Summary

The January 2019 Comprehensive Lake Management Plan for Bullhead Lake (available at Bullheadlake.com) documents a rapidly degrading lake ecosystem in which measures of water quality (e.g. phosphorous and chlorophyll), plant ecology (e.g. plant diversity, floristic quality), dissolved oxygen levels, and water clarity are worsening. The plan identifies the most likely cause of the changes to be internal nutrient loading, in which phosphorous contained in the bottom sediment is being released back into the water column at a high rate. The most obvious result is the tremendous growth of algae and decreased water clarity that the lake is experiencing during summer months. At times, the lake surface is covered with several acres of filamentous algae. These changes to the lake are reducing aesthetic quality, the ability to enjoy recreational activities, and property values.

The Lake Management plan recommended further study to verify that internal nutrient loading is the main culprit of water quality changes and, if that is the case, to pursue an alum (aluminum sulfate) treatment to remove phosphorous from the water column and permanently trap it in the bottom sediment. For 2019, the Bullhead Lake Advancement Association, Inc. (BLAA) received a matching DNR grant to perform an advanced water quality study/alum feasibility study. Data collected to date verifies very high phosphorous levels in the bottom sediment. This data is being used to calculate an alum dose and final cost and is expected to be completed by November 2019. The BLAA is planning to apply for an alum treatment during the 2020 grant cycle, with hopes that an alum treatment would occur in fall of 2020

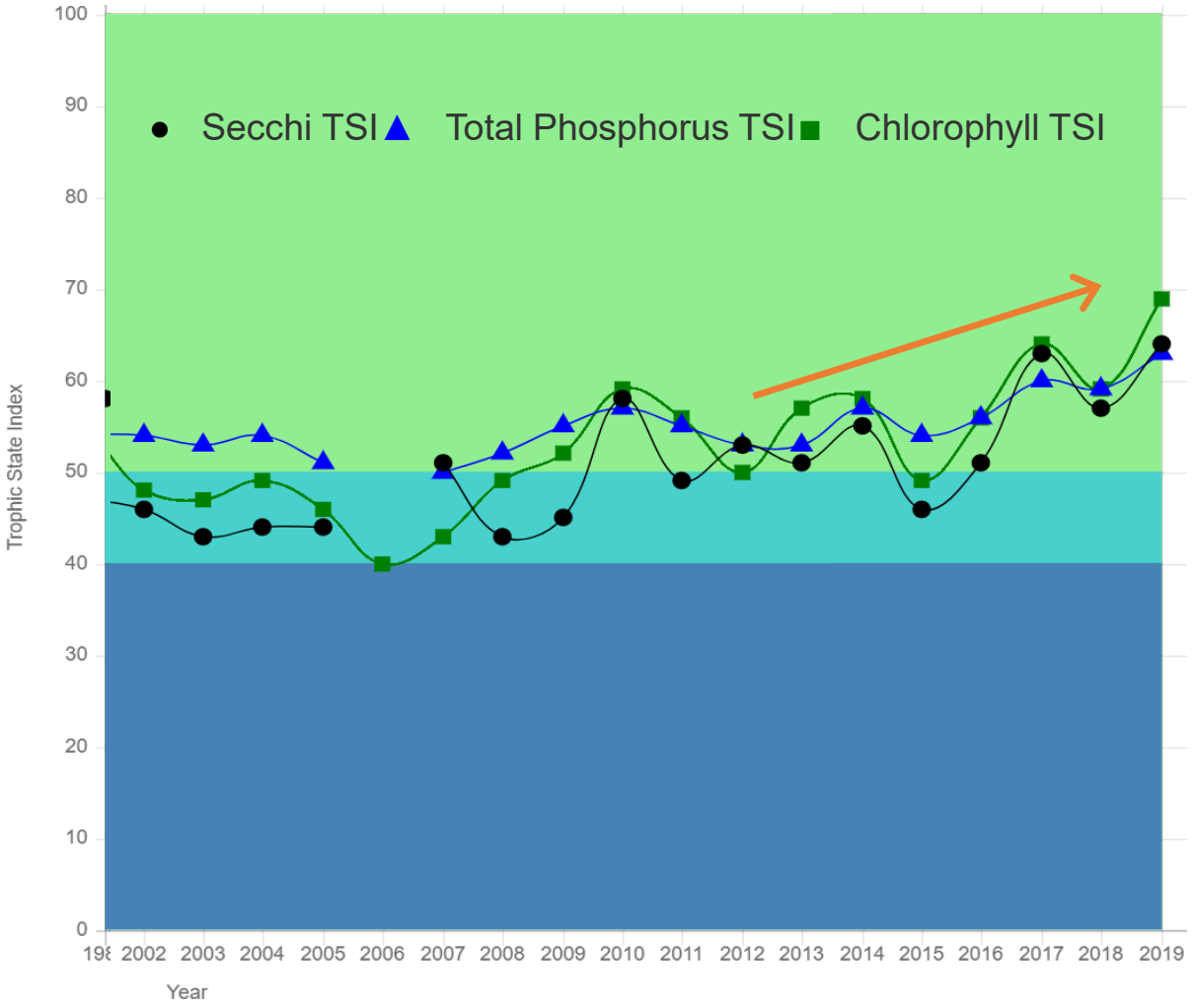
A Brief History of Bullhead Lake Water Quality and the Suspected Internal Nutrient Loading Occurring in the Lake

Manitowoc County Lakes Association Meeting

September 2019

Most Information Comes from the Bullhead Lake 2019 Comprehensive Lake Management Plan available at Bullheadlake.com

Problem: Trophic Sate Index (TSI) is Increasing/Water Quality is Decreasing



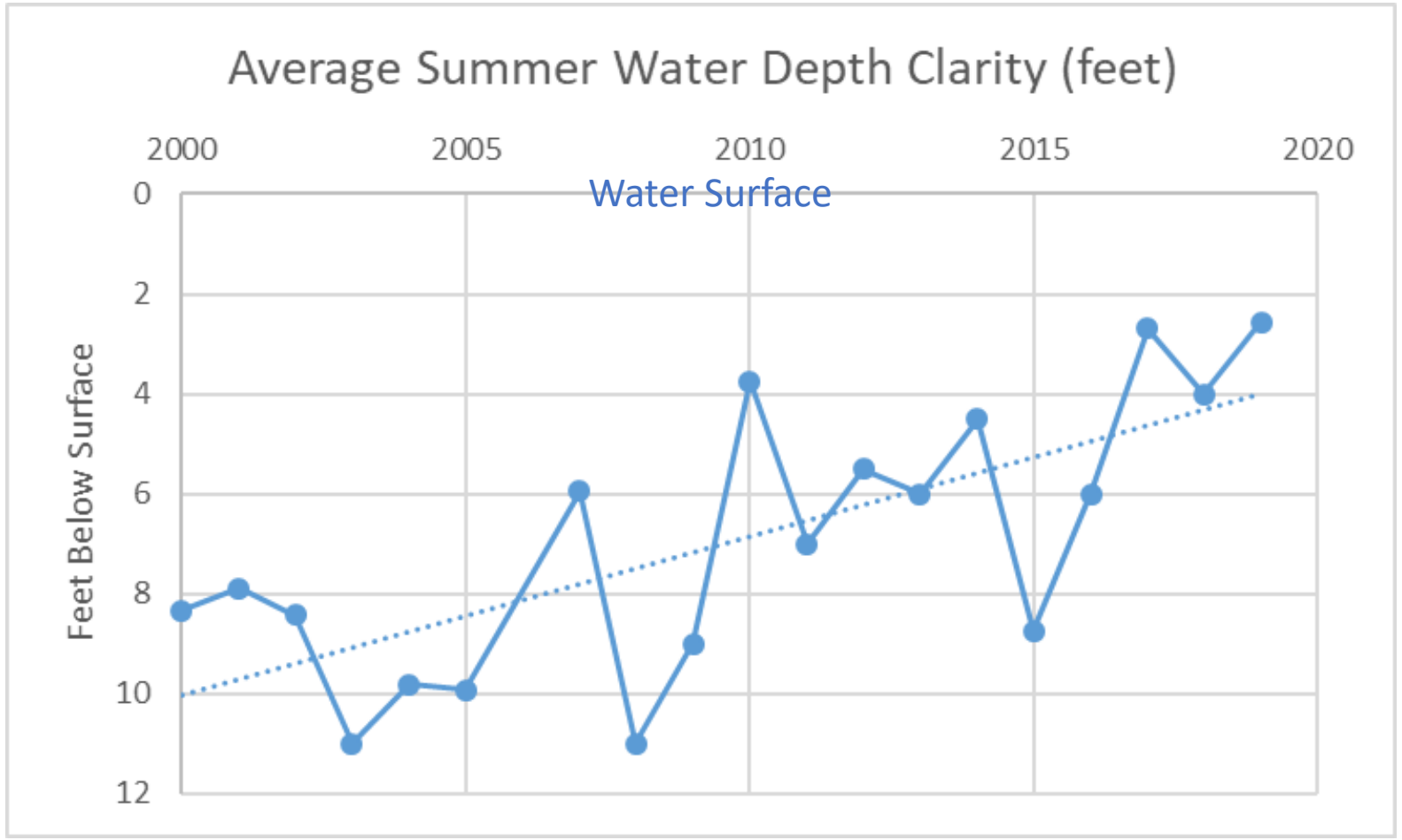
TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus

TSI	TSI Description
TSI 40-50	Water moderately clear but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).

This Eutrophic State is Driving Algae Growth …

… either as thick surface mats of filamentous algae ...

…. or as Algae Distributed Throughout the Water Column, Reducing Visibility



Trendline shows visibility has been reduced by **nearly 6 feet** over the last 19 years.

This significantly impacts property values.

These Water Quality Changes Reduce:

- Ability to enjoy leisure activities (kayak, paddleboat, swim).
- Aquatic diversity (plant life, fish habitat).
- Visual appeal.
- Property Values!
  - An analysis commissioned by Manitowoc County Lakes Association, conducted by Drs. Wolf and Kemp of the University of Wisconsin-Eau Claire demonstrated that lake water clarity directly impacts the property value of residences on that water body. The report concludes "… that a 1 meter increase in water clarity will result in a 10.5% increase in home values for properties located within 250 meters of a lake." Conversely, the more water clarity is degraded, the more property values are reduced.

Water quality is currently decreasing Bullhead Lake Property by about 20%.

That is a total impact of $1.5 – 2 million!

Changing Water Quality is Also Impacting Plant Life

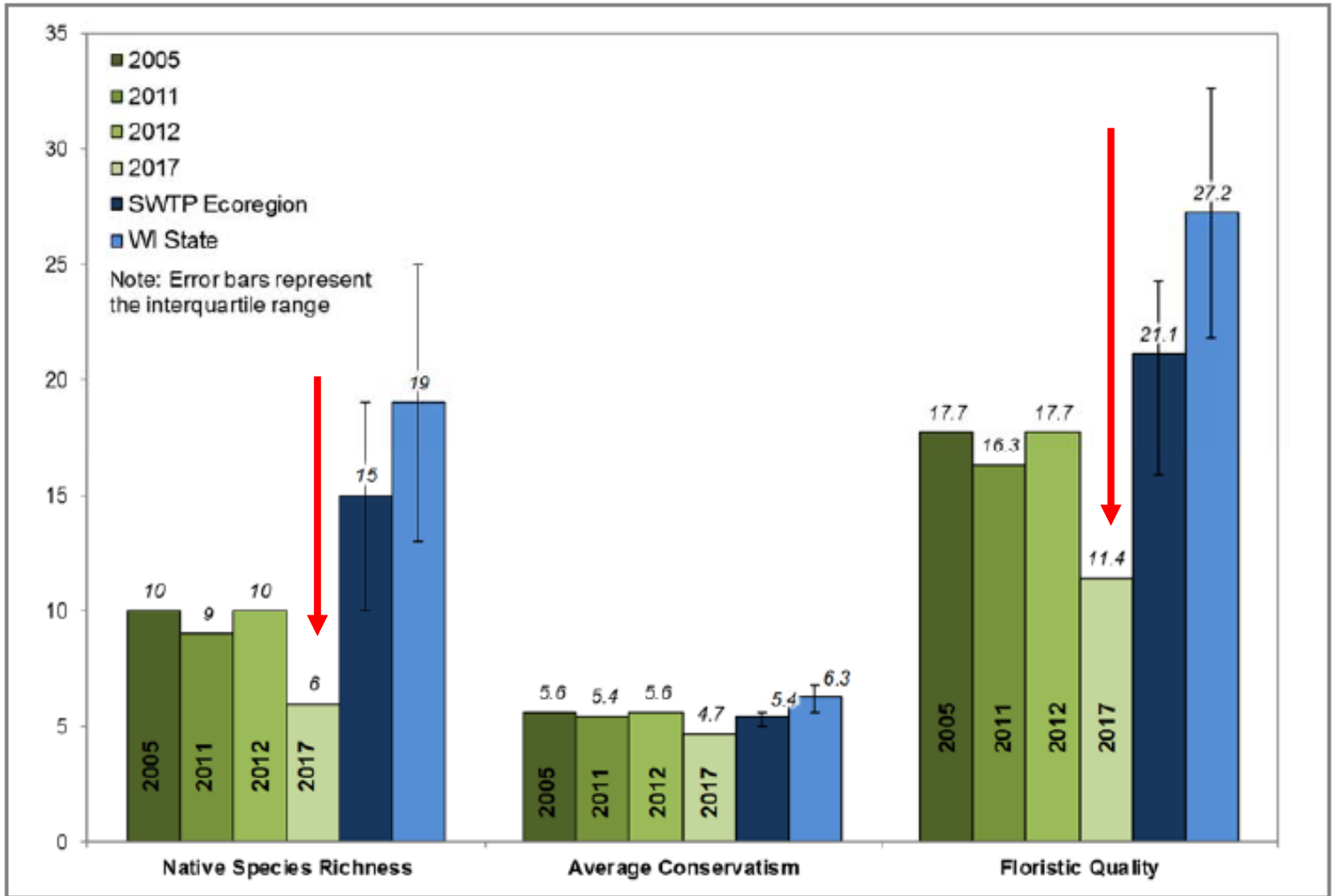


Figure 3.4-6. Bullhead Lake Floristic Quality Assessment. Created using data from WDNR 2005, 2011, and 2012, and Onterra 2017 whole-lake point-intercept surveys. Analysis follows Nichols (1999).

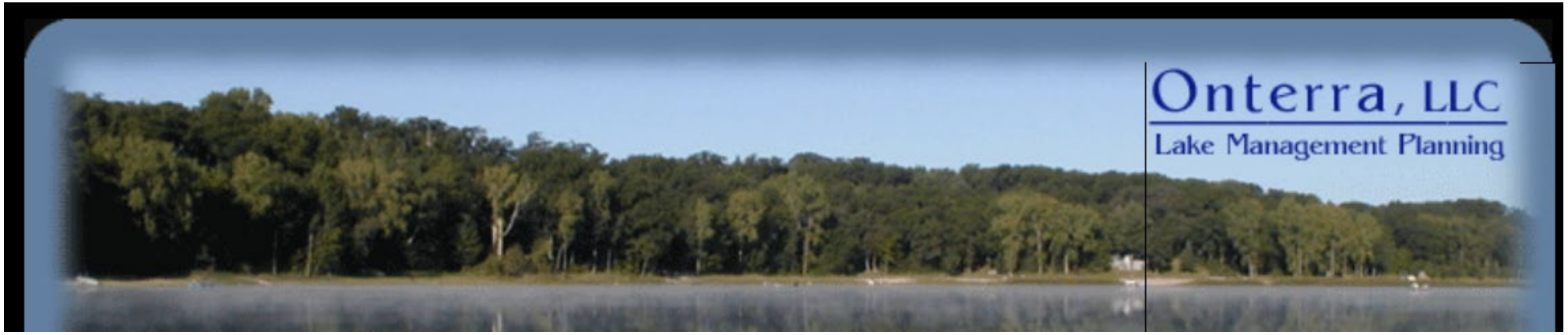
In a 5-year period, all measures of plant diversity and health have decreased.

This will also impact the quality of the fishery. For example, large leaf pondweed decreased significantly between 2012 and 2017.

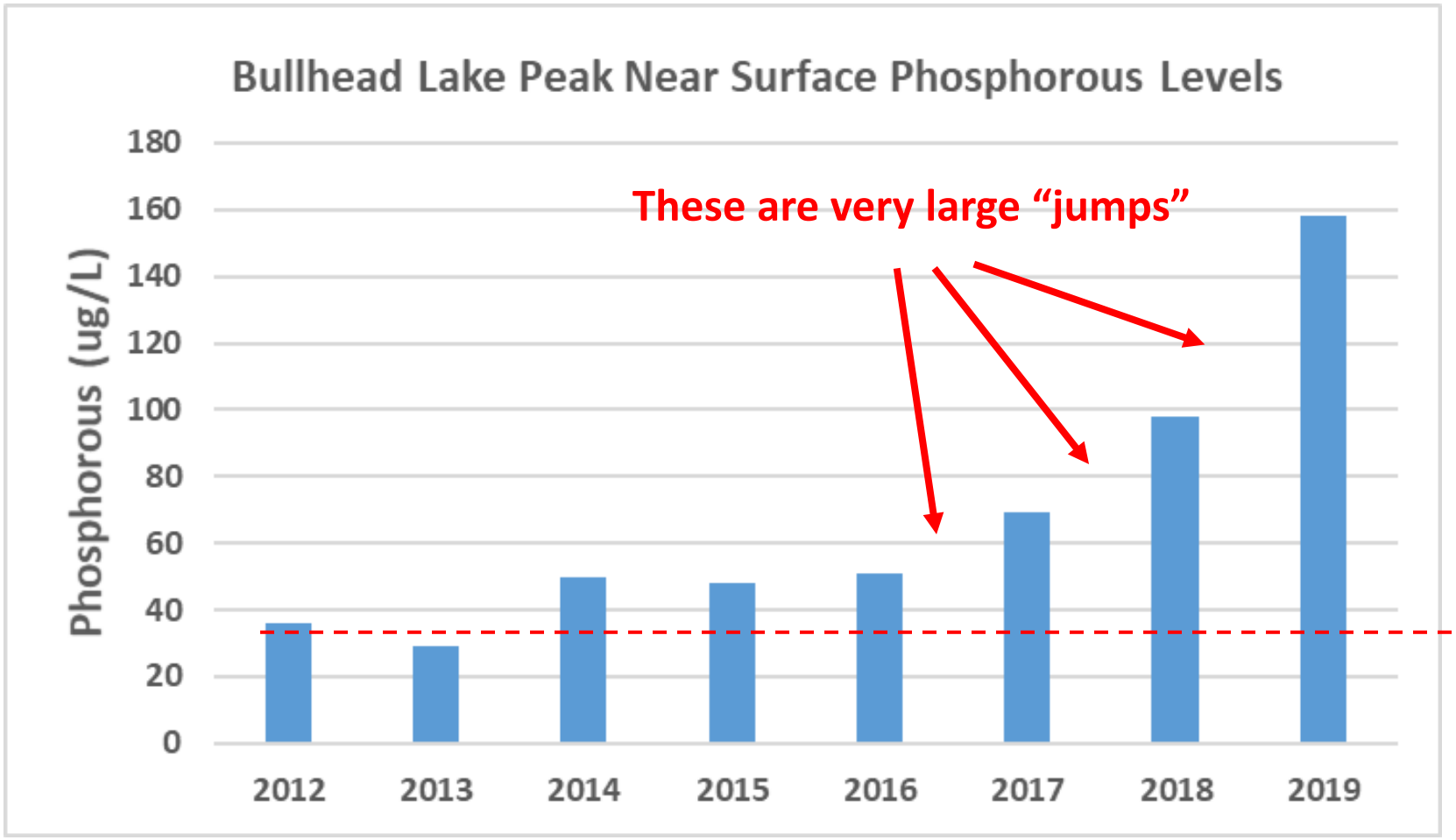
Unfortunately, this is the "fastest" decline in plant measures that the aquatic specialists have seen!

How to Determine the Basis for These Changes?

- Partnered with Onterra, LLC. and DNR for two projects:
  - Comprehensive Management Plan (2017-2019). Approximately $15,000 project with 65% funded by a DNR grant.
  - Alum Feasibility Study in 2019. Approximately $20,000 project with 75% funded by a DNR grant. This grant reimburses when project is complete.



Major Focus Was Phosphorous Levels, which are Rising



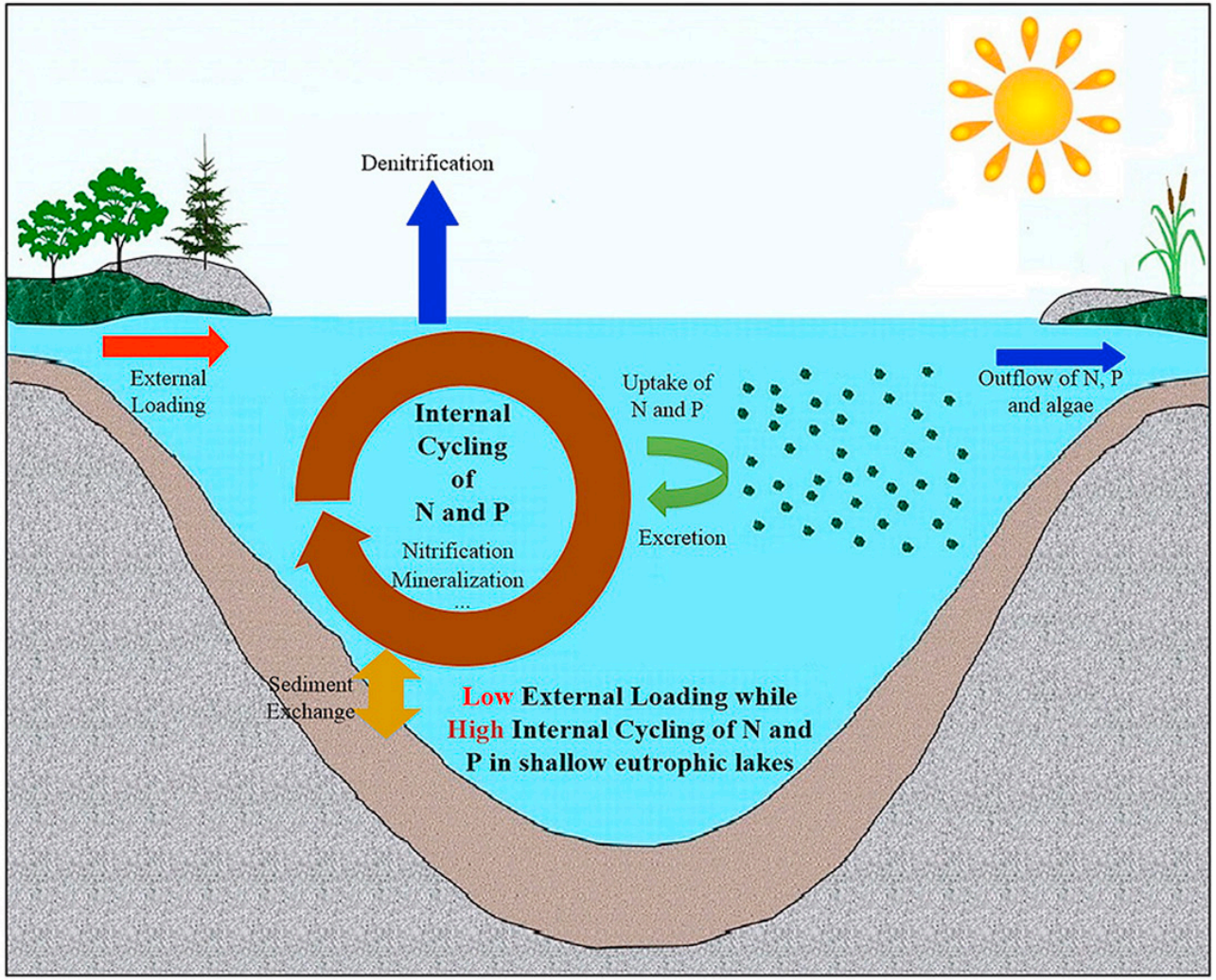
Note that these are near-surface and are over 150 ug/L in 2019.

Ideally, phosphorous levels should be near 20 ug/L.

Historical average is near 36 ug/L

Where is the Phosphorous Coming From?

- Comprehensive Lake Management plan (see bullheadlake.com for the full report) investigated a variety of sources. It concluded that – **internal nutrient loading** is a major contributor.



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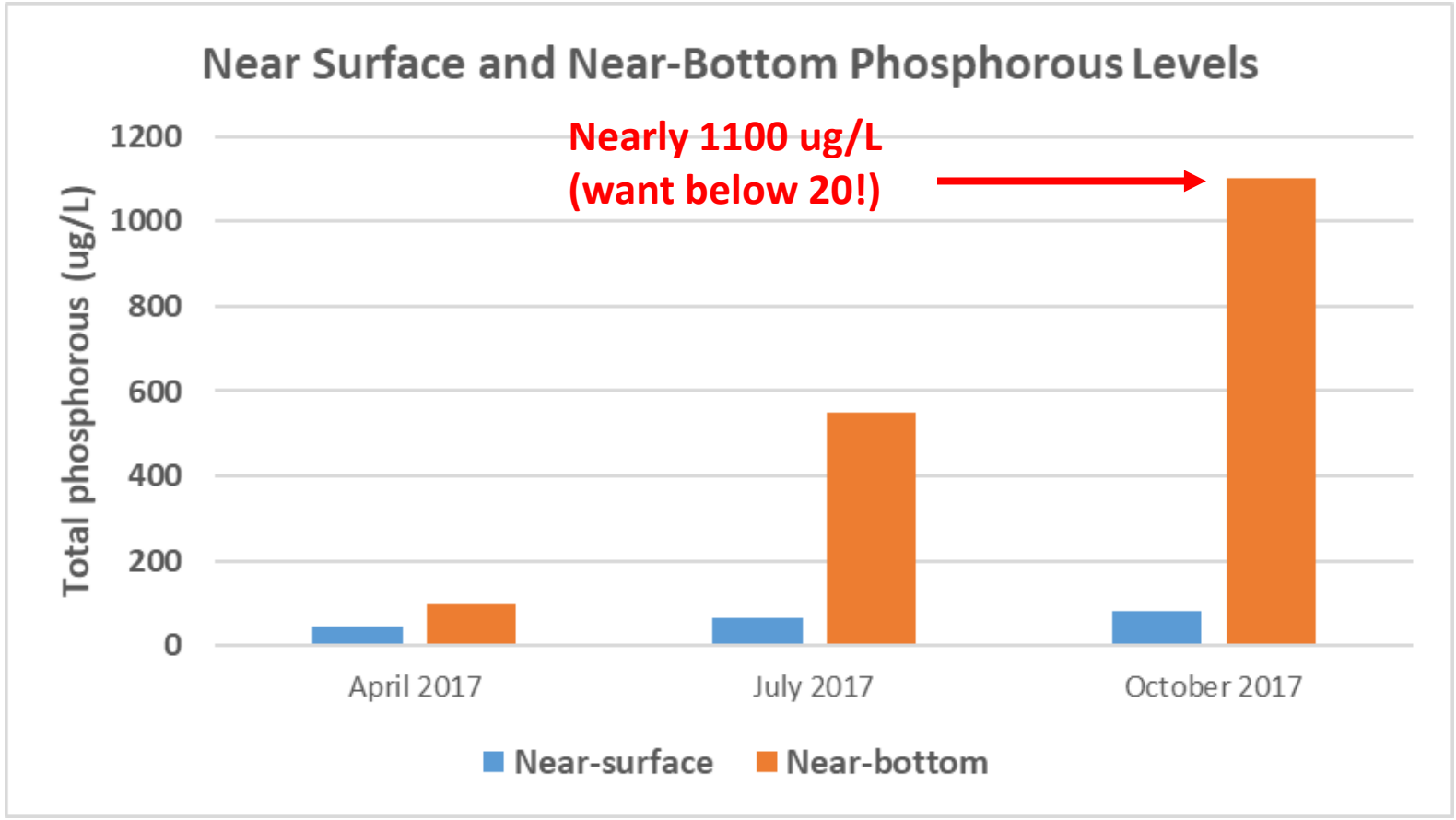
Evidence for Internal Loading: Near-Bottom Phosphorous Levels are Extremely High



Near-bottom concentrations rise tremendously throughout the summer. This is an indicator that the phosphorous is being released from the lake sediment.

Evidence: The Lake is Becoming more Anoxic (less oxygen), which Stimulates the Release of Phosphorous from Iron in the Bottom Sediment

In July 2017 (similar in 2019), there was little oxygen below 8 feet, which predisposed most of the lake bottom to release phosphorous into the water column. This has been getting worse over the past few years. In 1991 (soon after the last alum treatment) dissolved oxygen went down to 20 feet.

The decrease in oxygen levels will also impact fish. Most fish require greater than 5 mg/L of oxygen and many (exceptions are carp and bullhead) cannot live below 3 mg/L for an extended time.

Oxygen profile changes when lake water mixes.

The greatest degree of anoxia is created mid- to late-summer when algae start to decay on the lake bottom. The decay process uses up the available oxygen.

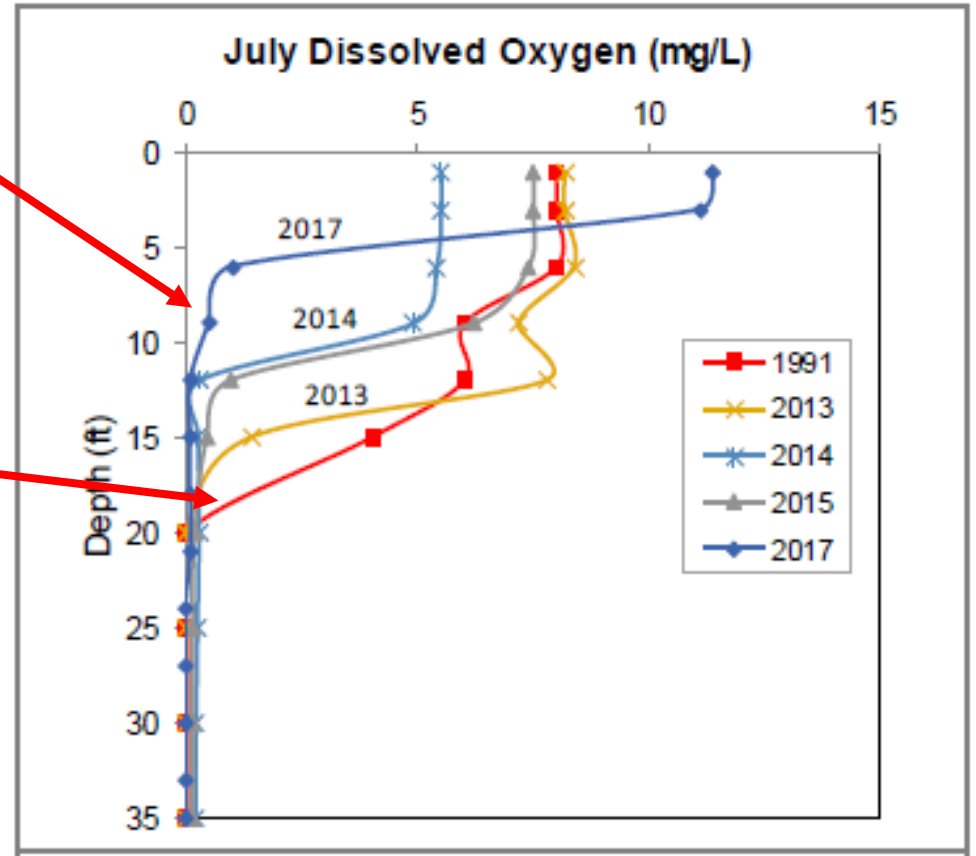


Figure 3.1-12. Selected DO profiles in Bullhead Lake from the period 1991-2017. The increasing amount of anoxia since 2013 is an indication of the worsening of the lake's trophic state.

Evidence: There is a LOT of phosphorous in the Bottom of the Lake

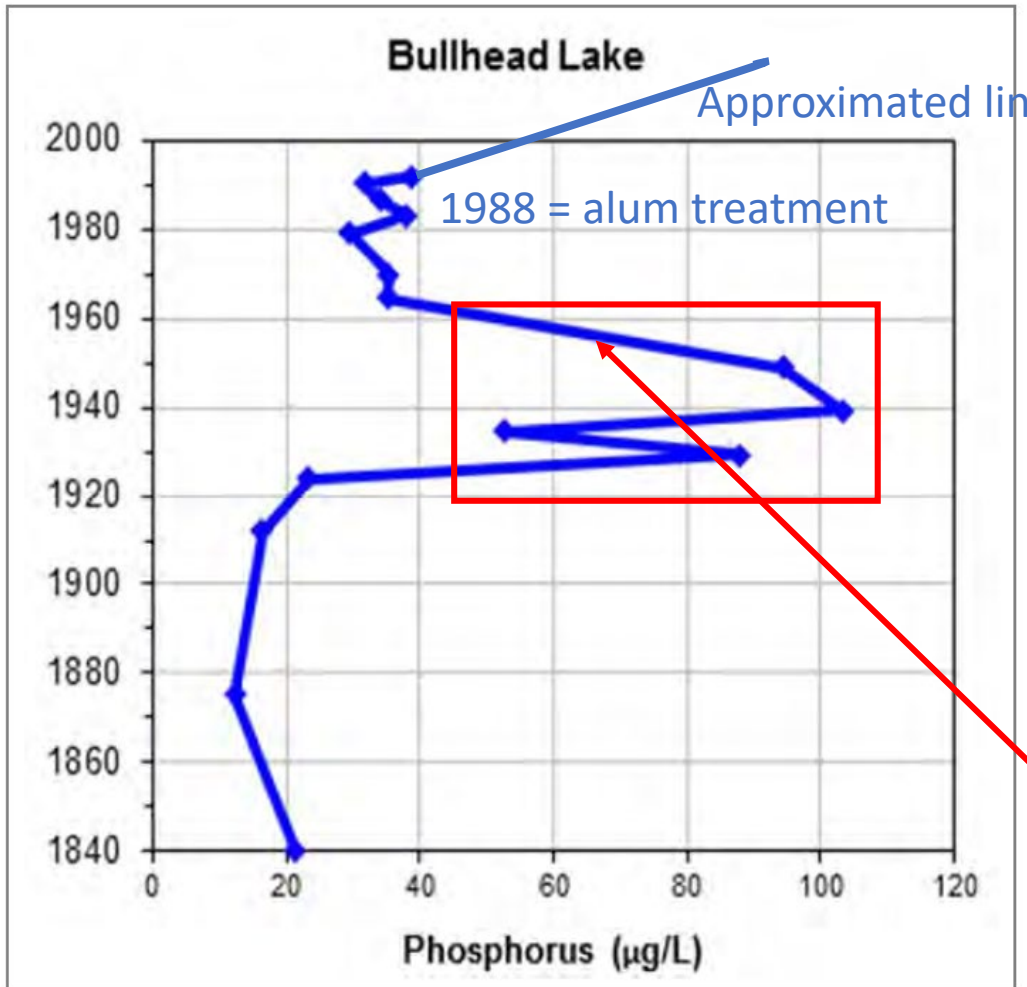


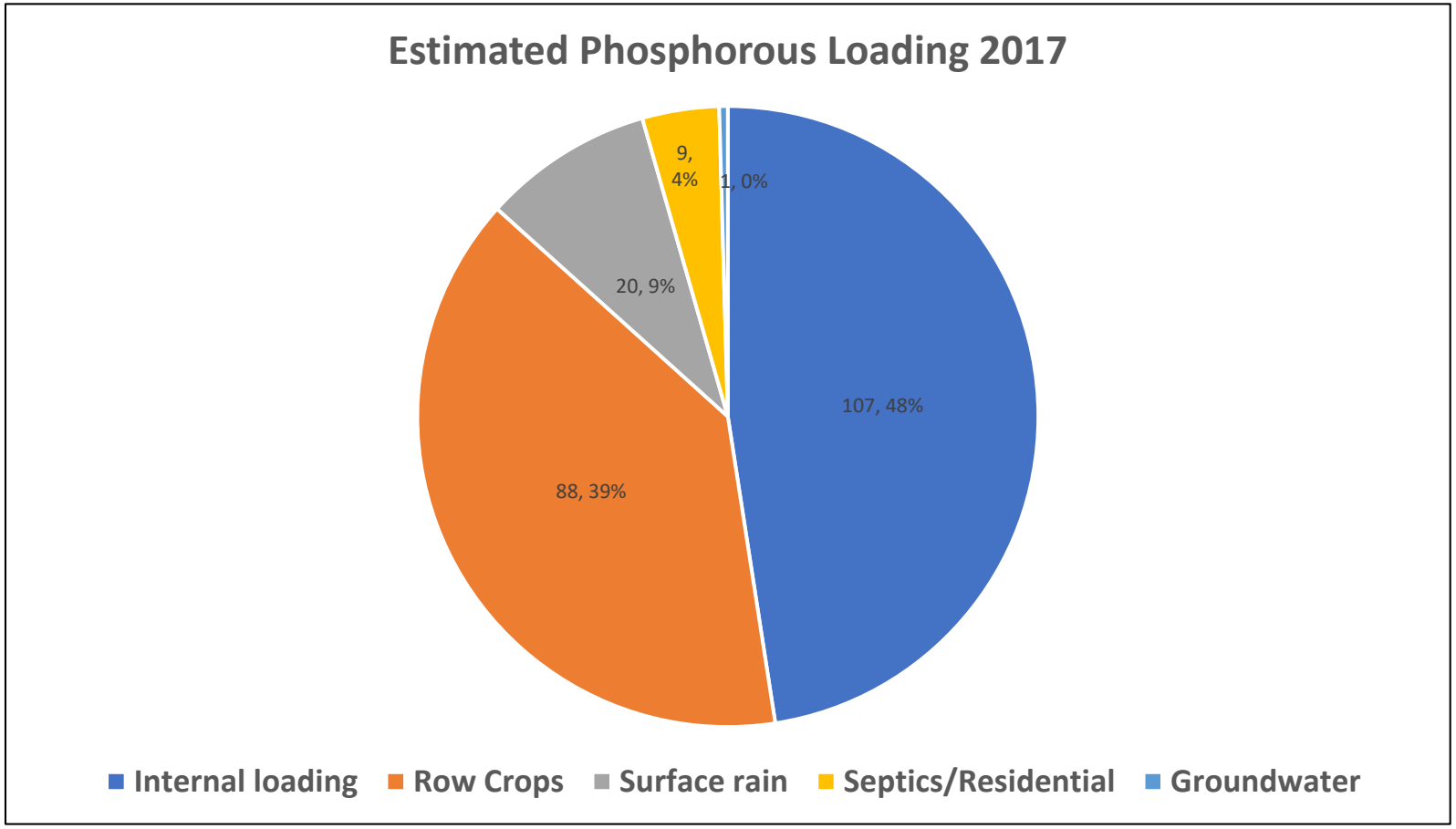
Figure 3.1-4. Historical phosphorus concentrations in Bullhead Lake estimated from the diatom community.

Data from bottom core sediments collected in the mid 1980s

There was tremendous phosphorous loading in the lake in the 1920s-1950s, likely due to high phosphorous fertilizers and farm fields that went to the lake edge. This phosphorous settled in the lake bottom over the subsequent years. As the shoreline was developed, it provided some barrier to phosphorous runoff.

Lake was chemically eradicated of fish in 1957 because of carp dominance and poor gamefish health. It was restocked as water quality improved.

Internal Loading May be the Largest Source of Phosphorous



In 2017, internal loading was estimated to be about half of the phosphorous entering the water column. Other contributors are agricultural runoff, rain onto the lake surface and residential sources. Groundwater phosphorous is minimal.

What Can be Done? = More Detailed Analysis

- The 2019 Alum Feasibility Study is aimed at determining if an alum (aluminum) treatment, which reduces water phosphorous levels, would be an effective long-term solution for the lake.
  - Take a closer look at agricultural practices in the watershed and work with the local agricultural community to make sure phosphorous from agricultural sources is minimized.
  - Analyze core (bottom) samples from the lake to measure the amount of phosphorous bound to iron and calculate a dose of alum necessary to trap this phosphorous in the bottom.
  - Make a final recommendation regarding an alum treatment and determine the associated cost.
    - Initial (= very rough) estimate is $140,000

What Do We Expect?

- That additional data will support that the major cause of the degrading water quality is internal loading and that an alum treatment will be recommended.

What Do We Hope?

- That we can use this information/data to submit a competitive grant that would help fund an alum treatment.

More to Do

- Create a funding plan for the Lake Association portion of any future treatment.
  - In the process of petitioning the Manitowoc County Board to create a Lake District.
  - Start a fundraising campaign once a final recommendation for an alum treatment is received.