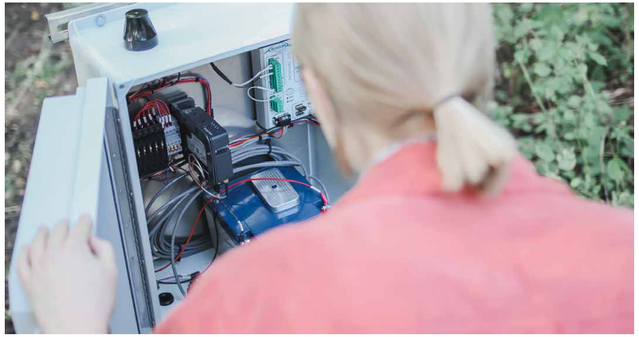
STREAM SENSORS

The Lilly Center has studied 14 local freshwater, all-sport, lakes weekly through the summer since 2012. Year-round since 2014, we have also studied the major streams surrounding six of these lakes. To gain a more complete picture of these waterways, the Lilly Center installed 12 remote stream sensors at inflowing and outflowing streams around Winona, Wawasee, Syracuse, Tippecanoe, Oswego, and James Lakes.

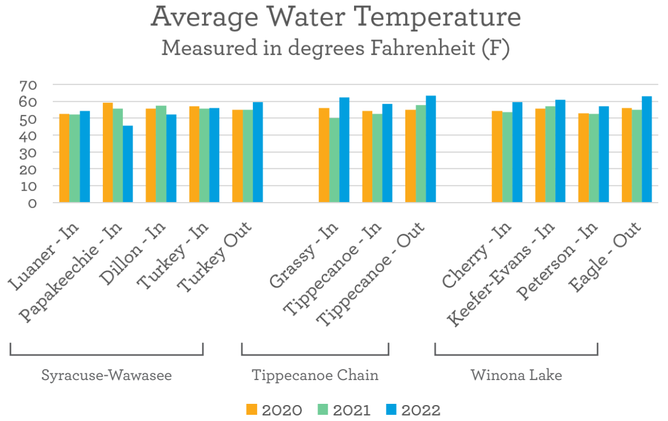
The solar-powered sensors consist of two main parts: **the sensor** that sits in the stream and **the box**, mounted outside the stream, that receives and sends out the data. Sensors use Doppler technology to measure how fast particles move through the stream. They also know the shape of the stream which we calculated and uploaded to the equipment. **The sensors calculate the volume of water moving through the stream by using the shape of the stream and the speed of the water at various points across the stream.** Sensors also measure other properties such as water and air temperature, and the total depth of the stream.

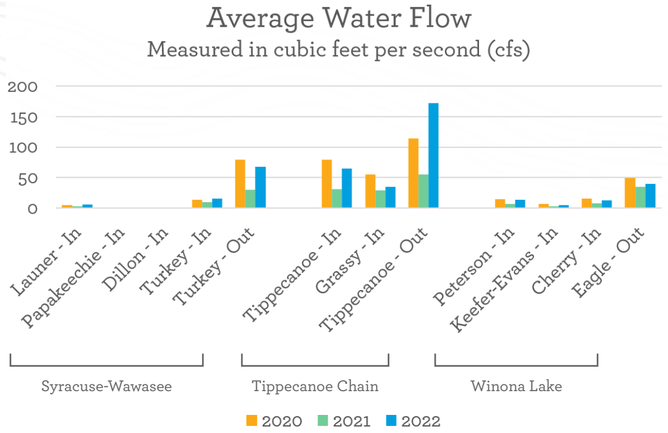
These two graphs show water temperature and water flow data collected from September 2019 to August 2022. Papakeechie's water temperature was low this year (45.5 F) as this stream mostly dried up in the summer, resulting in very few data points from July through September.

Stream sensors are mounted on bridges or are free standing. Only Lilly Center staff are authorized to service stream sensors, but if you see an issue email lakes@grace.edu!



Lilly Center staff member inspects the inner-workings of a stream sensor box. Maintenance is crucial to keeping the sensor operational and monitoring the stream.





The Tippecanoe chain, the largest watershed at over 72,847 acres, exhibits the highest flow into and out of the lake system. The Syracuse-Wawasee and Winona Lake watersheds are around 20,000 acres and thus show a smaller volume of water entering and leaving each lake. As indicated by the graph, stream flows in 2021 were lower than in 2020 and 2022. This is likely due to less precipitation in 2021 than during the other two years.

Coupling the stream flow data with nutrient samples can **help to determine the amount, or load, of nutrients entering our lakes through the streams.** The real-time collection of stream data allows us to coordinate nutrient samples with high-flow events. This data aids in the creation of nutrient budgets that can then be used to identify areas of concern as well as when high levels of nutrients may enter the lakes. We can then create actionable steps alongside our partners to help keep the waterways of Kosciusko County clean, healthy, safe, and beautiful.

See live stream sensor data on our website: **lakes.grace.edu/live-data.**

LILLY CENTER PARTNERS

We work with each of these organizations to analyze or provide relevant data. We also co-host events, provide lake-focused 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 | visitkosciuskocounty.org

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 initial 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

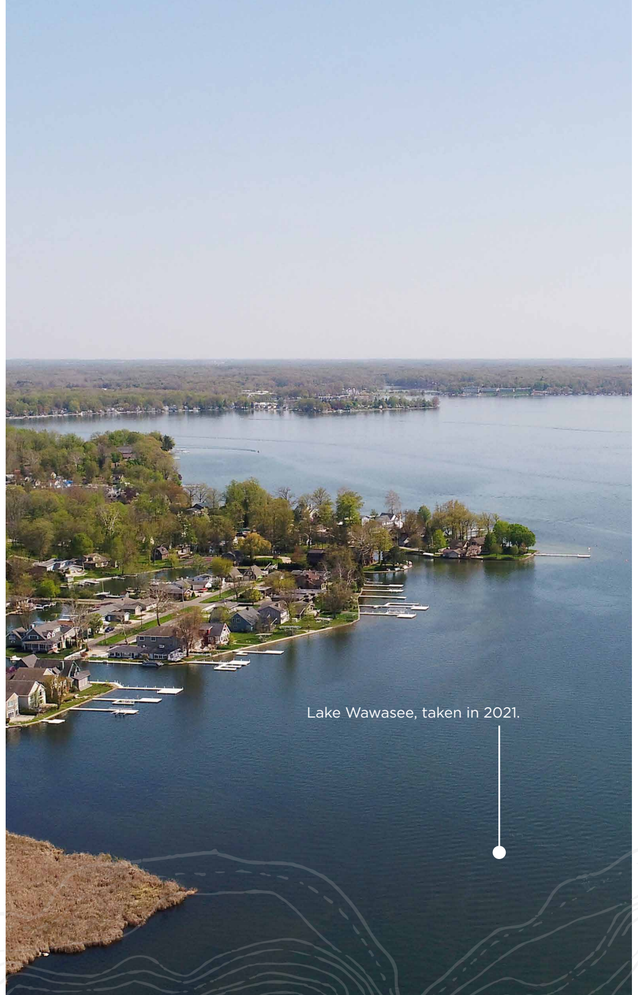
Tucked into the northeast corner of Kosciusko County, Wawasee and Syracuse lakes share a channel and acres of wetlands. Wawasee is Indiana's largest natural lake, with a surface area of over 3,000 acres and a watershed reaching well into Noble County.

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



Lake Wawasee, taken in 2021.

MICROCYSTIN (MC)

Summer Microcystin Concentrations (ppb)

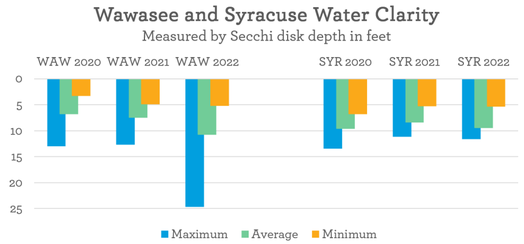
Sampling Location		2020	2021	2022
Wawasee Open Water	max.	0.7	1.3	0.7
	avg.	0.4	0.6	0.2
Syracuse Open Water	max.	0.8	2.0	0.5
	avg.	0.3	0.7	0.2
Syracuse Community Center Beach	max.	1.0	1.8	0.3
	avg.	0.4	0.7	0.2
Syracuse Hoy's Beach	max.	0.9	1.9	0.6
	avg.	0.4	0.6	0.3

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

Microcystin levels have varied over the past three years in the sampling locations. None of the sampling locations registered at or over IDEM's pet or human exposure threshold concentrations in 2022. Toxin levels this year were the lowest they have been in the last 3 years. During 2020, Kosciusko County lakes, as a whole, experienced relatively low microcystin levels. This year's levels at Wawasee and Syracuse were even lower than in 2020 and substantially lower than concentrations reported in 2021. The goal of sampling Lake Wawasee and Syracuse Lake in the summer is not only to monitor our lakes for human health and safety but also to identify key management strategies to reduce toxin spikes and maintain average low levels.

WATER CLARITY

Even though its deepest point is over twice that of Syracuse Lake, Lake Wawasee tends to have a lower average water clarity. However, this year was an exception! Wawasee's average Secchi depth was 10.8 ft compared to 9.5 ft at Syracuse. Wawasee's water clarity this year was the deepest it has been in the last six years. Water clarity in Syracuse continues to show very little variability. Syracuse benefits from Lake Wawasee as water moves northwest through Mud Lake and its wetlands. Lake Wawasee and the wetland areas filter nutrients and allow particles to settle before the water reaches Syracuse Lake.



DID YOU KNOW?

Thanks to its large surface area, Lake Wawasee loses vast quantities of water to evaporation. While evaporation is essentially invisible, it is possible to observe its effects. Even during dry summers, Launer Ditch and Turkey Creek move millions of gallons of water into Lake Wawasee each month. At times, the outflow of the system can even be nearly dry and stagnant. We calculated that the lake loses about one-third of the inflowing water to evaporation during the hot summer months. This can cause the lake levels to drop slightly!

LIMIT of FISH HABITAT

WAW 24.7 ft
SYR 19.4 ft

WATER CLARITY

WAW 10.8 ft
SYR 9.5 ft

AVERAGE TEMPERATURE

WAW 76.5 ˚F
SYR 78.1 ˚F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2022 RESEARCH

dewart & webster

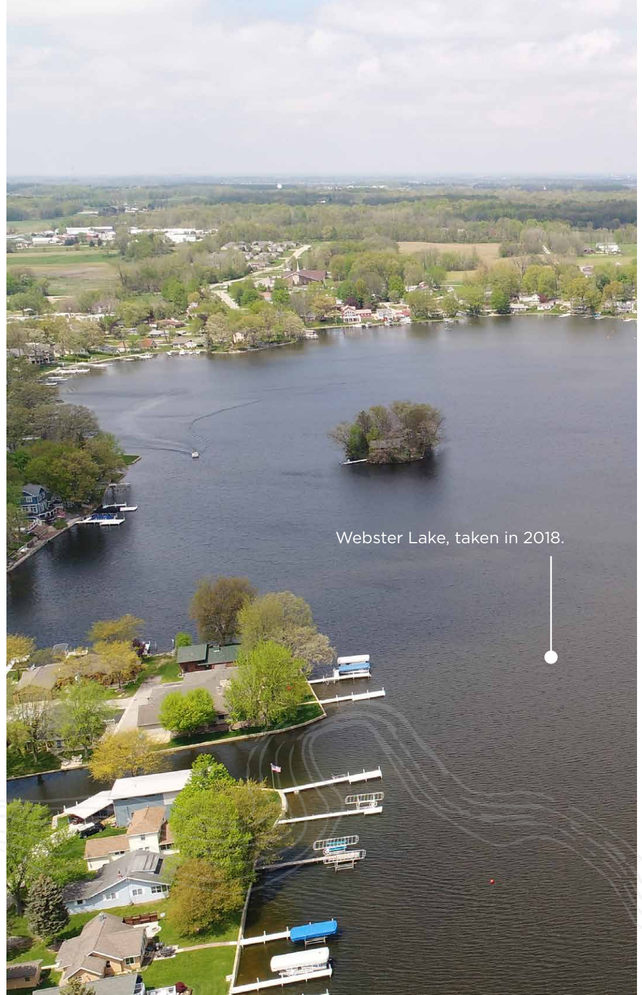
Although Dewart and Webster have few comparable aspects, they are among the county's deepest lakes (Dewart) and most influential for the Tippecanoe River's journey through Kosciusko County (Webster). Both lakes also have islands!

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



Webster Lake, taken in 2018.

MICROCYSTIN (MC)

Similar to 2021, none of Webster Lake's microcystin results, in open water or the beach, approached IDEM's threshold for human health concern. This year's test results were nearly identical to the 2021 microcystin levels but higher than concentrations observed in 2020.

Dewart has experienced substantially higher microcystin levels this year than in 2020 and 2021. In fact, Dewart averaged 1.0 ppb in 2022 which is above IDEM's pet safety threshold of 0.8 ppb. The last time Dewart had microcystin concentrations above the pet safety threshold was in 2019. These 2022 levels are the highest recorded at Dewart in the past six years. To read more about microcystin and the cyanobacteria that produce it, see page 8.

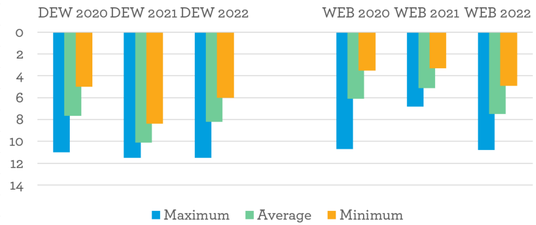
Summer Microcystin Concentrations (ppb)

Sampling Location		2020	2021	2022
Webster Open Water	max.	nd	0.4	0.5
	avg.	nd	0.2	0.2
Webster Beach	max.	nd	0.2	0.3
	avg.	nd	0.2	0.2
Dewart	max.	0.6	0.7	1.7
	avg.	0.3	0.3	1.0

** 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?

Kosciusko County is split into two major watersheds. Rain that falls on the north side of the weather station will end up in Dewart Lake, then flow north to the Elkhart River and into the Great Lakes. Rain that falls a few yards south will flow south into the Tippecanoe Chain, then to the Mississippi River and into the Gulf of Mexico. You may drive over this Continental Divide without even realizing it!

WATER CLARITY

Dewart Lake is one of the deepest of the major Kosciusko County lakes, similar in depth to Winona and Wawasee. Secchi depth at Dewart decreased from 10.1 ft last year to 8.2 ft this summer. Despite this decrease in clarity, Secchi depth at Dewart was slightly better this year compared to 2020 and close to the lake's historical average of 9.0 ft. The maximum Secchi disk reading has been consistent for the last three years, holding steady at about 11.5 ft.

Webster Lake is fed by Backwater Lake and is one stop along the Tippecanoe River's trek across Kosciusko County. It has experienced moderate water clarity over the past three years compared to the other 13 major lakes that the Lilly Center samples. However, Webster's minimum, average, and maximum Secchi depth readings were higher in 2022 than in 2021 or 2020.

LIMIT of FISH HABITAT

DEW 25.3 ft
WEB 17.4 ft.

WATER CLARITY

DEW 8.2 ft
WEB 7.5 ft

AVERAGE TEMPERATURE

DEW 78.1 °F
WEB 78.6 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2022 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

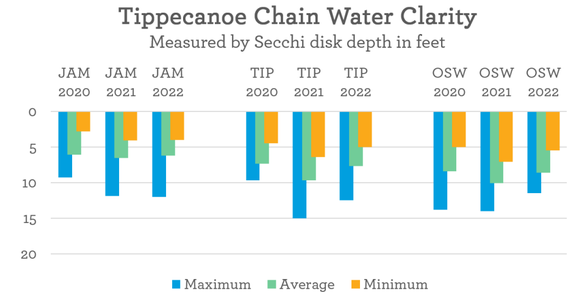
OSW

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

Tippecanoe Chain, taken in 2020.

WATER CLARITY

Clues to the Tippy Chain's health and overall water quality can be observed in its water clarity from the past three years. Sediment settles to the lake bottom as water gently flows between the lakes through no-wake natural areas full of nutrient-hungry plants. These features result in increased water clarity as the water travels. So James likely receives water with a fair amount of particulate matter, Tippecanoe a little less, and Oswego a little less than that. But other factors such as lake shape, algae growth, and wind patterns across the lake can cause changes between these interconnected bodies of water and impact water clarity and quality in more complex ways. Tippecanoe's depth, for example, means that nutrients and particulate matter can get out of the sunlight and not be as accessible for algae and cyanobacteria that are trying to grow in the upper epilimnion layer. Oswego is much shallower, which can make algae blooms (and subsequently, lower water quality) a little more common.



MICROCYSTIN (MC)

The Tippecanoe Chain has experienced generally low microcystin toxin levels the past few years. Concentrations have been well below both the human (8.0 ppb) and pet (0.8 ppb) safety thresholds established by IDEM. Similar to several other lakes, lakes of the Tippecanoe Chain had no detectable levels of microcystin in 2020 and concentrations very close to 2021 levels.

Summer Microcystin Concentrations (ppb)

Sampling Location		2020	2021	2022
James (Little Tippy)	max.	nd	0.5	0.3
	avg.	nd	0.2	0.1
Tippecanoe	max.	nd	0.2	0.1
	avg.	nd	0.1	0.1
Oswego	max.	nd	0.2	0.3
	avg.	nd	0.1	0.1

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

Mudpuppy
Photo by Kevin Fouts

DID YOU KNOW?

We have been looking for evidence of mudpuppies in Kosciusko County for several years, and in 2022 we finally found some in Oswego Lake! Mudpuppies are fascinating native salamanders with frilly gills on the outside of their head, making them look like they have big fluffy ears. However, due to those gills, they are very susceptible to pollution and have become harder and harder to find.

LIMIT of FISH HABITAT

JAM	19.4 ft
TIP	78.4 ft
OSW	12.1 ft

WATER CLARITY

JAM	6.1 ft
TIP	7.7 ft
OSW	8.6 ft

AVERAGE TEMPERATURE

JAM	78.8 °F
TIP	79.2 °F
OSW	81.3 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2022 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

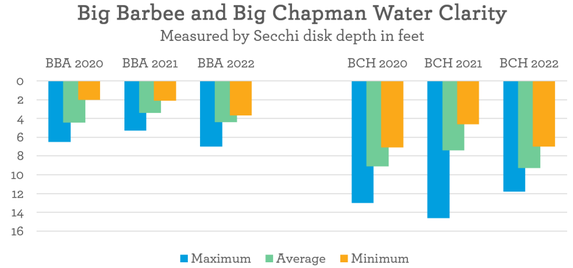
BCH

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

Big Chapman Lake, taken in 2020.

WATER CLARITY

Big and Little Chapman lakes lie just east of the Barbee lake chain. On average, Big Chapman is typically one of our clearer lakes. Big Barbee, on the other hand, usually has below average Secchi depth readings. In 2022, Big Barbee's water clarity was slightly better than in 2020 and 2021. Big Barbee's average Secchi depth in 2020 and 2022 were both 4.4 ft, but the minimum and maximum Secchi depths in 2022 were deeper than those in 2020. Big Barbee's phosphorus and nitrogen levels are higher than most of the other 13 lakes. These nutrient levels help explain the lower water clarity, suggesting high algae activity in these waters. At Big Chapman, the average Secchi depth was 9.3 ft. This is the deepest annual average in the last six years even though the maximum Secchi depth reading is lower than the previous two years.



MICROCYSTIN (MC)

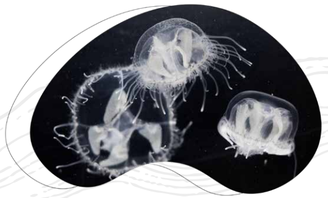
Despite high nutrient levels, microcystin toxin concentrations on Big Barbee are lower compared to a number of the lake's clearer counterparts. Barbee is a perfect example of the complex cyanobacteria/green algae populations and toxin production. None of Big Barbee's summer microcystin values have approached IDEM's threshold for human health concern.

Just the opposite of Big Barbee, Big Chapman has experienced higher microcystin levels despite its higher water clarity. Big Chapman's toxin levels fall below IDEM's threshold for human health concerns but are generally higher than the majority of the other 13 lakes. While still higher than many other lakes, microcystin levels in 2022 were considerably lower than those detected in 2021.

Summer Microcystin Concentrations (ppb)

Sampling Location		2020	2021	2022
Big Barbee	max.	nd	0.2	0.4
	avg.	nd	0.1	0.1
Big Chapman	max.	0.3	3.8	0.9
	avg.	0.1	1.6	0.4

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



Craspedacusta sowerbii, freshwater jellyfish are about the size of a penny

DID YOU KNOW?

Did you know that there are freshwater jellyfish in Indiana? They are too small to sting humans and, despite being a non-native species, they do not seem to do much ecological harm. They are found all around Indiana, including many ponds and lakes in Kosciusko County. We recently found them in a pond near Winona Lake, however, they have also been reported in Big Chapman Lake and Waubee Lake, among others.

LIMIT of FISH HABITAT

BBA 12.1 ft
BBC 19.3 ft

WATER CLARITY

BBA 4.4 ft
BBC 9.3 ft

AVERAGE TEMPERATURE

BBA 79.3 °F
BBC 78.8 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2022 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

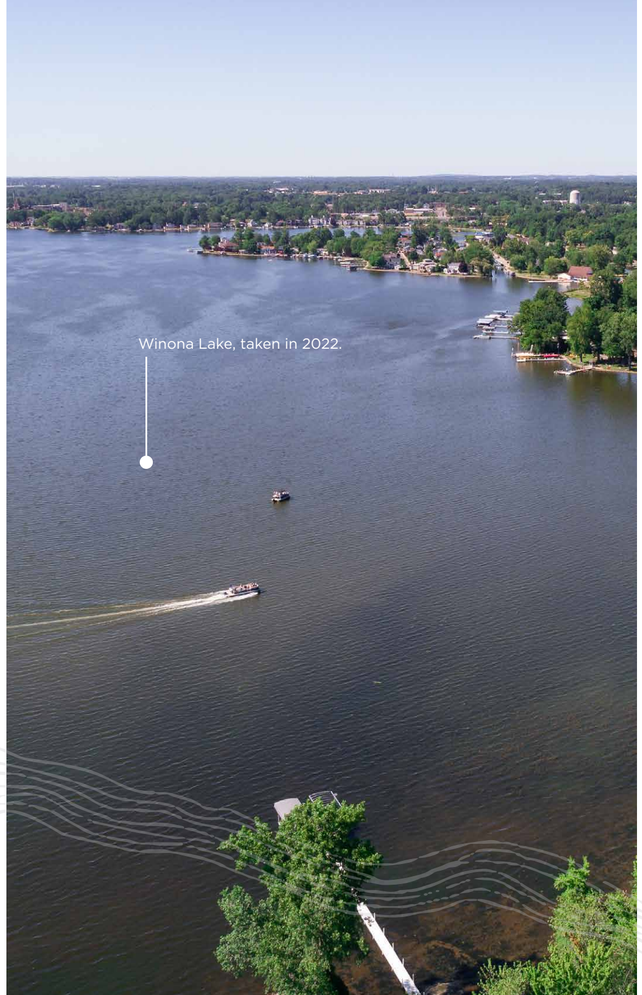
Surface area	120 acres
Max. depth	43 ft
Avg. depth	16.5 ft
Watershed	9,611 acres

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



Winona Lake, taken in 2022.

Summer Microcystin Concentrations (ppb)

Sampling Location		2020	2021	2022
Center Open Water	max.	nd	2.5	0.3
	avg.	nd	0.5	0.2
Center Beach	max.	nd	1.7	0.3
	avg.	nd	0.4	0.2
Pike Open Water	max.	0.5	0.6	0.6
	avg.	0.1	0.3	0.3
Pike Beach	max.	0.2	0.6	0.4
	avg.	0.1	0.3	0.3
Winona Open Water	max.	nd	nd	1.3
	avg.	nd	nd	0.2
Winona Beach	max.	nd	0.2	0.2
	avg.	nd	0.1	0.1

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

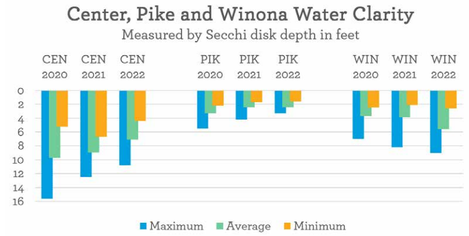
MICROCYSTIN (MC)

Center, Pike, and Winona lakes are perfect examples of how different lakes can be in spite of how close they are geographically. Watershed size and use, lake morphology (or size and shape of the lake under the water), and retention time (how long a lake typically holds onto a drop of water that enters it) all have a huge impact on the ecology of each beautiful local lake.

Microcystin toxin levels were well below IDEM's threshold for human health safety (8.0 ppb) at all Center, Pike, and Winona sampling locations. Likewise, only one sample from all three lakes (Winona open water, 1.3 ppb) had a level above IDEM's pet safety threshold of 0.8 ppb. With the exception of the Winona Lake open water site, 2022 microcystin levels were similar to 2021.

WATER CLARITY

Center Lake is typically one of the clearest of our 14 lakes. However, in the last 3 years Secchi depth minimum, average, and maximum measurements have been decreasing. This summer, water clarity was the lowest it's been since sampling began on Center Lake in 2018. Similarly, Pike Lake water clarity has decreased in the last three years. Pike typically has very low clarity and its decline is not as pronounced as Center Lake. Pike Lake contains higher concentrations of phosphorus and nitrogen than many other Kosciusko County lakes, especially in the surface water. Total phosphorus concentrations in the epilimnion of Pike Lake have increased consistently since 2020, perhaps contributing to the decrease in water clarity. In comparison to Center and Pike, water clarity at Winona Lake has improved over the last 3 years. The average Secchi depth in Winona has increased nearly 2 ft since 2020.



DID YOU KNOW?

Even a small stream can become dangerous in the right conditions. A common place for young adventurers to discover crawfish and darters is in the quiet waters of Cherry Creek as it flows towards Winona Lake. In early February, heavy rain on top of a dense snowpack caused Cherry Creek to flow nearly fifty times stronger than normal. It ripped our stream sensor right out of the stream bed!

LIMIT of FISH HABITAT

CEN	15.8 ft
PIK	9.5 ft
WIN	27.9 ft

WATER CLARITY

CEN	7.1 ft
PIK	2.4 ft
WIN	5.6 ft

AVERAGE TEMPERATURE

CEN	76.8 °F
PIK	75.7 °F
WIN	77.0 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2022 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 mussels, cyanobacteria, and algae populations on lakes throughout the county.

BEA

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

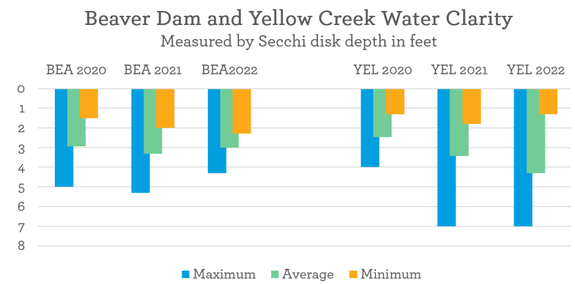
YEL

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

Yellow Creek Lake, taken in 2021.

WATER CLARITY

Beaver Dam and Yellow Creek are a unique pair of our 14 sampling lakes. They are isolated from our other sampling locations by being situated in the southwest corner of the county. Their phosphorus and nitrogen levels are higher compared to the other lakes, and their water clarity is slightly lower. Secchi depths at Beaver Dam have been fairly consistent since 2020. Average Secchi depth at Yellow Creek has increased each year since 2020. Water clarity at Yellow Creek has improved by nearly 2 ft in the last three years.



MICROCYSTIN (MC)

Despite relatively low clarity and higher levels of nutrients, microcystin toxin levels are rarely a concern at these two lakes. Since 2017, microcystin concentrations have not approached IDEM's human health safety threshold (8.0 ppb) and only on a few occasions exceeded the dog safety threshold (0.8 ppb).

Summer Microcystin Concentrations (ppb)

Sampling Location		2020	2021	2022
Beaver Dam	max.	1.2	0.6	0.5
	avg.	0.4	0.2	0.2
Yellow Creek	max.	nd	0.2	0.1
	avg.	nd	0.1	0.1

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

DID YOU KNOW?

Water always flows down, but that does not mean it takes the fastest route down. Sometimes the topography of the area directs water through the 'scenic route'. For example, Yellow Creek could flow just five miles north to Palestine Lake to quickly get to the Tippecanoe River. Instead, it flows almost thirteen miles west into the Tippecanoe River near Talma.

LIMIT of FISH HABITAT

BEA 12.1 ft
YEL 15.8 ft

WATER CLARITY

BEA 3.0 ft
YEL 4.3 ft

AVERAGE TEMPERATURE

BEA 77.7 °F
YEL 78.1 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2022 RESEARCH

BEST PRACTICES TO TRY AT HOME

Having the information is one thing; how can you act on what you have learned? The answer will look a little different for every lake. At the Lilly Center, we make sure every research project we do has a local application. Consider joining your lake association (page 14) to share in the efforts happening on your own shoreline.

PRACTICE MINDFUL BOATING

Boating with the health of your lake in mind keeps nutrients trapped in the lake floor, reducing the chances of harmful algae blooms. Here's the bottom line: look for at least 10 feet of water depth before creating a wake. See the following page for more on this!

USE NATIVE PLANTS ON YOUR SHORELINE

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

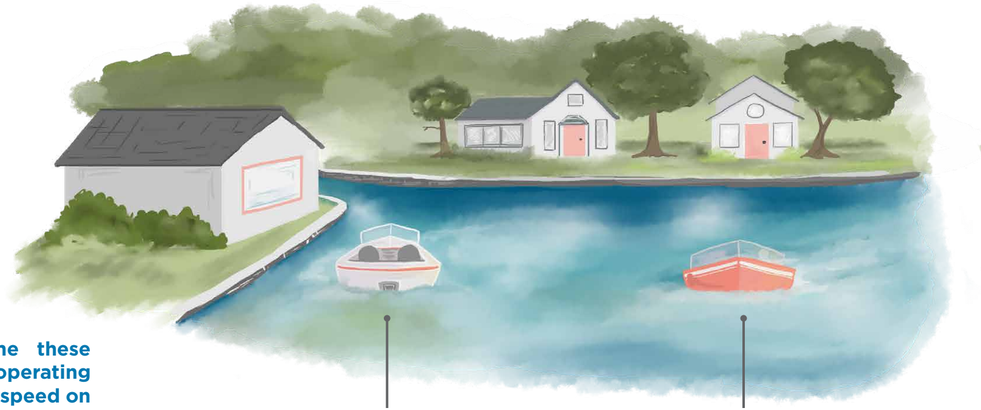
DON'T PUT YARD WASTE IN YOUR LAKE

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.

Do you learn best with hands-on education? Lilly Center events are a great way to apply best management practices by rubbing shoulders with other like-minded individuals. Visit the Lilly Center's Facebook page (**@centerforlakes**) or **lakes.grace.edu/events** to see what events are on our community event calendar so you can experience your lake in a new way!

MINDFUL BOATING

The actions we take on or near local lakes will have an impact on the health of the water, and on what lives in it. But how does that apply to boating, one of the most-loved summertime activities? Here's the bottom line: Use parts of the lake that are **at least 10 feet deep for any boating activities that create a wake** and may stir up nutrient-rich sediment. That means fewer nutrients for algae and weeds to grow in your lake!



Let's assume these boats are operating at the same speed on the same afternoon.

The one on the left is in 5 feet of water; the other is in 15 feet.

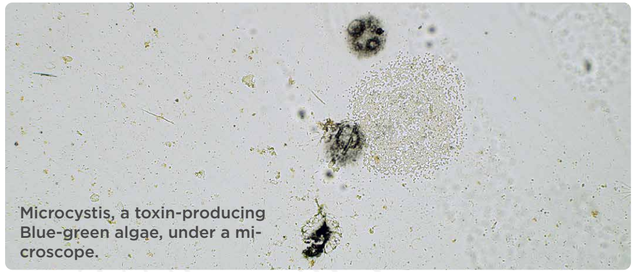
Notice the plume behind this boat. That dark greenish-brown color is actually millions of particles, primarily some form of sediment with assorted nutrients from the bottom of the lake.

There isn't a plume behind this boat; it's operating deeper than 10 feet. The water is still being stirred, but the prop and action of the water isn't catching sediment from the bottom.

When the Lilly Center research team ran boating tests in 2018, they used five different kinds of watercraft (loaned by Wawasee Boat Company) and operated them at three speed categories over sand, marl, and two muck substrate types in multiple depths of water. Analysis of water samples, video and other measurements taken at the time showed that when a boat is operated at any speed in 10 feet or deeper, no measurable sediment (and therefore nutrients) is kicked up by boat props. **Fewer nutrients lead to fewer algae and weeds in the lake.** Keep this in mind while you boat to help protect the water. Learn more about original Lilly Center research by going to **lakes.grace.edu**.

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.**



Microcystis, a toxin-producing Blue-green algae, under a microscope.

RESEARCH DATABASE

Gathering good data is crucial to every research project. The ability to analyze that data is key to a deeper understanding of our lakes and creating actionable steps to protect them. The Lilly Center is partnering with Winona IT to create a custom, full-scale database to ensure the highest data quality possible. This database will help clarify the relationship between blue-green algae, environmental and ecosystem factors, and the toxin blue-green algae produces. Learn more about microcystin toxins on page 8.

STUDENT FELLOWSHIPS

The educational programs and scientific research run by the Lilly Center would not be possible without the 35+ interns that join the team every year. These students come from a wide variety of backgrounds and come together with one purpose: to make our lakes clean, healthy, safe, and beautiful. By investing in current college students for the duration of their college careers, we can launch future environmental professionals into our region. Learn more about Lilly Center interns at **lakes.grace.edu**.

FOUNDERS CIRCLE

Education and research make a difference in the lives of youth today. But how can we ensure that future generations reap the benefits and continue a tradition of safe, healthy, lakes? Making a legacy gift, also called planned giving or an estate gift, supports research and education initiatives in Kosciusko County for years to come. We invite you to consider creating a legacy on your lake by being one of the first 20 individuals or families to commit to a planned estate gift. Your grandchildren and your lake will thank you. Learn more by going to **lakes.grace.edu/give**.

Sign up for our monthly e-newsletter

Get curated environmental news and local lake research delivered to your inbox. Scan the QR code or follow the link to sign up.

lakes.grace.edu/get-involved

Join us at an event

Start by visiting our Events page to see what webinars, workshops and Expeditions are up next.

lakes.grace.edu/events

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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.

THE LILLY CENTER FOR LAKES & STREAMS | 1 LANCER WAY, WINONA LAKE, IN, 46590

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