Amherst Millpond

Introduction

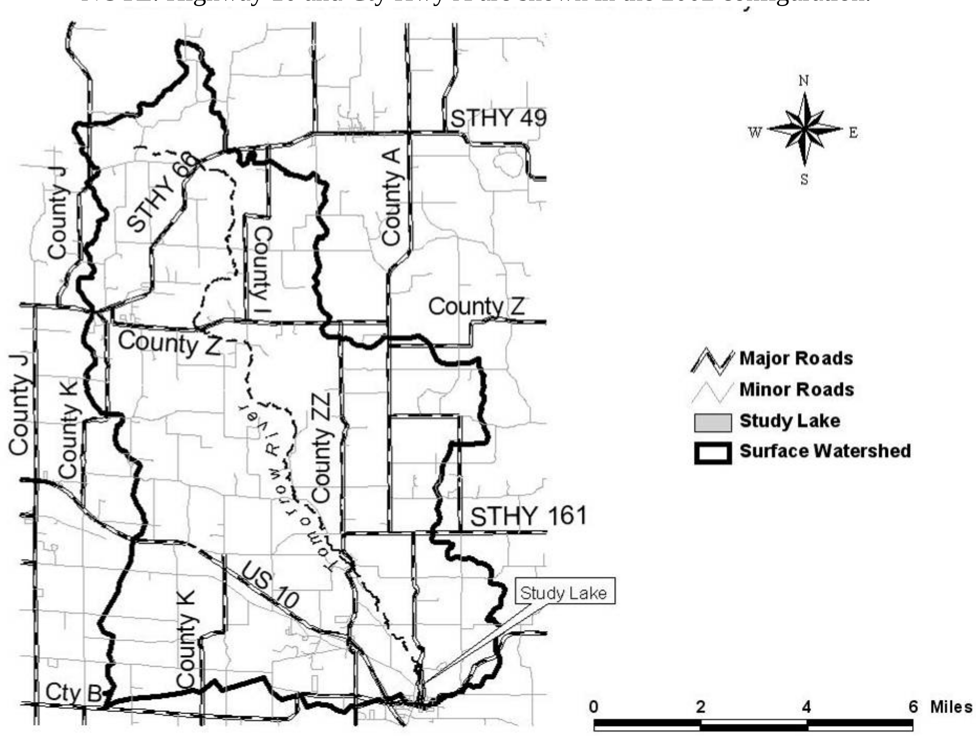
Amherst Millpond is a 48 acre, **hard water impoundment** located in the Village of Amherst. Created by a dam on the Tomorrow River for power to the local feed mill, the pond has a maximum depth of five feet and a bottom consisting of sand covered with silt. The estimated volume of the pond in 116 acre feet, the shoreline length is 2.8 miles. The Tomorrow River is navigable above and below the dam, and there are two public access points on the east side of the pond; the boat landing and Cates Park. The pond was chemically treated with fish toxicants in 1971 and restocked with preferred species. Currently northern pike and panfish are present. The shoreline is heavily developed.

Land Use and Watershed

The surface **watershed** of Amherst Millpond is 51,089 acres, traveling up to the headwaters of the Tomorrow River in northern Portage County (Figure 1). There are varying types of land uses within this area but it is predominantly non-irrigated cropland (37%) and forest (37%). Shrub cover is the secondary land cover followed by irrigated agriculture, residential, and transportation which are all of similar total acreage (Figure 2 and Figure 3). The boundaries of the **groundwater watershed** of the Amherst Millpond are presented here, however, as with the other **impoundments** additional data on the **groundwater watershed** is beyond the scope of this study (Figure 4). According to the records there are 28 potentially failing septic systems found within the boundary of the surface **watershed**. There are also three landfill sites, all in the southern half of the surface **watershed**.

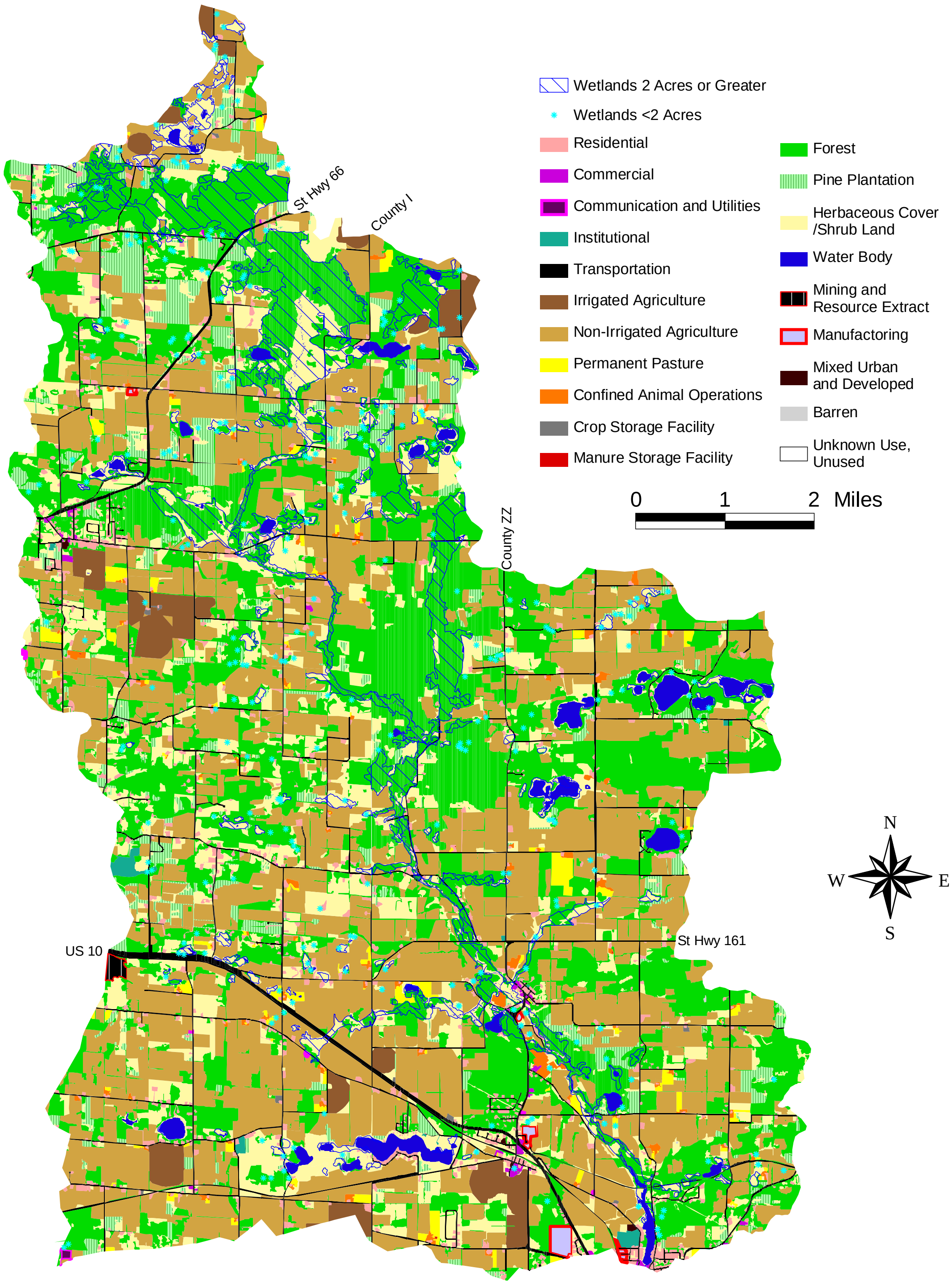
Figure 1. Amherst Millpond surface watershed boundary.

NOTE: Highway 10 and Cty Hwy A are shown in the 2002 configuration.



*Terms in bold, see glossary pp 13-17

Figure 2. Land use in the Amherst Millpond watershed (2002).



*Terms in bold, see glossary pp 13-17

Figure 3. Land use in the Amherst Millpond surface watershed (2002).

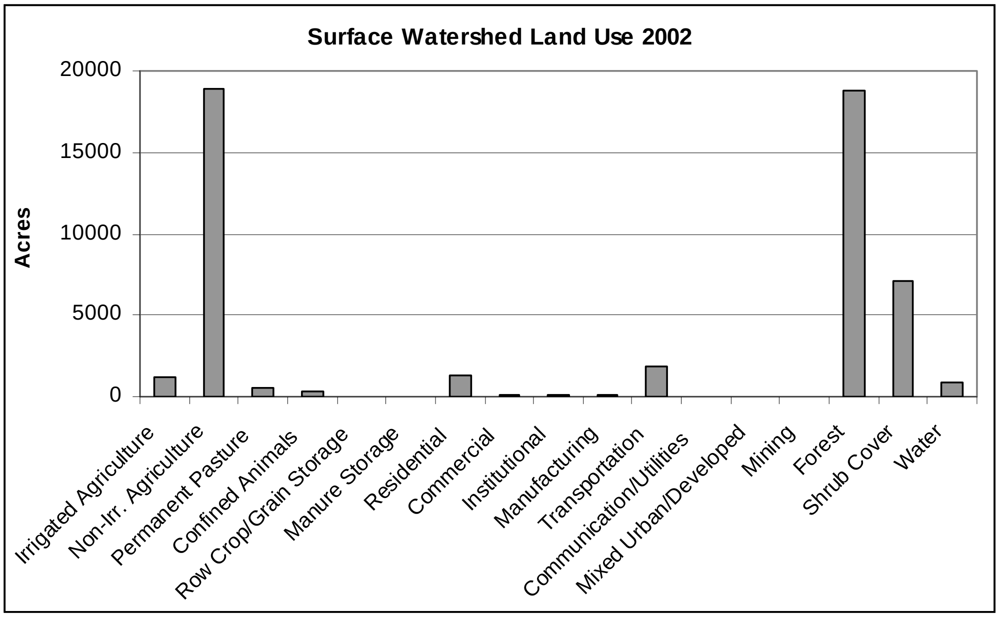
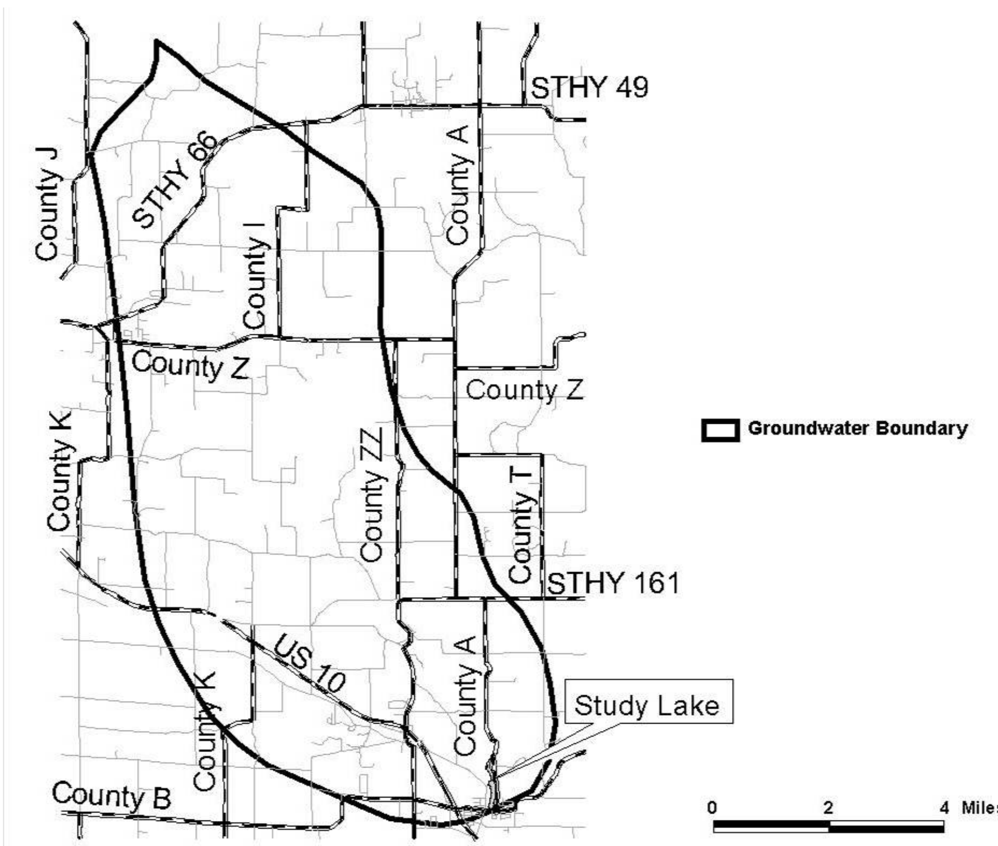


Figure 4. Amherst Millpond groundwater watershed boundary.

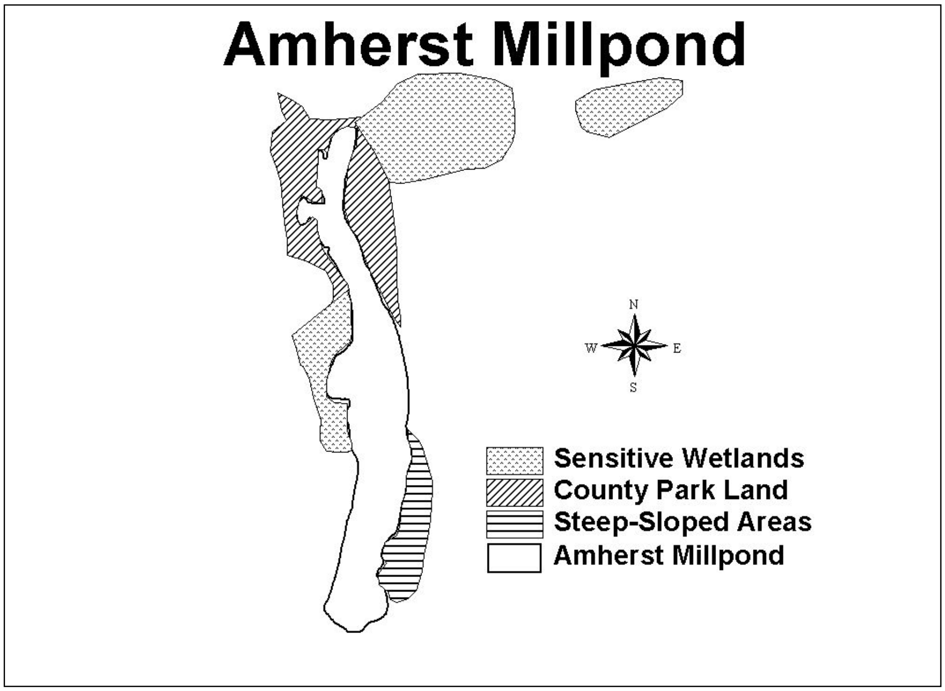
NOTE: Highway 10 and Cty Hwy A are shown in the 2002 configuration.



*Terms in bold, see glossary pp 13-17

Upland Sensitive Areas
The survey of upland sensitive areas was conducted to note areas immediately around the millpond that are particularly valuable, or sensitive to disruption. There is a County Park and associated land encompassing most of the northern half of Amherst Millpond providing a public recreation area. There are three wetlands found near the millpond, two to the northeast of the pond and the other adjacent to a portion of its western shore. A steep slope lines a small part of the southeastern banks (Figure 5). This area is well developed and should be managed for to control **erosion**.

Figure 5. Upland sensitive areas near Amherst Millpond.



Reptiles and Amphibians
Amphibians (frogs and toads) were included in this survey because with their permeable skin and biphasic lifecycle (meaning that the young live in water while adults can survive on land) they are considered excellent indicators of overall ecosystem health. Furthermore, both turtles and amphibians utilize both aquatic and terrestrial habitats and especially the shoreline interface between these two habitats, and thus are of particular relevance.

Large sections of continuous natural shoreline on lakes are ideal habitats for many frog species. Natural areas with large amounts of submergent, emergent, and floating-leaf vegetation provide protection and a place for attachment of eggs during the breeding season. The upland areas surrounding these lakes also provide important habitat as many frog species migrate to lakes and other bodies of water in the spring or fall to breed and spend the summer months foraging in the uplands. Several species also use the surrounding uplands for overwintering. The turtle species found associated with lakes are predominantly aquatic, usually departing from the water only to deposit eggs in a nest. Nests are usually on south facing slopes above the shoreline where there is

*Terms in bold, see glossary pp 13-17

open vegetation and sandy soil. The newly hatched young then find their way to the water. Thus, both turtles and anurans are intimately associated with lakes and the associated habitats of a **watershed**.

Five frog species were identified during the survey of Amherst Millpond [spring peeper (*Pseudacris crucifer*), American toad (*Bufo americanus*), gray treefrog (*Hyla versicolor*), green frog (*Rana clamitans*), and chorus frog (*Pseudacris triseriata*)]. The primary amphibian habitat is located on the north side of the pond (sensitive areas are identified in red on Figure 6). Some of the key features of this habitat include protected areas of marsh with large amounts of submergent, emergent, and floating-leaf vegetation. The good news is that large areas of natural habitat are present on portions of the pond. However, there are also high levels of shoreline alteration due to development. During the reptile survey Amherst Millpond was found to contain one turtle species [snapping turtle (*Chelydra serpentine*)].

Figure 6. Regions of primary amphibian habitat around Amherst Millpond.

Aquatic Plants

There were 21 species of vascular plants that were found in the lake or rooted in wet soil along the shore of the expanded millpond, excluding the marshy area northeast (upstream) of the millpond. This is lowest of all Portage County lakes. The average **coefficient of conservatism** (**c-value**) of these 21 species is 4.3 which is slightly under the average for the Portage County

*Terms in bold, see glossary pp 13-17

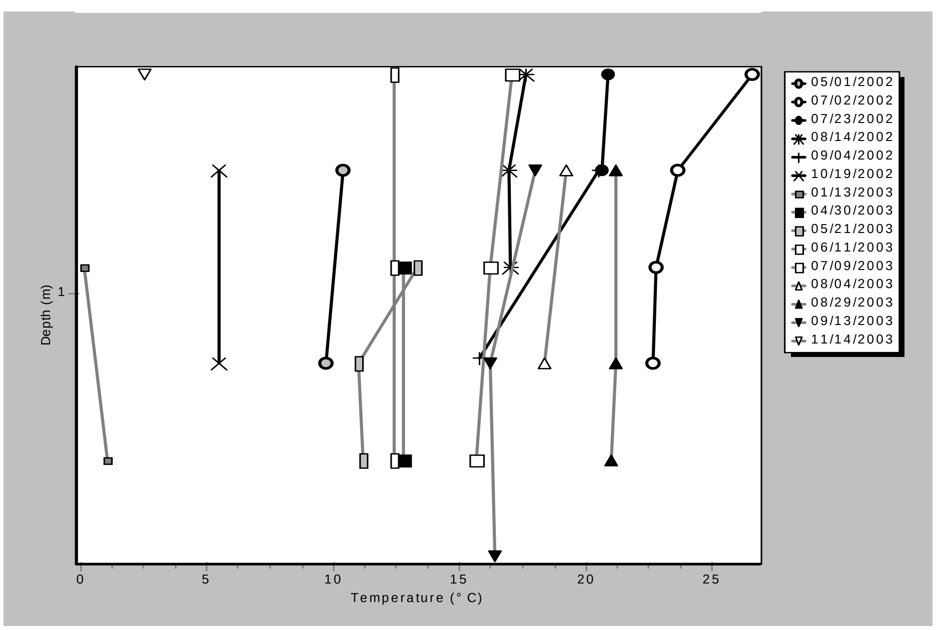
lakes. The **floristic quality index** is 20.6 (19.6, plus one point for a special concern species). This is below the average for the Portage County lakes.

The UWSP Herbarium has no collections or reports of botanical observations prior to 2003. The lack of prior studies probably depresses the **FQI** for Amherst Millpond and also makes it difficult to discuss vegetation change over the years. Amherst Millpond is lined by homes, most of which have preserved little native vegetation. The millpond is also surrounded by steep shores, providing little habitat for wetland plants along the shore. There are a few areas of wetland toward the north end of the pond, not remarkable except for the presence of slim-stem reedgrass (*Calamagrostis stricta*), and a marshy area along the west bank south of the railroad bridge. Submersed vegetation is sparse in the millpond and the invasive alien species, curlyleaf pondweed (*Potamogeton crispus*), is abundant, and may increase in the future. This plant grows early in the year and dies back in late June, releasing **phosphorus** into warm water and often fueling filamentous **algae** blooms for the rest of the summer.

Current Water Quality Conditions

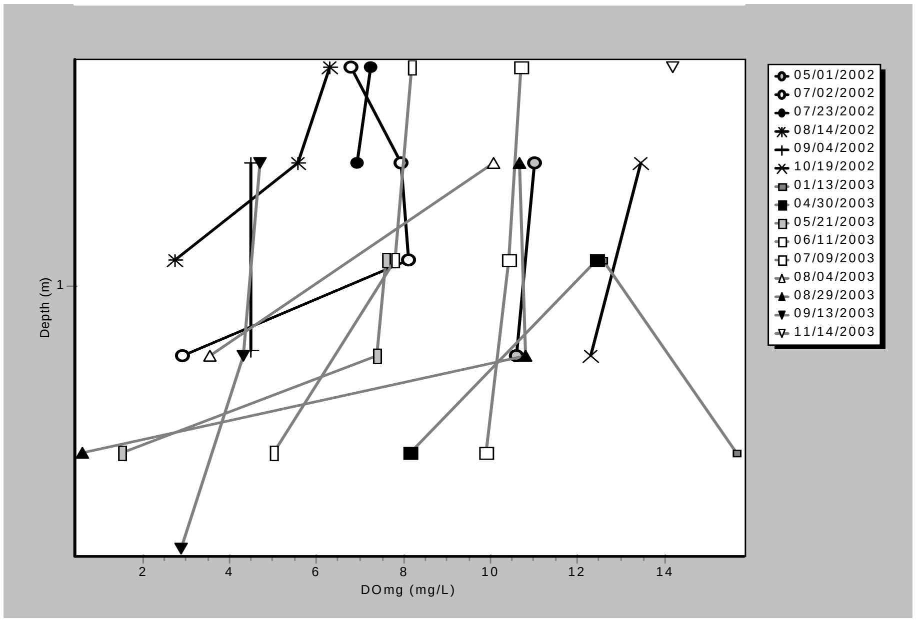
Water quality in lakes is assessed by measuring different characteristics including temperature, dissolved oxygen, water **clarity**, **chlorophyll *a***, water chemistry, and the algal community. Profiles of temperature and dissolved oxygen were measured during each sampling period. Typical of many shallow **impoundments**, the water in Amherst Millpond remains mixed from top to bottom for most of the year (Figure 7). However, dissolved oxygen profiles show that during the summer dissolved oxygen concentrations fall below the 5 **mg/l** needed for survival by many aquatic organisms below about 2 feet (Figure 8).

Figure 7. Profile of temperature in Amherst Millpond 2002-2004.



*Terms in bold, see glossary pp 13-17

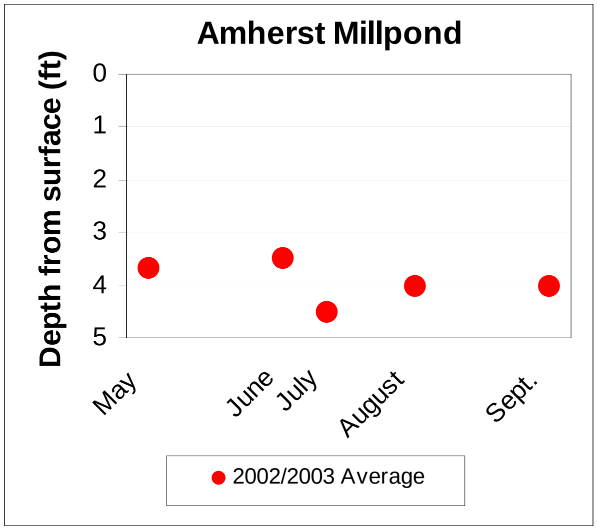
Figure 8. Profile of dissolved oxygen in Amherst Millpond 2002-2004.



Water **clarity** is a measure of how deep light can penetrate. It is an aesthetic measure and is related to how deep **rooted aquatic plants** can grow. Water **clarity** is affected by water **color** and suspended materials in the water (**turbidity**). **Turbidity** consists of **suspended solids**, such as suspended sediments and **algae** (**chlorophyll *a***). During the recent study **chlorophyll *a*** concentrations ranged from 0.7 to 17.6 **mg/l**. The mid-June measure of 17.6 **mg/l** was an unusual high that may have been related to an **algae** bloom resulting from the die off of curly leaf pondweed; the corresponding water **clarity** measure was 3.5 feet. **Color** and **turbidity** were measured during spring and fall overturn. Water **color** was low during the later part of the study, but measured quite high (27 and 37) in fall 2002 and spring 2003. Generally **color** in this region is associated with brown stained water from wetlands. **Turbidity** measures were consistently low.

The water **clarity** in Amherst Mill Pond is difficult to compare with similar lakes in the region because it is so shallow. The average **Secchi disc** depth for similar lakes in the region is five feet. Amherst Mill Pond appears to have poorer **clarity** than this, however in some cases the bottom of the pond was reached before the maximum **clarity** reading could be taken. This may have resulted in poorer **clarity** readings than may actually be the case. The **Secchi disc** depth measures in Amherst Millpond ranged from 3 to 5 feet. During 2002-03, the water **clarity** of Amherst Mill Pond was the best during the month of July. This type of fluctuation throughout the summer is normal as **algae** populations and **sedimentation** increase and decrease (Figure 9).

Figure 9. Monthly average water clarity measurements in Amherst Millpond 2002-2003.



Nutrients (**phosphorus** and **nitrogen**) are important measures of water quality in lakes because they are used for growth by **algae** and aquatic plants (similar to houseplants and crops). In Amherst Millpond, **nitrogen** concentrations are very high, particularly in the form of **nitrate**, which is easily used by aquatic plants and **algae**. **Phosphorus** concentrations fluctuated substantially throughout the year, but were often high enough to fuel excessive **algae** blooms and aquatic plant growth (Table 1). Although **phosphorus** was high for **algae**/aquatic plant growth, it was on the lower range measured in **impoundments**.

Chloride levels, and to a lesser degree **sodium** and **potassium** levels, are commonly used as an indicator of how strongly a lake is being impacted by human activity. Concentrations of **potassium** and **sodium** were low, but **chloride** and **sulfate** concentrations were elevated (Table 2). Although these constituents are not detrimental to the aquatic ecosystem, they indicate that sources of contaminants (road salt, fertilizer, animal waste and/or septic system effluent) are entering the lake from either surface runoff or via **groundwater**. **Sulfate** sources are often a result of combustion of sulfur containing fossil fuels. **Atrazine** was found in low concentrations (0.1 µg/L) in the lake water, however some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels. The presence of **atrazine** indicates that other agri-chemicals may also be entering Amherst Millpond.

Table 1. 2002-2003 water quality of seasonal averages in Amherst Millpond.

Amherst Millpond	TP (ug/L)	RP (ug/L)	TN (mg/L)	NO2+NO3 (mg/L)	NH4 (mg/L)	Alkalinity (mg/L)	Total Hardness (mg/L)	Calcium Hardness (mg/L)	Color (CU)	Turbidity (NTU)	Chlorophyll a (ppm)
Spring Averages	33.0	9.0	3.09	2.46	0.05	199.0	224.0	123.0	27	1.3	2.8
Summer Averages	32.1	11.7	2.96	2.44	0.03	222.5	241.5	127.5	13	1.3	4.0
Fall Averages	22.0	14.5	3.36	3.65	0.04	216.0	259.0	139.5	23	1.5	
Winter Averages	68.0	47.0	4.45	3.70	0.18						
2002-2004 Averages	38.8	22.1	3.36	3.12	0.08	213.3	245.0	131.4	21	1.4	4.6

TP=total **phosphorus**; RP=reactive or soluble **phosphorus**; TN=total **nitrogen**; NO2+NO3=**nitrite** and **nitrate nitrogen**; NH4=**ammonia nitrogen**

*Terms in bold, see glossary pp 13-17

Table 2. 2002-2003 Amherst Millpond water chemistry and reference value.

Amherst Millpond	*Low*	*Medium*	*High*	**Reference Values**	*Low*	*Medium*	*High*
Sulfate		12.60		*Sulfate*	<10	10-20	>20
Chloride		8.21		*Chloride*	<3	3-10	>10
Potassium	1.70			*Potassium**	<2.16	2.16-4.30	>4.30
Sodium	4.88			*Sodium**	<2.28	2.28-5.09	>5.09

**Ranges of low, medium, high defined by taking the median values from the lake study and dividing into thirds.*

Algal Community

The algal community in Amherst Millpond was mildly diverse but dynamically monotonous. The dominant group was the **blue-green algae** (Cyanobacteria, 36% of all cells counted). The green **algae** (Chlorophyta, 18% of all cells counted) and the euglenoids (Euglenophyta, 18% of all cells counted), and to a lesser extend the yellow-green **algae** and **diatoms** (Ochrophyta, 14% of all cells counted) were the subdominants (Figure 6). These four phyla represented 86% of all cells counted during the 2003 sampling season. In the 2200 cells counted during this period there were 8 genera of Cyanobacteria, 11 genera of Chlorophyta, 11 genera of Ochrophyta (including 11 **diatom** genera), 3 genera of Euglenophyta, 1 genus of Dinophyta, and 1 genus of Cryptophyta identified.

Table 3. Algal phyla and mean seasonal composition in Amherst Millpond from May to November 2003.

AMHERST MILLPOND

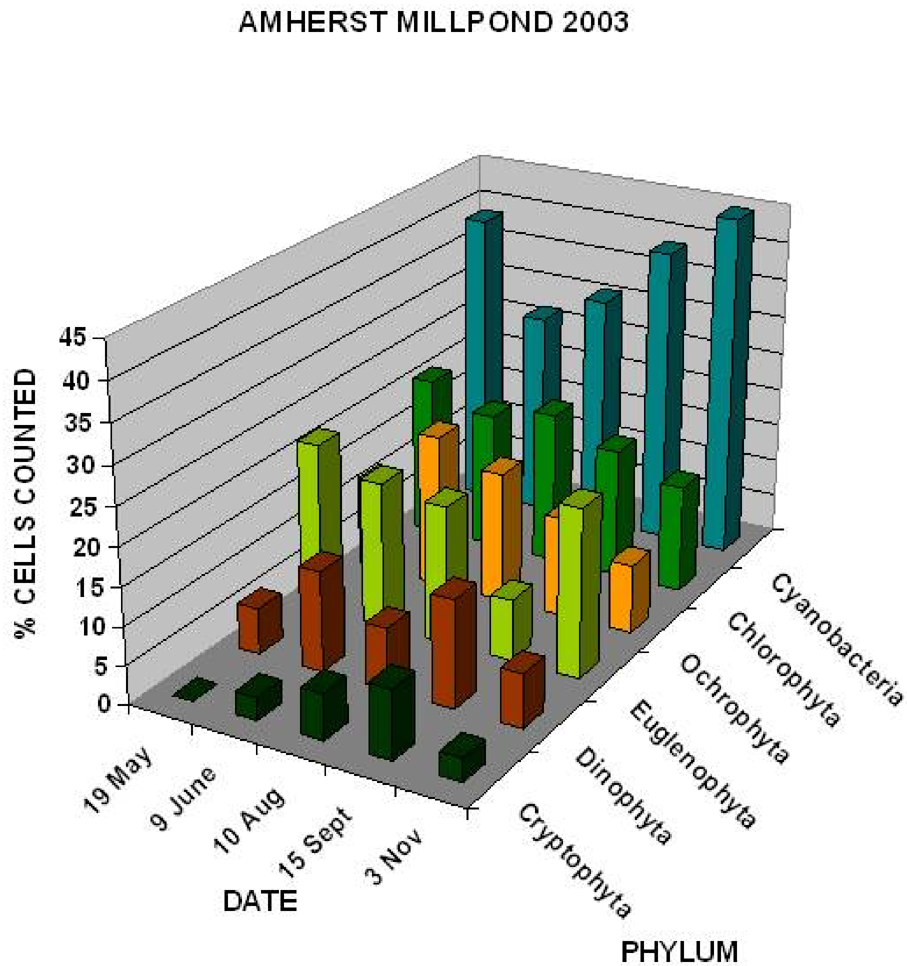
PHYLUM	% CELLS COUNTED BY PHYLUM AND DATE					**MEAN**
	19 May	9 June	10 Aug	15 Sept	3 Nov	
Cyanobacteria	39	27	31	39	45	36
Chlorophyta	21	18	20	17	14	18
Ochrophyta	12	20	17	13	9	14
Euglenophyta	22	19	18	8	22	18
Dinophyta	6	13	8	14	7	10
Cryptophyta	0	3	6	9	3	4

There was very little cycling of the algal community during the 2003 sampling period. The blue-green **algae** were by far the dominant phylum in every sample. The accounted for no less that 27% of all cells counted in every sample and their dominance increased of the sampling periods (except June). The green **algae** (Chlorophyta) and euglenoids (Euglenophyta) represented nearly equal community composition across the sampling period as subdominants and were rarely more than few percentage points apart over the season. The **diatoms** (Ochrophyta) never rose to more than 20% of all cells counted but were a steady 12-20% until November. The other two phyla

*Terms in bold, see glossary pp 13-17

(Dinophyta, Cryptophyta) combined for 14% of all cells counted, ranging from 0-14% with the dinoflagellates being more than twice as common as the cryptophytes (Figure 10).

Figure 10. Algal community composition by date in Amherst Millpond from May to November 2003 (total phylum cells counted divided by total cells counted).



Two unbranched, filamentous cyanobacterial genera dominated the genus abundance analysis. The non-heterocystous genus *Oscillatoria* and the heterocystous genus *Anabaena* occupied 7 of the top 15 abundance slots included all five of the most abundant positions (Figure 11). *Oscillatoria* dominated early in the season but remained very common throughout while *Anabaena* was a subdominant early and was the dominant organism from the August samples forward. Two euglenoid genera were abundant, the dendritically colonial genus *Colacium* appeared twice (May, June) and the loricate, motile unicellular genus *Trachelomonas* was abundant in August. The large, armored unicellular dinoflagellate genus *Peridinium* was abundant in June and September. Any other taxa present (1 green, 1 **diatom**, 1 cryptophyte) were all distant subdominants in the third most abundant positions over the sampling periods (Table 4).

The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Amherst Millpond presents a picture of a **mesotrophic** lake. The 35 genera identified

*Terms in bold, see glossary pp 13-17

during the sample periods were relatively common and none of those that reached numerical dominance in the sample counts are associated with toxins or health issues (with the possible exception of *Anabaena*). The shallow nature of Amherst Millpond allows for light to penetrate all the way to the bottom. This creates problems as algal mats of blue-greens and **diatoms** can carpet the bottom and as they trap photosynthetically-produced oxygen in the interwoven mat material they will lift off the bottom and float to the surface. At the surface they get too much sunlight, bleach to yellow/white and then decay. The decay can be aesthetically displeasing and in some cases the bacterial decomposition of this material leads to oxygen depletion and perhaps to fish kills.

Figure 11. Algal community composition by phylum in Amherst Millpond from May to November 2003.

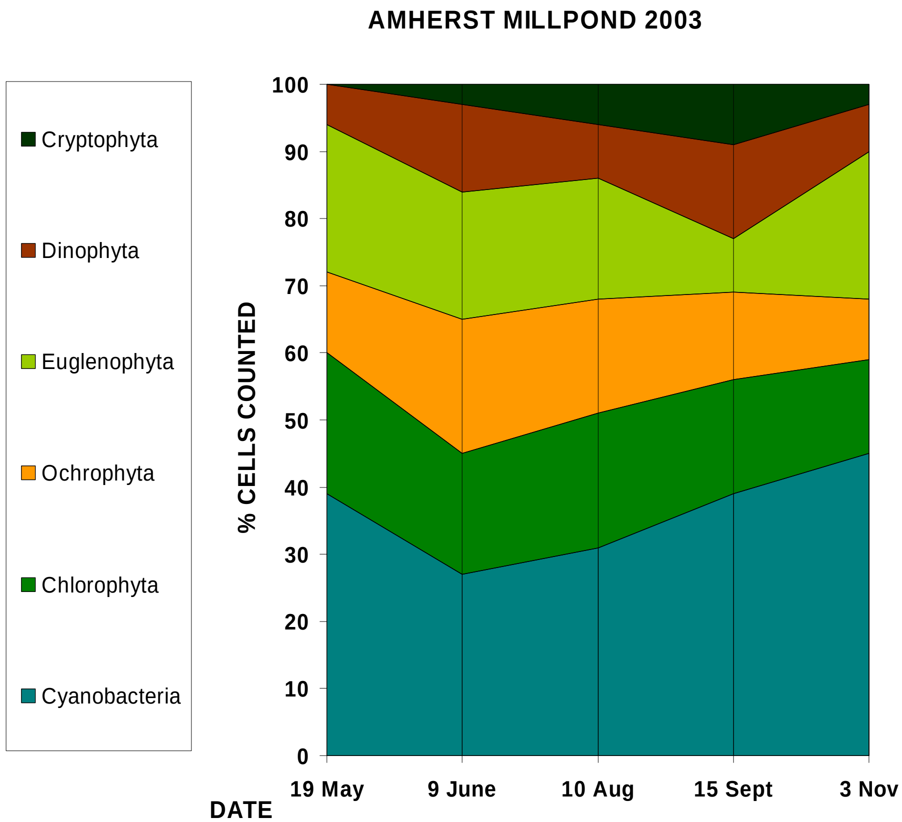


Table 4. Most common algal genera by date in Amherst Millpond from May to November 2003.

DATE	TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT)		
19 May	*Oscillatoria*	*Colacium*	*Anabaena*
9 June	*Oscillatoria*	*Peridinium*	*Colacium*
10 August	*Anabaena*	*Trachelomonas 1*	*Cocconeis*
15 September	*Anabaena*	*Peridinium*	*Cryptomonas*
3 November	*Anabaena*	*Oscillatoria*	*Gloeocystis*

*Terms in bold, see glossary pp 13-17

Amherst Millpond Study Highlights

- Amherst Millpond is lined by homes, most of which have preserved little native vegetation. The millpond is also surrounded by steep shores, providing little habitat for wetland plants along the shore. There are a few areas of wetland toward the north end of the pond, not remarkable except for the presence of slim-stem reedgrass and a marshy area along the west bank south of the railroad bridge. Submersed vegetation is sparse in the millpond and the invasive alien species, curlyleaf pondweed, is abundant, and may increase in the future.
- Dissolved oxygen profiles show that during the summer below the upper 3 feet of water dissolved oxygen concentrations fall below the 5 **mg/l** needed for survival by many aquatic organisms.
- The water **clarity** in Amherst Mill Pond is difficult to compare with similar lakes in the region because it is so shallow. The average **Secchi disc** depth for similar lakes in the region is five feet. Amherst Mill Pond appears to have poorer **clarity** than this, however in some cases the bottom of the pond was reached before the maximum **clarity** reading could be taken.
- In Amherst Millpond, **nitrogen** concentrations are very high, particularly in the form of **nitrate**, which is easily used by aquatic plants and **algae**. **Phosphorus** concentrations fluctuated substantially throughout the year, but were often high enough to fuel excessive **algae** blooms and aquatic plant growth.
- **Chloride** and **sulfate** concentrations were elevated. **Atrazine** was found in low concentrations in the lake water, however some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels. The presence of **atrazine** indicates that other agri-chemicals may also be entering Amherst Millpond.
- The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Amherst Millpond presents a picture of a **mesotrophic** lake. The a identified during the sample periods were relatively common and none of those that reached numerical dominance in the sample counts are associated with toxins or health issues (with the possible exception of *Anabaena*). The shallow nature of Amherst Millpond allows for light to penetrate all the way to the bottom. This creates problems as algal mats of blue-greens and **diatoms** can carpet the bottom. The decay can be aesthetically displeasing and in some cases the bacterial decomposition of this material leads to oxygen depletion and perhaps to fish kills.

*Terms in bold, see glossary pp 13-17

Glossary

Algae:

One-celled (phytoplankton) or multicellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphyton). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to classify the trophic status of a lake. Numerous species occur. Algae are an essential part of the lake ecosystem and provides the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day, as life cycles are short.

Alkalinity:

A measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity is the main indicator of susceptibility to acid rain. Increasing alkalinity is often related to increased algae productivity. Expressed as milligrams per liter (mg/L) of calcium carbonate (CaCO3), or as microequivalents per liter (ueq/l). 20 ueq/l = 1 mg/L of $CaCO_3$.

Ammonia, Ammonium:

A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays. It can be used by most aquatic plants and is therefore an important nutrient. It converts rapidly to nitrate (NO_3) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic to fish at relatively low concentrations in pH-neutral or alkaline water. Under acid conditions, non-toxic ammonium ions (NH_4^+) form, but at high pH values the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for fish and aquatic life is 0.02 mg/L of NH_4OH. At a pH of 7 and a temperature of 68^o F (20^o C), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH 8, the ratio is 26:1.

Atrazine:

The nation's most widely used weedkiller for both grassy and broadleaf weeds.

Blue-Green Algae:

Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N_2) from the air to provide their own nutrient.

Chloride (Cl-):

Chlorine in the chloride ion (Cl^-) form has very different properties from chlorine gas (Cl_2), which is used for disinfecting. The chloride ion (Cl^-) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll *a*:

Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae and is therefore used as a common indicator of water quality.

Clarity:

see "Secchi disc."

Coefficient of Conservatism (c-value):

Indicates on a scale of 0 to 10 the degree to which a species can tolerate disturbance to a native plant community; a species with a c value of 10 is found only in relatively undisturbed areas of native plant community, whereas a species with a c value of 0 never grows in undisturbed areas of native plant communities. Plants with low numbers tend to occur in a wide range of more-or-less disturbed plant communities. Alien species are also assigned a c value of 0. The c values are used in this report in calculating the Floristic Quality Index for each lake.

*Terms in bold, see glossary pp 13-17

Color:

Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. The average color value for Wisconsin lakes is 39 units, with the color of state lakes ranging from zero to 320 units. Color also affects light penetration and therefore the depth at which plants can grow.

Concentration Units:

Express the amount of a chemical dissolved in water. The most common ways chemical data is expressed is in milligrams per liter (mg/L) and micrograms per liter (ug/L). One milligram per liter is equal to one part per million (ppm). To convert micrograms per liter (ug/L) to milligrams per liter (mg/L), divide by 1000 (e.g. 30 ug/l = 0.03 mg/L). To convert milligrams per liter (mg/L) to micrograms per liter (ug/L), multiply by 1000 (e.g. 0.5 mg/L = 500 ug/L). Microequivalents per liter (ueq/L) is also sometimes used, especially for alkalinity; it is calculated by dividing the weight of the compound by 1000 and then dividing that number into the mg/L.

Diatoms:

A major group of eukaryotic algae, which are one of the most common types of phytoplankton. Diatom communities are a popular tool for monitoring environmental conditions, past and present, and are commonly used in studies of water quality; often the brown stuff attached to rock surfaces.

Drainage Basin:

The total land area that drains toward the lake.

Drainage Lakes:

Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems but generally have shorter retention times than seepage lakes. Watershed protection is usually needed to manage lake water quality.

Endocrine:

An integrated system of small organs that involve the release of extracellular signaling molecules known as hormones. The endocrine system is instrumental in regulating metabolism, growth, development and puberty, tissue function, and also plays a part in determining mood.

Erosion:

The lowering of the land surface by weathering, corrosion, and transportation, under the influence of gravity, wind, and running water.

Eutrophic:

Eutrophic lakes are high in nutrients and support a large biomass (all the plants and animals living in a lake). They are usually either weedy or subject to frequent algae blooms, or both. Eutrophic lakes often support large fish populations, but are also susceptible to oxygen depletion. Small, shallow, eutrophic lakes are especially vulnerable to winterkill which can reduce the number and variety of fish. Rough fish are commonly found in eutrophic lakes.

Eutrophication:

The process by which lakes and streams are enriched by nutrients, and the resulting increase in plants and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

*Terms in bold, see glossary pp 13-17

Fen:

A fen is a type of wetland fed by surface and/or groundwater. Fens are characterized by their water chemistry, which is neutral or alkaline, unlike bogs, which are generally acid.

Floristic Quality Index (FQI):

The FQI is a standardized method for evaluating natural plant communities by multiplying the average coefficient of conservatism (c-value) for all species by the square root of the total number of species found at that lake; an additional point is added to the index for each state-listed special concern species, two points added for a threatened species, and three points added for an endangered species. A higher floristic quality index, such as FQI=60, indicates a higher floristic quality and biological integrity and a lower level of disturbance impacts. A lower floristic quality index, such as FQI=20, indicates a lower floristic quality and biological integrity and a higher level of disturbance impacts.

Groundwater:

Water found below the land surface in pore spaces between soil particles or in cracks in rock. It moves slowly from higher to lower areas on the landscape and may provide water to a lake.

Groundwater Drainage Lake:

Often referred to a spring-fed lake, has large amounts of groundwater as its source, and a surface outlet. Areas of high groundwater inflow may be visible as springs or sand boils. Groundwater drainage lakes often have intermediate retention times with water quality dependent on groundwater quality.

Hardness, Hard Water:

The quantity of multivalent cations (cations with more than one +), primarily calcium (Ca++) and magnesium (Mg++) in the water expressed as milligrams per liter of $CaCO_3$. Amount of hardness relates to the presence of soluble minerals, especially limestone, in the lake watershed. Moderately hard water has 61-120 mg/L $CaCO_3$, hard water has 121-180 mg/L $CaCO_3$, and very hard water has more than180 mg/L $CaCO_3$.

Impoundment:

Manmade lake or reservoir usually characterized by stream inflow and always by a stream outlet. Because of nutrient and soil loss from upstream land use practices, impoundments ordinarily have higher nutrient concentrations and faster sedimentation rates than natural lakes. Their retention times are relatively short.

Littoral:

The shallow water zone near the shoreline that is home to most aquatic plants.

Macrophytes:

see "Rooted aquatic plants."

Macrophytic Algae:

Algae that resemble true plants in that they appear to have stems and leaves, and are attached to the bottom.

Marl:

White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) in hard water lakes. Marl may contain many snail and clam shells, which are also calcium carbonate. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Mesotrophic:

Mesotrophic lakes lie between the oligotrophic and eutrophic trophic stages. In late summer, they lose oxygen at depth, limiting cold water fish and causing phosphorus release from sediments.

*Terms in bold, see glossary pp 13-17

mg/L:

see "Concentration units"

Nitrate (NO_3^-):

An inorganic form of nitrogen important for plant growth. Nitrogen is in this stable form when oxygen is present. Nitrate often contaminates groundwater when water originates from manure pits, fertilized fields, lawns or septic systems. High levels of nitrate-nitrogen (over 10 mg/L) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO_3-N) plus ammonium-nitrogen (NH_4-N) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

Nitrite (NO_2^-):

A form of nitrogen that rapidly converts to nitrate (NO_3^-) and is usually included in the NO_3^- analysis.

Nitrogen:

A chemical element that is an essential plant nutrient and may occur in the form of nitrate, nitrite, ammonium, or organic nitrogen in lakes.

Oligotrophic:

A trophic state in which lakes are generally clear, deep and free of weeds or large algae blooms. Though beautiful, they are low in nutrients and do not support large fish populations. However, oligotrophic lakes often develop a food chain capable of sustaining a very desirable fishery of large game fish.

Phosphorus:

Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

Photosynthesis:

The process by which green plants convert carbon dioxide (CO_2) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base, and is an important source of oxygen for many lakes.

Potassium:

A chemical element that is an essential plant nutrient and may enter lakes from runoff of agricultural fertilizers and animal wastes.

Retention Time: (Turnover Rate or Flushing Rate)

The average length of time water resides in a lake, ranging from several days in small impoundments to many years in large seepage lakes. Retention time is important in determining the impact of nutrient inputs. Long retention times result in recycling and greater nutrient retention in most lakes. Calculate retention time by dividing the volume of water passing through the lake per year by the lake volume.

Rip Rap (Rip-Rap):

Hard rock, commonly granite or concrete rubble recycled from construction sites, used inland on lakes, rivers, coastlines, and other waterways to prevent bank erosion. Generally rip rap is not considered good management in lakes, due to its inability to provide adequate habitat, and is no longer commonly used.

Rooted Aquatic Plants: (Macrophytes)

Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

*Terms in bold, see glossary pp 13-17

Secchi Disc (Secchi Disk):

An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration). The disc is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. For best results, the readings should be taken on sunny, calm days.

Sedimentation:

Accumulated organic and inorganic matter on the lake bottom. Sediment includes decaying algae and weeds, marl, and soil and organic matter eroded from the lake's watershed.

Seepage Lakes:

Lakes without a significant inlet or outlet, fed by rainfall and groundwater. Seepage lakes lose water through evaporation and groundwater moving on a down gradient. Lakes with little groundwater inflow tend to be naturally acidic and most susceptible to the effects of acid rain. Seepage lakes often have long retention times, and lake levels fluctuate with local groundwater levels. Water quality is affected by groundwater quality and the use of land on the shoreline.

Sodium:

A chemical element that may enter lakes from runoff of road salt, fertilizers, and human and animal wastes.

Soft Water:

Water with less than 60 mg/L CaCO3 (see Hard water).

Stratification, Stratified:

The layering of water due to differences in density. Water's greatest density occurs at 39^{o}F (4^{o}C). As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 ft. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion or thermocline.

Sulfate (SO_4^{--}):

The most common form of sulfur in natural waters. The amounts relate primarily to soil minerals in the watershed. Sulfate (SO_4^{--}) can be reduced to sulfide (S^{--}) and hydrogen sulfide (H_2S) under low or zero oxygen conditions. Hydrogen sulfide smells like rotten eggs and harms fish. Sulfate input from acid rain is a major indicator of sulfur dioxide (SO_2) air pollution. Sulfate concentration is used as a chemical fingerprint to distinguish acid lakes acidified by acid rain from those acidified by organic acids from bogs.

Substrate:

The material found at the bottom of a lake, such as silt, mud, sand, clay, marl, gravel, etc.

Suspended Solids:

A measure of the particulate matter in a water sample, expressed in milligrams per liter. When measured on inflowing streams, it can be used to estimate the sedimentation rate of lakes or impoundments.

Turbidity:

The “cloudiness” or “murkiness” of water, caused by total suspended solids.

Vascular Plants:

Vascular plants are those plants that have tissues for conducting water, minerals, and food through the plant. Vascular plants include the ferns, clubmosses, flowering plants, and conifers.

Watershed:

The total land area that drains either surface water or groundwater toward a lake.

*Terms in bold, see glossary pp 13-17