lake. A good method to minimize impacts from manicured lawns is to construct a buffer strip near the shoreline.

The most important and sensitive areas of both lakes in the near shore environment are the preferred spawning areas for walleye and for muskellunge. Since these are the most important areas to protect, care should be taken to minimize the amount of runoff entering these spawning areas, since excess sediment (silt and clay), nutrients and other contaminants (such as oil from the roads) can have an adverse effect on these areas. This is especially true for walleye spawning areas, since the preferred spawning habitat for walleyes are sand and rocky bottoms, which would be most effected by the addition of silt and clay. See section 7 for the discussion and the location of the spawning areas of both lakes.

3.2 Water Budget

The water budget for a lake is the volume of water entering a lake minus the volume of water leaving the lake, with the difference being the change in volume of water stored in the lake (can be seen as the lake level decreasing or increasing in a set period of time). In the last 25 years the lake levels in both lakes has remained approximately the same.

Water enters lakes as precipitation, surface water inflow (including inflow from a connected up-stream lake) and ground water inflow. Water leaves both lakes through evaporation and surface water outflow (including that to a connected downstream lake or river). Both lakes water budget was estimated, and are summarized below.

3.2.1 Amnicon Lake

The sources of water into Amnicon Lake are groundwater, surface water runoff, the inlet from Dowling Lake, the net of precipitation minus evaporation, the three small inlets and several intermittent feeder streams. All of the water leaves Amnicon Lake via the outlet to the Amnicon River at the southwest end of the lake.

In the "Amnicon & Dowling Lakes Feasibility Study Results; Management Alternatives", WDNR, 1981 (1981 WDNR Report) it stated that the inlet from Dowling Lake, the streams into Amnicon Lake and the outlet from Amnicon Lake (to Amnicon River) were gauged or measured from October 1978 through September 1979. It stated that this time period was a near normal water year. Therefore we will use their gauging estimates for this project. We will also utilize the Wisconsin Lake Modeling Suite (WiLMS) to calculate the annual hydraulic loading, which is the amount of water entering the lake and the nutrient loading (which will be discussed in Section 3.3). From this information we estimate the hydraulic loading (how much water enters the lake in one year) into Amnicon Lake at 7,147 acre-feet. The specific volumes are broken down below, along with the percentage of total volume:

- Combined ground water/surface water = 2,964 acre-feet (41% of total)

- Dowling lake inlet = 2,400 acre-feet (34% of total)
- Three permanent steams/intermittent streams = 1,600 acre-feet (22% of the total)
- Net of precipitation-evaporation = 183 acre-feet (3% of total)

The gauged amount of water leaving Amnicon Lake via the outlet was 6,900 acre-feet. The difference between the numbers (7,147 acre-feet and 6,900 acre-feet) is probably a combination of water leaking around and under the outlet culvert, the change in storage and measuring errors. The lake volume of Amnicon Lake is 4,120 acre-feet and 6,900 acre-feet of water leaves through the outlet to the Amnicon River every year. Therefore the residence time or exchange time of the lake is 7 months, meaning every 7 months an entire lake volume leaves through this outlet.

3.2.2 Dowling Lake

The sources of water into Dowling Lake are groundwater, surface water runoff, the net of precipitation minus evaporation and at least five small seasonal inlets. All of the water leaves Dowling through the Dowling Lake Outlet to Amnicon Lake. Again using gauged values for the 1981 WDNR Report and WiLMS, we calculated the annual hydraulic loading into Dowling Lake as 2,493 acre-feet. The specific volumes are broken down below, along with the percentage of total volume:

- Combined groundwater/surface water = 1,576 acre feet (63% of total volume)
- Five or so small seasonal inlets = 850 acre-feet (34% of total volume)
- Net of precipitation-evaporation = 67 acre-feet (3%)

The gauged amount of water leaving Dowling Lake via the outlet to Amnicon Lake was 2,400 acre-feet, which is very close to our calculated volume. The lake volume of Dowling Lake 1,113 acre-feet and 2,400 acre-feet of water leaves through the outlet every year. Therefore the residence time or exchange time of Dowling Lake is 5 ½ months, meaning every 5 ½ months an entire lake volume leaves through the outlet.

3.3 Nutrient Budget

Phosphorus and nitrogen are essential for plant growth and are the nutrients that usually limit algal growth in Midwestern lakes. High nutrient concentrations can cause high algal population (blooms) and can, therefore, be the cause of eutrophication (that is, accelerated aging and increased productivity) of lakes. Phosphorus concentrations greater than about 20 ug/L or parts per billion (ppb) generally indicate eutrophic conditions.

All lakes receive nutrients from a variety of sources. The challenge is to minimize the amount of phosphorus and nitrogen inputs to both lakes in order to minimize algae blooms. Based on the numerous studies performed on these lakes as well as other lakes in

Northern Wisconsin and Northern Minnesota, it is unlikely that nitrogen is the limiting nutrient to algal growth. It is most likely that phosphorus is the nutrient limiting algal growth, so phosphorus is the nutrient to focus on and manage for when considering management efforts to improve water quality. Below is a summary of the estimated phosphorus loading into both lakes, based on WiLMS modeling.

3.3.1 Amnicon Lake

The most likely total phosphorus loading into Amnicon Lake is 449 kg per year, based on WiLMS modeling. The largest source is from the Dowling outlet, at 109.5 kg/year. The next two largest sources of phosphorus are the streams/intermittent stream and septic tank loading, both at approximately 73 kg/year. See the two graphics in Appendix 1 for a summary of the loading total sources.

3.3.2 Dowling Lake

The most likely total phosphorus loading into Dowling Lake is 155.4 kg/year, based on the WiLMS modeling. The largest sources are the streams/intermittent streams into the lake, at 45 kg/year. The next two largest sources of phosphorus are from septic tanks and from the forested part of the drainage area both approximately 26 kg/year. See the two graphics in Appendix 2 for a summary of the loading totals and sources.

3.3.3 Internal Loading

Phosphorus that is deposited in the lake sediments is not permanently removed from the lakes and may be released back to the water column. The rate of phosphorus release from sediments is greatly increased when the sediment-water interface becomes anoxic.

Internal loading means the amount of phosphorus of the total phosphorus load that derives from the lake sediments. There are many factors that influence internal loading, including how stratified or mixed the lake is, and the thickness of anoxic water near the water/sediment interface. Five sediment samples were collected from Dowling and five from Amnicon (10 total) in June of 2003. Among the parameters analyzed was total phosphorus. The average total phosphorus in Dowling was 663ppm and the average total phosphorus in Amnicon was 574ppm. However, based on several studies performed, there is no confirmed correlation or connection between TP in sediments to trophic status.

We input values into the WiLMS Model to ascertain the estimated gross internal loading. Based on this work, we estimate 65 kg of the 155.4 kg of annual phosphorus in Dowling or 42% is due to internal loading. Similarly, we estimate 20 kg of the 449 kg of annual phosphorus in Amnicon, or 4.5%, is due to internal loading.

The internal loading value for Amnicon is in the low to normal range, but the internal loading estimate for Dowling (42% of the total loading) is extremely high.

3.4 Shoreland Inventory

The shoreland inventory looked at three areas; upland fringe, the shoreland and shallow water area by the shore. A photographic inventory of Amnicon and Dowling lakes was conducted. The objectives of the survey were to characterize existing shoreland conditions which will serve as a benchmark for future comparisons.

Each photograph had the shoreline and upland condition observed. The grading criteria was based on the presence of natural vegetation in the understory and natural vegetation along the shoreland. The levels that were looked at were 50% and 75% of natural vegetation currently growing. See Appendix 3 for pictures of the entire shoreline of both Amnicon and Dowling Lakes, taken July 13, 2004.

Table 1 below shows the results of the study. The criteria would be considered subjective, but follows protocols which are commonly used to create shoreland inventories. It shows that each lake has under half of the lots with greater than 50% natural shoreland and natural upland cover. See Appendix 4 for tables summarizing all data for the shoreland inventories of Amnicon and Dowling Lakes.

Table 1. Summary of Upland and Shoreland conditions on Amnicon and Dowling Lakes.

Lake Name	**Natural Upland Condition**		**Natural Shoreland Condition**		**Total Lots Observed**	**Undevel Lots**	**Shoreland Structure**	
	>50%	**>75%**	**>50%**	**>75%**			**riprap**	**Wall**
Amnicon	**91**	**78**	**93**	**83**	**208**	53	**13**	**15**
	44%	38%	45%	40%		25%	6%	7%
Dowling	**45**	**25**	**48**	**31**	**98**	11	**6**	**3**
	46%	26%	49%	32%		11%	6%	3%

The more natural shoreland and natural upland vegetation there is, the lower the impact the lot on the lake. Below in Figure 3, you can see two graphics from the Wisconsin DNR. They depict the older cabins from when the northern lakes were first being developed versus the developments of today, which are year round homes with manicured and landscaped lawns. The combination added impervious area, along with the added vegetation and fertilizer contribute greatly to nutrient loading in Lakes.

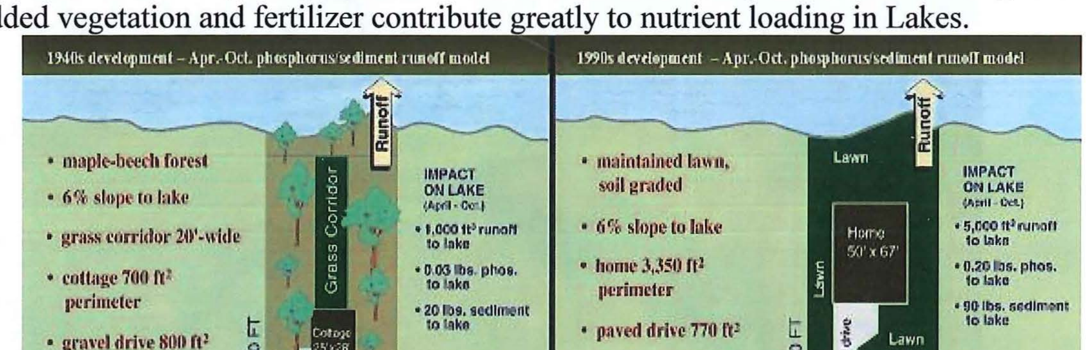


Figure 3

The above photograph represents a lot with both 50% natural Upland vegetation and 50% natural shoreland vegetation. The photo below shows a site that does not meet either of the criteria.

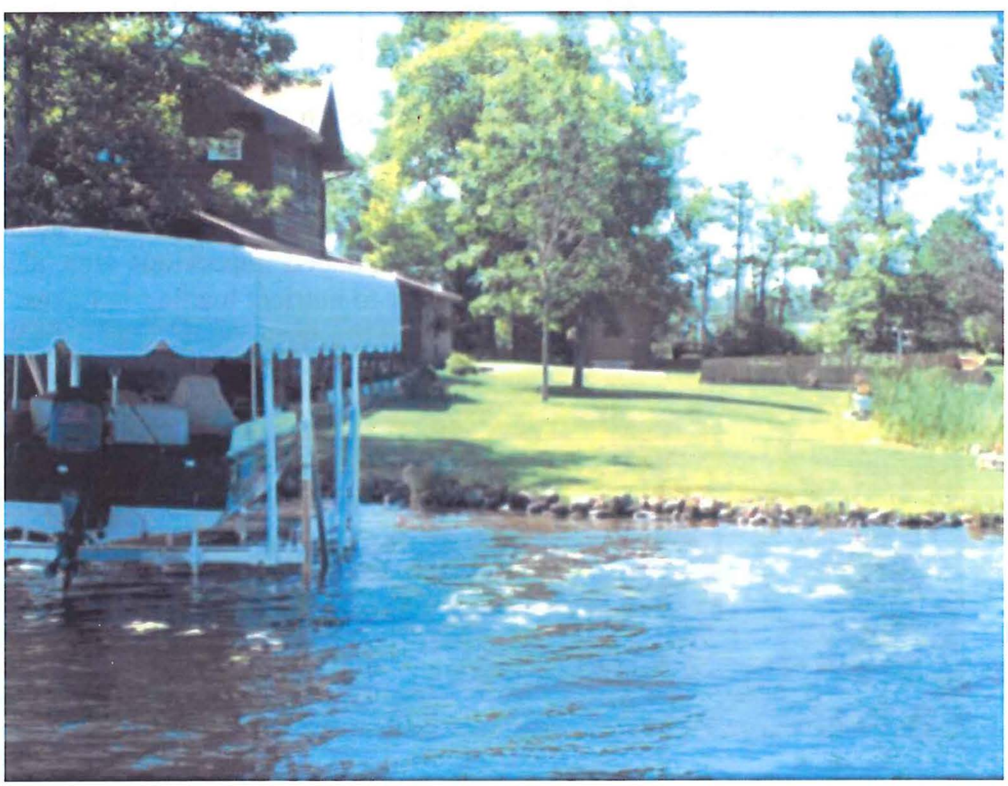


Table 2

Lake	County, State	Upland	Shoreline	Undev	Total Properties
Amnicon	Douglas, WI	44%	45%	25%	208
Dowling	Douglas, WI	46%	49%	11%	98
Round Lake	Polk, WI	27%	39%	14%	74
Big Bear Lake	Burnette, WI	82%	86%	13%	87
Upper Turtle Lake	Barron, WI	72%	76%	28%	309
Nancy Lake	Washburn, WI	77%	80%	19%	217
Bear Lake	Villas, WI	93%	84%	6%	115
East Rush	Chisago, MN	43%	43%	9%	192
Comfort	Chisago, MN	62%	50%	0%	100
Orchard	Dakota, MN	47%	53%	4%	109
Weaver	Hennepin, MN	47%	44%	5%	111

*Highlighted lakes above are lakes near or in urban areas of the Twin Cities.

Amnicon and Dowling lakes are both comparative to lakes near urban areas such as the lakes near the first tier suburbs in the Twin Cities area. Looking at several lakes in northern Wisconsin it is seen that a large portion of the lakes have about the same amount of development percentage wise, but more of these structures are probably older cabins or the owners have chosen a more natural look, with more native cover. The lakes selected to compare have roughly the same number of lots as Amnicon and Dowling.

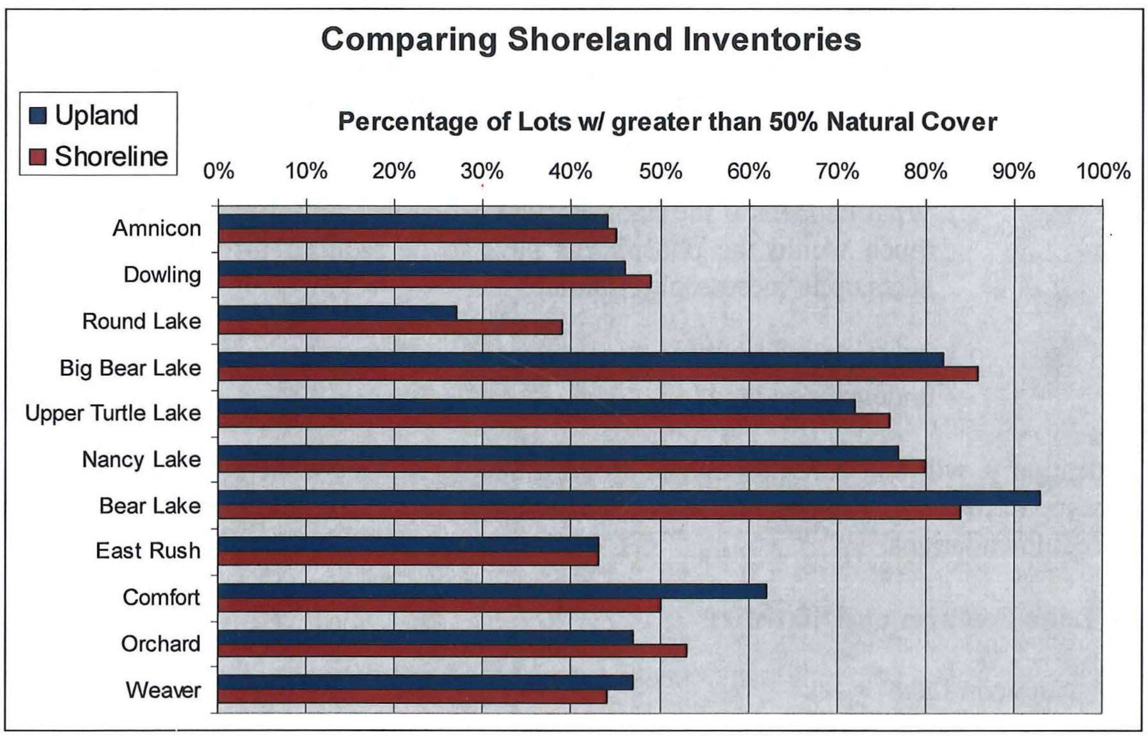


Figure 4

3.5 Ground Water and Onsite Treatment Systems

Septic Systems are generally not designed to remove nutrients. Once the soil retention capacity of the soil is exceeded for phosphorus, septic systems can and often do discharge high concentrations of phosphorus to the ground water. However, as discussed in Section 3.3, the estimated phosphorus load contributions of septic tanks and related onsite treatment systems, is only 16% to 17% of the total load. These percentages are on the high side of the normal range, but not the leading culprit in phosphorus loading to the lakes. For details on how we arrived at our estimates for septic tank loading, see Appendix 5.

3.6 Watershed Synopsis

The watershed area that drains to Amnicon Lake is dominated by wilderness areas composed of forests and wetlands which encompass 73% of the watershed. Similarly, the watershed area that drains to Dowling Lake is dominated by forests and wetlands with over 92% of the watershed coming from forests and wetlands.

Concerns have been raised about the water quality coming into both lakes. As will be discussed in detail in Section 4.3, results of water testing indicate the water coming into Amnicon is typical for the region, with the largest source of nutrients into Amnicon coming from the Dowling outlet. The results of water testing for Dowling indicate the water coming into the lake are on the high side of normal for the region, with the largest source of nutrients into the lake coming from the permanent and intermittent streams.

As previously stated, Amnicon is slightly mesotrophic to eutrophic and Dowling is considered eutrophic. Knowing that most of the watershed is undeveloped forests and wetlands, the following questions come to mind:

1.) What happens if the phosphorus loading to both lakes is reduced and how much would the phosphorus have to be reduced in order to bring both lakes up to mesotrophic status?

2.) How could this be accomplished, knowing that most of the watershed is undeveloped land?

Question 1, will be addressed in section 5.2 Loading Reduction Feasibility Analysis and question 2, will be addressed in section 5.2 and in section 7, Lake Management Ideas and Recommendations.

4. Lake Features and Statistics

4.1 Amnicon Lake

Amnicon Lake is a 426 acre stained drainage lake located in West Central Douglas County. The lake is relatively shallow with an average depth of 9.9 feet and a maximum depth of 31 feet. There are three state owned islands within the lake basin. The measured watershed is 2,615 acres which includes the 154 acres of Dowling Lake. Surface drainage consists of three inlets, two small intermittent streams from adjacent wetlands and the permanent inlet from Dowling Lake. Amnicon Lake is the headwaters of the Amnicon River, which drains into Lake Superior. As previously discussed, approximately three quarters of the watershed drainage into Amnicon is from forests and poorly drained wetlands.

4.2 Dowling Lake

Dowling Lake is a 154 acre drainage lake located upstream from Amnicon Lake. Dowling Lake is a shallow lake with an average depth of 7.2 feet and a maximum depth of 13 feet. There is one state owned island within the lake basin. The measured watershed is 1,391 acres. Surface drainage consists of at least 5 small seasonal inlets from small depressional poorly drained wetlands. Dowling Lake drains into Amnicon Lake from an outlet on the northwest side of the lake.

4.3 Lake Water Quality Summary

Water quality is described by a set of measurements or indicators of measurable physical, chemical, and biological factors. The factors that were looked at were Dissolved Oxygen (DO), Temperature, water clarity (as measured with a Secchi Disk), Total Phosphorous, and Chlorophyll a. See Appendix 6 for maps showing sampling locations and the field data sheets for the sampling performed in 2003 and 2004.

4.3.1 Dissolved Oxygen and Temperature

The growing season (May through September) DO and Temperature profiles for both Amnicon and Dowling Lakes for 2003 and 2004 are shown in the following sections. By examining the profiles, we can learn a great deal about the lake. The main thing that can be determined from the profiles during the growing season is whether or not the lakes are thermally stratified or mixed.

Dissolved oxygen is the amount of oxygen available for aquatic life to use in the water. Without oxygen, or with limited oxygen, aquatic organisms may have difficulty surviving. Lack of oxygen is a major cause of fish kills. Amnicon and Dowling are classified as weak dimictic to polymictic lakes, which means during the growing season months and winter, lakes will slightly stratify, however they also easily resist stratifying in summer and instead continually mix.

Thermally stratified means that the water column is segregated into discrete layers of water based on their temperature. The water near the surface that is warmed by the sun is less dense that the cooler water below it and “floats” forming a layer called the epilimnion. Since this water is frequently mixed by the wind, it is usually the approximate temperature of the air and is saturated with oxygen.

Below this eplimnion layer, is a region called the metalimnion, where water temperatures quickly decrease with depth. Water in this layer is isolated from gas exchange with the atmosphere. The oxygen level in the metalimnion usually declines with depth in a manner similar to the decrease in water temperature.

Below the metalimnion is a layer of cold dense water called the hypolimnion. This layer is completely cut off from exchange with the atmosphere and light levels are very low. In a thermally stratified lake, once the lake stratifies in the summer, oxygen concentrations on the hypolimnion progressively decline due to decomposition of plant and animal matter and respiration of benthic (bottom-dwelling) organisms.

A lake that stratifies twice (throughout summer and during winter) is termed a dimictic lake. A lake that rarely stratifies or does not stratify, due to constant mixing of the lake column, is termed a polymictic lake.

Below are the graphs for Amnicon and Dowling Lakes for the 2003-2004 summers.

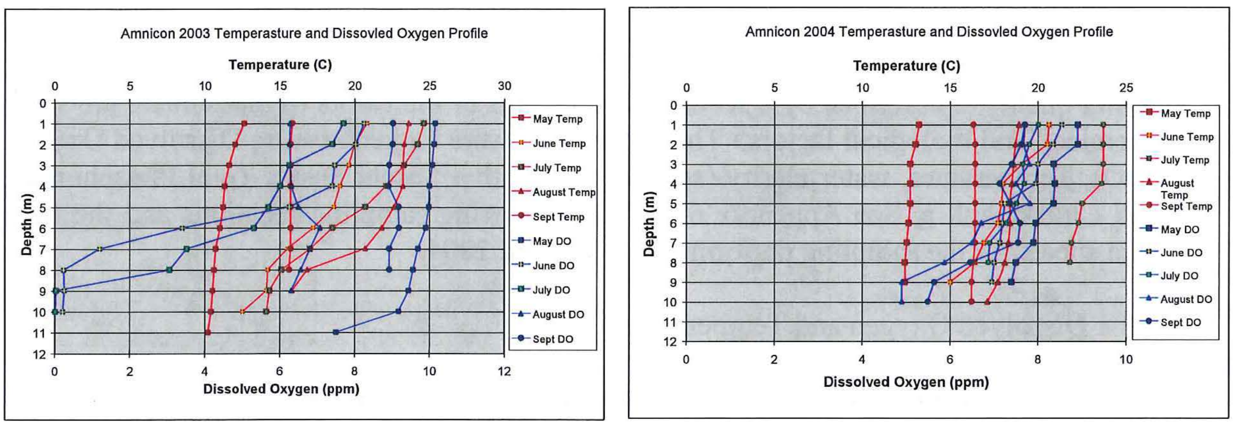


Figure 5 and 6 Amnicon Water Temp and DO 2003 and 2004

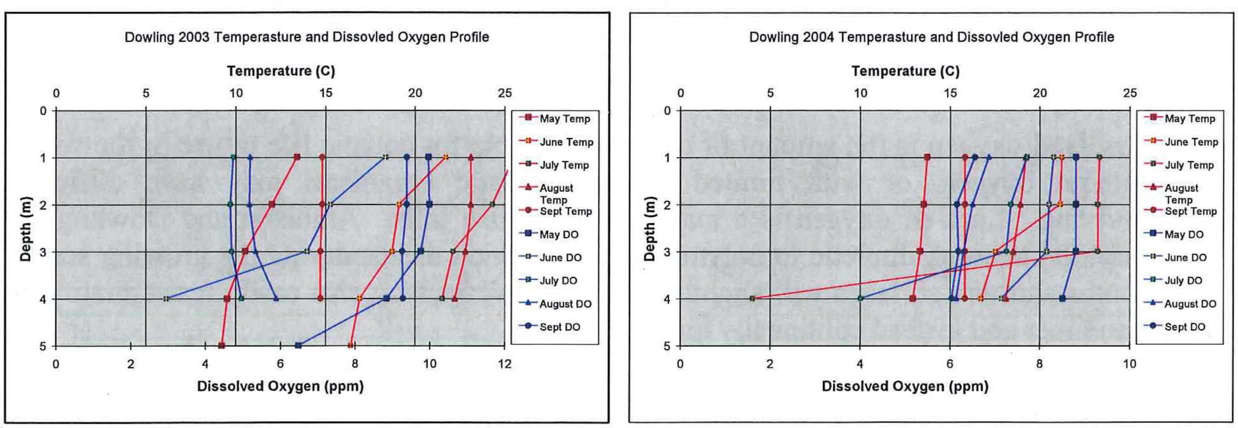


Figure 7 and 8 Dowling Water Temp and DO 2003 and 2004

4.3.2 Secchi Disc

Water clarity was measured with the use of a secchi disc. This is done by lowering the secchi disc over the side of a boat until the disc is no longer visible. Water clarity tests the amount of suspended particulate in the water as well as staining. Lakes with secchi disc readings between 6.5 and thirteen feet are said to be in the Mesotrophic range. Below are the secchi disk readings collected in 2003-2004.

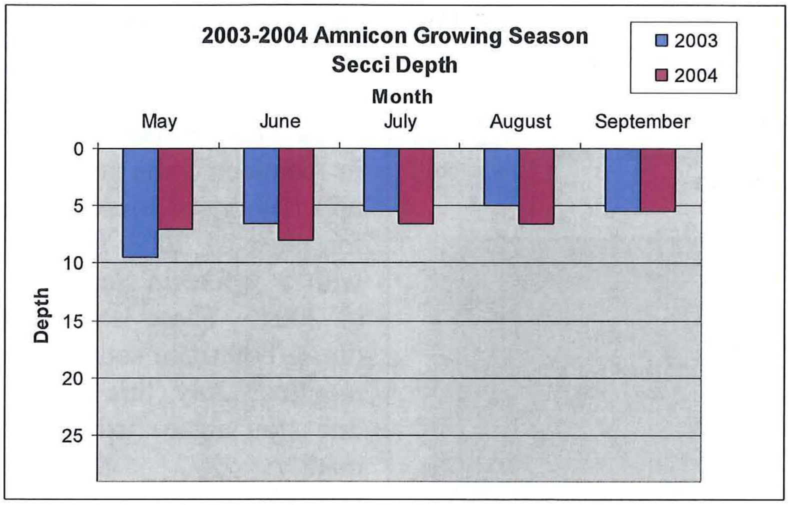


Figure 9

The general secchi disc reading for a lake to be classified as Eutrophic is 6.5 feet. The 2003 average secchi disc reading was 6.4, and the 2004 average was 6.7. The averages are on the border of being classified as Eutrophic. July through September in 2003 and September 2004 fell into the Eutrophic classification.

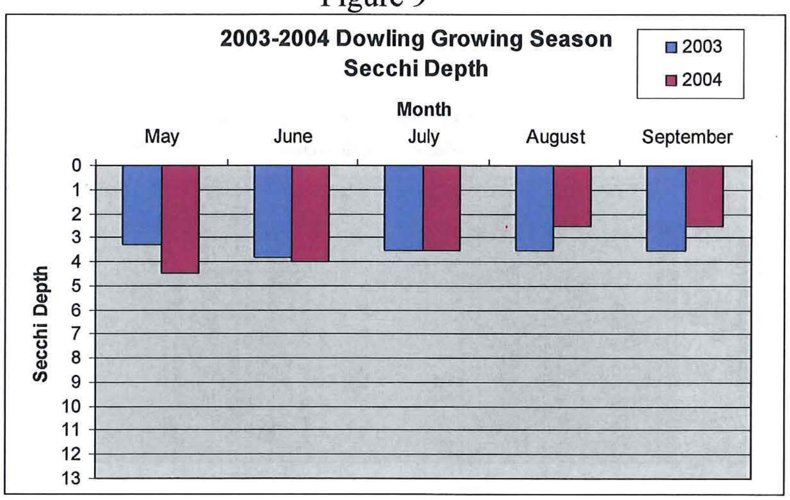


Figure 10

Dowling falls completetely within a Eutrophic classification when looking at the secchi disc readings for 2003 and 2004. In 2003 there was not much of a decline in visibility through the end of summer, but in 2004 visibility decreased in August and September.

4.3.3 Total Phosphorous

Water samples, were collected and analyzed in both lakes during the growing season in 2003 and in 2004. The samples were analyzed for total phosphorus and Chlorophyll (a). See Appendix 7 for the analytical reports.

Phosphorous is an essential nutrient for plant growth and commonly is the limiting nutrient effecting biological growth in Amnicon and Dowling Lakes. Measurements of 2003-2004 Phosphorous can be seen below. Total Phosphorous concentrations greater than 17 to 20 ppb indicate eutrophic conditions.

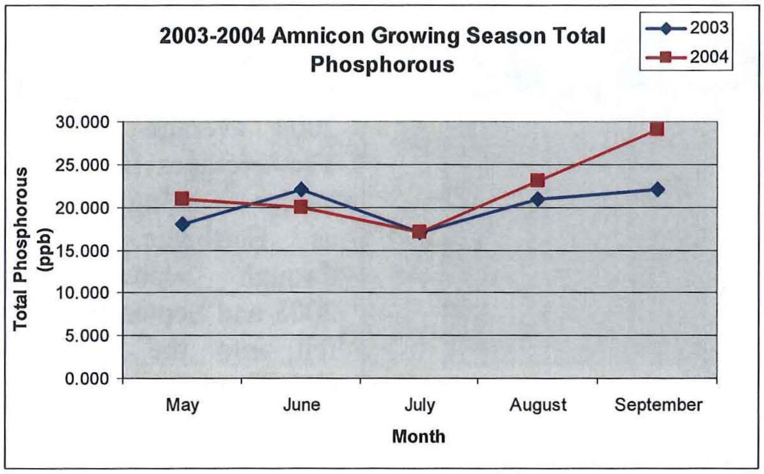


Figure 11

Total Phosphorous readings in Amnicon Lake are in the upper range of Mesotrophic for most of 2003 to 2004, with a spike in September of 2004. There is a slight dip in both data sets for the month of July, this may be due to algae using the readily available orthophosphate.

Total Phosphorous readings in Dowling Lake are in the Eutrophic range for 2003 to 2004, with a spike in August of 2004. There is a slight dip in both data sets for the month of July, this may be due to algae using the readily available orthophosphate.

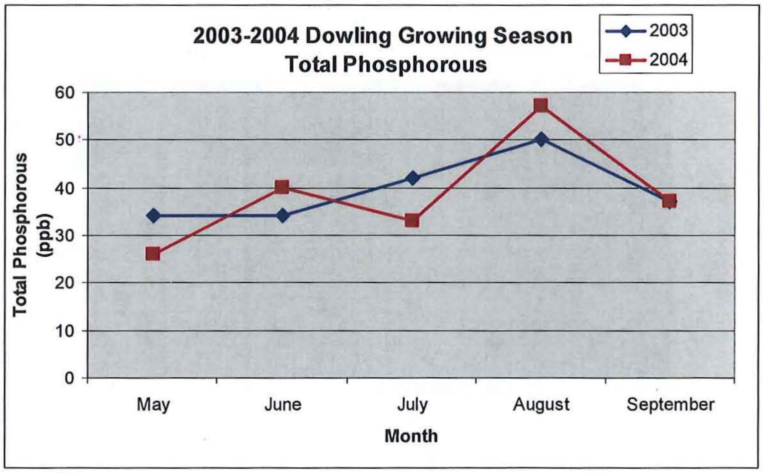


Figure 12

4.3.4 Chlorophyll a

Chlorophyll a is a photosynethic pigment that can be found in algae and other green plants. Its concentration can be used as a measurement of the amount of algae that is within a water body. Some algae is needed, but excess algae can choke out other organisms. Chlorophyll a levels greater than 7 to 10 ppb indicate eutrophic conditions.
Amnicon

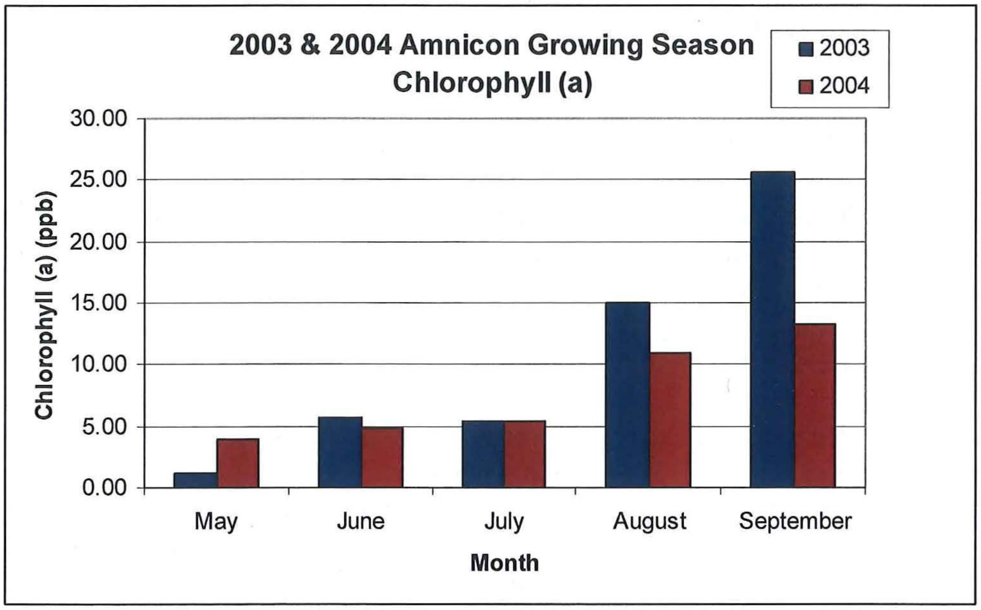


Figure 13

Chlorophyll tends to begin at lower numbers in spring, and as the growing season progresses generally is seen to rise. In lakes that have algae blooms, a spike may appear significantly higher than other samples such as in August 2004. Lakes that are Eutrophic are prone to algae blooms more frequently than Mesotrophic lakes.

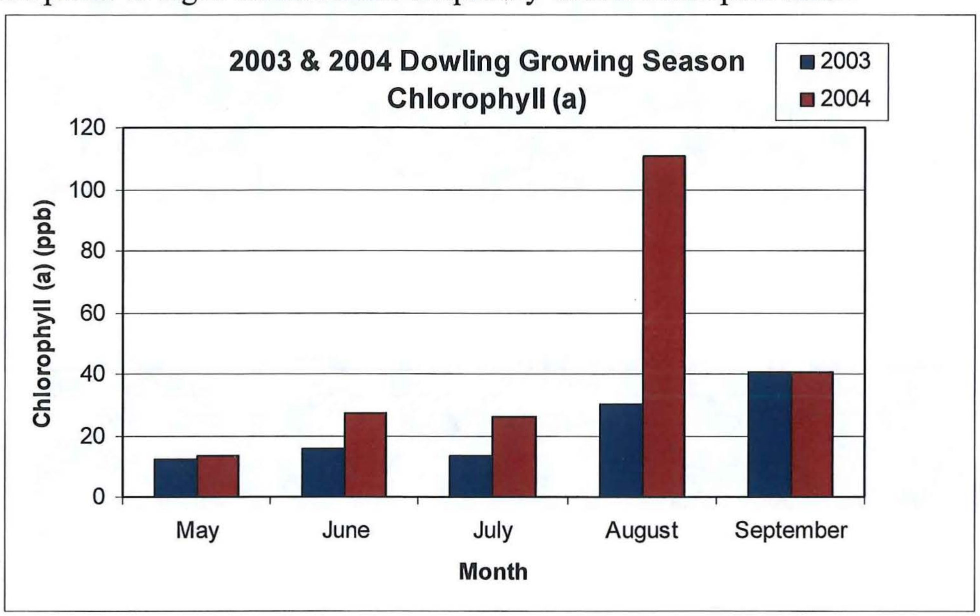


Figure 14

4.3.5 Historic Trophic State Index Summary

Water Clarity, Total Phosphorous, and Chlorophyll a have mathematical formulas that allow them to be placed on a similar scale called the Trophic State Index. This was first created by Carlson in 1977. The equations that were originally used were then modified to better suit Wisconsin Lakes, by the Wisconsin DNR. Using the equations created by the WDNR in 1993, the data collected was averaged for the entire year that data was collected. The data displayed below represents years in which three or more sampling dates were in the data set.

When looking at the assembled lake data, only years with more than three points through the five month growing season were included. This was due to the fact that if only two data points existed in the year in months such as May and September, readings would be lower and skew the results positively, and if two points existed in July and August, the data would be skewed negatively. Therefore it was decided to use years with data in three or more of the five months (May through September). See Appendix 8 for tabulated data of all previous results for this project.

Currently Amnicon Lake is clearly in the Eutrophic region to on the border between eutrophic and mesotrophic. However historical data places it in similar levels historically when recalculated using the 1993 modified equations, and has not noticeably deteriorated in over 25 years. However, the current data indicates that with cutting back on phosphorous loading, the lake may show improvement in TSI.

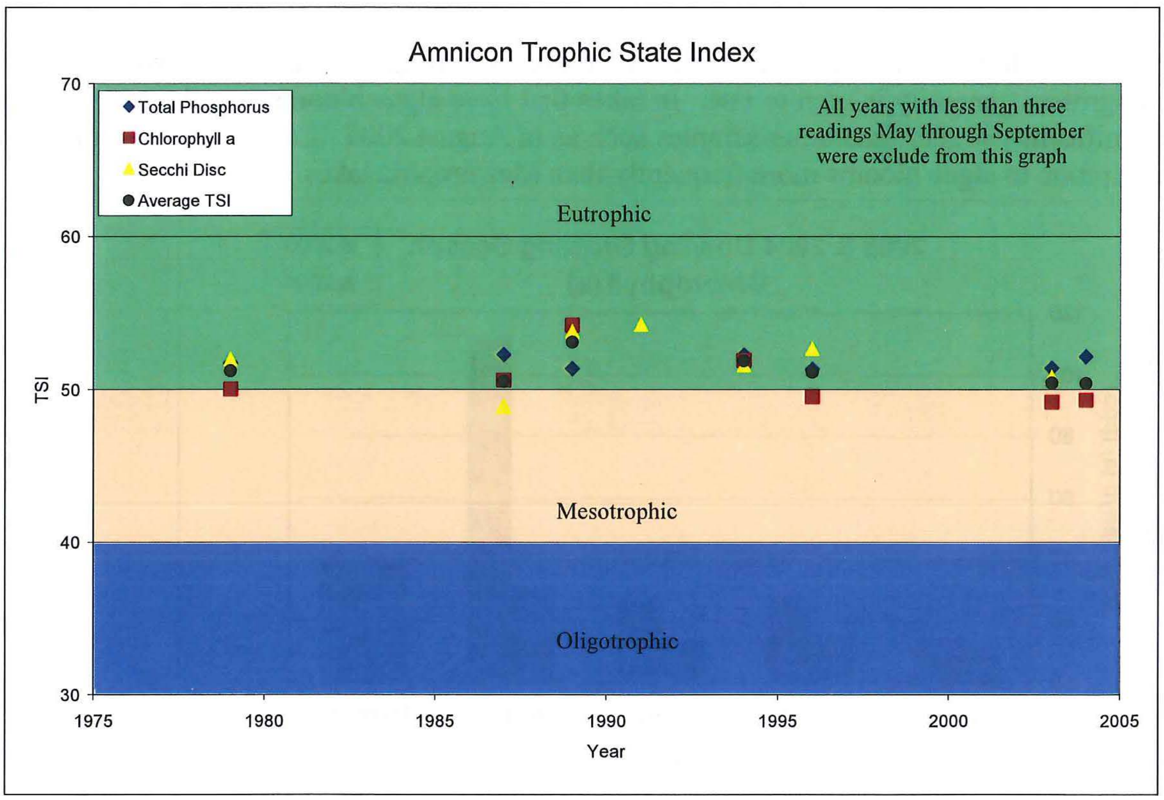


Figure 15

Dowling Lake shows a consistent rise in every year monitored in the data set. The graphbelow includes trend lines with R values. R values are indicaters that refer to the accuracy of the trend line. The closer to one, the more accurate the equation will be. After sorting through years that did not meet the criteria, only five to six points were left for each measure. Based on this, Dowling appears to be consistently worsening in water quality over the last 25 years.

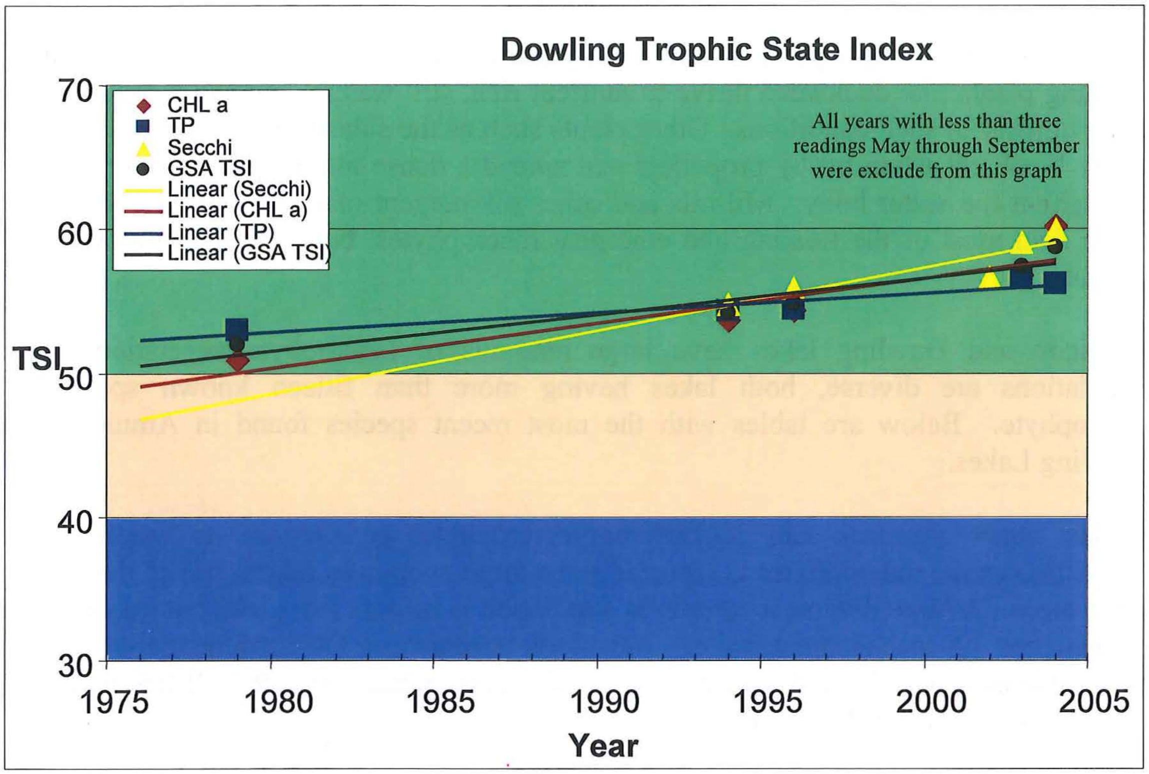


Figure 16

4.4 Aquatic Plant Status

Aquatic plants are an essential part of a healthy lake and fish population. Amnicon and Dowling Lakes have abundant and diverse macrophyte plant populations that provide habitat and food for the fish populations, and also help protect the shoreline. The lakes also have large populations of algae.

There are many types of algae, but the most notable is the blue-green algae or cyanobacteria. This is the algae that are generally responsible for the algae blooms that occur in late summer and are most associated with poor water quality. Algae blooms are generally allowed to occur due to elevated levels of available phosphorous. The larger problem created by algae blooms is the rapid decomposition of the algae which decreases the dissolved oxygen in the water.

Macrophyte plants come in three types; floating, emergent, and submergent. Floating macrophytes float on top of the water with no root system in the soils and sediments of the lake. Emergent macrophytes are water plants such as wild rice and cat tails. Submergent macrophytes like those in the water milfoil family may be entirely under the water or only slightly above the waters surface. The macrophyte plant population competes with the algae for nutrients and light. A large macrophyte population helps to limit the amount of algae by consuming phosphorous and other nutrients that contribute to algae blooms.

Macrophytes have many positive effects on water quality, but can also create a nuisance. Floating plants like duckweed thrive in nutrient rich, still waters, and can reproduce and grow quickly in such conditions. Other plants such as the submergent water milfoils can easily break off when hit by propellers and spread a dense mat of plant matter quickly throughout the water body. Milfoils and other submergent macrophytes have less food value than most of the floating and emergent macrophytes, but have the most value as habitat.

Amnicon and Dowling lakes have large amounts of macrophyte vegetation. The populations are diverse, both lakes having more than fifteen known species of macrophyte. Below are tables with the most recent species found in Amnicon and Dowling Lakes.

At last count Amnicon had 26 different macrophytes growing in its waters. The population of the macrophytes is reported to be large enough to inhibit use of the lake in some areas. A large diverse macrophyte population is healthy for a lake but may need to be managed. A management strategy must look at removing the nutrient source, not the plants themselves. This is because removal of excessive plant growth will free nutrients, and may destabilize sediment as well.

Dowling Macrophytes
American Elodea
Arrowhead
Bulrush
Burreed
Common Cattail
Filimenting Algae
Floating Leaf Pondweed
Horsetail
Moss
Pickerelweed
Richards Pondweed
Spikerush
Variable Pondweed
Wild Rice

Amnicon Macrophytes	
American Elodea	Raccoons Tail
Arrowhead	Ribbonlead Pondweed
Bulrush	Richards Pondweed
Burreed	Sedge
Common Cattail	Small Pondweed
Common Elodea	Spiral Pondweed
Eel Grass	Stonewart
Floating Leaf Pondweed	Water Marigold
Hornwart	Water Milfoil
Horsetail	Water Shield
Large Leaf Pondweed	Whilestem Pondweed
Moss	White Water Lily
Pickerelweed	Wild Rice

Wort Yellow Water Lily		

Table 3

Dowling Lake had 16 species found during the last complete survey and in 2004 while completing a fish survey the WDNR noted in the 2004 report from the Wisconsin DNR, that Dowling had Purple Loosestrife fairly widespread along the shoreline. The report also noted native macrophyte species that were observed were the yellow water lily, arrowhead and spikerush sp., common and floating-leaf bur-reed, pickerel weed, watersheild, horsetail, elodea, and bushy floating, and large-leaf pondweed. Judging by this, Dowling may be more diverse than the report from 1997 indicates. Dowling also has a high macrophyte population and due to the same concerns as in Amnicon, nutrient removal needs to be looked at before the removal of the vegetation.

4.5 Zooplankton and Other Invertebrates

Zooplankton and benthic communities are essential components of lake ecosystems. Zooplankton are small crustaceans that can feed on algae. Zooplankton samples were collected from Amnicon Lake in 1986 and in 1987 (Ryan, November 1993). The species found in both samples reflect a common lake zooplankton community and suggest a normal diverse benthic community.

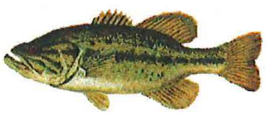
4.6 Fishery Status

Judging the status of a fishery is difficult. Studies that are done to count the number of fish can be positively or adversely affected by the time of year, water and weather conditions, and the area and species targeted. While the data presented below is accurate in the sense that it represents an actual count, but conditions present on the day of the study may cause an inaccuracy that could not be avoided.

Amnicon and Dowling Lakes were consistently stocked until 1970's with walleye and Muskellunge. From 1972-1978, Dowling shows that it was continued to be stocked with Musky and Amnicon was continually stocked with Musky from 1972-2001, only missing a couple of years. See Appendix 9 for the historical stocking information including the years, species, and numbers stocked. According to WDNR records, Amnicon received its first walleye stocking in 30 years in 2002, and again in 2003 with a total of more than 800,000 fry being introduced to the lake. Dowling has not had any Wisconsin DNR stocking in recent years.

Amnicon is designated by the WDNR as an A2 class Musky lake with a class 2 reproduction ranking; Dowling has an A2 classification as well, but is labeled a class 1 reproduction class. A class 1 reproduction class indicates that the population is completely sustained by natural reproduction; Class 2 indicates that is partially or mostly sustained by natural reproduction. An A2 class musky lake offers the most consistent Musky fishing, but may have very few large trophy fish.

To make better sense of the data currently available, it will be looked at in three sections, game fish (walleye, bass, muskellunge), pan fish (crappie and bluegill), and baitfish (white sucker and common shiner).

Game Fish	Panfish
 **Walleye**	 **Yellow Perch**
 **Muskellunge**	 **Bluegill (Sunfish)**
 **Largemouth Bass**	 **Black Crappie**

Photos by Virgil Beck

Figure 17

4.6.1 Game Fish

The most recent study done on Amnicon was in 1999, when there was a Wisconsin treaty lake walleye population count performed. This count differs in technique from when the Wisconsin DNR performs population count. The WDNR uses fyke nets to catch and mark fish followed with shocking to recapture. The company that performs the treaty assessment uses shocking for capture and recapture. To have the most accurate numbers, it is advisable to acquire a copy of the WDNR's records upon completion to have a greater detailed picture of the fish quantity in Amnicon. The walleye count at that time was found to be 4.3 adult walleye per acre. This is above the Wisconsin state average of 3.7 adult walleye per acre and well above the 3.0 fish per acre management goal. The DNR will be performing a population study in the spring of 2006 in Amnicon. At this

Amnicon Game Fish	1999	1997	1992
Walleye	17.84		3.91
Muskellunge	1.97	3.51	3.62
Largemouth Bass	0.55	0.74	0.88

Table 4

time the population seems to be steady. The musky population is also steady on the lake. The population of largemouth bass is growing which is expected in a mesotrophic lake.

The game fish present in Dowling are muskellunge, walleye, and largemouth bass. The 2003 walleye per hour was 5.68 versus 37.61 in 1991. The most recent walleye population count was in 1991.

Table 5

However, the 1991 figure is skewed high because it was performed during spawning and specifically targeting walleye. The walleye population at the time was found to be 7.24 adult fish per acre. The state average is 3.7 adult fish per acre and the management goal is to maintain populations above 3.0 adult. The muskellunge population is thought to be high given that Dowling is classified as a high density musky lake. The report from the WDNR by Cordell Manz says that the 5.68 fish per hour supports that Dowling has a large population of musky. 1977 was the last time that Dowling had a musky population count. It was found that the estimated musky population was 1.8 fish per acre with the state average at the current time .42 fish per acre. Largemouth bass appear to be increasing in numbers over the years but the lake has not had an assessment to ascertain their actual numbers.

The fish populations in Amnicon seem to be holding steady to slightly increasing. The walleye and musky catch per unit effort (CPUE) in 1999 may be deceptive since walleye was the targeted fish and the nets were placed in walleye spawning areas. This may also have effected the largemouth bass count. Looking at the 1997 count in comparison shows that the population is more likely holding steady. The pan fish populations seem to be holding steady to slightly increasing. This seems to indicate that overall, Amnicon has a healthy steady fishery that should continue current management practices. The 2006 count should be anticipated to get the most accurate and current information.

Dowling Game Fish	1991	2003
Walleye	37.61/hr	5.68/hr
Muskellunge	0.85/hr	6.82/hr
Largemouth Bass	1.71/hr	21.59/hr

The most recent fish study in Dowling was from the fall of 2003. Most all populations seem to be healthy and thriving save for the walleye which decreased sharply. It was noted by the WDNR surveyors' that the number of walleye that was sampled may have been affected by the water condition, or the timing. In a 2004 report by Cordell Manz, from the Wisconsin DNR noted, "Despite low catch rates for walleye in 2004 it is recommended that Dowling Lake continue to be managed for walleye, musky, and pan fish species." With the history the lake has had for natural reproduction, and knowing that lakes with natural reproducing populations have higher populations than lakes that continually stock and struggle with natural reproduction, an assumption can be made that the walleye population is not as low the sample would indicate.

4.6.2 Pan fish

Amnicon is not known as a pan fish lake, though it has adequate population. Crappies, bluegill, and perch are commonly found, though few are of adequate size to harvest. Crappies provide more of an opportunity than the bluegill or perch though both population have a higher average size than Dowling. Amnicon's catch per effort/ catch per hour is said to be lower than most lakes in the area as far as pan fish are concerned

Amnicon Panfish	1999	1992
Black Crappie	9.81	4.85
Bluegill	10.77	11.56
Yellow Perch	35.19	27.44

Table 6

Dowling is not considered a lake with a high density of pan fish. While the numbers in fish per hour greatly increased over the 1991 survey, the numbers were still below regional averages for the numbers being caught and do not seem to have size that is desirable for harvest. The black crappie population has also increased and has a slightly better size than the bluegills making them better for harvest, but still not in abundant numbers. There is also a growing population of yellow perch, but again not in a size that would be desirable to harvest.

Dowling Panfish	1991	2003
Black Crappie	6.00/hr	31.03/hr
Bluegill	66.00/hr	100/hr
Yellow Perch	3.42/hr	13.64/hr

Table 7

4.6.3 Bait Fish

The bait fish population in Amnicon Lake seems to be holding steady when looking at the white sucker population. The white sucker fish per hour total in 1992 was 5.68, but in the spring of 1999 was 6.71. This indicates there may have been a slight increase in the population, but could also be holding steady with fish slightly more active in the 1999. The common shiner population never was seen significantly high, however fyke netting is not an accurate method for documenting the bait fish population due to the smaller size of most bait fish.

The bait fish population is also increasing in Dowling judging by the comparison of the recent survey compared a much older survey with a similar method. The white sucker fish per hour total in 1977 was 0.44, but in the fall of 2003 was more than eight fish per hour. In 1977 the common shiner was seen in the shocking at a rate of 0.44 fish per hour and in 2003 was found at the rate of 3.45 fish per hour. Seine netting is the best method to count bait fish, but there was insufficient historical data to make a good comparison.

Amnicon Bait Fish	1999	1992
White Sucker	6.71	5.68
Common Shiner	0.16	0.62

Dowling Bait Fish	1977	2003
White Sucker	0.44/hr	8.62/hr
Common Shiner	0.44/hr	3.45/hr

Table 8 Table 9

5. Loading Reduction Feasibility Analysis

Both Amnicon and Dowling Lakes are generally located in the Northern Lakes and Forests Ecoregion, which in general consists of sandy glacial outwash deposits. See Appendix 10 for information regarding Ecoregions. Based on additional research of ecoregions and considering that the soils in the area are generally silt and clay, not sand, we used the "Laurentian Mixed Forest Province" instead of the Northern Lakes and Forests in our models. The main difference between the two is the estimated total phosphorus (TP) inflow. The TP inflow for Northern Lakes and Forests Ecoregion is 28 ug/L and for Laurentian Mixed Forest Province Ecoregion the estimated inflow if 83 ug/L. As stated previously, both lakes are currently classified as eutrophic (although Amnicon has higher water quality than Dowling).

Based on WiLMS models, Minnesota Lake Eutrophication Analysis Procedure (MnLEAP) and ecoregion values for the area, the predicted and observed TP values for Amnicon are 28 and 20 respectively. The predicted and observed TP values for Dowling are 33 and 39 respectively. The observed Chlorophyll a and Secchi depth are slightly worse than predicted in Amnicon and much worse than predicted in Dowling. See Appendix 11 for WiLMS and MnLeap Modeling data for both lakes

To determine how the response in water quality (TP, Chlorophyll a and Secchi Depth) varies with respect to changes in loading, we utilized WiLMS to simulate water quality conditions if TP loading was reduced and then what would happen if TP loading was increased. Each of the three water quality indices (TP, Chlorophyll a and Secchi Depth) were correlated to the Wisconsin Trophic State Index (TSI). A Wisconsin TSI of under 50 was considered mesotrophic and 50 and over was considered eutrophic.

5.1 Amnicon

We considered three TP loading scenarios for Amnicon. In the first scenario we removed the surface runoff for the residents around the lake (medium density urban) and the rural part of the watershed (rural) (Scenario 1). In the second scenario we removed all septic tank loading of TP in addition to removing MD Urban and Rural loading (Scenario 2). In the third scenario we increased the total TP loading by 25% (Scenario 3). The table below summarizes the expected Wisconsin TSI's for TP, Chlorophyll a and Secchi Depth for all three scenarios:

Scenario	**TSI-TP**	**TSI-Chlorophyll a**	**TSI-Secchi Depth**
1	50	50	52
2	49	49	50
3	53	52	52

Table 10