



## Memorandum

**To:** Valley Branch Watershed District Board of Managers  
**From:** Meg Rattei, Senior Biologist  
**Subject:** VBWD June 2013 Point Intercept Macrophyte Surveys  
**Date:** August 16, 2013  
**Project:** 23/82-0405  
**c:** John Hanson, Ray Marshall, Ray Roemmich, Melissa Imse

This memorandum summarizes methods and results of the June 2013 point-intercept plant surveys at Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, Eagle Point Lake, Lake Elmo, Horseshoe Lake, Lake Edith, Lake McDonald, and Sunfish Lake.

## Requested Manager Actions

1. Authorize the release of this memorandum and data to:
  - A. Maynard Kelsey of McDonald Lake, who has requested the information.
  - B. Brian Buchmayer of Friends of Long Lake, who has requested the information.
  - C. Roger Johnson of the VBWD Citizen Advisory Committee, a Lake DeMontreville area resident and a Tri-Lake Improvement Association member.
  - D. Jeff Berg of the VBWD Citizen Advisory Committee and Lake Elmo area resident.
  - E. Wendy Griffin, a Lake Elmo area resident.
2. Authorize Barr to prepare a work scope and estimate of cost to obtain a Minnesota Department of Natural Resources (MDNR) permit and treat the small infestation of yellow iris near the Lake DeMontreville boat landing with herbicide. Yellow iris is an invasive species sighted for the first time in a VBWD lake. The current infestation in Lake DeMontreville is small, but could spread if left unmanaged.
3. Authorize Barr to submit a request to the MDNR for beetles to be released during the spring of 2014 to control purple loosestrife near the Lake Jane boat landing. The current infestation is small, but could spread if left unmanaged.
4. Provide technical support to Friends of Long Lake to control Eurasian watermilfoil (EWM) in Long Lake. Technical support would consist of working with Endangered Resource Services, LLC to

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conduct the pretreatment plant survey, design the herbicide treatment, obtain the MDNR treatment permit, schedule the treatment, and provide other needed technical assistance for carrying out the treatment.

5. Authorize Barr to prepare a work scope and cost estimate to manage EWM in Long Lake, Lake DeMontreville, the channel between Lake DeMontreville and Lake Olson, Lake Jane, and Lake Elmo.
6. Authorize Barr to prepare a work scope and cost estimate to manage curlyleaf pondweed (CLP) in Eagle Point Lake and Lake Olson.

## Methods

Matt Berg of Endangered Resource Services, LLC conducted the point-intercept plant surveys on June 24, June 27, and June 28, 2013. He located equally spaced preset points in the field with GPS and took measurements at each point. His measurements included the following:

1. Individual species present
2. Overall density of plants, as measured by rake method
3. Density of individual species, as measured by rake method
4. Water depth
5. Dominant sediment type

## Results

The results are divided into two sections: (1) a discussion of survey results from the 10 surveyed lakes and (2) a detailed evaluation of herbicide treatment results in Long Lake.

In this memorandum, when frequency of a plant species is discussed, frequency means the percent of sites at which the plant was found at depths shallower than the maximum depth at which plant growth was observed in the lake.

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## Summary of VBWD Plant Survey Results

The results of the 2013 aquatic plant surveys of 10 VBWD lakes are summarized in Table 1. The following data are presented in the table:

- **Number of species** – the number of different plant species that were either collected on the rake or observed in the lake (e.g., water lilies or cattail beds not collected on the rake but observed). This number includes both invasive species and native species.
- **Number of native species** – the number of native plant species that were either collected on the rake or observed in the lake.
- **Number of native species collected on rake** – only native plants collected on the rake were used for this statistic.
- **Number of invasive species** – the number of invasive plant species that were either collected on the rake or observed in the lake.
- **Maximum depth of plant growth** – the maximum depth that plants were found in the lake.
- **Frequency of occurrence** – the frequency of occurrence at which plants were found at depths that were shallower than the maximum depth at which plants were found in the lake.
- **Average rake fullness** – the density of plant growth was measured by rake fullness on a scale of one to four. Plant density was estimated using the following ranking system:
  - 1 = less than 1/3 of the rake head full of plants
  - 2 = from 1/3 to 2/3 of the rake head full of plants
  - 3 = Plants filling more than 2/3 of the rake head
  - 4 = Rake head full of plants and plants over the top of the rake head.
- **Simpson Diversity Index Value** – index used to measure plant diversity, which assesses the overall health of the lake's plant communities. The index considers both the number of species



Endangered Resource Services used a rake (pictured above) to collect plants for the plant surveys. Rake fullness is a measure of plant density. On average, VBWD Lakes had a rake fullness of 2.18 in 2013, indicating the rake head was generally between one third and two thirds full of plants.



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present and the evenness of species distribution. The index scores range from 0 to 1. The scores represent the probability that two individual plants randomly selected from the lake will belong to different species. The higher score indicates a more diverse plant community and a higher probability that two individuals randomly selected from the lake will represent different species.

- **C value** – scale of values used to measure the average tolerance of the plant community to degraded conditions. Plant species are assigned C values on a scale of 0 to 10, with increasing values indicating plants are less tolerant of degraded conditions and, hence, are of better quality. An average of the C values of the individual species within a lake's plant community indicates the average tolerance of the lake's plant community to degraded conditions.
- **FQI value** – Floristic Quality Index (FQI) was used to assess the quality of the plant communities in VBWD lakes. FQI considers both the quality of the individual native species found in the lake (C Value) and the number of native species collected on the rake. Although Minnesota has not kept a record of FQI values, records of Wisconsin FQI values have ranged from 3 (representing degraded plant communities) to 49 (representing diverse native plant communities). The median FQI for Wisconsin is 22.

Table 2 summarizes invasive species data from the 10 VBWD lakes surveyed in 2013. The table shows the frequency of occurrence of species collected on the rake and indicates species that were observed in the lake, but not collected on the rake.

Table 3 summarizes plant species with a statistically significant change in frequency of occurrence during 2013. A statistical test was used to evaluate 2012 and 2013 data from VBWD lakes monitored during both years. Barr evaluated the change in frequency of occurrence of individual species by the statistical test to determine whether the change was statistically significant. Significant increase in frequency is depicted by a + while a significant decrease is depicted by a – in Table 3.



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**Table 1 2013 Valley Branch Watershed District Lake Plant Survey Summary Statistics**

| Lake          | Number of Species | Number of Native Species | Number of Native Species Collected on Rake* | Number of Invasive Species | Maximum Depth of Plant Growth (feet) | Frequency of Occurrence (%) | Average Rake Fullness | Simpson Diversity Index Value | C Value | FQI Value |
|---------------|-------------------|--------------------------|---|----------------------------|--------------------------------------|-----------------------------|-----------------------|-------------------------------|---------|-----------|
| Long          | 15                | 12                       | 10  | 3                          | 27.5                                 | 76                          | 1.80                  | 0.81                          | 5.6     | 17.7      |
| DeMontreville | 31                | 27                       | 22  | 4                          | 21.0                                 | 92                          | 1.89                  | 0.90                          | 5.6     | 26.2      |
| Olson         | 25                | 22                       | 18  | 3                          | 21.0                                 | 87                          | 1.36                  | 0.91                          | 5.9     | 25.2      |
| Jane          | 37                | 33                       | 29  | 4                          | 22.5                                 | 97                          | 2.18                  | 0.91                          | 6.1     | 32.7      |
| Eagle Point   | 21                | 19                       | 15  | 2                          | 8.5                                  | 100                         | 2.92                  | 0.88                          | 5.3     | 20.7      |
| Elmo          | 36                | 33                       | 20  | 3                          | 23.0                                 | 97                          | 2.96                  | 0.89                          | 5.1     | 22.8      |
| Horseshoe     | 15                | 12                       | 8   | 3                          | 13.5                                 | 67                          | 1.76                  | 0.80                          | 4.3     | 12.0      |
| Edith         | 23                | 21                       | 17  | 2                          | 11.0                                 | 82                          | 1.70                  | 0.89                          | 5.3     | 21.8      |
| McDonald      | 24                | 22                       | 16  | 2                          | 8.5                                  | 95                          | 3.12                  | 0.85                          | 5.6     | 22.3      |
| Sunfish       | 25                | 23                       | 16  | 2                          | 12.0                                 | 77                          | 2.08                  | 0.90                          | 4.9     | 19.5      |

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**Table 2 2013 Valley Branch Watershed District Invasive Species Summary:**  
**Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth**  
**(Percent or Observed)**

| Lake          | <b>Myriophyllum<br/>spicatum</b><br>(Eurasian<br>watermilfoil) | <b>Potamogeton<br/>crispus</b><br>(curlyleaf<br>pondweed) | <b>Phalaris<br/>arundinacea</b><br>(reed canary<br>grass) | <b>Lythrum<br/>salicaria</b><br>(purple<br>loosestrife) | <b>Iris<br/>pseudacorus</b><br>(yellow iris) |
|---------------|--|---|---|---|--|
| Long          | 19%  | 25%   | Observed*   |   |  |
| DeMontreville | 33%  | 42%   | Observed*   |   | Observed*                                    |
| Olson         | 5%   | 43%   | Observed*   |   |  |
| Jane          | 2%   | 12%   | Observed*   | Observed*   |  |
| Eagle Point   |  | 58%   | Observed*   |   |  |
| Elmo          | 37%  | Observed*   | 1%  |   |  |
| Horseshoe     | 10%  | 4%  | 7%  |   |  |
| Edith         |  | 4%  | Observed*   |   |  |
| McDonald      |  | 8%  | 10%   |   |  |
| Sunfish       |  | 4%  | 5%  |   |  |

\*Observed in the lake but not collected on the rake.

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**Table 3 2012-2013 Statistically Significant Changes in Frequency of Occurrence of Plant Species in Valley Branch Watershed District Lakes**

| Species<br>(Scientific<br>Name) | Species<br>(Common Name) | Long<br>Lake | Lake<br>DeMontreville | Lake<br>Olson | Lake<br>Jane | Eagle<br>Point<br>Lake | Lake<br>Elmo |
|---------------------------------|--------------------------|--------------|-----------------------|---------------|--------------|------------------------|--------------|
|                                 | filamentous algae        | +            | +                     |               |              |                        |              |
| Heteranthera<br>dubia           | water stargrass          | +            |                       |               |              |                        |              |
| Myriophyllum<br>spicatum        | Eurasian<br>watermilfoil |              | +                     |               |              |                        |              |
| Elodea<br>Canadensis            | common<br>waterweed      |              | +                     |               | -            | -                      |              |
| Potamogeton<br>robbinsii        | fern pondweed            |              | +                     |               |              |                        |              |
| Nitella sp.                     | nitella.                 |              | -                     |               |              |                        |              |
| Potamogeton<br>crispus          | curlyleaf<br>pondweed    |              |                       | +             |              | -                      |              |
| Najas flexilis                  | slender naiad            |              |                       | +             |              | +                      |              |
| Chara sp.                       | muskgrasses              |              |                       | -             |              |                        |              |
| Ceratophyllum<br>demersum       | coontail                 |              |                       |               |              | -                      |              |
| Spirodela<br>polyrhiza          | large duckweed           |              |                       |               |              | +                      |              |
| Lemna minor                     | small duckweed           |              |                       |               |              | +                      |              |
| Potamogeton<br>friesii          | Frie's pondweed          |              |                       |               |              | +                      |              |

+ Denotes a statistically significant increase in frequency of occurrence between 2012 and 2013

- Denotes a statistically significant decrease in frequency of occurrence between 2012 and 2013



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A brief summary of the 2013 plant survey results for each of the 10 VBWD lakes follows. After the individual lake summaries, Figures 1 through 6 compare the number of sites where individual plant species were found during June 2012 and June 2013 for lakes monitored during both years. Figures 7 through 10 depict plant frequency for those lakes sampled in 2013, but not in 2012 (i.e., Lake Edith, Horseshoe Lake, Sunfish Lake, and Lake McDonald).

**Long Lake** – Long Lake was treated with herbicide to manage Eurasian watermilfoil (EWM) in 2013. A detailed discussion of the treatment results follows this summary.

**Lake DeMontreville** – EWM was found to be problematic in Lake DeMontreville, occurring at about a third of the sample points. Several large EWM beds were observed, including a canopied bed (plants growing to the lake's surface) at the northern end of the lake. The number of sample points containing EWM increased from 4 in 2012 to 33 in 2013, which is statistically significant. Management of EWM is advised since it appears to be spreading rapidly in the lake.

A few yellow iris plants were observed near the Lake DeMontreville boat landing. This was the first sighting of this invasive species in a VBWD lake. Management is advised before it spreads.

Curlyleaf pondweed (CLP) was found to be prevalent, but not problematic in Lake DeMontreville. The CLP plants were mixed in with the native plants. CLP is not “acting invasively”—it is not displacing native plants and is not reaching the surface and forming problematic CLP beds. CLP occurred at a frequency of 42 percent in Lake DeMontreville. Although prevalent, the average density of CLP was low (i.e., 1).

The native plants in Lake DeMontreville were generally stable, although a few species observed significant changes. The late spring caused a significant decline in *Nitella*. The wet weather conditions caused significant increases in filamentous algae. Significant increases in two native species, *Elodea canadensis* (common waterweed), *Potamogeton robbinsii* (fern pondweed), were considered favorable for the lake. The other plant species did not change significantly in 2013.

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**Lake Olson** – Although CLP was not problematic in Lake Olson in 2013, the number of sample points containing CLP increased from 33 in 2012 to 51 in 2013—an increase in frequency from 28 percent in 2012 to 43 percent in 2013. This increase is statistically significant, indicating CLP is spreading rapidly in the lake. Although prevalent, the plants were mixed in with the native plants and occurred at a low density (i.e., 1). Nonetheless, the statistically significant increase in frequency is concerning because the long winter and late ice-out would typically prevent such an increase. Therefore, management of CLP in Lake Olson is advised to curtail its rapid spread.

EWM was present in Lake Olson, but was largely confined to the channel to Lake DeMontreville and immediate vicinity. Nonetheless, management of EWM is advised to prevent it from spreading into other parts of the lake.

The native plants in Lake Olson were generally stable, although significant changes were observed in a couple of species. A significant decline in *Chara sp.* (muskgrasses) frequency and a significant increase in *Najas flexilis* (slender naiad) occurred in 2013.

**Lake Jane** – EWM was observed in Lake Jane for the first time in 2012. The new EWM infestation consisted of a few scattered plants on the east side of the lake and was not collected on the rake during the 2012 survey. In 2013, EWM was abundant enough to be collected on the rake at a frequency of 2 percent. EWM had spread to the 10 foot depth along the eastern shoreline, where it was first observed in 2012, and had also spread to the western shoreline. Management of EWM is advised to curtail its spread.

Purple loosestrife was observed at the Lake Jane boat landing in both 2012 and 2013. In 2013, the infestation consisted of a few plants that were only a foot high. Barr recommends that the VBWD again submit a request to the MDNR for loosestrife-eating beetles to be released during the spring of 2014 in the purple loosestrife-infested area.

In 2013, CLP was not problematic in Lake Jane—it was not “acting invasively.” CLP occurred at a frequency of 12 percent in Lake Jane. The average CLP density was low (i.e., 1). Most CLP plants in Lake Jane were found on the south shoreline, mixed in with lilies and watershield. CLP did not change significantly in frequency between 2012 and 2013.

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In Lake Jane, reed canary grass increased in area during 2013. It was observed at one location on the eastern side of the lake in 2012 and was scattered throughout the shoreline in 2013.

An above-average plant community, as measured by both number of species and quality, is noted in Lake Jane. The community was generally stable between 2012 and 2013, although a significant decline in *Elodea canadensis* (common waterweed) occurred. Because this species grows through the winter, the long winter and late ice-out probably caused its decline.

**Eagle Point Lake** – Eagle Point Lake experienced problematic growths of CLP in both 2012 and 2013. In 2013, CLP was observed at a frequency of 58 percent and was canopied (reaching the lake's surface) throughout the lake at depths up to 8 feet. The only sample point where CLP was not found was at a deeper hole of 8.5 feet. CLP reached the surface in nearly the entire lake. The long winter and late ice-out in 2013 caused a decrease in CLP frequency from 84 sample points in 2012 to 62 sample points in 2013. This decrease is statistically significant. Nonetheless, CLP continued to be problematic in Eagle Point Lake during 2013 and management is advised.

The native plant community was generally stable during 2013, although significant declines in two native species, *Elodea canadensis* (common waterweed) and *Ceratophyllum demersum* (coontail) were observed. Because both species grow through the winter, the long winter and late ice-out probably caused their decline.

**Lake Elmo** – EWM was problematic in Lake Elmo, occurring at a higher frequency than other VBWD lakes surveyed in 2013. In Lake Elmo, EWM completely dominated the plant community in 10 to 15 foot depths where it formed a solid bed—an almost unbroken ring around the entire lake, except for areas with steep drop-offs. EWM was a significant navigation issue in both the north and south bays, where it was canopied (i.e., grew to the lake's surface) up to the 10 foot depth.

The native plant community was stable and no significant changes in frequency were observed during 2013.



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**Horseshoe Lake** – In Horseshoe Lake, EWM occurred at a relatively low frequency (10 percent). However, a problematic dense EWM bed was observed in the southwest bay of the lake.

Horseshoe Lake observed fewer plants than most VBWD lakes. Plants occurred at a frequency of 67 percent compared with 76 to 100 percent in the other nine lakes. The plant community was below average in quality as measured by a C value of 4.3 (average C value is 5) and an FQI value of 12 (WI median or middle value is 22).

**Lake Edith** – Lake Edith has a poor growing substrate for plants; the lake bottom consists of marly clay and thin muck over sand. This poor substrate protects the lake from problematic growth of invasive species.

Hence, even though CLP is present in the lake, the poor habitat limits its growth and will likely prevent CLP from becoming problematic. CLP was found at a frequency of 4 percent and at a low density (i.e., 1) in 2013.

Despite the poor growing substrate for plants, the lake's native plant community was relatively average in number of species and in quality. The community included Illinois pondweed, a broad-leaved plant that provides submergent fish habitat, and expansive beds of hardstem bulrush, an emergent plant that provides important habitat on the south edge of the lake.

**Sunfish Lake** –The wet weather conditions in June resulted in high water levels. Willow trees that were many years old were 2 feet underwater at the time of the plant survey. Neither invasive species nor native species were problematic in Sunfish Lake. The prevalence of muskgrasses (frequency of 25 percent) and coontail (frequency of 17 percent) is favorable because these species are nutrient absorbers and have a favorable impact on the lake's water quality.

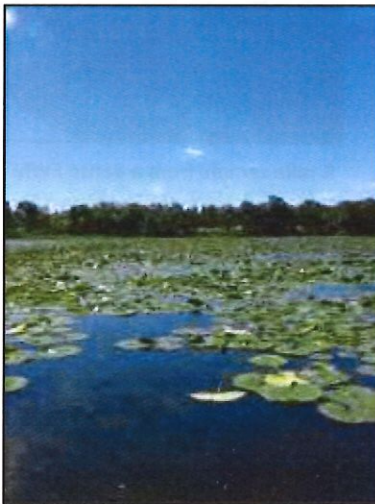


A rake sample from a dense EWM bed occurring in the southeast bay of Horseshoe Lake.

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**Lake McDonald** – Although invasive species are not problematic in Lake McDonald, densely growing native species impair navigation and make it difficult for residents to recreate on the lake. As shown in the pictures, coontail, white water lilies, and bladderwort were growing densely in the lake during the June survey making some areas of the lake nearly non-navigable. Because Lake McDonald is classified by the MDNR as a natural environment lake, herbicide use is not allowed. However, harvesting is allowed to manage plants on Lake McDonald.



Water lilies and coontail cause the north basin of Lake McDonald, pictured above, to be nearly non-navigable.

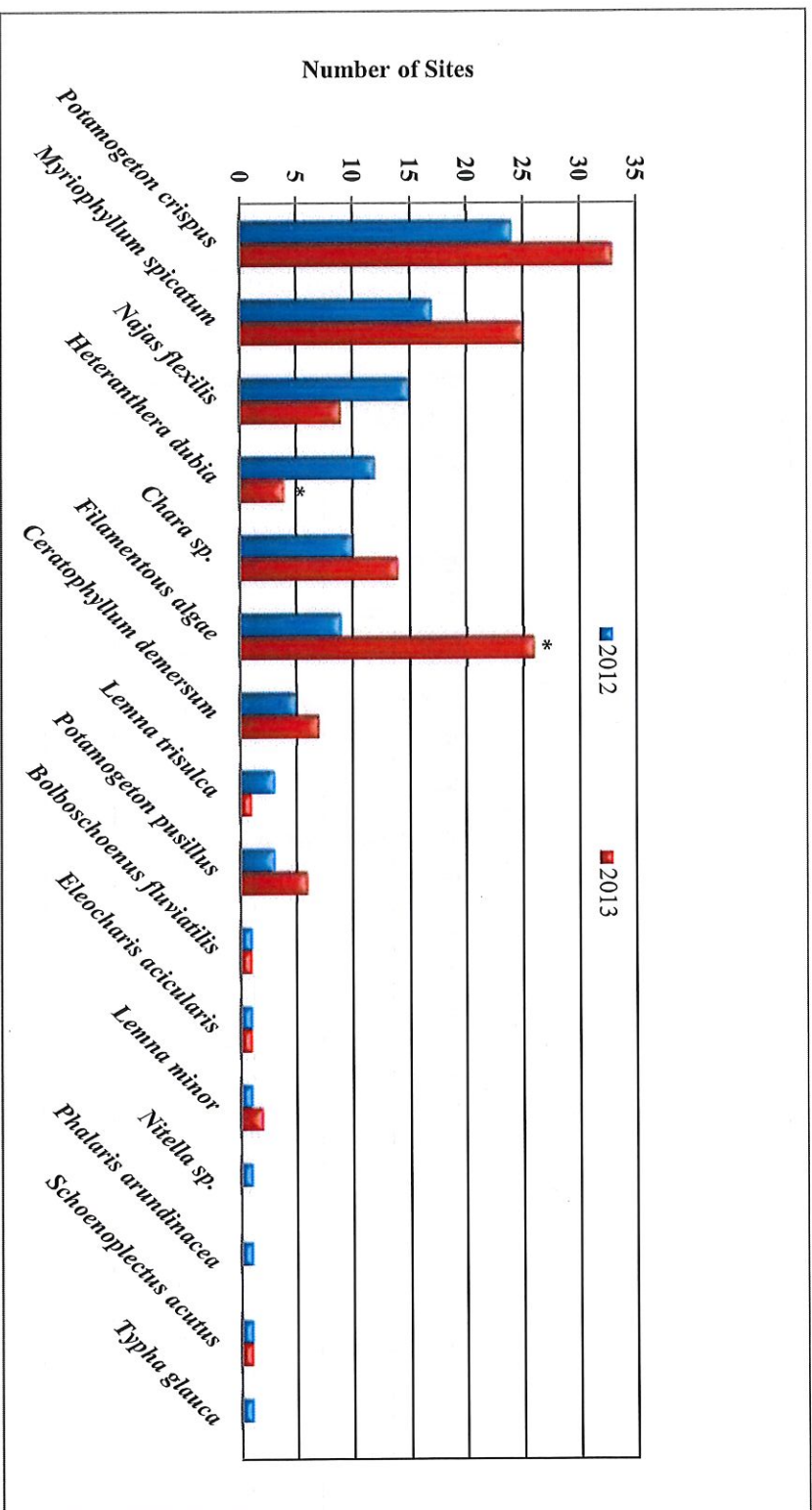


White water lilies in the south basin of Lake McDonald, pictured above, impair navigation.



Bladderworts in the extreme south bay of Lake McDonald cause navigation problems.

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**Figure 1. Comparison of Long Lake Plant Species Frequency of Occurrence in June of 2012 and 2013**

**Note:** \* indicates a significant change in frequency of occurrence between the two years.



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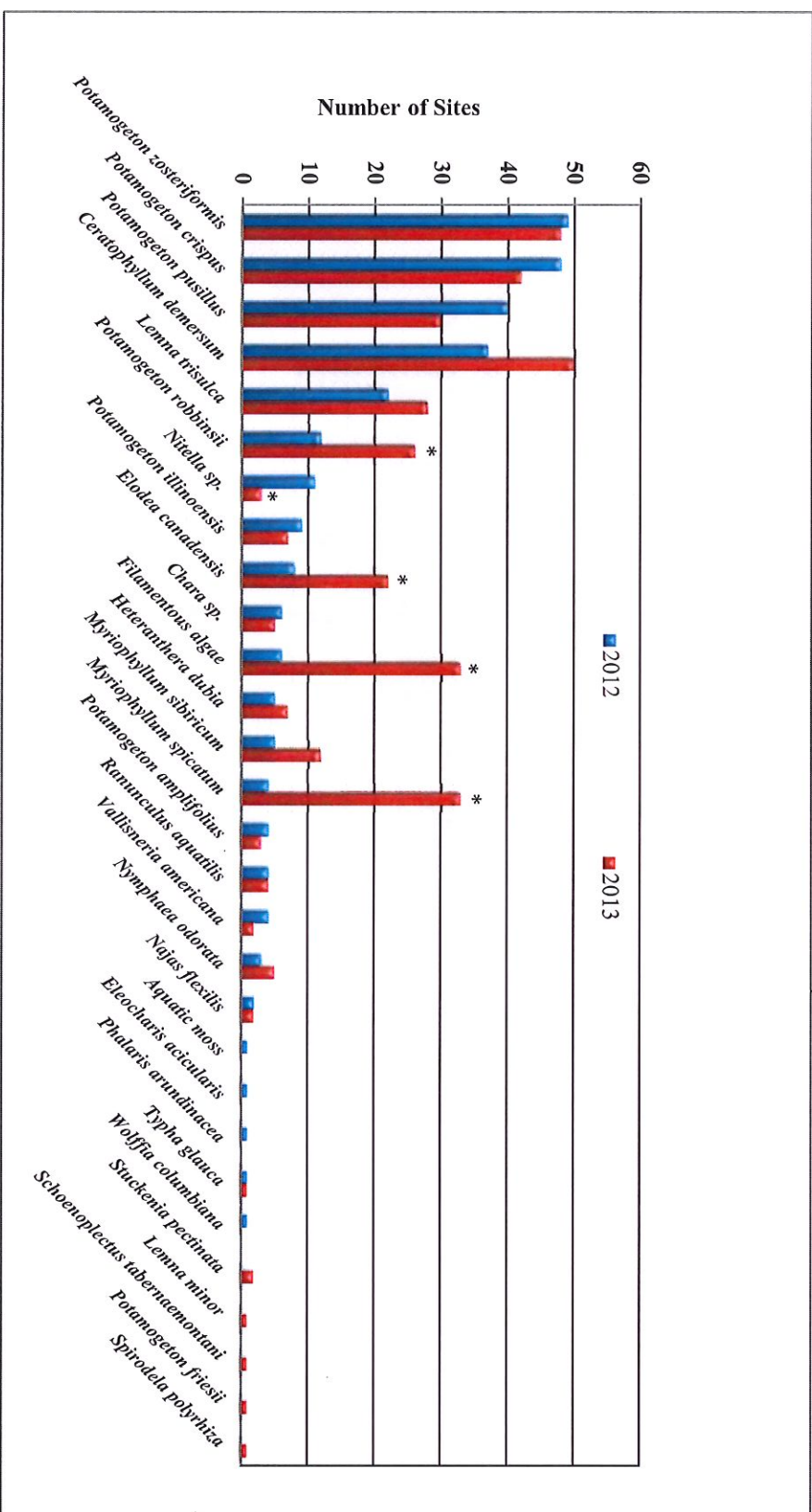


Figure 2. Comparison of Lake DeMontreville Plant Species Frequency of Occurrence in June of 2012 and 2013

Note: \* indicates a significant change in frequency of occurrence between the two years.

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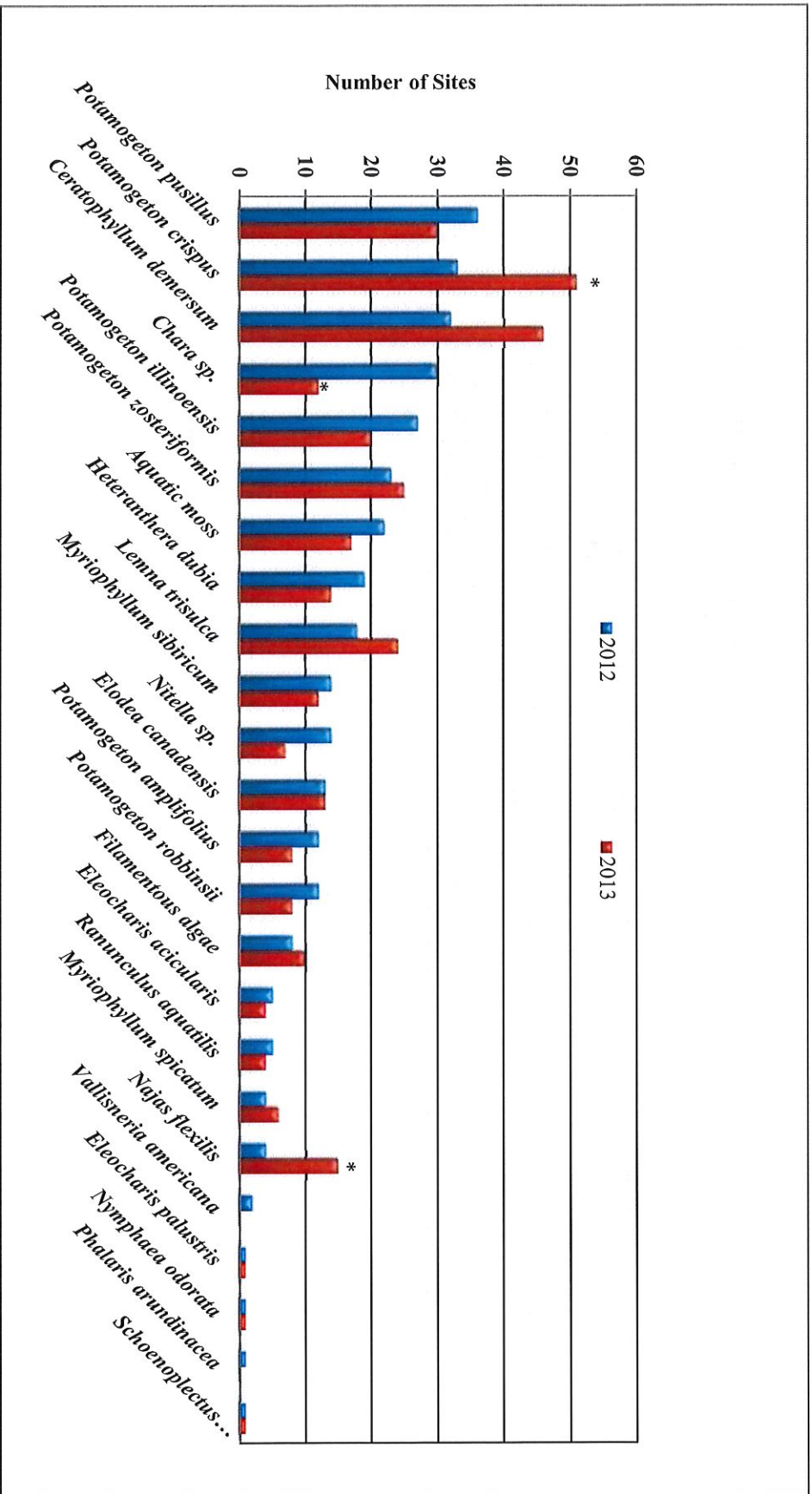


Figure 3. Comparison of Lake Olson Plant Species Frequency of Occurrence in June of 2012 and 2013  
 Note: \* Indicates a significant change in frequency of occurrence between the two years.

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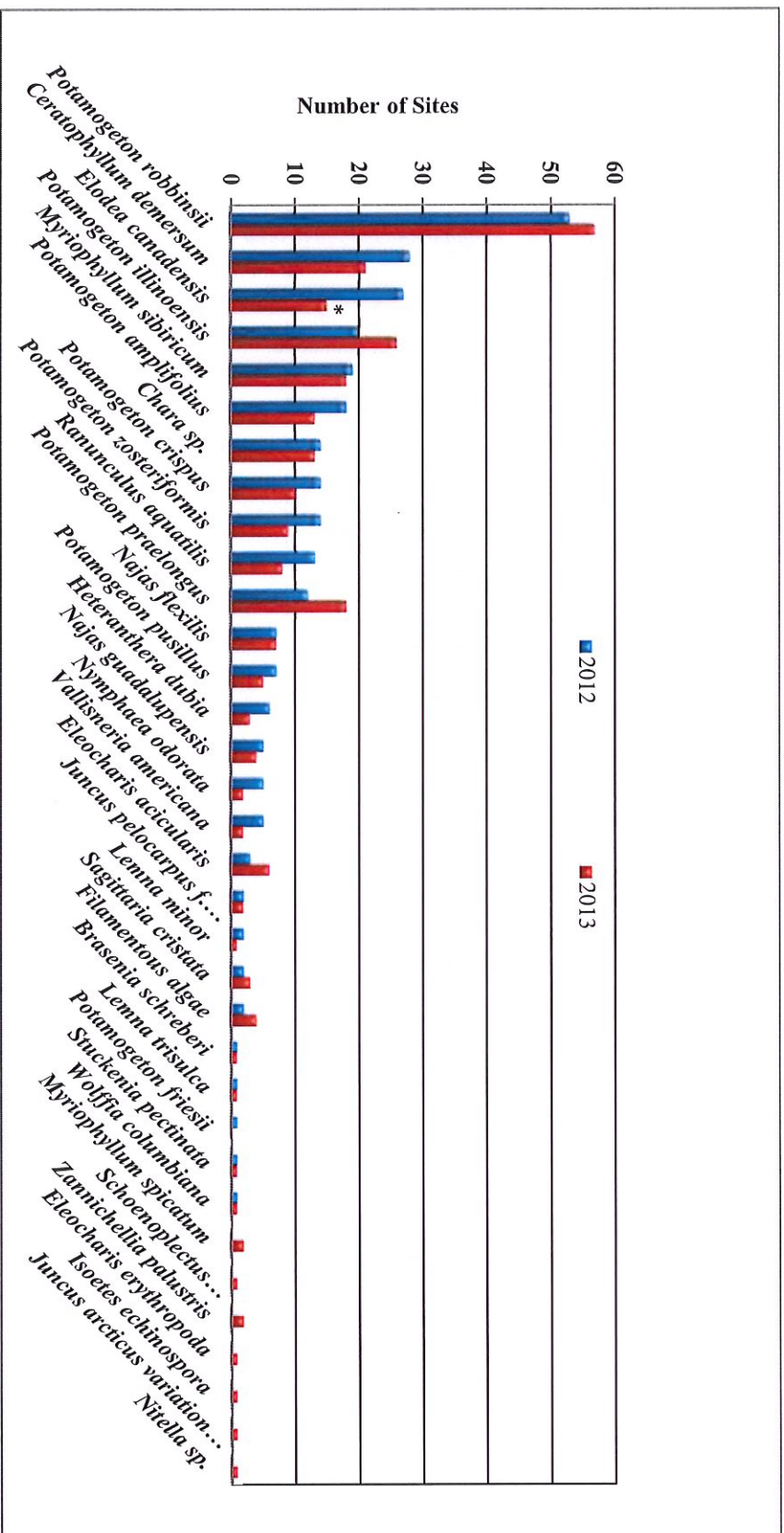


Figure 4. Comparison of Lake Jane Plant Species Frequency of Occurrence in June of 2012 and 2013

Note: \* indicates a significant change in frequency of occurrence between the two years.



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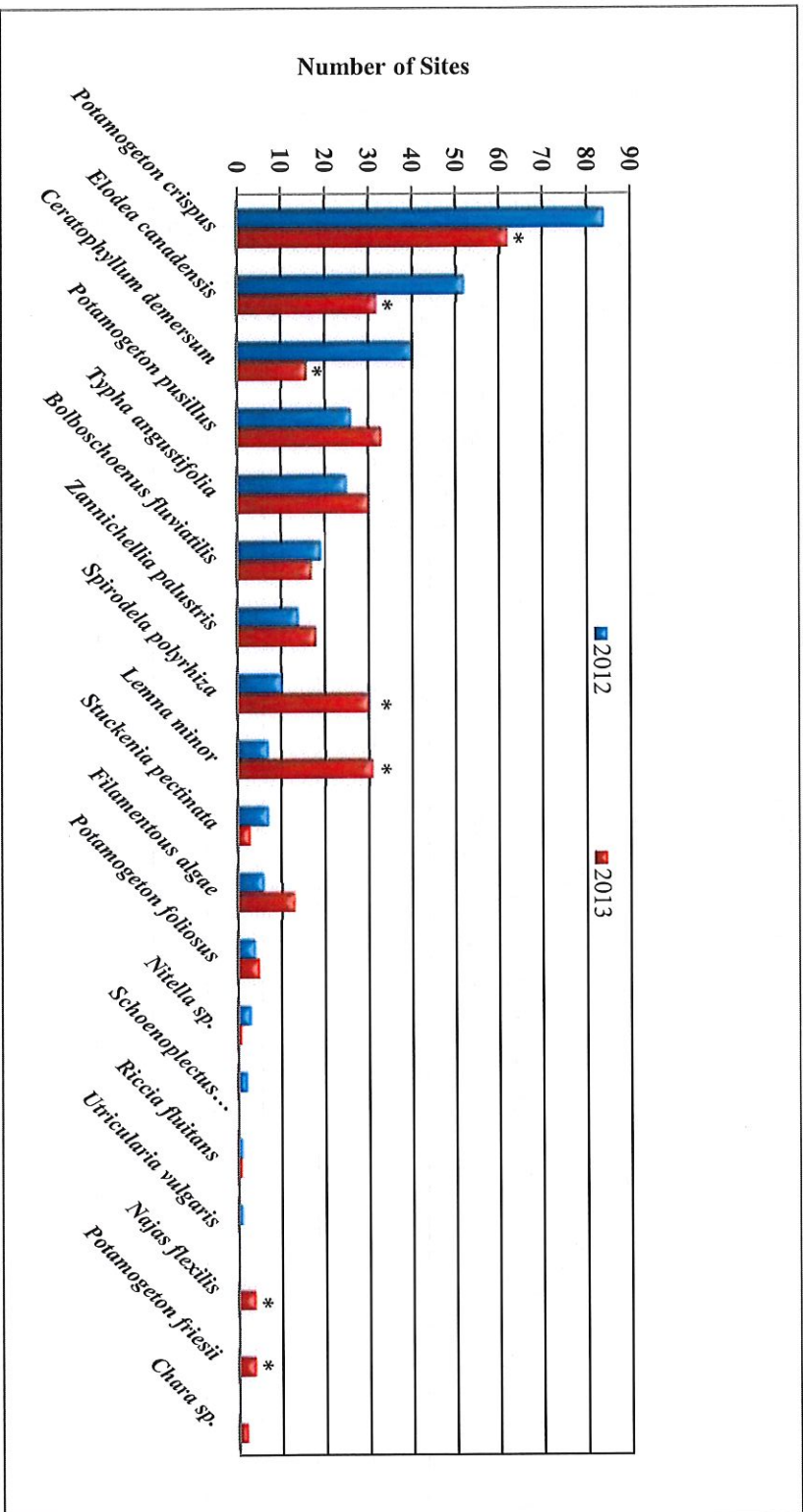
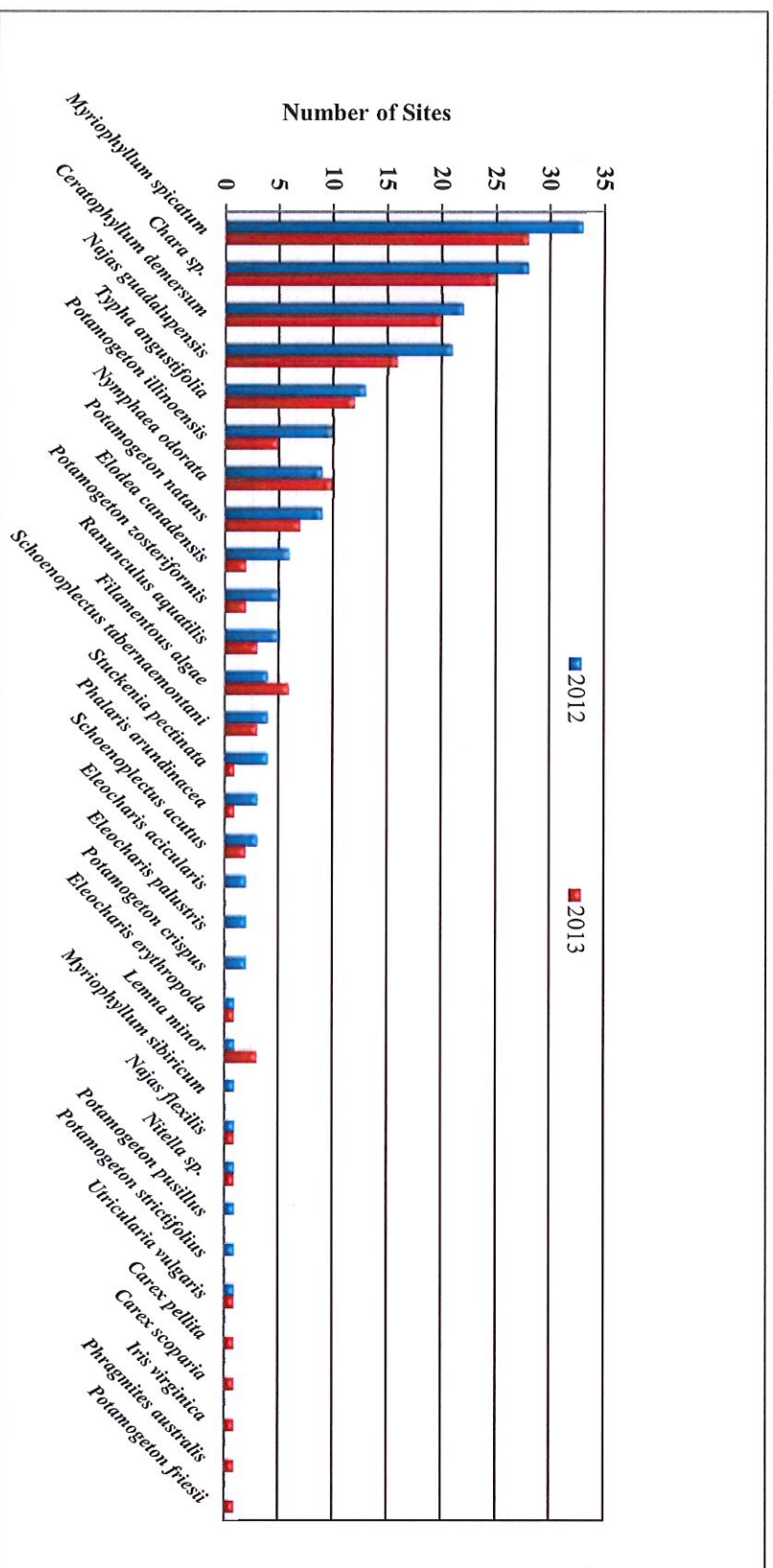


Figure 5. Comparison of Eagle Point Lake Plant Species Frequency of Occurrence in June of 2012 and 2013

Note: \* indicates a significant change in frequency of occurrence between the two years.

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**Figure 6. Comparison of Lake Elmo Plant Species Frequency of Occurrence in June of 2012 and 2013**

**Note:** There were no significant changes in frequency of occurrence between the two years.

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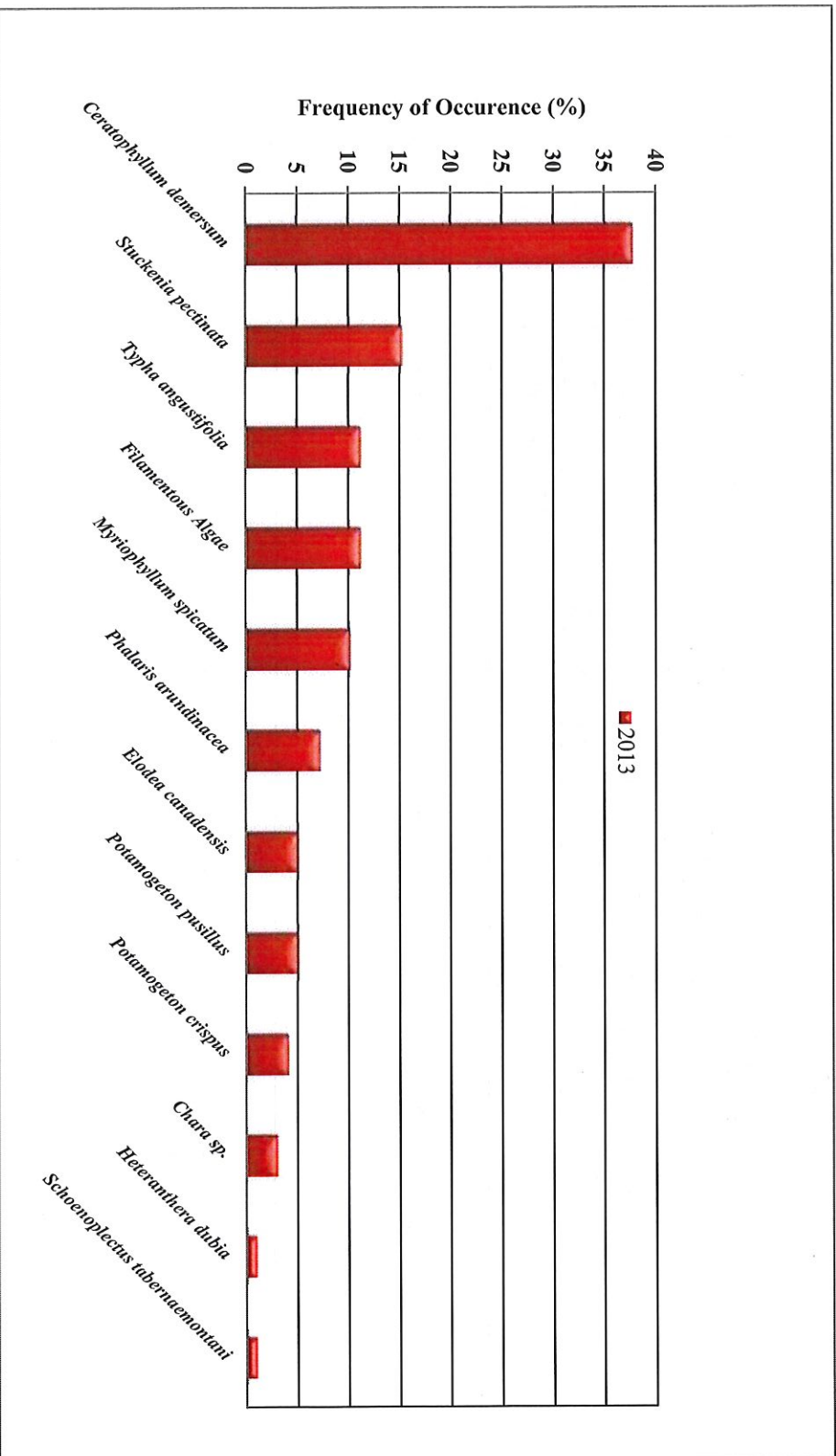


Figure 7. Horseshoe Lake Plant Species Frequency of Occurrence in June of 2013



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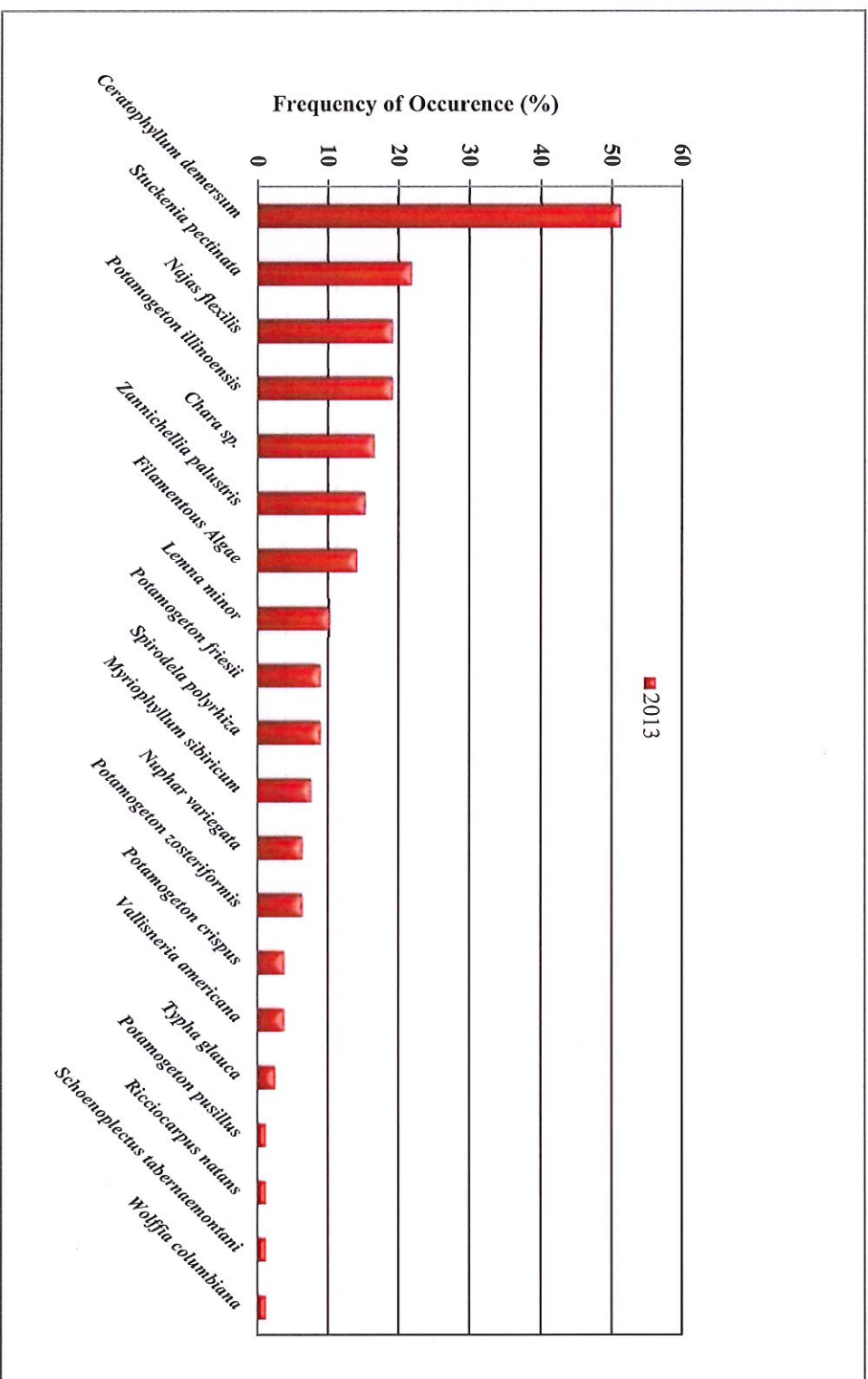


Figure 8. Lake Edith Plant Species Frequency of Occurrence in June of 2013

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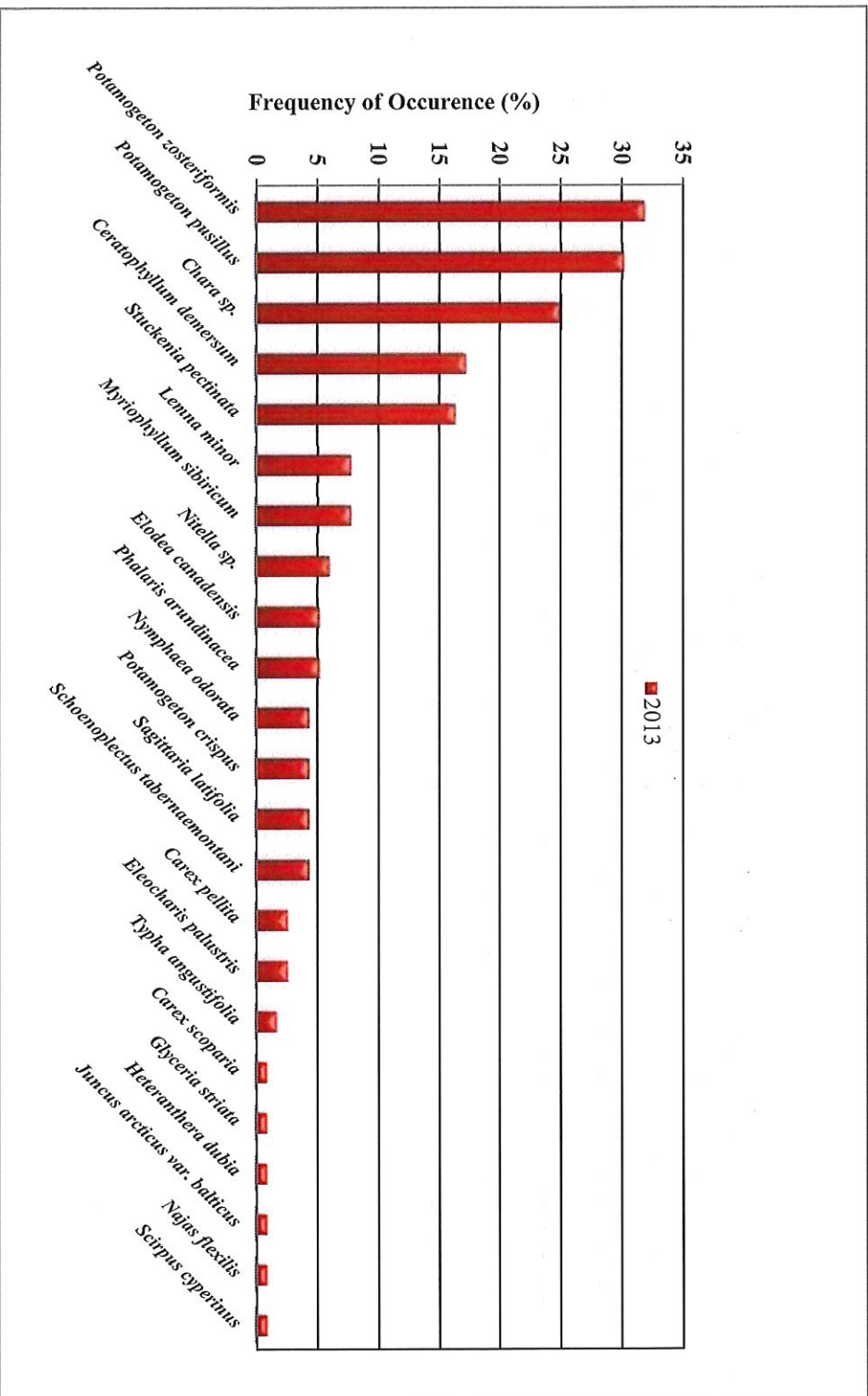


Figure 9. Sunfish Lake Plant Species Frequency of Occurrence in June of 2013

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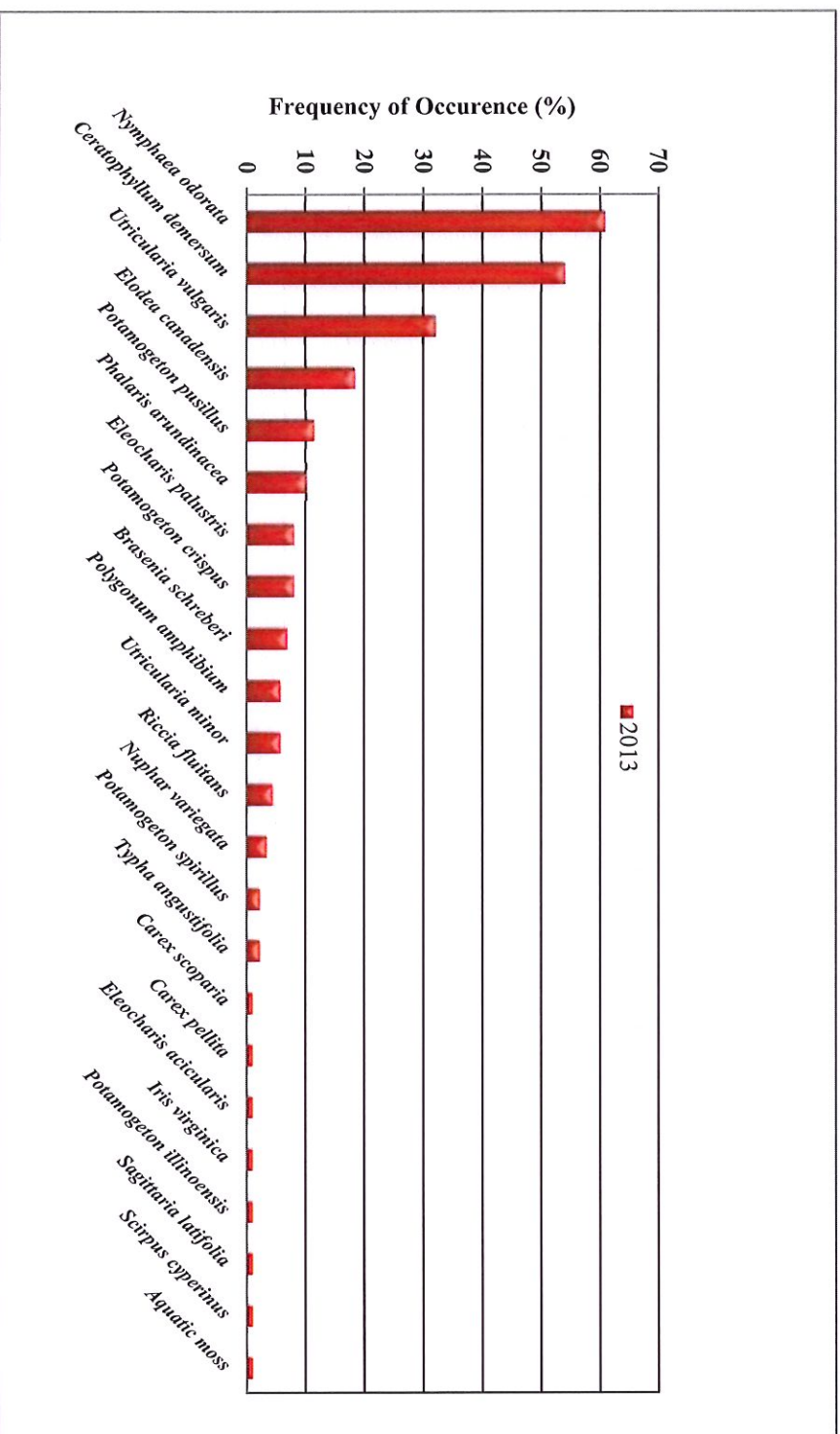


Figure 10. Lake McDonald Plant Species Frequency of Occurrence in June of 2013



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## Long Lake Herbicide Treatment Results

### Treatment

The Friends of Long Lake treated a 28-acre area within Long Lake with 215 gallons of 2,4-D on June 6, 2013, to control Eurasian watermilfoil (EWM). The treatment areas are shown in Figure 11 as green polygons. Approximately 46 percent of the lake surface area was treated. A dose of 0.87 parts per million (ppm) was applied to the treatment area.

After application, the herbicide typically mixes with untreated waters within the lake as waves and lake currents move the herbicide and untreated lake waters around the lake. The concentration of herbicide in the treatment area typically diminishes as the lake mixes and untreated lake waters dilute the herbicide.

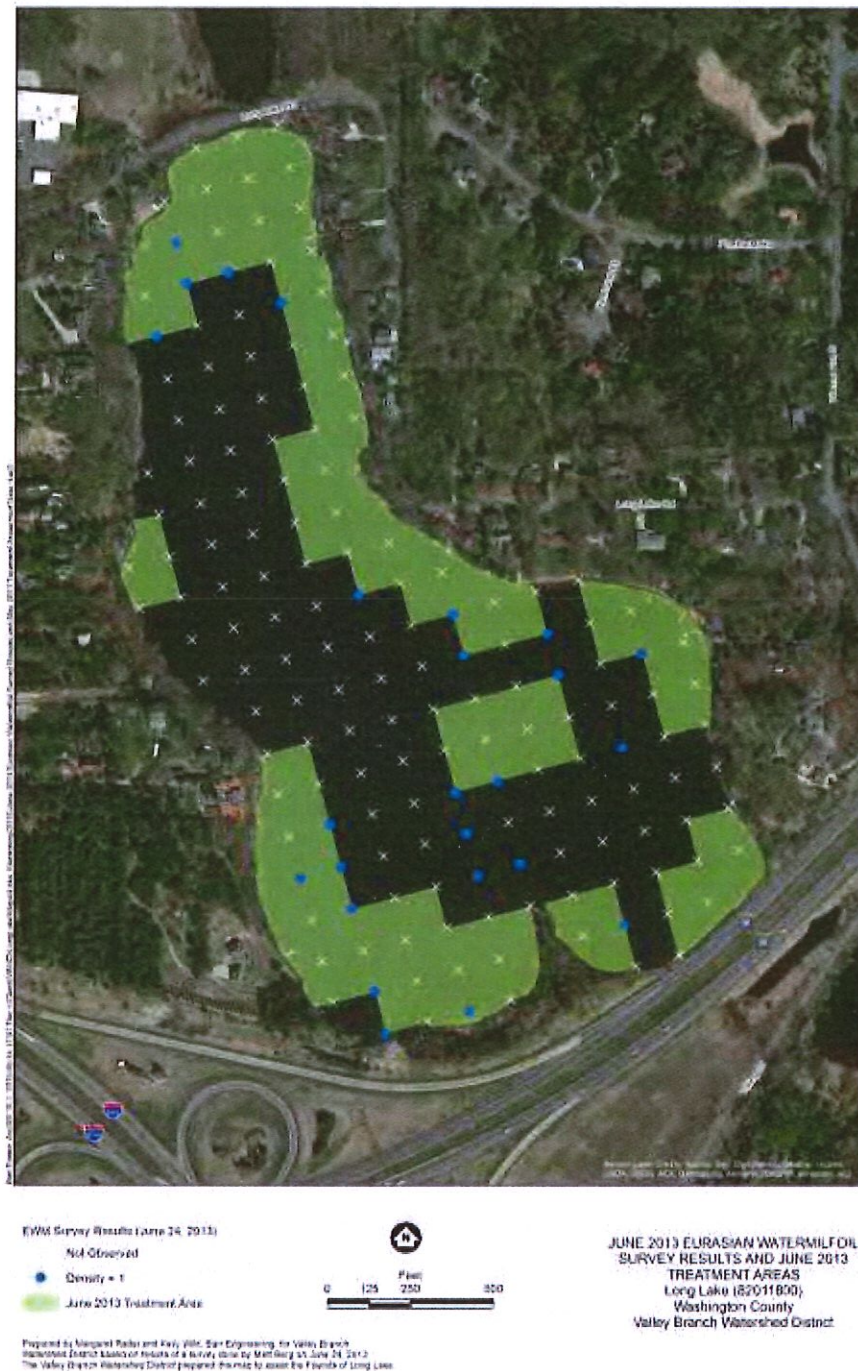
Stratification of a warmer upper layer and a deeper colder water layer also affects dilution of herbicide in lakes. Prior to treatment, Long Lake was expected to stratify into a warmer upper layer and a deeper colder layer. The temperature difference between the warmer and cooler layers of the lake would prevent the deeper waters from mixing with the shallower waters. When the herbicide was applied to Long Lake, Barr expected that it would only mix with the warmer, shallower waters of the lake and not penetrate to the deeper, colder layer of the lake. The dose selected for the Long Lake treatment (0.87 ppm) assumed that mixing with the lake's shallower waters would diminish the herbicide concentration to 0.3 ppm and that no mixing with the lake's deeper waters would occur.

### Herbicide Residue Monitoring

Herbicide residue monitoring data indicate that the goal of maintaining 2,4-D concentration of at least 0.3 ppm for at least 3 days was not attained. 2,4-D herbicide residue samples were collected in Long Lake on the day of treatment and 3 and 31 days after treatment. Samples were collected from four locations (Figure 12) on the day of treatment and 3 days after treatment. Stations 1, 3, and 4 were located within treatment areas and Station 2 was located outside of the treatment areas. Stations 1, 3, and 4 monitored 2,4-D concentrations in the shallower, warmer waters of the lake, up to the 5 foot depth. Station 2 monitored 2,4-D at the 15 foot depth to verify that the herbicide was confined to the upper warmer waters and that little or no 2,4-D was found in the deeper, colder waters of the lake.

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**Figure 11. 2013 June EWM Locations Compared with Treatment Areas**



**MAY 2013 HERBICIDE RESIDUE MONITORING LOCATIONS**  
**Long Lake (82011800)**  
**Washington County**  
**Valley Branch Watershed District**

Prepared by Margaret Rabin and Kelly WM, Ben Engineering, for Valley Branch Watershed District based on results of a survey done by Matt Berg on May 16, 2013.  
 The Valley Branch Watershed District prepared this map to assist the Friends of Long Lake.

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Immediately after treatment, a wide range of 2,4-D concentrations was observed at stations within the treatment areas (from 0.111 to 2.030 ppm), indicating the herbicide had little opportunity to mix prior to sample collection (Table 4). This wide range of herbicide concentrations immediately after treatment is expected. An average of the concentrations found in the treatment area sample locations immediately after treatment was 0.825 ppm, which is only slightly less than the application dose of 0.870 (Table 4). The data verify that the requested amount of herbicide was applied. The difference between the application dose and the average concentration from the samples verifies that some mixing and dilution by untreated waters occurred after treatment.

Three days after the treatment, 2,4-D concentrations within treatment areas were fairly similar (from 0.204 to 0.294 ppm), indicating the herbicide had mixed as expected after treatment (Table 4). However, the concentrations were below the expected 0.3 ppm target at all locations. The data indicate dilution from inflowing waters and/or the rate at which herbicide was carried out of the lake was greater than expected. At the time of treatment, the lake observed a high water level (about 2 feet above the outlet) due to runoff from recent rainstorms. The lake also experienced substantial inflow and outflow volumes.

Samples collected from Station 2, a deep location outside of the treatment area, verified that minimal mixing occurred between the warmer upper layers of the lake and the waters at the 15 foot depth. Thus, it appears that the lake had stratified and that the 15 foot depth was at or near the depth of stratification. Very low herbicide concentrations were observed at this station immediately after treatment (0.012 ppm) and at 3 days after treatment (0.005 ppm) (Table 4). The data verify that the herbicide was confined to depths above 15 feet and that only EWM at depths less than 15 feet would be controlled by the treatment.

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**Table 4 2013 Long Lake 2,4-D Residue Data Summary**

| Date Sampled | Days After Treatment | 2,4-D (ppm) |           |           |           |  |                       |
|--------------|----------------------|-------------|-----------|-----------|-----------|--|-----------------------|
|              |                      | Station 1   | Station 2 | Station 3 | Station 4 | Average of Treatment Locations (1, 3, and 4) | Average All Locations |
| 6/6/2013     | 0                    | 2.030       | 0.012     | 0.111     | 0.335     | 0.825  | 0.622                 |
| 6/9/2013     | 1                    | 0.204       | 0.005     | 0.277     | 0.294     | 0.258  | 0.195                 |
| 7/7/2013     | 3                    |             | 0.005     |           |           |  |                       |

#### **EWM Treatment Results**

The June plant survey results indicate that EWM was effectively controlled in areas of the lake that were less than 15 feet deep. This result is consistent with the herbicide residue data. The pretreatment plant survey identified 32 EWM locations within the range of 4 to 13.5 feet. The post-treatment survey indicated that EWM was found at only four locations below the 15 foot depth. Consequently, even though the target concentration of 0.3 ppm was not attained, the herbicide treatment was effective at controlling EWM at depths up to 15 feet. As shown on Figure 13, only two of the 32 locations containing EWM prior to treatment also contained EWM after treatment. Therefore, since EWM was eliminated from 30 of the 32 locations in which it was found in May, the success rate was 94 percent. Following the treatment, EWM spread to two new areas less than 15 feet deep—two areas that did not contain EWM in May. Hence, in June, EWM was found in 4 locations less than 15 feet deep.

The June plant survey found EWM at 22 locations deeper than 15 feet. Because the herbicide residue data indicates herbicide was confined to depths less than 15 feet, it is not surprising that EWM located deeper than 15 feet was not controlled.

The presence of EWM in the deeper areas of the lake was unknown when the treatment design was completed and the treatment occurred. This is because the spring pretreatment plant survey, which focused on verifying the continued presence of EWM at locations where it was found in June 2012 (at depths no greater than 10.5 feet) was restricted to areas of the lake up to 13.5 feet deep. Apparently, EWM spread to greater depths of the lake during the summer of 2012 and was present in the deeper areas

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during the spring of 2013. The drought during the summer of 2012 likely improved water transparency, which facilitated the EWM spread to the deeper areas of the lake.

The June 6 herbicide treatment occurred after the lake had stratified, which was ideal for a treatment to control EWM in the shallower areas of the lake. As noted earlier, the presence of EWM in deeper areas of the lake was unknown when the treatment occurred. Less herbicide is required to maintain a concentration of about 0.3 ppm in the upper 15 feet of the lake than would be required to maintain a concentration of about 0.3 ppm in the entire lake. Hence, a treatment occurring after stratification is cheaper than a treatment occurring before stratification because only waters shallower than 15 feet are considered when determining the volume of herbicide required to attain the target herbicide concentration. Unfortunately, EWM was present in the deeper areas of Long Lake and this EWM was not controlled by the herbicide treatment. Figure 11 shows the treatment areas relative to the areas containing EWM in June. The treatment areas are shown as green polygons and the EWM locations as blue dots. All but two of the locations containing EWM in June were either located at the edge of the treatment area or outside of the treatment area. As noted earlier, all but 4 of the June EWM locations were found in water deeper than 15 feet.

In the future, Barr recommends that a whole lake point intercept plant survey be completed prior to treatment to identify all locations in the lake containing EWM. If EWM is found in deeper waters, the herbicide needs to be applied prior to stratification to insure the herbicide mixes throughout the lake, including the deeper waters. Because of the urgency of completing the treatment before the lake stratifies, it will be important to quickly complete the treatment design, obtain the treatment permit, and schedule the treatment after completion of the plant survey. Delays in any of these essential activities could prevent application of the herbicide prior to stratification. Time is of the essence in attaining treatment success when EWM is found in deeper waters.

The 2011 treatment experience is an example of how to successfully complete a treatment when EWM is found in both deeper and shallower waters. The 2011 treatment occurred prior to lake stratification and EWM was fully controlled in both deeper and shallower waters. Despite the complete control of EWM by the 2011 treatment, EWM recolonized in the lake, probably from fragments reintroduced to the lake.



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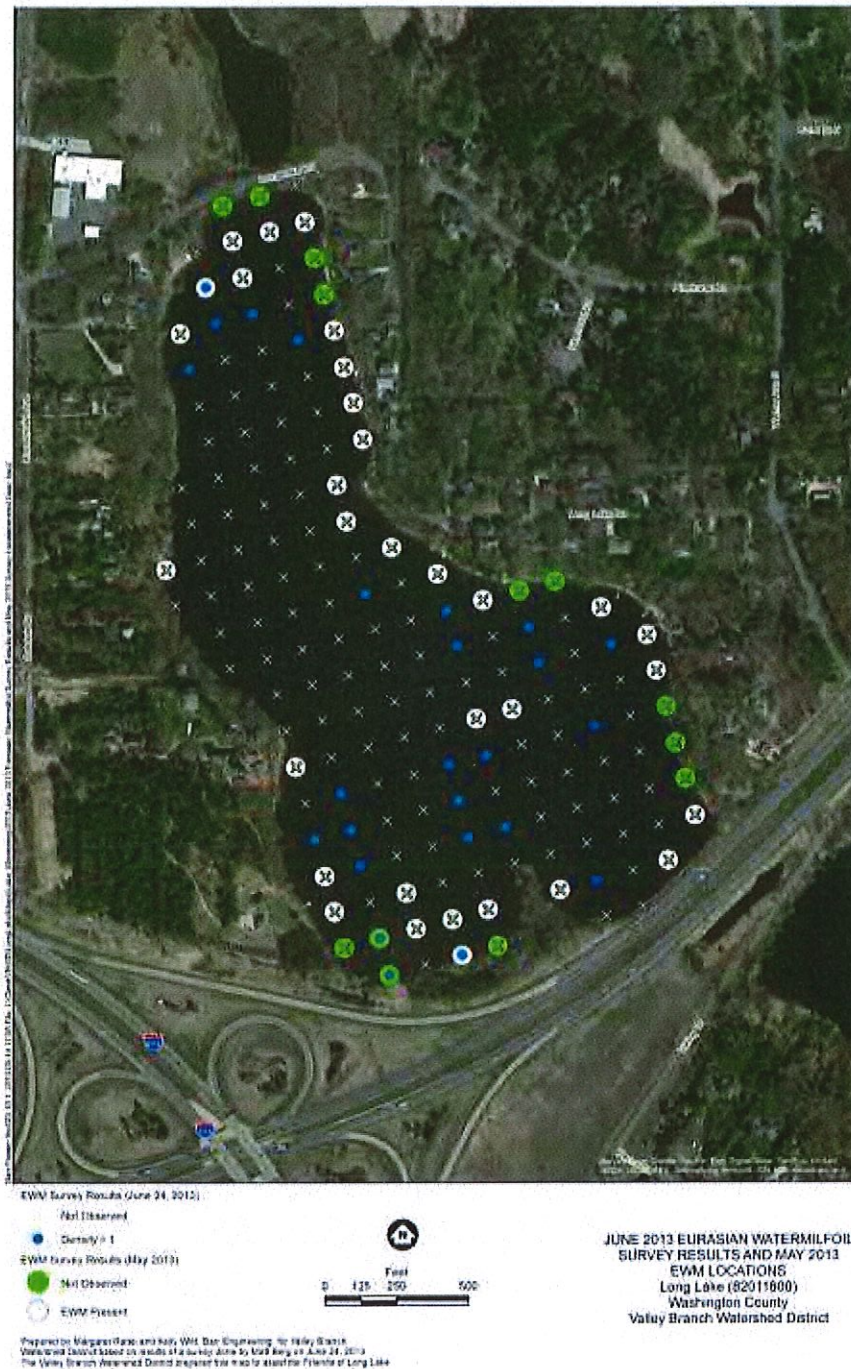


Figure 13. Comparison of May and June EWM Locations

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### **Aquatic Plant Survey Results**

The 2012 and 2013 plant survey results indicate Long Lake's native plant community was pretty similar during the two years. The data verify that the herbicide treatment did not adversely impact the lake's native plant community. A total of 12 native plant species were found in both 2012 and 2013. The frequency of occurrence of each individual species in each lake was compared between the two years using a statistical test to determine whether or not changes in frequency were significant. There were no significant declines in native species, verifying the herbicide did not harm native plants. A significant increase in one native species, *Heteranthera dubia* (water stargrass), following the 2013 treatment is a favorable change. Control of EWM provided the opportunity for expansion by this native species. A significant increase in filamentous algae also occurred in 2013. The increase likely resulted from the addition of nutrients carried in by stormwater runoff during the many significant rainstorms occurring in June. The lake was about 3 feet higher in June of 2013 compared to June of 2012.

The maximum depth at which plants were found in 2013 was much greater than 2011 and 2012 and was slightly greater than 2010. The maximum depth of plant growth was 27.5 feet in June of 2013 compared with 11.5 feet in June of 2012, 15.5 feet in August 2011, and 26.9 feet in June of 2010. The increased depth at which plants were found in 2013 is important because this means that EWM was able to grow at much greater depths in June of 2013 than June of 2012.

Plant diversity in Long Lake has remained stable since the initial 2011 herbicide treatment, which greatly reduced EWM within the lake. Native plants were able to expand their coverage after the 2011 herbicide treatment and the lake's plant diversity doubled as a result of their expansion. Since this initial improvement in plant diversity, the lake's plant diversity has remained stable. Diversity, measured by Simpson's Diversity Index on a scale of 0 to 1, estimates the probability that two individual plants randomly selected from the lake will belong to different species. Long Lake observed diversity scores of 0.40 in 2010, 0.80 in 2011, 0.85 in 2012, and 0.81 in 2013. The Long Lake scores indicate that in 2010, when EWM dominated the lake and few native species were present, there would be only a 40 percent chance that two plants selected from the lake at random would represent different species. The index score indicates there was a 60 percent chance the species would be the same—EWM. In 2010 through 2013, the chance that selecting two plants from the lake would result in two different species ranged from



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80 to 85 percent. The improved score indicates the lake has changed from poor to good plant diversity as a result of herbicide treatment to control EWM.

The quality of the plant community, measured by the Floristic Quality Index (FQI), has steadily improved since 2010. The improvement indicates that reducing EWM in the lake and allowing native plants to expand their coverage has improved the overall quality of the lake's plant community. FQI in Long Lake was 14.1 in 2010, 15.7 in 2011, 18.5 in 2012, and 17.7 in 2013. Although Minnesota has not kept a record of FQI values, recorded Wisconsin FQI values have ranged from 3 (representing degraded plant communities) to 49 (representing diverse native plant communities). The median FQI for Wisconsin is 22. Although Long Lake has experienced improvements in FQI since 2010, the current FQI score is still below the Wisconsin average. This is not unexpected since the quality of the Long Lake plant community was very poor prior to the initial 2011 herbicide treatment. The 20 percent improvement in FQI score during the past three years is considered good progress toward improved quality of the plant community.



