This file contains:

1. **Arrowhead Lake - Aquatic Plant Report with Management Recommendations (2014)**
2. **Tri-Lakes Management Plan Table (2015)**

EXECUTIVE SUMMARY

Aquatic plant surveys have been conducted on Arrowhead Lake several times over the past fifteen years. An updated transect aquatic macrophyte (plants) transect (line intercept) field study of Arrowhead Lake was conducted during July 2014 by a staff member of the Adams County Land & Water Conservation Department and employees of the Tri-Lakes Management District. Prior surveys were conducted in 2000, 2006, 2007, and 2009-2010.

Arrowhead Lake, a 300-acre impoundment, is located in the Town of Rome, Adams County, Wisconsin. It is the last in a series of impoundments that impound Fourteen-Mile Creek, as well as a couple of tributaries to that creek. Fourteen-Mile Creek empties into the Wisconsin River. There is a public boat ramp and a public swimming beach located on southwest side of the lake owned by The Adams County Parks Department. There are also private beaches and boat launches around the lake reserved for use by lake property owners. The lake opened in 1981.

The parameters of total phosphorus, chlorophyll-a, and water clarity are used world-wide to evaluate the trophic (nutrient) status of lakes. Testing results for Arrowhead Lake place it squarely in the "mesotrophic" range, with average total phosphorus of 31.4 micrograms/liter, average chlorophyll-a at 13.4 micrograms/liter, and average water clarity readings for 7.3 feet. In 2014, the lake was placed on the federal impaired waters list. Arrowhead Lake scores as "mesotrophic" in the three general parameters often used to gauge lake water health. With its phosphorus readings and chlorophyll a readings, moderate plant growth and occasional algal blooms would be expected.

Of the 50 species found in Arrowhead Lake in 2014, 46 were native and 4 were exotic invasives. In the native plant category, 31 were emergent, 3 were free-floating

plants, 1 was a rooted floating-leaf plant, and 11 were submergent species. Four non-native invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil), *Phalaris arundinacea* (Reed Canarygrass), *Potamogeton crispus* (Curly-Leaf Pondweed) and *Typha angustifolia* (Narrow-Leaved Cattail) were found.

Ceratophyllum demersum (Coontail) was the most frequently-occurring plant in Arrowhead Lake in 2014. Close behind in occurrence frequency were *Zosterella dubia* (Water Stargrass) and *Myriophyllum sibiricum* (Northern Milfoil). Based on dominance value, Coontail was the dominant aquatic plant species in Arrowhead Lake in 2014, but Water Stargrass was very close behind. Also occurring abundantly were Opposite Stonewort, Northern Milfoil, Small Pondweed, and Flat-Stemmed Pondweed.

Using the PI surveys done in 2010 and 2014, the frequency of occurrence index showed the plant communities were 77.6% similar; the relative frequency occurrence index was 78.1%. These figures suggest that although some of the aquatic plant species found have changed, to the extent that the aquatic plant community and water quality results mirror the health of Arrowhead Lake, Arrowhead Lake has remained relatively stable for at least the past 10 years.

The structure of the aquatic plant communities has changed somewhat. Whereas in 2000, over 90% of the aquatic plant community was submergent plants, the relative frequency of emergent plants has been increasing. The Average Coefficient of Conservatism of the aquatic plant community in Arrowhead Lake is in the lowest quartile for Wisconsin lakes and for lakes in the North Central Hardwood region, but the lake has a slightly above average Floristic Quality Index. The AMCI is at the top of average range for both North Central Hardwood Region and all Wisconsin lakes, indicating an aquatic plant community of average quality.

MANAGEMENT RECOMMENDATIONS

1) The Arrowhead Lake Association's Conservation Committee has been working steadily to have all the lake's shores in compliance with the Adams County Shoreland Ordinance, so that vegetated buffers are installed. This should continue.

2) The Association should also continue its monitoring even after the buffers installations appear to be completed. A review in the summer of 2014 showed that some buffers that had previously been installed were being mowed more than the percentage allowed for access corridors. Continued reinforcement of the message will apparently be needed for a few years.

3) Since 2010, the Association has been working with the Adams County Land & Water Conservation Department to restore several severely eroded points that it owns. There are still a few to be addressed. This should be done as soon as possible, since some include treefalls where there are large exposed sections of sloughing, loose bare soil.

4) Because aquatic vegetation is used by fish for a number of purposes (cover, feeding, spawning, etc), continued harvesting to open fishing lanes should continue in these areas. Removal should occur by hand in the shallower areas to be sure that entire plants are removed and to minimize the amount of disturbance to the sediment.

5) The Tri-Lakes Management District and the Arrowhead Lake Association should continue to cooperate with the WDNR to monitor and, if possible, control the zebra mussel infestation in the lake to protect the aquatic plant community.

6) Stormwater management of the many impervious surfaces around the lake is essential to maintain the current quality of the lake water and prevent further degradation. There are several areas of steep banks where runoff may be an issue, especially in the early spring where snow is beginning to melt but some of the ground is still frozen.

7) No chemicals should be used on properties around the lake. If they must be used, they should be used no closer than 50 feet to the shore. This recommendation is not limited to fertilizer, but also includes weed killer, large insecticide sprays, etc.

8) The lake management plan, including the aquatic plant management section, should continue to be reviewed annually and updated or altered as needed.

9) Aquatic plant surveys should be repeated every 3 to 5 years to monitor lake health and identify any changes in the aquatic plant community.

10) Due to the continued presence of EWM, alternate methods of addressing EWM growth need to be developed and pursued. The aquatic plant management plan also needs to address managing the Curly-Leaf Pondweed growth.

11) The Tri-Lakes Management District may want to continue to apply for grants from the Wisconsin Department of Natural Resources to help defray the cost of aquatic plant management. However, since these funds are becoming more limited, it is recommended that the Management District should consider setting aside a sum each year to build a "fund" to carry out management should grants become unavailable.

12) No broad-scale chemical treatments of native aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and decreased dissolved oxygen and opening up more areas to the spread of EWM and colonization by other aquatic invasvies.

13) Fallen trees should be left at the shoreline or in the water to increase shore area habitat. Consultation with the WDNR Fisheries Biologist is recommended to determine if the current habitat conditions are appropriate for the desired fish community.

14) The Tri-Lakes Management District should continue involvement in water quality and invasive species monitoring through the Citizen Lake Monitoring Program, the Clean Boats, Clean Waters program and grants for AIS management. Volunteers should be recruited and trained to cover such monitoring in case grants become unavailable.

15) Regular educational efforts directed at Arrowhead Lake residents and users to encourage them to identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs. Nutrients appear to have increased within the lake, so residents must take steps to reduce their nutrient inputs.

16) No drawdowns of water level except for DNR-approved purposes should occur.

17) The few sites where there is undisturbed shore, mostly in designated conservancy areas, should be maintained and left undisturbed.

18) Cooperation with the Adams County Parks Department in keeping the boat ramp and swimming beach in safe condition should help reduce any negative impacts caused by the heavy use of these public areas. A boat washing station at the park ramp area may help in decreasing other invasives from invading the lake.

19) The Tri-Lakes Lake Management plan has long included having an on-the-ground survey of the watersheds, but this has not occurred. In 2013, such a survey was done on most of the Big Roche a Cri Watershed, the watershed just below 14-Mile Creek. That survey revealed that there were many problem areas of runoff, sloughing banks, and erosion. Since similar conditions occur in the 14-Mile-Creek Watershed, completing the survey is very important to identify problem areas and, hopefully, address them in the near future, as they may be contributing to water quality problems in the Tri-Lakes.

THE AQUATIC PLANT COMMUNITY FOR ARROWHEAD LAKE
ADAMS COUNTY 2000-2014

I. INTRODUCTION

An updated modified Point Intercept (PI) aquatic macrophyte (plants) field study of Arrowhead Lake was conducted during July 2014 by a staff member of the Adams County Land & Water Conservation Department and employees of the Tri-Lakes Management District. Prior surveys were conducted in 2000, 2006, 2007, and 2009--2010.

Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). These studies will provide updated information to be used for effective management of Arrowhead Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. The data will be compared to the prior study results and also used for future studies, offering insight into any changes within the lake.

Ecological Role: Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

Characterization of Water Quality: Aquatic plants can serve as indicators of water quality because of their sensitivity to water quality parameters such as clarity and nutrient levels (Dennison et al, 1993).

Testing has shown that Arrowhead Lake has hard water. The average hardness reading for the last 20 years in Arrowhead Lake is 162 milligrams/liter of Calcium Carbonate. Lake water pH has ranged from 6.4 to 8.16. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes.

Background and History:

Arrowhead Lake is located in the Town of Rome, Adams County, Wisconsin. The impoundment is 300 surface acres in size. The lake is the last in a series of lakes, with Upper and Lower Camelot Lakes the farthest east, then Sherwood Lake in the middle of the Camelots and Arrowhead. The series of dams impound Fourteen-Mile Creek, as well as a couple of tributaries to that creek. Eventually, Fourteen-Mile Creek empties into the Wisconsin River. There is a public boat ramp and a public swimming beach located on southwest side of the lake owned by The Adams County Parks Department. There are also private beaches and boat launches around the lake reserved for use by lake property owners. The lake opened in 1981.

Arrowhead Lake is accessible off of State Highway 13 by turning west onto either Apache Avenue, then north on 15th Avenue, or turning west on County D, then south onto 15th Ave. Heavy residential development around the lake is found along most of the lakeshore. The surface watershed is 39.9% residential; 30.1% woodlands; 11.7% outdoor recreation (mostly golf courses); 9.8% water; 4.9% industrial/commercial/governmental; and 3.7% open grassland. The ground watershed, which extends into Waushara County, has much irrigated and non-

irrigated agriculture, except near the lakes. There are endangered or threatened resources in the watershed which include the Karner Blue Butterfly, the Persius Dusky Wing Butterfly; the Red-Shouldered Hawk; and the natural communities of northern sedge meadow and shrub-carr. There are no reported archeological or historical sites in the Arrowhead Lake surface watershed.

A fishery inventory in October 2004 revealed that walleye and largemouth bass are abundant in Arrowhead Lake; bluegills and white suckers are common; yellow perch and northern pike are scarce. Some fish stocking and installation of fish cribs have occurred since then.

Soils in the Arrowhead Lake surface watershed are sands of various slopes. Such soils tend to be excessively-drained, with infiltration of water being rapid to very rapid, and permeability also high. They also usually have low water-holding and low organic matter content, thus making them difficult to for vegetation establishment. These soils tend to be easily eroded by both water and wind.

Efforts at controlling aquatic plant growth have included both chemical treatments and mechanical harvesting. In the most recent years, these efforts have concentrated on mechanical harvesting and some hand-pulling. No chemicals have been used since 2000. Mechanical harvesting of aquatic plants in Arrowhead Lake started in 1995 and has continued through 2014. Plant samples are taken annually to a laboratory to be tested for the amount of phosphorus in milligrams per kilogram of aquatic plants. Figure 1 shows the approximate weight of aquatic vegetation removed from Arrowhead Lake from 1995 through 2014, including the amount of phosphorus removal.

FIGURE 1: MECHANICAL HARVESTING SUMMARY

	Pounds Removed	Pounds TP Removed
2005	135,000	28.2
2006	418,700	126.1
2007	1,386,000	109.3
2008	593,700	154.4
2000	497,200	118.1
2010	798,200	153.3
2011	356,250	132.7
2012	825,100	105.1
2013	393,400	59.4
2014	328,500	40.8
total	5,732,050	1027.4

An aquatic plant survey was conducted by Wisconsin Department of Natural Resources staff in 2000. A follow-up aquatic plant survey was conducted by Adams County Land & Water Conservation Department in 2006. In 2007, an aquatic plant survey was conducted on Arrowhead Lake as part of the Environmental Protection Agency's national lake survey. The aquatic plants were again surveyed in 2009-2010 by staff from the Adams County Land & Water Conservation Department and Tri-Lakes Management District.

In 2004, zebra mussels (*Dreissena polymorpha)* were found in Arrowhead Lake. The process of evaluating the level of infestation is still ongoing. Adams County has had divers examine the underwater dam structures, looking for zebra mussel accumulations. Plates are hung in various portions of the lake. Many of the submerged plants in Arrowhead Lake collected in 2009 and 2014 were heavily covered with zebra mussels. Zebra mussel shells wash up along the shore in Arrowhead Lake in most part of the lake.

Other aquatic invasives know in or around Arrowhead Lake include Chinese Mystery Snails (*Cipangopaludina chinensis),* Eurasian Watermilfoil (*Myriophyllum spicatum),* Reed Canarygrass (*Phalaris arundinacea),* and Curly-Leaf Pondweed (*Potamogeton crispus).*

II. METHODS

Field Methods

Surveys in 2000, 2006 and 2009 were all performed with methods based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 32 equal sections, with one transect placed randomly within each segment, perpendicular to the shoreline. The same transects were used for all three studies. Surveys in 2007, 2009-2010, and 2014 were conducted using the Point Intercept (PI) method. The original grid developed by the WDNR in Madison was modified by the WDNR in 2010 to capture aquatic plants in the shallows near shore.

The PI method involves calculating the surface area of a lake and dividing it (using a formula developed by the WDNR) into a grid of several points, always placed at the same interval from the next one(s). These points are related to a particular latitude and longitude reading. At each geographic point, the depth is noted and one rake is taken, with a score given between 1 and 3 to each species on the rake.

A rating of 1 = a small amount present on the rake;
A rating of 2 = moderate amount present on the rake;
A rating of 3 = large amount present on the rake.

A visual inspection was done between points to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording plants found.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. Relative frequency (number of species occurrences/total of all species occurrences) was also calculated. The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. Relative density (sum of species' density/total plant density) was also calculated. Where appropriate, "Mean density where present "(sum of species' density rating/number of sampling sites at which the species occurred) was calculated. Relative frequency and relative density results were summed to obtain a dominance value. Species diversity was measured by Simpson's Diversity Index.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of Conservatism is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservatism is the mean of the coefficients for the species found in the lake. The coefficient of conservatism is used to calculate the Floristic Quality Index, a measure of a plant community's closeness to an undisturbed condition.

To measure the quality of the plant community, an Aquatic Macrophyte Index was determined using the method developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated;

Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57.

III. RESULTS

Physical Data

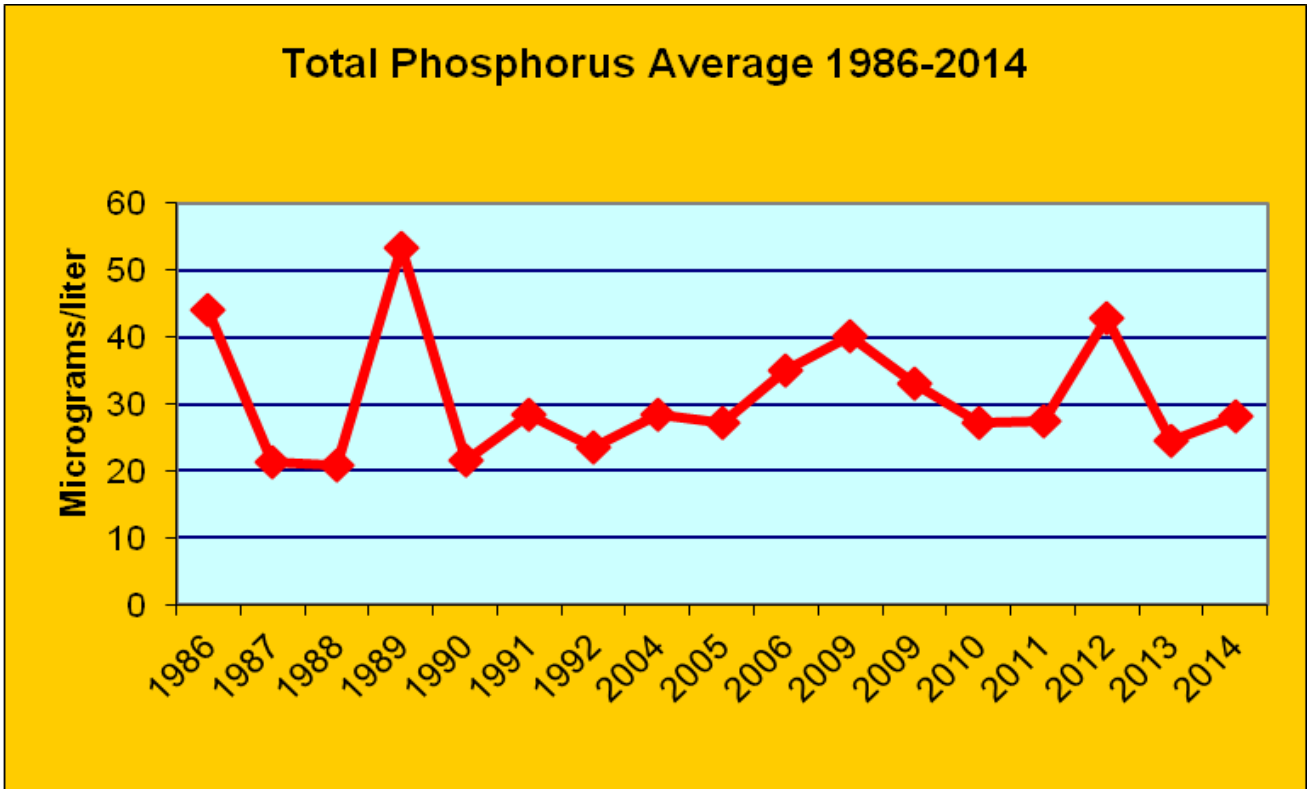
The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these boundaries. Lake morphology, sediment composition and shoreline use also affect the plant community. In addition, annual weather variations can also affect the aquatic plant community.

The trophic state of a lake is a classification of water quality. Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. Eutrophic lakes are very productive, with high nutrient levels and large biomass presence. Oligotrophic lakes are those low in nutrients with limited plant growth and small fisheries. Mesotrophic lakes are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

The limiting factor in most Wisconsin lakes, including Arrowhead Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 2004-2014 summer growing season

average total phosphorus concentration in Arrowhead Lake was 31.4 micrograms/liter (fair). This figure is considerably below the average impoundment total phosphorus level of 65 micrograms/liter and also below standard set for impaired waters of 40 micrograms/liter (Arrowhead Lake was placed on the federal impaired waterways list in 2014). This concentration suggests that Arrowhead Lake is likely to have some nuisance algal blooms, but not as frequently as many impoundments, and probably localized, rather than whole lake blooms. This places Arrowhead Lake in the "fair" water quality section for impoundments, and in the "mesotrophic" level for phosphorus.

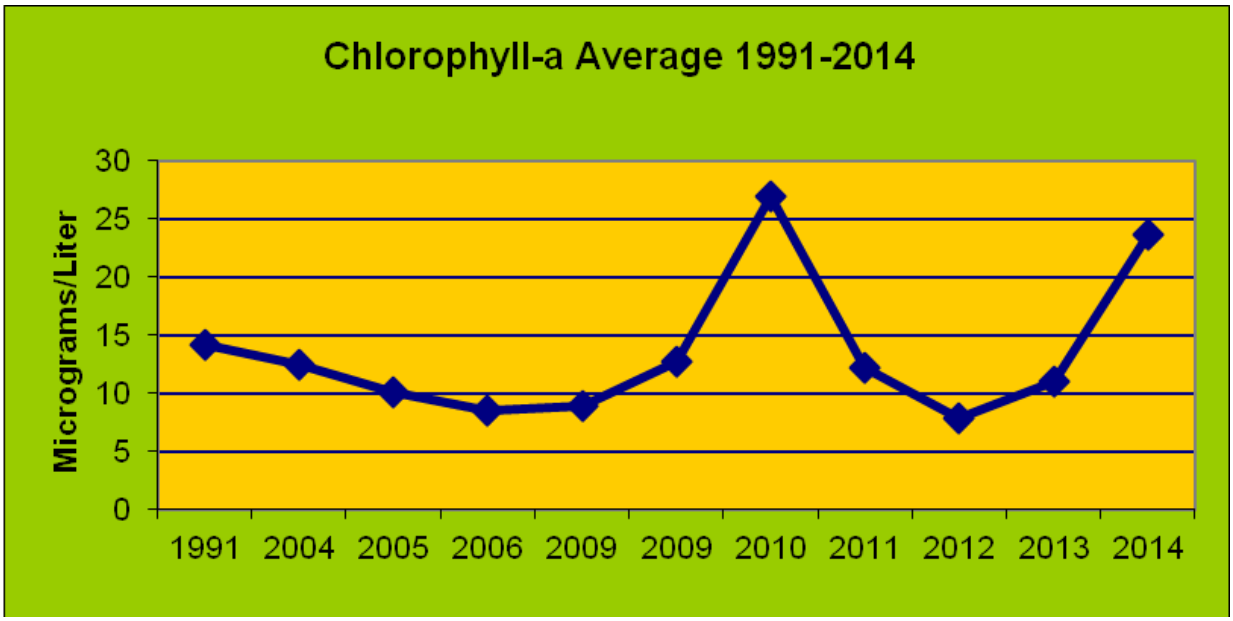
Figure 2: Total Phosphorus Averages in Arrowhead Lake



Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. The 2004-2014

summer growing season average chlorophyll-a concentration in Arrowhead Lake was 13.4 micrograms/liter. This chlorophyll-a level places Arrowhead Lake at the "fair" level for chlorophyll-a.

Figure 3: Average Chlorophyll-a Levels in Arrowhead Lake

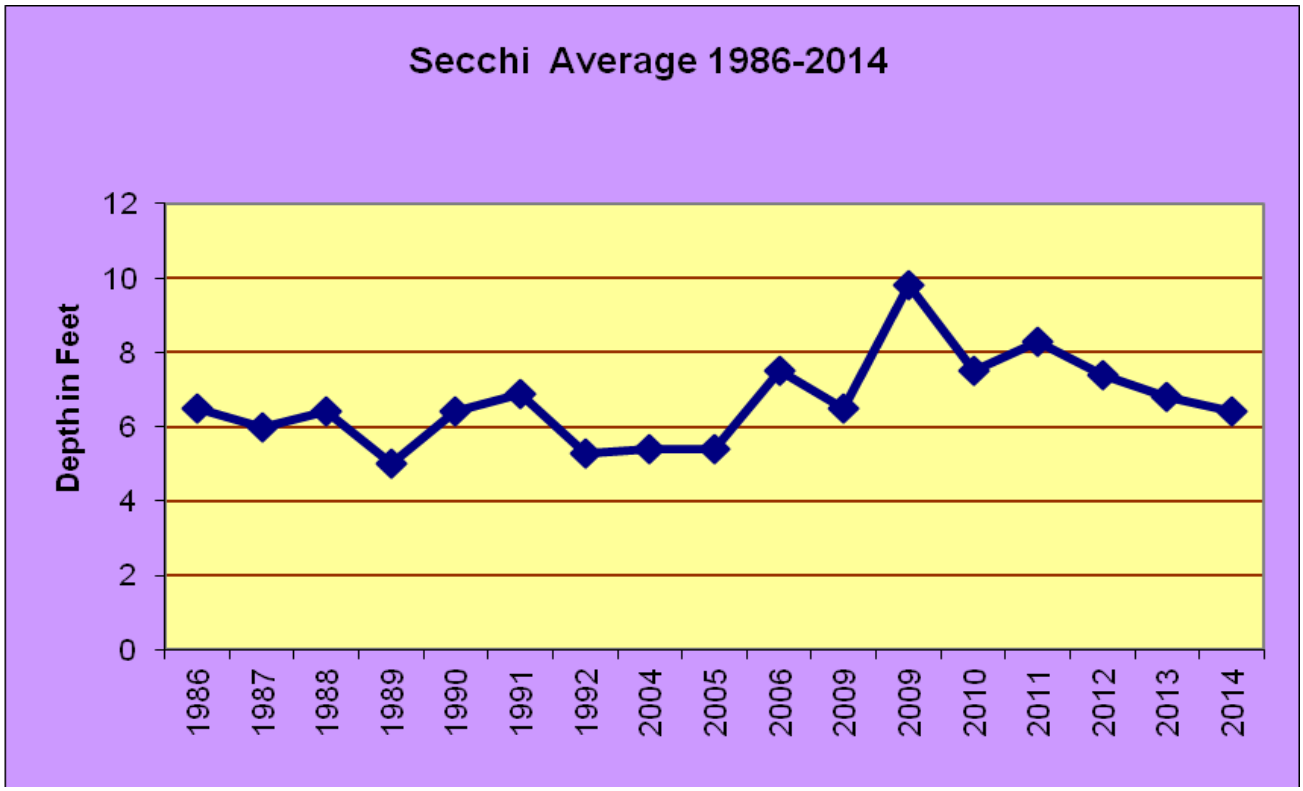


Water clarity is a critical factor for plants. If aquatic plants receive less than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. The average summer Secchi disk clarity in Arrowhead Lake from 2004 50 2014 was 7.1 feet. This is fair water clarity, putting Arrowhead Lake into the "fair" category for water clarity.

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early

summer, than decline as late summer and fall progress. Chlorophyll-a often rises in level as the water warms, then declines as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, improving as fall approaches.

Figure 4: Average Water Clarity in Arrowhead Lake



According to these results, Arrowhead Lake scores as "mesotrophic" in the three general parameters often used to gauge lake water health. With such water clarity, total phosphorus readings and chlorophyll a-readings, moderate plant growth and occasional algal blooms would be expected.

Figure 5: Trophic States—Average of Last 10 Years

Trophic State	Quality Index	Phosphorus (ug/ml)	Chlorophyll-a (ug/ml)	Sechhi Disk (ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	10 to 30	5 to 10	**6 to 8**
	Fair	**30 to 50**	**10 to 15**	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Arrowhead Lake		**31.4**	**13.4**	**7.3**

Lake Morphology

Lake morphology can be an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep slopes (Engel 1985).

Arrowhead Lake is a narrow lake that lies at the end of a series of lakes that are originally fed by a very large, multi-county multi-stream system. Much of the lake is shallow, although there are some areas of steeper drop-offs within the lake near the dam. Most of the slopes in the lake away from the dam area are fairly gentle slopes. With good water clarity, gentler slopes, and shallow depths, plant growth may be favored in much of Arrowhead Lake, since the sun reaches much of the sediment to stimulate plant growth.

Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and

abundance of macrophyte species that can survive in a particular location. Most of the sediment in Arrowhead Lake is hard (sand), with little natural fertility and low available water holding capacity. Although such sediment may limit growth, most hard sediment sites in Arrowhead Lake were vegetated. Nearly 68% of the sample sites visited in 2014 were vegetated in Arrowhead Lake, regardless of the sediment type. Many shallow sites without vegetation appeared to have been hand-harvested.

Shoreline Land Use

Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

Since about 2010, the Lake Arrowhead Association has made a concerted effort to encourage, even require, shores to be well-buffered. The Association actually owns the first one-hundred feet landward of the water-land intercept, but they have worked with the landowners behind that area to maintain the vegetation and reduce runoff into the lake. Some landowners are still mowing too close to the water across their waterfront, more than the access corridor allowed.

Macrophyte Data

Figure 6: Plants Found in Arrowhead Lake 2000-2014

		2001 (T)	2006(T)	2010 (T)	2010 (PI)	2014(PI)
Asclepis incarnata	Swamp Milkweed			x	x	x
Aster lanceolatus	White Panicle Aster			x		
Bidens frondosus	Common Beggar's Tick			x		
Bidens trichosperma	Tall Swamp Marigold			x		
Boehmeria cylindrica	Small Spike False Nettle				x	
Calamagrostis canadensis	Blue-Joint Grass			x		

Carex spp	Sedge	*x*		x	x	x
Carex aquatilis	Long-Brachted Tussock Sedge					x
Carex comosa	Bristly Sedge			x		x
Ceratophyllum demersum	Coontail	*x*	x	x	x	x
Chara contraria	Opposite Stonewort	*x*	x	x	x	x
Chelone glabra	Turtlehead				x	
Cicuta bulbifera	Bulb-Bearing Water Hemlock			x	x	x
Cinna arundinacerum	Common Wood Reed					x
Cirsium muticum	Swamp Thistle					x
Cornus amomum	Silky Dogwood			x	x	x
Cornus racemosa	Round-Leaved Dogwood			x	x	
Cyperus bipartitus	Shining Flat Sedge				x	
Cyperus strigosus	False Nut Sedge				x	x
Decodon verticillatum	Swamp Loosestrife		x			
Eleocharis acicularis	Creeping Spikerush		x			
Eleocharis palustris	Common Spikerush				x	x
Elodea canadensis	Common Waterweed	*x*	x	x	x	x
Elymus canadensis	Canada Wild Rye			x		
Epilobium leptophyllum	Bog Willow Herb				x	
Equisetum hyemale	Souring Rush			x	x	
Eupatorium maculatum	Spotted Joe Pye Weed					x
Eupatorium perfoliatum	Boneset				x	x
Euthamia graminifolia	Grass-Leaved Goldenrod				x	
Gentiana andrewsii	Bottle Gentian			x		
Hypericum perfolatum	Common St John's Wort			x		
Ilex verticillata	Common Winterberry				x	
Impatiens capensis	Jewelweed			x	x	x
Iris versicolor	Blue-Flag Iris		x		x	x
Leersia oryzoides	Rice-Cut Grass			x		
Lemna minor	Lesser Duckweed	*x*	x	x	x	x
Lycopus americanus	American Bugleweed			x	x	x
Lycopus uniflorus	Northern Bugleweed				x	x
Myriophyllum heterophyllum	Various-Leaved Milfoil			x	x	x
Myriophyllum sibiricum	Northern Milfoil	*x*	x	x	x	x
Myriophyllum spicatum	Eurasian Watermilfoil	*x*	x	x	x	x
Najas flexlis	Bushy Pondweed	*x*	x	x	x	x
Oenothera biennis	Common Evening Primrose					x
Onoclea sensibilis	Sensitive Fern		x	x	x	x
Phalaris arundinacea	Reed Canarygrass	*x*	x	x	x	x
Physostegia virgianiana	False Dragonhead					x
Potamogeton crispus	Curly-Leaf Pondweed	*x*	x	x	x	x
Potamogeton foliosus	Leafy Pondweed	*x*	x			
Potamogeton gramineus	Varible-Leaved Pondweed			x		
Potamogeton illinoensis	Illinois Pondweed			x		
Potamogeton nodosus	Long-Leaf Pondweed		x	x	x	x

Potamogeton pusillua	Small Pondweed	*x*	x	x	x	x
Potamogeton zosteriformis	Flat-Stemmed Pondweed	*x*	x	x	x	x
Prunella vulgaris	Heal-All				x	x
Ranunculus aquatilis	White Water Crowfoot	*x*	x		x	
Rumex cripus	Curly Dock			x		x
Rumex orbiculatus	Greater Water Dock			x		
Sagittaria latifolia	Common Arrowhead		x	x	x	x
Salix exigua	Sandbar Willow	*x*		x	x	x
Salix petiolaris	Meadow Willow					x
Sambucus canadensis	Elderberry					x
Schoenoplectus tabernaemontani	Soft-Stemmed Bulrush		x	x	x	x
Scirpus atrovirens	Black Bulrush					x
Scirpus cyperinus	Woolgrass				x	x
Scuterllaria laterifolia	Mad-Dog Skullcap					x
Silphium terebinthinaceum	Prairie Rosinweed			x		
Solanum dulcamara	Deadly Nightshade				x	
Solidago nemoralis	Field Goldenrod			x		
Sparganium emersum	Narrow-Leaved Burreed					x
Spirodela polyrhiza	Greater Duckweed	*x*	x	x	x	x
Stuckenia pectinata	Sago Pondweed	*x*	x	x	x	x
Typha angustifolia	Narrow-Leaved Cattail	*x*	x	x	x	x
Vallisneria americana	Water Celery	*x*	x	x	x	x
Verbena hastata	Blue Vervain			x	x	x
Wolffia columbiana	Common Watermeal	*x*	x	x	x	x
Zosterella dubia	Water Stargrass	*x*	x	x	x	x

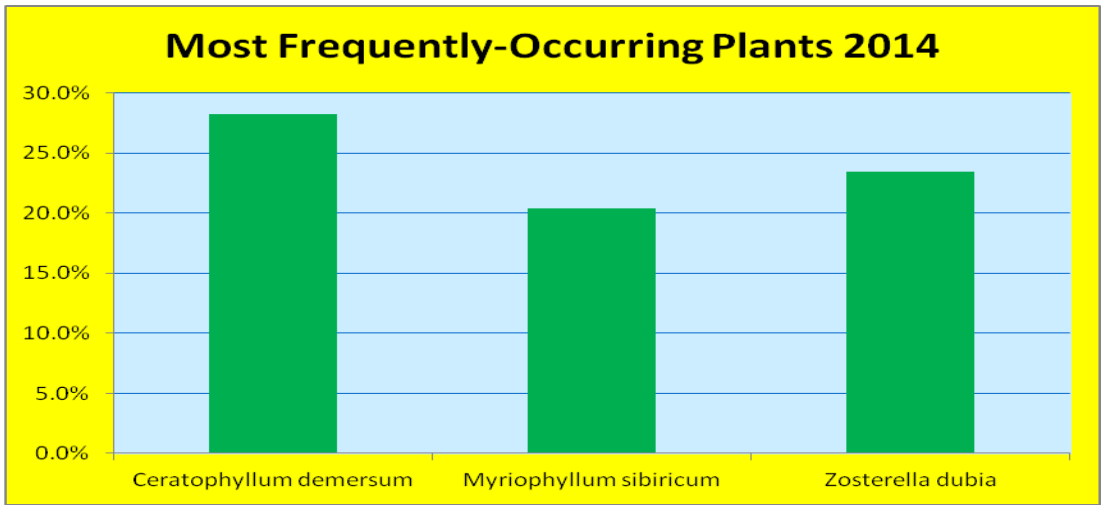
SPECIES PRESENT-2014

Of the 50 species found in Arrowhead Lake in 2014, 46 were native and 4 were non-native invasives. In the native plant category, 31 were emergent, 3 were free-floating plants, 1 was a rooted floating-leaf plant, and 11 were submergent species. Four non-native invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil), *Phalaris arundinacea* (Reed Canarygrass), *Potamogeton crispus* (Curly-Leaf Pondweed) and *Typha angustifolia* (Narrow-Leaved Cattail) were found.

FREQUENCY OF OCCURRENCE

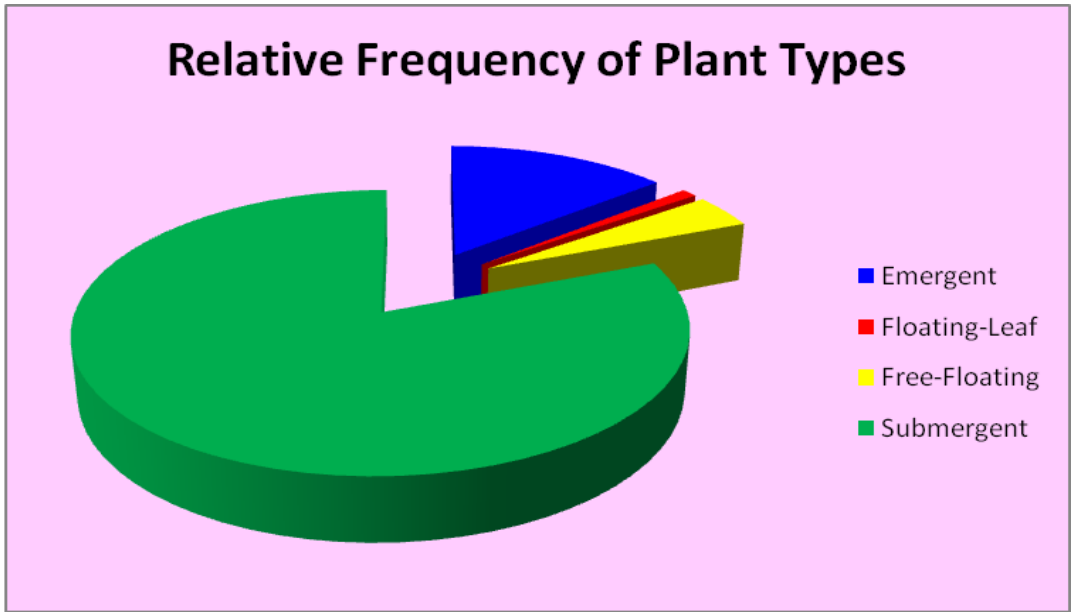
Ceratophyllum demersum (Coontail) was the most frequently-occurring plant in Arrowhead Lake in 2014. Close behind in occurrence frequency were *Zosterella dubia* (Water Stargrass) and *Myriophyllum sibiricum* (Northern Milfoil).

Figure 7: Most Frequently-Occurring Plant Species 2014



Arrowhead Lake continues to be dominated by submergent plants. However, emergent plants have been gaining in occurrence frequency since 2000 and are extremely important in buffering the soft sandy shores from wave action and erosion.

Figure 8: Relative Frequency of Occurrence by Plant Type 2014



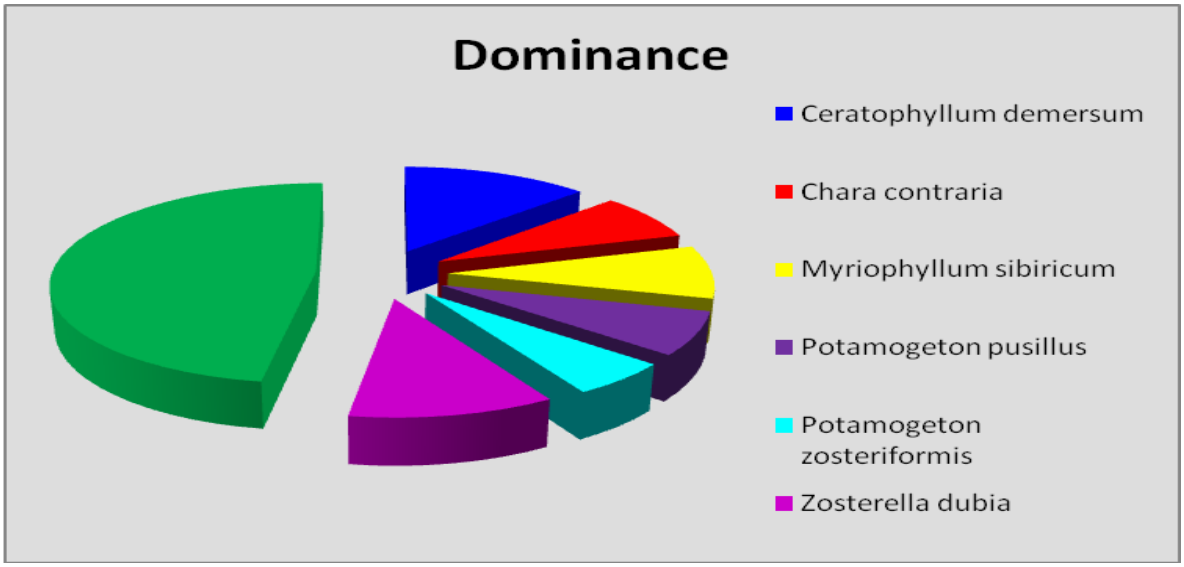
DENSITY OF OCCURRENCE

In the lake overall, none of the aquatic vegetation occurred at more than average growth density. Most of the aquatic species grew at fairly low densities. There were some localized dense patches, but no overall high density growth. The same pattern followed when survey results were examined for density where present. This figure looks not at how dense the plant growth is over all the lake, but how densely it occurs at the sites where it is found.

DOMINANCE

Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance value, Coontail was the dominant aquatic plant species in Arrowhead Lake in 2014, but Water Stargrass was very close behind. Also occurring abundantly were Opposite Stonewort, Northern Milfoil, Small Pondweed, and Flat-Stemmed Pondweed.

Figure 9: Dominance in 2014



DISTRIBUTION

Aquatic plants occurred at 67.5% of the sample sites in Arrowhead Lake to a maximum rooting depth of 18 feet in 2014. The following maps outline the distribution of various types of aquatic species in 2014.

Figure 10: Distribution of Emergent Plants 2014 (in blue)

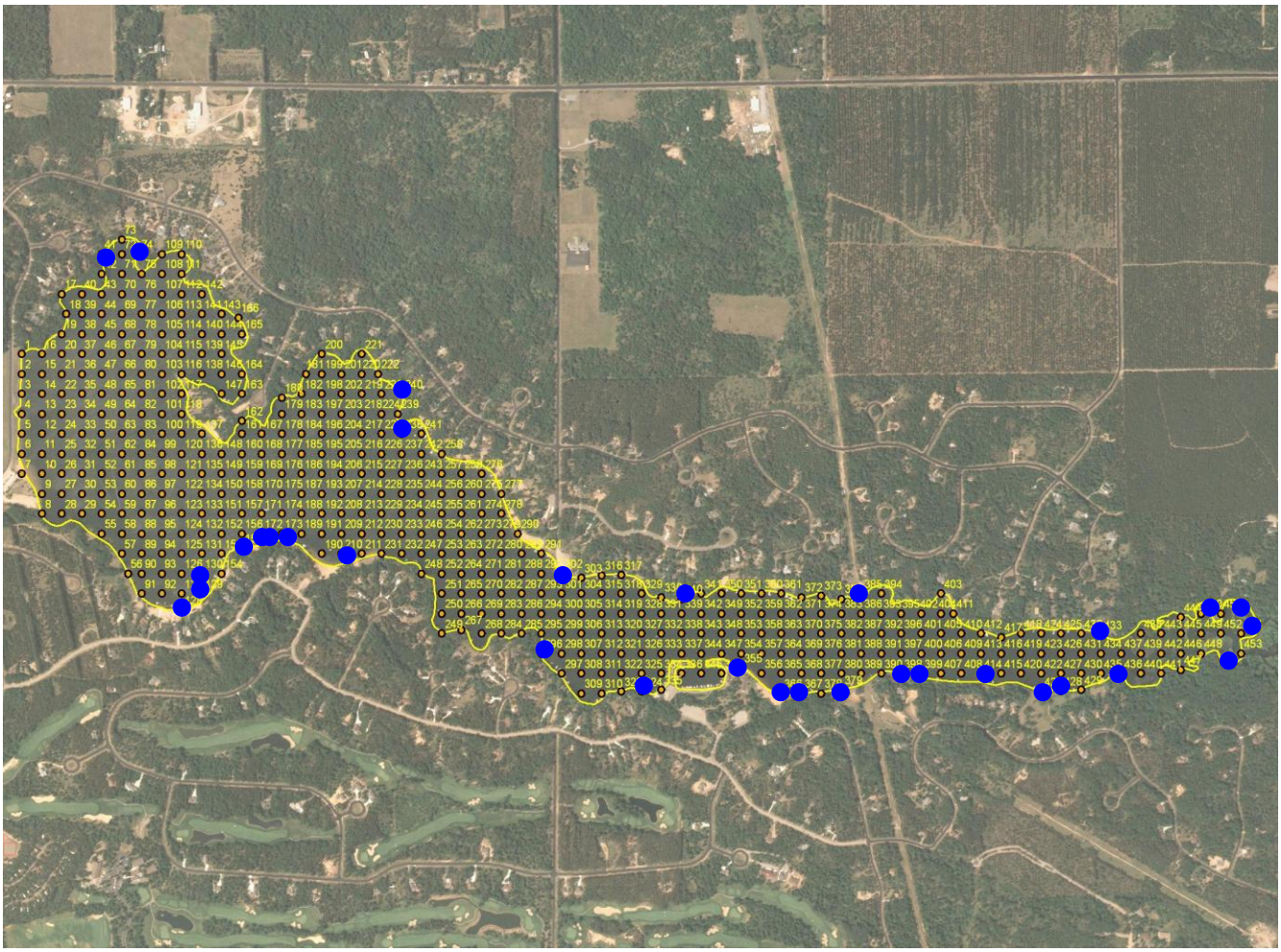


Figure 11: Distribution of Free-Floating & Floating-Leaf Plants 2014

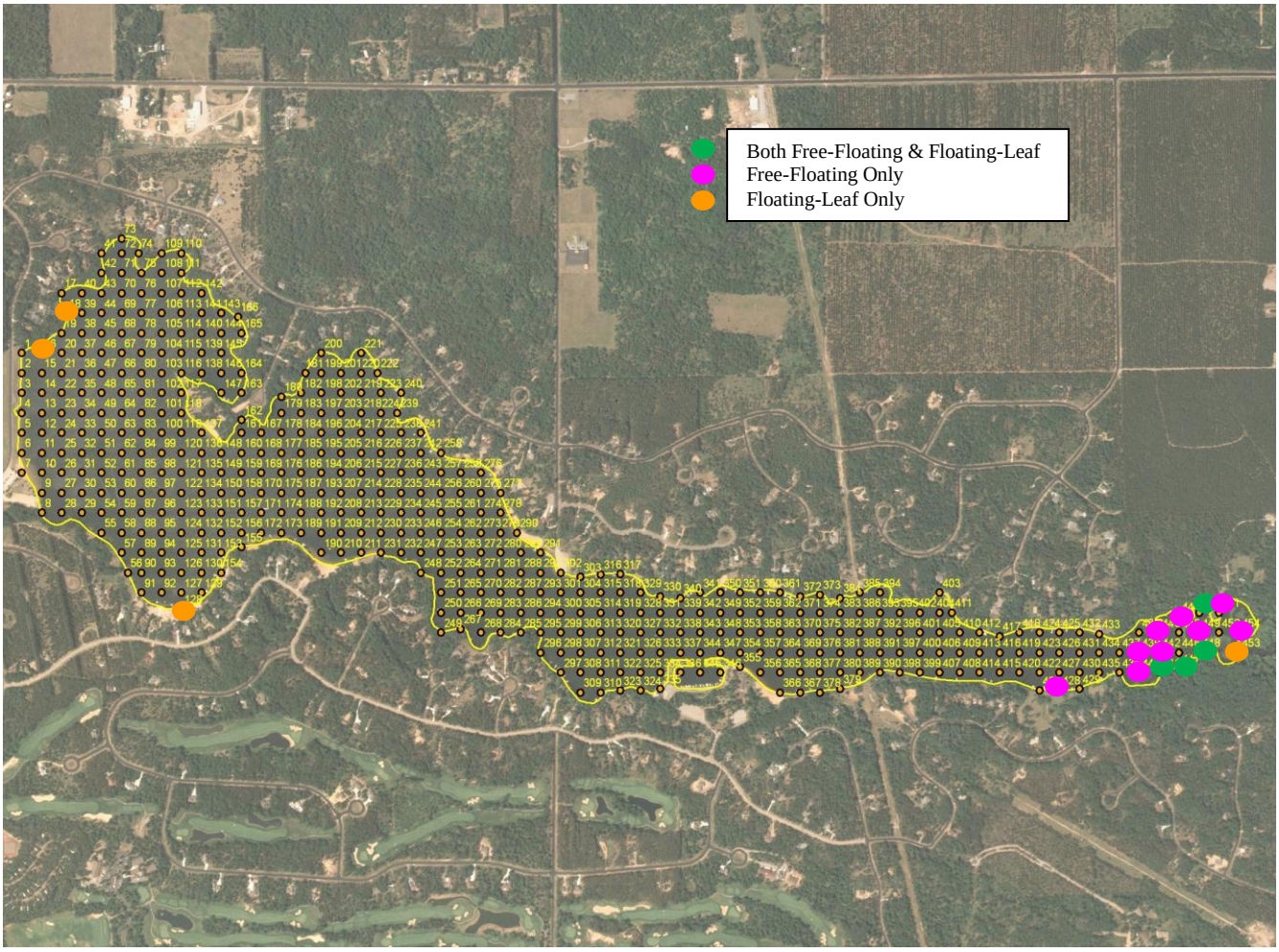
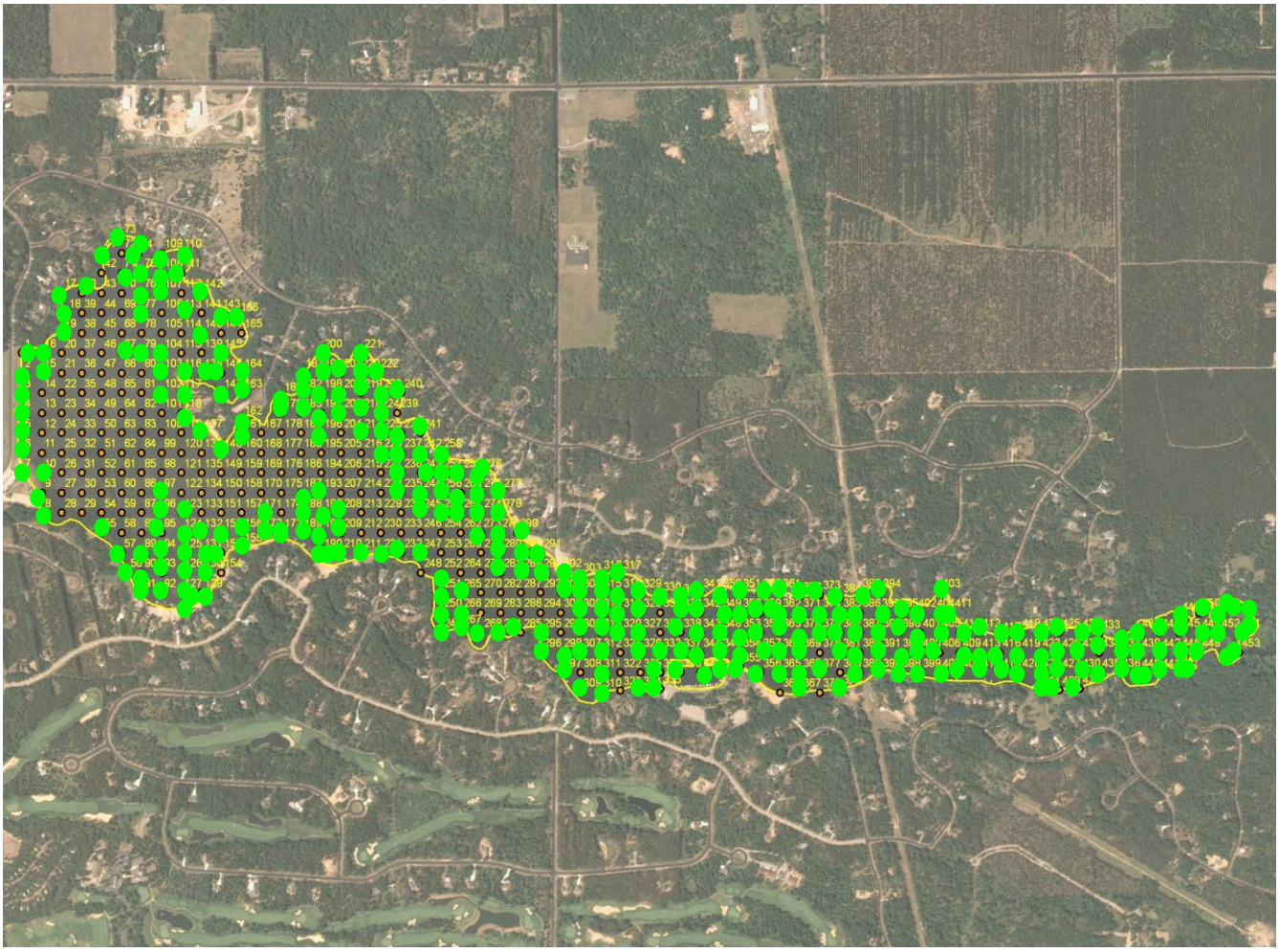
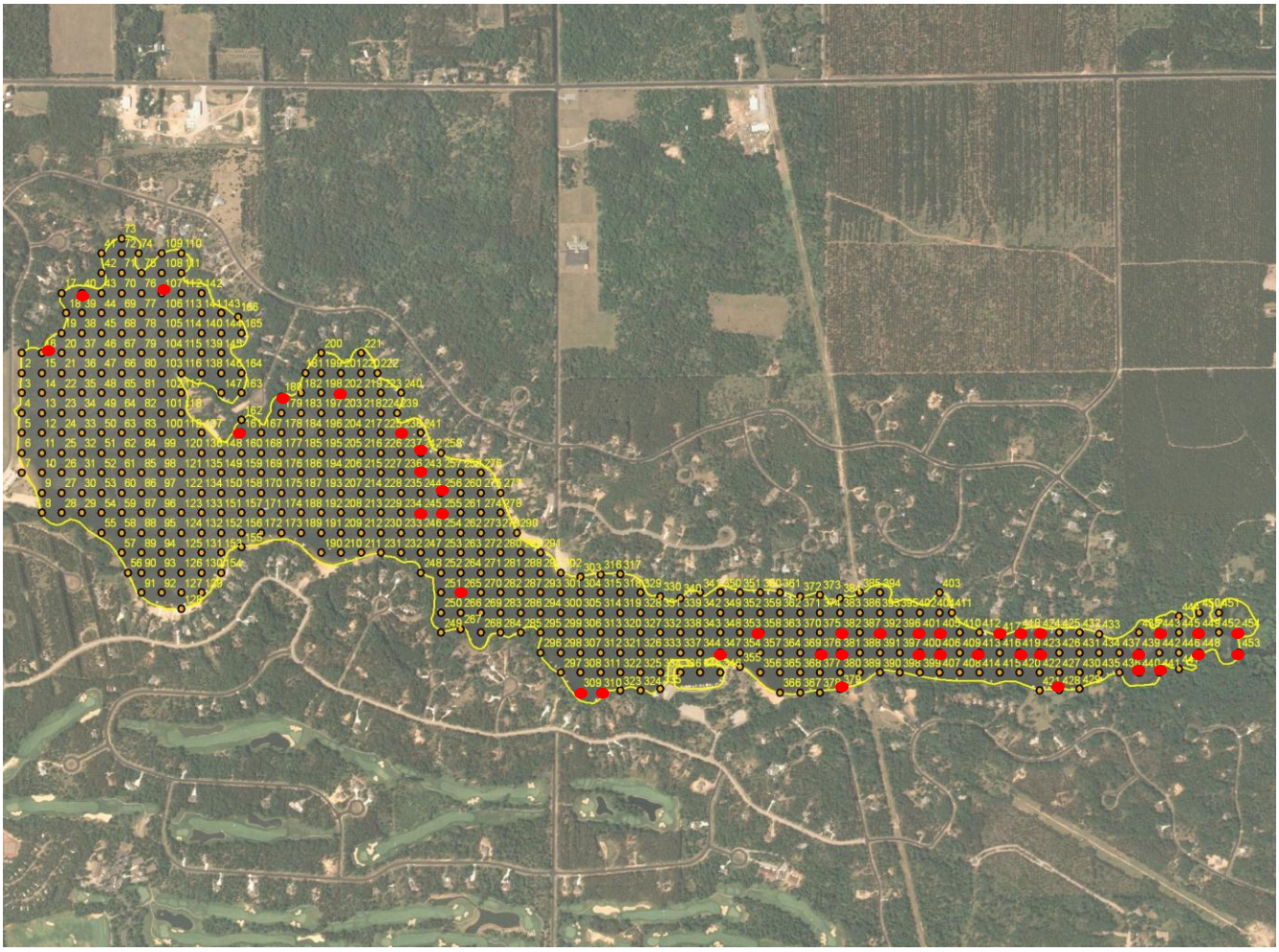


Figure 12: Distribution of Submergent Species 2014 (in green)



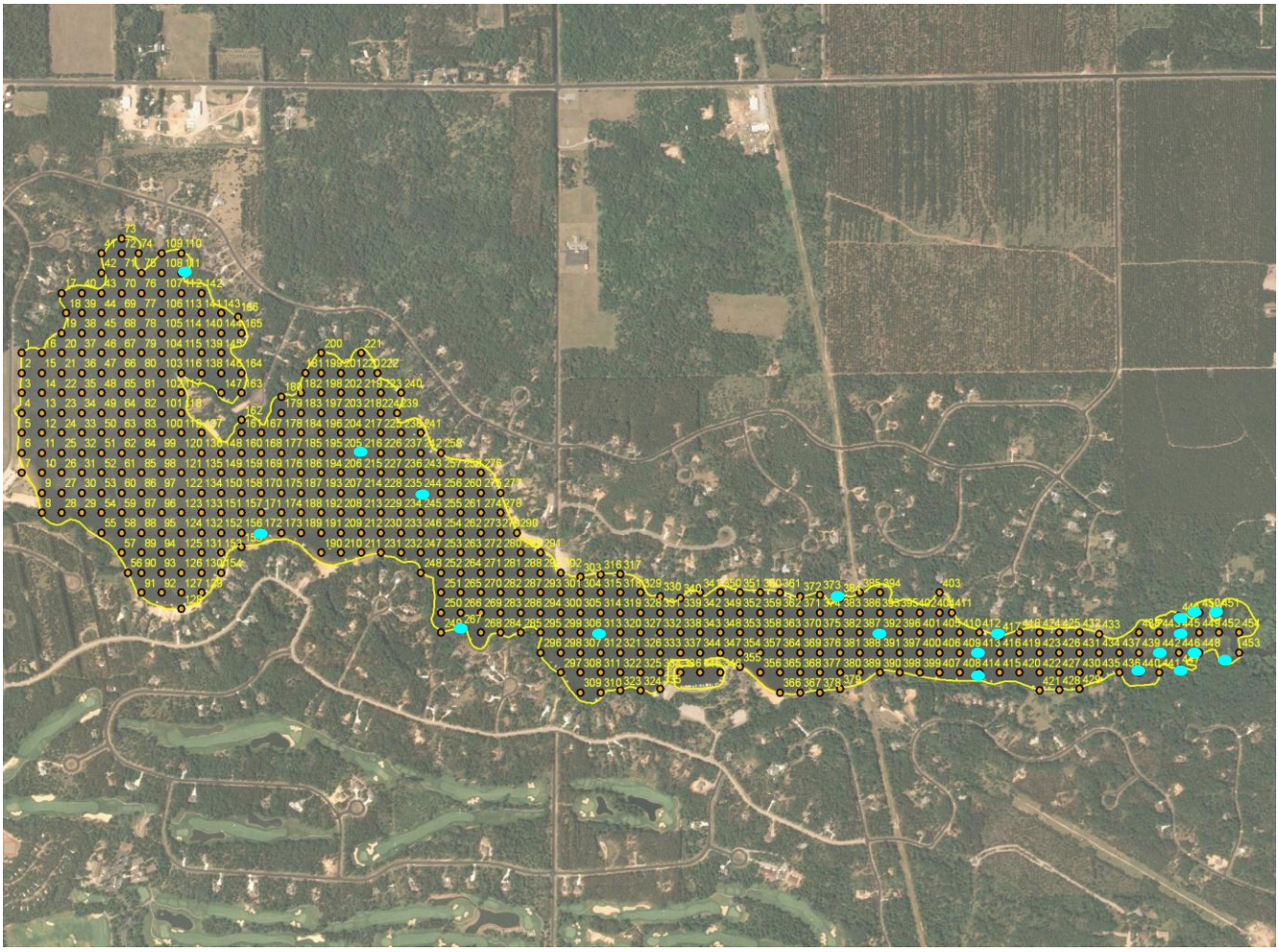
The aquatic invasives with the largest presence in Arrowhead Lake are Eurasian Watermilfoil and Curly-Leaf Pondweed. Both of these have been present in the lake since at least 2000. In 2000, Eurasian Watermilfoil was only 0.5% of the aquatic plant population, but by 2006, it had spread to 7.5% and spread even more by 2010 to 9.5%. In the 2014 survey, its presence was reduced to 3.5% of the overall aquatic plant community. It is currently being managed by on-going regular mechanical harvesting by the Tri-Lakes Management District.

Figure 13: Distribution of Eurasian Watermilfoil 2014 (in red)



In 2000, Curly-Leaf Pondweed was 6.5% of the aquatic plant community in Arrowhead Lake. By 2006, it had gone down slightly to 6.0%; by 2014, it was even a smaller portion at 2.0% of the aquatic plant community. Most of it is found in the far eastern end of the lake.

Figure 14: Distribution of Curly-Leaf Pondweed 2014 (in turquoise)



THE COMMUNITY

The Simpson's Diversity Index in 2014 for Arrowhead Lake is .93, showing very good species diversity. This is up slightly from the 2010 figure of .91. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The 2014 AMCI for Arrowhead Lake is 58, placing it just above the average range for North Central Wisconsin Lakes (48 to 57) and all Wisconsin Lakes (45 to 57).

FIGURE 15: 2014 AMCI FOR ARROWHEAD LAKE

Parameter		Value
Root depth	14	8
% litt veg	67.3	10
% sub	77	10
taxa #	50	10
% exotics	8	5
% sensitive	5	5
SI	0.93	10
		58

Four invasive aquatic plants were found in the 2014 PI survey, just as they were in the prior surveys. The most prevalent aquatic invasive continues to be Eurasian Watermilfoil (*Myriophyllum spicatum*). The other three invasives found—Reed Canarygrass, Curly-Leaf Pondweed, and Narrow-Leaved—had 5% or less frequency of growth.

An Average Coefficient of Conservatism and a Floristic Quality Index calculation were performed on the field results in 2014. Technically, the Average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Quality Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem.

Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservatism found in the Transect Survey in Arrowhead Lake in 2009 was 4.1, somewhat lower than the average COCs of 4.5 in 2006 and 2000. That figure put Arrowhead Lake in the lowest quartile for Wisconsin Lakes (6.0) and for lakes in the North Central Hardwood Region (5.6). For the 2010 and 2014 PI surveys, the figures were 4.5 and 3.7 respectively. The aquatic plant community in Arrowhead Lake is in the category of those very tolerant of disturbance, probably due to selection by a series of past disturbances.

Floristic Quality Index results were similar. The figure in 2000 was 19.1, which went up to 21.1 in 2006, then up to 26.7 in 2009. Using the PI grid in 2010, the FQI was up to 30.0, but down in 2014 to 24.2.

Figure 16: Floristic Quality and Coefficient of Conservatism of Arrowhead Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes.

	Average Coefficient of Conservatism †	Floristic Quality ‡
Wisconsin Lakes	5.5, 6.0, 6.9 *	16.9, 22.2, 27.5
NCHR	5.2, 5.6, 5.8 *	17.0, 20.9, 24.4
Arrowhead Lake 2014	3.68	25.23

* - Values indicate the highest value of the lowest quartile, the mean and the lowest value of the upper quartile.

† - Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant) to a high of 9.5 (least disturbance tolerant).

‡ - lowest Floristic Quality was 3.0 (farthest from an undisturbed condition) and the high was 44.6 (closest to an undisturbed condition).

The Floristic Quality Index is a tool that can be used to identify areas of high conservation value, monitor sites over time, assess the anthropogenic (human-caused) impacts affecting an area and measure the ecological condition of an area (M. Bourdaghs, 2006). The 2014 Floristic Quality Index of the aquatic plant community in Arrowhead Lake of 25.23 is slightly above average for Wisconsin Lakes (22.2) and the North Central Hardwood Region (20.9). These figures suggest that the plant community in Arrowhead Lake is making some progress to be a little closer to an undisturbed condition than the average lake in Wisconsin overall and in the North Central Hardwood Region. Using either scale, the aquatic plant community in Arrowhead Lake has been impacted by at least an average amount of disturbance, including human-caused disturbances.

"Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species (such as the Eurasian Watermilfoil, Reed Canarygrass and Curly-Leaf Pondweed found here), destruction of plant beds, or changes in aquatic wildlife can also negatively impact an aquatic plant community. Shore development and sediment deposition can also reduce the quality of the aquatic plant community.

In Arrowhead Lake, the likely disturbances include the high recreational use of the lake (which includes boat traffic, tubing, jet-skiing, and water-skiing), the on-going mechanical harvesting from May to September each year, heavy shore development, high level of docks and other hard structures close to the water, erosion, and the presence of aquatic invasives.

Arrowhead Lake was found to have zebra mussels (*Dreissena polymorphya*) in 2004. The Tri-Lakes Management District, the Adams County Land & Water Conservation Department and the WDNR have been monitoring the presence every year since then using a number of methods. Aquatic plants collected in 2009, 2010 and 2014 were covered with zebra mussels of various sizes. Some of the plants were so covered that it was difficult to determine their identification. Zebra mussels have obviously spread throughout the lake, attaching not only to docks, rocks and other hard structures, but also to grains of sand and aquatic plants (and to each other).

IV. COMPARISON TO PRIOR PLANT SURVEYS

Comparisons were done between the plant communities of 2000 and 2006 in Arrowhead Lake to that found in 2009 (transect surveys) and the aquatic plant communities of 2010 and 2014 (PI surveys) based on actual frequency of occurrence and relative frequency of occurrence. The coefficient of similarity is an index, first developed by Jaccard in 1901, which compares the similarity and diversity of sample sets. In this instance, the figure considers the frequency of occurrence and relative frequency of all species found, then determines how similar the overall aquatic plant communities are. Similarity percentages of 75% or more are considered statistically similar (Dennison et al, 1993).

According to the information gained from the 2006 and 2009 transect surveys and using the coefficient of similarity index, the aquatic plant communities in those two years were 92.0% similar based on actual frequency of occurrence and 84.2% based on relative frequency. Thus, the aquatic plant communities in Arrowhead Lake in 2006 and 2009 were statistically similar. The 2009 aquatic plant community was also compared, using the same method, to the aquatic plant community of 2000. According to those calculations, the 2009 and 2006 aquatic plant communities were

86.3% similar in frequency of occurrence and 94.9% similar in relative frequency. The 2006 and 2000 aquatic plant communities were also compared in similarity. They were 92.4% similar in frequency of occurrence and 76.9% similar in relative frequency.

Using the PI surveys done in 2010 and 2014, the frequency of occurrence index showed the plant communities were 77.6% similar; the relative frequency occurrence index was 78.1%.

These figures suggest that although some of the aquatic plant species found have changed, to the extent that the aquatic plant community and water quality results mirror the health of Arrowhead Lake, Arrowhead Lake has remained relatively stable for at least the past 10 years.

However, tstructure of the aquatic plant communities has changed somewhat. Whereas in 2000, over 90% of the aquatic plant community was submergent plants, the relative frequency of emergent plants has been increasing as submergents decreased in dominance.

Figure 17: Plant Types by Relative Frequency % of Occurrence

Plant Type	**2000**	**2006**	**2010**	**2014**
Emergent	2	5	11	14
Floating-Leaf				1
Free-Floating	2	7	5	4
Submergent	96	88	85	81

Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. They also help dampen waves, thus offering some protection to erosive shores. Since much of Arrowhead Lake's shore is sandy, this protection may be very important. Also, diversity of structure in the aquatic plant community increases the diversity of fish and wildlife that can be supported by the community.

Figure 18 outlines some of the benefits provided to various birds, fish and mammals by some of the plants found in Arrowhead Lake in 2014.

FIGURE 18: BENEFITS OF SOME AQUATIC PLANTS

	Fish	Water Fowl	Shore Birds	Upland Birds	Muskrat	Beaver	Deer
Ceratophyllum demersum	F,I,C,S	F,I,C			F		
Chara	F,S	F,I,C					
Lemna minor	F,I,C,S	F	F		F	F	
Myriophyllum heterophyllum	F,I,C,S	F,I	F		F		
Myriophyllum sibiricum	F,I,C,S	F,I	F		F		
Najas flexilis	F.C	F	F				
Stuckenia pectinata	F,I,C,S	F,I	F		F	F	F
Potamogeton zosteriformis	F,I,C,S	F,I	F		F	F	F
Scirpus validus	F,C,I	F,C	F,C,N	F	F	F	F
Typha latifolia	I,C,S	F	F,C,N		F,C,N	F	

F = Food; I = Shelters Invertebrates; C = Cover; S = Spawning; N = Nesting

Comparisons of the Aquatic Macrophyte Community Index support the results of the calculations of coefficients of similarity: the overall score is similar.

FIGURE 19: AMCI CALCULATIONS FOR 2010 and 2014

Parameter	Value	Score	Value	Score
max depth	18	10	14	8
litt veg %	68.1	10	67.3	10
sub %	92.0	7	77	10
taxa	45	10	47	10
% exot	14	4	8	5
% sens	12	6	5	5
SI	0.91	9	0.93	10
Total		56		58

V. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Arrowhead Lake is a mesotrophic impoundment lake with good water clarity and fair to good water quality. This trophic state should support substantial plant growth and occasional algal blooms. The aquatic plant survey results suggest that there is a stable aquatic macrophyte community.

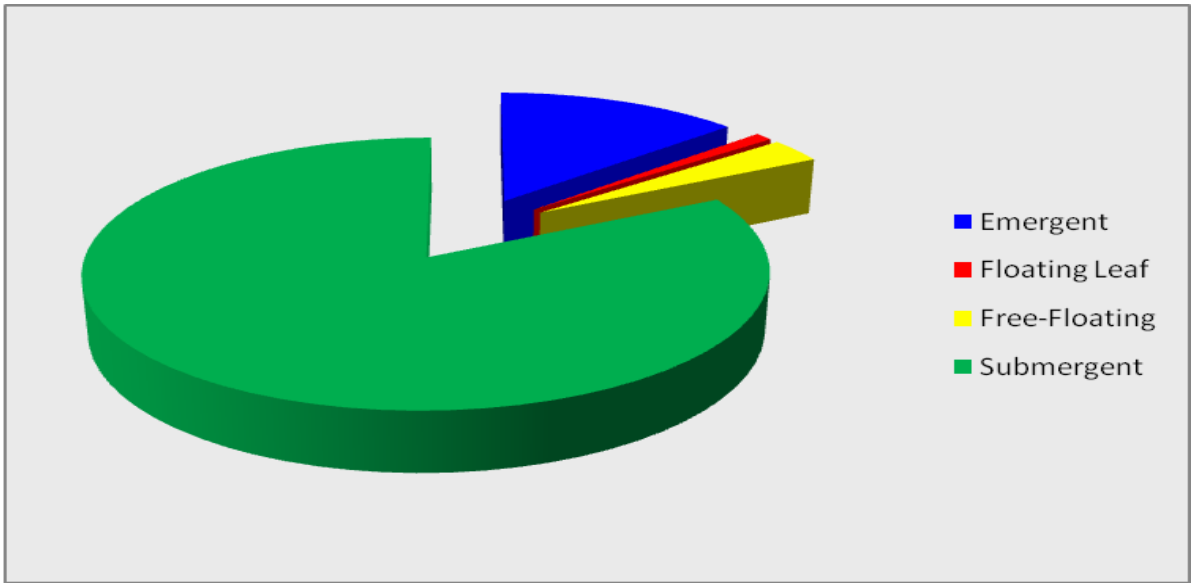
Sufficient nutrients (trophic state), hard water, good water clarity, shallow lake, and nutrient-rich inputs from increased shore development at Arrowhead Lake favor plant growth. Despite the sometime limiting effect of sand sediments on aquatic plant growth, over 67% of the lake is vegetated, suggesting that even the sand sediments in Arrowhead Lake hold sufficient nutrients to maintain aquatic plant growth or that there are plants present the prefer sand substrate.

Historically, many aquatic plant treatments in Arrowhead Lake were chemical. There has been mechanical harvesting to try to reduce plant growth in the last 10 years. A continued regular schedule and pattern of machine harvesting will help in removing vegetation from the lake and may somewhat help with nutrient reduction. It might also help to skim off the high density of filamentous algae and floating-leaf plants.

The lake does have a mixture of emergent, free-floating, and submerged plants. Since 2000, the percentage of emergent plants has been slowly increasing. This may be due at least partly to the change in winter drawdowns for the lakes that feed into Arrowhead Lake—Sherwood and Camelot. Until about 2007/2008, those lakes regularly drew down several inches each winter, thus exposing the seed beds for near-shore emergent plants to winter freezing. In the two surveys since those regular winter drawdowns have ceased, emergent plants rebounded from about 2% of the community in 2000 and 2006 to 11% in 2010 and 14% in 2014. However, they continue to be sparse in most areas of the lake, suggesting that this is still a vulnerable part of the aquatic plant community.

Coontail remains the most frequently-occurring species in the lake, although other more sensitive native species like Northern Milfoil and Water Stargrass are nearing its frequency of occurrence. Submergent plants are the top six most-commonly occurring aquatic species. Although the coverage of submergent plants has reduced slightly, they continue to dominate the aquatic plant community in Arrowhead Lake.

Figure 20: Coverage of Aquatic Species Types 2014



Aquatic plants occurred at 67.3% of the sample sites in Arrowhead Lake to a maximum rooting depth of 14 feet in 2014. Areas of native vegetation and wetland shores on the lake should be preserved because they maintain habitat and serve as a buffer for that area. Studies have suggested that runoff from such land is substantially less than that of developed areas. There are also some areas of deep erosion on steep banks that need to be addressed to prevent tree fall (and related root ball removal from bank) and bank preservation.

The presence of several invasive, exotic species could be a significant factor in the future. Currently, none of the exotic species appear to be taking over the aquatic plant community, but *Myriophyllum spicatum*, although declining from its highest frequency of occurrence in the 2010 survey, is still over 3% of the overall aquatic community. Since this species spreads most by fragmentation, mechanical harvesting needs to be carried out carefully to avoid further spreading this species.

On the other hand, *Potamogeton crispus* only had occurrence frequency in 2014 of 6.0%, down substantially from the 2006 frequency of occurrence of 23.9%. It is likely that this figure somewhat under-represents *Potamogeton crispus* in Arrowhead Lake, since the survey in 2014 was done in mid to late July, when Curly-Leaf Pondweed has generally started dying off. This species should still be continually monitored, since their tenacity and ability to spread to large areas fairly quickly could make them a danger to the diversity of Arrowhead Lake's current aquatic plant community.

Of the 50 species found in Arrowhead Lake in 2014, 45 were native and 4 were exotic invasives. In the native plant category, 31 were emergent, 3 were free-floating plants, 1 was a rooted floating-leaf plant, and 11 were submergent species. Four non-

native invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil), *Phalaris arundinacea* (Reed Canarygrass), *Potamogeton crispus* (Curly-Leaf Pondweed) and *Typha angustifolia* (Narrow-Leaved Cattail) were found.

The Simpson's Diversity Index in 2014 for Arrowhead Lake was .93, showing very good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The AMCI for Arrowhead Lake is 58, placing it at the top of the average range for North Central Wisconsin Lakes and all Wisconsin Lakes.

It is worth noting that the report on the 2000 aquatic plant surveys mentioned the absence of emergent plants in Arrowhead Lake. The 2014 and 2010 surveys suggest that emergent plants seem to be "coming back", i.e., are re-establishing in Arrowhead Lake, although some of the increase may be due to the changes in sampling technique. Whether this increase will stabilize will depend on a number of factors, including continued shore development, recreational uses of the lake, and weather patterns. Different sampling techniques could also change the results. At this time these increases tend to be localized. Arrowhead Lake continues to be almost devoid of rooted floating-leaf plants that provide habitat for fish and invertebrates, with only one rooted floating-leaf plant, Long-Leaf Pondweed, found in 2014.

VI: CONCLUSIONS

Arrowhead Lake is a mesotrophic impoundment with good water quality and water clarity. The Average Coefficient of Conservatism of the aquatic plant community in Arrowhead Lake is in the lowest quartile for Wisconsin lakes and for lakes in the North Central Hardwood region, but the lake has a slightly above average Floristic Quality Index. The AMCI is at the top of average range for both North Central

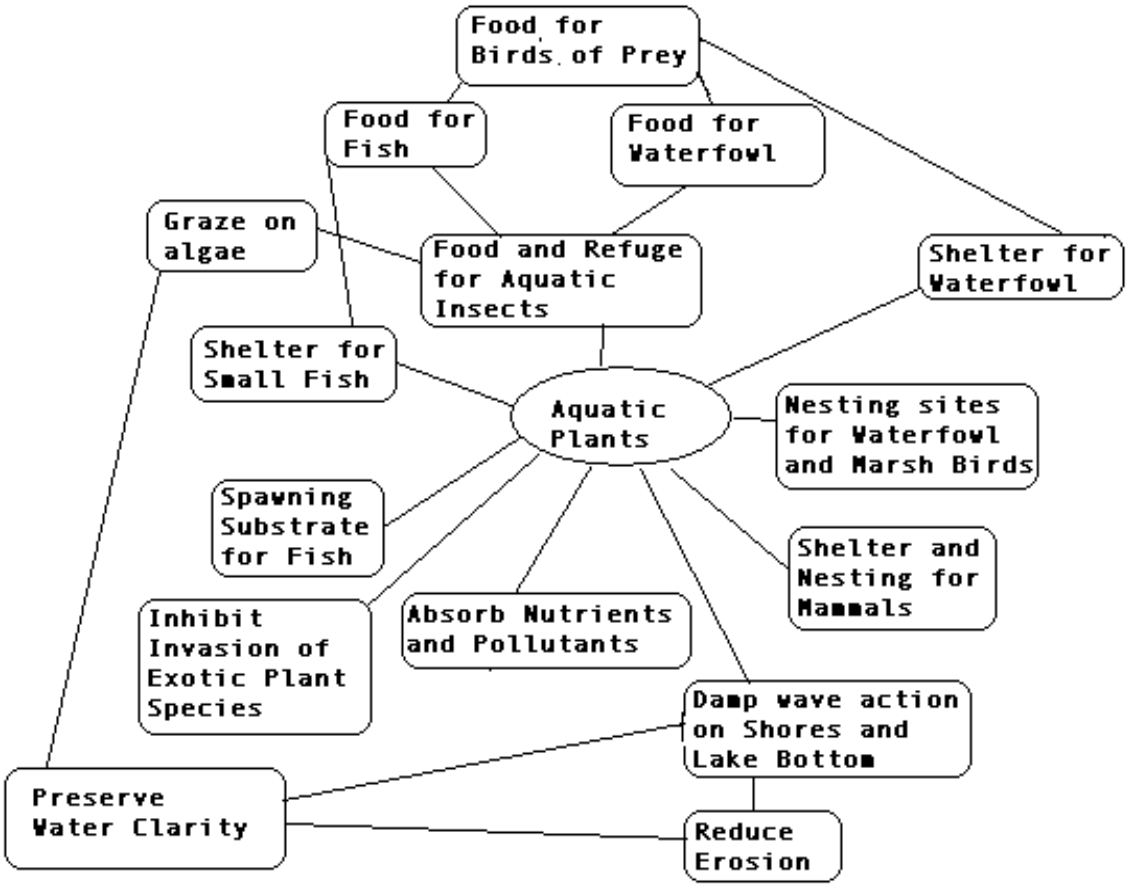
Hardwood Region and all Wisconsin lakes, indicating an aquatic plant community of high average quality. Structurally, the aquatic plant community contains emergent plants, free-floating plants, and submergent plants, although dominated by submergent species.

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise "take over" and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

FIGURE 21: LAKE ECOSYSTEM WEB



MANAGEMENT RECOMMENDATIONS

1) The Arrowhead Lake Association's Conservation Committee has been working steadily to have all the lake's shores in compliance with the Adams County Shoreland Ordinance, so that vegetated buffers are installed. This should continue.

2) The Association should also continue its monitoring even after the buffers installations appear to be completed. A review in the summer of 2014 showed that some buffers that had previously been installed were being mowed more than the percentage allowed for access corridors. Continued reinforcement of the message will apparently be needed for a few years.

3) Since 2010, the Association has been working with the Adams County Land & Water Conservation Department to restore several severely eroded points that it owns. There are still a few to be addressed. This should be done as soon as possible, since some include treefalls where there are large exposed sections of sloughing, loose bare soil.

4) Because aquatic vegetation is used by fish for a number of purposes (cover, feeding, spawning, etc), continued harvesting to open fishing lanes should continue in these areas. Removal should occur by hand in the shallower areas to be sure that entire plants are removed and to minimize the amount of disturbance to the sediment.

5) The Tri-Lakes Management District and the Arrowhead Lake Association should continue to cooperate with the WDNR to monitor and, if possible, control the zebra mussel infestation in the lake to protect the aquatic plant community.

6) Stormwater management of the many impervious surfaces around the lake is essential to maintain the current quality of the lake water and prevent further degradation. There are several areas of steep banks where runoff may be an issue, especially in the early spring where snow is beginning to melt but some of the ground is still frozen.

7) No chemicals should be used on properties around the lake. If they must be used, they should be used no closer than 50 feet to the shore. This recommendation is not limited to fertilizer, but also includes weed killer, large insecticide sprays, etc.

8) The lake management plan, including the aquatic plant management section, should continue to be reviewed annually and updated or altered as needed.

9) Aquatic plant surveys should be repeated every 3 to 5 years to monitor lake health and identify any changes in the aquatic plant community.

10) Due to the continued presence of EWM, alternate methods of addressing EWM growth need to be developed and pursued. The aquatic plant management plan also needs to address managing the Curly-Leaf Pondweed growth.

11) The Tri-Lakes Management District may want to continue to apply for grants from the Wisconsin Department of Natural Resources to help defray the cost of aquatic plant management. However, since these funds are becoming more limited, it is recommended that the Management District should consider setting aside a sum each year to build a "fund" to carry out management should grants become unavailable.

12) No broad-scale chemical treatments of native aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and decreased dissolved oxygen and opening up more areas to the spread of EWM and colonization by other aquatic invasvies.

13) Fallen trees should be left at the shoreline or in the water to increase shore area habitat. Consultation with the WDNR Fisheries Biologist is recommended to determine if the current habitat conditions are appropriate for the desired fish community.

14) The Tri-Lakes Management District should continue involvement in water quality and invasive species monitoring through the Citizen Lake Monitoring Program, the Clean Boats, Clean Waters program and grants for AIS management. Volunteers should be recruited and trained to cover such monitoring in case grants become unavailable.

15) Regular educational efforts directed at Arrowhead Lake residents and users to encourage them to identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs. Nutrients appear to have increased within the lake, so residents must take steps to reduce their nutrient inputs.

16) No drawdowns of water level except for DNR-approved purposes should occur.

17) The few sites where there is undisturbed shore, mostly in designated conservancy areas, should be maintained and left undisturbed.

18) Cooperation with the Adams County Parks Department in keeping the boat ramp and swimming beach in safe condition should help reduce any negative impacts caused by the heavy use of these public areas. A boat washing station at the park ramp area may help in decreasing other invasives from invading the lake.

19) The Tri-Lakes Lake Management plan has long included having an on-the-ground survey of the watersheds, but this has not occurred. In 2013, such a survey was done on most of the Big Roche a Cri Watershed, the watershed just below 14-Mile Creek. That survey revealed that there were many problem areas of runoff, sloughing banks, and erosion. Since similar conditions occur in the 14-Mile-Creek Watershed, completing the survey is very important to identify problem areas and, hopefully, address them in the near future, as they may be contributing to water quality problems in the Tri-Lakes.

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TRI-LAKES MANAGEMENT PLAN		
AQUATIC SPECIES MANAGEMENT: GOALS and ACTIONS ITEMS	**WHO**	**WHEN**
Machine harvest aquatic plants to improve water quality, to provide safe boating areas,		
and to improve aquatic habitat.		
1. Harvest maps will be followed by harvesting crew. Areas in the lake 6 feet deep or	Tri-Lakes Mgmt District	annually
greater will be harvested as needed to a depth of 5 feet. Areas shallower than 6 feet		
deep can have a harvested path of 60 feet wide with a harvest depth of 4 feet or less.		
The path will get no closer to the shoreline than the docks. No machine harvesting		
in the areas between the shoreline and the ends of the boat docks. A 30-foot wide		
path may be hand-harvested in these areas by the property owner. Harvest period will be		
between mid-May and end of September.		
2. Conservacy areas will be marked on the harvest maps.	Tri-Lakes Mgmt District	annually
Monitor the harvesting of aquatic plants.		
1. WDNR representative and a Tri-Lakes Management representative will meet annually to	Tri-Lakes Mgmt District	annually
inspect the harvesting operations.	WDNR	
2. Record the pounds of aquatic plants removed by taking an average weight of a trailer-full	Tri-Lakes Mgmt District	annually
of plants harvested and multiplying this by the number of trailer loads. This will be		
documented and reported to the WDNR Aquatic Plant Specialist by 12/31.		
3. Composite samples will be taken randomly from the harvested plans (per protocol provided	Tri-Lakes Mgmt District	annually
by the WDNR) and sent to a certified lab to measure the phosphorus content. This is done	WDNR	
to determine the amount of phosphorus being removed from the lakes by harvesting plants.		
4. Add GPS system to harvester to improve efficiency. Explore alternative product for	Tri-Lakes Mgmt District	ongoing
marine application for better efficiency.		
Eliminate the use of chemicals to control aquatic plants to improve water quality.		
This excludes noxious weed and invasive plant control.		
1. Educate individuals on aquatic plant control methods by placing article developed by	Lake Associations	annually
Adams LWCD in Lake Association communications.	Adams LWCD	

Update 2006 Aquatic Plant Community Survey		
1. WDNR Lake Classification grant specifies aquatic plant survey to be conducted. Aquatic	Adams County LWCD	2014
plants to be identified and quantified. Completed in 2006; Camelot completed 2009;	WDNR	
Arrowhead completed in 2010. Sherwood completed in 2011. Camelot completed in 2013.		
Arrowhead & Sherwood completed 2014. Reports posted on Adams County LWCD website.		
Prevent the spread of & try to eliminate invasive & noxious species.		
1. Invasive plants and noxious weeds will be mapped annually & in full aquatic plant surveys.	Adams County LWCD, WDNR	annually
2. Develop & implement plan to: control existing exotic, invasive & noxious species; and	Adams County LWCD	ongoing
prevent the introduction of exotic, invasive and noxious species. This plan will include both	WDNR	
educational & boat inspection components. CBCW program started in 2010 & has continued	Tri-Lakes Mgmt District	
every summer since then.	private consultants	
3. Make annual contacts with boat dealers, boat patrol & water ski team & landscapers	Tri-Lakes Mgmt District	annually
regarding methods to prevent spread of invasives.		
4. Pursue financial assistance for implementation of prevention & control plan.	Adams County LWCD, WDNR	December 1
	Tri-Lakes Mgmt District	each year
	Private Consultants	
5. Recontact Adams County Parks Committee to pursue installing boat washing equipment	Adams LWCD & Parks	2016-2017
at public boat landings.	Tri-Lakes Mgmt District	
6. Control Purple Loosestrife using pulling, chemical spot treatments & bio-controls.	Adams LWCD, others	Ongoing
TRI-LAKES MANAGEMENT PLAN		
AQUATIC SPECIES MANAGEMENT: GOALS and ACTIONS ITEMS (con'td)	**WHO**	**WHEN**
Manage impacts to lakes resulting from the zebra mussel invasion.		
1. Arrange for a series of articles & provide material to the Wisconsin Rapids newspaper,	Tri-Lakes Mgmt District	ongoing
Adams-Friendship newspaper, fishing clubs & lake associations.		

2. Use volunteer group to provide education.	Tri-Lakes Mgmt District	ongoing
	Lake Associations	
3. Develop an advertisement to be placed in lake association newsletters & local newspapers	Tri-Lakes Mgmt District	ongoing
to notify the public that there are zebra mussels in Lakes Arrowhead & Camelot & Sherwood.	Adams LWCD, WDNR	
4. Seek funding from AIS grant for boat launch attendant through the Clean Boats, Clean	Tri-Lakes Mgmt District	ongoing
Waters program.	Adams LWCD, WDNR	
Monitor the impact of zebra mussels.		
1. Monitor zebra mussel research on control methods.	Tri-Lakes Mgmt District	annually
	Adams LWCD, WDNR	
2. Improve coordination and communications with WDNR Specialist & Adams LWCD.	Tri-Lakes Mgmt District	annually
	Adams LWCD, WDNR	
DAMS: GOALS and ACTIONS ITEMS	**WHO**	**WHEN**
Maintain and operate Arrowhead, Sherwood, and Camelot Dams to:		
insure public safety, proper dam function, and a stable lake level.		
1. Conduct inspections and record findings as specified in WDNR standards	engineer certified by Nat'l	per DNR
	Assoc. of Prof. Eng.	schedule
2. Operate, inspect, and repair dams to meet Wisconsin laws in State Statute	Adams LWCD	at least 3
Chapter 31 and NR Chapter 330.		times/wkly
3. Review and update the Emergency Action Plan.	Adams LWCD	annually
4. Implement the Emergency Action Plan in times of emergencies. Evacuation route signs	County Board Chair, LWCD	as
added in 2014 by Adams County.	Emer Mgmt, Town of Rome	needed
5. Maintain water level gauges that are placed on the sides of the water flow control	Adams LWCD	ongoing
structures. These gauges will be the official tool used to determine lake levels.		
Lake level information may be obtained on line starting Juen 2010.		
6. Maintain history of levels; data can be obtained from Adams County LWCD at	Adams LWCD	annually
608-339-4268.		

RECREATION: GOALS and ACTION ITEMS	WHO	WHEN
Manage lakes for boating and skiing.		
1. Provide areas for boating/skiing as part of the harvest plan.	Tri-Lakes Mgmt District	ongoing
2. Regulate lake traffic to increase lake safety. This will be accomplished by implementing &	Town of Rome	ongoing
enforcing state laws, county and town ordinances. Pursue 2nd boat purchase & increase	WDNR	
awareness with Town of Rome.		
3. Implement methods of enforcing state laws, county and town ordinances. Methods may	Tri-Lakes Mgmt District	
include anonomous tips hotline, goodwill ambassador groups, & education. Once methods	Town of Rome	ongoing
have been identified, develop strategy to implement.		
4. Install no-wake buoys 100 feet off the face of the dams shortly after ice-out.	Adams County LWCD	ongoing
Manage lakes for fishing.		
1. Work with WDNR Fisheries Biologist about stocking bass, panfish & forage fish in the lakes	Lake Associations	ongoing
as funding allows.	Tri-Lakes Mgmt District	
2. Educate lake users about VHS & bait rules. Contact bait shops also.	Tri-Lakes Mgmt District	ongoing
	Adams LWCD	
3. Educate lake users about improve littoral & riparian zones to improve fish habitat as long as	Tri-Lakes Mgmt District	ongoing
navigation not impeded. Permit may be required.		
Manage lakes for swimming.		
1. IMaintain safety of public swim area on Camelot Lake by marking with buoys	Town of Rome	ongoing
	Adams Park & Rec.	
2. Report any illnesses from blue-green algae to www.dhs.wi.gov/eh/bluegreenalgae	Tri-Lakes Mgmt District	ongoing
Improve and develop parks associated with the Tri-Lakes		
	Town of Rome	
1. Coordinate efforts to develop plan to improve and develop Tri-Lakes parks. Improvements	Adams Park & Rec.	ongoing
include adding boat washing stations & containers to dispose of unused bait & aquatic	Lake Associations	
plants at boat landings.		

TRI-LAKES MANAGEMENT PLAN		
NUTRIENT REDUCTION: GOALS and ACTION ITEMS	**WHO**	**WHEN**
Reduce phopshorus and ammonia entering groundwater that then enters into Tri-Lakes.		
1. Inventory and map septic systems within the Tri-Lakes Management District.	Tri-Lakes Mgmt District	ongoing
Manage system to notify owners (pre-7/1/1992) to pump septic systems.		
2. Verify county & state-approved method of sanitary disposal on camping lots.	Town of Rome	ongoing
Reduce nutrients entering the Tri-Lakes by surface water.		
1. Continue upstream ditch testing started in 2007 and augmented in 2014, testing for	Adams LWCD	ongoing
phosphorus, nitrogen, chloride & total suspended solids, as well as flow amount.	Tri-Lakes Mgmt District	
Use information to identify problem areas & develop practices to address input.		
2. Conduct shore habitat assessment around lakes & streams in watershed, using WDNR	Adams LWCD	2017-2018
protocol.	Tri-Lakes Mgmt District	
3. Use information to develop plans to address identified problems areas.	Adams LWCD	2018-2019
	Tri-Lakes Mgmt District	
	Lake Associations	
4 Educate shoreline owners on the benefits of riparian buffers and storm water runoff	Tri-Lakes Mgmt District	ongoing
management utilizing meetings, newsletters, and individual visits.	Adams LWCD, P & Z	
5. Plan/design & offer cost share to install shoreline protection, riparian buffers, and	Adams LWCD	ongoing
storm water runoff management to areas identified in inventory. Utilize Adams	WDNR, landowners	
Soil & Water Resource Mgmt Program & WDNR financial assistance programs.	Lake associations	
Cost-sharing grants may be available to help.		
6. Assist lakeshore property owners with Shoreland Protection Ordinance riparian	Tri-Lakes Mgmt District	ongoing
compliance. Cost-sharing grants available to help. Compliance deadline is July 1, 2015.	Adams LWCD	
7. Monitor methods for sanitary disposal for year-round campers. Review town ordinance.	Town of Rome	ongoing
ordinance.	Adams County	
8. Develop compliance plan for shoreland protection buffer conformance, including plan for	Adams P & Z	2017-2018
dealing with beach clubs.		

WATER QUALITY: GOALS and ACTION ITEMS	WHO	WHEN
Reduce algae blooms and nutrient levels.		
1. Utilize the Citizen Monitoring Program to monitor water quality to measure water clarity,	Adams LWCD, Lake Assoc	ongoing
chlorophyll-a and total phosphorus.	Tri-Lakes Mgmt District	
2. Monitor water quality at six sites in the upper watershed. Monitor flow rates at 3 sites	Adams LWCD	ongoing
	Tri-Lakes Mgmt District	
3. Monitor additional 16 sites in the lakes (Arrowhead-4, Camelot-8, Sherwood-4)	Adams LWCD	ongoing
in the lakes and 2 toes drains at each dam.	Tri-Lakes Mgmt District	
	Lake Associations	
4. Work with the WDNR to learn new solutions as they become available. Utilize WDNR	Tri-Lakes Mgmt District	ongoing
website as well as Lake Specialist at Adams LWCD.		
5. Evaluate water quality report produced by UWSP & identify action plan.	Tri-Lakes Mgmt District	2015-2016
Educate community and public about ways to improve water quality.		
1. Write and publish informational articles in lake association newsletters, and .in Wis Rapids	Adams LWCD	ongoing
Tribune. Also post to websites & distribute mterials at public events & Tri-Lakes Annual	Lake Associations	
Meeting. Combine family activity days to reach a wider & younger audiences.	Tri-Lakes Mgmt District	
2. Distribute landowner packet of information prepared by Adams County LWCD	Tri-Lakes Mgmt District	ongoing
to waterfront property owners.		
3, Educate public about proper disposal of prescription drugs.	Tri-Lakes Mgmt District	ongoing
4. Establish website to serve as portal of information to the proper owners.	Tri-Lakes Mgmt District	2014
		completed
Practice proper land use utilizing Comprehensive Plans and Zoning		
1. Within the Tri-Lakes watershed, continue to implement existing township	Town of Rome	annually
comprehensive plan. Planning Commmission will be reviewing regularly.	Tri-Lakes Mgmt District	
2. Encourage smart growth plan development by attending town meetings in those	Adams County P & Z	ongoing
towns within the Tri-Lakes watershed who do not have comprehensive plans.		

LAKE LEVELS: GOALS and ACTION ITEMS	**WHO**	**WHEN**
Maintain lake levels that enhance water quality and meet the requirements		
of Wisconsin Statute Chapter 31.		
1. Operate dams to maintain lake levels and outflows as stated by WDNR. These levels are	Adams LWCD	ongoing
These operating levels are listed in Adams County I.O.M Plan (Inspection, Operation &		
Mainteance Plan). See Appendix G		
2. Investigate groundwater net flow around and through dams and determine what	Tri-Lakes Mgmt Dist.	ongoing
nutrient content the flow contains. Take water samples from toe drains for	Adams LWCD	
phosphorus content. Present findings to WDNR.	State Hygiene Lab	
Maintain stable stream flows into and out of the Tri-Lakes.		
1. Operate dams in proactive manner so large quantities of water are not released causing	Adams LWCD	annually
downstream flooding & streambank erosion. Lake levels will be lowered in a slow		
manner to accommodate anticipated heavy flows from the upper watershed.		
2. Develop plan to monitor flows.	Tri-Lakes Mgmt District	ongoing
	Adams LWCD	
	UWSP, WDNR	
3 Work with Central Sands water resource group.	Tri-Lakes Mgmt District	ongoing
WATERSHED: GOALS and ACTION ITEMS	**WHO**	**WHEN**
Reduce 50% the total phosphorus, total nitrogen, and total solid sediments entering		
Leola Ditch, 14 Mile Creek, and Unnamed Ditch 13-13 by 2020.		
1. Develop strategy to implement buffer corridor compliance. Maintain & monitor	Adams LWCD	completed
the buffer corridors.	Adams P & Z	
2. Invite the Leola Drainage District governing body & Adams County Drainage Board to	Tri-Lakes Mgmt District	ongong
attend a joint meeting and/or request tour of the ditches..		
3. Investigate and discuss methods to purchase land in the watershed in order to broker land	Tri-Lakes Mgmt District	2016-2017
use change.		

4. Sample & test water at the headwaters region of the drainage district & as it enter Lake	Tri-Lakes Mgmt District	ongoing
Camelot to determine clarity, dissolved oxygen, pH, temperature, biological conditions,	Adams LWCD	
total phosphorus, total nitrogen and total sediments.		
5. Implement the Adams County Stormwater Runoff ordinance to prevent and/or reduce	Adams LWCD	ongoing
nutrients & sediments from entering the state's waters.		
6. Monitor & advocate change in Drainage District legislation.	Tri-Lakes Mgmt District	ongoing
7. Implement State Agricultural Performance Standards by contacting agricultural producers	Tri-Lakes Mgmt District	ongoing
to offer cost share for compkliance with preventing runoff from livestock confinement	Adams LWCD	
operation and uncontained livestock manure; sedimentation due to soil erosion from		
croplands and stream banks; livestock access to stream sites.		
Create community awareness and improve community knowledge about		
watershed activities		
1. Educate landowners, agricultural producers, and community about State	Adams LWCD, NRCS	ongoing
Agricultural Performance Standards and best management practices utilizing	DNR, Waushara LWCD	
newsletters, meetings, and individual visits.	CREP	