BENEATH THE SURFACE

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

USE THIS **2019 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

We might not physically put a Secchi disk in your hands or outfit you in a pair of chest waders. But through this annual Beneath the Surface report, we hope to equip you with the data and analysis that will give your family, organization or agency the insights needed to care for our lakes in the best way possible.

At the Lilly Center for Lakes & Streams, we believe that a county-wide lakes culture needs county-wide research, education and collaboration. We are a team of lake-science and outdoor-education enthusiasts, and we consistently craft 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 effort. 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 we're talking about:

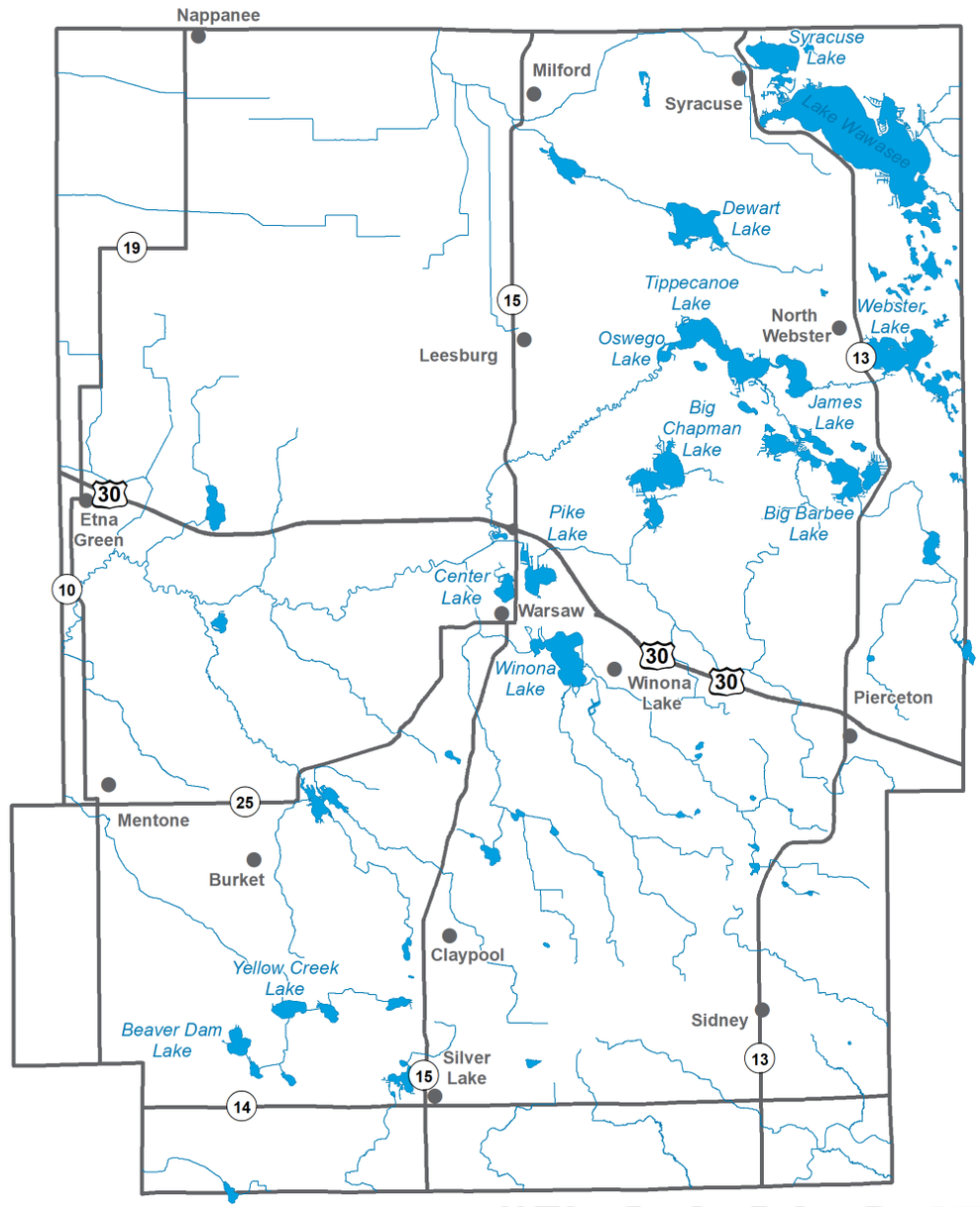
Beneath the Surface is a condensed form of the data Lilly Center staff and students gathered during the summers of 2017-19. Reviewing several years of data helps us accurately compare and contrast data points and catch any changes that may have occurred. All 14 lakes sampled by the Lilly Center are included in this summary.

What we do:

On a weekly basis from the beginning of June through the first 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 to use this summary:

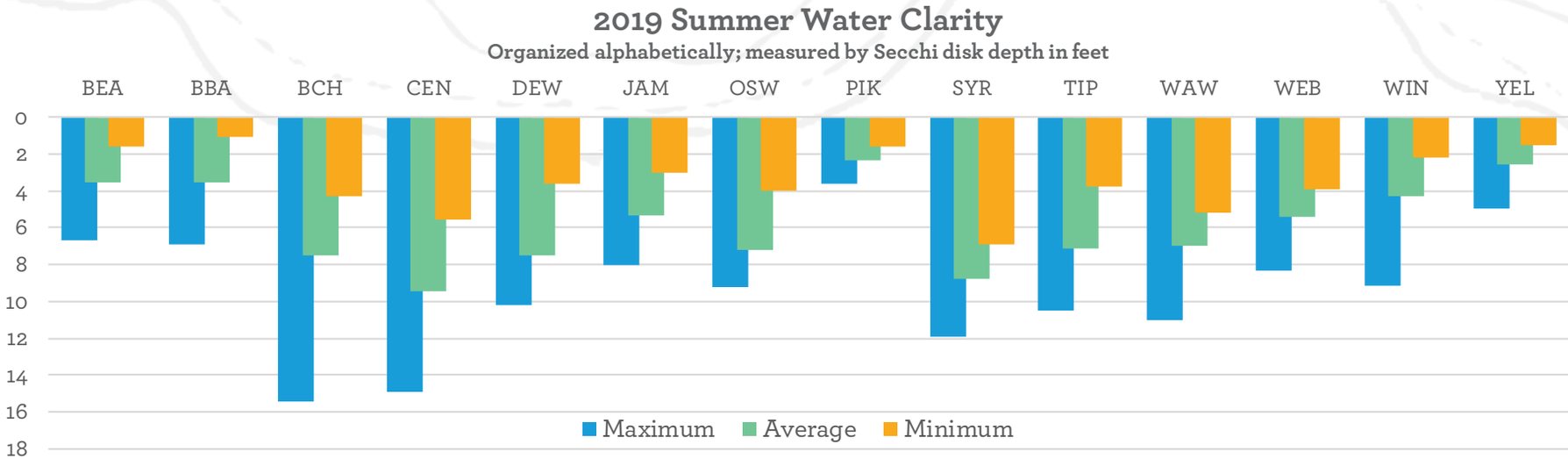
We want **you** to understand this data and use it to make the best decisions for your local lakes and their watersheds. That's what this report helps us do: Investigate and clarify the complex relationships between land, water and living organisms. After looking at the data presented in this book, we 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. These nutrients lead to increased algae growth, such that nutrients and sediments from streams and boats stirring up the lake bottom can lead to lower water clarity.

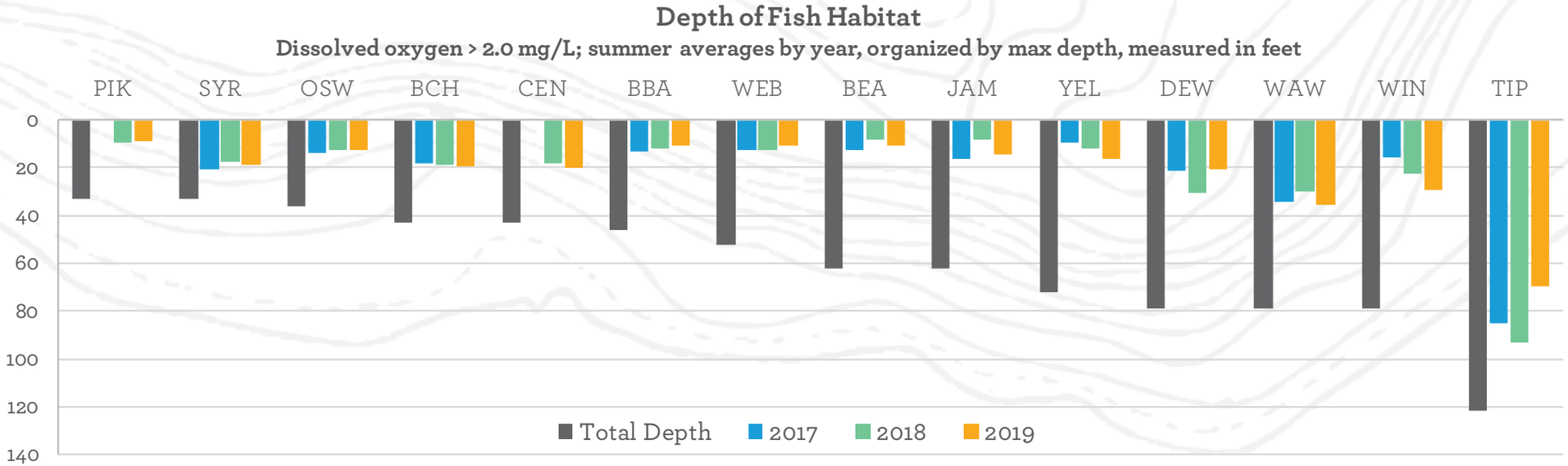


This Secchi disk graph shows the maximum, average and minimum depths we could see into each lake across all nine of our weekly measurements during the summer of 2019. The average of all summer 2019 Secchi disk readings was 5.8 ft. Note that the water clarity varies greatly across all lakes in each area of the county; there does not seem to be a spatial effect north to south.

DISSOLVED OXYGEN

As we know, we aren't the only ones paying attention to 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.



The lakes in this graph are organized from smallest to largest maximum depth. 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.

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. For instance, in 2018, Tippecanoe had the largest percentage of available habitat overall and compared to itself those three years (76.7%), while James experienced its lowest and the lowest overall percentage habitat in 2018 as well (13.5 %).

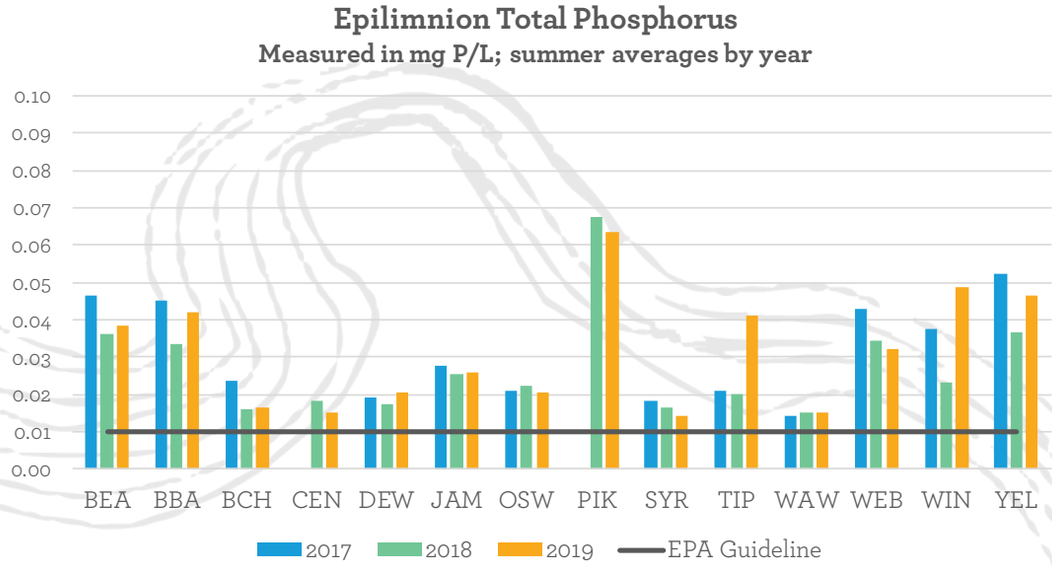
TOTAL PHOSPHORUS, TOTAL NITROGEN

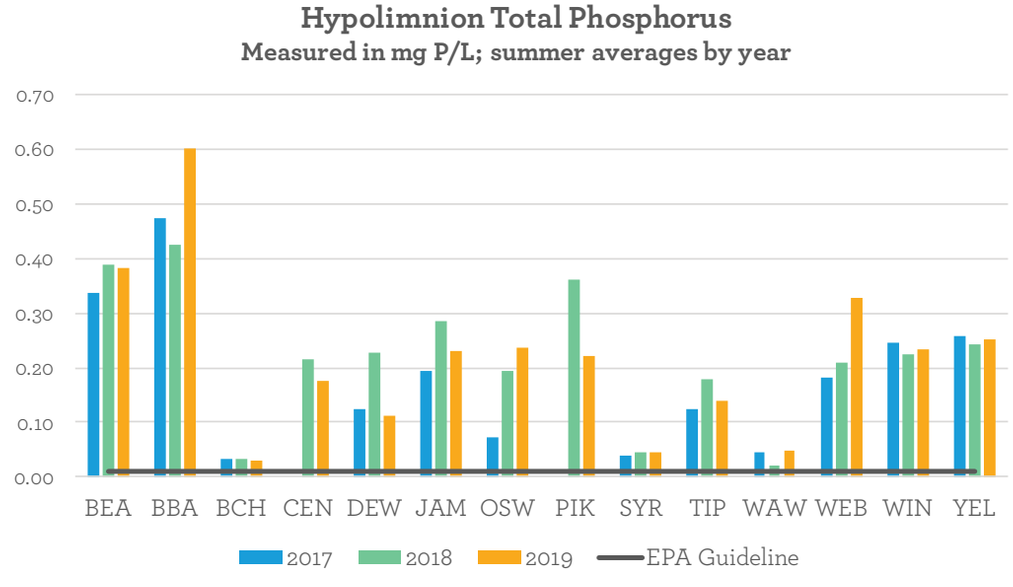
These four graphs show two nutrients – phosphorus and nitrogen – in two parts of the lake; the epilimnion is the top layer of water, and the hypolimnion is the bottom layer. (Epi- meaning "over," and hypo-, "under".) These layers do not mix in the summer, so we take a sample of both to gain a complete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

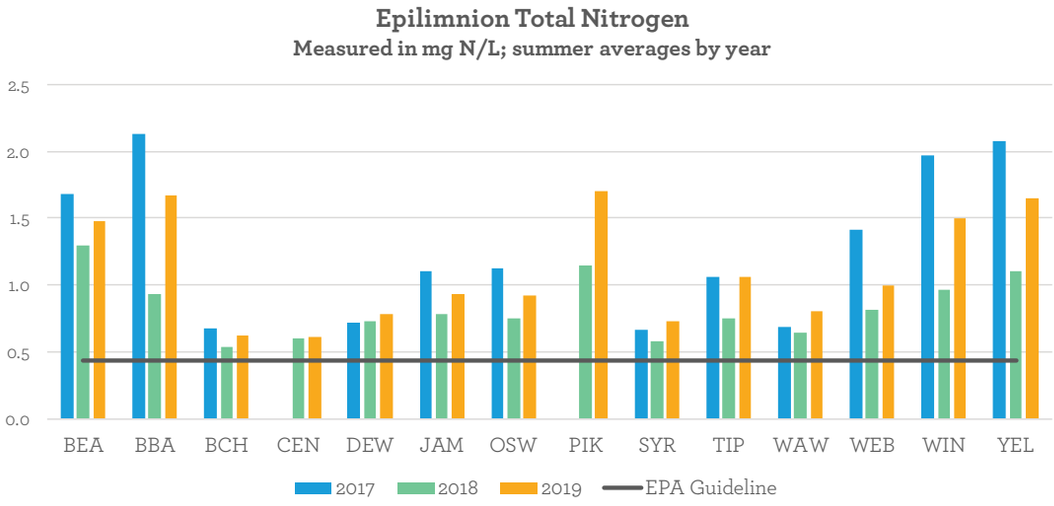
Phosphorus and nitrogen are two of our most important chemical parameters for lake health. They are both critical nutrients for supporting aquatic life, specifically rooted plants (weeds) and phytoplankton (algae) that make up the foundation of the food chain.

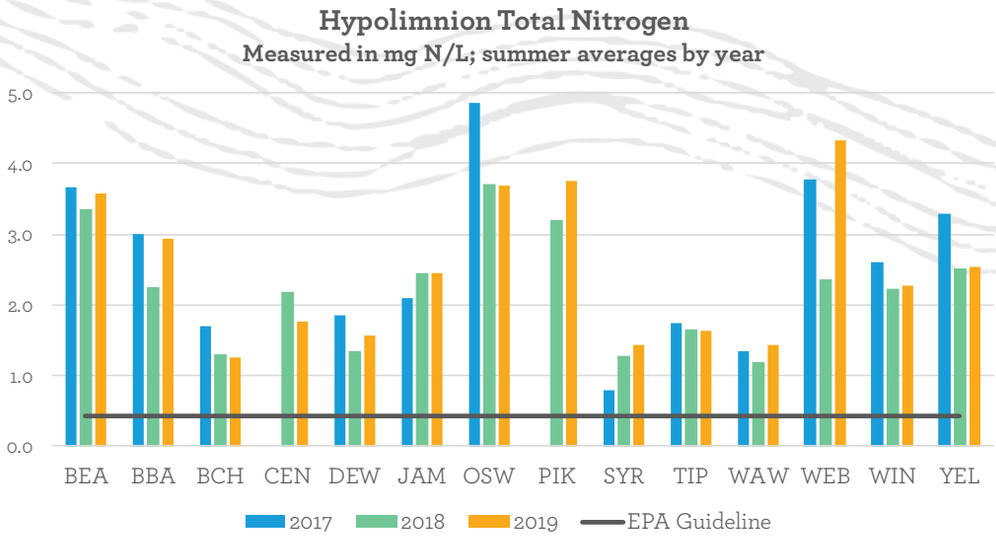
But just as eating too much of the wrong food can negatively impact our health, too much of these nutrients can take a toll on our lakes and their inhabitants.

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.









Note that the scales on these graphs are different, highlighting the fact that there is typically more nutrient 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 overall average total phosphorus in the 2019 epilimnion was 0.032 mg P/L, while the hypolimnion was 0.217 mg P/L. The EPA total nitrogen guideline is 0.43 mg N/L. The 2019 overall average total nitrogen was 1.10 mg N/L in the epilimnion and 2.47 mg N/L in the hypolimnion. Only 4% of 2019 measurements were beneath the total nitrogen guideline, and no measurements were beneath 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. While these organisms are a natural part of lake ecosystems, they have drawn attention for their recent dominance in lakes around the world, and for the toxins produced by some species. 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. Research on cyanobacteria is occurring at the Lilly Center and around the world. Much of the research is focused on the driving factors behind cyanobacteria blooms and toxin production.

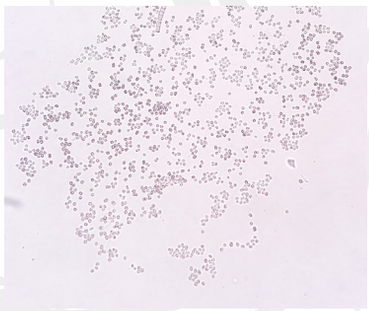
The series of pictures below shows parts of the process we follow as we seek to understand cyanobacteria in local lakes:

Exposure Thresholds

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

**State lakes & ponds*

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.



Cyanobacteria blooms can be localized to an area of the lake, especially by wind, and can lead to thick scums. While scums tend to contain concentrated amounts of toxin, amount 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 are pictured above, viewed under a microscope.

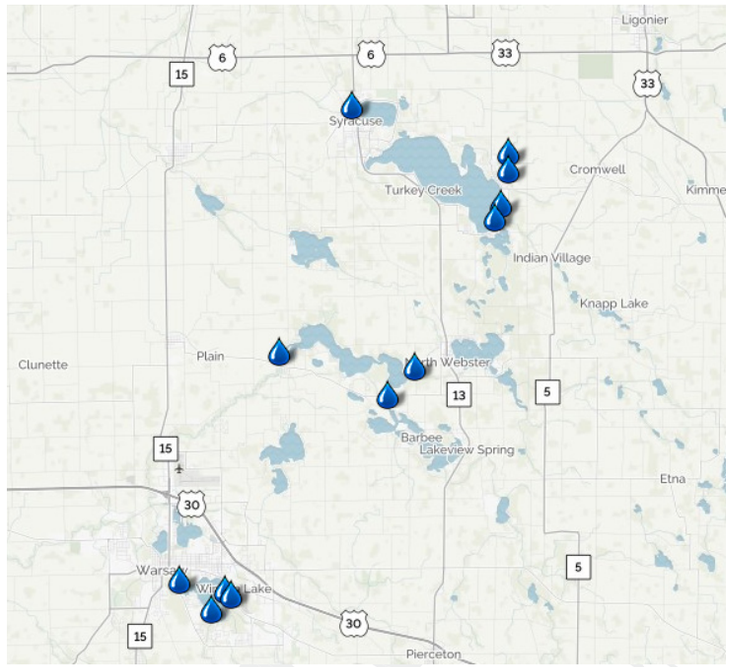
At each sampling site, we gather a water sample for future identification. All kinds of cells, cyanos and green algae included, are individually identified and counted under a microscope. This is a key clue for figuring out what organisms dominate in which conditions, and which cyanobacterial culprits may be producing toxin.

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.

A cyanobacteria bloom can look like spilled greenish paint on the surface, tiny grass clippings suspended in the water, or clumps or mats of green cells. Cyanobacteria will not be "stringy" (filamentous algae) or have small leaves or roots (duckweed or other plants).

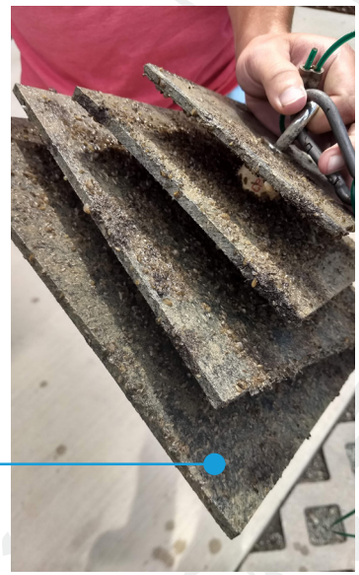
STREAM SENSORS

A lake's health is largely based on the water that enters the lake. Much of the water that enters lakes is from inflowing streams. Every other week all-year around, the Lilly Center measures water quality parameters (like nutrients, sediments and dissolved oxygen), and the total amount of water moving through the the inflowing and outflowing streams for Winona, Wawasee/Syracuse, and the Tippecanoe chain. And now, with the installation of a continuous stream sensor network covering all 12 of our sampling sites, we receive hour-by-hour data on the amount of water entering and leaving these major lakes. All of that data is online for you to explore at **lakes.grace.edu/live-data**. This ongoing data, coupled with biweekly nutrient sampling, allows the team to quickly find potential patterns between lake conditions, cyanobacteria growth, and toxin production, and identify where more unique management strategies may be required. Learn more on page 25!



ZEBRA MUSSELS

Zebra mussels are an aquatic invasive species. They often drastically improve water clarity in the first number of years after moving into a lake. Unfortunately, this benefit is temporary and does not outweigh the long term damage they do to a lake's ecology. Zebra mussels 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 report is soon to follow.



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.

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.

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 $200,000 into the Lilly Center's expanded research on the lakes and streams, including seven public beaches and two additional lakes. Their support also provided new lab equipment for in-house water testing and toxin analysis.

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 August 2019.

MICROCYSTIN

Microcystin levels have varied over the past three years in these sampling locations, especially in Lake Wawasee. None of our samples for either lake or the two swimming beaches registered at or over IDEM's human exposure threshold concentrations over the past 2-3 years, though there have been multiple instances in all locations over the dog recreation threshold in that same period. (See page 8 for IDEM's microcystin thresholds.) The goal in sampling Wawasee,

Syracuse, and other lakes and beaches in the summer is not only to monitor our lakes for human health and safety, but also to identify key management strategies over time in order to reduce toxin spikes and maintain average low levels.

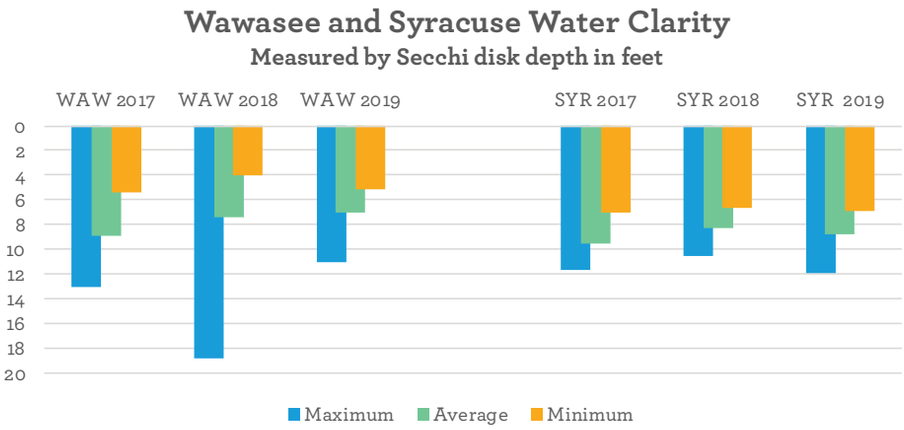
Summer Microcystin Concentrations (ppb)

Sampling Location		2017	2018	2019
Wawasee Open Water	max.	5.6	5.0	1.5
	avg.	1.5	2.3	0.7
Syracuse Open Water	max.	0.5	1.1	0.6
	avg.	0.2	0.4	0.2
Syracuse Community Center Beach	max.	-	1.4	0.6
	avg.	-	0.4	0.2
Syracuse Hoy's Beach	max.	-	1.1	0.7
	avg.	-	0.4	0.2

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 10ft or deeper. More on page 25!

WATER CLARITY

Take a look at the figure below. Even though its deepest point is over twice that of Syracuse Lake, Lake Wawasee tends to have lower water clarity, even on the same sampling day. Syracuse benefits from Wawasee as water moves northwest through the chain, including through Mud Lake and its wetlands. Lake Wawasee and these wetland areas filter nutrients and allow particulates to settle out before the water reaches Syracuse Lake. That slow-moving water warms in the sun as it travels, resulting in a small but fairly consistent temperature difference of 1 °F between Wawasee and Syracuse each sampling day and on average each summer. Water clarity is more difficult to measure on the swimming beaches: Shallow water does not allow a measurement all the way until the Secchi disk disappears. Lilly Center researchers measure as far as they can, and at the Syracuse beaches, that was almost always to the bottom of the swimming area! Both the Syracuse Community Center beach and Hoy's Beach have enjoyed clear water the past two summers.



MAX DEPTH of FISH HABITAT

WAW 35.7 ft
SYR 18.6 ft

WATER CLARITY

WAW 7.0 ft
SYR 8.8 ft

TEMPERATURE

WAW 76 °F
SYR 77 °F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2019 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

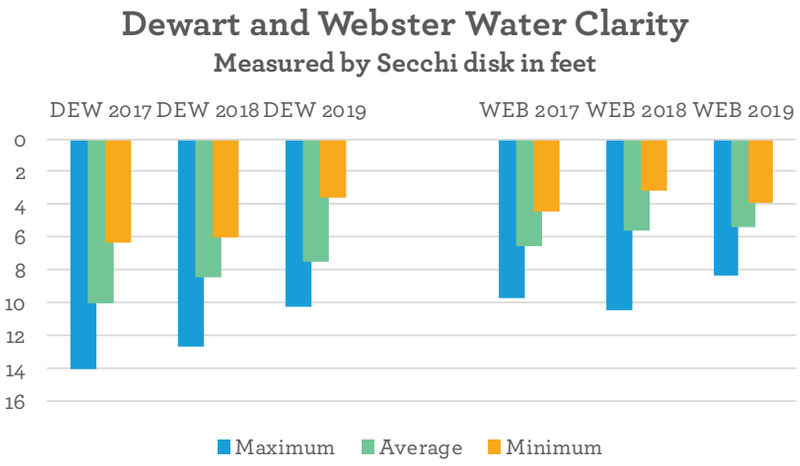
Surface area	653 acres
Max. depth	52 ft
Avg. depth	12.5 ft
Watershed	31,459 acres

Webster Lake, taken in 2018.

WATER CLARITY

Dewart

Dewart Lake is the one of the deepest of the major Kosciusko County lakes, similar in depth to Winona and Wawasee. Over the past three years, its nutrient levels have been lower than the other lakes. Even so, Dewart's water clarity has trended down (less clear) over those same years, with maximum, minimum, and average Secchi disk readings just a little bit shallower each year. Dewart's water clarity did not "bounce back" in the late summer of 2019 as it did in 2017 and 2018, resulting in a lower average overall in 2019. This may be related to the warmer temperatures arriving later in the summer in 2019 compared to the previous two years.



Webster

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 the past three years compared to the other 13 major lakes the Lilly Center samples, but the lake's clarity is not clearly trending deeper or shallower. We do know that variation in Secchi disk depth can change based on differences in summer heat and precipitation, which may have influenced the greater difference between Webster's 2018 maximum and minimum clarity.

MICROCYSTIN

Webster

None of Webster Lake's microcystin results, in open water or the beach, approached IDEM's threshold for human health concern, although one beach result this summer hit the dog recreation threshold. Total phosphorus and nitrogen levels in Webster Lake are average to slightly-above-average compared to the other 13 lakes. These results are reflected at the Webster Lake beach along South Dixie Drive. Water clarity at the beach was a little greater than 1 ft in both 2018 and 2019. Active efforts are made at the beach to reduce nutrient input and maintain water depth, such as deterring geese and removing aquatic plant matter.

Summer Microcystin Concentrations (ppb)

Sampling Location		2017	2018	2019
Webster Open Water	max.	0.2	0.3	0.3
	avg.	0.1	0.1	0.1
Webster Beach	max.	-	0.3	0.8
	avg.	-	0.1	0.2
Dewart	max.	1.1	1.0	1.3
	avg.	0.5	0.5	0.7

Dewart

Dewart has experienced slightly higher microcystin concentrations in 2019 than in 2017 and 2018, and is a little higher overall compared to other Kosciusko County lakes, but no microcystin results approached IDEM's threshold for human health concern. To read more about microcystin and the cyanobacteria that produce it, see page 8.

MAX DEPTH of FISH HABITAT

DEW 20.8 ft
WEB 10.6 ft

WATER CLARITY

DEW 7.5 ft
WEB 5.4 ft

TEMPERATURE

DEW 77.9 °F
WEB 77.4°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2019 RESEARCH

tippecanoe & james 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.

TIP

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

JAM

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

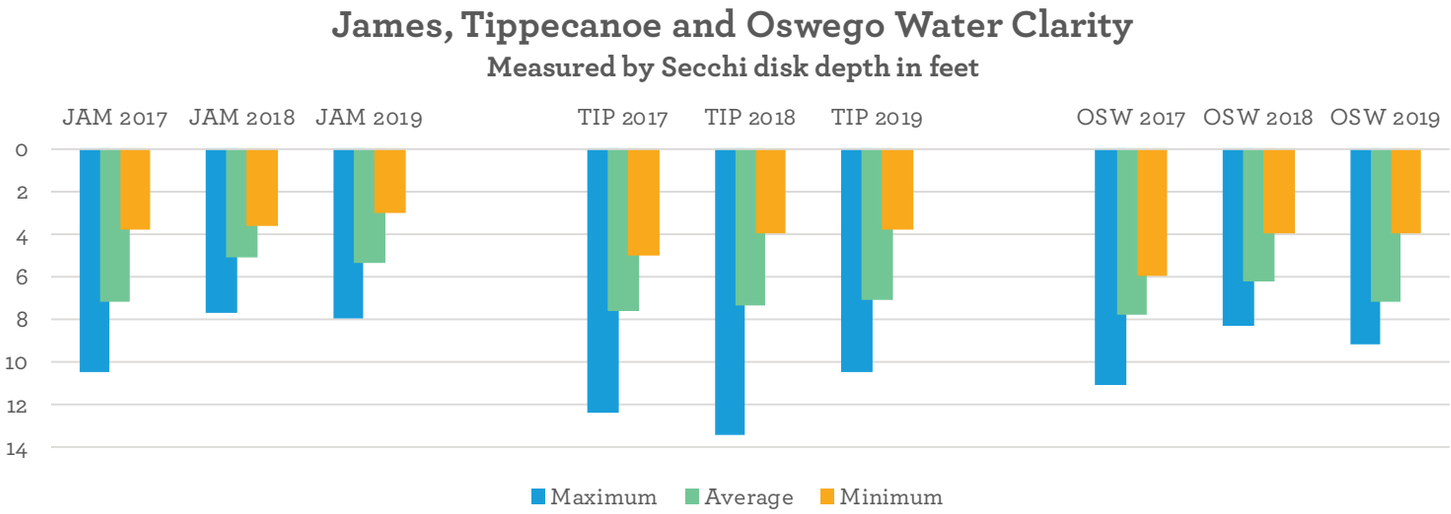
OSW

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

Tippecanoe Chain, taken in August 2019.

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, Tippy 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 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 overall, which can make algae blooms (and, subsequently, lower water clarity) a little more common.



MICROCYSTIN

The Tippecanoe Chain has experienced generally low microcystin toxin levels the past few years. See page 8 for more information on cyanobacteria and microcystin.

Summer Microcystin Concentrations (ppb)

Sampling Location		2017	2018	2019
James (Little Tippy)	max.	0.2	0.2	0.3
	avg.	0.1	0.1	0.1
Tippecanoe	max.	1.1	0.2	0.2
	avg.	0.3	0.1	0.1
Oswego	max.	0.3	0.2	0.3
	avg.	0.1	0.1	0.1

Lilly Center researchers conduct lake sampling on the Tippecanoe Chain.

MAX DEPTH of FISH HABITAT

TIP 69.6 ft
JAM 14.2 ft
OSW 12.8 ft

WATER CLARITY

TIP 7.1 ft
JAM 5.4 ft
OSW 7.2 ft

TEMPERATURE

TIP 77.4°F
JAM 77.0°F
OSW 77.3°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2019 RESEARCH

big chapman & big barbee

Big Chapman and Big Barbee 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.

BCH

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

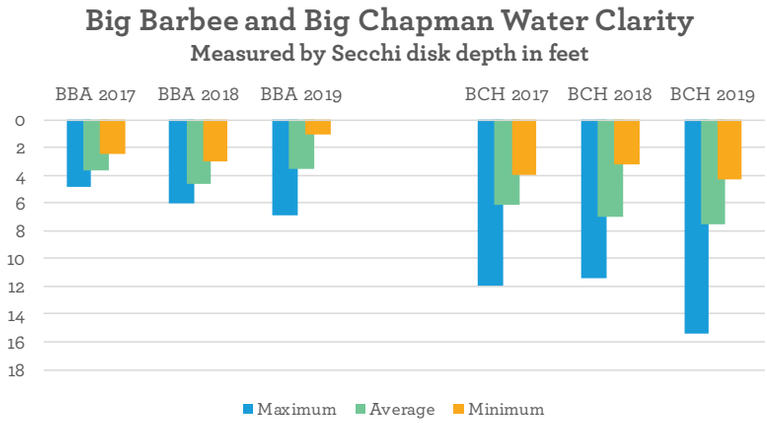
BBC

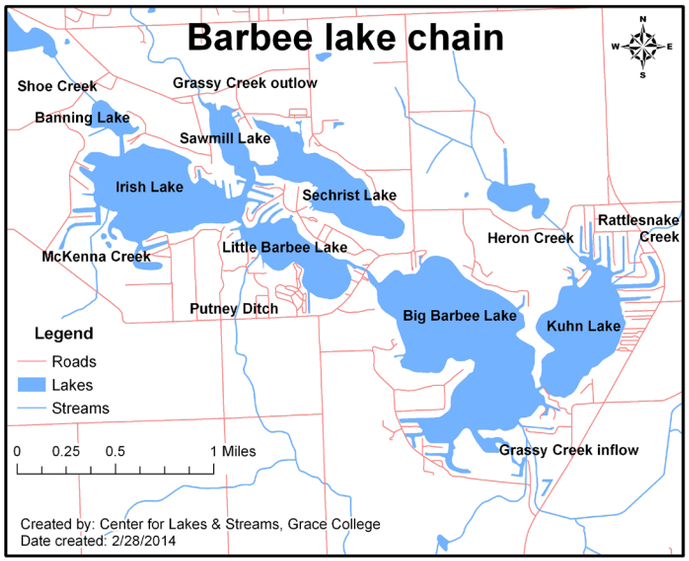
Surface area	311 acres
Max. depth	45 ft
Avg. depth	15.6 ft
Watershed	28,737 acres

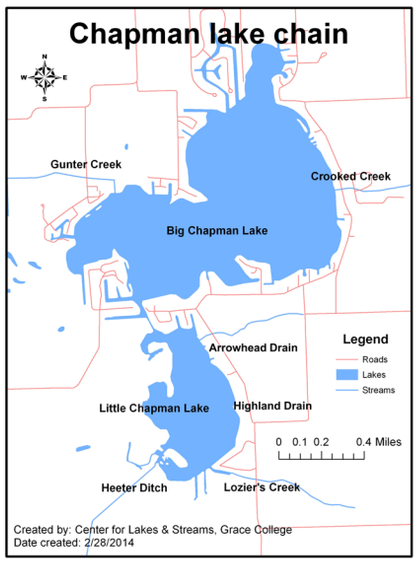
Big Chapman Lake, taken in 2018.

WATER CLARITY

Big and Little Chapman lakes lie just east of the Barbee lake chain. Big Chapman experienced the clearest 2019 Secchi disk reading of all 14 lakes at 15.4 ft, while Big Barbee experienced the most murky Secchi disk of the summer at 1.1 ft. Big Chapman's phosphorus and nitrogen levels have been some of the lowest of those lakes over the past three years. Big Barbee's phosphorus and nitrogen levels are higher than most of the other 13 lakes, especially phosphorus in the upper layer of water. These high nutrient levels help explain the lower water clarity, suggesting high algae activity in these waters.







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.

MICROCYSTIN

Big Chapman

Just the opposite of Big Barbee, however, Big Chapman has experienced some higher microcystin levels in spite of its higher water clarity. Again the values fall below IDEM's threshold for human health concern, but are generally higher than the majority of the other 13 lakes.

Summer Microcystin Concentrations (ppb)

Sampling Location		2017	2018	2019
Big Chapman	max.	5.1	1.9	1.6
	avg.	2.6	0.5	0.7
Big Barbee	max.	0.1	0.2	1.0
	avg.	0.1	0.1	0.3

Big Barbee

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

MAX DEPTH of FISH HABITAT

BCH 19.7 ft
BBA 10.9 ft

WATER CLARITY

BCH 7.5 ft
BBA 3.6 ft

TEMPERATURE

BCH 78.8°F
BBA 78.4°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2019 RESEARCH

winona center & pike

Winona, Center and Pike 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.

WIN

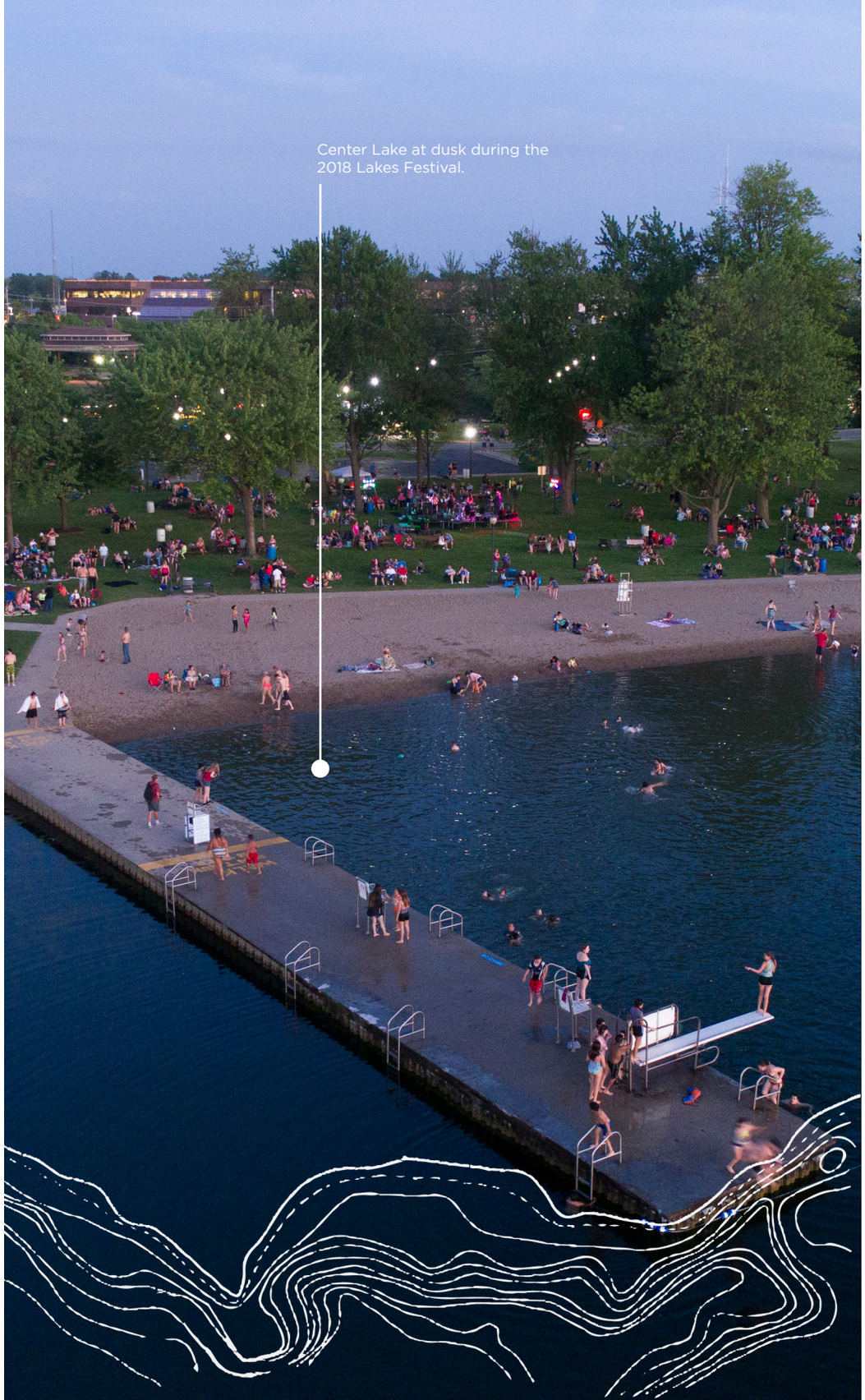
Surface area	571 acres
Max. depth	79 ft
Avg. depth	30 ft
Watershed	18,730 acres

CEN

Surface area	120 acres
Max. depth	43 ft
Avg. depth	14 ft
Watershed	9,611 acres

PIK

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



Center Lake at dusk during the 2018 Lakes Festival.

Winona, Center and Pike lakes are a perfect illustration 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

As discussed on page 8, microcystin can be found in elevated levels in scums that gather in the water or on shorelines, and we advise keeping people and pets from coming in contact with water that is experiencing a bloom. Each of the public swimming areas on these lakes reflect the observations described here in terms of water clarity and toxin levels. Analysis of open water and standard beach samples revealed no microcystin toxin levels near IDEM's threshold for human health concern.

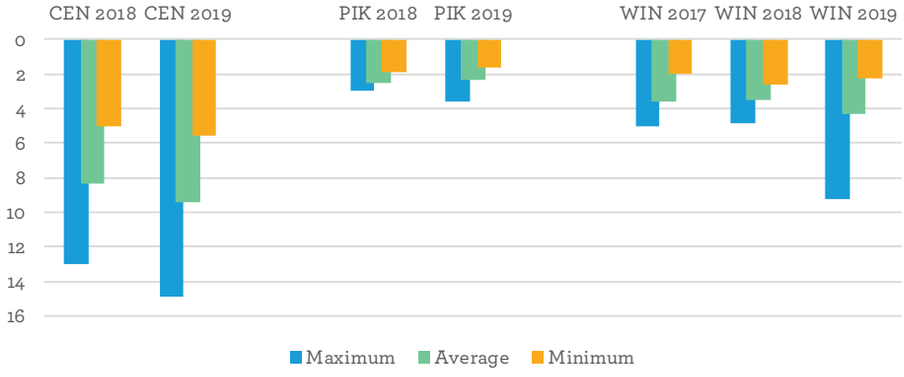
Blue-green algae will often have a paint-like consistency as in the picture above, taken in 2019.

Summer Microcystin Concentrations (ppb)

Sampling Location		2017	2018	2019
Center Open Water	max.	-	1.0	0.3
	avg.	-	0.3	0.1
Center Beach	max.	-	0.4	0.2
	avg.	-	0.2	0.1
Pike Open Water	max.	-	0.3	0.9
	avg.	-	0.2	0.5
Pike Beach	max.	-	0.3	0.8
	avg.	-	0.2	0.4
Winona Open Water	max.	0.1	0.3	1.7
	avg.	0.1	0.1	0.4
Winona Beach	max.	-	0.2	2.3
	avg.	-	0.1	0.5

WATER CLARITY

Center Lake was one of the clearest of our 14 lakes overall in 2019 and was slightly more clear than 2018, our first year of summer sampling on Center and Pike. Nutrient levels are relatively low to average in Center Lake as well. Pike Lake, made up of the basins Little and Big Pike, experienced low water clarity the past two years of sampling compared to other lakes. This is likely due to the amount and kind of nutrient entry into the lake. Shown on the graphs on pages 6-7, Pike Lake contains higher concentrations of phosphorus and nitrogen than many other Kosciusko County lakes, especially in the surface water. Winona Lake experiences slightly higher water clarity, and contains moderate to slightly higher than average amounts of nitrogen and phosphorus compared to our other thirteen sampled lakes. It also experienced a few instances of higher microcystin concentrations in 2019 compared to previous years, but none near IDEM's human health threshold.



MAX DEPTH of FISH HABITAT

WIN 20.0 ft
CEN 8.7 ft
PIK 29.5 ft

WATER CLARITY

WIN 4.3 ft
CEN 9.4 ft
PIK 2.4 ft

TEMPERATURE

WIN 77.1°F
CEN 77.4°F
PIK 75.5°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2019 RESEARCH

yellow creek & beaver dam

Yellow Creek and Beaver Dam 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.

YEL

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

BEA

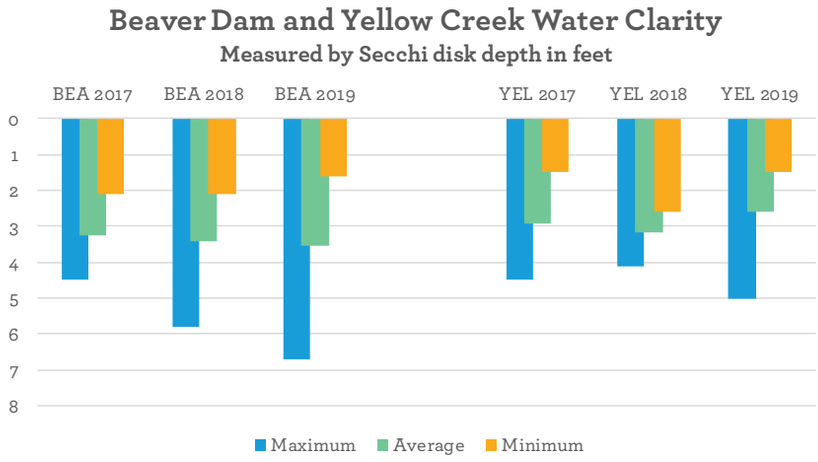
Surface area	155 acres
Max. depth	61 ft
Avg. depth	15.6 ft
Watershed	1,266 acres

Beaver Dam Lake, taken in 2020.

WATER CLARITY & MICROCYSTIN

Yellow Creek and Beaver Dam are a unique pair for our 14 sampling lakes; they are located in the southwest corner of the county, a bit isolated from our other locations. Their phosphorus and nitrogen levels are on the higher end compared to the other lakes, and their 2019 water clarity was slightly lower. The dissolved oxygen layer is also relatively small for their depth, meaning fish are confined to the warmer surface layer waters in the summer.

Both lakes have experienced a lot of variation in their water clarity over the past three years. In spite of known algae activity and lower clarity, both lakes had low microcystin toxin levels in each of the past three years.



Summer Microcystin Concentrations (ppb)

Sampling Location		2017	2018	2019
Beaver Dam	max.	0.1	0.3	1.2
	avg.	0.1	0.2	0.5
Yellow Creek	max.	0.1	0.3	0.3
	avg.	0.1	0.1	0.1


Yellow Creek Lake, taken in 2020.

ZEBRA MUSSEL SURVEY

One of the characteristics that sets Yellow Creek and Beaver Dam apart is that, unlike our other 12 major lakes in the county, zebra mussels have not invaded these two. This is great news for homeowners and the native wildlife! It's also good for the algae community. As the Lilly Center research team counts and analyzes cyanobacteria and algae populations, special attention will be paid to these lakes as they compare to the others. Our team's goal is to find more clues to the mystery of cyanobacteria domination and toxin production. See pages 8-9 for more information on cyanobacteria and our 2019 zebra mussel survey!

The zebra mussel samplers are four tiers of textured black plastic, separated by PVC pipe. By hanging them off piers, where zebra mussels frequently gather, the little invertebrates are encouraged to colonize for counting.

MAX DEPTH of FISH HABITAT

YEL 16.0 ft
BEA 10.6 ft

WATER CLARITY

YEL 2.6 ft
BEA 3.5 ft

TEMPERATURE

YEL 78.6°F
BEA 78.7°F

* ALL NUMBERS IN THIS SIDEBAR ARE AVERAGES FROM 2019 RESEARCH

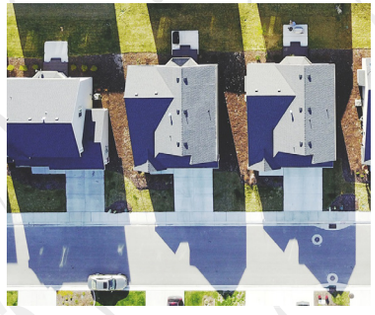
NOW WHAT?

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. If you have a lake association or watershed group, consider becoming a member to help be "the boots on the ground" with projects they are already doing. Work done by these organizations can have an immediate, positive impact on the lakes, which will likely be reflected in our research as we continue monitoring local waterways.

Here are a few ways to help protect the lakes from your own property -- whether or not you live along a shoreline.

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 decomposed material, nitrogen and phosphorus from fertilizers and other nutrient sources that can all be considered pollutants. Also consider installing a rain barrel to catch excess water for future uses!



Use nontoxic household products and properly dispose of hazardous household waste, such as electronics and yard waste. 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.

After boating in a lake or pond, remove plant fragments and mud by rinsing your boat, propeller, trailer and all other water equipment. Drain ballast water and allow your equipment to dry completely before transporting it into a new body of water. By taking these action steps, you prevent transfer of the invasive species from one lake to another. Zebra mussels are a prime example! Read more about these little bivalves on page 9.

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.

During the 2018 study, Lilly Center researchers used five kinds of watercraft for a variety of tests at different depths and different substrate (muck, sand, etc.). This greyish-brown plume shows the kind of resuspension that can occur when a boat speeds through the shallower parts of a lake.

THE BOATING STUDY

During the summer of 2018, Lilly Center researchers conducted a study to learn the impact of boating on the bottom of a lake. Suspended nutrients are a common culprit in excessive weed and algae growth, and although nutrients enter lakes through all kinds of sources (both natural and human-caused), resuspension of existing particles can be limited by simply adhering to boating best-practices.

That does not mean your family should avoid boating, though! Here are three ways to minimize resuspension while still enjoying all your lake offers.

STEP ONE

Participate in no-wake zones, which can protect beneficial plants and help reduce nutrient resuspension in those particularly shallow areas.

STEP TWO

Save “near-plane/plowing” activities for water greater than 10 ft deep and keep ballasts empty in shallower water.

STEP THREE

Share what you’ve learned about boating and lake health with your friends and neighbors so they can help protect your lake, too.

LILLY CENTER PROJECTS

These current and ongoing projects are part of the Lilly Center's mission to gather relevant, researched data on the lakes and help you make informed decisions for their future, along with your communities. 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.

STREAM SENSOR NETWORK

One way the Lilly Center is conducting ongoing research is with stream sensors. Since October 2019, the Lilly Center team has actively monitored the sites, gathered the data and made tweaks to the system. The sensors use doppler radar to measure water depth and speed across a section of the river, so it directly calculates flow. The research team regularly checks the sensors for gathered debris so they can measure cleanly, and all the sites will undergo further regular maintenance each spring. The stream sensor data is available 24 hours a day, seven days a week, at **lakes.grace.edu/live-data**. Analysis and implications of the data will be grafted into current and ongoing stream and lake sampling for a more complete picture of our waterways.

ALGAE RESEARCH LAB

The Lilly Center will begin reporting weekly microcystin results this summer. In partnership with the Indiana Department of Environmental Management, data gathered and analyzed by the Lilly Center will identify any elevated levels of the microcystin toxin. Analysis reporting will launch on our website later this year! 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.

CROP PRODUCER CERTIFICATION

This farmer certification program is being created by Grace College's agribusiness program, Kosciusko County Farm Bureau, Kosciusko Soil and Water Conservation District, and the Lilly Center. The certification will publicly recognize local crop producers whose practices positively impact the health of our lakes and streams, and encourage even greater adoption of these practices in the future, including nutrient management, reduced tillage, crop rotation and continuing education. Farmers play a crucial role in keeping our lakes, and therefore our economy, healthy!

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Start by reviewing the volunteer handbook on our website to see where your interests align with our programs.

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OUR MISSION & VISION

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

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