ARCHIBALD LAKE FLOWERING RUSH
CHEMICAL TREATMENT ANALYSIS
Steve / Karen Fleming & Brenda Nordin

The following is a summary report of the Archibald Lake flowering rush research and chemical treatment between July 2011 to June 2016.

Background

Archibald Lake is a 430 acre mesotropic seepage lake in Northeast Wisconsin. The Maximum depth is 50 feet and the average depth is 19 feet. It has 7.5 miles of shoreline. There are two distinct lobes; the west lobe is highly developed, the east lobe has over 50% undeveloped shoreline. A large portion of the east lobe shoreline is national forest. The Archibald Lake Association is a volunteer organization and has 150 members out of a possible 160 lake properties. Figure 1 shows a map of the lake.

Archibald Lake is one of a number of lakes in Wisconsin and the United States to have flowering rush. Best estimates indicate that flowering rush has been in Archibald Lake since the early 1980's. Starting in 2008 the Archibald Lake Association has been researching different methods of trying to control this invasive plant. Figure 1 is a map of the flowering rush in Archibald Lake as of 2009.

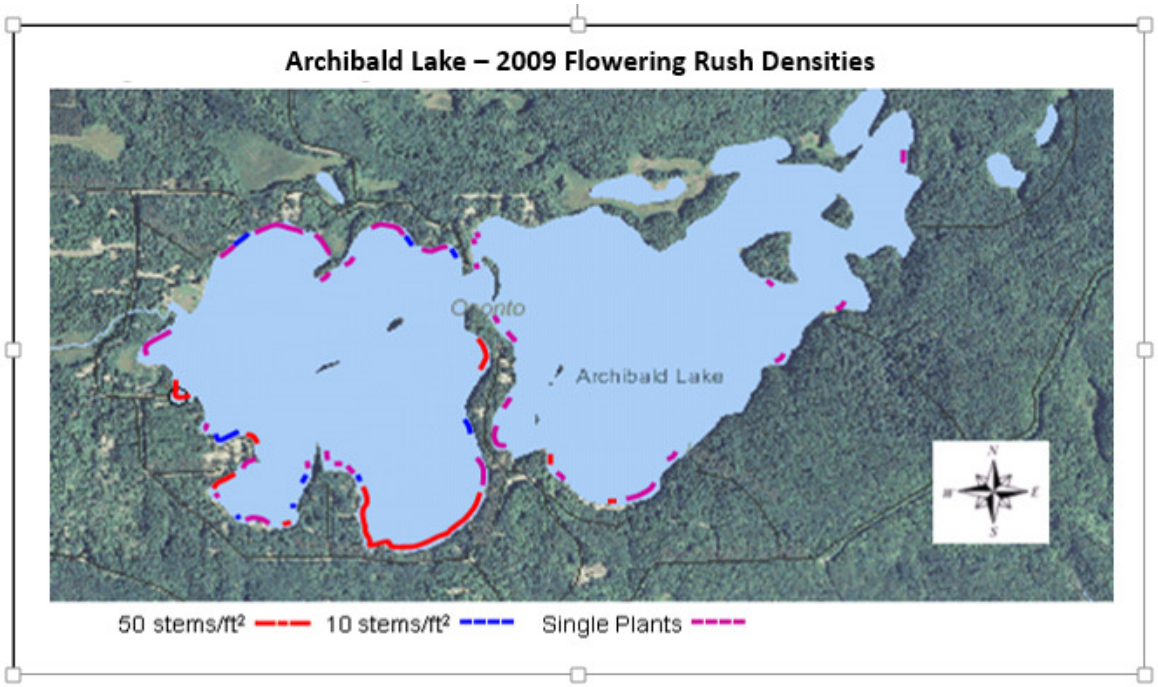


Figure 1

A number of methods have been tried with little or no success. The methods tried have been hand digging, repeated cutting, and cutting flowering buds before they release their seeds.

In 2011, the Lake Association received a Research and Control Grant from the Wisconsin DNR. The grant was written in such a way that the Association could try different chemical treatment approaches until one was found that worked and then implement that method for control. This report will present the results in three sections. The **Section 1** will be a high level summary of the overall results. **Section 2** will be the detailed results of the research portion of our plan, and **Section 3**, the final section, will be the results of the ongoing treatment.

Chronology of Events

2010 – Received WDNR Grant for Research and Control
2011 – Two trial areas / two chemicals – Aquathol Super K (Endothall) and Renovate Max G (Triclopyr / 2,4D)
2012 – No treatment due to timing to collect 2011 regrowth data
2013 – Expanded the areas. Two trial areas / two chemicals - Renovate Max G (Triclopyr / 2,4D) and two applications of Tribune (Diquat)
2014 –Continued trials using two applications of Tribune (Diquat) / larger application areas
2015 – Re-treated the same areas as 2014 using one Reward (Diquat) application
2016 – Re-treated the same areas as 2014 (Without the original Renovate Max G area) using two Reward (Diquat) applications

Guidance and Support

Initial guidance regarding chemical application and measurements was provided by Peter Rice, University of Montana and Greg Sevener, Wisconsin DNR. After the first year we received excellent advice and guidance from Brenda Nordin, Wisconsin DNR, Peter Rice, Dr. John Madsen, through his research in Detroit Lakes and Patrick Selter, PLM.

Section 1 – High Level Summary

Overall, our data indicates that the treated areas of flowering rush in Archibald Lake have been significantly reduced as a result of the chemical treatments. Specifically:
Overall

- Areas treated for 4 years using a combination of Renovate Max G (Triclopyr / 2,4D) and Tribune (Diquat) showed an overall leaf count reduction of 98%.
- Areas treated for 3 years Tribune (Diquat) showed an overall leaf count reduction of 94%. Note: If we remove the emergent boat landing area the reduction was 97%.
- Areas treated for 2 years with Tribune / Reward (Diquat) showed an overall leaf count reduction of 68%.

Initial Research Results

- For 1 year, areas treated with Renovate Max G (Triclopyr / 2,4D) showed a 59% reduction in overall leaf count densities. However, it showed a 71% reduction in submerged plant densities.
- Diquat showed a complete elimination of plants in the first year. One-year regrowth showed a leaf reduction in excess of 51% after two applications during a given year. Research by Dr. John Madsen indicates that complete plant elimination with Diquat could be attained by following a twice per year regimen of Diquat treatments for 3-5 years.
- In our first year treatment, Aquathol Super K (Endothall) had no statistically significant impact on plant densities. As a result, it was decided to not do a second year of treatment.
- Figure 2 below shows an interval plot of 7/30/11 leaf count data as compared to 6/24/16. Overall, an 85% leaf count reduction was seen. This data includes areas that have been treated for 2 years, 3 years and 4 years. The detailed report, Section 3 below, shows the results based on the number of years treated. For areas that were treated 3 years or more there was a 96% reduction in leaf counts.

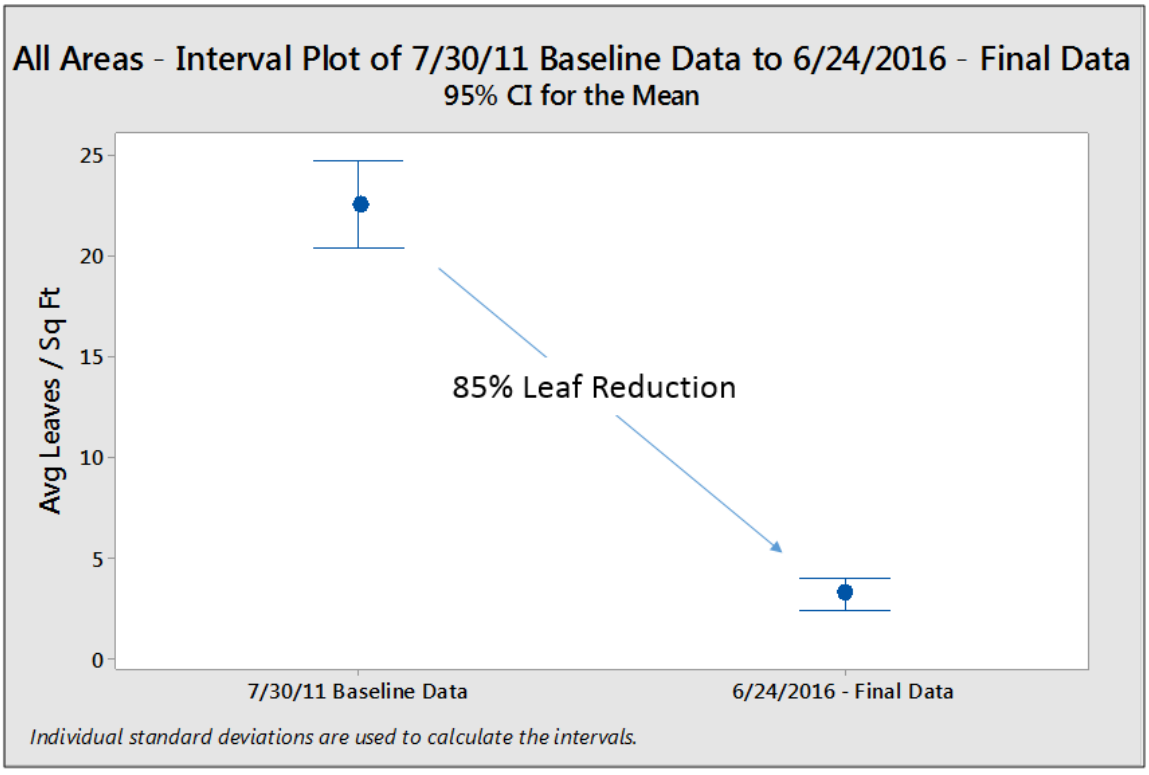


Figure 2

Note: Figure 2 is an interval plot. The center dot in each vertical line is the average leaf count of the sample of data. The vertical lines show the 95%

confidence interval around the average for each location. All future graphs / analysis in this report will be displayed using interval plots.

- Taking Dr. Madsen's 3 – 5-year recommendation into account, we saw a 95% reduction in leaf counts for areas that have been treated 3 or more years. Figure 2 shows an interval plot of all areas that have been treated for 3 or more years.

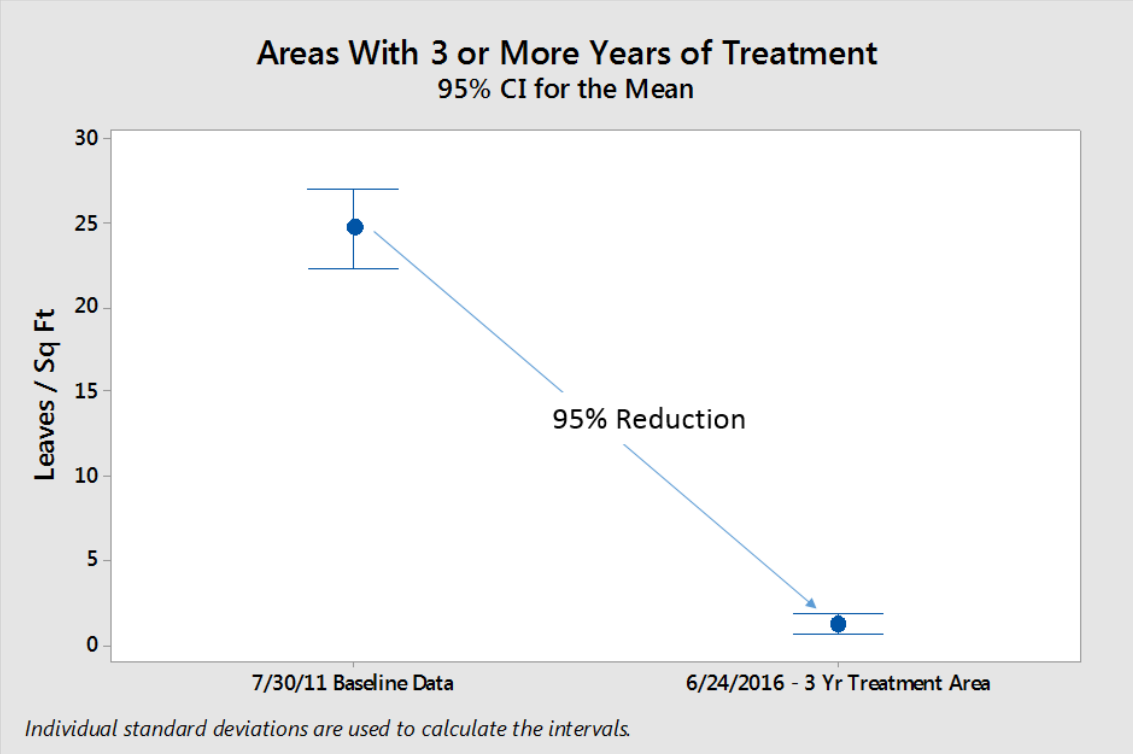


Figure 3

- As with all analysis, it is important to determine whether our data matches our observations. Figure 4 and Figure 5 below are two typical water surface pictures showing before and after treatment. Both pictures were taken before any treatment was done during that year. We have more pictures of other locations if anyone is interested.

Archibald Lake – 2011 Before Any Treatment

Figure 4

Archibald Lake – 2014 After 2 Treatments

Figure 5

- One concern, as a Lake Association, has always been the impact that these chemical treatments might have on native plants. A Wisconsin DNR Point Intercept Survey was done in 2013 and showed little or no impact to the native plants in the surrounding areas. Each year as we collect the flowering rush leaf

count data we also look for the presence or absence of native plants in the treated areas. Realizing that this is not a scientific analysis, we have observed an abundance of native plants filling in these areas. We recorded chara, water celery, water shield, water lilies, and bull rush. Again, these observations do not represent a scientific analysis but anecdotally they are a positive indication.

Section 2 - Research Treatment and Results

2011 Chemical Treatment

After final discussions with Peter Rice and the Wisconsin DNR, it was decided to do two trial chemical applications; one of Renovate Max G (Tryclopyr / 2,4D) and one of Aquathol Super K (Endothall). The two locations were chosen such that they were over 1,000 feet apart. A third location was chosen as a "Control area."

Note: It is important to note that the littoral zone in Archibald Lake is relatively narrow due to the lake's depth. As a result, the flowering rush treatment areas were relatively narrow. In all cases the plants were growing within 100 feet of the shore and in water depths ranging from zero to eight feet.

Plant densities were measured in all three areas before and after treatment. Figure 6 shows the 2011 treatment and control areas. On July 11, area 1 (1/2 acre) was treated with Aquathol Super K (Endothal) for a concentration of 2.19 ppm. ***Note that this was not the allowed maximum concentration of 5 ppm. Area 2 (1/2) acre was treated with Renovate Max G (Triclopyr/2,4d) for a concentration of 3.01 ppm.

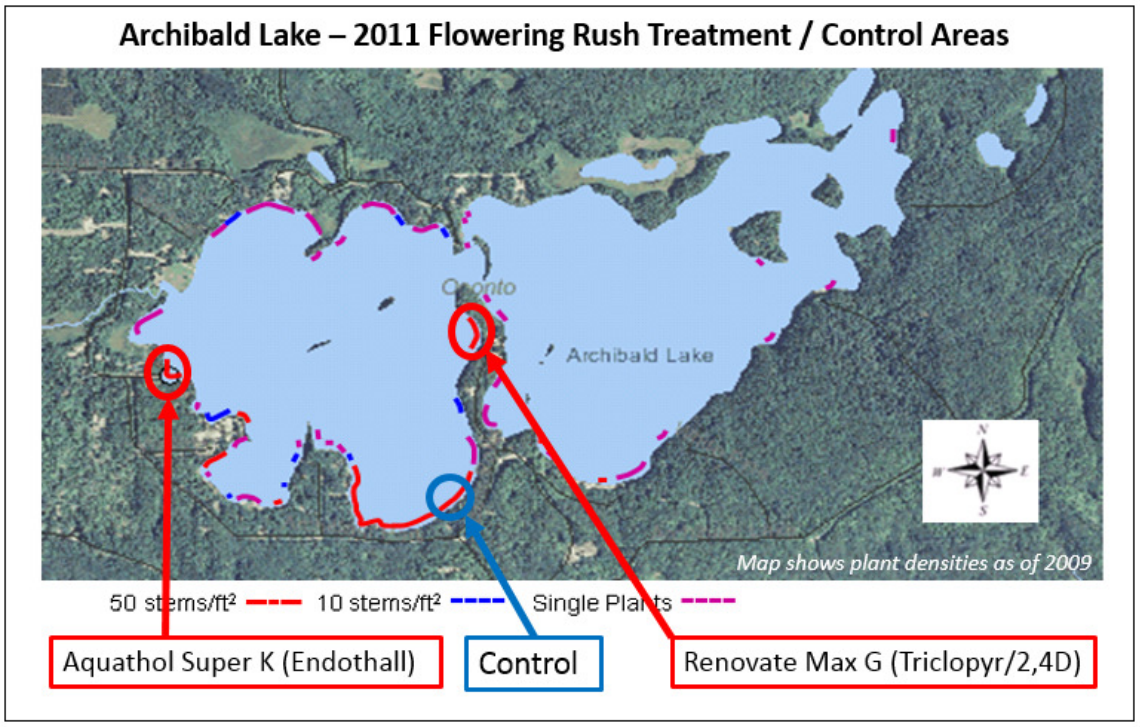
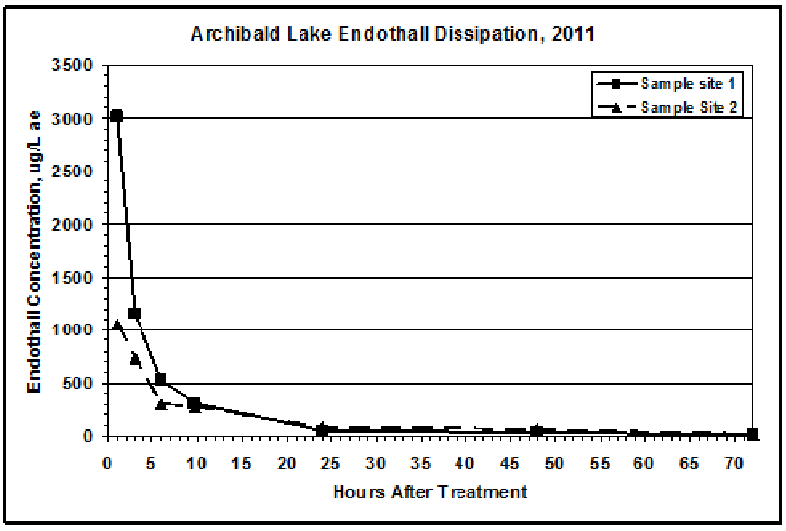
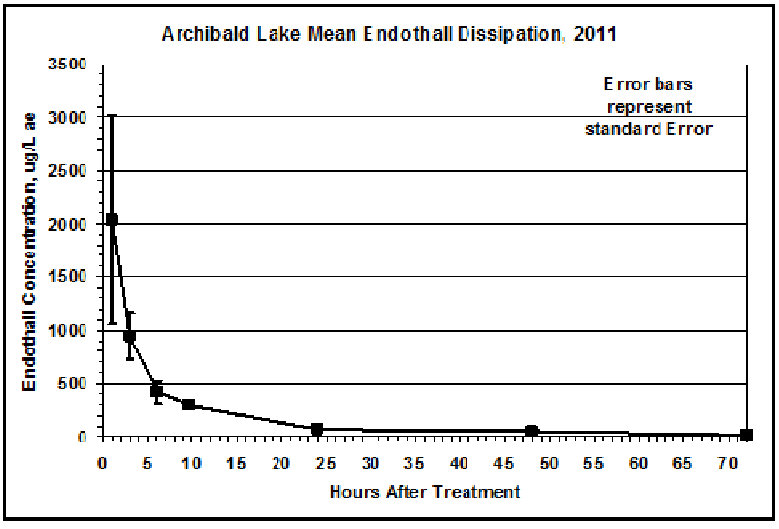
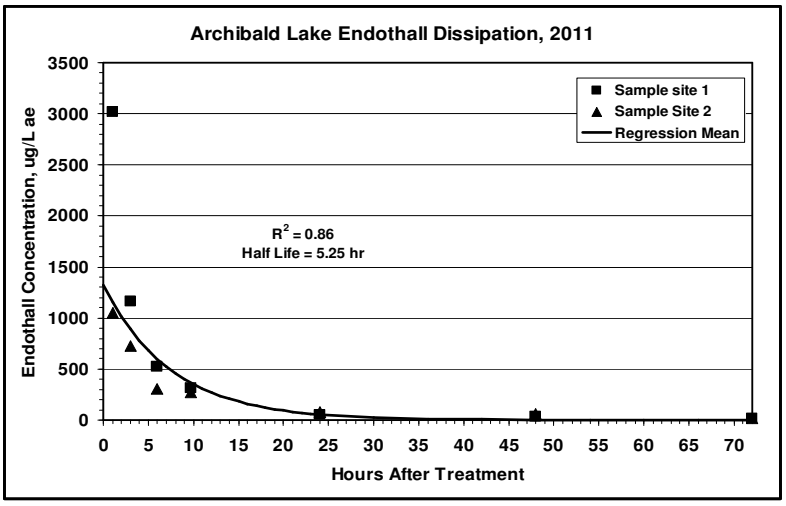


Figure 6

The "Before Treatment" plant density data was taken on 7/3/11 and the chemical application was completed 7/11/11. Water samples were gathered immediately following the treatment per the instructions provided by Jon Skogerboe, Army Corps of Engineers, and Mark A. Heilman, Ph.D., SeaPRO. Water Samples were collected from 2 sites in Archibald Lake, 11-14 July 2011, by lake resident volunteers. Samples were fixed with 3 drops of muriatic acid and stored in a refrigerator until they were shipped to the ERCL laboratory at the Center for Aquatic and Invasive Plants, Gainesville, FL. Data showed rapid dissipation (Figure 1). The mean for each time interval and the standard error were calculated (Figure 2). Concentration data were log transformed and a linear regression was conducted to determine the mean, R^2, and half life (**data and graphs provided by John Skogerboe**).







The "After Treatment" plant density data was taken on 9/8/12 (14 months after treatment).
Plant densities for all measurements was done by dropping a one foot square PVC pipe into the water and counting the number of leaves present inside the square.
The "before" and "after" plant density data for all three locations is shown in Figure 7.

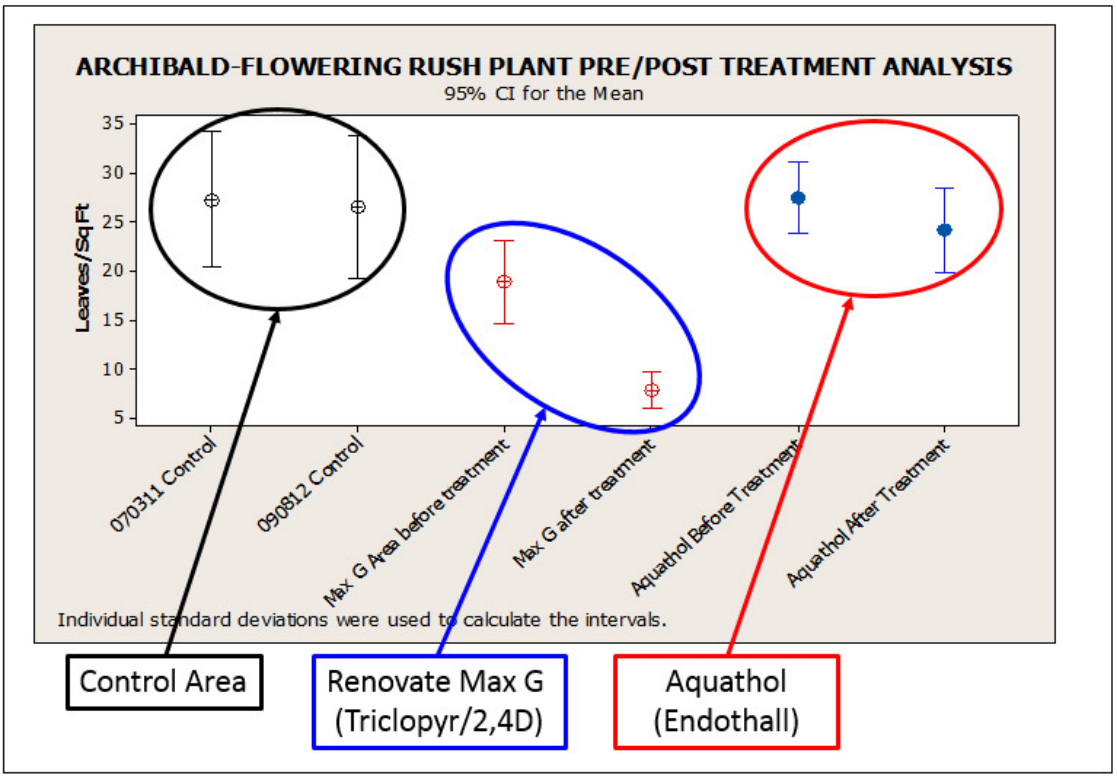


Figure 7

The "Control" area showed no significant density change between the pre-treatment and post-treatment data. Renovate Max G (Triclopyr / 2,4D) at an application rate of 3.01 ppm showed a statistically significant 59% reduction and the Aquathol Super K (Endothall) at an application rate of 2.19 ppm showed a slight reduction but it was not statistically significant (statistics by Steve Fleming).

After looking at the data more completely we found that the Renovate Max G (Triclopyr / 2,4D) had a different impact depending on whether the plant was submerged or partially emerged. Figure 8 shows the results of this analysis.

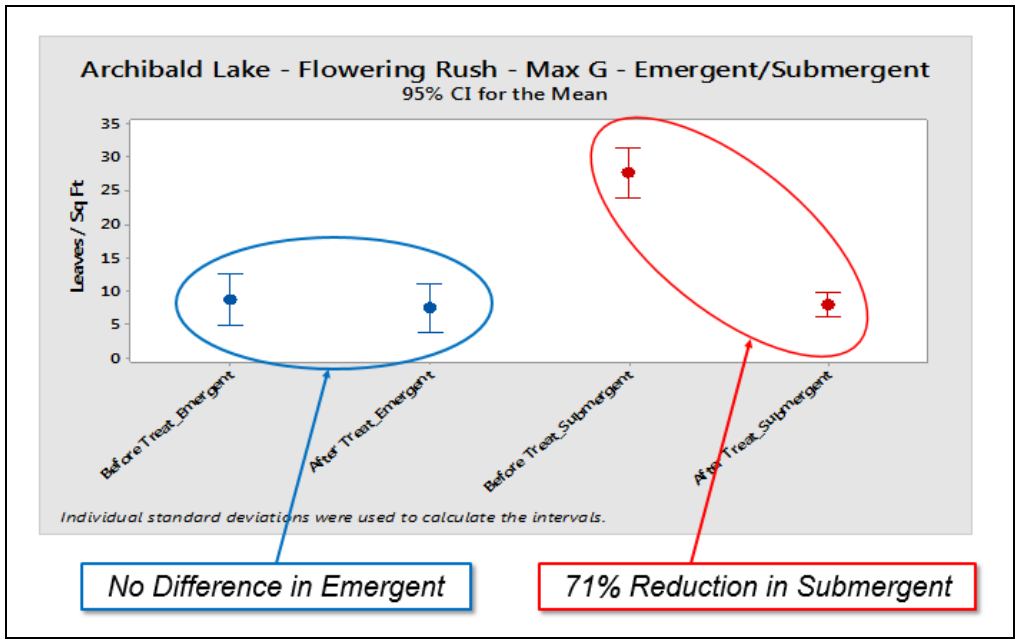


Figure 8

The before data was again taken in July, 2011 and the after data in September 2012. There was no difference in emergent leaf densities. However, the submergent leaf densities showed a 71% reduction in leaves per square foot.

Chemical application rates along with residual analysis, where it was done, for each year's application can be found in the appendix

2013 Chemical Treatment

Based on research from Detroit Lakes in Minnesota and our own experience it was decided to do two trials, one using Renovate Max G (Triclopyr / 2,4D) and one using Tribune (Diquat). On 06/10/2013, 2.5 acres (submergent) were treated using Renovate Max G(Triclopyr/2,4D) at 2.65 ppm. On 06/10/2013, 3 acres (submergent) were treated using Tribune (Diquat) at a rate of .553ppm. On 08/26/2013, 3 acres (emergent) were treated using Tribune (Diquat) at .553 ppm.

The treatment areas are shown below in Figure 9.

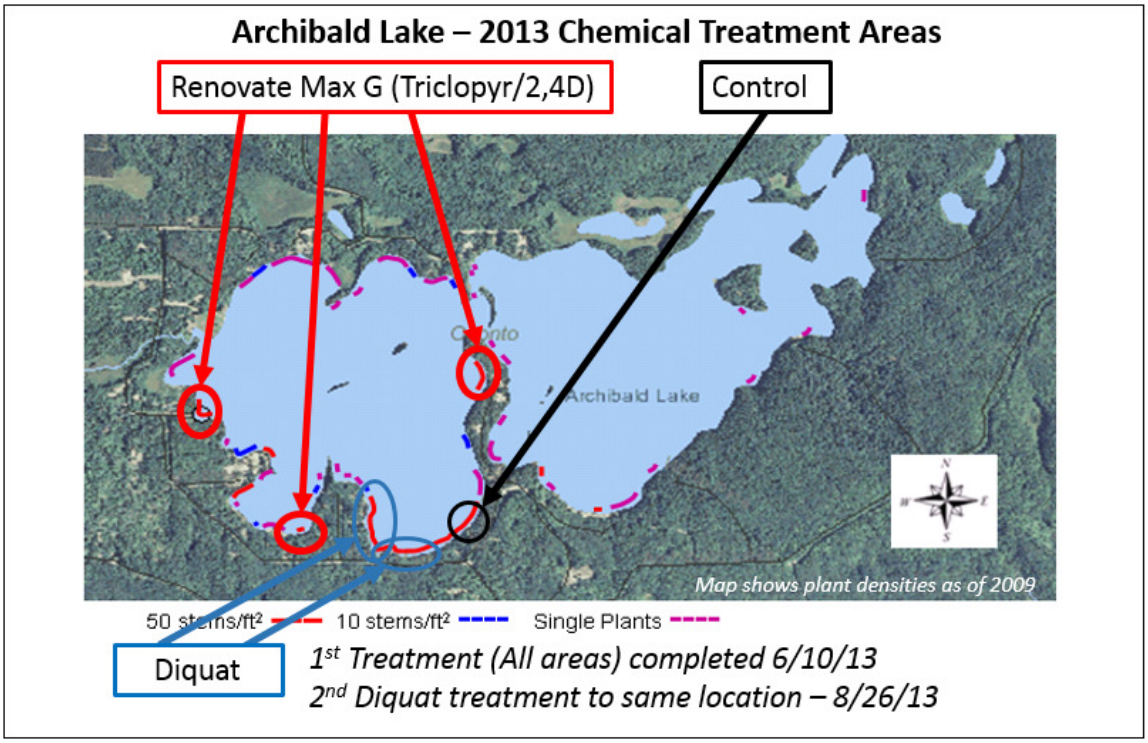


Figure 9

The Renovate Max G (Triclopyr / 2,4D) total area increased in size from 1 acre in 2011 to 2.5 acres in 2013 and the Tribune (Diquat) area was 3 acres' total. The Renovate Max G (Triclopyr / 2,4D) area at an application rate of 1.2 ppm saw a 62% leaf reduction and the Tribune (Diquat) at an application rate of 0.301 ppm saw an 86% reduction. The Renovate Max G (Triclopyr / 2,4D) trials again had significant impact in submergent plants and little or no impact on emergent plants. Tribune (Diquat) had a significant impact on both emergent and submergent plants. The data analysis results are shown in Figure 10. The "pre" data on Figure 10 was taken in June 2013 and the "post" data was taken in July 2014

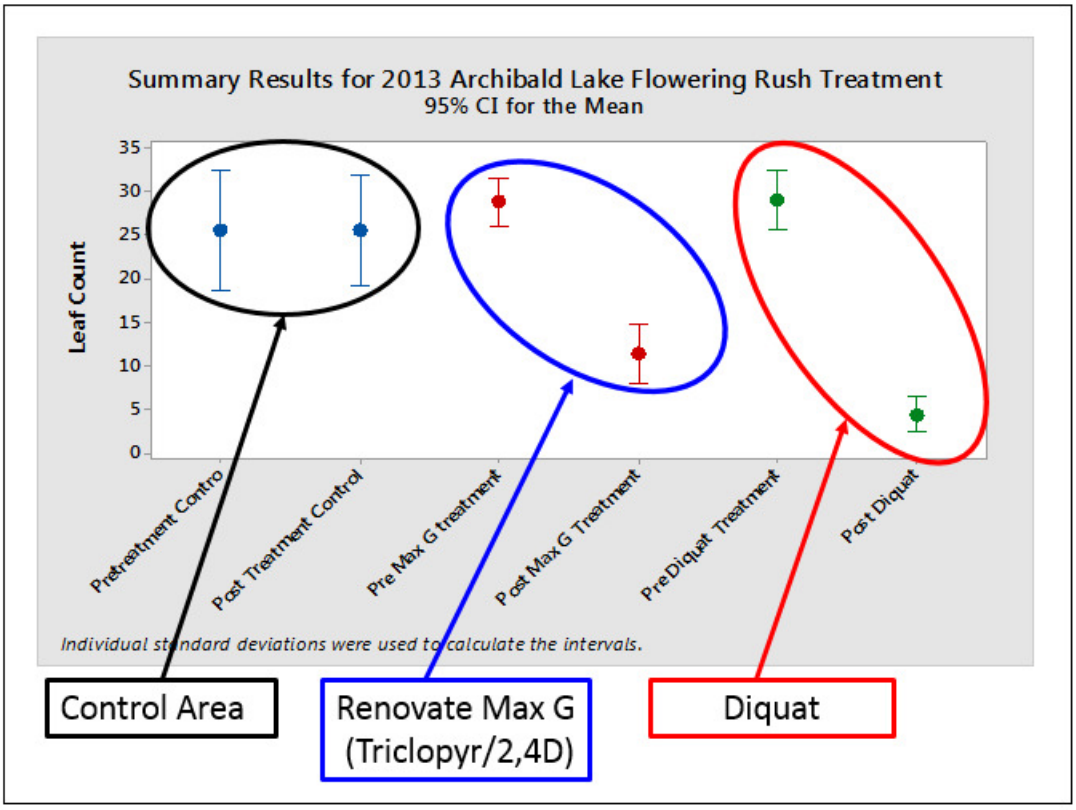


Figure 10

Section 3 – Ongoing Treatment Results 2014 - 2016

Starting in 2014 we made the decision to treat larger areas using only Diquat. The reason for this decision is that Diquat impacts both emergent and submergent and Diquat is cheaper to apply. In addition, our 2012 data indicated that Diquat was indeed having the desired impact. However, Diquat needs two applications per year to be effective and from Dr. Madsen's research in Detroit Lakes, he believes it will take 3-5 years of repeat Diquat treatment to completely kill the flowering rush rhizomes. Figure 11 shows the treatment areas for the 2014 through 2016 applications. Each area identified on Figure 11 was started in a different year (identified by the year shown in each area).

In 2014, 7.59 acres treated with Tribune (Diquat) treated at a rate of .553 ppm On 07-27-2015 and on 06/27/2016, 6 acres were treated at concentrations of - A16 .409 ppm, E16 .318 ppm, F16 .319 ppm, G16 .226 ppm, I16 .226 ppm, J16 .223 ppm, K16 .315 ppm. On 09/13/2016, 6 acres were treated at a concentration of - A16 .409 ppm, E16 .318 ppm, F16 .319 ppm, G16 .226 ppm, I16 .226 ppm, J16 .223 ppm, K16 .315 ppm.

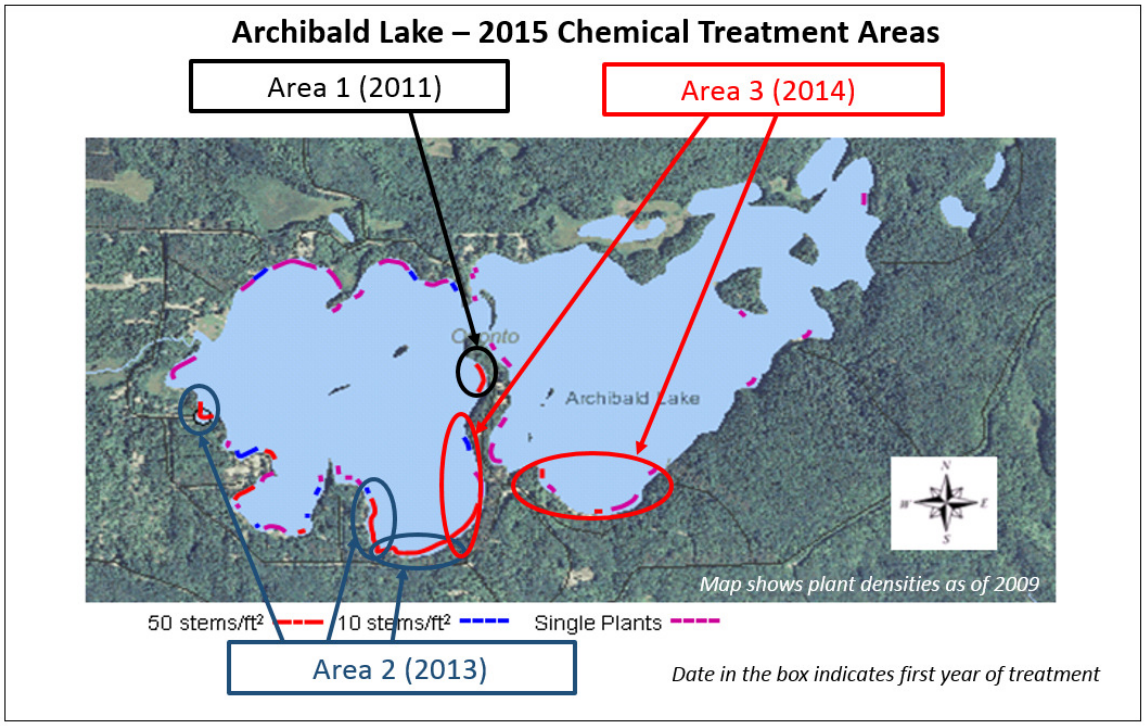


Figure 11

Since current research indicates that the expected yearly impact of Diquat on flowering rush is not as important as the long term impact, this report will not focus on each year but rather look at the cumulative impact of the multiple year treatments for each area shown in Figure 11.

Area 1 Results

"Area 1"is the first area treated with the first year of treatment being 2011. There was no treatment in 2012 to allow for time to collect regrowth data. The second year of treatment for this area was in 2013. The last year of treatment for this area was 2015. Figure 12 shows an interval plot of the "Area 1" treatment results.

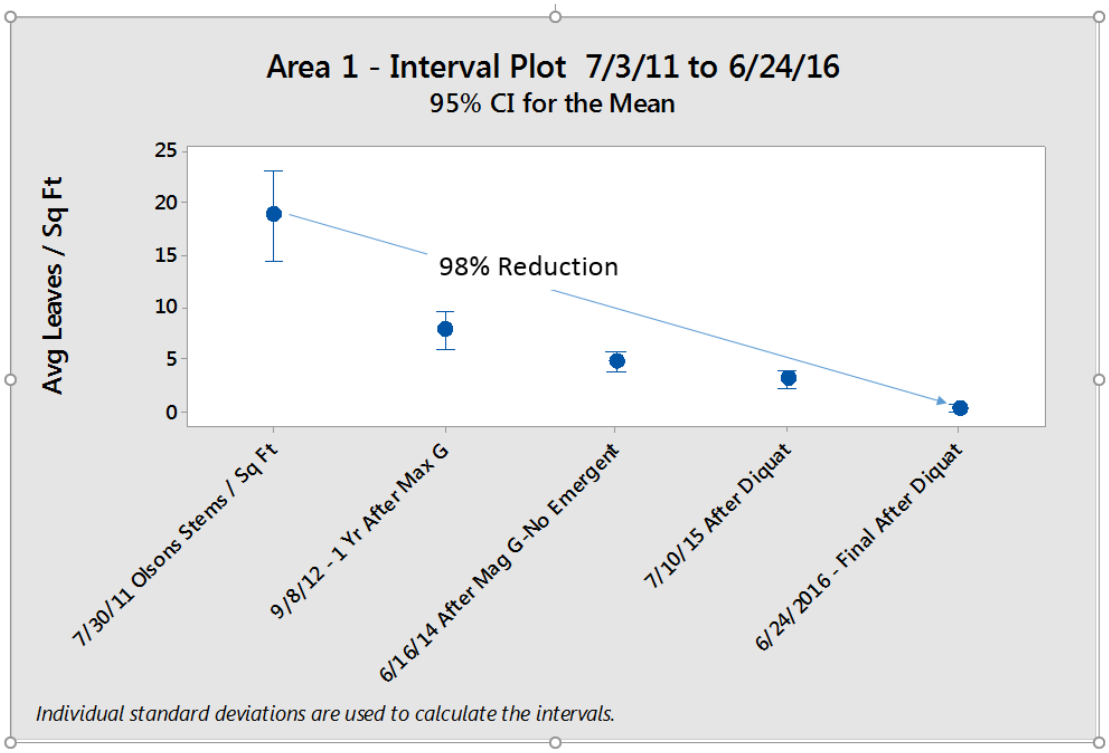


Figure 12

It should be noted that "Area 1" had two years of treatment with Renovate Max G (Triclopyr / 2,4D) (???ppm) and two years of treatment with Tribune (Diquat) (???ppm). A 98% leaf reduction was observed as a result of the 4 years of chemical treatment.

"Area 2" Treatment Result

"Area 2" (Shown in Figure 11) started treatment in 2013. This area includes the original Aquathol treated area since that area did not see any results from the 2011 treatment. The results from this "Area 2" are shown in Figure 13.

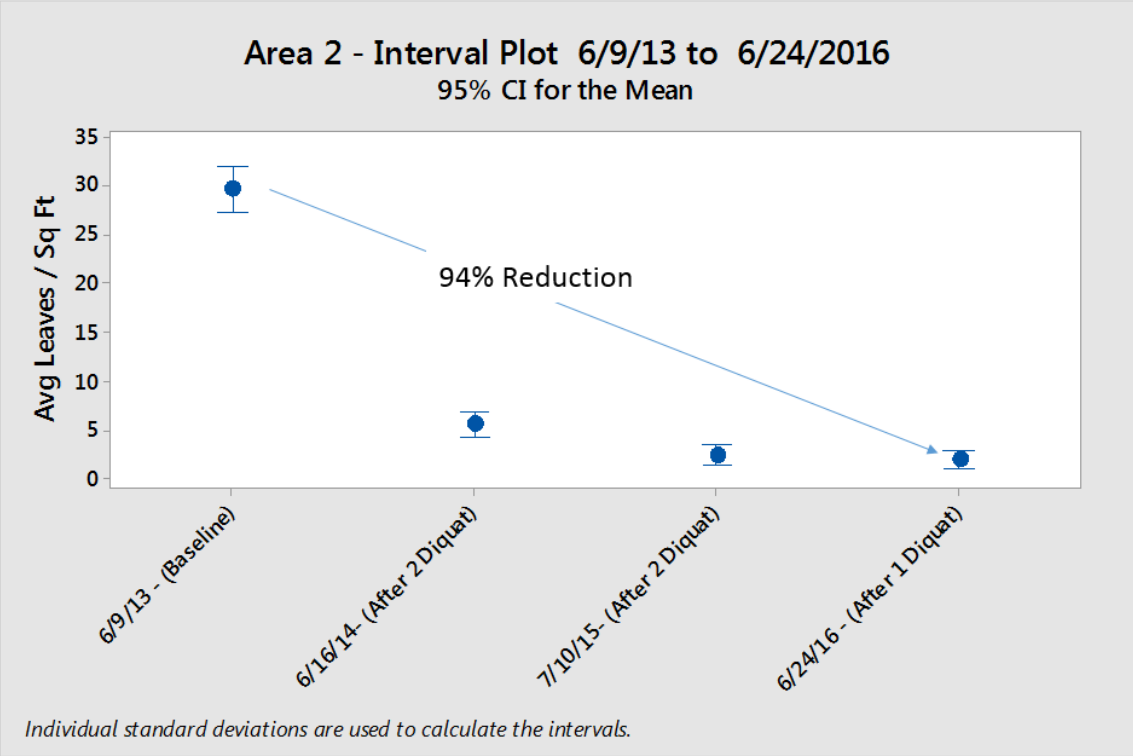


Figure 13

"Area 2" overall leaf count was 94%. However, in analyzing the data, it was observed that the area by the boat landing (the original Aquathol treatment area) did not see the same level of reduction in the final year of treatment as the other areas.

Figure 14 is an interval plot of Area 2 without the Boat landing area.

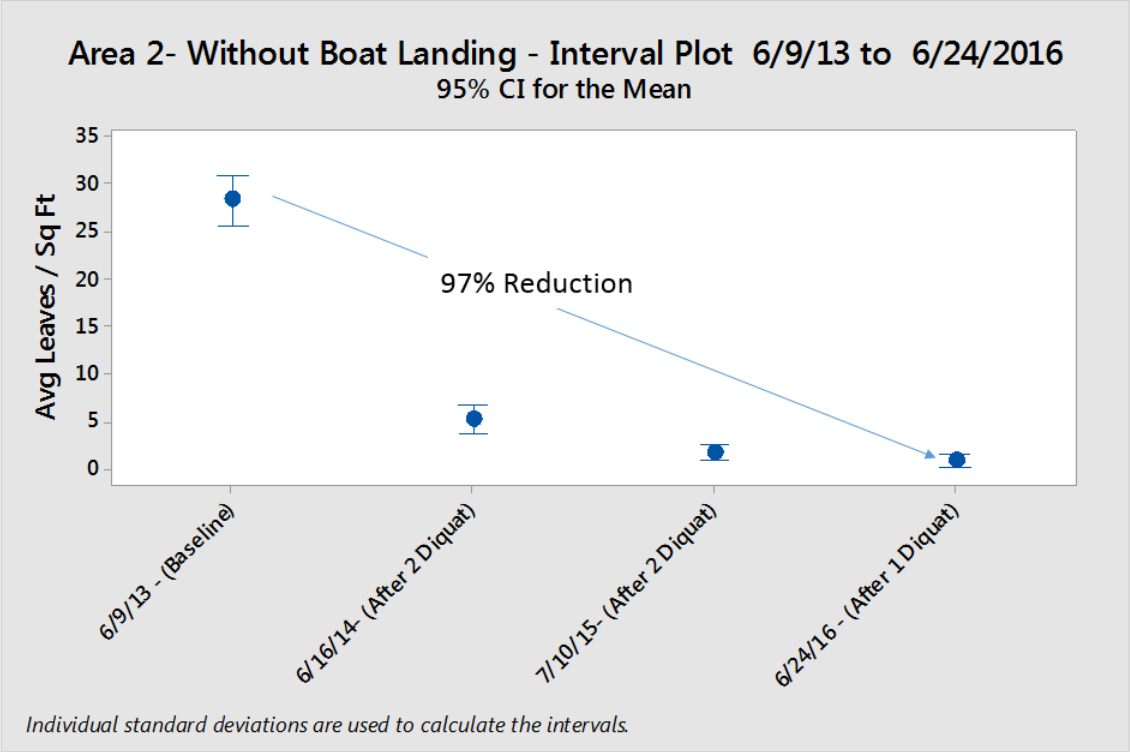


Figure 14

A 97% leaf count reduction was shown in "Area 2" when the boat landing was not included as compared to a 94% reduction when we included the boat landing area.

.

Figure 15 is an interval plot of just the boat landing area

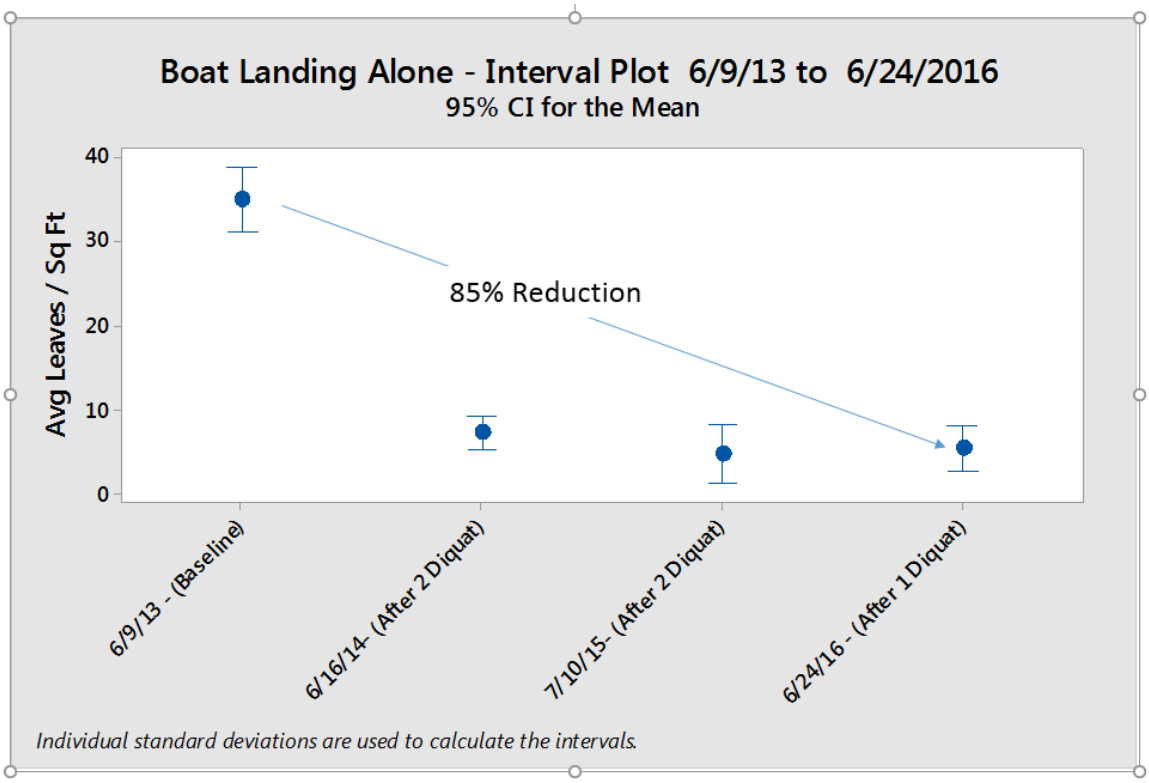


Figure 15

An overall 85% leaf count reduction was shown for the boat landing area. This is obviously a very different than the other areas. All other areas treated at the same time showed a 97% reduction. Looking at the data further, this is the only area that did not show a significant reduction between years 2 and 3 of treatment. One thing that we did note was that the boat landing area was the only area that had significant populations of emergent flowering rush remaining at the time of treatment. Since it was the only area with emergent flowering rush we have no basis to do any further comparisons.

Figure 16 is an interval plot of Area 3 (Shown on Figure 11 map)

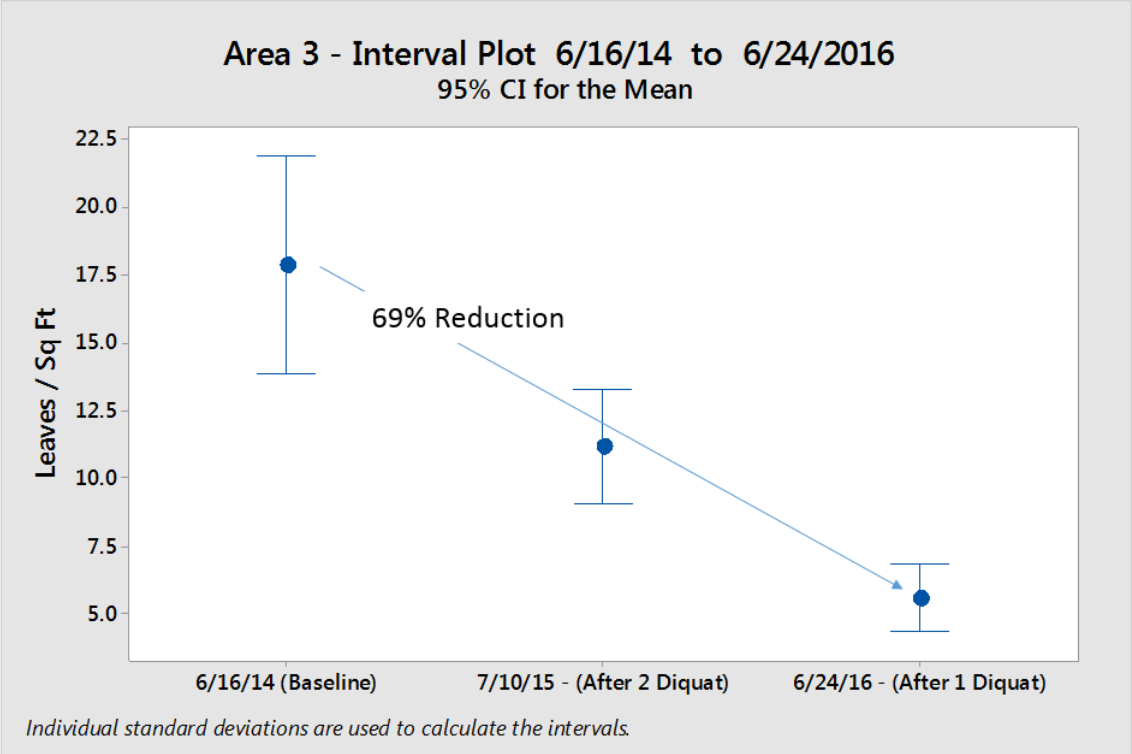


Figure 16

An overall 68% leaf count reduction was shown for "Area 3". This reduction is obviously less than any of the other areas. It is not at all surprising since the current research indicates that 3 – 5 years of Diquat treatment is required to eliminate flowering rush. This area has only received 2 years of treatment and one of those years only had 1 treatment during the year.

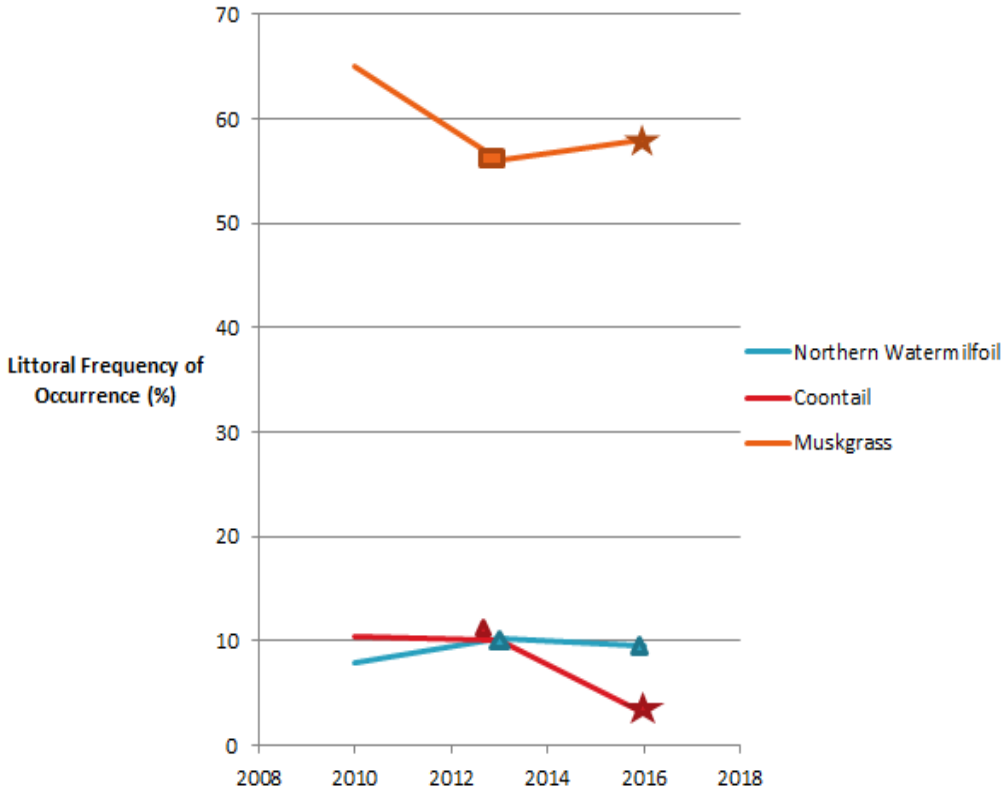
2011 through 2016 Results

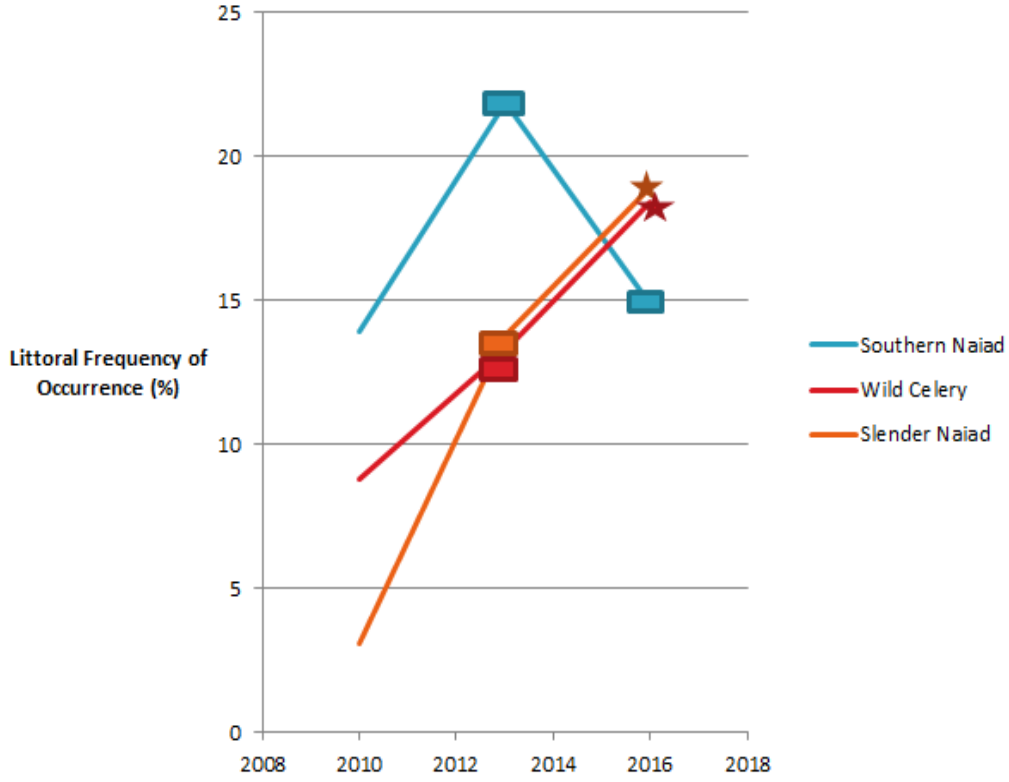
As was stated and has been shown in the "Section 1 - Summary" (Figure 2 and 3 above), the data shows an 85% reduction in overall plant densities when looking at all areas treated between 2011 to the spring of 2016, and a 95% reduction for areas that have been treated for 3 or more years. We believe that our data supports Dr. Madsen's analysis that 3 – 5 years of Diquat treatment are required for flowering rush elimination.
Visually looking at Figure 4 and Figure 5, it is obvious that flowering rush growth has been significantly reduced in Archibald Lake.

Native Plant Impacts

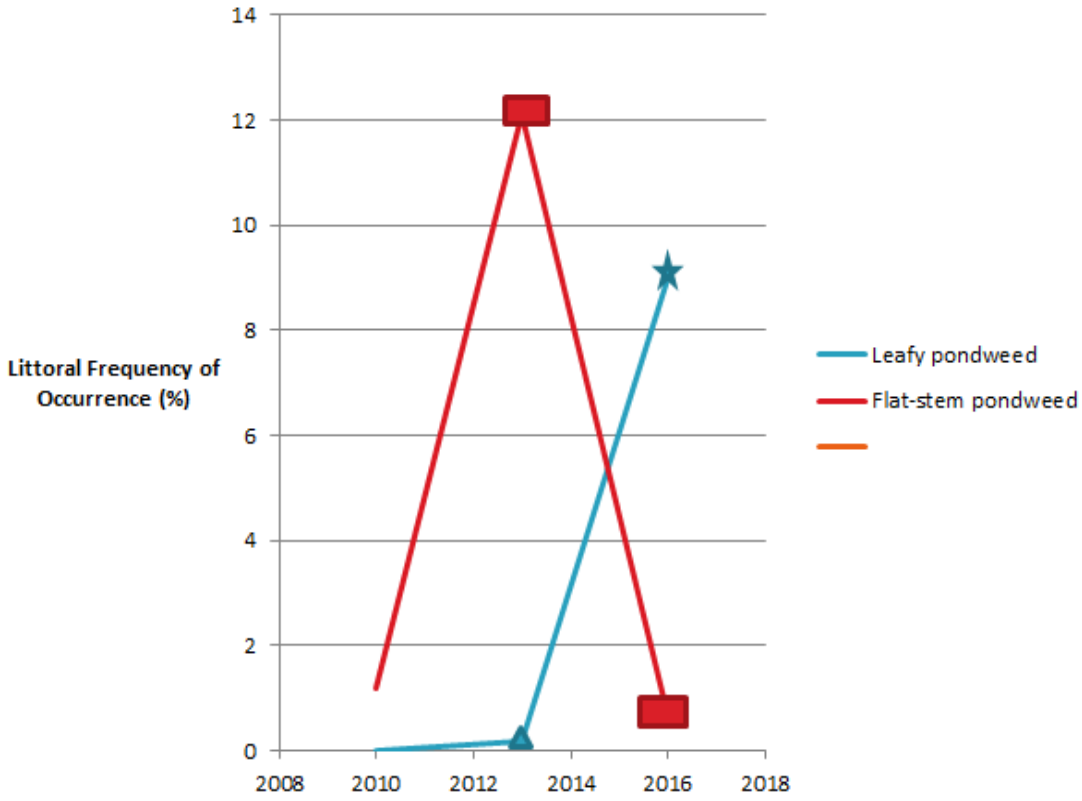
Native plant impacts are not clearly known in this study as the subpolygon data collection method was not utilized. As the chemicals used are not 100% selective, native plant impact most likely occurred in and near the treatment areas. Whole lake plant data however was collected (below) in 2010 (Springbob and Winn), 2013 (Nordin and Fleming, DNR) and 2016 (Onterra), graphs also provided by Onterra).

***Rectangle represents statistically valid change from previous survey**
***Triangle means not statistically different from previous survey**
***Star in 2016 means statistically different from 2010**




Littoral Frequency of Occurrence (%)
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
Southern Naiad
Wild Celery
Slender Naiad


Littoral Frequency of Occurrence (%)
30
25
20
15
10
5
0
2008
2010
2012
2014
2016
2018
Variable-leaf pondweed
Large-leaf pondweed
Common waterweed



Final Thoughts and Considerations

We realize that this was a non-replicated trial performed over several years in one lake. Our results may or may not be confirmed in other lakes. With limited funds it was not possible to do all the detailed data collection and analysis that some people would like to have seen. At the same time, the purpose of this work was to provide as much scientific information as possible while solving an invasive plant problem in Archibald Lake. Every attempt was made to be rigorous in our data collection and analysis of the leaf densities. Therefore, from a statistical and observation standpoint we are confident that Renovate Max G (Triclopyr / 2,4D) has the potential for long term control of submergent flowering rush in Archibald Lake. We are also confident that Tribune / Reward (Diquat) has the potential for long term control of both submergent and emergent flowering rush. There is no question that statistically and visually these chemical treatments have significantly reduced flowering rush in the areas that were treated in Archibald Lake. As an afterthought and as the science of the aquatic plant management pre and post data collection method evolves, it would be a good practice to quantify native plant damage by using the aforementioned subpolygon data collection method.

Next Steps

Starting 2016, the Archibald Lake Association had one year remaining on the WDNR Flowering Rush Research and Treatment Grant. As a result, Area's 2 and 3 have been treated for a 4th and 3rd year respectively which means we will be gathering leaf count data again in 2017. In the interest of being thorough, in 2017 we will update this report one last time. The Archibald Lake Association is also in the middle of doing a comprehensive Lake Management Plan. The future planning for flowering rush management will be part of that plan.

Acknowledgments

The Archibald Lake Association would like to thank; first and foremost the Wisconsin DNR for the grant funding and specifically Brenda Nordin (and her team) for the **many hours** developing and reviewing treatment plans and providing feedback on this document, Peter Rice for his willingness to share his wealth of knowledge, patience, and guidance in getting us started, Dr. John Madsen for sharing his research and his thoughts / suggestions regarding our approach, John Skogerboe and the Army Corps for their chemical analysis and suggestions, and SeaPRO (Mark Heilman, Ph.D.) for their chemical donations and for their chemical analysis. In addition, we would like to thank the many people who live on Archibald Lake who have shared anecdotal information over the years. Specifically, we would also like to than Dick Boyer and Stan Hall for some of the early data collection that helped provide water analysis data shown in the appendix.

If you have any questions, comments or suggestions please contact me at

Steve and Fleming
262.993.4228
Steve_fleming@sigmaxsolutions.com

Treatment Records

Renovate Max G (Triclopyr / 2,4D) Residual Analysis

Sample Site ID	Date Treated	Date Sample Collected	Sample Location	Products	Acres Treated	Rate	Active	Result
1	07/11/2011	07/11/2011		Renovate MAX G - Tri	0	0	Triclopyr	0.135 ppm
1	07/11/2011	07/11/2011		Renovate MAX G - 24D	0	0	2-4D	486.4 ppb
2	07/11/2011	07/11/2011		Renovate MAX G - Tri	0	0	Triclopyr	0.101 ppm
2	07/11/2011	07/11/2011		Renovate MAX G - 24D	0	0	2-4D	375.4 ppb
1	07/11/2011	07/14/2011		Renovate MAX G - Tri	0	0	Triclopyr	0.001 ppm
1	07/11/2011	07/14/2011		Renovate MAX G - 24D	0	0	2-4D	7.7 ppb
2	07/11/2011	07/14/2011		Renovate MAX G - Tri	0	0	Triclopyr	0.000 ppm
2	07/11/2011	07/14/2011		Renovate MAX G - 24D	0	0	2-4D	4.7 ppb
1	07/11/2011	07/18/2011		Renovate MAX G - Tri	0	0	Triclopyr	0.000 ppm
1	07/11/2011	07/18/2011		Renovate MAX G - 24D	0	0	2-4D	3.6 ppb
2	07/11/2011	07/18/2011		Renovate MAX G - Tri	0	0	Triclopyr	0.000 ppm
2	07/11/2011	07/18/2011		Renovate MAX G - 24D	0	0	2-4D	3.8 ppb

2013 Chemical Application Information

Pesticide Application Record

Aquatics and/or Commercial Aquatic Pest Control Application

PLM Lake and Land Management Corp.

Preserving Our Precious Natural Resources

Applicator's Company Name		Applicator's Company Address		
PLM Lake and Land Management Corp		2509 Business Hwy 371		
Phone	**Fax**	**City**	**State**	**Zip**
(218) 568-5379	(866) 527-6399	Brainerd	MN	56401

Customer's Name		Customer's Address		
Archibald Lake Association		16570 Appleton Lane		
Phone	**Fax**	**City**	**State**	**Zip**
(262) 943-4228		Townsend	WI	54915

County	Lake Name or Other	DNR Permit No.	Units Treated(acres):
Oconto	Archibald	NE-2013-43-701	5.5
Description of Application Site:			
Flowering Rush Treatment for the Season.			

Date Of Application		Time of application		
6/10/2013		Started: 09:00 AM Finished: 11:50 AM		
Avg Depth of Treatment Area		**Water Temp**		
2.5 -5 Foot		63		
Wind Direction	**Wind Speed**	**Air Temp**		
W	3	58		
Target Pests	Nusiance and exotic aquatic plants and/or algae			
Brand Name	**EPA Reg No**	**Quantity**	**Dosage**	
Renovate Max G	67690-50	620	248 Pound per Acre	
Tribune	100-1390	6	2 Gallon per Acre	

Area Treated
5.5 Acres

x

Applicator's Name	Applicator's Signature	Applicator's License Number
Patrick Selter	Patrick M Selter	92580

Pesticide Application Record

Aquatics and/or Commercial Aquatic Pest Control Application

PLM Lake and Land Management Corp.

Preserving Our Precious Natural Resources

Applicator's Company Name		Applicator's Company Address		
PLM Lake and Land Management Corp		2509 Business Hwy 371		
Phone	**Fax**	**City**	**State**	**Zip**
(218) 568-5379	(866) 527-6399	Brainerd	MN	56401

Customer's Name		Customer's Address		
Archibald Lake Association		16570 Appleton Lane		
Phone	**Fax**	**City**	**State**	**Zip**
(262) 943-4228		Townsend	WI	54915

County	Lake Name or Other	DNR Permit No.	Units Treated(acres):
Oconto	Archibald	NE-2013-43-701	3
Description of Application Site:			
Flowering Rush Treatment for the Season.			

Date Of Application	Time of application		Area Treated
8/26/2013	Started: 10:00 AM Finished: 10:30 AM		3 Acres
Avg Depth of Treatment Area	**Water Temp**		
5 Foot	76.1		
Wind Direction	**Wind Speed**	**Air Temp**	
Calm	Calm	78	
Target Pests Nusiance and exotic aquatic plants and/or algae			x

Brand Name	EPA Reg No	Quantity	Dosage
Tribune	100-1390	6	2 Gallon per Acre
Cidekick II	Not Required	1	.33 Gallon per acre

Applicator's Name	Applicator's Signature	Applicator's License Number
Patrick Selter	Patrick M Selter	92580

2014 Chemical Application Information

2 identical treatments as listed below.

Pesticide Application Record

Category F, Aquatics and/or Commercial Aquatic Pest Control Application

PLM Lake and Land Management Corp.

Preserving Our Precious Natural Resources

Applicator's Company Name		Applicator's Company Address		
PLM Lake and Land Management Corp		2509 Business Hwy 371		
Phone	**Fax**	**City**	**State**	**Zip**
1-866-OUR-LAKE	(866) 527-6399	Brainerd	MN	56401

Customer's Name		Customer's Address		
Archibald Lake Association		W292 N6973 Dorn Road		
Phone	**Fax**	**City**	**State**	**Zip**
(262) 993-4228		Hartland	WI	53029

County	Lake Name or Other	DNR Permit No.	Units Treated(acres):
Oconto	Archibald	NE-2014-43-179	8.000

Description of Application Site:
Treatment of Invasive Species Flowering Rush and Eurasian Water Milfoil

Date Of Application	Time of application		Area Treated
6/16/2014	Started: 09:00 AM Finished: 11:03 AM		7.59 acres of Flowering Rush .51 acres of EWM
Avg Depth of Treatment Area	**Water Temp**		
5 Foot	70.5		
Wind Direction	**Wind Speed**	**Air Temp**	
SSW	0-5	78	
Target Pests: Nusiance and exotic aquatic plants and/or algae			x

Brand Name	EPA Reg No	Quantity	Dosage
Tribune	100-1390	16	2.00 Gallon per Acre

Applicator's Name	Applicator's Signature	Applicator's License Number
Patrick Selter	Patrick M Selter	20088528

Minnesota Statutes, Chapter 18B.37

2015 Chemical Application Information

Treatment Site Layout

Archibald Lake 2015 Treatment Area & Herbicide Rate Data				Reward (liquid diquat)	
ID	Acreage	Mean Depth Estimate	Volume	Qty/Acre	Total
A-15	0.4	3.0	1.2	2.0	0.8
E-15	3.3	3.0	9.9	2.0	6.6
F-15	0.5	3.0	1.5	2.0	1.0
G-15	0.2	3.0	0.6	2.0	0.4
H-15	0.6	3.0	1.8	2.0	1.2
I-15	0.6	3.0	1.8	2.0	1.2
J-15	0.7	3.0	2.1	2.0	1.4
K-15	0.3	3.0	0.9	2.0	0.6
Totals:	6.6		19.8		13.2