Shawano Lake

Shawano County, Wisconsin

2014 EWM Monitoring & Trial Treatment Assessment Report

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Created by: Eddie Heath, Brenton Butterfield, Tim Hoyman
Onterra, LLC
De Pere, WI

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1.0 INTRODUCTION

Shawano Lake, Shawano County, is an approximate 6,258-acre drainage lake with a maximum depth of 38 feet and a mean depth of 9.8 feet (Onterra 2014) (Photo 1). The lake's watershed encompasses approximately 74-square miles, and is comprised of mixed agriculture, rural residential areas, forested lands, and urbanized areas. Shawano Lake is drained by the Shawano Lake Outlet which flows through the City of Shawano and ultimately into the Wolf River.

Photo 1. Shawano Lake, Shawano County.

Shawano Area Waterways Management, Inc. (SAWM) was created over a decade ago by members of the Shawano Lake Property Owners Association (SLPOA). Shawano Lake and its watershed have been studied since 1991 when the SLPOA was awarded the first of many Wisconsin Department of Natural Resources (WDNR) Grants. More intense studies of the lake's nutrient budget were led by the University of Wisconsin-Stevens Point Center for Watershed Science and Education, the results of which were presented in a final report produced in 2008. In 2009, results of these studies were used to create the Shawano Lake Watershed Strategic Management (WSM) Plan and the Shawano Lake Aquatic Plant Management (APM) Plan.

The 2009 APM Plan contains 16 recommendations, including further studies, implementation of watershed best management practices, potential funding sources, and the control of native and non-native aquatic plants. Aquatic plant management activities include a combination of herbicide use, mechanical harvesting, and hand-removal to control both native and non-native plants. The 2009 WSM Plan contains 22 goals/objectives within eight categories, including monitoring, harvesting, chemical treatment, property owner participation, funding, education, research, and governance. Many of these goals/objectives directly overlap with the recommendations contained within the two plans, including the creation of an updated aquatic plant management plan by 2015.

SAWM has been conducting aquatic plant control on Shawano Lake as outlined in the 2009 APM Plan, including limited use of an association-owned harvester and nuisance herbicide applications by an association-employed applicator. After three years of implementing the plan's recommendations, the WDNR requested a more precise plan that gives comprehensive guidance on controlling exotics, in addition to the natives, using both chemical and harvesting techniques. SAWM also wanted to discover ways to protect and restore the native aquatic plant community by controlling exotics on a lake-wide scale.

During the winter of 2012-2103, SAWM contracted with Onterra to develop an updated APM Plan that addresses the following issues:

1. Updated actions for the control of nuisance levels of native and non-native aquatic plants. These actions would likely include the use of hand-harvesting, mechanical harvesting, and herbicide applications aimed at assuring recreational accessibility of the lake while minimizing impacts to native habitat.
2. Management alternatives for reducing non-native plant species within Shawano Lake on a lake-wide basis with the intention of restoring native aquatic plant habitat. These actions may include mechanical harvesting of specific species, early-season herbicide treatments, and/or water level drawdown. Likely, in tandem with this outcome, nuisance aquatic plant control would be completed as described above.

The non-native, aquatic invasive plants Eurasian water milfoil (*Myriophyllum spicatum*; EWM) and curly-leaf pondweed (*Potamogeton crispus*; CLP) have been present in Shawano Lake for at least 20 years, but likely longer. In 2013, Onterra ecologists mapped areas of CLP and EWM in Shawano Lake and located approximately 1,500 acres of colonized CLP and 1,900 acres of colonized EWM. While the majority of the CLP located was comprised of lower-density colonies (*scattered* and *highly scattered*), the majority of the EWM population was comprised of colonies of higher density (*dominant* and *highly dominant*). In addition, the 2013 whole-lake point-intercept survey indicated that EWM had a relatively high littoral frequency of occurrence of approximately 17%.

In 2010, samples of EWM were sent to the Annis Water Resources Institute at Grand Valley State University in Michigan to determine if the EWM population in Shawano Lake was of hybrid origin; a cross between EWM and the indigenous northern water milfoil (*M. sibiricum*). Hybrid water milfoil (HWM) presents some complications for management as research is indicating that certain strains may have a higher tolerance to aquatic herbicides. The specimens processed in 2010 from Shawano Lake were confirmed as HWM. In 2013, additional milfoil specimens were collected and sent in for DNA analysis and the results indicated they were pure-strain EWM. These differing results indicate that Shawano Lake contains populations of both HWM and EWM.

During the 2014 Aquatic Plant Management Planning Project, the SAWM Planning Committee decided to focus their management attention away from attempting to control the CLP population within Shawano Lake. During the meetings with this group, several CLP control strategies were discussed, all of which were cost prohibitive and unclear as to whether control objectives would be met. Overviews of these discussions are included within the 2014 APM document (April 2014). SAWM decided to focus their attention on managing the lake's population of EWM.

After consideration of multiple management options, it appeared that large-scale herbicide treatment is the most appropriate method for targeting the EWM population within Shawano Lake. While this strategy has been implemented on many lakes throughout Wisconsin, large-scale (may or may not be *whole-lake*) treatment strategies remain experimental in nature and have not been conducted in a Wisconsin lake of Shawano Lake's scale. Lake managers and SAWM Planning Committee members discussed several implementation challenges of large-scale management that require information before implementation would be warranted: logistical feasibility, efficacy concerns, uncertainty in ecological response, financial constraints, and ability to gain sociological backing (i.e. stakeholder support) (Figure 1).

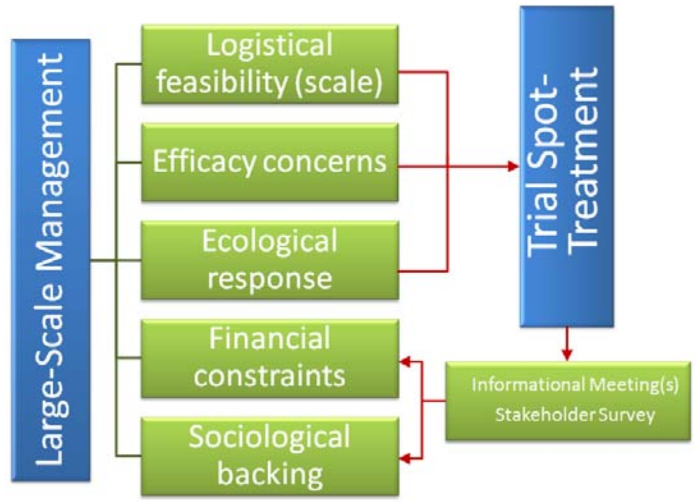

Figure 1. Flow chart addressing concerns of implementing a whole-lake treatment on Shawano Lake.

To address these concerns, it was proposed that a smaller-scale trial 2,4-D treatment could be implemented on Shawano Lake. If the trial treatment satisfactorily addresses the first three implementation challenges listed above, a positive feedback loop of sociological backing (stakeholder support) resulting in additional financial contributions (e.g. individual, municipal, business, agency, etc.) for implementation of a large-scale treatment strategy may occur. If the trial treatment does not adequately address these implementation challenges, a modified experimental approach may be warranted until the desired goals are met.

2.0 2014 PROPOSED EWM SPOT-TREATMENT STRATEGY

Over the winter of 2013-14, a trial spot-treatment strategy was devised for Shawano Lake where approximately 145 acres of EWM on the western side of the lake would be targeted for control (Figure 2). This area was chosen because it met the following conditions:

- It is a large, contiguous area of high density EWM.
- It is located within an area where greater herbicide exposure time is anticipated as opposed to the center of lake where it would be more exposed to wind/wave action. Therefore an increased likelihood of a successful treatment is brought about.
- There is separation between the EWM that is targeted by the treatment and adjacent colonies. Dense areas of EWM adjacent to the treatment area jeopardize the success of the treatment (re-colonization) as well as cloud the stakeholder perception of the treatment (lake users do not know exactly where the treatment took place and will see EWM and think the treatment did not work).
- No WDNR Sensitive Areas are located within or adjacent to the treatment area
- Target area is within a high use and high visibility location

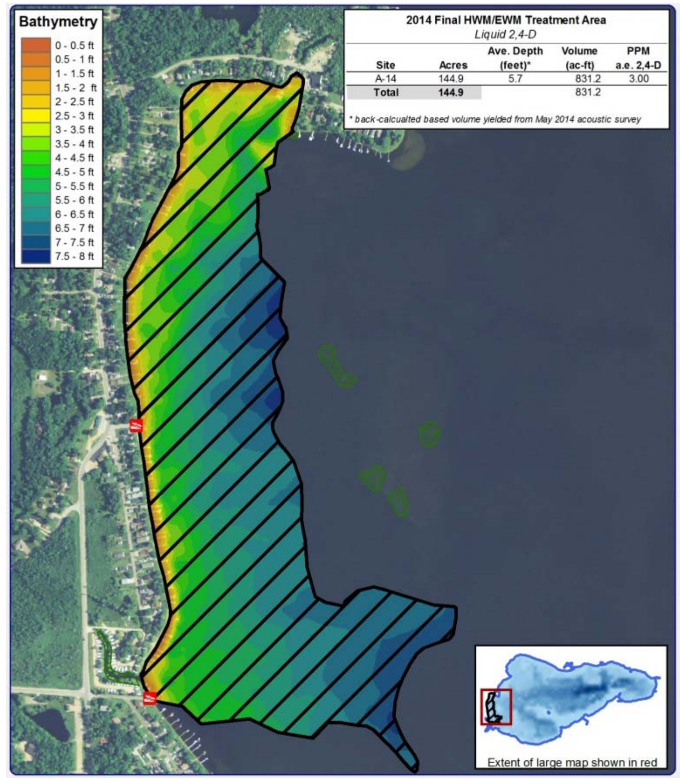

Figure 2. Trial herbicide treatment proposed for Shawano Lake during the spring of 2014.

The 145-acre treatment site was proposed to be targeted with liquid 2,4-D at 3.0 ppm acid equivalent (ae) during the spring when surface water temperatures are between 50-60°F. Conducting these treatments early in the spring minimizes adverse impacts to valuable native aquatic plants, many of which have yet to begin actively growing. The partial success of any herbicide treatment strategy relies upon accurate dosing. One component of accurately determining how much herbicide is required requires and understanding of the water depth within the treatment site. During the 2014 Spring Pretreatment Confirmation & Refinement Survey, Onterra systematically collected continuous, advanced sonar data within the proposed trial treatment site, of which the data was sent to a Minnesota-based firm for processing (ciBiobase, Navico). The resulting data produced an updated bathymetric map for this area to allow for a more-accurate and updated dosing strategy to be developed for this treatment (Figure 2). The average depth of this site was found to be 5.7 feet. It was estimated that if the amount of herbicide applied to the treatment area necessary to achieve a concentration of 3.0 ppm ae within this area was diluted and dispersed throughout the entire lake, the lake-wide concentration would be approximately 0.042 ppm ae, an insufficient concentration to impact plants on a lake-wide scale.

Along with providing updated depth information, the acoustic mapping survey also indicated the percent biomass of aquatic plants within the areas the data was collected at. While the map output would not differentiate between aquatic plant species, it would indicate where high bio-volumes of vegetation exist in the lake. This information may be important for fisheries and lake managers to understand the structural impacts of the macrophyte communities in association with the trial treatment. Pairing this data with additional quantitative plant data (discussed in the next section) may provide indication of the plant species/type contributing to the bio-volume present following the treatment.

3.0 MONITORING METHODOLOGIES & SUCCESS CRITERIA

The objective of any herbicide treatment strategy is to maximize target species (EWM) mortality while minimizing impacts to valuable native aquatic plant species. Two types of aquatic plant monitoring were completed to determine treatment effectiveness;

1) Qualitative monitoring comparing pre- and post-treatment EWM mapping data
2) Quantitative monitoring using point-intercept data
    a. Point-intercept sub-set data utilizing locations from whole-lake grid that are within (Figure 3, red sample locations) and adjacent to the spot-treatment application area (Figure 3, green sample locations). Pretreatment data were collected at these locations during the summer of 2013 and would be compared to the summer of 2014 (post treatment). Data collected at these locations would be analyzed in terms of EWM treatment efficacy and native plant selectivity (statistical difference in pre- and post-EWM presence).
    b. Point-intercept sub-sample data consisting of a new grid of points placed over treatment area, much closer together than whole-lake point-intercept grid (50 meters vs 165 meters). These sub-sample locations would be sampled the spring (April-May) before the treatment (pretreatment) and the late-summer following the treatment (post treatment). Data collected at these locations would be only analyzed in terms of EWM treatment efficacy, as it is not appropriate to use native plant frequency of occurrence data during the early-spring pretreatment survey to compare against surveys completed later in the summer due to phenological differences in these plants' life cycles.

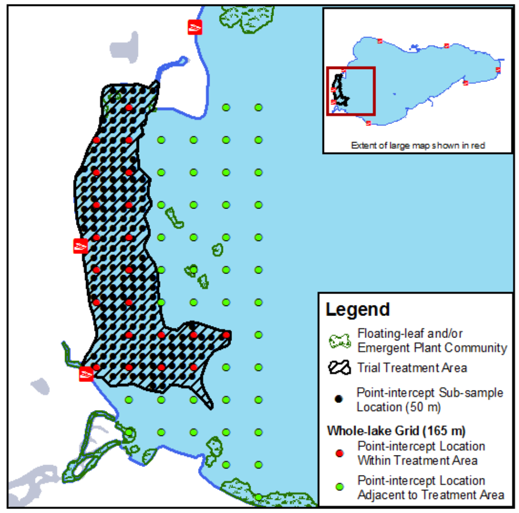

Figure 3. Shawano Lake Quantitative Monitoring Strategy

The quantitative and qualitative predetermined success criteria standards outlined within the 2014 APM Plan are as follows:

1. Qualitatively, a successful treatment would include a reduction of EWM density as demonstrated by a decrease in two density ratings (e.g. *Highly Dominant* to *Scattered)* when comparing the 2013 EWM mapping data with data collected post-treatment in 2014.
2. Quantitatively, a successful treatment would include a significant reduction in EWM frequency following the treatments as exhibited by at least a 75% decrease in exotic frequency from the pre- and post-treatment point-intercept sub-set and sub-sampling.

Successful herbicide treatments entail maximizing efficacy against target species while minimizing impacts to the native (non-target) plant community. Many actions are taken to reduce the chance of herbicide impacts on native aquatic species, including the selection of the herbicide type/concentration and the time of year that the herbicide is applied. By conducting the herbicide treatment early in the growing season, when many native plants have not yet begun growing, the herbicide is theorized to be more selective towards EWM. While 2,4-D was traditionally thought to be selective towards broad-leaf (dicot) species, emerging data from the WDNR and US Army Corps of Engineers (USACE) indicate that some narrow-leaf (monocot) species are impacted by this herbicide. Although a specific success criteria standard was not established for native plant collateral impacts, the long-term goals of SAWM rely on a healthy native plant population to fill the empty niche left by EWM in the case of an effective treatment. The long-term success of this control strategy will be based on whether the desired native plant community can repopulate this area faster than EWM recolonizes it. Ongoing research indicates that some native plants have been shown to recover quickly the year following an herbicide treatment, whereas others take more time.

In conjunction with the WDNR and USACE, herbicide concentration monitoring at strategic locations within the treatment area (Figure 5) took place to understand the concentration/exposure time of the herbicide at different time periods and locations following the treatment. This information indicates whether or not the amount of herbicide applied is sufficient for causing EWM mortality and if any adjustments in treatment strategy need to be made. Water samples were collected by trained volunteers from the lake. The properly preserved samples were sent to the WI State Laboratory of Hygiene for analysis. Coupling the herbicide concentration data with the aquatic plant monitoring components are valuable for assessing the trial treatment.

4.0 PRETREATMENT CONFIRMATION AND REFINEMENT SURVEY

On May 20, 2014, Onterra ecologists conducted the HWM Pretreatment Confirmation and Refinement Survey on Shawano Lake. Based upon a temperature profile collected during the survey, the lake was showing signs of becoming loosely stratified with a slightly warmer, upper layer of water (epilimnion) of around 60°F extending down to approximately six feet. However, relatively warm water (55°F) in the bottom layer (hypolimnion) indicated that a fair amount of mixing throughout the water column was occurring (Figure 4).

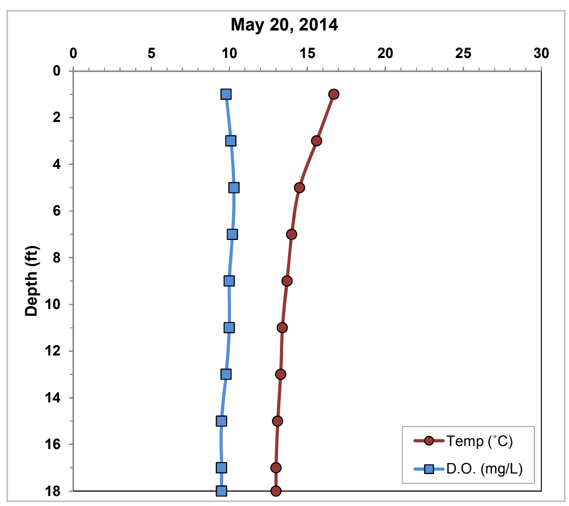

Figure 4. Temperature and dissolved oxygen profile collected on Shawano Lake. Data collected on May 20, 2014.

The treatment was conducted by Clean Lakes, Inc. on June 4, 2014 using their LittLine® NextGen Technology – an application system that reportedly minimizes herbicide diffusion by delivering the herbicide closer to the target plant's root system where plant biomass is greatest. The applicator started the application on the western shore and worked their way eastward (lakeward).

The applicator reported near-surface water temperatures of approximately 71°F and winds of 1-10 mph during application. Wind speed and direction data were also obtained from a weather station at the Shawano airport, less than a mile from the treatment site. These data indicate that winds were predominantly out of the east and south at the time of the application, ranging in speed from approximately 4 to 11 mph during herbicide application. Over the next 14 hours following application, the winds remained relatively light with speeds recorded at 4-7 mph. These data indicate that wind-driven water movement in Shawano Lake during the application where highest, with relatively light winds occurring approximately half-way through the treatment through the next 14 hours.

Figure 5. Applicator track and herbicide concentration monitoring locations.

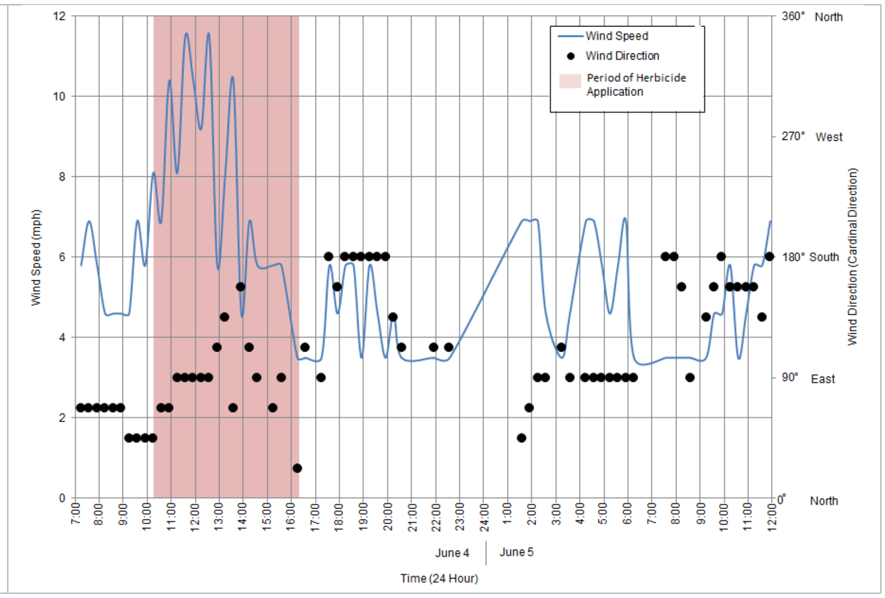

Figure 6. Wind speed and direction approximately 4 hours before and 14 hours after herbicide was applied on Shawano Lake. Graph created using data from Weather Underground Station

5.0 POST TREATMENT MONITORING RESULTS

5.1 Herbicide Concentration Monitoring Results

Spot treatments, the strategy utilized for the trial treatment on Shawano Lake, 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 effects outside of that area. Herbicide application rates for spot treatment are formulated volumetrically, typically targeting EWM with 2,4-D at 3-4.0 ppm acid equivalent (ae). This means that sufficient 2,4-D is applied within the *Application Area* such that if it mixed evenly with the

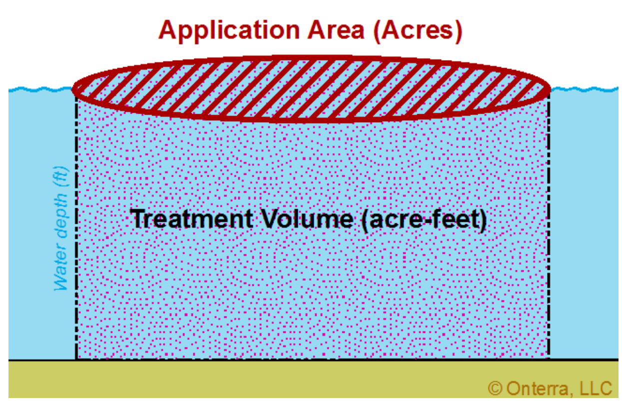

Figure 7. Herbicide Spot Treatment diagram.

Treatment Volume, it would equal 3-4.0 ppm ae. This standard method for determining spot treatment use rates is not without flaw, as no physical barrier keeps the herbicide within the *Treatment Volume* and herbicide dissipates horizontally out of the area before reaching equilibrium (Figure 7). While lake managers may propose that a particular volumetric dose be used, such as 3-4.0 ppm ae, it is understood that actually achieving 3-4.0 ppm ae within the water column is not likely due to dissipation and other factors.

The target liquid 2,4-D concentration for the 2014 trial spot treatment was 3.0 ppm ae. Collection of water samples began 1 hour after the treatment started (HAT), and herbicide was not detected at any of the four sampling locations until 3 HAT with an average concentration of 0.6 ppm ae (Figure 8 and Figure 9). This may be explained by the applicator working from west to east and not having yet applied any herbicide near the monitoring locations during the early sample collections.

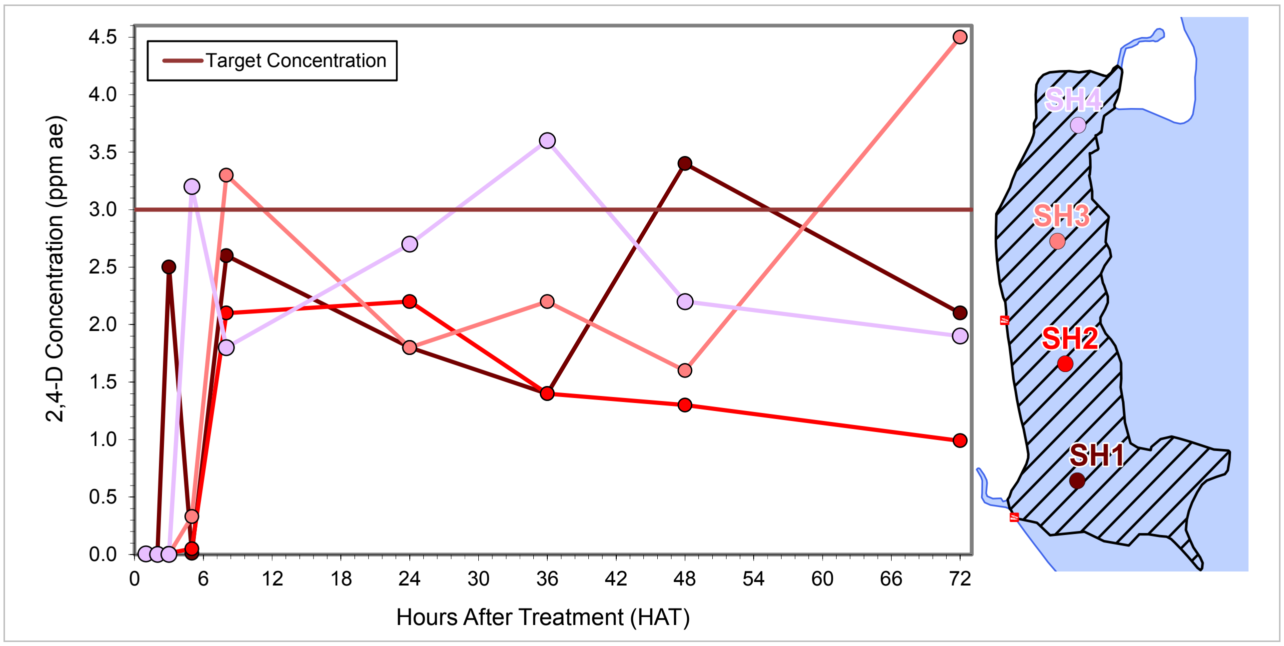

Figure 8. Shawano Lake 2014 trial spot treatment 2,4-D concentrations from four sampling locations from 1 to 72 hours after treatment.

By 8 HAT, the mean 2,4-D concentration had increased to 2.5 ppm ae, with concentrations ranging from 3.3 ppm ae at site SH3 to 1.8 ppm ae at SH4. The average 2,4-D concentration from 8 to 72 HAT remained relatively constant, with an average of 2.2 ppm ae. Overall, the herbicide concentration monitoring data indicate that concentrations from 1-72 HAT were slightly below the target concentration of 3.0 ppm ae. This was likely due to some herbicide dissipation outside of the area where it was directly applied. Ongoing research indicates that herbicide quickly dissipates and dilutes from spot treatments, especially small spot treatments (less than 5 acres). This was the first treatment site of this size where comprehensive herbicide concentration monitoring occurred. These data confirm preliminary findings that large treatment sites maintain herbicide concentration-exposure times (CET) longer that smaller sites. The CETs observed are likely also impacted by lack of water exchange in this area due to east, southeast winds creating eddy effects.

The volunteers that collected the herbicide concentration samples also collected water temperature data at each of the four sampling locations following the treatment. Average water temperature increased from 22.1°C (71.8°F) at 1 HAT to 24.0°C (75.2°F) 8 HAT (Figure 10). Water temperature then declined slightly and ranged from 21.6°C (70.9°F) to 23.1°C (73.6°F) from 24-72 HAT.

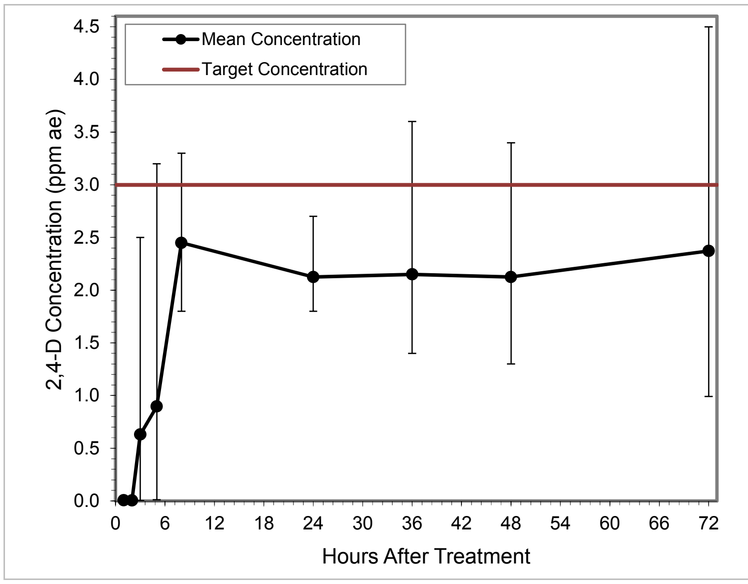

Figure 9. Shawano Lake 2014 trial spot treatment mean 2,4-D concentrations from four sampling locations from 1 to 72 hours after treatment. Error bars represent minimum and maximum values.

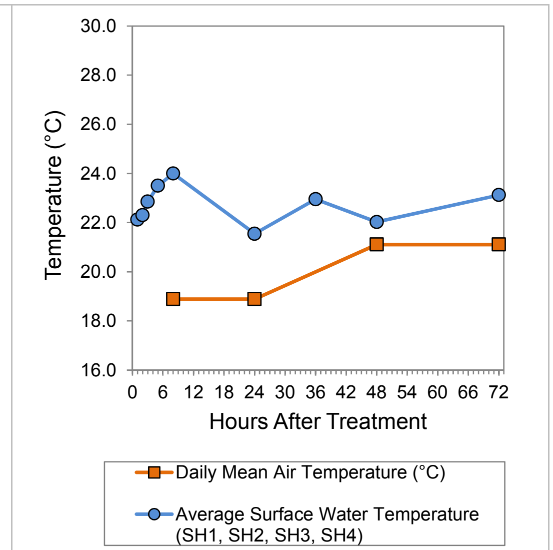

Figure 10. Average surface water temperature and air temperature following the 2014 trial spot treatment. Daily mean air temperature data obtained from the National Weather Service.

5.2 Aquatic Plant Monitoring Results

5.2.1 Efficacy

In the spring of 2014 prior to treatment, EWM was located at 161 (80.1%) of the 201, 50-meter resolution point-intercept sub-sample locations located within the 2014 treatment area (Figure 11). Following the 2014 treatment, the EWM was located at 35 (17.4%) of the 201 point-intercept sampling locations, representing a statistically valid reduction in occurrence of 78% (Chi-square $\alpha = 0.05$) and exceeding the pre-determined quantitative success criterion (75% reduction).

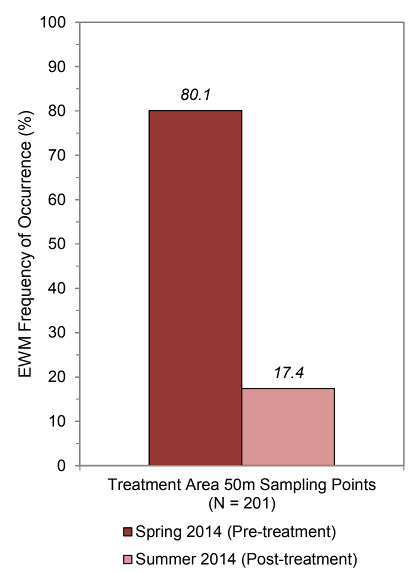

Figure 11. EWM frequency of occurrence of sub-sample locations

Qualitatively, 97.6% of the EWM acreage within the 2014 trial treatment area saw a reduction of at least two density ratings following the treatment, meeting the pre-determined qualitative success criterion (Figure 12). Prior to treatment, this area contained approximately 115 acres of dominant, highly dominant, and surface matted EWM. Following the treatment, approximately 2 acres of dominant EWM remained, along with approximately 8 acres of scattered and highly scattered EWM.

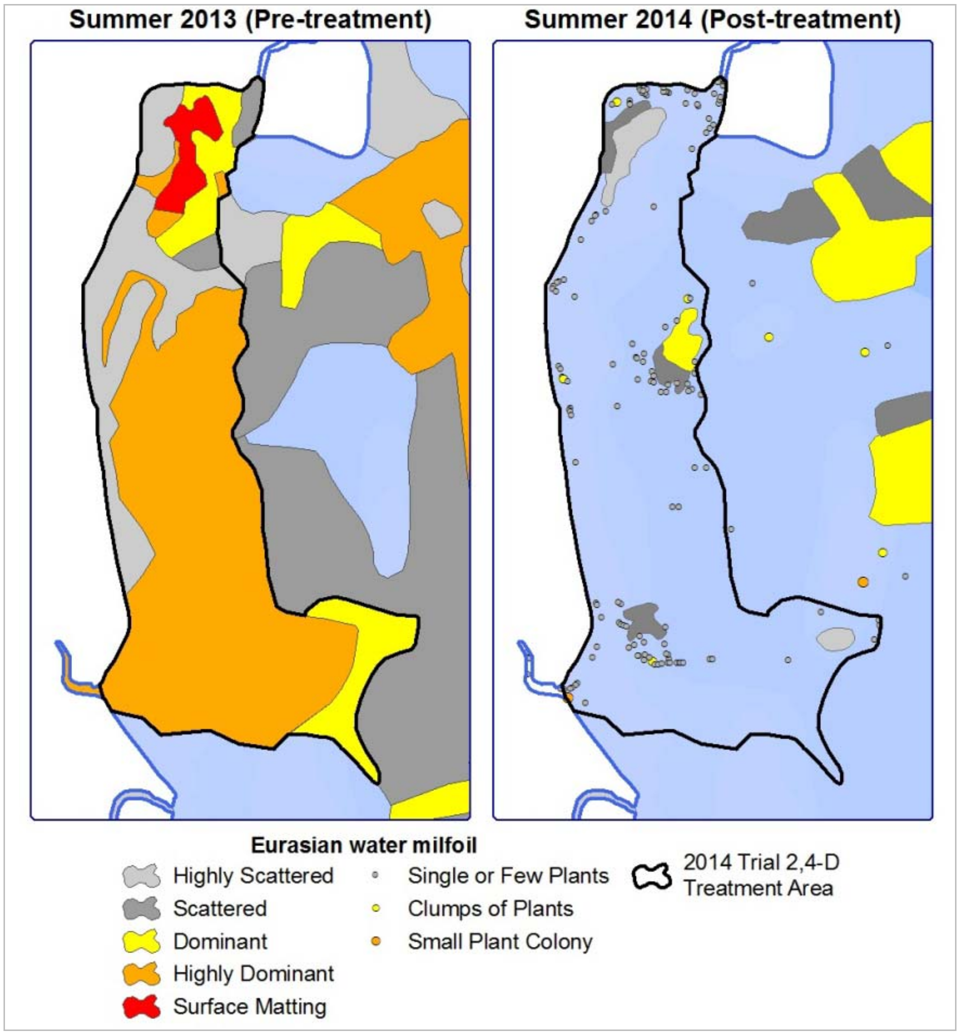

Figure 12. Locations of EWM within the 2014 trial 2,4-D treatment area in the summer of 2013 and summer 2014. Created using data collected during 2013 and 2014 Late-Summer EWM Peak-Biomass Surveys.

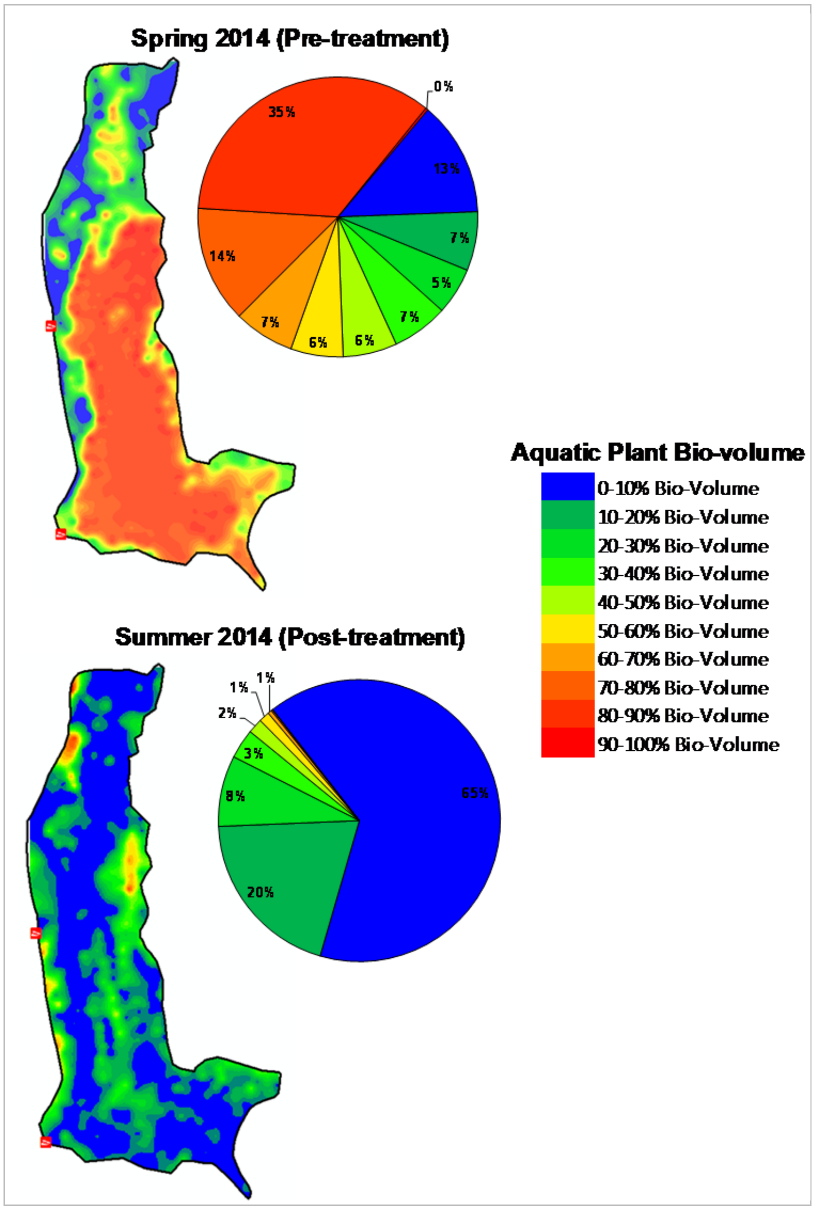

Figure 13. Shawano Lake 2014 trial 2,4-D treatment area aquatic plant bio-volume pre- and post-treatment. Created using data from May and September 2014 acoustic survey data.

In the spring of 2014 prior to treatment and the summer of 2014 following the treatment, Onterra ecologists conducted acoustic surveys with two primary goals: 1) to obtain accurate bathymetric data for the proposed 2014 trial treatment area to ensure accurate herbicide dosing, and 2) to document the change in aquatic plant bio-volume from before and after the treatment. Aquatic plant bio-volume is measured as a percentage of the water column that is occupied by aquatic plants. The results of these surveys are displayed in Figure 13, and as illustrated, areas where aquatic plants occupy the majority of the water column are indicated in areas of orange/red while areas with little to no aquatic plant growth are indicated by green/blue.

Prior to treatment, approximately 62% of the 2014 trial treatment area contained aquatic plant bio-volume of 50% or greater, while 35% contained aquatic plant volumes of 80-90% (Figure 9). It is assumed that the areas of highest bio-volume recorded during this survey were comprised of EWM because most native aquatic plants were not actively growing at this time and these areas of highest bio-volume align well with the densest areas of EWM mapped in the summer of 2013. Following the treatment, the summer 2014 survey revealed that approximately 2% of the trial treatment area contained aquatic plant bio-volume of 50% or greater, and 65% of the area contained aquatic plant bio-volumes of 0-10% indicating a large reduction in aquatic plant bio-volume. Comparing the 2014 EWM mapping survey results (Figure 12, map on right) with where the highest bio-volumes during the late-summer of 2014 (Figure 13, map on bottom), it appears that the remnant EWM occurrences comprise the high biomass locations. To some degree this was expected, as the dense monoculture of EWM that existed within this area had likely displaced most native species over time. Additional time will be needed for the native plants to reclaim this part of the lake.

5.2.2 Selectivity

As discussed, data regarding the presence of native aquatic plants were not recorded at the 201, 50-meter resolution sub-sampling point-intercept locations during the spring 2014 pre-treatment survey because most of these plants were not yet actively growing. However, native aquatic plant data were recorded in the summer of 2013 at 63, 165-meter resolution point-intercept locations within and around the immediate area of the 2014 treatment as part of the comprehensive whole-lake point-intercept survey (Figure 3). Following the treatment in the summer of 2014, data regarding both EWM and native aquatic plants were again collected at these 63 locations. The frequency of occurrence of EWM and native aquatic plant species with an occurrence of at least 5% in either survey is shown in Figure 14. Eurasian water milfoil exhibited a statistically valid reduction of 63% following the treatment within this dataset (includes sampling locations within and in proximity to the 2014 treatment area), declining from an occurrence of approximately 48% in 2013 to 18% in 2014.

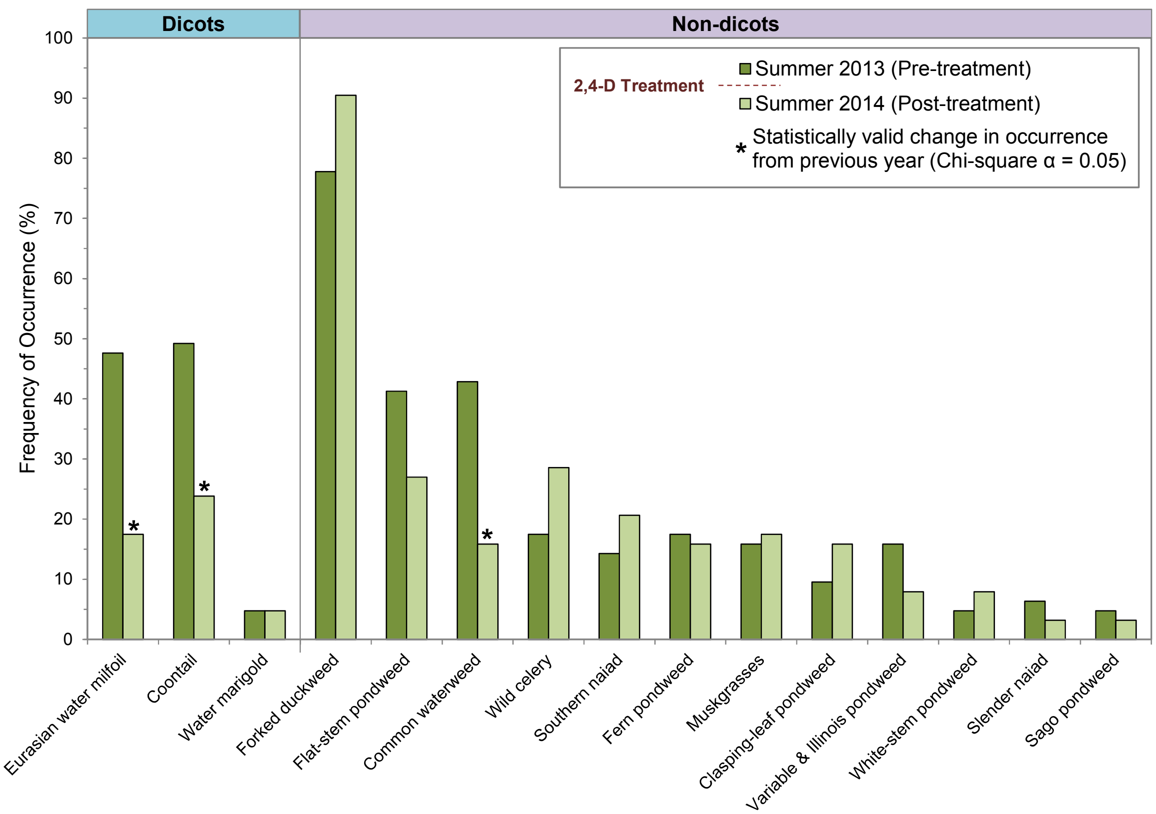

Figure 14. Pre- and post-treatment frequency of occurrence of aquatic plant species within and around the 2014 trial treatment area. Only those species with an occurrence of at least 5% in one of two surveys are displayed. Created using data from 63, 165-meter resolution point-intercept survey locations.

In addition to EWM, two native aquatic plant species exhibited statistically valid reductions in their occurrence following the treatment: coontail and common waterweed. Coontail exhibited a 52% reduction in occurrence following the treatment and common waterweed was reduced by 63% following the treatment. Ongoing research confirms that these species are frequently impacted by early-season herbicide treatment strategies of EWM. Reductions of these species may be two fold. First, these species are actively growing at the time of the treatment, particularly when water temperatures exceed 65°F, making them vulnerable to the control strategy. Secondly, these plants are largely non-rooted or loosely-rooted species that may have been utilizing the dense milfoil canopy as habitat during the summer prior to the treatment. With this “substrate” removed, these species may inherently not perform as well in the absence of EWM.

While two native aquatic plant species exhibited declines following the treatment, the occurrences of the other 12 native species were not statistically different from before and after the treatment (Figure 14).

5.3 Lake-Wide EWM Assessment

In 2014, surveys were not only aimed at assessing the 2014 trial 2,4-D treatment, meander-based surveys were conducted to understand the EWM population throughout the entire lake. Map 1 illustrates that there was approximately 1,881 acres of colonized EWM in Shawano Lake in 2013. In 2014, surveys found that this was reduced by over 600 acres to approximately 1,215 acres in 2014 (Figure 11 and Map 2). Of this 600-acre reduction, at least 140 acres can be attributed to the 2014 trial treatment in the western portion of the lake. Comparing Maps 1 and 2, reductions of colonized EWM were observed in adjacent areas to the trial treatment as sufficient herbicide CETs were likely met in these areas as well. Additional reduction in acreage can likely be attributed to environmental conditions of the 2014 growing season – the ice-out was later than average in 2014 and the summer was cooler than average. Eurasian water milfoil growth, and growth of many native aquatic plants, was observed to be less in many lakes throughout Wisconsin in 2014.

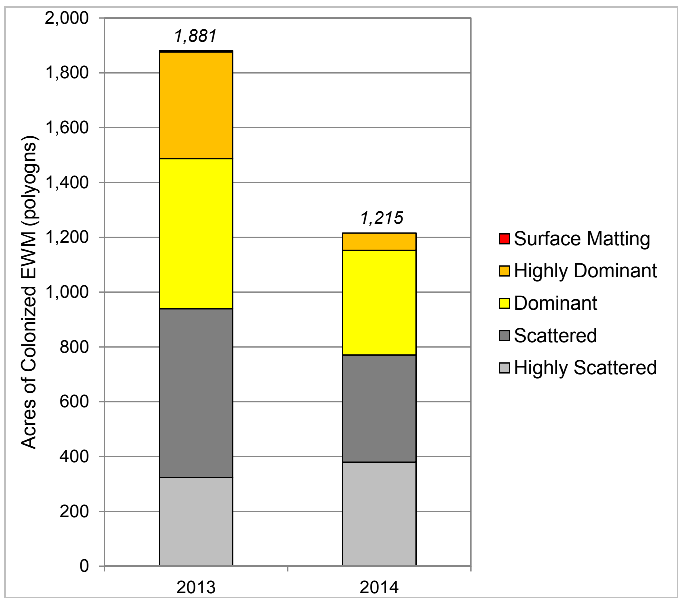

Figure 11. Acreage of colonized EWM in Shawano Lake in 2013 and 2014. Created using data from Onterra 2013 and 2014 summer surveys.

6.0 CONCLUSIONS AND DISCUSSION

All metrics examined demonstrate that the 2014 trial treatment on Shawano Lake was successful. As outlined within the Introduction Section (1.0), the 2014 trial treatment was designed to address several of the predetermined implementation challenges that SAWM faced before conducting a large-scale EWM control program. This section will specifically outline the three implementation challenges addressed by the trial treatment and the subsequent stakeholder involvement that will be needed to work towards a large-scale EWM control program in 2016.

6.1 Implementation Challenges Addressed

6.1.1 Efficacy Concerns

The trial treatment exceeded the pre-determined success criteria for both the qualitative and quantitative monitoring components. Measured herbicide concentrations support that large spot treatments can hold sufficient concentration-exposure times (CET) for a successful spot treatment. The success of this treatment indicates that a large-scale spot treatment strategy may be an effective management tool for targeting areas EWM elsewhere in Shawano Lake. However, before future treatment strategies are implemented, more information is needed regarding the genetic composition of the EWM population in Shawano Lake and its response to various concentrations and types of herbicides.

As discussed, genetic analysis has indicated that Shawano Lake contains populations of both pure-strain EWM and populations of HWM. The concept of heterosis, or hybrid vigor, is important in regards to HWM management on Shawano Lake. The root of this concept is that hybrid individuals typically have improved function compared to their pure-strain parents. Hybrid water milfoil typically has thicker stems, is a prolific flowerer, and grows more rapidly than pure-strain EWM (LaRue et al. 2012). Data gathered from whole-lake 2,4-D treatments in Wisconsin from 2009-2013 suggest that treatments on lakes with populations of HWM were not as successful when compared to lakes with pure-strain EWM. In other words, it appears that some strains of HWM, but not all, are more tolerant of 2,4-D treatments than pure-strain EWM. Hybrid water milfoil can be controlled by 2,4-D, but the concentrations required to do so would also impact native aquatic plants beyond "acceptable" levels.

To determine if the milfoil in Shawano Lake consists of herbicide-tolerant strains, laboratory studies termed "challenge testing" can be conducted. SePRO, one of the companies that produces aquatic and terrestrial herbicides, has the ability to conduct baseline challenge testing (PlanTEST) of the milfoil on the herbicide products they manufacture (2,4-D – Sculpin®, triclopyr – Renovate®, and fluridone – Sonar®). In the late summer of 2014, members from SePRO and Clean Lakes, Inc. collected hundreds of live milfoil apical stems from six locations, three in the northwest and three in the eastern area of the lake, and sent them to the SePRO Research and Technology Campus for herbicide challenge testing. Plants from each of the six locations were also sent to the Annis Water Resources Institute at Grand Valley State University in Michigan for DNA analysis.

The DNA analysis conducted at Grand Valley State University found that all six plants were comprised of pure-strain EWM individuals. This suggests that a large component of the milfoil population in Shawano Lake may be comprised of pure-strain EWM; however, some of the population is likely comprised of hybrid individuals. The results of the herbicide challenge testing on these plants are not yet available, but once the response of these plants to the challenge testing is understood, appropriate EWM control strategies can begin to be developed.

6.1.2 Ecological Response

Only two native aquatic plant species, coontail and common waterweed, exhibited declines in occurrence following the 2014 trial treatment. As explained within the Post Treatment Monitoring Results Section (5.2.2), these species are largely non-rooted plants that produce large floating mats in some parts of the lake. Because of the impediment to navigation caused by these species, SAWM's 2014 APM Plan outlines a strategy to use their mechanical harvesting equipment to pick up these *floaters* using the shallowest setting on their equipment. During the 2013 whole-lake point-intercept survey, these were the third (coontail) and sixth (common waterweed) most abundant plant species within the lake. While some losses in these species may have been observed within the trial treatment area, ample population of these species exists in the remainder of the lake.

The susceptibility of these two species to particular herbicide control actions and their large composition of the aquatic plant community of Shawano Lake require additional consideration when planning a large-scale treatment strategy.

6.1.3 Logistic Feasibility (Scale)

The scale of both Shawano Lake and its EWM population are at the foundation of all aspects requiring attention. During the selection of the herbicide application firm to conduct the 2014 trial treatment, SAWM asked perspective applicators to "demonstrate that they have the capacity to conduct both treatments [2014 trial treatment and potential large-scale treatment in 2016]," with selection preference given to that applicator. SAWM's acceptance of the proposal provided by Clean Lakes, Inc. indicates a certain level of confidence exists that the firm can handle implementation of large-scale treatment efforts in 2016. Additional follow-up investigations and discussions regarding herbicide applicator capacity will occur prior to implementation of the large-scale treatment

The success of the 2014 trial treatment indicates that this large spot treatment strategy may be an effective management tool for targeting areas EWM elsewhere in Shawano Lake. Additional consideration will be given to implementing simultaneous spot treatments on Shawano Lake in a large-scale capacity that balances whole-lake equilibrium herbicide concentrations. This strategy may have advantages to contain collateral native plant impacts to areas being treated. The implementation of multiple different herbicide strategies also warrants consideration. Below are a few large-scale management options being considered for Shawano Lake:

- <u>Whole-lake Treatment</u> Targeting colonized EWM within Shawano Lake with an herbicide such that equilibrium whole-lake concentrations meet current operational standards. Within the 2014 APM Plan, attention was given to the use of liquid 2,4-D in whole-lake scenarios to achieve initial concentration of 0.3-0.4 ppm ae throughout the epilimnion. Other herbicide options employed for targeting EWM (particularly hearty strains of HWM) include 1) simultaneous application of liquid 2,4-D & endothall; or 2) fluridone (likely as a liquid formulation, but perhaps in tandem with liquid and pelletized formulations).

- Set of Large Spot Treatments Utilizing Liquid 2,4-D This management technique would be similar to the trial treatment conducted in 2014, but targeting more location throughout the lake. The treatment sites would be targeted with liquid 2,4-D, setting target treatment site concentrations of 3.0-4.0 ppm ae. This would differ from a whole-lake strategy because whole-lake herbicide concentrations would be below levels (<0.2 ppm ae) that would cause sustained impact to native and non-native plant species outside of the areas where the herbicide was directly applied.

Additional discussion will take place whether the success observed during the 2014 trial treatment can be extrapolated to other locations in Shawano Lake. Two of the five justifications for selecting the location of the 2014 trial treatment where based upon conditions that were most likely to result in an effective treatment:

- It is a large, contiguous area of high density EWM.
- It is located within an area where greater herbicide exposure time is anticipated as opposed to the center of lake where it would be more exposed to wind/wave action.

The EWM colonies along the eastern shoreline near the Village of Cecil also fit these parameters, but many of the other EWM colonies do not. In treatment scenarios where increased dissipation threatens achieving proper concentration-exposure times (CET), a number of additional herbicide use patterns are given consideration. The following two options appear to contain the most applicability to Shawano Lake at this time:

- Set of Large Spot Treatments Utilizing Pelletized Fluridone Fluridone is a slow-acting enzyme inhibitor that specifically disrupts photosynthetic pathways (carotenoid synthesis inhibitor) in aquatic plants. Because the herbicide requires long exposure times (>60 days) to cause mortality to EWM, this herbicide's past use has almost exclusively been in whole-lake liquid treatment scenarios. Several pelletized formulations of fluridone products are available that have differing slow-release capacities for different aquatic plant management and conditions. Technical guidance from the manufacturer (SePRO Corp.) suggests that while a few *booster* or *bump* treatments may be required, a use pattern can be developed that will meet CETs required for EWM control in large spot treatment scenarios. Fluridone has historically been critiqued because of reduced selectivity towards some native aquatic plants. Emerging use patterns of this herbicide, particularly in the pelletized formulation with slightly later start times, appear to demonstrate increased selectivity towards native plants.
- Combination 2,4-D and Endothall An additive or a synergistic advantage is theorized when combining 2,4-D and endothall. The simultaneous exposure to endothall and 2,4-D has been shown to provide increased control of EWM in outdoor growth chamber studies (Madsen et. al 2010). A handful of HWM treatments in Wisconsin utilizing this strategy have been conducted to date with promising results of control and selectivity, even in medium-sized (15-acre) spot treatment scenarios.

6.2 Stakeholder Components

Because the trial treatment satisfactorily addresses the first three implementation challenges listed above, it is anticipated that a positive feedback loop of sociological backing (stakeholder support) resulting in additional financial contributions (e.g. individual, municipal, business, agency, etc.) for implementation of a large-scale treatment strategy would occur. The proper monitoring of the trial treatment produced sound data on the management action that will be presented to the general public through a distributed written report (this document) and potentially several informational meetings. Along with conveying this information to the public, additional awareness campaigns, including an anonymous, written stakeholder survey, would be conducted to understand the broader wishes of the Shawano Lake user group.

6.2.1 Stakeholder Survey

During the early summer of 2015, comments and opinions would be solicited from Shawano Lake stakeholders to gain important information regarding their understanding of the lake and thoughts on how it should be managed. The information would be collected through a written survey/comment form made available either as an online survey or a paper version. This information would be critical to the development of a realistic plan by supplying an indication of the needs of the stakeholders and their perspective on the management of the lake. The stakeholder survey would be developed by Onterra with involvement from the SAWM AIS Workgroup with additional input from UW–Extension and Wisconsin Lakes as appropriate. The WDNR would also review and approve the survey before distribution.

6.2.2 Informational Opportunities

In addition to the general membership meetings, public awareness of the project would be promoted by association-submitted news releases to local newspapers.

- ***Late Fall/Early Winter 2014-15***
  - Release would contain information regarding project and results of 2014 trial treatment
  - Potentially, this would lead to interview-based article by newspaper
- ***Summer 2015***
  - This release would disclose more definition about the large-scale treatment options that are being considered in 2016
  - Expected benefits and potential risks would be discussed
  - Project costs would be outlined
  - Public information meeting discussed below would be announced
- ***February 2016***
  - Release would contain information regarding proposed control in spring 2016
  - Early spring public information meeting would be announced

Informational meeting are tentatively planned for summer 2015 and early-spring 2016

- ***June/July 2015***
  - Duplicate meetings would be held; one during a weekday evening and one on a weekend
  - Presentation content would include:
    - Benefits and risks of utilizing herbicides on spot and whole-lake treatment levels

- Proposed treatment plan for Shawano Lake during 2016
- Importance and contents of written stakeholder survey

- ***Public Information Meeting – Early Spring 2016***
  - Meeting would layout specific plan for AIS control in 2016

6.3 Large-Scale Treatment Implementation Planning

The stakeholder components outlined within the previous sub-section (6.2) will inform SAWM about whether Shawano Lake stakeholders are in favor of moving forward with large-scale EWM management. If sufficient stakeholder buy-in and resulting funding capability occur, SAWM will move toward the implementation of a large-scale treatment strategy in the following season. The tentative outline is for this level of support and financial capabilities to come to fruition during 2015, with large-scale management occurring during the spring of 2016. SAWM understands that it may need to shift these activities to the future in 1-year increments if stakeholder buy-in and financial capabilities are not understood by the middle of summer prior to treatment. This is largely because a series of pretreatment plant surveys will be required to be conducted during the summer prior to implementing a large-scale treatment. The surveys (Late-Summer EWM Mapping Survey and EWM Mapping Survey) need to be completed by the end of the growing season, preferably by the second week in September. If SAWM does not feel they will gain support for a spring 2016 treatment by the middle of summer 2015, it would be in their best interest to forego the 2015 pretreatment aquatic plant surveys. They could be then completed during the late-summer of 2016 in preparation for an early-spring 2017 treatment.

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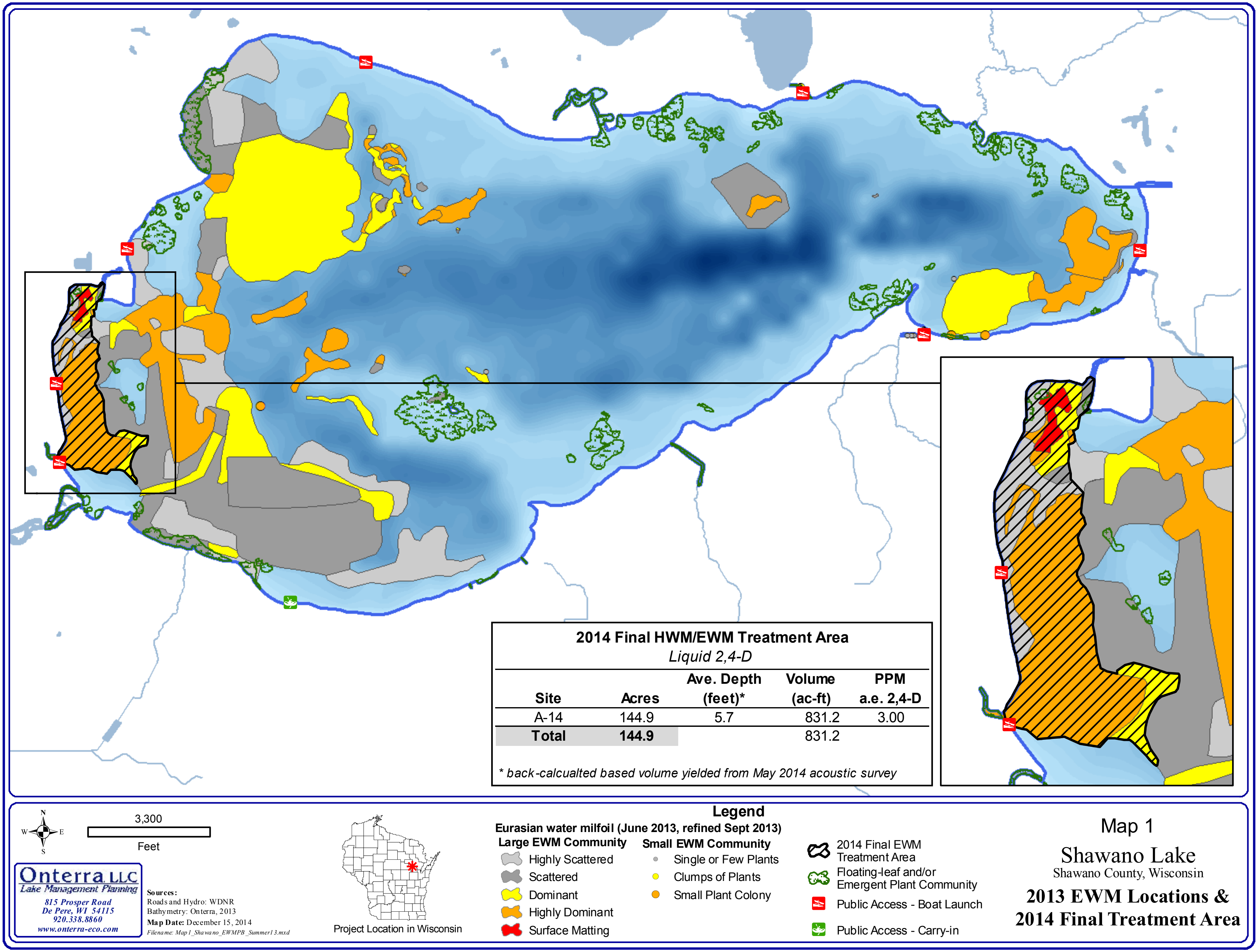
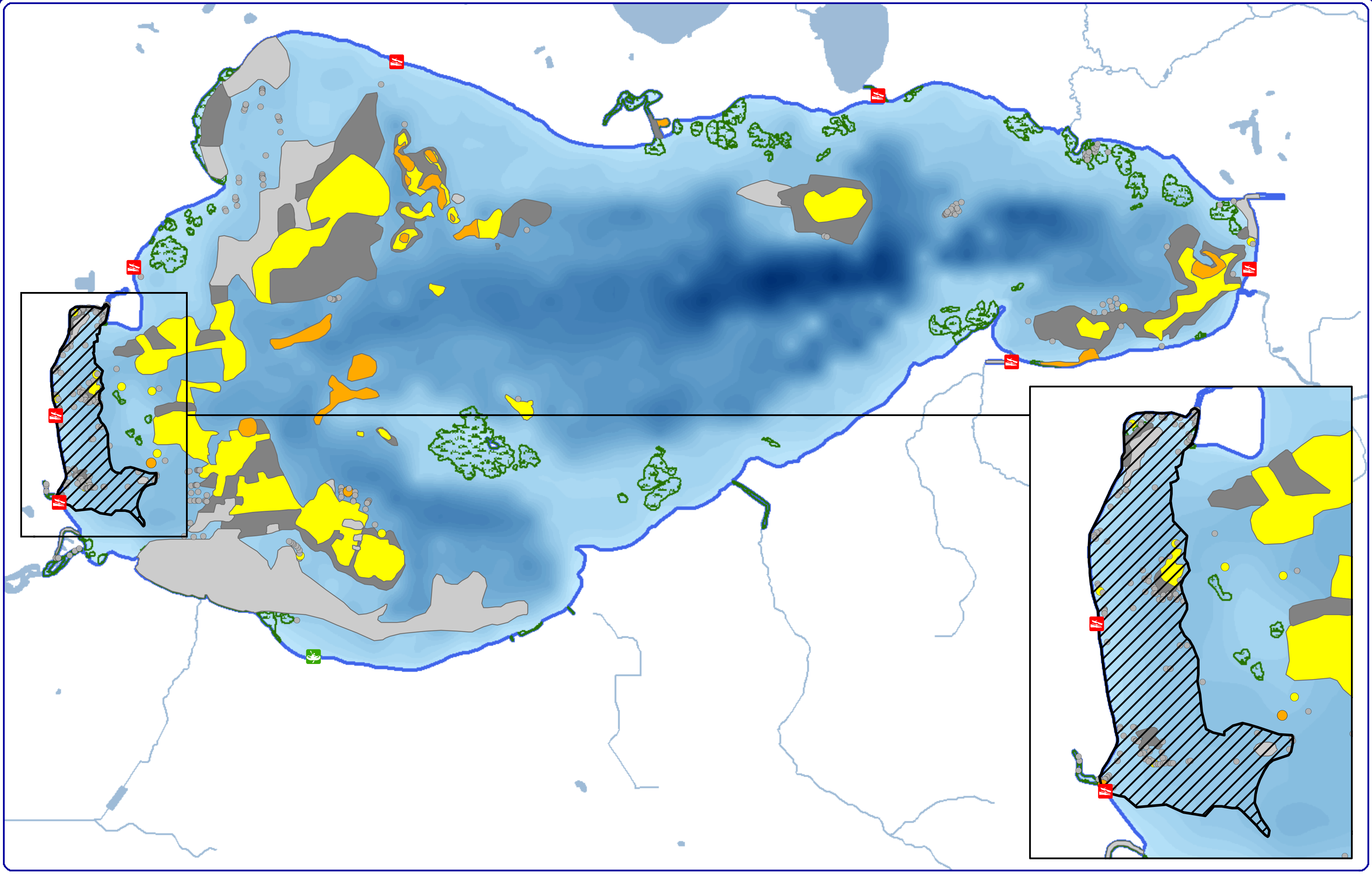


2014 Final HWM/EWM Treatment Area

Liquid 2,4-D

Site	Acres	Ave. Depth (feet)*	Volume (ac-ft)	PPM a.e. 2,4-D
A-14	144.9	5.7	831.2	3.00
Total	**144.9**		831.2	

** back-calcualted based volume yielded from May 2014 acoustic survey*



Legend

Eurasian water milfoil (June 2014, refined Sept 2014)

Large EWM Community
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting

Small EWM Community
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

- 2014 Final EWM Treatment Area
- Floating-leaf and/or Emergent Plant Community
- Public Access - Boat Launch
- Public Access - Carry-in

3,300
Feet

Project Location in Wisconsin

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

Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra, 2013
Map Date: December 15, 2014
Filename: Map1_Shawano_EWMPB_Summer13.mxd

Map 2

Shawano Lake

Shawano County, Wisconsin

2014 EWM Locations