550 South Snelling Ave
St. Paul, MN 55116

651.690.9602
mccomas@pclink.com

North Pipe Data Review

Steve McComas, Blue Water Science, March 31, 2022

- Water quality objectives for North Pipe lake are to meet Wisconsin water quality criteria and North Central Hardwood Forests (NCHF) ecoregion values and prevent future water quality declines.
- Summary of Pipe and North Pipe characteristics are shown in Table 1.

Table 1. Lake characteristics for Pipe and North Pipe.

	Pipe	North Pipe
Watershed area (ac)	974	1,208
Lake size (ac)	293	64
Watershed to lake area ratio	3.3	18.9
Maximum depth (ft)	68	37
Mean depth (ft)	27	18.5
Hydrologic lake type	Seepage	Drainage

- Predicted values based on NCHF ecoregion criteria for runoff of 5.1 inches and stream phosphorus concentrations of 150 ppb (using a MnLEAP model)(growing season May-Sept) are listed in Table 2. The actual lake values are better than the predicted values for undeveloped lakes in the NCHF ecoregion.

Table 2. Predicted values for undeveloped lakes in the NCHF ecoregion using MnLEAP and actual concentrations (May-Sept). Data for 2015 and 2016 are from Pipe and North Pipe Lake Management Plan, 2018-2023 (Polk Co Land and Water Resources Department).

	Pipe			North Pipe		
	Actual (2015)	Actual (2016)	Predicted (MnLEAP)	Actual (2015)	Actual (2016)	Predicted (MnLEAP)
Secchi disc (m)	4.6	4.3	2.8	1.4	1.7	1.5
TP (ppb)	11	14	21	26	30	44
Chl a (ppb)	3.6	2.5	5.5	24.5	13.4	16.7

- Pipe and North Pipe actual averages and Wisconsin impaired water quality criteria (Table 3). North Pipe does not meet Wisconsin water quality criteria for TP and Chl a consistently.

Table 3. Wisconsin water quality criteria and actual lake concentrations.

	Pipe			North Pipe		
	Actual		Wisconsin Water Quality Criteria	Actual		Wisconsin Water Quality Criteria
	2015	2016		2015	2016	
Secchi disc (m)(May-Sept)	4.6	4.3	--	1.4	1.7	--
TP (ppb)(June 1-Sept 15)	11	14	≥20	24	31	≥30
Chl a (ppb)(July 15-Sept 15)	3.6	2.5	≥27	31.8	15.9	≥27

Water Quality Status

There are many different approaches to evaluate the status of lake water quality such as Ecoregion criteria, Wisconsin criteria, and using water quality averages from May-September, or averages from July and August. Even trend analyses produce various water quality conclusions depending on how the variables are treated. From an ecological perspective, the May through September seasonal averages are appropriate. For recreational use, July and August averages are informative although the length of seasonal lake use has increased in the last few decades. Years ago it was common to put the dock in on Memorial Day and take it out on Labor Day (June-September - 4 months). Now-a-days it is common for active lake use to occur from May Day (May 1) through Halloween (6 months).

In summary, the existing water quality in North Pipe Lake for at least the last 20 years has been better than expected based on Ecoregion criteria for undeveloped lakes with a watershed of 1,208 acres and a lake area of 65 acres (mean depth 18.5 ft). In 2021, even though water quality has decreased slightly in the last 20 years, North Pipe water quality is still close to what than would be expected for an undeveloped lake in the North Central Hardwood Forest Ecoregion.

Notes and Comments

- Pipe Lake meets ecoregion criteria and Wisconsin water quality criteria.
- North Pipe Lake meets ecoregion criteria but not Wisconsin water quality criteria for chlorophyll and phosphorus every year.
- Regarding improving North Pipe Lake water quality, there is a significant challenge. Existing North Pipe water quality is generally better than would be predicted based on unimpacted reference lakes with a runoff phosphorus concentration of 150 ppb in the NCHF ecoregion using a MnLEAP model. However, North Pipe does not meet Wisconsin water quality for chlorophyll and phosphorus in every year. The challenge is that North Pipe is in good shape based on modeling for an undeveloped NCHF ecoregion lake but phosphorus and chlorophyll should be decreased to meet Wisconsin water quality criteria. This means North Pipe needs to have better water quality than undeveloped ecoregion reference lakes.
- North Pipe watershed is large and that is why the model predicted the annual lake TP concentration of 44 ppb.
- Still, there is an apparent declining North Pipe water quality trend over the last 20 years based on analysis by the Pipe Lake Water Quality Committee. The decline is only partially due to changes in the large watershed drainage area, rather the bulk of the water quality changes are probably due to nearshore and in-lake actions.
- Based on years of monitoring, as well as intensive lab studies, internal loading for North Pipe appears to be about normal compared to other slightly eutrophic lakes.
- A report by Bill James and Stout University researchers examined internal loading in North Pipe Lake. In-lake restoration actions were proposed and an alum application to reduce internal phosphorus loading was considered. However if alum was to be applied to North Pipe, the benefits would likely be short-lived lasting a year or two. The watershed area is too large and watershed loading is not likely to be significantly reduced, therefore water quality conditions would probably return in a year or two.
- North Pipe declining water quality trends are likely a combination of minor but incrementally important lake impacts which include things such as:
    - Increasing shoreline development that results in a loss of vegetation buffers.
    - Increased lake use with more boats results in more shoreline wave impacts and erosion.

- Over the last 20 years, boats and motors are bigger and prop wash produces a deeper mixing depth than lower horsepower motors.
- Expanded active lake use (boating and fishing) in the last 30 years has gone from 4 months to 6 months.
- With more developed lots and an increase in the number of lake residents, fishing pressure could reduce top down lake impacts (fewer gamefish resulting in less predation and more forage fish, which prey on zooplankton, reducing zooplankton grazing pressure on algae resulting in more algae). This could decrease water clarity.

• Similar impacts are occurring in Pipe Lake. In fact over the last 23 years, water clarity has decreased more in Pipe Lake (4.0 foot loss) than in North Pipe (3.1 foot loss)(analyses from Pipe Lake Water Quality Committee).

Possible Lake Actions

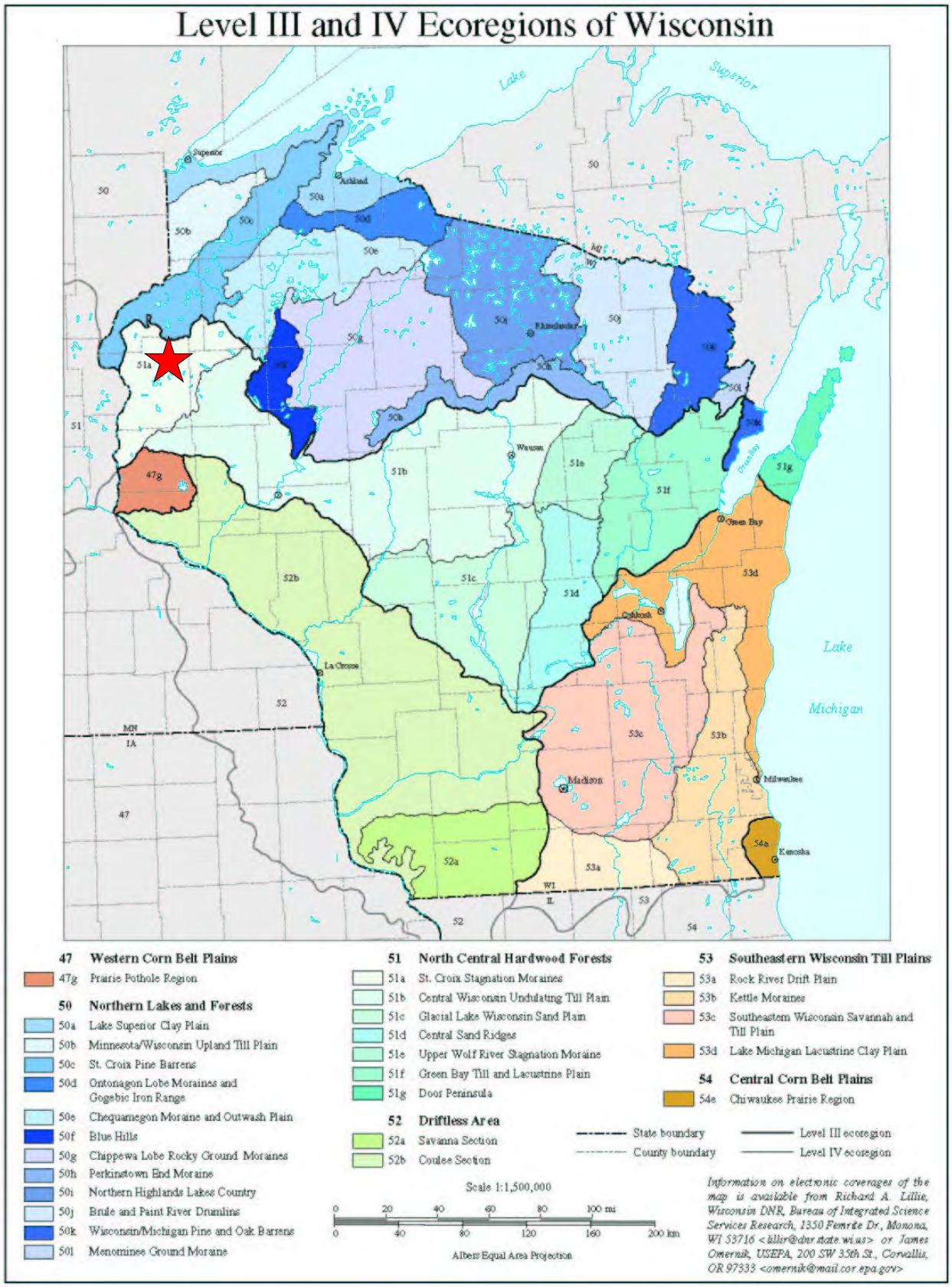
• What are the solutions to improving North Pipe Water Quality? Some examples include:
- Watershed p-reduction projects (need to be ongoing). (***High Priority***)
- Shoreline protection by maintaining or installing vegetative buffers. (***High Priority***)
- Biomanipulation and fish stocking. (***Moderate Priority***)
- Reduction of P-translocation from lake sediments. Low doses of hydrogen peroxide algaecides have been selective for cyanobacteria and does not impact other algal groups. However, H_2O_2 is expensive at over $900/acre/year. (***Low Priority***)
  (Some years translocation is not important. However, in some years algal resting cells release. Not sure what triggers release and would be helpful to know).
- Annual alum treatments (expensive at $3,000 to $4,000/acre for multiple treatments). Alum is effective for inactivating phosphorus from Fe-P dissolution. Unfortunately, alum doesn't inactivate the sediment phosphorus associated with resting cells in the organic-P fraction. (***Low Priority***)

Future Projects

• Finding a solution to keep the sediment algal resting cells from releasing and translocating phosphorus would solve North Pipes excessive chlorophyll and phosphorus concentrations and likely meet water quality criteria. It would also solve problems for many eutrophic lakes in temperate zones around the world. More work is needed in this area.

• Possible ultrasonic algae treatments have been reviewed. Ultrasound is effective for controlling algae in laboratory settings, but results are not as clear for whole-lake projects. Also there is conflicting information from the vendor and the research literature regarding algal nutrient release after algal dieback and impacts of ultrasound to other aquatic organisms. An ultrasonic algae treatment for North Pipe would be expensive (likely greater than $150,000 with an annual O&M cost of greater than $5,000). This project topic remains under review.

• Nano-iron impregnated media suspended in the lake's water column to intercept phosphate before it transfers to algal growth is being tested in a Minnesota lake in 2022. If this form of iron is shown to reduce harmful algal blooms, North Pipe could be a candidate lake for a nano-iron project in the future. Initial costs are less than $400 per acre. The iron media is removed at the end of the season and phosphorus is stripped from the iron and phosphorus is removed from the lake. The iron media can be reused the following year.



Pipe and North Pipe Lakes are located in the North Central Hardwood Forest Ecoregion (red star).