INTRODUCTION

The Long Lake Preservation Association, Inc. (LLPA) contracted with Onterra in 2010 to conduct a three-year, aquatic invasive species (AIS) monitoring project for Long Lake, Fond du Lac County. Specifically, the goal of this project is to monitor and assess herbicide treatments for curly-leaf pondweed (CLP) and Eurasian water milfoil (EWM) from 2011-2013. This report discusses the second year of treatment monitoring under this WDNR grant-funded project.

CLP primarily reproduces annually via structures called turions (asexual reproductive shoots). The majority of turions are produced along the stem in the leaf axils and fall to the bottom of the lake in late summer when the plants die back. Some turions are produced lower on the plant and along the underground rhizome. The turions lie dormant until autumn when they germinate to produce small winter foliage. While not really growing, the fact that these plants exist under the ice gives this plant a head start on outcompeting many of our native species in the spring. The intent of any CLP treatment is to kill the plants before they produce and release their turions. A single year of treatment effectively controls a single year of CLP without allowing it to produce subsequent generations. Still, the treatment areas will need to be focused on for 3-5 years until the turion base within that area is exhausted.

On April 4, 2012, Onterra ecologists visited Long Lake to conduct a meander survey of littoral areas to locate and map CLP in order to create treatment areas for that spring. Special attention was given to areas treated in the previous year (spring 2011) as it was expected that continued CLP growth would be observed from turions buried in the sediment.

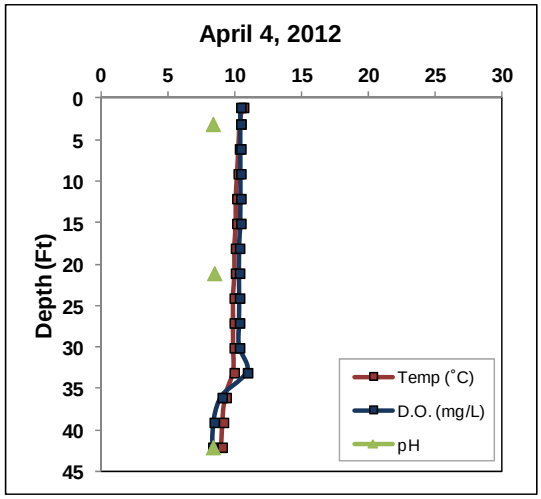


Figure 1. Temperature, dissolved oxygen, and pH profile for Long Lake – Deep Hole. May 16, 2011.

During this survey, a temperature, dissolved oxygen, and pH profile was taken at Long Lake's deep hole site. Figure 1 shows that water surface temperatures were around 51°F. Winds were minimal, and the water within the lake was exceptionally clear (Secchi disk reading = 19.7 feet). Following this survey, a treatment permit map was created with 49.5 acres of CLP treatment (Map 1). Onterra ecologists noted during the survey that the CLP plants were actively growing at that time, and in correspondence with LLPA representative and others two days later (April 6, 2012) recommended that the treatment take place as soon as possible.

On May 1, 2012, the herbicide application was conducted by Aquatic Biologists Incorporated (ABI). The applicator reported surface water temperatures of 53°F and winds of 10-20 mph out of the south. During treatment, the herbicide applicator included an additional 1.3 acres within the treatment (Map 1).

2012 CLP Treatment Monitoring

The goal of any herbicide treatment is to maximize target species (normally CLP and/or EWM) mortality while minimizing impacts to valuable native aquatic plant species. Monitoring herbicide treatments and defining their success incorporates both quantitative and qualitative methods. As the name suggests, quantitative monitoring involves comparing number data (or quantities) such as plant frequency of occurrence before and after the control strategy is implemented. Qualitative monitoring is completed by comparing visual data such as EWM or CLP colony density ratings before and after the treatments.

Quantitative evaluation methodologies follow WDNR protocols in which point-intercept data is collected within treatment areas both the summer before and the summer immediately following the treatments take place. Evaluation of CLP treatments includes comparing data from a spring pretreatment survey (year of treatment) to a spring post-treatment survey (the year following treatment, but previous to that year's treatment). Because CLP naturally dies back in early summer, it is impossible to determine if the treatment was successful based upon a post-treatment survey completed during early summer. Because of the logistical timing of this project, pretreatment quantitative data was not able to be collected in 2011. This data was however collected in 2012, at roughly 200 point-intercept sub-sampling locations within 2012 treatment areas. These points will be revisited in spring of 2013 to collect presence/absence data concerning CLP.

Spatial data reflecting CLP locations were collected using a sub-meter Global Positioning System (GPS) before and after the 2012 treatment. Comparisons of the survey results are used to qualitatively evaluate the 2012 herbicide treatment on Long Lake.

2012 CLP Treatment Results

On May 22, 2012, Onterra ecologists visited Long Lake to complete the post-treatment assessment of the 2012 treatment areas and to conduct a lake-wide survey for CLP. Map 2 displays the results of the mid-June survey. CLP was found in many areas of Long Lake during this survey, some within treatment areas and some outside of treatment areas. Finding CLP within treatment areas can indicate the treatment was not completely effective. While it is not expected that every CLP plant be killed during a treatment, finding large numbers of plants certainly indicates failure.

Successful treatments were observed in most 2012 treatment areas, including the lower portion of A-12, upper portion of D-12, lower C-12, G-12, O-12, H-12, I-12, J-12 and K-12 (Maps 1 and 2) Density was greatly reduced within sites K-12 and N-12, which held dominant and highly dominant (respectively) CLP colonies in summer 2011. Few plants were spotted within and outside of treatment areas located along the western shoreline of the lake.

Areas with a non-successful treatment include the upper portion of A-12 and C-12, lower D-12, E-12, M-12 and L-12. Additionally, several sizeable CLP colonies, small plant colonies and scattered plants were observed along the east side of Long Lake. This is the first year in which CLP was documented along this shoreline. Several existing treatment areas (A12, C-12, M-12 and L-12) continued to display abundant CLP following the 2012 treatment. Interestingly, these treatment areas are located in places on the lake that might exhibit greater water flow than open

areas of the lake. Dilution of herbicide is a primary concern in AIS chemical management, and may play a factor in these areas.

2013 CLP Treatment Strategy

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to dilute herbicide concentration within aquatic systems. Understanding concentration-exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of a joint research project between the WDNR and US Army Corps of Engineers (USACE). Based on their preliminary findings, lake managers have adopted two main treatment strategies; 1) whole-lake treatments, and 2) spot treatments.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (of the lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of whole-lake treatments is dictated by the volume of water in which the herbicide will reach equilibrium with. Because exposure time is so much greater, target herbicide levels for whole-lake treatments are 10 times less than for spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. This is the strategy implemented on Long Lake. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. For CLP, endothall is typically applied between 1.5 and 4.0 ppm a.i. in spot treatment scenarios. A newly adopted term, 'micro-treatments' is being used to describe very small spot treatments (working definition is less than 5 acres). Because of their small size, it is extremely difficult to predict treatment effectiveness due to rapid dilution of the herbicide. Larger treatment areas tend to be able to hold effective concentrations for a longer time.

A little over half of the 2012 treatment acreage (49.5 acres) were comprised by four treatment sites (D-12, E-12, J-12 and L-12) that were approximately 5 acres or greater. In general, greater success is expected within these larger treatment areas because it is anticipated that the herbicide will remain in the local area longer. However, as described above mixed success was observed within the large areas. The remaining treatment areas fall into the micro-treatment subcategory. Emerging information suggests that in order for an application of 2.0 ppm a.i. endothall to be effective at controlling CLP, the concentration likely needs to be maintained for at least 8-12 hours (or longer). That length of exposure time is very difficult to achieve, especially in micro-treatment situations. Some of the micro-treatments were shown to be effective likely because they were all positioned in relatively sheltered areas where dilution of herbicide is less rapid.

Additional research by the USACE indicates that injured CLP plants are still able to produce turions, and these stressed plants may produce even more turions in this condition (John Skogerboe, personal comm.). In these instances, the herbicide treatments may appear to be

effective, but the injured plants are still able to produce turions particularly low on the plant and on the rhizome. This is always a concern when monitoring CLP treatments.

Comparisons of Map 1 and Map 2 show that many of the 2012 treatments were moderately effective, and some troubled areas still exist as do new populations of CLP along the east shoreline of the lake. While the 2012 treatment killed CLP that sprouted from turions produced in years past, many viable turions produced in previous years are likely still present within the sediment in these areas. It is unknown exactly how long turions can remain viable in the sediment, but it is believed to be at least 3-5 years. For this reason, all of the areas that were treated in 2012 are proposed to be retreated in 2013 (Map 3). Multiple years of treatment over these same areas will need to occur to kill CLP sprouting from previously deposited turions. Additionally, several new areas of colonized CLP located along the eastern shoreline are included in the proposed 2013 treatment. In total, 52.9 acres are initially proposed for treatment in 2013 (Map 3). These areas will be focused on during the 2013 spring pretreatment survey and may be refined based on those survey results. If sufficient CLP is not located within a particular area during this survey, it will be removed from the final treatment plan.

One of the major goals of this project is to monitor the treatment effectiveness and 'tune' or refine the treatment strategy in order for the most effective results to be achieved. In general, treatment areas that are less than five acres are proposed to be treated with liquid endothall at a rate of 3.0 ppm a.i., while treatments greater than five acres will be treated at a rate of 2.5 ppm a.i. Due to its narrow width, treatment site J-12 (7.9 acres) is proposed to be treated at 3.0 ppm a.i. These rates are slightly (0.5 ppm) higher than application rates prescribed in 2012. The intent of this higher dosing is to achieve higher mortality rates of the CLP within these treatment areas. A few of the proposed treatment sites are approaching a point at which the herbicide application areas are too small to consistently predict if the endothall will cause CLP mortality, regardless of the dose rate. Therefore, potential treatment sites less than 0.5 acres were not proposed for treatment due to their extremely small size and unlikely nature of being successful.

The past two years of this AIS control program (2011 and 2012), the LLPA's chosen applicator has added additional treatment areas to the final treatment permit during the herbicide application. For 2013, it is recommended that the applicator contact Onterra ecologists if the need arises to treat additional acreage on Long Lake. Onterra ecologists will visit the new areas before treatment to collect data on the CLP plants in these areas, which will aid in the 2013 treatment efficacy analyses. Also, Onterra will be able to determine if the added areas fit into the control strategy that has been approved by the WDNR through the AIS control project.

2012 EWM Monitoring

According the WDNR's online AIS database, Eurasian water milfoil (EWM) was first observed in Long Lake in 2002. Whole-lake point-intercept surveys were conducted by the WDNR in 2007 and 2010. EWM was not located at any of the sampling points during the 2007 survey and only located at two sampling locations during the 2010 survey. EWM occurrences were mapped during the summer of 2011 and 2012 to determine changes in the abundance and density of this non-native species within Long Lake. As Map 4 shows, no areas of colonized EWM were located during 2011 although numerous occurrences were noted. During Onterra's 2012 EWM survey, numerous EWM colonies were located (Map 5). 2012 was what AIS managers in Wisconsin are calling a "banner year" for EWM; the early ice-out in the inland lakes, coupled

with exceptionally warm water and air temperatures made for ideal conditions to spur EWM growth. This may help to explain why EWM, which was sluggish to spread in Long Lake in years past, grew quite well within the lake in 2012.

2012 EWM Treatment Strategy

The LLPA, already facing tough decisions and financing in a battle with CLP, is now looking at an emerging threat with the increased presence of EWM. The Long Lake ecosystem is clearly conducive to growth of native milfoil species (various leaved water milfoil and northern water milfoil were found with 19% and 14% littoral frequency, respectively, in a 2010 WDNR aquatic plant survey), so the system is likely optimal for the non-native species as well. EWM now colonizes over 14 acres of Long Lake, while additional scattered plants, clumps and small plant colonies can be found throughout the littoral zone of the lake (Map 5). It is recommended that a treatment be conducted in 2013 to target the colonized EWM in Long Lake. With placing a 40 foot buffer around these colonies, the total proposed treatment comes to 14.5 acres. While quantitative monitoring of the treatment areas would not be conducted as pretreatment summer data was not collected because of the uncertainty over a treatment even occurring in 2013, qualitative pretreatment data collected in September 2012 may be compared to a late summer 2013 survey. This comparison would indicate the efficacy of the proposed spring 2013 EWM treatment, and provide further information to the LLPA regarding the EWM population in Long Lake.

An alternative to the proposed treatment strategy is to instead monitor EWM colonies again in late summer 2013. From 2002 through 2011, EWM has had minimal impact on the ecology of the Long Lake aquatic plant community. In 2012, colonies of EWM have certainly expanded much, but this expansion may be due to extremely good growing conditions that were exhibited in this year.

2012 Final CLP Treatment Areas

(Liquid Endothall)

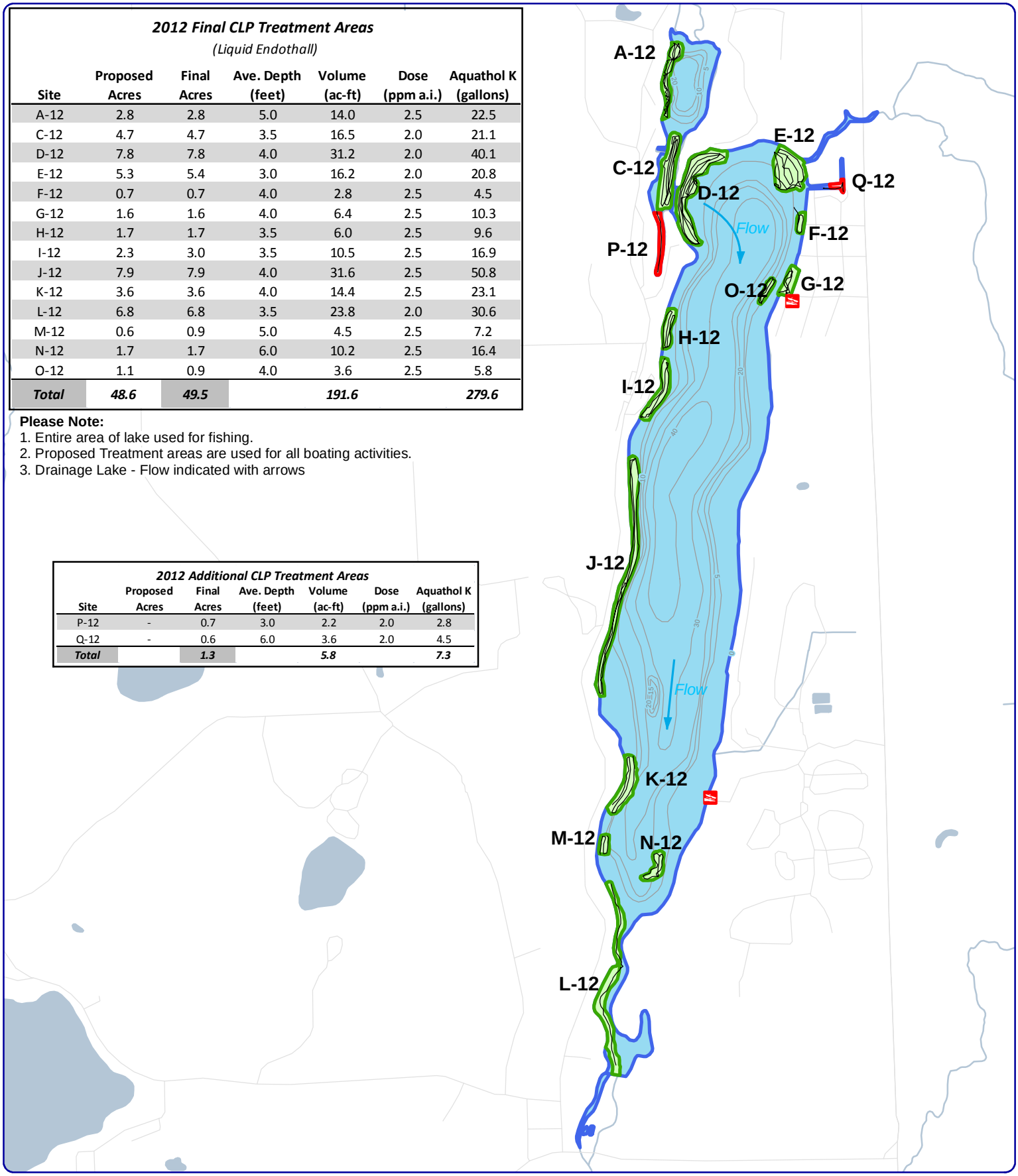
Site	Proposed Acres	Final Acres	Ave. Depth (feet)	Volume (ac-ft)	Dose (ppm a.i.)	Aquathol K (gallons)
A-12	2.8	2.8	5.0	14.0	2.5	22.5
C-12	4.7	4.7	3.5	16.5	2.0	21.1
D-12	7.8	7.8	4.0	31.2	2.0	40.1
E-12	5.3	5.4	3.0	16.2	2.0	20.8
F-12	0.7	0.7	4.0	2.8	2.5	4.5
G-12	1.6	1.6	4.0	6.4	2.5	10.3
H-12	1.7	1.7	3.5	6.0	2.5	9.6
I-12	2.3	3.0	3.5	10.5	2.5	16.9
J-12	7.9	7.9	4.0	31.6	2.5	50.8
K-12	3.6	3.6	4.0	14.4	2.5	23.1
L-12	6.8	6.8	3.5	23.8	2.0	30.6
M-12	0.6	0.9	5.0	4.5	2.5	7.2
N-12	1.7	1.7	6.0	10.2	2.5	16.4
O-12	1.1	0.9	4.0	3.6	2.5	5.8
Total	***48.6***	***49.5***		***191.6***		***279.6***

Please Note:

1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.
3. Drainage Lake - Flow indicated with arrows

2012 Additional CLP Treatment Areas

Site	Proposed Acres	Final Acres	Ave. Depth (feet)	Volume (ac-ft)	Dose (ppm a.i.)	Aquathol K (gallons)
P-12	-	0.7	3.0	2.2	2.0	2.8
Q-12	-	0.6	6.0	3.6	2.0	4.5
Total		***1.3***		***5.8***		***7.3***



N
W E
S

1,850

Feet

Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources
Roads and Hyrdo: WDNR
Aquatic Plants: Onterra, 2011 & 2012
Map Date: April 6, 2012
Filename: Map1_LongFDL_T2012CLPtr_Perm1.mxd

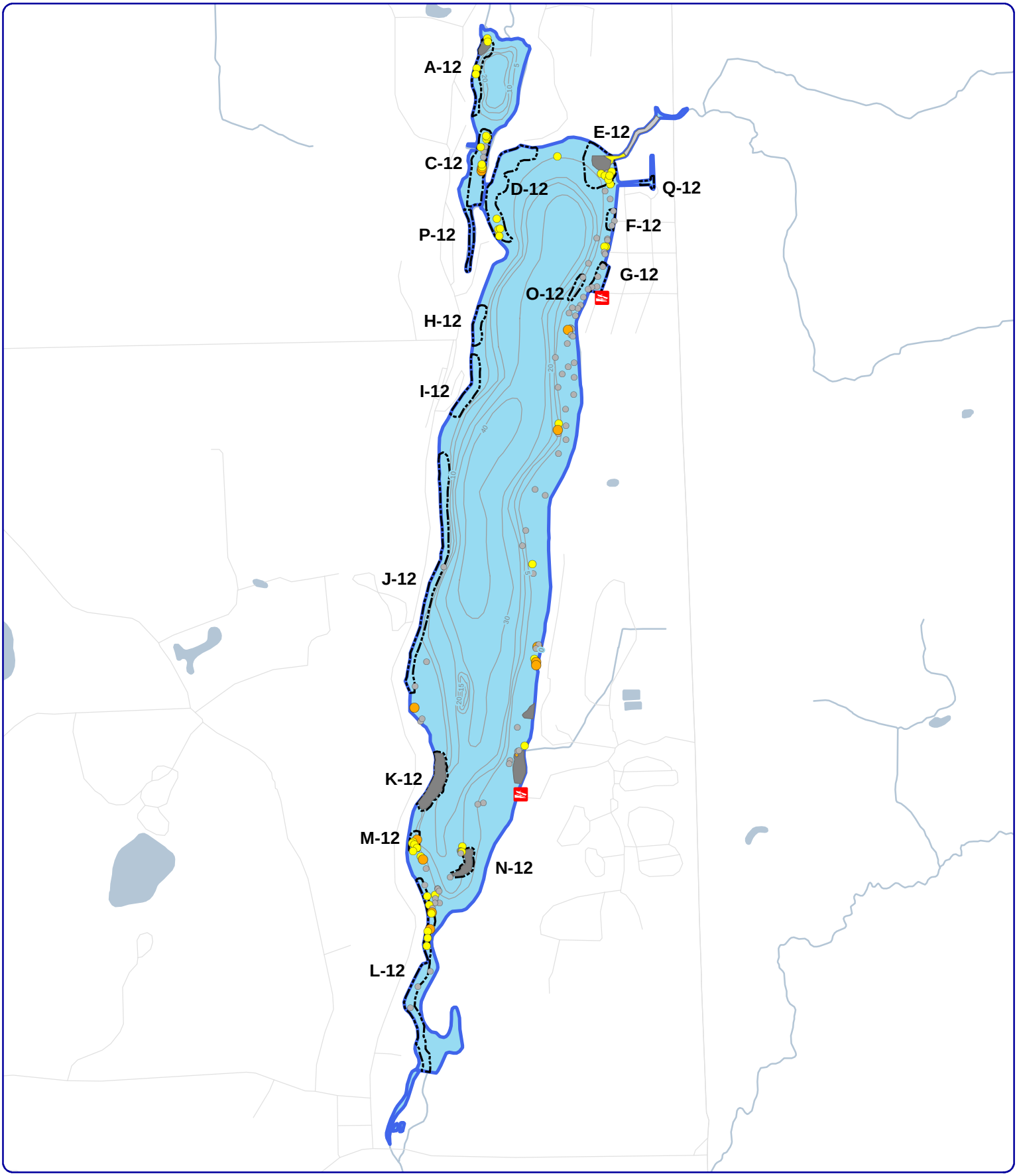
Project Location in Wisconsin

Legend

- 2012 Final Treatment Area
- 2012 Additional Treatment Area (*Added by ABI in field*)
- Public Access
- ABI Treatment Tracklog

Map 1
Long Lake
Fond du Lac County, Wisconsin

2012 Final CLP Treatment Areas



1,850
Feet

Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hyrdo: WDNR
Aquatic Plants: Onterra, 2011
Map Date: January 19, 2012
Filename: *Map2_LongFDL_CLP_2012_PB.mxd*


Project Location in Wisconsin

Legend

- Highly Scattered *(None)*
- Scattered *(None)*
- Dominant
- Highly Dominant
- Surface Matting *(None)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2012 Final Treatment Area

Map 2
Long Lake
Fond du Lac County, Wisconsin

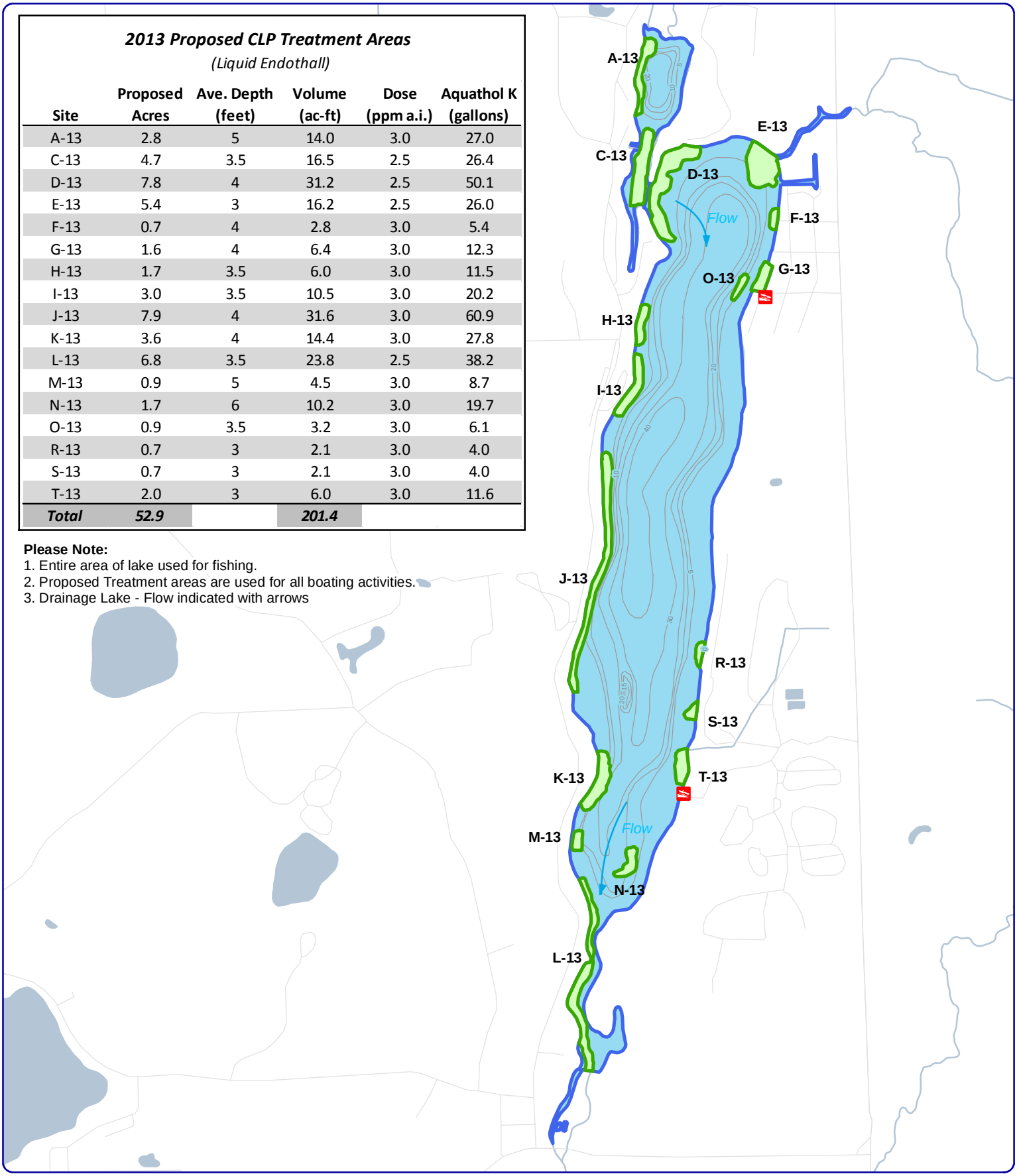
May 2012
CLP Locations

2013 Proposed CLP Treatment Areas

(Liquid Endothall)

Site	Proposed Acres	Ave. Depth (feet)	Volume (ac-ft)	Dose (ppm a.i.)	Aquathol K (gallons)
A-13	2.8	5	14.0	3.0	27.0
C-13	4.7	3.5	16.5	2.5	26.4
D-13	7.8	4	31.2	2.5	50.1
E-13	5.4	3	16.2	2.5	26.0
F-13	0.7	4	2.8	3.0	5.4
G-13	1.6	4	6.4	3.0	12.3
H-13	1.7	3.5	6.0	3.0	11.5
I-13	3.0	3.5	10.5	3.0	20.2
J-13	7.9	4	31.6	3.0	60.9
K-13	3.6	4	14.4	3.0	27.8
L-13	6.8	3.5	23.8	2.5	38.2
M-13	0.9	5	4.5	3.0	8.7
N-13	1.7	6	10.2	3.0	19.7
O-13	0.9	3.5	3.2	3.0	6.1
R-13	0.7	3	2.1	3.0	4.0
S-13	0.7	3	2.1	3.0	4.0
T-13	2.0	3	6.0	3.0	11.6
Total	***52.9***		***201.4***		

Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.
3. Drainage Lake - Flow indicated with arrows



N
W E
S

1,850
Feet

Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hyrdo: WDNR
Aquatic Plants: Onterra, 2012
Map Date: January 19, 2012
Filename: *Map3_LongFDL_CLP_T2013_Cond1.mxd*

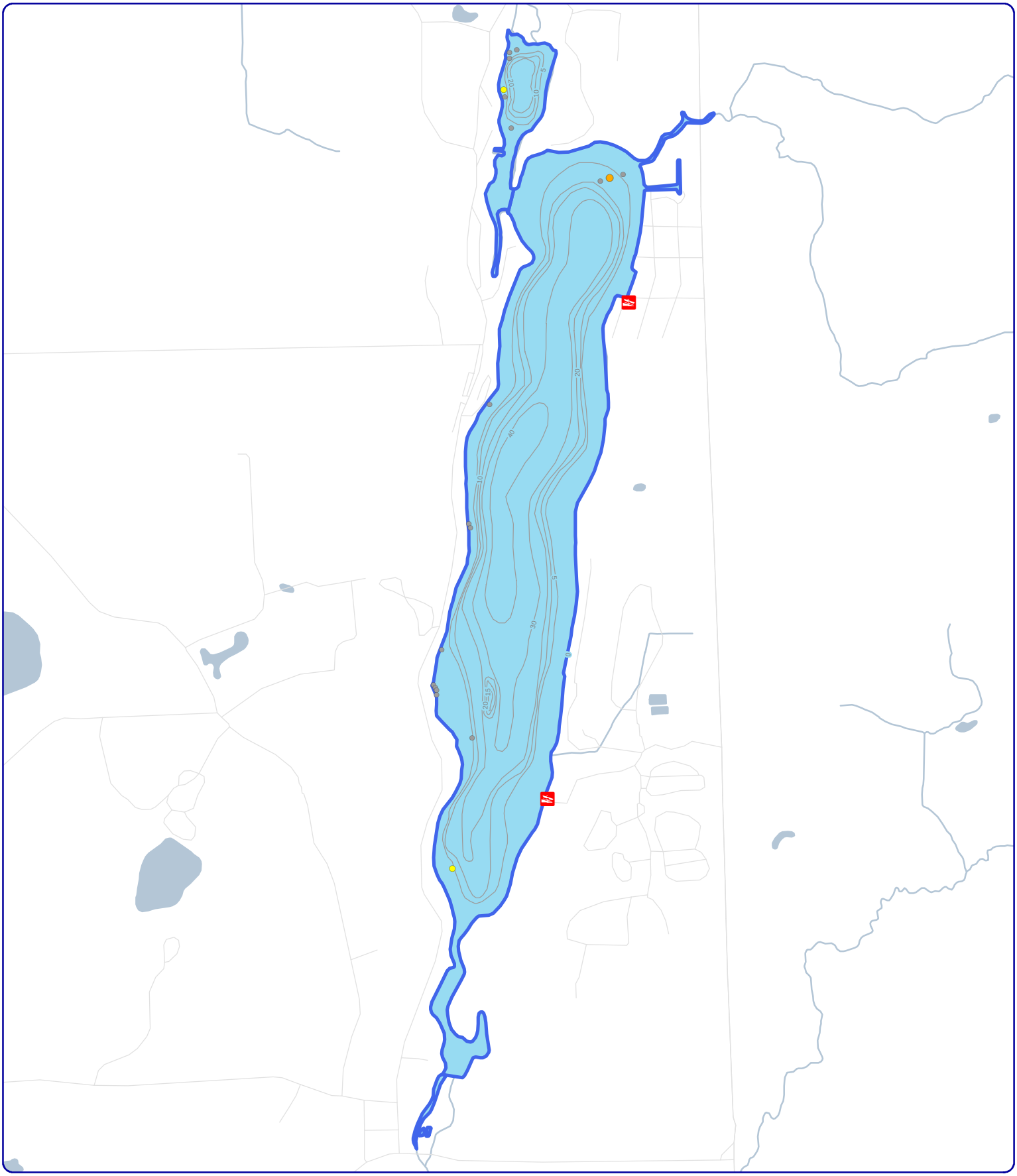
Project Location in Wisconsin

Legend

- 2012 Final Treatment Area
- Public Access

Map 3
Long Lake
Fond du Lac County, Wisconsin

2013 Proposed CLP Treatment Areas



Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hyrdo: WDNR
Aquatic Plants: Onterra, 2011
Map Date: January 19, 2012
Filename: *Map4_LongFDL_EWMPB_June11.mxd*


Project Location in Wisconsin

Legend

- Highly Scattered *(None)*
- Scattered *(None)*
- Dominant *(None)*
- Highly Dominant *(None)*
- Surface Matting *(None)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

Map 4
Long Lake
Fond du Lac County, Wisconsin

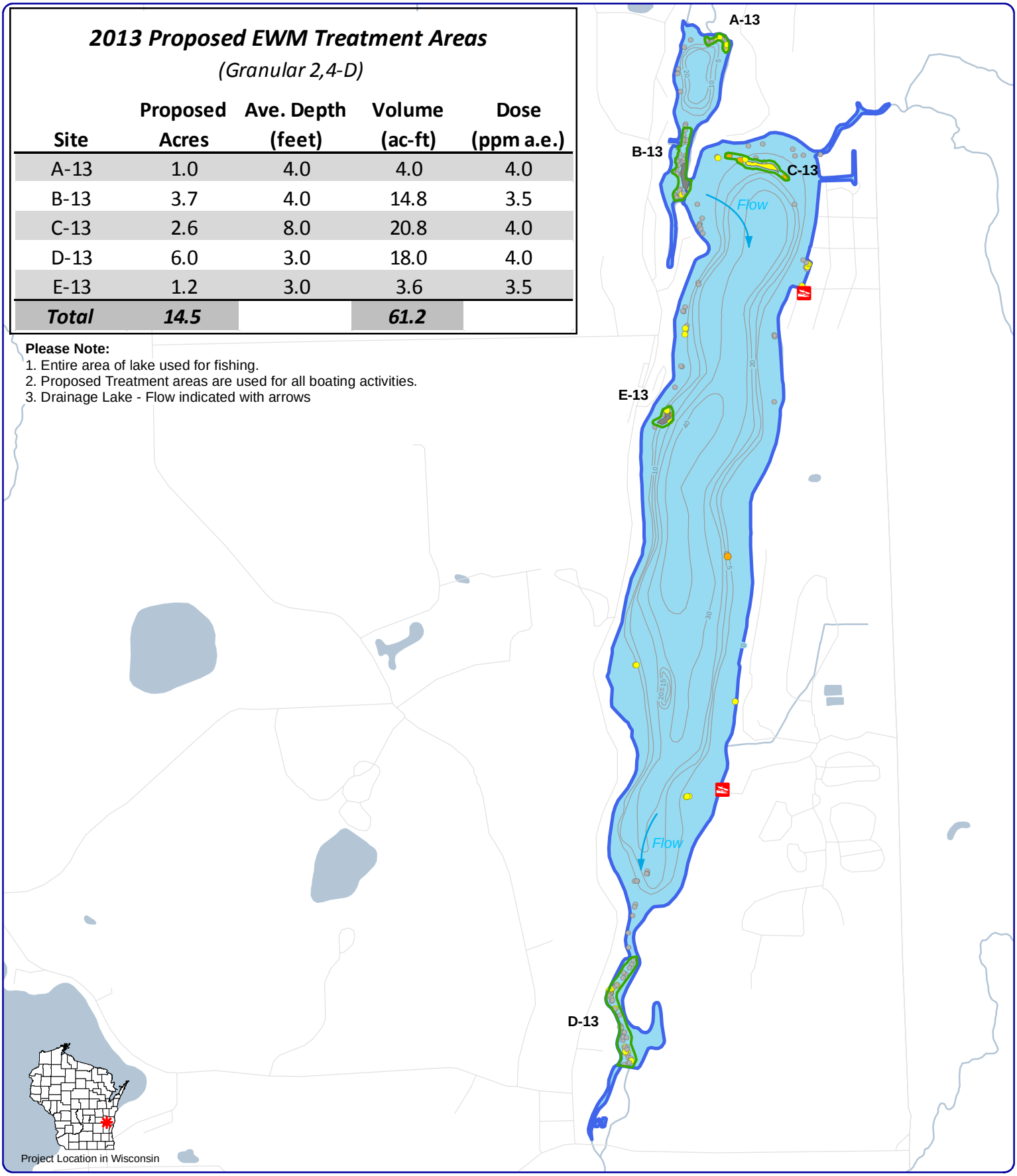
2011 EWM Locations

2013 Proposed EWM Treatment Areas

(Granular 2,4-D)

Site	Proposed Acres	Ave. Depth (feet)	Volume (ac-ft)	Dose (ppm a.e.)
A-13	1.0	4.0	4.0	4.0
B-13	3.7	4.0	14.8	3.5
C-13	2.6	8.0	20.8	4.0
D-13	6.0	3.0	18.0	4.0
E-13	1.2	3.0	3.6	3.5
Total	***14.5***		***61.2***	

Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.
3. Drainage Lake - Flow indicated with arrows



Project Location in Wisconsin

N
W E
S

1,850
Feet

Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hyrdo: WDNR
Aquatic Plants: Onterra, 2012
Map Date: January 15, 2013
Filename: *Map5_LongFDL_EWMPB_2012.mxd*

Legend

- Highly Scattered *(None)*
- Scattered
- Dominant
- Highly Dominant *(None)*
- Surface Matting *(None)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Proposed 2013 Treatment Area

Map 5
Long Lake
Fond du Lac County, Wisconsin
2012 EWM Locations & 2013 Proposed Treatment Areas