

# **Crooked Lake Aquatic Vegetation Management Plan 2007 Update Steuben County, Indiana**

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## Executive Summary

Aquatic Control was contracted by the Crooked Lake Association to complete aquatic vegetation sampling in order to update their lakewide, long-term integrated aquatic vegetation management plan which was originally completed in 2007. Funding for the update of this plan was obtained from the Crooked Lake Association and the Indiana Department of Natural Resources-Division of Fish and Wildlife as part of the Lake and River Enhancement program (LARE). The update will serve as a tool to track changes in the vegetation community, to adjust the action plan as needed, and to maintain eligibility for additional LARE funds. Items covered include the 2007 sampling results, a review of the 2007 vegetation controls, and updates to the budget and action plans.

Aquatic vegetation is an important component of lakes in Indiana; however, as a result of many factors this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, is described as plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, aesthetic, and lakefront property values. The primary nuisance species within Crooked Lake is the exotic plant Eurasian watermilfoil (*Myriophyllum spicatum*), hereafter called milfoil. Curlyleaf pondweed (*Potamogeton crispus*) is another exotic species abundant in Crooked Lake. The original plan recommended a pre-treatment invasive species mapping survey followed by treatment of milfoil with a combination of fluridone in the third basin and 2,4-D spot treatments in the second basin followed by a summer Tier II survey. Other recommendations in the original plan included the following; posting of signs at all ramps encouraging boaters to thoroughly clean their boats and trailers of all plant material, eco-zones be explored for areas on the first and second basins, purple loosestrife be physically removed on individual property, limited treatment on native vegetation in high-use areas, act upon recommendations in the watershed study, and cooperation with other lakes in the watershed in reducing invasive species and improving water quality. The association has contracted JF New and Associates to complete a three year littoral zone restoration study for Crooked Lake. The first year of the study was completed in 2007.

As planned, Aquatic Control Inc. completed invasive species sampling prior to treatment on May 9, 2007. This sampling indicated the presence of approximately 62.0 acres of Eurasian watermilfoil in the first and second basins. Milfoil was present in nearly the entire third basin (approximately 184 acres). Curlyleaf pondweed was documented in 23.6 acres of the first and second basins and nearly the entire third basin. On May 14, Aquatic Management Inc. applied an initial dose of fluridone to third basin with a goal of maintaining above 3 ppb fluridone for 90 days. The third basin treatment required several bump applications, but 3 ppb was maintained for the required time. On May 22, spot treatments were completed on the first and second basin with 2,4-D granular herbicide for control of milfoil. Aquatic Management Inc. conducted contact treatments for individual lot owners on June 6<sup>th</sup>, 2007. A mixture of Reward, Nautique, and Aquathol was applied to 7.2 acres of near-shore areas throughout the first two basins to alleviate nuisance levels of aquatic vegetation. A summer Tier II survey was completed on August 8, 2007. A total of 12 native submersed species was collected. Chara (*Chara*

*spp.*) was the most abundant species followed by slender naiad (*Najas flexilis*). Milfoil was significantly reduced when compared to 2006 survey results.

In 2008, it is unlikely that milfoil will be abundant in the third basin; however, it will be present in the first and second basins but likely at a lower abundance. It is important that these remaining beds of milfoil be treated with systemic herbicides next season in order to further reduce its abundance and reduce the chances of reinfestation in the third basin. The third basin should also be thoroughly sampled in case any milfoil survived or was introduced. It is estimated that up to 50 acres of milfoil may require treatment next season. In addition, curlyleaf pondweed will likely continue to be a problem. Up to 155 acres of curlyleaf pondweed may be present in Crooked Lake next season. This estimate is based upon the findings from the 2007 invasive plant mapping survey. Curlyleaf pondweed will likely be most abundant in the third basin (133 acres). Priority should be placed on controlling the milfoil, but the grant request should include the curlyleaf pondweed treatment.

It is recommended that the Crooked Lake Association request \$17,500 for treatment of up to 50 acres of milfoil with 2,4-D herbicide, \$38,750 for early season treatment of up to 155 acres of curlyleaf pondweed, \$5,000 for basic plant sampling and plan update, and an additional \$5,000 for curlyleaf turion sampling and early spring Tier II survey (only to be completed if curlyleaf treatment is completed).

## **Acknowledgements**

Funding for the vegetation sampling and preparation of an aquatic vegetation management plan was provided by the Crooked Lake Association and the Indiana Department of Natural Resources Lake and River Enhancement Program. Aquatic Control, Inc. completed the fieldwork, data processing, and map generation. Contributors to this plan include Keith Hoskins and the Crooked Lake Association, Neil Ledet with the Indiana Department of Natural Resources-Division of Fish And Wildlife, Gwen White and Angela Sturdevant Aquatic Biologist from the Lake and River Enhancement Program (LARE), Sara Peel of JFNew and Associates, and Neil and Nick Gerber with Aquatic Management Incorporated. Author of this report update is Nathan Long of Aquatic Control. The author would like to acknowledge the valuable input from Brian Isaacs, Joey Leach, Barbie Huber, and Brendan Hastie of Aquatic Control for their field assistance, map generation, review, and editing of this report.

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## **1.0 INTRODUCTION**

This report was created in order to update the Crooked Lake Aquatic Vegetation Management Plan. The update will serve as a tool to track changes in the vegetation community, to adjust the action plan as needed, and to maintain eligibility for additional LARE funds. Items covered include the 2007 sampling results, a review of the 2007 vegetation controls, and updates to the budget and action plans. The plan update was funded by the Indiana Department of Natural Resources Lake and River Enhancement Program (LARE) and the Crooked Lake Association (CLA).

## **2.0 PROBLEM STATEMENT**

Aquatic vegetation is an important component of lakes in Indiana. However, as a result of many factors, this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, describes plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, aesthetic, and lakefront property values. The primary nuisance species within the Crooked Lake is the exotic species Eurasian watermilfoil. Curlyleaf pondweed is another submersed exotic species that is present in Crooked Lake and has the potential to create nuisance conditions. Purple loosestrife is an invasive exotic emergent species that was also detected. It is unlikely that purple loosestrife will create nuisance conditions for lake users, but this species could have negative impacts on native wetland species in and around Crooked Lake.

## **3.0 VEGETATION MANAGEMENT GOALS**

An effective aquatic vegetation management plan must include well-defined goals. Listed below are three goals formulated by LARE program staff and Division of Fish and Wildlife Biologists and approved by the Crooked Lake Association.

### *Vegetation Management Goals*

1. Develop or maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species
2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.
3. Provide reasonable public recreational access while minimizing the negative impacts on plant and fish and wildlife resources.

## **4.0 WATERSHED AND WATER BODY CHARACTERISTICS** (Summarized from JFNew & Associates, Inc. 2003 & IDNR 2001)

Crooked Lake is an approximately 802 acre natural lake that consists of three sections called the first (401 acres), second (217 acres), and third basins (184 acres). The average depth of Crooked Lake is 12.0 feet and the maximum depth is 77 feet. The third basin is by far the shallowest of the three basins. Crooked Lake is classified as Mesotrophic, which means the lake is moderately productive. Secchi measurements taken during plant surveys ranged from 8.0 to 10.5 feet in the first and second basins and from 4.0-5.0 feet in the third basin.

## **5.0 PRESENT WATER BODY USES**

Crooked Lake is used for a variety of activities. A public access site and beach are located in the eastern end of the first basin of Crooked Lake at a Steuben County Park. Several private boat ramps are located on all three basins. The entire shoreline of the first and second basin is developed residentially. The eastern shore of the third basin is also residentially developed while the western shore of the third basin remains primarily undeveloped. Swimming, boating and fishing are popular activities on Crooked Lake. At a recent public meeting, lake users indicated that 100.0% use the lake for swimming, 93.0% use the lake for boating, 50.0% use the lake for irrigation, and 43.0% use the lake for fishing (survey included 14 individuals, all were property owners on the Lake).

## **6.0 2007 SAMPLING RESULTS**

Aquatic Control completed two plant surveys on Crooked Lake in 2007. An invasive species mapping survey was completed on May 9. The invasive mapping survey allowed for the determination of potential control areas and the documentation of any changes in the abundance of invasive species. A Tier II survey was completed on August 8. This survey was completed in order to document success or failure of the control techniques, document changes in the native plant community, and aid in the planning for future actions. The data from the Tier II survey was also analyzed by individual basin due to the different characteristics and control techniques used in the different basins.

### **6.1 Spring Invasive Mapping Results**

On May 9, 2007, an invasive mapping survey was completed on Crooked Lake. A Secchi disc reading was taken and found to be 15.0 feet. The water temperature was 65.4F at the surface and 58.2F at the bottom. Dissolved oxygen was 10.1 mg/L at the surface and 9.8 mg/L at the bottom. Sampling indicated the presence of approximately 62.0 acres of Eurasian watermilfoil in the first and second basins (Figure 1). Milfoil was present in nearly the entire third basin, but more dense in the northern half of the basin (Figure 2). Curlyleaf pondweed was documented in 23.6 acres of the first and second basins (Figure 3). Curlyleaf was mixed in with the milfoil throughout the third basin and most abundant near the middle of the basin (Figure 2).

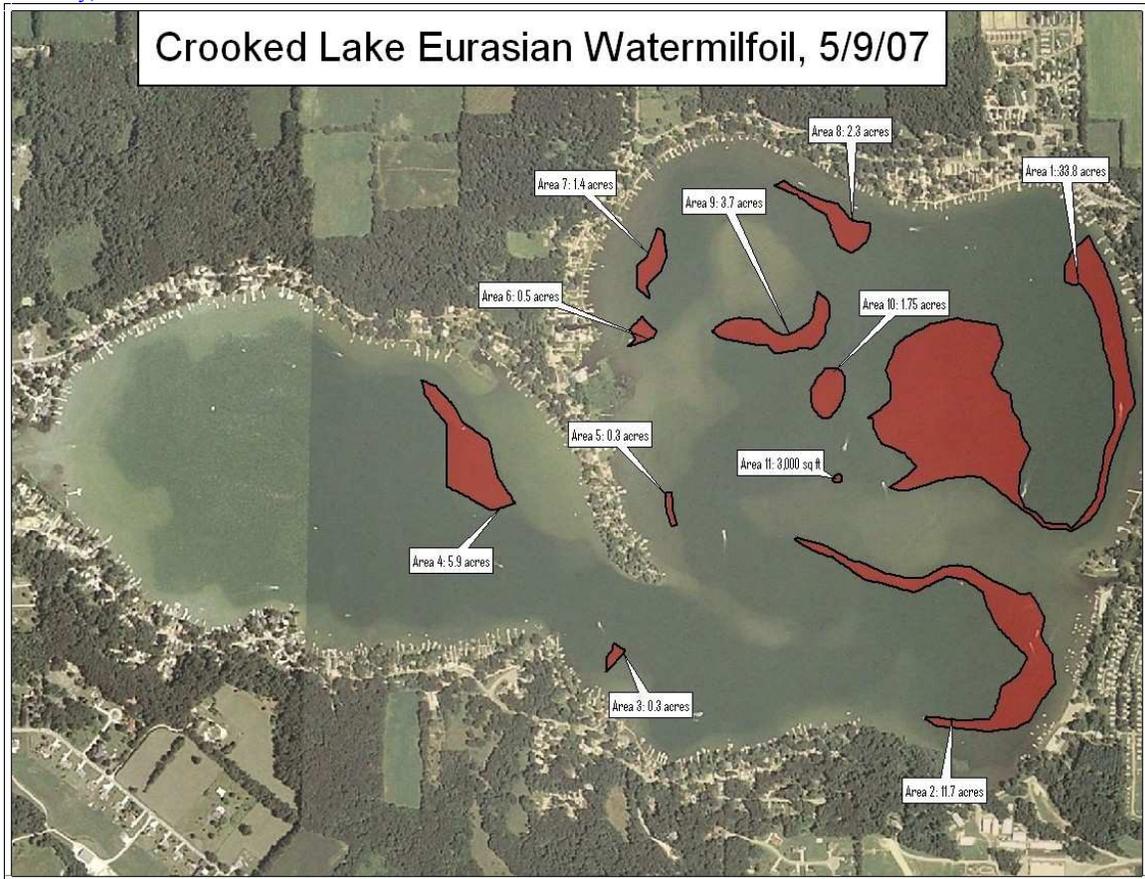


Figure 1. Eurasian watermilfoil beds, Crooked Lake, first and second basin, May 9, 2007

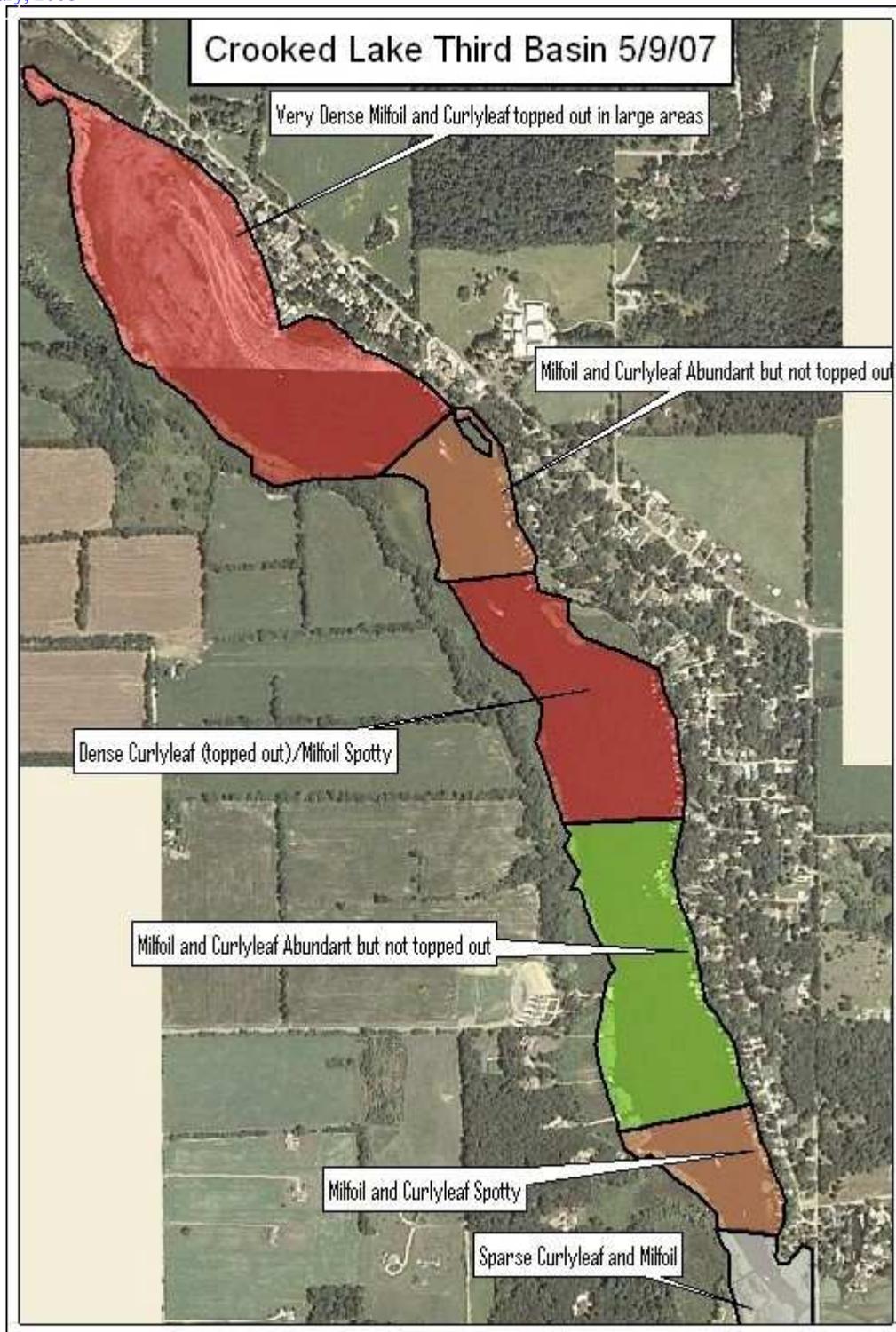


Figure 2. Eurasian watermilfoil and curlyleaf pondweed beds, Crooked Lake, third basin, May 9, 2007

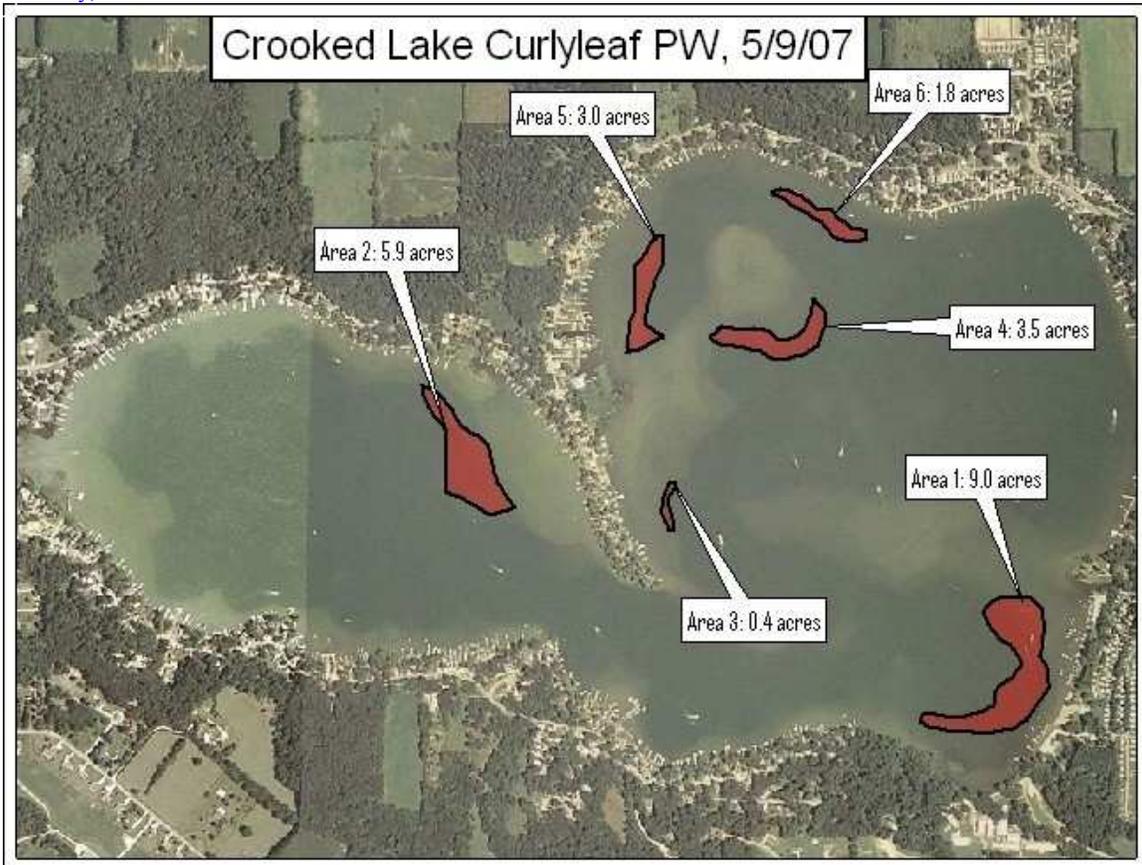


Figure 3. Curlyleaf pondweed beds, Crooked Lake, first and second basin, May 9, 2007

## 6.2 Summer Tier II Survey

In 2007, a single Tier II survey was completed by Aquatic Control on Crooked Lake. The data from the survey will be presented and analyzed as Whole Lake, Basin 1, Basin 2, and Basin 3.

### 6.2.1 Summer Tier II Survey results for the Whole Lake

On August 14, 2007 a Tier II survey was completed on Crooked Lake. A Secchi disk reading was taken in the first basin prior to sampling and was found to be 6.0 feet. Plants were present to a maximum depth of 20.0 feet. The same 100 sites that were sampled in 2006 were again sampled in 2007. Plants were present at 64 of the sample sites and native plants were present at 63 of the sites. A total of 14 species were collected of which 12 of the species were native. The mean number of species collected per site was 1.50 and the mean number of native species collected was 1.34. The species diversity index was 0.87 and the native species diversity index was 0.84 (Table 1).

**Table 1. Occurrence and abundance of submersed aquatic plants in Crooked Lake, August 14, 2007.**

Occurrence and abundance of submersed aquatic plants in Crooked Lake						
County:	Stuben	Sites with plants:	64	Mean species/site:	1.50	
Date:	8/14/2007	Sites with native plants:	63	Standard error (ms/s):	0.1501	
Secchi (ft):	6	Number of species:	14	Mean native species/site:	1.34	
Maximum plant depth (ft):	20	Number of native species:	12	Standard error (mns/s):	0.1358	
Trophic status:	Mesotrophic	Maximum species/site:	7	Species diversity:	0.87	
Total sites:	100			Native species diversity:	0.84	
All depths (0 to 20 ft)		Frequency of Occurrence				Plant Dominance
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
Chara	33.0	67.0	17.0	6.0	10.0	9.4
slender naiad	29.0	71.0	13.0	6.0	10.0	11.4
Eurasian watermilfoil	16.0	84.0	9.0	3.0	4.0	4.4
common coontail	14.0	86.0	8.0	1.0	5.0	5.6
curlyleaf pondweed	10.0	90.0	5.0	2.0	3.0	4.0
sago pondweed	10.0	90.0	4.0	0.0	6.0	4.4
American elodea	9.0	91.0	0.0	2.0	5.0	3.0
large leaf pondweed	9.0	91.0	4.0	1.0	4.0	3.8
Richardson's pondweed	8.0	92.0	2.0	1.0	5.0	4.0
flatstemmed pondweed	5.0	95.0	1.0	2.0	2.0	1.4
eel grass	3.0	97.0	1.0	1.0	1.0	0.6
southern naiad	2.0	98.0	2.0	0.0	0.0	0.4
common bladderwort	1.0	99.0	0.0	0.0	1.0	0.6
leafy pondweed	1.0	99.0	1.0	0.0	0.0	0.2
Depth: 0-5 ft		Frequency of Occurrence				Plant Dominance
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
Chara	40.5	59.5	27.0	2.7	10.8	11.4
large leaf pondweed	16.2	83.8	8.1	0.0	8.1	5.4
slender naiad	16.2	83.8	5.4	2.7	8.1	6.5
common coontail	10.8	89.2	2.7	0.0	8.1	6.5
curlyleaf pondweed	10.8	89.2	5.4	0.0	5.4	3.2
Eurasian watermilfoil	10.8	89.2	8.1	0.0	2.7	2.2
Richardson's pondweed	10.8	89.2	0.0	2.7	8.1	7.6
American elodea	8.1	91.9	0.0	0.0	8.1	3.8
flatstemmed pondweed	8.1	91.9	0.0	2.7	5.4	2.7
sago pondweed	8.1	91.9	2.7	0.0	5.4	2.7
common bladderwort	2.7	97.3	0.0	0.0	2.7	1.6
eel grass	2.7	97.3	2.7	0.0	0.0	0.5
Depth: 5-10 ft		Frequency of Occurrence				Plant Dominance
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
slender naiad	41.9	58.1	16.3	9.3	16.3	18.6
Chara	39.5	60.5	14.0	11.6	14.0	11.6
Eurasian watermilfoil	23.3	76.7	11.6	4.7	7.0	7.4
curlyleaf pondweed	14.0	86.0	11.6	4.7	2.3	6.5
sago pondweed	14.0	86.0	4.7	0.0	9.3	7.4
common coontail	11.6	88.4	7.0	0.0	4.7	4.2
American elodea	9.3	90.7	2.3	2.3	4.7	1.9
Richardson's pondweed	9.3	90.7	4.7	0.0	4.7	2.8
large leaf pondweed	7.0	93.0	2.3	2.3	2.3	4.2
eel grass	4.7	95.3	0.0	2.3	2.3	0.9
flatstemmed pondweed	2.3	97.7	0.0	2.3	0.0	0.5
leafy pondweed	2.3	97.7	2.3	0.0	0.0	0.5
southern naiad	2.3	97.7	2.3	0.0	0.0	0.5
Depth: 10-15 ft		Frequency of Occurrence				Plant Dominance
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
common coontail	80.0	20.0	60.0	20.0	0.0	24.0
Eurasian watermilfoil	40.0	60.0	20.0	20.0	0.0	8.0
slender naiad	40.0	60.0	20.0	20.0	0.0	8.0
Depth: 15-20 ft		Frequency of Occurrence				Plant Dominance
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
slender naiad	20.0	80.0	20.0	0.0	0.0	4.0
American elodea	13.3	86.7	6.7	6.7	0.0	5.3
Chara	6.7	93.3	6.7	0.0	0.0	1.3
common coontail	6.7	93.3	6.7	0.0	0.0	1.3
flatstemmed pondweed	6.7	93.3	6.7	0.0	0.0	1.3
sago pondweed	6.7	93.3	6.7	0.0	0.0	1.3
southern naiad	6.7	93.3	6.7	0.0	0.0	1.3

Chara ranked first in frequency of occurrence (33.0%) and second in dominance (9.4). Location and density of Chara is illustrated in Figure 4. Slender naiad was the second most frequently occurring species (29.0%) but ranked first in dominance (Figure 5). Eurasian watermilfoil was collected at 16% of sample sites making it the most frequently occurring exotic species and ranking third in overall frequency (Figure 6). Milfoil frequency was higher than expected, but that was likely due to the inclusion of identifiable milfoil stems in the third basin that were likely not viable. Common coontail (*Ceratophyllum demersum*) ranked fourth in frequency (Figure 7), followed by curlyleaf pondweed (Figure 8), sago pondweed (*Potamogeton pectinatus*), American elodea (*Elodea canadensis*), largeleaf pondweed (*Potamogeton amplifolius*) (Figure 9), richardson's pondweed, listed as imperiled and rare in the state of Indiana, (*Potamogeton richardsonii*), flatstem pondweed (*Potamogeton zosteriformis*), eel grass (*Valisneria americana*), southern naiad (*Najas guadalupensis*), common bladderwort (*Utricularia vulgaris*), and leafy pondweed (*Potamogeton foliosus*). Flatstem pondweed was the only species collected in the August 2007 survey that was not collected in August, 2006. Variable pondweed (*Potamogeton gramineus*), Illinois pondweed (*Potamogeton illinoensis*), brittle naiad (*Najas minor*), water stargrass (*Zosterella dubia*), variable watermilfoil (*Myriophyllum heterophyllum*), small pondweed (*Potamogeton pusillus*), and western elodea (*Elodea nuttallii*) were collected in August of 2006 but not in August of 2007.

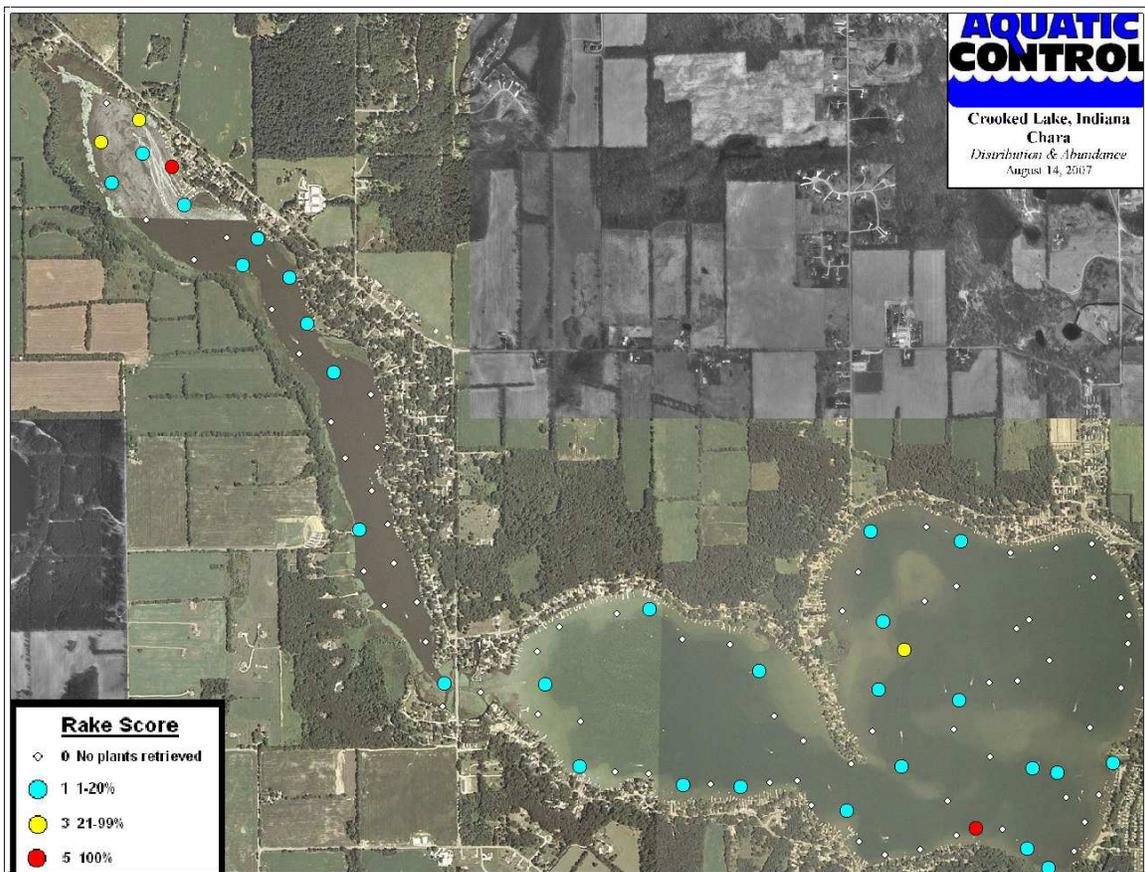


Figure 4. Crooked Lake, Chara distribution and abundance, August 14, 2007.

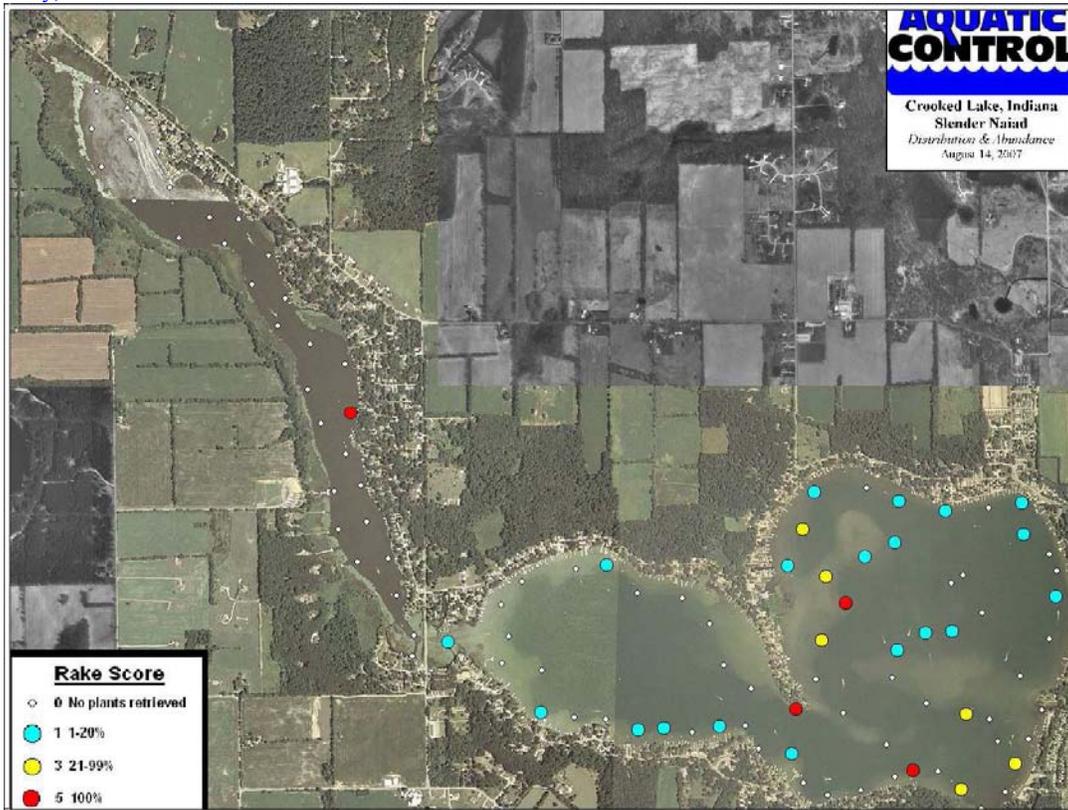


Figure 5. Crooked Lake, slender naiad distribution and abundance, August 14, 2007.

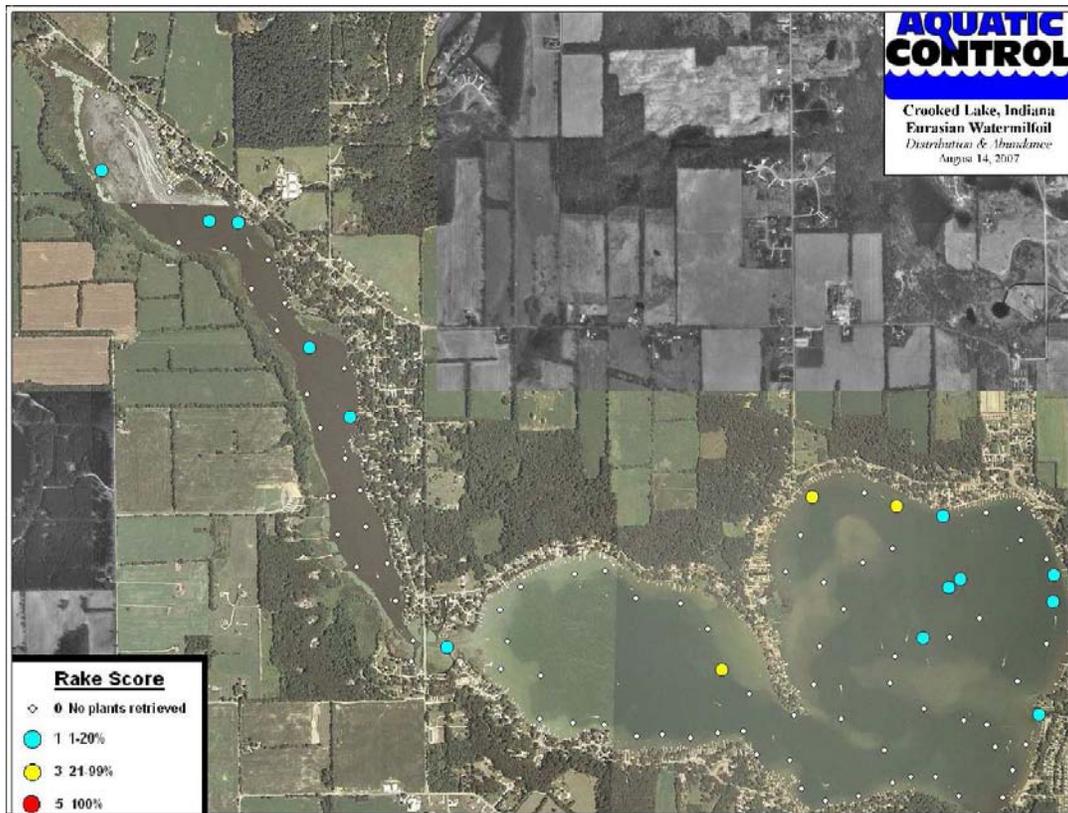


Figure 6. Crooked Lake, Eurasian watermilfoil distribution and abundance, August 14, 2007.



Figure 7. Crooked Lake, common coontail distribution and abundance, August 14, 2007.

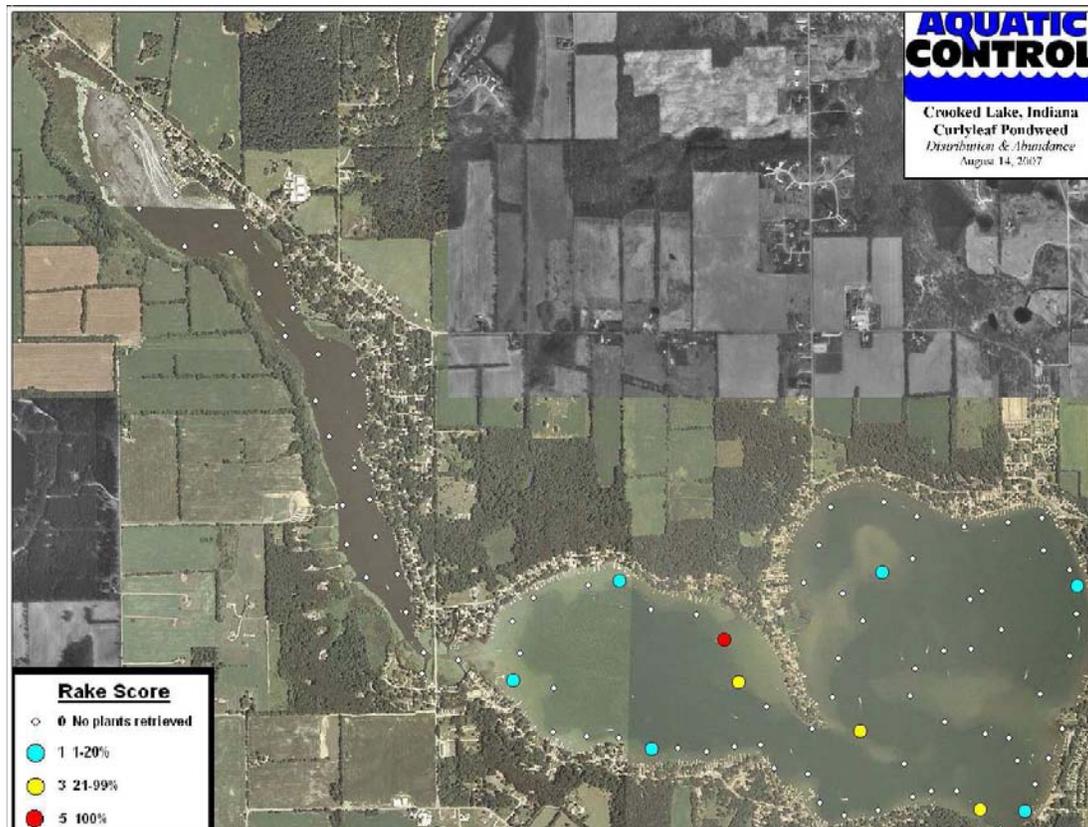


Figure 8. Crooked Lake, curlyleaf pondweed distribution and abundance, August 14, 2007.



Figure 9. Crooked Lake, largeleaf pondweed distribution and abundance, August 14, 2007.

### 6.2.2 Summer Tier II Survey results for the First Basin

Slender naiad was at 45.8% of the sampling sites in the first basin and showed the highest dominance (Table 2). Chara was the second most frequently occurring species (29.2%) followed by common coontail (25.0%), Eurasian watermilfoil (20.0%), American elodea (16.7%), Richardson's pondweed (14.6%), curlyleaf pondweed (10.4%), sago pondweed (10.4%), eel grass (6.3%), flatstem pondweed (4.2%), southern naiad (4.2%), largeleaf pondweed (2.1%), and leafy pondweed (2.1%).

**Table 2. Occurrence and abundance of submersed aquatic plants in Crooked Lake, first basin, August 14, 2007.**

Occurrence and abundance of submersed aquatic plants in Crooked Lake Basin 1						
County: Stuben	Sites with plants: 34	Mean species/site: 1.92				
Date: 8/14/2007	Sites with native plants: 34	Standard error (ms/s): 0.2225				
Secchi (ft): 6	Number of species: 13	Mean native species/site: 1.71				
Maximum plant depth (ft): 20	Number of native species: 11	Standard error (mns/s): 0.2018				
Trophic status Mesotrophic	Maximum species/site: 5	Species diversity: 0.87				
Total sites: 48		Native species diversity: 0.83				
Depths: 0 to 20 ft		Rake score frequency per species				Plant Dominance
Species	Frequency of Occurrence	0	1	3	5	
slender naiad	45.8	54.2	18.8	10.4	16.7	19.2
Chara	29.2	70.8	6.3	8.3	14.6	8.3
common coontail	25.0	75.0	14.6	2.1	8.3	10.8
Eurasian watermilfoil	20.8	79.2	10.4	4.2	6.3	5.8
American elodea	16.7	83.3	0.0	4.2	8.3	5.8
Richardson's pondweed	14.6	85.4	2.1	2.1	10.4	7.9
curlyleaf pondweed	10.4	89.6	4.2	2.1	4.2	3.8
sago pondweed	10.4	89.6	2.1	0.0	8.3	6.3
eel grass	6.3	93.8	2.1	2.1	2.1	1.3
flatstemmed pondweed	4.2	95.8	2.1	0.0	2.1	1.7
southern naiad	4.2	95.8	4.2	0.0	0.0	0.8
large leaf pondweed	2.1	97.9	0.0	0.0	2.1	2.1
leafy pondweed	2.1	97.9	2.1	0.0	0.0	0.4
Depths: 0 to 5 ft		Rake score frequency per species				Plant Dominance
Species	Frequency of Occurrence	0	1	3	5	
Richardson's pondweed	40.0	60.0	0.0	10.0	30.0	28.0
slender naiad	40.0	60.0	10.0	10.0	20.0	20.0
Chara	30.0	70.0	10.0	0.0	20.0	6.0
common coontail	30.0	70.0	10.0	0.0	20.0	22.0
American elodea	20.0	80.0	0.0	0.0	20.0	12.0
curlyleaf pondweed	20.0	80.0	0.0	0.0	20.0	8.0
eel grass	10.0	90.0	10.0	0.0	0.0	2.0
Eurasian watermilfoil	10.0	90.0	10.0	0.0	0.0	2.0
flatstemmed pondweed	10.0	90.0	0.0	0.0	10.0	6.0
sago pondweed	10.0	90.0	0.0	0.0	10.0	2.0
Depths: 5 to 10 ft		Rake score frequency per species				Plant Dominance
Species	Frequency of Occurrence	0	1	3	5	
slender naiad	60.9	39.1	21.7	13.0	26.1	27.8
Chara	47.8	52.2	8.7	17.4	21.7	14.8
Eurasian watermilfoil	30.4	69.6	13.0	4.3	13.0	9.6
American elodea	17.4	82.6	4.3	4.3	8.7	3.5
common coontail	17.4	82.6	8.7	0.0	8.7	7.0
sago pondweed	17.4	82.6	4.3	0.0	13.0	12.2
curlyleaf pondweed	13.0	87.0	13.0	4.3	0.0	4.3
Richardson's pondweed	13.0	87.0	4.3	0.0	8.7	4.3
eel grass	8.7	91.3	0.0	4.3	4.3	1.7
large leaf pondweed	4.3	95.7	0.0	0.0	4.3	4.3
leafy pondweed	4.3	95.7	4.3	0.0	0.0	0.9
southern naiad	4.3	95.7	4.3	0.0	0.0	0.9
Depths: 10 to 15 ft		Rake score frequency per species				Plant Dominance
Species	Frequency of Occurrence	0	1	3	5	
common coontail	80.0	20.0	60.0	20.0	0.0	24.0
Eurasian watermilfoil	40.0	60.0	20.0	20.0	0.0	8.0
slender naiad	40.0	60.0	20.0	20.0	0.0	8.0
Depths: 15 to 20 ft		Rake score frequency per species				Plant Dominance
Species	Frequency of Occurrence	0	1	3	5	
American elodea	20.0	80.0	10.0	10.0	0.0	8.0
slender naiad	20.0	80.0	20.0	0.0	0.0	4.0
common coontail	10.0	90.0	10.0	0.0	0.0	2.0
flatstemmed pondweed	10.0	90.0	10.0	0.0	0.0	2.0
southern naiad	10.0	90.0	10.0	0.0	0.0	2.0

6.2.2 Summer Tier II Survey results for the Second Basin

Chara and slender naiad were the most frequently collected species (both at 28.6%) in the second basin (Table 3). Curlyleaf pondweed was the next most frequently occurring species (23.8%) and showed the greatest dominance (10.5) followed by sago pondweed (14.3%), Eurasian watermilfoil (4.8%), flatstem pondweed (4.8%), large leaf pondweed (4.8%), and Richardson's pondweed (4.8%). Table 3 displays the results of the Tier II survey.

**Table 3. Occurrence and abundance of submersed aquatic plants in Crooked Lake, second basin, August 14, 2007.**

Occurrence and abundance of submersed aquatic plants in Crooked Lake Basin 2						
County: Stuben	Sites with plants: 13	Mean species/site: 1.14				
Date: 8/14/2007	Sites with native plants: 13	Standard error (ms/s): 0.2515				
Secchi (ft): -	Number of species: 8	Mean native species/site: 1.10				
Maximum plant depth (ft): 18	Number of native species: 6	Standard error (mns/s): 0.2479				
Trophic status Mesotrophic	Maximum species/site: 3	Species diversity: 0.81				
Total sites: 21		Native species diversity: 0.74				
Depths: 0 to 18 ft		Frequency of Occurrence				Plant Dominance
Species	Occurrence	0	1	3	5	
Chara	28.6	71.4	23.8	0.0	4.8	5.7
slender naiad	28.6	71.4	19.0	4.8	4.8	9.5
curlyleaf pondweed	23.8	76.2	14.3	4.8	4.8	10.5
sago pondweed	14.3	85.7	9.5	0.0	4.8	2.9
Eurasian watermilfoil	4.8	95.2	0.0	4.8	0.0	2.9
flatstemmed pondweed	4.8	95.2	0.0	4.8	0.0	1.0
large leaf pondweed	4.8	95.2	4.8	0.0	0.0	1.0
Richardson's pondweed	4.8	95.2	4.8	0.0	0.0	1.0
Depths: 0 to 5 ft		Frequency of Occurrence				Plant Dominance
Species	Occurrence	0	1	3	5	
Chara	33.3	66.7	33.3	0.0	0.0	6.7
curlyleaf pondweed	33.3	66.7	33.3	0.0	0.0	6.7
large leaf pondweed	16.7	83.3	16.7	0.0	0.0	3.3
slender naiad	16.7	83.3	16.7	0.0	0.0	3.3
Depths: 5 to 10 ft		Frequency of Occurrence				Plant Dominance
Species	Occurrence	0	1	3	5	
slender naiad	40.0	60.0	20.0	10.0	10.0	16.0
Chara	30.0	70.0	20.0	0.0	10.0	6.0
curlyleaf pondweed	30.0	70.0	0.0	10.0	10.0	18.0
sago pondweed	20.0	80.0	10.0	0.0	10.0	4.0
Eurasian watermilfoil	10.0	90.0	0.0	10.0	0.0	6.0
flatstemmed pondweed	10.0	90.0	0.0	10.0	0.0	2.0
Richardson's pondweed	10.0	90.0	10.0	0.0	0.0	2.0
Depths: 15 to 18 ft		Frequency of Occurrence				Plant Dominance
Species	Occurrence	0	1	3	5	
Chara	20.0	80.0	20.0	0.0	0.0	4.0
sago pondweed	20.0	80.0	20.0	0.0	0.0	4.0
slender naiad	20.0	80.0	20.0	0.0	0.0	4.0

6.2.3 Summer Tier II Survey results for the Third Basin

Chara was the most frequently occurring species (41.9%) in the third basin at the time of the Tier II survey (Table 4). Largeleaf pondweed was the second most frequently occurring plant (22.6%) followed by Eurasian watermilfoil (16.1%), common coontail (6.5%), flatstem pondweed (6.5%), sago pondweed (6.5%), American Elodea (3.2%), common bladderwort (3.2%), and slender naiad (3.2%). The Tier II data is summarized in Table 4.

**Table 4. Occurrence and abundance of submersed aquatic plants in Crooked Lake, third basin, August 14, 2007.**

Occurrence and abundance of submersed aquatic plants in Crooked Lake Basin 3						
County: Stuben	Sites with plants: 17	Mean species/site: 1.10				
Date: 8/14/2007	Sites with native plants: 16	Standard error (ms/s): 0.2718				
Secchi (ft): -	Number of species: 9	Mean native species/site: 0.94				
Maximum plant depth (ft): 7	Number of native species: 8	Standard error (mns/s): 0.2362				
Trophic status Mesotrophic	Maximum species/site: 7	Species diversity: 0.78				
Total sites: 31		Native species diversity: 0.72				
Depths: 0 to 7 ft						
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
Chara	41.9	58.1	29.0	6.5	6.5	13.5
large leaf pondweed	22.6	77.4	9.7	3.2	9.7	8.4
Eurasian watermilfoil	16.1	83.9	12.9	0.0	3.2	3.2
common coontail	6.5	93.5	3.2	0.0	3.2	1.3
flatstemmed pondweed	6.5	93.5	0.0	3.2	3.2	1.3
sago pondweed	6.5	93.5	3.2	0.0	3.2	2.6
American elodea	3.2	96.8	0.0	0.0	3.2	0.6
common bladderwort	3.2	96.8	0.0	0.0	3.2	1.9
slender naiad	3.2	96.8	0.0	0.0	3.2	0.6
Depths: 0 to 5 ft						
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
Chara	47.6	52.4	33.3	4.8	9.5	15.2
large leaf pondweed	23.8	76.2	9.5	0.0	14.3	8.6
Eurasian watermilfoil	14.3	85.7	9.5	0.0	4.8	2.9
flatstemmed pondweed	9.5	90.5	0.0	4.8	4.8	1.9
sago pondweed	9.5	90.5	4.8	0.0	4.8	3.8
American elodea	4.8	95.2	0.0	0.0	4.8	1.0
common bladderwort	4.8	95.2	0.0	0.0	4.8	2.9
common coontail	4.8	95.2	0.0	0.0	4.8	1.0
slender naiad	4.8	95.2	0.0	0.0	4.8	1.0
Depths: 5 to 7 ft						
Species	Frequency of Occurrence	Rake score frequency per species				Plant Dominance
		0	1	3	5	
Chara	30.0	70.0	20.0	10.0	0.0	10.0
Eurasian watermilfoil	20.0	80.0	20.0	0.0	0.0	4.0
large leaf pondweed	20.0	80.0	10.0	10.0	0.0	8.0
common coontail	10.0	90.0	10.0	0.0	0.0	2.0

### 6.3 Aquatic Vegetation Sampling Discussion

One of the main actions recommended in the 2006 plan was the continued monitoring of vegetation. As previously mentioned, sampling consisted of invasive mapping in the spring followed by a Tier II survey in the summer.

Invasive mapping appeared to be effective at locating the majority of the milfoil problem areas. This conclusion is reached when comparing the summer Tier II milfoil map to the spring milfoil map. The summer survey detected very little milfoil outside of the areas that were mapped in the spring. Spring invasive mapping also allowed for an acreage estimate on curlyleaf pondweed. This mapping provides a good baseline data set in order to monitor the potential spread of this species and to allow for budget estimates for control.

One of the primary goals of the plan is to reduce the negative impacts caused by nuisance invasive species. The primary nuisance species in Crooked Lake is Eurasian watermilfoil. This species exhibited a significant decline this season that can likely be attributed to vegetation controls (Figure 10). It is likely that an even more significant decline in milfoil would have been observed if the survey summer survey was completed later in the year, since much of the milfoil appeared to be dying in third basin and there were still lethal levels of fluridone present at the time of the survey. Prior to treatment, milfoil and curlyleaf pondweed made navigation in the third basin difficult if not impossible. Navigation was not a serious problem at the time of the summer survey.

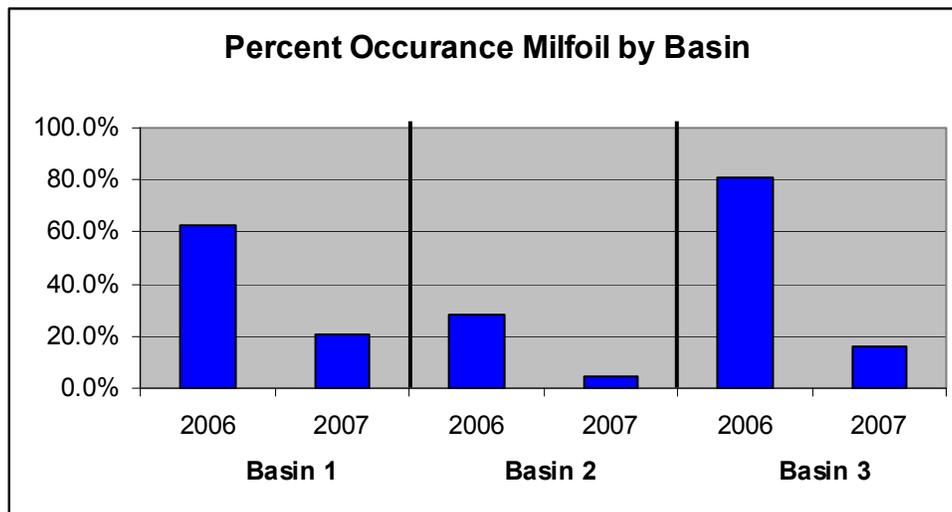


Figure 10. Crooked Lake, Eurasian watermilfoil percent occurrence in the last two summer surveys.

Curlyleaf pondweed is one of the most common invasive species in Crooked Lake. This species tends to decline by late summer, but has been documented in past summer surveys. There appears to have been an increase in the abundance of this species in 2007 when compared to past surveys (Figure 11). This is somewhat surprising since curlyleaf was not detected in the third basin this season due to the fluridone application. The reason for the increase is not entirely clear, but may be attributed to a change in herbicides. Last season milfoil beds were treated with a contact herbicide that also

impacts curlyleaf pondweed, while this season these beds were treated with a selective systemic herbicide that has no effect on pondweeds.

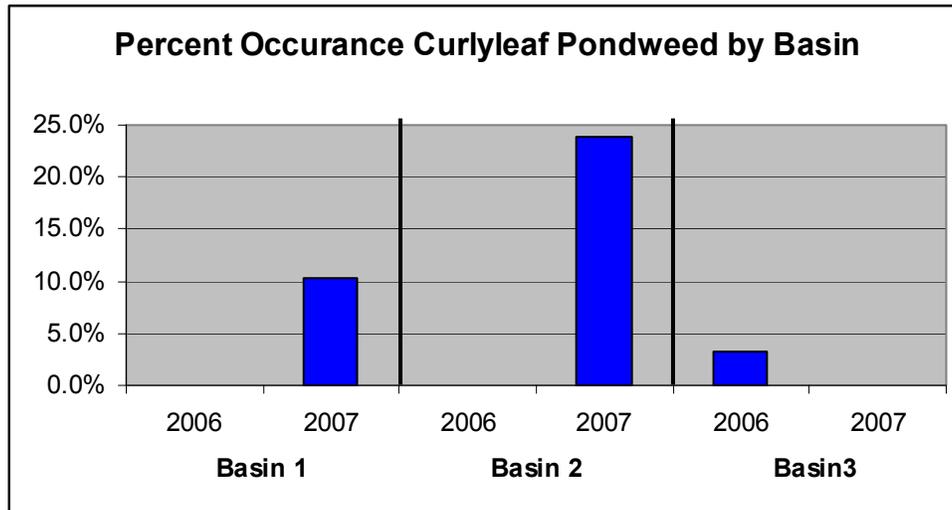


Figure 11. Crooked Lake, Curlyleaf pondweed percent occurrence in the last two summer surveys.

Another goal of the original plan was to maintain a stable, diverse, aquatic plant community. The Tier II surveys offer a tool for quantifying changes in the submersed native plant population. Overall, metrics appear to reflect an increase in these metrics in basin 1 and 2 with a slight decrease in basin 3 (Figures 12 & 13).

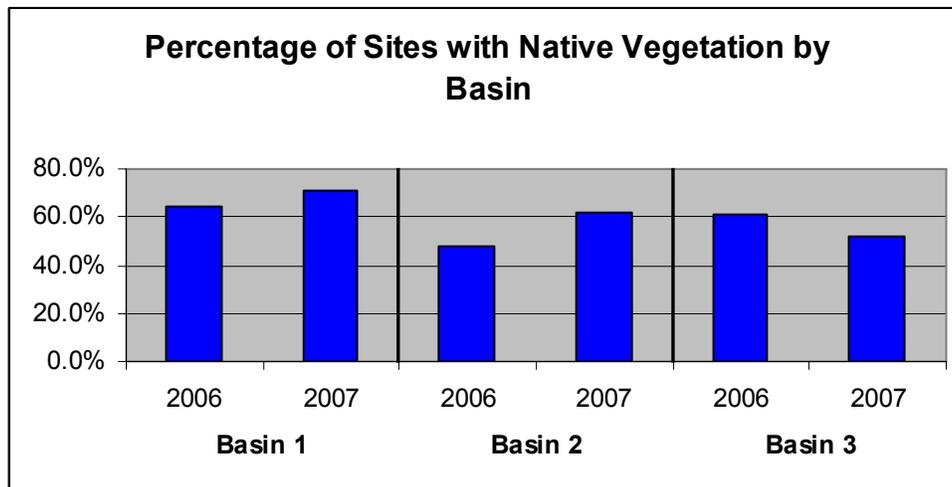


Figure 12. Crooked Lake, percentage of sample sites with native vegetation in the last two summer surveys.

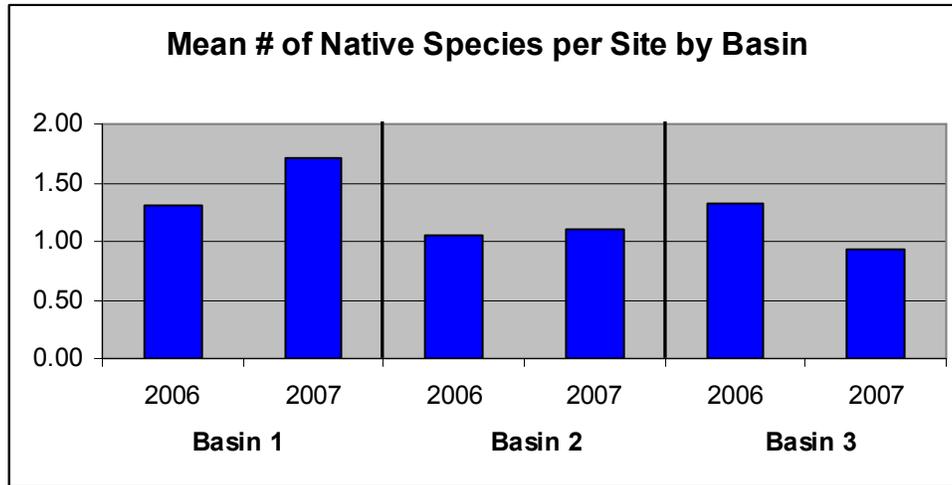


Figure 13. Crooked Lake, mean number of native species per site in the last two summer surveys.

Table 5 summarizes the data from the past three surveys as it relates to percent occurrence of individual species. Small pondweed, variable milfoil, variable pondweed, brittle naiad, western elodea, water stargrass were all collected in 2006 but not in 2007. Most of these species were present at a low percentage of sites in 2006 with the exception of variable pondweed. The reduction may be due to some native impact from the fluridone treatment in third basin and recovery should be noticed by next season. Southern naiad, leafy pondweed, and flatstem pondweed were all collected in the 2007 survey but not collected in 2006. Reduction in frequency of occurrence was most evident in Eurasian watermilfoil which dropped from 60% to 16% occurrence.

**Table 5. Percent occurrence of species collected in the last three Tier II surveys on Crooked Lake (2005 data provided by IDNR).**

Species	% of survey sites (9/05)	% of survey sites (8/06)	% of survey sites (8/07)
Eurasian watermilfoil ( <i>Myriophyllum spicatum</i> )	32.1%	60.0%	16.0%
curlyleaf pondweed ( <i>Potamogeton crispus</i> )	6.7%	1.0%	10.0%
common coontail ( <i>Ceratophyllum demersum</i> )	11.2%	10.0%	14.0%
Chara (Chara spp.)	13.4%	29.0%	33.0%
Slender naiad ( <i>Najas flexillis</i> )	7.5%	40.0%	29.0%
sago pondweed ( <i>Potamogeton pectinatus</i> )	19.4%	5.0%	10.0%
small pondweed ( <i>Potamogeton pusillus</i> )	-	1.0%	-
eel grass ( <i>Vallisneria americana</i> )	2.2%	1.0%	3.0%
American elodea ( <i>Elodea canadensis</i> )	1.5%	1.0%	9.0%
southern naiad ( <i>Najas guadalupensis</i> )	-	-	2.0%
spiny naiad ( <i>Najas marina</i> )	0.7%	-	-
leafy pondweed ( <i>Potamogeton foliosus</i> )	-	-	1.0%
flatstemmed pondweed ( <i>Potamogeton zosteriformis</i> )	1.5%	-	5.0%
Richardson's pondweed ( <i>Potamogeton richardsonii</i> )	3.0%	1.0%	8.0%
large leaf pondweed ( <i>Potamogeton amplifolius</i> )	-	8.0%	9.0%
variable pondweed ( <i>Potamogeton gramineus</i> )	23.1%	10.0%	-
variable milfoil ( <i>Myriophyllum heterophyllum</i> )	-	2.0%	-
water stargrass ( <i>Zosterella dubia</i> )	3.0%	3.0%	-
common bladderwort ( <i>Utricularia vulgaris</i> )	2.2%	4.0%	1.0%
western elodea ( <i>Elodea nuttali</i> )	-	1.0%	-
brittle naiad ( <i>Najas minor</i> )	-	3.0%	-
Illinois pondweed ( <i>Potamogeton illinoensis</i> )	1.5%	5.0%	-

Crooked Lake has three distinct basins that received different treatments during the 2007 season. It is advantageous to view the plant communities of the three basins separately. The results of the past two years of Tier II sampling within the first basin can be viewed in Table 6. As is shown, there was a 40% decrease in Eurasian watermilfoil between the 2006 and 2007 Tier II surveys. Curlyleaf pondweed was the only other exotic species found in the first basin. As noted above, the switch from a broad based contact herbicide to a selective systemic herbicide for milfoil control may account for the increased frequency of curlyleaf pondweed during the 2007 survey. Richardson's pondweed, a plant listed as rare in Indiana, increased in frequency from 2.1% in 2006 to 14.6% in 2007. American elodea, Chara, common coontail, curlyleaf pondweed, southern naiad, largeleaf pondweed, eel grass, flatstem pondweed, and sago pondweed all exhibited increases in frequency, while Eurasian watermilfoil, leafy pondweed, variable pondweed, Illinois pondweed, water stargrass, western elodea, and brittle naiad decreased in frequency.

**Table 6. Percent occurrence of species collected in the last two Tier II surveys on Crooked Lake, Basin 1.**

<b>Species Basin 1</b>	<b>% of survey sites (8/06)</b>	<b>% of survey sites (8/07)</b>
Eurasian watermilfoil ( <i>Myriophyllum spicatum</i> )	62.5%	20.8%
curlyleaf pondweed ( <i>Potamogeton crispus</i> )	-	10.4%
Slender naiad ( <i>Najas flexillis</i> )	56.3%	45.8%
Chara (Chara spp.)	20.8%	29.2%
common coontail ( <i>Ceratophyllum demersum</i> )	18.8%	25.0%
leafy pondweed ( <i>Potamogeton foliosus</i> )	6.3%	2.1%
variable pondweed ( <i>Potamogeton gramineus</i> )	6.3%	-
Illinois pondweed ( <i>Potamogeton illinoensis</i> )	6.3%	-
sago pondweed ( <i>Potamogeton pectinatus</i> )	4.2%	10.4%
water stargrass ( <i>Zosterella dubia</i> )	4.2%	-
western elodea ( <i>Elodea nuttali</i> )	2.1%	-
brittle naiad ( <i>Najas minor</i> )	2.1%	-
Richardson's pondweed ( <i>Potamogeton richardsonii</i> )	2.1%	14.6%
American elodea ( <i>Elodea canadensis</i> )	2.1%	16.7%
southern naiad ( <i>Najas guadalupensis</i> )	-	4.2%
large leaf pondweed ( <i>Potamogeton amplifolius</i> )	-	2.1%
eel grass ( <i>Vallisneria americana</i> )	-	6.3%
flatstemmed pondweed ( <i>Potamogeton zosteriformis</i> )	-	4.2%

The results of the past two years of Tier II surveys conducted in the second basin are shown in Table 7. The frequency of occurrence for Eurasian watermilfoil dropped from 28.6% in 2006 to 4.8% in 2007. It should also be noted that curlyleaf pondweed increased from non-detect in 2006 to 23.8% during this time. Slender naiad, largeleaf pondweed, variable pondweed, small pondweed, eel grass, brittle naiad, and Illinois pondweed all decreased in frequency, while Chara, sago pondweed, flatstem pondweed, and richarson's pondweed all exhibited increases in frequency of occurrence.

**Table 7. Percent occurrence of species collected in the last two Tier II surveys on Crooked Lake, Basin 2.**

<b>Species Basin 2</b>	<b>% of survey sites (8/06)</b>	<b>% of survey sites (8/07)</b>
Eurasian watermilfoil ( <i>Myriophyllum spicatum</i> )	28.6%	4.8%
curlyleaf pondweed ( <i>Potamogeton crispus</i> )	-	23.8%
Slender naiad ( <i>Najas flexillis</i> )	38.1%	28.6%
Chara (Chara spp.)	19.0%	28.6%
sago pondweed ( <i>Potamogeton pectinatus</i> )	9.5%	14.3%
large leaf pondweed ( <i>Potamogeton amplifolius</i> )	9.5%	4.8%
variable pondweed ( <i>Potamogeton gramineus</i> )	9.5%	-
small pondweed ( <i>Potamogeton pusillus</i> )	4.8%	-
eel grass ( <i>Vallisneria americana</i> )	4.8%	-
brittle naiad ( <i>Najas minor</i> )	4.8%	-
Illinois pondweed ( <i>Potamogeton illinoensis</i> )	4.8%	-
flatstemmed pondweed ( <i>Potamogeton zosteriformis</i> )	-	4.8%
Richardson's pondweed ( <i>Potamogeton richardsonii</i> )	-	4.8%

The third basin exhibited a 64.5% decrease in the frequency of Eurasian watermilfoil (Table 8). Since there was still fluridone present at the time of the survey, this decrease may have been higher if sampling were conducted a few weeks later in the season. There were also decreases in the frequencies of curlyleaf pondweed, variable pondweed, common bladderwort, variable milfoil, Illinois pondweed, and water stargrass. Largeleaf pondweed, sago pondweed, American elodea, and flatstem pondweed all increased in frequency. Common coontail remained at 6.5% of sites in both surveys.

**Table 8. Percent occurrence of species collected in the last two Tier II surveys on Crooked Lake, Basin 3.**

<b>Species Basin 3</b>	<b>% of survey sites (8/06)</b>	<b>% of survey sites (8/07)</b>
Eurasian watermilfoil ( <i>Myriophyllum spicatum</i> )	80.6%	16.1%
curlyleaf pondweed ( <i>Potamogeton crispus</i> )	3.2%	-
Chara (Chara spp.)	48.4%	41.9%
large leaf pondweed ( <i>Potamogeton amplifolius</i> )	19.4%	22.6%
variable pondweed ( <i>Potamogeton gramineus</i> )	16.1%	-
common bladderwort ( <i>Utricularia vulgaris</i> )	12.9%	3.2%
Slender naiad ( <i>Najas flexillis</i> )	12.9%	3.2%
common coontail ( <i>Ceratophyllum demersum</i> )	6.5%	6.5%
variable milfoil ( <i>Myriophyllum heterophyllum</i> )	6.5%	-
Illinois pondweed ( <i>Potamogeton illinoensis</i> )	3.2%	-
sago pondweed ( <i>Potamogeton pectinatus</i> )	3.2%	6.5%
water stargrass ( <i>Zosterella dubia</i> )	3.2%	-
American elodea ( <i>Elodea canadensis</i> )	-	3.2%
flatstemmed pondweed ( <i>Potamogeton zosteriformis</i> )	-	6.5%

## 7.0 2007 VEGETATION CONTROLS

In 2007, Eurasian watermilfoil was the primary target of vegetation controls. The action plan called for a whole basin fluridone treatment in the third basin and spot treatments with 2,4-D granular herbicide in the first and second basins.

The goal of the third basin fluridone treatment was to maintain a fluridone concentration above 3ppb for 90 days. In order to monitor the concentration, five sets of FasTests were scheduled to be taken over the 90 day period. These tests allow the applicator to make precise and timely bumps to the fluridone levels. Tests were taken from three different locations within the third basin (Figure 14).



Figure 14. Crooked Lake, 2007 FasTEST sample locations.

Aquatic Management applied an initial 8 ppb dose of fluridone on May 14 (brand name of fluridone product was Sonar AS which is a liquid formulation). An application boat fitted with submersed dropper hoses was used to spread Sonar AS evenly throughout the third basin. Initial testing was completed on May 17 in order to monitor the actual fluridone concentrations. Tests were taken from three sites and the average of the 3 tests was 6.8 ppb. A bump application was completed on May 23 with a 2.8 ppb dose of fluridone in order to keep the concentration above 3 ppb. Tests were completed on June 6 and results indicated the third basin had an average concentration of 5.4 ppb. Another test was completed on June 26 and results averaged out to be 3.1 ppb. The third and final bump treatment was completed on July 2 with a 3 ppb dose. Tests were completed on July 18 and averaged 5.0 ppb. The final tests were completed on August 6 and averaged 3.5 ppb (Figure 15). The goal of maintaining a concentration above 3 ppb for 90 days had been achieved and the milfoil was significantly reduced.

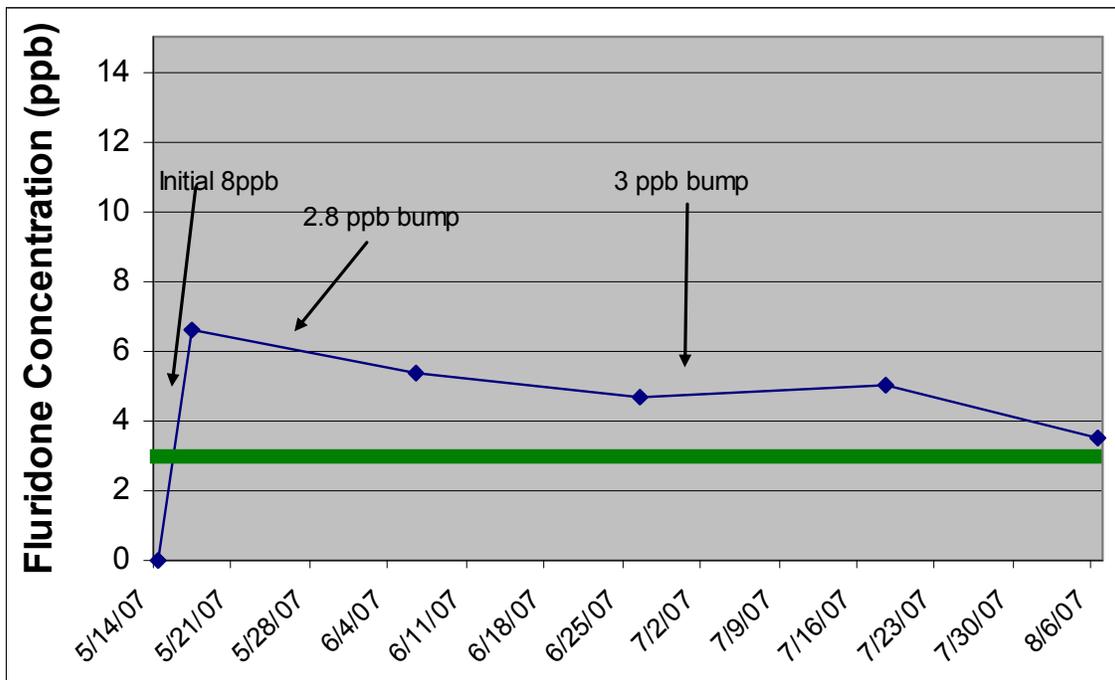


Figure 15. Crooked Lake, 2007 average of third basin fluridone concentrations.

In addition to the third basin fluridone treatment, on May 22, Aquatic Management treated 62 acres of milfoil in the first and second basins (Figure 16). Treatment areas were mapped out during the previously discussed invasive mapping survey. Aquatic Control supplied Aquatic Management with the coordinates of the milfoil beds. Aquatic Management downloaded the coordinates onto their GPS devices in order to insure the product was being applied to the proper areas. Granular 2,4-D was used in this treatment (trade name Navigate). The granular material was applied with two gas powered spreaders mounted on the front of the boat. Both treatments significantly reduced milfoil abundance.

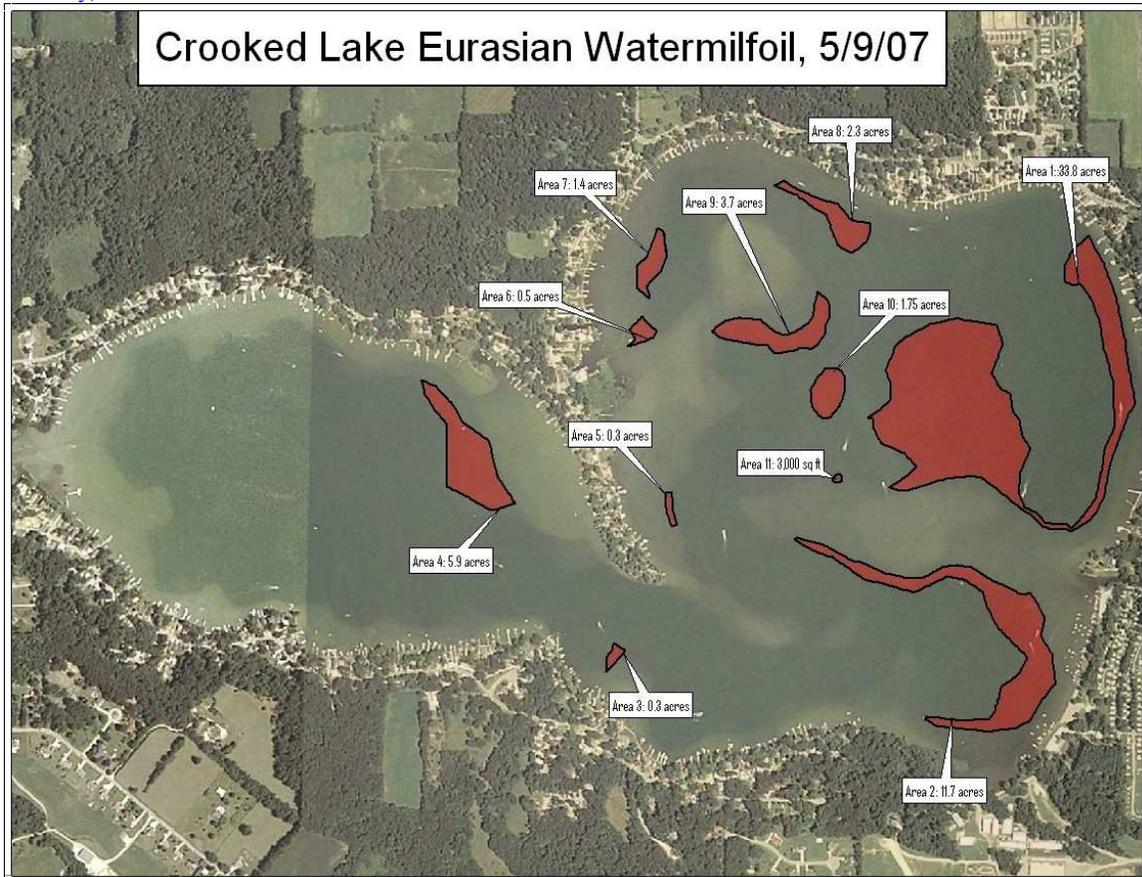


Figure 16. Crooked Lake first and second basin 2,4-D treatment areas, May 22, 2007.

Aquatic Management completed contact treatments on June 6<sup>th</sup>, 2007 to several locations in the first two basins for individual lot owners. No contact treatments were permitted in the third basin. A mixture of Reward, Aquathol, and Nautique was applied to control nuisance vegetation growing no further than 100 feet from the shoreline for a total of 7.2 acres. This treatment was funded solely by the individual lot owners. LARE does not grant funding for this type of treatment.

## 8.0 PUBLIC INVOLVEMENT

A public meeting was held on September 19, 2007 at a real estate office near Crooked Lake. Approximately 14 lake users attended the meeting along with Neil and Nick Gerber of Aquatic Management. Aquatic Control presented information on plant management activities, plant sampling, invasive species, and property owner best management practices.

A survey of lake users was also distributed at the meeting. Of those that responded: 100.0% were property owners and 79% had lived on the lake for over 10 years. When responding to individual uses of the lake, 100% responded that they use it for swimming, 93% use it for boating, 50% for irrigation, and 43% used it for fishing.

On questions concerning aquatic vegetation in Crooked Lake: 21% of respondents felt that they had plants at their shorelines in nuisance amounts, 28% said that aquatic

vegetation interfered with their use and enjoyment of the lake, 64% felt that the level of vegetation affected their property values, 100% were in favor of continuing efforts to control vegetation in the lake., and 86% were satisfied with the LARE funded invasive treatment for the season.

When asked about issues of concern with the lake: 50% responded that dredging was needed, 50% felt that the use of jet skis were a problem, 43% said their were pier/funneling problems, 36% felt that there were too many boats with access to the lake, 21% thought there were too many aquatic plants, 14% said there were not enough aquatic plants and there is overuse by non residents, and 7% expressed that there was poor water quality. Results of this survey are summarized in Table 9.

**Table 9. Crooked Lake, lake user survey, September 19, 2007.**

<b>Crooked Lake User Survey 9/19/07</b>		
Are you a lake property owner?	Yes 100%	No 0%
Are you currently a member of your lake association?	Yes 100%	No 0%
How many years have you been at the lake?	2 or Less: 7%	5 to 10: 14%
	2 to 5: 0%	Over 10: 79%
How do you use the lake (mark all that apply)	100% Swimming	50% Irrigation
	93% Boating	0% Drinking water
	43% Fishing	0% Other _____
Do you have aquatic plants at your shoreline in nuisance quantities?	Yes: 21% No: 79%	
Does aquatic vegetation interfere with your use or enjoyment of the lake?	Yes: 28% No: 72%	
Does the level of vegetation in the lake affect your property values?	Yes: 64% No: 36%	
Are you in favor of continuing efforts to control vegetation on the lake?	Yes: 100% No: 0%	
Are you aware that the LARE funds will only apply to work controlling invasive exotic species, and more work may need to be privately funded?	Yes: 100% No: 0%	
Were you satisfied with the results of the LARE funded invasive treatments this season?	Yes: 86% No: 7% (7% no response)	
Mark any of these you think are problems on your lake:		
36% Too many boats access the lake		
50% Use of jet skis on the lake		
0% Too much fishing		
0% Fish population problem		
50% Dredging needed		
14% Overuse by nonresidents		
21% Too many aquatic plants		
14% Not enough aquatic plants		
7% Poor water quality		
43% Pier/funneling problem		

Another topic discussed at the public meeting was the discovery of Hydrilla (*Hydrilla verticillata*) in Lake Manitou. Hydrilla is an invasive aquatic species that was originally discovered in Florida in the 1960's. There are many characteristics of hydrilla that make it a threat to Indiana waterways. This species can grow in lower light conditions than most native species, grows faster than most native species, and can shade out other species by forming a surface canopy. Hydrilla can be easily confused with native elodea. The best way to distinguish hydrilla is that it typically has five leaves along each whorl along with visible serrated edges along the leaf margin (Figure 17). What makes controlling the spread of Hydrilla difficult is the fact that it can be spread by fragments. **That is why it is vitally important that lake users remove all plants and sediment from their boats when entering and leaving Crooked Lake.** More information about controlling the spread of hydrilla can be found at [www.protectyourwaters.net](http://www.protectyourwaters.net).



Figure 17. Illustration of hydrilla on the left compared to native elodea on the right. Hydrilla typically contains five toothed leaves per whorl while native elodea typically has three leaves per whorl and the teeth are not visible on the leaves (Illustrations provided by Applied Biochemist).

## 9.0 ACTION PLAN AND BUDGET UPDATE

In 2007, the primary vegetation management action focused on the control of milfoil. A combination of spot treatments with 2,4-D in the first and second basins along with a third basin fluridone treatment was completed. LARE funded \$20,000 of the treatment cost while the Association picked up the remaining expenses. The treatments were effective at significantly reducing milfoil abundance and relieving nuisance conditions in 2007. The key to the plan is providing long-term control of milfoil. In order to achieve long term control, any remaining areas of milfoil will have to be addressed. It is unlikely that milfoil will be eradicated with the 2,4-D treatments in the first and second basins, but it is likely that next season's abundance will be reduced. Milfoil was detected during the summer survey which adds to the likelihood that some will be present in 2008. Based on the summer survey and past experience it is estimated that less than 50 acres of milfoil

will be present in 2008. Figure 18 illustrates areas of concern for next season. These are areas in the first and second where milfoil was detected during the summer Tier II survey. It is unlikely that the third basin will require significant treatment since it was treated with fluridone, however, if any milfoil is detected in third basin it should be treated.



Figure 18. Crooked Lake, milfoil areas of concern for the 2008 season.

One of the more difficult but important aspects of the action plan will be detection and mapping of the milfoil areas. This should be completed in early to mid May with treatment being completed in mid to late May in order to lessen the likelihood of milfoil spread. If Secchi readings are normal, the majority of mapping can be completed by driving a boat in a tight zigzag fashion over the littoral area. When milfoil is located a GPS unit should be used to outline the plant bed. A rake should be used to check for milfoil throughout historical areas of infestation and in the areas marked in Figure 18. A follow-up Tier II survey should also be completed in the summer of 2008 in order to monitor native vegetation to check the effectiveness of the potential controls.

Curlyleaf pondweed will likely return at nuisance levels in 2008, especially in the third basin. The whole basin fluridone treatment may have reduced the amount of turions produced by curlyleaf in 2007, but since curlyleaf turions can survive for several seasons before sprouting there will likely be nuisance levels of curlyleaf in the spring of 2008. Curlyleaf was also present at higher levels in the first basin when comparing the 2007 data to the 2005 and 2006 data. Turion formation typically occurs at peak biomass (Woolf & Madsen, 2003), so treatment of curlyleaf should occur well before this time. In

northern Indiana peak biomass usually occurs in late May or early June. Based on past experience, personal communication with product manufacturers and researchers, along with a journal review, we believe that treatment should occur once the water reaches a consistent 50 degrees Fahrenheit. In addition to reduced turion production, early applications may improve the selective potential of the herbicide because fewer native plant species are actively growing in cooler water temperatures and therefore are less susceptible to herbicide treatment (Poovey et. al. 2002). In addition, algae blooms have been associated with senescence in response to the release of nutrients following decline of large stands of curlyleaf pondweed (Hill 1979, Hill and Webster 1982 cited in Netherland et. al., 2000). Early season control of curlyleaf should help reduce the amount of nutrients taken from the substrate and made available to microscopic algae in the water column.

Curlyleaf is very susceptible to low doses of endothal (trade name Aquathol K). Diquat also has good activity on curlyleaf, but endothal appears to be more effective in cool water (Poovey et. al. 2002). Applicators have varied treatment rates for control of curlyleaf from a low of 0.5 ppm to a high of 1.5 ppm. We typically recommend a rate of 1.0 ppm for early season control. This rate is based on past experience, literature review, ongoing Army Corp of Engineers research, labeled rates, and the manufacturer's recommendation.

Up to 155 acres of curlyleaf pondweed may be present in Crooked Lake next season (Figure 19). This estimate is based upon the findings from the 2007 invasive plant mapping survey. Curlyleaf pondweed will likely be most abundant in the third basin (133 acres). This basin is relatively shallow with an average depth of approximately 4.0 feet, so that would reduce the cost of treatment compared to treating lakes with much deeper areas (in order to achieve 1.0 ppm in 133 acres of the third basin you would need 2.4 gallons of Aquathol K per acre). This treatment should be completed for at least three consecutive seasons in order to exhaust turion supplies. The author understands the budget limitations of the Association and LARE to fund such a treatment, however, if an invasive species such as curlyleaf is to be controlled potential actions need to be addressed. Control and monitoring of the Eurasian watermilfoil should take precedent over the potential curlyleaf controls because milfoil has a greater chance of interfering with summer boating activities and large initial milfoil control investments were already made in 2007.

If a large-scale curlyleaf treatment is funded next season it will be important to have good baseline curlyleaf abundance data. This should at least include a pre-treatment Tier II survey. In addition to the Tier II sampling, curlyleaf turion sampling would help address the reduction in the turion population, which is the ultimate goal of the treatment program. Sampling should be done in summer at the time of the summer Tier II survey. Sites where beds of curlyleaf pondweed are known to have existed in the past should be used for the purpose of turion sampling. When a location of sufficient turion density is found, it will be marked on a handheld GPS unit for sampling in subsequent years. Two sampling sites will be assigned per basin for a total of 6 sampling sites. Sampling will be done using a sediment sampler that is 2-6 inches in diameter and can obtain a core at least 5 inches in depth. Twenty-five core samples will be taken per sampling location in an area ~2,500 square feet from the GPS waypoint for that site. Core samples will be placed

in a wash bucket or similar device to separate turions from other benthic material. The turions will then be counted and recorded. This sampling protocol should be continued for at least 3 years in order to document the reduction of turion presence. Changes may need to be made to this protocol as the abundance of turions decreases.

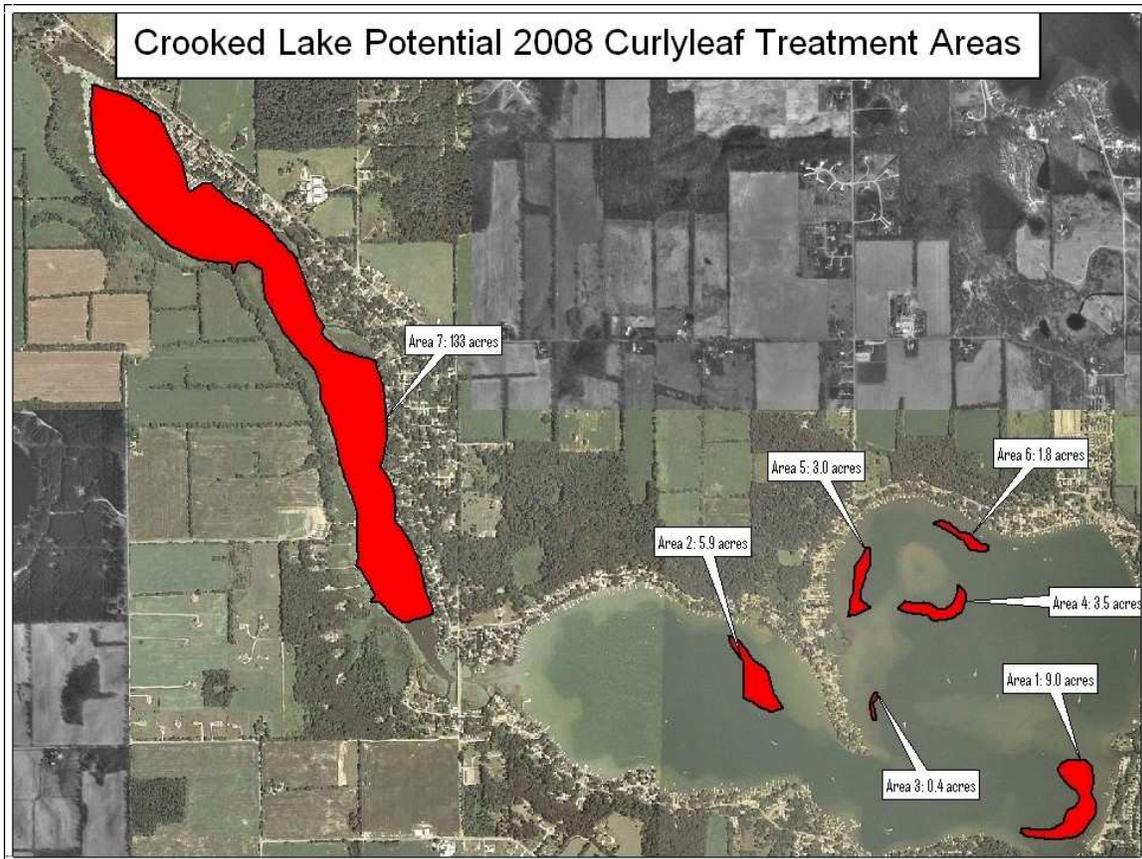


Figure 19. Crooked Lake, 2008 potential curlyleaf pondweed treatment areas.

There are high use areas of the lake that may require some control of native vegetation. These areas include, docks, boat ramps, and beaches. Treatment of native vegetation should be limited to these high-use areas and only completed where native vegetation is actually impacting lake use. Registered contact herbicides are effective for short term relief of nuisance conditions and ideally a professional should complete the treatment. A professional applicator will have to apply for permits in order to complete such a treatment. However, homeowner's can legally control vegetation in a 625 square-foot areas of their shoreline without a permit. Any vegetation treated with herbicides or manually removed that extends beyond the 625 square foot area will require an IDNR permit.

Efforts to educate residents on the benefits of native vegetation should be continued. This may include annual meetings, newsletters, ILMS conferences or workshops and website postings. Educating residents on the value of native vegetation and proper shoreline maintenance may help enhance the Crooked Lake ecosystem. In addition, educating residents on the need to properly clean boats and trailers may help reduce the movement of invasive species into or out of Crooked Lake. It is our recommendation

that public meetings should be scheduled in the future to address these concerns and further the education of the general public.

**It is recommended that the Conservancy request \$65,250 from the LARE program for treatment and the plan update. A total of \$17,500 would be for treatment of approximately 50 acres of milfoil, \$38,750 would be used for treatment of approximately 154 acres of curlyleaf pondweed and \$10,000 would go towards plant sampling and plan updates (Table 10).**

**Table 10. Crooked Lake, four year budget estimate.**

	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
2,4-D Treatment for control of Eurasian watermilfoil (Eurasian watermilfoil only)	\$17,500	\$15,000	\$12,500	\$10,000
Early season Endothal treatment for control of curlyleaf pondweed	\$38,750	\$38,750	\$38,750	-
Vegetation Sampling & Plan Update	\$5,000	\$5,000	\$5,000	\$5,000
Curlyleaf turion sampling and early spring Tier II Survey	\$5,000	\$5,000	\$5,000	
<b>Total w/curlyleaf:</b>	<b>\$65,250</b>	<b>\$63,750</b>	<b>\$61,250</b>	<b>\$15,000</b>
<b>Total w/out curlyleaf</b>	<b>\$22,500</b>	<b>\$20,000</b>	<b>\$17,500</b>	<b>\$15,000</b>

## **10.0 References Cited**

- IDNR. 2001. Lake Survey Report: Crooked Lake. IN Department of Natural Resources, Division of Fish Wildlife
- JFNew and Associates. 2007. Crooked Littoral Zone Restoration Research Project 2007-2009. Prepared for Crooked Lake Association. Walkerton, Indiana.
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- Netherland, M.D., Skogerboe, J.D., Owens, C.S., & Madsen, J.D. 2000. Influence of Water Temperature on the Efficacy of Diquat and Endothall versus Curlyleaf Pondweed. *Journal of Aquatic Plant Management* 38: 25-32.
- Poovey, A.G., Skogerboe, J.G., & Owens, C.S. 2002. Spring Treatments of Diquat and Endothall for Curlyleaf Pondweed Control. *Journal of Aquatic Plant Management* 40: 63-67.
- Woolf, T.E. & Madsen, J.D. 2003. Seasonal Biomass and Carbohydrate Allocation Patterns in Southern Minnesota Curlyleaf Pondweed Population. *Journal of Aquatic Plant Management* 41:113-118

# 11.0 Appendix Update

## 11.1 2007 Sampling Data-Tier II Survey

Lake	Date	Latitude	Longitude	Design	Site	Depth	RAKE	MYSF2	POCR3	CEDE4	CH7AR	NAFL	POPE6	YAAM3	ELCA7	NAGU	POZO	PCR12	POAM	UTMA
Crooked Lake	8/14/07	41 682269	-85 071143			1	6.0													
Crooked Lake	8/14/07	41 689485	-85 037534			2	16.0													
Crooked Lake	8/14/07	41 670536	-85 039176			3	6.0													
Crooked Lake	8/14/07	41 670979	-85 041236			4	6.0													
Crooked Lake	8/14/07	41 671969	-85 042999			5	20.0													
Crooked Lake	8/14/07	41 673695	-85 041262			6	9.0													
Crooked Lake	8/14/07	41 673751	-85 038995			7	10.0													
Crooked Lake	8/14/07	41 674494	-85 038336			8	19.0													
Crooked Lake	8/14/07	41 672039	-85 036361			9	17.0													
Crooked Lake	8/14/07	41 673494	-85 034848			10	13.0													
Crooked Lake	8/14/07	41 675094	-85 034485			11	11.0													
Crooked Lake	8/14/07	41 676772	-85 034856			12	16.0													
Crooked Lake	8/14/07	41 670749	-85 036299			13	18.0													
Crooked Lake	8/14/07	41 678601	-85 037997			14	6.0													
Crooked Lake	8/14/07	41 678421	-85 040259			15	9.0													
Crooked Lake	8/14/07	41 678798	-85 042654			16	7.0													
Crooked Lake	8/14/07	41 679336	-85 044353			17	20.0													
Crooked Lake	8/14/07	41 679155	-85 047047			18	7.0													
Crooked Lake	8/14/07	41 677716	-85 047545			19	4.0													
Crooked Lake	8/14/07	41 675295	-85 048436			20	2.0													
Crooked Lake	8/14/07	41 675882	-85 046444			21	6.0													
Crooked Lake	8/14/07	41 676665	-85 044432			22	6.0													
Crooked Lake	8/14/07	41 677194	-85 042857			23	20.0													
Crooked Lake	8/14/07	41 674842	-85 045441			24	6.0													
Crooked Lake	8/14/07	41 673309	-85 046558			25	8.0													
Crooked Lake	8/14/07	41 671897	-85 048962			26	12.0													
Crooked Lake	8/14/07	41 670583	-85 045529			27	6.0													
Crooked Lake	8/14/07	41 669376	-85 043287			28	10.0													
Crooked Lake	8/14/07	41 670711	-85 048019			29	6.0													
Crooked Lake	8/14/07	41 671561	-85 050335			30	7.0													
Crooked Lake	8/14/07	41 672468	-85 051787			31	6.0													
Crooked Lake	8/14/07	41 674072	-85 052495			32	7.0													
Crooked Lake	8/14/07	41 675063	-85 053824			33	7.0													
Crooked Lake	8/14/07	41 675263	-85 056273			34	19.0													
Crooked Lake	8/14/07	41 676326	-85 057841			35	6.0													
Crooked Lake	8/14/07	41 676198	-85 059457			36	19.0													
Crooked Lake	8/14/07	41 675702	-85 062236			37	6.0													
Crooked Lake	8/14/07	41 674737	-85 063327			38	16.0													
Crooked Lake	8/14/07	41 673587	-85 062343			39	4.0													
Crooked Lake	8/14/07	41 673344	-85 066096			40	4.0													
Crooked Lake	8/14/07	41 673612	-85 067886			41	5.0													
Crooked Lake	8/14/07	41 675174	-85 068762			42	5.0													
Crooked Lake	8/14/07	41 675653	-85 069322			43	7.0													
Crooked Lake	8/14/07	41 670025	-85 070319			44	6.0													
Crooked Lake	8/14/07	41 679458	-85 070633			45	7.0													
Crooked Lake	8/14/07	41 680692	-85 071396			46	5.0													
Crooked Lake	8/14/07	41 684214	-85 071459			47	6.0													
Crooked Lake	8/14/07	41 685006	-85 073278			48	5.0													
Crooked Lake	8/14/07	41 686771	-85 074573			49	5.0													
Crooked Lake	8/14/07	41 680454	-85 075943			50	5.0													
Crooked Lake	8/14/07	41 689867	-85 076859			51	6.0													
Crooked Lake	8/14/07	41 689934	-85 078502			52	6.0													
Crooked Lake	8/14/07	41 691088	-85 080567			53	4.0													
Crooked Lake	8/14/07	41 692407	-85 081116			54	4.0													
Crooked Lake	8/14/07	41 692969	-85 082579			55	6.0													
Crooked Lake	8/14/07	41 694199	-85 082754			56	5.0													
Crooked Lake	8/14/07	41 694821	-85 084349			57	5.0													
Crooked Lake	8/14/07	41 693384	-85 084623			58	6.0													
Crooked Lake	8/14/07	41 691915	-85 0841			59	5.0													
Crooked Lake	8/14/07	41 690589	-85 082435			60	5.0													
Crooked Lake	8/14/07	41 689128	-85 080008			61	6.0													
Crooked Lake	8/14/07	41 688867	-85 077703			62	4.0													
Crooked Lake	8/14/07	41 697238	-85 076282			63	4.0													
Crooked Lake	8/14/07	41 68572	-85 074966			64	5.0													
Crooked Lake	8/14/07	41 683213	-85 073379			65	5.0													
Crooked Lake	8/14/07	41 681873	-85 072699			66	6.0													
Crooked Lake	8/14/07	41 67922	-85 072009			67	4.0													
Crooked Lake	8/14/07	41 677757	-85 071794			68	3.0													
Crooked Lake	8/14/07	41 676504	-85 070624			69	5.0													
Crooked Lake	8/14/07	41 672822	-85 067943			70	3.0													
Crooked Lake	8/14/07	41 672519	-85 063297			71	4.0													
Crooked Lake	8/14/07	41 672274	-85 061199			72	7.0													
Crooked Lake	8/14/07	41 670585	-85 061274			73	18.0													
Crooked Lake	8/14/07	41 670417	-85 059624			74	5.0													
Crooked Lake	8/14/07	41 670377	-85 0579			75	4.0													
Crooked Lake	8/14/07	41 669916	-85 056205			76	5.0													
Crooked Lake	8/14/07	41 669979	-85 054854			77	6.0													
Crooked Lake	8/14/07	41 669848	-85 053402			78	6.0													
Crooked Lake	8/14/07	41 670043	-85 051999			79	6.0													
Crooked Lake	8/14/07	41 67009	-85 050625			80	16.0													
Crooked Lake	8/14/07	41 669189	-85 049933			81	16.0													
Crooked Lake	8/14/07	41 668978	-85 048208			82	7.0													
Crooked Lake	8/14/07	41 667886	-85 047613			83	7.0													
Crooked Lake	8/14/07	41 667395	-85 046354			84	17.0													
Crooked Lake	8/14/07	41 667582	-85 044645			85	8.0													
Crooked Lake	8/14/07	41 666096	-85 042877			86	5.0													
Crooked Lake	8/14/07	41 66632	-85 041936			87	7.0													
Crooked Lake	8/14/07	41 666832	-85 040615			88	5.0													
Crooked Lake	8/14/07	41 667592	-85 039431			89	5.0													
Crooked Lake	8/14/07	41 666883	-85 038379			90	4.0													
Crooked Lake	8/14/07	41 667516	-85 037112			91	4.0													
Crooked Lake	8/14/07	41 666589	-85 036618			92	5.0													
Crooked Lake	8/14/07	41 666589	-85 035914			93	4.0													
Crooked Lake	8/14/07	41 670716	-85 035252			94	3.0													

### 11.2 2007 Vegetation Control Permit Application

	<b>APPLICATION FOR AQUATIC VEGETATION CONTROL PERMIT</b>		<b>FOR OFFICE USE ONLY</b>		Return to: Page <b>1</b> of <b>4</b>
	State Form 26727 (R / 11-03)		License No.		DEPARTMENT OF NATURAL RESOURCES
	Approved State Board of Accounts 1987		Date Issued		Division of Fish and Wildlife
	<input type="checkbox"/> Whole Lake <input checked="" type="checkbox"/> Multiple Treatment Areas Check type of permit		Lake County		Commercial License Clerk
INSTRUCTIONS: Please print or type information				FEE: \$5.00	
Applicant's Name Crooked Lake Association			Lake Assoc. Name Crooked Lake Association		
Rural Route or Street 801 West Coliseum Blvd.			Phone Number 260-482-7665		
City and State Fort Wayne, IN			ZIP Code 46808		
Certified Applicator (if applicable)		Company or Inc. Name		Certification Number	
Rural Route or Street			Phone Number		
City and State			ZIP Code		
Lake (One application per lake) Crooked Lake		Nearest Town Angola		County Stueben	
Does water flow into a water supply				<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
<b>Please complete one section for EACH treatment area. Attach lake map showing treatment area and denote location of any water supply intake.</b>					
Treatment Area #	1	LAT/LONG or UTM's	All three basins. Areas TBD following spring survey		
Total acres to be controlled	<75	Proposed shoreline treatment length (ft)	Perpendicular distance from shoreline (ft)		
Maximum Depth of Treatment (ft)	12	Expected date(s) of treatment(s)	mid to late May		
Treatment method:	<input checked="" type="checkbox"/> Chemical <input type="checkbox"/> Physical <input type="checkbox"/> Biological Control <input type="checkbox"/> Mechanical				
Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control.					
Eurasian watermilfoil spot treated with 2,4-D herbicide following mapping survey					
Plant survey method:	<input checked="" type="checkbox"/> Rake <input type="checkbox"/> Visual <input type="checkbox"/> Other (specify)     Data collected during 2007 T-2 survey				
Aquatic Plant Name		Check if Target Species		Relative Abundance % of Community	
Eurasian Watermilfoil		x		15	
Curlyleaf pondweed				10	
Chara				25	
Coontail				10	
eel grass				5	
Largeleaf pondweed				5	
sago pondweed				10	
Common Bladderwort				1	
Slender naiad				15	
Richardsons pondweed				1	
leafy pondweed				1	
variable watermilfoil				1	
flatstem pondweed				1	

			Page <b>2</b> of <b>4</b>
Treatment Area #	2	LAT/LONG or UTM's	Areas TBD following spring survey-predicted areas on map
Total acres to be controlled	155	Proposed shoreline treatment length (ft)	Perpendicular distance from shoreline (ft)
Maximum Depth of Treatment (ft)	12	Expected date(s) of treatment(s)	April or when water temp is consistent 50 degrees
Treatment method:	<input checked="" type="checkbox"/> Chemical	<input type="checkbox"/> Physical	<input type="checkbox"/> Biological Control <input type="checkbox"/> Mechanical
Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control.			
Early season aquathol K at 1 ppm when water reaches consistent 50 degrees			
Plant survey method:	<input checked="" type="checkbox"/> Rake	<input type="checkbox"/> Visual	<input type="checkbox"/> Other (specify)
Data collected in summer T2 survey			
Aquatic Plant Name	Check if Target Species	Relative Abundance % of Community	
Eurasian Watermilfoil		15	
Curlyleaf pondweed	x	10	
Chara		25	
Coontail		10	
eel grass		5	
Largeleaf pondweed		5	
sago pondweed		10	
Common Bladderwort		1	
Slender naiad		15	
Richardsons pondweed		1	
leafy pondweed		1	
variable watermilfoil		1	
flatstem pondweed		1	
<i>INSTRUCTIONS: whoever treats the lake fills in "Applicant's Signature" unless they are a professional. If they are a professional company who specializes in lake treatment, they should sign on the "Certified Applicant" line.</i>			
Applicant Signature			Date
Certified Applicant's Signature			Date
<b>FOR OFFICE ONLY</b>			
<input type="checkbox"/> Approved <input type="checkbox"/> Disapproved		Fisheries Staff Specialist	
<input type="checkbox"/> Approved <input type="checkbox"/> Disapproved		Environmental Staff Specialist	
Mail check or money order in the amount of \$5.00 to:			
<b>DEPARTMENT OF NATURAL RESOURCES</b>			
DIVISION OF FISH AND WILDLIFE			
COMMERCIAL LICENSE CLERK			
402 WEST WASHINGTON STREET ROOM W273			
INDIANAPOLIS, IN 46204			

### Vegetation Control Permit Application Map (Page 3 of 4)

DE LORME

XMap® 5.0 GIS Enterprise

Crooked Lake Potential 2008 Milfoil Treatment Areas



**Vegetation Control Permit Additions (Page 4 of 4):**



XMap® 5.0 GIS Enterprise

### Crooked Lake Potential 2008 Curlyleaf Treatment Areas

