BENEATH THE SURFACE

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

USE THIS **2020 REPORT** TO INVESTIGATE AND CLARIFY THE COMPLEX RELATIONSHIPS BETWEEN LAND, WATER AND LIVING ORGANISMS IN KOSCIUSKO COUNTY.

LILLY CENTER FOR LAKES & STREAMS | GRACE COLLEGE

LILLY CENTER FOR LAKES & STREAMS

A Division of Grace College

If you are reading this, you probably love your lake and want to preserve it for future generations of skiers, fishers and swimmers. (We do, too!) Through this annual Beneath the Surface report, we hope to equip you with the data and analyses that will give your family, organization or agency the insights needed to care for our lakes in the best possible ways.

The Lilly Center for Lakes & Streams at Grace College was started in 2007. We believe that a county-wide lakes culture needs county-wide research, education and collaboration. Our team of lake-science and outdoor-education enthusiasts consistently crafts standard-exceeding, data-rooted content for those in kindergarten through retirement. Due to the Lilly Center's diligent, strategic work, the lakes and streams 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 reveal specific management steps.

The Lilly Center has three trained aquatic scientists: Dr. Nathan Bosch, Alex Hall and Adrienne Funderburg. The Lilly Center's research is guided and quality-assured by their efforts. Adrienne also leads a team of Grace College students in gathering and analyzing research.

We invite you to pull out your imaginary Secchi disk and dive Beneath the Surface with us.

Enjoy!

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What is Beneath the Surface?

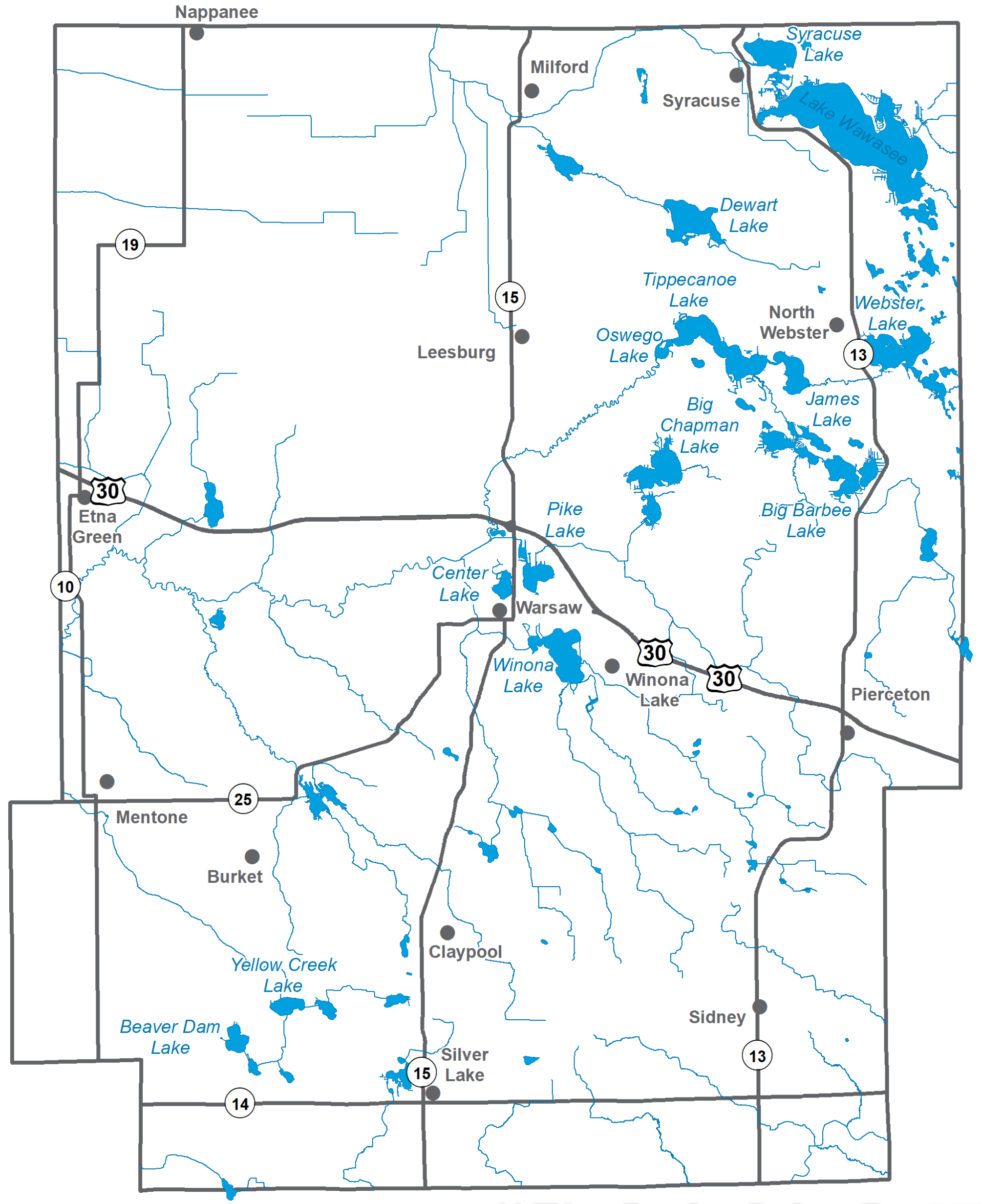
Beneath the Surface is a condensed form of the data Lilly Center staff and students gathered during the summers of 2018-20. Reviewing several years of data helps us accurately compare and contrast data points and catch any potential changes that may have occurred. All 14 lakes sampled by the Lilly Center are included in this summary.

How do we conduct research?

On a weekly basis 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 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 (the hypolimnion and epilimnion, respectively). The cyanobacterial toxin **microcystin** is sampled from a mixed sample of the top six feet of water, as well as in three feet at beaches, where residents are most likely to come in contact with the water. Measurements and notes are also taken on atmospheric conditions, past and present weather, resident observations and recent management work.

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's what this report helps us do: investigate and clarify the complex relationships between land, water and living organisms. After looking at the data presented in this book, we encourage you to share it with others. Use it as a tool to enhance the knowledge you already have, and to understand the relationship between the people and lakes in our county.



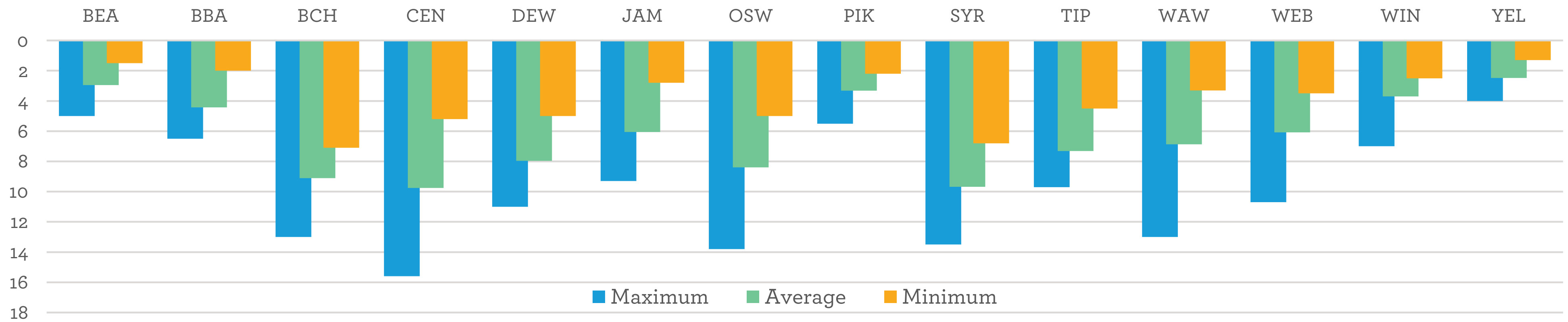
WATER CLARITY

Secchi disk depth is a measure of water clarity, one of the first things you observe as you look down into a lake. Water clarity is reduced by the "stuff" suspended in the water – usually soil particles and algae. The size and content of the watershed, precipitation and water temperature all influence how much particulate and algae are present in the lake and how clear or murky the water appears as a result.

Nutrients can come from inflowing streams and the sediment at the bottom of a lake, stirred up by waves or boat props. These nutrients lead to increased algae growth, contributing to murky water.

2020 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 eleven of our weekly measurements during the summer of 2020. The average of all summer 2020 Secchi disk readings was 6.3 ft, half of a foot deeper than 2019's average of 5.8 ft. A higher overall average doesn't mean the water clarity increased in each lake this summer, however. Take a look at the individual lake pages for a closer look at each lake's 2020 Secchi disk measurements.

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

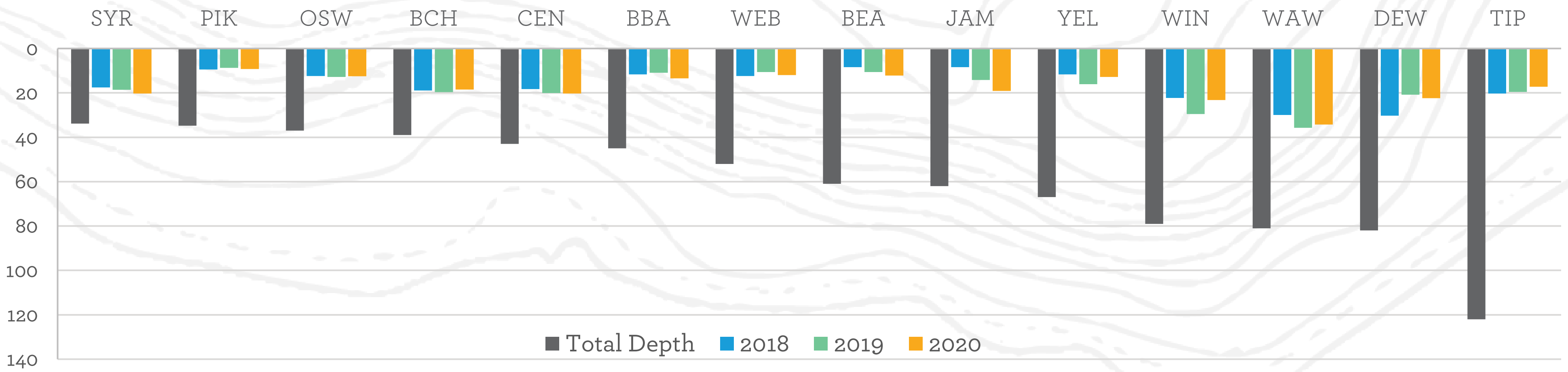
DISSOLVED OXYGEN

We aren't the only ones interested in water quality. Fish rely on healthy lakes, and their habitat can be limited by a lack of oxygen in the water. Oxygen is consumed by microbes, fish, and other organisms at the bottom of a lake, and as the lake warms in the summer, the oxygen near the bottom can run out.

Oxygen from the air can't get all the way down to replenish the cool bottom layer of water. Only fish that can live in warm water near the surface get the oxygen they need. By reducing the amount of material decomposing at the bottom of a lake, we can hopefully slow that use of oxygen and make more room in the lake for fish to inhabit in the summer.

Depth of Fish Habitat

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. Fish require a concentration of at least 2.0 mg/L of oxygen in the water to survive, so depth of habitat is where dissolved oxygen was measured greater than or equal to 2.0 mg/L oxygen. That oxygen concentration is a bare minimum, however; many species of fish need 3 or more times that amount to thrive and produce healthy offspring.

An interesting observation visible on this graph is that oxygen does not seem to vary from year to year in the same way among lakes. Many lakes' fish habitat only varied by a foot or two of water from one year to the next, while others, like James, Winona, and Dewart, experienced greater shifts since 2018.

TOTAL PHOSPHORUS, TOTAL NITROGEN

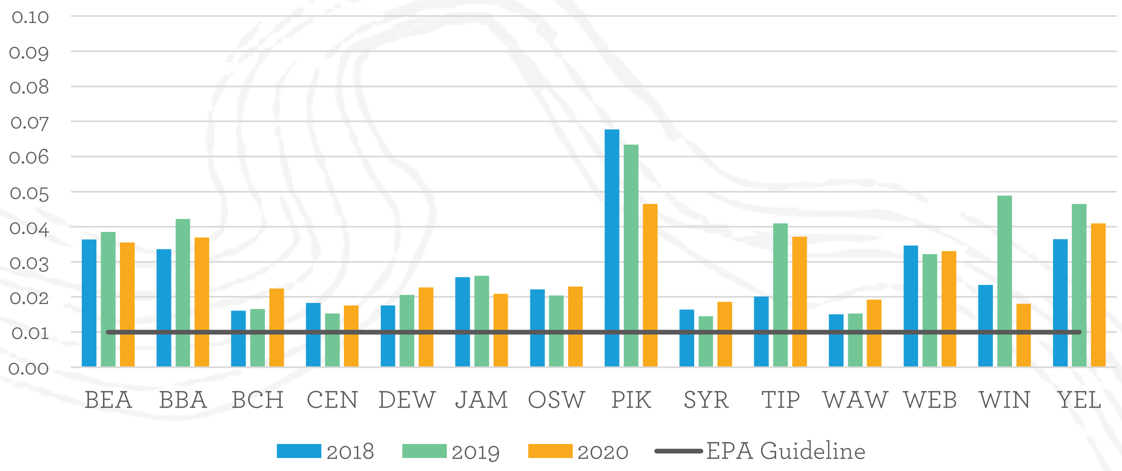
These four graphs show two nutrients – phosphorus and nitrogen – in two parts of the lake; the epilimnion is the top layer of water, and the hypolimnion is the bottom layer. (Epi- meaning "over," and hypo-, "under".) These layers do not mix in the summer, so we take a sample of both to gain a complete picture of each lake's nutrient levels.

Phosphorus and nitrogen are two of our most important chemical parameters for lake health. They are both critical nutrients for supporting aquatic life, specifically rooted plants (weeds) and phytoplankton (algae) that make up the foundation of the food chain.

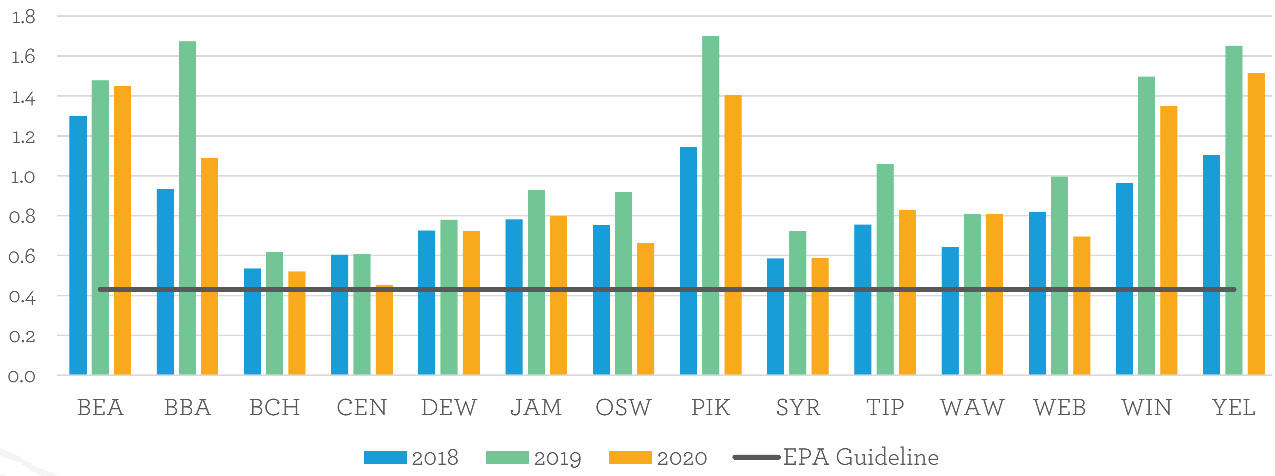
But just as eating too much of the wrong food can negatively impact our health, too much of these nutrients can take a toll on our lakes and their inhabitants.

The gray bar on each of the nutrient graphs marks the EPA water quality guideline for a minimally impacted lake in our ecoregion. It is a low bar, which means it is a high goal! All of our lakes need help to reduce the amount of nutrients coming in to increase water clarity and the depth of fish habitats.

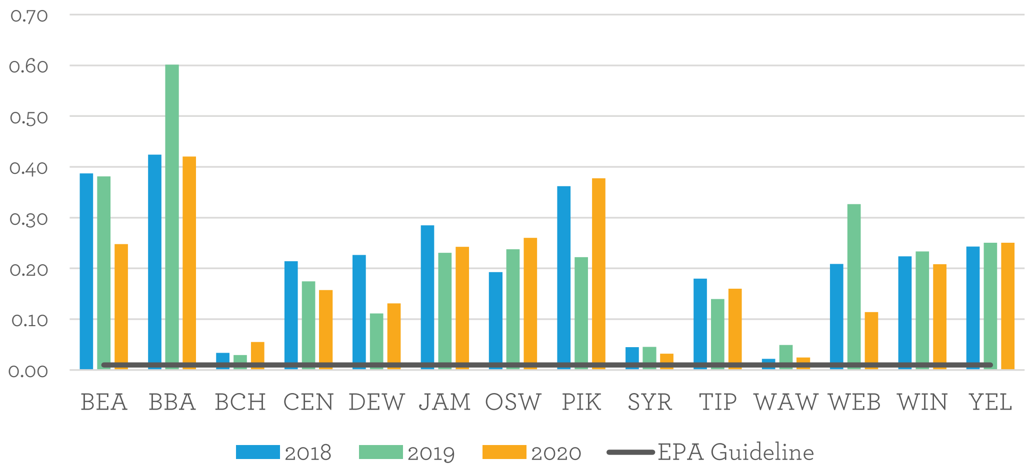
Epilimnion Total Phosphorus
Measured in mg P/L; summer averages by year



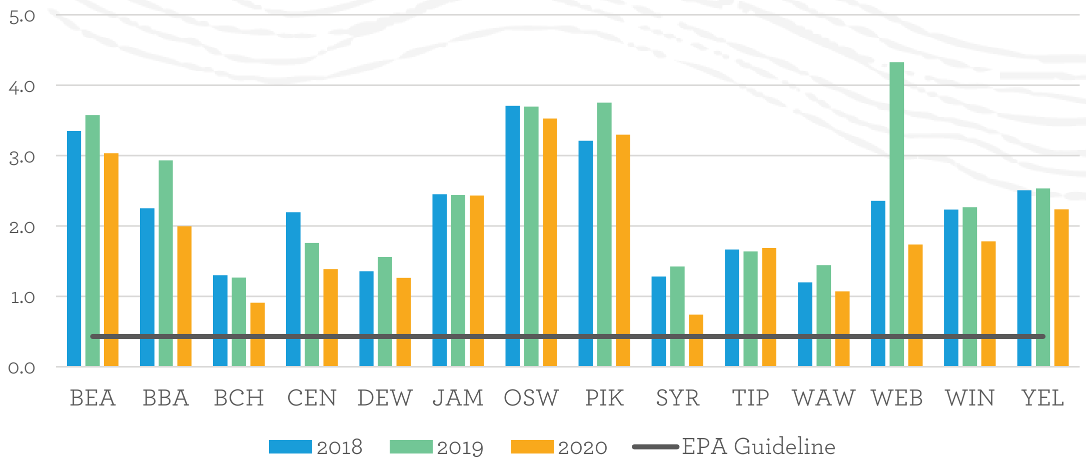
Epilimnion Total Nitrogen
Measured in mg N/L; summer averages by year



Hypolimnion Total Phosphorus
Measured in mg P/L; summer averages by year



Hypolimnion Total Nitrogen
Measured in mg N/L; summer averages by year



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 coming from the bottom sediments of the lakes in addition to inflowing streams.

You can also observe 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.

The EPA guideline for total phosphorus is 0.010 mg P/L. The average total phosphorus across all 2020 epilimnion samples was 0.043 mg P/L, while the hypolimnion was 0.192 mg P/L. The EPA total nitrogen guideline is 0.43 mg N/L. The 2020 overall average total nitrogen was 0.921 mg N/L in the epilimnion and 1.935 mg N/L in the hypolimnion. 91% of 2020 samples were above the EPA guideline for total nitrogen, and 81% were above the total phosphorus guideline.

BLUE-GREEN ALGAE

Cyanobacteria (nicknamed "blue-green algae") is a type of bacteria that survive through photosynthesis, like plants and green algae do. Cyanobacterial toxins, such as microcystin, can cause rashes, sickness and organ damage in humans, and can be especially fatal to dogs and other animals that come in contact with toxin-containing water. Our research focuses on the driving factors behind cyanobacteria blooms and toxin production in Kosciusko County.

Microcystin Exposure Thresholds

Human Recreation Caution	**8.0** ppb
Dog Recreation Prohibited*	**0.8** ppb

**State lakes & ponds*

MICROCYSTIN IN 2020

In 2020, there was a drop in microcystin concentrations in the 14 local lakes we sample. In fact, the average of all microcystin samples taken in 2020 was almost half of 2018 and 2019's averages. That last bit is the most important! Although great news, this change is not yet a positive trend. The Lilly Center will continue researching to determine what led to this sudden dip, if it will stay that way in 2021 and beyond, and how we might permanently reduce toxin levels in the future.

- There were 33 and 39 fewer instances of detected microcystin in 2020 compared to '18 and '19, respectively.
- Eight lakes had **no detections (nd)** of microcystin in 2020: Winona, Big Barbee, Center, Yellow Creek, Webster, Tippecanoe, Oswego, and James. All 14 lakes had at least one detection in both 2018 and 2019.

ZEBRA MUSSELS

Zebra mussels are an aquatic invasive species. They filter-feed on green algae but do not consume cyanobacteria, throwing the phytoplankton community out of balance. In 2019, the Lilly Center surveyed the zebra mussel populations of the 14 major lakes using samplers set up on a number of residential piers; a full report is available on our website: **lakes.grace.edu**

- Zebra mussel spawning is triggered by warm water, a fact evidenced by high colonization numbers in July.
- The story of zebra mussels in our lakes is complex. The amount of summer spawning and colonization varies between our lakes and across them from area to area. Right now, zebra mussels seem to be a lot more prevalent in some lakes than others.
- Careful recreation is still super important! Two of our major lakes – and maybe more of our smaller ones – are still uninfested!


Zebra mussels cling to solid surfaces submerged in shallow water. This PVC pyramid is a zebra mussel sampler; they are hung under piers to act as "habitat." Our researchers retrieved the samplers monthly to count and compare zebra mussel infestations between lakes.

FROM LAKE TO LAB

We take water samples from their lake or stream of origin and transport them to our research lab. Here is an overview of some essential parts of the data-gathering process:

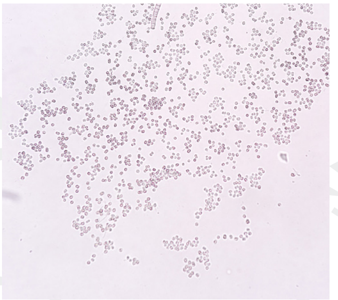
STREAM SENSORS

We currently know that cyanobacteria thrive in warm water, and blooms often occur in high heat, especially after a rain event. Rain washes in nutrients, and the warmth allows the cyanobacteria to use the influx of nutrients and sunlight to multiply rapidly. Our stream sensors (pictured above) help identify high-flow rain events and pinpoint where nutrients may be coming from.

WATER SAMPLES

At each of our sampling sites on 14 local lakes, we gather a water sample for lab testing. All kinds of cells, cyanobacteria and green algae included, are individually identified and counted under a microscope. This is a key clue for figuring out what organisms dominate in which conditions, and which cyanobacterial culprits may be producing toxin.

ALGAE BLOOMS



As often as we can, we sample cyanobacterial blooms, which tend to occur over the summer while the weather is warm. While scums tend to contain high amounts of toxin, amounts of the cyanobacteria and the toxin are not always well correlated with each other, and scums aren't always present during or after a bloom. Microcystis cells as viewed under a microscope are pictured above.

SAMPLE TESTING

With analytical equipment in-house, microcystin levels can be measured at the end of each sampling week, giving us relevant data on the lake conditions. This is done by mixing water samples with a series of special reagents that grab onto any microcystin in the water sample and change the color of the water based on the concentration of microcystin.

LILLY CENTER PARTNERS

Collaboration is at the heart of what we do. Our partners share our passion for clean, healthy lakes! We work with each of these organizations to analyze or provide relevant data related to the water. We also co-host events, speak at presentations and collaborate on other activities within the county's watersheds. We get the privilege of working with dozens of individuals and businesses, including the following lake associations, state and local government agencies and water-related organizations. 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

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

DEWART LAKE PROTECTIVE ASSOCIATION
Syracuse, IN | dewartlake.org

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

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

PIKE LAKE ASSOCIATION
Warsaw, IN

WAWASEE AREA CONSERVANCY FOUNDATION
Syracuse, IN | wacf.com

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

THE WATERSHED FOUNDATION
North Webster, IN | watershedfoundation.org

YELLOW CREEK LAKE CONSERVATION CLUB
Claypool, IN

View a full list of our partners on our website: **lakes.grace.edu**.

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

Many 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


Lake Wawasee, taken in 2020.

MICROCYSTIN

In the table to the right, you can see the past three years of microcystin data for each of our sampling sites around Wawasee and Syracuse lakes. These data are summarized as the average of each week's measurement and the maximum microcystin concentration measured that summer. The maximum measurement is significant because public health conditions work in extremes; just like wind, temperature, and precipitation, extreme conditions have a great impact on safety, even if they do not occur very often. The maximum microcystin results this summer were near or above the pet health threshold of 0.8 ppb but far below the caution level for humans, 8.0 ppb. (For more information on these health guidelines, see page 8!) This summer saw generally lower maximums than '18 and '19, and similar averages.

Sampling Location		2018	2019	2020
Wawasee Open Water	max.	5.0	1.5	0.7
	avg.	2.3	0.7	0.4
Syracuse Open Water	max.	1.1	0.6	0.8
	avg.	0.4	0.2	0.3
Syracuse Community Center Beach	max.	1.4	0.6	1.0
	avg.	0.4	0.2	0.4
Syracuse Hoy's Beach	max.	1.1	0.7	0.9
	avg.	0.4	0.2	0.4

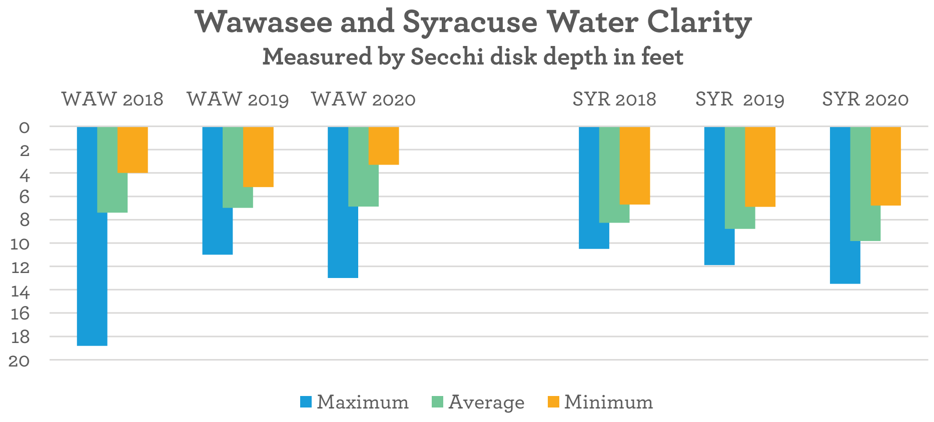
* Measured in parts per billion (ppb)
nd - no toxin detected



In 2018, we conducted a study on the impact of boating using Lake Wawasee as our test lake. To limit stirring up sediment on the bottom of the lake, it is best to normally operate in water that is 10 ft or deeper.

WATER CLARITY

Wawasee and Syracuse lakes experienced greater variation in their water clarity than last year; the clearer days were clearer and the murkier days were murkier in 2020 than 2019. You can observe this in the graph below, represented in the distance between the maximum and minimum bars. The year 2018 illustrates summer clarity variation well. Less space between the ends of those colored bars means all summer measurements fell between two close depths that year, like at Syracuse Lake in 2018. A greater distance between the bars, on the other hand, means that the water clarity fluctuated greatly between a shallow minimum clarity and a deep maximum reading, such as in Wawasee in 2018. The bottom line is that these lakes, while directly connected, are impacted uniquely by weather events, changes in ecology, and human actions! You can learn more about them and follow our research on the Lilly Center's website.



LIMIT of FISH HABITAT
WAW 34.3 ft
SYR 20.3 ft

WATER CLARITY
WAW 6.9 ft
SYR 9.7 ft

TEMPERATURE
WAW 77.9°F
SYR 78.6°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2020 RESEARCH

DEWART & WEBSTER

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

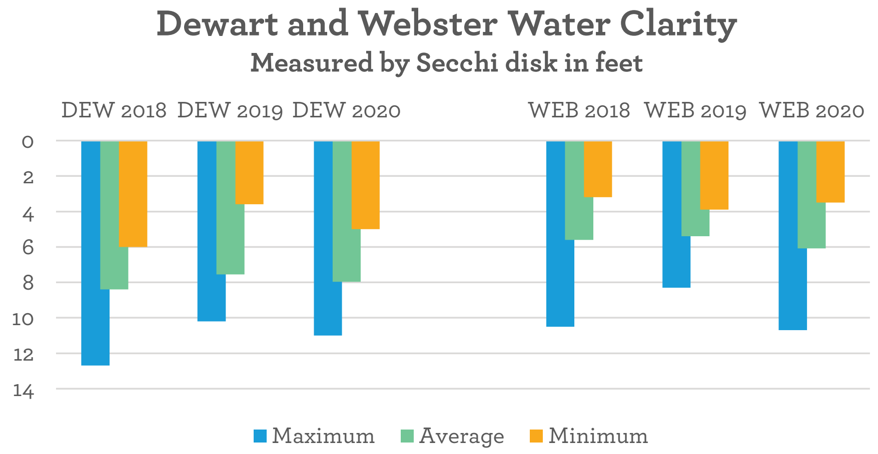
Surface area	653 acres
Max. depth	52 ft
Avg. depth	12.5 ft
Watershed	31,459 acres

Webster Lake, taken in 2018.

WATER CLARITY

Dewart

Dewart Lake holds its own among our cohort of lakes. Its smaller-than-average watershed no doubt plays a role in its lower-than-average nutrient levels and slightly-above-average water clarity. This year, like the past two, Dewart experienced typical water clarity compared to our other lakes, with a maximum of 11 ft of visibility and a minimum of 5 ft. Lined up against its own 2018 and 2019 measurements, this year fell right in the middle. July 2020 was tougher on Dewart's water clarity than previous years, but both June and August were clearer.



Webster

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 a notable impact on the lake. This summer, we observed Webster water clarity much like 2018: a high high, a low low, and an average that was closer to the minimum water clarity measurement for that summer than the maximum. This means that Webster saw a few high water clarity events, but mostly lower visibility days across the summer.

MICROCYSTIN

Dewart

Microcystin toxin levels were also low for Dewart Lake this summer. This year, unlike the previous two, no toxin results reached IDEM's 0.8 ppb threshold for pet health (pg. 8). In fact, detections and levels of microcystin were low across all of our sampled lakes this summer. Our blue-green algae and toxin research is focused on understanding patterns in toxin production and how we can keep our lakes healthy for present and future recreation (pg. 27).

Sampling Location		2018	2019	2020
Webster Open Water	max.	0.3	0.3	nd
	avg.	0.1	0.1	nd
Webster Beach	max.	0.3	0.8	nd
	avg.	0.1	0.2	nd
Dewart	max.	1.0	1.3	0.6
	avg.	0.5	0.7	0.3

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

Webster

In spite of lower clarity, no microcystin was detected on Webster Lake, either in open water or the public swimming beach, in this summer's weekly samplings. Clear water, low nutrients, and no toxin are some of the marks of a healthy lake. While this summer was great on Webster for one of those categories, there is more work to do to understand why that was the case, and how we can best improve and protect Webster Lake and the rest in each way! There are some tried-and-true methods that everyone in the watershed can do to help. Check them out on pages 24-25.

LIMIT of FISH HABITAT
DEW 22.4 ft
WEB 11.9 ft

WATER CLARITY
DEW 8.0 ft
WEB 6.1 ft

TEMPERATURE
DEW 79.2°F
WEB 79.0°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2020 RESEARCH

TIPPECANOE, JAMES & OSWEGO

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

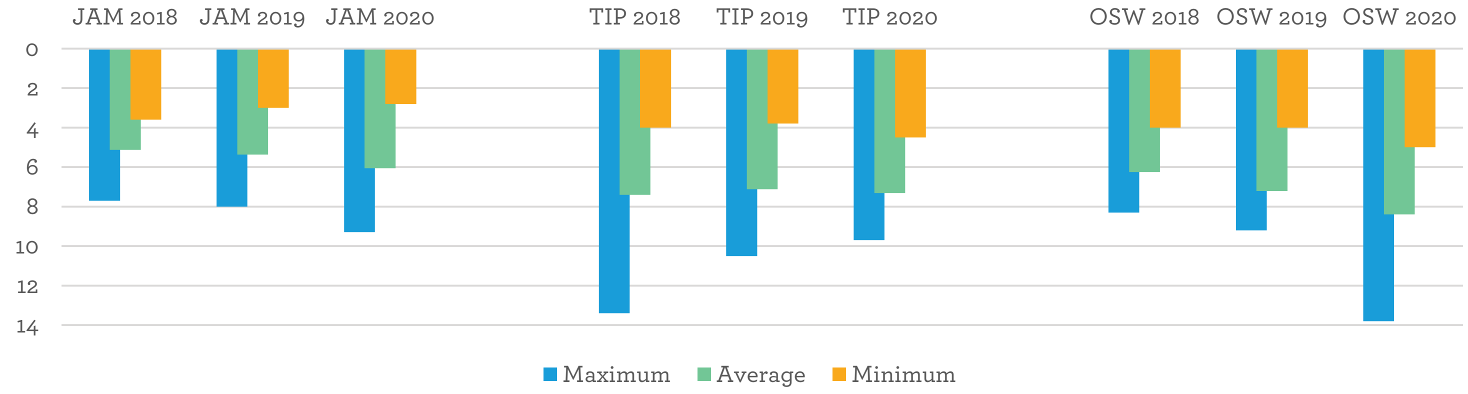
Tippecanoe Chain, taken in 2020.

WATER CLARITY

Even directly connected lakes are unique from one another. They undergo many of the same weather conditions and they sequentially receive water from the same swath of land, but that water is not quite the same from one lake to the next. Sediment in streamwater will slowly settle out once it reaches calmer waters. If the inflowing stream is shady, the water will likely get warmer once it mixes with the open, sunny, summertime lake. James (Little Tippy) is the recipient of streamwater that will be used and changed in the process of flowing toward Tippecanoe and Oswego. Due to their orientation, we anticipate that James is the least clear, as it is the first settling area for water from the Tippecanoe River on this chain. Tippecanoe would be the second most clear, and Oswego the clearest. This is what we observed this summer, as you can see on the graph below. But we notice that is not the case for nutrients in the bottom layers of these lakes (pgs. 4-5). James and Oswego, as the shallower lakes, are more susceptible to the stirring up of nutrients and sediment by boat traffic. Light can also reach to the bottom of larger portions of those lakes, meaning there is quite a lot of area for lake plants and algae to grow, die, and decay, releasing nutrients again into the bottom layer of water.

James, Tippecanoe and Oswego Water Clarity

Measured by Secchi disk depth in feet



MICROCYSTIN

The blue-green algae of the Tippy chain have not produced much microcystin in the past three years. For this year, that was even more true. We had no detections of the toxin on any of these three lakes this summer. For more information on blue-green algae and microcystin, see page 8.

Sampling Location		2018	2019	2020
James (Little Tippy)	max.	0.2	0.3	nd
	avg.	0.1	0.1	nd
Tippecanoe	max.	0.2	0.2	nd
	avg.	0.1	0.1	nd
Oswego	max.	0.2	0.3	nd
	avg.	0.1	0.1	nd

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

LIMIT of FISH HABITAT

JAM 19.1 ft
TIP 17.2 ft
OSW 12.5 ft

WATER CLARITY

JAM 6.1 ft
TIP 7.3 ft
OSW 8.4 ft

TEMPERATURE

JAM 78.4°F
TIP 78.6°F
OSW 79.0°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2020 RESEARCH

&big barbee big chapman

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 are the subject of the Lilly Center's DNR-funded sewer impact study. You can read the pre-study 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

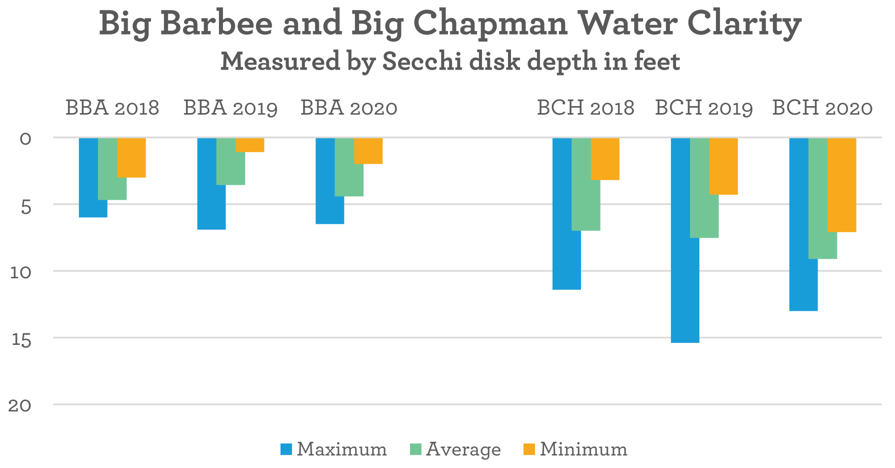
Surface area	504 acres
Max. depth	39 ft
Avg. depth	12.5 ft
Watershed	4,500 acres

Big Chapman Lake, taken in 2020.

WATER CLARITY

Big Barbee

Big Barbee, like many of our lakes, fell in-between 2018 and 2019 in terms of water clarity. July was not as harsh in 2020 as 2019, but Big Barbee's water clarity was lower in the late summer compared to both years. Back on page 5, we see that the bottom water (hypolimnion) of Big Barbee is a large source of phosphorus in the lake. This "internal nutrient loading" can be reduced by continuing to reduce and remove organic matter from the water that will eventually sink and decay, releasing nutrients.



Big Chapman

The bottom water of Big Chapman is also acting as a source for total phosphorus, but to a lesser degree. (Make sure to note the different scales between the two phosphorus graphs!) With a watershed over six times smaller than that of Big Barbee, Big Chapman has to handle a lot less inflowing material and water. This is likely a positive influence on its water clarity. But the same is not true for Beaver Dam and Yellow Creek lakes, which also have small watersheds. These differences in water clarity and nutrient levels lead us back to the core of our research program: blue-green algae.

The Barbee sewer study is a prime example of the critical relationship between lake and stream health. The six inflowing Barbee streams and the five inflowing Chapman streams collect water from land of a variety of uses and conditions, including those used for septic seepage. This water, along with water that runs directly into lakes off of shorelines, takes with it nutrients and sediments that limit water quality and clarity. Then each of the lake chains' outflowing streams release that water and its contents downstream. More on page 27!

MICROCYSTIN

Big Barbee & Big Chapman

Big Chapman had lower concentrations than the previous two years, and we detected none at all in Big Barbee samples this summer. To learn more about our algae and microcystin research, see page 8.

Sampling Location		2018	2019	2020
Big Chapman	max.	1.9	1.6	0.3
	avg.	0.5	0.7	0.1
Big Barbee	max.	0.2	1.0	nd
	avg.	0.1	0.3	nd

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

LIMIT of FISH HABITAT
BBA 18.5 ft
BCH 13.4 ft

WATER CLARITY
BBA 9.1 ft
BCH 4.4 ft

TEMPERATURE
BBA 79.7°F
BCH 79.3°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2020 RESEARCH

CENTER, PIKE & WINONA

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

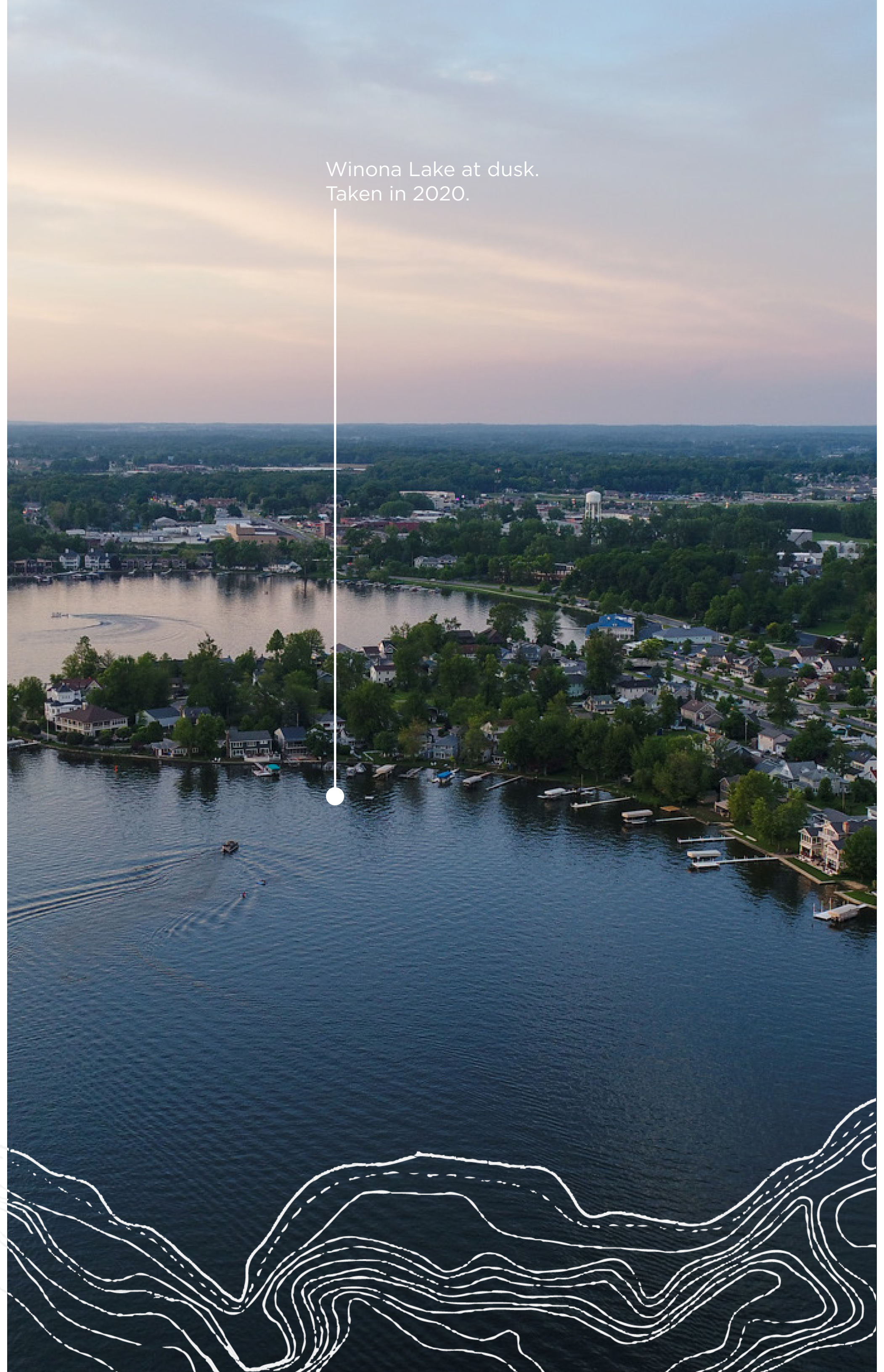
Surface area	120 acres
Max. depth	43 ft
Watershed	9,611 acres

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



Winona Lake at dusk. Taken in 2020.

MICROCYSTIN

All three of these lakes, like our other sampled lakes, experienced low microcystin toxin levels this year. Pike's open water had a higher maximum reading compared to 2018, but the average is lower, and no measurements this year were at or near the IDEM pet recreation threshold like the 2019 maximum. On Center and Winona, no microcystin was detected this year in open water or swimming beaches. To learn more about our blue-green algae and microcystin research, see page 8.

Blue-green algae will often have a paint-like consistency as in the picture above, taken in 2019.

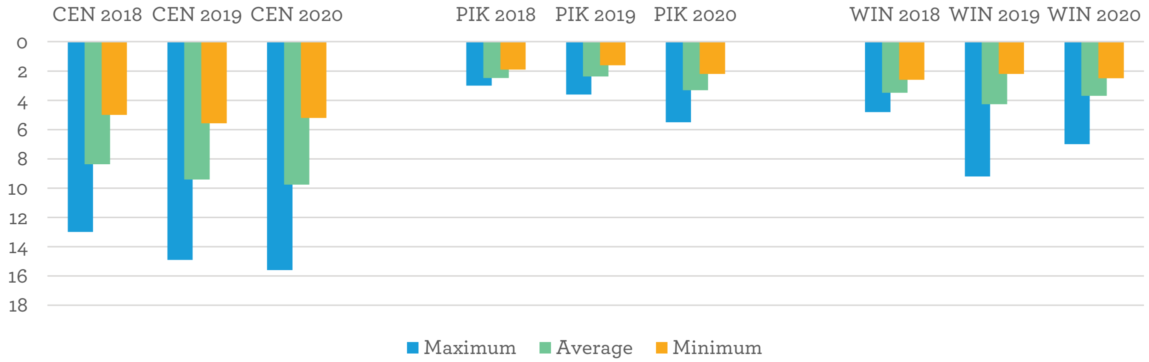
Sampling Location		2018	2019	2020
Center Open Water	max.	1.0	0.3	nd
	avg.	0.3	0.1	nd
Center Beach	max.	0.4	0.2	nd
	avg.	0.2	0.1	nd
Pike Open Water	max.	0.3	0.9	0.5
	avg.	0.2	0.5	0.1
Pike Beach	max.	0.3	0.8	0.2
	avg.	0.2	0.4	0.1
Winona Open Water	max.	0.3	1.7	nd
	avg.	0.1	0.4	nd
Winona Beach	max.	0.2	2.3	nd
	avg.	0.1	0.5	nd

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

WATER CLARITY

Center Lake is low in nutrients compared to our other lakes overall, as seen on page 5. Low nutrients go hand-in-hand with deep water clarity, because high sediment and algae (which feed on nutrients) block the light in lake water and make water appear murky. We observe this in Pike as well, where water clarity is low and nutrient measurements are high in both the top and bottom layers of water. Despite generally lower clarity, this summer's water clarity on Pike was greater than the past two years; the murkiest day was less murky and the clearest day was more clear than 2018 and 2019. Winona Lake saw moderately high nutrients and a moderate year for water clarity compared to other lakes this year and previous years of its own measurements.

Center, Pike and Winona Water Clarity
Measured by Secchi disk depth in feet



LIMIT of FISH HABITAT

CEN 20.3 ft
PIK 9.2 ft
WIN 23.3 ft

WATER CLARITY

CEN 9.8 ft
PIK 3.3 ft
WIN 3.7 ft

TEMPERATURE

CEN 78.3°F
PIK 77.0°F
WIN 77.9°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2020 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

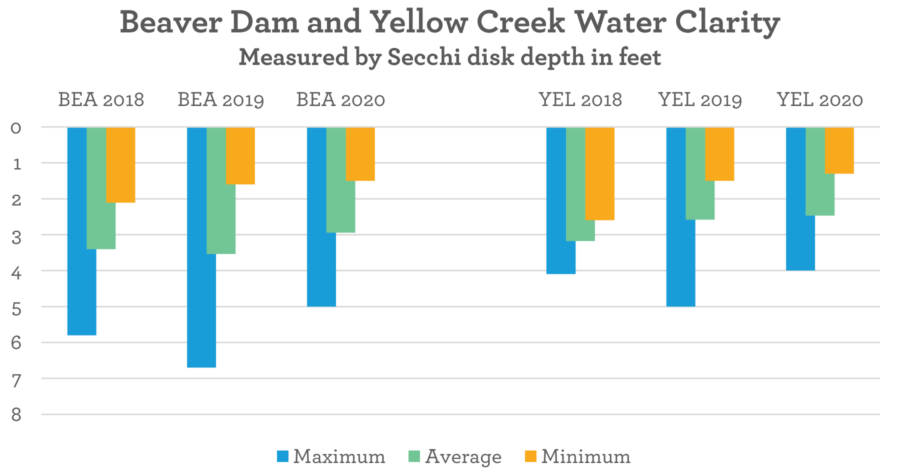
YEL

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 & MICROCYSTIN

Beaver Dam and Yellow Creek both experienced slightly lower water clarity than previous years, and lower clarity compared to other sampled lakes this year. Nutrients are also higher in these lakes in both layers of water this year and in the previous two (pg. 5), which feed the algae populations of these lakes. We anticipate some similarities like these due to parallels in their morphology, or shape, and locations. Both have small watersheds and surface areas, are geographically close, and have similar maximum depths. But in spite of these similarities, they have differed in their microcystin toxin levels in 2019 and 2020. Yellow Creek had little to no toxin over the past three years (with no detections at all in 2020). Beaver Dam has had more regular low level detections with a few higher readings mid-summer.



Sampling Location		2018	2019	2020
Beaver Dam	max.	0.3	1.2	1.2
	avg.	0.2	0.5	0.4
Yellow Creek	max.	0.3	0.3	nd
	avg.	0.1	0.1	nd

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

Yellow Creek Lake, taken in 2020.

Another important morphological difference between these lakes is their average depth, which would influence the potential impact of watercraft and their ability to stir up the lake bottom and release nutrients. In order to limit this impact, the Lilly Center recommends keeping regular, high impact boating to water 10 ft deep or deeper.

This fall and winter, we are working in the lab to identify and count the populations of green and blue-green algae found in these lakes and the twelve others we sample. These will help us understand when and why blue-green algae communities decide to produce toxin, and why such similar lakes can differ in their toxin levels. Along the way, we will look at how the lack of invasive, green-algae-eating zebra mussels may be a factor in the algae communities of Beaver Dam and Yellow Creek in how they compare to our other county lakes. To read more about zebra mussels, see page 8.

LIMIT of FISH HABITAT
BEA 12.2 ft
YEL 12.8 ft

WATER CLARITY
BEA 2.9 ft
YEL 2.5 ft

TEMPERATURE
BEA 80.1°F
YEL 79.5°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2020 RESEARCH

NOW WHAT?

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. Sometimes, the lessons learned on one lake will apply to several others. The same is true for best practices and next-steps! The choices you make for your lake have a much broader impact. Here are a few ways you can join the Lilly Center team to protect local waterways:

KNOW YOUR NEIGHBORS

Lake life is uniquely communal. "Neighbors" can mean the person who lives one pier over **or** on the opposite shoreline. But especially during the summer, everyone shares a single resource. Whether for recreation or relaxation, from a pier or a boat, for the summer or year-round, the lake brings neighbors closer together. When you know your neighbors, you can share the importance of keeping the water healthy.

Use this annual report to help guide conversation! Share about what makes your lake unique or how it fits into the overall picture of Kosciusko County.

OBSERVE YOUR LAKE

It is safe to say that a lake's **beauty** is high on the list of reasons why we all love the water! How often do you sit on your porch or patio or deck and observe the colors and plants in the water, or the critters along the shoreline? Next time, take a notepad and pencil and record what you see. Try observing at different times of day. Grab your phone or camera and snap a few pictures. Observation is the first step in the scientific method, one the Lilly Center team uses all the time.

Spot something unique or unpleasant, like blue-green algae? Tell us about it! We might be able to identify what you find and tell you more about its role in your lake's ecosystem.

BEST PRACTICES TO TRY AT HOME

Searching for a way to apply best practices, like the ones below? Check out the Lilly Center's Facebook page (**@centerforlakes**) to see what events we have on our community event calendar! You can join us for workshops, webinars, Expeditions and more.

USE NATIVE PLANTS

Use native plants in your landscaping, especially along the shores of lakes and streams. The roots of the plants will help strip rainwater of nutrients, much like the water filter in a kitchen faucet. The roots remove nitrogen and phosphorus from fertilizers and other nutrient sources that can all be considered pollutants. Look back at pages 6-7 to see current nutrient levels in the 14 lakes the Lilly Center samples!

DISPOSE OF HAZARDOUS WASTE

Use nontoxic household products and properly dispose of hazardous household waste, such as electronics and paint supplies. Recycle used motor oil and maintain your car to keep oil, coolant, antifreeze or other chemicals from leaking onto the ground. Even a simple choice like washing your car at a carwash will help protect the lakes! During heavy rain, pollutants left on hard surfaces (like driveways) can be washed into the waterways.

DON'T PUT YARD WASTE IN YOUR LAKE

During autumn, collect your leaves for removal according to your local guidelines. Be sure not to sweep them into the street and cause them to clog storm drains. Leaves are also an excellent way to naturally enrich the soil in your garden! Use them to create a healthy compost pile. Be sure not to dispose of them in your lake. As the leaves decompose, they release extra nutrients that algae and plants can use to flourish.

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. Data visibility is key to making this happen! The stream sensor network and algae research lab both allow you to view the same numbers we do and take part in positive change for healthy, safe waterways.

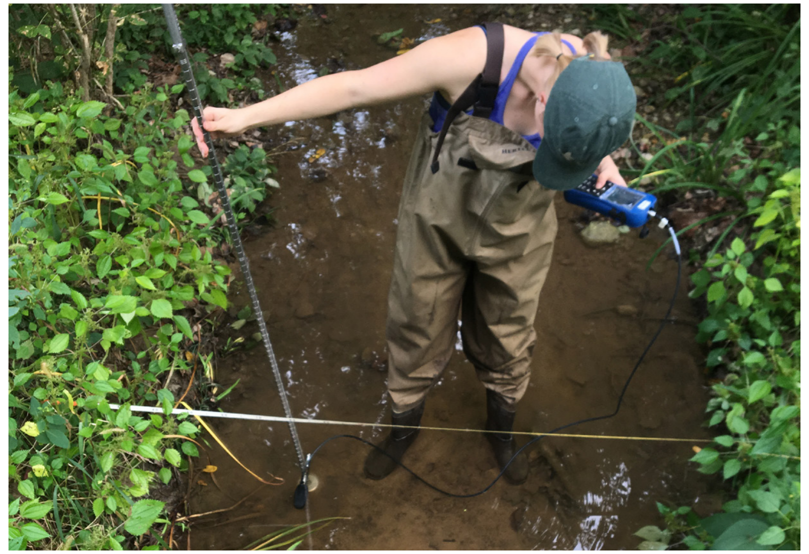
You can read blog posts and studies about each of these and other research projects on our website: **lakes.grace.edu**

STREAM SENSOR NETWORK

We have 12 stream sensors installed across the inflowing and outflowing streams to six lakes, continually monitoring water flow and stream characteristics. View the data here: **lakes.grace.edu/live-data**! This helps piece together the story of our lakes. For instance, Launer Creek (an inflowing stream to Wawasee) experienced a rain event near the end of August which doubled the amount of water flowing through the stream. The water temperature also increased, indicating much of the water originated from surface runoff rather than groundwater, which is colder. The sensor detected greater water velocity, which means more erosion of the stream banks, and higher water depth, which means more of the bank is underwater and likely to erode. Just one rain event monitored by a stream sensor helps us understand what is impacting our lakes!

ALGAE RESEARCH LAB

The Lilly Center reports weekly microcystin results each summer. In partnership with the Indiana Department of Environmental Management, data gathered and analyzed by the Lilly Center identifies elevated levels of the microcystin toxin. Aside from the 14 lakes mentioned in this data summary, sampled public beaches include: Center Lake Park; Hoy's Beach and Community Center Beach on Syracuse Lake; Pike Lake Beach; Waubee Lake Park; North Webster Beach; and Winona Lake Limitless Park. Our current hypothesis is that differences in lake algal communities play a key role in the health and management of our lakes. During the winter of 2020, we are focused on counting and identifying algae in preserved water samples from 2018-2020 so we can test our hypothesis. Differences in algal communities may also have an impact on the production of the blue-green algae toxin, microcystin.



BARBEE-CHAPMAN STUDY

In 2012-2013, the Lilly Center received a DNR Lake and River Enhancement grant in order to study the Barbee Lakes chain before the installation of a sewer district. This "pre-sewer" study set a baseline for lake and stream quality on this chain while it was still surrounded by private septic systems. We surveyed everything from lake and stream *E. coli* to nutrient concentrations, shoreline erosion, and stream insect communities. Now that the sewer system has been installed and operational, the Lilly Center has repeated all of those surveys to see if and how the switch impacted water quality. The Chapman chain was used as an experimental control, as the lake did not switch from septic to sewers during that time. Keep an eye out for the final report comparing the pre-sewer and post-sewer studies by following us on Facebook. If you want to be sure not to miss it, sign up for our e-newsletter or find it alongside the rest of our research at: **lakes.grace.edu/original-research**

Follow us on Facebook (@centerforlakes)

Like our page to see the links, pictures and events we share throughout the week.

Sign up for our monthly e-newsletter

Get our latest K-12, community and research news and pictures delivered to your inbox: lakes.grace.edu/get-involved

Join us for events

Start by visiting our Facebook page to see what webinars, workshops and Expeditions are up next: facebook.com/centerforlakes

LILLY CENTER FOR
LAKES
& STREAMS

GRACE
COLLEGE

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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