Amnicon and Dowling Lakes Aquatic Plant Management Plan

AIS Education, Prevention and Planning

Douglas County, Wisconsin

DNR No. AEPP-323-12
SEH No. AMNIC 119733

April 26, 2017

Amnicon and Dowling Lakes Aquatic Plant Management Plan

AIS Education, Prevention and Planning
Douglas County, Wisconsin

Prepared for:
Amnicon-Dowling Lakes Management District
Superior, WI

Prepared by:

Dave Blumer, Lake Scientist

Short Elliott Hendrickson Inc.
Short Elliott Hendrickson Inc., 1701 West Knapp Street, Suite B, Rice Lake, WI 54868-1350
SEH is an equal opportunity employer | **www.sehinc.com** | 715.236.4000 | 800.903.6970 | 888.908.8166 fax

Assisted in Preparation by:

Sara Hatleli, Owner

Aquatic Plant & Habitat Services, LLC
N4236 Highway 54, Black River Falls, WI 54615
Smschmidt79@yahoo.com 715-299-4604

Distribution List

No. of Copies	Sent to
4	Dan Corbin, Chair Amnicon-Dowling Lake Management District 7804 S. County Road A Superior, WI 54880

Executive Summary

Amnicon and Dowling Lakes are located in central Douglas County, Wisconsin. Dowling Lake (141 acres) is a shallow drainage lake situated east of Amnicon Lake (390 acres), which is also a drainage lake with a maximum depth of 31 feet. Waters from Dowling Lake flow west into Amnicon Lake via an unnamed stream and ultimately into the Amnicon River. The shorelines of both lakes have moderate to heavy development with residences and vacation homes except for some stretches along the southern shoreline of Amnicon Lake.

Amnicon Lake is designated by the Wisconsin Department of Natural Resources as an Area of Special Natural Resource Interest due to the presence of wild rice, which is granted special protections due to its ecological and cultural significance. Dowling Lake is a Priority Navigable Waterway based on its natural reproduction of walleye and muskellunge. The health and quality of the native plant community is well above the state-wide average in Amnicon while Dowling has a diverse but very low density aquatic plant community. The lakes support a fishery that includes walleye, muskellunge, panfish, and largemouth bass. Loons are present from spring through fall on Amnicon Lake with some success of loon reproduction documented by volunteer monitors.

Dowling Lake is a nutrient rich system, or eutrophic, and trends indicate the water clarity will decrease if current conditions persist; while Amnicon Lake water quality is on the cusp of becoming eutrophic. Water quality conditions have been relatively stable since monitoring began on Amnicon in 1973. Water clarity on Dowling has seen a significant linear trend (R^2 0.67) toward lower water clarity, with a summer average in 1997 of 5.3 feet declining to 1.6 feet in 2012. Monitoring on Dowling began in 1994. Historic phosphorus concentrations were revealed during a sediment core analysis at levels of 25 µg/L while more recent phosphorus have tripled in Dowling Lake (86 µg/L (micrograms per liter, or parts per billion)) but remained constant in Amnicon Lake. Dowling Lake has moved from a macrophyte (aquatic plant) dominated state to an algae dominated state. Amnicon Lake is not necessarily algae dominated, but the sediment core analysis suggests there are more macrophytes present now than in the past. Chlorophyll-*a* measured over the last 40 years in Amnicon Lake averaged 8.3 µg/L during the summer months while Dowling Lake averaged 18.7 µg/L during the last 20 years. Total phosphorus averages 36.6 µg/L in the summer months in Amnicon and 78.5 µg/L in Dowling. Amnicon Lake is dimictic meaning the lake stratifies into layers during the summer with cooler, low-oxygen water at lower depths and oxygen rich, warmer water near the surface. Dowling Lake is considered a shallow lake and does not thermally stratify because wind action keeps the lake mixed throughout the summer.

Curly-leaf pondweed (*Potamogeton crispus*) was officially documented in Amnicon Lake in 2008. A CLP survey in 2012 found individual plants to be uncommon and very widely scattered throughout the lake north and east of Tomahawk Island. However, south and west of the island CLP was relatively common. CLP was present in the rake at seven sample points or approximately 1.4% of the lake. Three beds of monotypic CLP were surveyed totaling 5.36 acres.

Purple loosestrife (*Lythrum salicaria*), another non-native aquatic invasive species, was found in scattered patches around both lakes. Every purple loosestrife plant suffered extensive damage from *Galerucella sp.* beetles. Eurasian watermilfoil (*Myriophyllum spicatum*) was not found in Amnicon or Dowling Lake in 2012 or during any previous surveys. A primary concern of the Amnicon-Dowling Lake Management District is the introduction of Eurasian watermilfoil and other aquatic invasive species.

The overall goal of aquatic plant management in Amnicon and Dowling Lakes is to protect the lakes from degradation by preventing new invasions of non-native species and through the containment and control of existing aquatic invasive species. A secondary goal is to improve access to open water for property owners on Amnicon Lake whose ability to navigate to open water is impeded by dense aquatic plant growth. The primary objectives of this aquatic plant management plan are to monitor for the introduction of new aquatic invasive species (early detection and rapid response) and to contain and, where and when appropriate, control curly-leaf pondweed in Amnicon Lake. Other objectives support the protection and enhancement of desirable aquatic vegetation and management actions that will maintain or improve water quality.

When selecting appropriate management alternatives, the WDNR Northern Region management strategy, public acceptance, and the following were considered: wild rice beds in Amnicon Lake are in close proximity to the densest beds of curly-leaf pondweed, rendering manual and physical control to be the best options ; the exceptional native plant community in Amnicon Lake makes it more resistant to invasion and incidental damage to the native plant community during curly-leaf control activities; the low density of aquatic plants in Dowling Lake makes it more susceptible to invasion of non-native species.

The objectives for this plan and the actions to be undertaken by the Amnicon-Dowling Lake Management District are:

1) **Preservation and Restoration.** Protect and restore the native plant species community in and around the lakes to decrease susceptibility to the introduction of new aquatic invasive species and improve water quality.

   Action: Provide shoreland restoration materials (online, newsletter).
   Action: Conduct a baseline shoreland evaluation (by boat).
   Action: Host shoreland restoration training event.
   Action: Recognize lake residents who implement shoreland restoration and habitat improvement projects.
   Action: Establish "Slow, No Wake" areas near wild rice beds to protect them.
   Action: Promote limited disruptions to native plant community on shore and in water to improve water clarity and prevent establishment of AIS.

2) **Prevention.** Prevent the introduction and establishment of new aquatic invasive species through early detection and rapid response

   Action: Provide training for riparian owners and volunteers as needed to identify and monitor for AIS.
   Action: In-lake and shoreline aquatic invasive species monitoring by riparian owners (casual) and trained volunteers (structured).
   Action: Watercraft inspection at the 2 public access points; participate in 4th of July Landing Blitz.
   Action: Update contact information on Eurasian watermilfoil Rapid Response Plan annually and as needed.

3) **Management.** Implement aquatic plant management actions that will: improve access to open water for Amnicon Lake property owners struggling with nuisance levels of aquatic vegetation that limits navigation; reduce the existing curly-leaf pondweed in Amnicon Lake; improve water quality and increase native aquatic plant growth in Dowling Lake; continue to keep purple loosestrife in check; and that will protect desirable native aquatic plant species that are essential to overall lake health on both lakes.

Executive Summary (Continued)

Action: Water Quality - Promote shoreland practices, and aquatic plant management actions that protect water quality. Promote regular septic system inspections.
Action: Native Plant Management - Use physical removal and harvesting techniques to create open water access lanes in areas of Amnicon Lake where navigation is impeded. Support physical removal efforts by property owners as this management action is generally more protective of native plants, while still providing relief from excessive or nuisance level plant growth.
Action: Curly-leaf Pondweed Control - Encourage manual (hand, rake, and diver) removal of sparse occurrences north and east of Tomahawk Lake and any pioneer populations. Coordinate education and removal efforts. Evaluate the purchase a mechanical harvester for managing CLP beds and maintaining designated navigations channels through dense growth native aquatic vegetation. Complete harvesting of CLP in the beds identified in the 2012 plant survey. Hire a resource professional to map CLP beds and density annually.
Action: Purple Loosestrife Control. Continue physical and biological control.

4) **Education and Awareness.** Continue public outreach and education programs on aquatic invasive species.

Action: Summarize Aquatic Plant Management Plan for wider distribution.
Action: Distribute aquatic invasive species educational materials.
Action: Facilitate aquatic invasive species public education opportunity in each year that the APM Plan is implemented (for example; Lake Fair, workshop, guest speakers).
Action: Develop and maintain a webpage and/or newsletter.
Action: Maintain, update, and improve aquatic invasive species signage a public access points.
Action: Present summary of water quality information during public event(s).
Action: Continue Loon Watch monitoring program on the lakes.
Action: Provide education opportunities and information on wildlife and wildlife monitoring programs.

5) **Research and Monitoring.** Develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded lake monitoring efforts.

Action: Evaluate ability to conduct CLMN Expanded water quality monitoring.
Action: Purchase a dissolved oxygen meter and conduct dissolved oxygen monitoring.
Action: Conduct water quantity monitoring (lake stage and precipitation).
Action: Develop a comprehensive lake management plan.

6) **Adaptive Management.** Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

Action: Draft annual reports summarizing events and activities, and presenting strategy revisions and future management activities.
Action: Draft end of project report reviewing success and failures after 5-year implementation of this plan.
Action: Complete whole-lake point-intercept aquatic plant survey every 5 years.

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

List of Tables

Table of Contents (Continued)

List of Figures

List of Appendices

Table of Contents (Continued)

Amnicon and Dowling Lakes Aquatic Plant Management Plan

AIS Education, Prevention and Planning

Prepared for Amnicon-Dowling Lakes Management District

1.0 Introduction

Amnicon and Dowling Lakes are located in central Douglas County (Figure 1). Amnicon Lake has a surface area of 390 acres and 5.11 miles of shoreline. Dowling Lake, which drains into Amnicon Lake, has a surface area of 141 acres and 1.95 miles of shoreline. Amnicon Lake has established colonies of curly–leaf pondweed (CLP). Both Amnicon and Dowling Lakes have infestations of reed canary grass, and purple loosestrife.

Amnicon Lake is designated as an Area of Special Natural Resource Interest by the Wisconsin Department of Natural Resources (WDNR) due to the presence of wild rice while Dowling Lake is a Priority Navigable Waterway based on its natural reproduction of walleye and muskellunge. Amnicon Lake is also a WDNR Long Term Trend Lake and is considered an “Impaired Water” according to standards of the Clean Water Act Section 303(d).

The Amnicon-Dowling Lake Management District (ADLMD) has been active in protecting the lakes since the development of a lake management plan in 1994 funded in part by a WDNR grant. Additional WDNR grant projects include water quality monitoring in 1996 and 1997, the development of a comprehensive lake management plan in 2003, and aquatic invasive species (AIS) education and prevention in 2009. The most recent grant provided funding to complete an Aquatic Plant Management Plan for both lakes incorporating a plant survey, paleocore study, expanded citizen lake monitoring efforts, purple loosestrife management, a lake user survey, and AIS monitoring.

Lake user survey results from 2013 suggest residents of Amnicon Lake are concerned about abundant plant growth (some of which is CLP) resulting in a hindrance to navigation and water quality. Dowling Lake residents are primarily concerned about water quality. These concerns coupled with the aspiration to prevent further AIS infestations prompted the ADLMD to pursue funding for an aquatic plant management plan.

The purpose of this plan is to guide the effective management and protections of aquatic plants in Amnicon and Dowling Lakes. The primary goal of this plan is to establish long-term and realistic goals for managing nuisance and non-native plants species while protecting valuable native species thereby perpetuating their important habitat functions for both lakes. This plan supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, and the recreational and aesthetic values of the lakes. This plan also lays out a strategy to prevent the introduction of new infestations such as Eurasian water-milfoil (EWM) not currently found in the lakes.

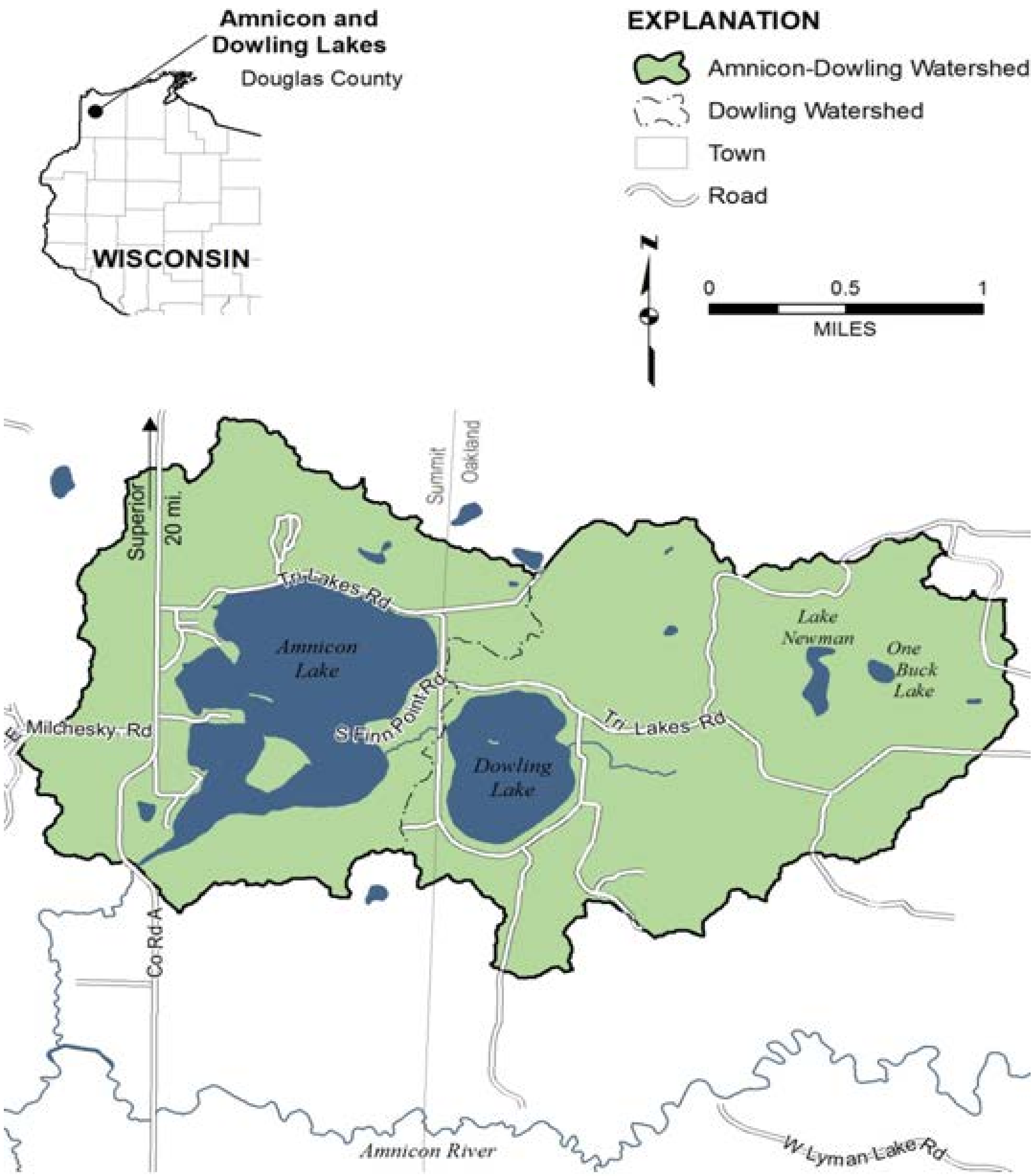


Figure 1 – Amnicon and Dowling Watershed

2.0 Aquatic Plant Management Strategy

The WDNR aquatic plant management guidelines and the Northern Region Aquatic Plant Management Strategy (Appendix A) formed the framework for the development of this APM plan. All existing and new APM plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. APM plans developed for northern Wisconsin lakes are evaluated according to the Northern Region APM Strategy goals that went into effect in 2007. Additional review may be completed by the Voigt Intertribal Task Force (VITF) in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

The VITF is composed of nine tribal members and a chairperson. The VITF recommends policy regarding inland harvest seasons, resource management issues, and budgetary matters to the Board of Commissioners. The VITF addresses matters that affect the treaty rights of the member tribes in the 1837 and 1842 Treaty ceded territories. The VITF recommends harvest seasons and regulations for each inland season. Those recommendations are then taken to the respective tribal councils for ratification prior to becoming an ordinance.

GLIFWC is an agency of eleven Ojibwa member tribes from Minnesota, Wisconsin, and Michigan, who retain off-reservation treaty rights to hunt, fish, and gather in treaty-ceded lands. GLIFWC exercises powers delegated by its member tribes and assists member bands in implementing off-reservation treaty seasons and in the protection of treaty rights and natural resources. GLIFWC provides natural resource management expertise, conservation enforcement, legal and policy analysis, and public information services. All member tribes retained hunting, fishing and gathering rights in treaties with the U.S. government, including the 1836, 1837, 1842, and 1854 Treaties.

This Aquatic Plant Management Plan supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, and the recreational and aesthetic values of the lake. This plan also lays out a strategy to prevent the introduction of new AIS not currently known to be in the lakes, which includes a monitoring program to aid in early detection of any new AIS. This five-year plan is intended to be a living document to be evaluated on an annual basis and revised as needed to ensure goals and community expectations are being met.

3.0 Public Participation and Input

The ADLMD provided input, support and review of draft documents during the development of this aquatic plant management plan. Further public input was collected through a public input survey developed by Aquatic Plant and Habitat Services LLC with input from WDNR and SEH, Inc. The survey was distributed by SEH, Inc. in the spring of 2013. Surveys were mailed to 300 randomly selected households within the ADLMD. Ninety-five (95) completed surveys were returned (31.6% return rate), 59 of which were from Amnicon lake residents while 36 were from Dowling Lake residents.

Amnicon and Dowling Lake residents reported using the lakes primarily for swimming, relaxing, fishing, viewing wildlife, and quiet sports. When asked which lake characteristics have undergone the greatest change, residents of both lakes selected game fishing, pan fishing, and swimming while Amnicon residents also selected motorized sports. When asked whether the quality of various lake characteristics have increased, decreased, or remained the same, Amnicon Lake respondents indicated that the amount of vegetation, motorized boats and the use of jet skis have increased while the amount of wild rice has decreased. Dowling Lake residents implied that green scum on the water, the use of jet skis, and noise pollution has increased while public use and garbage in the lake have decreased.

When asked whether they would be willing to have their septic system inspected as part of a lake improvement project, 61.7% overall replied “yes.” This is possibly due to the 1994 Lake Management Plan suggestion that faulty septic systems were contributing to poor water quality. Although this could be the case, no data were found in the report to support this claim (1). When asked about their perception of water quality, Amnicon respondents answered good (15%), fair (61%), or poor (21%). Dowling residents answered good (14%), fair (28%), or poor (47%).

Survey respondents were queried about their knowledge of AIS and most admitted having meager knowledge of invasive snails, CLP, spiny water fleas, rusty crayfish, and EWM but they implied some knowledge of purple loosestrife and zebra mussels. However, 55.8% of respondents said they would attend an AIS training session if offered, which is encouraging.

Property owners on both lakes support the implementation of aquatic plant management actions. The use of physical removal and mechanical harvesting are the most supported options while chemical herbicides are least supported. In addition, Amnicon residents are not supportive of a “no management” alternative and Dowling residents are not supportive of biological control. Respondents feel the WDNR and ADLMD should be responsible for managing aquatic plant growth in the lakes.

Input and review of the Aquatic Plant Management Plan was provided by various Lake District representatives throughout the process of developing this plan. A draft version of the APM Plan was presented to Lake District constituents on August 31, 2013. Another version was presented to the Lake District in December, with that version being posted on the Lake District’s webpage.

Webpage posting is done to encourage other constituents of the Lake District and other to review and comment. A full record of public input is included in Appendix B.

4.0 Documentation of Problems and Need for Management

This document asserts the need for aquatic plant management in Amnicon and Dowling Lakes. In Amnicon, curly-leaf pondweed and dense native aquatic plant growth present conditions suggesting management may improve the lake. Wild rice is present in Amnicon Lake and management will have to account for its protection. Poor water quality is an issue in Dowling Lake, some of which can be attributed to a lack of aquatic plant growth in the lake.

4.1 Aquatic Invasive Species

Curly-leaf pondweed (CLP) is currently found in Amnicon Lake, but not in Dowling. Prior to the early 1990s, CLP was considered only a minor threat to waterbodies in Wisconsin and was often not managed; however, with the development of management strategies for EWM, resource professionals started to look at CLP as a manageable AIS.

CLP was first documented in Amnicon Lake in 2008 during an AIS survey conducted by Steven Garske with the Great Lakes Indian Fish and Wildlife Commission. A voucher specimen was collected July 10, 2008 near the boat landing at the northwest side of the lake (2). As part of this APM plan, an early season CLP survey revealed three beds of CLP west and southwest of Tomahawk Island in 4-9 feet of water. The CLP beds covered 5.4 acres, or 1.4% of the lake surface area, and appeared to exploit disturbed areas (3). These beds of CLP are posing navigation issues in the southwest portion of Amnicon Lake and likely impacting wild rice growth.

A lake user survey in 2013 revealed Amnicon Lake residents believe that dead and dying vegetation in the lake holds high potential for impacting the water quality. Since CLP senesces in mid-summer, the decaying plant material can indeed release nutrients for algae, which are actively growing during that time. Internal lake nutrient models have not been performed to confirm or refute this belief, but management of CLP to relieve navigation issues may help with water quality issues as well.

Purple loosestrife is a non-native AIS found near and around both Amnicon and Dowling Lakes. Purple loosestrife can be found in wetlands adjacent to the lake and along the shoreline as single plants, small patches, or in large beds. During the 2012 aquatic plant surveys, purple loosestrife was found at only one survey point on the western shore of Amnicon Lake (3). Purple loosestrife has been managed in the past using *Galerucella sp.* beetles as a form of biocontrol. The efforts have been largely successful, as evidenced by the 2012 plant surveys, and continued monitoring will help perpetuate management of purple loosestrife.

Reed canary grass is a non-native AIS found in and around both Amnicon and Dowling Lakes. It forms dense and persistent stands in wetlands and riparian areas that can outcompete native vegetation. Mechanical and chemical control is possible in areas where native plant restoration is desired.

In the survey distributed to ADLMD residents in 2013, the majority of respondents (more than 96%) supported some form of aquatic plant management (primarily large scale mechanical harvesting of >10 acres [40%] and hand pulling or raking in shallow water [28%]). Respondents were least in favor of a no management alternative (26%) and large-scale chemical herbicide treatment (37%). The survey also found that the majority of respondents believe the WDNR and ADLMD are responsible for managing aquatic plant growth (excluding algae) in the lakes. Education and outreach are needed in order to implement community supported aquatic plant management alternatives.

Both lakes are at risk for the introduction of new AIS including Eurasian water-milfoil (EWM). Although EWM was not found in either lake during the 2012 aquatic plant survey work completed as a part of this project, it remains a concern because of its presence in other lakes such as the St. Croix Flowage, which is approximately 17 miles southeast of Amnicon and Dowling Lakes (2). EWM can be transported via boat traffic from this and other lakes that are infested. Continuing watercraft inspection, in-lake AIS monitoring, and education and outreach efforts are necessary to prevent the introduction and establishment of EWM and other AIS in the lakes.

4.2 Navigation on Amnicon Lake

An important aspect of this management plan is protecting the native plants in and near the lake while maintaining recreational uses. The southwest region of Amnicon Lake harbors dense native aquatic plants as well as CLP, both of which interfere with lake access. Therefore, the native aquatic plants in this region of the lake are at a nuisance level and some management is required.

4.3 Wild Rice

Amnicon Lake is designated as an Area of Special Natural Resource Interest by the WDNR due to the presence of wild rice, which has a high coefficient of conservatism value (8 out of 10) and therefore is sensitive to human disturbance (Nichols, 1999) . Wild Rice is present along the southern shoreline, which is has low human development and a relatively natural shore land and littoral zone (3). Despite the lack of obvious human impacts in the nearshore areas, densities of wild rice are low with presence at only 23 survey points (4.6%) during the 2012 macrophyte survey (3). Wild rice was not found in Dowling Lake during the 2012 macrophyte survey (3) but introduction is a possibility.

4.4 Water Quality

Amnicon Lake is classified as an "Impaired water" system by the WDNR, meaning it does not meet water quality standards according to the Clean Water Act Section 303(d). Amnicon is impaired due to low dissolved oxygen levels, elevated water temperature, and degraded habitat. These impairments are caused by pollutants including sediment/suspended solids and excessive total phosphorus, which fuels nuisance algal blooms and degrades habitat. Past management reports attribute poor water quality to faulty septic systems, although data are not provided to substantiate this (1). Appropriate aquatic plant management actions are likely to maintain or improve water quality in both lakes.

5.0 Lake Information

Identifying appropriate aquatic plant management recommendations for Amnicon and Dowling Lakes requires a basic understanding of their chemical, physical, and biological characteristics including morphology (size, structure, and depth), the fish and wildlife, water quality (temperature, clarity, oxygen, phosphorus, and chlorophyll *a*), land use, soils, and lake sediment. All of these factors have the potential to influence aquatic plant growth and vice versa. Water quality and plant survey data provide the necessary information for evaluating the effects of aquatic plant management as well as other management activities.

5.1 Physical Characteristics

5.1.1 Lake Morphology

Amnicon Lake is a drainage lake, meaning it has an outlet leading to a river or stream (in this case, the Amnicon River) and receives a higher proportion of water from surface water than direct precipitation or groundwater. Amnicon has a surface area of 390 acres with a maximum depth of 31 feet, a mean depth of 10 feet, and a volume of approximately 4,210 acre-feet (Table 1). Depth soundings taken at Amnicon Lake's 501 survey points during the 2012 aquatic plant survey revealed muck bays sloped gradually to 10ft+ of water while the central basin was a patchwork of shallow bars, sunken islands and sharp drop-offs into 20ft+ of water. In addition to those shallow areas, many other small bars and humps were located between survey points (Figure 2). The lake has an irregular shape with a shoreline distance of 5.11 miles (5.99 miles with islands). There are two islands, one small linear island in the west-central area and one large known as Tomahawk Island in the southern area of the lake. An unnamed stream (WBIC 2858200) flows for approximately 0.25 miles from Dowling Lake into Amnicon along the eastern shore. The lake drains into the Amnicon River (WBIC 2848900) southwest of the lake.

Dowling Lake is also a drainage lake with a surface area of 141 acres, maximum depth of 13 feet, a mean depth of 7 feet, and a volume of approximately 1,113 acre-feet (Table 1). Depth soundings taken at Dowling Lake's 253 points during the 2012 aquatic plant survey illustrated 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 2). The lake is somewhat oval shaped with a shoreline distance of 1.95 miles (2.06 miles with island). There is one small island northwest of the lake center. An unnamed stream (WBIC 2858200) flows into Dowling Lake along the eastern shore and empties along the western shore flowing about 0.25 miles before reaching Amnicon Lake.

Table 1
Physical Characteristics of Amnicon & Dowling Lakes

Lake	Area (acres)	Volume (acre-feet)	Shoreline (miles)	Maximum depth (feet)	Average depth (ft)
Amnicon	390	4,210.4	5.11	31	10
Dowling	141	1,113.3	1.95	13	7
Total	**1,657.5**	**21,733.3**	**26.14**	**64**	**13.1**

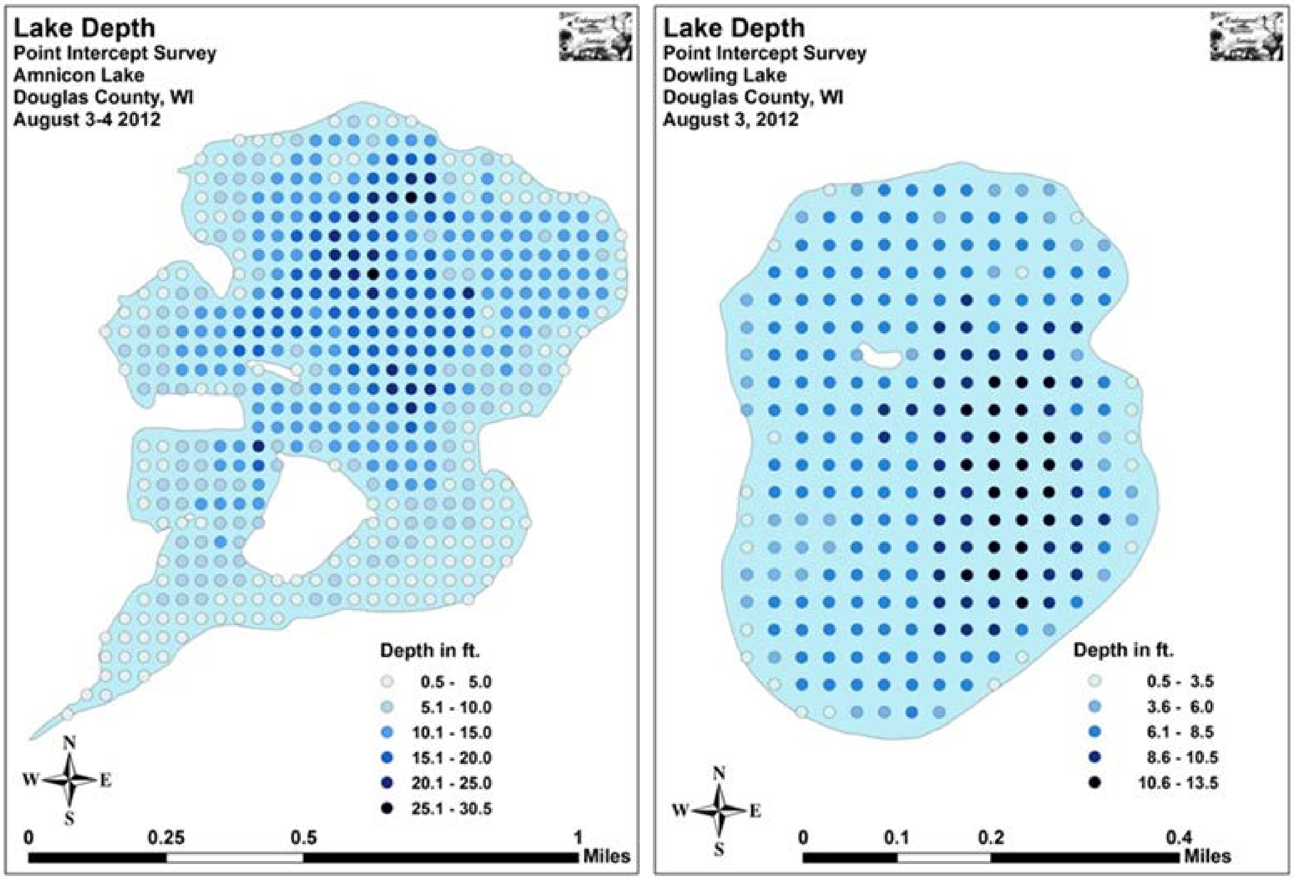


Figure 2 – Amnicon and Dowling Lakes Depth Distribution

It is important to consider the significant differences between deep and shallow lake systems. Shallow lakes are those with a maximum depth of less than 20 feet or with an average depth of less than 10 feet (4). These criteria classify Dowling Lake as shallow system and Amnicon Lake as a deep system. The water quality of a deep lake is generally driven by external nutrient sources whereas the water quality of a shallow lake is driven by internal processes with aquatic plants playing an important role.

5.1.2 Shallow Lake Management Considerations

Shallow lakes generally exist in one of two alternative states: the algae-dominated turbid water state and the plant-dominated clear water state (Figure 3). The turbid water state is characterized by dense algae (phytoplankton) populations, an undesirable bottom feeding fish community, and few aquatic plants whereas the clear water state is characterized by abundant aquatic plant growth, a greater number of zooplankton, and a diverse and productive gamefish community [2]. The majority of respondents of the 2011 survey indicated they prefer a plant-dominated system over an algae-dominated system.

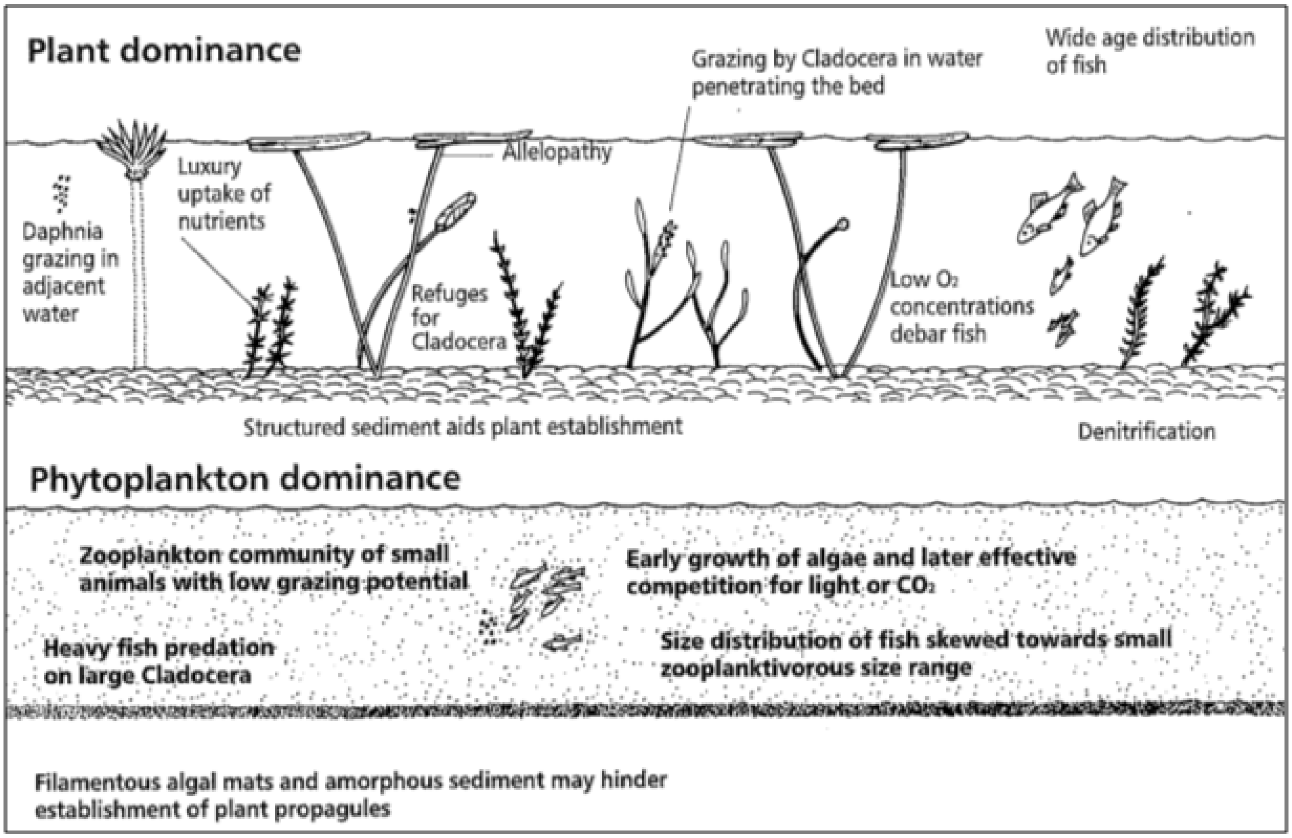


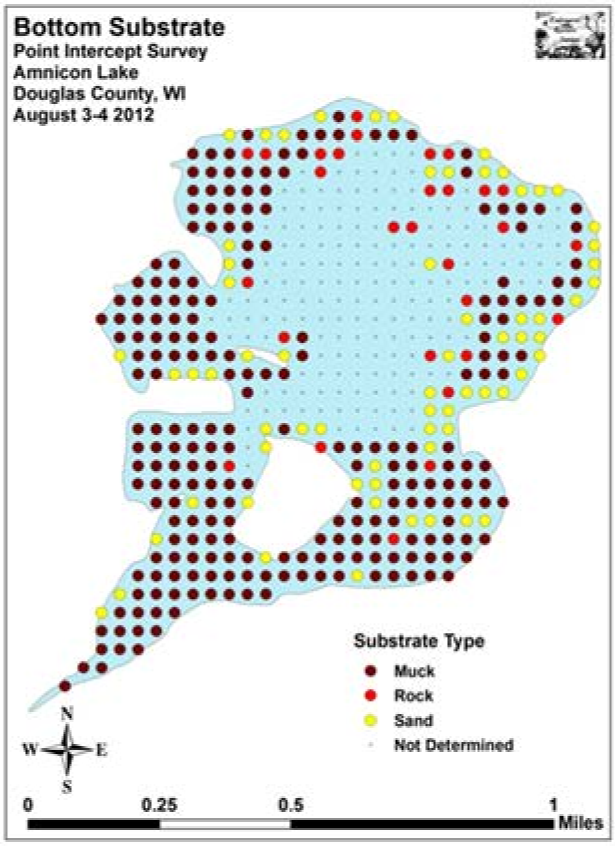
Figure 3 – Shallow Lake Alternative States and Stabilizing Mechanisms

It is uncommon to find a shallow lake free of both aquatic plants and algae and it is unrealistic to expect such a lake to occur without a large investment of money and energy (4). The chance of macrophyte-free, clear water is much greater in deep lake systems. Shallow lakes are more susceptible to internal nutrient loading (for example, lake sediment phosphorus release) and strong biological manipulations (additions or removals of fish that affect the entire aquatic food web) than deep lakes, which are more responsive to changes in the external nutrient load (4).

5.1.3 Lake Sediment

During the 2012 aquatic plant surveys, sediment types were also documented in Amnicon and Dowling Lakes. In Amnicon Lake, sediment type could be determined at 330 survey points, 71.2% of which were muck, 8.8% were rock, and 20.0% were pure sand (Figure 4) (3). Organic muck dominated the lake bottom in the western and southern bays while sandy muck was common in deeper areas with limited plant growth beyond the sandy/rocky north and eastern shorelines. In the main basin, most of the exposed points, bars, and islands were also sandy or rocky in nature. Plants were found growing at 218 sites or approximately 43.5% of the entire lake bottom and in 77.9% of the littoral zone.

In Dowling Lake, thin, sandy muck dominated the bottom of the lake's bowl covering 78.3% of survey points (Figure 4) (3). 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). 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.



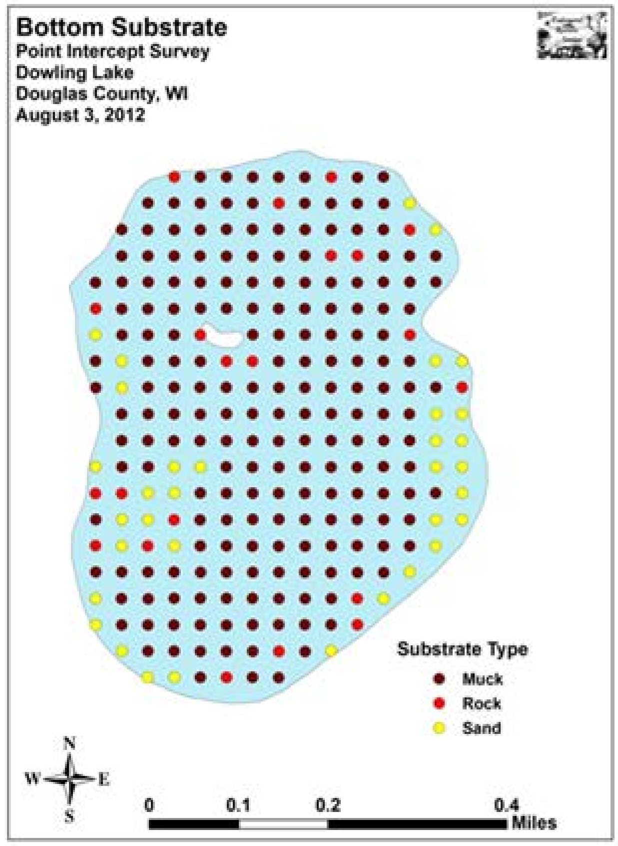


Figure 4 – Bottom Substrate in Amnicon and Dowling Lakes

5.1.4 Watershed, Soils, & Land Use

A watershed is an area of land from which water drains to a common surface water feature, such as a lake, stream, or wetland. A lake is a reflection of its watershed's size, topography, soils, land use and vegetation. The Amnicon-Dowling Lakes watershed covers 3,120 acres (1,432 acres for Amnicon and 1,688 acres for Dowling (Figure 5). The land cover in the watershed is predominantly forests which cover 45% of the landscape, followed by wetlands covering 32% of the landscape (Table 2). Agriculture covers less than 1% while residential covers only about 4% of the land. The Amnicon-Dowling Lakes watershed is situated within the Amnicon and Middle River watershed, which has an area of 184,907 acres (289 square miles) and drains into Lake Superior (5). The watershed contains 7,915 acres of lakes, 42,307 acres of wetlands, and 641 miles of rivers and streams. Forests (55%) and wetlands (23%) make up the predominant land cover (5).

The majority of soils (44%) in the Amnicon-Dowling Lakes watershed belong to Hydrologic Soils Group A, which are sand, sandy loam, or loamy sand and have high infiltration rates. Thirty-five percent (35%) of soils in the watershed belong to Group C, which are sandy clay loam and consist of soils with a layer that hinders downward movement of water. The soils in the watershed are rated "Very Limited" for septic tank absorption field (6). This rating indicates that the soil has one or more features that are unfavorable for the specified use and poor performance and high maintenance can be expected. The limitations generally cannot be overcome without major soil reclamation, special design (for example, tertiary systems), or expensive installation procedures.

According to responses in the 2013 Lake User Survey, approximately 40% of all private on-site waste water treatment (septic) systems are holding tanks with an additional 31% being conventional systems with a drain field. Because of the soil characteristics, it is important to have these and other systems checked regularly for proper function and to prevent excessive nutrient loading to the lakes.

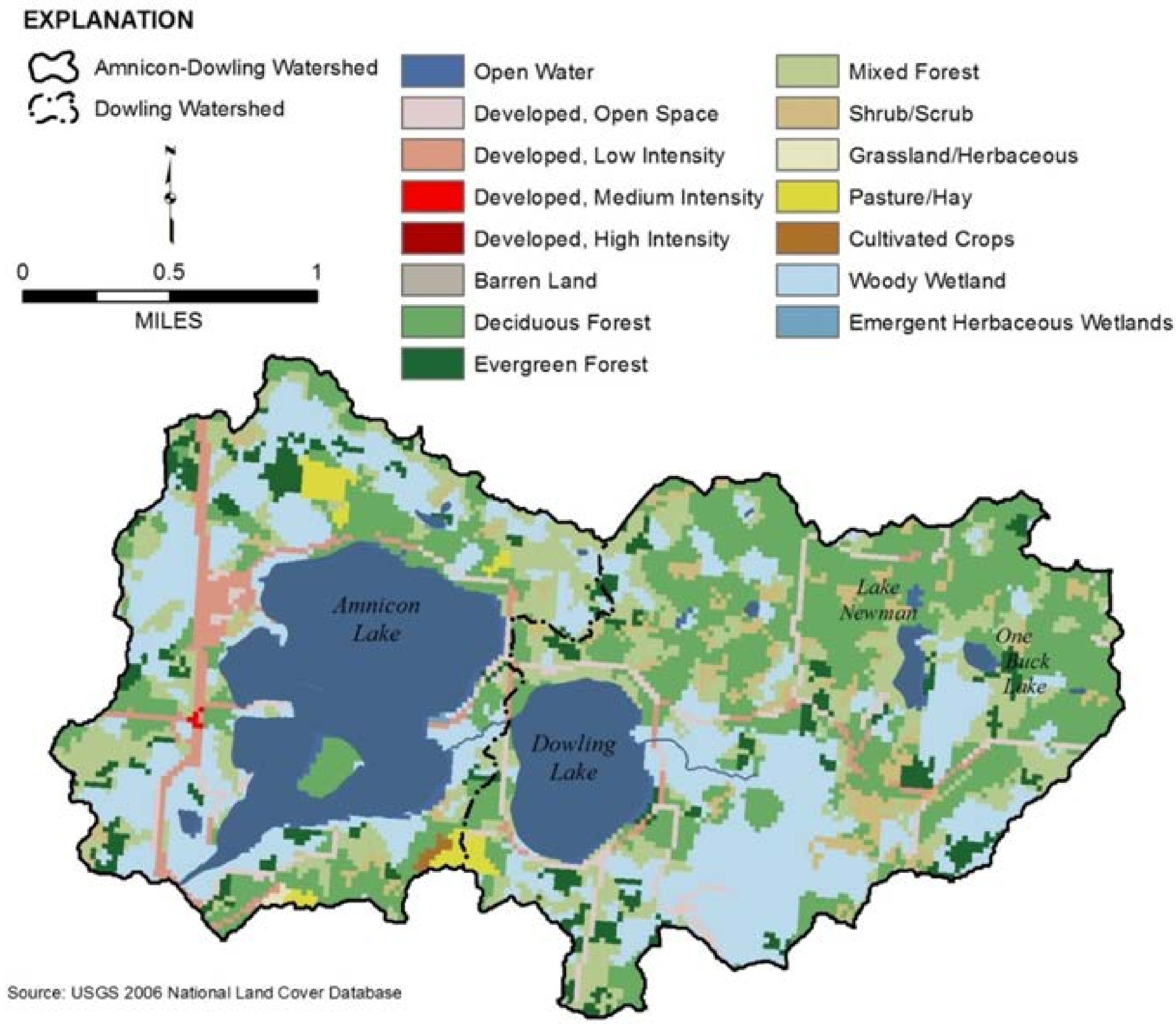


Figure 5 – Amnicon and Dowling Lake Watersheds and Land Use

Table 2
Land Use and Land Cover in the Amnicon and Dowling Lakes Watershed

Land Use	Square Miles	Percent of Total
Developed/Urban	0.20	4.1
Agriculture	0.01	0.1
Forest	2.20	45.1
Grassland/shrubland	0.08	1.7
Wetland	1.54	31.5
Water	0.85	17.5
Total	**4.88**	
Source: 2006 National Land Cover Database		

5.2 Water Quality

The water quality of a lake influences the aquatic plant community and vice versa. Water clarity, total phosphorus, and chlorophyll *a* are water quality measures that can be used to determine the productivity or trophic status of a lake. The Carlson Trophic State Index (TSI) is frequently used to determine biomass in aquatic systems. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have abundant aquatic plant growth, high nutrient concentrations, and low water clarity due to algae blooms. Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth. Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms.

Amnicon Lake is one of 65 *Long Term Trend Lakes* in Wisconsin. WDNR staff monitor these *Long Term Trend Lakes* annually to provide reference conditions for regional trophic classification and to track changes within and among lakes in Wisconsin. *Long Term Trend Lake* monitoring occurred at station 163120 (Deep Hole) with temperature, dissolved oxygen, water clarity, phosphorus, and chlorophyll *a* data available from 1973 to 2013 (7). Four other sites were monitored sporadically for total phosphorus as well.

Water quality data (temperature, dissolved oxygen, water clarity, phosphorus, and chlorophyll *a*) for Dowling Lake were collected for Dowling Lake from 1994 through 2012 at station 163091 (Deep Hole) (7). Total phosphorus was monitored sporadically at three other sites in the lake as well.

5.2.1 Paleolimnology

Aquatic organisms are good indicators of water quality because they are strongly impacted by changes in water chemistry. Diatoms are a type of algae with cell walls made of silica and therefore persist in lake sediment long after the alga has died and sunk to the lake bottom. Different species of diatoms thrive in different water quality conditions. For example, some species are found in nutrient poor lake environments while others thrive when elevated levels of phosphorus are present. The diatoms found in sediment cores make it possible to compare recent lake conditions (the top of the core) to historic lake conditions (the bottom of the core). Historic phosphorus concentrations can also be calculated using models that employ present day conditions for calibration.

A sediment core collection and analysis was conducted by the WDNR near the deep area of Amnicon Lake (22 feet) in August, 2012. In Amnicon, the top sample (current lake conditions) had more diatom species associated with submerged aquatic vegetation while the bottom sample (historic lake conditions) contained more planktonic (free-floating, open water) diatoms. The phosphorus concentration was very similar in the top (26 µg/L) and bottom (25µg/L) samples. Therefore, it appears that Amnicon Lake has undergone little change in phosphorus levels but submerged aquatic vegetation has increased (8).

A sediment core was also collected in Dowling Lake near the deep area (12 feet) in August 2012. The top sample had many more diatom species associated with higher phosphorus levels while the bottom sample contained more species associated with submerged aquatic vegetation (8). The current phosphorus concentration (top sample) was over three times greater (86 µg/L) than historic levels (25 µg/L). Therefore, it appears that Dowling Lake has undergone a very large increase in phosphorus levels and loss of submerged aquatic vegetation confirming its transition from a plant dominated state to an algae dominated state. A more detailed report of the sediment core results can be found in Appendix C.

5.2.2 Temperature and Dissolved Oxygen

Temperature and dissolved oxygen are important factors that influence aquatic organisms and nutrient availability in lakes. As temperature increases during the summer in deeper lakes, the colder water sinks to the bottom and the lake develops three distinct layers as shown in Figure 6. This process, called stratification, prevents mixing between the layers due to density differences which limits the transport of nutrients and dissolved oxygen between the upper and lower layers. In most lakes in Wisconsin that undergo stratification, the whole lake mixes in the spring and fall when the water temperature is about 39°F, a process called overturn. Overturn begins when the surface temperatures become colder and therefore denser and begin to sink. Below about 39°F, colder water becomes less dense and begins to rise (which is why ice floats) and inverse stratification (warmer water on bottom) occurs throughout the winter.

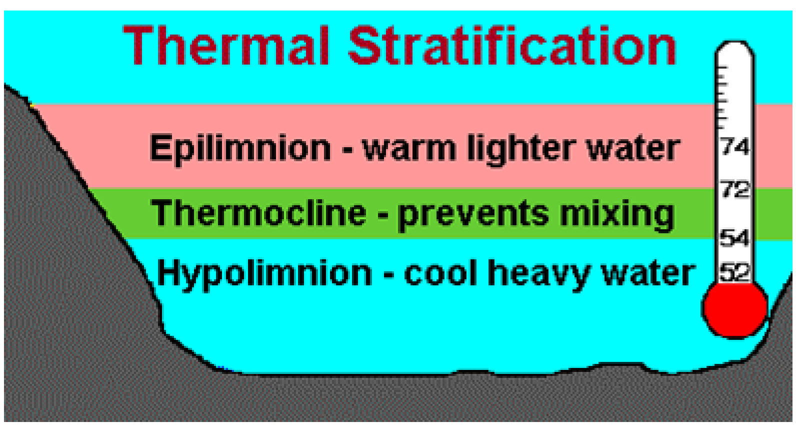


Figure 6 – Summer Thermal Stratification

During the summer months, the upper warm layer, called the epilimnion, remains well oxygenated due to wind and wave action and photosynthesis. The middle layer, called the metalimnion or thermocline, is where changes in temperature and dissolved oxygen are greatest. This middle layer acts as a barrier that prevents warmer, oxygen rich waters in the upper layer from mixing with colder, deeper waters It is common for dissolved oxygen levels to be depleted in the lower layer, called the hypolimnion, as there is no source of new oxygen and the decomposition of organic matter consumes oxygen.

Dissolved oxygen levels below 5 mg/L stresses many fish species. The dissolved oxygen level of 2 mg/L, called hypoxia, is an important criterion of sediment phosphorus release. When near-bottom dissolved oxygen is at 2 mg/L or less, the sediment-water interface is likely anoxic (no oxygen) and therefore releasing phosphorus. If the phosphorus released from sediments reaches the upper part of the lake (for example, during lake overturn in spring and fall), it can provide a significant internal source of phosphorus to fuel algae blooms.

Amnicon Lake is dimictic with mixing in the fall and summer (7). Hypoxia at the Deep Hole monitoring station (163120) occurred at depths of 16 feet or greater during the summer months (June – August). Dowling Lake is a shallow headwater lake, meaning it does not stratify during the summer months and the immediate watershed is less than 4 square miles. Dissolved oxygen data were collected at station 163091 (Deep Hole) intermittently from 1994 through 2012 and once in May 1976 and April 1977. No hypoxia was documented at this monitoring station.

5.2.3 Water Clarity

The depth to which light can penetrate is a factor that limits aquatic macrophyte growth. Water clarity is measured by lowering a black and white Secchi disk in the water and recording the depth of disappearance. The disk is then lowered further and slowly raised until the reappears. The Secchi depth is the mid-point between the depth of disappearance and the depth of reappearance. Because light penetration is usually associated with nutrient levels and algae growth, a lake is considered eutrophic when Secchi depths are less than 6.5 feet. Secchi depths vary throughout the year, with shallower readings in summer when algae concentrations increase, thus limiting light penetration. Conversely, deeper readings occur in spring and late fall when algae growth is limited.

Some lakes are “stained” due to dissolved organic substances that cause the water to appear brown or tea-colored. These lakes are known as dystrophic, which refers strictly to water color and not nutrient content that causes algal growth. Dystrophic lakes will have a lower water clarity than non-dystrophic lakes with the same nutrient concentrations and algae growth. Both Amnicon and Dowling Lakes are dystrophic and consequently, it is important to bear this in mind when considering water clarity in these systems.

Secchi data is available for Amnicon Lake at one monitoring station 163120 (Deep Hole) from 1973 through 2013 (Figure 7). Mean summer (June-August) Secchi depths range from 4 feet to 8 feet with an overall average of 6 feet. The overall mean summer Secchi depths classify Amnicon Lake as a eutrophic system. However, mean summer values range from eutrophic to mesotrophic conditions. Secchi data were also collected at monitoring station 163301 (NW Tomahawk Island) during the summer of 1994 with an overall average of 6 feet.

Dowling Lake Secchi depth data are available for one monitoring station (Deep Hole 163091) from 1994 through 2012 (Figure 8). Mean summer (June-August) Secchi depths range from 1.6 feet to 5.3 feet with an overall average of 3.6 feet. The overall mean summer Secchi depths classify Dowling Lake as a eutrophic system.

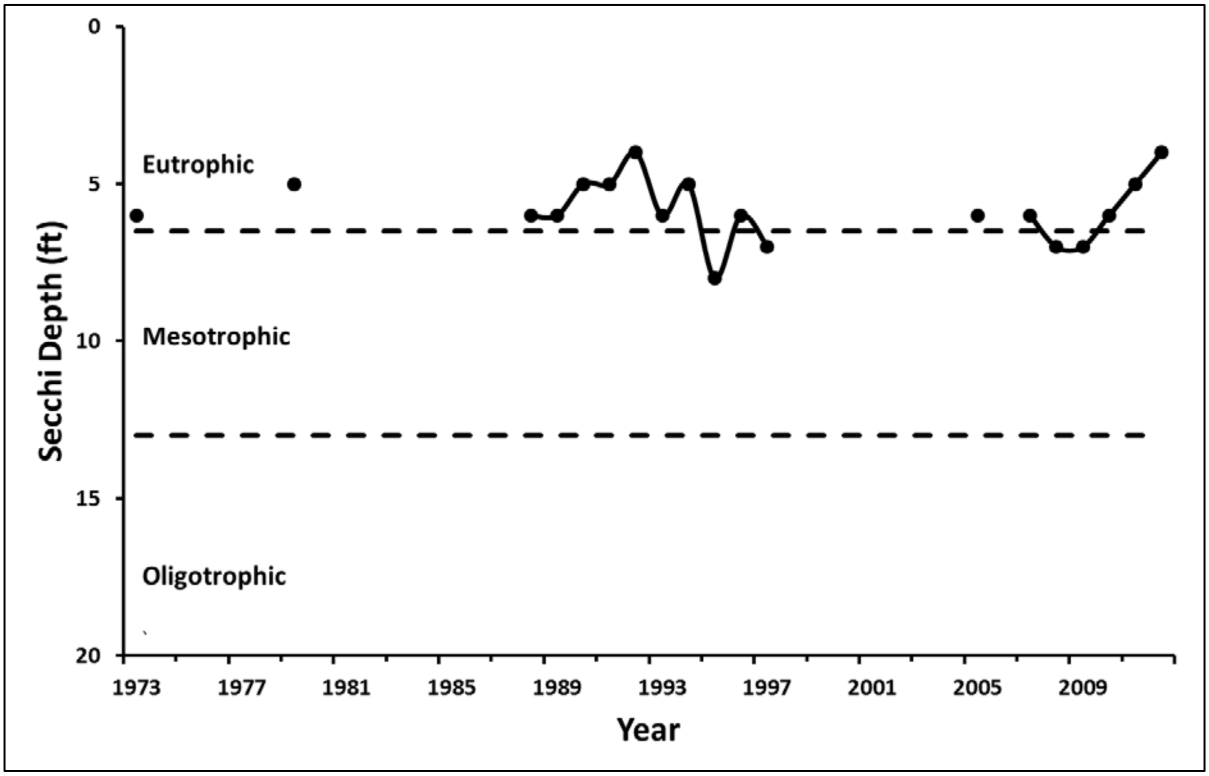


Figure 7 – Mean Summer (June-August) Water Clarity in Amnicon Lake

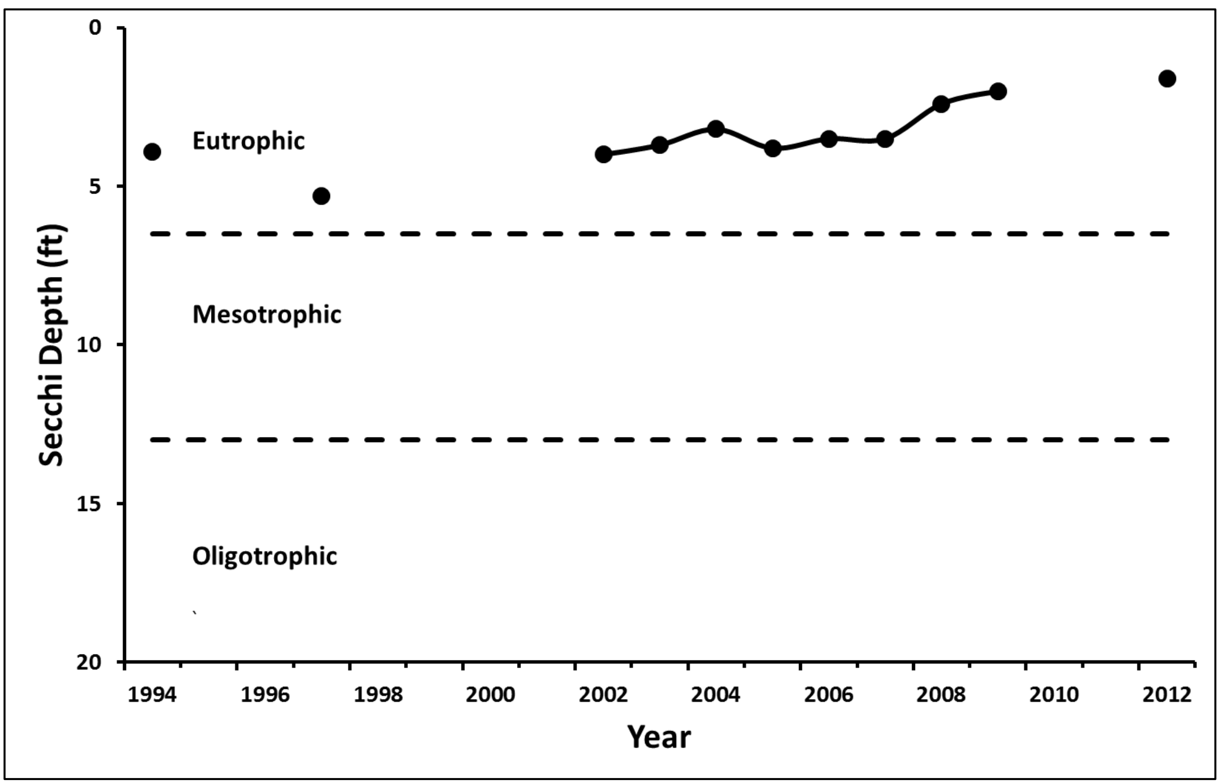


Figure 8 – Mean Summer (June-August) Water Clarity in Dowling Lake

5.2.4 Phosphorus

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. As a limiting factor, addition of small quantities of phosphorus to a lake can cause dramatic increases in plant and algae growth and should therefore be the focus of management efforts to improved water quality. Deep lakes are more responsive to reductions of external phosphorus inputs, whereas shallow lakes such as Dowling are likely to be more responsive to biomanipulations (alteration of an ecosystem by adding or removing species) (4). Phosphorus can be monitored at various depths, especially in deep lakes, because when a lake is thermally stratified, higher levels of phosphorus are found in deeper waters. This is due to decomposition and sinking of zooplankton and algae, thereby causing a "build-up" of nutrients in deeper waters that do not readily mix during thermal stratification. Also due to the lack of mixing in summer, the oxygen levels in deeper waters fall. When oxygen is depleted, chemical changes at the sediment-water interface allow phosphorus that was trapped in the sediment to be re-suspended into the water column.

Total phosphorus was monitored at five stations in Amnicon Lake from 1973 through 2013 with a near-surface (0-6 feet) summer average of 36.6 µg/L classifying Amnicon Lake as a eutrophic system (Figure 9). Monitoring occurred at station 163301 (Northwest Tomahawk Island) during the summer of 1994 with a mean value of 26 µg/L, however depths were not recorded so values from this station are not figured into the overall summer average. Station 163400 (Intermittent Tributary to Amnicon Lake) was monitored in June of 2003 and 2004 with surface values of 31 µg/L and 41 µg/L respectively and an overall average of 36 µg/L. Station 163401 (Intermittent Tributary to Amnicon Lake) was monitored in June of 2003 and 2004 with surface values of 47 µg/L and 81 µg/L respectively and an overall average of 64 µg/L, yielding the highest phosphorus value and overall average of all the stations. Station 163399 (Outlet) was monitored in 2003 and 2004 with mean phosphorus values of 23.3 µg/L and 20 µg/L respectively and an overall surface water summer average of 21.7 µg/L. Station 163120 (Deep Hole) was monitored in 1973, 1974, 1979, 1988-1998, and 2003-2011 with an overall summer average of 24.6 µg/L. Most of the phosphorus values at station 163120 with depths greater than 6 feet ranged from 10 µg/L to 102 µg/L, although these are not depicted in Figure 9. However, one summer measurement yielded a very high phosphorus value of 441 µg/L at 30 feet in July 2004.

Total phosphorus was monitored at four stations in Dowling Lake from 1994 through 2012 with a near-surface (0-6 feet) summer average of 78.5 µg/L classifying Dowling Lake as a eutrophic system (Figure 10). The greatest number of monitoring events occurred at station 163091 (Deep Hole) in 1994, 1996-1998, 2003-2004, and 2012 with mean summer surface values ranging from 20 µg/L to 59 µg/L and a mean value of 36 µg/L. Station 163402 (Outlet) was monitored in 2003 and 2004 with surface water values of 38 µg/L and 31 µg/L respectively and an overall average of 35 µg/L. Stations 163403 (Intermittent Tributary to Dowling Lake North Shore) and 163405 (Intermittent Tributary to Dowling Lake South Shore) were monitored in 2004 and yielded very high phosphorus levels of 95 µg/L and 148 µg/L respectively. Phosphorus values at depths greater than 6 feet ranged from 20 µg/L to 80 µg/L among the four monitoring sites. Near-surface summer averages for the four monitoring sites (36 µg/L, 35 µg/L, 95 µg/L, and 148 µg/L) yield an overall mean of 78.5 µg/L. If the tributary stations are removed from the data set (163405 and 163403), Dowling Lake does not exhibit any mean phosphorus values that fall within the hypereutrophic range but is still considered eutrophic with a mean average phosphorus value of 35.5 µg/L.

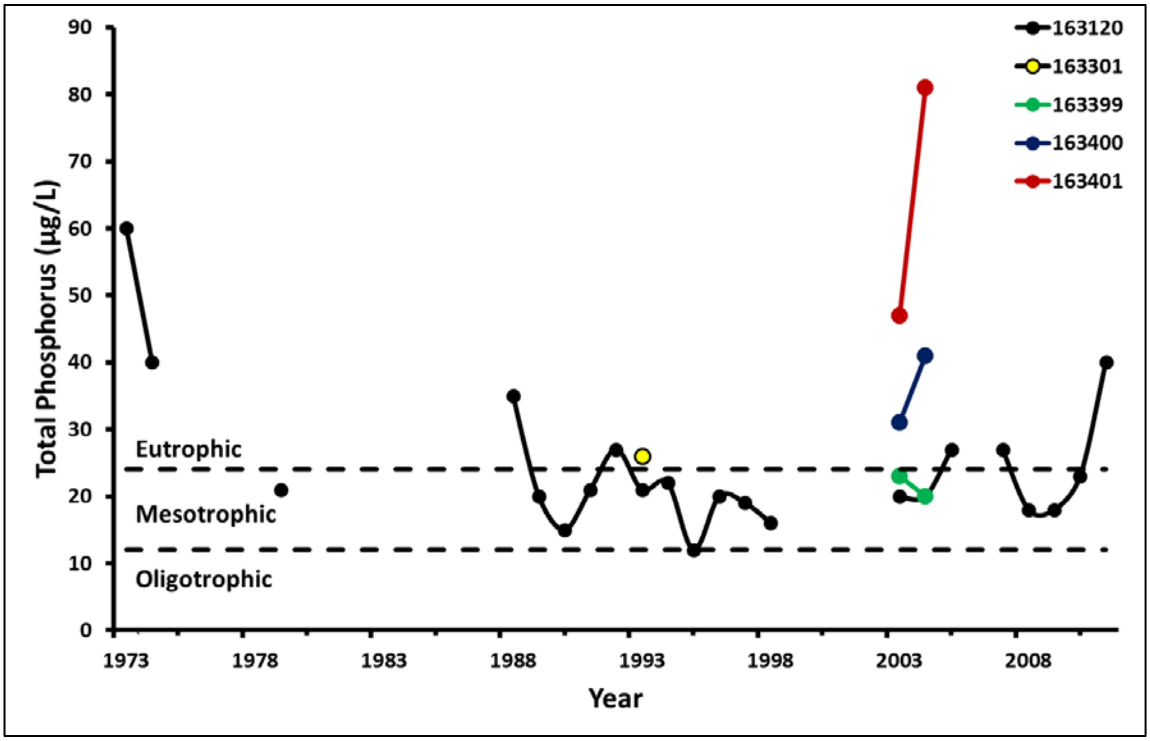


Figure 9 – Mean Summer (June-August) Near-Surface (0-6 feet) Total Phosphorus in Amnicon Lake

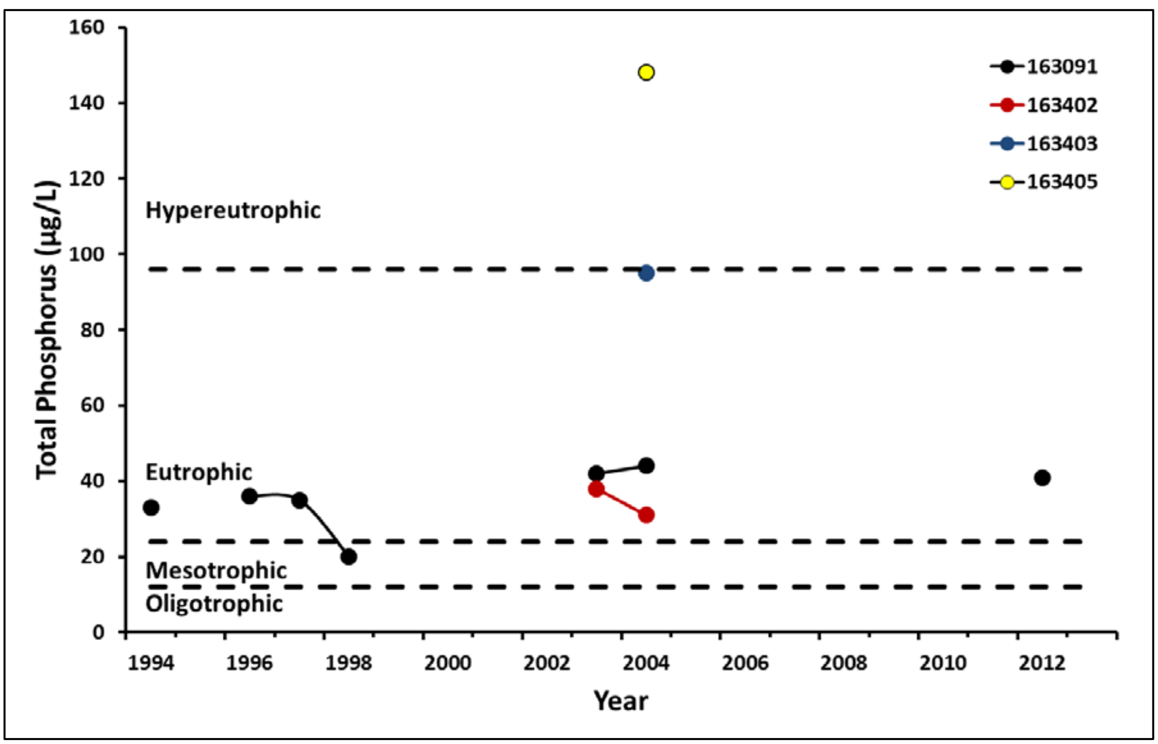


Figure 10 – Mean Summer (June-August) Near-Surface (0-6 feet) Total Phosphorus in Dowling Lake

5.2.5 Chlorophyll *a*

Chlorophyll *a* is the green pigment found in plants and algae. The concentration of chlorophyll *a* is used as a measure of the algal population in a lake. Concentrations greater than about 10 µg/L are considered indicative of eutrophic conditions and concentrations 20 µg/L or higher are associated with algal blooms. For trophic state classification, preference is given to the chlorophyll *a* trophic state index (TSI_{CHL}) because it is the most accurate at predicting algal biomass.

Chlorophyll-*a* data is available for Amnicon Lake monitoring station 163120 (Deep Hole) intermittently from 1979 through 2011 (Figure 11). The trophic state index (TSI) values for near-surface (0-6 ft) samples range from 31 to 62. The overall summer average was 8.3 µg/L with a TSI value of 50, which is borderline mesotrophic-eutrophic.

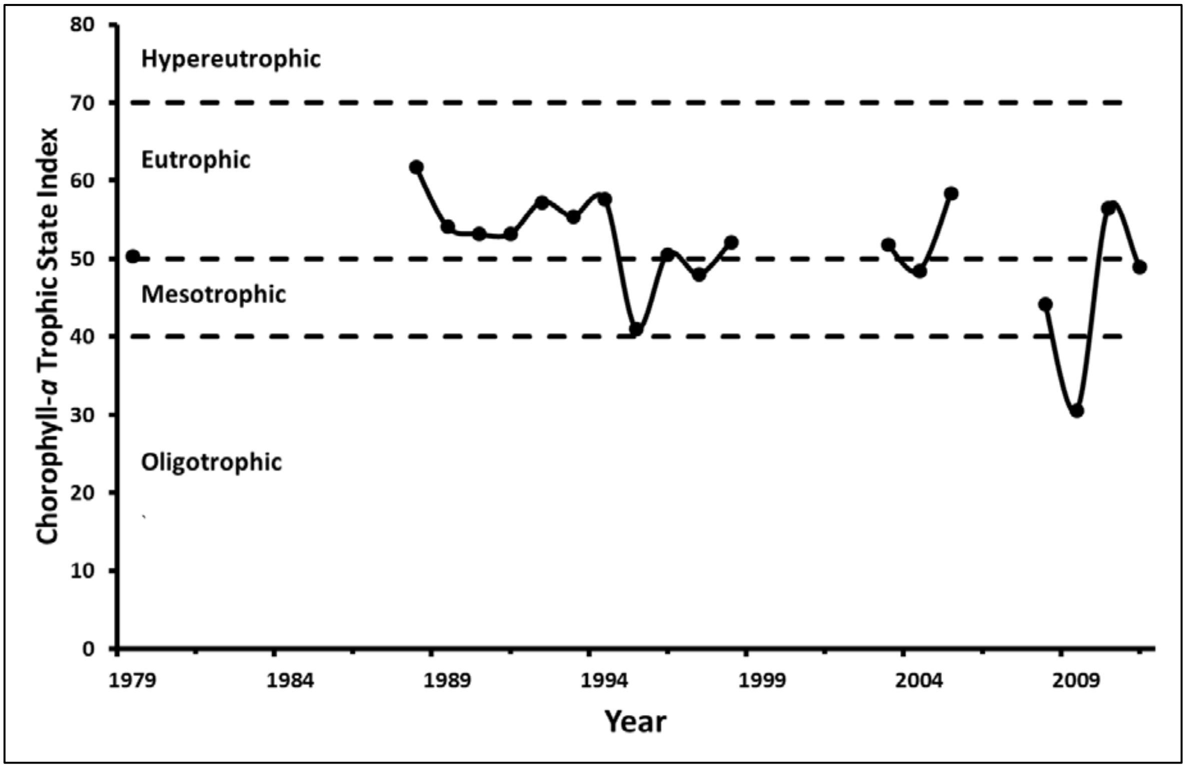


Figure 11 – Mean Summer (June-August) Surface Water (0-6 feet) Chlorophyll-*a* Trophic State Index for Amnicon Lake

Chlorophyll-*a* data is available for Dowling Lake monitoring station 163091 (Deep Hole) intermittently from 1994 through 2012 (Figure 12). The trophic state index (TSI) values for near-surface (0-6 ft) samples range from 51 to 69. The overall summer average was 18.7 µg/L with a TSI value of 57 classifying Dowling Lake as a eutrophic system.

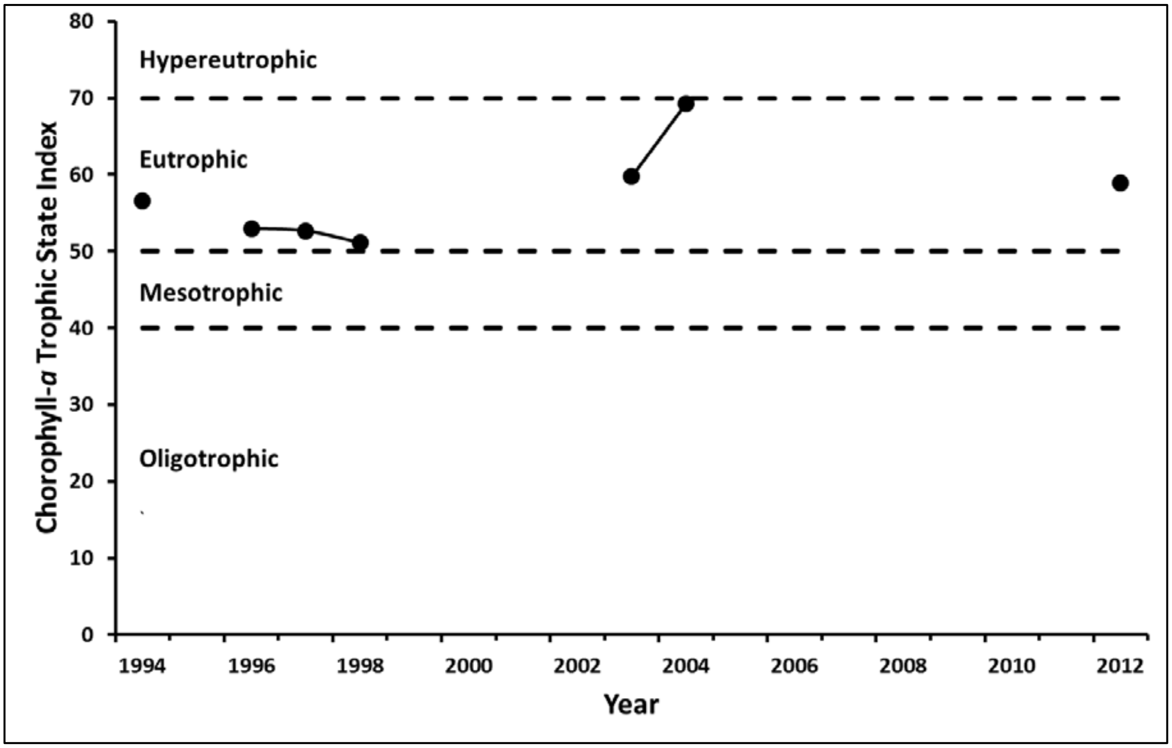


Figure 12 – Mean Summer (June-August) Surface Water (0-6 feet) Chlorophyll-a Trophic State Index for Dowling Lake

5.2.6 Water Quality Discussion

Since monitoring began on Amnicon Lake in 1973 at Station 163120, mean water clarity and mean phosphorus values classify the lake as eutrophic while the mean TSI_{CHL} of 50 is borderline mesotrophic-eutrophic (Table 3). For trophic state classification, preference is given to the TSI_{CHL} because it is the most accurate at predicting algal biomass. Linear trend lines for all three variables point toward a mesotrophic classification in the future, but these trend lines are not significant (Secchi $R^2 = 0.01$, phosphorus $R^2 = 0.17$, TSI_{CHL} $R^2 = 0.15$). Therefore, it cannot be inferred that the water quality is indeed moving toward a more oligotrophic (low nutrient, clear water) state.

Phosphorus is likely the limiting factor for plant and algae growth in Amnicon Lake. Slight increases in phosphorus could lead to increased algae growth and nuisance macrophyte growth. Due to the undeveloped nature of the watershed, the largest source of phosphorus to the system is likely runoff from development along shore and potentially internal nutrient loading. Because mean TSI_{CHL} is borderline, even slight phosphorus increases could "push" Amnicon water quality toward a eutrophic (higher nutrient, decrease water clarity) state.

Dowling Lake mean water clarity, mean phosphorus, and mean TSI_{CHL} (57) classify the lake as eutrophic (Table 3) and linear trend lines point toward a more eutrophic state in the future. Mean phosphorus ($R^2 = 0.30$) and mean TSI_{CHL} ($R^2 = 0.28$) trend lines are not significant, while the mean Secchi ($R^2 = 0.67$) linear trend is significant. Unfortunately, the lake's naturally tannic stained water coupled with moderate amounts of suspended particles (stirred up sediment and green algae like *Volvox* sp.) has resulted in poor water clarity. These conditions are severely restricting light penetration, and, consequently, most plants are not able to grow much deeper than 5 feet (9). This lack of rooted plants appears to be creating a negative feedback loop: Lack of light kills macrophytes → decomposing macrophytes release nutrients into the water column → excessive nutrients results in more algae which further decrease clarity.

Table 3
The Trophic State Index (TSIO) and Associated Conditions

TSI	Trophic State	Description of Associated Conditions
<30	Oligotrophic	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
30 - 40		Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
40 - 50	Mesotrophic	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
50 - 60	Eutrophic	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
60 - 70		Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
70 - 80		Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
>80		Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

Amnicon 50

Dowling 57

6.0 Aquatic Ecosystems

A healthy lake is dependent on a healthy lake ecosystem. Native aquatic plants and animals (including fish), wetlands, rare and endangered species, and the habitat critical for all of these entities help to maintain and protect a healthy overall lake ecosystem. When management is recommended for a body of water, care must be taken to protect, maintain, and when possible enhance those parts of the overall ecosystem.

6.1 Aquatic Plants

Aquatic plants, also known as macrophytes, are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. Native macrophytes have many important functions and values to a lake ecosystem. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other life.

Aquatic plants provide valuable fish and wildlife habitat. More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Panfish eat aquatic plants in addition to aquatic insects and crustaceans. Plants also provide shelter for young fish. Northern pike spawn in marshy and flooded areas in early spring and bass, sunfish, and yellow perch usually nest in areas where vegetation is growing.

Many submerged plants produce seeds and tubers (roots) which are eaten by waterfowl. Bulrushes, sago pondweed, wild celery, and wild rice are especially important duck foods. Submerged plants also provide habitat to a number of insect species and other invertebrates that are, in turn, important foods for brooding hens and migrating waterfowl.

The lake aesthetic valued by so many is enhanced by the aquatic plant community. The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy.

Aquatic plants improve water clarity and water quality. Certain plants, like bulrushes, can absorb and break down polluting chemicals. Nutrients used by aquatic plants for growth are not available to algae, thus reducing algae abundance and improving water clarity. Algae, which thrive on dissolved nutrients, can become a nuisance when too many submerged water plants are destroyed. Aquatic plants also maintain water clarity by preventing the re-suspension of bottom sediments. Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.

Native aquatic plant communities also offer protection from non-native aquatic invasive species. Current scientific literature generally accepts the concept that invasions of exotic plants are encouraged, and in some cases induced, by the disruption of natural plant communities. Curly-leaf pondweed, which is present in Amnicon Lake, is an opportunistic plant. Much like lawn and agricultural weeds that germinate in newly disturbed soil, curly-leaf pondweed is more likely to invade areas in which the native plant community has been disturbed or removed. Removing the natural competition from native plants may also open up the door to new invasive species and less desirable plant communities.

As a natural component of lakes, aquatic plants support the economic value of all lake activities. Wisconsin's $13 billion tourism industry is anchored by 15,081 lakes and 12,600 rivers and streams which draw residents and tourists to hunt, fish, camp, and watch wildlife on and around lakes. According to the WDNR, the world class fishery lures more than 1.4 million licensed anglers each year, supports more than 30,000 jobs, generates a $2.75 billion annual economic impact, and $200 million in tax revenues for state and local governments.

6.2 Wetlands

In Wisconsin, a wetland is defined as an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions (Wisconsin Statue 23.32(1)). Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes. Wetlands are protected under the Clean Water Act and state law and in some places by local regulations or ordinances. Landowners and developers are required to avoid wetlands with their projects whenever possible; if the wetlands can't be avoided, they must seek the appropriate permits to allow them to impact wetlands (for example, fill, drain or disturb soils).

According to the National Wetland Inventory, emergent, forested/shrub and aquatic bed (lake and freshwater pond) wetlands are present in Amnicon-Dowling Lake watershed. Dowling Lake has very little wetland along its shoreline whereas forested/shrub wetlands make up a large portion of the southeast, south, and southwest shores of Amnicon Lake. Emergent wetlands are wetlands with saturated soil and are dominated by grasses such as redtop and reed canary grass, and by forbs such as giant goldenrod. Forested/shrub wetlands are wetlands dominated by mature conifers and lowland hardwood trees. Forested/shrub wetlands are the dominant form of wetlands in the watershed and are important for stormwater and floodwater retention and provide habitat for various wildlife. Aquatic bed wetlands are wetlands characterized by plants growing entirely on or within a water body that is no more than six feet deep.

Wetlands serve many functions that benefit the ecosystem surrounding Amnicon and Dowling Lakes. Wetlands support a great variety of native plants and are more likely to support regionally scarce plants and plant communities. 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. Contrary to popular belief, healthy wetlands reduce mosquito populations; natural enemies of mosquitoes (dragonflies, damselflies, backswimmers, and predacious diving beetles) need proper habitat (that is, healthy wetlands) to survive.

Wetlands provide flood protection within the landscape by retaining stormwater from rain and melting snow and capturing floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months.

Wetland plants and soils provide water quality protection by storing and filtering pollutants ranging from pesticides to animal wastes. Wetlands also provide shoreline protection by acting as buffers between the land and water. Wetland plants protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This is important in waterways where high boat traffic, water currents, and wave action may cause substantial damage to the shore.

Although some small (two acres or less) wetlands may not appear to provide significant functional values when assessed individually, they may be very important components of a larger natural system. Not only do small wetlands provide habitat functions, they also store phosphorus and nitrogen and trap pollutants such as heavy metals and pesticides. Draining these small wetlands, which often do not appear on maps, not only requires the proper permits, but can also release the once-stored pollutants and nutrients into lakes and streams.

6.3 Critical Habitat

Every body of water has areas of aquatic vegetation or other features that offer critical or unique aquatic plant, fish and wildlife habitat. Such areas can be mapped by the WDNR and designated as Critical Habitat. Critical Habitat areas include important fish and wildlife habitat, natural shorelines, physical features important for water quality (for example, springs) and navigation thoroughfares. These areas, which can be located within or adjacent to the lake, are selected because they are particularly valuable to the ecosystem or would be significantly and negatively impacted by most human induced disturbances or development. Critical Habitat areas include both Sensitive Areas and Public Rights Features. Sensitive Areas offer critical or unique fish and wildlife habitat, are important for seasonal or life-stage requirements of various animals, or offer water quality or erosion control benefits.

Critical habitat designations for Amnicon and Dowling Lakes were proposed in 2011, but are not yet completed.

6.4 Fishery

6.4.1 Amnicon Lake

Muskellunge and panfish are common in Amnicon Lake while largemouth bass *and* walleye are present (10). Walleye stocking has occurred from 2002 through 2007 while muskellunge stocking was done from 1972 through 1997 (Table 4). Older stocking records existing back to 1934 indicate largemouth bass, bluegill, and crappie were also stocked (11). Other fish species include northern pike, bluegill, pumpkinseed, rock bass, black crappie, yellow perch, white sucker, yellow bullhead, black bullhead, trout perch, creek chub, tadpole madtom, brook stickleback, johnny darter, Iowa darter, central mudminnow, common shiner, and golden shiner (11).

The WDNR conducted a survey in 2006 and 2007 to determine the status of walleye, muskellunge, and largemouth bass population abundance, growth, size structure, and harvest. Results suggest that Amnicon Lake supports a diverse fish community with good to excellent natural reproduction of all species. Adult walleye abundance is slightly below average with 2.8 fish/acre when compared to Bayfield and Douglas Counties at 3.7 fish/acre. Muskellunge, the most pursued game fish in Amnicon Lake, is more abundant than other northern Wisconsin waters with 1.12 fish/acre ≥ 30 inches. Angler catch rates for musky were around 9 hours/fish while the average catch rate statewide is 35 hours/fish. Black crappie was the most pursued (25% of directed effort) panfish with and estimated harvest of 2,264 (11). More detailed information on the fishery and management recommendations can be found in the full WDNR 2006-2007 Fishery Report for Amnicon Lake in Appendix D.

Table 4
Amnicon Lake Fish Stocking Records

Year	Species	Age Class	Number Stocked	Average Fish Length (in)
2007	Walleye	Small Fingerling	5,635	2.80
2006	Walleye	Small Fingerling	8,124	1.50
2005	Walleye	Small Fingerling	8,050	1.60
2003	Walleye	Small Fingerling	8,048	1.60
2002	Walleye	Small Fingerling	8,472	1.60
1997	Muskellunge	Large Fingerling	200	12.10
1996	Muskellunge	Fingerling	1,600	10.90
1993	Muskellunge	Fingerling	400	9.90
1992	Muskellunge	Fingerling	400	10.00
1991	Muskellunge	Fingerling	400	11.00
1990	Muskellunge	Fingerling	200	11.00
1989	Muskellunge	Fingerling	200	11.00
1988	Muskellunge	Fingerling	400	9.00
1987	Muskellunge	Fingerling	600	11.00
1986	Muskellunge	Fingerling	400	9.00
1981	Walleye	Fingerling	32,050	4.6
1977	Walleye	Fingerling	33	4.33
1977	Muskellunge	Fingerling	465	3
1976	Muskellunge	Fingerling	2,000	8.33
1976	Walleye	Fingerling	39,539	3
1974	Walleye	Fingerling	25,029	3
1972	Muskellunge	Fingerling	800	15
Source: WDNR Lake Pages (online)				

6.4.2 Dowling Lake

Muskellunge and walleye are common in Dowling Lake while largemouth bass and panfish are present (10). Dowling Lake is also considered a Priority Navigable Waterway based on its natural reproduction of walleye and muskellunge. No fish stocking data were available for Dowling Lake but a fish survey done by the WDNR in spring 2012 revealed the following species present; walleye, muskellunge, largemouth bass, rock bass, white sucker, bluegill, pumpkinseed, black crappie, yellow perch, yellow bullhead, golden shiner, common shiner, spot-tailed shiner, central mudminnow, and tadpole madtom (12).

6.5 Wildlife

Citizen monitoring of the Common Loon was done in 2009, 2010, and 2011 revealing loon arrival on Amnicon Lake in early March and early to mid-April respectively and departure in mid-October in 2009 and mid-September in 2010. No departure date was recorded for 2011.

Each year, one loon pair resided on Amnicon Lake and successfully hatched two loon chicks that survived to eight weeks of age in 2011 and one loon chick in 2009. Although a loon pair was recorded to take up residence on Amnicon Lake in 2010, no nesting activity was documented for that year.

6.6 Rare and Endangered Species Habitat

The Wisconsin Natural Heritage Inventory (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. Species are listed by township: Amnicon Lake is in the Town of Summit (T46, R14W) and Dowling Lake is in the Town of Oakland (T46, R13W). 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.

One Threatened species (seaside crowfoot) and five Species of Special Concern are listed for T46, R14W in the Town of Summit (the gray wolf, the bald eagle, the American bittern, the arctic fritillary, and Le Conte's sparrow, Five Special Concern species are listed for T46, R 13W in the Town of Oakland (the bald eagle, the Rocky Mountain sprinkled locust, the arctic fritillary, the Connecticut warbler, and the Forcipate emerald). Descriptions of these species can be found at http://dnr.wi.gov/topic/EndangeredResources/biodiversity.html/ (last accessed 2013-11-21). During the 2012 aquatic plant survey, no Wisconsin Species of Special Concern were documented in Amnicon or Dowling Lakes.

The Natural Heritage Inventory Program 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 T46, R14W in the Town of Summit include: black spruce swamp, northern dry-mesic forest, and open bog. Natural communities listed for the T46, R13W in the Town of Oakland include: boreal forest, lake—soft bog, and northern wet forest. Full descriptions of these communities including current threats can be found on the WDNR website at: http://dnr.wi.gov/topic/endangeredresources/communities.asp (last accessed 2013-11-21).

The Natural Heritage Inventory Program 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. Bird rookery is one such natural feature listed for T46, R14W in the Town of Summit. A full description of a bird rookery can be found on the WDNR website at: http://dnr.wi.gov/topic/endangeredresources/OtherElements.asp (last accessed 2013-11-21)

A number of high value aquatic plant species listed in NR 107 including Potamogeton amplifolius, P. Richardsonii, P. robbinsii, Eleocharis spp., Scirpus spp. (also known as Schoenoplectus spp.), Valisneria spp., and Brasenia schreberi were found in Amnicon Lake while Potamogeton Richardsonii, Eleocharis spp., Scirpus spp. (also known as Schoenoplectus spp.), and Brasenia schreberi were 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.

7.0 Aquatic Plant Communities

Aquatic plants play an important role in lakes. They anchor sediments, buffer wave action, oxygenate water, and provide valuable habitat for aquatic animals. The amount and type of plants in a lake can greatly affect nutrient cycling, water clarity, and food web interactions. Furthermore, plants are very important for fish reproduction, survival, and growth, and can greatly impact the type and size of fish in a lake.

Unfortunately, healthy aquatic plant communities are often degraded by poor water clarity, excessive plant control activities, and the invasion on non-native nuisance plants (13). These disruptive forces alter the diversity and abundance of aquatic plants in lakes and can lead to undesirable changes in many other aspects of a lake's ecology (Figure 13). Consequently, it is very important that lake managers find a balance between controlling nuisance plant growth and maintaining a healthy, diverse plant community.

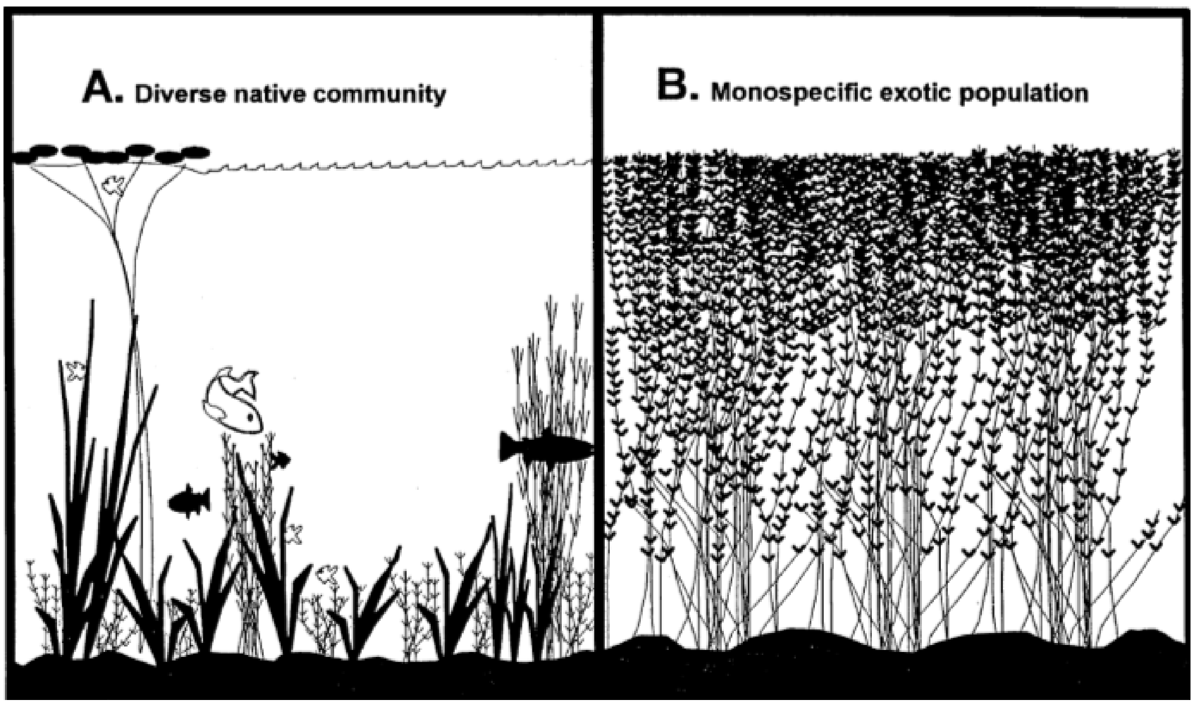


Figure 13 – Submersed Aquatic Plant Communities

An aquatic plant survey was completed late spring and mid-summer of 2012 by Endangered Resources Services; LLC (ERS) (St. Croix Falls, Wis.) with the objective of establish baseline information and identify any issues of concern such as the presence of non-native AIS. Amnicon Lake was found supporting an extremely diverse and healthy native aquatic plant community occurring in light to moderate density. Although curly-leaf pondweed (CLP) had already been documented, this survey formally recorded the location and density of CLP beds. The Dowling Lake survey revealed a moderately diverse plant community that was low in abundance. No CLP was documented in Dowling Lake. The 2012 ERS investigations (the most recent and extensive plant surveys) were used to develop this plan and are summarized below.

ERS conducted two lake-wide plant surveys on each of the lakes in 2012. The first investigation was an early-season curly-leaf distribution and bed mapping survey completed on May 19th and the second a whole-lake point intercept survey in early August. The surveys provide detailed statistical assessments of the aquatic plant communities in Amnicon and Dowling Lakes and establish a baseline for evaluating any changes in the plant community over the coming years which will help guide responsible aquatic plant management planning. A detailed report was written for each lake by ERS and distributed to project partners in 2012.

The **Simpson Diversity Index** was calculated for each lake using the results of the aquatic plant surveys. The Simpson Diversity Index is a value that allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. The index value represents the probability that two individual plants (randomly selected) will be different species. The index values range from 0 to 1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Plant communities with high diversity also tend to be more resistant to invasion by exotic species

The **Floristic Quality Index or FQI** is a measure of the impact of human development on a lake's aquatic plants. The Floristic Quality Index was computed for each lake using results from the plant survey. There are 124 species in the index; each assigned a **Coefficient of Conservatism, or C value**, which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species.

7.1 Amnicon Lake

The Amnicon Lake ecosystem is home to an exceptionally rich and diverse plant community, including seven extremely high value/sensitive species. A total of 501 points were surveyed with plants found growing at 218 sites, or 43.5% of the entire lake bottom and in 77.9% of the littoral zone. Despite a maximum littoral depth of 11 feet, most plant growth ended in 8 feet of water, and those plants were rapidly dying back due to lack of light/poor water quality (Figure 14).

Overall diversity was extremely high with a Simpson Diversity Index value of 0.94. Species richness was also very high with a total of 60 species growing in and immediately adjacent to the water. Plant growth was slightly skewed to deep water as the mean depth of plant growth was 4.5ft, but the median was 4.0ft. Total rake fullness was moderately high averaging 2.21 at sites with vegetation. In general, species richness, diversity and total rake biomass declined rapidly at depths beyond 6ft (Figure 14).

Nitella, Coontail, Wild celery, and Flat-stem pondweed were the most common macrophyte species, found at 40.83%, 35.32%, 29.36%, and 28.44% of survey points with vegetation respectively. Together, they combined for a very low 36.64% of the total relative frequency which indicated a high level of evenness in the plant community (Often, the top four species in a lake are >50%). Fern pondweed (6.40), Creeping bladderwort (5.52), Slender naiad (4.89), Watershield (4.64), White water lily (4.27) and Variable pondweed (4. 14) were the only other species with relative frequencies over 4.0.

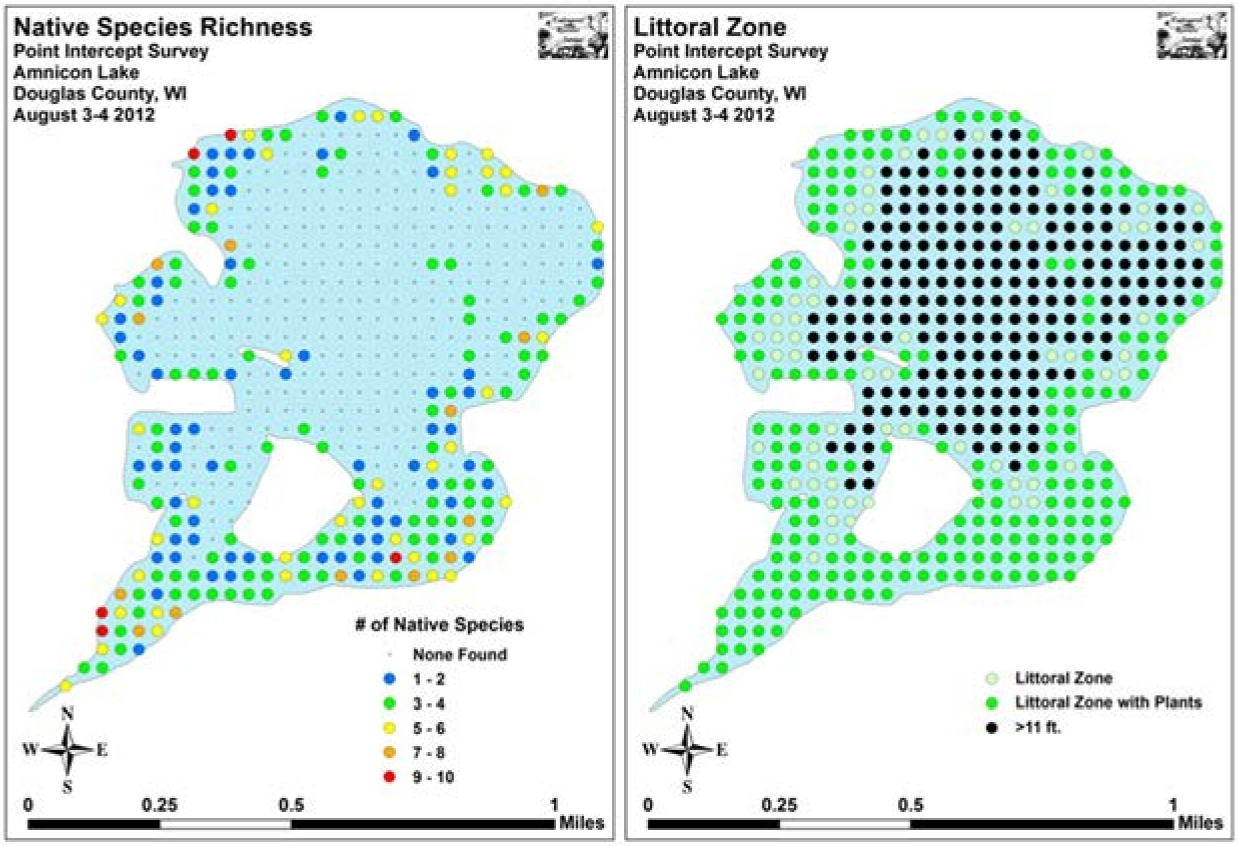


Figure 14 – Amnicon Lake Native Species Richness and Littoral Zone

A total of 46 native Floristic Quality Index (FQI) plants were found on the rake during the point intercept survey. They produced a mean Coefficient of Conservatism of 6.8 and a Floristic Quality Index of 45.9. An average mean C for the Northern Lakes and Forest Region is 6.7 (14) putting Amnicon Lake slightly above average for this part of the state. The FQI was, however, well above the median FQI of 24.3 for the Northern Lakes and Forest Region (14). This exceptionally high value is likely a result of Amnicon Lake's variable substrate, large areas of undeveloped shoreline, and apparent good water quality. All of these factors create a diversity of microhabitats which offer a wide variety of plants suitable growing conditions. Specifically, the lake supported seven extremely high value/sensitive species including Wild calla (C = 9), Dwarf water milfoil (C = 10), Crested arrowhead (C = 9), Floating-leaf bur-reed (C = 10), Creeping bladderwort (C = 9), Flat-leaf bladderwort (C = 9), and Small bladderwort (C = 10).

Northern wild rice, a plant of significant wildlife and cultural value, was found in Amnicon Lake and is described in further detail in Section 8.0.

No evidence of Eurasian water-milfoil was found in Amnicon Lake. Curly-leaf pondweed (CLP) was present at 7 survey points in May and at 6 sites in August. CLP and other invasive species documented in Amnicon Lake are described further detail in Section 9.0.

More information about the aquatic plant community in Amnicon Lake can be found in the 2012 Amnicon Lake Aquatic Plant Survey Report completed by ERS (3).

7.2 Dowling Lake

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. A total of 253 points were surveyed with plants found growing at only 29 sites, or 11.5% of the entire lake bottom and in 29.9% of the littoral zone. Despite a maximum littoral depth of 7feet, the species richness, diversity, and total rake biomass declined rapidly at depths beyond 4 feet (Figure 15). Unfortunately, the lake's naturally tannic stained water coupled with moderate amounts of suspended particles (stirred up sediment and green algae like *Volvox* sp.) has resulted in poor water clarity. These conditions are restricting light penetration and most plants are not able to grow much deeper than 5ft. This lack of rooted plants appears to be creating a negative feedback loop: Lack of light kills macrophytes → decomposing macrophytes release nutrients into the water column → excessive nutrients results in more algae which further decrease clarity.

Of the sites with vegetation, an average of 1.79 species were found, but that average dropped to only 0.54 species per site when considering just the littoral zone. The mean and median depths of plant growth were both 3.5ft, and the total rake fullness was moderately low averaging 1.52 at sites with vegetation. Overall diversity was moderately high with a Simpson Diversity Index value of 0.88. Species richness was, however, low with only 16 species found in the rake during the survey (Figure 15). This total jumped to 33 when including visuals and plants found during the boat survey. However, most of these species were only found in the channel leading in from the lake's boat landing and not seen anywhere else.

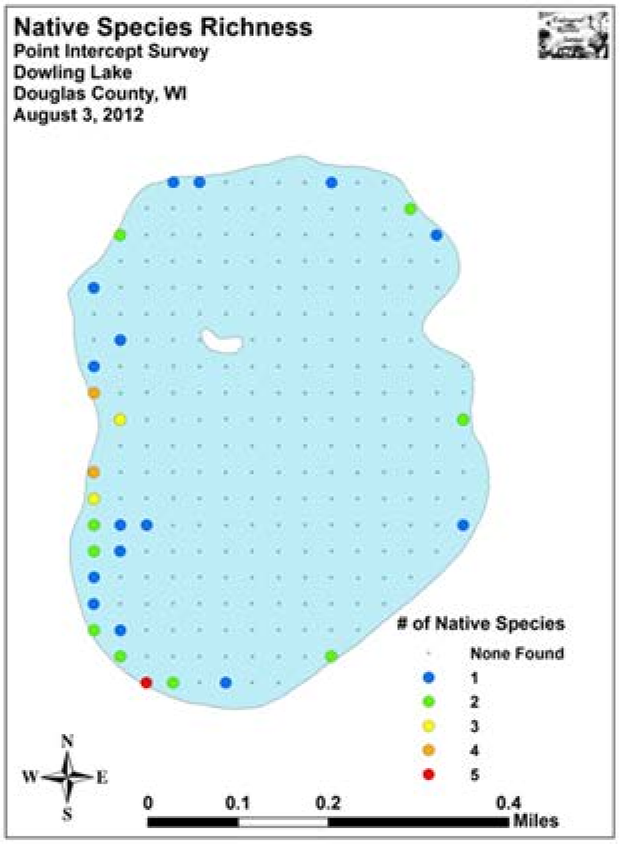
Nitella, Watershield, Spiral-fruited pondweed, and Water horsetail *were* the most common macrophyte species found at 41.38%, 34.48%, 17.24%, and 13.79% of survey points with vegetation respectively. Together, they combined for just under 60% of the total relative frequency. Spatterdock (5.77), Pickerelweed (5.77), and Floating-leaf pondweed (5.77) were the only other species with a relative frequency over 4.0.

A total of 16 Floristic Quality Index species were found on the rake during the point intercept survey. They produced a mean Coefficient of Conservatism of 6.3 and a Floristic Quality Index of 25.3. The average mean C for the Northern Lakes and Forest Region is 6.7 (14) while Dowling Lake is slightly below this average for this region of Wisconsin. The FQI was, however, slightly above the median FQI of 24.3 for the Northern Lakes and Forest Region (14). High value plants of note included Pickerelweed (C = 8), Spiral-fruited pondweed (C = 8), and Floating-leaf bur-reed (C = 10).

Northern wild rice, a plant of significant wildlife and cultural value, was not found in Dowling Lake, but is described in further detail in Section 8.0 because it was found in Amnicon Lake.

No evidence of Eurasian water-milfoil or curly-leaf pondweed was found in Dowling Lake.

Other invasive species were documented and are described in further detail in Section 9.0. More information about the aquatic plant community in Dowling Lake can be found in the 2012 Dowling Lake Aquatic Plant Survey Report completed by ERS (9).



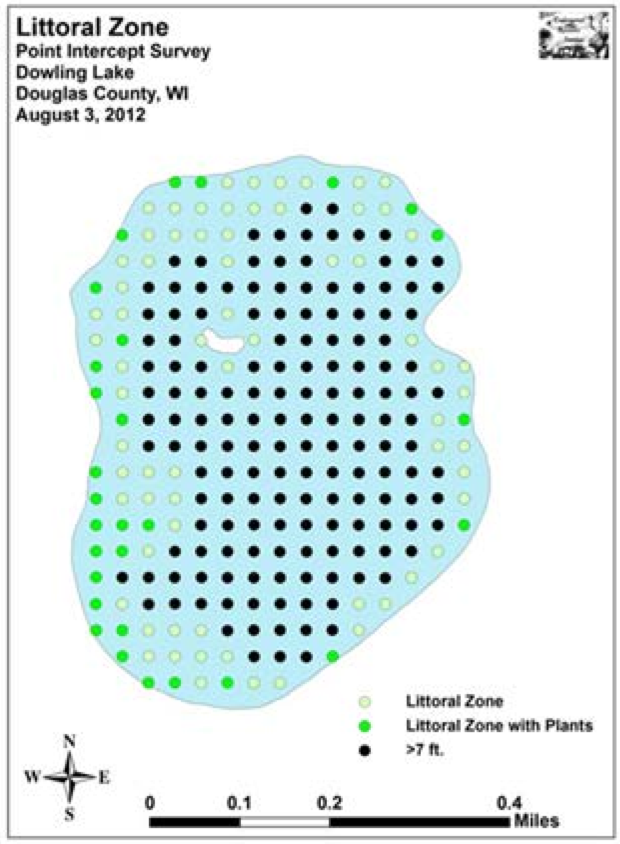


Figure 15 – Species Richness and Littoral Zone of Dowling Lake

8.0 Northern Wild Rice

Northern wild rice was widely scattered throughout the bays and narrows south of Tomahawk Island in Amnicon Lake during the 2012 aquatic plant surveys (Figure 16). All total, wild rice was found in the rake at 17 points. Of these, none had a rake fullness value of 3, three were a 2, and the other 14 were a one. We also recorded rice as a visual at six additional points. Although rice plants were essentially continuous in many areas, even at its highest densities, it was extremely patchy and not fit for harvest (Figure 17).

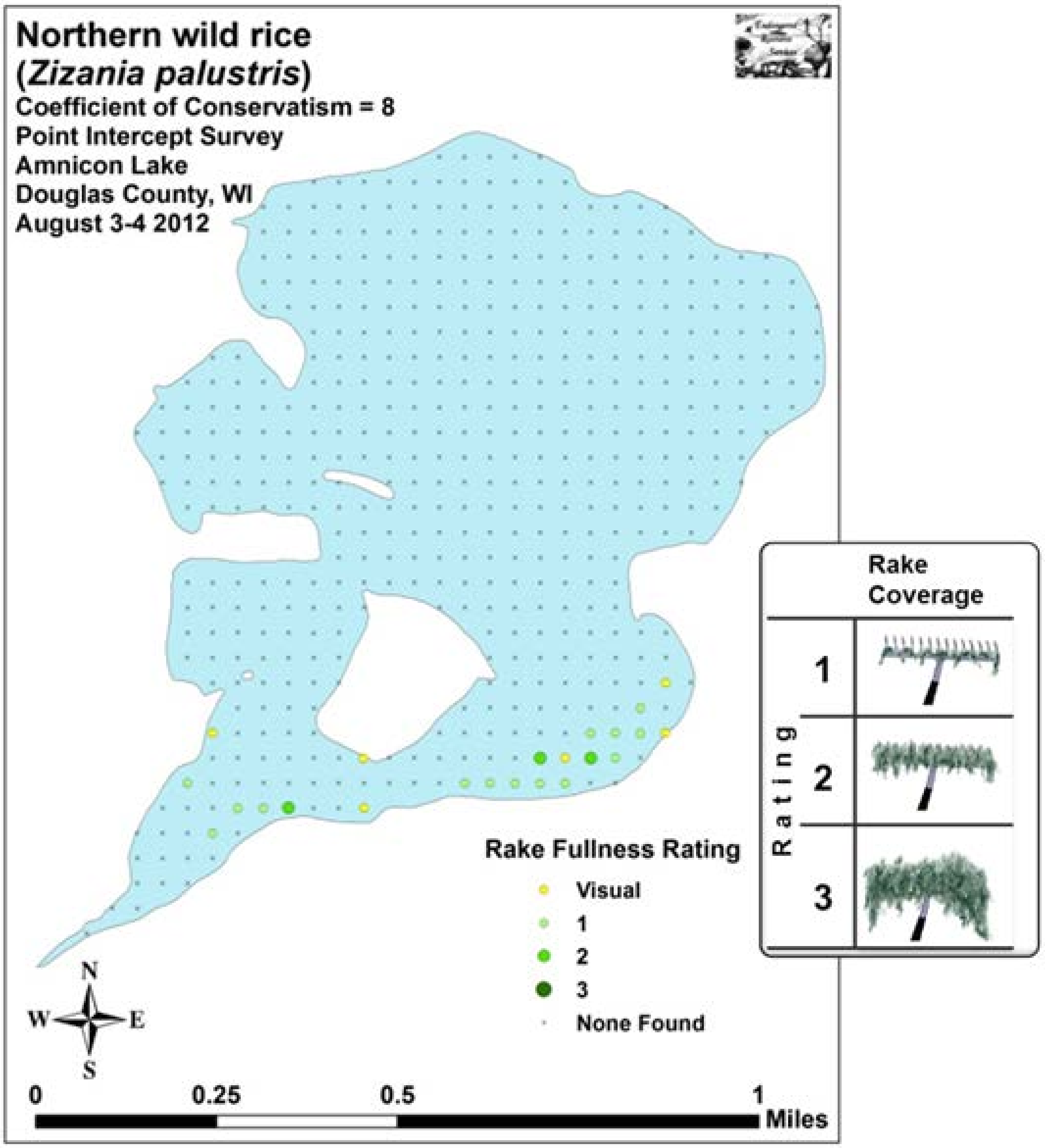


Figure 16 – Distribution of Wild Rice in Amnicon Lake, August 2012

Wild rice is afforded numerous protections due to its ecological and cultural significance. Management is therefore focused on harvest goals and protection of the resource rather than removal. According to the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), 33 pounds total of wild rice was harvested in 2004 and 2007. Any activity included in a comprehensive lake or aquatic plant management plan that could potentially impact the growth of wild rice in any body of water that has in the past, currently has, or potentially could have wild rice in the future requires consultation with the Tribal Nations. This consultation is usually completed by the WDNR in cooperation with GLIFWC during their review of lake management documents.

Wild rice is an annual aquatic grass that produces seed that is a nutritious source of food for wildlife and people. As a native food crop, it has a tremendous amount of cultural significance to the Wisconsin and Minnesota Native American Nations. Wild rice pulls large amounts of nutrients from the sediment in a single year and the stalks provide a place for filamentous algae and other small macrophytes to attach and grow. These small macrophytes pull phosphorous in its dissolved state directly from the water. Wild rice can benefit water quality, provide habitat for wildlife, and help minimize substrate re-suspension and shoreland erosion.

In Wisconsin, wild rice has historically ranged throughout the state. Declines in historic wild rice beds have occurred statewide due to many factors, including dams, pollution, large boat wakes, and invasive plant and animal species. Renewed interest in the wild rice community has led to large-scale restoration efforts to reintroduce wild rice in Wisconsin's landscape. Extensive information is available on wild rice from GLIFWC and the WDNR.

Figure 17 – Low Density Wild Rice South of Tomahawk Island

9.0 Non-native Aquatic Invasive Species Present in the Lakes

Six non-native species were found in Amnicon Lake during the 2012 plant surveys: 1) Three beds of curly-leaf pondweed were found and mapped. More information on these findings is in Section 9.2; 2) Purple loosestrife findings are covered in Section 9.3; and 3) Reed canary grass was present in scattered disturbed shoreline areas. It was uncommon occurring in scattered patches near the boat landing, along the road on the north shoreline, and in a few patches in the lake's west bay. 4) Common forget-me-not was scattered near the boat landing among the alders. It was uncommon, and did not appear to be invasive. 5) Joint rush was also noted at the boat landing in a small monotypic patch and appeared to require compacted ground so it is not likely to spread beyond the landing. 6) Narrow-leaved cattail is native to southern but not northern Wisconsin. It is potentially invasive and often excludes the native Broad-leaved cattail from places where the two are found together. Because of this, there is the potential that it will continue to spread beyond the few plants documented near the lake outlet in 2012.

Only two non-native species were documented in Dowling Lake during the 2012 plant surveys: 1) Purple loosestrife findings are covered in Section 9.3; 2) Reed canary grass 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 Blue joint.

9.1 AIS Monitoring Efforts

Amnicon Lake was monitored for 11 aquatic invasive species (AIS) between 2005 and 2012 (Table 5) (2). A voucher specimen of curly-leaf pondweed (CLP) was obtained during an AIS survey conducted by Steven Garske with the Great Lakes Indian Fish and Wildlife Commission (15). The specimen was collected July 10, 2008 near the boat landing at the northwest side of the lake. For Amnicon Lake, Purple loosestrife was officially documented in the WDNR Surface Water Integrated Monitoring Systems database in 2009 (2).

Dowling Lake was monitored for 11 aquatic invasive species (AIS) between 2005 and 2011 (Table 5). For Dowling Lake, Purple loosestrife was officially documented in the WDNR Surface Water Integrated Monitoring Systems database in 2010 (2).

Table 5
Aquatic Invasive Species Monitoring Efforts in Amnicon & Dowling Lakes

Aquatic Invasive Species	Year(s) monitored		Year AIS Found	
	Amnicon	Dowling	Amnicon	Dowling
Curly-leaf pondweed	2008-2012	2010-2012	2008	—
Purple Loosestrife	2009-2012	2010-2012	2009	2010
Eurasian water-milfoil	2009-2012	2010-2012	—	—
Freshwater jellyfish	2009-2011	2010	—	—
Zebra mussels	2005, 2009-2011	2010, 2011	—	—
Hydrilla	2009, 2010	2010	—	—
Fishhook water flea	2005, 2009-2011	2009, 2010	—	—
Spiny water flea	2005, 2009, 2010	2009, 2010	—	—
Banded mystery snail	2009-2011	2010	—	—
Chinese mystery snail	2009-2011	2010	—	—
Rusty Crayfish	2009, 2010	2010	—	—

9.2 Curly-leaf Pondweed (*Potamogeton crispus*)

Curly-leaf pondweed is a submerged aquatic perennial that is native to Eurasia, Africa, and Australia. It was introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant and was planted in Michigan lakes as a food source for ducks. Curly-leaf pondweed has been documented throughout the U.S. In some lakes, curly-leaf pondweed coexists with native plants and does not cause significant problems; in other lakes, it becomes the dominant plant and causes significant problems (16). Dense growth can interfere with late spring and early summer recreation. Furthermore, the nature of CLP is such that is senesces during the height of the summer growing season thereby releasing nutrients that can fuel algal blooms. Phosphorus release rates from the senescence of monotypic curly-leaf beds have been reported as high as nearly 10 pounds per acre and averages about 5 pounds per acre (17) (18) (19).

The leaves of curly-leaf pondweed are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed (Figure 18). The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. Curly-leaf is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures.

Figure 18 – Curly-leaf Pondweed

Curly-leaf pondweed spreads through burr-like winter buds called turions (Figure 19). These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf one of the first nuisance aquatic plants to emerge in the spring, often starting to grow late in the fall and staying green under the ice. Growth is accelerated in spring when light and temperature conditions are best suited for growth. Turions begin to grow in June and by late June and early July, the warm water conditions cause curl-leaf to senesce, dropping turions to the sediment while the rest of the plant decays (Figure 19).

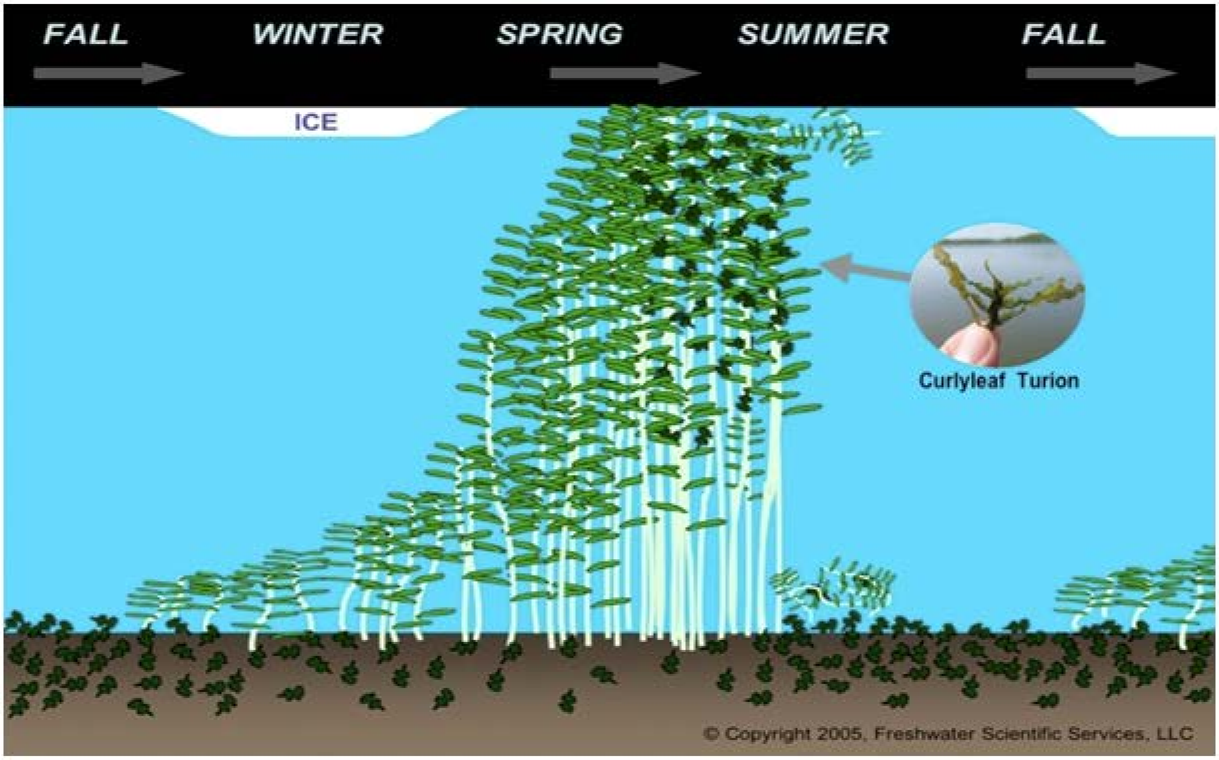


Figure 19 – Curly-leaf pondweed Life Cycle

9.2.1 Curly-leaf Pondweed in Amnicon Lake

Curly-leaf was first documented in Amnicon Lake in 2008 during an AIS survey by the Great Lakes Indian Fish and Wildlife Commission (15). The May 2012 CLP survey found that individual plants were uncommon and very widely scattered throughout the lake north and east of Tomahawk Island. However, south and west of the island CLP was relatively common and rooted in soft sediment at depths of 5-9 feet with the densest areas occurring in 6-8 feet of water. CLP was present in the rake at seven sample points or approximately 1.4% of the lake. Of these, a rake fullness value of 2 was recorded at one point and a rake fullness value of 3 was recorded at two points. This extrapolated to only 0.6% of the lake having a significant infestation. CLP was also a visual at one additional point (Figure 20) (3). During the August 2012 aquatic plant survey, the CLP was very sparse with a single plant found at each of only six points.

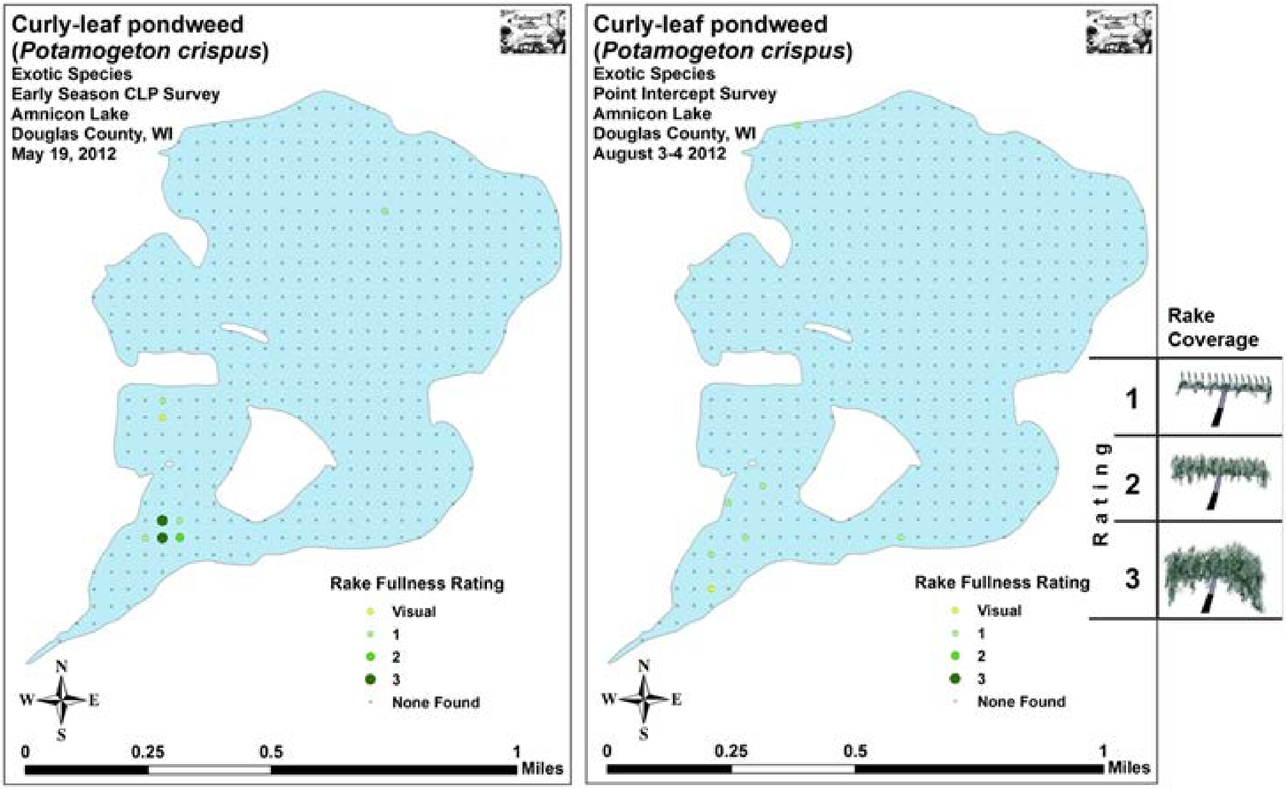


Figure 20 – Distribution of Curly-leaf Pondweed in Amnicon Lake, May and August 2012

Three beds of monotypic CLP were surveyed totaling 5.36 acres (1.4% of the lake's 360 acres), the largest of which was 4.09 acres (Bed 3) and the smallest being 0.30 acre (Bed 2) (Table 6) (Figure 21). A bed is defined as an area where CLP comprises greater than 50% of the plant biomass in the area with clearly defined borders. Each of these beds was canopied or near canopied, and plants extended to 9.5ft although most growth ended abruptly at 8.5ft forming a hard outer edge to the beds. The inner edges were more fragmented with some plants growing as shallow as 4-5ft, but the monotypic areas generally started in 6ft of water. Another potential bed occurred due south of Tomahawk Island in 5ft of water. The bottom in this area was disturbed by boat traffic, and CLP seemed to have exploited this narrow channel with most plants seized out by the roots or growing in scattered small clusters rather than in beds (3).

Table 6
Curly-leaf Pondweed Bed Summary for Amnicon Lake, May 2012

Bed Number	Acreage	Estimated Mean Rake Fullness
1	0.97	2-3
2	0.30	1-3
3	4.09	1-3
Total	**5.36**	--

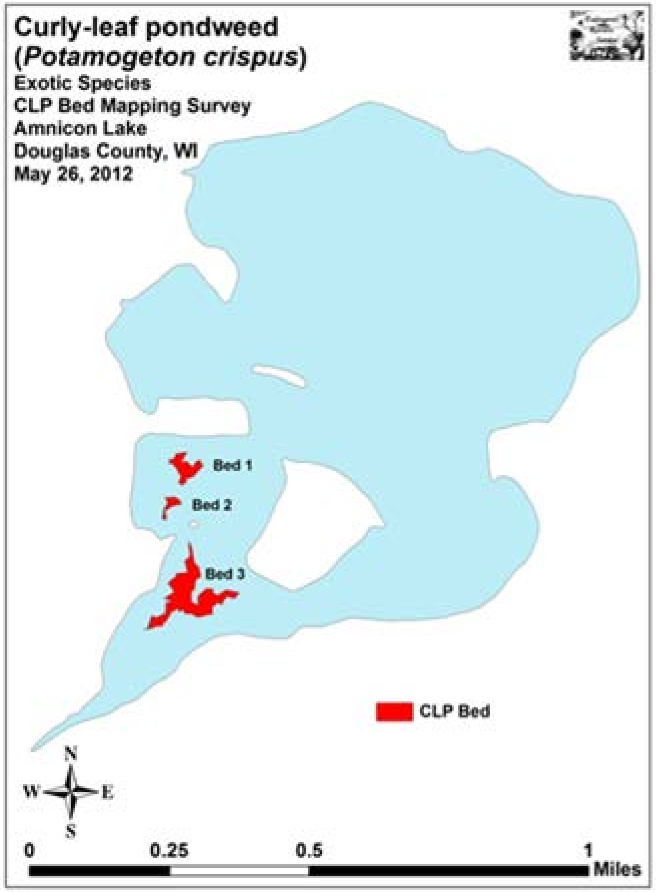


Figure 21 – Beds of Curly-leaf Pondweed in Amnicon Lake, May 2012

9.3 Purple Loosestrife (*Lythrum salicaria*)

Purple loosestrife is a perennial herb 3 to 7 feet tall with a dense bushy growth of 1 to 50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta; possess 5 to 6 petals aggregated into numerous long spikes, and bloom from July to September. It is easiest to distinguish in late July and August as it has a very distinctive flowering head. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat (Figure 22).

Figure 22 – Purple Loosestrife

The reproductive success of purple loosestrife across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America. This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions.

Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many wetlands, lakes, and rivers. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

9.3.1 Purple Loosestrife around Amnicon and Dowling Lakes

During the 2012 aquatic plant survey in Amnicon Lake, purple loosestrife was widely scattered in patches near the boat landing, by the lake outlet, and around the islands. In Dowling Lake, purple loosestrife was scattered near the boat landing, on the northeast side of the lake, and in the ditches in low areas on roads around the lake. Although this would normally be a cause for concern as loosestrife can exclude all other native plant species, every loosestrife plant showed extensive damage from Galerucella beetle (*Galerucella* spp.) herbivory (Figure 23). On Little Island in Dowling Lake, most plants were little more than sticks as they had been nearly completely defoliated by the beetles.

Figure 23 – Galerucella Beetle Herbivory on Purple Loosestrife

10.0 Non-Native Aquatic Invasive Species Threats

Introduction of new aquatic invasive species is a constant threat to lakes and rivers. The non-native species of most concern are Eurasian water-milfoil, zebra and quagga mussels, spiny water flea, giant reed grass, New Zealand mudsnails, and hydrilla. Preventing infestation is the best and least costly alternative, but if a new AIS infestation occurs, early detection is helpful for keeping the species in check. Aquatic invasive species monitoring recommended in this Aquatic Plant Management Plan and supported by the Amnicon-Dowling Lake Management District will be watching for the introduction of these and other aquatic invasive species.

10.1 Eurasian Water-milfoil (*Myriophyllum spicatum*)

Eurasian water-milfoil is a submerged aquatic plant native to Europe, Asia, and northern Africa (Figure 24). Although Eurasian water-milfoil was not found in the Amnicon and Dowling Lakes during extensive surveying in 2012, its introduction remains a concern because of its presence in other lakes such as the St. Croix Flowage, which is approximately 17 miles southeast of the lakes (2).

Figure 24 – Eurasian Watermilfoil

Eurasian water-milfoil first arrived in Wisconsin during the 1960s and is the only non-native milfoil in the state. During the 1980s it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. Eurasian water-milfoil grows best in alkaline systems with a high concentration of dissolved inorganic carbon and fertile, fine-textured, inorganic sediments. In less productive lakes Eurasian water-milfoil is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nutrient-laden runoff, and heavy-use lakes.

Unlike many other plants, Eurasian water-milfoil is not dependent on seed for reproduction. In fact, its seeds germinate poorly under natural conditions. Eurasian water-milfoil reproduces by fragmentation, allowing it to disperse over long distances by currents and inadvertently by boats, motors, and trailers. The fragments, which are produced after the plant fruits once or twice during the summer and by destruction of the plant (for example by propellers), can stay alive for weeks if kept moist.

Once established in an aquatic community, Eurasian water-milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). Stolons, lower stems, and roots persist over winter and store the carbohydrates that help the plant claim the water column early in spring. The rapid growth can form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block the sunlight needed for native plant growth often results in monotypic stands.

Monotypic stands of Eurasian water-milfoil provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways. For example, dense stands disrupt predator-prey relationships by fencing out larger fish and reduce the number of nutrient-rich native plants available for waterfowl. Dense stands of Eurasian water-milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on Eurasian water-milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". The cycling of nutrients from sediments to the water column by Eurasian water-milfoil may lead to deteriorating water quality and algae blooms in infested lakes.

Eurasian water-milfoil may or may not thrive in Amnicon and Dowling Lakes; northern water-milfoil (*Myriophyllum sibiricum*), a native macrophyte and close relative to Eurasian water-milfoil was found in Amnicon Lake, but only at one site, and was not found in Dowling Lake (3) (9). Illinois pondweed (*Potamogeton illinoensis*), a common associate of Eurasian water-milfoil, was not found in either lake (14). The well distributed, healthy native plant community in Amnicon Lake will help protect that lake from the introduction and subsequent establishment of Eurasian water-milfoil. Research has shown that the abundance of Eurasian water-milfoil in a lake is inversely related to cumulative native plant cover (20). For this reason it is important to maintain healthy and diverse native stands of vegetation (21). Dowling Lake, therefore, may be more susceptible to EWM invasion because of the low abundance of native plants.

10.2 Rusty Crayfish and Chinese Mystery Snail

Rusty crayfish are omnivores, meaning they forage on both plant and animal material. Originally from parts of the United States south of Indiana, they are larger and more aggressive than species of crayfish native to Wisconsin (Figure 25). Rusty crayfish prefer hard bottoms and tend to avoid soft sediment or mucky areas of lakes. When introduced they tend to replace native populations of crayfish, and then multiply rapidly. As omnivores they eat many things, including plant material, fish eggs, minnows, invertebrates and other crustaceans. In some lakes, they have devastated the aquatic plant community. Often, after reaching large populations, the number of rusty crayfish in the system declines rapidly. Some research suggests that this is because of a parasite infecting the crayfish. Management of this invasive species is limited, focusing on trapping or removal by residents.

Little is known about the ecological impact of Chinese mystery snails (Figure 25) and banded mystery snails, except that large die-offs are particularly offensive to the nose and impair lake aesthetics. Management is limited and basically consists of landowner removal and disposal of snails and empty shells washed up on shore.

Figure 25 – Rusty Crayfish (left) and Chinese Mystery Snail (right)

10.3 Douglas County Aquatic Invasive Species Strategic Plan

In 2009, Douglas County (DC) completed a strategic plan of action to address aquatic invasive species in the County. The DC AIS Strategic Plan identifies the following four goals for addressing AIS:

- **Goal 1: Aquatic invasive species (AIS) infestations already existing in the county are controlled or eradicated and prevented from spreading; new AIS infestations are prevented.**
- **Goal 2: Communication between lake and river residents, watershed groups, visitors, and other waterway organizations is improved and education is provided for all users.**
- **Goal 3: The county and municipalities participate in the protection of water resources and understand how critical the resource is to the county, municipalities, northern Wisconsin and the region.**
- **Goal 4: Sustainable funding for AIS research, monitoring, planning, restoration and education activities are adequately provided by private, local, county, state, federal, and tribal sources.**

Twelve objectives are identified that will enable the County to meet those goals. The objectives focus on a watercraft inspection program, volunteer and professional AIS monitoring, assistance and training for early detection and rapid response, education & communication, legislative support, support for other biological, chemical and physical monitoring, support for AIS research, modeling and identification of best management practices, LCC oversight of the AIS Strategic Plan implementation and evaluation, inter-governmental and inter-departmental cooperation and assistance, and funding sources, assistance and partnerships.

The DC AIS Strategic Plan identifies the need for AIS coordinators to implement most of the activities in the plan and begin marketing the County as an active collaborator in AIS control and prevention. The DC AIS Strategic Plan communicates to citizens, local officials, and the scientific community that it wants to work together on AIS and it provides a framework for the County to lead and assist on projects. If fully funded, the

County will hire 40 seasonal workers to monitor landings and lakes for AIS. The effort would not only protect waterways, it would create jobs in our communities and increase our understanding of the waterways that provide the county with its high quality of life.

The DC AIS Strategic Plan also identifies the need for a research specialist that could organize a team of scientists and stakeholders to direct a Douglas County Modeling, Monitoring, and Research Plan. A research planning effort would enable the County to become an active player in identifying and answering questions about the unique AIS challenges it faces. A research group would be able to stay on top of existing and emerging issues known to scientists but not known locally because of the time involved and the general lack of communication between scientific and local communities.

The DC AIS Strategic Plan should be considered a dynamic document that can adapt to a changing environment. A steering committee created under the DC Strategic AIS Plan will help direct and approve implementation and any future changes. Funding will be pursued by the County to implement the DC AIS Strategic Plan over the next 2-3 years.

The Amnicon-Dowling Lake Management District was part of the workgroup helping to develop the plan and will continue to support the efforts made by Douglas County to monitor and control the introduction and spread of AIS.

11.0 Aquatic Plant Management Alternatives

Nuisance aquatic plants can be managed a variety of ways in Wisconsin. The best management strategy will be different for each lake and depends on which nuisance species needs to be controlled, how widespread the problem is and the other plants and wildlife in the lake. In many cases, an integrated approach to aquatic plant management that utilizes a number of control methods is necessary.

Control methods for nuisance aquatic plants can be grouped into four broad categories:

- **manual and mechanical control**, which include harvesting, hand-pulling, and raking plants;
- **biological control**, which includes the use of organisms such as herbivorous insects, parasitic organisms, and planting aquatic plants;
- **physical habitat alteration**, which includes dredging, drawdown, lake bottom covers, and non-point source nutrient controls; and
- **chemical control**, which involves the use of herbicides.

Each of the above control categories are regulated by the WDNR and most activities require a permit from the State. Most control methods are regulated under Chapter NR 109 (Appendix E) except for chemical control which is regulated under Chapter NR 107. Installing lake bottom covers, which is not a commonly accepted practice, also requires a Chapter 30 permit.

Regardless of the target plant species, native or non-native, sometimes no active management of the aquatic plant community is the best option. Plant management activities can be disruptive to native plant species their ecological functions, and may open up areas for new invasive species to colonize. Other benefits of no management include no financial cost, no system disturbance, and no unintended effects of chemicals. Not managing aquatic invasive species, however, may allow small populations of a plant to become larger and more difficult to control.

The benefits and limitations of a number of management techniques are described below. Although many of the available control methods are currently not applicable for the Amnicon and Dowling Lakes, informed decision-making on aquatic plant management options requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake.

11.1 No Manipulation

No manipulation of the aquatic plant community is often the easiest, cheapest, and in some cases most effective aquatic plant management alternative, even for non-native invasive species like curly-leaf pondweed. Not actively managing aquatic plants in the Amnicon and Dowling Lakes is recommended in areas where excess aquatic plant growth does not impact lake uses, where the benefit of management is far out-weighed by the cost of management, where water quality or other lake characteristics limit nuisance growth conditions, and where highly valued native plants or habitat would be negatively impacted (for example, areas with Wild Rice in Amnicon Lake).

11.2 Manual and Mechanical Controls

Except for wild rice, manual removal of aquatic plants by means of a hand-held rake or by pulling the plants from the lake bottom by hand is allowed within a 30-foot-wide corridor along a 100-foot length of shoreline without a permit, provided the plant material is removed from the Lake (Figure 26). Plant fragments can be composted or added directly to a garden.

Although up to 30 feet of shoreland vegetation can be removed, removal should only be done to the extent necessary. Clearing large swaths of aquatic plants not only disrupts lake habits, it also creates open areas for non-native species to establish. If an aquatic invasive species such as curly-leaf pondweed is the target species, then removal by this means is unrestricted as long as native plants are not damaged or eliminated.

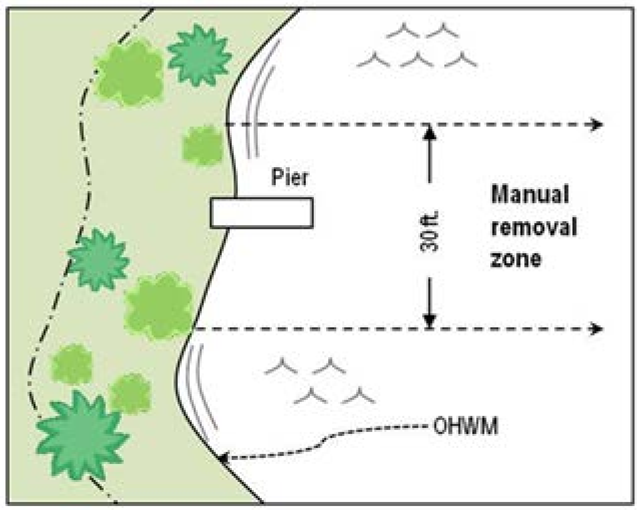


Figure 26 – Aquatic Vegetation Manual Removal Zone

Manual removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. Manual removal is most effective in shallow, hard bottom areas of a lake. Pulling aquatic invasive species while snorkeling or scuba diving in deeper water can be done without a permit and can be effective at slowing the spread of a new aquatic invasive species infestation within a lake when done properly. When harvesting curly-leaf pondweed it is important that all material is removed as free-floating curly-leaf fragments can remain viable and produce turions for up to two weeks.

11.2.1 Large-scale Manual Removal

Hand-pulling or diver removal is typically used when an aquatic invasive species exists as single plants or isolated beds, as in new infestations. Large-scale hand or diver removal projects have successfully reduced or controlled established aquatic invasive species populations (22). One such effort which involved the removal of Eurasian water-milfoil using diver hand harvesting of the entire littoral zone of the lake at least twice each summer for three years followed by three years of maintenance management successfully reduced the overall distribution of Eurasian water-milfoil in the lake from 16% of the littoral zone to 3%. Overall costs ranged from a high of $796 per hectare of Eurasian water-milfoil removed during the three years of intensive management effort, to about $300 per hectare during the three year maintenance period (22).

Several local lake groups have and continue to use large-scale manual removal to manage Eurasian water-milfoil. Horseshoe Lake in Barron County uses diver removal on small or isolated areas of Eurasian water-milfoil, and uses chemical herbicides on larger, more expansive sites. Early in the management phase, Sand Lake in Barron County participated in diver removal, but stopped using divers when the Eurasian water-milfoil expanded too rapidly for the divers to keep up. For several years the St Croix Flowage in Douglas County attempted to control the spread of Eurasian water-milfoil by diver removal. While successful in the first couple of years, the use of small-scale herbicide application has been added to the control regime.

In 2011, the Red Cedar Lakes Association performed diver removal on a dense, isolated one acre bed of curly-leaf pondweed in Red Cedar Lake. This large-scale effort was conducted by a group of local high school students (members of the Conservation Club) and a Red Cedar Lake Association representative. Water depths and inexperience made removal difficult; however, the effort was fairly successful and the divers were able to remove a large boat load of curly-leaf pondweed. In 2012 during early summer curly-leaf bed mapping, a determination was made on whether a bed could be hand harvested based experience from the previous year. In mid-summer, volunteers re-visited sites and removed on average 83% of the curly-leaf in 14 different beds.

11.2.2 Mechanical Control

Mechanical control methods use motorized accessories to assist in vegetation removal. Mechanical control can be used for both small- and large-scale control efforts and require WDNR permits regardless of the size of the area to be managed. As with manual control, plant fragments must be removed from the water to the extent practical.

The most common form of mechanical control is the use of large-scale mechanical harvesters on the lake. The harvesters are generally driven by modified paddle wheels and include a cutter that can be raised and lowered to different depths, a conveyor system to capture and store the cuttings, and the ability to off-load the cuttings. Harvesters operate a depths ranging from skimming the surface to remove floating plant fragments to as much as five feet deep.

Harvesters can remove thousands of pounds of vegetation in a relatively short period of time. By removing the plant biomass, harvesting also removes nutrients form a lake. Everything in the path of the harvester will be removed including the target species, other plants, macro-invertebrates, semi-aquatic vertebrates, forage fishes, young-of-the-year fishes, and even adult game fish found in the littoral zone (23). An advantage of mechanical aquatic plant harvesting is that the harvester typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments (24). Large-scale plant harvesting in a lake is similar to mowing the lawn. Plants are cut at a designated depth, but the root of the plant is often not disturbed. Plant composition can be modified by cutting away dense cover which may increase sunlight penetration enough to stimulate growth of underlying species (Figure 27) (24). Cut plants will usually grow back after time, just like the lawn grass. Re-cutting during the growing season is often required to provide adequate annual control (25). Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (25). Some research indicates that after cutting, reduction in available plant cover causes declines in fish growth and zooplankton densities. Other research finds that creating deep lake channels by harvesting increases the growth rates of some age classes of bluegill and largemouth bass (26).

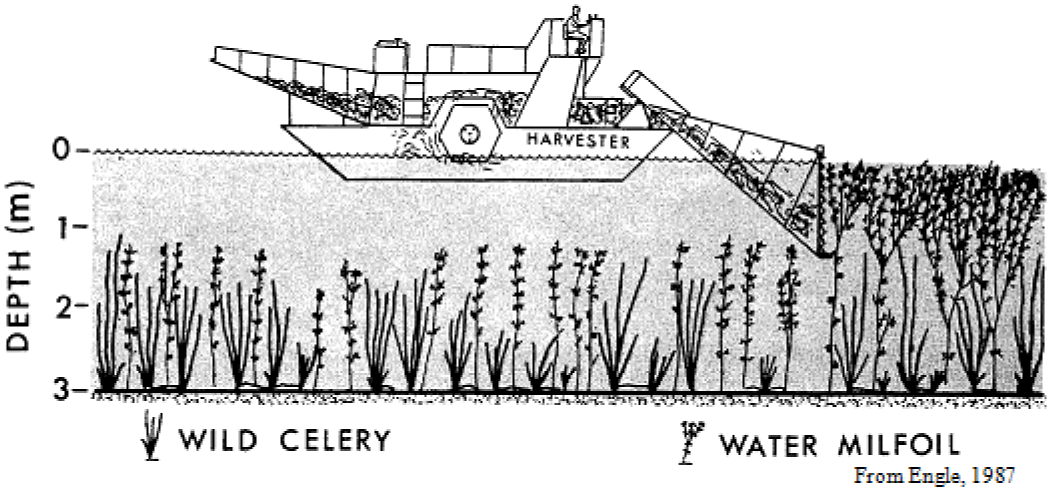


Figure 27 – Harvesting Surface Foliage to Maintain Habitat and Simulate Basal Plant Growth

Recent cost per acre for contracting harvesting services average $410 per acre whereas costs for purchasing, operating, and maintaining a harvester average $567 per acre (27). In general, the cost of harvesting decreased with increasing total acreage harvested, from about $500 per acre at 40 acre sites to about $250 per acre at 160 acre sites (27). The Rice Lake Protection and Rehabilitation District in Barron County, Wisconsin owns and operates three harvesters at a cost of approximately $420 per acre harvesting a total of approximately 220 acres. The costs supporting a harvesting program administered by a given lake group may be reduced by purchasing smaller or used equipment, determining a local, low cost disposal site, increasing the amount of acreage harvested, and through other cost analyses

There are a wide range of small-scale mechanical management techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with large-scale mechanical harvesting, removing the cut plants is required and often accomplished with a rake. Commercial rakes and cutters range in prices from $100 for rakes and cutters that can be thrown from the shore or attached to a boat to around $3000 for electric cutters with a wide range of sizes and capacities.

One of the best ways for riparian property owners to gain navigation relief near their docks is to actively use their watercraft to create open channels. Although not truly considered mechanical management, plant disruption by normal boat traffic is a legal method of management. Most macrophytes do not grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat in circles to clear large areas is not only potentially illegal, but it can also re-suspend sediments, clear paths for aquatic invasive species growth and cause ecological disruptions.

11.2.3 Suction Dredging

Suction dredging is a form of mechanical harvesting where diver-operated suction tubes connected to barge- or pontoon-mounted pumps and strainer devices are used to vacuum plants uprooted by hand. This management technique is considered harvesting and not dredging because sediments are not removed from the system. Suction dredging is mostly used for control of isolated, new infestations of aquatic invasive species.

11.2.4 Other Mechanical Management

The mechanical aquatic plant control methods described below are not recommended for use in Amnicon and Dowling Lakes because they are often extremely disruptive to aquatic ecosystems. These methods are, however, used in other states or inappropriately employed in Wisconsin and are therefore discussed.

Cutting without plant removal, grinding and returning the vegetation to the water body, and rotovating (tilling) are also methods employed to control nuisance plant growth in some lakes. Cutting is just like harvesting except the plants are left in the lake. Grinding incorporates cutting and then grinding to minimize the biomass returned to the lake. Smaller particles disperse quicker and decay more rapidly. Rotovating works up bottom sediments dislodging and destroying plant root crowns and bottom growth.

Bottom rollers and surface sweepers are devices usually attached to the end of a dock or pier and sweep through an area adjacent to the dock. Continued disruption of the bottom area causes plants to disappear and light sediments to be swept out. The use of rollers may disturb bottom dwelling organisms and spawning fish. Plant fragmentation of nuisance weeds may also occur. In soft bottom areas, sediment disturbance can be significant. These devices are generally not permitted in Wisconsin. A permit under Section 30.12(3) is required which governs the placement of structures in navigable waters.

Another common method for removing aquatic plants from a beach or dock area is for riparian owners to hook a bed spring, sickle mower blade, or other contraption to the back of a boat, lawn mower, or ATV and drag it back and forth across the bottom. This type of management is considered mechanical and is generally not permitted by the WDNR.

11.3 Biological Controls

Biological control for aquatic plant management involves using animals, fungi, insects, or pathogens as a means to control nuisance plants. The goal of bio-control is to develop a predator-prey relationship where the growth of nuisance plants is reduced, but not eliminated. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

Specific biological controls of curly-leaf pondweed are not known at this time. Ongoing research on naturalized and native herbivores and pathogens that impact nuisance aquatic and wetland plants is increasing the number of potential biological control agents that could be incorporated into invasive plant management programs (28).

The grass carp (*Ctenopharyngodon idella*), which feeds on aquatic plants and has been used as a biological tool to control nuisance aquatic plant growth in other states, is not permitted in Wisconsin. These fish can severely disrupt the aquatic ecosystem and have been known to nearly wipe out all aquatic vegetation in the lakes they inhabit.

One species of insect has proven to be extremely effective for control of purple loosestrife is the *Galerucella* beetle (*G. calmariensis* and *G. pusilla*). These beetles have been used across North America to manage purple loosestrife, including in and around Amnicon and Dowling Lakes. Use of *Galerucella* beetles for purple loosestrife management should be continued.

The milfoil weevil (*Euhrychiopsis lecontei*) is a native aquatic weevil that feeds on aquatic milfoils. Their host plant is typically northern water-milfoil, but they prefer Eurasian water-milfoil when it is available. Utilizing the milfoil weevil for Eurasian water-milfoil control has resulted in variable levels of control, with little control achieved on lakes with extensive motorized boat traffic. EnviroScience, Inc has taken a patent on rearing and distributing the milfoil weevil. They have successfully introduced weevils to more than 100 lakes in the United States and Canada in the last ten years. Costs for the EnviroScience program run about $1.50 per weevil purchased, but includes the costs of mapping, stocking, and monitoring of effects. Researchers in Wisconsin have been developing a protocol for layperson rearing of the milfoil weevil. This process involves setting up large tanks with Eurasian water-milfoil and purchasing starter weevils from EnviroScience. With proper care and management, it is anticipated that this rearing method may be able to produce a 10 to 100 fold increase in weevils to be released into an affected area.

Plant fungi and pathogens are currently still in the research phase. Certain species for control of hydrilla and Eurasian water-milfoil have shown promise, but only laboratory tests in aquariums and small ponds have been conducted. Methods are not available for widespread application. Whether these agents will be successful in flowing waters or large-scale applications remains to be tested (24).

Selectively planting native aquatic plants to encourage or stimulate growth of desired plant species is another form of biological control. Introducing native plants is uncommon as it is often difficult and costly and requires a fairly large source of new plants and substantial short-term labor for collecting, planting, and maintaining the stock. Maintenance of plantings may require protection from fish and birds and temporary stabilization and protection of sediment in the planting area from wind and waves. Allowing the natural re-growth of native plants in cleared areas can prevent curly-leaf and other non-native invasive plant species from establishing in those sites.

11.4 Physical Habitat Alteration

Reducing nutrient loading from the watershed (for example, reducing fertilizer use or controlling construction erosion) provides fewer nutrients available for plant growth. Runoff from development in the near-shore area and from other parts of the watershed can increase the amount of phosphorus available for plant and algae growth. The limited light penetration due to increased algae in the water will be beneficial for plants adapted to low light conditions, such as curly-leaf pondweed. Higher nutrient concentrations also favor other non-native plants such as Eurasian water-milfoil and native plants, such as coontail, that tend to be nuisance.

Research has shown that as shoreline development increases, the amount of aquatic plant growth near that lake shore decreases. In a Minnesota study of 44 lakes with varying amounts of developed shoreline, the average loss of aquatic plants in developed areas was 66% (30). On a lake wide basis, this loss of aquatic plant growth can lead to higher levels of phosphorus and an increase in the growth of algae, including filamentous algae that may attach to structures within the littoral zone or form surface mats. Reducing nutrient loading from the watershed (for example, reducing fertilizer use, controlling construction erosion, or shoreland restoration and buffers) is a viable option for Amnicon and Dowling Lakes.

Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, have inadequate pelagic and hypolimnetic zones, need deepening for navigation, or require removal of toxic substances. A WDNR permit is required to perform any dredging in a waterbody or wetland. This method can be detrimental to desired plants, as all macrophytes would be prevented from growing for many years. This high level of disturbance may also create favorable conditions for the invasion of other invasive species. Dredging is not recommended for aquatic plant management in Amnicon and Dowling Lakes

Benthic barriers or other bottom-covering approaches are another physical management technique that has been in use for many years. The basic idea is that the plants are covered over with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic and synthetic materials, sediments such as dredge sediment, sand, silt or clay, fly ash, and combinations of the above. WDNR approval is required and screens must be removed each fall and reinstalled in the spring to be effective over the long term.

Dropping the lake level to allow for the desiccation, aeration, and freezing of lake sediments has been shown to be an effective aquatic plant management technique. For control of certain aquatic plants, such as Eurasian water-milfoil, repeated winter drawdown lasting 4 to 6 months that include a freezing period are the most effective. Control of aquatic plants in these cases can last a number of years. The low lake levels may negatively affect native plants, provides an opportunity for adventitious species such as annuals, often reduces the recreational value of a waterbody, and can impact the fishery if spawning areas are affected. The cost of a drawdown is dependent on the outlet of the lake; if no control structure is present, pumping of the lake can be cost prohibitive whereas costs can be minimal if the lake can be lowered by opening a gate. Raising water levels to flood out aquatic plants is uncommon and has a number of negative effects including the potential for shoreland flooding, shoreland erosion, and nutrient loading.

11.5 Chemical Control

Aquatic herbicides are granules or liquid chemicals specifically formulated for use in water to kill plants or cease plant growth. Herbicides approved for aquatic use by the U.S. Environmental Protection Agency are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on herbicide use. There are a number of aquatic herbicides registered for use in Wisconsin. Factsheets for each can be found on the WDNR website at http://dnr.wi.gov/lakes/plants/factsheets/ (last accessed November 2013).

A WDNR permit is required to use chemical herbicides in aquatic environments and a certified pesticide applicator is required for application on most lakes. The WDNR requires aquatic plant surveys before and after chemical application when introducing new treatments to lakes where the treatment size is greater than 10 acres or greater than 10% of the lake littoral area and more than 150 feet from shore. The pre- and post-treatment survey protocol can be found at: http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/Appendix-D.pdf (last accessed November 2013).

The advantages of using chemical herbicides for control of aquatic plant growth are the speed, ease and convenience of application, the relatively low cost, and the ability to somewhat selectively control particular plant types with certain herbicides. Disadvantages of using chemical herbicides include possible toxicity to aquatic animals or humans, oxygen depletion after plants die and decompose which can cause fishkills, a risk of increased algal blooms as nutrients in released into the water by the decaying plants, adverse effects on desirable aquatic plants, loss of fish habitat and food sources, water use restrictions, and a need to repeat treatments due to existing seed/turion banks and plant fragments. Chemical herbicide use can also create conditions favorable for non-native aquatic invasive species to outcompete native plants (for example, areas of stressed native plants or devoid of plants).

When properly applied, the possible negative impacts of chemical herbicide use can be minimized. Early spring to early summer applications are preferred because exotic species are actively growing and many native plants are dormant, thus limiting the loss of desirable plant species; plant biomass is relatively low minimizing the impacts of deoxygenation and contribution of organic matter to the sediments; fish spawning has ceased; and recreational use is generally low limiting human contact. The concentration and amount of herbicides can be reduced because colder water temperatures enhance the herbicidal effects. Selectivity of herbicides can be increased with careful selection of application rates and seasonal timing (26). Lake hydrodynamics must also be considered; steep drop-offs, inflowing waters, lake currents and wind can dilute chemical herbicides or increase herbicide drift and off-target injury. This is an especially important consideration when using herbicides near environmentally sensitive areas or where there may be conflicts with various water users in the treatment vicinity.

Chemical herbicides are not recommended for control of curly-leaf pondweed in Amnicon Lake at this time because of the presence of wild rice.

12.0 Aquatic Plant Management Goal, Objectives, and Actions

Amnicon Lake contains an exceptionally diverse aquatic plant community. Dowling Lake has a diverse aquatic plant community, but very low density of plants and low water quality. The overall goal of aquatic plant management in Amnicon and Dowling Lakes is to protect the existing native aquatic plant resource from degradation by maximizing prevention of new invasions and through the containment and control of existing aquatic invasive species.

The objectives for this plan are to:

- **Preservation and Restoration**. Protect existing wild rice beds. Protect the native plant species community in and around the lakes to decrease susceptibility to the introduction of new aquatic invasive species and to improve water quality.
- **Prevention**. Prevent the introduction and establishment of new aquatic invasive species through early detection and rapid response.
- **Management**. Provide open water access and navigation relief to property owners impacted by dense growth aquatic vegetation. Reduce existing curly-leaf pondweed density and distribution in Amnicon Lake through containment and control. Improve water quality in Dowling Lake by protecting and enhancing native plant growth. Continue physical removal and biological control of purple loosestrife around both lakes.
- **Education and Awareness**. Continue public outreach and education programs on aquatic invasive species.
- **Research and Monitoring**. Develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.
- **Adaptive Management**. Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

12.1 Preservation and Restoration

Eighty percent of the plants and animals on the Wisconsin Endangered and Threatened Species List spend all or part of their life cycle within the near-shore zone and as many as ninety percent of the living things in lakes and rivers are found along the shallow margins and shores. Activities along a lakeshore and in the immediate shoreland area can have major impacts on overall lake quality.

Preserving and restoring native shoreland plant communities is undertaken on many lakes to reduce erosion, increase and improve native habitat, reduce shoreland runoff, improve water quality, and compliment the lake aesthetic. The restoration or re-establishment of aquatic plants in the shallow waters adjacent to the shore, which focuses on emergent plant species like rushes, sedges, pickerel weed, wild rice, and other plants that make up the wetland fringe, is less frequently completed. These species anchor sediments, fend off the invasion of non-native species, buffer against shoreland erosion, and improve fish and wildlife habitat. Allowing the re-growth of native plants in cleared areas can prevent curly-leaf pondweed and other non-native invasive plant species from establishing in those sites.

Shoreland buffers also provide non-point source nutrient control by slowing runoff and utilizing nutrients (and contaminants) before they reach the lake. Curly-leaf pondweed can grow in more turbid waters than many native plants, so improving the water clarity of Amnicon Lake helps native plants compete more effectively with curly-leaf. Improving water clarity of Dowling Lake should allow the native plant densities to increase naturally thereby decreasing the likelihood that CLP would thrive if ever introduced. As the native plant densities in Dowling Lake increase, water clarity should also improve.

To maintain or improve the lake ecosystem, the Amnicon-Dowling Lake Management District (District) will provide riparian owners with educational materials on shoreland improvement and sponsor shoreland restoration training events. Often, the main barrier preventing lake residents from implementing shoreland restoration is not knowing where to begin. General information on shoreland restoration will be provided to all members in a newsletter, on a webpage, and during public events.

Recent research has revealed that riparian property owners evaluate their own shorelines significantly more natural than biologists' evaluations (32). It is recommended that a shoreline evaluation be performed by resource professionals or trained volunteers. The information collected will provide baseline data on the status of the shoreline along Amnicon and Dowling Lakes and will allow for focused education and outreach efforts.

The District should further encourage riparian property owners to diversify the shoreland environment by recognizing riparian owners who implement shoreland restoration and habitat improvement projects. Recognition can be in a number of ways, for example, by displaying a special sign on the shoreline or posting a notice on the webpage.

The District may also want to consider establishing "Slow, No Wake" buoys near the wild rice beds to prevent them from being uprooted during their vulnerable floating-leaf stage. If navigation channels are established through the thick submergent vegetation, buoys could also serve to mark these channels for boaters. Annual monitoring of wild rice beds in August will help determine whether wild rice density and distribution are increasing.

12.2 Prevention

Early detection and rapid response efforts increase the likelihood that a new aquatic invasive species will be addressed successfully while the population is still localized and levels are not beyond that which can be contained and eradicated. Once an aquatic invasive species becomes widely established in a lake, all that might be possible is the partial control of negative impacts. The costs of early detection and rapid response efforts are typically far less than those of long-term invasive species management programs.

The District will continue to implement and further develop a proactive and consistent aquatic invasive species monitoring program that includes both casual observers and trained monitors. At least three times during the open water season, trained volunteers will patrol the shoreline and littoral zone looking for curly-leaf pondweed, Eurasian water-milfoil, purple loosestrife, Chinese mystery snails, zebra mussels, and other invasive species..

Monitoring will be completed as a part of the UW-Extension Lakes/WDNR Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring Program. Training is available through the Wisconsin Citizen Lake Monitoring Network (different from Clean Boat Clean Waters monitoring) and the WDNR provides an excellent guide for monitoring called *Aquatic Invasive Species, A Guide for Proactive & Reactive Management* which can be found online at http://dnr.wi.gov/Aid/documents/AIS/AISguide06.pdf (last accessed November, 2013). Volunteers can select AIS of interest; learn when, how and where to monitor; and find out how to report a new find. Many new Eurasian water-milfoil and other invasive species finds have been from volunteers who know their lake. All monitoring data will be recorded annually and submitted to the WDNR SWIMS database.

Property owners will be encouraged to monitor their shoreline and open water areas for new growths of aquatic invasive species. These casual observers can undergo more simplified training than the trained monitors via meeting presentations or from more technically trained monitors. If a suspect aquatic invasive species is found, it will be reported to the District, County, and the WDNR. Note: the contacts found in the Rapid Response Plan (Appendix F) pertain to all aquatic invasive species.

Aquatic invasive species can be transported via a number of vectors, but most invasions are associated with human activity. Monitoring of the boat launches on Amnicon and Dowling Lakes by paid and volunteer inspectors will continue following WDNR/UW-Extension Clean Boats, Clean Waters guidelines. All watercraft inspection data collected should be submitted to the WDNR SWIMS database. The District will participate in the Fourth of July Landing Blitz, an outreach effort to warn boaters of the dangers of transporting invasive species that takes place on the Fourth of July, a high-boat traffic day. The District will also continue to maintain and update signage at the boat launches as necessary.

Preventing the introduction of invasive species is the first line of defense against invasions, but even the best prevention efforts may not stop all invasive species introductions. A Eurasian Water-milfoil Rapid Response Plan has been created for the Amnicon and Dowling Lakes and in included as Appendix F of this plan. The Rapid Response Plan contains information on what to do if a potential aquatic invasive species is found including contacts for authoritative verification and what should be done if a positive identification is made.

The ADLMD will continue to support the efforts made by Douglas County to monitor and control the spread of AIS in the county.

12.3 Management

Aquatic plant management in Amnicon Lake will follow an integrated management approach that relies on a combination of methods and techniques. Manual, mechanical, and biological control methods are included. Chemical herbicides are not recommended for use in Amnicon Lake due to the close proximity of northern wild rice to possible management areas. Aquatic plant management in Dowling will focus on maintaining or enhancing the existing native plant community and implementing shoreland management actions that will improve water quality.

Native plant removal on both lakes should be limited to the amount needed to access open water areas. Coarse woody habitat (tree falls, logs, etc.) should be left in the water. Coarse woody habitat is a critical feature of lakes influencing fish behavior, spawning, predator-prey interactions, growth, and species diversity. Research has shown that the growth of largemouth bass and bluegill are positively correlated with coarse woody habitat in lakes and a whole lake removal of coarse woody habitat led to the collapse of a yellow perch population (33).

Manual harvesting will be done to control both nuisance native and non-native plant growth around docks, in navigation channels, and in beds of curly-leaf pondweed. Manual removal of aquatic plants may be completed at any time following the guidelines and regulations set forth in NR 109, which can be found in Appendix E. Mechanical harvesting will be implemented in areas where dense aquatic plant growth (CLP or native plants) impedes navigation and/or property owner access to open water and cannot reasonably be controlled by physical removal. Larger scale harvesting of CLP beds will be completed once the ADLMD has obtained their own aquatic plant harvesting equipment or contracted harvesting services. Physical removal of CLP will not be limited, and the goal of harvesting is to reduce the size of existing CLP beds by at least 50%.

12.3.1 Shoreland Management Practices to Protect Water Quality

Management practices that protect water quality should be implemented by property owners. For example, property owners should avoid mowing down to the lakeshore and reduce grass clippings runoff, fertilizer applications, pet waste, ash from fire pits, and other sources of nutrients near the lakeshore. Improved water quality is important for promoting a healthier native aquatic plant community, especially in Dowling Lake. Property owners on both lakes should also be encouraged to have regular septic system inspections to protect water quality.

12.3.2 Curly-leaf Pondweed

The goal of CLP management is to reduce the distribution and density of CLP in Amnicon Lake by at least 50% based on levels found during the May 2012 curly-leaf pondweed survey. Curly-leaf pondweed was first officially documented in Amnicon Lake in 2008. The May 2012 CLP survey found that individual plants were uncommon and very widely scattered throughout the lake north and east of Tomahawk Island. However, south and west of the island CLP was relatively common. Three beds of monotypic CLP were surveyed totaling 5.36 acres (1.4% of the lake’s 360 acres). Another potential bed occurred due south of Tomahawk Island in 5ft of water.

Physical (manual) and mechanical controls are recommended for CLP management. Chemical control (herbicide) is not recommended because the largest areas of curly-leaf pondweed are established near beds of wild rice, which could be negatively impacted byteh use of chemical herbicides.

12.3.2.1 Physical Removal

The densest CLP growth in Amnicon Lake is found in 6-8 feet of water, an area not generally supportive of abundant native aquatic vegetation. In waters less than 5 feet, the sparse occurrence of CLP north and east of Tomahawk Island and near docks should be manually harvested (hand, rake, or diver removed) from the lake and monitored for expansion into monotypic beds. Physical removal of CLP will not be restricted. In both lakes, pioneer populations of CLP less than 0.25 acres with a rake fullness rating of 3 should also be manually controlled. The District will coordinate physical removal education and larger scale removal efforts, either by assigning these responsibilities to a committee or by forming a new committee. Members of the District will be taught to remove individual plants and small clusters of curly-leaf in shallow, easily accessible areas of the lakes. Instructional materials and training will be provided to aid riparian owners in the identification and removal of curly-leaf. The District will also sponsor an annual Curly-leaf Removal Day in early to mid-summer during which volunteers will employ a vigorous removal program.

12.3.2.2 Mechanical Harvesting

Mechanical harvesting is recommended for long term management of CLP in 5-9 feet of water southwest of Tomahawk Island near the outlet. Specifically, mechanical harvesting is recommended for curly-leaf beds 1, 2, and 3 in Amnicon Lake (Figure 21). These areas of dense CLP growth prevent native plants from establishing early in the season. Later in the season, when CLP dies back it increases the amount of organic material building up in the sediment in this already fertile area of the lake. Removal of CLP in these areas may increase the amount of desirable vegetation in an area that currently does not support abundant native aquatic vegetation in the summer due to water clarity issues.

Harvesting of CLP will occur before it begins setting turions (generally prior to June 15th) and only in areas where wild rice is not present. No mechanical harvesting will occur in water <3-ft deep and cutting depth cannot exceed 2/3 of the water depth. All harvested areas will be pre-determined. One spring harvesting of CLP is recommended, although this cutting may take place over several days or weeks. Harvested material will be disposed of away from the lake. CLP harvesting will be based on prior year monitoring and mapping in an area identified in the annual aquatic plant harvesting permit application required by the WDNR (Appendix H).

12.3.2.3 CLP Bed Mapping and Density

The ADLMD will hire a resource professional to complete bed mapping and density monitoring in Amnicon Lake annually to account for management success and to identify areas that are candidates for future control activities. Monitoring should be completed in mid-June when curly-leaf is near its peak growth before senescence. Density will be measured using rake sampling following current WDNR aquatic plant monitoring guidelines (e.g., the 0 to 3 rake fullness density measurement). New growth areas and beds with a rake density rating of 3 will be priority control areas. A bed is defined as an area where CLP comprises greater than 50% of the plant biomass in the area with clearly defined borders.

12.3.3 Native Plant Management

Management of native aquatic plants should only be implemented when plant density reaches nuisance levels, or impedes property owner access to open water. Physical removal will be implemented by individual property owners following guidelines in NR109, and mechanical harvesting to maintain navigation and open water access channels will be implemented by the

ADLMD. Navigation and open water access channels will be identified and approved by the WDNR through a mechanical harvesting permit completed annually by the ADLMD.

12.3.3.1 Physical Removal

Manual or physical removal is the most appropriate management method to control aquatic plant growth around docks and in areas where the water depth is shallower than 3 feet. To aide in physical removal of aquatic plants in small, shallow areas adjacent to shore, at least one plant removal rake and/or razor will be purchased by the ADLMD and made available for property owners to use. As mentioned in a previous section, physical removal of aquatic plants is allowable without a permit within an area up to 30 feet wide near a dock or along a shoreline used for recreational activities, provided the parts of the plant cut or pulled are removed completely from the water and disposed of properly. By its very nature, physical removal is often a difficult and daunting task, thus minimizing how much plant material is actually removed. Native plant removal will be limited only to the amount needed to access open water areas or provide navigation and access lanes.

12.3.3.2 Mechanical Harvesting

In deeper water and in larger areas where relief from nuisance aquatic plant growth for navigation purposes is needed, a harvesting plan will be created annually and will be included in the aquatic plant harvesting permit application required by the WDNR. Harvesting plans will be designed to enhance both the ecological balance and recreational uses of the lake by establishing common use navigation channels and individual riparian access lanes. A common use navigation channel is a common navigation route for the general lake user. It is off shore and connects areas that boaters commonly would navigate to or across, and is for public benefit. An individual riparian access lane is an access lane to shore that normally is used by an individual riparian shore owner. Navigation channels will be limited to 40-ft wide and individual riparian access lanes will be limited to 20-ft wide and both must be in water at a depth of 3-ft or greater. Once harvested, these areas should be kept open through regular use of watercraft. If the navigation channels or access lanes fill in again, they can be re-cut under the same harvesting permit that allowed their initial cutting.

Mechanical harvesting of aquatic plants can only be completed in water 3-ft or greater in depth. Harvesting in waters shallower than this can greatly disturb bottom sediments causing them to be re-suspended in the water column decreasing water quality. Bottom dwelling biota critical to the health of the lake can also be negatively impacted. Damage to the harvester may also occur. In waters at or deeper than 3-ft, aquatic plants can be cut to two-thirds of the water column or to the maximum depth of the harvester, whichever is less. At off-loading sites, the operator will attempt to return game fish, turtles, and other wildlife back to the water.

It is recommended that GPS units capable of tracking the movements of the harvester be installed on or, at a minimum, carried with the operator whenever harvesting is occurring and must be turned on. At the end of each day, a tracking log should be downloaded from the GPS unit and stored in digital form either on a computer or data disk. Regardless of GPS tracking, daily log sheets that include the following harvesting information: estimated total daily tonnage, number of loads, surface acres covered, plant ID list, percentage of each plant species removed, and plant bed density information, will be kept of all harvesting actions.

Clear-cutting of aquatic vegetation adjacent to riparian shoreline for the purpose of creating weed free areas for swimming or other recreational purposes is not an acceptable use of the mechanical harvester and is not recommended action in this plan. Landowners, however, are not prohibited from physically removing aquatic vegetation in these areas and will be encouraged to do so provided guidelines presented in NR 109 are followed.

The harvesting plan will be assessed annually to determine if changes should be made. Areas designated for harvesting in a given year, can be repeatedly harvested as needed in that year to maintain their function without the need for additional WDNR permitting or fees. An example harvesting plan for the first year of active management is included in Appendix I. Changes in the harvesting plan can be requested by property owners, and will be evaluated on an individual case basis as they come up. Larger changes in the harvesting plan may be necessary due to variability in water levels, changes in lake use patterns, or with the introduction of a new aquatic invasive species.

12.3.3.3 Acquisition of the Mechanical Harvester

It is recommended that the ADLMD purchase and operate their own small aquatic plant harvester, as this would give them the greatest flexibility in managing aquatic vegetation in the lake. A new harvester able to cut a 4-6 foot swath of vegetation has an expected price range of $45,000 to $65,000 depending on the type, construction, and features. Several companies in WI build small harvesters specifically for the type of aquatic plant management being recommended in this APM Plan. The Recreational Boating Facilities grant program supported by the WDNR can be used to help offset up to 50% of the costs of purchasing an aquatic plant harvester. There is no official grant deadline for application, but it should be done early in the year as it typically takes 6-9 months for the approval process.

In the interim, or as an alternative to purchase of a large-scale mechanical harvester, the ADLMD could purchase a smaller, boat mounted aquatic plant cutter to start harvesting in 2014. The cost of a device of this nature is in the $3,000 - $5,000 range. Use of a bow mounted cutter also requires removal of cut vegetation from the water. A bow mounted cutter would not remove this material, so arrangements would need to be made to have other watercraft following the cutter, using rakes and nets to remove the material that is cut.

Contracted harvesting is a viable option, with costs per acre averaging between $400 and $700. Contracted harvesting has several issues. Availability of contracted services is limited, with only a small handful of companies offering such services. Transportation of the equipment, keeping it clean so as not to infest a new lake with cuttings from a previous water body, arranging for off-loading and transportation of harvested materials, licensing requirements from state to state, and timing are all critical issues that must be addressed. Owning and operating a harvester also has issues including maintenance, storage, and possibly transportation. Insurance coverage may be necessary. Finding, training, and paying an operator will be necessary. Initial investments to purchase the equipment can be expensive, but it can be expected that the machinery used will be functional for a decade or more if properly maintained.

Unloading, hauling, and disposal of harvested aquatic vegetation adds to the cost of a harvesting program, particularly if additional equipment like a conveyor system and/or trailer are needed to move harvested material around, and if additional transport is needed to dispose of harvested material. The ADLMD will identify an off-loading site and a dumping site for harvested plant material.

Based on harvesting reports from Rice Lake in Barron County (Trigg, 2011 & 12), opening and maintaining 60 acres of navigation channels in Rice Lake from July – September produced about 5 tons of wet plant biomass per acre. Almost 95% of aquatic plant biomass when first harvested is water. It is expected that 4-8 acres of dense growth CLP and navigation and access corridors will be harvested annually from Amnicon Lake, producing 20-40 tons of wet plant biomass annually. Once draining and drying has occurred only 1-2 tons of plant material will remain.

12.3.4 Purple Loosestrife

Purple loosestrife control will be continued to prevent it from becoming monotypic stands along the shoreline and in adjacent wetlands. Success will be measured by keeping this plant at levels equal to or below current levels. Appropriate management alternatives for purple loosestrife control include hand-pulling and digging and biological control (*Galerucella* beetles). Monitoring Amnicon and Dowling Lakes for new purple loosestrife plants will be completed by volunteers in July and August. The District will identify and offer training and support materials to the volunteers. Physical removal will be used to control individual plants or isolated pioneering sites.

12.4 Education and Awareness

Providing education and outreach opportunities and materials to the lake community will improve the general knowledge base and likely increase participation in lake protection and restoration activities. To allow for greater and easier distribution, the District will condense the Executive Summary, Implementation Plan, Aquatic Plant Management Goals, Objectives and Actions, and the Rapid Response Plan (Appendix F) and any other portions of this report deemed necessary into a summary report available to the membership.

The Amnicon-Dowling Lake Management District will continue to cultivate a lake community that is aware of aquatic invasive species and has enough knowledge to aid in detection, planning, and implementation of management alternatives. The District should also foster a greater understanding and appreciation of the entire aquatic ecosystem and the important role plants, animals and people play in that system.

It is important for the lake community and lake users to know how their activities impact the aquatic plants and water quality of the lakes. The District will distribute educational materials and provide educational opportunities on aquatic invasive species and other factors that impact Amnicon and Dowling Lakes. At least one annual activity (Lake Fair, public workshop, guest speakers, etc.) will be sponsored and promoted by the District that focuses on aquatic invasive species. Maintaining signs and continuing active inspections of watercraft at public launches will educate boaters about what they can do to prevent the spread of aquatic invasive species. Results of water quality monitoring should be shared with the lake community at the annual meeting or another event to promote a greater understanding of the lake ecosystem which may increase participation in planning and management.

The District will also provide education and informational materials related to wildlife and wildlife monitoring programs during public events, in newsletters, on the webpage, and during public meetings. Volunteers are currently participating in the Loon Watch program sponsored by the Sigurd Olson Institute. Other programs sponsored by the Citizen-based Monitoring Network of Wisconsin (http://wiatri.net/cbm/) will be promoted by the District and member participation encouraged. The District will help make arrangements for training opportunities for these and other wildlife monitoring and appreciation events.

12.5 Research and Monitoring

The purpose of this recommendation is to develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.

12.5.1 Water Quality

Volunteers will continue to participate in the Citizen Lake Monitoring Network (CLMN) Water Quality Monitoring Program. Water clarity (Secchi), temperature, total phosphorus, and chlorophyll-*a* should be completed at monitoring station 163120 (Deep Hole) in Amnicon Lake and station 163091 (Deep Hole) in Dowling Lake. Since Amnicon is a *Long Term Trend Lake*, the WDNR may already conduct phosphorus and chlorophyll-*a* monitoring at station 163120, so efforts need not be duplicated. This level of monitoring will continue so long as no major aquatic plant management activities or changes to the watershed (for example, large scale development) occur. If large-scale management (≥10 acres) of CLP or any other aquatic plant species is completed in either lake, the water quality monitoring efforts will be re-evaluated and potentially expanded.

12.5.1.1 Dissolved Oxygen

The District will evaluate the purchase of a digital dissolved oxygen meter to support their water quality monitoring efforts. Grant funding is available from the WDNR to offset the cost of a water quality meter. Monthly temperature and dissolved oxygen profiles (readings taken at intervals of 3 feet or less from the lake surface to very near the bottom) should be taken at the Deep Hole sites in each lake for at least one year. Determining if stratification occurs in each lake, at what depths, and at what levels will provide valuable information for determining internal nutrient loading and identifying fishery habitat conditions.

Continuing to collect temperature and dissolved oxygen profiles can be used to identify the factors leading to changes to water quality such as aquatic plant management activities, changes in the watershed land use, and the response of the lakes to environmental changes. The background information and trends provided by these data can prove invaluable for comprehensive lake management planning.

12.5.2 Water Quantity

Water quantity monitoring will also be completed. This information can be used for comprehensive planning when determining hydrologic and nutrient budgets. Long-term lake level monitoring can provide information on how much water levels vary in a normal year (or longer time period) which can in turn be used to identify processes that drive lake hydrology and identify processes behind anomalies so management or adaptation can begin. Lake levels can be recorded by reading a staff gauge that is installed on a permanent structure in the lake or placed in reference to a permanent and unchanging structure on the shore. To facilitate daily readings, the staff gauge should be installed at the property of a volunteer who is a permanent resident on the lake.

12.5.3 Comprehensive Lake Management Planning

To further understand those factors affecting the Amnicon and Dowling Lakes and where to focus lake protection and management efforts, the District will develop a Comprehensive Lake Management Plan within the next five years. Comprehensive Lake Management Plans typically address five key components: water quality, aquatic plants, fisheries, the watershed, and public involvement. A Comprehensive Plan will help the District work towards long-term lake goals such as sustained water quality, a better understanding of the complex lake ecosystem, and increased lake protection.

12.6 Adaptive Management

This Aquatic Plant Management Plan is a working document guiding management actions on Amnicon and Dowling Lakes over the next five years (2017-2021). This plan will follow an adaptive management approach by evaluating results and adjusting actions on the basis of what has been learned. This plan is therefore a living document, successively evolving and improving to meet environmental, social, and economic goals, to increase scientific knowledge, and to reduce tensions among stakeholders. Annual and end of project assessment reports are necessary to monitor progress and justify changes to the management strategy. Project reporting will meet the requirements of all stakeholders, gain proper approval, allow for timely reimbursement of expenses, and provide the appropriate data for continued management success. Success will be measured by the efficiency and ease in which these actions are completed

The District will compile, analyze, and summarize management operations, public education efforts, and other pertinent data into an annual report each year. The information will be presented to members of the District, Douglas County and the WDNR and made available in hardcopy and digital format on a website that has yet to be developed by the District. These reports will serve as a vehicle to propose future management recommendations and will therefore be completed prior to implementing following year management actions (approximately March 31st annually). At the end of this five year project, all management efforts (including successes and failures) and related activities will be summarized in a report to be used for revising the Aquatic Plant Management Plan.

Whole-lake point intercept aquatic plant surveys will be completed at three- to five-year intervals after management implementation begins to determine the impacts of management activities on both target and non-target aquatic plants.

13.0 Implementation Plan and Funding Sources

Appendix G is an Implementation Matrix to accompany the actions included in this APM Plan. The matrix lists the actions associated with each management objective included in this plan. It indicates in what year or years an action is to take place; who is to complete the action; and what possible funding source there may be for the action. Funding for all eligible management activities including but not limited to shoreline restoration training, AIS monitoring and control, and education and outreach programs will be sought through the WDNR Lake Grant program. Funding for other activities such as maintaining a webpage and developing the newsletter will be generated through lake district funds, donations, and volunteer efforts. Funding for a mechanical harvester will be sought through the WDNR Recreational Boating Facilities Grant.

14.0 Works Cited

1. **Berg, M.S.** *Curly-leaf pondweed Density and Bed Mapping, and Warme Water Point Intercept Macrophyte Surveys: Amnicon Lake - Douglas County, WI (WBIC: 2858100). 124 pp.* 2012a.
2. **Smart, R.M., et al., et al.** *Establishing Native Submersed Aquatic Plant Communities in Southern Reservoirs. Technical Report A-96-2.* Visckburg, MS : U.S. Army Engineer Waterways Experiment Station.
3. *Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications.* **Nichols, SA.** 1999, Journal of Lake and Reservoir Management, Vol. 15 (2), pp. 133-141.
4. **Barr Engineering.** *Spider Chain of Lakes Macrophyte Survey and Management Recommendations.* 2001. p. 105. LPL-667.
5. **Berg, M.** *Curly-leaf Pondweed Density and Bed Mapping, and Warm Water Point Intercept Macrophyte Surveys: Spider Lake, Clear Lake, North Lake, Fawn Lake – Sawyer County, WI.* 2012.
6. **Wisconsin Department of Natural Resources.** *Fisheries Information Sheet, Spider Lake, Sawyer County*. 2008.
7. —. *Surface Water Integrated Monitoring System.* [http://prodoasjava.dnr.wi.gov/swims/login.jsp]
8. —. Lake Pages. [Online] [Cited: September 29, 2012.] http://dnr.wi.gov/lakes/lakepages/.
9. **Thwaits, B.F.** *Watercraft Insepction and Vistor Use on the Spider Chain of Lakes, Sawyer County, Wisconsin: End of Season Report.*
10. **Kalf, J.** *Limnology - Inland Water Ecosystems.* New Jersey : Prentice Hall, 2002.
11. **Shaw, B., Mechenich, C. and Klessig, L.** *Understanding Lake Data.* Madison WI : University of Wisconsin—Extension, 2004.
12. **McComas, S.** *Curlyleaf Pondweed: Another Exotic Aquatic Plant in Minnesota.* Brainerd, MN : Minnesota Lakes Association, 2000.
13. **Roesler, C.** *Evaluation of Curly-leaf pondweed phosphorus content in Big Chetac Lake. Unpublished data.* Hayward, WI : Wisconsin Department of Natural Resources, 2003.
14. *Predicting Invasion Success of Eurasian Water-milfoil.* **Madsen, J.D.** 1998, Journal of Aquatic Plant Management, Vol. 36, pp. 28-32.
15. **Scholl, C.** *Aquatic Invasive Species: A Guide for Proactive and Reactive Management.* s.l. : Wisconsin Department of Natural Resources. Project No. ASPL-001-04, 2006.
16. *Fish Populations Dynamics in a Northern Wisconsin Lake Following a Whole-Lake Addition of Coarse Woody Habitat.* **Sass, G., et al., et al.** 2012. North American Lake Management Society 32nd Annual Symposium Program: Lakes in the Landscape. pp. 61-62.
17. *Cost and Effectiveness of Hand-harvesting Eurasian Water-milfoil in Upper Saranc Lake NY.* **Kelting, D.L. and Laxson, C.L.** Journal of Aquatic Plant Management, Vol. 48, pp. 1-5.
18. *Vertebrates Removed by Mechanical Weed Harvesting in Lake Keesus Wisconsin.* **Booms, T.** 1999, Journal of Aquatic Plant Management, Vol. 37, pp. 34-36.
19. *Concepts in lake management: restructuring littoral zones.* **Engle, S.** Madison WI : Wisconsin Department of Natural Resources, March 1987, Research Management Findings , Vol. 2.
20. *Advantages and Disadvantages of Aquatic Plant Management Techniques.* **Madsen, J.** 2000, Lakeline, Vol. 20(1), pp. 22-34.
21. **Wilson, K. and Carpenter, S.** Making the Weed Line Work for Your Lake. *Wisconsin Natural Resources Magazine.* April 1997.
22. **Johnson, J.A.** *Analysis of Aquatic Plant Harvesting Cost: Owned vs. Contracted.* Maple Grove MN : Freshwater Scientific Services, LLC, 2009. p. 3.
23. **James, W.F., et al., et al.** *Contribution of Potamogeton crispus Decay to the Phosphorus Budget of McGinnis Lake, Wisconsin. APCRP-EA-15.* Vicksburg, MS : U.S. Army Engineer Research and Development Center, 2007.
24. **Freedman, Jan, et al., et al.** *Potential Use of Native and Naturalized Insect Herbivores and Fungal Pathogens of Aquatic and Wetland Plants. , Vicksburg, Mississippi.* Vicksburg, Mississippi : Army Corp ERDC Environmental Laboratory, 2007.

25. **Crowell, W.** *Curly Pondweed: New Management Ideas for an Old Problem Exotic Species Program.* s.l. : Minnesota Department of Natural Resources, UNDATED.
26. **Greenfield, B., et al., et al.** *Aquatic Pesticide Monitoring Program - Review of Alternative Aquatic Pest Control Methods for California Waters.* Oakland CA : San Francisco Estuary Institute, 2004. p. 109.
27. *Consequences Of Human Lakeshore Development on Emergent and Floating-Leaf Vegetation Abundance.* **Radomski, P. and Goeman, T.J.** 2001, North American Journal of Fisheries Management, Vol. 21, pp. 46-61.
28. **Scholl, C.** *Aquatic Invasive Species: A Guide for Proactive and Reactive Management.* s.l. : Wisconsin Department of Natural Resources, 2006. Project No. ASP-001-04.
29. *The Challenge of Self-enhancement Bias for Educational Programs Designed to Encourage Natural Shorelines.* **Amato, M.S., Shaw, B.R. and Haack, J.** 3, s.l. : Lake and Reservoir Management, 2012, Vol. 28, pp. 206-211.
30. **Skogerboe, J.G. and Netherland, M.D.** *Evaluation of the June 2009 Aquatic Herbicide Treatments on Gray's Bay and Phelps Bay, Lake Minnetonks, Minnesota.* s.l. : U.S. Army Engineer Research and Development Center, 2009.

Appendix A

Northern Region Aquatic Plant Management Strategy

Appendix B

Public Input Record

Appendix C

WDNR Paleocore Report

Appendix D

2006-07 WDNR Fishery Report for Amnicon Lake

Appendix E

NR 109

Appendix F

AIS Rapid Response Plan

Appendix G

Implementation and Funding Matrix

Appendix H

WDNR Aquatic Plant Harvesting Permit Application

Appendix I

Sample CLP and Navigation and Access Lanes Harvest Plan