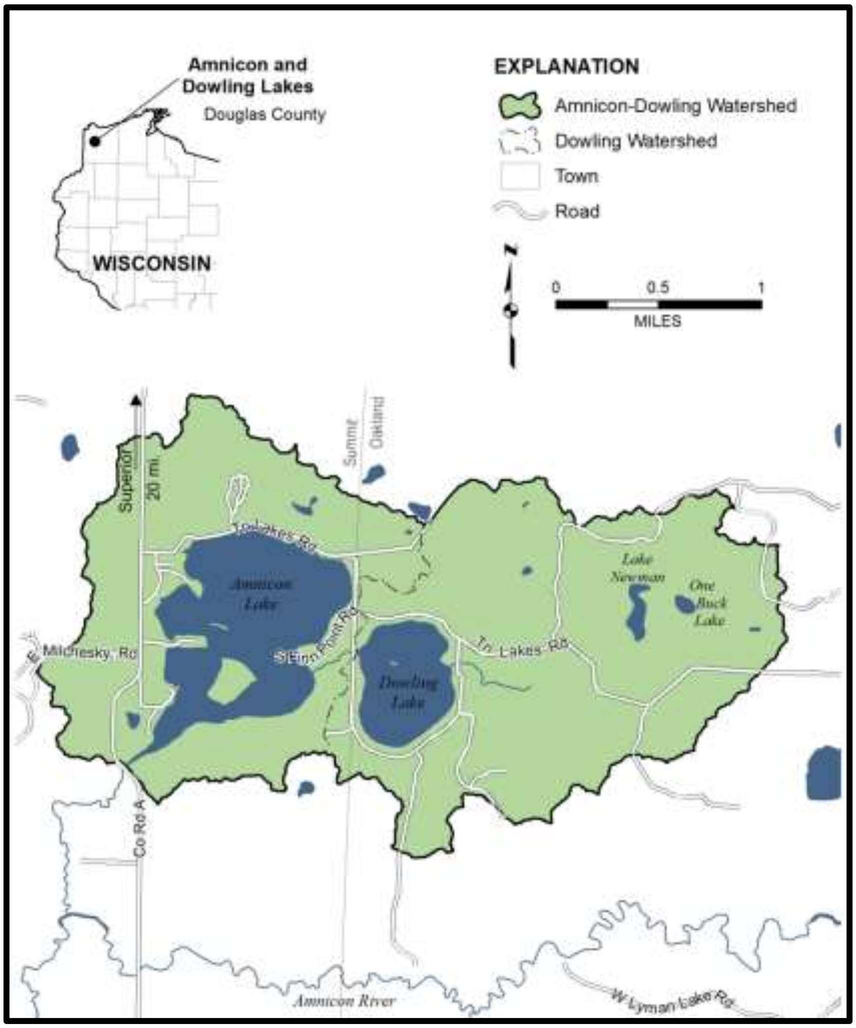
DOWLING LAKE

DOUGLAS COUNTY

2022-31 Comprehensive Lake Management Plan
Amnicon Dowling Lake Management District
December 2021



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Funded by: Wisconsin Dept. of Natural Resources Lakes Grant Program
LPL-171619

Acknowledgements

This management planning effort was a team-based project and could not have been completed without the input from many individuals and partners.

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Executive Summary

Dowling Lake (WBIC: 2858300) is a scenic, 141 acre, shallow headwater lake to the Amnicon River located in Northwest Wisconsin in Douglas County. Dowling lies upstream of Amnicon Lake (WBIC: 2858100), and the two lakes are connected by a small, unnamed stream that is approximately 450m long. The two lakes are nestled in the Upper Amnicon River watershed (HUC 12), but the area that drains specifically to Dowling is rather small – 4.04 mi^2 – with mostly undeveloped woody wetlands and mixed forests. The shoreline of the lake is virtually totally developed with homes and cabins. With a maximum depth of 13.5 feet, an average depth of 7.6 feet, and typically high levels of nutrients, Dowling is considered eutrophic and impaired with excessive algal growth. Increased phosphorus levels are thought to originate from nonpoint source inputs from the drainage basin and along the shoreline, internal loading, and from septic systems around the lake. The dark, tannin-stained water and overall poor water clarity confines the littoral zone to no deeper than approximately 4 feet, which limits floating and submerged aquatic vegetation growth. However, the emergent plant community is diverse and likely important habitat for fish, waterfowl, and other organisms.

Lake organization members were concerned with the excessive levels of nutrients and subsequent blue-green algal blooms and the impacts of these conditions; thus, the Amnicon-Dowling Lake Management District (ADLMD) requested a grant from the Wisconsin Department of Natural Resources (WDNR) to help fund a Comprehensive Lake Management Plan for Dowling Lake. The group hired Lake Education and Planning Services, LLC (LEAPS) in 2019 to complete it.

The intent of this project was to assemble all available report and planning recommendations related to Dowling Lake and assess current and past data to determine if those recommendations have been met and if they were successful in improving the lake. To accomplish this, a review of all publicly available reports, plans, and datasets related to lake use, fisheries, water quality, watershed land cover, shoreline habitat assessments, and aquatic plant surveys was performed in order to gauge the effectiveness of past management recommendations so that a clear, achievable, and effective plan can be made going forward.

The management recommendations in this comprehensive plan are the results of a combination of data analyses, discussions with the ADLMD, and an extensive review of past reports and documents. Summarized strategies for management consist of: education, protection, nutrient reduction, adaptive management, and continued monitoring. It is crucial that the ADLMD focus on ways to limit nutrient inputs to the lake, as well as internal loading, to improve the condition of Dowling Lake.

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COMPREHENSIVE WATERSHED MANAGEMENT PLAN-DOWLING LAKE

PREPARED FOR THE AMNICON DOWLING LAKE MANAGEMENT DISTRICT

1.0 Introduction

Dowling Lake is located in Northwest Wisconsin in Douglas County (map shown left). It has a small drainage area within the larger Upper Amnicon River Watershed (HUC 12) and is the headwaters to the Amnicon River. Dowling Lake has a small outlet that flows to Amnicon Lake, a larger lake from which the Amnicon River flows. The Amnicon River is part of the Lake Superior Basin and is famous for a series of waterfalls in the Amnicon Falls State Park.

The area that drains directly to Dowling Lake is mostly wooded wetlands and mixed forest cover with development circling the lake in the form of homes and cabins. Water flows into the lake through a small inlet stream that is considered the headwaters of the Amnicon River, as well as from surface and groundwater flow. There are at least two additional intermittent inlets that add water and nutrients during spring snowmelt and large rain events. Adjacent to Dowling's drainage is the area that drains to Amnicon Lake, which is mostly woody wetlands and mixed forest with some areas of high development and agriculture. The high density of parcels around the lake is indicative of Dowling's popularity and attraction for families with cabins and homes (Figure 1). Both Amnicon and Dowling have public boat access points that allow public lake users to recreate on the lakes (Figure 1).

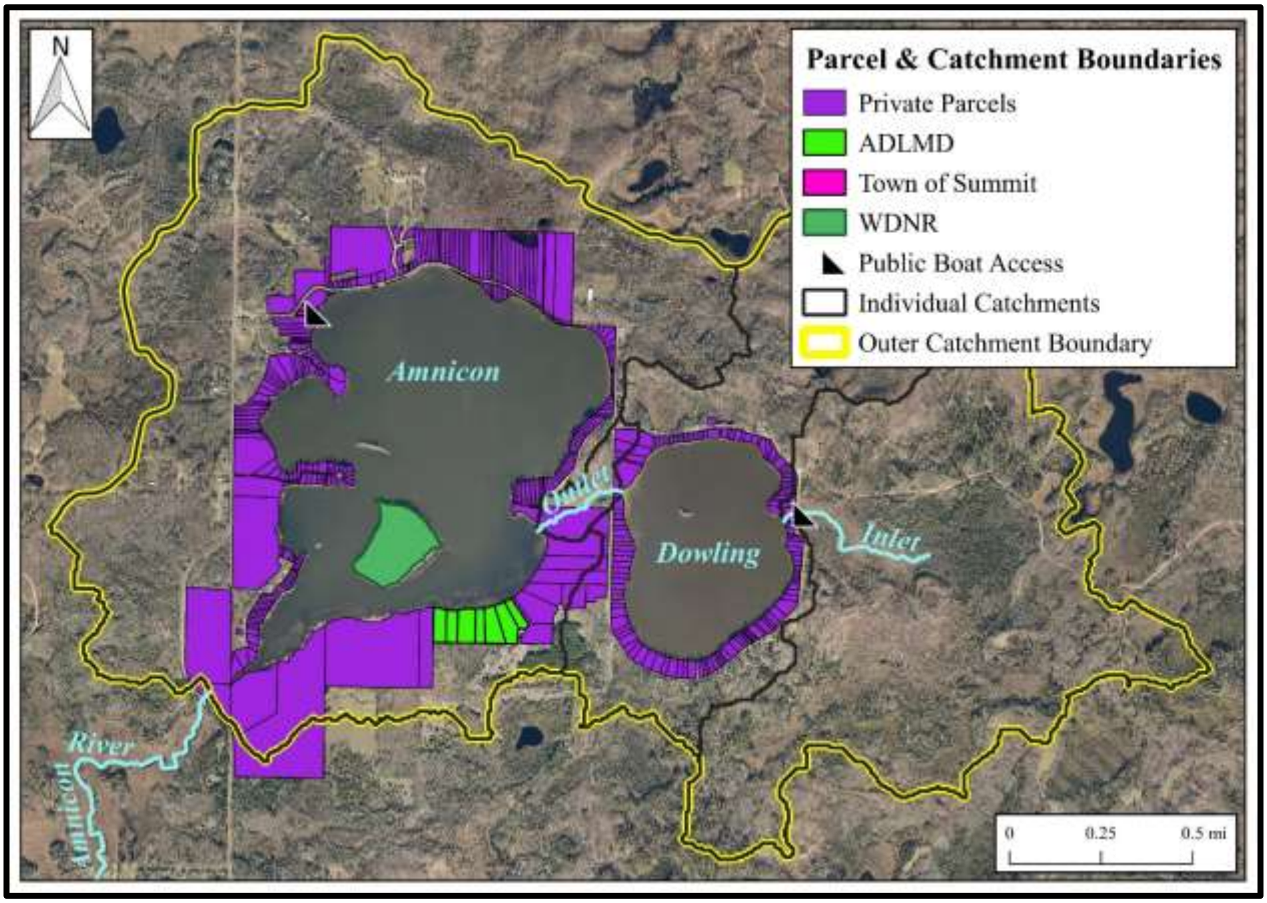

Figure 1: Parcel and catchment boundaries around Amnicon and Dowling Lakes

1.1 Planning Process and Public Input

To begin the project, the ADLMD planning committee members met with their consultant, LEAPS, to discuss their growing concerns about Dowling Lake. From that discussion, it was determined that a grant to complete a data search and analysis project should be submitted in late 2018. Soon after, the lake management planning grant was awarded to the ADLMD in early 2019. LEAPS then met again with officers of the ADLMD board and members of the ADLMD constituency to discuss the process of implementation. Tasks for the members were explained and assigned. Volunteers were identified to complete tributary and lake monitoring and to assist with the Shoreland Habitat Assessment. Another member took on the responsibility of compiling the history of Dowling Lake and the surrounding community. Each year through the project, LEAPS met with the ADLMD board and its constituency to update project results and progress and to obtain feedback.

Over the course of the project, LEAPS worked to compile the data, create visual displays of the data, research the natural history of the area, and begin drafting the plan document. Part of the data collection involved significant time working to complete research of the lake and modeling of the watershed, soils, and the lake water quality. LEAPS made contact with Douglas County Zoning and the Land & Water Conservation and Forestry Departments with the county to gather additional information about the Dowling Lake shoreland and watershed. Additionally, the local Wisconsin Department of Natural Resources (WDNR) Fish Biologist was consulted and interviewed about the past and current status of the fishery population and management initiatives.

The original completion date of this project was June 30, 2021, but an extension through the end of 2021 was requested due to delays caused by Covid-19. Throughout 2021, LEAPS compiled all the existing data and developed this Comprehensive Plan. A draft of this plan was delivered to the ADLMD in late December 2021 for review and approval, and it has also been posted on the LEAPS Client Webpage at https://leapsllc.com/index.php/amnicon-dowling-lake-management-district/. The ADLMD is currently creating a Lake District webpage; once completed, the Comprehensive Plan will be posted there as well. Formal notification of Plan posting will be sent to ADLMD constituents in January 2022 with a request for constituent review and comment. After ADLMD review and approval has been completed, the Plan will be submitted to the WDNR for additional review and approval. After the completion of all reviews and approvals, the Plan will be formally presented to the ADLMD constituency during its first organization meeting in 2022.

2.0 Purpose, Problem, and Project History

The purpose of this project is to explain why water quality in Dowling Lake has deteriorated so significantly in recent years and to develop realistic and achievable actions to begin restoring the lake. It is an immense challenge to improve water quality in a eutrophic lake (nutrient-rich, algal blooms, poor water clarity). The task is complicated even further by predicted changes in climate, increasing potential for pollution, land use changes, and invasive species. The ADLMD can only hope to meet this goal through a committed effort to improve and restore the shoreline, protect and enhance native vegetation, decrease nutrient inputs to the lake, educate lake property owners and lake users on what they can do to benefit the lake, and take an adaptive management approach that uses current information to guide future plans.

2.1 Eutrophication of Shallow Lakes

Eutrophication is the process in which lakes receive nutrients (phosphorus and nitrogen) and sediment from the surrounding watershed and become more fertile and shallow. The additional nutrients are food for algae and fish, so the more eutrophic a lake is, the more living organisms it sustains. When a lake becomes shallower from added sediment, even more plants can grow because the littoral area (the area of the lake that is shallow enough for light to reach the bottom) increases in overall percentage (Figure 2). Eutrophication is a natural process that a lake goes through over hundreds to thousands of years. Natural eutrophication is also sometimes referred to as lake aging (RMB Environmental Laboratories, Inc, 2021). All lakes are aging, it is a natural process that by itself, should not be considered a bad thing. However, when this aging process is accelerated, almost always as a result of anthropogenic (human) influence, there is reason to consider it problematic.

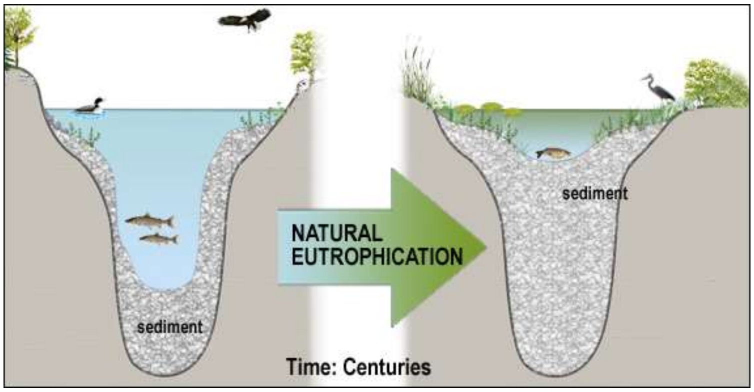

Figure 2: Natural Eutrophication (nutrient enrichment) (RMB Environmental Laboratories, Inc, 2021)

Humans can speed up the process of eutrophication by adding excess nutrients and sediment quickly, where the lake will change trophic states in a matter of decades. This type of eutrophication is called cultural eutrophication because it is caused by humans (Figure 3). Land practices such as agriculture, animal feedlots, urban areas, and heavy shoreline development contain very concentrated amounts of nutrients that can wash into lakes through surface water runoff across impervious (hard) surfaces, lawns, fields, and other disturbed areas during heavy rains and spring snowmelt. They also enter the lake through groundwater that flows into the lake picking up nutrients and other pollutants as it moves through septic system drain fields, through and away from agricultural fields, and places where human activities have intentionally or unintentionally left pollutants uncontained. The additional nutrients build up in the lake causing algal blooms, additional plant growth and overall poor water quality, making the lake less suitable for recreation.

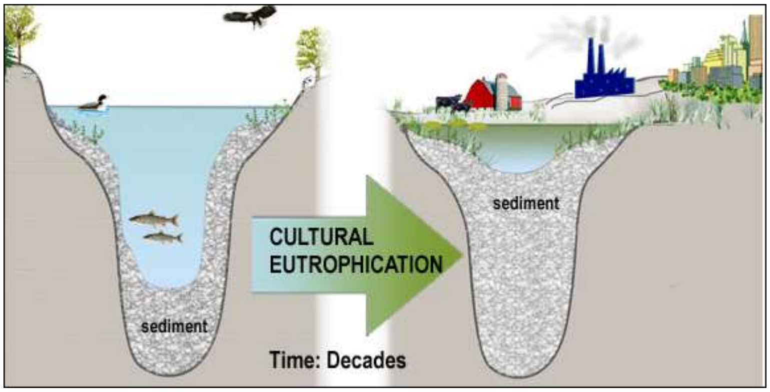

Figure 3: Cultural Eutrophication (RMB Environmental Laboratories, Inc, 2021)

After the last glaciers left behind Dowling Lake, it may have been deeper, nutrient-poor, and oligotrophic for a short time. As the lake aged and the climate became warmer, more plants grew in and around the lake, and it likely became more mesotrophic. With more aging, more plants, and more nutrients being added to the lake present-day Dowling Lake is shallow, warm, turbid, has algal blooms, low water clarity, and occasional algal blooms. Into the future, the natural course of the lake is to become even more eutrophic and to continue filling in until it becomes a wetland and then eventually dry land. Poor watershed practices, large amounts of development, improper treatment of waste and yard trimmings, removing native vegetation, starting up boat motors in shallow water, and many more practices can increase the rate of eutrophication in a lake faster than it would occur without any human activity.

2.2 Top/Bottom Paleo-Limnological Analysis

Dowling Lake was not always so turbid. A sediment core analysis from a top/bottom paleo-limnological analysis study completed in 2013 indicated that Dowling has switched from a clear water state to a turbid state within the last 100 years (Garrison, 2013). The study used diatoms - a type of algae with silica cell walls - which preserve them very well in the sediment at the bottom of a lake. Certain species of diatoms are only found under nutrient poor conditions, while others are more common under elevated nutrient levels. Thus, whichever species are present in the layers of sediment indicate the conditions of that time period – either clear or turbid waters (Garrison, 2013).

The diatom community in the Dowling sediment core was dominated by planktonic diatoms (those that float in the open water), and there appeared to be more submerged aquatic vegetation (SAV) in the past than at the present time. This indicates that within the last century, Dowling switched from clear to turbid. The greatest change in the diatom community was the dominance of diatoms in the most recently deposited sediment layers that are usually found when phosphorus levels are elevated. This indicates that phosphorus concentrations in Dowling Lake at the present time are much higher than they were historically (Garrison, 2013).

The most recently deposited layers of sediment in Dowling Lake show that phosphorus levels are over 3 times higher than levels 100 years ago. This increase in phosphorus is unusual in northern Wisconsin lakes (Garrison, 2013). The large increase in phosphorus may be attributed to increased internal phosphorus loading from the bottom sediments. Historically, the internal loading rate may have been low, but increased external loading from shoreland development may have been enough to push these lakes past the threshold where internal loading now plays a significant role in elevating phosphorus loading (Garrison, 2013).

2.3 Trophic State and Water Quality

Trophic state and water quality are often used synonymously; however, they are not the same. Trophic state describes the biological condition of a lake using a scale – Trophic State Index (TSI) – that is based on water clarity, total phosphorus, and chlorophyll-a (Carlson, 1977).

By combining data for water clarity, phosphorus, and chlorophyll-*a* in Dowling Lake, the trophic state as determined by Carlson's Trophic Status Index (1977) is able to be determined (Figure 4). Eutrophic lakes typically have large amounts of aquatic plant growth, higher nutrient concentrations, low water clarity due to algae blooms, and oxygen-depleted bottom waters. On the other end of the spectrum, oligotrophic lakes are nutrient-poor, have clear and cold water, and oxygen throughout the water column continually. Mesotrophic lakes fall in the middle and have intermediate nutrient levels, occasional algal blooms, and may experience bottom water oxygen depletion in the summer. Measures of water quality in Dowling consistently show that Dowling is eutrophic (Figure 4). Results from the Paleo-Limnological Analysis suggest this has happened within the last 100 years, a period of heavy anthropogenic influence on the lake.

TSI	Chlorophyll-a (ug/L)	Secchi Depth (ft)	Total Phosphorus (ug/L)	Classification	Attributes	Fisheries and Recreation
<30	<0.95	>26	<6	ULTRAOLIOGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water, cold water	oxygen-sensitive, cold water fish species in deep lakes
30-40	0.95 - 2.6	13 - 26	6 - 12	OLIGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water except possibly in shallow lakes, cold water	oxygen-sensitive, cold water fish species in deep lakes only
40-50	2.6 - 7.3	6.5 - 13	12 - 24	MESOTROPHIC	water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer	walleye may dominate
50-60	7.3 - 20	3 - 6.5	24 - 48	EUTROPHIC	decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident	warm-water fisheries (pike, perch, bass, etc.)
60-70	20 - 56	1.5 - 3	48 - 96	EUTROPHIC	blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible	thick aquatic vegetation and algal scums may discourage swimming and boating
70-80	56 - 155	0.75 - 1.5	96 - 192	HYPEREUTROPHIC	heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight)	summer fish kills possible, rough fish dominant
>80	>155	<0.75	192 - 384	HYPEREUTROPHIC	Algal scums, few plants	

Figure 4: Trophic status and attributes. Dowling Lake values are circled in red

Water quality is typically based on a perception of the lake, which may be subjective for different lake users. People who use the lake for primarily swimming usually classify lakes with clear water as having better water quality while the same lake might be classified as having poor water quality by a fisherman because the low productivity limits fish growth. Volunteers with the ADLMD have been periodically monitoring water quality at the Deep Hole site (Station ID: 163091) on Dowling Lake following WDNR Citizen Lake Monitoring Network (CLMN) protocol from 1976 to present. Volunteers measured quantitative parameters such as temperature, dissolved oxygen, and Secchi depth; and collected water samples which were sent to the Wisconsin State Lab of Hygiene for analysis of TP and chlorophyll-a. Qualitative observations such as lake level, color, and perception of water quality were also recorded.

2.4 Impaired Waters

Every two years, Sections 303(d) and 305(b) of the Federal Clean Water Act (CWA) require states to publish a list of all waters not meeting water quality standards and an overall report on the surface water quality status of all waters in the state. To assess surface water quality throughout the state, Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM) is used. WisCALM uses available data to determine impairments based on two categories: natural (fish and aquatic life, FAL) and recreational (human/full body emersion activities, REC). A lake can exceed state standards in either or both of these categories, and designations are generally based on the concentration of total phosphorus (TP) -- the nutrient that supports aquatic life -- and the concentration of chlorophyll-*a* (Chl-*a*), a measurement used to determine the biomass of algae in the water.

The Wisconsin acceptable standard for summer TP in the REC category for inland lakes like Dowling is a mean concentration ≤30-μg/L (Figure 5). If the summer mean concentration of TP exceeds this level, the water is considered impaired. The Wisconsin standard for Chl-*a* is based on the number of days in a sampling season (July 15-September 15) that have moderate algal levels based on Chl-*a* concentrations that exceeds 20-μg/L. Once that level has been exceeded, the amount of algae in the surface water it represents discourages people from swimming (Figure 6). If the concentration of Chl-a exceeds 20-μg/L on more than 5% of the expected lake use days, then the water is considered impaired.

Figure 5: Wisconsin numeric water quality standards for phosphorus (WI-DNR, 2019)

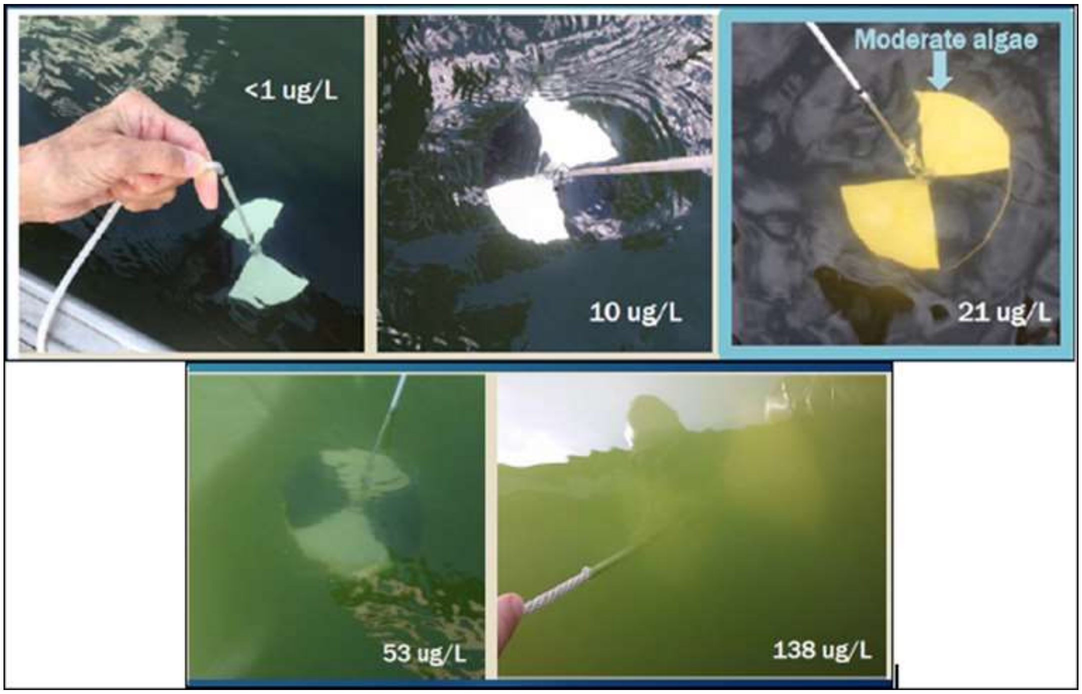

Figure 6: Chl-*a* concentrations and the corresponding water clarity measured with a Secchi disk

Dowling Lake was assessed for the first time during the 2014 impaired waters listing cycle. In that assessment, Chl-*a* exceeded 2014 WisCALM listing thresholds for the REC use but TP did not. TP and Chl-*a* data did not exceed FAL thresholds in 2014. In 2014, TP and Chl-*a* did not exceed FAL thresholds.

The lake was evaluated again during the 2022 impaired waters assessment cycle. Chl-*a* values again exceeding WisCALM listing thresholds. Excess algal growth restricts the recreational use of the lake under the designation of "full body contact – swimming and boating". The impaired waters list includes priority rankings, and Dowling was given a low priority.

2.5 Past Studies of Dowling Lake

There have been multiple studies completed on Dowling Lake (and Lake Amnicon) trying to determine the source of nutrient enrichment to the lakes (Figure 7). The most recent studies completed in 1996-97, 2003-04, and 2019-20, and they concur that addressing shoreline development, groundwater pollution, and internal loading are essential for improving the condition of the lake.

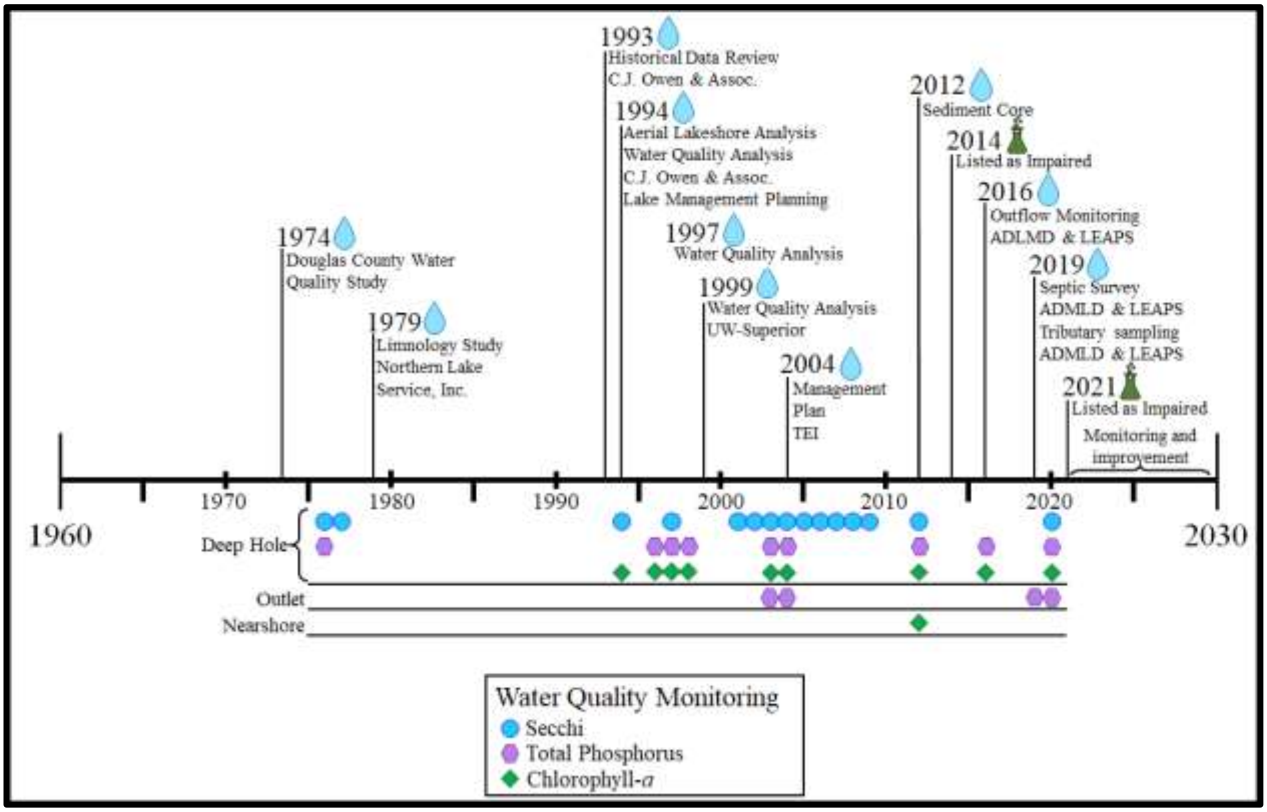

Figure 7: Dowling Lake timeline of water quality studies

2.5.1 C.J. Owen and Associates/A.W. Research Laboratories

In 1996-97, work completed by C.J. Owen and Associates and A.W. Research Laboratories indicated that the manner in which lakeshore/watershed residences relate to the lakes needed to be addressed. A lack of sound shoreline best management practices (BMPs) was accelerating the process of eutrophication. Both lakes were sensitive to external and internal additions of nitrogen (N) and phosphorus (P). The sources of these nutrients were both above ground (surface water runoff) and below ground (groundwater and internal loading). Groundwater sampling in this study determined that human-based contamination was entering the lake and could be an issue of concern.

2.5.2 Thatcher Engineering Inc.

A study completed by Thatcher Engineering Inc. in 2003-04 led to a Lake Management Plan for Dowling Lake and Lake Amnicon in 2006 (Thatcher Engineering Inc, 2006). Using the WiLMS Model[1] they estimated internal nutrient loading contributed 42% of the total nutrient load in Dowling Lake, compared to only 4.5% in Amnicon. Thatcher Engineering also completed a shoreland inventory of both lakes. For Dowling, the inventory showed less than 50% of the shoreland and upland area within the developed band around the lake was in a natural state. Out of 98 lots observed, only 11 were undeveloped. The 2006 Thatcher Report concluded that the water quality in Dowling Lake had consistently worsened over the last 25 years as a result of land use changes and increased nutrient inputs to the lake.

2.5.3 Lake Education and Planning Services, LLC

In the most recent study (2019-20), for which this plan is an outcome, what was documented in both 1996-97 and 2003-04 is still true today. Trend lines for water quality data (Chl-*a*, TP, and Secchi) continue to show deteriorating water quality, although it is not considered statistically significant ($p>0.05$; Figures 8-10). When comparing the mean of all water quality data analyzed for the 2003-04 Plan and the mean of all water quality data collected since that time (through 2020), Secchi readings of water clarity are less, TP values are higher, and Chl-*a* values are slightly lower (Figure 11). Overall, Trophic Status Index (TSI) values that are used to designate trophic status – oligotrophic (clear water and low nutrients), mesotrophic (fairly clear water, moderate nutrients), or eutrophic (turbid water, high nutrients; Figure 4) – are higher now than they were when the 2006 management plan was completed, indicating that Dowling Lake's water quality has continued to decline.

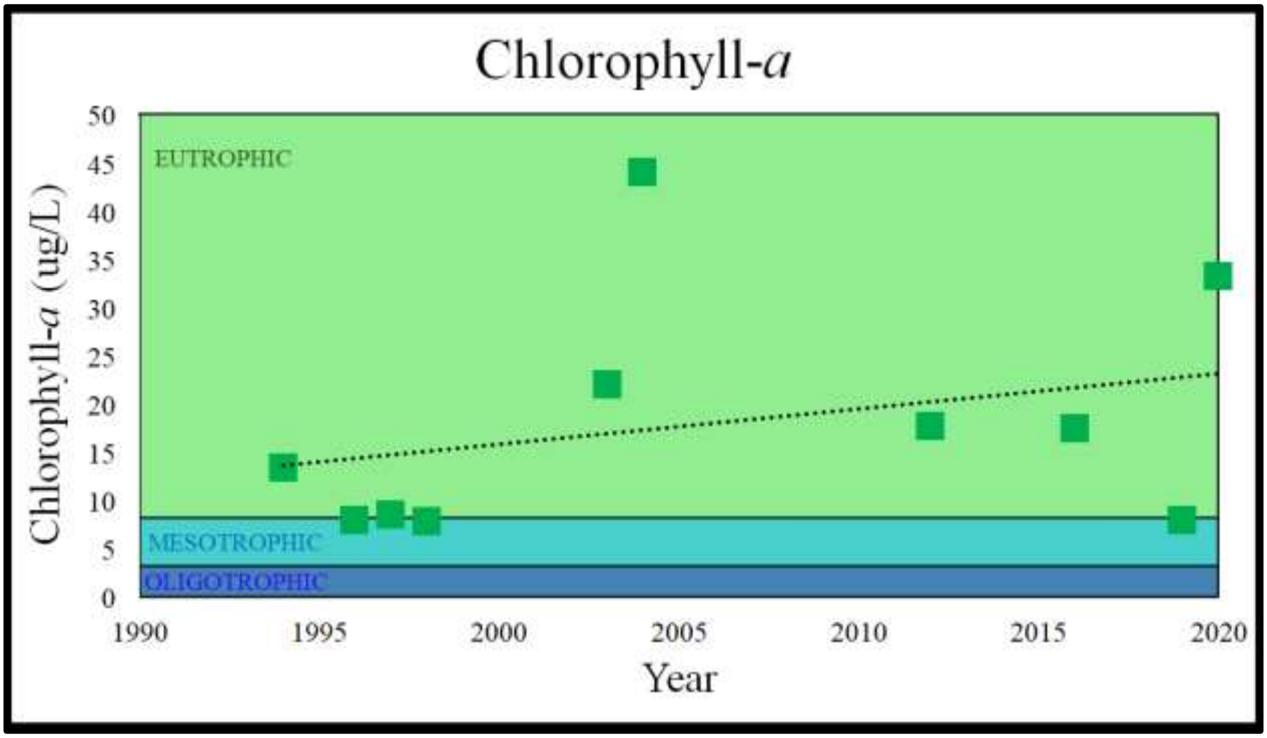

Figure 8: Chlorophyll-*a* trend since the 1990's

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[1] For more information about the WiLMS Model go to: https://dnr.wi.gov/lakes/model/

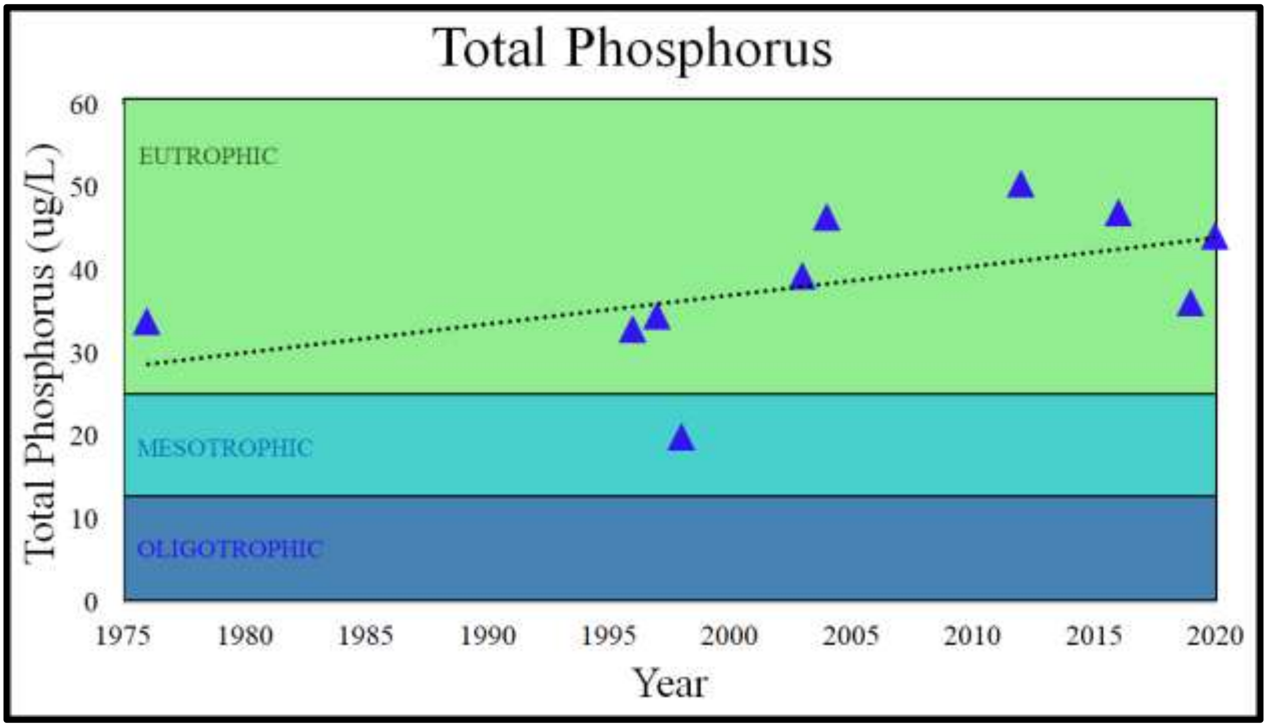

Figure 9: Total phosphorus trend

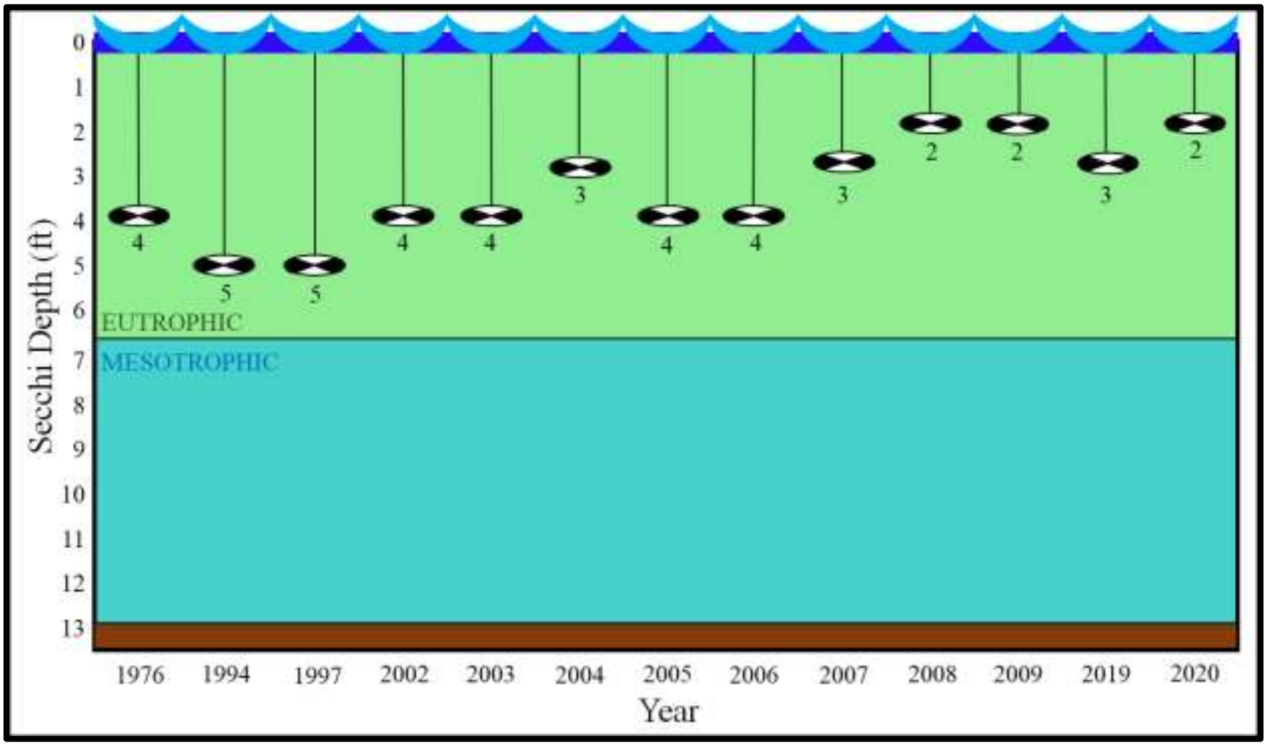

Figure 10: Average annual Secchi readings of water clarity

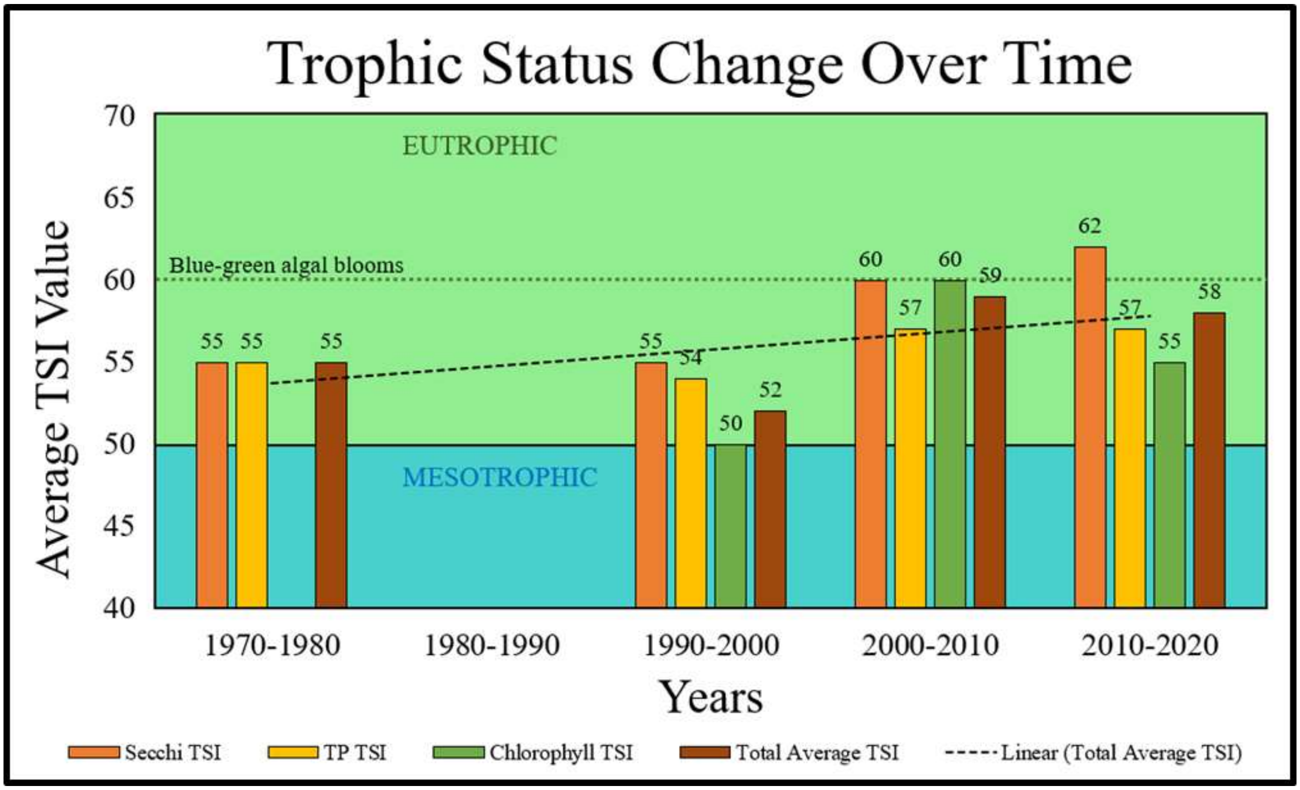

Figure 11: Average annual actual and TSI values for Secchi, TP, and Chl-a before 2005 and after 2004

3.0 Current Conditions in the Watershed

The watershed of a lake, also called the drainage basin, is all of the land and water areas that drain toward a particular river or lake. The condition of a lake generally reflects the watershed's topography, geology, land use, soil fertility and erodibility, and vegetation. Thus, the condition of a lake is often a reflection of the state of its watershed.

3.1 Land Cover in the Dowling Lake Watershed

At 4.04 square miles, the drainage area that feeds into Amnicon and Dowling Lakes is just a small piece of the much larger Amnicon River Watershed, which covers about 314 square miles (Figure 12). There is a small main inlet to Dowling Lake – the head waters to the Amnicon River – that drains a woody wetland complex. There are two other small inlets to the lake: an intermittent stream on the north end of the lake, and a small inlet from Newman Lake on the east shore. Dowling then feeds into Amnicon through another small channel, and then Amnicon Lake drains through the southwest corner to the Amnicon River.

The main land cover in the Amnicon and Dowling Lakes combined watershed is wetland (38%), followed by forests (30%), open water (21%), developed area (4%), and all other land cover (7%; Figure 13). In Dowling Lake's drainage, the main land cover is wetlands (43%), followed by forests (38%), open water (13%), and developed area (6%). Agriculture is almost non-existent in the Dowling Lake drainage area.

Figure 12: Amnicon River Watershed and the location of the Amnicon-Dowling drainage area

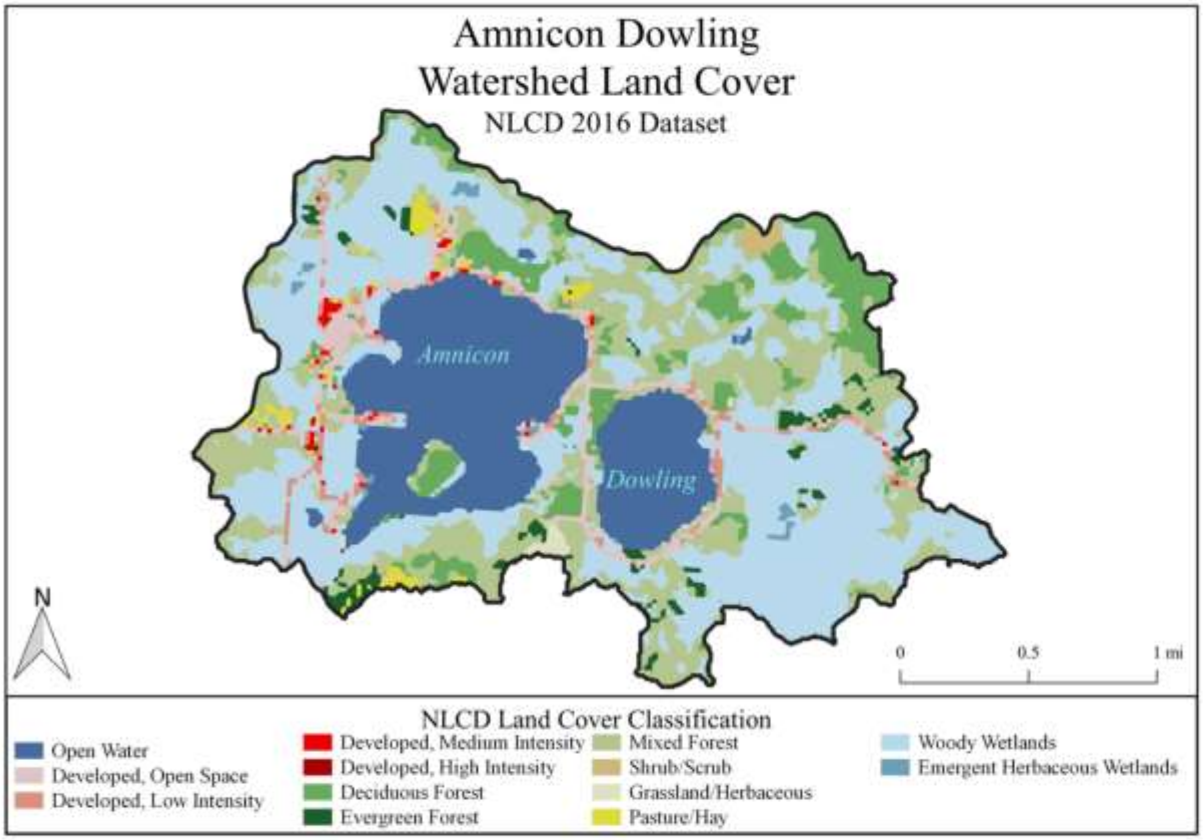

Figure 13: Land Cover in the Amnicon and Dowling Lakes Watershed

3.1.1 Forests

Trees and forests play an incredible role in reducing storm water and filtering pollutants that would otherwise wind up in our waterways. The Chesapeake Bay Executive Council in 2006 summarizes the benefits of forests in the watershed with the statement: "Forests are the most beneficial land use for protecting water quality, due to their ability to capture, filter, and retain water… Forests are also essential to the provision of clean drinking water…and provide valuable ecological services and economic benefits including carbon sequestration, flood control, wildlife habitat, and forest products" (https://www.allianceforthebay.org/).

Through an extensive review of land management impacts on water quality in North America, research complied by the EPA determined that there is the potential for forestry operations to adversely affect water quality if best management practices (BMPs) are poorly implemented. Sediment concentrations can increase due to accelerated erosion; water temperatures can increase due to removal of over story riparian shade; slash and other organic debris can accumulate in water bodies depleting dissolved oxygen; and organic and inorganic chemical concentrations can increase due to harvesting and fertilizer/pesticide applications. These potential increases in contaminants are usually proportional to the severity of site disturbance. Impacts of nonpoint-source pollution from forestry activities depend on site characteristics, climatic conditions, and the forest practices employed (Fulton & West, 2002).

If BMPs are properly designed and implemented, the adverse effects of forestry activities on hydrologic response, sediment delivery, stream temperature, dissolved oxygen, and concentrations of nutrients and pesticides can be minimized.[2]

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[2] For more information about forestry BMPs in Wisconsin, go to: https://dnr.wisconsin.gov/topic/forestmanagement/bmp

3.1.1.1 Dowling Lake Watershed Forests

According to Logan Jones, Douglas County Forester, most of the forest land in the Amnicon-Dowling watershed was acquired by the county in 2015. Previous harvesting had likely been done 20-35 years ago. At present, there are no future timber sales planned in the area. He also stated that no harvesting of low-lying swamp hardwoods or swamp conifer stands occurred in the past either (Logan Jones, personal communication, December 2021). Despite this, the ADLMD should be vigilant and watch for local timber harvests and communicate concerns with the purveyor when they arise.

3.1.2 Wetlands

A wetland is an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic (water-loving) vegetation and which has soils indicative of hydric (wet) conditions. Wetlands have many functions that benefit the ecosystem. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl. Wetlands also provide flood protection within the landscape. The dense vegetation and location on the landscape allows them to slow snowmelt and rain water, mitigating large amounts of flooding, and minimizing impacts to downstream areas. Wetland plants and soils have the capacity to store and filter pollutants, ranging from pesticides to animal wastes, which also protects water quality.

Wetlands along the shoreline of a lake provide protection by acting as buffers between land and water. They protect against erosion by absorbing the force of waves and by anchoring sediments. Wetlands also provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. Wetlands can also stabilize and maintain stream flows, especially during dry months.

The Dowling Lake catchment area is 43% wetland. However, there are some areas that could potentially be restored to improve and/or restore the wetland (Figure 14).

3.1.2.1 Wetland Restoration

Restoring wetlands through vegetative or hydrologic improvements in impacted or drained wetlands is a common practice in Wisconsin. There are multiple programs that fund a range of wetland restoration efforts, including the U.S. Fish and Wildlife Service's North America Wetlands Conservation Act, Natural Resources Conservation Service Wetlands Reserve Program and the DNR Wisconsin Wetlands Conservation Trust. Some restoration projects may require permits.

Wetland restoration can be a great tool to increase a wetland's functional value for wildlife habitat and water quality. Landowners can take any level of steps to restore a wetland, including controlling wetland invasive species, to conducting a large-scale hydrologic and vegetative restoration.

The WDNR partnered with The Nature Conservancy to create an online decision support tool to identify the best sites to restore and protect wetlands – and the most promising watersheds to work in. This tool and supporting documents can be found by visiting the Wetlands By Design webpage[3] and could be used by ADLMD and watershed landowners planning to restore their property.

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[3] For more information about wetland restoration and active links to references made, go to: https://dnr.wisconsin.gov/topic/Wetlands/restoration.html

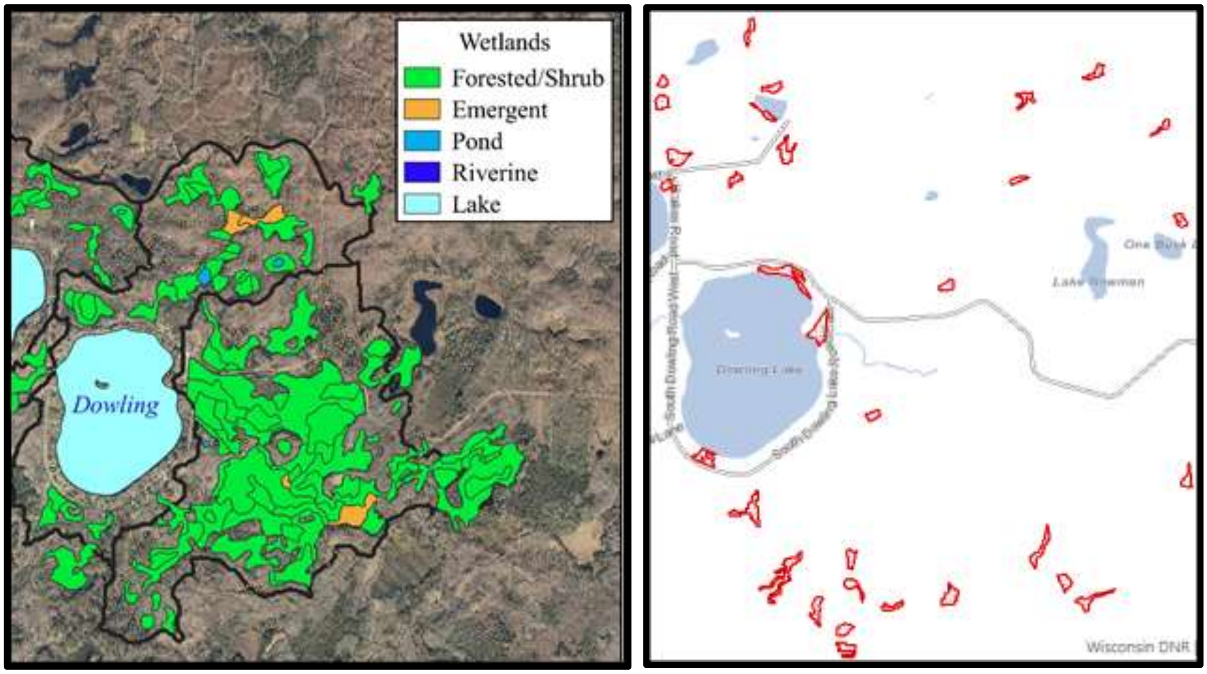

Figure 14: Wetlands within the Dowling Lake watershed (left) and potentially restorable wetlands (right) (WDNR Surface Water Viewer)

3.1.3 Agriculture

Fortunately for both Amnicon and Dowling lakes, there is almost no agriculture in their catchment basins. The 2016 NCLD database shows approximately 31 acres of pasture/hay – less than 2% of the total land use in the watershed.

3.2 Climate

The climate of an area is defined based on **long-term** trends in temperature and precipitation. Measured and monitored by the National Weather Service through the National Oceanic and Atmospheric Administration, temperature and precipitation change on a daily basis: this is weather. When this data is compiled over many years, this is climate. Both temperature and precipitation (which includes snowfall and rain) in the Amnicon and Dowling Lake area are continuously measured by the Duluth Weather Station.

3.2.1 Temperature

The average yearly temperature for Amnicon and Dowling lakes area is approximately 41°F (Figure 15). This measurement relates to the fact that Northern Wisconsin can reach temperatures well below 0°F in the winter and over 100°F in the summer. The average yearly temperature from 1981-2010 indicates that the plant community of Douglas County is hardy and can survive wild fluctuations in conditions. The lakes are also subject to freezing in the winter, turnover in the fall and spring, and stratification in the summer. These conditions are conducive to nutrient release from the sediment and potentially winterkill when oxygen becomes depleted in shallow lakes like Dowling.

3.2.2 Precipitation

The average yearly amount of precipitation, including ice and snow, for the Amnicon and Dowling Lakes area is approximately 31.50 inches (Figure 15). About two-thirds of this value currently falls during the growing season. Plants use the water from precipitation and snowmelt in photosynthesis and release much of it back into the atmosphere through evapotranspiration. This water also replenishes the shallow aquifer of the area, as rainfall and snowmelt easily infiltrate into the sandy soils of the area, which in turn helps maintain lake and river levels through groundwater infiltration and springs.

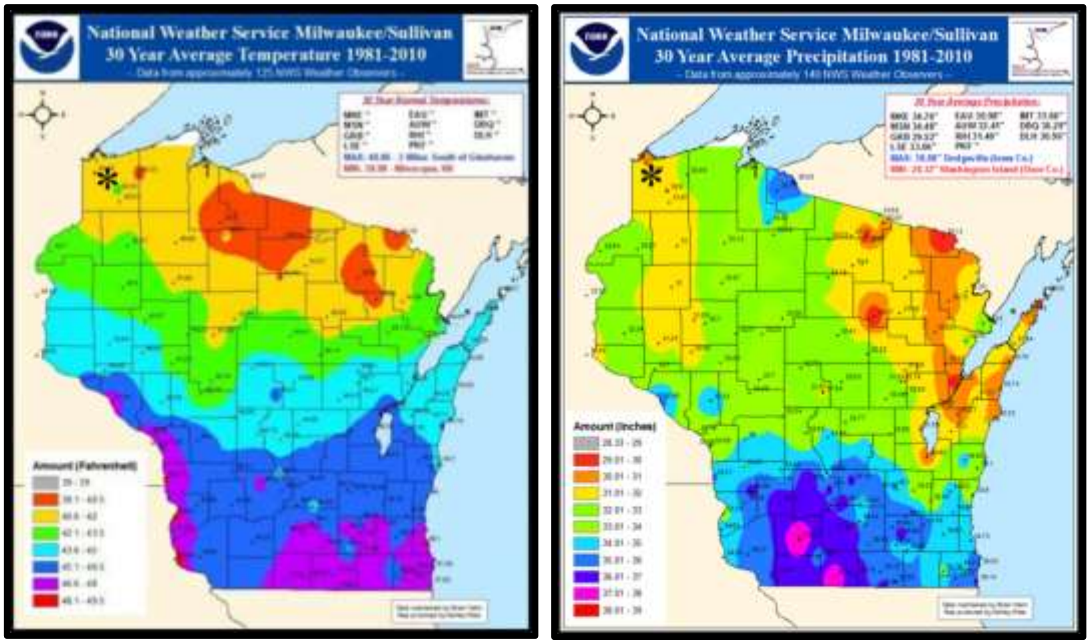

Figure 15: 30 year averages for temperature and precipitation

Data from 1950 to 2018 has shown that Douglas County has received less precipitation and has become significantly warmer (Figure 16). Research from the University of Wisconsin-Madison has revealed that Douglas County receives 5% less annual precipitation now than it did in 1950, and the area is 4°F warmer on average now than it was in 1950 (Figure 16). Based on current climate and predicted future climatic conditions, it is likely that the Amnicon-Dowling area will become even warmer and more dry (less precipitation) in the future (Figure 17). This means that the soils will contain less moisture, lake levels may decrease, and there will be fewer days of ice cover on the lakes. These conditions will likely stress the plants and animals that live in the lakes and may cause a shift towards species that can tolerate warmer water and lower oxygen levels within the next 40 years. Higher temps and less rainfall also mean more algae and less flushing of the lake to remove available phosphorus that promotes algae growth.

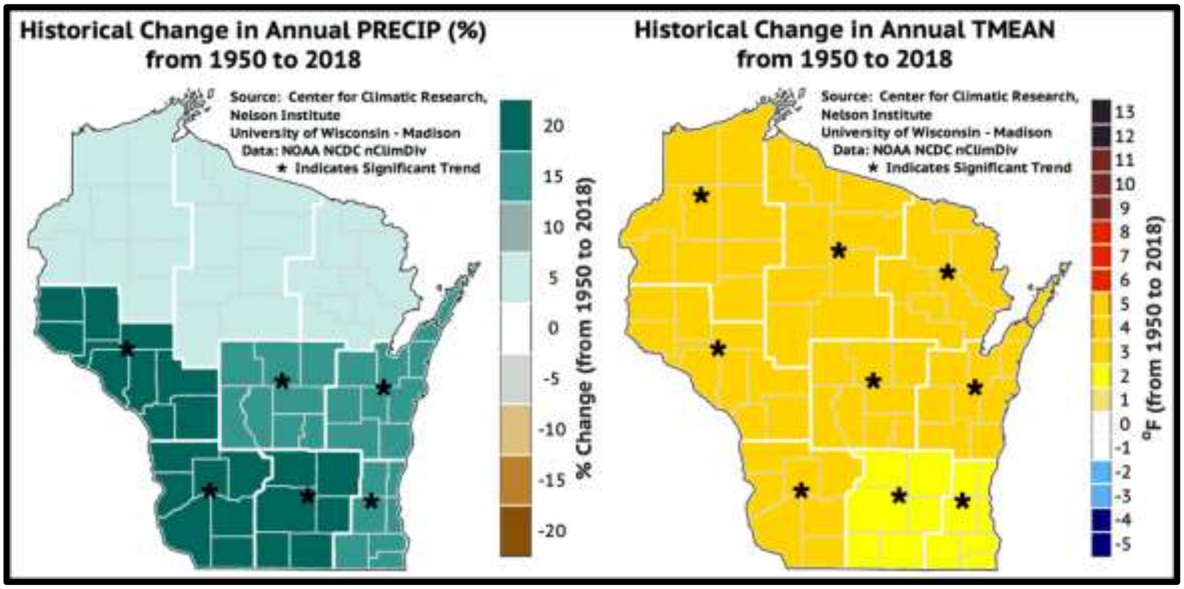

Figure 16: Historical changes in annual precipitation and mean temperature in WI

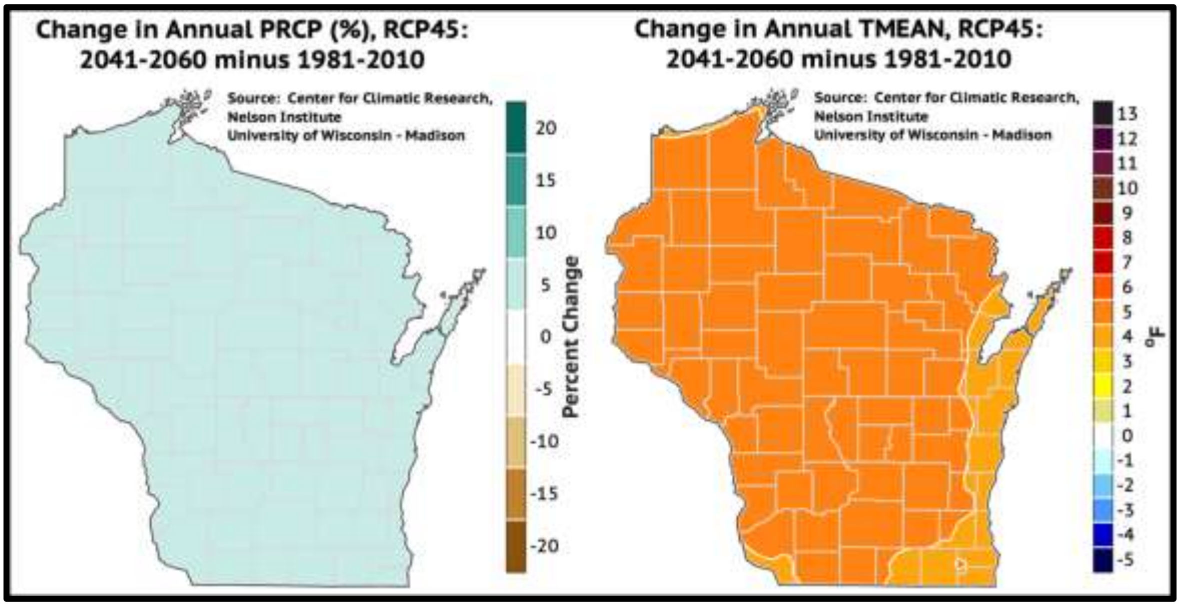

Figure 17: Predicted future changes in precipitation and mean temperature in WI

4.0 Lake Characteristics

Dowling Lake is a fairly representative of most shallow lakes in northern Wisconsin. Based on survey work completed in 2012 (Berg, 2012), the average depth is 7.6 feet with the deepest point being 13.5 feet. Depth soundings taken at Dowling Lake's 253 points in 2012 showed the lake was a generally shallow bowl with most shoreline areas dropping off rapidly to 5ft+ of water before sloping gradually to 8-10ft. The deepest area of the lake is a broad 10-13ft flat southeast of the island. Just north of this flat and west of the mid-lake point that juts out by the boat landing channel, a small sunken island topped out at 3ft. In the lake's southwest corner, a 5-6ft flat extended approximately 250 yards to the northeast (Figure 18). Thin, nutrient poor sandy muck dominated the bottom of the lake's bowl covering 78.3% of survey points. The majority of the lake's shoreline, as well as the southeastern flat, were primarily composed of sand (8.3% of survey points) with rock covering the areas around the island, the sunken island, and a few additional scattered shoreline areas (13.4% of survey points; Figure 18).

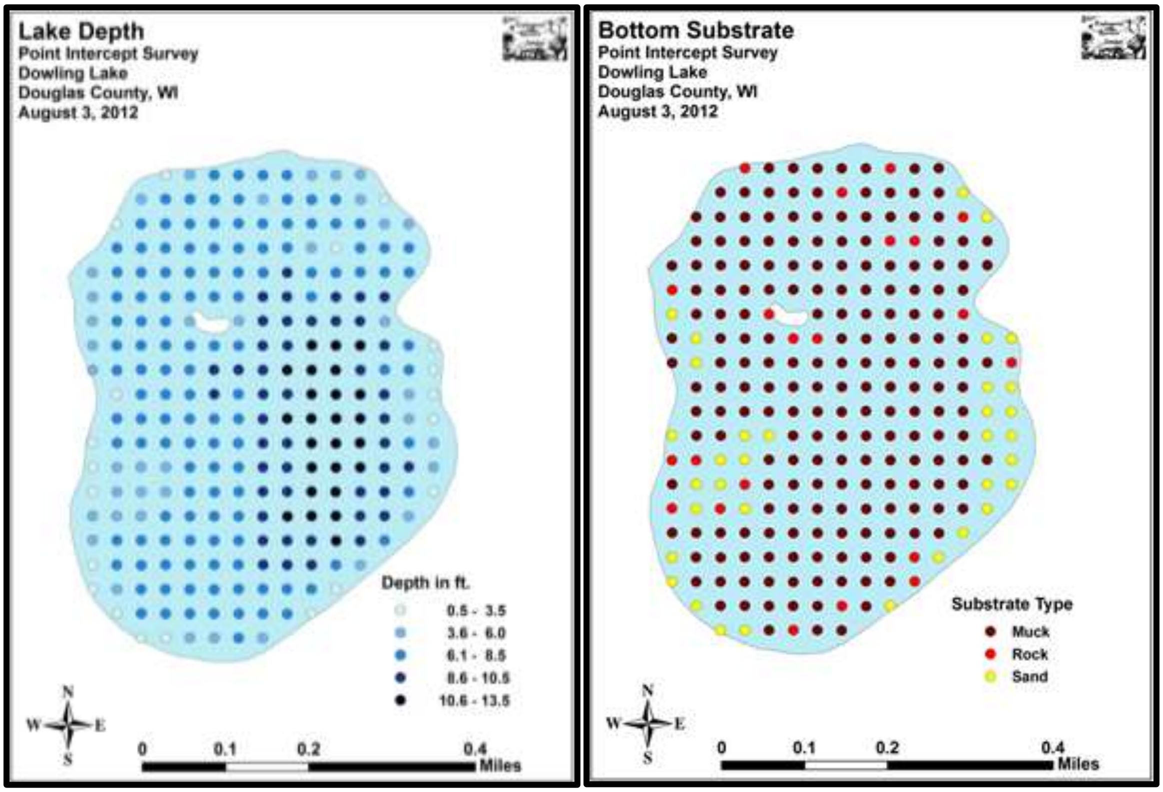

Figure 18: Lake depth and bottom substrate (Berg, 2012)

4.1 Polymictic Lakes

Dowling is a shallow, polymictic lake – meaning that it remains in a "mixed" state with uniform temperature and dissolved oxygen levels from the surface to the bottom of the lake during the open water season (Figure 19, bottom). It does not generally experience significant thermal stratification that a deeper lake does (Figure 19, top). The lake may occasionally stratify during periods of warm weather and calm wind, but heavy boat traffic and an increase in wind will cause the lake to become mixed once again. Citizen Lake Monitoring Network (CLMN) data shows that the lake is not often stratified but does experience low levels of oxygen throughout the water column. This is likely a result of excessive algal growth caused by phosphorus and subsequent decomposition of the decaying material that uses up available oxygen.

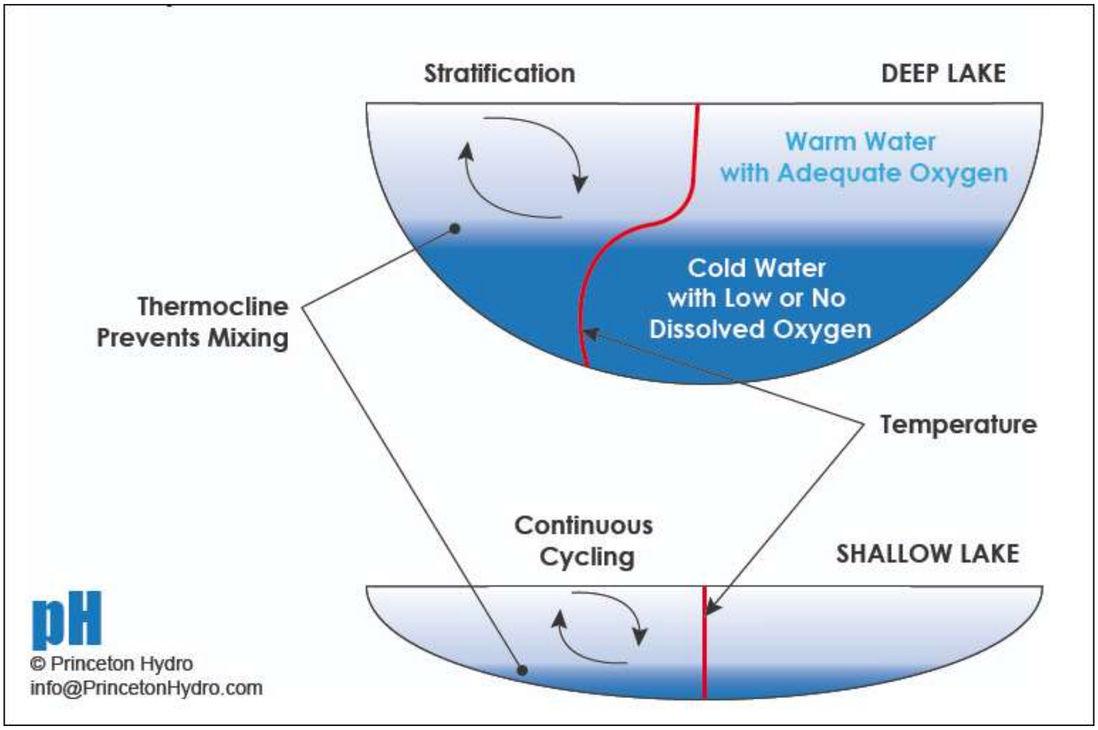

Figure 19: Stratified versus mixed lakes. https://princetonhydro.com/deep-vs-shallow-lakes/

4.1.1 Temperature and Dissolved Oxygen

As a polymictic lake, temperature and dissolved oxygen (DO) are usually pretty consistent from the surface to the bottom. CLMN data supports this point. In the few occasions' temperature and DO profiles have been collected, temperature readings show complete mixing of the water column throughout the open water season.

4.1.2 Water Clarity

Water clarity is depth to which light can penetrate into the water. It affects algae – the base of the food web – by limiting the depth algae can grow, which in turn affects the rest of the food web and has implications for algal blooms. It also affects macrophytes (aquatic plants) by limiting their depth as well. Most life in lakes occurs in the littoral zone, which is the area where light can reach all the way to the bottom. Thus, water clarity has the potential to affect many aspects of aquatic life.

Water clarity also affects recreation and human enjoyment of lakes. Murky, cloudy water is aesthetically unappealing and can even be hazardous in some situations. Increased water clarity is shown to increase recreational enjoyment and is linked to higher property values (Angradi et al. (2018) (Ng & Mohammad, 2017).

In Dowling Lake, water clarity is naturally limited by the dark, tannin-stained waters that give the lake its 'root beer' coloring. Tannins are created as water passes through peat soils and decaying vegetation and the water that flows into Dowling comes directly from tannin-rich woody wetlands and peaty organic soils.

Water clarity can be reliably measured using a Secchi disk. Lowered into the water on a marked rope, the depth at which the disk disappears from sight is representative of water clarity. The average Secchi depth on Dowling is 3.4 feet but has ranged from 1.3-7.7 feet. These values fall within eutrophic ranges based on the 1977 Carlson Trophic Status Index.

4.1.3 Total Phosphorus and Chlorophyll-*a*

The concentration of total phosphorus (TP) and chlorophyll-*a* (Chl-*a*) in Dowling Lake have been more consistently monitored. Citizen volunteers have monitored TP levels at the Deep Hole since 1974 (1974, 1996-98, 2003-05, 2012, 2016 and 2019-20). The CLMN data has shown that surface water TP levels at the deep hole have ranged from 20ug/L to 74ug/L with an average of 40.3ug/L. These values are consistently in the eutrophic range. Water samples collected near the bottom of the lake show an average of 47ug/L, not much higher than the surface water, again indicating little additional phosphorus is being added to the water column as a result of no oxygen in the bottom water. In contrast, a small lake in Barron County that does stratify and become devoid of oxygen in the bottom waters shows a surface water concentration of about 30ug/L, but a bottom concentration of 486ug/L during stratification.

Algae are an important part of the food web, and algae produces oxygen (a crucial need for aquatic life) as a byproduct of photosynthesis (converting light into energy). However, too much algae can overwhelm a lake by preventing light from penetrating into the water and limiting plant growth, and it can cause a reduction in oxygen levels when the algae dies and the process of decomposition uses significant amounts of oxygen.

In Dowling Lake, high levels of phosphorus and warm, shallow waters are conducive to promoting algal blooms. Blooms can occur rapidly and are often recognized as a green-colored scum on the surface of the water. Some blooms of cyanobacteria can be detrimental to human and animal health when toxins are released into the water – these are harmful algal blooms (HAB; see Section 6.1.4.4).

CLMN data at the Deep Hole site for Chl-*a* is available for 1994, 1996, 1997, 2003-04, 2012, 2016, and 2019-20. The chlorophyll data ranges from 2.79ug/L to 111ug/L with an average of 20.20ug/L in summer months. These values are consistent with being eutrophic. A nearshore algal bloom was monitored in 2012 and a chlorophyll value of 36.9ug/L was reported.

4.1.4 Precipitation

At least one volunteer collected and reported rainfall data as a part Community Collaborative Rain, Hail, and Snow (CoCoRaHS) program during the 2019-20 study[4]. The CoCoRaHS program presents collected precipitation data over a period of time from October to September each year called a “water year”. There is one site near Amnicon and Dowling lakes on the west side of Amnicon Lake (WI-DG-27). Rainfall data was recorded beginning in June 2019 and continued through October 2020. This is seasonal rainfall and does not include snowfall. Figures 20 and 21 reflect seasonal rainfall data collected at this site over the 2019 and 2020 open water seasons. Total seasonal rainfall added up to 23.4 inches in 2019 and 23.2 inches in 2020. Rainfall data suggests that the amount of rainfall received each month in both years is lower than the 30yr average, except in September 2019 and July 2020, when precipitation levels were much higher than average. Over this same time frame, there were as many as four storm events when more than 2.0 inches of rain was recorded.

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[4] For more information on CoCoRaHS go to: www.cocorahs.com

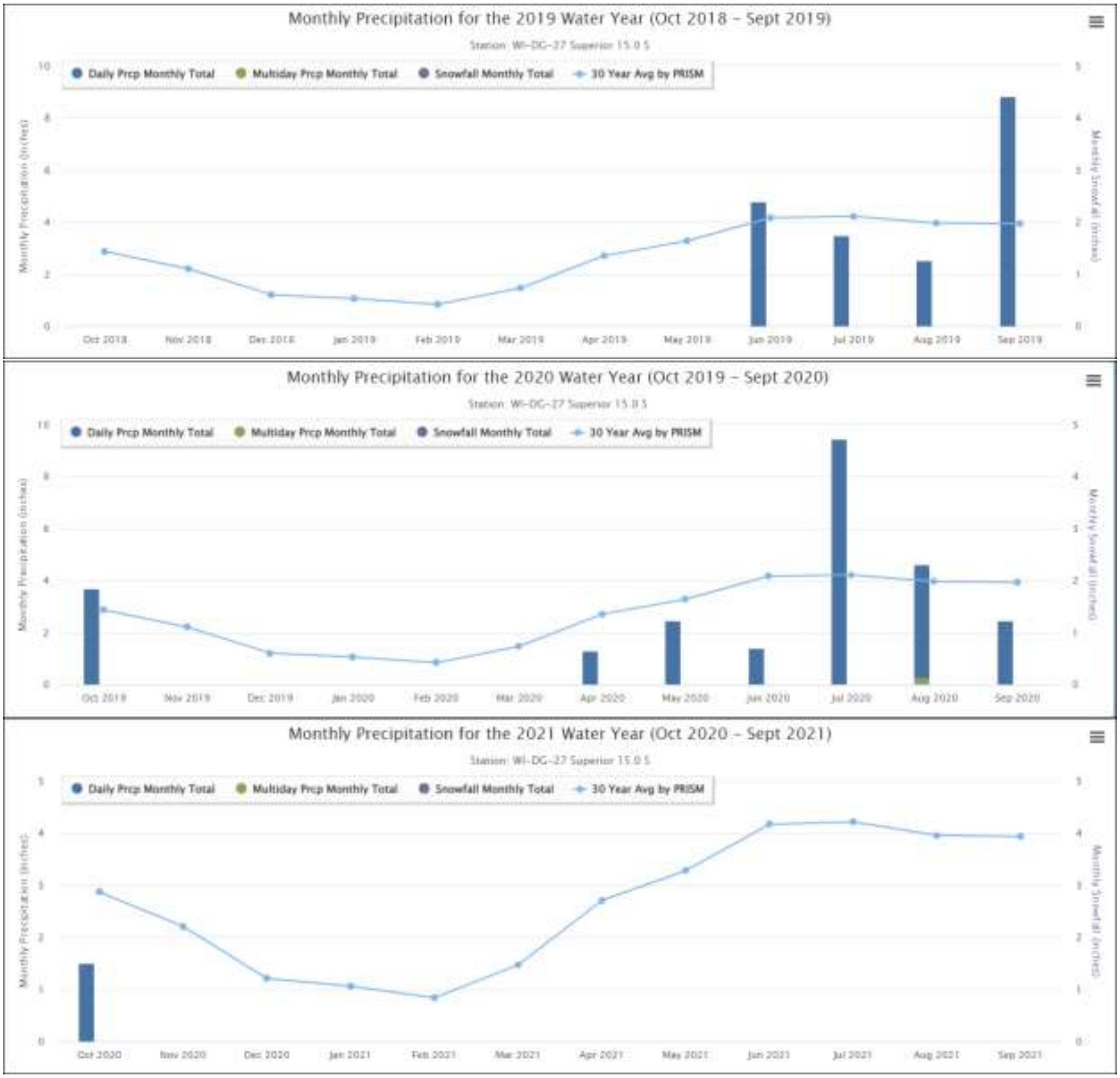


Figure 20: Monthly precipitation for the 2019 and 2020 water years - Site WI-DG-27

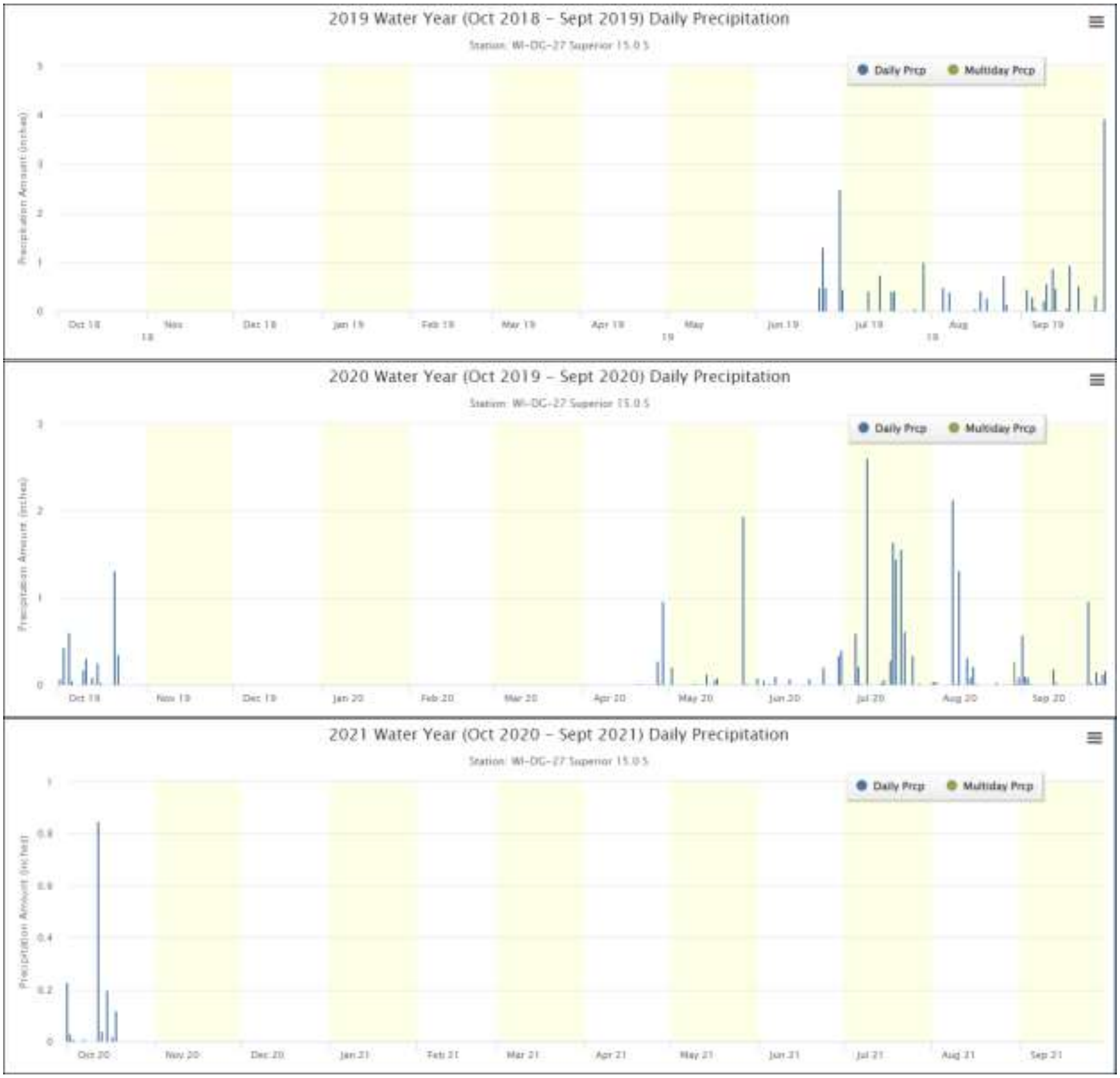


Figure 21: Daily precipitation for the 2019 and 2020 water years - Site WI-DG-27

4.2 Limiting Nutrients

When nutrients that are essential for plant growth are available in smaller quantities than other essential nutrients, they become limiting because plant and algal growth cannot occur without those nutrients, even if others may be in excess. In aquatic systems, the limiting nutrient is often phosphorus or sometimes nitrogen.

4.2.1 Phosphorus as a Limiting Nutrient

Phosphorus (P) is an essential nutrient for algae and aquatic plants (which in turn are food for zooplankton, fish, and aquatic invertebrates). Therefore, P is an important element of the food chain within a lake. Phosphorus is usually present in very small amounts in a lake and is considered a 'limiting factor' for algae and plant growth; i.e., even if there are plenty of other nutrients such as nitrates and carbonates, algae and plants will not grow if there is not enough P (UMassAmherst, 2021).

Phosphorus is found naturally in many types of rocks and soils and can be picked up by groundwater as it moves through the aquifer to the lake. Different soils and rocks have different amounts of P available, so it is possible to have areas where groundwater flowing into a lake has very high or very low levels of natural P. Unfortunately, P is also one of the most readily available nutrients as a direct result of human activities including fertilizers put on the land to grow crops or make lawns more green and lush; wastewater disposal from septic systems, farms, and pet waste; and stormwater runoff from impervious (hard) surfaces (rooftops and driveways), across lawns and other disturbed areas, and from the roads around a lake – all the direct result of residential development. Through these other sources, what is normally considered limited in availability can become available in excess.

Phosphorus that enters a lake is utilized in many different ways. In particulate form attached to soil particles in the water, much of it can drop out of the water column and build up in the sediment at the bottom of the lake where it is used by rooted plants to support growth. If there are not enough plants to use up all of the P, it can remain in the sediment until something happens to make it usable again. In a shallow lake, P can settle to the bottom of the lake, but can quickly and frequently be re-suspended in the water column by waves from wind and boats. It can also be re-suspended when stirred up by fish and other creatures in the lake. In a dissolved form within the water column, algae and other non-rooted plants can use it to grow, often to excessive amounts if there is a lot of P available.

4.2.2 Nitrogen as a Limiting Nutrient

Second only to phosphorus as an important nutrient for plant and algae growth, nitrogen (N) can sometimes limit algae growth. A lake's N sources vary widely. Nitrogen compounds are often in rainfall, so precipitation may be the main N source for seepage and some drainage lakes (lakes with no incoming tributaries). Nitrogen may also come from fertilizer and animal wastes on agricultural lands, human waste from sewage treatment plants or septic systems, and lawn fertilizers used on lakeshore property. Nitrogen can also be pulled directly from the atmosphere by some bacteria, including cyanobacteria that are the source of toxic blue-green algal blooms in many lakes. Organic forms of N may also enter a lake from surface runoff or groundwater sources (UMassAmherst, 2021). High levels of N in its dissolved form can point to poor farm management practices, such as improper manure storage, and failing septic systems, which lead to bacterial pollution.

If the ratio of dissolved forms of N most readily used by aquatic plants to dissolved forms of P is very low, it is possible that adding N will stimulate algae growth. One study (Lee & Jones, 1998), reports that if the ratio of the concentration of available dissolved forms of N (ammonia and nitrate) to that of the available dissolved form of P (soluble orthophosphate) in a water sample collected during the period of water quality concern is <7.5 to 1, N is likely to be the limiting nutrient. If the ratio is >7.5 to 1, then P is the limiting nutrient. Past studies of Dowling Lake have indicated some level of N pollution in the lake.

Using the data collected in 2019 and 2020, nitrogen to phosphorus ratios were explored for Dowling Lake (Table 1). In many cases, the amount of dissolved nitrogen was below the detectable limits of the State Lab of Hygiene (0.051mg/L), so 0.05mg/L is used to represent dissolved nitrogen. The actual values could be much lower, making the ratio even smaller. These ratios show that it is very possible that nitrogen could be the limiting nutrient, not phosphorus, in more cases than not. Conclusions made in the 1996-97 study also indicated that the lake was co-limited by both phosphorus and nitrogen.

Table 1: Dissolved nitrogen (ammonia and nitrates/nitrite – using lowest detectable concentration (0.050)) and dissolved phosphorus ratios

DATE OF SAMPLE	Dissolved forms of nitrogen (mg/L)	Dissolved forms of phosphorus (mg/L)	dissolved N:dissolved P ratio	Limiting Nutrient
5/28/2019 11:00	0.0502	0.0057	8.81	P
6/18/2019 9:00	0.0597	0.00748	7.98	P
7/29/2019 8:30	0.0698	0.0132	5.29	N
8/26/2019 9:00	0.05	0.0104	4.81	N
10/1/2019 7:00	0.05	0.00841	5.95	N
10/28/2019 10:00	0.05	0.0109	4.59	N
5/18/2020 9:00	0.05	0.0105	4.76	N
6/16/2020 9:00	0.05	0.00553	9.04	P
7/20/2020 9:30	0.05	0.00532	9.40	P
8/19/2020 9:30	0.05	0.00889	5.62	N
9/22/2020 9:30	0.05	0.0115	4.35	N
10/13/2020 9:30	0.05	0.0215	2.33	N

4.2.3 Determining the Limiting Nutrient

Since it is not entirely clear whether P or N is the limiting nutrient in Dowling Lake, and given that land use around the lake could definitely be increasing the amount of nitrogen in the lake, it would be beneficial to do more to identify which nutrient is most limiting in the lake. There are several methods to determine which nutrient is limiting outlined below and their feasibility for Dowling Lake.

4.2.3.1 Algal Bioassay

Surface water samples are collected during periods of high algal growth (likely late summer in Dowling) and known quantities of individual nutrients are added to the samples in a lab. The effects of the nutrients on the algae's growth can be used to decide which nutrient was limiting. For example, if the addition of phosphorus stimulated greater growth than the sample that nitrogen was added to, then phosphorus is assumed to be the limiting nutrient. This technique can be expensive and newer techniques using chemical analyses can be more accurate and less costly; thus, this option is not recommended for the ADLMD to pursue.

4.2.3.2 Stoichiometry

Using known stoichiometric (the relationship between quantities of reactants and products before, during, and after chemical reactions) relationships between algae and the amount of nutrients they take up, the limiting nutrient can be determined. Surface samples are collected during high algal growth or a bloom and analyzed chemically for available nitrogen and phosphorus. This provides an assessment of the amounts of nutrients that are still in excess after the peak biomass has been reached. The nutrients that are still in excessive amounts relative to the known amounts needed for growth are not limiting. If soluble orthophosphate concentrations are at or below 0.002 mg/L, phosphorus is limiting; if the available nitrogen concentration is at or below 0.015 mg/L, nitrogen is limiting. If both nutrient levels are greater than these levels, some other factor, like available light or the presence of a toxicant, may be the limiting factor. This technique requires samples to be taken at peak algal biomass and then processed by a certified lab. The ADLMD already takes water samples on the lake and are familiar with the process; thus, this type of procedure is a viable option for the ADLMD to use to determine the limiting nutrient in Dowling Lake.

4.2.3.3 Nutrient Diffusing Substrates (NDS)

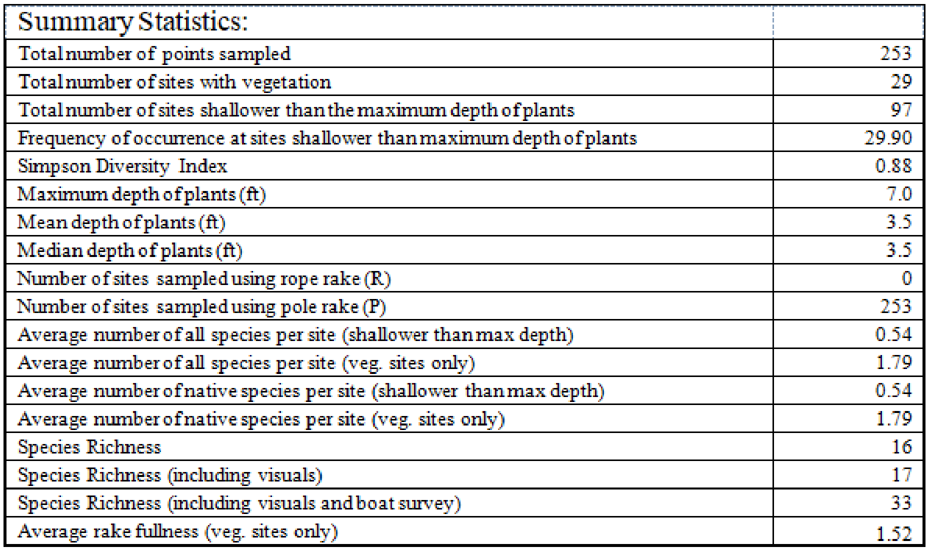
NDS can be used to determine the limiting nutrient in Dowling Lake. An array of small pots can be seeded with N, P, both, and neither. After several weeks in the lake, whichever designation of pots with a specific treatment has the greatest algal growth is the limiting nutrient. This design is relatively cost effective, repeatable, and can be done with a small amount of volunteer effort. This method can be utilized by the ADLMD to determine Dowling's limiting nutrient.

4.3 Aquatic Plants

Like trees in a forest, a lake's native plants are the basis of the aquatic ecosystem. They capture the sun's energy and turn it into usable food, "clean" the water of excess nutrients, and provide habitat for other organisms like aquatic invertebrates and the lake's fish populations. Because of this, preserving them is critical to maintaining the lake's overall health. Unfortunately, when phosphorus and nitrogen levels exceed what the lake's macrophytes can utilize, it tends to promote algae blooms which impact these sensitive species as well as general lake aesthetics.

Dowling Lake has a very limited plant community in both density and distribution. During the 2012 whole-lake aquatic plant survey, plants were found growing at only 29 sites or approximately 11.5% of the entire lake bottom and in 29.9% of the 7ft littoral zone (Table 2, Figure 22). Total rake fullness was moderately low averaging 1.52 at sites with vegetation. During a plant density survey completed in 2016, repeated random raking to establish the extent of the littoral zone never turned up submergent plants deeper than 5ft; apparently due to the poor water clarity. Even when present, the majority of rake samples had just a few plants on the head. In general, the Dowling Lake ecosystem is home to a diverse but very limited plant community that, in most areas, extends no more than 20 yards from shore (Figure 22).

Table 2: Aquatic Plant Survey Summary Statistics. Dowling Lake, Douglas County August 3, 2012



Summary Statistics:	
Total number of points sampled	253
Total number of sites with vegetation	29
Total number of sites shallower than the maximum depth of plants	97
Frequency of occurrence at sites shallower than maximum depth of plants	29.90
Simpson Diversity Index	0.88
Maximum depth of plants (ft)	7.0
Mean depth of plants (ft)	3.5
Median depth of plants (ft)	3.5
Number of sites sampled using rope rake (R)	0
Number of sites sampled using pole rake (P)	253
Average number of all species per site (shallower than max depth)	0.54
Average number of all species per site (veg. sites only)	1.79
Average number of native species per site (shallower than max depth)	0.54
Average number of native species per site (veg. sites only)	1.79
Species Richness	16
Species Richness (including visuals)	17
Species Richness (including visuals and boat survey)	33
Average rake fullness (veg. sites only)	1.52

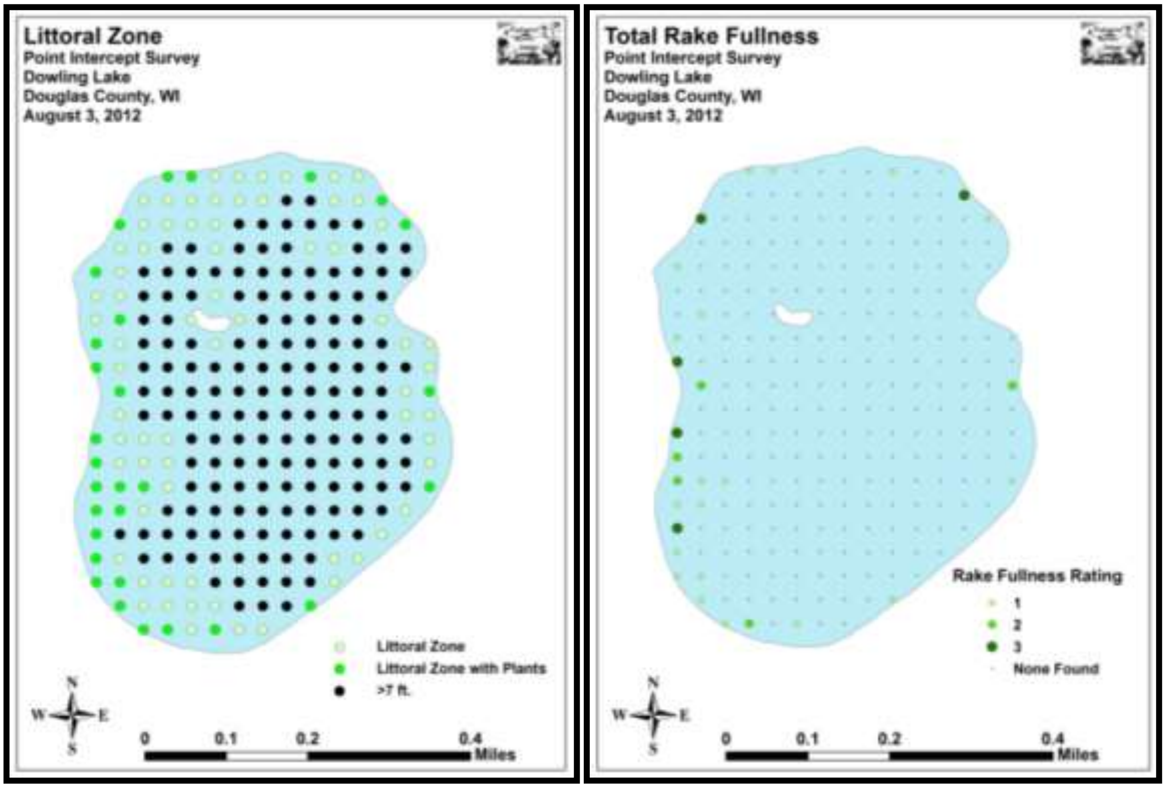


Figure 22: 2012 Littoral Zone and Total Rake Fullness

No wild rice was found in 2012 or 2016 in the lake; however, the overall emergent community is both rich and diverse. With so few plants anywhere else in the lake, these beds are likely important fish habitat; especially during spawning. Dominated by Hardstem bulrush (*Schoenoplectus acutus*), Creeping spikerush (*Eleocharis palustris*), and Pickerelweed (*Pontederia cordata*), the emergents seldom extended more than 10 meters (Figure 23).

Figure 23: Typical narrow emergent aquatic plant community

The floating-leaf community tended to have low richness and diversity. Throughout much of the lake, scattered Watershield (*Brasenia schreberi*), Spatterdock (*Nuphar variegata*), and Floating-leaf bur-reed (*Sparganium fluctuans*) occurred as isolated clusters or in small patches that grew in a narrow band just beyond the emergents. The only exception to this was along the western shoreline where beds stretched a few 10's of meters to the east along shallow flats (Figure 24).

Figure 24: Densest floating-leaf area on the western shoreline

During data collection for the 2006 plan, it was reported that 16 species of aquatic plants were identified in Dowling Lake. It was also reported that Dowling Lake had a high macrophyte (large plant) population due to the eutrophic nature of the water. Data collected since then does not support the notion of a high large plant population. Rather, due to poor water clarity and excessive algae growth, the large plant community is extremely limited.

4.3.1 Algae

Algae are a necessary and vital part of the food web in a lake. Not only does it provide food to many critters in the water (like grass is food for cattle), it also helps create the oxygen necessary to support most aquatic life. Occasionally, algae can be troublesome. The concentration of phytoplankton (free-floating algae) in the water strongly influences water clarity. Benthic (growing on the bottom of the lake) algal blooms and filamentous/periphyton (attached to aquatic plants or other underwater structures) algal blooms can create accumulations along shorelines and have the potential to interfere with recreational activities such as boating and swimming, and block lake access and navigation. Algal blooms can block sunlight, shading out submersed aquatic plants, which are necessary in a lake. Algal blooms can also trigger a chain of events that can result in a fish kill, most likely to occur after several days of hot weather with overcast skies and related to depletion of oxygen in the water, not toxicity. News reports often describe instances of toxic algae; however, most forms of algae are not toxic and pose very little danger to humans. Known health issues associated with algae blooms are generally tied to several species of cyanobacteria, often referred to as blue-green algae (Florida Lakewatch, 2000).

The availability of phosphorus, and likely nitrogen, is the main driver for excess algal growth. Numerous studies have shown that high loading of phosphorus leads to high phytoplankton biomass, turbid water, loss of biodiversity, disappearance of submerged vegetation, fish stock changes, and decreasing top-down control by zooplankton on phytoplankton Sondergaard et al.(2003). To reduce the amount of available nutrients, focus is often put on sources outside of the lake (external) including the watershed and nearshore area around a lake. Unfortunately, reducing external sources is in many cases, not enough to support a shift from a turbid to a clear water state. Phosphorus built up in the sediment within the lake over long periods of time is released back into the water by many difference processes. This release of phosphorus from the sediment may be so intense and persistent that it prevents any improvement of water quality for a long period of time, even after all external sources have been reduced Sondergaard et al. (2003).

This is likely what is happening in Dowling Lake. The flushing rate of the lake and its nutrient loading history influence internal loading. The release and availability of phosphorus from the sediment in a shallow, mixed lake is influenced by numerous other mechanisms including resuspension, chemical reactions, pH, bioturbation, mineralization and microbial processes, temperature, and submerged aquatic plants Sondergaard et al. (2003). It is likely that all of these mechanisms are at play in Dowling Lake, but not all of them have solutions to reduce their impact (See Section 5.1).

4.4 Fish and Wildlife

4.4.1 Fish

Dowling Lake supports a warm water fishery comprised of muskie, panfish species, largemouth bass, and walleye. Dowling has been stocked with a variety of species extending back to 1934 when walleyes, muskies, bass, and panfish were first stocked in the lake (Manz, 2004). Walleyes and muskies were stocked annually from 1940-1970, and the stocking of muskies continued up until 1978 (Manz, 2004). Fishery surveys in 1947, 1967, 1989, 1991, 2004, and 2012 have shown that walleye, muskies, and black crappie are common in the lake. A comprehensive fishery survey in 1977 also found that stocking muskies and walleye in Dowling was no longer necessary because of low growth rates, high population numbers, and natural reproduction (Manz, 2004). The WDNR performed other fishery surveys on the lake in 1978 and 1982, and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) surveyed the lake in fall of 1989 and spring of 1991. The 1989 fall electrofishing survey and the 1991 spring walleye population estimate survey found sufficient numbers of walleyes of harvestable size (at least 15 inches; (Manz, 2004). A 2004 electrofishing study of Dowling Lake found the spawning population of walleyes in Dowling to be almost twice as high as other lakes in the area – 7.24/acre and 3.7/acre, respectively – and above the statewide goal of 3.0/acre (Manz, 2004). Stocking of walleyes has resumed in Dowling intermittently from 2010-2019.

Fish species other than walleye and muskie known to be in the lake are largemouth bass, rock bass, pumpkinseed, black crappie, yellow bullhead, black bullhead, white sucker, tadpole madtom, johnny darter, fathead minnows, and golden, common, spottail, and blacknose shiners (Figure 25). Largemouth bass and other panfish species (black crappie, bluegill, pumpkinseed, etc.) are known to be in relatively high numbers with adequate growth but few reaching significant size. Historically, Northern pike have not been in Dowling Lake, but in recent years, their population has been increasing raising some concern.

The latest available fish survey from 2012 indicates that Dowling has a lower bluegill population than is typical for lakes in the area; however, the method used in the survey (electrofishing) often does not accurately represent populations of smaller bodied fish like bluegill.

4.4.2 Zooplankton

The zooplankton community is an essential component of a lake ecosystem. Zooplankton are organisms that have animal-like traits. The biggest are only five millimeters long and the smallest are just one thousandth of this size. They float, drift or weakly swim in the water. Freshwater zooplankton are found in lakes, streams and swamps. They are most abundant nearer the surface as they eat phytoplankton (microscopic plants/algae) which need light to photosynthesize. Many species move into shallower waters at night.[5]

One of the most common zooplankton species in lakes is *Daphnia sp.* (Figure 25). Daphnia populations can be found in a range of water bodies, from huge lakes down to very small temporary pools, such as rock pools and vernal pools (seasonally flooded depressions). Often they are the dominant zooplankton and are an essential part of the food web in lakes and ponds. Zooplankton like daphnia are the predominant food for macroinvertebrates and planktivorous fish, at least at times. As such, their distribution and life history are closely linked with the

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[5] For more information about zooplankton and daphnia go to: https://www.doc.govt.nz/nature/native-animals/invertebrates/zooplankton/ or https://www.ncbi.nlm.nih.gov/books/NBK2042/

occurrence of predators. Because many zooplankton, like Daphnia, graze on phytoplankton, having a healthy and robust zooplankton community can help reduce certain species of algae in a lake, in turn helping to maintain a more natural balance of algae. However, predation by an over-abundant panfish community reduces the number of zooplankton available to consume algae (Figure 25). Predation is not the only reason a beneficial zooplankton community may suffer. Variations in water quality such as changes in nutrient levels, conductivity, temperature or pH, can lead to changes in species composition and abundance.

BLUEGILL SUNFISH

- Eats *Daphnia*
- Bluegill sunfish usually forage for the larger ones
- They will select smaller *Daphnia* if the larger ones are too far away
- Not selective when density of *Daphnia* is low
- Selective for larger if high density

Figure 25: *Daphnia sp.* and bluegill predation (https://slidetodoc.com/option-e-6-further-studies-of-behaviour-assessment/)

The last time the zooplankton community was evaluated was in 1986-87, and only in Amnicon Lake. At that time, the species present reflected a common lake zooplankton community. It is these zooplankton that feed on many different species of available algae or phytoplankton. Sampling of zooplankton in both Amnicon and Dowling lakes and making comparisons might provide some insight into the how this community is or is not impacting Dowling Lake, and could provide valuable information about implementing management actions that manipulate the trophic interactions within the lake.

4.4.3 Wildlife

While no official wildlife surveys have been performed in the lake or in the drainage basin, many species are known to inhabit the watershed and the surrounding area, and it reasonable to assume that a variety of species can, and do, use Dowling Lake for a variety of purposes during their life cycles. The WDNR lists bald eagles, gray jays, Nashville warblers, bog copper butterflies, and bog fritillary butterflies as present in the watershed. The Wisconsin Natural Heritage Inventory (NHI) tracks 24 species of rare plants that have been documented in the Northwest Lowlands as of 2009. Of these, three are Wisconsin Endangered, six are Wisconsin Threatened, and 13 are Wisconsin Special Concern (WDNR, 2015). White-tailed deer, moose American black bear, American beaver, North American river otter, fisher, bobcat, Ruffed Grouse, American Woodcock, Mallard, Wood Duck, and Ring-necked Duck are all important for hunting, trapping, and wildlife viewing and are known to use, or may possibly use, Dowling Lake for part of their life cycle or on a seasonal basis (WDNR, 2015).[6]

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[6] See *The ecological landscapes of Wisconsin* Chapter 16 for more information at: https://dnr.wi.gov/topic/Landscapes/documents/1805Ch16.pdf#view=Fit

The NHI program is part of an international network of programs that focus on rare plants and animals, natural communities, and other rare elements of nature. Each species has a state status including Special Concern, Threatened, or Endangered. It is important for lake managers to consider impacts to these valuable species, nearly all of which can be directly affected by aquatic plant management. Choosing the proper management techniques and the proper timing of management activities can greatly reduce or prevent negative impacts.
Five Special Concern species are listed for the area – the bald eagle, the Rocky Mountain sprinkled locust, the arctic fritillary, the Connecticut warbler, and the Forcipate emerald.

The NHI tracks examples of all types of Wisconsin's natural communities that are deemed significant because of their undisturbed condition, size, what occurs around them, or for other reasons. Natural communities listed for the area include: boreal forest, lake – soft bog, and northern wet forest.

The NHI also tracks other natural features that provide important habitat for certain plants and animals and are places where a catastrophic event could have an impact on a large number of common and/or rare species. A bird rookery is one such natural feature listed for the area.

A number of high value aquatic plant species listed in NR 107 including Richardson's Pondweed (*Potamogeton richardsonii)*, aquatic sedges (*Eleocharis spp.*), aquatic rushes (*Scirpus spp.*) (also known as *Schoenoplectus spp.*), and watershield (*Brasenia schreberi*) have been found in Dowling Lake. These plant species are known to offer important value to the aquatic ecosystem and any plant control activities in areas containing these high value species will be done in a manner which will not result in long-term or permanent changes to the plant community.

4.4.4 Dowling Lake Food Web – Trophic Cascade

Dowling's food web is ultimately driven by sunlight that drives photosynthesis that algae and plants at the bottom of the food web use for energy. Zooplankton (microscopic animals) eat the phytoplankton (algae), and in turn the zooplankton get eaten by macroinvertebrates (aquatic bugs insects like caddisfly larvae, dragonfly larvae, snails, and crayfish; Figure 26). The macroinvertebrates are eaten by the next higher trophic level (the next hierarchy in the food web) that is mostly minnows, shiners, darters, suckers, fish larvae, and small (young of year) fish (Figure 26). The small fish are eaten by bigger fish like largemouth bass (that can eat other adult fish) bluegill, pumpkinseeds, and black crappies that also eat larger zooplankton into adulthood (Figure 26). The next trophic level are the piscivores (fish eaters) that primarily eat only other fish (Figure 26). In Dowling, this would be walleye and muskies, although muskies are known to eat birds and mammals as well. Fish will ultimately eat just about anything that they can fit in their mouth – including other fish of the same species (cannibalism), their own young, a variety of other fish, invertebrates (aquatic and terrestrial bugs and insects), frogs, turtles, snakes, rodents, other small mammals, birds (ducklings especially), etc. In turn, fish of all sizes can be eaten by birds, otters, humans, etc. Food webs and trophic interactions are complex and often over simplified.

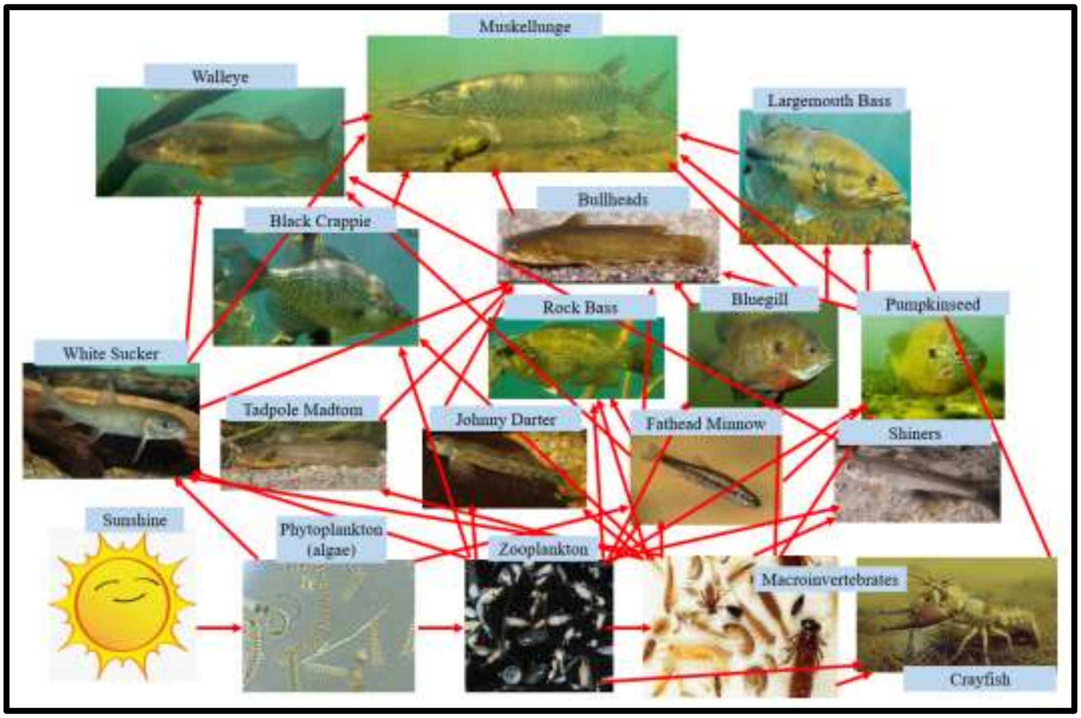


Figure 26: Dowling Lake food web interactions

Trophic Cascade/Biomanipulation in Lakes

A trophic cascade is an ecological phenomenon triggered by the addition or removal of top predators and involving reciprocal changes in the relative populations of predator and prey through a food chain, which often results in dramatic changes in ecosystem structure and nutrient cycling. In lakes, trophic cascades are used to improve water quality through biomanipulation, a management practice in which humans intentionally remove whole species from ecosystems (see Section 5.2.2).

4.5 Shorelands/Nearshore Area

Shoreline management can have big impacts on the water quality and health of a lake. Natural shorelines prevent polluted runoff from entering lakes, help control flooding and erosion, provide fish and wildlife habitat, may make it harder for aquatic invasive species (AIS) to establish themselves, muffle noise from watercraft, and preserve privacy and natural scenic beauty. Many of the values lake front property owners appreciate and enjoy about their properties -- natural scenic beauty, tranquility, privacy, relaxation -- are enhanced and preserved with good shoreland management. Additionally, healthy lakes with good water quality translate into healthy lake front property values.

Shorelands may look peaceful, but they are actually the hotbed of activity on a lake. At least 90% of all living things found in lakes – from fish, to frogs, turtles, insects, birds, and other wildlife –are found along the shallow margins and shores. Many species rely on shorelands for all or part of their life cycles as a source of food, a place to sleep, cover from predators, and shelter to raise their young. Shorelands and shallows are the spawning grounds for fish, nesting sites for birds, and where turtles lay their eggs. There can be as much as 500% more species diversity at the water's edge compared to adjoining uplands.

Lakes are buffered by shorelands that extend into and away from the lake. These shoreland buffers include shallow waters with submerged plants (like coontail and pondweeds), the water's edge where fallen trees and emergent plants like rushes might be found, and upward onto the land where different layers of plants (low ground cover, shrubs, trees) may lead to the lake.

Shorelands are critical to a lake's health. Activities such as replacing natural vegetation with lawns, clearing brush and trees, importing sand to make artificial beaches, and installing structures such as piers, can cause water quality decline and change what species can survive in the lake.

4.5.1 Protecting Water Quality

Shoreland buffers of native vegetation can slow down rain and snow melt (runoff). Runoff can add nutrients, sediment, and other pollutants into lakes, causing water quality declines. Slowing down runoff provides more time for water to soak (infiltrate) into the ground. Water that infiltrates into the ground is less likely to damage lake quality, and it recharges the groundwater that supplies water to lakes. Slowing down runoff also reduces flooding, and stabilizes stream flows and lake levels.

Different types of natural shorelands provide different benefits to the lake's ecosystem and overall health. Shoreland wetlands act like natural sponges trapping nutrients where nutrient-rich wetland sediments and soils support insects, frogs, and other small animals eaten by fish and wildlife. Shoreland forests act as filters, retainers, and suppliers of nutrients and organic material to lakes. The tree canopy, young trees, shrubs, and forest understory all intercept precipitation, slow runoff, and contributing to water infiltration by keeping the soil's organic surface layer well-aerated and moist. Forests also slow down water flowing overland, often capturing its sediment load before it can enter a lake or stream. In watersheds with a significant proportion of forest cover, the erosive force of spring snow melts is reduced as snow in forests melts later than snow on open land, and melt water flowing into streams is more evenly distributed. Shoreland trees grow, mature, and eventually fall into lakes where they protect shorelines from erosion, and are an important source of nutrients, minerals and wildlife habitat.

4.5.2 Protecting Against Invasive Species

In addition to removing essential habitat for fish and wildlife, clearing native plants from shorelines and shallow waters can increase opportunities for invasive species to take over. Like tilling a home garden to prepare it for seeding, clearing shoreland plants exposes bare earth and removes the existing competition (the cleared shoreland plants) from the area. While the same native shoreland plants may recover and reclaim their old space, many invasive species possess "weedy" traits that enable them to quickly take advantage of new territory and out-compete natives.

The act of weeding creates continual disturbance, which in turn benefits plants that behave like weeds. The modern-day practice of mowing lawns is an example of keeping an ecosystem in a constant state of disturbance to the benefit of invasive species like turf grass, dandelions, and clover, all native to Europe. Keeping shorelines intact is a good way to minimize disturbance opportunities for invasive species to gain a foothold.

4.5.3 Threats to Shorelands

When a landowner develops a waterfront lot, many changes may take place, including the addition of driveways, houses, boat houses, decks, garages, sheds, piers, rafts, wells, septic systems, lawns, sandy beaches and more. Many of these changes result in the compaction of soil and the removal of trees and native plants, as well as the addition of impervious surfaces, all of which alter the path that precipitation takes to the water.

Each of these alterations decreases the ability of the shoreland area to serve its natural functions. Removal of trees and native plants eliminates the food and shelter on which wildlife depends; natural beauty is replaced with manmade materials; water cannot soak into the ground thereby increasing stormwater runoff that carries fertilizers, pesticides and other pollutants to the lakes and streams. If 50% of a lot is converted to impervious surfaces, half of this lot is no longer capable of filtering rainwater or providing the food and shelter on which wildlife depends. Changing one waterfront lot in this fashion may not result in a measurable change in the quality of the lake or stream., but cumulative effects when several or many lots are developed in a similar way can be enormous. A lake's response to stress depends on what condition the system is in to begin with, but bit by bit, the cumulative effects of waterfront property owners "cleaning up" their shorelines, are destroying the shorelands that protect their lakes. Increasing shoreline development and development throughout the lake's watershed can have undesired cumulative effects. Figure 27 is a real-life example how a new development project can change the landscape in just two years.

Figure 27: New lakeside development not on Dowling Lake (2016-left), same site (2018-right)

4.5.4 Shoreland Preservation and Restoration

If a native buffer of shoreland plants exists on a given property, it can be preserved and care taken to minimize impacts when future lake property projects are contemplated. If a shoreline has been altered, it can be restored. Shoreline restoration involves recreating buffer zones of natural plants and trees. Not only do quality wild shorelines create higher property values, but they bring many other values too. Some of these are aesthetic in nature, while others are essential to a healthy ecosystem. Healthy shorelines mean healthy fish populations, varied plant life, and the existence of the insects, invertebrates and amphibians which feed fish, birds, and other creatures. More information about healthy shorelines can be found at the following website: http://wisconsinlakes.org/index.php/shorelands-a-shallows.

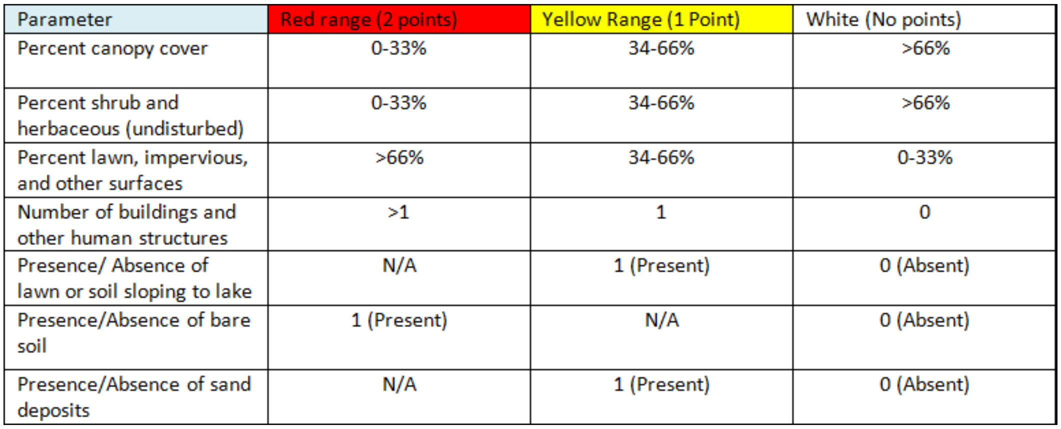
4.6 Shoreland Habitat Assessment

The shoreline and upland areas surrounding Dowling Lake are highly developed. Thatcher Engineering's shoreland inventory of Dowling Lake in the 2003-04 study showed that <50% of the shoreland and upland area within the developed band around the lake was in a natural state. In the 2019-20 study, LEAPS and volunteers from the ADLMD completed a "shoreland habitat assessment" following WDNR protocols, as well as a land use digitizing examination of a 300-ft band of the land around the lake. The results of the shoreland habitat assessment and land use digitizing agree with the findings of the 2003-04 study: Dowling's shoreline is heavily developed with little "natural" land remaining.

4.6.1 Habitat Improvement Potential Ranking Parameters

Included in the shoreland habitat assessment were rankings for each parcel (developed by LEAPS) that create a hierarchy for which parcels have major issues and the most potential for improvement that could be addressed with BMPs. The parameters used to determine the potential were considered to be those that would have the biggest impact on rainwater runoff and habitat quality. This includes percentage of canopy cover, as well as the percentage of undisturbed vegetation and a summed percentage of ground covered by manicured lawn, impervious surfaces, and easily eroded surfaces such as exposed soil or shredded vegetation such as pine needles, loose leaves, small branches, etc. also known as duff. Additional consideration was given to the number of buildings present in the riparian zone and the presence or absence of lawns that sloped directly to the lake. For each factor that was considered, there are value ranges assigned to each parameter which determine the color to be assigned, the value ranges can be seen below in Table 3. Values that fall within the red range are worth 2 points, values in the yellow range are worth 1 point, and values in the white range are not given any points. The points are then summed and the properties sorted based on the point range for the entire lake.

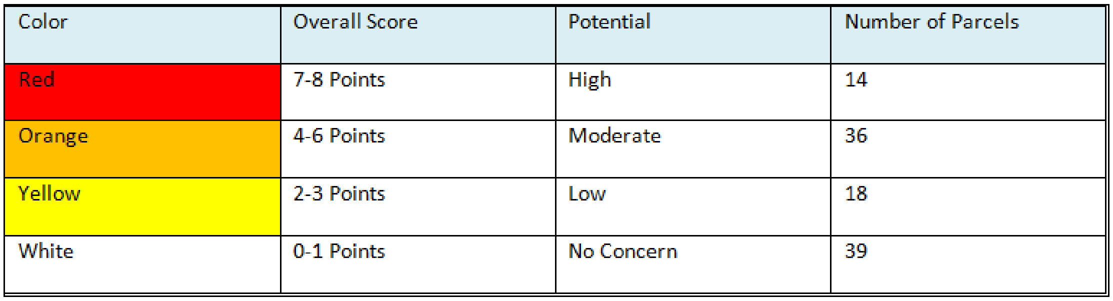
Table 3: Value ranges for color assignments for each parameter of concern



Parameter	Red range (2 points)	Yellow Range (1 Point)	White (No points)
Percent canopy cover	0-33%	34-66%	>66%
Percent shrub and herbaceous (undisturbed)	0-33%	34-66%	>66%
Percent lawn, impervious, and other surfaces	>66%	34-66%	0-33%
Number of buildings and other human structures	>1	1	0
Presence/ Absence of lawn or soil sloping to lake	N/A	1 (Present)	0 (Absent)
Presence/Absence of bare soil	1 (Present)	N/A	0 (Absent)
Presence/Absence of sand deposits	N/A	1 (Present)	0 (Absent)

Based on these parameters, a maximum score of 16 could be generated for each parcel. The higher the score, the higher priority, or potential for habitat improvement and runoff reduction projects is determined. The maximum score generated from the 108 parcels assessed on Dowling Lake was an 8. Parcels that generated a score of 7 or 8, were given a high priority, 4-6 points a moderate priority; 2-3 points low priority, and 0 or 1 point essentially no priority meaning the parcel was pretty much in a natural state (Table 4).

Table 4: Score ranges and project potential rankings for the 108 parcels assessed



Color	Overall Score	Potential	Number of Parcels
Red	7-8 Points	High	14
Orange	4-6 Points	Moderate	36
Yellow	2-3 Points	Low	18
White	0-1 Points	No Concern	39

More than 46% (50 of 108) of the parcels assessed received a moderate or high potential rating, suggesting that much could be done to improve habitat and minimize runoff (Figure 28). For each parcel, management recommendations were made based on projects that could be funded via a WDNR Healthy Lakes and Rivers grant. These include rain gardens, native plantings, diversions, infiltration trenches, and installation of “fishsticks” coarse woody habitat projects. A separate document holds all of the results of the shoreland habitat assessment and recommendations made and can be used to help guide shoreland improvement projects.

From the 2003 Management Plan (Thatcher Engineering Inc, 2006), Amnicon and Dowling Lakes are the most highly developed per acre surface water of all lakes in Douglas County with both 2 and 3 tier development. Currently, there are about 125 parcels around the Dowling Lake with a lake perimeter of 1.95-mi. This makes the average amount of shoreline with each parcel about 88-ft. Of the 125 parcels, 85 of them have houses based on the current Douglas County GIS data, or about 68% are developed. In 2003-04, about 50% of the properties evaluated had >50% of the shoreland area in a natural condition. From the 2019 shoreland habitat assessment, again about 50% of the parcels in the 35-ft riparian zone had >50% natural shoreland. The average amount of natural shoreland for each parcel across all parcels evaluated was about 57%.

4.6.2 300-ft Nearshore Land Use Digitizing

In addition to the shoreland habitat assessment of the first 35-ft of the riparian zone, land use digitizing was completed in a 300-ft band around the lake (Figure 29). In total, the area assessed covers a little more than 71 acres. Within that area, there is nearly 9 acres of impervious surface and 24 acres of lawn, meaning a little more than 46% of the area is disturbed. About 54% was in a natural state with forests, shrubs, and wetlands. In the 2003-04 study, about 46% of the parcels evaluated had >50% of the upland area in a natural state.

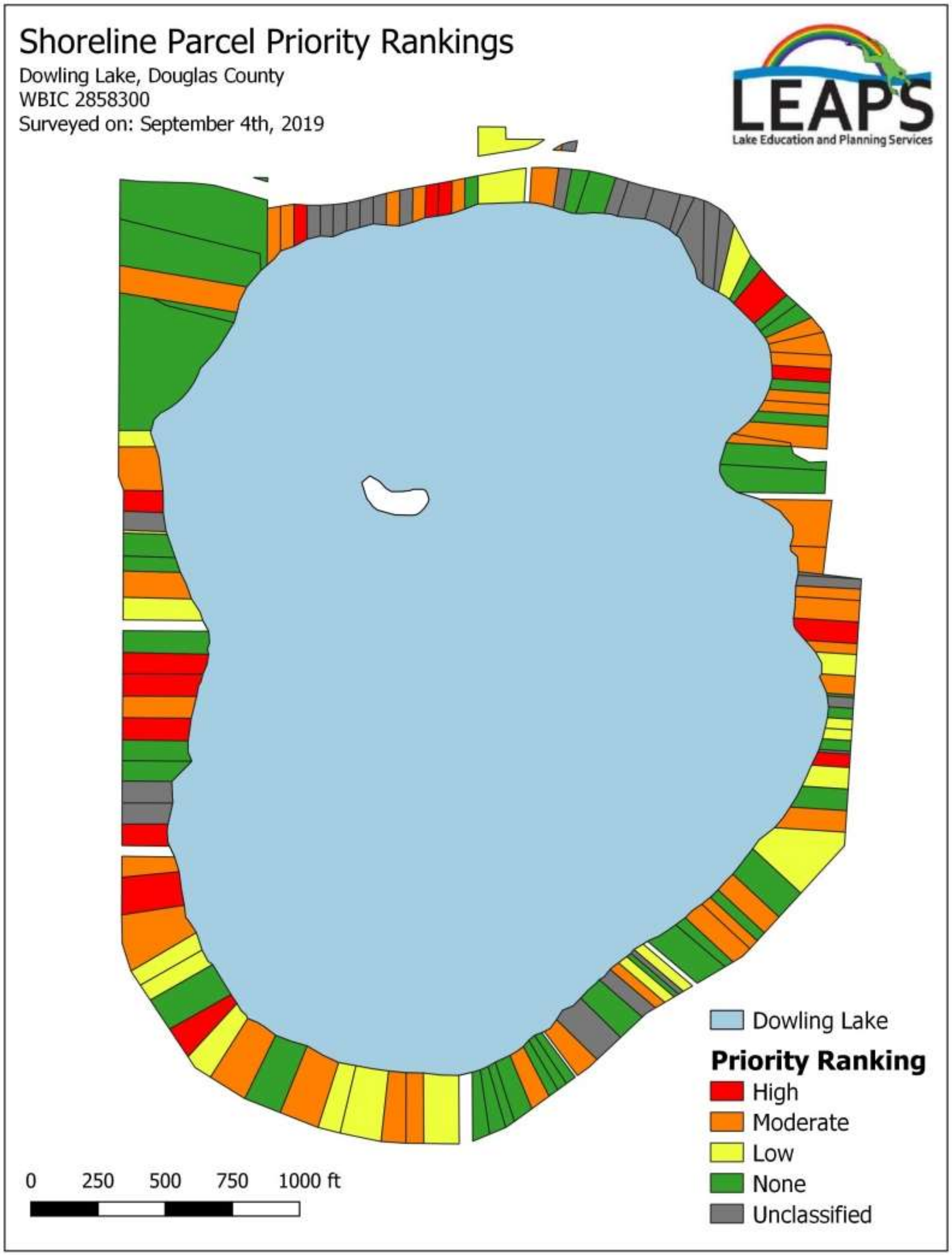


Figure 28: Individual parcel "potential projects" rankings from 2019 for Dowling Lake

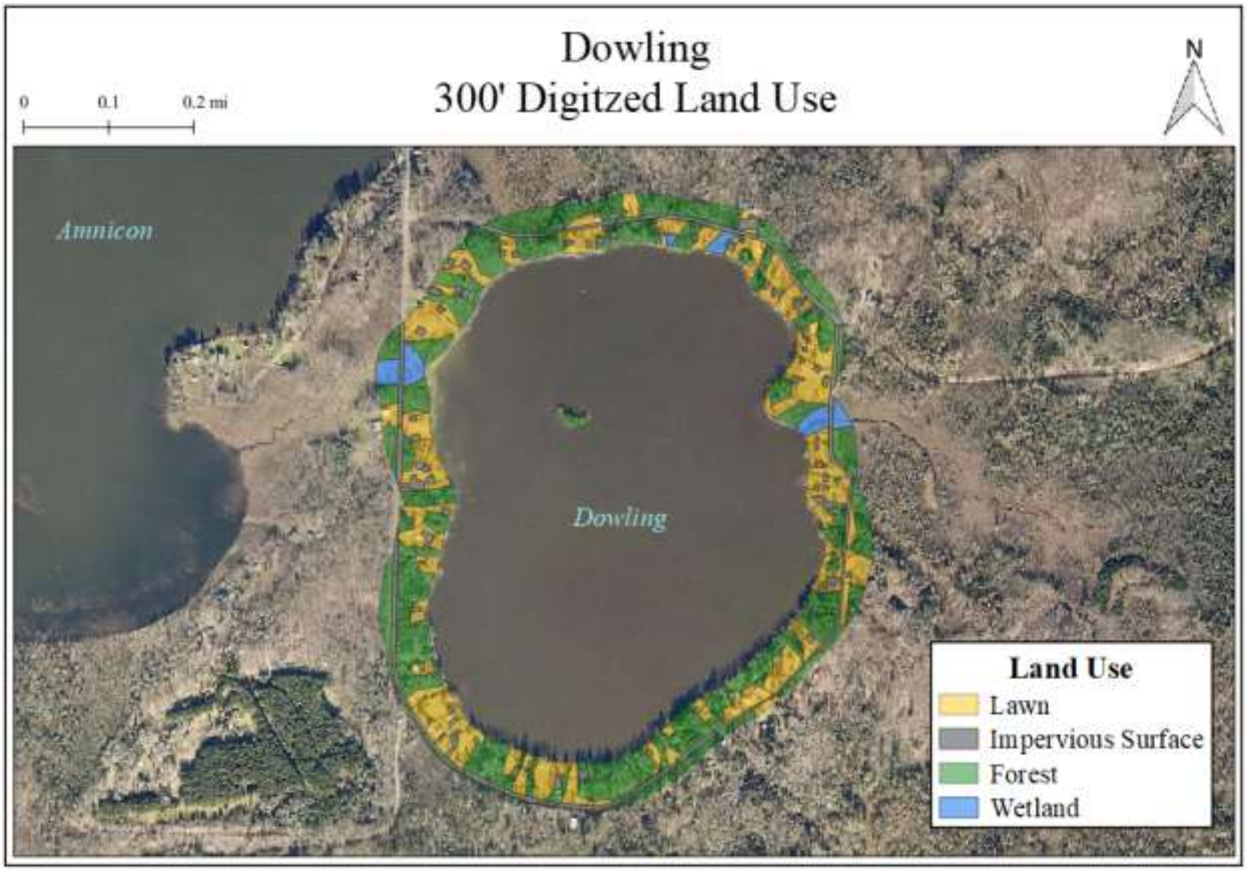


Figure 29: 2019 Land use digitizing results from Dowling Lake

Since the completion of the shoreland habitat assessment, at least two parcels on Dowling Lake have been taken from a mostly natural state to a developed state. Lakeshore property and shoreline modifications are sometimes necessary and can be done in a way that benefits the lake. Before beginning any and all shoreland modifications, make sure all town, county, and state zoning rules and regulations have been followed. Even with permits in hand, it is beneficial to spend at least a little time with a shoreland specialist to help determine how best to deal with an issue – legally. If not done legally, a property owner may be forced to restore a disturbed area, mitigate changes by others means, pay fines, or all three.

4.6.3 Coarse Woody Habitat

Coarse woody habitat (CWH) in lakes is classified as trees, limbs, branches, roots, and wood fragments at least 4 inches in diameter that enter a lake by natural (beaver activity, toppling from ice, wind, or wave scouring) or human means (logging, intentional habitat improvement, flooding following dam construction). CWH in the littoral or near-shore zone serves many functions within a lake ecosystem. The presence of CWH has been shown to prevent the suspension of sediments, thereby improving water clarity (Sass, 2009). CWH also serves as important refuge, foraging, and spawning habitat for fish, aquatic invertebrates, turtles, birds, and other animals. The amount of littoral CWH occurring naturally in lakes is related to characteristics of riparian forests and likelihood of toppling. However, humans have also had a large impact on amounts of littoral CWH present in lakes through time. During the 1800's the amount of CWH in northern lakes was increased beyond natural levels as a result of logging practices (Sass, 2009). But changes in the logging industry and forest composition along with increasing shoreline development have led to reductions in CWH present in many northern Wisconsin lakes.

CWH is often removed by shoreline residents to improve aesthetics or for select recreational opportunities (swimming and boating). Jennings et al. (2003) found a negative relationship between lakeshore development and the amount of CWH in northern Wisconsin lakes. Similarly, Christensen et al. (1996) found a negative correlation between density of cabins and CWH present in Wisconsin and Michigan lakes. While it is difficult to make precise determinations of natural densities of CWH in lakes it is believed that the value is likely on the scale of hundreds of logs per mile. The positive impact of CWH on fish communities have been well documented by researchers, making the loss of these habitats a critical concern (Wolter, 2012).

The Shoreland Habitat Assessment performed by LEAPS in 2019 assessed the amount of CWH present in the lake. Figure 30 shows all the locations in Dowling Lake where CWH was identified. While many points with CWH were identified during the survey, much of this consisted of a log or branch in the water (simple CWH) versus a whole tree with many branches and larger stumps or logs all intertwined (complex CWH).

WDNR Fisheries Managers have expressed their support for the construction of "Fishsticks" projects along the shores of lakes like Dowling with relatively little naturally occurring CWH. Fishsticks are fish structures created from whole trees cut and stacked on top of each other (Figure 31). Fishsticks are typically installed in the winter and anchored to the shore. During ice melt the trees sink to the bottom creating the habitat where it remains until its natural decomposition.

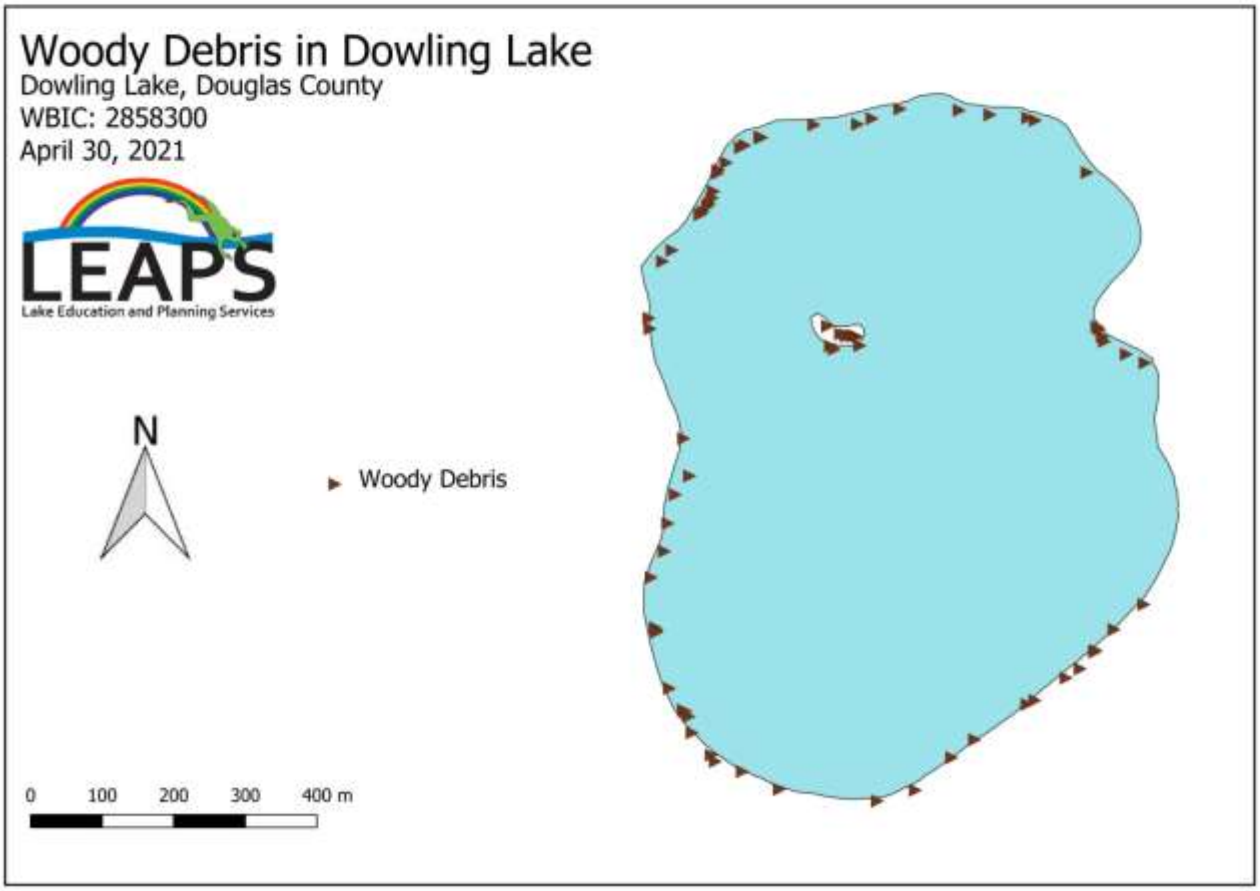


Figure 30: Coarse woody habitat around Dowling Lake

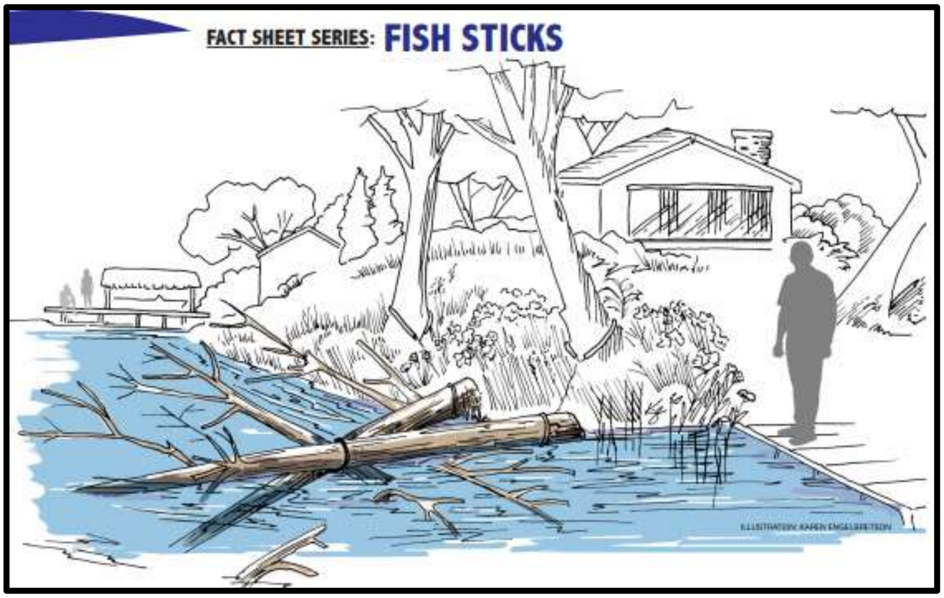


Figure 31: Healthy Lakes Fact Sheet Series: Fishsticks. WDNR/Wisconsin Lakes Partnership

4.7 Aquatic Invasive Plant Species

To date, no Eurasian watermilfoil (*Myriophyllum spicatum*, EWM) has been found in the lake. Curly-leaf pondweed (*Potamogeton crispus*, CLP), another submersed non-native, aquatic plant, has been documented in the lake but was not seen in either the 2021 or 2016 plant surveys. Purple loosestrife (*Lythrum salicaria*), a shoreland/wetland non-native, invasive species was found scattered near the boat landing, on the north and west sides of the lake (Figures 32 and 33), and in ditches through low areas on roads around the lake. Gallerucella beetles (Figure 33) have been released and are established on Dowling Lake, but did not appear to be impacting purple loosestrife documented during the 2016 survey.

During the 2016 survey, Yellow iris (*Iris pseudacorus) (*Figure 34), another shoreland non-native invasive species was found at seven locations scattered along the shoreline (Figure 34). It had not been documented in previous surveys. It appeared to be spreading rapidly, and the worst areas occurred along the north and northeast shorelines (Figure 35).

The only other exotic species found on the lake was Reed canary grass (*Phalaris arundinacea*). This ubiquitous wetland species was present in limited numbers on the northeast shoreline and near the public boat landing. It was generally much less common than the native and very similar looking Bluejoint (*Calamagrostis canadensis*) (Figure 36).

Figure 32: Purple loosestrife along the north shore

Figure 33: Purple loosestrife and Galerucella beetles

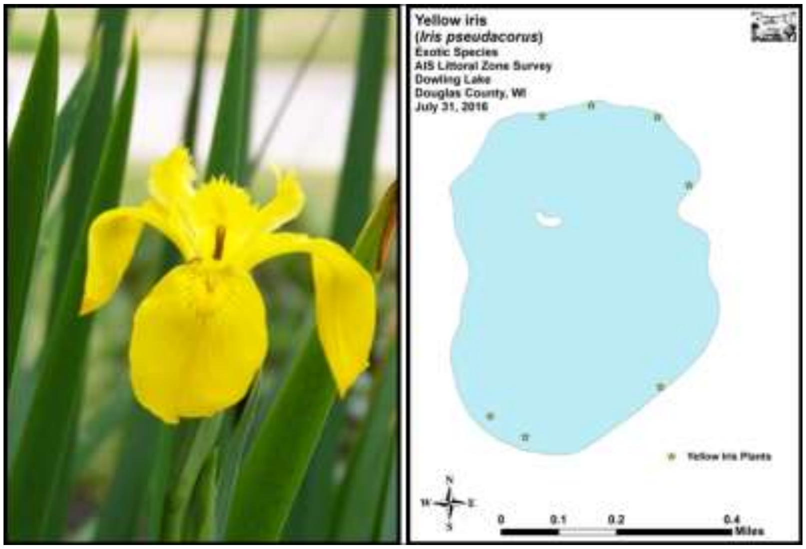


Figure 34: Yellow iris distribution 7/31/16

Figure 35: Dense yellow iris along the northeast shoreline 7/31/16

Figure 36: Non-native reed canary grass and native bluejoint grass

4.8 Water and Nutrient Budgets

Tributary data was collected once monthly from April through October for two years (2019 & 2020) at the main inlet to Dowling Lake on the east side adjacent to the public boat landing. Additional data was collected from two intermittently flowing sites – one on the north shore and one on the south shore. Monthly data was also collected at the outlet of Dowling Lake to Lake Amnicon. Data collected included total phosphorus, total suspended solids (TSS), and flow. TP and TSS water samples collected by Amnicon Dowling Lake Management District (ADLMD) volunteers and were analyzed at the WI State Laboratory of Hygiene (SLOH). Flow data (Table 5) was calculated using the float method described in the Water Action Volunteer (WAV) stream monitoring program[7].

4.8.1 Water Budget

Based on this data, the three tributaries to Dowling Lake contribute a little more than 81% of the seasonal (May – September) water load into Dowling Lake – 77% of that comes from the main inlet or east shore tributary. Based on area rainfall data, precipitation minus evaporation adds another 4.6% of the seasonal water load (Figure 37). The outlet of Dowling Lake averaged about 795-acft for a seasonal outflow over the two years,

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[7] https://wateractionvolunteers.org/files/2019/10/StreamFlowMethods_2015.pdf

leaving about 112-acft or 14.1% of the water coming into the lake via groundwater and overland drainage directly to the lake. At 5.2-acft per day leaving the lake, it would take about 206 days or almost seven months to exchange all the water in the lake one time.

These values are different than what was reported in the 2006 Plan. Their numbers, based on data collected in 1981, indicated the inlets contributed 34% of the water; precipitation/evaporation 3%; and combined groundwater and surface water 63%. Residence time or the time to exchange all the water was about 165 days.

Table 5: 2019-20 Tributary inflow and other sources of water, and outflow via the Outlet to Amnicon Lake

2019-20 Seasonal (May -Sept) Inflow/Outflow Calculations					
Source	**Type of Flow**	**Acft/day**	**# of Days w/flow**	**Acft/Season**	**% of Inflow**
East Shore Trib	Perennial	4.01	153	613.53	77.2
South Shore Trib	Intermittent	0.08	153	11.48	1.4
North Shore Trib	Intermittent	0.14	153	21.42	2.7
Precip minus evap	Ave. Daily	0.24	153	36.72	4.6
Groundwater	Ave. Daily	0.73	153	111.69	14.1
Outlet	Perennial	5.20		794.84	100.0

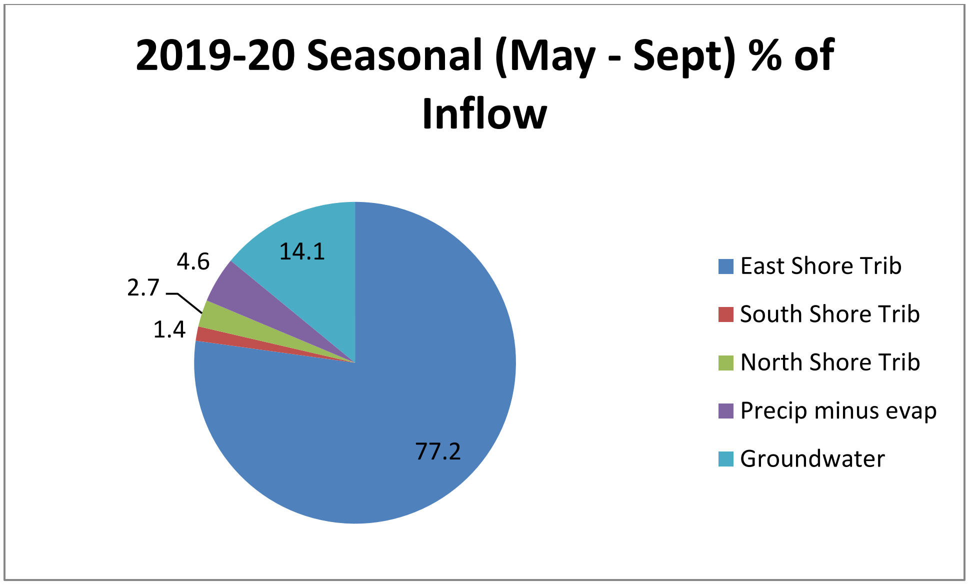

Figure 37: Seasonal water budget for Dowling Lake

4.8.2 Phosphorus Budget

Based on water sampling in 2019 and 2020, one perennial tributary (East Shore) and two intermittent tributaries (South Shore and North Shore) carry in about 33-lbs of phosphorus seasonally (Figure 38). The outlet to Amnicon carries out about 75-lbs of phosphorus over the same time period (Figure 38). If P carried into the lake is to equal the P carried out of the lake, then this suggests that about 42-lbs (56%) of phosphorus is entering the lake from other sources – overland runoff directly into the lake (not from the tributaries), groundwater/internal loading, and atmospheric deposition.

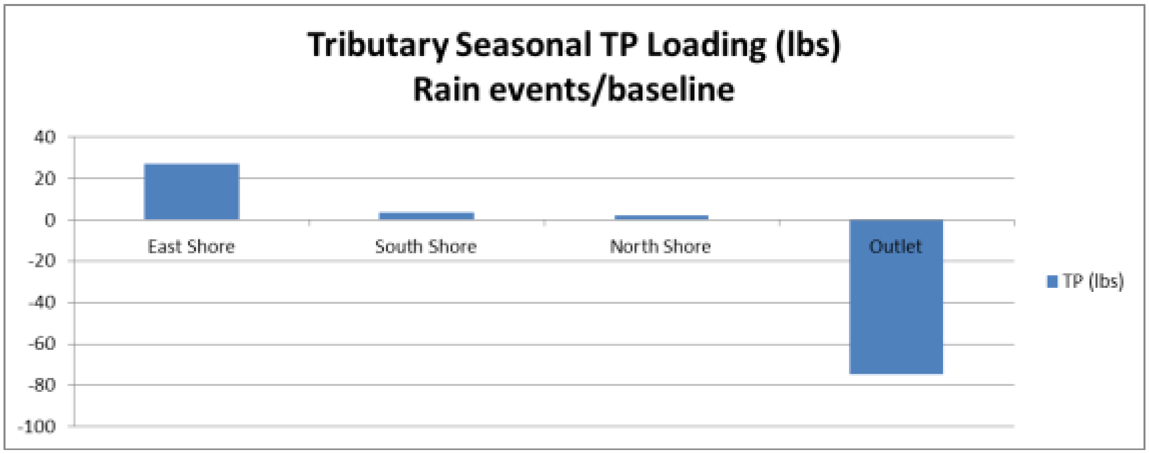

Figure 38: Seasonal loading from three tributaries and the outlet (2019-20 data)

Using WiLMS modeling, an estimated phosphorus budget can be determined. The model suggests that the most likely total amount of phosphorus entering the lake in a year is 289.5lbs. The main sources of P to the lake are the watershed (forest, wetland, and lakes), the developed or nearshore area of the lake, septic systems, and internal loading (Figure 39).

The 17.9% value for septic system loading is cause for concern. On many lakes, the total contribution of septic systems is usually much lower at 3-5%. According to one study, when septic systems are functioning property, the net loading of phosphorus per household per year is about 0.14 pounds.[8] With 85 properties with houses, that would equate to about 11.9-lbs, or only about 4% of the total load to Dowling Lake. Then consider that half of the systems in place are already holding tanks; the contribution from septic systems might be as low as 2%. Internal loading accounts for almost 30% of the total P load. This is a quite a bit less than what was calculated in 2003-04 (42%), but still much higher than what was calculated for Amnicon Lake in 2003-04 (only 4.5%). No new modeling has been completed for Amnicon Lake since the 2003-04 study.

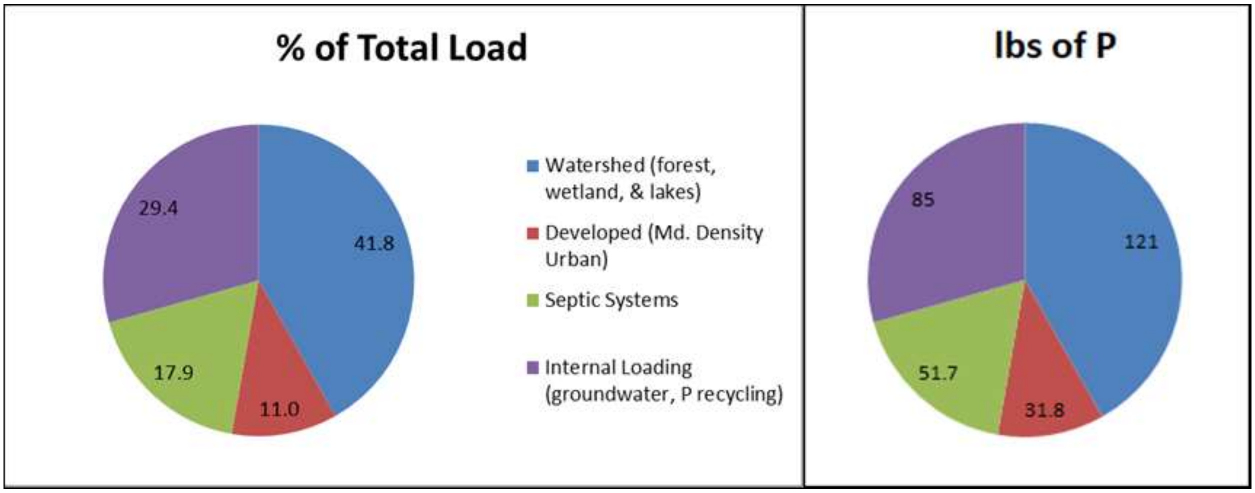

Figure 39: Sources of P to Dowling Lake. % of total load (left) and total lbs/yr. (right) from each source

4.9 Private Onsite Wastewater Treatment Systems (POWTS)

A common source of nutrients in groundwater is from private onsite wastewater treatment systems (POWTS), more commonly known as septic systems. Failing septic systems can seep raw sewage heavily laden with phosphorus, nitrogen, bacteria, and many other pollutants directly into a lake. This can cause issues for human

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[8] https://www.waterqualityplaybook.org/2-1-quantify-annual-nutrient-loads-from-septic-systems/

health if pollutants get into drinking water wells through groundwater and for a lake when the nutrient-rich water enters a lake either through direct overland flow or by the flow of groundwater. Even properly functioning septic systems can contribute nutrients to a lake or groundwater depending on the type of system it is and where it is placed.

The sandy, well-drained soils that surround Dowling Lake are highly conducive to allowing water to percolate into the ground and flow beneath the surface of the earth. Grains of sand have small spaces between them called pore space. Water fills these spaces and flows underground, and eventually, over the course of days to years, the groundwater flows into the lake. As the water moves underground, it can also dissolve minerals from the sand and other substrate, and it can pick up more pollutants, like nutrients. Conventional septic systems can pose an issue when they are installed in an area that is less appropriate due to soil types and other factors (see Figure 41 for a visual on conventional septic systems). Ideally, the effluent is treated by microbes as it moves through the soil, but in places where the soil is highly permeable – like around Dowling Lake – the effluent can reach the lake with very little treatment and high nutrient content.

In 2019, a septic system survey was sent to all property owners on Dowling Lake. Of the 55 surveys returned, 44 (or 80%) of them had some sort of POWTS, but 20% did not. Of the properties with POWTS, holding tanks were the most prevalent septic system at 55%. Conventional and mound systems were second at 36%. Several properties still had outhouses. Based on a 1993 public survey sent to property owners on both lakes, the 1996-97 study indicated that 24% of systems around both lakes were holding tanks with 62% still being systems with drainfields, and 12% of properties had no system at all. They concluded that increased loading to septic systems (from conversion from seasonal to primary residents), the primary use of septic systems with drainfields placed in inappropriate soils, aging systems with >38% being 20+ years old, close proximity of the systems to the lake with a high occurrence of saturated soils, and the majority of properties below a 10-ft shoreland contour created ideal conditions for unwanted transport of nutrients from ground water to the lake.

When calculating the impact of phosphorus loading from septic systems a “capita-years” use value is needed. This value is the average number of days a property is in use, multiplied by the number of people using that property at any given time. During the 2003-04 study a per capita value of 131 was used to determine phosphorus loading from septic systems. At that time, WiLMS modeling suggested that septic systems contributed about 17% of the total loading. With the 2019 survey the capita-years value was updated to 470 -- more than three times the value used in the previous study. WiLMS modeling suggests with the current capita-years value, phosphorus loading from septic systems could be as high as 25% of the total. There are likely 51.8lbs of phosphorus added, with potentially as much as 165.8lbs added. Even if one considers that half of the septic systems around the lake are holding tanks and technically not adding any septic effluent to the soils and groundwater around the lake, it still suggests 26-83lbs added seasonally by other septic systems.

4.9.1 E. coli and DNA Testing

Another pollutant of concern is E. coli bacteria. The natural habitat for the E. coli bacteria is in the intestinal tract of warm-blooded animals, and it is not found naturally in well water or groundwater. As such, it is an indicator of fecal contamination. Water samples can be sent to the Wisconsin State Lab of Hygiene to test for E. coli. If E. coli is found to be present, DNA testing can be performed to determine whether the source of the E. coli is human or not. If it is found to be human, then the likely cause is leaky septic systems. E. coli testing is strongly recommended to the ADLMD.

4.9.2 Updated Septic Systems

Due to the nature of the soil around the lakes, it is recommended that septic tanks (both those associated with holding tanks and those that are part of a conventional or mound system) should be checked for leaks, and conventional drainfield systems (Figure 40) should be phased out and replaced as quickly as possible. There is a potential risk to human health by allowing drainfields to continue to be the norm around the lake, and the effects of allowing effluent to enter a lake through the groundwater are well-documented – algal blooms, eutrophication, lowered dissolved oxygen, die-offs of aquatic organisms and fish, etc. Overall, reducing the inflow of nutrients to Dowling is one of the keys to restoring the lake, and reducing groundwater pollution from sewage-derived nutrients should be a focus going into the future.

Figure 40: Diagram of a conventional septic system and drain field

4.10 Iron in Relation to Phosphorus

Iron, aluminum, manganese, calcium, clay and other elements have the capacity to bind and release P from the sediments of a shallow lake. In the presence of dissolved oxygen sustained throughout the water column by continuous mixing, much of the phosphorus can be bound with iron and kept in a state that is not available to support the growth of algae if the ratio of iron (Fe) to P is high enough. One study determined that with a Fe:P ratio above 15 it may be possible to control internal P-loading by keeping the surface sediment oxidized (Jensen et al. (1992). Unfortunately, when and if the lake stratifies, even for a very brief time during periods of calm water, anoxic conditions (low or no DO) allows the separation of the P from the Fe. Then, as soon as the lake mixes again, that P is available to support algae growth. The Fe:P ratio in the bottom waters of Dowling Lake from July through September in both 2019 and 2020 was much greater than 15, ranging from 25 to 41.

However, even when there is adequate binding of phosphorus by iron, certain conditions including high pH and high temperature can increase phosphorus release from the sediment (See Sections 5.1.3 & 5.1.7).

4.11 Waves and Watercraft

While not exactly a watershed characteristic, the use of large watercraft on Dowling Lake for recreational purposes including waterskiing, tubing, wake boarding, and wake surfing may occur and has an impact. Waves created by these large boats, in addition to wind-driven waves, stir up bottom sediments and erode shorelines, which in turn re-suspends sediments in the water causing temporary or even long-term changes in water clarity and available nutrients that feed plant and algal growth.

4.11.1 Wake Boats

Low-speed boating is a relatively new phenomenon on Wisconsin lakes. It involves watercraft specifically designed to be driven at slow speeds to create large wakes for skiing, boarding, and surfing. Specialized "wake boats" are designed to increase wave height in the wake. These specialized boats are often built with a hull shaped to achieve maximum wake, may have a hydrofoil device that lowers the stern of the boat when under power, and may have built in ballast tanks to increase weight in the back of the boat causing more water to be displaced and larger waves created.

The problem with increased wake height is related to the adverse effects that go along with large waves. The larger the wave, the more energy it delivers when it crashes against the shore, exacerbating erosion along both natural and disturbed shorelines, and the larger the wave, the deeper it can churn sediment in shallow water. The boats can create turbulence that can reach the bottom in as much as 10-ft of water, again disturbing the lake bed and churning up sediments (Apslund, 2000).

Whether it is propeller-induced or the result of boat-induced waves, sediment and nutrients can become re-suspended due to boat traffic. Depending on how fine the sediment is, it could take up to 24-hrs for sediment to settle back to the bottom of the lake. This reduces water clarity, limits sunlight penetration that is vital for aquatic plant growth, and makes nutrients available for algal uptake. Often re-suspended P fuels rapid algae growth (blooms) which can further contribute to water clarity and quality issues.

Operating boats in shallow water, especially with deep propellers can also uproot or fragment aquatic vegetation, leading to the destruction of desirable aquatic plants or the spread of non-native invasive species like Eurasian watermilfoil.

4.11.2 General Motorized Boating

It is not just the relatively new phenomenon of wake boats that can cause problems in lakes; motor boat use in general can cause the same impacts. Large or small, fishing or other recreation, if driven in the wrong place.in the wrong way, or at the wrong time, drivers can cause lake issues with their watercraft. In a review of existing studies related to boats and how they affect lakes, (Apslund, 2000) concluded that boats in general have been shown to affect water clarity and can be a source of nutrients and algal growth in aquatic ecosystems, and that shallow lakes, are highly susceptible to impacts.

Boats impact aquatic plants by direct cutting, scouring of sediments in shallow areas preventing aquatic plant growth, uprooting of plants, and increased wave activity (Figure 41)(Sagerman et al. (2020). The effects of boating on the fishery is less studied and basically centers around disturbing fish from spawning nests, or in changing fish habitat (water clarity, sediment, aquatic plant beds, etc.). Effects on wildlife are also little studied, but include temporary disturbance (waterfowl, birds of prey) and in some cases more permanent disturbance (loons and loon nesting).

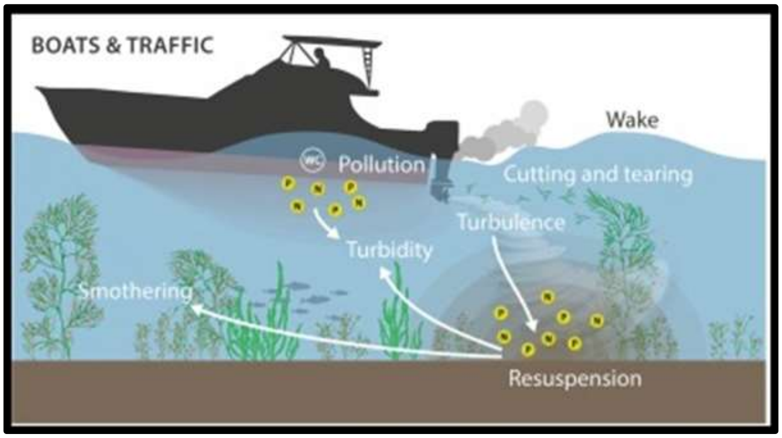


Figure 41: Mechanisms by which recreational boating activities affect submerged aquatic vegetation and re-suspend sediment (Sagerman et al. 2020)

4.11.3 Boating Impacts on Dowling Lake

With its shallow depth and small size, wake boats should not be operated on Dowling Lake. In the last few years, as wake boating has become more popular, many lakes across many states have been trying to regulate or ban them from use due to their destructive nature. As an example, the Sand Lake Management District covering Sand Lake in Barron County, just recently passed an ordinance, not limiting wake boats specifically, but rather limiting when large waves can be created.

Often, negative impacts caused by boating in general (not just wake boats) can be minimized through education. Continuous boater reminders of the "no wake" areas of the lake -- within 100-ft of the shore for boats and within 200-ft for PWC -- should be made. Encouraging lake users to minimize motor startups close to shore and in shallow water can also help. Regulating boat use is a much more complicated and controversial management issue, one that the ADLMD need only address if they feel that it is necessary.

5.0 Shallow Lake Management

Shallow lakes exist in two alternative stable states: clear water and turbid water. The clear water state is characterized by clear water and significant macrophyte (plant) growth; the turbid water state is dominated by phytoplankton (algae) and murky, green water (Figure 42). The clear water state is generally preferred and actively managed to maintain or achieve. As mentioned, Dowling Lake is currently in a turbid state. The main goal of management is to try to shift it back to a clearer water state with more native aquatic plants and less frequent algae blooms.

Aquatic plants are the key to clearer water in shallow lakes. A shallow lake that is free of both aquatic plants and algae is uncommon, and it is unrealistic to expect this to occur without a large investment in money and energy. Shallow lakes are most responsive to changes in the internal nutrient loading (for example, lake sediment phosphorus release) and biomanipulation (additions or removals of fish that affect the entire aquatic food web).

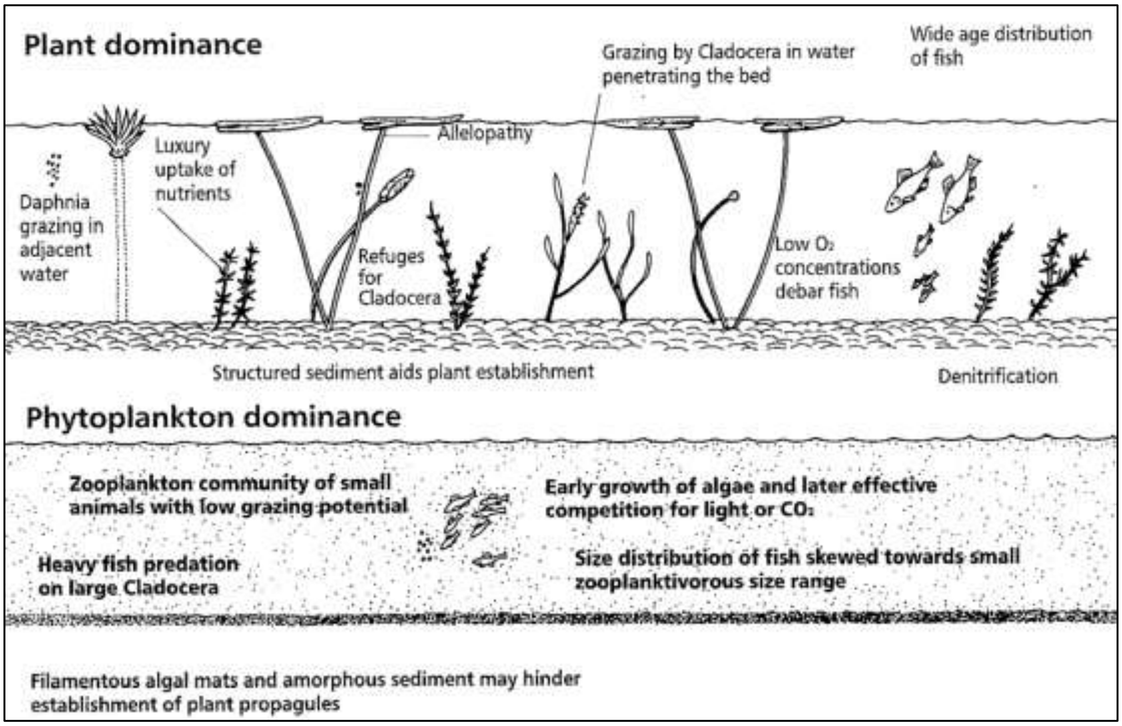


Figure 42: Shallow lake alternative states and stabilizing mechanisms

5.1 Mechanisms that Increase Internal Loading

Several factors come into play before P ever makes it to the sediment at the bottom of the lake. The amount of water coming in and the time it takes to completely flush out a given body of water directly influences how much P and other pollutants stay in a lake. Quick turnover of all of the water in a lake can limit the time P has in the lake to settle out or to support the growth of algae. Under normal or base inflow conditions Dowling Lake has a flushing rate of about seven months, meaning it takes at least that long for any water entering the lake to completely exit the lake; unfortunately, this is a lot of time for phosphorus carried in that water to be utilized in lake processes. Large rain events leading to high inflow and outflow can flush available nutrients through and out of the lake very rapidly. Historic external loading – high or low has already left its mark on the lake building up P in the lake sediments for years. Efforts must be made to reduce the external sources of P to the lake and the P already in the lake has to be reduced.

5.1.1 Resuspension

In shallow lakes, wind and wave-induced resuspension, whether natural or human-generated is a mechanism that frequently causes increased concentrations of suspended solids in the lake water. Particulate bound forms of P settling to the bottom may be re-suspended several times before permanent sedimentation. In very shallow lakes, resuspension events increase the contact between sediment and water, more or less continuously. Reducing the activities that re-suspend sediment in the lake can help to reduce available P, as can protecting and enhancing shoreland vegetation that helps hold sediment in place.

5.1.2 Chemical Reactions

In the presence of oxygen, iron can bind with P removing it from the water column and capturing it in the sediment preventing its release back into the water column. Unfortunately, under conditions when no or very low oxygen levels occur near the water/sediment interface, a chemical reaction occurs that breaks that bond, releasing the P back into the water column. Then when waves and other activities mix that newly released phosphorus with the surface waters, an algae bloom often results. Phosphorus can be bound by other elements than iron. Aluminum, calcium, magnesium and other metals can combine with phosphorus forming phosphides. When bound with aluminum, as in the application of aluminum sulfate (alum) to a lake with high P, a precipitate is formed that cannot be broken as a result of natural processes. That precipitate settles out of the water column and then forms a sealed layer on the surface of the sediment. Adding oxygen to lake water through aeration is sometimes used in an attempt to minimize times when no oxygen is present in the bottom waters.

5.1.3 High pH

pH is particularly important in lake sediments where the capacity to retain P depends on iron, because the P binding capacity of the oxygenated sediment layer decreases with increasing pH. High pH, which is common in eutrophic lakes during the summer, may markedly increase the internal P loading risk when linked with intensive resuspension.

5.1.4 Bioturbation

Where lake water from above and sediment from below meet in the lake bottom, there is a thin layer called interstitial water that forms a direct link between soluble P in the water and the solid forms in the sediment. Disturbances caused by benthic invertebrates in this layer and/or gas bubbles produced deeper in the sediment that pass through this layer is called bioturbation. The gas bubbles are often formed by the process of microbial decomposition of organic materials deposited in the lake sediment. Both of these processes can increase the movement of P in the sediment through the interstitial layer to become available to support the growth of algae in the water column.

5.1.5 Mineral and Microbial Processes

In shallow, eutrophic lakes, the sediment continuously receives high amounts of freshly produced organic material that is not decomposed before reaching the sediment. Thus, sediment bacteria may have a significant role in the uptake, storage and release of P. High organic input creates the potential for a high mineralization rate, provided that the supply of oxygen or nitrate is sufficient. A typical sediment profile will have oxygen penetrating a few millimeters into the sediment, followed by nitrate which can be found several centimeters into the sediment depending on the decomposition rate and the nitrate input. If nitrate concentrations are low, but sulfate levels and the supply of biodegradable organic matter high, de-sulfurication and sulfur cycling may become important parts of the sediment processes. Hydrogen sulfide formed from sulfate reduction induces the formation of iron sulfide and decreases the potential of P binding by iron and increases the potential P release from the sediment.

5.1.6 Submerged Plants

In shallow lakes, submerged macrophytes have the potential to be very abundant. Macrophytes influence the P cycle both negatively and positively. Decreased release is seen when oxygen released from the roots increases the ability of iron to bind with P, and when the high abundance of macrophytes diminishes the resuspension rate and reduces the P release from the sediment. However, increased P release may be recorded in dense macrophyte beds and beneath macrophyte canopies due to low oxygen concentrations, or due to increased pH.

5.1.7 Temperature

Temperature reflects many of the biologically mediated processes in the lake just discussed. The pronounced seasonality in internal loading and retention capacity strongly indicates that the release mechanisms are linked to temperature and biological activity. These include stimulation of the mineralization of organic matter, the release of inorganic phosphate with increasing temperatures, and increased sedimentation of organic material related to the seasonal variation in phytoplankton productivity. As organic loading increases during spring and mineralization processes are strengthened, the penetration depth of oxygen and nitrate into the sediment declines. The temperature effect on P release is likely strongest in lakes with a large proportion of iron-bound phosphorus. With increasing temperatures, the thickness of the interstitial layer is reduced. The thickness of this oxic sediment can thereby directly influence the concentration of P in the whole water body.

5.2 Possible Mechanisms to Reduce Internal Loading

In order to combat internal P loading and accelerate lake recovery after decreased external loading, numerous lake restoration techniques may need to be implemented. They comprise both physical measures, such as sediment dredging by which nutrient-rich sediment is removed, as well as chemical methods. For all types of restoration measures, an important prerequisite for obtaining success and long-term effects is the elimination of the underlying reasons for the impoverished water quality, i.e. a sufficient reduction of the external P loading.

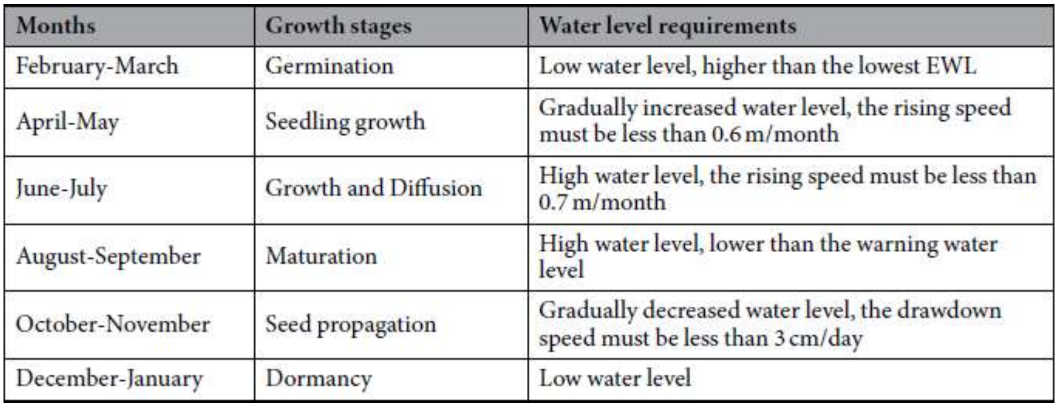
5.2.1 Water Level Manipulation

In the past decades, the hydrological regime (natural rising and falling) of lake levels has changed significantly due to the impacts of human activities and climate change, leading to a series of ecological problems, such as aquatic environment depravation, eutrophication, and lakeside habitat destruction Yang et al. (2020). Water level is an important characteristic for influencing the distribution and diversity of organisms in shallow lakes. Fluctuating water levels may have a strong impact on sediment and nutrient fluxes in shallow lakes, mainly through the development of vegetation covering both the shoreline and the lake bottom; and the planktonic food web of shallow lakes by favoring phytoplankton loss factors like sedimentation and grazing. Naturally fluctuating water levels in lakes may favor the clear-water shift, and tend to stabilize the clear-water state. Water level management should be part of a manager’s toolbox for restoring shallow lakes, along with nutrient and fisheries management, but managers should be mindful of how extending the upper and lower limits of the water level impact other things. Water level management may also have socio-economic consequences as well. Navigability of lakes, adapting to high and low water conditions, and the estate value of properties built on the lake should all be considered (Coops & Hosper, 2002).

To maintain a lake’s basic ecological function, the concept of lake Ecological Water Level (EWL) has been developed. EWL is defined as the optimal water level for maintaining ecosystem integrity, protecting biodiversity, improving environmental quality, and ensuring ecosystem stability (Yang et al. 2020).
EWL management is based on the needs of the aquatic plant community within a lake. The growth and reproduction of aquatic vegetation are closely related to the water level fluctuation. The growth periods of aquatic plants are generally divided into six stages: germination, seedling growth, growth and diffusion, maturation, seed propagation, and dormancy. During germination, a low EWL is needed to increase the amount of shallow water area exposed to sunlight. In the seedling growth period, it is necessary to keep the EWL rising steadily but slowly to a moderate EWL. In the growth and diffusion period, it is suitable to move toward a higher EWL. Moving to a higher EWL not only promotes the spread of aquatic plants, but it also prevents the lakeshore from shrinking. To prevent terrestrial plant invasion and lake swamping, the EWL should be kept at a high level during the maturation period, but it should not exceed the flood level of the lake. To promote seed propagation and spread, it is necessary to keep the EWL steady or slowly decreasing until the dormancy period, when the EWL should maintain a medium or low value (Table 6).

While the different plant growth stages and EWL requirements are likely applicable to Dowling Lake, the months referenced may need to be modified to account for northern Wisconsin climate. Furthermore, in Dowling Lake, the fluctuations in water depth would likely be measured in inches, or at most feet, not meters.

Table 6: Water level requirements of aquatic vegetation during each growth period Yang et al. (2020)



Months	Growth stages	Water level requirements
February-March	Germination	Low water level, higher than the lowest EWL
April-May	Seedling growth	Gradually increased water level, the rising speed must be less than 0.6 m/month
June-July	Growth and Diffusion	High water level, the rising speed must be less than 0.7 m/month
August-September	Maturation	High water level, lower than the warning water level
October-November	Seed propagation	Gradually decreased water level, the drawdown speed must be less than 3 cm/day
December-January	Dormancy	Low water level

On Dowling Lake, there are both natural and manmade water level fluctuations. One example of manmade fluctuations is when a concerned property owner placed a board across the outlet culvert of the lake to hold higher water levels in the summer. It may be possible to construct an outlet on Dowling Lake that would allow fluctuations in water level of perhaps up to about 2-ft. With such a structure in place, a more concerted effort could be made to support appropriate and beneficial water level manipulations.

5.2.2 Biomanipulation

Another management action to support a reverse switch from a turbid water state to a clear water state is biomanipulation. The goal of biomanipulation is to reduce the concentration of harmful phytoplankton, such as toxic blue-green algae. The most direct method to control harmful algal blooms is to reduce inputs of nutrients. In cases where the arrival of nutrients to the ecosystem is delayed or slow to develop, biomanipulation can be used to hasten the decline of harmful algae.

In order to reverse the alternate stable state from turbid to clear in Dowling Lake, biomanipulation would need to focus on increasing piscivorous (fish eating) fish by stocking more fish like walleye. This would decrease the population of bluegills and other zooplanktivores (fish that eat zooplankton), allowing the zooplankton to flourish and decrease the amount of algae (Figure 43).

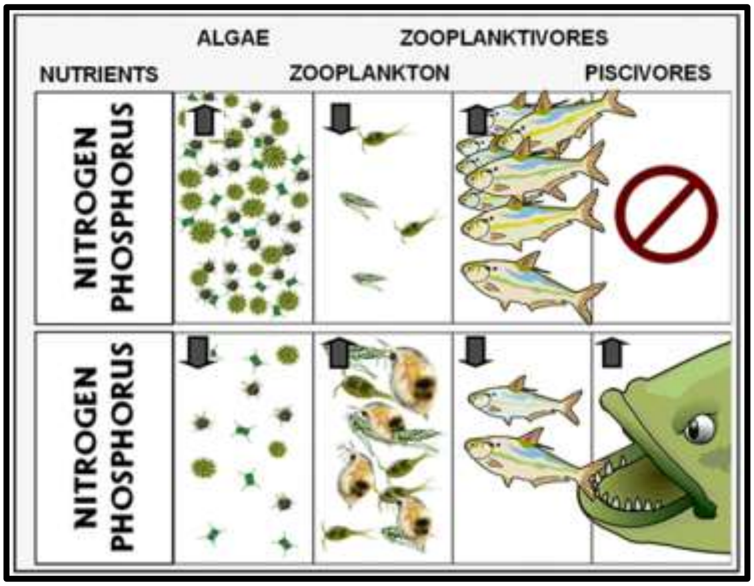


Figure 43: A representation of biomanipulation to reduce the number of zooplankton-feeding fish in a lake. Image: Anthony Thorpe, Lakes of Missouri Volunteer Program.

The benefits of biomanipulation are as follows:

- Increases desirable game fish like walleye
- Reduces algae in the water and increases water clarity
- Helps restore macrophyte communities by improving water clarity
- Increases average size of crappie and bluegills by preventing stunting from lack of resources

The disadvantages of biomanipulation are as follows:

- Can be costly to stock walleyes and other fish like muskies
- Requires additional efforts to decrease nutrient loading in the lake
- Can take several years to see desired affects
- Decrease in some fishing opportunities by decreasing fish like bluegills
- Results can be unpredictable and may vary

While concurrently making a concerted effort to reduce external nutrient inputs to the lake, biomanipulation is an effective tool for returning a lake to a clear water state. The ADLMD should consider this management strategy in addition to other concurrent efforts, but may want to gather more data about the present zooplankton community and the abundance of zooplanktivores (likely panfish).

5.2.3 Alum Treatment

Alum can be used as a chemical agent to promote nutrient precipitation. This process essentially binds nutrients, like phosphorus, to particles of aluminum and locks them up at the bottom of the lake in the sediment where it cannot be used by algae. This process seals the bottom of the lake and prevents future release of nutrients from the sediment. These actions reduce the overall concentration of nutrients in the water, which results in decreased algae levels and increased water clarity. This method is often used on lakes with significant internal loading – like Dowling – where external nutrient loads are already low.

Through a process called flocculation, the chemical agent binds to the phosphorus, which causes it to form heavier aggregates that sink to the bottom (Figure 44). Aluminum sulfate (alum), or sometimes iron salts, have a high affinity for phosphorus, and due to their molecular make up, are highly attracted to one another. Once they are bound together, the phosphorus is no longer available for organisms like algae to use. Treatments must take into consideration a number of variables such as depth, pH, and the buffering capacity (alkalinity) of the water to reduce impacts to fish and other biota. Additionally, treatments may not compromise environmental safety nor exceed acceptable levels of aluminum and acidity.

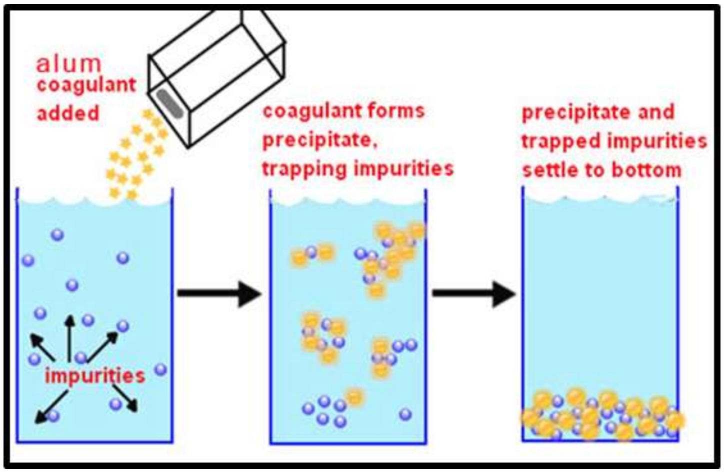


Figure 44: How alum works (http://www.bionicsro.com/water-treatment-chemicals/alum-salt.html)

An alum treatment may be an option for the ADLMD to strongly consider. It would provide relief from internal loading for about 10 years and allow the group to implement more management strategies while the lake recovers. Treatments cost an average of $450 per acre (141 acres x $450 = $63,450 on Dowling). The initial cost can be amortized over several years, so the long-term cost may not be as great other treatment options.

The benefits of alum application are as follows:

- Efficiently removes phosphorus for about 10 years
- Seals the bottom sediment to prevent further internal loading
- Increases water clarity
- Increased water clarity can increase plant growth, which provides important habitat and further reduces available phosphorus in the water
- Can be cost effective compared to other methods like dredging
- Works very quickly – effects can often be seen within an hour
- Pre-buffered solutions can be used to reduce free aluminum and negative impacts

The disadvantages of alum application are as follows:

- Other sources of nutrients need to be reduced as much as possible to get the most benefit from the treatment
- Increases the potential for elevated free aluminum and lowered pH (dissolved concentrations of free aluminum above 100 ppb can be toxic to many fish species, while other species may show acute or chronic toxicity symptoms at concentrations as low as 50 ppb)
- Cost – can be very expensive based on the amount of water to treat and the number of times it is treated

5.2.4 Dredging

Dredging uses mechanical means to physically remove bottom sediments from a lake to increase depth, eliminate debris and plants, and remove nutrient-rich sediment (Figure 45). Over time, sediment and organic material builds up on the bottom, decreasing the lake's depth and potentially acting as a continual source of nutrients. Removing the buildup of sediment and organic material on the bottom of Dowling Lake is another potential restorative management option.

Figure 45: 2019 Dredging operations on Lake Redstone in Sauk County (Photo credit-LRPD)

The benefits of dredging are as follows:

- Deepens the lake, which may potentially allow the lake to stratify and lock away nutrients in the sediment during the summer

- Physically removes sediment and nutrients from the lake

The disadvantages of dredging area as follows:

- Very costly
- Difficult to obtain permits
- Removes habitat for fish, plants, and other wildlife
- Physically removes aquatic invertebrates
- Can greatly increase turbidity in the lake for a period of time
- Disposing of the sediment can be difficult and expensive

This process can be costly, and ultimately does not reduce phosphorus loading for the long term. The ADLMD might consider this management strategy if all other options have been exhausted.

5.2.1 No Wake and Boating Ordinances

Boats affect water clarity and can be a source of nutrients and algae growth in lakes. Motor boats are a well-known forward switch mechanism in shallow lakes. Shallow lakes, shallow parts of lakes, and channels connecting lakes are the most susceptible to impacts.

No-wake zones are already in place by State Law within 100-ft of shore (200-ft for personal watercraft) and in proximity to other boaters and swimming rafts. But with a maximum depth of only 13.5-ft and an average depth of only 7.6-ft, even in the center of Dowling Lake, large boat motors can disturb sediments. In addition, waves created by large boats can crash into shorelines stirring up more sediment and causing erosion issues.

The ADLMD should consider ordinances to limit boat use that creates large wakes and/or the times when boating activities like waterskiing and wakeboarding can be done on the lake. They could also consider a no wake ordinance all the time for the entire lake. The process of implementing and ordinances that restrict lake use will require substantial public input, education, and participation in order to balance recreational needs and the protection of water quality.

5.2.2 Aeration and Artificial Circulation

Aerators and artificial circulation (fountains) are frequently used in small, shallow ponds, but can complement other larger management actions on lakes. Companies marketing aeration units and fountains list the following benefits from adding aeration to a lake.

- Improves water quality
- Reduces the likelihood of excessive algae growth
- Removes foul odors
- Enhances fish habitat
- Decreases mosquito activity
- Reduces the accumulation of bottom sediment

While all of this may be true at some level, and lake fountains can certainly be beautiful, most aeration projects only provide the above-mentioned benefits on a very limited scale. There is one instance when aeration may not only be a nice addition, but also a necessary action to maintain lake health. That would be in cases where small, shallow lakes experience occasional fishkills, particularly during the winter season, when oxygen levels under the ice get very low.

5.2.1 Artificial Floating Islands and Wetlands

From BioHaven®, floating treatment wetlands (FTWs) leverage natural systems and science to restore and improve water quality (Figure 46).[9] Microbes play a critical role in breaking down pollutants. The microbes float naturally in the water but need surface area to grow – the more surface area, the more removal. Under the water, the planted vegetation's roots that grow down into the water coupled with the island's matrix provide necessary substrates for microbes to colonize. These microbes, and the sticky secretions they produce (biofilm), will collect nearby algae and zooplankton forming a community of periphyton (an underwater organism or community of microbes, algae, cyanobacteria, zooplankton and invertebrates attached to a substrate).

Periphyton is the primary agent responsible for cleaning water and sequestering excess nutrients from urban and agricultural run-off. The microbes will help break down the majority of the nutrients in contact while algae (clinging to the island) and planted vegetation uptake some of the nutrients for growth. Periphyton is also the base of most aquatic food webs, meaning the islands provide valuable habitat for fish, reptiles and invertebrates as well as providing necessary sustenance for the aquatic community.

FTWs also provide a carbon sequestration system to the waterway. The periphyton and roots from the island's surface vegetation will use dissolved carbon dioxide for photosynthesis and other dissolved organic carbons will be trapped and consumed by the periphyton. The island also allows for consumption of total nitrogen to be safely converted back into nitrogen gas and released into the air, helping to prevent or slow down the process of eutrophication. Total phosphorous is removed/sequestered through a number of biological and mechanical pathways. Particulate phosphate will be filtered in the island matrix and periphyton and either remain inventoried in the man-made wetland or settle to the bottom. Phosphorous will also be absorbed by autotrophic plants for growth and in the case of algae and periphyton, it will be consumed by aquatic organisms and will be dispersed through the food chain.

The processes that promote nutrient removal associated with floating wetlands are key factors in cleaning the water and the increased surface area periphyton is able to produce areas that are able to out compete floating algae for nutrients preventing harmful "algae blooms."

There appears to be limited research on the effectiveness of floating islands or wetlands, but one review of available research concluded that traditional floating islands can remove nutrients, but their efficiency is low (Chang et al. (2017).

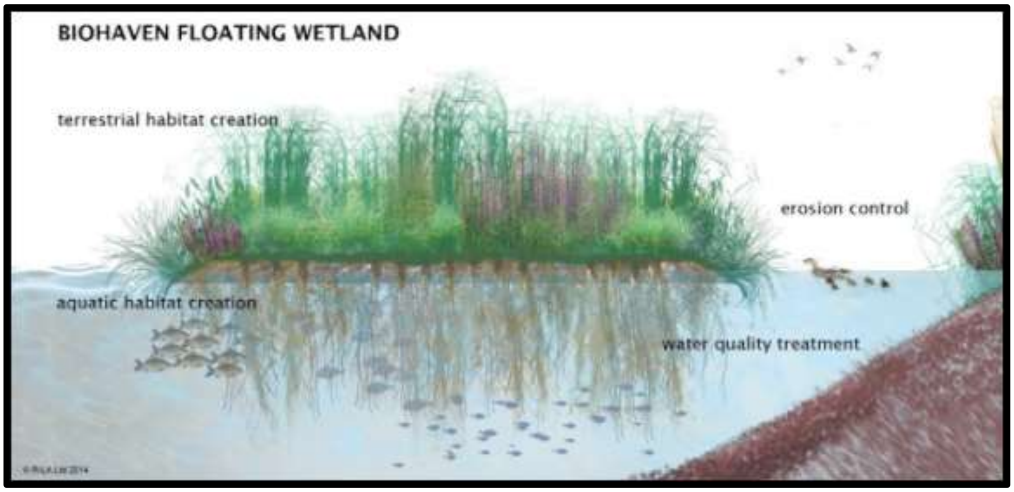


Figure 46: BioHaven® Floating Wetland

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[9] For more information about BioHaven® go to: https://midwestfloatingisland.com/

BioHaven® also makes what it markets as Mini Floating Islands/Floating Water Gardens that cost in the range of $200-$1200.00 (https://aquaculturedirect.com/product/mini-biohaven-floating-islands-floating-water-garden/). Other companies also make similar systems.

5.3 Reducing External Loading

As previously stated, in order for internal loading reductions to work, external sources of P have to be controlled. External sources of P and other pollutants are the watershed, nearshore or developed area of the lake, and septic systems. Groundwater can also be considered an external source, but is essentially invisible and difficult to quantify or to manipulate/manage.

5.3.1 Watershed

The impact of the watershed on lake water quality is evident in the relation of nutrient loading to the watershed to lake surface area ratio. Typically, water quality decreases with an increasing ratio of watershed area to lake area (Figure 47). This is obvious when one considers that as the watershed to lake area increases, there are additional sources (and volumes) of runoff to the lake.

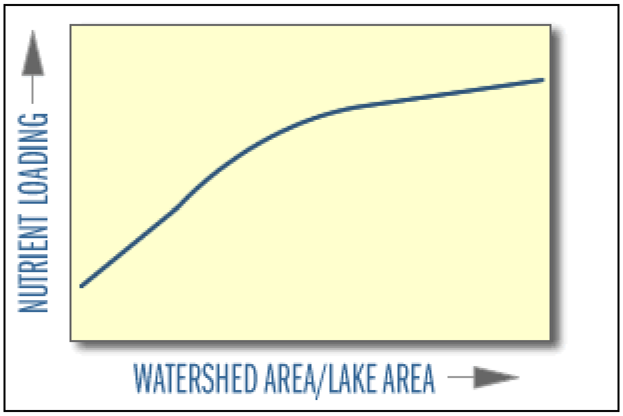

Figure 47: General pattern of nutrient loading associated with increasing watershed size relative to lake area (https://www.waterontheweb.org/under/lakeecology/06_watershed.html)

Fortunately, Dowling Lake has a relatively small watershed to lake ratio (a little more than 8:1) and is mostly forest and wetland. Only the immediate area around the lake, approximately 72 acres, is developed, and there is no agriculture. However, just because much of the watershed is forested, does not mean there are no issues. Forestry practices, road maintenance, and even natural activities like the building of beaver dams can impact the lake under certain conditions. Figure 48 shows a large beaver pond in 2019 and again in 2021 held back by a beaver dam (red circles). There is a fair amount of research on the impact of beaver dams to downstream waters, some positive like holding back sediment and nutrients, and others negative like raising or lowering water levels and increasing the amount of mercury present in the water.

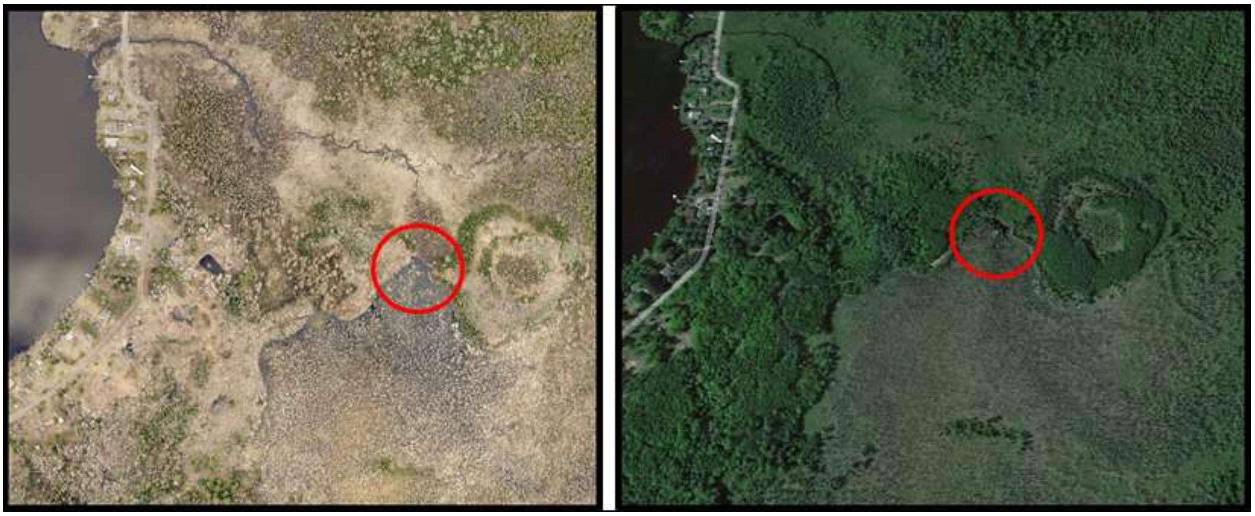

Figure 48: Dowling Lake watershed beaver dam and wetland complex in 2019 (left) and 2021 (right)

5.3.2 Nearshore or Developed Area

The riparian zone, the area that borders the lake, is highly developed. Usually, nutrient and other pollutant loading in the riparian area pales in comparison to the larger watershed. However, in some cases like Dowling Lake, the developed area might be a substantial contributor to external nutrient loading.

The shoreland habitat assessment specifies properties with the highest potential to implement habitat improvement and runoff reduction projects. The properties identified are a place to start focusing shoreland improvement actions. However, nearly every property on, or adjacent to, the lake can take action to reduce runoff and/or improve habitat. This includes the local Township in how they take care of their roads and right-of-ways. Local businesses can also support a better riparian area around the lake – from real estate agents who encourage new buyers to implement BMPs and understand that a natural landscape around a home is better for the lake than a mowed lawn – to bars, restaurants, bait and boat dealers, landscapers, dock and lift installers, etc. who service those who live on and around or use the lake. Getting "buy-in" from all of these stakeholders and others is imperative to improving the lake and then maintaining those improvements.

5.3.3 Septic Systems and Sanitary District

Installing a city sewer system all the way around Dowling Lake is a management alternative that would benefit the lake, albeit at a high cost. Septic systems are estimated to contribute up to 25% of the total nutrient load to the lake. It is important to note that septic systems contribute nutrients and other chemicals to groundwater and lakes even if they are working properly; septic systems are designed to remove solids and pathogens, not necessarily dissolved nutrients.

In septic systems that rely on some form of drainfield (conventional systems, mound systems, etc.), P is initially retained in the soil, but once the soil retention capacity is exceeded, septic systems can and often do, discharge high concentrations of P to the groundwater which ultimately reaches the lakes. Nitrogen is rarely retained and travels with the water. In some cases, property owners with holding tanks may discharge graywater outside of the house onto the surface of the land nearby instead of running it into the holding tank. Graywater is water that has already been used domestically, commercially or industrially. This includes the leftover, untreated water generated from clothes washers, bathtubs and bathroom sinks. Like septic system effluent, gray water may also contain nutrients and other pollutants that could harm the lake. In shoreland areas it is particularly important to maintain septic systems properly because soil and water conditions near shore may make the system less efficient in treating wastewater. All of the soils in the near shore area of Dowling Lake are rated poorly for septic tank absorption fields. Incomplete treatment can result in health risks for humans and water quality problems.

There are really only a few things the ADLMD can do to address septic system loading. They can provide information on septic system maintenance and encourage property owners to maintain, improve, or replace systems that rely on drainfields. When properties are bought and sold or new construction is planned, evaluations of septic systems are usually completed. It is expected that during these times, problem systems would be replaced with less impacting systems.

5.4 Aquatic Plant Management

The Dowling Lake ecosystem is home to a very limited plant community. At present, there is little to no negative impact on the lake from invasive plant species; and little to no aquatic plant growth that causes lake use or navigational impairment. The lack of aquatic plant growth in the lake is a substantial reason for the dominance of algae. Protecting the plants that are present in the lake and encouraging more aquatic plant growth would likely benefit the lake. If water clarity can be improved during the growing season, it may help create a healthier plant community.

5.4.1 Re-establishing Aquatic Plants

Although it is generally quite difficult to re-introduce or plant native vegetation into a lake, neighboring Amnicon Lake provides a ready source for plant propagation stock. Amnicon also presents similar water quality conditions, so plants that are doing well there, could potentially succeed in Dowling if efforts to improve water clarity are also being made. Attempts could be made to reestablish several plant species including nitella sp., water celery, bladderwort, and flat-stem or fern-leaf pondweed in shallow, mucky areas of the lake.

Wild rice is abundant in Amnicon Lake, but not present in Dowling. Wild rice uses massive amounts of phosphorus during the growing season, so an attempt to re-introduce wild rice to the lake may be beneficial. However, if wild rice becomes established, many state mandated safeguards come into play.[10]

In general, no aquatic plant management, at least to remove undesirable species or to improve access, is needed on Dowling Lake. Protecting the density, distribution, and diversity of the existing plant community as well as implementing efforts to enhance this community if possible are the most important plant management issues at the present time.

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[10] State of Wisconsin Wild Rice Rules and Regulations:
https://docs.legis.wisconsin.gov/statutes/statutes/29/ix/607 and
https://docs.legis.wisconsin.gov/code/register/2008/635b/remove/nr19

6.0 Monitoring

Determining whether or not actions implemented are having the desired effect is dependent on adequate monitoring. Monitoring provides opportunity to review and analyze what is being done, and makes it possible to make adapt or modify actions to make them better accomplish what is expected. Many monitoring activities are recommended in this plan. Many can be done by ADLMD volunteers while some must be done in partnership with other entities.

6.1 Physical Conditions

Physical conditions include any aspect of a lake that is not dependent on chemical interactions. This includes lake parameters like water clarity, lake level, and precipitation. It also includes the plants and creatures that live in the lake.

6.1.1 Water Clarity

Water clarity is a measured using a Secchi disk that is lowered from the surface by a rope marked in measurable increments (Figure 51). The water clarity reading is the point at which the Secchi disk when lowered into the water can no longer be seen from the surface. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (cloudy, windy, or sunlight) can impact how far a Secchi disk can be seen down in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view. Water clarity monitoring using a Secchi disk is a staple in the CLMN water quality monitoring program and should be completed 2-4 times a month from ice off to ice on.

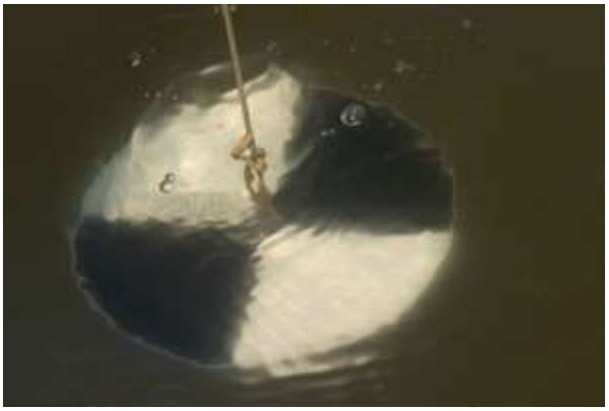

Figure 49: Black and white Secchi disk

6.1.2 Lake Level and Precipitation

Fluctuations of lake levels are important to document, whether they result from floods, droughts, or just a normal water year. Knowing and understanding the history of lake levels can help shoreland owners and others who use the lake to accept and cope with the natural fluctuations of a lake. The levels of all lakes fluctuate, primarily in response to changes in precipitation (rain and snow), human activities such as the construction or operation of a dam, or from acts of nature like beaver activity. As discussed in Section 5.2.1, changing the existing water level regime could benefit water quality in Dowling Lake. As such, more accurate and long-term water level monitoring should be performed.

The CLMN program, along with many County Land and Water Conservation Departments can work with lake volunteers to set up a formal lake level monitoring program.

Precipitation monitoring is directly related to lake level changes. If both are done, eventually it will be possible to predict how much impact a given rain event may have on lake level. The Community Collaborative Rain Hail and Snow (CoCoRaHS) program is a world-wide volunteer monitoring program that provides resources and direction to collect and report precipitation data including rain, snow, and hail. By using low-cost measurement tools, stressing training and education, and utilizing an interactive Web-site, their aim is to provide the highest quality data for natural resource, education and research applications. At least one volunteer from the ADLMD has participated in this program in the past, and current volunteers should be encouraged to join.

6.1.3 Native Aquatic Plants

The last formal whole-lake, point-intercept, aquatic plant survey was completed in 2012. Since that time, vegetation in the lake has only been surveyed in 2016 as a part of a plant density and aquatic invasive species survey. Since one of the keys to improving water quality in the lake is to increase the density, distribution, and diversity of native aquatic vegetation, another whole-lake, point-intercept survey should be completed no later than the third year into implementation of the new Comprehensive Plan, and then again five years after that. The survey should be conducted by an aquatic plant survey specialist during both the early, cold-water season and late warm water season of plant growth.

6.1.4 Biota

The animal and plant life of a particular region, habitat, or geological period is called biota. Recommendations in this plan attempt to change the make-up of both plant and animal communities currently established in Dowling Lake. As such, monitoring of and within those communities is necessary.

6.1.4.1 Zooplankton Survey

A zooplankton survey could provide information about the current makeup of the zooplankton community in Dowling Lake. Working with the WDNR and other resources, the ADLMD could identify an entity that could help complete this kind of study. Most likely this would be completed through a college or university.

6.1.4.2 Fish Survey

The last DNR fisheries survey of Dowling Lake was in the early 2000's (see Section 4.6.1). At that time, the population of larger predator fish, like walleye, was above average, and panfish populations were lower than average. Contacting the WDNR to determine when Dowling Lake will be surveyed next would be the first step in monitoring the fish population.

6.1.4.3 Galerucella Beetle Survey

Gallerucella beetles that eat invasive purple loosestrife have been released on Amnicon and Dowling Lake over the last 10-15 years. An established population is known to exist on both lakes; however, no beetles have been released in recent years. During a 2016 plant survey, the plant surveyor documented purple loosestrife along the shores and adjacent to the lake but specifically reported not seeing any beetle activity. A more comprehensive survey for beetle activity should be completed, but it is likely that introducing more beetles will be warranted.

6.1.4.4 Blue-green Algae

Blue-green algae[11], also known as Cyanobacteria, are a group of photosynthetic bacteria that many people refer to as "pond scum." Blue-green algae are most often blue-green in color, but can also be blue, green, reddish-purple, or brown. Blue-green algae generally grow in lakes, ponds and slow-moving streams when the water is warm and enriched with nutrients like phosphorus or nitrogen. Blue-green algae are generally not eaten by other aquatic organisms and are not an important part of the food chain.

When environmental conditions are just right, blue-green algae can grow very quickly. Most species are buoyant and will float to the surface where they form scum layers or floating mats. When this happens, it is often referred to as a Harmful Algal Bloom or HAB. In Wisconsin, HABs generally occur between mid-June and late September, although in rare instances, blooms have been observed in winter, even under the ice.

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[11] The information presented here is from the WDNR webpage on blue-green algae. For more information go to: https://dnr.wisconsin.gov/topic/lakes/bluegreenalgae.

Concerns associated with blue-green algae include discolored water, reduced light penetration, taste and odor problems, dissolved oxygen depletions during die-off and toxin production. Discolored water is an aesthetic issue, but when blue-green algae reach bloom densities, they can actually reduce light penetration, which can adversely affect other aquatic organisms both directly (e.g., other phytoplankton and aquatic plants) and indirectly (e.g., zooplankton and fish that depend on phytoplankton and plants). When a blue-green algae bloom dies off, the blue-green algae cells sink and are broken down by microbes. This breakdown process requires oxygen and can create a biological oxygen demand, which can lead to fish kills in severe cases.

There is no reliable treatment for blue-green algae blooms. If treated with an herbicide or algaecide, toxins contained in the cells could be released, releasing toxins into the water. It is best to stay out of water experiencing a bloom and wait for the bloom to dissipate on its own.

The WDNR is not currently conducting routine statewide monitoring for blue-green algae or blue-green algal toxins. However individuals and lake groups can submit samples for testing at the SLOH if there are concerns. However, the SLOH is unable to provide interpretation or guidance for testing results. Significant blue-green algae blooms can also be reported to the WDNR. When doing so, the location of the bloom, the name of the water body, nearest town, county, the size and duration of the bloom, and overall and close-up photographs for verification should be included.

6.2 Water Chemistry

Water chemistry includes those parameters that are directly influenced by chemical interactions that occur in the lake and include dissolved oxygen and temperature, chlorophyll-*a*, nitrogen and phosphorus, pH, specific conductivity, and E. coli.

6.2.1 Dissolved Oxygen and Temperature

Regular temperature and dissolved oxygen profiles should be collected during the open water season, preferably on a weekly basis. The ADLMD currently owns a digital dissolved oxygen meter; however, profile results measured in late 2019 and 2020 have suspect results that may be attributed to a faulty meter. It will be important for the ADLMD to either figure out the issues with the current meter or consider the purchase of a replacement. It may be as simple as calibrating the existing meter. Regardless, a digital meter can be used on both Dowling, and Lake Amnicon.

6.2.2 Chlorophyll-*a*

Chlorophyll, the green compound that allows plants (including algae) to perform photosynthesis, can be used to measure algal biomass in a waterbody.

Chlorophyll can be used to classify the trophic condition of a waterbody. Concentrations of Chl-*a* greater than about 10μg/L are considered indicative of eutrophic conditions and concentrations 20μg/L or higher are associated with algal blooms. For trophic state classification, preference is given to the Chl-*a* trophic state index (TSICHL) because it is the most accurate at predicting algal biomass.

6.2.3 Nitrogen and Phosphorus

Both nitrogen and phosphorus are crucial to the growth of aquatic plants and algae. Phosphorus is the most common limiting nutrient in lakes (see Section 4.2 for more information); however, there is evidence to suggest that N may also be a limiting nutrient, or at least co-limiting with phosphorus, in Dowling Lake. As such, it is necessary to monitor both nutrients in their particulate and dissolved forms

TP is included in the CLMN expanded water quality testing program, but monitoring for the dissolved forms of both nitrogen and phosphorus are not. ADLMD volunteers and researchers have collected water samples as a part of the CLMN water quality monitoring program and as a part of the various studies that have been completed. These samples have been analyzed at the WI State Laboratory of Hygiene (SLOH) for N and P parameters at a cost ranging from $25-$40 per sample analyzed. This level of water sampling and testing can continue, but certain parameters could be analyzed without expensive SLOH analysis. Various inexpensive test kits from Hach and CHEMets (and maybe others) can be used to sample the dissolved forms of N and P. Collecting TKN and TP data will likely continue to require water samples collected by volunteers and analyzed at the SLOH or similar lab.

6.2.3.1 Nitrites/Nitrates

Alternative to SLOH testing, there is a kit manufactured by Hach that tests nitrate (range 1 to 50 ppm) and nitrite (range 0.15 to 3.0) on the same test strip. This is adequate for most field samples (Figure 50). Anything higher than zero in streams or ponds may be a concern. However, 10 ppm is the maximum contaminant level in drinking water.

Figure 50: Hach Company nitrate/nitrite test strips

6.2.3.2 Ammonia

A similar kit is available to test ammonia in a water sample. These test strips are sensitive to levels between 0.25 and 6.0ppm NH4 (Figure 51). Because the relative proportion of free ammonia rapidly increases with pH and temperature increases, measuring those values is also recommended.

Figure 51: Hach Company ammonia test strips

6.2.3.3 Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) measures a combination of organic N and ammonia+ammonium. Total nitrogen (TN) is a combination of all forms of nitrogen in the water. TKN results can be added to nitrate/nitrite results to get TN (Figure 52). Ammonia (NH4) cannot be separated from the TKN result, so one either monitors TKN and nitrate/nitrites; or TKN, ammonia, and nitrate/nitrite. If a measure of TN is needed then water samples would have to be analyzed for TKN at the SLOH or similar lab.

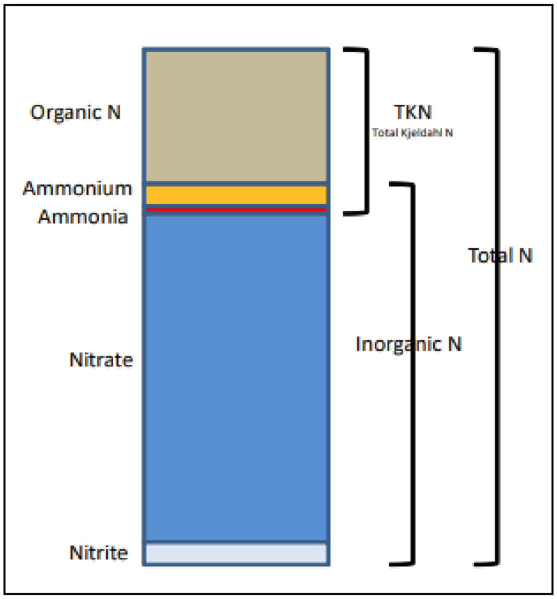

Figure 52: Schematic diagram of the relative amounts of different N forms commonly found in Minnesota surface waters with elevated N levels (Wall, 2013).

6.2.3.4 Total Phosphorus

TP is one of the parameters collected via the CLMN expanded water quality testing program. A request could be made to the WDNR to add Dowling Lake to this program. Lake Amnicon is already a part of the CLMN expanded monitoring program, as well as being a WI Long-term Trend Lake.[12] If Dowling Lake is not accepted in the expanded monitoring program, then the ADLMD should consider collecting TP water samples for analysis at the SLOH following CLMN protocols, but covering the cost of analysis through grants or ADLMD funding.

6.2.3.5 Orthophosphates

Orthophosphates, biologically available phosphorus, in water samples can be analyzed at the SLOH. However, it may be reasonable to use a citizen science test kit developed by CHEMets because it is accurate, easy to use, and reasonably priced. Results are presented as PO4, similar to an agricultural soil test, rather than PO4 -P, more common for water samples. To use this kit, a water sampling device, sample containers, and distilled water to rinse the test-kit mixing container is needed. This kit comes with glass vials instead of plastic test strips, so they need to be handled and disposed of carefully and properly after running the test.

Detectable levels of orthophosphates are rarely found in surface water unless there have been recent additions from some source. The primary reason for this is the quick use by plants and algae when it is available. Any P detected with the CHEMets test kit would indicate a recent addition of P that has the potential to cause eutrophication. The CHEMets kit gives a reading as PO4, which is three times greater than the equivalent lake orthophosphate value, so results should be recorded accordingly.

6.2.4 pH and Conductivity

pH measures whether the water is more acidic (lower pH) or basic (higher pH), compared to a reading of 7.0 as neutral. Often the pH reading, on its own, does not tell much about water quality. However, it can give valuable clues as to what else is going on in the water, as the pH will affect things like the solubility of various minerals in the water.

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[12] For more information about Wisconsin's Long Term Trend Lakes Monitoring Program go to: https://dnr.wisconsin.gov/topic/SurfaceWater/Monitoring.html

Commercially available pH test strips are a cost effective and convenient alternative to consumer-grade electronic pH meters. Several types are available at pool and pet stores as well as through scientific and educational suppliers. Hach Company, or similar, brand strips are recommended. These test strips have a wide range (pH 4 to 9), in increments of whole pH units.

Conductivity is a measure of the ability of water to pass an electrical current.
Conductivity is useful as a general measure of water quality. Each water body tends to have a relatively constant range of conductivity that, once established, can be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity could then be an indicator that a discharge or some other source of pollution has entered the lake. Generally, human disturbance tends to increase the amount of dissolved solids entering waters which results in increased conductivity.

Conductivity in water samples can be measured at the SLOH or similar lab. A conductivity meter could also be used

6.2.5 E. Coli

See Section 4.9.1.

6.2.6 Sediment Phosphorus Release Study

Aquatic sediment is often an important source of P in lakes, and control of sediment P is essential in lake rehabilitation. In Dowling Lake, there is a need to quantify the actual amount of P from the sediment that is contributing to internal loading. Completing a sediment release study would help do this. A sediment release study involves collecting sediment from the bottom of the lake and then incubating it in a lab setting under different conditions that are likely to occur. Phosphorus release under high pH, high temperature, and under anoxic (no oxygen) are just a few of the conditions that could be tested. The University of Wisconsin-Stout’s Center for Limnological Research and Rehabilitation (CLRR) could assist with these tests.

6.3 Tributary Monitoring

Based on data collected in 2019 and 2020 (See Section 4.8), tributary loading of nutrients accounts for about 42% of the total entering the lake. Quantifying the overall nutrient loading from tributaries is difficult to do accurately and is highly dependent on the conditions (weather and watershed) that exist during a sampling period. As such, it would be beneficial to collect additional tributary data including flow, volume, sediment, and P at various times during the implementation of this plan. More frequent or repeated data collection and comparison increases the confidence in the data.

Past monitoring of the main inlet to the lake on the east side near the boat landing, intermittent tributaries on the north and south side of the lake, and at the outlet of the lake has been completed by volunteers using guidelines established by the Water Action Volunteer (WAV) program (See Section 4.8). This process should be repeated for a period of 2-3 years at two different times during implementation of this plan.

6.4 Aquatic Invasive Species

Currently, the only aquatic invasive species present along the shores of Dowling Lake are purple loosestrife, yellow iris, and reed canary grass. Property owners and volunteers should monitor the shores of the lake for these invasive species and remove them if they can. Purple loosestrife can be pulled or dug out, or it can be left in place while cutting the flowering heads to prevent new seeding. Yellow iris control and removal should also be explored. Reed canary grass is not generally managed except that it could be replaced with more desirable species during native plantings along the shore.

Other invasive species, including Eurasian watermilfoil (EWM) and curly-leaf pondweed (CLP) should be monitored for on a regular basis. There are several other non-native animals that could be introduced to the lake, including zebra mussels, New Zealand Mudsnails, Chinese mystery snails, and rusty crayfish. More information about these species is included in Appendix A.

6.5 Impaired Waters Evaluation and Monitoring

Listing and delisting of a lake on the Impaired Waters list is dependent on an evaluation of appropriate data from the most recent 10-yr period, with data from the most recent 5-yrs given preference as it is more likely to be representative of the current conditions (Bureau of Water Quality Program Guidance, 2020). For both TP and Chl-a, it is the goal of the WDNR to have at least three samples per year over at least two qualifying years for both TP and Chl-a that meet the following data requirements:

- Sampling season for TP is June 1 - Sept 15.
    - For TP samples in May and/or late September may be added if it can be demonstrated that the lake is thermally stratified during that time period.
- Sampling season for Chl-a is July 15 - Sept 15
- One sample per month, taken as close to the middle of the month as possible
- Sample dates must be spaced at least 15 days apart to evenly represent the season
- Field collection, preservation and storage should follow procedures outlined in the WDNR Filed Procedures Manual and the Citizen Lake Monitoring Manual
- Laboratory analysis should follow standard methods (WSLH 1993)
- Only surface samples taken from the top 2 meters of the lake collected using depth-integrated methods
- Both TP and Chl-a results should be expressed in μg/l.

It is important that the water quality data collected by the ADLMD and other entities meet these requirements so evaluations of change over time can be completed. Ultimately, delisting of Dowling Lake will be dependent on the quality of the data collected.

6.6 Citizen Lake Monitoring Network (CLMN)

This volunteer-based monitoring network which has been referenced many times in this report provides an opportunity for citizens to take an active role in monitoring and maintaining water quality. Aquatic invasive species monitoring involves searching the lake for aquatic invasive species. The frequency that volunteers perform AIS monitoring varies, but most volunteers do this a few times per year. Most volunteers conduct AIS monitoring in high-risk sites around their lakes (like boat landings) to detect early populations of AIS. Early detection of AIS is crucial for effective, inexpensive management, so these volunteers are incredibly valuable.

Through this network, lake volunteers and resource professionals can learn more about individual lakes across Wisconsin.

7.0 Education and Outreach

Every property owner on Dowling Lake is contributing to the decline of the lake. So, improving the lake has to start with the property owners. Changing property owner and lake user attitudes is probably the one single, most important goal to achieve.

Through education and outreach, the ADLMD has to create public awareness of water quality issues and what contributes to them; increase public involvement in lake and watershed stewardship; and increase communication and coordination among the stakeholders and partners that are most able to help implement management actions.

7.1 Objectives

The following is a list of objectives related to Education and Outreach

- Develop targeted educational and informational materials for appropriate audiences in the lake and watershed and distribute through newsletters, brochures, website and Facebook posts, etc.
- Host workshops, meetings, and events that landowners can attend to learn more about BMPs that will help maintain or improve the lake.
- Explore what level of professional support various resource agencies can offer to help plan and implement management strategies to improve the lake.
- Solicit involvement and support from local businesses, schools, clubs, and other organizations.

7.2 Target Audience

Multiple audiences will be targeted with this education and outreach plan. Target audiences include, but are not limited to, property owners on and adjacent to Dowling Lake; businesses on or adjacent to Dowling Lake; lake users; local clubs, organizations, and schools; ADLMD and other local government officials (Town of Summit, Town of Oak Creek), and Douglas County.

7.2.1 Property Owners

How property owners view and treat the lake, often called lake stewardship, is vital to maintaining the health of the lake. Lake stewardship can encompass many things including but not limited to how a property adjacent to the shore is managed, proper septic system maintenance, lighting along the shore, noise, being a good neighbor, responsible boat use, following fishing rules and regulations, and doing what is necessary to avoid spreading aquatic invasive species.

Lake stewardship will be promoted through lake organization meetings and publications. Many organizations create specific awards, brochures, or other materials promoting and/or recognizing good stewardship practices and the people who are practicing them.

People use lakes in different ways, and may have different goals for enjoyment of the lake. Discussing these goals in an open forum can help people understand each other's view points and vision for the lake. Additionally, gaining an understanding of general lake processes and ecology can help people understand what is happening in their lake. Determining the current condition of the lake can then provide a knowledge base that can be used to protect and restore the lake.

7.2.2 Lake Users

Lake users can be anybody with property on the lake or who come to the lake for some purpose. While access is limited, Dowling Lake still receives outside users for fishing, power boating, water skiing, tubing, and use of personal watercraft. A continued effort toward providing education and information regarding transport and introduction of AIS; safe and legal use of watercraft; and use of watercraft in a way that does not harm Dowling Lake helps protects the people and the overall health of the lake. Fishing is another popular activity on Dowling Lake practiced by both property owners and outside lake users. Like other good lake stewardship practices, following fishing rules and regulations related to size and bag limits, proper handling of catch and release fish, draining livewells, and proper disposal of live bait will also help protect the health of the lake.

7.2.3 Real Estate

When ownership of a property changes due to sale, foreclosure, or by some other means, this is a good opportunity to approach the new owners with information about what they can do to make their new property more lake friendly. Being part of a lake district, each new property owner automatically pays extra taxes to support a healthy lake. Providing information to these new property owners about what their extra taxes are being used for may increase support for what the ADLMD does. Ultimately, taxes will be less and home/property values more when a lake is considered generally healthy with only minor issues. While mowed and manicured properties may sell better, a fact often noted by real estate agents, they are less healthy to the lake overall.

The ADLMD should be actively engaged in property sales around the lake. When a property exchanges hands, representatives of the ADLMD should welcome the new owner and pass on materials about how and what that property owner can do to maintain or improve the lake into the future.

7.3 Outside Resources

Many of the actions recommended in this plan cannot be completed solely by the ADLMD. Multiple outside resources and expertise will be needed to guide implementation. The following is a list of outside resources that the ADLMD will need to partner with to implement the actions in this plan.

7.3.1 Douglas County Departments

7.3.1.1 Land Conservation

The Land Conservation Department's mission is to administer the Douglas County Land and Water Conservation Program to meet local priorities, conditions, and the needs of Douglas County land users through utilizing the Douglas County Land and Water Resource Management Plan as guidance and the State-funded, cost-share program for implementing conservation practices. The Land Conservation Department is responsible for administering programs such as: Aquatic Invasive Species Program; Environmental Reserve Fund; short-term, grant-funded programs; providing technical assistance for all types of conservation practices; implementing information and education programs; updating various soil and water resource inventories; and nurturing partnerships with other county, state, and federal agencies.

https://www.douglascountywi.org/305/Land-Conservation

7.3.1.2 Planning and Zoning

The Planning and Zoning Department's responsibility is: to protect the public interest and our natural resources by the administration of land use policies and ordinances emerging from comprehensive plans; to provide assistance to citizens, elected officials, and partners to guide decision-making; and to enhance staff capabilities, operational processes, and collaboration with County departments and outside agencies. The Planning and Zoning Department's responsibilities also include regulating shoreland development, lot size, building permits, impervious surface, POWTS, etc. around and adjacent to county water resources.

https://www.douglascountywi.org/327/Planning-Zoning

7.3.1.3 Forestry, Parks, and Recreation

The primary responsibilities of the Douglas County Forestry Department are to: 1) Provide stewardship to forest resources; 2) Develop and maintain recreational opportunities; and 3) Serve as an informational resource to the public. Management must balance local needs by integrating sound forestry and practices related to wildlife, fisheries, endangered resources, water quality, soil, and recreation. Forest resources are managed for environmental needs such as the protection of watersheds and rare plant and animal communities as well as the maintenance of plant and animal diversity. These same resources, however, also must provide for societal needs including recreational opportunities and production of raw materials for wood-using industries.

https://www.douglascountywi.org/211/Forestry-Parks-Recreation

7.3.1.4 Cooperative Extension

County-based Extension educators are University of Wisconsin (UW) faculty and staff who are experts in agriculture and agribusiness, community and economic development, natural resources, family living, and youth development. Extension county-based faculty and staff live and work with the people they serve in communities across the State. Extension specialists work on UW System campuses where they access current research and knowledge. Collaboration between county and campus faculty is the hallmark of Cooperative Extension in Wisconsin.

https://www.douglascountywi.org/205/Extension

7.3.2 University and Collegiate

7.3.2.1 Lake Superior Research Institute – UW-Superior

The Lake Superior Research Institute (LSRI) at UW-Superior was created in 1967 and formally recognized by the UW Board of Regents in 1969. LSRI's mission is to conduct environmental research and provide services that directly benefit the people, industries, and natural resources of the Upper Midwest, the Great Lakes Region, and beyond; provide non-traditional learning and applied research opportunities for undergraduate students; and foster environmental education and outreach in the Twin Ports and surrounding communities.

Areas of expertise include: analytical chemistry; aquatic invasive species monitoring and outreach; benthic and zooplankton taxonomy; habitat restoration; microbiology; sediment and aquatic toxicology; quality assurance and data management; watershed management and planning; and wetland assessment and monitoring. Current research includes: aquatic and sediment toxicity testing, aquatic invasive species ecology, ballast water management system testing, beach monitoring and microbial source testing, biological monitoring and inventory of aquatic and terrestrial communities, endangered species management planning, habitat restoration, and mercury analysis in biota.

https://www.uwsuper.edu/lsri/index.cfm

7.3.2.2 Mary Griggs Burke Center for Freshwater Innovation

The Mary Griggs Burke Center for Freshwater Innovation (Burke Center) at Northland College in Ashland, WI focuses on scientific research, communication, and thought leadership on water issues in the Great Lakes region and beyond. The Burke Center specializes in "translating" science to the general public, government agencies, NGOs, agriculture, and the private sector, helping to edify water policy in a wide variety of geographies and subject areas. Two such areas are Integrated Ecosystem Management and Environmental Monitoring and Assessment.

Effective management of freshwater ecosystems is dependent on an understanding of how human activities and value sets intersect with the environmental processes that sustain water resource integrity. Their work focuses on integrating approaches from the natural and social sciences to conduct and develop integrated assessments and management plans for freshwater ecosystems.

Public decision-making surrounding water resources is dependent on a range of data that describe the condition of freshwater ecosystems and the current—and potential future—stressors that may impact their integrity. Their work focuses on the use of environmental monitoring and analytical technologies to develop long-term data sets to support public decision-making for freshwater resources. The Burke Center is involved in multiple projects that collect and analyze a variety of data including bacteria, e-coli, zooplankton, aquatic plants, wild rice, water quality, etc.

https://www.northland.edu/centers/mgbc/

7.3.2.3 Center for Land Use Education

The Center for Land Use Education (CLUE) is a joint venture of the College of Natural Resources at the UW-Stevens Point and the UW-Madison Division of Extension. It is a focal point for land-use planning and management education. Through applied research, teaching and outreach, CLUE specialists and faculty support students, local government officials, communities and K-12 audiences on a variety of land and water topics including planning and zoning, land divisions, fragmentation, sustainability, bio- and renewable energy, food systems, shorelands and wetlands. By providing up-to-date and comprehensive training on planning and zoning tailored to address specific local needs, CLUE specialists are able to assist towns, villages, cities and counties in making sound land use decisions.

https://erc.cals.wisc.edu/programs/center-for-land-use-education/

7.3.2.4 Center for Watershed Science and Education

The Center for Watershed Science and Education (CWSE) at UW-Stevens Point supports watershed understanding and stewardship across and beyond the state of Wisconsin. The center includes specialists with expertise in groundwater, lakes, streams, water chemistry and analysis, and data science. The center helps individuals, organizations and private and public water resources professionals understand water quality and quantity in private wells, groundwater, lakes and rivers. Through their programming, center staff provides guidance on sampling and data collection, education on water quantity and quality, and interpretation and evaluation of monitoring results. The center also performs applied research and creates data visualization tools to improve watershed understanding.

Current research explores the movement of nitrate-nitrogen in soil and groundwater, the quantity and chemistry of groundwater, changes in lake water quality and the occurrence of pharmaceuticals and new pesticides in the water.

https://erc.cals.wisc.edu/programs/center-for-watershed-science-and-education/

7.3.2.5 Center for Limnological Research and Rehabilitation

The Center for Limnological Research and Rehabilitation (CLRR) at UW-STOUT focuses on eutrophication issues and management solutions for freshwater systems. They provide limnological research services to the surrounding community, including: diagnosing eutrophication-related problems in lakes and reservoirs; conducting comprehensive hydrologic and limnological monitoring programs; identifying and quantifying important phosphorus sources that drive cyanobacterial blooms; and developing and implementing management plans to sustainably rehabilitate degraded aquatic systems.

Their laboratory facilities provide an array of analytical capabilities for the examination of nutrients (primarily phosphorus species) and algae in water and sediment. They have a variety of field monitoring equipment for quantifying tributary flow and phosphorus loads discharging into lakes, boats and sampling equipment for monitoring lake chemistry and biology, and coring capabilities for the examination of aquatic sediment. In particular, they have unique expertise for determining important mobile phosphorus fractions in aquatic sediments and nutrient exchanges between sediments and the overlying water.

https://www.uwstout.edu/directory/center-limnological-research-and-rehabilitation

7.3.2.6 Natural Resources Education Program

7.3.2.6.1 NRE Water Programming - Leading and facilitating water quality projects across the state

Natural Resource Educators (NRE) are providing leadership on nutrient reduction and water quality projects across the state. Key efforts include outreach to increase local capacity to reduce nonpoint source pollution in the Lower Fox, Wisconsin, St. Croix, Red Cedar and Rock River watersheds and the Lower Fox River Demo Farm Network initiative. Projects are carried out in collaboration with federal, state and local partners as well as producer-led watershed initiatives. The Demo Farm initiative works with farmers and their advisers to conduct on-farm demonstrations that measure and share the effectiveness of conservation practices to reduce erosion and sediment runoff, control phosphorus runoff and address other nonpoint sources of pollution.

7.3.2.6.2 NRE Forestry Programming - Engaging private woodland owners to encourage sustainable forest management.

ERC-based Natural Resources Educators and key partners are leading classes (Learn About Your Land and Your Land, Your Legacy) and other efforts to engage landowners in the sustainable management of Wisconsin's privately-owned forests. NREs create content for landowners on a variety of topics in publication, video, and website formats.

https://erc.cals.wisc.edu/programs/regional-natural-resources-education-program/

7.3.2.7 Aquatic Invasive Species Outreach

Wisconsin's aquatic invasive species (AIS) program focuses on preventing the introduction of new invasive species to Wisconsin, containing the spread of invasives that are already in the state, and managing established populations when possible. In close cooperation with the Wisconsin Department of Natural Resources and Extension Lakes program, UW– Madison Division of Extension education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers and other water users the steps they should take to prevent transporting aquatic invasives to new waters. Efforts also address other potential mechanisms of introduction, including aquarium pet release and water gardening.

https://erc.cals.wisc.edu/programs/aquatic-invasive-species-outreach/

7.3.2.8 UW-Extension Lakes Program

Based at UW-Stevens Point, the Extension Lakes Program seeks to preserve Wisconsin's legacy of lakes through education, communication and collaboration. The program works with over 800 local lake associations and lake districts in Wisconsin, assisting them through education and capacity building. Lakes also partners with the Wisconsin DNR to coordinate a number of programs and projects to assist those concerned with the future of our lakes, including the Citizen Lake Monitoring Network, the Clean Boats, Clean Waters program and the Lake Leaders Institute. The *Lake Tides* newsletter reaches thousands of readers throughout the region.

https://erc.cals.wisc.edu/programs/extension-lakes-program/

8.0 Funding Sources

In addition to the outside resources and expertise needed to successfully implement recommended actions, financial assistance will be needed. While outside sources of funding exist, the ADLMD will have to contribute, making it imperative that the constituency be fully aware and supportive of what is planned and implemented. The following lists other sources of funding, but is not exhaustive. Other funding sources will likely have to be identified and explored as well.

8.1 Douglas County Environmental Reserve Fund

A significant sum of money from the ATC came with that agreement to be used for environmental purposes as a way to mitigate environmental impacts of the new line. Douglas County combined some of this money with other sources to develop the Environmental Reserve Fund, administered by the Douglas County Land Conservation Committee (LCC) with oversight by the Administration Committee and County Board. The purpose of the fund is to make available modest amounts of money to small, Douglas County entities working on environmental issues; while earning interest, which will be applied to the principal, to continue the fund into the future.

https://www.douglascountywi.org/718/Environmental-Reserve-Fund

8.2 WI-DNR Surface Water Grants[13]

The surface water grant program provides cost-sharing grants for surface water protection and restoration. Funding is available for education, ecological assessments, planning, implementation, and aquatic invasive species prevention and control. With many different projects eligible for grant funding, you can support surface water management at any stage: from organization capacity development to project implementation.

- Education
- Planning
- Comprehensive Management Planning
- County Lake Grants
- Healthy Lakes and Rivers
- Surface Water Restoration
- Management Plan Implementation
- Clean Boats, Clean Waters
- AIS Supplemental Prevention
- AIS Early Detection and Response
- AIS Large- or small-scale Population Management
- AIS Research and Demonstration
- Land Acquisition
- Early Detection and Response Projects
- Established Population Control Projects
- Maintenance and Containment Projects
- Research and Demonstration Projects

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[13] For more information on WI-DNR Surface Water Grants go to: https://dnr.wisconsin.gov/aid/SurfaceWater.html

9.0 Goals, Objectives, and Actions

Lake management plans help protect natural resource systems by encouraging partnerships between concerned citizens, lakeshore residents, watershed residents, agency staff, and diverse organizations. Lake management plans identify concerns of importance and set realistic goals, objectives, and action items to address each concern. Additionally, lake management plans identify roles and responsibilities for meeting each goal and provide a timeline for implementation.

Lake management plans are living documents which are under constant review and adjustment depending on the condition of a lake, available funding, level of volunteer commitments, and the needs of lake stakeholders.

The following three items provide basic guidance on how this lake management plan should be implemented.

- Lake management decisions are data driven and evidence-based to incorporate an analysis of past, present, and future data and are implemented in a manner that will limit unintended negative environmental impacts.
- Member education, engagement, and neighbor-to-neighbor communications for all generations are important to meet the vision of and manage the future of Dowling Lake.
- Clear and concise multi-channel communications to members express the ever-evolving nature of lake management and the complexity of issues.

9.1 Goal 1: Provide information and education with the intent of changing stakeholder behaviors to protect Dowling Lake.

Getting support and buy-in from all Dowling Lake property owners and lake users, along with support from local agencies is imperative to successfully managing the lake.

9.1.1 Objective 1. Establish a constituent supported “committees” structure to address major areas of lake management.

- Education and Information
    - Main task would be communication and information sharing through Facebook, webpage, newsletter, and other social media outlets
- Shoreland Improvement
    - Main task would be to encourage, promote, and support activities to improve shorelands
- Water Quality
    - Main task would be to collect water quality data on the lake, report it, and share with other stakeholders
- Aquatic Plants, Algae, and Aquatic Invasive Species
    - Main task would be to support aquatic plant (and algae if determined necessary) monitoring and potential management
- Fisheries and Wildlife
    - Main task would be to work with WDNR and other partners to support fish stocking and other management actions
- Government and Grants
    - Main task would be to coordinate efforts between the ADLMD, Town, County, University, and State. Would also take the lead on soliciting grant funding.

9.1.2 Objective 2. Use existing channels to deliver at least one focused educational message per quarter to meet the goals of this plan.

- Community forums, Web and Facebook pages, Newsletters, Emails, Presentations and brochures at the ADLMD meetings, and Press releases in local newspapers
- Special educational sessions such as pontoon classrooms, property tours, Healthy Lakes workshops, and CBCW trainings

- Create stickers or signs to symbolize participation in different lake improvement programs as a way to start a conversation with neighbors

9.2 Goal 2: Reduce nuisance algae growth by reducing sources of phosphorus

Dowling Lake is on Wisconsin's Impaired Waters List under the Federal Clean Water Act, Section 303(d). Sources of phosphorus should be reduced such that Dowling Lake is removed from the Impaired Waters List as indicated by an in-lake average seasonal total phosphorus concentration of 30µg/L and in-lake chlorophyll value of less than 20µg/L for 30% of the days in the sampling season. Both external and internal sources of phosphorus and other nutrients need to be addressed.

2A - External Loading

9.2.1 Objective 1. Plan and install 1-3 shoreland improvement projects annually.

- Develop and deliver an educational message regarding the importance of healthy shoreland areas and how it reduces sources of P
- Organize annual workshops to encourage property owner participation in healthy lakes projects: native plantings, rain gardens, diversions, and infiltration practices
    - Use results from the Shoreland Habitat Assessment as a guide
- Identify property owners interested in installing practices
- Prepare Healthy Lakes Grant applications to provide technical assistance and cost sharing to fund practices
- Implement shoreland improvement projects

9.2.2 Objective 2. Reduce the amount of foreign debris (grass clippings, leaves, road salts, sand and sediment, etc.) that get into the lake.

- Develop and deliver an educational message regarding the importance of appropriate disposal of lawn debris (encourage sweeping and raking, bagging, composting, mulching, etc.)
- Work with the local Township to come up with ways to clean up/reduce sand and salt applied to roads around the lake (curbs and catch basins, street sweeping, etc.)

9.2.3 Objective 3. Upgrade 100% of existing non-compliant, failing, and drainfield-based septic systems; eliminate all gray water discharge to the lake.

- Develop and deliver an educational message regarding the relationship between increased phosphorus in the lake and non-compliant or failing septic systems, septic systems that rely on drainfields, and graywater discharge
- Identify shoreline property owners willing to upgrade their septic system
- Support non-mandatory upgrades to existing septic systems with WDNR Surface Water or other funding if possible

9.2.4 Objective 4. Protect and preserve undisturbed/undeveloped property around the lake.

- Identify areas of the lake to protect and preserve
- Research and explore the formation of a conservancy, purchase of easements, grant funding, and other opportunities for protecting and preserving land
- Identify property owners who may be interested in preserving property around the lake

9.2.5 Objective 5. Restore wetlands adjacent to Dowling Lake.

- Identify restorable wetland areas adjacent to the lake
- Identify property owners willing to participate in wetland restoration projects
- Develop a wetland restoration plan in cooperation with Douglas County and the WDNR and

implement it

9.2.6 Objective 6. Prevent forestry timber management operation from negatively impacting Dowling Lake.

- Monitor forestry activities within the direct watershed of Dowling Lake
- Communicate forestry concerns to Douglas County

2B - Internal Loading

9.2.7 Objective 7. Reduce sediment disturbances caused by boating.

- Develop and deliver an educational message regarding the relationship between boat traffic and P release from the sediment to property owners and visiting boaters
- Consider a boating or wave restriction ordinance to minimize sediment disturbance caused by boating

9.2.8 Objective 8. Maintain or increase the amount of existing shallow lake and wetland/lake fringe vegetation (See Goal 4, Objectives 2-4).

- Develop and deliver an educational message regarding the importance and value of aquatic vegetation along the shore and in the shallow areas of the lake in reducing shoreland erosion and sediment resuspension

9.2.9 Objective 9. Investigate the construction/installation of a controllable water outlet for the lake.

- Work with property owners to garner support for and to promote the benefits of water level manipulation in lake management
- Design/engineer and install an outlet structure that would allow controlled water level manipulations
- Develop and implement a water level manipulation plan to encourage growth of aquatic vegetation

9.2.10 Objective 10. Consider the use of biomanipulation to improve water quality.

- Work with the WDNR and/or Tribal Resources to complete a fisheries survey
- Continue stocking of walleye and other predator fish species
- Complete a zooplankton survey

9.2.11 Objective 11. Consider the use of an alum application to improve water quality.

- Complete a sediment release study
- Work with property owners to garner support for and to promote an alum treatment for the lake
- Develop and implement an alum application plan

9.2.12 Objective 12. Install one or more fountains and/or artificial floating island/wetland.

- Research, build, install, and monitor one or more artificial floating islands in the lake
- Research, install, and monitor one or more fountains in the lake

9.3 Goal 3: Prevent the introduction of new invasive species and manage existing invasive species.

Currently purple loosestrife and yellow iris, two shoreland emergent plants are relatively common along the shoreline of Dowling Lake. New efforts should be made to control purple loosestrife and the impact of yellow iris and the ability to control its spread should be evaluated. Curly-leaf pondweed is the only submerged aquatic invasive species listed to be in the lake, although in the last two surveys (2012 and 2016) none was located. Annual bedmapping surveys should be completed to determine the extent of CLP in the lake and if its distribution and density increases over time.

Efforts should be made to prevent new introductions of AIS. EWM, giant reed grass (non-native phragmites), zebra mussels, New Zealand mudsnails, and spiny waterflea are all present in nearby waters.

9.3.1 Objective 1. Monitoring and management of existing AIS.

- Purple loosestrife (survey work, physical removal and/or bio-control)
- Yellow iris (survey work, physical removal and/or aquatic herbicides)
- Curly-leaf pondweed (survey work, physical removal)

9.3.2 Objective 2. Prevent the introduction and spread of new aquatic invasive species.

- Participate in a CBCW monitoring and education program at boat landings on Amnicon and Dowling Lakes
    - Consider other local measure to inform boaters and lake users given that 200 hours at the Dowling Lake landing is likely unnecessary
    - Combine both the Lake Amnicon and Dowling Lake into one CBCW monitoring program
    - Participate in additional WDNR statewide programs including the Landing Blitz and Drain Campaign
- Place and update AIS signage at the boat landings as necessary
- Participate in the Citizen Lake Monitoring Network AIS Monitoring program
- Develop and implement an AIS Rapid Response Plan

9.4 Goal 4: Protect and enhance native aquatic plant growth

Increasing the amount of aquatic plant growth in Dowling Lake will be critical to improving water quality. For better information related to the plant community, the whole lake needs to be surveyed again as soon as possible, likely in the second year of this plan's implementation. Property owners should be encouraged to minimize any plant removal in an effort to protect what is already present.

Consideration should be given to reintroducing some level of new aquatic plant growth. Wild rice may be the easiest plant to establish, but partnering with St. Croix Tribal Resources and GLIFWC to get this done is a must. Further, if wild rice were to become established in the lake, special plant protection rules automatically come into play. Property owners and lake users should be informed and involved in any such endeavor so they know what to expect. Other species that could be considered would be Nitella sp., water celery, flat-stem pondweed, and fern-leaf pondweed. These four species were the most abundant plant species in Amnicon Lake in 2012, which may provide a ready source of plant stock to collect and transplant into Dowling Lake.

9.4.1 Objective 1. Document changes in native aquatic plant density, distribution, and diversity.

- Redo a spring and summer whole-lake, point-intercept, aquatic plant survey
    - Apply for grant implementation money in 2022 and with the survey completed in 2023
    - Repeat again in 2028

9.4.2 Objective 2. Protect existing native aquatic vegetation in the nearshore and wetland fringe area of the lake.

- Develop and deliver an education and information program to promote the benefits and importance of aquatic plants to improving water quality
- Provide recognition signs to property owners who support no management or re-establishment of aquatic plants on their shoreline

9.4.3 Objective 3. Re-establish wild rice in Dowling Lake.

- Work with SCTR, GLIFWC, and lake property owners to develop a wild rice reintroduction program on Dowling Lake

    - Identify property owners willing to support the reintroduction of wild rice adjacent to their property
    - Identify public locations around the lake for wild rice reintroduction

9.4.4 Objective 4. Reintroduce certain species of native aquatic plants into Dowling Lake.

- Develop and implement an aquatic plant reintroduction strategy, including planting protection if determined necessary
- Identify property owners willing to support re-establishment of aquatic plants on their shoreline
- Identify and collect aquatic plants in Amnicon that can be used to help reestablish aquatic vegetation in Dowling

9.5 Goal 5: Evaluate the progress of lake management efforts and needs through monitoring

The main goal of this plan is to improve water quality in Dowling Lake. The main metric for measuring this is positive changes in water clarity, chlorophyll-*a*, and total phosphorus. These are the values that will be looked at in future impaired waters listings (2024, 2026, 2028, and 2030) included in the 10 years covered by this plan. ADLMD volunteers on Dowling Lake should continue their involvement in CLMN, requesting participation in the expanded water quality monitoring program if they are not already in it. If this is not possible, then certain water quality parameters should be included in any grants that are applied for or paid for out of ADLMD funds.

Several whole-lake management actions to improve water quality are being considered in this plan. They include water level manipulation, biomanipulation, aquatic plant re-introduction, and possibly application of alum. Each of these actions does or may include certain additional parameters to be monitored including zooplankton (see Section 7.3.1), lake level, and precipitation.

Tributary monitoring should be repeated at least twice during the 10 years of implementation. Each time it should be collected monthly and with storm events for a minimum of two years in a row, three would be better.

Shoreland improvements and a campaign to replace all conventional septic systems with holding tanks justifies additional monitoring for dissolved forms of nitrogen and phosphorus, pH, conductivity, and bacteria/E-coli. Multiple studies have indicated that nitrogen is either more limiting than phosphorus or co-limiting with phosphorus it terms of supporting the growth of algae. In addition, tracking changes in shoreland development either by protecting undeveloped properties or by making improvements to existing shoreland is necessary.

Finally, while bio-control of purple loosestrife has been in place on Amnicon and Dowling lakes for many years, an official survey to determine the extent of the beetle population has not been done and should be completed in the future of this plan.

9.5.1 Objective 1. Monitor short and long-term changes to water chemistry as a reflection of water quality.

- Continue to monitor Chlorophyll-*a* and Total Phosphorus – CLMN expanded monitoring program
- Complete monitoring for the dissolved forms of nitrogen and phosphorus
- Complete NDS testing to help provide greater clarity as the limiting nutrient in Dowling Lake
- Collect pH and conductivity data
- Monitor for bacteria and E-coli

9.5.2 Objective 2. Monitor physical lake characteristics.

- Water clarity – CLMN program using a Secchi disk
- Lake level – CLMN program or WDNR/County water level monitoring
- Precipitation – Community, Collaborative, Rain, Hail and Snow monitoring program
- Dissolved oxygen and temperature profiles – CLMN program, digital meter owned by the ADLMD

9.5.3 Objective 3. Document tributary loading of nutrients.

- Collect flow, volume, and N and P parameters monthly and during storm events at three inlet sites and the outlet
    - Collect data for a period of 2-3 consecutive years, twice during the 10 year period of this Plan
- Consider upgrading sampling methods for more consistent data

9.5.4 Objective 4. Document progress made in shoreland improvement.

- Repeat a Shoreland Habitat Assessment again in year 5 and year 10 of implementation

9.5.5 Objective 5. Document the status of past Galerucella beetle rearing and release projects.

- Complete a general survey of the beetle population around Dowling Lake

9.6 Goal 6: Follow through with implementation of this plan

Not every action in the plan is intended to be implemented immediately. Some are intended to be implemented on an annual basis throughout the entire timeframe covered by the plan. Others have a specified time frame. Some actions will require additional support from consultants and the WDNR through its grant funding programs, and some can be done by the ADLMD or other entities with little implementation costs.

Included in the Implementation Matrix is a list of all the individual goals, objectives, and actions that are to be implemented over the course of the next ten years and a when during that ten-year period, each of the actions should be implemented. It is important for the ADLMD to view this schedule and determine what parts of it are of highest priority to them so that both human resources and financial support can be appropriately applied and maximized. The Implementation Matrix provides a place for the ADLMD to prioritize their actions. Once that has been done, implementation begins leading to the objectives associated with this goal.

9.6.1 Objective 1. Complete project implementation and assessment reports annually.

- Prepare annual summary reports of the actions implemented in each year
    - Adapt as necessary

9.6.2 Objective 2. Complete mid- and end-of-project reports.

- Take stock of the actions that have and have not been accomplished midway through the implementation
    - Evaluate the focus of the first five years and modify if necessary for the second five years
- Take stock of the actions that have and have not been accomplished near the end of implementation
    - Fully evaluate the accomplishments of the 10-year project
    - Identify actions that still need to be accomplished, that should be removed, or that should be added for the next 10 years

9.6.3 Objective 3. Develop and maintain the necessary partnerships to support implementation.

- Maintain the open dialogue, constituent involvement, partner involvement, etc. necessary to complete the actions in this plan
- Identify new partners and resources that could help implement the actions in this Plan

10.0 Implementation and Evaluation

The management goals for Dowling Lake were developed as a collaborative effort between the ADLMD and lake managers from LEAPS. The goals were developed to be believable and actionable and are derived from the values of the Amnicon and Dowling lakes community. This plan is not intended to be a static document, but rather a living document that will be evaluated on an annual basis and updated as necessary to ensure goals and community expectations are being met.

The prioritization and implementation of activities presented in this report can be completed in a number of ways. Below is a list of implementation strategies assembled by Patrick Goggin of the UW- Extension Lakes program.

10.1 Phased Approach — Incremental vs. System Functionality

Determining the best way to approach implementation of this plan will be influenced by the following questions.

- Do we want/need all activities/function/services available "Day One"?
- Can we absorb that level of change at one time?
- Can we take on that level of implementation work at one time?
- If not, based on the priorities of project goals and depending on the time and resources that can be allocated:
    - What functions do we want/need immediately?
    - In what sequence should we add the other functions?
    - Over what time period?

10.2 Money or Time Notion

Some lake organization put pledges in from the memberships, asking them to either volunteer for lake management projects for 4 hours per season, or commit to making a financial contribution to pay for 4 hours of worker time as match to ongoing grant work.

10.3 Building Committees

When determining committees to provide oversight and guidance toward implementation of certain parts of this plan, all of the following should be included.

- People skilled and knowledgeable about plan contents.
- Lake community leadership/change agents.
- Local lake community representation – people who make up your lake community – lake leaders, county LWCD, WDNR, UWEX, etc.
- Networkers, connectors and communication specialists – web sites, newsletter, blog, email lists, etc.
- Trainers, educators, and mentors.

To do this it is will be important to match people with their skill-sets and interests. The Asset-Based Community Development Institute (ABCD) is at the center of a large and growing movement that considers local assets as the primary building blocks of sustainable community development. Building on the skills of local residents, the power of local associations, and the supportive functions of local institutions, asset-based community development draws upon existing community strengths to build stronger, more sustainable communities for the future. This is certainly applicable to the community around Amnicon and Dowling.

https://resources.depaul.edu/abcd-institute/Pages/default.aspx

10.4 Behavioral Change/Community-based Social Marketing

Social marketing consists of several basic components including: exchange, positioning, focusing on behaviors, understanding the target audience, creating and delivering messages that will prompt people to change certain behaviors, and forming strategic partnerships with community resources. One of the challenges to community-based social change around a lake is the average 10-yr flip of lakefront properties.

https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/shoreland/marketing.aspx

10.5 Communication

Communication is the key to successful implementation of this Plan. Lake Coordinator, contractors or service providers, organization members, town and county boards, county zoning and land and water conservation department, etc. all have to be on the same page. Newsletters, blogs, websites, workshops, special sessions, forums, fact sheets, etc. can be utilized to help achieve this. Sometimes coming up with the appropriate language to share ideas is difficult. Water Words That Work, LLC is a for-profit company with a mission to protect nature and control pollution; they do this by helping non-profit organizations.

https://www.waterwordsthatwork.com/

10.6 Try to Make it Fun

Above all, through the course of implementation, it has to be fun for those involved. Some ideas include making lake maps on t-shirts, sweatshirts, and other lake gear, boat parades, potlucks and social gatherings.

10.7 Some Common Contributing Factors to Implementation Failure

There are many reasons why a management plan like this could suffer from implementation failure. Be mindful of the following issues:

- Lack of planning: unclear vision, goals, and approach; not aligned with vendor/service provider incentives; schedules; other program priorities and other resource responsibilities.
- Incomplete, unclear, and (or) changing requirements.
- Lack of executive/community support and commitment.
- Lack of resources dedicated to the project (staff, time, money, participant involvement, project management, and IT support).
- Unrealistic expectations for what can be accomplished and how quickly it can occur.
- Believing the vendor/service provider will assume responsibility for all tasks.
- Hoping the vendor/service provider will fix your operations and personnel problems.
- Fear of change.
- Fear of technology.

A lake management plan implementation matrix is included as an Appendix to this plan. The matrix includes the goals, objectives, and actions also outlined in the next section; briefly identifies methods; identifies who should take the lead on implementation; provides an implementation timeframe; and indicates possible funding sources. It also provides an opportunity to rank management objectives and actions based on ADLMD board and constituency priorities.

WORKS CITED

Angradi, T., Ringold, P., & & Hall, K. (2018). Water clarity measures as indicators of recreational benefits provided by US lakes: Swimming and aesthetics. *Ecological Indicators 93*, 1005-1019.

Apslund, T. R. (2000). *The Effects of Motorized Watercraft on Aquatic Ecosystems.* Madison: Wisconsin Department of Natural Resources.

Berg, M. (2012). *Curly-leaf Pondweed and Full Warm Water Point/Intercept Macrophyte Surveys.* St. Croix Falls, WI: Endangered Resources Services, LLC.

Betz, C., & Howard, P. (2020). *Wisconsin Citizen Lake Monitoring Training Manual (Chemistry Procedures).* Madison, WI, USA: Bureau of Science Services.

Bureau of Water Quality Program Guidance. (2020). *Wisconsin 2020 Consilidated Assessment and Listing Methodology (WisCALM) for CWA Section 3030(d) and 305(b) Integrated Reporting.* Madison: Wisconsin Department of Natural Resources.

Carlson, R. (1977). A trophic state index for lakes. *Limnology and Oceanography*, 361-369.

Chang, Y., Cui, H., Huang, M., & and He, y. (2017). Artificial floating islands for water quality improvement. *Environmental Reviews Volume 25 Number 3.*

Christensen, D., Hewig, B., Schindler, D. E., & Carpenter, S. (1996). Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. *Ecological Applications 6 (4)*, 1143-1149.

Coops, H., & Hosper, H. (2002). Water-level Management as a Tool for the Restoration of Shallow Lake in the Netherlands. *Lake and Reservoir Management 18:4*, 293-298.

Dewitz, J. (2019). National Land Cover Database (NLCD) 2016 Products: U.S. Geologiocal Survey data release. Retrieved from https://doi.org/10.5066/P96HHBIE

EPA. (2021, December 12). Indicators: Conductivity. Retrieved from https://www.epa.gov/national-aquatic-resource-surveys/indicators-conductivity

Florida Lakewatch. (2000, August). A Begginner's Guide to Water Management - Nutrients. Gainesville, FL, USA.

Fulton, S., & West, B. (2002). Forestry Impacts on Water Quality. In D. N. Wear, & J. G. Greis, *Southern Forest Resource Assessment* (pp. 501-518). Asheville, NC: United States Department of Agricluture.

Garrison, P. (2013). *Results of Sediment Cores taken from Amnicon and Dowling Lake, Douglas County, Wisconsin.* Madison: WDNR.

James, W. (2016). Internal P Loading: A Pesistent Management Problem in Lake Recovery. *Lake and Reservoir Management - NALMS.*

Janke, R., Moscou, R., & and Powell, M. (2006, June). Citizen Science Water Quality Testing Series. Kansas, USA.

Jennings, M., Emmons, E., Hatzenbeler, G., Edwards, C., & Bozek, M. (2003). Is littoral habitat affected by residential development and land use in watersheds of Wisconsin lakes? *Lake Reservoir Management, 19 (3)*, 272-279.

Jensen, J., Kristensen, P., Jeppesen, E., & and Skytthe, A. (1992). Iron:phosphorus ratio in surface sediment as an indicator of phosphate release from aerobic sediments in shallow lakes. *Hydrobiologia Vol 235*, 731-743.

Lee, G., & Jones, R. (1998). *Determination of nutrient limiting maximum algal biomass in waterbodies.* El Macero, CA: Fred Lee and Associates.

Manz, C. (2004). *Fisheries Information Survey - Dowling Lake, Douglas County.* Madison: Wisconsin Department of Natural Resources.

Ng, I., & Mohammad, H. (2017). The impact of water clarity on home value in Northern Wisconsin. *The Appraisal Journal 85(4)*, 285-306.

RMB Environmental Laboratories, Inc. (2021, November 30). *RMB Environmental Laboratories, Inc.* Retrieved from Lakes Monitoring Program: https://www.rmbel.info/primer/lake-eutrophication/

Sagerman, J., Hansen, J., & Wickstrom, S. (2020). Effects of boat traffic and mooring infrastructure on aquatic vegetation: A systematic review and meta-analysis. *Ambio*, 517-530.

Sass, G. (2009, Volume 1). Coarse Woody Debris in Lakes and Streams. *Encyclopedia of Inland Waters*, pp. 60-69.

Sondergaard, M., Jensen, P., & and Jeppesen, E. (2003). Role of sediment and interal loading of phosphorus in shallow lakes. *Hydrobiologia*, 135-145.

Thatcher Engineering Inc. (2006). *Final Report Amnicon and Dowling Lake 2003.* Minneapolis: Thatcher Engineering.

UMassAmherst. (2021, November 30). Retrieved from Massachusetts Water Watch Partnership: https://www.umass.edu/mwwp/resources/factsheets.html

Wall, D. (2013). *A2. Nitrogen in Waters: Forms and Concerns.* Minneapolis: Minnesota Pollution Control Agency.

WDNR. (2015). Northwest Lowlands Ecological Landscape, Chapter 16. In *The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management.* Madison: WDNR PUB-SS1131R.

WI-DNR. (2019). *Total Maximum Daily Loads for Total Phosphorus in the Wisconsin River Basin.* Madison: Wisconsin Department of Natural Resouces.

WI-DNR. (2021). *Wisconsin 2022 Consolidated Assessment and Listing Methodology (WisCALM) for CWA Section 3030(d) and 305(b) Intergrated Reporting.* Madison: Bureau of Water Quality Program Guidance.

Wolter, M. (2012). *Lakeshore Woody Habitat in Review.* Hayward, WI: Wisconsin Department of Natural Resources.

Yang, W., Xu, M., Li, R., Zhang, L., & Deng, Q. (2020). Estimating the ecological water levels of shallow lakes: a case study in Tangxun Lake, China. *Scientific Reports*.