Aquatic Plant Management Plan

Tarrant Lake

Columbia County, Wisconsin
December 2012

Sponsored By
Columbia County Land and Water Conservation

Prepared By

Columbia County Land and Water conservation Department

University of Stevens Point, Center for Watershed Science

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Tarrant Lake Preservation Committee

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Executive Summary

This document, Tarrant Lake Aquatic Plant Management Plan will cover the years 2014 through 2020. The plan includes data about the plant community, watershed and water quality of the lake.

This Aquatic Plant Management Plan (APMP) covers the years 2014 through 2020. The plan includes data about the plant community, watershed, and water quality of the lake. There is no known historical aquatic plant data for Tarrant Lake.

The historically native plants provide fish and wildlife habitat, stabilize bottom sediments, reduce the impact of waves against the shoreline, and prevent the spread of non-native invasive plants all critical functions for the lake.

This Aquatic Plant Management Plan, developed with input from the Tarrant Lake Preservation Committee (TLPC) including the limited lake property owners carries out activities to meet aquatic plant management goals. The implementation plan describes the actions that will be taken toward achieving these goals.

The Columbia County Land and Water Department (CCLWCD) has been active in the study and management of Tarrant Lake and its' watershed. This has included an extensive nutrient and water budget analysis conducted by the Columbia County Land and Water Conservation Department. This plan works in conjunction with these efforts by considering habitat, water quality and aesthetics in the plant management.
A special thank you is extended to the Tarrant Lake Preservation Committee for the assistance with plan development.

Plan Goals

1. ***Reduce current AIS***
2. ***Restore critical, native habitats in Tarrant Lake.***
3. ***Restore developed shorelines to native vegetation***
4. ***Protect Tarrant Lake fish Community***

Introduction

The Aquatic Plant Management Plan for Tarrant Lake is sponsored by the Columbia County Land and Water Conservation Department with partial funding from a Wisconsin Department of Natural Resources Lake Planning Grant. The plan includes data about the plant community, fish community, watershed, and water quality of the lake. This plan will guide the Village of Cambria and the Wisconsin Department of Natural Resources in aquatic plant management for Tarrant Lake over the next five to six years (from 2014 through 2020).

Public Input for Plan Development

The TLPC provided input for the development of this plan through a series of meetings. The TLPC held a, Aquatic Plant Management workshop on two occasions: November 15 and December 18. At the first meeting on November 15 2012, the committee reviewed the aquatic plant management planning requirements, plant survey results and discussed aquatic plant management concerns. At a second meeting on December 2012, reviewed goals, developed objectives and updated action steps. Once again in a meeting on April 2012, the committee developed more action items and discussed methods extensively. The TLPC concerns are reflected in the goals and objectives for aquatic plant management in this plan. In a final meeting on October 30, 2013 the TLPC once again extensively reviewed and approved action items and methods.

The TLPC expressed a variety of concerns that are reflected in the objectives for plan development and in the goals for aquatic plant management in this plan. Management concerns ranged from water quality, protection of the fishery and the ecosystem to the density of invasive plant community in Tarrant Lake.

The TLPC announced the availability of the draft Aquatic Plant Management Plan for review with a public notice in the weeks of June of 2013. Copies of the plan were made available to the public at the Cambria City Hall and the Cambria Library.

Lake Information

Tarrant Lake is a 27 acre impoundment located in Columbia County in the Village of Cambria (T13N, R12E, S32 & T12, R12E, S05). This lake is managed for fishing and swimming and is currently not considered impaired. Its Water Body Identification Code is (1269100). It has a maximum depth of 15 feet.

Table 1.Tarrant Lake Information

Size (Acres)	27
Mean depth (feet)	7
Maximum depth (feet)	15
Littoral zone depth (feet)	7.1
Average Secchi depth (feet) 2010	6.4

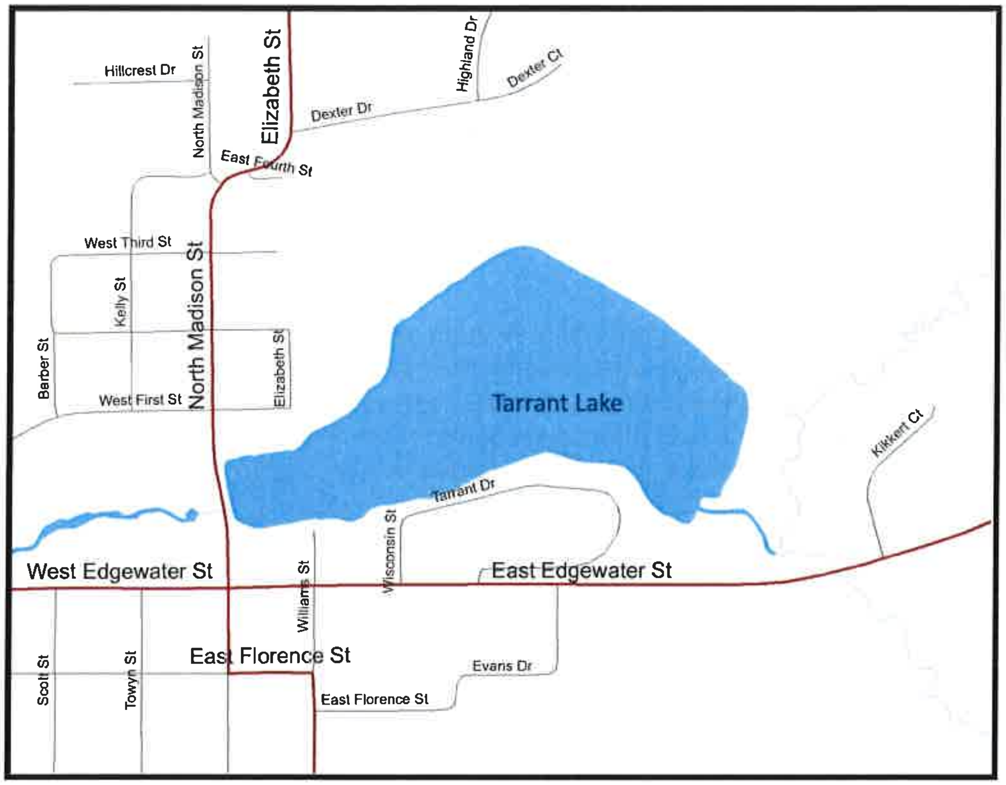


Figure 1. Map of Tarrant Lake

Summary History

With its location in Central Wisconsin in Columbia County, Tarrant Lake, T12N, 13N, R12E, Section 32, 5, Tarrant Lake is located within the Duck Creek Watershed. Tarrant Lake is an impoundment on the North Branch of Duck Creek in the Town of Cambria. The dam creating Tarrant Lake was built on Duck Creek in 1845 on the site of the saw-mill erected by Samuel P. Langdon in what was called than the Village of Florence. Even then, the mill pond was the feature attraction to the community and the four blocks surveyed and platted out around the mill were referred to as Langdon's Mills. Since 1851, Tarrant Lake has meant many things to many people in the Village of Cambria and surrounding area. The waters of Tarrant Lake have been the source of ice for several ice houses and many more area freezers. It has been a place to swim, fish, and duck hunt. On Sundays during World War II, Tarrant Lake provided German Prisoners of War a break from their 6 day a week canning factory commitments to recreate and exercise.

In the 1950's Tarrant Lake was drained (reasons though are uncertain). "In 1993 the spillway of the existing dam was washed out by heavy rains. In 2004 seasonal flooding caused the dam to wash out; as a result, a temporary diversion channel was built. In 2004 the dam washed out, as a result, of a 9" rain, resulting in a temporary diversion channel to be built. In 2005, the temporary diversion channel flooded as well. In "2006 and 2007 the current dam was constructed" lake (Lois Frank, 2008) with 23 foot of head and is owned by the Village of Cambria. During the time of Dam construction the lake bottom was dredged for a total volume of 44,412 cubic yards of soil form the impoundment bottom (Personal communication Domino, 2008). A "test" re fill occurred during May

2006 – October 2006. The lake than started a dewatering process in fall of 2006. In early 2007 Tarrant Lake was refilled and has been full since.

The pond is quite fertile and generally turbid. Weeds and algae are major summer use problems. Largemouth bass and panfish define the fishery; bullheads are abundant. Carp, though present, do not constitute a problem. A village park provides access. There are 68 acres of wetland contiguous with the lakeshore.

Watershed

Tarrant Lake Watershed is located within the Duck Creek and Rocky Run watershed which is 140.89 mi^2, figure 2. Land use in the watershed is primarily agricultural (58.17%), forest (18.97%) and a mix of wetland (16.33%) and other uses (6.53%). This watershed has 232.25 stream miles, 1,895.92 lake acres and 16,023.66 wetland acres Figure 3.

This watershed is ranked medium for streams, low for lakes and high for groundwater and therefore has an overall rank of high. This water is not ranked for pollution runoff.

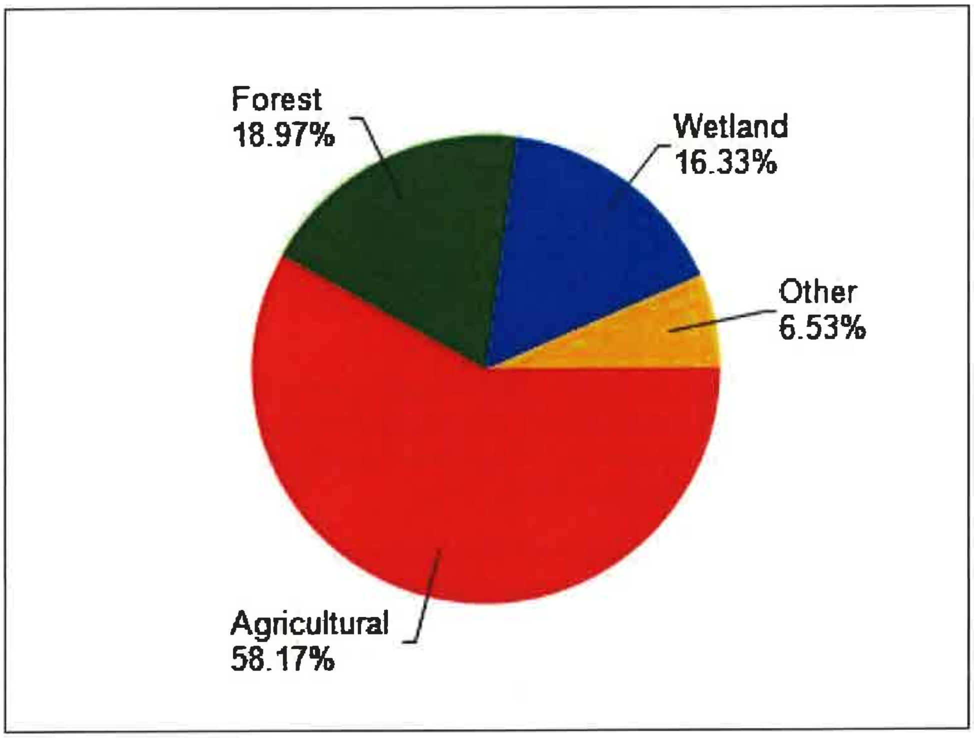


Figure 2. Watershed Land Use (WDNR 2013)

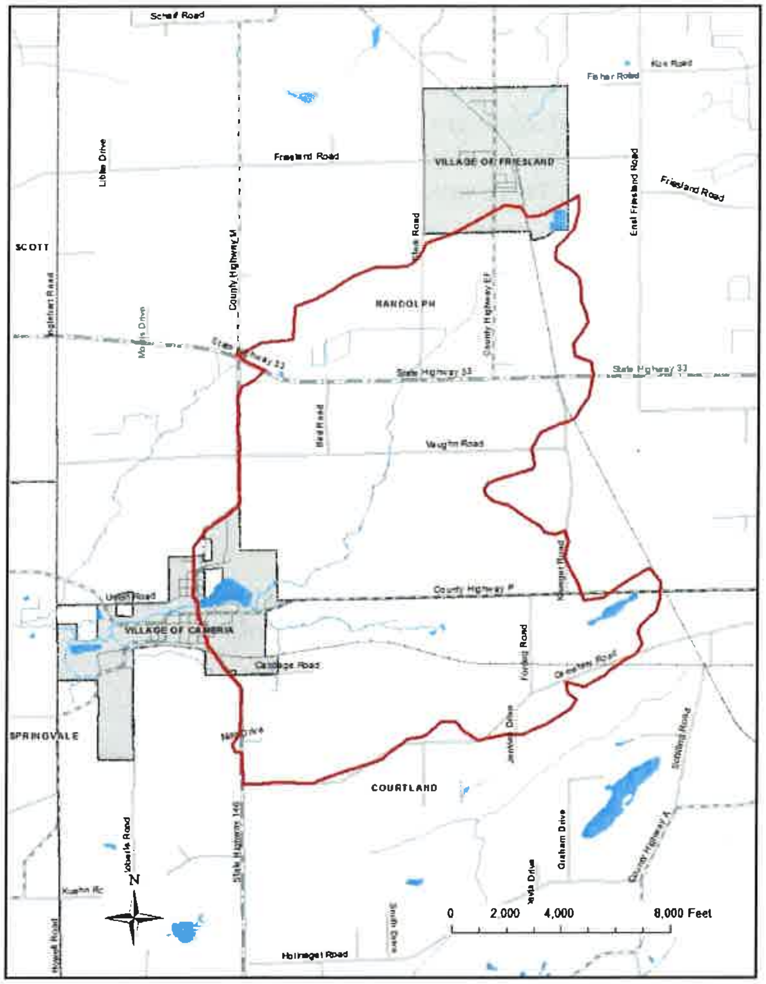


Figure 3. Tarrant Lake Watershed

Water Quality

In the summer of 2009 Columbia County began collecting and compiling water quality and discharge data in portions of the Tarrant Lake watershed. Samples and measurements were taken about every two weeks at the sites noted above and were taken between the dates of 6/3/2009 and 09/08/2010 at five tributaries sites in the Tarrant Lake watershed.

The Total Phosphorus **(TP)** median concentrations (**Error! Reference source not found.**) at 3 of the 5 primary sites exceeded the proposed DNR phosphorus reference standard of 75 µg/l for wadeable streams except TL01 and TL02 which is 58 and 54 µg/, respectively (WDNR 2005). Median concentrations at TL04, 94 µg/l, were higher than the proposed standards (**Error! Reference source not found.**). The median concentrations at TL03 and TL05 exceeded this standard (246 µg/l and 152 µg/l, respectively). In addition, TL03 exhibited great variability ranging in value from 34-813 µg/l. Also, the TP concentrations at TL03 seem to be related to stage height such that increase in stage (i.e. runoff) results in elevated TP concentrations (Figure 5.).

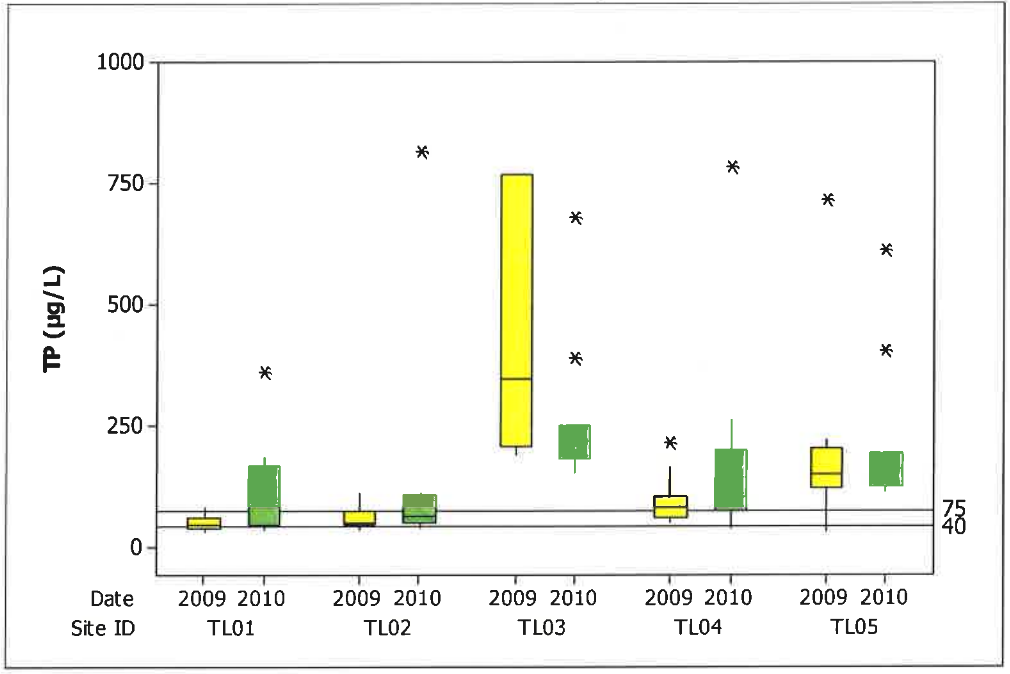


Figure 4.Range of Total Phosphorus Concentrations Measured at Primary Sampling Sites.

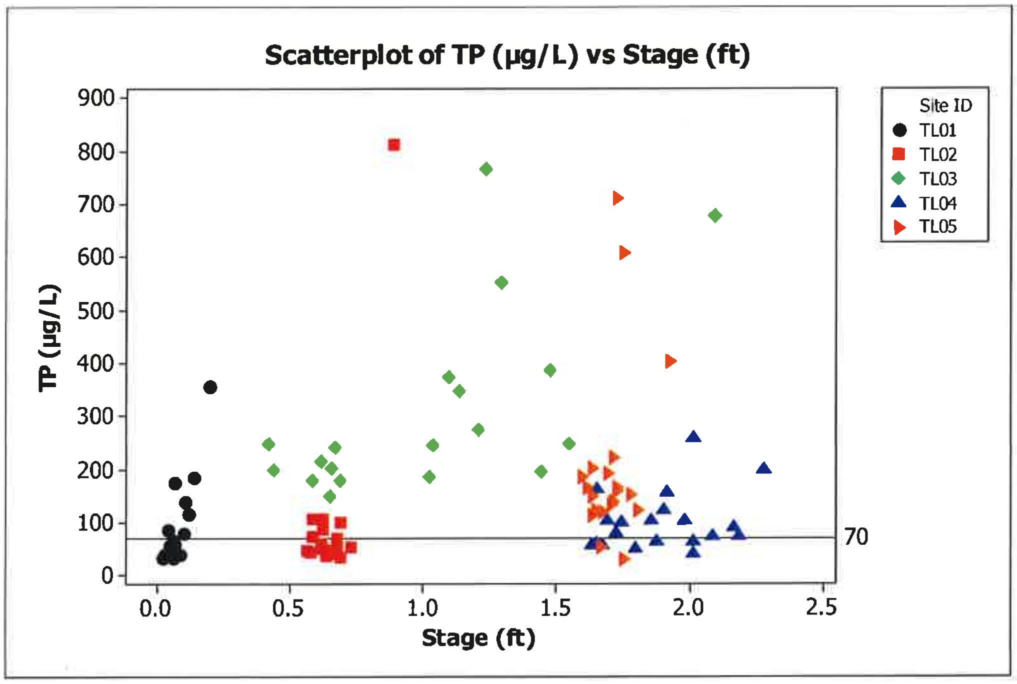


Figure 5.Total Phosphorus Concentrations vs. Stage Height. The horizontal line represents the reference standard of 70 µg/l.

Nitrate represents the major form of nitrogen compounds measured at all sites. The median concentrations at all sites exceeded the reference standard for algal blooms in lakes of 0.3 mg/l and ranged from 4.7 mg/l-11 mg/l (**Error! Reference source not found.**). TL02 had the greatest variability in concentration ranging from 1.9 to 11.5 mg/l.

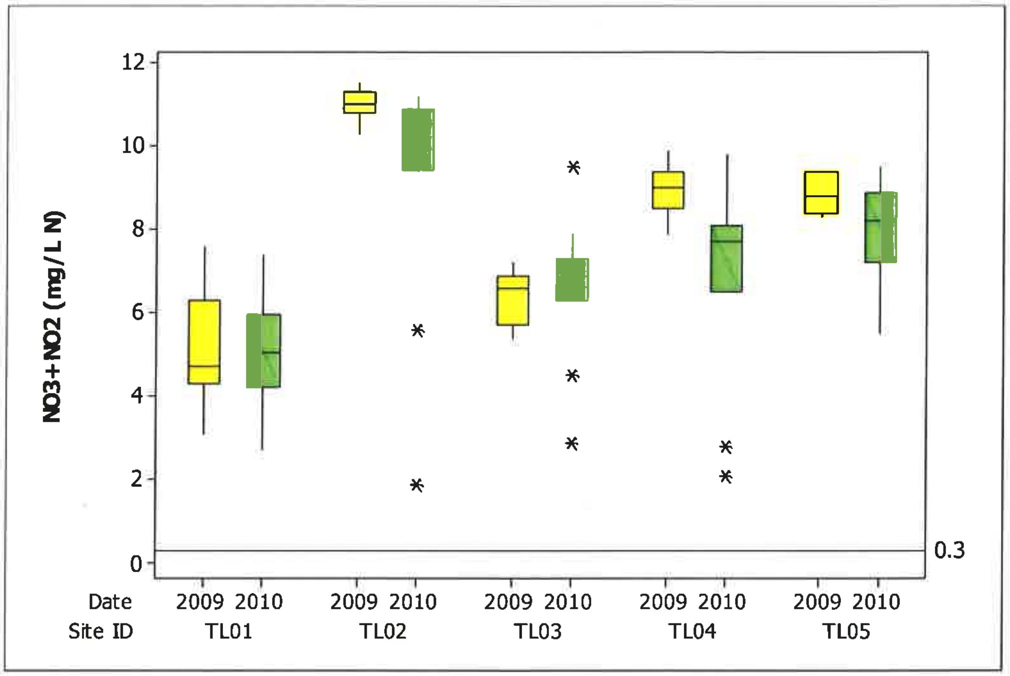


Figure 6. Range of Nitrate Concentrations at Primary Sites

Total Suspended Solids or TSS concentration medians ranged from 6-20 mg/l . TL01 had the greatest variability with concentrations between 2 and 58 mg/l.

Chloride concentrations measured at all primary sites were all above 25 mg/l and exceeded the regional average of 10 mg/l (Shaw et al. 2002).TL01 and TL04 exhibited high variability in concentrations ranging from 10.8-35.7 mg/l at TL03 and 25.6-35 mg/l at TL04. The stream stage heights and chloride concentrations seem to suggest a link to groundwater particularly at TL01, TL02 and TL05 (Figure 12).

The specific conductance (SpC) measurements were elevated at all primary sites, nearly measurements exceeded 700 µmhos. The median value at TL03 was 1025 µmhos (Figure 14).

The pH measured at all primary sites ranged between from 8.7 to 7.6). The median value for TL01 was the highest at 8.5 most likely because it is located at the outflow of the dam. The median values for TL02, 03, 04 and 05 are 7.95, 8, 8.2 and 8.3 respectively.

The Dissolved Oxygen concentrations were measured during each sampling period. The lowest recorded value was 5.09 mg/l.

Tarrant Lake is eutrophic and is receiving a high Nutrient load from the Watershed. Recent modeling efforts by the LWCD and University of Stevens Point summarized in Table 2, suggest the low end of growing season Total Phosphorus loading (April-November)to be at 350-700 lbs. The modeling efforts are scewing low as high flow data was not readily available. It should also be noted up to 40 % of the TP load can be delivered during December –March and this would not be accounted for in a growing season monitoring and modeling effort.

In Lake TP median of 57 ug/l through 2009-2010 Figure 7, Tarrant Lake is above the the 40ug/l Phosphorus standard.

Table 2. Tarrant Lake flux and WilMs Modeling

Tarrant Lake Growing Season TP							
	Name	**2009**	**2009**	**2010**	**2010**	**WilMs**	**WilMs**
		Growing Season TP	Average Per Second Q	Growing Season TP	Average Per Second Q	37567.0 ac.	5267 Ac.
		Total Phosphorus		Total Phosphorus		Total Phosphorus	Total Phosphorus
Units		lbs.	cfs	lbs	cfs	lbs	lbs
Site ID							
TL 01	Dam Outlet	112.28	1.68	147.07	1.86		
TL02	Cabbage Road	28.43	0.49	15.43	0.31		
TL03	Hwy 33	210.22	0.66	118.41	0.39		
TL04	Duck Creek Bridge	154.49	1.38	207.34	1.65		
Total TP		393.14		341.18		718	1112

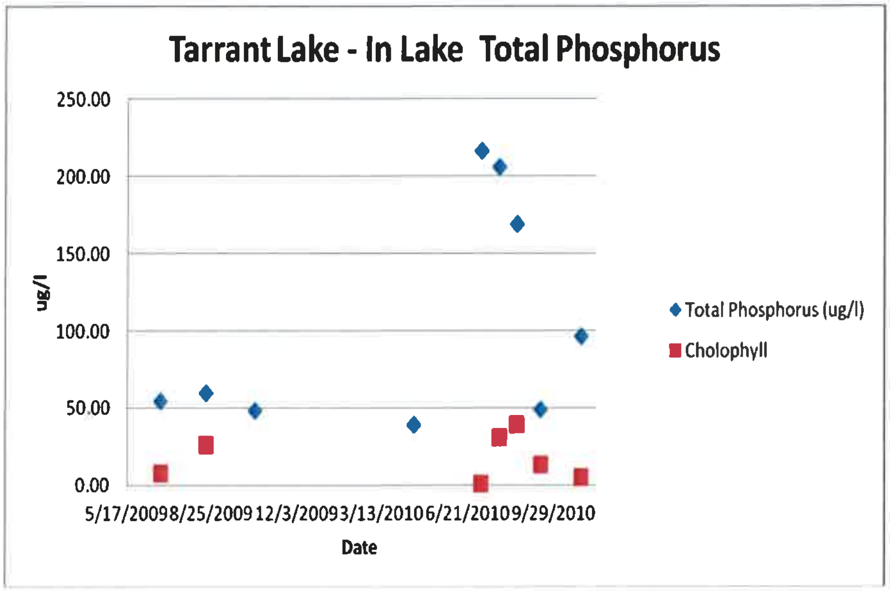


Figure 7. In Lake Total Phosphorus

The DO profiles levels in July and August 2010 seen in Figure 8 combined with the TP levels seen in Figure 7 suggest a TP release under anaerobic conditions.

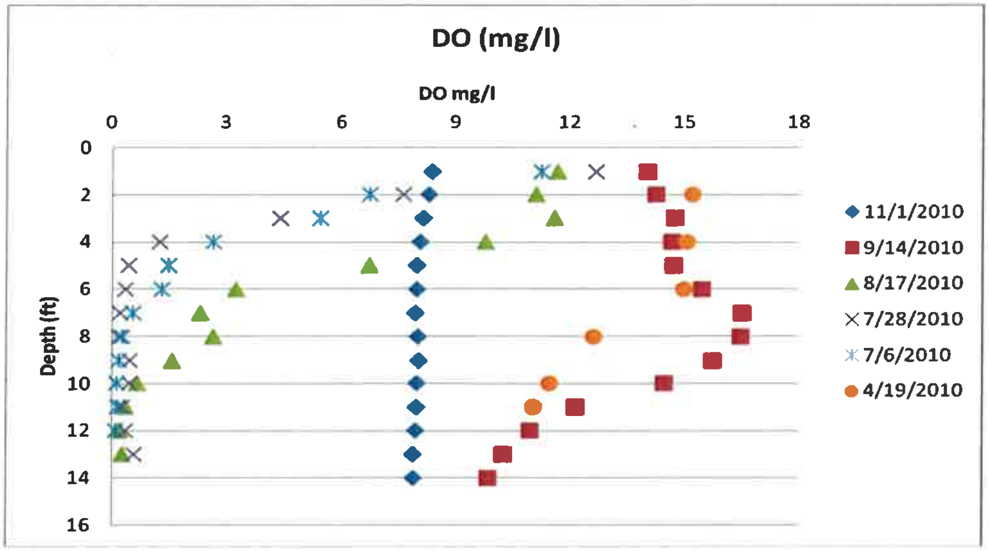


Figure 8. In Lake DO (mg/l) Profile

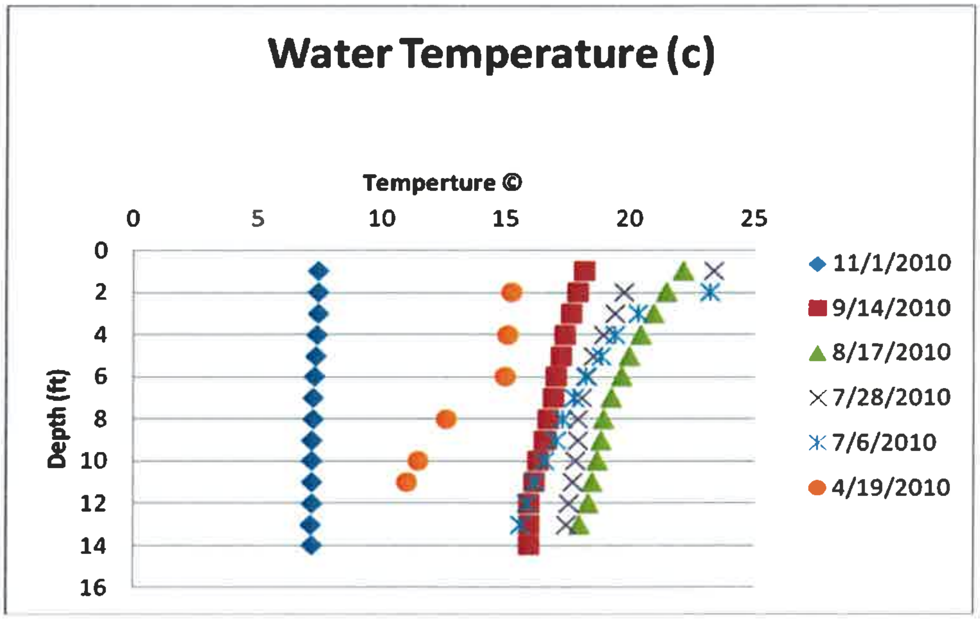


Figure 9. In Lake Water Temperature (c)Profile

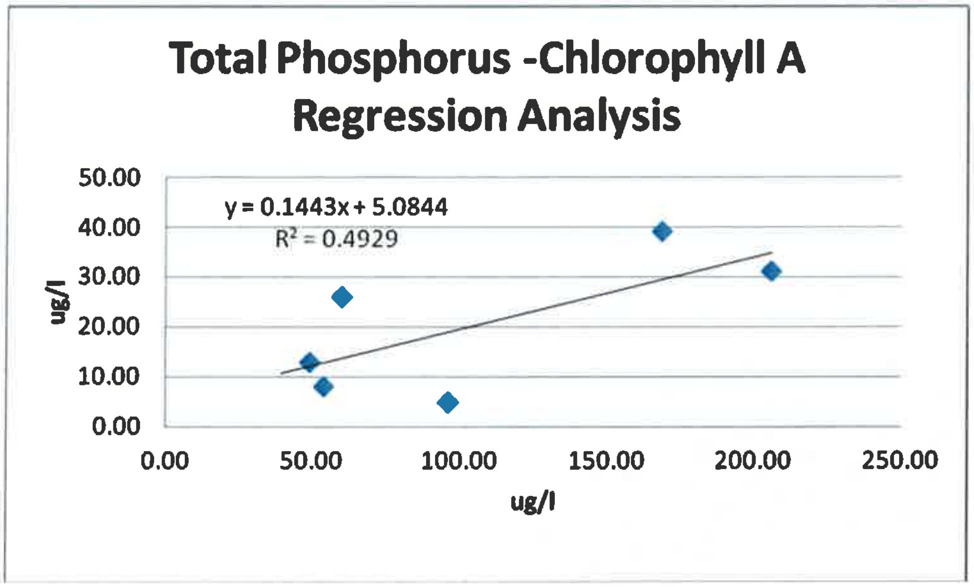


Figure 10. Total Phosphorus, Chlorophyll A

Bathometric Mapping

In conjunction with the 2006 and 2007 construction that occurred on the dam there was a dredging a project to remove sediment on the western side of the lake. As a result of the dredging the 1967 WDNR Tarrant Lake Bathometric map was outdated. As part of the PI study data, using the new depth data gathered during the PI study new Depth (Figure 11) and Bathometric maps(Figure 12) were created.

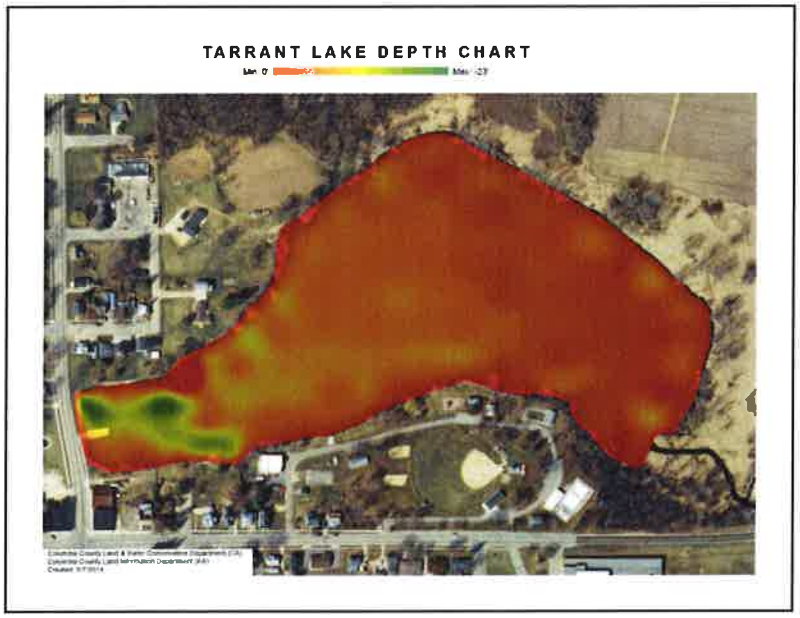


Figure 11. Tarrant Lake Depth Map

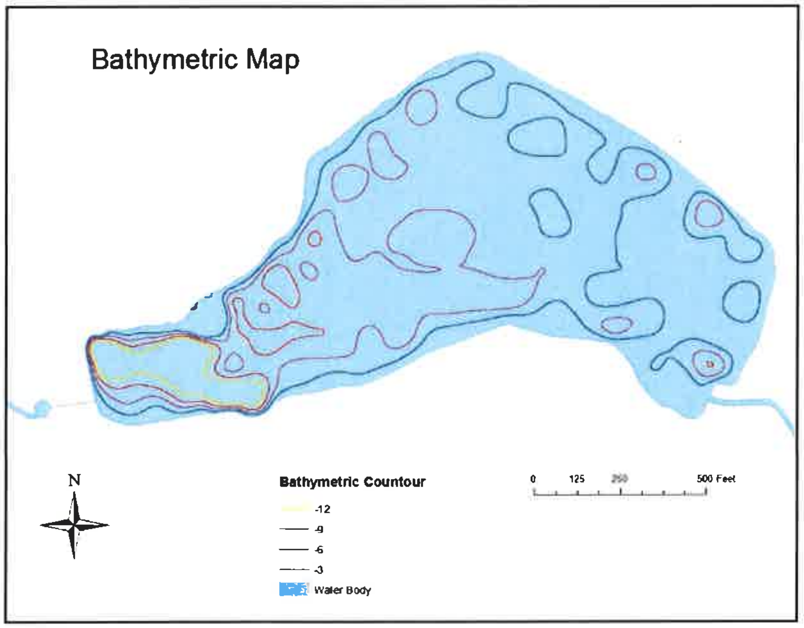


Figure 12. Bathymetric Map

Shoreland Health Study

In November of 2012, the LWCD evaluated the health of the 1 mile of shoreland of Tarrant Lake was inventoried to establish the current conditions of the shoreland identifying areas that may warrant intervention or protection and can be used to evaluate change over time..

The area where the land meets the water provides critical habitat for aquatic and terrestrial biota and can either be a source of water quality problems or can help to improve the quality of runoff from the nearby landscape prior to entering the lake. The shoreland is a part of the landscape that can often be modified to reduce some of the impacts from nearby land management practices. As seen in Figure 8, the Tarrant Lake shoreline ranges from high density residential to completely untouched. The inventory can be found Online at: http://cclid.maps.arcgis.com/apps/Compare/storytelling_compare/index.html?appid=ca81555d641841b18df1a41a838799e5 .

AS can be seen in Figure 13 much of the developed shoreline on Tarrant Lake is lacking a tree and shrub layer and has blue grass sod with1-5' of the lake.

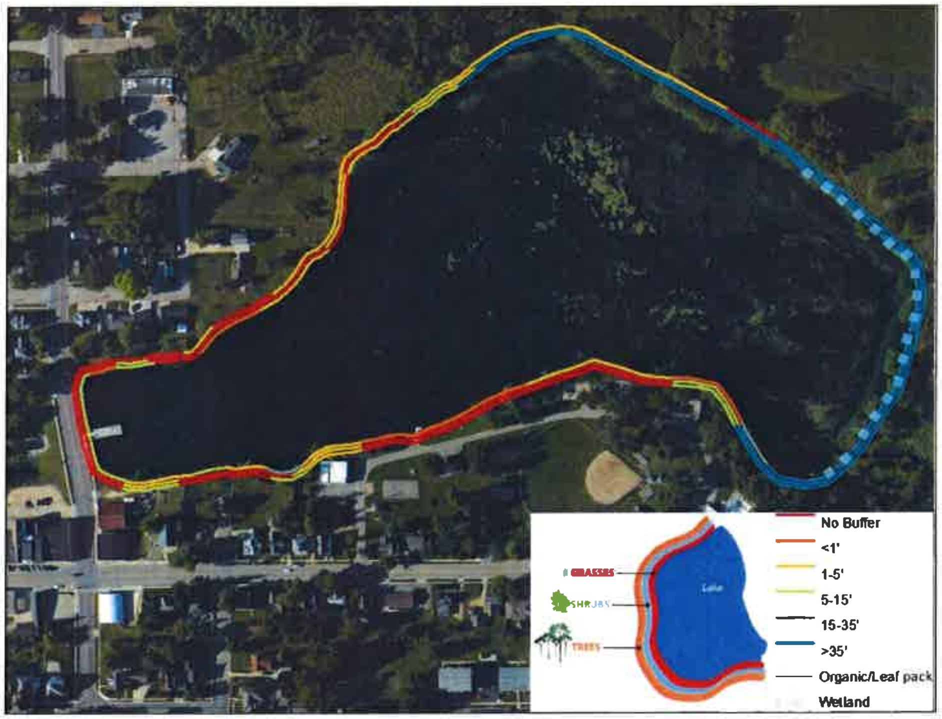


Figure 13. Shoreland Health Study Summary

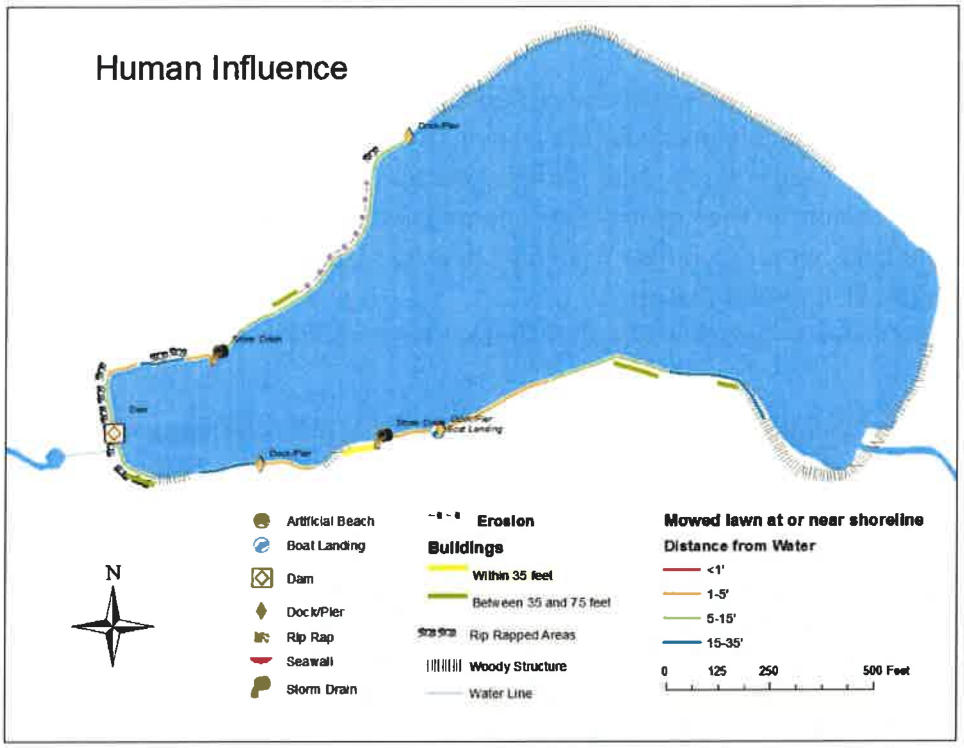


Figure 14. Human Influence Map

Rare, Endangered, or Protected Species Habitat

Tarrant Lake is located in the Village of Cambria (13N, R12E Section 32 & T12N, R12E Section5). Natural Heritage Inventory records are provided to the public by town and range and not by section,

The proposed actions within the plan are not anticipated to affect native plants and wildlife including the natural heritage species listed below in table 3.

Table 3 Rare, Endangered, or Protected Species Habitat

Common Name	Scientific	State Status
American Bittern	Botaurus lentiginosus	Special concern
Slender Glass Lizard	Ophisaurus attenuatus	Special concern

Fishery

Tarrant Lake was drained in 2006 to facilitate dam repair, and was re-filled during the spring of 2007. Adult bluegills were stocked in May 2007 in time to spawn in the lake. The lake was surveyed in late August 2008 and it was evident that the bluegills stocked in 2007 successfully spawned in 2007 and 2008; age-0 and age-1 bluegills were present. Over 6,000 large fingerling largemouth bass were stocked in the fall of 2007, while 305 yearling largemouth bass were stocked in spring 2008. These were present in the 2008 survey as well. Small fingerling northern pike (2 inch fish) were stocked in spring 2008 but were not caught in the survey. There were two large bass (14.1 and 20.0 inches) in the 2008 survey that must have been holdovers from before the lake was drained. Green sunfish were the only additional species captured in 2008, and following the survey, approximately 2,400 large fingerling largemouth bass were stocked into the lake in October. The results of the 2008 survey are in Table 3.

Moving on, small fingerling northern pike and bass were stocked in spring 2009. The lake was surveyed again in 2009 and this time it was done in late September. The bluegill catch rate was essentially unchanged from 2008, but the size structure had improved. The largemouth bass catch rate improved significantly, although no fish greater than 14 inches were caught (minimum length for harvest). Low numbers of green sunfish and black crappie were captured in addition to bluegill and largemouth bass. Results of the survey for bluegill can be seen in Table 3 and bass in Table 4.

Table 4. 2008,2009, and 2011 Bluegill Survey Results

Tarrant Lake Blue Gill Survey Results			
	2008	2009	2011
Distance Shocked (miles)	0.95	1	0.4
Time Shocked (hours)	0.75	0.75	0.25
Number Caught	91	91	205
Bluegill CPUE fish/hour	121.3	121.3	820
Bluegill CPUE fish/mile	95.8	91	512.5
%>6"	0%	2%	46%
%>7	0%	0%	3%

Table 5. 2008, 2009 and 2011 Large Mouth Bass Results

Tarrant Lake Large Mouth Bass Survey Results			
	2008	2009	2011
Distance Shocked (miles)	0.95	1	0.9
Time Shocked (hours)	0.75	0.75	0.52
Number Caught	9	65	60
LMB CPUE fish/hour	12.0	86.7	116.1
LMB CPUE fish/mile	9.5	65.0	66.7
%>12"	0%	11%	63%
%>14"	0%	0%	8%

In 2010 and 2011, additional stockings of small fingerling northern pike and large fingerling largemouth bass occurred. The lake was not surveyed again until May 2011. By that time, the bluegill catch rate had improved significantly to over 500 fish per mile, or 800 fish per hour of electrofishing. Size structure of bluegill was improving as 46% of fish surveyed were greater than 6 inches long, while few were even greater than 7 inches. No age-0 bluegill would have been caught in this survey because it occurred prior to the spawn. Northern pike appeared in the survey for the first time, although northern pike do not electrofish well. Three of the eight pike caught were longer than the 26 inch minimum length limit. Several bass greater than the 14 inch minimum size limit were caught as well. The results of the 2011 survey are in Table 4.

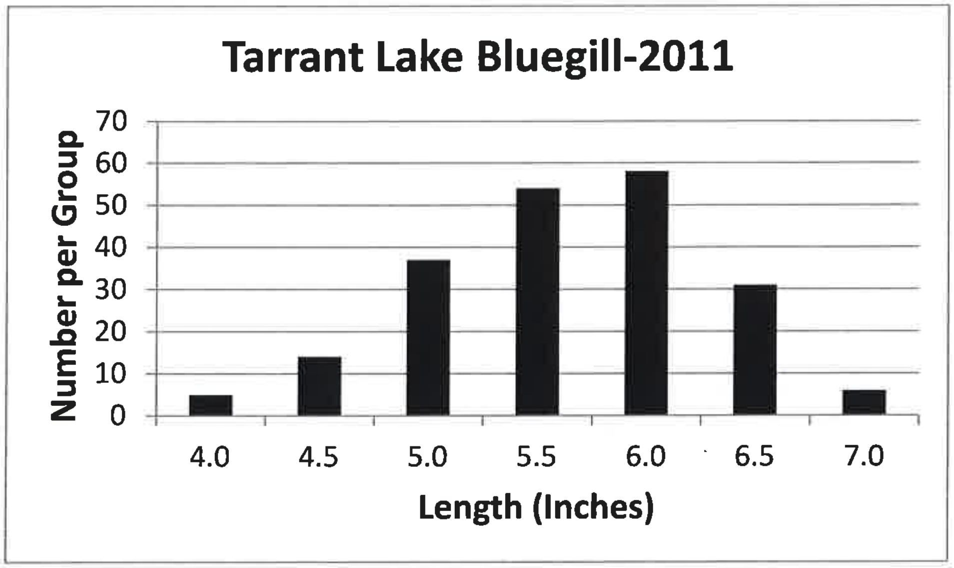


Figure 15. Tarrant Lake 2011 Bluegill Growth Distribution

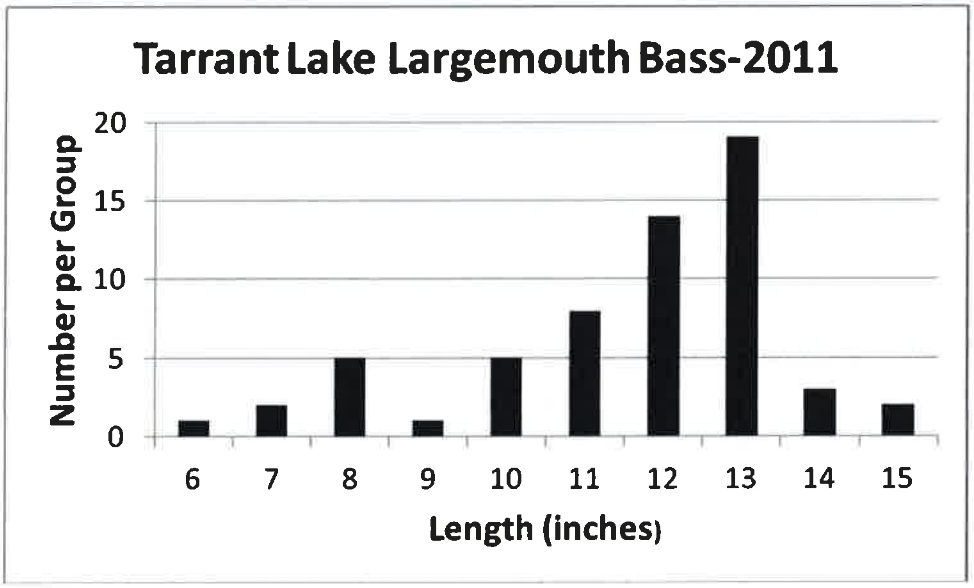


Figure 16. Tarrant Lake 2011 Large Mouth Bass Growth Distribution

<u>Conclusion:</u> Tarrant Lake is a very low-complexity fishery, consisting of bluegill, bass, and northern pike with low levels of other panfish such as green sunfish and black crappie. No carp have been found in DNR surveys and the goal is to keep it that way. Bluegill and largemouth bass are abundant, and northern pike are present in good size and numbers. Bass are essential to preventing bluegill from becoming overpopulated and stunted. Northern pike will aide in this as well, but bass predation will be the main driver of bluegill numbers and size structure. As of 2011, Tarrant Lake appears to be headed towards providing a quality angling opportunity for bluegill, bass, and panfish. This bodes well for the installation of a new ADA accessible fishing pier installed in the spring of 2014.

Stocking Recommendations: The fishery is making excellent progress, and the Wisconsin DNR recommends no additional fish stockings in 2013. The DNR would like to conduct another electrofishing survey of Tarrant Lake in 2013 to re-assess the fish community, and fish stockings can be re-evaluated at that time. Fish Spawning Times and Considerations

Fish Species	**Spawning Temp. (F)**	**Spawning Substrate / Location**	**Comments**
Largemouth Bass Bluegills	Mid 60s to lower 70s	Nests are built in water less than 3 feet deep	Nest Builders
Black Crappie	Upper 50s to lower 60s	Nests are built in 1-6 feet of water	Nest Builders
Northern Pike	Upper 30s – mid 40s (right after ice-out)	Emergent vegetation 6-10 inches of water	Eggs are broadcast

In order to increase growth rates of bluegill and largemouth bass in Tarrant Lake, it is recommended that aquatic macrophyte harvesting be conducted in an effort to remove approximately 20% of the macrophyte biomass. Removing more than half of the vegetation can actually have detrimental effects, specifically decreasing fish growth (Trebitz and Nibbelink 1996). When an intermediate amount of vegetation is removed, however, growth rates and population size structure of largemouth bass and bluegills respond positively (Trebitz and Nibbelink 1996, Olson et al. 1998, Unmuth et al. 1999). Removals can be accomplished through radial cuttings approximately 2m wide (Unmuth et al. 1999). Increases in fish growth will be short term, however, if cuttings are not maintained on at least an every-other-year basis. Olson et al. noted that macrophyte removals in the first year of a plant removal study on Wisconsin lakes lasted through year 2, but by year 3 macrophytes had essentially returned to pre-manipulation densities. Plant re-growth on Tarrant Lake should be monitored closely to determine the frequency with which cuttings should occur in order to maintain open lanes and optimize largemouth bass and bluegill growth while minimizing financial cost to TLPC.

Functions and Values of Native Aquatic Plants

Naturally occurring native plants are extremely beneficial to the lake. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.

Water Quality

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algal growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of sediments from the lake bottom. Stands of emergent plants (whose stems protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline. Poor water clarity can limit aquatic plant growth by limited light penetration.

Shallow lakes typically have two alternative stable states—phytoplankton (algae)-dominated or macrophyte (plant)-dominated (Newton and Jarrell, 1999). In moderate densities, macrophytes are beneficial in these lakes. Macrophytes keep sediment from being resuspended by the wind and, therefore, help keep the water less turbid. Macrophytes also provide a place for attached algae to grow and remove phosphorus from the water column. If the macrophytes are removed or if external phosphorus inputs increase, the lake can shift from a macrophyte-dominated state to an algal-dominated state. Once a lake is in the algal-dominated state, macrophytes have a difficult time reestablishing themselves because algae reduce the penetration of light. Of these two conditions, it is commonly believed that the macrophyte-dominated state, which is present in Tarrant Lake, is more desirable for human and biological use than the algal-dominated state (Newton and Jarrell, 1999).

Fishing

Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish, such as bluegills, graze directly on the plants themselves. Plant beds in shallow water provide important spawning habitat for many fish species.

Waterfowl

Plants offer food, shelter, and nesting material for waterfowl. Birds eat both the invertebrates that live on plants and the plants themselves.[4]

Protection against Invasive Species

Non-native invasive aquatic species threaten native plants in Wisconsin. The most common are Eurasian water milfoil (EWM) and curly leaf pondweed (CLP). These species are described as opportunistic invaders. This means that they take over openings in the lake bottom where native plants have been removed. Without competition from other plants, these invasive species may successfully become established and spread in the lake. This concept of opportunistic invasion can also be observed on land, in areas where bare soil is quickly taken over by weeds.

Removal of native vegetation not only diminishes the natural qualities of a lake, but it increases the risk of non-native species invasion and establishment. The presence of invasive species can change many of the natural features of a lake and often leads to expensive annual control plans. Allowing native plants to grow may not guarantee protection against invasive plants, but it can discourage their establishment. Native plants may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.[5]

Plant Community

Aquatic Plant Survey Results

In June and August of 2012 full lake point intercept (PI) surveys were completed. In June a *Potamogeton crispus (Culry Leaf Pondweed)* survey was completed with a full lake survey of all species completed later in the growing season in August. This survey involved the sampling of 114 predetermined points on Tarrant Lake. Figure 17 shows the sample location grid.

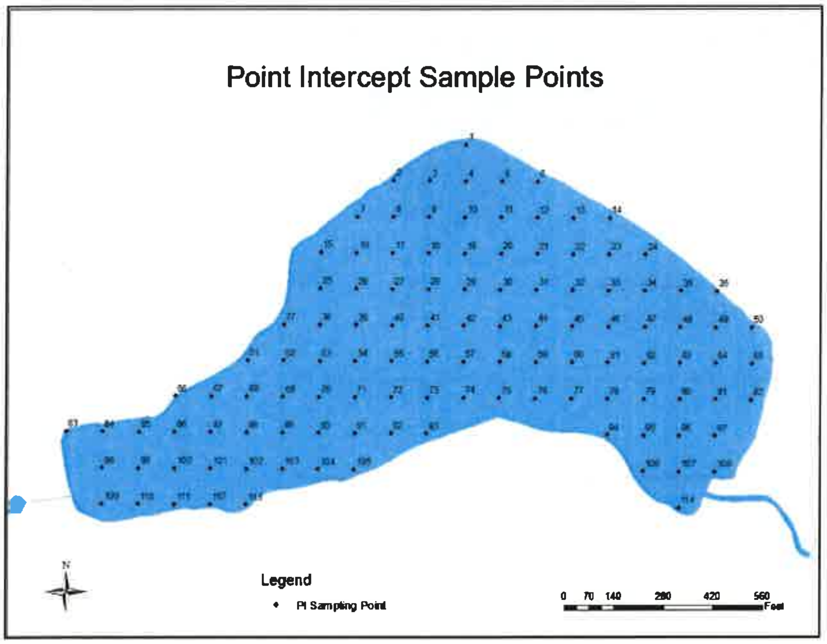


Figure 17. Point Intercept Sample Points

At each sample point, a 14 tined rake was towed 1 meter and retrieved. Each plant species on the rake or that fell off of the rake was identified and recorded at a density (1-3). Each sample point was given a combined full rake density (due to all plants on the rake), ranging from1-3. Figure19 shows the average rake density of plants at each sample point. The map in Figure 18 shows the littoral zone, which is the area with plants in Tarrant Lake. Any location with a green, yellow or red dot has plants present. The "0" represent areas where no plants were sampled.

The littoral zone of Tarrant Lake can be found on 22.9 acres or 81% lake bottom. There were 114 sample points on Tarrant Lake, plants were not found below 7.1 feet thus defining the depth of the littoral zone leaving 100 samples. Of these 100 sample points, 73 had vegetation. The rake density map shows 25 sample points with a plant density of "3". Of the 73 sample points with vegetation, 25 had a density of 3, or 34%.

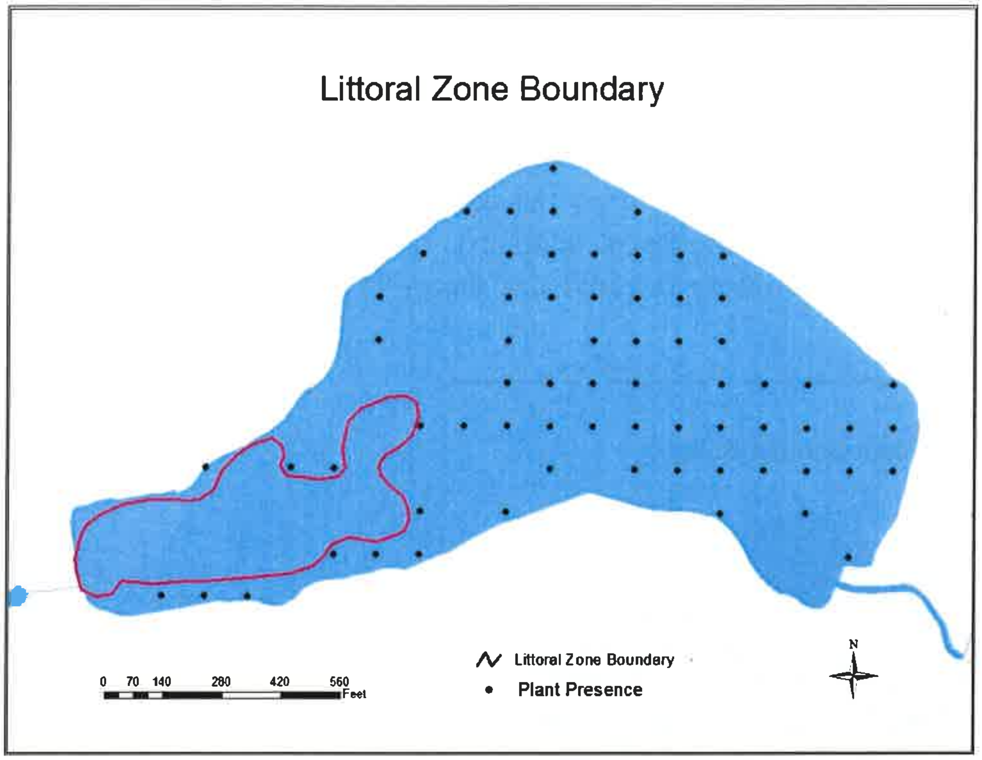


Figure 18. Littoral Zone Boundary

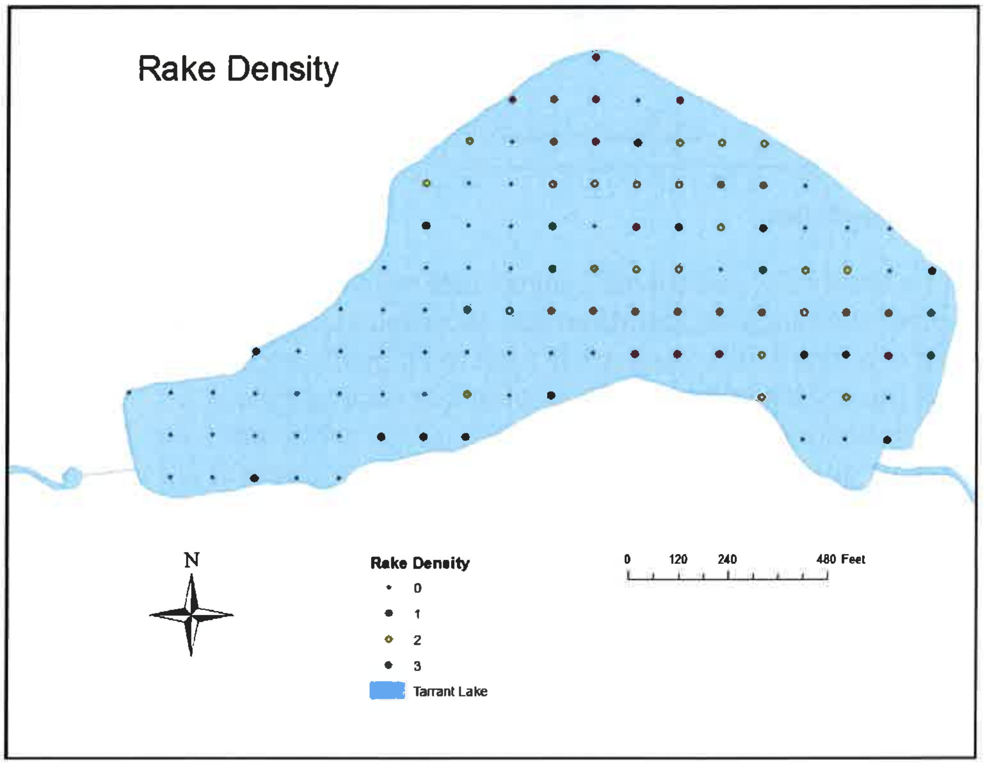


Figure 19. Rake Density

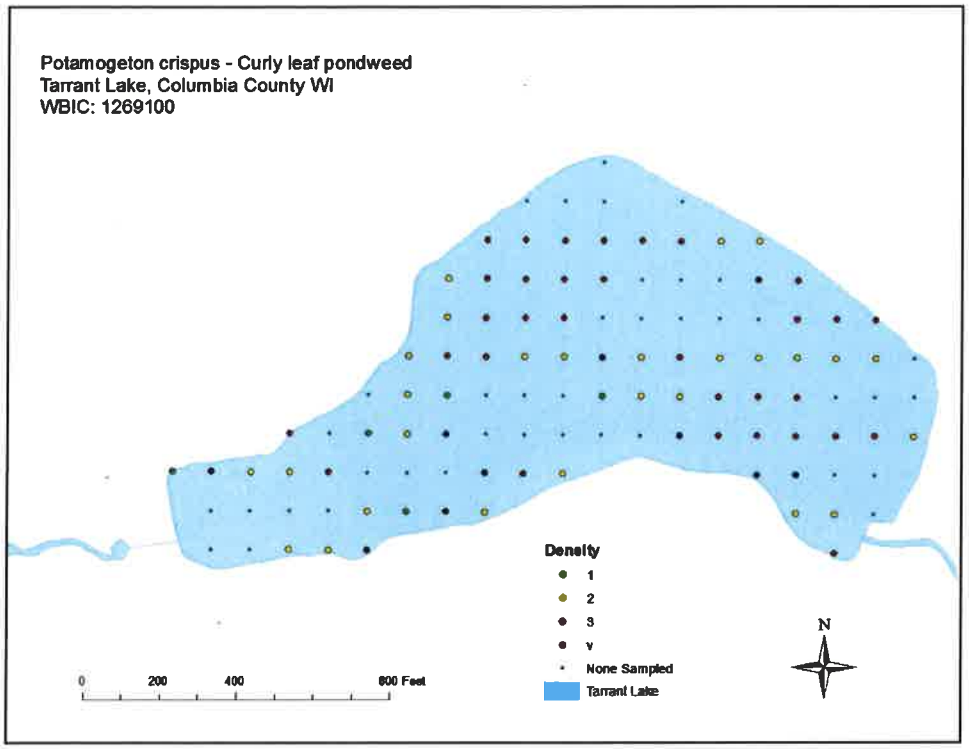


Figure 20. Potamogenteon crispus Density Map

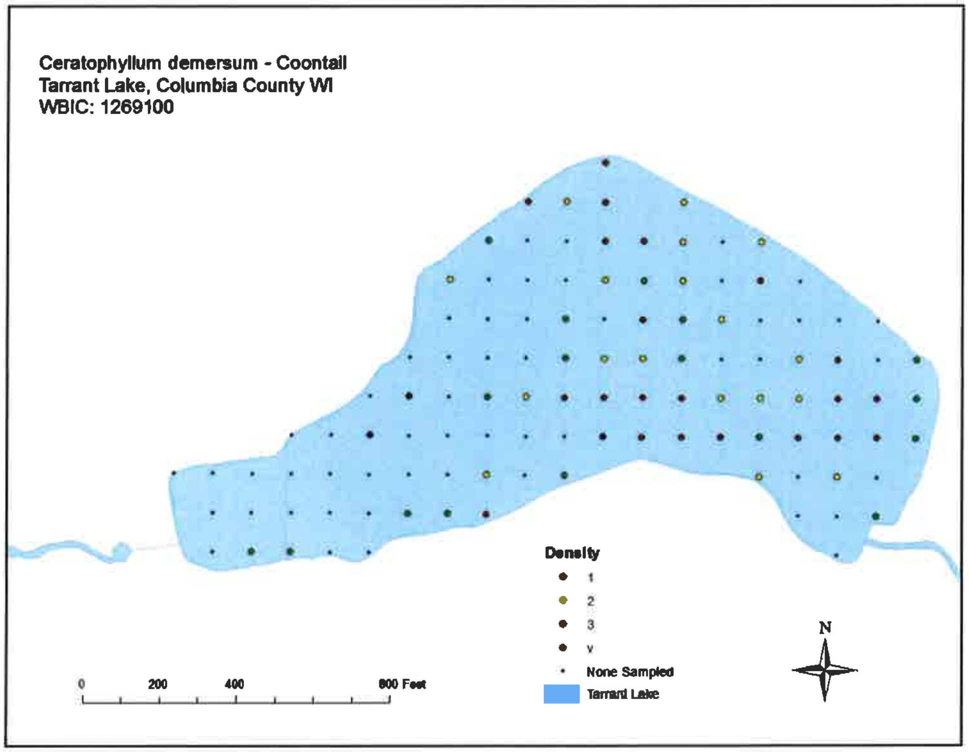


Figure 21. Ceratophyllum demersum Density Map

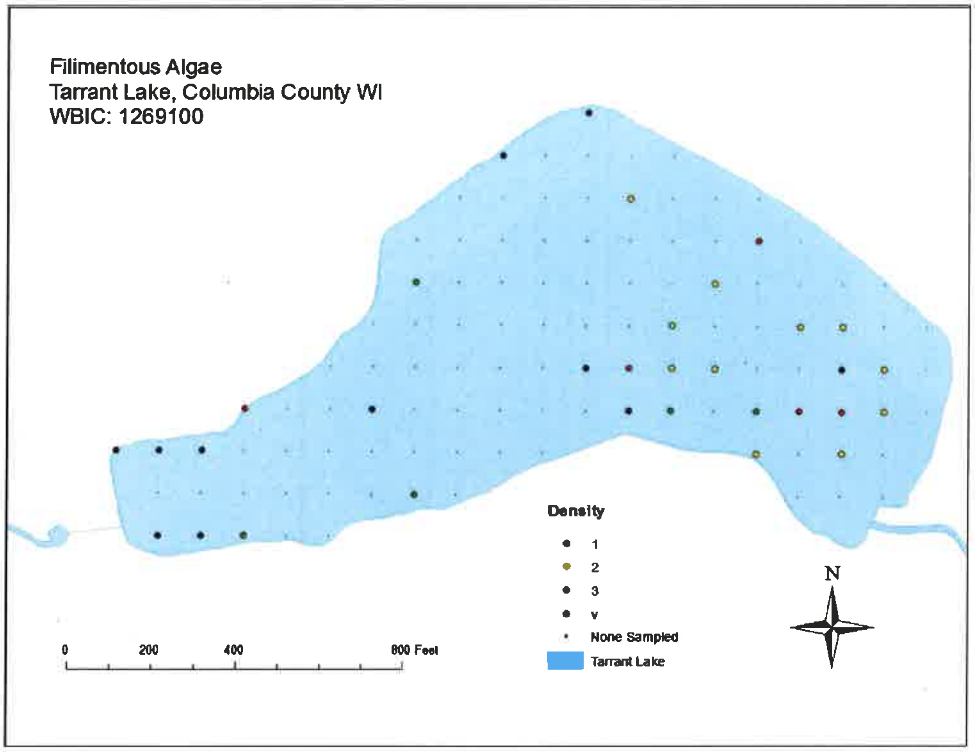


Figure 22. Filimentous Algae Density Map

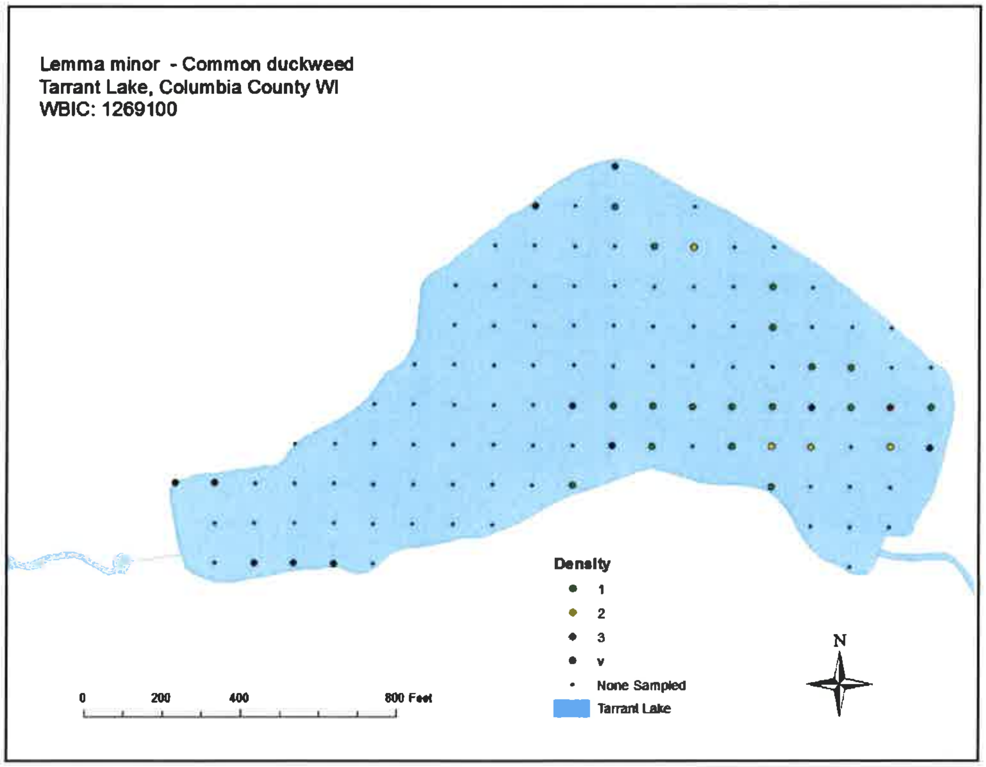


Figure 23. Lemma minor Density Map

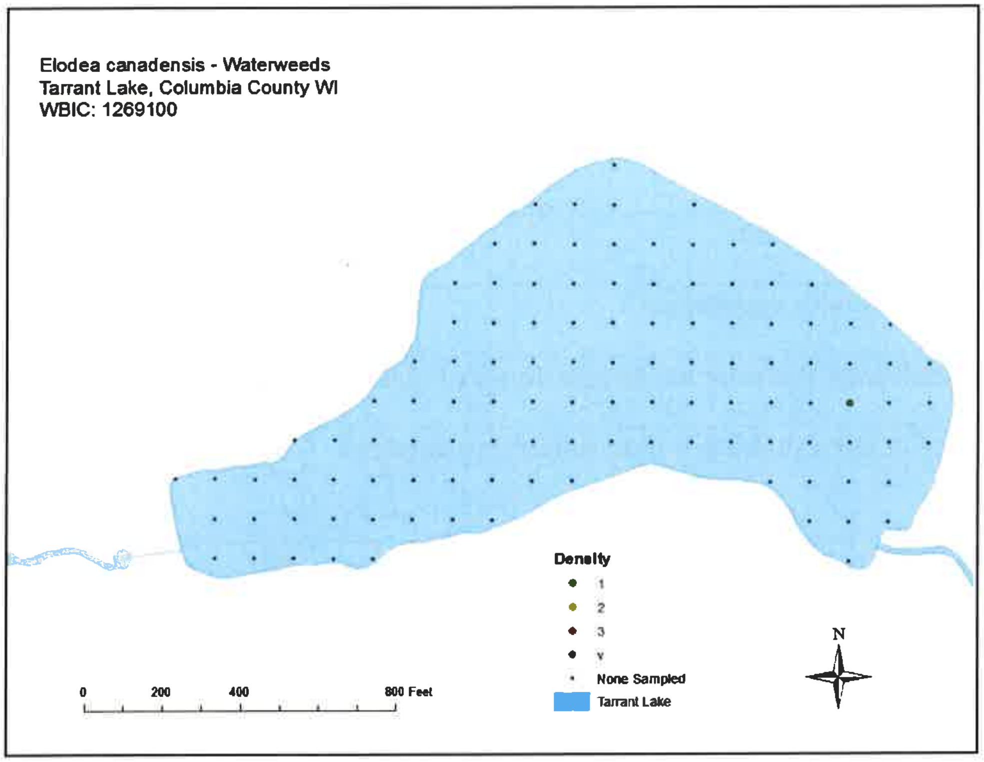


Figure 24. Elodea canadensis Density Map

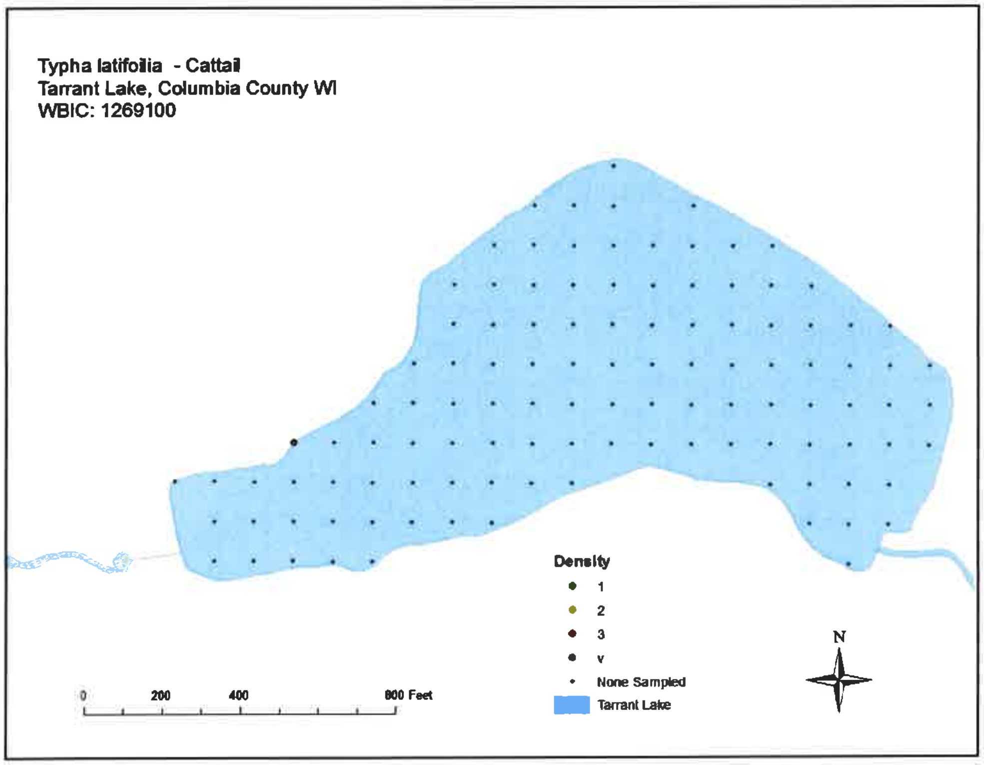


Figure 25. Typha latifolia Density

Table 6: Summary of Point Intercept Survey Statistics- June 2012

Point Intercept Survey Statistics –June 2012	
Total number of sample points	114
Total number of sample points visited	114
Total number of sample sites with vegetation	64
Total number of sites shallower than the maximum depth of plants	110
Frequency of occurrence at sites shallower than maximum depth of plants	58.18
Simpson Diversity Index	0.0
Floristic Quality Index (FQI)	6.2
Maximum depth of plants (ft)	15.0
Average number of all species per site (shallower than max. depth)	0.58
Average number of native species per site (veg. sites only)	1.0
Average number of native species per site (shallower than max depth)	0.0
Average number of native species per site (veg. sites only)	0.0
Species Richness	1
Species Richness (including visuals)	4

Table 7:Summary of Point Intercept Survey Statistics August 2012

Point Intercept Survey Statistics –August 2012	
Total number of sample points	114
Total number of sample points visited	104
Total number of sample sites with vegetation	60
Total number of sites shallower than the maximum depth of plants	108
Frequency of occurrence at sites shallower than maximum depth of plants	55.56
Simpson Diversity Index	0.43
Floristic Quality Index (FQI)	6.2
Maximum depth of plants (ft)	12.0
Average number of all species per site (shallower than max. depth)	0.72
Average number of native species per site (veg. sites only)	1.32
Average number of native species per site (shallower than max depth)	0.72
Average number of native species per site (veg. sites only)	1.32
Species Richness	3
Species Richness (including visuals)	6

The Simpson's diversity index is a calculation that gives the probability that two species randomly sampled will be different. The Simpson's diversity index for Tarrant Lake is 0.43 (0.43% probability two species will differ), which is quite low and supports a low diversity of the plant community in the lake. There were nearly 4 species (3.71) sample on average at each sample point.

Table 8. Tarrant Lake Vegetation Summary Statistics

Species	Frequency	Relative Frequency	# of sites Species Found	Average Density	# viewed
Ceratophyllum demersum **Coontail**	93.33	70.9	56	2.07	3
Elodea Canadensis **Common waterweed**	5.0	3.8	3	1	5
Leman Minor **Small duckweed**	33.3	25.3	20	1.30	8
Stuckenia pectinata **Sago pondweed**	0.0	0.0	0.0	0.0	4
Typha latifolia **Broad-leaved cattail**	0.0	0.0	0.0	0.0	1
Bolboschoenus fluviatilis, River bulrush	0.0	0.0	0.0	0.0	1

Aquatic Plant Management

This section reviews the potential management methods available and reports recent management activities on the lakes.

Discussion of Management Methods

Permitting Requirements

The Department of Natural Resources regulates the removal of aquatic plants when chemicals are used, when plants are removed mechanically, and when plants are removed manually from an area greater than thirty feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. **A permit is required for any aquatic chemical application in Wisconsin.** The requirements for manual and mechanical plant removal are described in *NR 109 – Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations.* A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline up to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal refers to the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.6

The *Department of Natural Resources Northern Region Aquatic Plant Management Strategy* (May 2007) requires documentation of impaired navigation or nuisance conditions before native plants may be managed with herbicides. Severe impairment or nuisance will generally mean that vegetation grows thickly and forms mats on the water surface. Techniques to control the growth and distribution of aquatic plants are discussed in the following text. The application, location, timing, and combination of techniques must be considered carefully.

Manual Removal

Manual removal—hand pulling, cutting, or raking—will effectively remove plants from small areas. It is likely that plant removal will need to be repeated more than once during the growing season. The best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants with rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment and for private landowners who wish to remove small areas of curly leaf pondweed growth. Raking is recommended to clear nuisance growth in riparian area corridors up to thirty feet wide. SCUBA divers may engage in manual removal for invasive species like Eurasian water milfoil. Care must be taken to ensure that all plant fragments are removed from the lake.

Mechanical Control

Larger-scale control efforts require more mechanization. Mechanical cutting, mechanical harvesting, diver-operated suction harvesting, and rotovating (tilling) are the most common forms of mechanical control available. WDNR permits under Chapter NR 109 are required for mechanical plant removal.

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment, and generally cut to depths from one to six feet. A conveyor belt on the cutter head brings the clippings onboard the machine for storage. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel.

The size, and consequently the harvesting capabilities, of these machines vary greatly. As they move, harvesters cut a swath of aquatic plants that is between 4 and 20 feet wide, and can be up to 10 feet deep. The on-board storage capacity of a harvester ranges from 100 to 1,000 cubic feet (by volume) or 1 to 8 tons (by weight).

In some cases, the plants are transported to shore by the harvester itself for disposal, while in other cases, a barge is used to store and transport the plants in order to increase the efficiency of the cutting process. The plants are deposited on shore, where they can be transported to a local farm to be used as compost (the nutrient content of composted aquatic plants is comparable to that of cow manure) or to an upland landfill for proper disposal. Most harvesters can cut between 2 and 8 acres of aquatic vegetation per day, and the average lifetime of a mechanical harvester is 10 years.

Mechanical harvesting of aquatic plants presents both positive and negative consequences to any lake. Its results—open water and accessible boat lanes—are immediate, and can be enjoyed without the restrictions on lake use which follow herbicide treatments. In addition to the human use benefits, the clearing of thick aquatic plant beds may also increase the growth and survival of some fish. By eliminating the upper canopy, harvesting reduces the shading caused by aquatic plants. The nutrients stored in the plants are also removed from the lake, and the sedimentation that would normally occur as a result of the decaying of this plant matter is prevented. Additionally, repeated treatments may result in thinner, more scattered growth.

Aside from the obvious effort and expense of harvesting aquatic plants, there are many environmentally-detrimental consequences to consider. The removal of aquatic species during harvesting is non-selective. Native and invasive species alike are removed from the target area. This loss of plants results in a subsequent loss of the functions they perform, including sediment stabilization and wave absorption. Shoreline erosion may therefore increase. Other organisms such as fish, reptiles, and insects are often displaced or removed from the lake in the harvesting process. This may have adverse effects on these organisms' populations as well as the lake ecosystem as a whole.

While the results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Much like mowing a lawn, harvesting must be conducted numerous times throughout the growing season. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow the invasive plant species to propagate and colonize in new, previously unaffected areas of the lake. Harvesting may also result in re-suspension of contaminated sediments and the excess nutrients they contain.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures don't make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the efficiency of the operation, in terms of time as well as cost.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. For curly leaf pondweed, it should also be before the plants form turions (reproductive structures) to avoid spreading the turions within the lake. If the harvesting is conducted too early, the plants will not be close enough to the surface, and the cutting will not do much damage to them. If too late, turions may have formed and may be spread, and there may be too much plant matter on the surface of the lake for the harvester to cut effectively.

If the harvesting work is contracted, the equipment should be inspected before and after it enters the lake. Since these machines travel from lake to lake, they may carry plant fragments with them, and facilitate the spread of aquatic invasive species from one body of water to another. Harvesting contractors are not readily available in northern Wisconsin, so harvesting contracts are likely to be very expensive. One must also consider prevailing winds, since cut vegetation can be blown into open areas of the lake or along shorelines.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on a barge or pontoon boat. The dredge hoses are from 3 to 5 inches in diameter and are handled by one diver. The hoses normally extend about 50 feet in front of the vessel. Diver dredging is especially effective against the pioneering establishment of submersed invasive plant species. When a weed is discovered in a pioneering state, this methodology can be considered. To be effective, the entire plant, including the subsurface portions, should be removed.

Plant fragments can result from diver dredging, but fragmentation is not as great a problem when infestations are small. Diver dredging operations may need to be repeated more than once to be effective. When applied to a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates play an important role in the effectiveness of a diver dredging operation. Soft substrates are very easy to work in. Divers can remove the plant and root crowns with little difficulty. Hard substrates, however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment. Diver dredging will be considered as a rapid response control measure for Eurasian water milfoil if discovered in the lake.

Biological Control

Biological control is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control counteracts the problems that occur when a species is introduced into a new region of the world without a complex or assemblage of organisms that feed directly upon it, attack its seeds or progeny through predation or parasitism, or cause severe or debilitating diseases. With the introduction of pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

The effectiveness of bio-control efforts varies widely (Madsen, 2000). Beetles are commonly and successfully used to control purple loosestrife populations in Wisconsin. Weevils are used as an experimental control for Eurasian water milfoil once the plant is established. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, an herbivorous fish, is sometimes used to feed on pest plant populations, but grass carp introduction is not allowed in Wisconsin. As a result, grass carp is not a viable bio-control in Wisconsin lakes and won't be utilized.

Weevils have potential for use as a biological control agent against Eurasian water milfoil. There are several documented "natural" declines of EWM infestations with weevil present. In these cases, EWM was not eliminated but its abundance was reduced enough so that it did not achieve dominance.

There are advantages and disadvantages to the use of biological control as part of an overall aquatic plant management program. Advantages include longer-term control relative to other technologies, lower overall costs, and plant-specific control. On the other hand there are several disadvantages to consider, including very long control times (years instead of weeks), a lack of available biological control agents for particular target species, and relatively specific environmental conditions necessary for success. Biological control is not without risks; new non-native species introduced to control a pest population may cause problems of its own.

Re-vegetation with Native Plants

Another aspect to biological control is native aquatic plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols 1991; Smart and Doyle 1995). However, in communities that have only recently been invaded by nonnative species, a propagule (seed) bank probably exists that will restore the community after nonnative plants are controlled (Madsen, Getsinger, and Turner, 1994).

Physical Control

In physical management, the environment of the plants is manipulated, which in turn acts upon the plants. Several physical techniques are commonly used: dredging, drawdown, benthic (lake bottom) barriers, and shading or light attenuation. Because they involve placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 WDNR permit would be required. Such permits are not commonly granted.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson 1982). Lakes that are very shallow due to sedimentation tend to have excess plant growth. Dredging can form an area of the lake too deep for plants to grow, thus creating an area for open water use (Nichols 1984). By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community (Nichols 1984). Results of dredging can be very long term. However, due to the cost, environmental impacts, and the problem of disposal, dredging should not be performed for aquatic plant management alone. It is best used as a lake remediation technique.

Drawdown, or significantly decreasing lake water levels can be used to control nuisance plant populations. With drawdown, the water body has water removed to a given depth. It is best if this depth includes the entire depth range of the target species. Drawdowns need to be at least one month long to ensure thorough drying and effective removal of target plants (Cooke 1980a). In northern areas, a drawdown in the winter that will ensure freezing of sediments is also effective. Although drawdown may be effective for control of hydrilla for one to two years (Ludlow 1995), it is most commonly applied to Eurasian water milfoil (Geiger 1983; Siver et al. 1986) and other milfoils or submersed evergreen perennials (Tarver 1980).

10 Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

Although drawdown can be inexpensive and have long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the drawdown period. Lastly, species respond in very different manners to drawdown and individual species responses can be inconsistent (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy species, particularly annuals. Drawdown requires a mechanism to significantly lower water levels.

Benthic barriers or other bottom-covering approaches are another physical management technique. The basic idea is to cover the plants with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic, and synthetic materials; sediments such as dredge sediment, sand, silt or clay; fly ash; and various combinations of the above materials (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with synthetic sheeting is that the gases evolved from plant and sediment decomposition collect underneath and lift the barrier (Gunnison and Barko 1992).

The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984).

Benthic barriers will typically kill the plants under them within 1 to 2 months, after which time they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). Synthetic barriers, if left in place for multi-year control, will eventually become sediment-covered and will allow colonization by plants. Benthic barriers may be best suited to small, high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily affect benthic communities by removing fish and invertebrate habitat. A WDNR permit would be required for a benthic barrier, and these barriers are not recommended.

Shading or light attenuation reduces the amount of light plants have available for growth. Shading has been achieved by fertilization to produce algal growth, application of natural or synthetic dyes, shading fabric, or covers, and establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general these techniques are only of limited applicability. Physical control is not currently proposed for management of aquatic plants in Tarrant Lake.

Herbicide and Algaecide Treatments

Herbicides are chemicals used to kill plant tissue. Currently, no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability, or persistence in the environment (Joyce, 1991). Thus, there are a limited number of active ingredients that are assured to be safe for aquatic use (Madsen, 2000).

An important caveat is that these products are considered safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. WDNR permits under Chapter NR 107 are required for herbicide application.

Contact herbicides

Contact herbicides act quickly and are generally lethal to all plant cells they contact. Because of this rapid action, or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants directly. They are generally more effective on annuals (plants that complete their life cycle in a single year). Perennial plants (plants that persist from year to year) can be defoliated by contact herbicides, but they quickly resprout from unaffected plant parts. Submersed aquatic plants that are in contact with sufficient concentrations of the herbicide in the water for long enough periods of time are affected, but regrowth occurs from unaffected plant parts, especially plant parts that are protected beneath the sediment. Because the entire plant is not killed by contact herbicides, retreatment is necessary, sometimes two or three times per year. **Endothall, diquat,** and **copper** are contact aquatic herbicides.

Systemic herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil active herbicides and those that are absorbed by leaves are referred to as foliar active herbicides.

2,4-D, dichlobenil, fluridone, and glyphosate are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides. They must move to the part of the plant where their site of action is. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides also generally have more selectivity than contact herbicides.

Broad spectrum herbicides

Broad spectrum (sometimes referred to as nonselective) herbicides are those that are used to control all or most species of vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad spectrum aquatic herbicide. **Diquat, endothall, and fluridone** are used as broad spectrum aquatic herbicides, but can also be used selectively under certain circumstances.

Selective herbicides

Selective herbicides are those that are used to control certain plants but not others. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, timing, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

Environmental considerations

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats and otters). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect one or more of the organisms in the community, and in turn affect other organisms or weed control operations. These operations can also impact water chemistry which may result in further implications for aquatic organisms.

Brand Name(s) Chemical Target Plants

Cutrine Plus, CuSO4, Captain,
Navigate, Komeen
Copper compounds Filamentous algae,
coontail,
wild celery, elodea, and
pondweeds
Reward Diquat Coontail, duckweed, elodea,
water milfoil, and pondweeds
Aquathol, Aquathol K, Aquathol
Super K,
Hydrothol 191

Endothall Coontail, water milfoil,
pondweeds, and wild celery as
well as other submersed
weeds and algae
Rodeo Glyphosate Cattails, grasses, bulrushes,
purple loosestrife, and water
lilies
Navigate, Aqua-Kleen,
DMA 4 IVM, Weed-Rhap
2, 4-D Water milfoils, water lilies, and
bladderwort

Copper

Copper is a naturally occurring element that is essential at low concentrations for plant growth. It does not break down in the environment, but it forms insoluble compounds with other elements and is bound to charged particles in the water. It rapidly disappears from water after application as an herbicide. Because it is not broken down, it can accumulate in bottom sediments after repeated or high rates of application. Accumulation rarely reaches levels that are toxic to organisms or significantly above background concentrations in the sediment.

2,4-D

2,4-D photodegrades on leaf surfaces after being applied to leaves, and is broken down by microbial degradation in water and in sediments. Complete decomposition usually takes about 3 weeks in water but can be as short as 1 week. 2,4-D breaks down into naturally occurring compounds.

A recent study in Tomahawk Lake in Bayfield County, Wisconsin illustrated a much slower breakdown time of 2,4-D than described above. Following a whole lake treatment of .5 mg/L 2,4-D, the chemical was still present 160 days after treatment. While there was successful removal of the target plant, Eurasian water milfoil, there were also significant declines in native plant biomass. A potential explanation was the low nutrient conditions in Lake Tomahawk which was described as an oligo-mesotrophic lake. (Nault 2010, Toshner 2010)

Diquat

When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection levels 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and bound tightly to particles in the water and bottom sediments. When bound to certain types of clay particles, diquat is not biologically available. When diquat is bound to organic matter, it can be slowly degraded by microorganisms. When diquat is applied foliarly, it is degraded to some extent on the leaf surfaces by photodegradation. Because it is bound in the plant tissue, a proportion is probably degraded by microorganisms as the plant tissue decays.

Endothall

Like 2,4-D, endothall is rapidly and completely broken down into naturally occurring compounds by microorganisms. The by-products of endothall dissipation are carbon dioxide and water. Complete breakdown usually occurs in about 2 weeks in water and 1 week in bottom sediments.

Fluridone

Dissipation of fluridone from water occurs mainly by photodegradation. Metabolism by tolerant organisms and microbial breakdown also occurs, and microbial breakdown is probably the most important method of breakdown in bottom sediments. The rate of breakdown of fluridone is variable and may be related to time of application. Applications made in the fall or winter, when the sun's rays are less direct and days are shorter, result in longer half-lives. Fluridone usually disappears from pondwater after about 3 months but can remain up to 9 months. It may remain in bottom sediment between 4 months and 1 year.

Glyphosate

Glyphosate is not applied directly to water for weed control, but when it does enter the water it is bound tightly to dissolved and suspended particles and to bottom sediments and becomes inactive. Glyphosate is broken down into carbon dioxide, water, nitrogen, and phosphorus over a period of several months.

Copper Compounds

Copper-based compounds are generally used to treat filamentous algae. Common chemicals used are copper sulfate and Cutrine Plus, a chelated copper algaecide.

Herbicide Used to Manage Invasive Species

Eurasian Water Milfoil

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil (EWM): 2,4-D, diquat, endothall, fluridone, and triclopyr.All of these herbicides with the exception of diquat are available in both granular and liquid formulations. It is possible to target invasive species by using the appropriate herbicide and timing of application. The herbicide 2,4-D is most commonly used to treatEWM in Wisconsin. This herbicide kills dicots including native aquatic species such as northern water milfoil, coontail, water lilies, spatterdock, and watershield.
Early season (April to May) treatment of Eurasian water milfoil is recommended to limit the impact on native aquatic plant populations because EWM tends
to grow before native aquatic plants.

Granular herbicide formulations are more expensive than liquid formulations (per active ingredient). However, granular formulations are generally thought to release the active ingredient over a longer period of time. Granular formulations, therefore, may be more suited to situations where herbicide exposure time will likely be limited, as is the case of treatment areas in small bands or blocks. In large, shallow lakes with widespread EWM, a whole lake treatment with a low rate of liquid herbicide may be most cost effective because exposure time is greater. Factors that affect exposure time are size and configuration of treatment area, water flow, and wind.

Application rates for liquid and granular formulations are not interchangeable. A rate of 1 to 1.5 mg/L 2,4-D applied as a liquid is a moderate rate that will require a contact time of 36 to 48 hours. Negative impacts to native plants have occurred at whole-lake dosage rates as low as 0.5 mg/L.16 Application rates recommended for Navigate (granular 2,4-D) are 100 pounds per acre for depths of 0 to 5 feet, 150 pounds per acre for 5 to 10 feet, and 200 pounds per acre for depths greater than 10 feet. Allowed and recommended application rates are found on herbicide labels.

Curly Leaf Pondweed

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies three herbicides for control of curly leaf pondweed: diquat, endothall, and fluridone. Fluridone requires exposure of 30 to 60 days making it infeasible to target a discreet area in a lake system. The other herbicides act more rapidly. Herbicide labels provide water use restriction following treatment. Diquat (Reward) has the following use restrictions: drinking water 1-3 days, swimming and fish consumption 0 days. Endothall (Aquathol K) has the following use restrictions: drinking water 7 – 25 days, swimming 0 days, fish consumption 3 days.

Studies have demonstrated that curly leaf pondweed can be controlled with Aquathol K (a formulation of endothall) in 50 to 60 degree F water, and that treatments of CLP this early in its life cycle can prevent turion formation.17 Since curly leaf pondweed is actively growing at these low water temperatures and many native aquatic plants are still dormant, early season treatment selectively targets curly leaf pondweed. Staff from the Minnesota Department of Natural Resources and the U.S Army Engineer Research and Development

Center have conducted trials of this method. These methods are accepted as standard operating procedures being approved in Wisconsin for aquatic invasive species control projects.

Because the dosage is at lower rates than the dosage recommended on the label, a greater herbicide residence time is necessary. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration, and be rendered ineffective.19 Steep drop-off, high winds, and other factors that increase herbicide dilution and contact time can decrease treatment effectiveness.20 Early season treatment similar to that described above can be used to treat corridors for navigation purposes. Because of potential for drift, a higher concentration of endothall is generally used in navigation corridors.

Efforts are also made to treat as early in the season as possible and to absolutely not treat when temperatures reach 60 degrees F. Lake volunteers help to ensure that specified treatment conditions are followed. Because CLP is a monocot like many other aquatic plants, it is not possible to target its control later in the season when many other native plants are growing.

Plans and Strategies

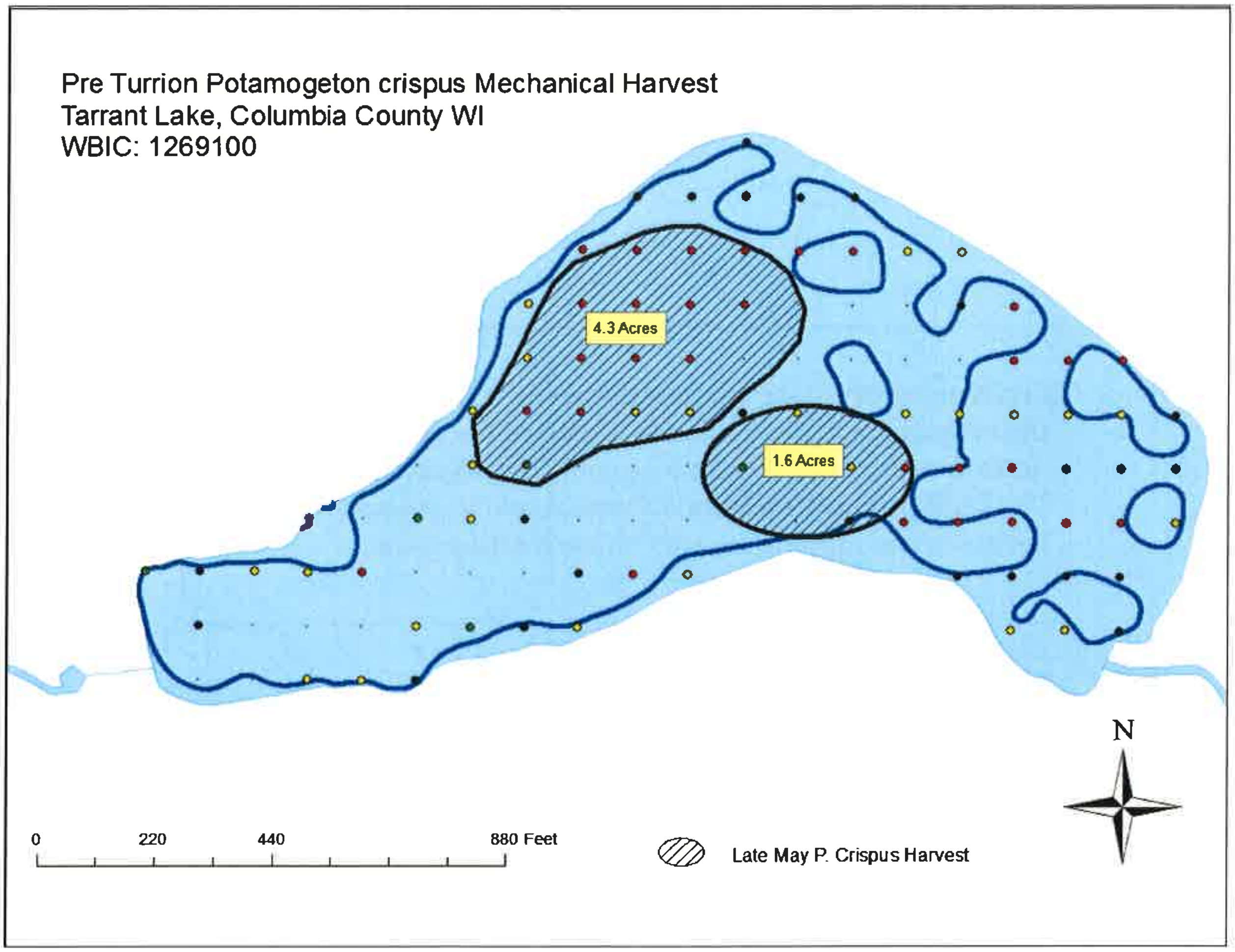
This section of the plan lists goals and objectives for aquatic plant management for Tarrant Lake. It also presents a strategy of actions that will be used to reach aquatic plant management plan goals.

Goals are broad statements of direction.
Objectives are measurable steps toward the goal.
Actions are actions to take to accomplish objectives.
The **Implementation Plan** outlines timeline, resources needed, partners, and funding sources for each action item.

Tarrant Lake Plan Goals

1. Reduce current AIS
2. Restore critical, native habitats in Tarrant Lake.
3. Restore developed shorelines to native vegetation
4. Protect Tarrant Lake fish community

Figure 26:Pre Turrion Potamogeton crispus Mechanical Harvest



Goal 1-Reduce current AIS.

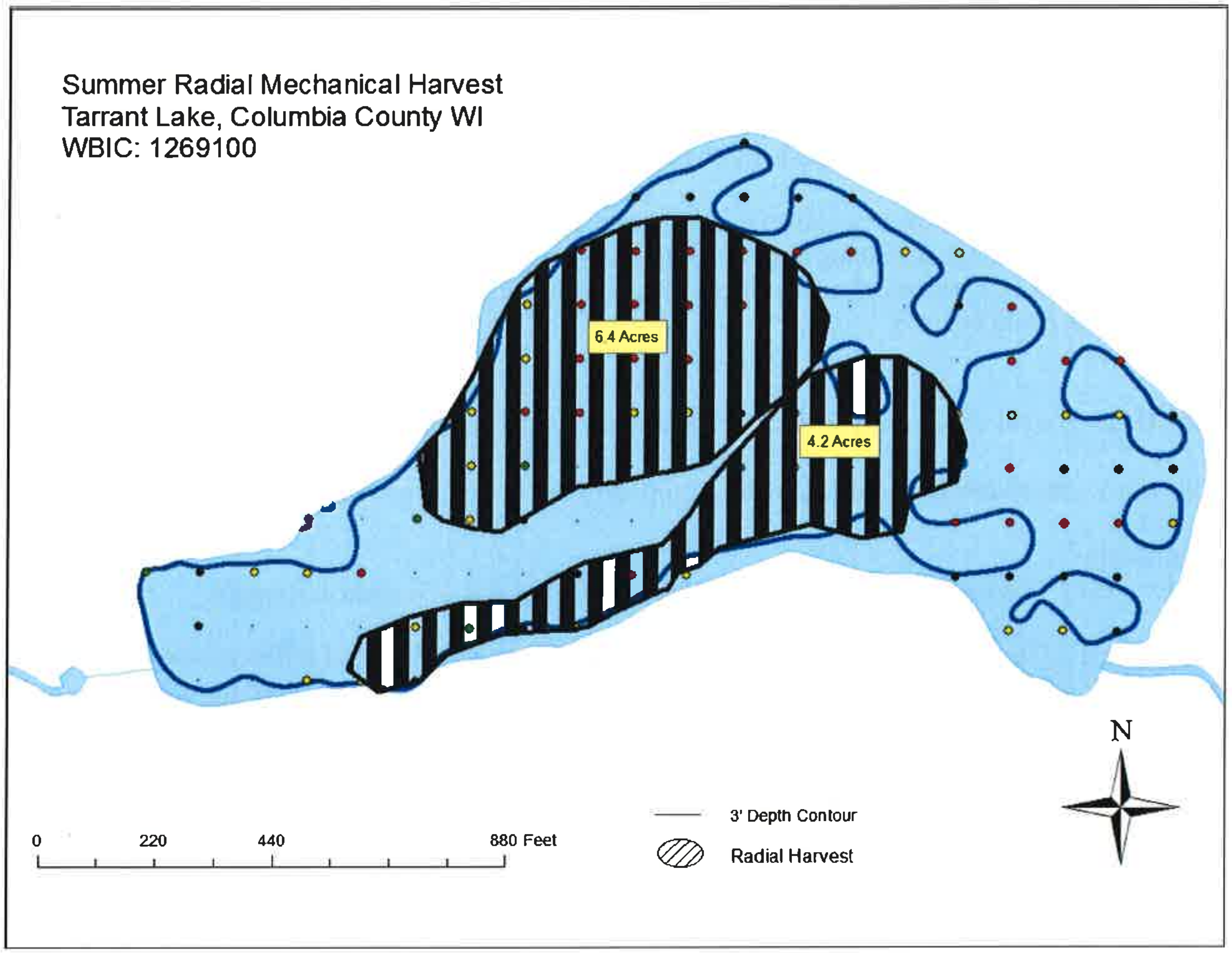
Objective – Mechanically harvest Curly Leaf Pondweed in waters with >3' of depth in target

Action Items –

1. Year 1 -Target harvesting area (Figure 22)for a Preturion Late May Mechanical Harvest
2. Year 1-Target harvesting areas (Figure 23)for a summer radial and coontail and filamentous algae surface skimming mechanical harvesting
3. Year 2-The following year conduct follow up Point Intercept Aquatic Plant Study
4. Year 2-Mechanically harvest to be determined areas in >3' based on data from aquatic plant community

5. When CLP in .3' of water is reduced to manipulate water 2.25 ' to freeze out the remaining CLP in the shallow areas.

Figure 27: Summer Radial Mechanical Harvest



Goal 2– Restore critical native habitats in Tarrant

Objective - Increase abundance and diversity of Native Plant Community

Action items-

1. Provide follow up PI study year after in June for CLP and August for all aquatic plants to quantify response of the plant community to the CLP mechanical harvesting and redevelop mechanical harvesting plan based on data
2. Develop Informational fact sheet on native shore land for Tarrant Lake community members
3. Develop plan for Native shoreland on Public lands adjacent to Tarrant Lake

4. Utilize LWCD cost sharing to restore the native plant community of I private property adjacent to Tarrant Lake.

Goal 3 – Restore developed shorelines to native vegetation

Objective – Increase linear footage of native shoreland

Action items

1. Develop Informational fact sheet on native shore land for Tarrant Lake community members
2. Develop plan for Native shoreland on Public lands adjacent to Tarrant Lake
3. Utilize LWCD cost sharing to restore the native plant community of I private property adjacent to Tarrant Lake. If multiple property owners have interest WDNR Lake protection funds could be used.

Goal 4 Protect Fish Community of Tarrant Lake from impacts of Harvesting

Objective1 – Mechanical Harvesting will be limited to 5% of the lake area annually

Action Item

1. Year 1 -Target harvesting area for a Preturion Late May Mechanical Harvest

2. Year 1-Target harvesting areas for a summer radial and coontail and filamentous algae surface skimming mechanical harvesting corresponding with mechanical harvesting and water level manipulation time frame

Objective2- Monitor In Lake Water Chemistry

Action Items

1. 14 day interval, In Lake Secchi disc, TP and Cholophyl a samples will be acquired from May – September

Objective-Monitor fish community for growth responses to mechanical harvesting in bluegills and Large mouth bass

Action items

1. If possible WDNR will provide annual spring mini boom fish shocking corresponding with mechanical harvesting and water level manipulation time frame

Figure 28.Annual Implementation Plan Chronology

Year	Action Item	Responsible Lead	Conducting Action Item	Month
2014	Submit APMP to WDNR	LWCD	LWCD	June
2014	Apply for 5 year AP Harvesting Permit to WDNR	TLPC	WDNR Lake Coordinator	JUne
2014	Conduct In Lake Secchi, TP and CHL A Sampling	TLPC/LWCD	TLPC,LWCD, or Private Firm	Summer
2014	Develop Native Shore land Fact sheet	LWCD	LWCD	Summer
2014	Develop Public land Native shore land Restoration Plan	TLPC/LWCD	TLPC/LWCD	Summer/Fall
2015	Pre Turrion mechanical harvesting	TLPC	Private Company	Late May
2015	Summer radial and surface skimming harvesting	TLPC	Private Company	Before Summer Festival
2015	Conduct In Lake Secchi, TP and CHL A Sampling	TLPC/LWCD	TLPC,LWCD, or Private Firm	May-September
2015	Point Intercept Aquatic Plant Inventory	TLPC or LWCD	Private Firm, LWCD	CLP – June 2nd-August
2015	Summer radial and surface skimming harvesting	TLPC	Private Company	Before Summer Festival
2015	Pre Turrion mechanical harvesting	TLPC	Private Company	Late May

References:

Trebitz, A.S., and N. Nibbelink. 1996. Effect of pattern of vegetation removal on growth of bluegill: a simple model. Canadian Journal of Fisheries and Aquatic Sciences 53: 1844-1851.

Olson, M. H., and nine coauthors. 1998. Managing macrophytes to improve fish growth: a multi-lake experiment. Fisheries 23(2): 6-12.

Unmuth, J. M., M. J. Hansen, and T. D. Pellett. 1999. Effects of mechanical harvesting of Eurasian watermilfoil on largemouth bass and bluegill populations in Fish Lake, Wisconsin. North American Journal of Fisheries Management 19: 1089-1098.

Village of Cambria
111 West Edgewater Street
Cambria, Wisconsin 53923

Posted November 15, 2012

NOTICE

The Lake Preservation Committee will convene in special session at 6:30 pm on Thursday, November 29, 2012 in the Cambria Village Office Meeting Room at 111 West Edgewater Street, Cambria, Wisconsin.

AGENDA

--6:30 pm Call to Order; Roll Call

--Chris Arnold - Aquatic Plant Survey and Grant

--Approve February Meeting Minutes

--Financial Report

--Basketball Tournament

--Youth Ice Fisheree

--Pier

--Officers

Lois Frank MMC, WCPC, CMTW
Clerk/Treasurer

This facility is handicapped accessible. If anyone with disabilities needs further assistance please contact the Village Office at 348-5443 prior to the meeting.

VILLAGE OF CAMBRIA
111 WEST EDGEWATER STREET
CAMBRIA, WI 53923

NOTICE

The Tarrant Lake Preservation Committee will convene in special session on Wednesday October 30 at 6:30 p.m. in the Cambria Community Room at 115 West Edgewater Street, Cambria, Wisconsin.

AGENDA

--6:30 p.m. Call to Order; Roll Call; Motion to Approve Agenda

--Handicap fishing pier grant
    -Match
    -Committee responsibilities

--Handicap fishing pier order and installment timeline

--8th grade basketball tournament

--Aquatic plant issue

-- Youth Ice Fishery

--Review of financial holdings

--Discussion on committee officers and appointment timelines

--Open discussion on future events and involvements

Village of Cambria
111 West Edgewater Street
Cambria, Wisconsin 53923

Posted January 9, 2013

NOTICE

The Lake Preservation Committee will convene in special session at 6:00 pm on Tuesday, January 22, 2013 in the Cambria Community Room at 115 West Edgewater Street, Cambria, Wisconsin.

AGENDA

--6:00 pm Call to Order; Roll Call

--Approve December Meeting Minutes

--Financial Report
    -Tournament Results

--Aquatic Plant Grant
    -Treatment Plan

--Pier Grant

--Youth Ice Fishery

--Woods Clean Up Contribution
    -County Forester Input

--Donation for Principal Payment of Dredging Loan

--New Membership Drive

Lois Frank MMC, WCPC, CMTW
Clerk/Treasurer

This facility is handicapped accessible. If anyone with disabilities needs further assistance please contact the Village Office at 348-5443 prior to the meeting.

Village of Cambria
111 West Edgewater Street
Cambria, Wisconsin 53923

Posted November 8, 2013

NOTICE

The Tarrant Lake Preservation Committee will convene in special session on Thursday, November 21 at 6:30 p.m. in the Cambria Community Room at 115 West Edgewater Street, Cambria, Wisconsin.

AGENDA

--6:30 p.m. Call to Order; Roll Call; Motion to Approve Agenda

--Approve October 30, 2013 meeting minutes

--Approval of Aquatic Plant Plan

--Approval of handicap pier location

--8th grade basketball tournament

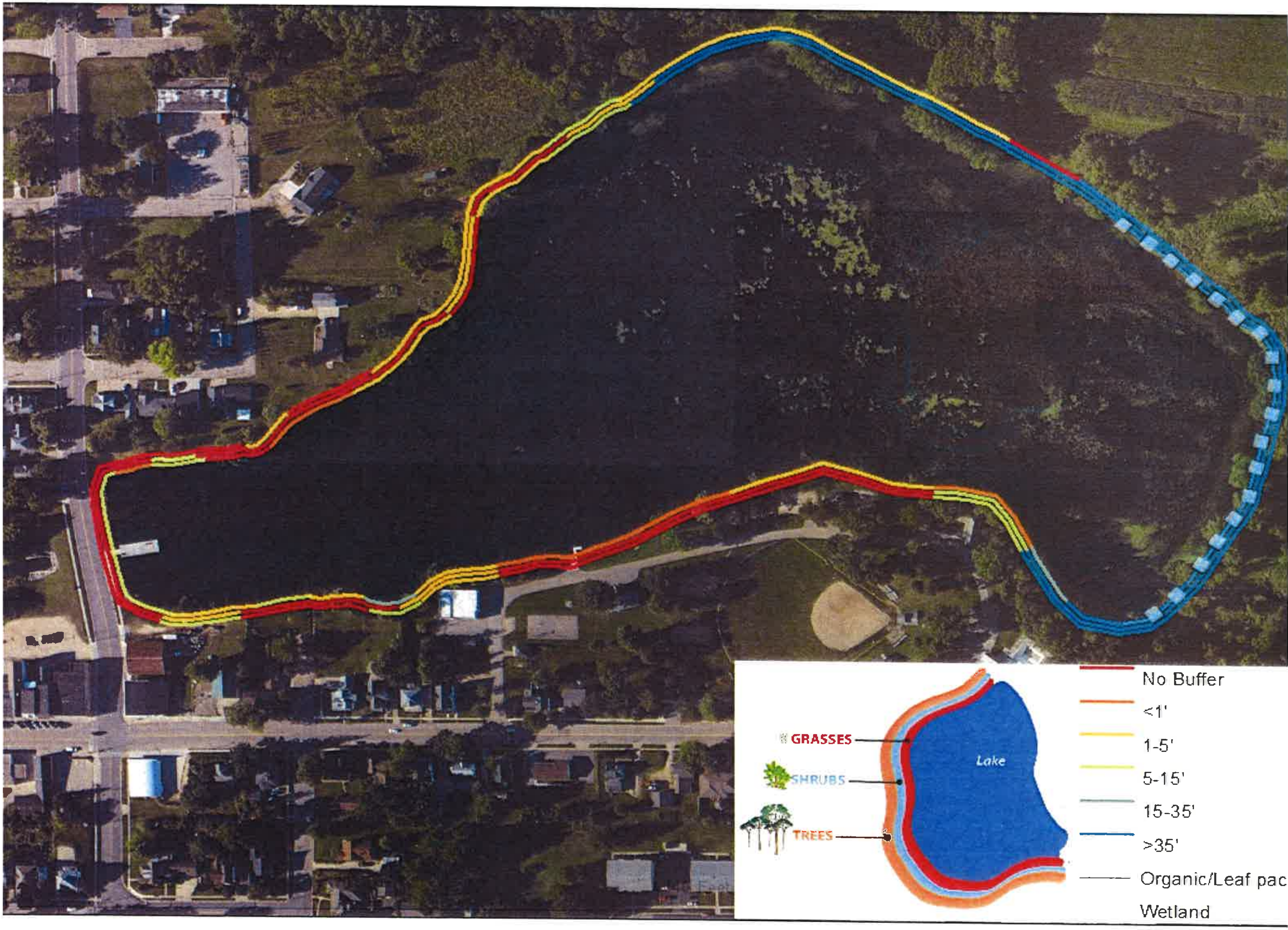
--Youth Ice Fishery

--Financial report

--Future events and involvements

Lois Frank MMC, WCPC, CMTW
Clerk/Treasurer

This facility is handicapped accessible. If anyone with disabilities needs further assistance please contact the Village Office at 348-5443 prior to the meeting.


No Buffer
<1'
1-5'
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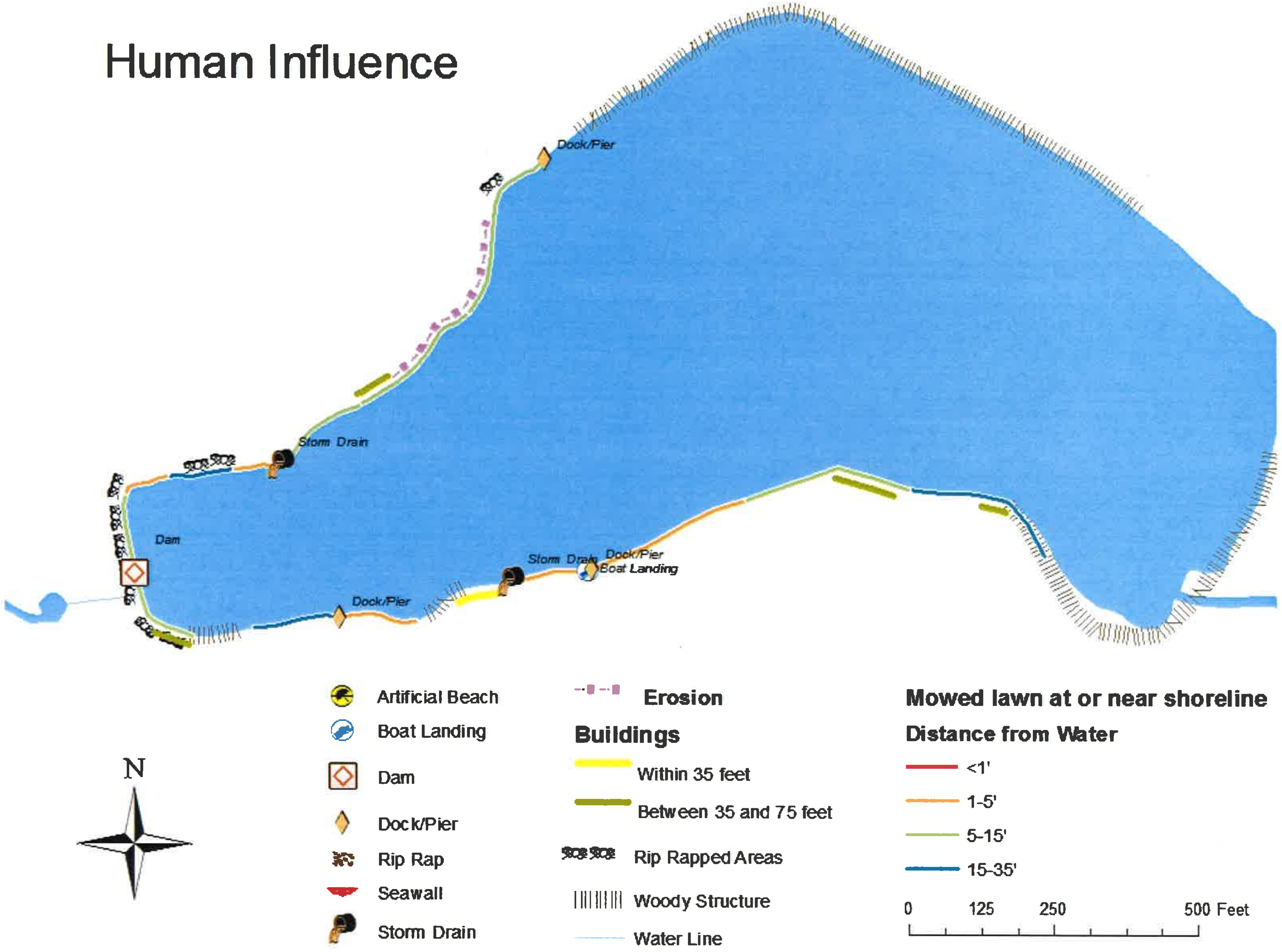
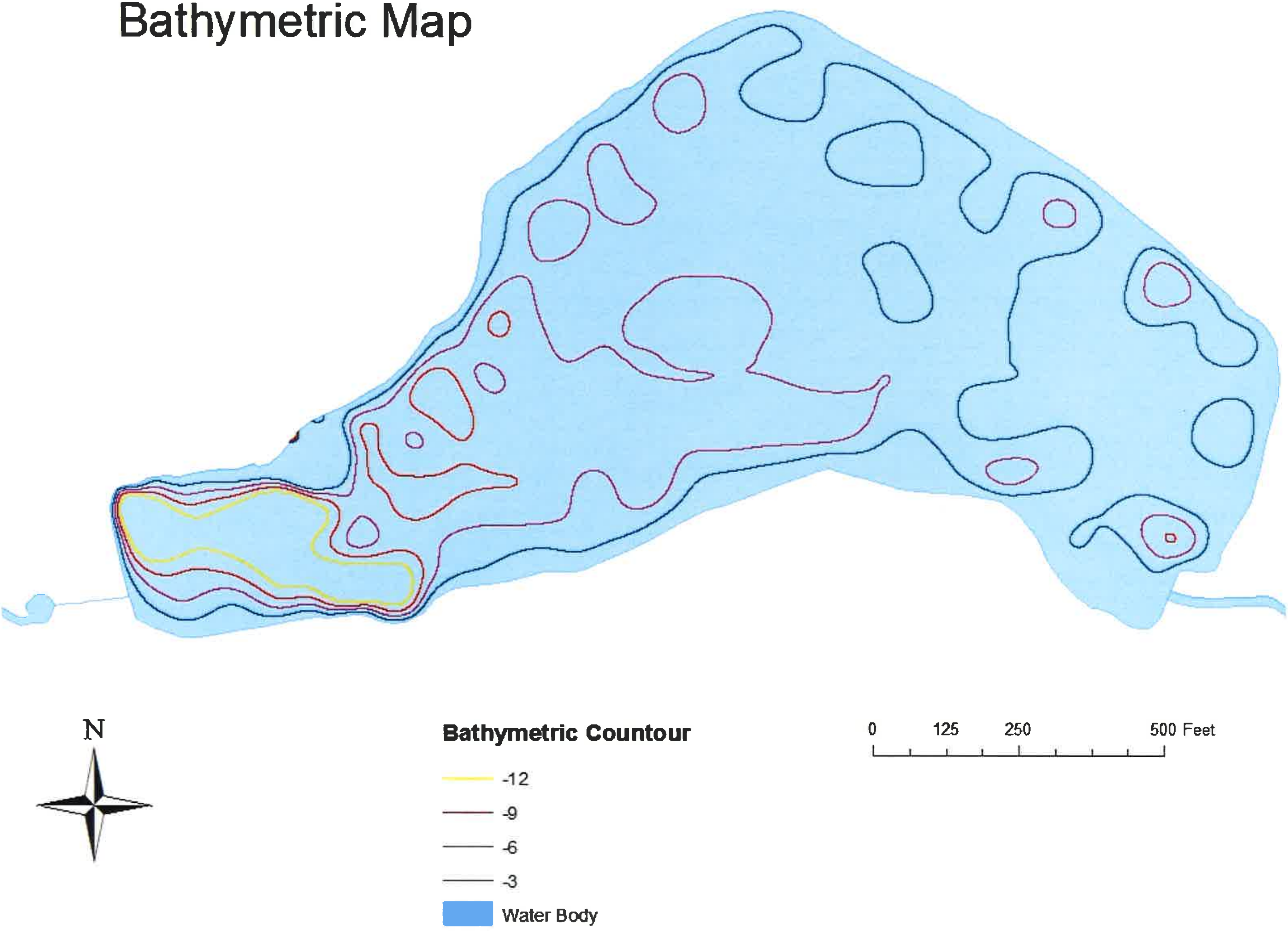
Wetland
Lake
GRASSES
SHRUBS
TREES

Human Influence



Bathymetric Map



Tarrant Lake Watershed Water Modeling Summary Report

June 2014

Watershed Description:

Tarrant Lake is located in the northeast portion of Columbia County. The surrounding surface covers approximately 140 square kilometers in size and contains 614 kilometers of streams (Figure 1). The land use in the watershed is dominated by agriculture, forests and some wetlands. The Tarrant Lake Watershed also includes the town of Cambria in addition to two ethanol plants.

Lake Description:

Tarrant Lake is a 24 acre impoundment of the North Branch of Duck Creek with a maximum depth of 2 meters and a mean depth of 1.2 meters WDNR (2005). The lake has hard water with extensive aquatic plant and algal growth and is considered eutropic.

Background and Water Quality Results:

In the summer of 2009 Columbia County began collecting and compiling water quality and discharge data in portions of the Tarrant Lake watershed. Samples and measurements were taken about every two weeks at the sites noted above and were taken between the dates of 6/3/2009 and 9/08/2010 at five tributaries sites in the Tarrant Lake watershed. Synoptic sampling was conducted on these and eight additional sites (TL06-TL13) within the watershed to get a bigger picture of the watershed.

The Total Phosphorus **(TP)** median concentrations at all primary sites exceeded the proposed DNR phosphorus reference standard of 70 µg/l for wadeable streams except TL01 and TL 02 which is 58 µg/l and 52 µg/l respectively (WDNR 2005). The median concentrations at TL03, TL04, and TL05 exceeded this standard (245 µg/l, 94 µg/l, and 152 µg/l respectively). In addition, TL03, TL04, TL05 exhibited great variability ranging in value from 186-768 µg/l, 38-783 µg/l and 30-609 µg/l . Also, the TP concentrations at TL03 and TL04 seem to be related to stage height such that increase in stage (i.e. runoff) results in elevated TP concentrations. Generally, the soluble reactive phosphorus (SRP) concentrations increased with an increase in TP concentration at all sites

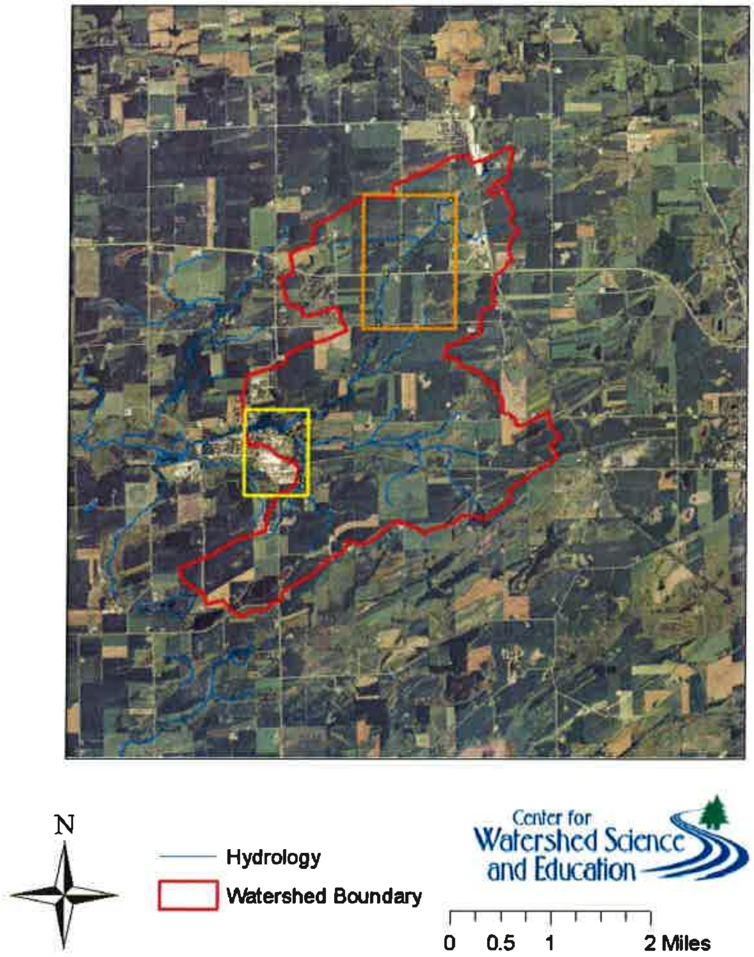


Figure 1: Map of Tarrant Lake Watershed and Tributary Sampling Site Regions highlighted in yellow and orange.

Methods

Stream levels (stages) were recorded over time using pressure transducers (Solinst, Georgetown, ON). The loggers were set to record a new stream level during any time that the stream level was changing. Software that was provided with the logger was used to correct the measurement for barometric pressure. The resulting file provided date, time and the water level relative to an unspecified datum.

Stream flow was estimated from the barometrically corrected logger data. The logger data was adjusted for a zero-flow offset and then fitted with a log-linear relationship between logger reading and measured stream flow. The resulting power function ($Q=aH^b$), where Q is the stream flow and H is the adjusted logger reading) was used to estimate stream flow for the other logging periods. The stream flow estimates were used to calculate the total water flow between logging points. The total flow during the recording period was calculated by summing all of the flow quantities between logging points.

Stream concentration measurements were used to develop a relationship between stream flow and total phosphorus concentration. A log-linear power function (C=aQb) was used to assign a concentration to each logging period flow. The phosphorus mass associated with each of those periods was calculated by multiplying the total flow volume in the period times the estimated total phosphorus concentration. The total exported phosphorus mass was estimated by summing the phosphorus load from each logging period.

The Wisconsin Lake Modeling Suite (WiLMS) model is a lake water quality-planning tool was run for Tarrant Lake as well. The model was run over the watershed as a whole and with a portion of the watershed removed accounting for the drainage area that was not accounted for in the modeling as the TL05 monitoring site had unusable data results.

Results:
Site TL 05 on the north Branch of Duck Creek at Highway P did into produce data that allowed for modeling. It is believed that the down water impacts in Tarrant Lake created a back water effect that gave very little variation in the level logger and the staff gauge readings despite wide variation in the flow and water chemistry data. These created a roughly 1400 acre centrally located drainage area that is not represented in the modeling. The WilMs model as seen in Table 1 was run a second time to account for this difference in area, reducing the runoff by 35%.

The TP load numbers as seen in Table 1 for 2009 and 2010 at TL 01, TL 02, TL 03 and TL 04 represent a monitoring season extending to the beginning of December with minor differences depending on the site. This timeframe represents a growing season average and does not represent the TP load associated with winter runoff and spring flush.

Based on the size of the watershed and the extensive agriculture that is present within the Tarrant Lake watershed is felt the modeling numbers for all sites in 2009 and 2010 are significantly lower due to concentration and flow data being limited for the higher flow events. The limitations in measured flow data can be seen in Table 2. AS flow data was gathered when river samples were acquired there was limited high flow TP samples obtained as well. The model is missing the higher concentrations at high flow events thus underestimating the TP load.

The shallow water impoundment of Tarrant Lake is serving as a settling basin for the watershed; as a result, Phosphorus sink.

Tarrant Lake Growing Season TP

	Name	2009	2009	2010	2010	WilMs	WilMs
		Growing Season TP	Average Per Second Q	Growing Season TP	Average Per Second Q	37567.0 ac.	5267 Ac.
		Total Phosphorus		Total Phosphorus		Total Phosphorus	Total Phosphorus
Units		lbs.	cfs	lbs	cfs	lbs	lbs
Site ID							
TL 01	Dam Outlet	112.28	1.68	147.07	1.86		
TL02	Cabbage Road	28.43	0.49	15.43	0.31		
TL03	Hwy 33	210.22	0.66	118.41	0.39		
TL04	Duck Creek Bridge	154.49	1.38	207.34	1.65		
Total TP		393.14		341.18		718	1112

Table 1. Tarrant Lake Growing Season TP Modeling

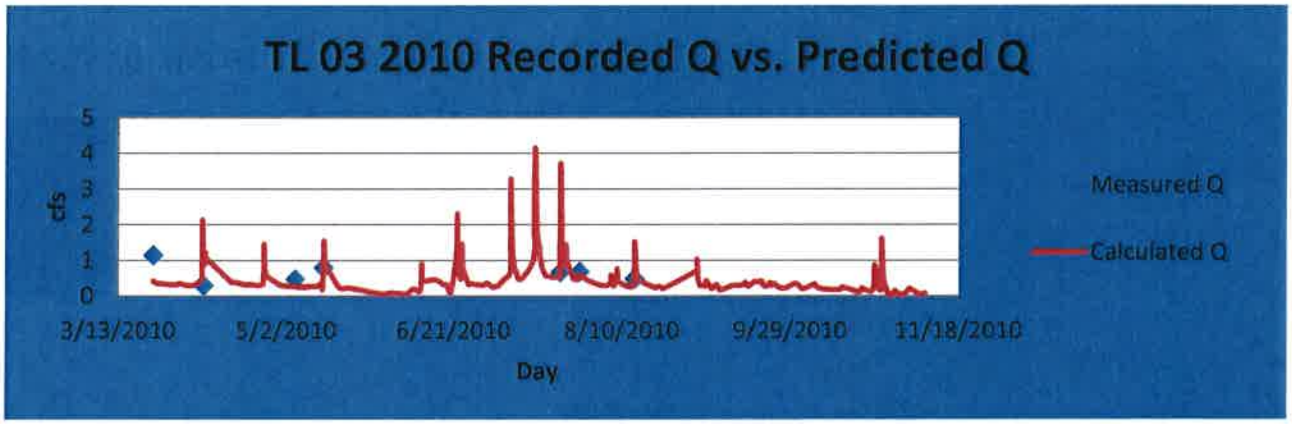


Table 2. Tarrant Lake TL03 Recorded Q vs. Predicted Q