Anvil Lake

Vilas County, Wisconsin

2017-2019 Final EWM Monitoring & Control Strategy Assessment Report

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Created by: Todd Hanke, Eddie Heath, and Tim Hoyman
Onterra, LLC
De Pere, WI

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1.0 INTRODUCTION

Anvil Lake, Vilas County, is an approximate 357-acre mesotrophic seepage lake with a maximum depth of 30 feet (measured in 2014) and a mean depth of 19 feet (Figure 1.0-1). The lake harbors a high-quality native aquatic plant community with 37 native species, 22 of which have a coefficient of conservatism of 7 or higher. Anvil lake also contains a population of Vasey's pondweed (*Potamogeton vaseyi*), a native aquatic plant listed as special concern in Wisconsin due to its relative rarity. The lake has high water clarity, with an average summer Secchi disk depth of 12 feet.

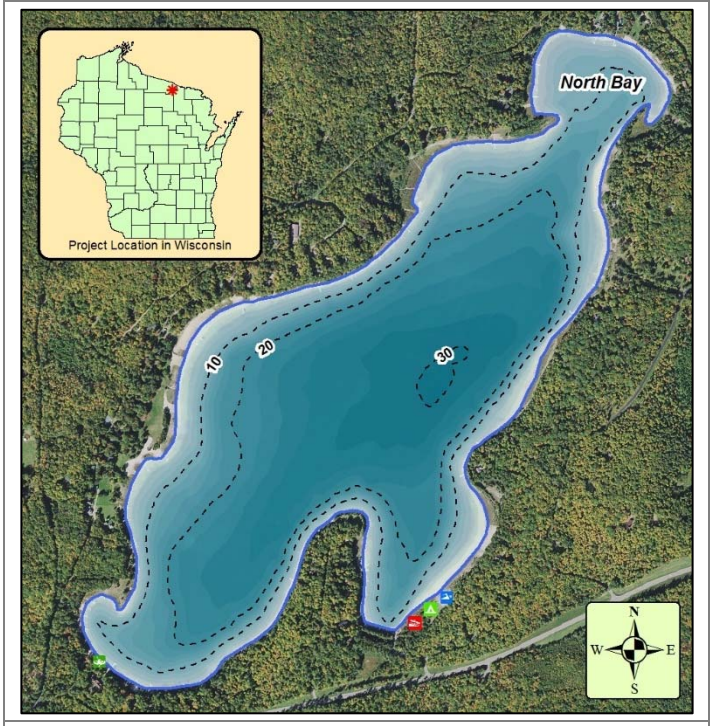


Figure 1.0-1. Anvil Lake, Vilas County, Wisconsin.

The non-native, invasive aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*; EWM) was discovered in Anvil Lake in the summer of 2012 by Great Lakes Indian Fish and Wildlife Commission (GLIFWC) staff. After being made aware of GLIFWC's discovery, the Wisconsin Department of Natural Resources (WDNR) completed a whole-lake aquatic plant point-intercept survey that same summer which confirmed additional occurrences of EWM within the lake's approximate 25-acre northern bay (North Bay). The Anvil Lake Association (ALA) contracted with Onterra, to map the EWM in Anvil Lake in August of 2012 with guidance from ALA volunteer monitoring locations. The 2012 WDNR point-intercept survey indicated that the EWM population was small, with a littoral frequency of occurrence of just 0.5%. Similarly, Onterra's 2012 mapping survey found that the EWM population was mainly isolated to North Bay and largely comprised of single-plant occurrences.

Like many other seepage lakes in Wisconsin, Anvil Lake experiences more dramatic fluctuations in water levels through time when compared to lakes that receive surface water inflow and outflow (drainage lakes). There is a long, mostly continuous, record of lake levels for Anvil Lake spanning from 1936 to present (Figure 1.0-2). Some of the lowest water levels on record occurred approximately from 2004-2015. Since 2015, water levels have risen approximately four feet and as of 2019, are closer to the historical average depths observed during the first 50 years of available data. The lake level in 2019 is at the highest it has been in a period of 32 years dating back to 1987. Record rainfall in many parts of Wisconsin in 2019 contributed to the relatively rapid increase in water depth in Anvil Lake during the year.

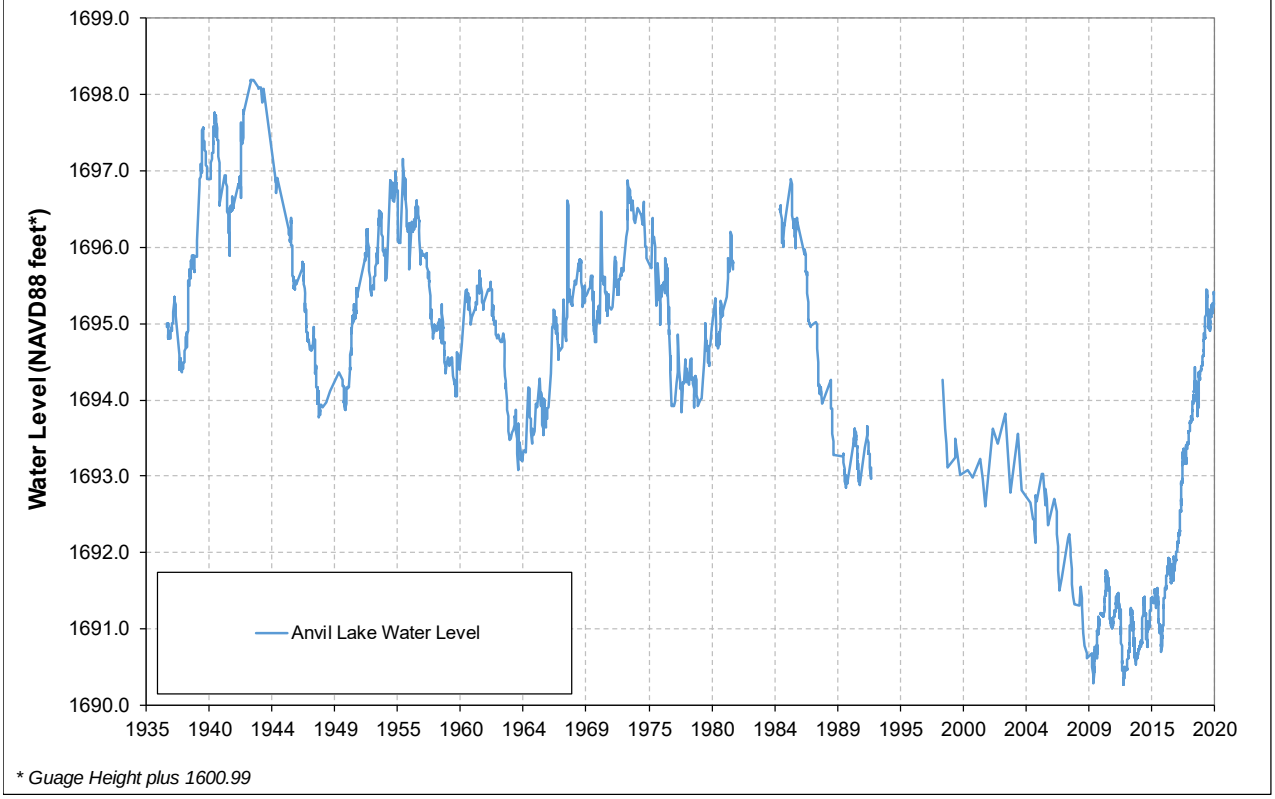


Figure 1.0-2. Anvil Lake water levels from 1936 through 2019. Created using online data from USGS Gage 05390500 with additional data and benchmarks provided by Dale Robertson, USGS).

1.1 Historic AIS Management

Following initial detection, the ALA elected to implement traditional (non-mechanical) hand-harvesting using volunteers and professionally-operated diver-assisted suction harvesting (mechanical; DASH) to remove EWM from Anvil Lake. While these control efforts have likely slowed the pace of the spread and expansion of the EWM population, they have been unable to maintain or reduce the population of EWM in Anvil Lake. Professional monitoring surveys completed annually from 2012-2016 showed that most of the EWM expansion has occurred within North Bay. Sub-sample point-intercept survey data collected within North Bay showed that the occurrence of EWM increased from 4% to 57% from 2012-2016. The inability to maintain or reduce the level of EWM in Anvil Lake during this timeframe is an indication that the rate of expansion of the EWM population was exceeding the pace of removal efforts.

In 2014, the ALA was awarded a WDNR AIS-Education, Planning and Prevention (EPP) Grant to aid in funding a project aimed at creating an updated *Comprehensive Management Plan*, building off previous studies and management plans. While the management planning update project involved the collection of a wide variety of data to gain a more holistic understanding of the Anvil Lake ecosystem, one of the primary objectives of the project was to reassess the ALA's EWM management strategy and develop a long-term monitoring and management strategy for AIS.

The *Comprehensive Management Plan* (Jan 2018) included the development of a more aggressive EWM hand-harvesting control strategy for Anvil Lake. The strategy involved a three-year trial program from

2017-2019 to evaluate the effectiveness of using a combination of paid and volunteer DASH and traditional hand-removal implemented at a much higher level of effort than what had been conducted from 2013-2016. The ALA received a series of grants to fund the hand-harvesting (ACEI-194-17) and monitoring (AEPP-497-17) aspects of the three-year trial program. The trial program proposed implementing a total of 350 hours of EWM harvesting each year with annual revisions being made to the amount of time allocated to DASH versus traditional hand-harvesting based on the level of EWM. The objective of this project is to determine whether or not this increased level of hand-harvesting effort can reduce and maintain an EWM population to a level which exerts little to no detectable impact on the lake's ecology, recreation, and aesthetics.

In addition to monitoring Anvil Lake's EWM population and developing control strategies, this project also includes continued monitoring of the lake's non-native curly-leaf pondweed (*Potamogeton crispus*; CLP). Curly-leaf pondweed was discovered in Anvil Lake in 2013, and its population has since remained small. Continued monitoring of the CLP population will yield information on its dynamics in Anvil Lake and allow for active management techniques to be developed in the event the population expands.

During the final year of the project (2019), a whole-lake point-intercept survey was conducted to understand changes in the aquatic plant population during this time period. Also, during 2019, the ALA solicited riparian stakeholder input by sending out a written stakeholder survey to judge the level of support for continued EWM management and support for alternative management strategies (e.g. herbicide treatment, mechanical harvesting). Based on the data collected over the three-year project, the ALA would revisit their management plan as it applies to Eurasian watermilfoil control and monitoring. This report serves as the final report for the three-year (2017-2019) AIS monitoring and control project.

1.2 2019 EWM Population Management Strategy

The ALA's *Comprehensive Management Plan for Anvil Lake* (January 2018) outlines criteria for initiating the various levels of hand-harvesting within Anvil Lake:

- Using EWM findings from the most recent Peak-Biomass Survey, professional ecologists will work with the ALA to delineate priority areas within the North Bay over the winter months. Those areas containing EWM populations of *dominant* density or greater would be targeted first by the DASH operations as they exert the greatest ecological strain and are the largest sources for future spread. Volunteer-based efforts using snorkelers would occur in the shallow margins of the lake.
- The isolated EWM occurrences outside of the North Bay would be categorized based upon the level of EWM within each area. Sites containing *small plant colonies* would be classified as areas requiring the greatest need for hand-removal, or primary focus sites, while areas containing *clumps of plants* and only *single or few plants* would be classified as secondary and tertiary focus sites, respectively.

Given the large, dense population of EWM in North Bay, it was not believed that DASH can achieve the original goal of reducing (or maintaining) the EWM population in North Bay. The management goals were adjusted since the start of the project as a result of the expanding EWM population and as the ALA has gained experience. The aim of the project was re-directed from a goal of reducing the EWM population in North Bay to creating navigation lanes through the dense EWM colonies beginning in

2018. Based on the knowledge and experience gained during the first two years of the project, the following objectives were created for 2019:

1. Utilize DASH, including the 'dockside' harvesting method developed in 2018, in the North Bay to maintain open lanes of navigation from shore to open water through dense areas of EWM
2. Utilize DASH in other areas of the lake outside of the North Bay in an effort to reduce EWM expansion or establishment in new locations
3. Utilize traditional hand-harvesting to harvest areas with small, initial infestations of EWM or in any areas where volunteers wish to work.

The 2019 hand-harvesting efforts would be considered successful if they met the management objectives outlined above.

2.0 2019 AQUATIC PLANT MONITORING RESULTS

2.1 2019 Early-season AIS Survey (Pre-Hand-Harvesting)

On June 20, 2019 Onterra ecologists conducted the Early-Season AIS (ESAIS) Survey on Anvil Lake. Field crews noted cloudy conditions during the survey. At the time of the survey, the majority of the EWM population was not visible by viewing from bow of the survey boat due to higher water levels and early growth stage of the EWM plants. Therefore, the field crews deployed submersible cameras in order to locate and map EWM around the lake. The survey results showed the densest area of EWM continued to be within the North Bay of the lake. The survey also found the EWM population expanded in the southwest end of the lake forming a contiguous colony consisting mostly of a scattered density rating (Map 1). During the submersible camera search around the lake, the field crews encountered low-density EWM occurrences forming a nearly complete 'ring' around the lake in depths of approximately 6 to 15 feet of water. The majority of the 'ring' of EWM was designated as *highly scattered* in density, the lowest density rating on the five-tiered scale used in Onterra's mapping methodology. While a natural disturbance, the changing water levels of Anvil Lake may favor EWM expansion.

The survey allowed for lake managers to adjust the final hand-harvesting strategy as appropriate based on the results. This provides the hand-harvesting teams with the most up-to-date and accurate information regarding locations of EWM within the lake. Based upon the findings, no revisions to the hand-harvesting permit were deemed necessary. Continuing efforts on the navigation lanes and giving priority to site A-19 in the southwest end of the lake were suggested as this area contains some similar habitat conditions as the North Bay. The results of the ESAIS Survey were provided to the ALA in the form of electronic maps and the data were digitally formatted into a basemap that was loaded onto the association's GPS unit for their use.

Although typically at its peak growth stage in early summer, no occurrences of CLP were located during the June 2019 ESAIS survey. Since initial discovery in 2014, the CLP population has remained relatively low in Anvil Lake all known occurrences consisting of single plants, clumps of plants, or small plant colonies (Figure 2.1-1). No CLP has been located during the past two surveys; however, it is assumed that CLP remains present in the lake in relatively low levels. Continued monitoring of this species is important to determine whether or not CLP will integrate into the plant community or eventually expand and grow in an invasive manner.

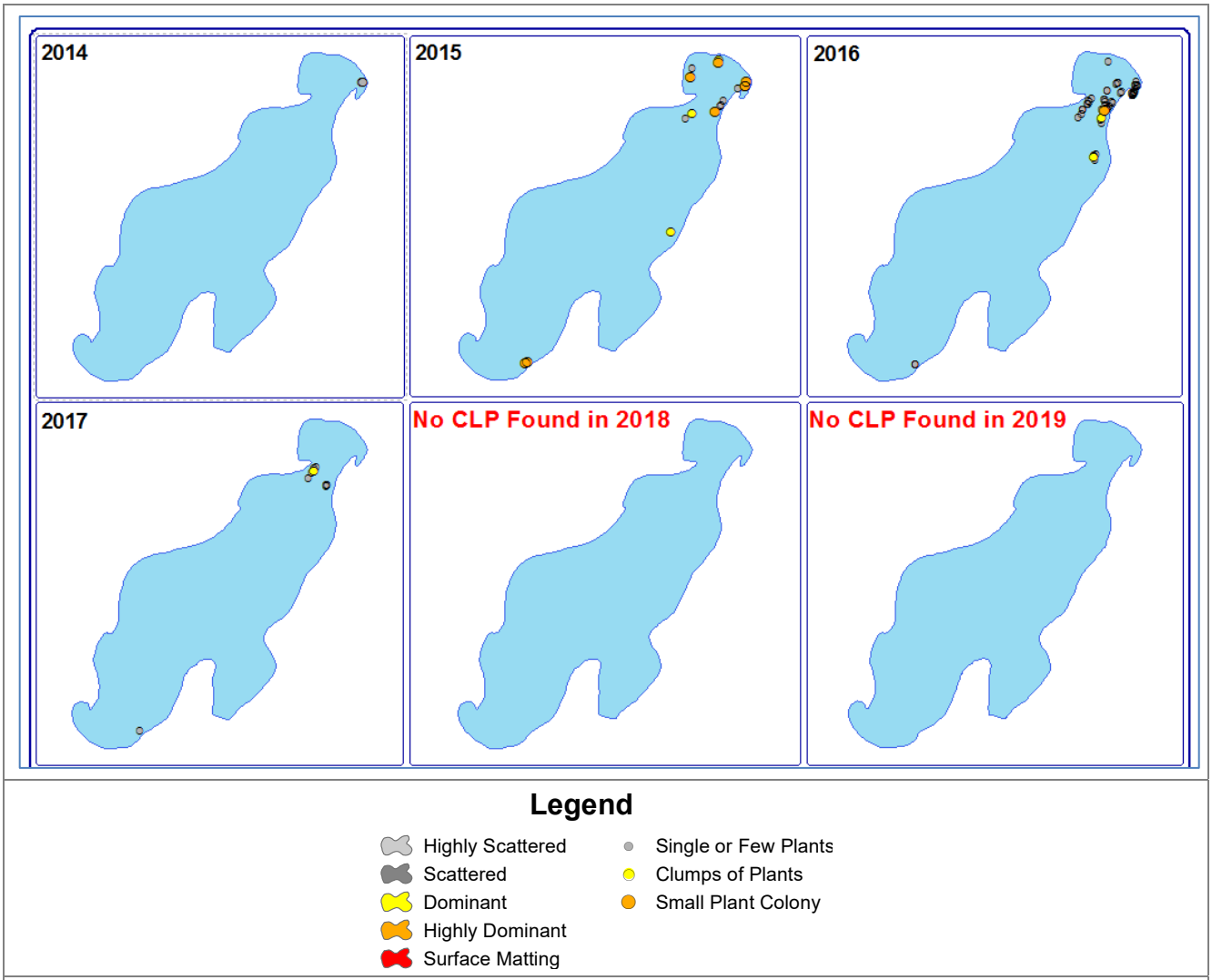


Figure 2.1-1. CLP Population Distribution in Anvil Lake from 2014-2019. Data from annual Onterra Early Season AIS surveys.

2.2 ALA DASH & Hand-harvesting Activities Summary

Over the course of the past three growing seasons spanning from 2017-2019, the ALA invested a great amount of effort in managing the EWM population in the lake through a combination of DASH harvesting, traditional hand-harvesting and monitoring efforts. The ALA also developed a 'dockside' DASH methodology in 2018 that showed promising results. This method included bringing the DASH unit to the edge of a riparian dock and harvesting plants from the immediate vicinity of the dock which provided nuisance relief at the desired location. Table 2.2-1 displays a summary of the number of hours that the ALA invested in DASH efforts and the resulting EWM harvest totals from 2017-2019.

The table does not account for harvesting efforts that utilize traditional techniques (no DASH). Over the course of the past three years, volunteers from the ALA have collectively devoted hundreds of hours of effort each year to harvesting EWM plants in the lake by wading into shallow waters, collecting floating fragments from around the lake, and diving with snorkel or SCUBA gear without the aid of DASH.

Typically, these techniques are employed when DASH in not ideal for the setting, and in areas where the DASH permit did not cover.

Table 2.2-1. Summary of DASH Efforts in Anvil Lake during 2017-2019. Table derived from records submitted by the ALA.

	2017	2018	2019	2017-2019 Total
Hours (DASH)	129.00	182.50	323.75	635.25
Harvest (lbs)	23740.00	22734.00	19371.00	65845.00

Native species by-catch occurs during the harvesting efforts, however the ALA reports that EWM accounts for approximately 95-100% of the harvested biomass based on an inspection of a representative harvest sample bag. The harvested material is trailered and offloaded to a local farmer that is testing the application of EWM as a source of fertilizer.

Detailed records of the DASH harvesting efforts are required as a condition of the WDNR permit. A formal DASH summary report authored by the ALA is attached with this report in Appendix A. The ALA harvest logs indicate that most of the 2019 DASH activities took place in North Bay. A substantial amount of effort was also directed to the southwest end of the lake where the EWM population has been increasing in recent years. In 2019, the total pounds of EWM harvest was lower than previous years despite the fact that more hours of effort took place. As the hand-harvesting strategy has shifted over the course of this project, more efforts were focused within navigation lanes and areas in close proximity to riparians docks, rather than attempting to harvest as much material as possible from a broader area, which likely contributed to the overall reduction in harvested plants. Modest additional efforts took place in other permitted sites during 2019 (Appendix A).

2.3 2019 Late-Season EWM Mapping Survey

Late-Season EWM Mapping Surveys have been completed annually on Anvil Lake since 2012. Initially, the population was largely contained within the North Bay of the lake, however, additional EWM occurrences in the lake have shown signs of establishment in recent years, most notably extending lakeward out from North Bay as well as in the southwest end of the lake (Map 2).

On September 10, 2019, Onterra ecologists conducted the Late-Season EWM Mapping Survey on Anvil Lake. The survey serves to document the EWM population in the lake and to assess whether the hand harvesting strategy has met the goals and objectives for the year. Additionally, the survey results are used to develop a preliminary monitoring and management strategy for the following year. The densest EWM colonies in the lake continue to be found in North Bay, however the EWM colonies in the southwest end of the lake have increased to include areas designated as *dominant* or *highly dominant* densities. A few other relatively small, but *dominant* density colonies were located on the southern end of the lake (Map 3).

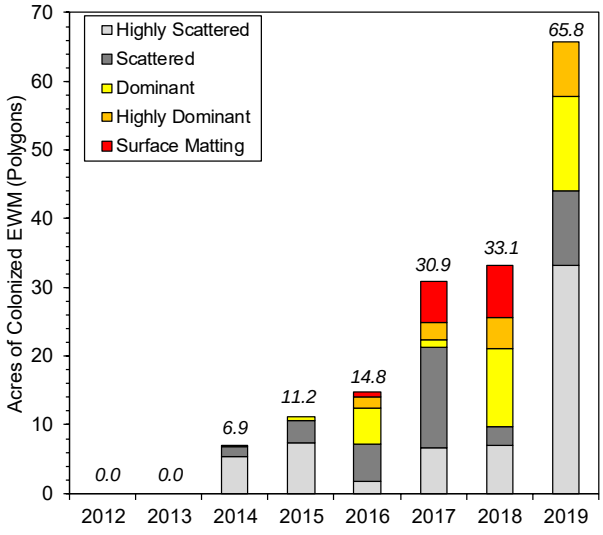


Figure 2.3-1. Anvil Lake acreage of colonized EWM (polygons) from 2012-2019. Created using data from 2012-2019 late-summer EWM mapping surveys.

It is important to note that Figure 2.3-1 displays only those EWM occurrences that were mapped with area-based (polygons) mapping methodologies. No colonized EWM was present until 2014, with 2012-2013 occurrences only consisting of point-based methods (Figure 2.3-1). Colonized EWM increased from just under 7 acres in 2014 to almost 31 acres in 2017, the first year of this three-year trial management program. EWM total acreage remained largely the same from 2017 to 2018, although the density of the EWM during 2018 was much greater. The 2019 Late-Season EWM Mapping Survey indicated a significant increase in the acreage of EWM colonies in the lake compared to the previous surveys (Map 3). The majority of the increase stems from the expansion of areas that had previously harbored EWM in lower densities that required point-based mapping methodologies in previous surveys however they were better represented by a *highly scattered* colony at the time of the 2019 survey. Of the 65.8 acres of colonized EWM mapped in 2019, approximately 21.8 acres consisted of either *dominant* or *highly dominant* densities (Figure 2.3-1).

The majority of the DASH efforts completed in 2019 took place in the North Bay in an effort to create and maintain open navigation lanes from riparian docks, through the dense EWM colonies, and out to deeper waters. The 2019 Late-Season EWM Mapping Survey shows some areas of lower density EWM surrounded by denser colonies located presumably where DASH efforts took place as a part of the navigation lanes.

The ALA prioritized site A-19 in the southwest end of the lake for DASH efforts in 2019 with approximately 44.5 hours of documented DASH time. These efforts yielded a reported 3,194 pounds of EWM harvest (Appendix A). Comparing the 2018 Late-Summer EWM Mapping Survey results with the 2019 Late-Summer Survey results show that the EWM population grew in size and overall density during this time period (Map 2 and Map 3). This indicates that the expanding EWM population out-paced the rate at which the DASH efforts could harvest plants from this site.

2.4 Whole-lake Point-Intercept Survey

In the summer of 2010 and 2012, the WDNR conducted a whole-lake point-intercept surveys on Anvil Lake. Onterra ecologists completed another survey in 2015 as a component of a comprehensive management planning project. The survey was replicated in 2019 in the final year of a three-year AIS-EPC project. The survey results from these surveys are explored in the following section. Aquatic plant communities are dynamic, and the abundance of certain species from year to year can fluctuate depending on climatic conditions, herbivory, competition, active management, and disease among other factors.

In recent years water levels have increased in Anvil Lake. Figure 2.4-1 displays the water levels in Anvil Lake at the times of the point-intercept surveys dating back to 2010. The data show that water levels were fairly similar at the times of the 2010, 2012, and 2015 point-intercept surveys with levels varying be approximately six inches. From 2015 to 2016 water levels at the time of the point-intercept surveys rose by about seven inches, and by the time of the 2017 survey had risen an additional 18 inches. Levels continued higher in 2018 with another nine inches of depth since the 2017 survey and increased another 12 inches by the time of the 2019 survey. All told, the water levels have risen approximately four feet between 2015 and 2019.

The impact that the rising water levels may impose on the aquatic plant communities in Anvil Lake are difficult to determine. Certainly, some species are well adapted to fluctuating water levels, whereas other species may struggle to adapt and survive in deeper waters. The littoral zone in Anvil Lake has changed in recent years as areas that were previously near the deepest limits of plant growth prior to 2015 may now be too deep for aquatic plants to obtain sufficient light to persist. Additionally, exposed lakebed that were present around much of Anvil Lake during periods of low lake levels, are now underwater again and results in "new" littoral areas for plants to establish. Pioneer species, which can include invasive plants such as EWM, are often at an advantage in establishing newly available habitat (i.e. empty niches) in lakes.

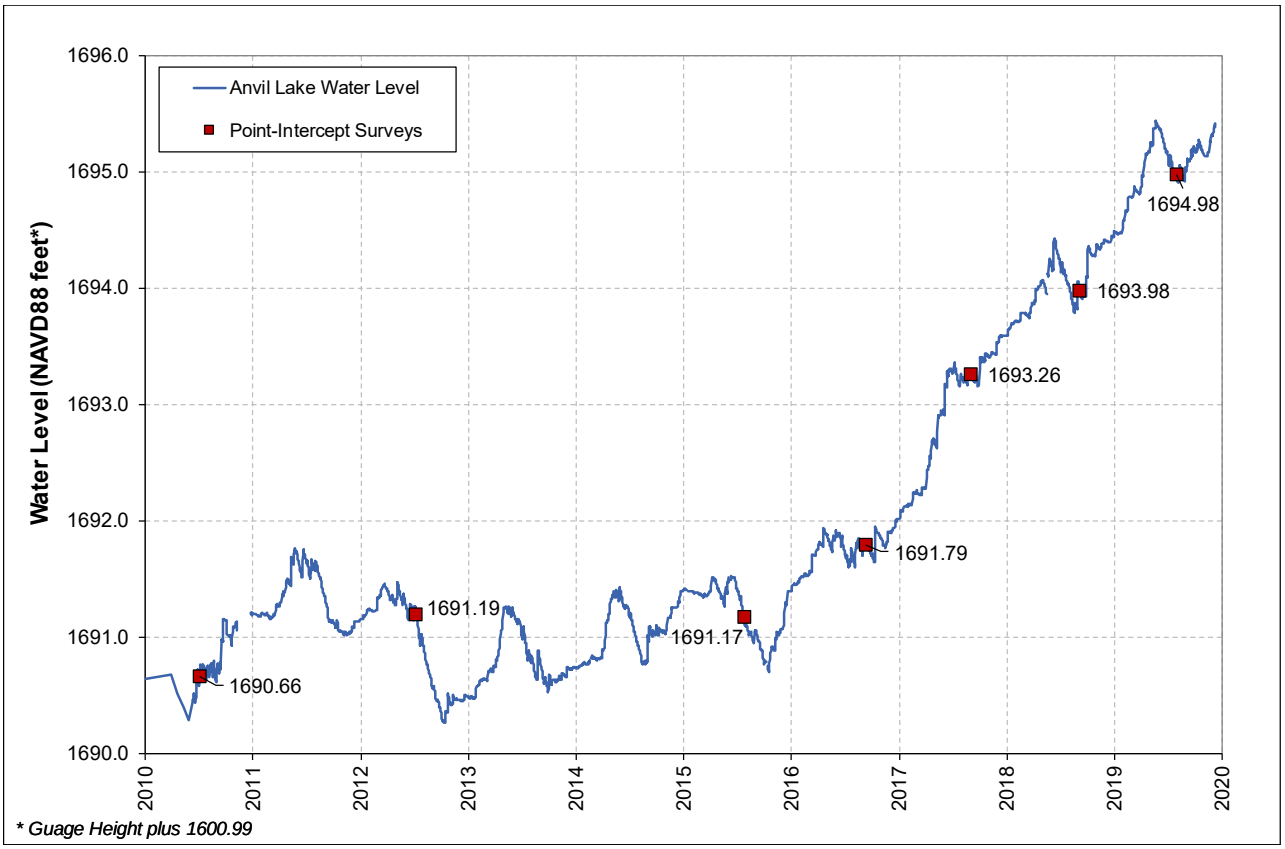


Figure 2.4-1. Anvil Lake water levels from 2010 through December 2019. Created using online data from USGS Gage 05390500 with additional data and benchmarks provided by Dale Robertson, USGS. Red dots indicate timing of 2010, 2012, 2015, & 2019 whole lake point-intercept surveys and 2016-2018 North Bay subset point-intercept surveys.

Onterra ecologists completed a whole-lake point intercept survey on Anvil lake on August 6-7, 2019. The results of the 2019 survey are compared to previous surveys completed in 2010, 2012, and 2015 in the following analysis. Aquatic plants were found growing to a maximum depth of 24 feet in the 2019 survey. The most frequently encountered species were stoneworts (*Nitella* spp.), wild celery (*Vallisneria americana*), common waterweed (*Elodea canadensis*), and Eurasian watermilfoil (*Myriophyllum spicatum*). A total of 25 native aquatic plant species were documented in the 2019 survey. Two native species, northern naiad (*Najas gracillima*), and Vasey's pondweed (*Potamogeton vaseyi*) are designated as special concern in Wisconsin due to their limited known distribution.

The littoral frequency of occurrence analysis allows for an understanding of how often each plant species is located during the point-intercept survey. Figure 2.4-2 displays the littoral frequency of occurrence of native aquatic plant species identified during the point-intercept surveys in Anvil Lake. Only the species that had at least an occurrence of 5% were included in the analysis. Because of their morphological similarity and often difficulty in differentiating between them, the occurrences of muskgrasses (*Chara* spp.) and stoneworts and the occurrences of common and slender waterweeds (*Elodea nuttallii*) were combined for this analysis.

Important Note:
Littoral frequency of occurrence (LFOO) is used to describe how often each species occurred in the point-intercept survey sampling points that are within the maximum depth of plant growth (littoral zone), and is displayed as a percentage.

Stoneworts and muskgrasses are types of macroalgae and have been the most commonly encountered species in each of the point-intercept surveys. Stoneworts were the only species that was present in water depths beyond 18 feet in the 2019 survey and were most abundant between 15 to 24 feet. While they are not vascular plants, muskgrasses and stoneworts still grow to a considerable size and form large, dense beds along the lake bottom where the supply oxygen to deeper waters and provide structural habitat for aquatic invertebrates and fish. Studies have also shown that these plants stabilize bottom sediments and improve water quality by removing nutrients to the water that would otherwise be available to algae.

Wild celery, also known as tape or eel grass, was the second-most abundant plant in Anvil Lake in 2019 and has been consistently one of the most commonly encountered plants in each point-intercept survey since 2010. In the 2019 survey, wild celery was most abundant between 8 and 13 feet. The long leaves of wild celery provide excellent habitat for aquatic organisms, while its extensive root systems stabilize bottom sediments. Additionally, the leaves, fruits, and winter buds are food sources for numerous species of waterfowl and other wildlife.

The waterweeds have been frequently encountered in Anvil Lake, with a littoral frequency of occurrence of greater than 20%, in each of the four point-intercept surveys. Common waterweed is an aquatic plant species with a wide distribution across North America. Common waterweed provides habitat and food sources to both aquatic and terrestrial wildlife. Lacking true roots and able to obtain the majority of its nutrients directly from the water, common waterweed often forms large mats which break free from the bottom and can continue to grow suspended in the water column or floating on the lake's surface. While not problematic in Anvil Lake, in lakes with higher nutrient content, common waterweed can grow to excessive levels where it can interfere with recreational activity. The 2019 occurrence of common waterweed (20.5%) was statistically lower than the previous survey completed in 2015 (Figure 2.4-2). Common waterweed was most abundant between 10 and 18 feet in the 2019 survey.

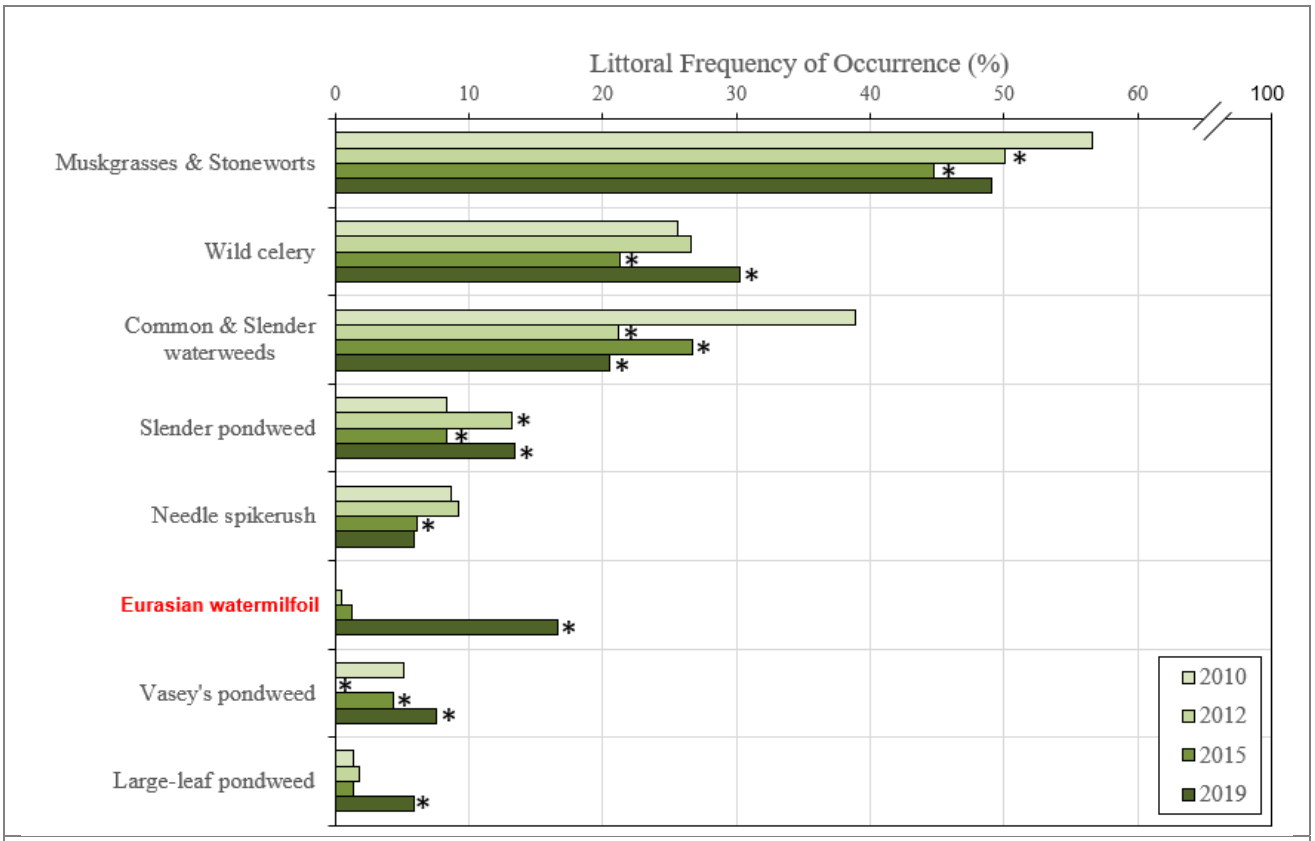


Figure 2.4-2. Anvil Lake Littoral Frequency of Occurrence of Aquatic Plants. Created using data from WDNR 2010, WDNR 2012, and Onterra 2015 & 2019 whole-lake point-intercept surveys. Asterisk represents statistically valid change in occurrence since previous survey.

Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while wild celery was found at 30% of the littoral sampling locations in Anvil Lake in 2019, their relative frequency of occurrence is 18%. Explained another way, if 100 plants were randomly sampled from Anvil Lake, 18 of them would be muskgrasses.

Figure 2.4-3 displays the relative occurrence of aquatic plant species in Anvil Lake in each of the four point-intercept surveys, and illustrates the uneven distribution of species within the community. Charophytes (stoneworts or muskgrasses), wild celery, and common waterweed, combined to account for over 60% or the composition of the aquatic plant population in Anvil Lake in 2019. These species have dominated the aquatic plant community in each survey dating back to 2010, although they comprised nearly 80% of the aquatic plant population in the 2010 survey.

The relative frequency of isoetids species, collectively needle spikerush (*Eleocharis acicularis*), dwarf watermilfoil (*Myriophyllum tenellum*), quillworts (*Isoetes spp*), waterwort (*Elatine minima*), and brown fruited rush (*Juncus pelocarpus*) in this dataset, have been consistent during the time period of study with relative frequencies between approximately 8-12% in each survey.

Thin-leaved pondweeds, which represents the collective occurrences of small pondweed (*Potamogeton pusillus*), Vasey's pondweed (*Potamogeton vaseyi*), and spiral-fruited pondweed (*Potamogeton spirillus*) in this dataset, have been relatively stable during the 2010, 2012, and 2015 surveys with occurrences around 9-10%, before increasing somewhat in the 2019 survey to 13.8%.

The relative frequency of occurrence of EWM has increased from 0% in 2010, to 9.9% in the 2019 survey.

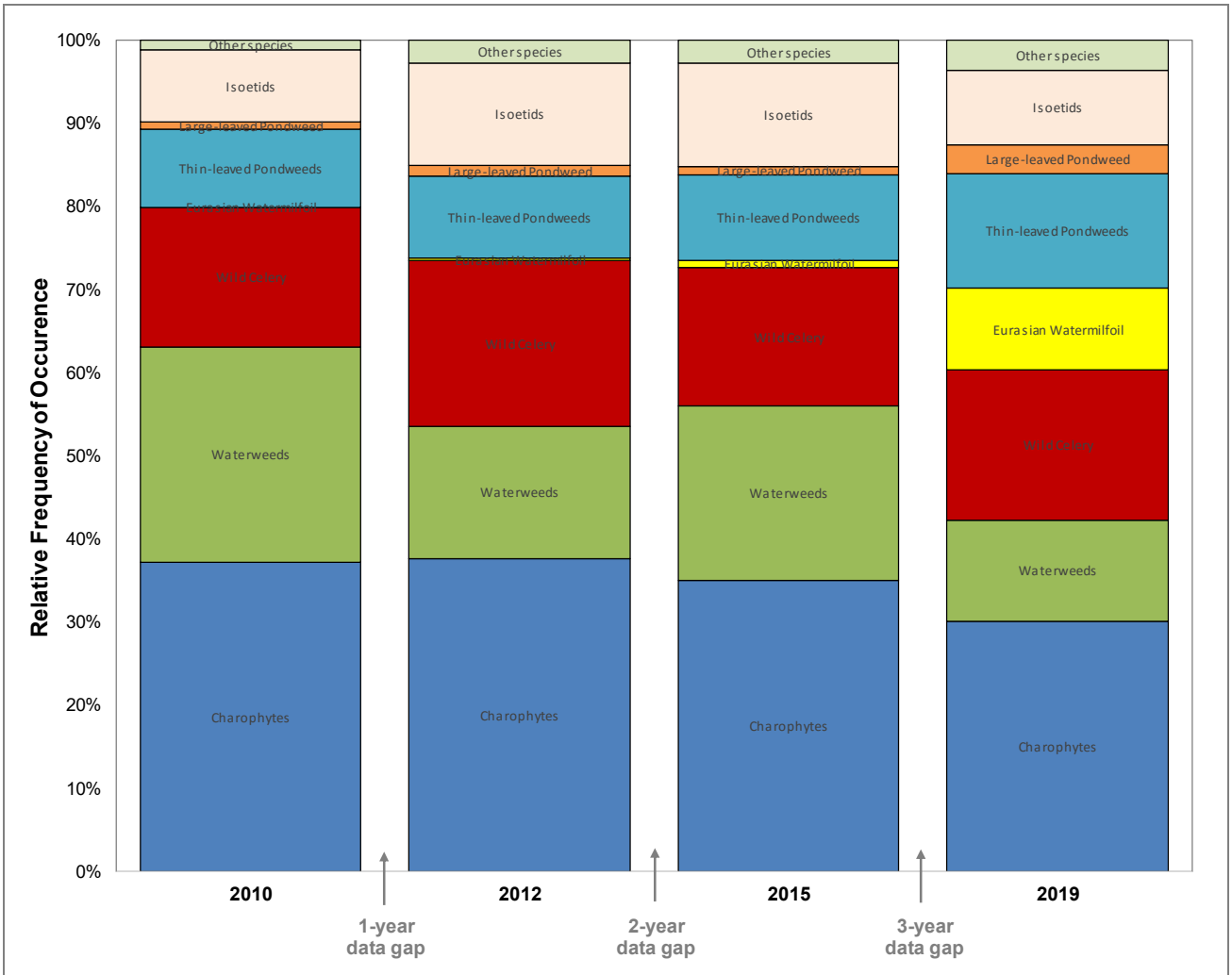


Figure 2.4-3. Anvil Lake relative frequency of occurrence of aquatic plant species. Created using data from 2010, 2012, 2015, & 2019 whole-lake point-intercept surveys.

The calculations used to create the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during each point-intercept survey and does not include incidentally-located species. The native species encountered on the rake during the 2010, 2012, 2015 and 2019 point-intercept surveys and their conservatism values were used to calculate the FQI of Anvil Lake's aquatic plant community. Figure 2.4.4 compares Anvil Lake's FQI components to median values of lakes within the Northern Lakes and Forests – Lakes (NLFL) ecoregion and lakes throughout Wisconsin. The FQI value for Anvil Lake in 2019 of 37.0 falls above the median values for the ecoregion and state.

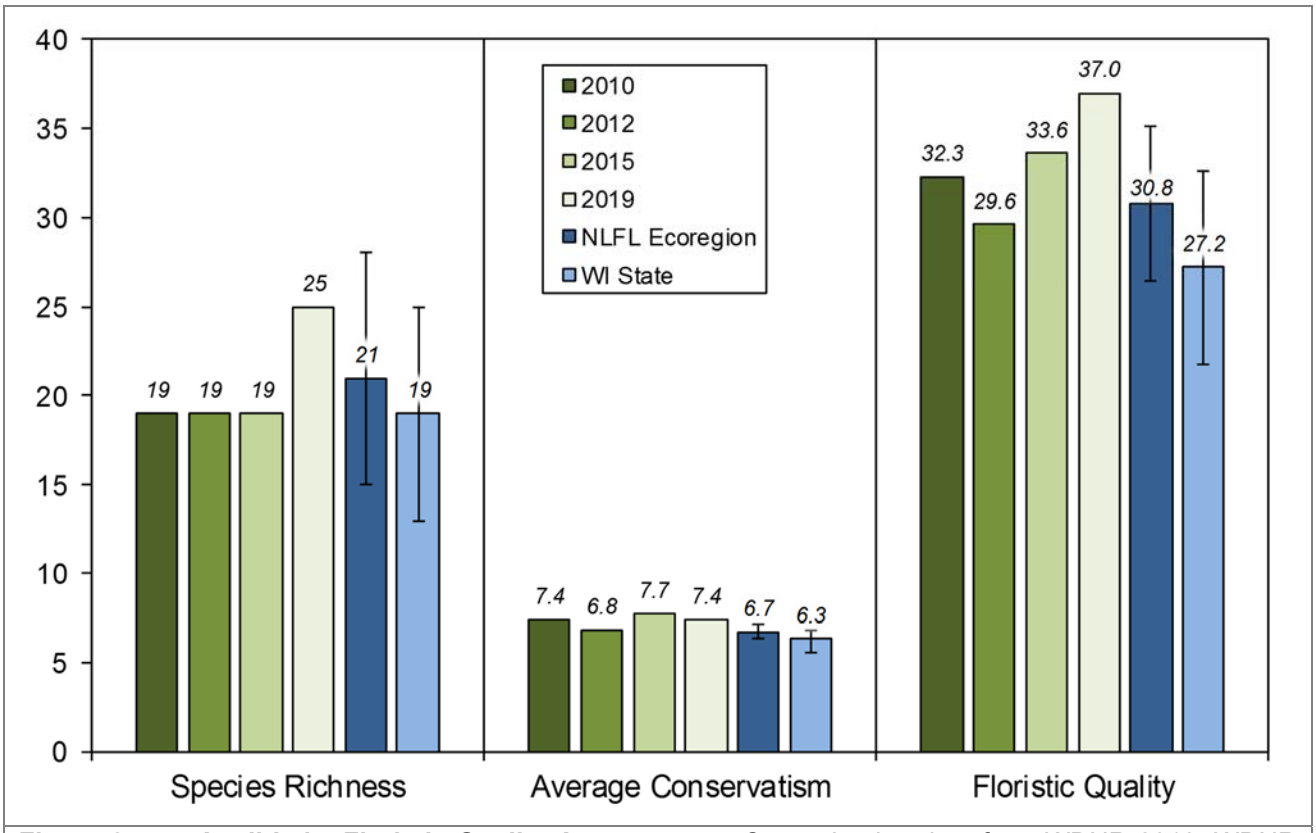
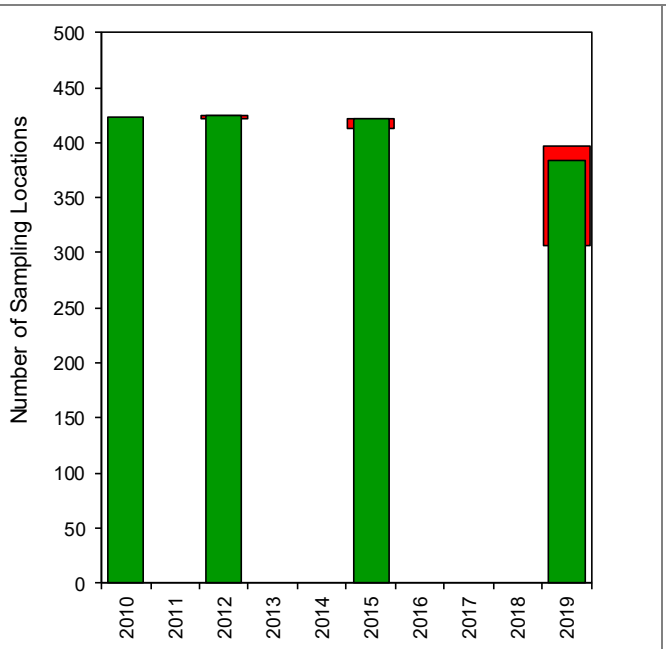


Figure 2.4-4. Anvil Lake Floristic Quality Assessment. Created using data from WDNR 2010, WDNR 2012, and Onterra 2015 & 2019 point-intercept surveys. Analysis follows Nichols (1999).

On lakes with changing water levels, there may be an expanded littoral zone footprint as some species persist for a few years at the deeper end. This results in a larger denominator (total littoral points) and decreases the LFOO. While LFOO is the standard metric in most analysis, the total number of sampling points is displayed in this case as it is more reflective of the vegetated part of the lake. Figure 2.4-5 displays the number of point-intercept survey sampling locations that contained either native plants only, EWM plants only, or native plants and EWM plants from surveys completed in 2010-2019 in Anvil Lake. The 2019 survey indicates that most of the sampling points that contained EWM also included native aquatic plants. These data also indicate that the native aquatic plant population of Anvil Lake has decreased since 2015 as the EWM population has increased. The number of sampling locations that contained native aquatic plants was consistently between 421-425 during the surveys between 2010, 2012, and 2015, compared to 384 points in the 2019 survey (Figure 2.4-5).



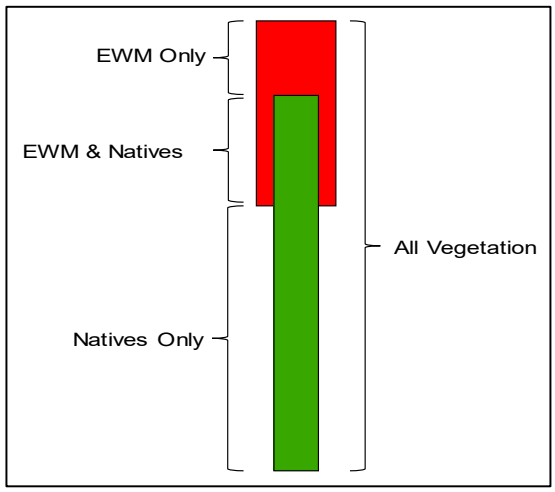


Figure 2.4-5. Number of point-intercept sampling locations that contained native plants, EWM, or native plants and EWM during surveys completed from 2010-2019 in Anvil Lake.

2.5 Sub-set Point-intercept Data Analysis

A subset of the whole lake point intercept survey located in the North Bay of Anvil Lake has been sampled annually from 2015-2019. Figure 2.5-1 displays the location of the sub-set sampling locations that are included in the following analysis. A total of 73 sampling locations are included in the analysis, however in any given year, some sampling locations were not sampled when the sampling location was found to be terrestrial or non-navigable. This dataset was intended to specifically monitor the EWM and native plant population dynamics during this timeframe.

The EWM occurrence increased every year during the period of monitoring from 2010 to 2018, reaching a high of 88.1% in 2018. The 2019 occurrence decreased to 79.7%, however this was not statistically different than the 2018 survey. Since the EWM population's rapid increase in frequency between 2015-2019, the average number of native species per sampling site has decreased from 2.71 in 2015, to between 1.34 and 1.52 in 2017-2019 (Figure 2.5-2).

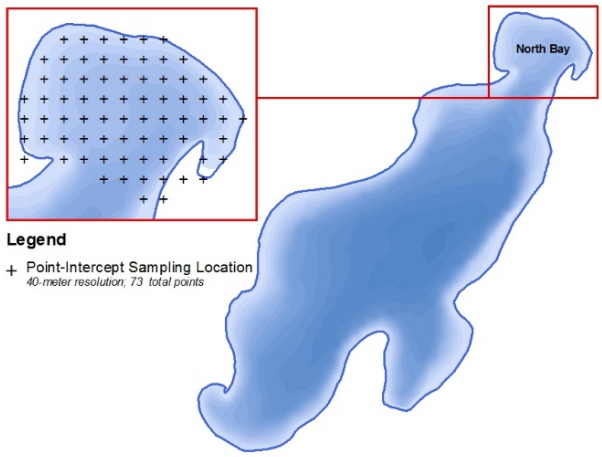


Figure 2.5-1. Sub Point-Intercept Survey Sampling Locations in North Bay of Anvil Lake. (40-meter spacing, N=73)

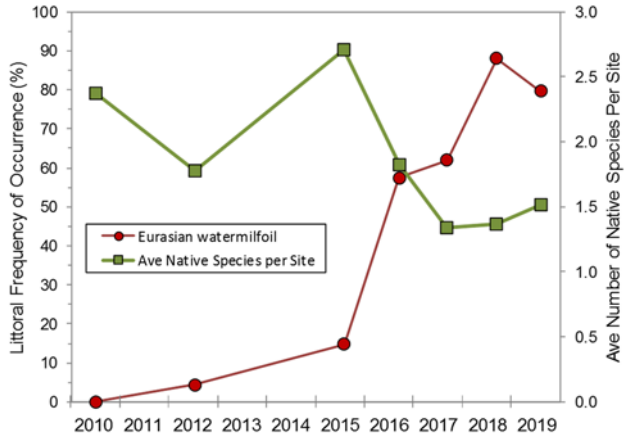


Figure 2.5-2. Frequency of occurrence of EWM and native aquatic plant species within North Bay of Anvil Lake from 2010-2019. 2010 n = 58; 2012 n = 69; 2015 n = 61; 2016 n = 61; 2017 n = 50, 2018 n = 67, 2019 n=69.

The combined occurrences of muskgrasses and stoneworts as well as common and slender waterweed exhibited a recent declining population trend over the past several years corresponding with the timeframe during which the EWM population increased substantially (Figure 2.5-3). It is difficult to determine if these native species declines are the result of displacement from an expanding EWM population, bycatch during hand-harvesting, natural changes in environmental conditions such as water levels, or a combination of these.

The sub-sample point-intercept data indicate wild celery exhibited a statistically valid decrease in population between from 65.6% in 2016 to 38.0% in 2017. Continued monitoring showed wild celery had an occurrence of 41.8% in 2018 before declining to 31.9% in 2019 (Figure 2.5-3).

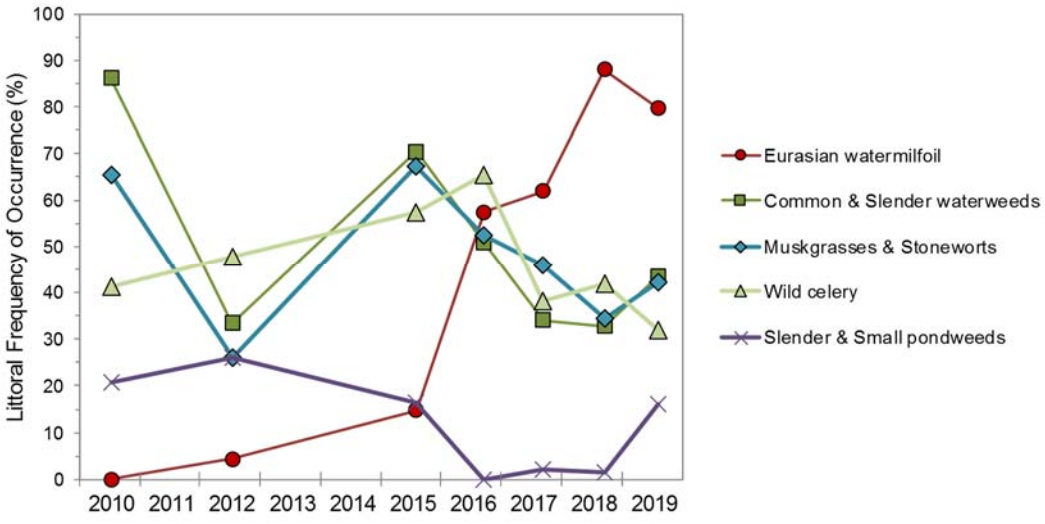


Figure 2.5-3. Frequency of occurrence of EWM and common native aquatic plant species within North Bay of Anvil Lake from 2010-2019. 2010 n = 58; 2012 n = 69; 2015 n = 61; 2016 n = 61; 2017 n = 50, 2018 n = 67, 2019 n=69.

The occurrence of slender pondweed exhibited a statistically valid decrease in occurrence from 16.4% in 2015 to 0% in 2016. The occurrence remained low at 2.0% in 2017 and 1.5% in 2018 before increasing to 15.9% in 2019.

Figure 2.5-4 displays the littoral frequency of occurrence of sub-set point-intercept survey sampling locations that contained either native plants only, EWM plants only, or native plants and EWM plants from point-intercept surveys completed between 2010-2019 in Anvil Lake. The figure illustrates the expanding footprint of the EWM population while the littoral frequency of occurrence for native species initially went down between 2016-2017 and has been relatively consistent since.

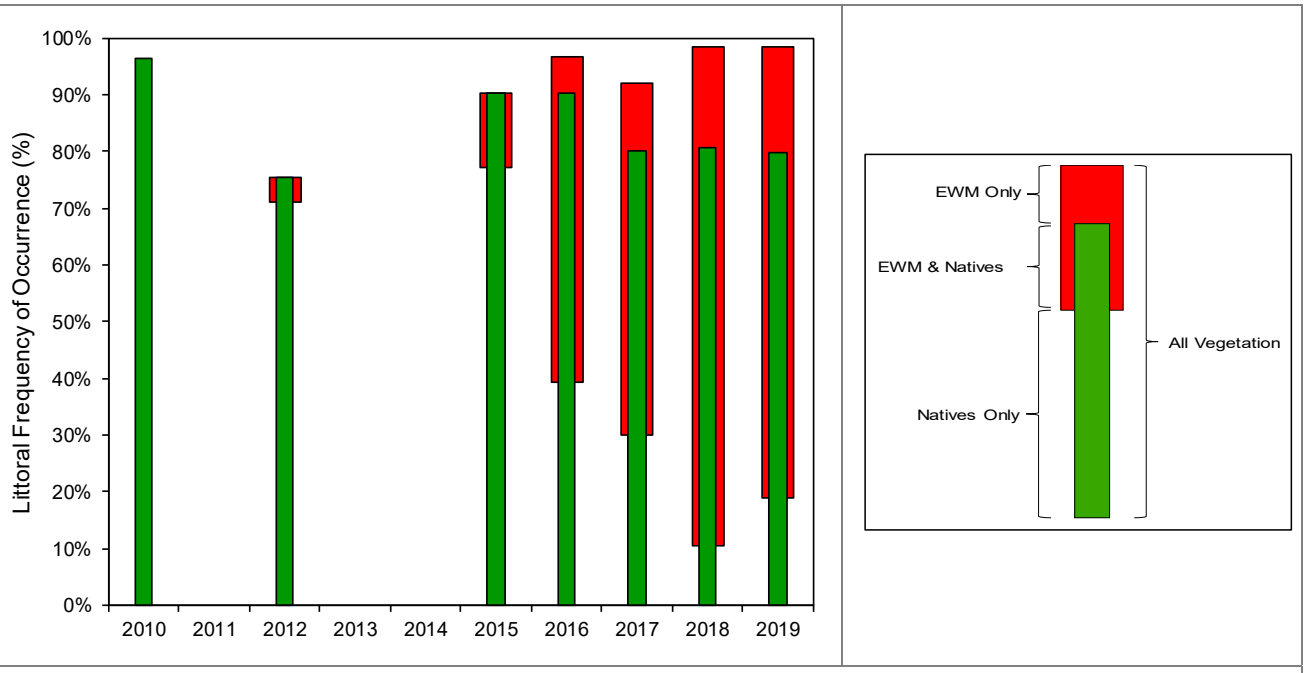


Figure 2.5-4. Littoral frequency of occurrence of native plants and EWM from sub-set point intercept surveys completed in 2010, 2012, & 2015-2019 in Anvil Lake.

Figure 2.5-5 displays the relative occurrence of aquatic plant species in the North Bay of Anvil Lake in each of the four point-intercept surveys. The figure documents the increasing relative frequency of EWM over this time period, from 0% in 2010 to a high of 39% in 2018. The relative frequency of occurrence of EWM in the 2019 survey was 34.4%. From 2017-2019, EWM has exhibited a higher relative frequency of occurrence than any native species in North Bay during the same time period. Since 2015, the collective relative frequency of occurrence of several groups of native species has declined as EWM has come to account for a greater proportion of the plant community in this sample area.

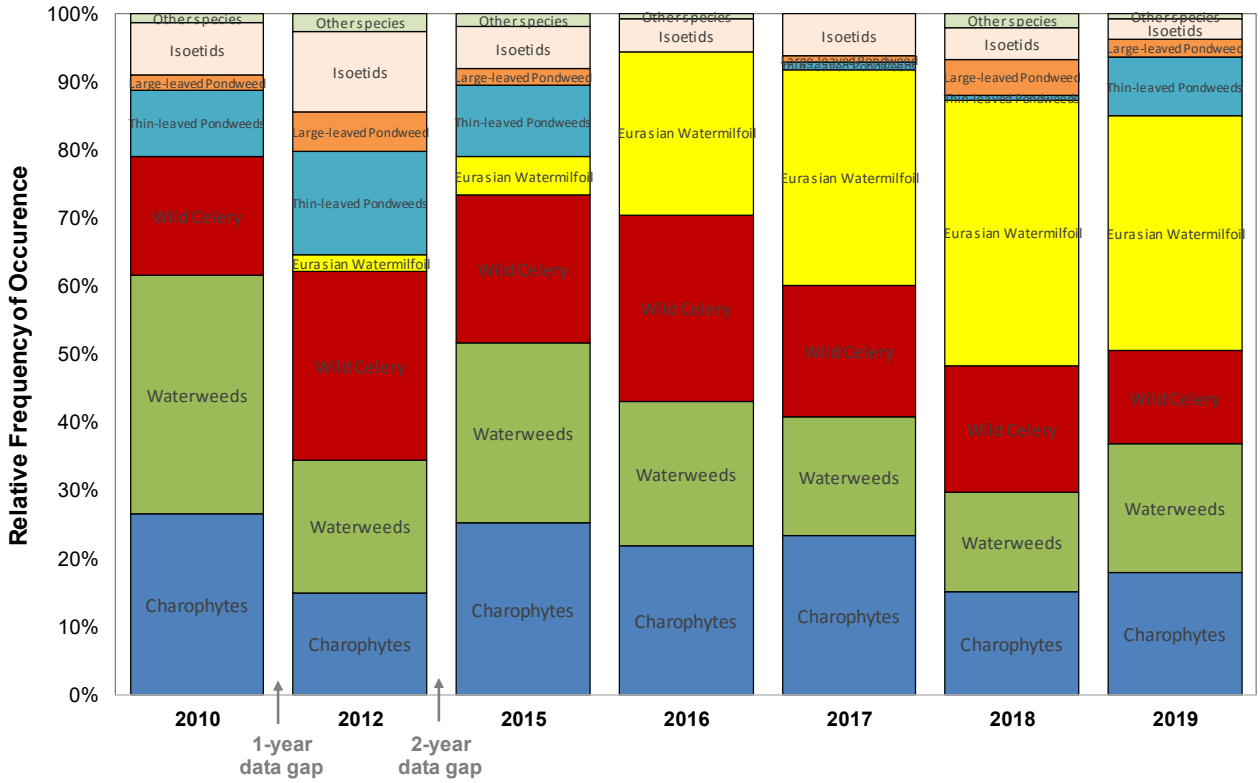


Figure 2.5-5. North Bay relative frequency of occurrence of aquatic plant species. Created using data from a subset of the 2010, 2012, 2015 & 2019 point-intercept surveys in Anvil Lake (n=73).

3.0 CONCLUSIONS AND DISCUSSION

Aquatic plant surveys completed in 2019 on Anvil Lake showed that the native plant community was composed of a diverse collection of species. Aquatic plant species have fluctuated in the lake over the course of monitoring dating back to 2010. Increasing water depths over the past four years in Anvil Lake likely influence some native aquatic plant species populations as some species are well adapted to adjust to the changing conditions while other species may be negatively impacted.

The EWM population in Anvil Lake continued to expand into a larger footprint in 2019 as most littoral areas around the lake now harbor at least a low-density EWM population. Much of the EWM population around the lake is of relatively low-density colonies mapped as *highly scattered* or *scattered* in density. The EWM population in the North Bay of the lake continues to have the densest colonies in the lake. The ALA has carried out a great amount of effort over the years attempting to manage this population through a coordinated hand-harvesting control strategy. Shortly after the initial detection of EWM in the bay, attempts were made to harvest all plants as a part of an eradication strategy. As the population continued to expand, eradication was no longer a feasible goal and the EWM control strategy shifted to a maintenance strategy for a period of time where efforts were taken to attempt to maintain the EWM population at modest levels. The strategy ultimately shifted to a nuisance control strategy as the population continued to increase and cause problems for the riparians that owned properties in the bay. The goal of the nuisance relief strategy was to provide access to deeper waters of the lake through surface matting EWM colonies with the creation of navigation lanes.

The goals of the hand harvesting efforts in 2019 were to meet the three objectives listed in section 1.3 and are listed again here:

1. *Utilize DASH, including the 'dockside' harvesting method developed in 2018, in the North Bay to maintain open lanes of navigation from shore to open water through dense areas of EWM.*

The fine-scale nature of the harvesting lanes is not well represented by the EWM mapping surveys, however reductions in EWM densities were delineated in some navigation lanes at the time of the 2019 Late-Season EWM Mapping survey (Map 3). A better determination of whether this objective was met in 2019 can be made by ALA members that observed the navigation lanes over the course of the growing season. If these lanes were maintained in a way that allowed for reasonable navigation by the individual users of the lanes over the course of the growing season, they would have met the goal of the strategy in those lanes. Anecdotal reports from the ALA suggested that the navigation lanes were maintained during the course of the 2019 growing season in a way that met the objective of the efforts.

2. *Utilize DASH in other areas of the lake outside of the North Bay in an effort to reduce EWM expansion or establishment in new locations.*

Mapping surveys completed during 2019 show that this objective was not met as the EWM population was found to expand and establish in many new areas of Anvil Lake.

3. *Utilize traditional hand-harvesting to harvest areas with small, initial infestations of EWM or in any areas where volunteers wish to work.*

Volunteers from the ALA worked towards this objective during 2019. The applicability of traditional hand-harvesting activities is of a relatively small scale including shallower water locations or small and isolated EWM occurrences.

Over the course of the three-year DASH trial program, the ALA has learned a lot about the capabilities of DASH and hand-harvesting as an EWM management tool on Anvil Lake. The DASH-focused EWM management effort over the past three years has not been able to maintain or reduce the population on a lake-wide scale and only through a great deal of effort, has DASH been able to approach the objective of providing navigation lanes in North Bay. Hand harvesting efforts have not been able to stop EWM from inhabiting new areas around the lake in recent years.

4.0 STAKEHOLDER SURVEY RESULTS

As outlined within the ALA's *Comprehensive Management Plan* (Jan 2018) for Anvil Lake, the ALA would solicit riparian stakeholder input during the final year of the three-year trial project in regards to their past and future EWM management efforts.

The ALA board of directors worked with Onterra and WDNR lakes biologists to aggregate information and studies regarding EWM management and associated risks. This information where shared with stakeholders during meetings, direct email mailings, and through its newsletter (*The Chime*). Following this coordinated educational campaign, the ALA designed an anonymous written stakeholder survey to be sent to ALA members and Anvil Lake property owners. The survey design and administration methodology were developed by the planners with guidance and approval from a WDNR Research Social Scientist. The survey was administered through a web-based platform and aspects were facilitated

by a contractor to ensure anonymity. A paper copy of the survey was available by request for those without internet access.

A total of 121 surveys were distributed and 78 responses were returned representing a 64% response rate. In instances where stakeholder survey response rates are 60% or above, the results can be interpreted as being a statistical representation of the population. Therefore, the results of the stakeholder survey are reflective of the sentiments of the ALA members and Anvil Lake riparian property owners. The complete results of the stakeholder survey are included with this report as Appendix B.

Stakeholders that indicated they were able to identify EWM (Appendix B, #26) were then asked about how the EWM Population has negatively impacted their enjoyment of Anvil Lake. The highest number of stakeholders indicated that *motor boating* was negatively impacted by the EWM population, followed by *aesthetics*, and *open water fishing* (Figure 4.0-1). *Ice fishing* was the activity most stakeholders believed the EWM population was not negatively impacting.

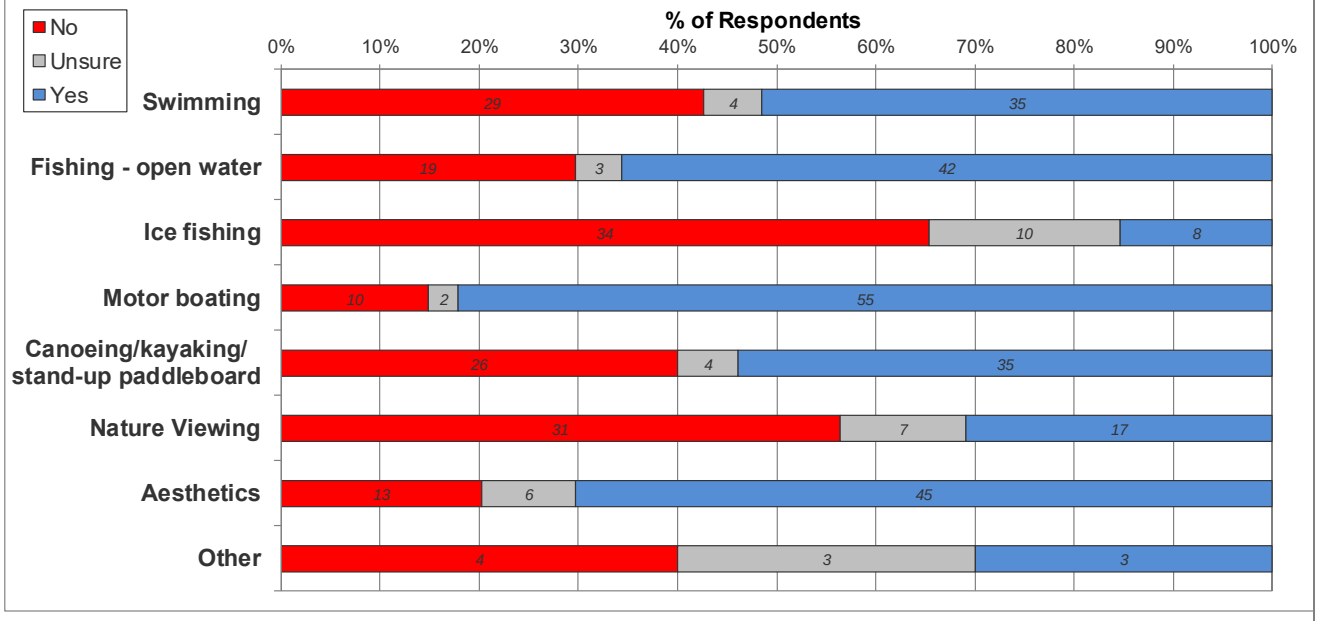


Figure 4.0-1. Stakeholder survey response to Question #27. Has the Eurasian watermilfoil population ever had a negative impact on your enjoyment of Anvil Lake? For each activity, please select the appropriate box.

Slightly over 97% of riparian stakeholders indicated that they believed the EWM population should be actively managed in Anvil Lake, pooling the responses from *definitely yes* and *probably yes* (Appendix B #28). The remainder of respondents (two stakeholders) were unsure if EWM should be actively managed and no respondents indicate they did not believe the EWM population should be managed (either *probably no* or *definitely no*.

The North Bay of Anvil Lake has harbored the most concerning population of EWM for the past several years. As discussed, a revised EWM management strategy was implemented during the past two years where hand-harvesting with DASH was implemented to open up navigation lanes. The planning

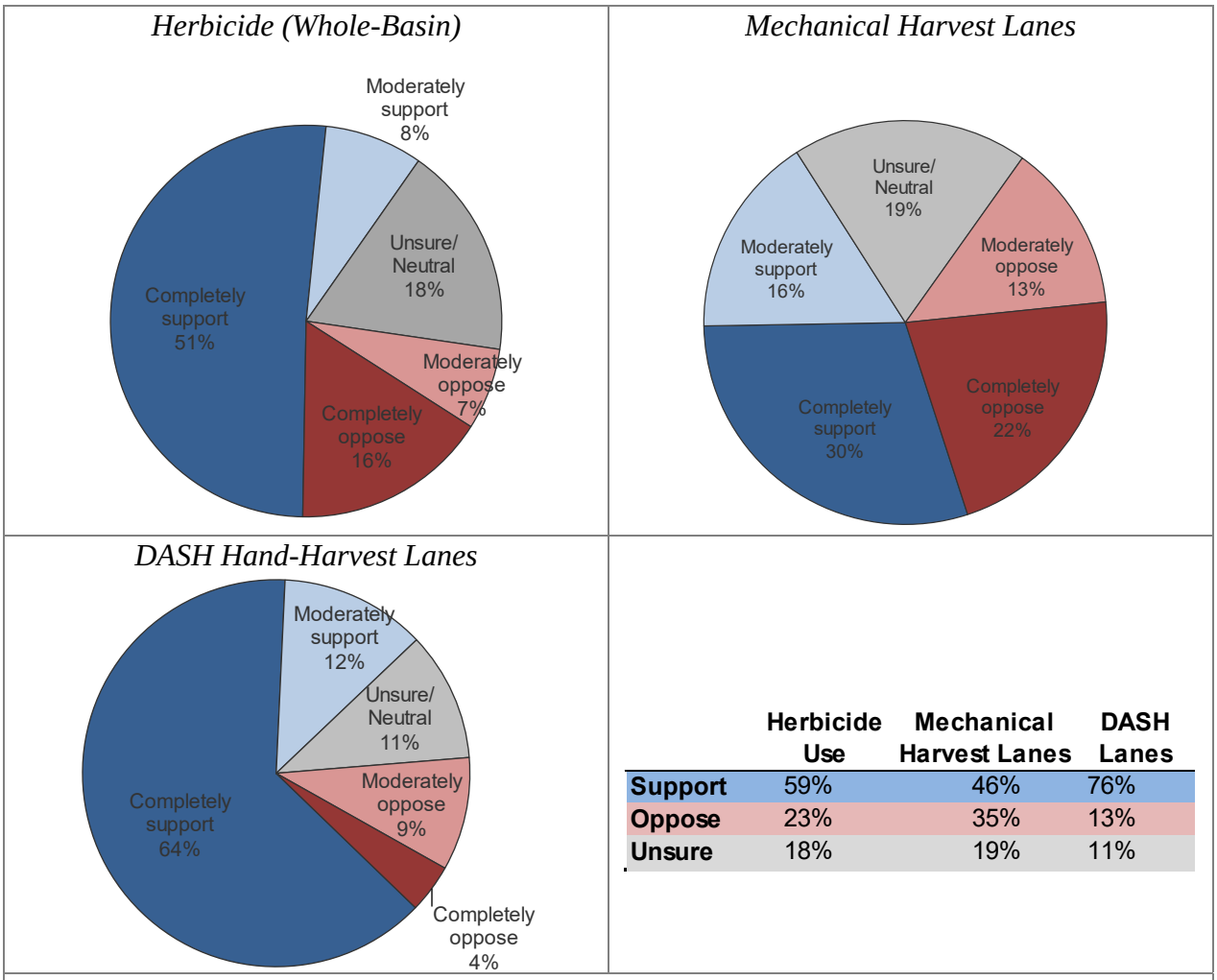
committee wanted to understand the stakeholders' perceptions on this approach as well as alternatives. Therefore, the following question series was developed and are displayed on Figure 4.0-2.

29. Are you in favor of the current use of DASH (Diver Assisted Suction Harvest) to create navigation lanes in the North Bay similar to the lanes displayed in green on the map?

31. Would you be in favor of contracting mechanical harvesting (weed cutter) to create navigation lanes in the North Bay similar to the lanes displayed in green on the map

32. Would you be in favor of conducting an herbicide treatment to target the entire Eurasian watermilfoil population in the North Bay??

Figure 4.0-2 shows that each technique has a split amongst respondents as to the level of support with some supportive respondents and some opposed with each of the management techniques. The greatest level of support is for the use of DASH to create navigation lanes in the North Bay represented by a total of approximately 76% of survey respondents. Almost 60% of the survey respondents were supportive of conducting an herbicide treatment in North Bay, whereas just under 46% of respondents were supportive of a mechanical harvesting control strategy in North Bay (Figure 4.0-2).



	Herbicide Use	Mechanical Harvest Lanes	DASH Lanes
Support	59%	46%	76%
Oppose	23%	35%	13%
Unsure	18%	19%	11%

Figure 4.0-2. Stakeholder survey response Question #29, 31, 32. Table pools *highly supportive* & *moderately supportive responses* for support and *not supportive* & *moderately un-supportive* for oppose.

Stakeholder survey respondents were also asked about their level of support for the use of DASH in areas outside of the North Bay to manage the EWM population, with 85% indicating support and 9% opposing (Appendix B #30). Half of stakeholder respondents indicated support for a whole-lake herbicide treatment of Anvil Lake, whereas almost 40% indicated opposition to this management technique (Appendix B #33).

As previously discussed, all management techniques carry risks which need to be discussed when determining a management strategy. Figure 4.0-3 captures the Anvil Lake stakeholder concerns of the three potential management actions within the North Bay. Stakeholders had the highest concern of herbicidal impacts including unknown impacts and impacts to plants, animals, and humans. Stakeholders had the least concern that herbicide use was likely going to be ineffective compared with DASH or Mechanical Harvesting of lanes within the North Bay.

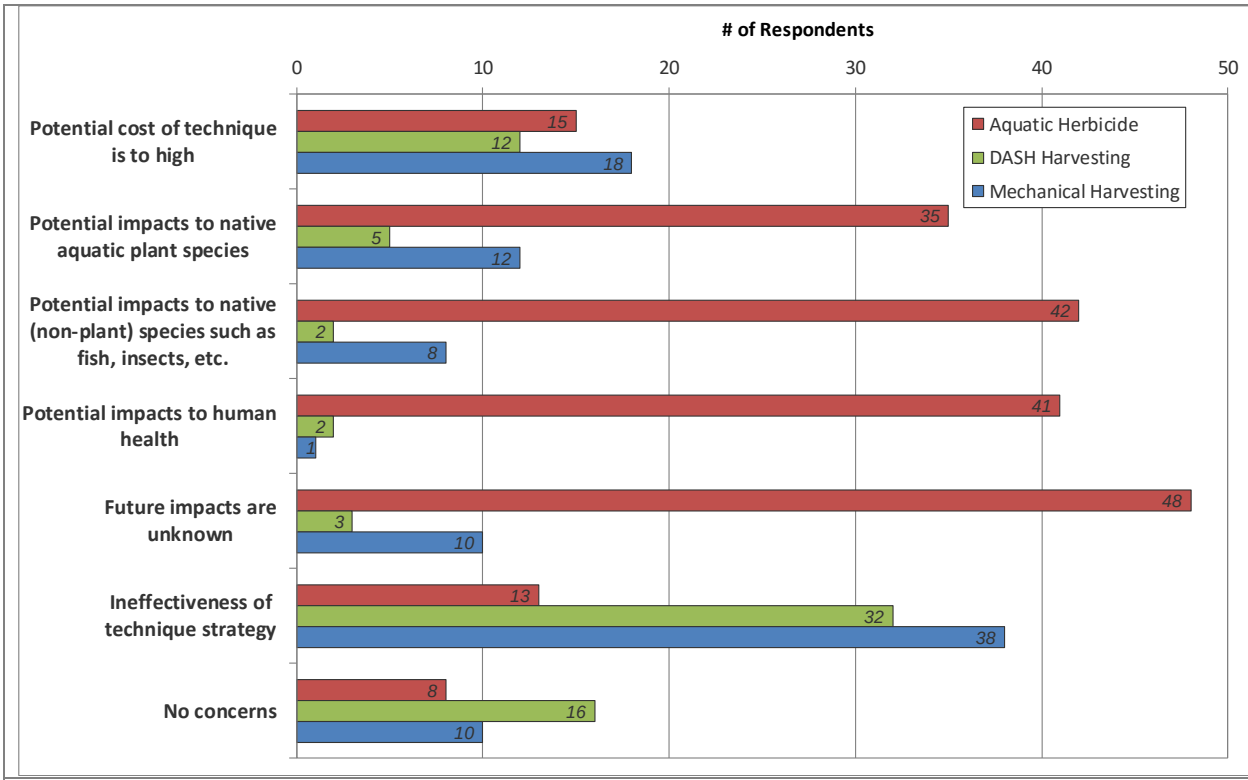


Figure 4.0-3. Stakeholder survey response Question #34. What concerns, if any, do you have for the future use of the following techniques?

5.0. 2020 EWM MANAGEMENT STRATEGY DEVELOPEMENT

During the fall and early-winter of 2019/2020, the ALA actively engaged the WDNR and Onterra to seek guidance in managing the EWM population in Anvil Lake. Considering the experience and knowledge the ALA has gained over the course of the last eight years of EWM management, as well as the results of the stakeholder survey, the ALA Board held a meeting during which several future management options were discussed. The ALA Board approved a 2020 plan that would include an herbicide treatment in the North Bay and EWM hand harvesting with the DASH unit prioritizing the denser colonies outside of the North Bay. In the years following, hand-harvesting with DASH would target rebounding EWM in the North Bay and continue to address dense EWM colonies in the remainder

of Anvil Lake. The following sections discuss the details of the proposed EWM management strategies and the alternatives analysis that ALA conducted.

5.1 Diver Assisted Suction Harvesting (DASH) & Manual Removal

At current EWM levels in the lake, DASH alone cannot lower the lake-wide EWM population of Anvil Lake. Hand harvesting, with or without DASH, is a management option that may be appropriate for providing nuisance relief or navigation lanes in areas of Anvil Lake where nuisance conditions exist. Stakeholders generally support the use of DASH on Anvil Lake, both in regards to creating navigation lanes in the North Bay or targeting other EWM populations within Anvil Lake. While stakeholders indicated support for this type of management, it has become clear that there are definite scale limitations of this method.

The ALA has supported conducted as much hand-harvesting in the North Bay as they could find people to conduct the work and have funds to pay for the effort. EWM population suppression within the lanes occurs from these efforts; but without continual maintenance, EWM simply fills back in within a short time.

Outside of the North Bay, no other areas of the lake have experienced nuisance conditions to-date as a result of the EWM population. This is due to the fact that much of the rest of lake-wide EWM population is in deeper waters and the plants are not growing up to near the waters' surface. The ALA has concerns regarding the recent expansion of the EWM population in the southwest end of the lake and the possibility that nuisance conditions may occur in coming years if the EWM population continues to expand. The ALA will focus DASH efforts in this area of the lake in an effort to slow the EWM expansion and density increase.

5.2 Mechanical Harvesting

The ALA has explored the option of utilizing a mechanical harvesting operation to provide nuisance relief from the EWM population in the lake. It is understood that the hand-harvesting with DASH in the North Bay cannot keep up with the EWM population, so mechanical harvesting of lanes may be a more efficient and scale-appropriate method. Riparian support for mechanical harvesting was mixed, with 46% favorability, 35% opposition, and 19% unsure (Figure 4.0-2).

Onterra developed a preliminary mechanical harvesting strategy in which navigation lanes were placed in North Bay as well as in the southwest end of the lake. The ALA continues to collect information related to the costs and capabilities of a mechanical harvesting EWM management technique. The ALA has reached out to other lake groups in northern Wisconsin to discuss the mechanical harvesting programs that they are undertaking in an effort to gain more knowledge about the topic. At this time, the ALA is not considering a mechanical harvesting strategy for 2020, however may explore this option in the future, particularly if WDNR grant funding would be applicable to this management technique.

5.3 Herbicide Treatment

The ALA explored herbicide treatment in the North Bay where the highest density EWM populations are located. The North Bay is a relatively protected part of the lake that if targeted with herbicides, may function like a whole-bay treatment such that the contained nature of the bay may hold herbicide concentrations and exposure times for an extended period of time compared to traditional spot-treatment

scenarios. If herbicides were applied to the North Bay, it is expected that the herbicide would dissipate beyond the initial application areas and mix with the entirety of the water volume in the North Bay within a period of hours to days after treatment. There would also be herbicide loss out to the main body of Anvil Lake but would quickly dilute into the much more voluminous basin.

The ALA initially explored two herbicide treatment designs for a North Bay basin-wide treatment, 2,4-D or florpyrauxifen-benzyl (ProcellaCOR). Onterra provided the ALA with potential treatment designs that reflected each of the two options under consideration.

Option 1: ProcellaCOR

The FLA explored the option of using florpyrauxifen-benzyl, commercially available as ProcellaCOR™ (SePRO) to meet EWM management goals for 2020. This herbicide is specifically designed to control invasive watermilfoil populations. ProcellaCOR™ is in a new class of synthetic auxin mimic herbicides (arylpicolinates) with short concentration and exposure time (CET) requirements compared to other systemic herbicides. Uptake rates of ProcellaCOR™ into EWM were two times greater than reported for triclopyr (Haug 2018, Vassios et al. 2017). ProcellaCOR™ is primarily degraded by photolysis (light exposure), with some microbial degradation. The herbicide is relatively short-lived in the environment, with half-lives of 4-6 days in aerobic environments and 2 days in anerobic environments (WSDE 2017). The product has a high affinity for binding to organic materials (i.e. high KOC).

Netherland and Richardson (2016) and Richardson et al. (2016) indicated control of select non-native plant species with the active ingredient in ProcellaCOR™, including invasive watermilfoils (EWM and HWM) at low application rates compared with other registered spot treatment herbicides. The majority of native plants tested to date also suggest greater tolerance to this mode of action. Water lilies, pickerelweed, arrowheads, and native watermilfoils have shown sensitivity to ProcellaCOR™. Coontail may also be impacted at higher application rates. Because this is a new herbicide, data available from field trials is relatively limited.

The EPA Ecological Risk Assessment places the risk to non-target wildlife into the "no risk concern" category and the impacts to bees, birds, reptiles, amphibians, and mammals in the "practically non-toxic" category. The EPA has also indicated that there are no risks of concern to human health. There are no restrictions on swimming, drinking, fish consumption, or turf irrigation. However, there would be an approximate 1-day waiting period of the proposed application for shoreland irrigation due to concerns of herbicidal impacts. Appendix C contains the WDNR fact sheet for this herbicide.

Option 2: Liquid 2,4-D

Liquid 2,4-D amine is commonly used in whole-lake or whole-basin approaches for EWM control. Some strains of HWM have shown to be more tolerant of 2,4-D use patterns, but properly implemented whole-lake 2,4-D herbicide treatments on pure-strain EWM populations can be highly effective, with minimal EWM, often zero, being detected for a year or two following the treatment (Figure 5.3-1). Some whole-lake 2,4-D treatments have been effective at reducing EWM populations below pretreatment for 5-6 years following the application.

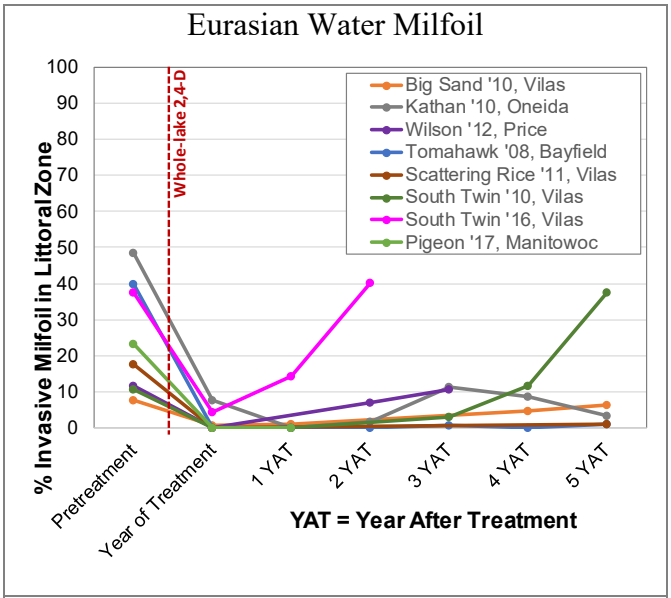


Figure 5.3-1. Littoral frequency of occurrence of invasive milfoil in lakes managed with whole-lake 2,4-D treatments.

2,4-D is broken down biologically (microbial digestion) and can degradation rates can differ from lake to lake depending on the microbial community. Nault et al. 2018 indicated the 2,4-D half-life of whole-lake treatments was shown to range from 4-76 days within the 28 lakes studies, with the "rate of herbicide degradation to be slower in lower-nutrient seepage lakes." Anvil Lake is a seepage lake with moderate (mesotrophic) productivity. A USGS study indicated that groundwater inputs in the North Bay contained relatively high amounts of phosphorus, which may be why EWM has become so established in this bay. The higher nutrients in this area may degrade 2,4-D faster than other whole-lake treatments.

Some native plants are quite resilient to whole-lake/whole-basin 2,4-D treatments, either because they are inherently tolerant of the herbicide's mode of action or they emerge later in the year than when the herbicide is active in the lake. Other species, particularly dicots, some thin-leaved pondweeds, and naiad species, can be impacted and take a number of years to recover.

The EPA-approved maximum application rate for liquid 2,4-D amine is 4.0 ppm acid equivalent (ae). At these rates, there are no restrictions on swimming, fish consumption, human drinking water, or pet/livestock drinking water. There are irrigation restrictions such that specific plants, particularly dicot species, should not be watered with concentrations above 0.07 ppm for concerns of herbicidal impacts to terrestrial plants

As outlined within the WDNR's 2,4-D chemical fact sheet (Appendix C), there are human risks of being exposed to 2,4-D, especially for high-exposure populations (herbicide applicators and farmers). 2,4-D is currently classified by EPA as a Group D herbicide, which indicates the inability to prove or disprove that there is human carcinogenicity (USDA FS 2006).

2020 EWM Control & Monitoring Plan

Control Plan

Given the available EWM management options for Anvil Lake, the ALA Board approved a 2,4-D control strategy that targets the EWM in the North Bay of the lake. The Board cited the limited toxicological research data and longer-term efficacy evaluations available related to ProcellaCOR treatments as well as cost differentials between the two options as being factors in the decision-making process. A preliminary herbicide treatment strategy that targets the EWM in the North Bay is included on Map 4. The black outlined areas indicate the areas where the herbicide would be applied. The red outline denotes the Area of Potential Impact (AOPI), which is the area it is believed the herbicide will directly dissipate into while being at a sufficient concentration and exposure time to impact EWM and potentially native plants following application.

Whole-lake 2,4-D treatments typically target 0.30-0.35 ppm acid equivalent (ae) lake-wide when there is negligible herbicide loss outside of the lake. Onterra has had experience targeting basins with a similar amount of predicted herbicide loss to the main body of water. The liquid 2,4-D amine use pattern being considered for Anvil Lake is to target specific areas in North Bay at a dose of 1.0 ppm ae to achieve a bay-wide concentration of 0.6 ppm ae in North Bay (Map 4).

If the herbicide applied to the North Bay reaches equilibrium with the entire epilimnion of Anvil Lake, the modeled lake-wide concentration would be 0.036 ppm ae. Onterra has observed lake-wide impacts to some sensitive native plants when lake-wide concentrations were above 0.10 ppm ae; but lake-wide impacts are not predicted in Anvil Lake based on the modeled concentration.

Map 5 offers a preliminary DASH strategy for 2020 that includes the southwest end of the lake as well as a few other sites which were found to harbor dominant density EWM colonies in the 2019 Late-Season EWM Mapping Survey. In total, 13.1 acres are included in the preliminary DASH strategy. The EWM population in site B-20 already is of a scale in which DASH efforts are not expected to manage the entire population. Rather, the DASH efforts in this site would focus on targeting the densest areas within the bay in an effort to maintain the overall population in the bay at a lowered density level in 2020. A realistic goal for all of the preliminary DASH sites site may be to manage the population such that the EWM is kept below a dominant density rating.

In order to preserve the gains made by a 2020 North Bay treatment, follow-up hand-harvesting with DASH in 2021 and beyond would occur.

Monitoring Plan

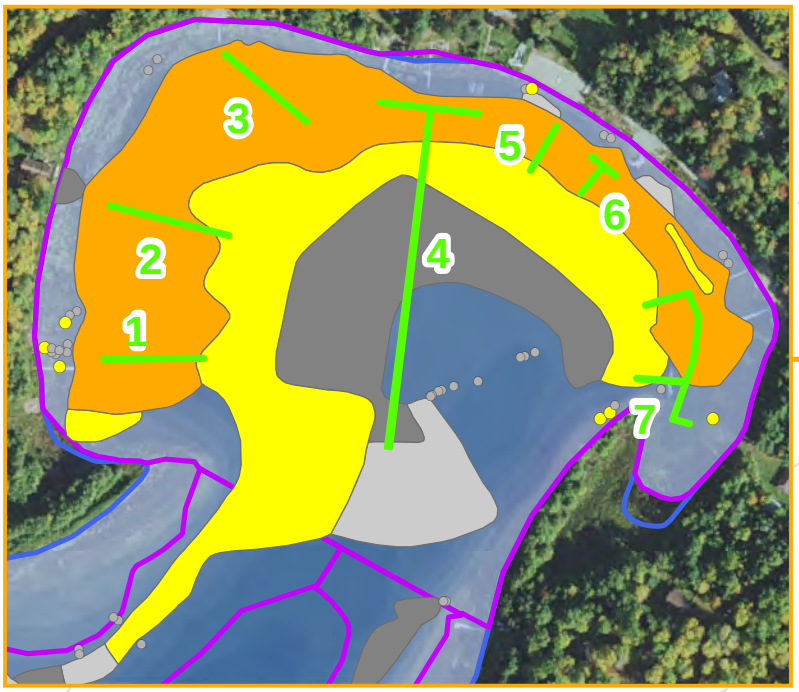
The 2020 herbicide treatment would be monitored through the quantitative and qualitative evaluations. The quantitative assessment would be completed through the replication of the sub point-intercept survey that occurred in the North Bay during 2019 (*year before treatment*, n=73) in 2020 (*year of treatment*) and 2021 (*year after treatment*). The 2020 survey will allow for an understanding of which species were initially impacted by the treatment. Understanding the EWM population in the *year of treatment* (2020) is important, however the results of a replication of the survey in 2021 (*year after treatment*) will allow for a better understanding of the efficacy of the treatment and help to understand whether EWM mortality was achieved rather than the treatment simply injuring the plants and suppressing their growth during the year of treatment. The quantitative success criteria for the 2020 treatment would be a 70% reduction

in the littoral frequency of occurrence from 2019 (*year before treatment*) to 2021 (*year after treatment*). The 2021 survey will aid in the understanding of the changes of aquatic plant populations in the treated area and assess the recovery stage of any native species that were initially impacted.

A qualitative assessment of the 2020 herbicide treatment would include comparing the 2019 Late-Season EWM Mapping Survey (*year before treatment*)) to the 2020 Late-Season EWM Mapping Survey (*year of treatment*)) mapping results. The treatment would be considered successful in meeting the EWM control goals if the *year of treatment* survey indicates little to no EWM present in the targeted areas during the year of treatment. Further, reductions in EWM in the targeted areas would be expected to last into 2021.

Herbicide concentration monitoring would occur in the hours and days following the herbicide treatment. The design of the herbicide concentration monitoring will be based off of similar monitoring programs completed by Onterra with WDNR input and will attempt to provide as much value as possible in advancing the understanding of treatments of this nature. Volunteers from the ALA will be recruited to carry out the post-treatment sample collection and will be trained and provided supplies by Onterra, or the WDNR as needed.

The ALA has solicited Onterra to assist in the creation and submittal of a multi-year AIS-EPC grant for the February 2020 grant cycle that reflects a 3-year project utilizing the Control & Monitoring Strategy outlined here.



J-19
I-19
H-19
D-19
G-19
C-19
B-19
F-19
E-19
A-19

2019 Preliminary Control Strategy: DASH Hand-Harvest			
Site	Priority after Nav. Lanes	Preliminary Acres	Ave Depth (feet)
A-19	1st	4.9	7 (3-12)
B-19	1st	2.3	8 (4-14)
C-19	1st	3.7	10 (4-15)
D-19	1st	0.4	8 (6-11)
E-19	2nd	0.4	5 (4-6)
F-19	2nd	0.4	11 (8-16)
G-19	2nd	0.6	7 (4-9)
H-19	2nd	8.1	9 (4-14)
I-19	2nd	7.1	9 (4-14)
J-19	3rd	27.0	8 (2-14)
Total		54.9	

N
W E
S

840
Feet

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

Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra, 2019
Orthophotograph: NAIP, 2017
Bathymetry: Onterra, 2014; processed by C-Map USA
Map date: June 24, 2019 JMB
File name: *Anvil_EWM_June19.mxd*

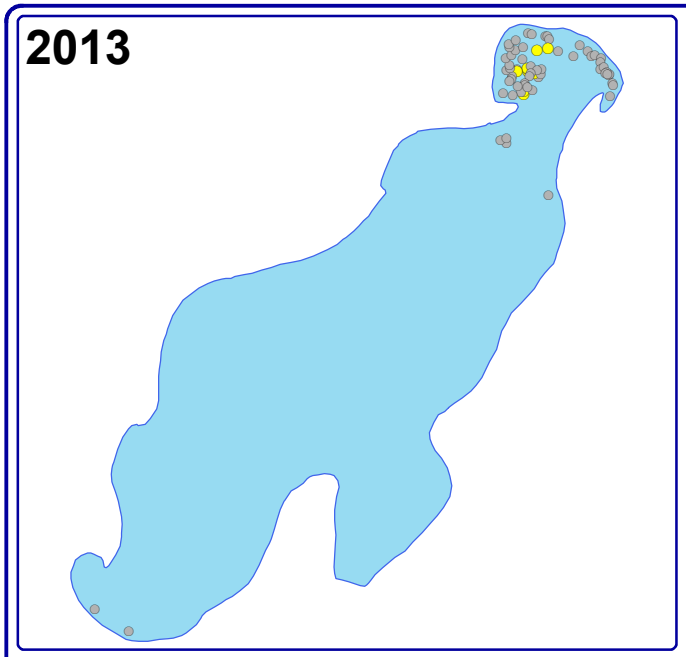

Project Location in Wisconsin

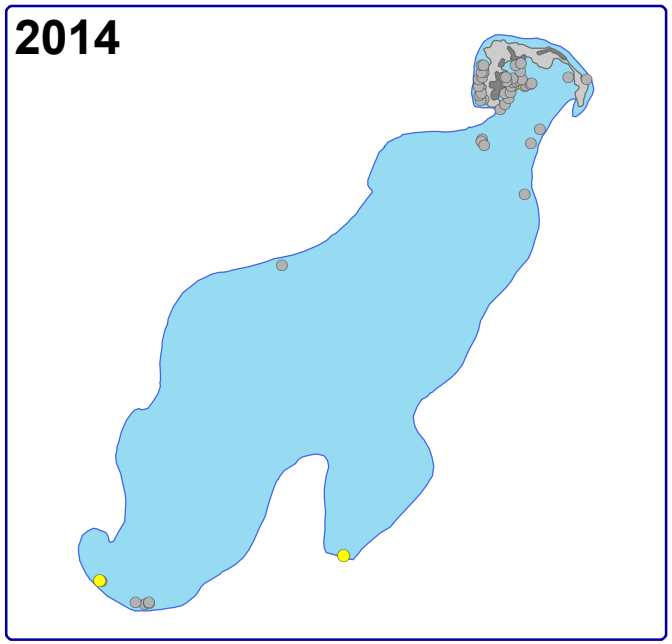
Legend

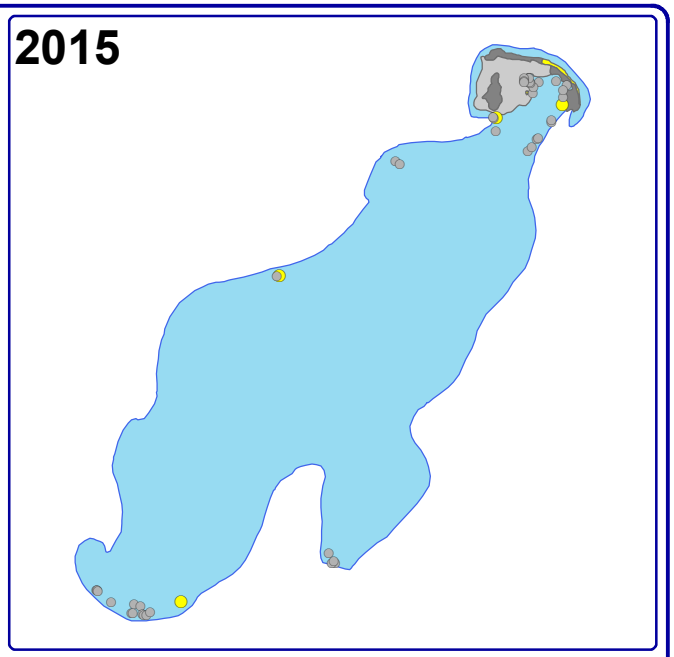
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting *(none found)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2019 DASH Hand-Harvest Locations
- 2018 DASH Navigation Lanes (15' wide; 0.6 acres)

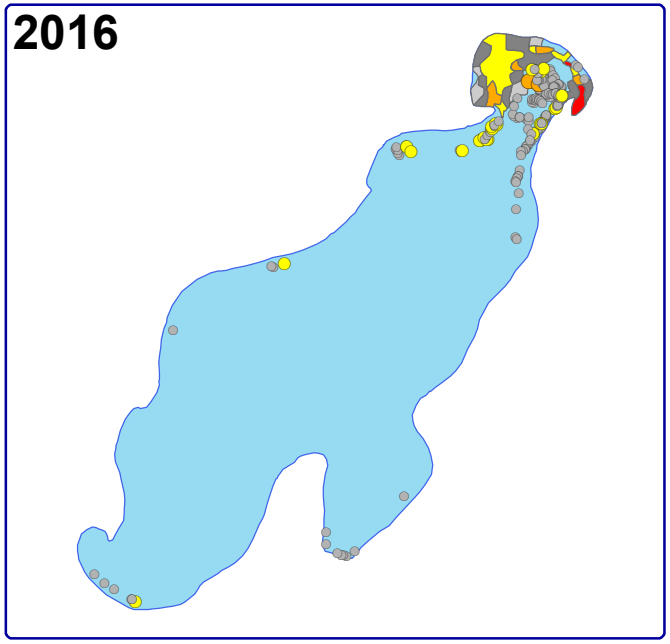
Map 1
Anvil Lake
Vilas County, Wisconsin

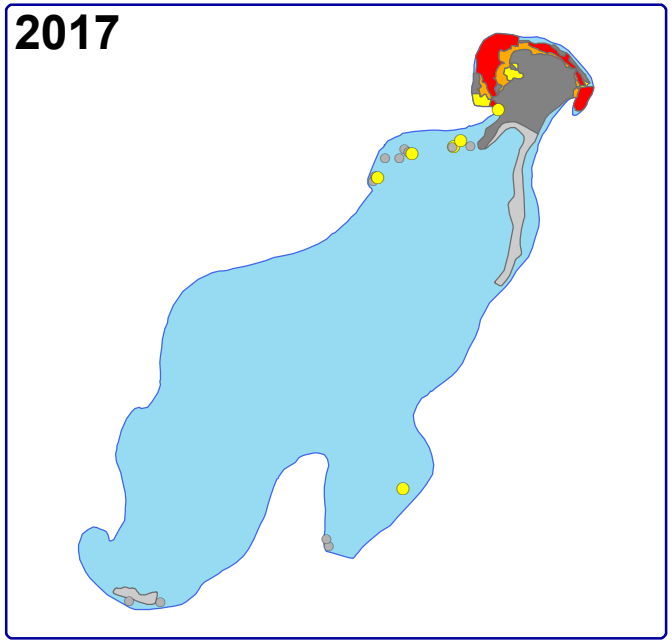
June 2019 EWM Survey Results

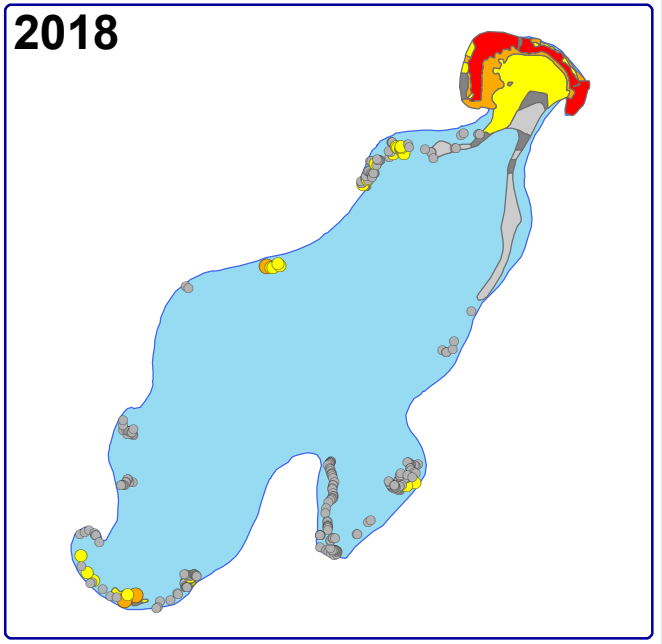












N
W E
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2,000
Feet

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

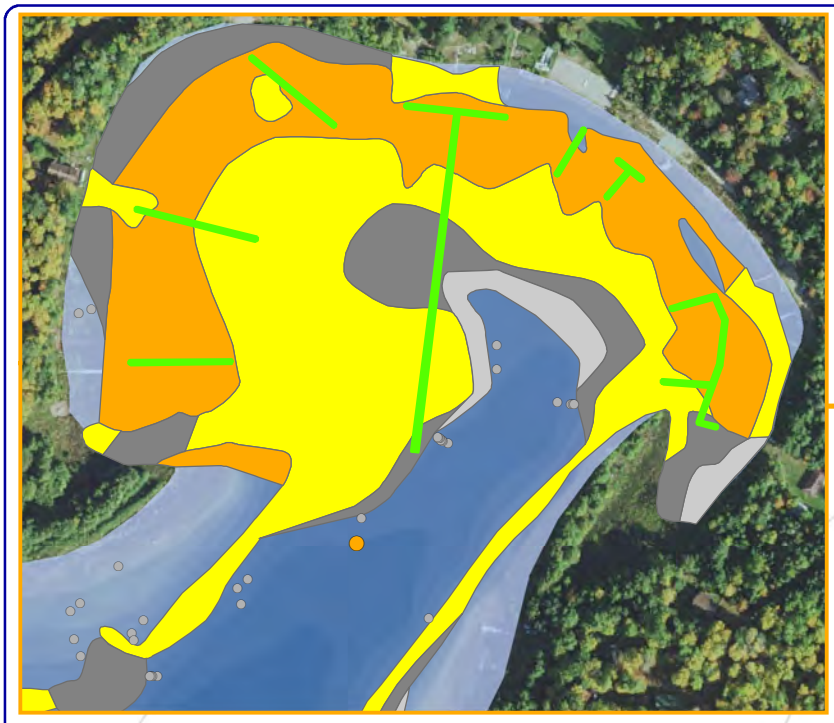
Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra
Aquatic Plants: Onterra, 2014-2019
Orthophtography: NAIP, 2017
Map Date: January 8, 2020 AMS
Filename:Anvil_EWMcompare_2013-2018.mxd


Project Location in Wisconsin

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

Map 2
Anvil Lake
Vilas County, Wisconsin
2013-2018 EWM Survey Results



J-19
I-19
H-19
D-19
G-19
F-19
E-19
A-19
C-19
B-19

N
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840
Feet

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Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2019
Orthophotograph: NAIP, 2017
Bathymetry: Onterra, 2014; processed by Navico
Map date: *December 30, 2019 AMS*


Project Location in Wisconsin

Legend

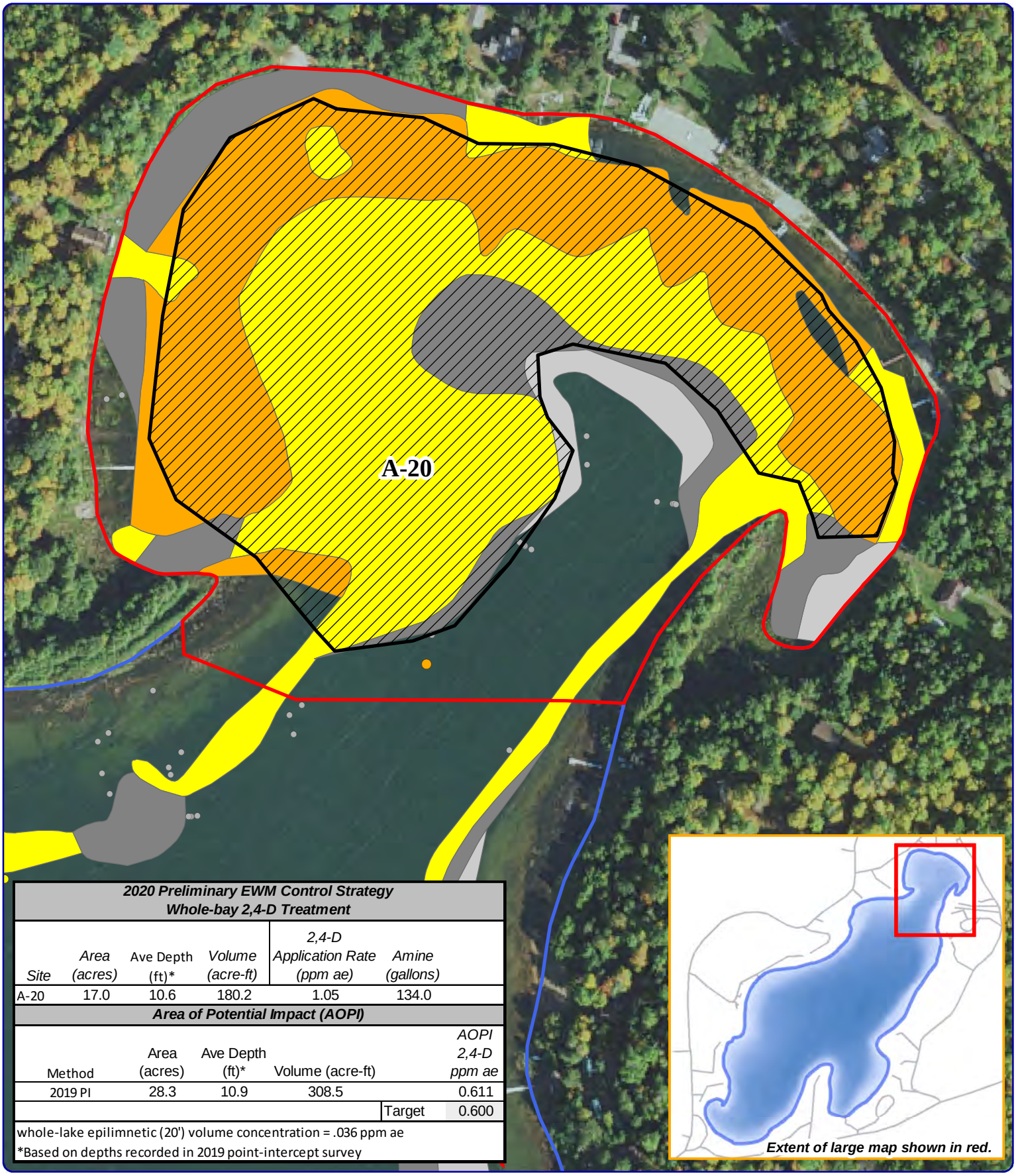
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2018 DASH Navigation Lanes (15' wide; 0.6 acres)
- 2019 DASH Locations

Map 3

Anvil Lake

Vilas County, Wisconsin

September 2019 EWM Survey Results



2020 Preliminary EWM Control Strategy
Whole-bay 2,4-D Treatment

Site	Area (acres)	Ave Depth (ft)*	Volume (acre-ft)	2,4-D Application Rate (ppm ae)	Amine (gallons)
A-20	17.0	10.6	180.2	1.05	134.0

Area of Potential Impact (AOPI)

Method	Area (acres)	Ave Depth (ft)*	Volume (acre-ft)		AOPI 2,4-D ppm ae
2019 PI	28.3	10.9	308.5		0.611
				Target	0.600

whole-lake epilimnetic (20') volume concentration = .036 ppm ae

*Based on depths recorded in 2019 point-intercept survey

N W E S

200

Feet

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

Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2019
Orthophotograph: NAIP, 2017
Bathymetry: Onterra, 2014; processed by Navico
Map date: *September 13, 2019 JMB*

Legend

September 2019 EWM Survey Results

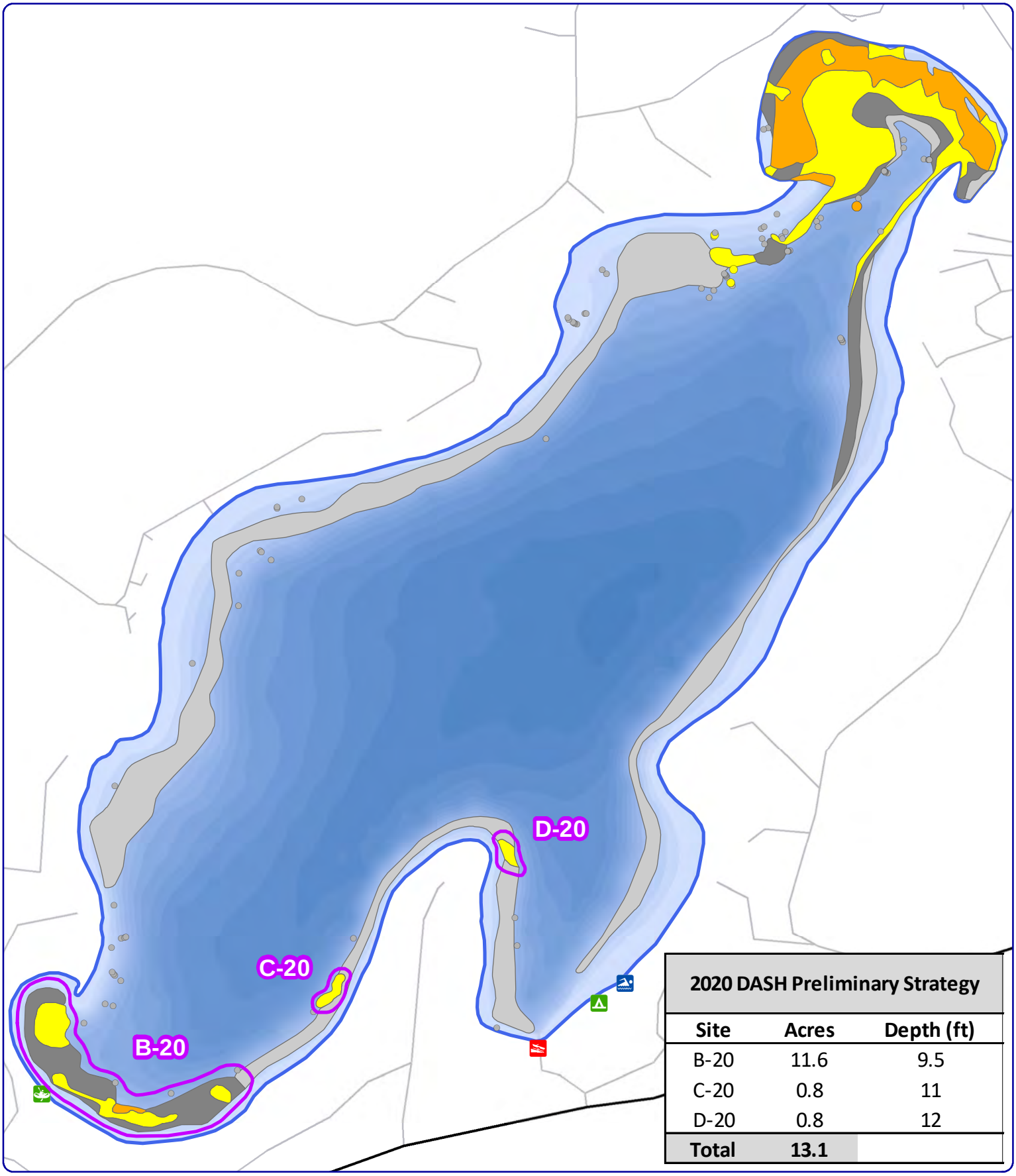
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Area of Potential Impact (AOPI)
- Proposed Herbicide Application Areas

Map 4

Anvil Lake

Vilas County, Wisconsin

Proposed 2020 EWM Herbicide Treatment Strategy



2020 DASH Preliminary Strategy		
Site	**Acres**	**Depth (ft)**
B-20	11.6	9.5
C-20	0.8	11
D-20	0.8	12
Total	**13.1**	

N
W E
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750
Feet

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www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2019

Bathymetry: Onterra, 2014; processed by Navico

Map date: *December 30, 2019 AMS*

Project Location in Wisconsin

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2020 Preliminary DASH Site

Map 5
Anvil Lake
Vilas County, Wisconsin

September 2019 EWM Survey Results & 2020 Preliminary DASH Strategy

A

APPENDIX A

2019 EWM Hand-Harvesting Report – Anvil Lake Association

2019 Eurasian Watermilfoil Harvest Report
Anvil Lake Association

Submitted to:

Anvil Lakes Association and Wisconsin Department of Natural Resources
Amy Kuhns: amykuhnsala@gmail.com
Ty Krajewski: ty.krajewski@wisconsin.gov
Kevin Gauthier: kevin.gauthiersr@wisconsin.gov

Submitted by:

Gene Welhoefer
gwelhoef@gmail.com

December 9, 2019

Introduction:

The Anvil Lake Association invested in the components to build a Diver Assisted Suction Harvesting (DASH) unit for use on Anvil Lake in 2019. This summer was the third summer the DASH was available for the entire season. The DASH unit was used to manage Eurasian watermilfoil (EWM) in the North Bay of the lake and other approved areas. A permit was granted to the Anvil Lake Association for the EWM removal by the Wisconsin Department of Natural Resources to allow mechanical harvesting on 12 acres in the north bay of the lake and other selected areas. The DASH unit remained on Anvil Lake for the entire harvest season.

Dive Methods:

The divers have had a range of experience hand-harvesting EWM. Experienced divers were used to train inexperienced divers on the use of the DASAH and harvesting techniques. Three experienced and 4 new divers utilized the unit during the 2019 harvest season. During harvest, one or two people were present on the DASH working as deck hands to handle the boat duties and bagging system. To begin the work with the DASH unit a general overall plan was developed to work in the north bay to establish navigation channels into the main lake body as well as working in other areas where clusters/colonies were present. The approach allowed the harvest team to work one area from a fixed beginning point and systematically clear areas. Additional sites were determined based upon identification of emergent plants. In general, the boat was anchored in one location and the diver was able to harvest within the 50-foot radius of the boat during one harvest session.

The DASH unit was most effective in areas when the EWM was concentrated. In these locations, the divers were able to hover above the plants or descend to the lakebed to remove the EWM plant and root. The mass was then feed through the suction hose and into the bagging system located on the DASH pontoon boat. The plants were either fed into the suction hose by the root ball or top of the plant. The plant moves through the suction hose and is "caught" in bags located on the boat deck. The bagging system used 40-pound mesh bags, typically sold for storage of onions or potatoes. The boat is designed to allow for the discharge hose to be pivoted between two mesh bags. When one bags is filled the discharge hose is pivoted to the second bag. While the second bag is being filled the full bag is tied, remove from the stand, and moved to a storage section of the pontoon. An empty bag is place in the collection station. This process continues throughout harvest. During the harvest a sample bags is used to determine the quality of the harvest. This sample is weighed, and separated into EWM and non-EWM material. At the end of the harvest day, the bags are removed from the DASH pontoon and loaded on a trailer. The collected materials are taken to a local farmer who is testing the application of EWM as a source of fertilizer.

Harvest Summary:

A total of 323.75 hours were clocked on the water utilizing the DASH unit. During this time the divers removed approximately 19,371 pounds of EWM. The harvest sample indicated the percent EWM harvested was between 95-100%. Six harvest data logs are attached to the report.

Anvil La[illegible] DASH
Harvest Data

Date	Location	GPS Waypoints	Dive Time hrs.	EWM (lbs)	Native Vegetation (lbs)	Incidental Harvest of Native Vegetation	Total Harvest (lbs)	Local Conditions Temperature, Wind Waves, Depth, Water Clarity
6/4/18	86		4	73	~~0~~	~~0~~	73	~~WINDY~~, 72° CLOUDY, 3-5'
6-5-18	86		4		0	0		Calm, 51°-65°
6/1/18	81			43	25	~~STAY~~ Bird	146	
~~5/3/18~~	81							
6/3/19			8	630	0	0	630	Overcast 57°
6/4/19	noren bay		6	78	0	0	78	calm 76° F
6/5/19	North Bay		4	696	0	0	696	Calm 79°F
6/6/19	No Bay		4	610	0	0	610	Calm 81°F
6/6/19	N B		1	29	0	0	29	Lookout down
6/9/19	N B		5	150	0	0	150	Lane to shoreline (Thin)
[illegible]	N B		1.5	40	0	0	40	~~Tons~~ Training
6/14/19	N B		3	32	0		32	Rainy / windy
6/17/19	N B		4	105	/	/	105	Sunny 70°
6/18	N B		3	18	0	0	18	Cloudy
6/18	NB		3	44	0	0	44	Cloudy
6/19	NB		3	20	0	0	20	Sunny, little wind
6/19	NB		4	110	0	0	110	Partly Cloudy
6/20	NB		4	30	0	0	120	Partly cloudy
6/20	NB		4	22	0	0	88	low visibility/cloudy
6/21	NB		4	38	0	0	132	DeVos Dock

61.5 2908

Anvil Lake [illegible]SH
Harvest Data

Date	Location	Dive Time hrs.	EWM weight (lbs/bag)	Total Bags Harvested	% Milfoil Harvest Sample	Total Harvest (lbs)	Local Conditions Temperature, Wind Waves, Depth, Water Clarity
8/16	C-18 4	3	35	7	90%	245	cloudy, breezy
8/27	C-18 3	2.5	288	13	96%	298 weighted on 8/29/18	cloudy & windy
8/4	A-18	3	35	7	95%	245	sunny, calm good clarity
9/1	A-18	3	35	10	95%	350	partly sunny light breeze
9/2	A-18	3	35	12	95%	420	fair clarity
8/20	C-18 3	2	35	8	95%	280	over cast fair clarity
~~6/3/19~~	~~C-18 5~~	~~8~~	~~630~~	~~21~~	~~95%~~	~~630~~	~~overcast 57°~~
~~6/4/19~~	~~Anvil Lake~~	~~6½~~	~~78~~	~~6~~	~~95%~~	~~78~~	~~76° Shore, calm~~
6/24/19	NB	4	28	3	95%	~~56~~ 85	78° calm
6/25/19	NB	4	30	4	100%	120	80° windy
6/[illegible]/19	NB	3	14	2	95%	28	68° windy very cloudy & dark
6/25/19	NB	5	28	5	95%	169 pics	Rain, cloudy 69°
6/25/19	NB	4	28	2	95%	50	sun, windy 75°
6/26/19	NB	1	45	1	95%	45	Too windy !!!
6/27/19	NB	3	30	6	100%	150 16	80° Sunny. Calm
6/27/19	NB	4	21	3	100	63	80° Sunny Calm
6/28	NB	3	40	4	95%	142	75° rainy windy

Note: The outboard and water pump both use regular gasoline. No Oil Mix

61

3393

Anvil Lake CISH
Harvest Data

Date	Location	Dive Time hrs.	EWM weight (lbs/bag)	Total Bags Harvested	% Milfoil Harvest Sample	Total Harvest (lbs)	Local Conditions Temperature, Wind Waves, Depth, Water Clarity
6/28/19	North Bay	4	281	8	100%	281	77° Partly Cloudy
6/30/19	ND	4	160	4	95%	160	78° Partly cloudy
7/1/19	ND	3	300	8	95%	300	75° Rain
7/2/19	NB	3	105	3	100%	105	80° Sunny Calm
7/2/19	ND	4	269	8	95%	269	79° Sunny Calm
7/3/19	NB	4	32	3	100	96	85° Sunny
7/6/19	A-18	4	35	5	100%	175	85° Sunny
7/8/19	North Bay	4	43	10	100%	430	75° Sunny South wind
7/8/19	North Bay	3	25	8	100%	200	77° Sunny Calm
7/9/19	ND	4	38	7	100%	300	79° Sunny Calm
7/10/19	ND	3	30	10	100%	300	79° Windy
7/10/19	ND	3:45	20	4	100%	64	77° Partly cloudy & Windy
7/11/19	NB	4	035	3	95%	105	75° Windy
7/11/19	A-18	84	25	6	100%	125	75 Windy
7/12/19	SA	6	40	3	100%	120	70° Windy, Partly Cloudy
7/15/19	ND	4	35	5	95%	160	78° Sunny
7/15/19	ND	2.5	35	6	100%	170	75° Sunny
7/16/19	NB	4	38	8	100%	304	75° Sunny

Note: The outboard and water pump both use regular gasoline. No Oil Mix

68.25

3626

Anvil Lake [illegible]SH
Harvest Data

Date	Location	Dive Time hrs.	EWM weight (lbs/bag)	Total Bags Harvested	% Milfoil Harvest Sample	Total Harvest (lbs)	Local Conditions Temperature, Wind Waves, Depth, Water Clarity
7/16/19	North Bay		28	10.5	100	294	75, Calm
7/17/19	North Bay		27	52	100	54	81
7/17/19	N.B.	3	30	6	90%	180	windy
7/19/19	N.B.	4	50	2	95%	100	85, calm
7/19/19	A-18	4	40	6	95%	240	85 calm
7/22/19	N.B.	4	30	10	95%	300	72 windy
7/22/19	N.B	3	27	11	100%	300	80°
7/23/19	N.B	4	33	9	90%	297	75°
7/23/19	N.B.	3	27	7.5	95%	202	75°
7/24/19	NB	3.5	40	2	100%	80	75° Sunny
7/24/19	NB	4	30	9	95%-100%	280	75° Sunny
7/25/19	N.B	4	30	8	95%	240	80 sunny windy
7/26/19	N.B	1.5	40	2	100%	80	78° [illegible]
7/29/19	N.B	4	30	9	100%	270	75° Cloudy
7/29/19	N.B	3.5	25	4	100%	100	75° windy
7/30/19	North Bay	4	35	9	100%	300	65° Breezy
7/30/19	N.B.	4	30	12	100%	360	70° Breezy & Calm
7/31/19	N.B	4	35	2	100%	70	80° Calm Sunny

Note: The outboard and water pump both use regular gasoline. No Oil Mix

46 587 3747

Anvil Lake SH

Harvest Data

Date	Location	Dive Time hrs.	EWM weight (lbs/bag)	Total Bags Harvested	% Milfoil Harvest Sample	Total Harvest (lbs)	Local Conditions Temperature, Wind Waves, Depth, Water Clarity
7/31/19	NB	4	36	13	95%	424	Sunny, calm
8/1/19	NB	4	35	7.5	95%	260	Sunny Calm,
8/2/19	NB	8	35	8	95%	310	Sunny, & light wind
8/6/19	NB	4	25	11.5	95%	287	nice out
8/6/19	NB	2	21	3	100%	63	80° Sunny Calm
8/7/19	NB	2.5	25	2	100%	50	70 Cloudy
8/8/19	NB	4	25	4	100%	100	Sunny Windy 70
8/8/19	NB	2.5	39	2.5	95%	97	Sunny, windy
8/9/19	NB	4	32	5.5	95%	176	Sunny/windy
8/9/19	NB	3	20	2	95%	40	70° sunny & Windy
8/10/19	NB	4	41	12	100%	500	70° Sunny
8/10/19	NB	3.5	31	4	100%	125	75 Sunny
8/12/19	A-18	4	31	4	~~100~~ 95%	126	75° Partly Cloudy
8/12/19	A-18	4	33	12	95%	400	75° Cloudy
8/13/19	A-18	1.5	30	1	100	30	57° Cloudy drizzles
8/14/19	NB	5	37	9.5	95%	357	Sunny little wind
~~8/17/19~~	~~Camp Ground~~	2	42	2	95%	85	Sunny little wind
8/17/19	Camp Ground	4	35	3	95%	105	75° Sunny

Note: The outboard and water pump both use regular gasoline. No Oil Mix

8/19/19	A-18	4	33	18	95%	608	75° sunny
8/19/19	A-18	3	28	2	95	56	77° Sunny/Windy
8/20/19	A-18	2	30	7	100%	210	62° Cloudy
8/20 19	NB	1.5	33	8	95%	268	64° Cloudy
		78	667			4677	

Anvil Lake SH
Harvest Data

Date	Location	Dive Time hrs.	EWM weight (lbs/bag)	Total Bags Harvested	% Milfoil Harvest Sample	Total Harvest (lbs)	Local Conditions Temperature, Wind Waves, Depth, Water Clarity
8/28/19	A-18	6	45	6	95%	270	Wind and temperature
8/29/19	A-18	3	25	3	99%	750	
						1020	
		9	65				
		323.25				19,371	

Note: The outboard and water pump both use regular gasoline. No Oil Mix

B

APPENDIX B

2019 ALA Stakeholder Survey Results

Anvil Lake - Anonymous Stakeholder Survey

Surveys Distributed: 121
Surveys Returned: 78
Response Rate: 64%

Anvil Lake Property

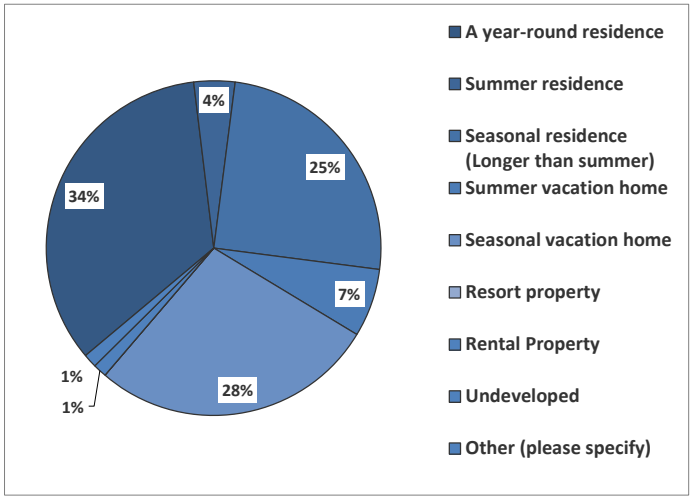
1. Is your property on the lake or off the lake?

Answer Options	Response Percent	Response Count
On the lake	98.7%	75
Off the lake	1.3%	1
answered question		76
skipped question		2

2. How is your property on or near Anvil Lake utilized?

Answer Options	Response Percent	Response Count
A year-round residence	34.2%	26
Summer residence	4.0%	3
Seasonal residence (Longer than summer)	25.0%	19
Summer vacation home	6.6%	5
Seasonal vacation home	27.6%	21
Resort property	0.0%	0
Rental Property	0.0%	0
Undeveloped	1.3%	1
Other (please specify)	1.3%	1
answered question		76
skipped question		2

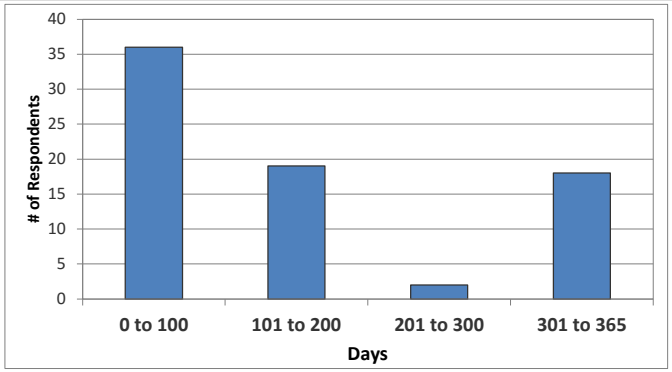
Number	Other (please specify)
1	May thru October



3. How many days each year is your property used by you or others?

Answer Options	Response Count
	75
answered question	75
skipped question	3

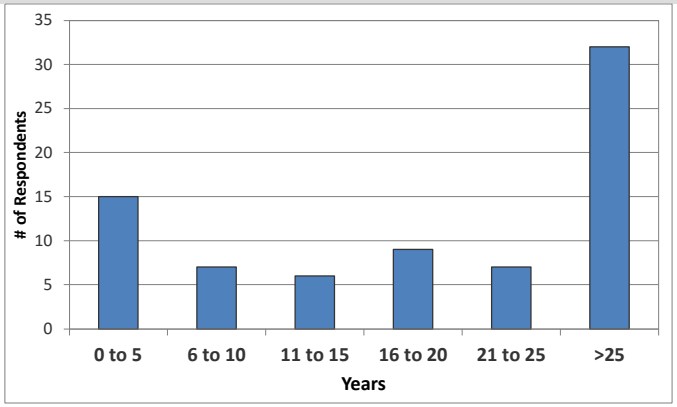
Category (# of days)	Responses	
0 to 100	36	48%
101 to 200	19	25%
201 to 300	2	3%
301 to 365	18	24%



4. How long have you owned your property on or near Anvil Lake?

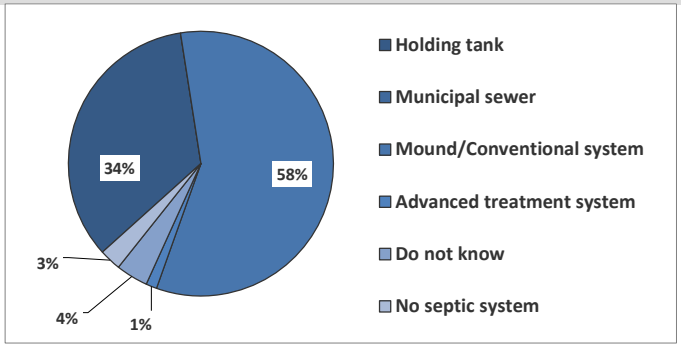
Answer Options	Response Count
	76
answered question	76
skipped question	2

Category (# of years)	Responses	% Response
0 to 5	15	20%
6 to 10	7	9%
11 to 15	6	8%
16 to 20	9	12%
21 to 25	7	9%
>25	32	42%



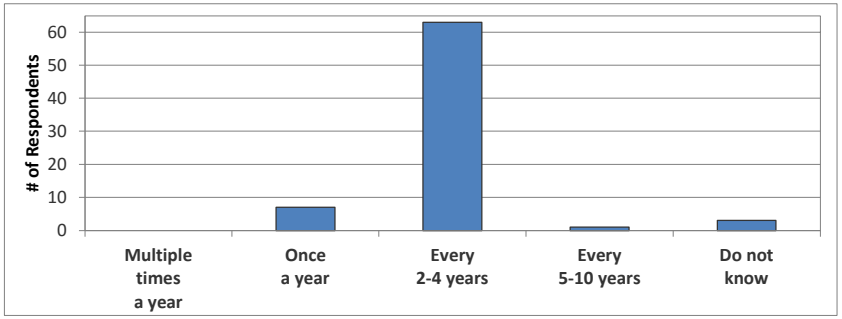
5. What type of septic system does your property utilize?

Answer Options	Response Percent	Response Count
Holding tank	34.2%	26
Municipal sewer	0.0%	0
Mound/Conventional system	57.9%	44
Advanced treatment system	1.3%	1
Do not know	4.0%	3
No septic system	2.6%	2
answered question		76
skipped question		2



6. How often is the septic system on your property pumped?

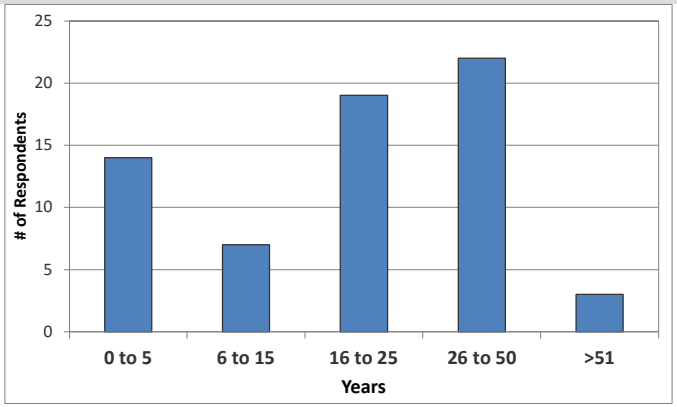
Answer Options	Response Percent	Response Count
Multiple times a year	0.0%	0
Once a year	9.5%	7
Every 2-4 years	85.1%	63
Every 5-10 years	1.4%	1
Do not know	4.1%	3
answered question		74
skipped question		4



7. How long have you owned your property on or near Anvil Lake?

Answer Options	Response Count
	70
answered question	70
skipped question	8

Category (# of years)	Responses	% Response
0 to 5	14	20%
6 to 15	7	10%
16 to 25	19	27%
26 to 50	22	31%
>51	3	4%
Do not know	5	7%

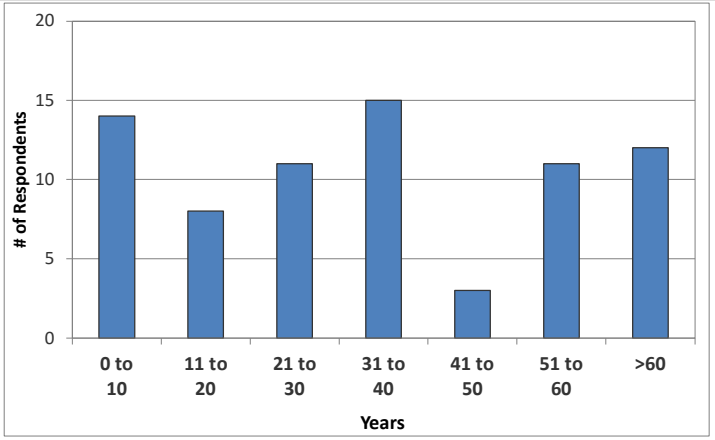


Recreational Activity on Anvil Lake

8. How many years ago did you first visit Anvil Lake?

Answer Options	Response Count
	74
answered question	74
skipped question	4

Category (# of years)	Responses	% Response
0 to 10	14	19%
11 to 20	8	11%
21 to 30	11	15%
31 to 40	15	20%
41 to 50	3	4%
51 to 60	11	15%
>60	12	16%



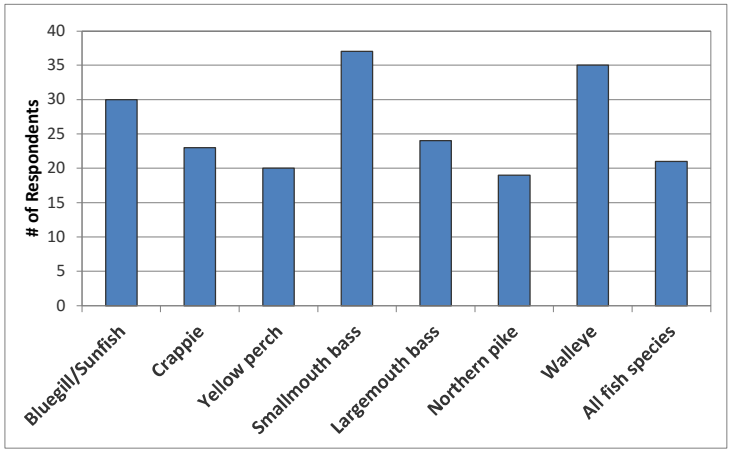
9. Have you personally fished on Anvil Lake in the past three years?

Answer Options	Response Percent	Response Count
Yes	85.3%	64
No	14.7%	11
answered question		75
skipped question		3

10. What species of fish do you like to catch on Anvil Lake?

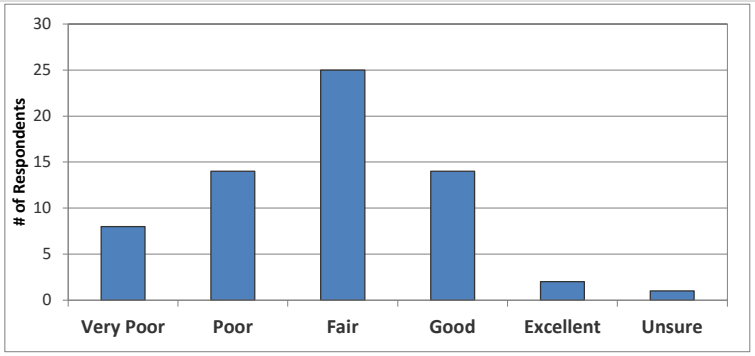
Answer Options	Response Percent	Response Count
Bluegill/Sunfish	46.9%	30
Crappie	35.9%	23
Yellow perch	31.3%	20
Smallmouth bass	57.8%	37
Largemouth bass	37.5%	24
Northern pike	29.7%	19
Walleye	54.7%	35
All fish species	32.8%	21
Other	3.1%	2
answered question		64
skipped question		14

Number	Other (please specify)
1	walleye, perch
2	Rock bass



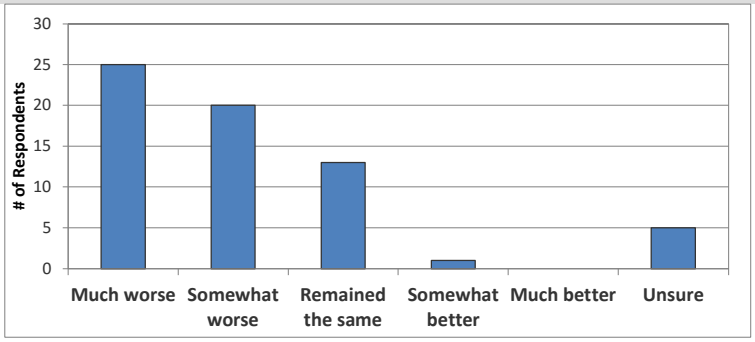
11. How would you describe the current quality of fishing on Anvil Lake?

Answer Options	Very Poor	Poor	Fair	Good	Excellent	Unsure	Response Count
	8	14	25	14	2	1	64
						answered question	**64**
						skipped question	**14**



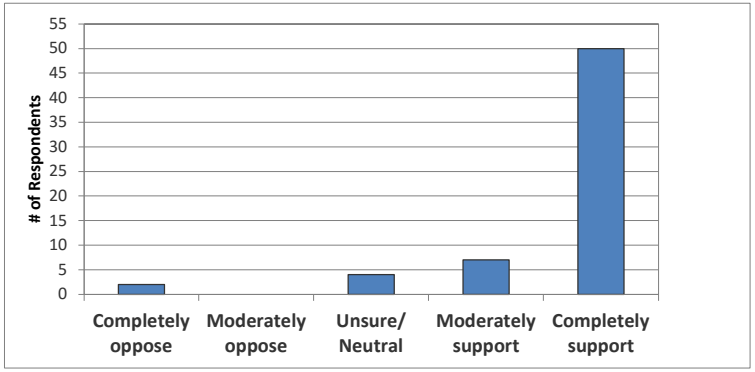
12. How has the quality of fishing changed on Anvil Lake since you have started fishing the lake?

Answer Options	Much worse	Somewhat worse	Remained the same	Somewhat better	Much better	Unsure	Response Count
	25	20	13	1	0	5	64
						answered question	**64**
						skipped question	**14**



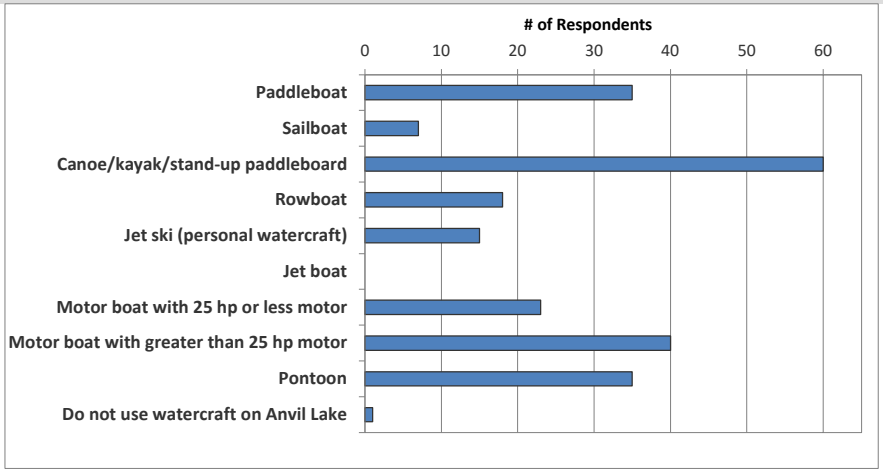
13. Are you in favor of the Wisconsin Department of Natural Resources stocking fingerling walleye on Anvil Lake in 2020?

Answer Options	Completely oppose	Moderately oppose	Unsure/ Neutral	Moderately support	Completely support	Response Count
	2	0	4	7	50	63
					answered question	**63**
					skipped question	**15**



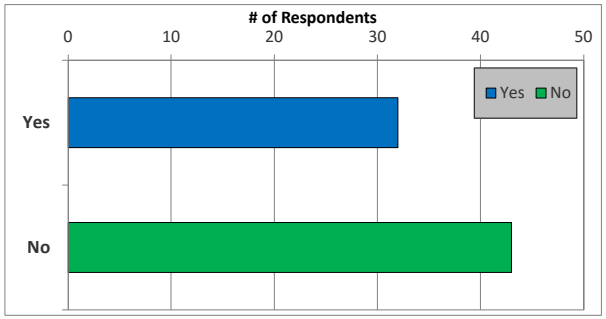
14. What types of watercraft do you currently use on Anvil Lake?

Answer Options	Response Percent	Response Count
Paddleboat	46.7%	35
Sailboat	9.3%	7
Canoe/kayak/stand-up paddleboard	80.0%	60
Rowboat	24.0%	18
Jet ski (personal watercraft)	20.0%	15
Jet boat	0.0%	0
Motor boat with 25 hp or less motor	30.7%	23
Motor boat with greater than 25 hp motor	53.3%	40
Pontoon	46.7%	35
Do not use watercraft on Anvil Lake	1.3%	1
answered question		75
skipped question		3



15. Do you use your watercraft on waters other than Anvil Lake?

Answer Options	Response Percent	Response Count
Yes	42.7%	32
No	57.3%	43
answered question		75
skipped question		3



16. What is your typical cleaning routine after using your watercraft on waters other than Anvil Lake?

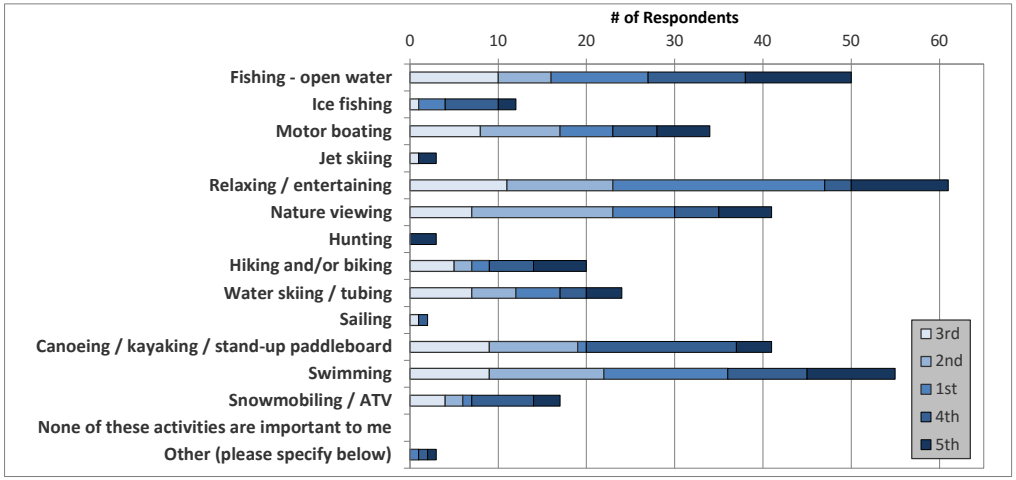
Answer Options	Response Count
Remove aquatic hitchhikers (ex. plant material, clams, mussels)	30
Drain bilge	15
Rinse boat	10
Power wash boat	1
Apply bleach	0
Air dry boat for 5 or more days	9
Do not clean boat	0
Other	1
answered question	**32**
skipped question	**46**

Number	Other (please specify)
1	other family members use other waters

17. For the list below, rank up to five activities that are important reasons for owning your property on Anvil Lake, with 1st being the most important.

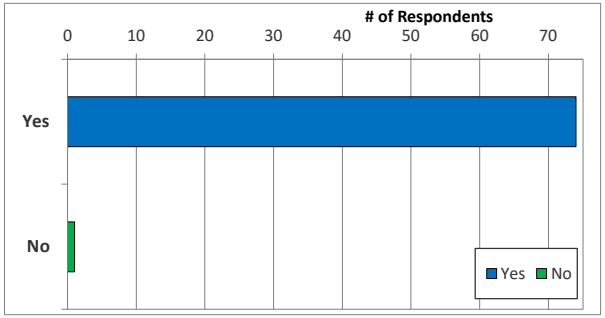
Answer Options	1st	2nd	3rd	4th	5th	Rating Average	Response Count
Fishing - open water	11	6	10	11	12	3.1	50
Ice fishing	3	0	1	6	2	3.3	12
Motor boating	6	9	8	5	6	2.9	34
Jet skiing	0	0	1	0	2	4.3	3
Relaxing / entertaining	24	12	11	3	11	2.4	61
Nature viewing	7	16	7	5	6	2.7	41
Hunting	0	0	0	0	3	5.0	3
Hiking and/or biking	2	2	5	5	6	3.6	20
Water skiing / tubing	5	5	7	3	4	2.8	24
Sailing	0	0	1	1	0	3.5	2
Canoeing / kayaking / stand-up paddleboard	1	10	9	17	4	3.3	41
Swimming	14	13	9	9	10	2.8	55
Snowmobiling / ATV	1	2	4	7	3	3.5	17
None of these activities are important to me	0	0	0	0	0	0.0	0
Other (please specify below)	1	0	0	1	1	3.3	3
						answered question	**75**
						skipped question	**3**

Number	"Other" responses
1	Peace & Solitude
2	snowshoe and cross country ski
3	Visiting neighbors



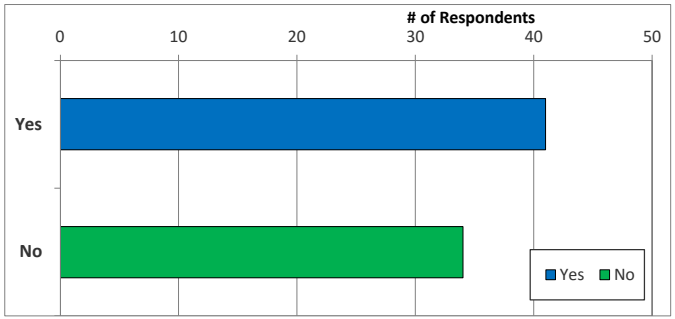
18. During a typical summer, do you or your family ever swim in Anvil Lake?

Answer Options	Response Percent	Response Count
Yes	98.7%	74
No	1.3%	1
answered question		75
skipped question		3



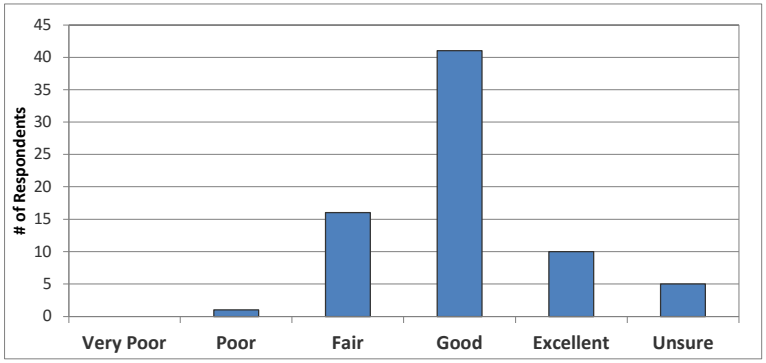
19. Do you have pets that spend time in the water of Anvil Lake?

Answer Options	Response Percent	Response Count
Yes	54.7%	41
No	45.3%	34
answered question		75
skipped question		3



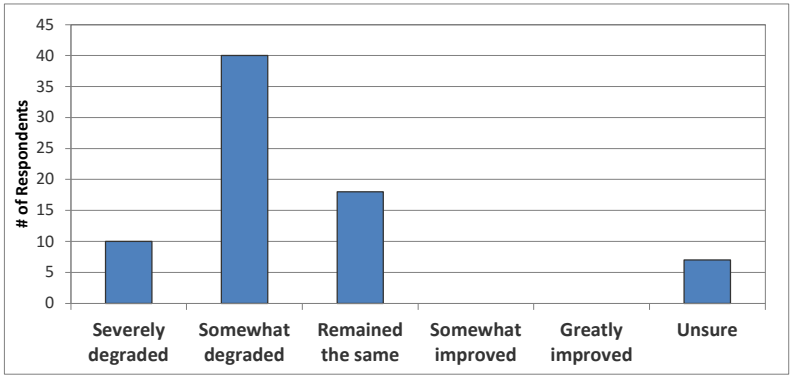
20. How would you describe the overall current water quality of Anvil Lake?

Answer Options	Very Poor	Poor	Fair	Good	Excellent	Unsure	Response Count
	0	1	16	41	10	5	73
						answered question	**73**
						skipped question	**5**



21. How has the overall water quality changed in Anvil Lake since you first visited the lake?

Answer Options	Severely degraded	Somewhat degraded	Remained the same	Somewhat improved	Greatly improved	Unsure	Response Count
	10	40	18	0	0	7	75
						answered question	**75**
						skipped question	**3**



22. Considering how you answered the questions above, what do you think of when describing water quality?

Answer Options	Response Percent	Response Count
Water clarity (clearness of water)	89.3%	67
Aquatic plant growth (not including algae blooms)	68.0%	51
Algae blooms	40.0%	30
Smell	26.7%	20
Water level	30.7%	23
Fish kills	8.0%	6
Other	1.3%	1
answered question		**75**
skipped question		**3**

Number	"Other" responses
1	Presence of milfoil

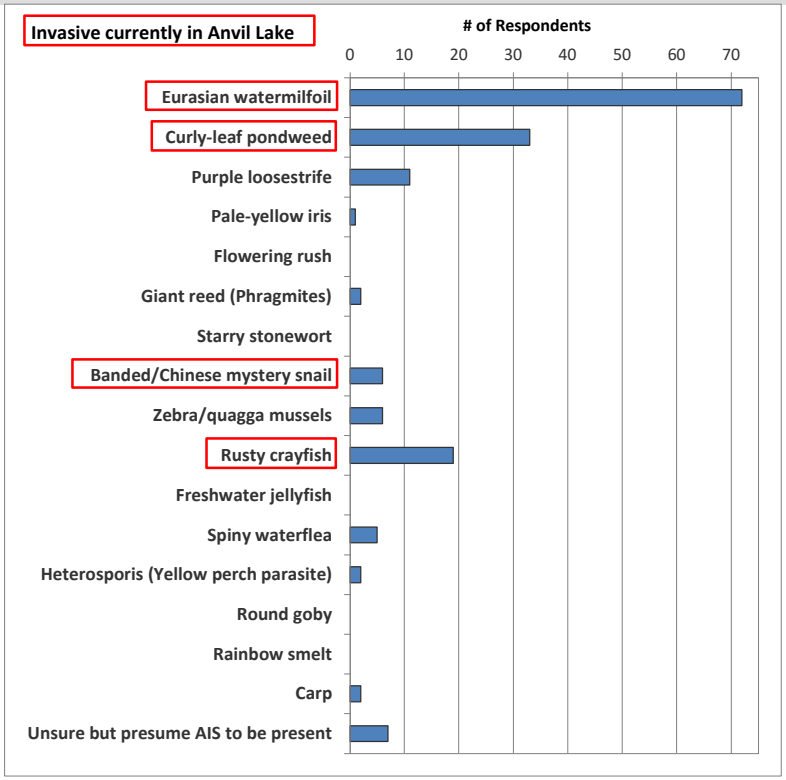
23. Based on your answer above, which of the following would you say is the single most important aspect when considering water quality?

Answer Options	Response Percent	Response Count
Water clarity (clearness of water)	57.3%	43
Aquatic plant growth (not including algae blooms)	32.0%	24
Water color	2.7%	2
Algae blooms	2.7%	2
Smell	0.0%	0
Water level	2.7%	2
Fish kills	0.0%	0
Other	2.7%	2
answered question		**75**
skipped question		**3**

24. Which aquatic invasive species do you believe are in Anvil Lake?

Answer Options	Response Percent	Response Count
Eurasian watermilfoil	98.6%	72
Curly-leaf pondweed	45.2%	33
Purple loosestrife	15.1%	11
Pale-yellow iris	1.4%	1
Flowering rush	0.0%	0
Giant reed (Phragmites)	2.7%	2
Starry stonewort	0.0%	0
Banded/Chinese mystery snail	8.2%	6
Zebra/quagga mussels	8.2%	6
Rusty crayfish	26.0%	19
Freshwater jellyfish	0.0%	0
Spiny waterflea	6.9%	5
Heterosporis (Yellow perch parasite)	2.7%	2
Round goby	0.0%	0
Rainbow smelt	0.0%	0
Carp	2.7%	2
Unsure but presume AIS to be present	9.6%	7
Other (please specify)	5.5%	4
answered question		**73**
skipped question		**5**

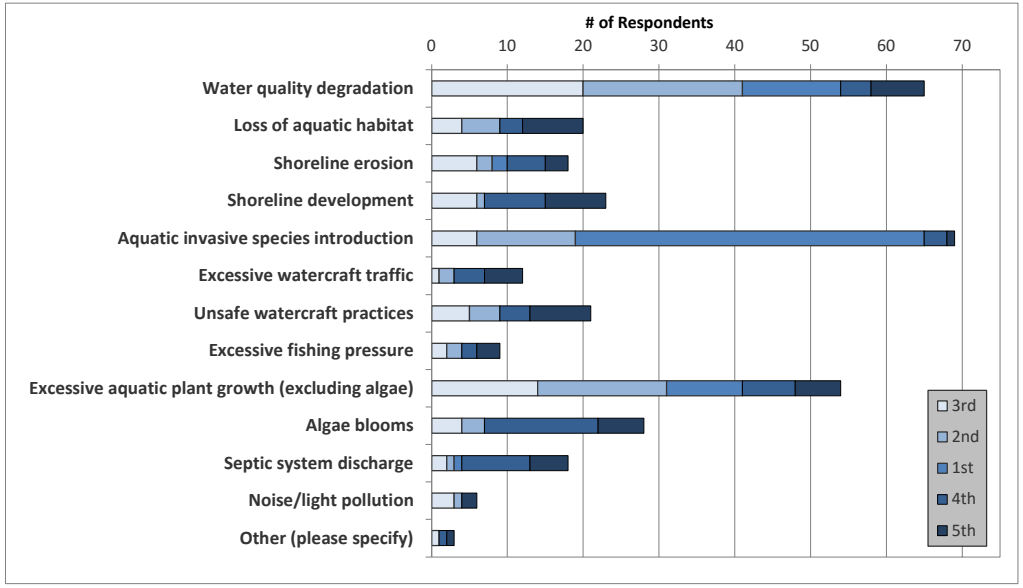
Number	"Other" responses
1	probably more
2	what ever types put into the lake by {ALA}
3	Invasive thistles
4	can't comment on this yet



25. From the list below, please rank your top five concerns regarding Anvil Lake, with 1 being your greatest concern.

Answer Options	1st	2nd	3rd	4th	5th	Response Count
Water quality degradation	13	21	20	4	7	65
Loss of aquatic habitat	0	5	4	3	8	20
Shoreline erosion	2	2	6	5	3	18
Shoreline development	0	1	6	8	8	23
Aquatic invasive species introduction	46	13	6	3	1	69
Excessive watercraft traffic	0	2	1	4	5	12
Unsafe watercraft practices	0	4	5	4	8	21
Excessive fishing pressure	0	2	2	2	3	9
Excessive aquatic plant growth (excluding algae)	10	17	14	7	6	54
Algae blooms	0	3	4	15	6	28
Septic system discharge	1	1	2	9	5	18
Noise/light pollution	0	1	3	0	2	6
Other (please specify)	2	1	1	1	1	6
					answered question	**74**
					skipped question	**4**

Number	"Other" responses
1	Health of the fishery
2	water level
3	NATIVE AMERICAN OVERFISHING
4	fertilizer run off
5	Health of the fishery
6	Health of the fishery
7	other types of fish put into the lake by ALA & DNR
8	current aquatic invasive plants
9	lack of respect visitors have for the health of Anvil Lake
10	Poor fishing due to spearing by indians
11	excessive fishing only applies to spearing



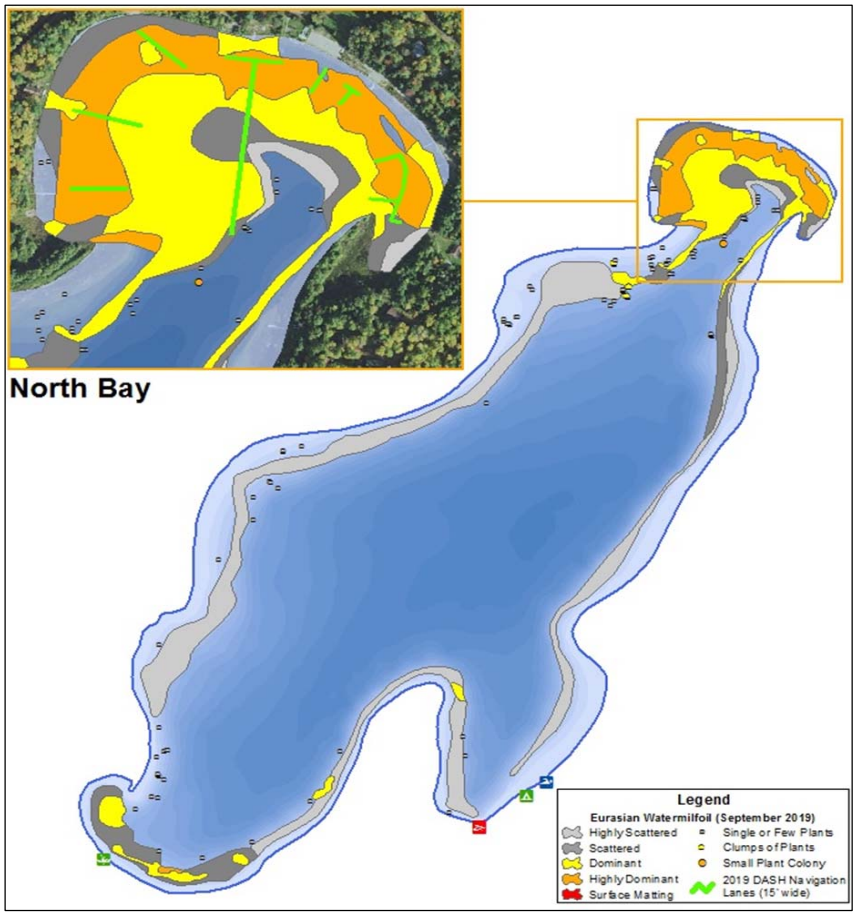
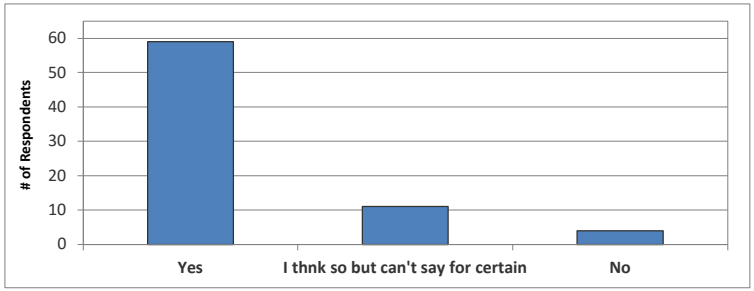


Figure 1. 2019 Late-Summer EWM Survey Results and Nuisance Navigation Lanes in North Bay (inset).

26. Do you believe you are able to identify Eurasian watermilfoil from Anvil Lake?

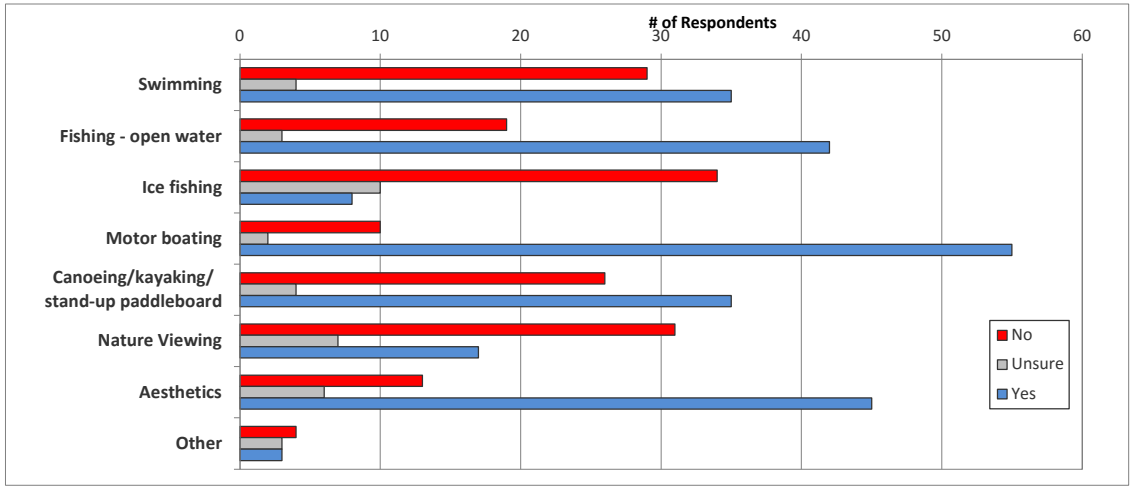
Answer Options	Yes	I thnk so but can't say for certain	No	Response Count
	59	11	4	74
			answered question	**74**
			skipped question	**4**



27. Has the Eurasian watermilfoil population ever had a negative impact on your enjoyment of Anvil Lake?

Answer Options	Yes	Unsure	No	Response Count
Swimming	35	4	29	68
Fishing - open water	42	3	19	64
Ice fishing	8	10	34	52
Motor boating	55	2	10	67
Canoeing/kayaking/ stand-up paddleboard	35	4	26	65
Nature Viewing	17	7	31	55
Aesthetics	45	6	13	64
Other	3	3	4	10
			answered question	**71**
			skipped question	**7**

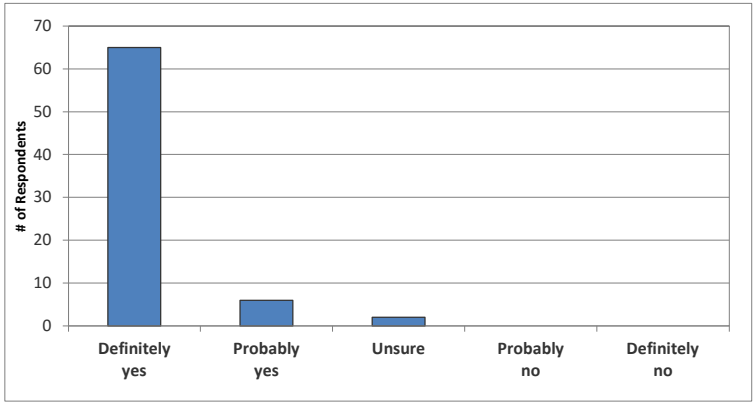
Number	"Other" responses
1	We are concerned it will spread, especially to our swimming area
2	SOME ANSWER
3	Knowing where it's growing, we have to avoid a large section of the lake. We haven't been in the north bay for year now, it's sad.
4	The time and cost it takes to manage EWM
5	Diminished property values



28. Do you believe the Eurasian watermilfoil population should be managed in Anvil Lake?

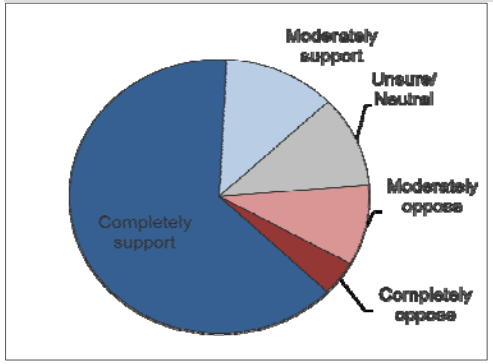
Answer Options	Definitely yes	Probably yes	Unsure	Probably no	Definitely no	Response Count
	65	6	2	0	0	73
					answered question	**73**
					skipped question	**5**

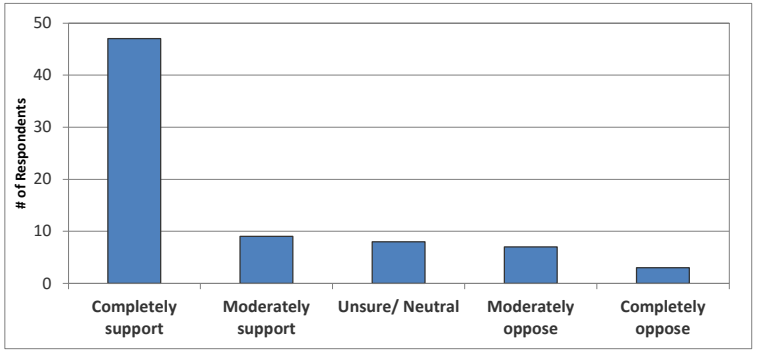
Number	"Other" responses
1	Our property is in N Bay. We are avid swimmers
2	I do not believe it can be controlled by DASH



29. Are you in favor of the current use of DASH (Diver Assisted Suction Harvest) to create navigation lanes in the North Bay similar to the lanes displayed in green on the map prior to Question 26?

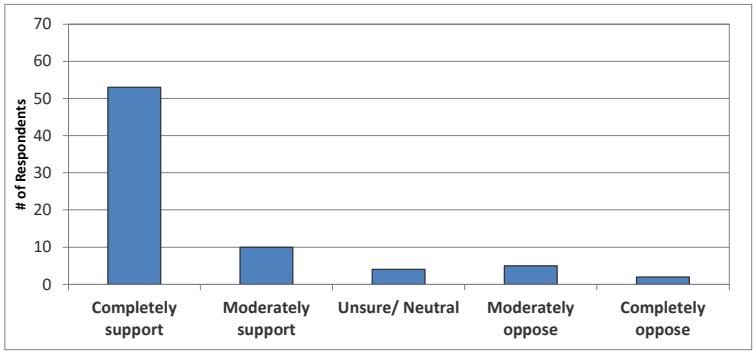
Answer Options	Completely support	Moderately support	Unsure/ Neutral	Moderately oppose	Completely oppose	Response Count
	47	9	8	7	3	74
					answered question	**74**
					skipped question	**4**





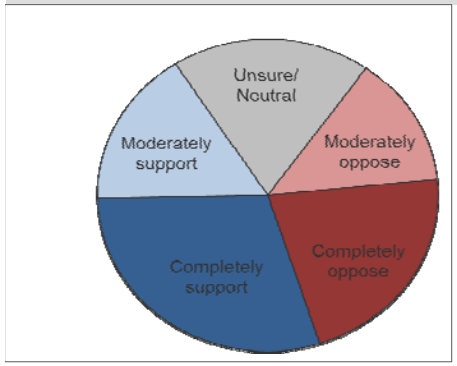
30. Are you in favor of the current use of DASH (Diver Assisted Suction Harvest) in areas outside of the North Bay to manage the Eurasian watermilfoil population?

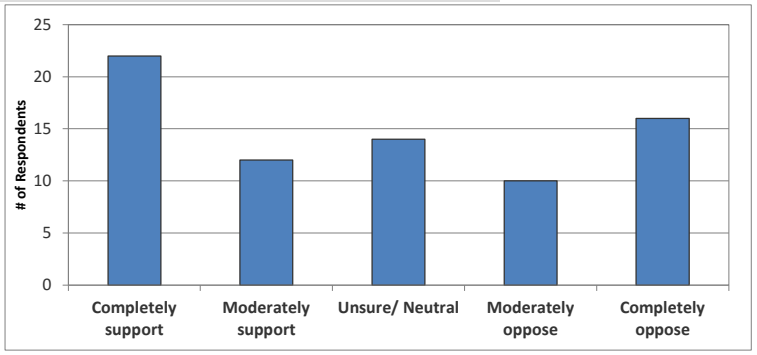
Answer Options	Completely support	Moderately support	Unsure/ Neutral	Moderately oppose	Completely oppose	Response Count
	53	10	4	5	2	74
					answered question	**74**
					skipped question	**4**



31. Would you be in favor of contracting mechanical harvesting (weed cutter) to create navigation lanes in the North Bay similar to the lanes displayed in green on the map prior to Question 26?

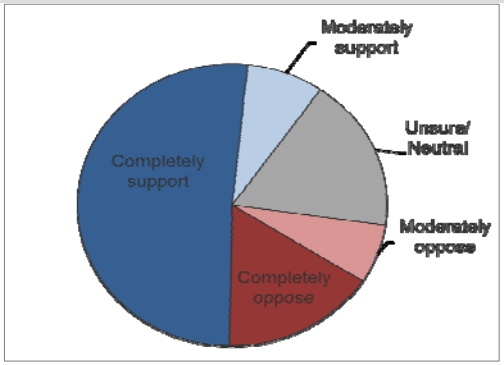
Answer Options	Completely support	Moderately support	Unsure/ Neutral	Moderately oppose	Completely oppose	Response Count
	22	12	14	10	16	74
					answered question	74
					skipped question	4

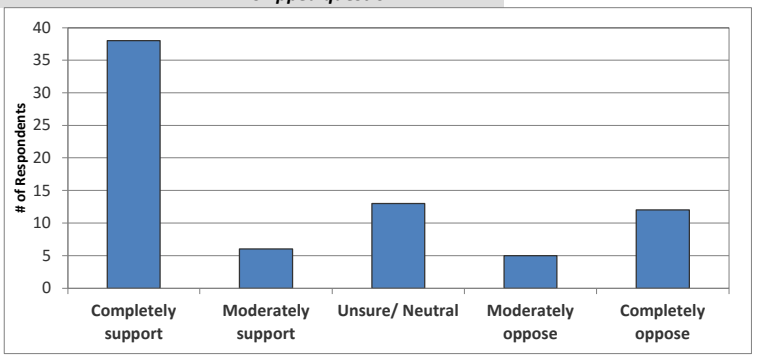




32. Would you be in favor of conducting an herbicide treatment to target the entire Eurasian watermilfoil population in the North Bay?

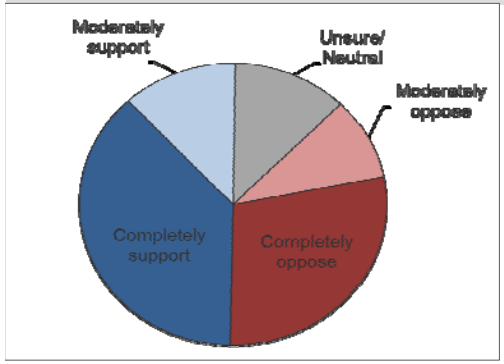
Answer Options	Completely support	Moderately support	Unsure/ Neutral	Moderately oppose	Completely oppose	Response Count
	38	6	13	5	12	74
					answered question	74
					skipped question	4

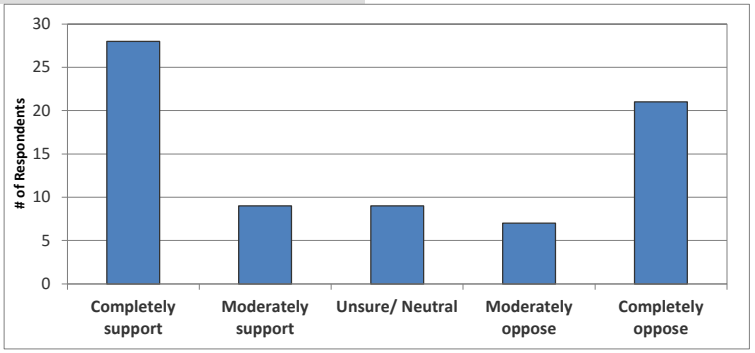




33. Would you be in favor of conducting a whole-lake herbicide treatment to target the Eurasian watermilfoil population in Anvil Lake?

Answer Options	Completely support	Moderately support	Unsure/ Neutral	Moderately oppose	Completely oppose	Response Count
	28	9	9	7	21	74
					answered question	**74**
					skipped question	**4**

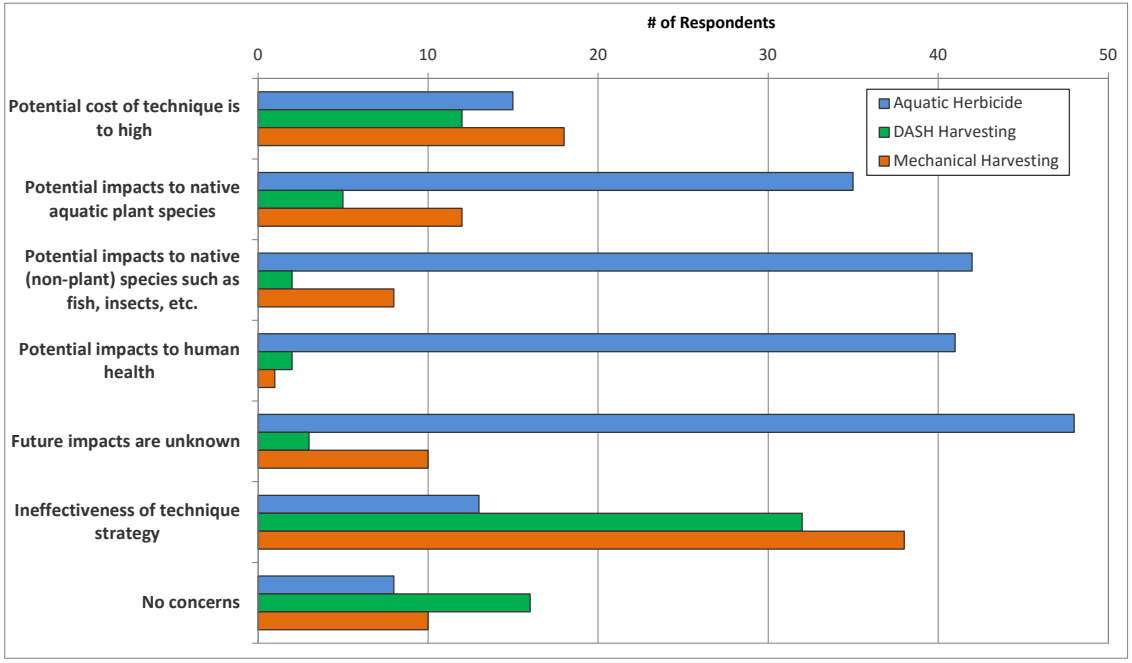




34. Below are three options currently being considered by the Anvil Lake Association to manage Eurasian watermilfoil. Please tell us what concerns you have for the use of each management option.

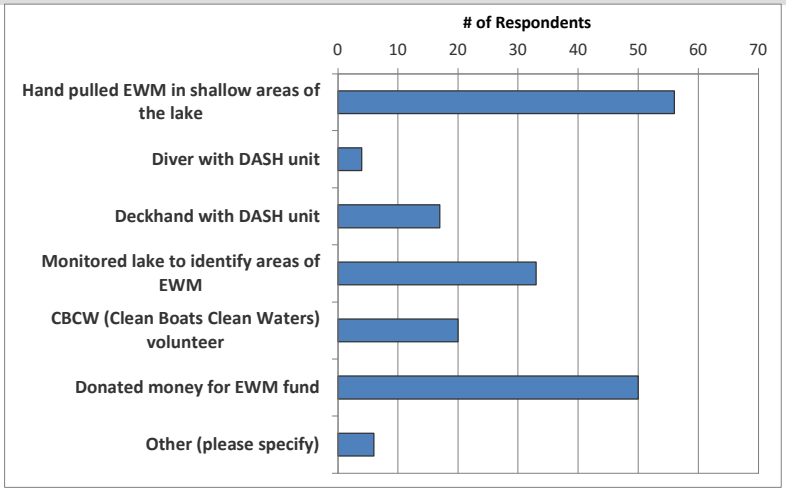
Answer Options	Aquatic Herbicide	DASH Harvesting	Mechanical Harvesting	Response Count
Potential cost of technique is to high	15	12	18	32
Potential impacts to native aquatic plant species	35	5	12	40
Potential impacts to native (non-plant) species such as fish, insects, etc.	42	2	8	44
Potential impacts to human health	41	2	1	42
Future impacts are unknown	48	3	10	52
Ineffectiveness of technique strategy	13	32	38	53
No concerns	8	16	10	21
			answered question	**72**
			skipped question	**6**

Number	"Other" responses
1	I think the only way to solve EWM is herbicide but side effects must be known before use.
2	If mechanical harvester collects the weed, can the DASH divers go get the roots? Would prefer to control this without chemicals if possible.
3	I have heard too many contradicting reports about herbicides
4	Does mechanical harvesting remove EWM roots?
5	Don't know enough to answer properly
6	mechanical harvesting increases spread of milfoil
7	How are cuttings harvested?
8	Please do not use herbicide due to human health concerns
9	I think Chemical treatment is the way to go BUT i want to be reassured that down the road we don't have an Agent Orange situation



35. What involvement have you or your family had with Eurasian watermilfoil (EWM) removal from Anvil Lake?

Answer Options	Response Percent	Response Count
Hand pulled EWM in shallow areas of the lake	77.8%	56
Diver with DASH unit	5.6%	4
Deckhand with DASH unit	23.6%	17
Monitored lake to identify areas of EWM	45.8%	33
CBCW (Clean Boats Clean Waters) volunteer	27.8%	20
Donated money for EWM fund	69.4%	50
Other (please specify)	8.3%	6
answered question		72
skipped question		6



Number	"Other" responses
1	Removed from pier
2	none
3	helped diver w/o DASH ;
4	removed much milfoil washed up on shore
5	none
6	remove loose milfoil floating in the lake

Anvil Lake Association (ALA)

36. Before receiving this mailing, have you ever heard of the Anvil Lake Association?

Answer Options	Response Percent	Response Count
Yes	100.0%	73
No	0.0%	0
answered question		73
skipped question		5

37. What is your membership status with the Anvil Lake Association?

Answer Options	Response Percent	Response Count
Current member	81.1%	60
Former member	12.2%	9
Never been a member	6.8%	5
answered question		74
skipped question		4

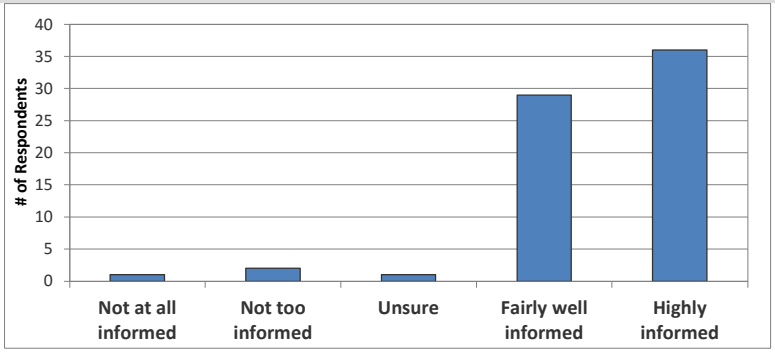
38. If you are not a current member please indicate the reason below.

Answer Options	Response Percent	Response Count
Dues are too high	0.0%	0
Never been contacted	0.0%	0
Haven't received renewal notice	37.5%	3
Other	62.5%	5
answered question		8
skipped question		70

Number	"Other" responses
1	Haven't been to my property in 7 years.
2	Feel the ALA has become an elitist group and those of us who are not part of the group are left out of the loop in regards to lake updates etc.
3	Former leaders opposing views to mine
4	Left when former regime was in power.
5	Just not a member

39. How informed has (or had) the Anvil Lake Association kept you regarding issues with Anvil Lake and its management?

Answer Options	Not at all informed	Not too informed	Unsure	Fairly well informed	Highly informed	Response Count
	1	2	1	29	36	69
answered question						69
skipped question						9



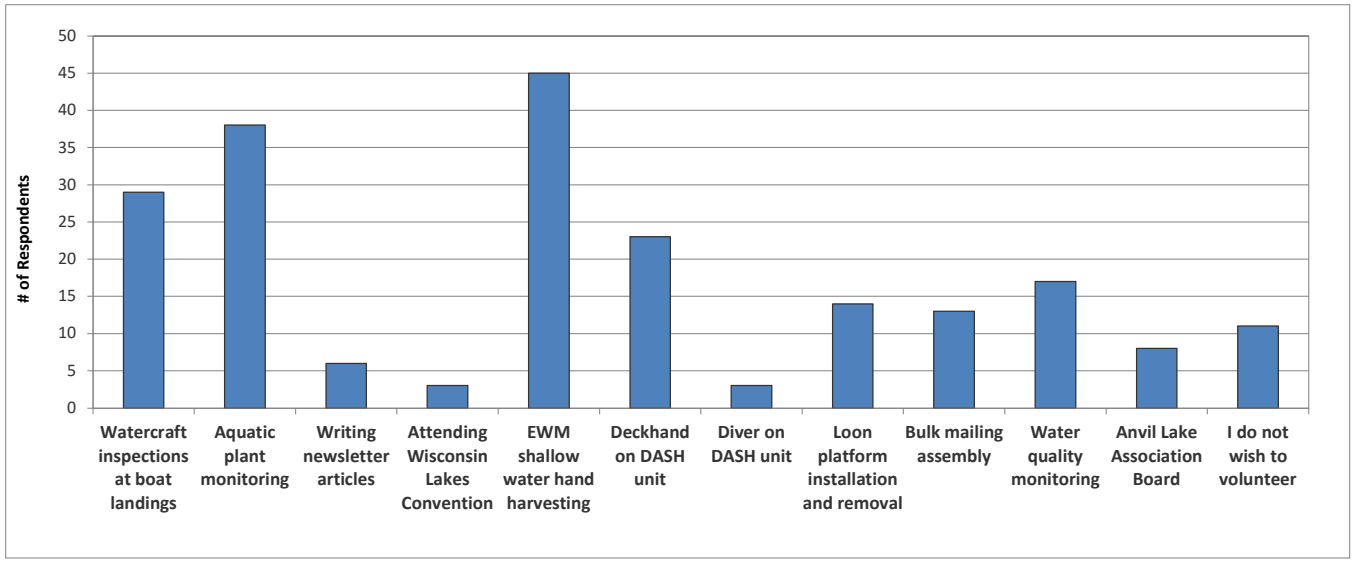
40. Stakeholder education is an important component of every lake management planning effort. Which of these subjects would you like to learn more about?

Answer Options	Response Percent	Response Count
Aquatic invasive species impacts, means of transport, identification, control options, etc.	57.1%	40
How to be a good lake steward	30.0%	21
How changing water levels impact Anvil Lake	64.3%	45
Social events occurring around Anvil Lake	35.7%	25
Enhancing in-lake habitat (not shoreland or adjacent wetlands) for aquatic species	28.6%	20
Ecological benefits of shoreland restoration and preservation	17.1%	12
Anvil Lake fishery	68.6%	48
Volunteer lake monitoring opportunities (Clean B(clean Boats Clean Waters, Citizens Lake Monitoring Network, Loon Watch, LakeGroup programs, etc.)	24.3%	17
Not interested in learning more on any of these subjects	2.9%	2
Some other topic	1.4%	1
	answered question	**70**
	skipped question	**8**

Number	Other (please specify)
1	How soon can we chemically treat, the cost and is there grants available to help cover or offset the cost

41. The effective management of Anvil Lake will require the cooperative efforts of numerous volunteers. Please circle the activities you would be willing to participate in if the Anvil Lake Association requires additional assistance.

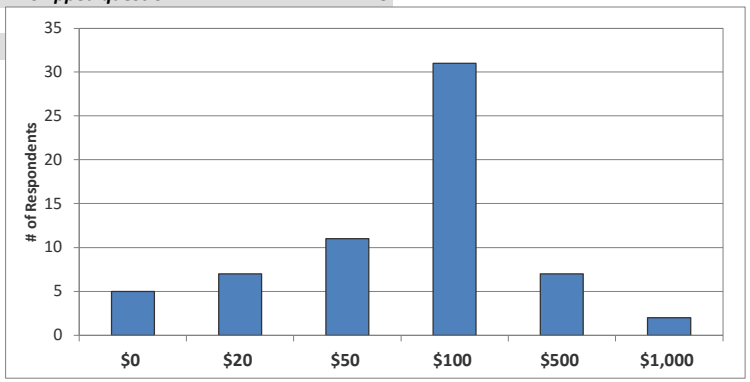
Answer Options	Response Percent	Response Count
Watercraft inspections at boat landings	42.0%	29
Aquatic plant monitoring	55.1%	38
Writing newsletter articles	8.7%	6
Attending Wisconsin Lakes Convention	4.4%	3
EWM shallow water hand harvesting	65.2%	45
Deckhand on DASH unit	33.3%	23
Diver on DASH unit	4.4%	3
Loon platform installation and removal	20.3%	14
Bulk mailing assembly	18.8%	13
Water quality monitoring	24.6%	17
Anvil Lake Association Board	11.6%	8
I do not wish to volunteer	15.9%	11
answered question		**69**
skipped question		**9**



42. What would you be willing to contribute (in addition to annual membership dues) to support management of non-native species in Anvil Lake?

Answer Options	$0	$20	$50	$100	$500	$1,000	Response Count
	5	7	11	31	7	2	63
answered question							63
skipped question							15

Number	Other (please specify)
1	5000
2	It depends on what method. I'd donate more to get the job done right.
3	200
4	200
5	$100 for Herbicide & $200 Treatment to North Bay
6	200



43. Please feel free to provide written comments concerning Anvil Lake, its current and/or historic condition and its management.

Answer Options	Response Count
	29
answered question	29
skipped question	49

Number	Response Text
1	Use of chemicals scares me because we swim in the lake, our young family members swim, and our dogs swim and drink the lake water. Our lake doesn't have an outlet, which makes adding chemicals concerning. Is there a way to increase mechanical harvesting or an alternative that doesn't have so many health risks?
2	The problem of EWM is existential for the lake as we know it. Yet we have active participation of just one half of the lake owners. ALL of the EWM management approaches are expensive. ALL will require funding from riparian owners and the DNR. Major concern is that of free riders - - those unwilling to voluntarily share the cost of keeping the EWM situation manageable. Only real prospect to get this under control is the establishment of a lake district that requires participation in the form of assessments to fund the required management of EWM. Otherwise, the EWM invasion, left unchecked, will change the lake itself and our enjoyment of this resource.
3	We hope to be able to restore the clarity and keep a percentage of beach shoreline while keeping native plant growth on the majority of the shoreline. Many new beaches and increased watercraft use seem to have had an impact on the water.
4	The Assoc. has invested a great amount of time and money into the EWM problem. It seems that even the DNR and the universities are not sure as to what to do to handle this problem. It might just be the time to look into herbicides. At the rate of growth of the EWM it seems that it will soon be a problem that will never be able to be managed.

5	ALA DOING EXCELLENT JOB KEEPING STAKEHOLDERS INFORMED AND DEALING WITH EWM SITUATION
6	It saddens me to see the invasive species in a lake I knew as pristine with little in the way of grasses. I am aware that the increase in homes on the lake influences it's use and traffic flow as well as outsiders using the lake. Just am hoping we can find a solution that avoids the lake getting more clog with matted EMF
7	Water Clarity
8	The meetings need to be MUCH more concise, both board meetings and annual meeting. The level of detail is too great for a meeting setting. Attention spans are short!!
9	Let's Make Anvil Great Again (LMAGA) ;-)
10	N/A
11	Please continue strong interest in EWM & other invasive species removal. Our family chose to invest in property on Anvil Lake for its healthy clear quality of water & our love for swimming off shoreline.
12	keep up the good work!!
13	1. We have been spinning our tires pulling weeds in the North Bay. The problem now is growing every year. It's proven pulling weeds creates more weeds. Now we need chemical controls then maintenance of pulling weeds. This is common sense control. 2. The walleye population has been severely depleted, we need to restock the lake with walleyes. Spearing has changed our lake, they should pay to restock it. The Tribes have the money to do it.
14	We have owned the land for 102 years and the ALA & DNR Have dun things to hurt Fishing and other types of plants.
15	The Anvil Lake Board members are doing a great job in their roles.
16	It would help if every property owner checked their shallow water for EWM weekly. Group removal activities in areas outside the north bay could be scheduled regularly. Info to fisherfolk about dangers of fishing near loons , collection container for used fishing line at boat landing so animals(eagles, dogs, loons, waterfowl) are not endangered by stray pieces.
17	Invasive plant species need to be controlled in areas including areas with limited infestation Water quality only slightly poorer than in the 1970s
18	We have only been on the lake 3 years but the milfoil invasion has increased dramatically. We bought here because of the beautiful clear water. Something more needs to be done to preserve this lake
19	We need to consider stronger clean boat enforcement and perhaps shutting down or limiting the launch hours during this infection period.
20	Please do NOT use herbicides in our lake!
21	Absolutely opposed to any herbicide treatments!
22	Thank you for managing the ALA. We hope that a chemical lake treatment plan can be developed to reduce weed growth in Anvil Lake before the entire lake looks like the north bay. It is unfortunate that the north bay residents have had no improvement in the last several years.
23	The ALA has done a great job educating the lake residents about EWM. We would like to find out the historic data of lake water levels.
24	We must stop the spread of the milfoil now! Lake will continue to get worse each year. We cannot keep the status quo mentality. Treat with chemicals now and be done for it once and for all!!! If the spread continues I will sell and move to another lake.
25	We are on North Bay. The milfoil has caused major problems, including damage to boat motor. I have yet to see the navigation lanes they claim are present. I think herbicide is the only solution.
26	I am so proud of our board and how proactive they are on the milfoil issue..I am also so disappointed in the DNR and heir skiddish and reluctant attitude towards the issue
27	Mechanical cutting is a very temporary solution, the milfoil would grow back very quickly plus it leaves loose pieces floating that could potentially spread. Grew up on a lake that used them, it had to be done constantly thru the summer months.
28	My financial contribution would be contingent on the efficacy of the program/s it supports
29	Association meeting minutes should be released to the membership on a more timely basis. I will only contribute extra money for AIS mitigation if herbicides are used. The DASH unit has proven to be a waste of time and money.

C

APPENDIX C

WDNR Chemical Fact Sheets

- **Florpyrauxifen-benzyl (ProcellaCOR™)**
- **2,4-D**

Florpyrauxifen-benzyl Chemical Fact Sheet

Formulations

Florpyrauxifen-benzyl was registered with the EPA for aquatic use in 2017. The active ingredient is 2-pyridinecarboxylic acid, 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)-5-fluoro-, phenyl methyl ester. The current Wisconsin-registered formulation is a liquid (ProcellaCOR™ EC) solely manufactured by SePRO Corporation.

Aquatic Use and Considerations

Florpyrauxifen-benzyl is a systemic herbicide that is taken up by aquatic plants. The herbicide is a member of a new class of synthetic auxins, the arylpicolinates, that differ in binding affinity compared to other currently registered synthetic auxins. The herbicide mimics the plant growth hormone auxin that causes excessive elongation of plant cells that ultimately kills the plant. Susceptible plants will show a mixture of atypical growth (larger, twisted leaves, stem elongation) and fragility of leaf and shoot tissue. Initial symptoms will be displayed within hours to a few days after treatment with plant death and decomposition occurring over 2 – 3 weeks. Florpyrauxifen-benzyl should be applied to plants that are actively growing; mature plants may require a higher concentration of herbicide and a longer contact time compared to smaller, less established plants.

Florpyrauxifen-benzyl has relatively short contact exposure time (CET) requirements (12 – 24 hours typically). The short CET may be advantageous for localized treatments of submersed aquatic plants, however, the target species efficacy compared to the size of the treatment area is not yet known.

In Wisconsin, florpyrauxifen-benzyl may be used to treat the invasive Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid Eurasian watermilfoil (*M. spicatum* X *M. sibiricum*). Other invasive species such as floating hearts (*Nymphoides* spp.) are also susceptible. In other parts of the country, it is used as a selective, systemic mode of action for spot and partial treatment of the invasive plant hydrilla (*Hydrilla verticillata*). Desirable native species that may also be negatively affected include waterlily species (*Nymphaea* spp. and *Nuphar* spp.), pickerelweed (*Pontederia cordata*), and arrowhead (*Sagittaria* spp.).

It is important to note that repeated use of herbicides with the same mode of action can lead to herbicide-resistant plants, even in aquatic plants. Certain hybrid Eurasian watermilfoil genotypes have been documented to have reduced sensitivity to aquatic herbicides. In order to reduce the risk of developing resistant genotypes, avoid using the same type of herbicides year after year, and utilize effective, integrated pest management strategies as part of any long-term control program.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated waterbodies, or using water for drinking water. There is no restriction on irrigation of turf. Before treated water can be used for non-agricultural irrigation besides turf (such as shoreline property use including irrigation of residential landscape plants and homeowner gardens, golf course irrigation, and non-residential property irrigation around business or industrial properties), follow precautionary waiting periods based on rate and scale of application, or monitor herbicide concentrations until below 2 ppb. For agricultural crop irrigation, use analytical monitoring to confirm dissipation before irrigating. The latest approved herbicide product label should be referenced relative to irrigation requirements.

Herbicide Degradation, Persistence and Trace Contaminants

Florpyrauxifen-benzyl is broken down quickly in the water by light (i.e., photolysis) and is also subject to microbial breakdown and hydrolysis. It has a half-life (the time it takes for half of the active ingredient to degrade) ranging from 1 – 6 days. Shallow clear-water lakes will lead to faster degradation than turbid, shaded, or deep lakes.

Florpyrauxifen-benzyl breaks down into five major degradation products. These materials are generally more persistent in water than the active herbicide (up to 3 week half-lives) but four of these are minor metabolites detected at less than 5% of applied active ingredient. EPA concluded no hazard concern for metabolites and/or degradates of florpyrauxifen-benzyl that may be found in drinking water, plants, and livestock.

Florpyrauxifen-benzyl binds tightly with surface sediments, so leaching into groundwater is unlikely. Degradation products are more mobile, but aquatic field dissipation studies showed minimal detection of these products in surface sediments.

Impacts on Fish and Other Aquatic Organisms

Toxicity tests conducted with rainbow trout, fathead minnow, water fleas (*Daphnia* sp.), amphipods (*Gammarus* sp.), and snails (*Lymnaea* sp.) indicate that florpyrauxifen-benzyl is not toxic for these species. EPA concluded florpyrauxifen-benzyl has no risk concerns for non-target wildlife and is considered "practically non-toxic" to bees, birds, reptiles, amphibians, and mammals.

Florpyrauxifen-benzyl does not bioaccumulate in fish or freshwater clams due to rapid metabolism and chemical depuration.

Human Health

EPA has identified no risks of concern to human health since no adverse acute or chronic effects, including a lack of carcinogenicity or mutagenicity, were observed in the submitted toxicological studies for florpyrauxifen-benzyl regardless of the route of exposure. EPA concluded with reasonable certainty that drinking water exposures to florpyrauxifen-benzyl do not pose a significant human health risk.

For Additional Information

Environmental Protection Agency Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
http://dnr.wi.gov/lakes/plants/

National Pesticide Information Center
1-800-858-7378
http://npic.orst.edu/

Washington State Department of Ecology. 2017.
https://fortress.wa.gov/ecy/publications/documents/1710020.pdf

2,4-D Chemical Fact Sheet

Formulations

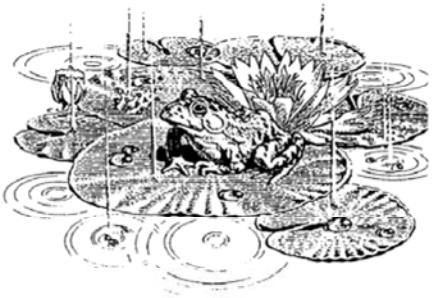
2,4-D is an herbicide that is widely used as a household weed-killer, agricultural herbicide, and aquatic herbicide. It has been in use since 1946, and was registered with the EPA in 1986 and re-reviewed in 2005. The active ingredient is 2,4-dichloro-phenoxyacetic acid. There are two types of 2,4-D used as aquatic herbicides: dimethyl amine salt and butoxyethyl ester. Both liquid and slow-release granular formulations are available. 2,4-D is sold under the trade names Aqua-Kleen, Weedar 64 and Navigate (product names are provided solely for your reference and should not be considered endorsements nor exhaustive).

Aquatic Use and Considerations

2,4-D is a widely-used herbicide that affects plant cell growth and division. It affects primarily broad-leaf plants. When the treatment occurs, the 2,4-D is absorbed into the plant and moved to the roots, stems, and leaves. Plants begin to die in a few days to a week following treatment, but can take several weeks to decompose. Treatments should be made when plants are growing.

For many years, 2,4-D has been used primarily in small-scale spot treatments. Recently, some studies have found that 2,4-D moves quickly through the water and mixes throughout the waterbody, regardless of where it is applied. Accordingly, 2,4-D has been used in Wisconsin experimentally for whole-lake treatments.

2,4-D is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Desirable native species that may be affected include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (Utricularia spp.) also can be affected.



Post-Treatment Water Use Restrictions

There are no restrictions on eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Following the last registration review in 2005, the ester products require a 24-hour waiting period for swimming. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of 2,4-D (the time it takes for half of the active ingredient to degrade) ranges from 12.9 to 40 days depending on water conditions. In anaerobic lab conditions, the half-life has been measured up to 333 days. After treatment, the 2,4-D concentration in the water is reduced primarily through microbial activity, off-site movement by water, or adsorption to small particles in silty water. It is slower to degrade in cold or acidic water, and appears to be slower to degrade in lakes that have not been treated with 2,4-D previously.

There are several degradation products from 2,4-D: 1,2,4-benzenetriol, 2,4-dichlorophenol, 2,4-dichloroanisole, chlorohydroquinone (CHQ), 4-chlorophenol and volatile organics.

Impacts on Fish and Other Aquatic Organisms

Toxicity of aquatic 2,4-D products vary depending on whether the formulation is an amine or an ester 2,4-D. The ester formulations are toxic to fish and some important invertebrates such as water fleas (*Daphnia*) and midges at application rates; the amine formulations are not toxic to fish or invertebrates at application rates. Loss of habitat following treatment may cause reductions in populations of invertebrates with either formulation, as with any herbicide treatment. These organisms only recolonize the treated areas as vegetation becomes re-established.

Available data indicate 2,4-D does not accumulate at significant levels in the bodies of fish that have been tested. Although fish that are exposed to 2,4-D will take up some of the chemical, the small amounts that accumulate are eliminated after exposure to 2,4-D ceases.

On an acute basis, 2,4-D is considered moderately to practically nontoxic to birds. 2,4-D is not toxic to amphibians at application rates; effects on reptiles are unknown. Studies have shown some endocrine disruption in amphibians at rates used in lake applications, and DNR is currently funding a study to investigate endocrine disruption in fish at application rates.

As with all chemical herbicide applications it is very important to read and follow all label instructions to prevent adverse environmental impacts.

Human Health

Adverse health effects can be produced by acute and chronic exposure to 2,4-D. Those who mix or apply 2,4-D need to protect their skin and eyes from contact with 2,4-D products to minimize irritation, and avoid inhaling the spray. In its consideration of exposure risks, the EPA believes no significant risks will occur to recreational users of water treated with 2,4-D.

Concerns have been raised about exposure to 2,4-D and elevated cancer risk. Some (but not all) epidemiological studies have found 2,4-D associated with a slight increase in risk of non-Hodgkin's lymphoma in high exposure populations (farmers and herbicide applicators). The studies show only a possible association that may be caused by other factors, and do not show that 2,4-D causes cancer. The EPA determined in 2005 that there is not sufficient evidence to classify 2,4-D as a human carcinogen.

The other chronic health concern with 2,4-D is the potential for endocrine disruption. There is some evidence that 2,4-D may have estrogenic activities, and that two of the break-down products of 2,4-D (4-chlorophenol and 2,4-dichloroanisole) may affect male reproductive development. The extent and implications of this are not clear and it is an area of ongoing research.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
http://dnr.wi.gov/lakes/plants/

Wisconsin Department of Health Services
http://www.dhs.wisconsin.gov/

National Pesticide Information Center
1-800-858-7378
http://npic.orst.edu/

Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707-7921

DNR PUB-WT-964 2012