A Quick Glance Summary of Findings from a LakeScan™
Guided Survey and LakeScan™ analysis of:

Wabeek Lake

Oakland County, MI

Submitted by:

Dr. G. Douglas Pullman
Aquest Corporation

LakeScan™

PREFACE

Lakes are complicated systems. There is no simple way to consider all of the interacting systems within a lake and the impact of watersheds and invasive species invasions on these valuble resources. LakeScan™ is a comprehensive system of analysis that is necessary to properly consider conditions in a lake and make reasonable, scientific and empirically based recommendations for management and improvement of aquatic ecosystems. Persons who are already familiar with the LakeScan™ method may wish to skip to Part 2 since the methods and approach sections are primarily "boilerplate". This report is only the "tip of the iceberg". All recommendations are based on the comprehensive record of data that are included in the Wabeek Lake, LakeScan™ annual review document. That report is available under separate cover.

TABLE OF CONTENTS

PART 1

BACKGROUND

(Understanding the Project)

Goals, Objectives, Methods, Definitions, and Rationale

Introduction

How to Read This Report: Lakes are complex and a wide range of data and analysis are necessary to create a proper lake management plan. However, many people are satisfied to read a review of selected data rather than taking the time to examine the data that were used to create an executive summary. LakeScan™ reports are now divided into three separate documents. An executive summary, monitoring data document, and a geopolitical administrative document are provided to satisfy different needs and perspectives. Most people will benefit from reading the executive summary and may wish to go no further. The monitoring data document will satisfy those who wish to gain a better understanding of lake conditions. Finally, the geopolitical-administrative document changes little from year to year, but is available for consideration and review. It may be especially helpful to persons who may be considering the purchase of real estate on a lake.

LakeScan™ project goals and objectives do not change dramatically from year to year. The first part, PART 1. of this executive summary provides an outline of these goals and the rationale for the following data review. Yes, it is mostly boiler plate. Persons who are familiar with this lake and have already studied LakeScan™ reports may wish to skip to PART 2. AND the category analysis that follow this section. Category reviews are based on a very comprehensive and detailed data set. These data are available separately. This report is intended to provide a very "easy to read" summary of some of the management conclusions that can be drawn from a much larger data set.

The Goal

Because "Without a Defined Target – Lake management will certainly miss the point!"

Job 1: Establish Meaningful, Attainable, Reasonable, and Sustainable Goals, That Can Satisfy Most People Who Enjoy and Use Lakes

The LakeScan™ Standard Goal:

To Preserve, Protect, and if Possible – Improve Aquatic Ecosystem Biological Diversity and System Stability.

"Just killing a nuisance" will certainly backfire – there will always be "another nuisance" and badly directed lake management plans worsen the consequences of killing nuisance organisms without the proper focus on ecosystem health"

The Project Goal: This Wabeek Lake Management Plan is goal driven. The primary goal of this plan is to preserve, protect, and if possible – improve the Wabeek Lake aquatic ecosystem. This can only be accomplished when critical habitat is protected and when biological diversity and ecosystem stability are enhanced. Lakes that are managed with this goal are best suited for all forms of recreation, fishery production and exhibit superior aesthetic qualities. This goal is the basis for a sustainable management approach that can provide long-term benefits and cost savings for lake communities.

The evaluations, comments and recommendations that are included in this report are not based on a "quick spin around the lake". They are not based on the application of important, but irrelevant analysis of the wrong part of a complex ecosystem. Specific measures have been selected to address problems and measure success in meeting

lake management goals. For example, water quality data are not used to singularly inform decisions about weed management and plant community data is not used as the sole source to recommend improvements of lake water quality. Essentially, the LakeScan™ method provides the most appropriate empirical data that is needed to make reasonable management decisions and to evaluate the effectiveness of the overall program. Lake associations, special assessment districts, and any of the various governmental units that provide the administrative support to any lake management program must have these kinds of data to ensure that their management program is being administered in a responsible and transparent way. The management of publically held resources that is funded by special tax assessments must be based on relevant data and professional guidance or it will fail responsibly satisfy the public trust and to meet the expectations of stakeholders.

Principal Elements of the 2016 Wabeek Lake Protection and Improvement Project.

The Selection of Appropriate Metrics for the Wabeek Lake Monitoring and Management Guidance Project. All lakes are complex and are the sum of several independent but interactive systems. External factors influence these different systems in very different ways. There are a wide range of LakeScan™ monitoring and management guidance methods that can be used to address nearly every one of the subsystems in lake ecosystems. It is helpful if the reader recognizes that lake ecosystems are very much like the human or animal body and the parallels between human and veterinary medicine and lake ecosystem management are can be very helpful. Imagine a person with a brain disorder who is seeking a brain scan but receives a colonoscopy instead. Brain scans and colonoscopies are both extremely important, but it is critical that testing is done in a relevant and responsible manner to preserve the health of the patient and address problems with the "impaired system". This is also true of lakes where it is critical to consider appropriate data to formulate sustainable and effective management and protection projects. Too often valid, but inappropriate testing is applied to a lake as a means or basis for the development of management project plans. This is a waste of resources and can misinform lake residents and other stakeholders involved in the lake management process. The 2016 Wabeek Lake monitoring and management guidance project is focused on large plant and weed community. No obvious water quality impairments were observed and this might be expected from a lake of this size and where there is so much shallow water is dominated by plant growth. The terms "eutrophic, mesotrophic, or oligotrophic" were developed to describe the conditions of the open water systems in lakes and are not applicable as a reasonable assessment of the condition or impairments to the plant community. Fortunately, LakeScan™ Category 700 metrics and methods can be used to evaluate the condition of the plant community system and make reasonable and numbers-based evaluations of the impacts of the management interventions that are applied to the lake.

LakeScan™
Monitoring for Effective Aquatic Resource Management

LakeScan™ management plans are based on "real and relevant numbers". These are critical for effective lake management planning and assessment.

LakeScan™ studies are system based and always relevant. For example, water quality data does not qualify as a basis for weed control. LakeScan™ is the only available system that can provide kind of comprehensive and meaningful data that can serve as a basis for targeted, effective and efficient lake management.

LakeScan™ helps to focus attention on management outcomes (biodiversity, ecosystem stability, low weediness, etc.) and can help to establish realistic user group expectations.

LakeScan™ is the proof that lake management monies are being managed wisely and demonstrate that administrative bodies are acting responsibly. Everyone wants to be assured that the best technology is being used for each individual lake and that programs are guided by professionals.

LakeScan™ saves money. Management programs provide a coherent and inclusive approach to resource management. This reduces wasted or misguided efforts that can unnecessarily increase costs.

Aquest recognizes that every lake is different and develops individual management prescriptives each year, for each lake. The monitoring data and management guidance provided in this report are based on real numbers and relevant measurements. Each lake is different and these data are needed to properly create the management plan, establish annual management objectives and to evaluate the short and long term impacts of the applied elements of the lake management project for each individual lake. Management guidance and recommendations are not only based on the quality and character of the lake ecosystem, but are also framed in the context of regulatory, lake use, and budget considerations. Wabeek Lake is a multi-use lake and this is an important consideration. A goal focused lake management project where diversity and stability are targeted can provide benefits to lake users from anglers to jet skiers, protect the public health and support property values.

What is Category 700 Analysis of the Plant Community (System)?

LakeScan™ is comprised of various component parts or "Categories" that can be used to analyze everything in a lake from microbes to wildlife. The LakeScan™ method uses 8 different measures of the plant community to determine the condition of this critical part of the lake ecosystem. These measures or metrics are used to characterize the plant community in the entire lake but they are also calculated for distinct or individual areas in the lake. For example, each metric is calculated for the distinct biological tiers or the distinct plant communities that are present and depend on the distance from the shore. LakeScan™ also identifies different management zones or areas in the lake where different management objectives are applied. And finally, the metrics are calculated for treatment zones and these data area critical to evaluate the impact and consequences of applied management objectives. Each metric can also be applied to different groupings of plant species when they differ in quality or impact on the lake ecosystem. For example; plant community biodiversity is calculated "with weed species" or "without weed species". Research has also revealed that different plant species are found in different lake ecosystems. Ranking scales have been used to describe these different plant qualities and a thorough analysis of these quality differences is also a part of the LakeScan™ system.

LakeScan™ data can be used to compare observations of conditions that are surveyed at different times of the year. They are also used to compare conditions found in the same lake in different years. For example, early and late season plant communities can be very different and the amount of difference may be significant. Everyone knows that each individual lake can be very different from other lakes, but LakeScan™ data can also be used to compare one lake to another and place these comparisons in reasonable context. The result is that nearly 100 different metric values are calculated for each lake. All of these are considered and reviewed and used to formulate the most appropriate plant community management plan for individual lakes. LakeScan™ is unique because it provides the data necessary to make certain that any management interventions result in no further degradation of the lake ecosystem. A typical LakeScan™ report is over 100 pages, but is presented in an easy to understand, graphical format. Histograms (bar graphs) are used to provide a quick understanding of lake conditions. Readers are encouraged to read the entire annual LakeScan™ report for this and other lakes. The following is a very small part of the analysis used to evaluate the Wabeek Lake plant community, but does provide a general overview of conditions.

Category 700 LakeScan™ Metrics

Species Richness
(total species present)
Species Percent Occurrence
Predominant Leaf Type
Morphotype Richness
(total morphotypes present)
Biodiversity
Biodiversity of Preferred Species
Morphological Diversity
BioVolume
Weediness of Lake
Perceived Nuisance Levels

Category 700 LakeScan™ Qualifiers

Species Density
Species Distribution
Species Coefficient of Conservatism
Species Assigned Control Target Level

Category 700 LakeScan™ Time and Event

Seasonal Events
Survey Events VS1 to VS6
Treatment Events
Sum Season Surveys and Treatments
Year to Year

Category 700 LakeScan™ Areas

Biological Tier Areas
Usually vary with depth and distance from shore
Management Zones
Where different management objectives are established
Treatment Zones
Areas where different herbicides, herbicide combinations, mechanical controls, physical controls or biological controls are applied

Lake Management Actions and Objectives

"Whatever is done to a lake must be based on clear understanding of the goals and solid and empirical data that is relevant to the problems that have been identified through good monitoring."

Management Planning Benefits

~ Harvesting, Herbicides, Algaecides, Biological Manipulations, Physical and Mechanical Interventions – These are a few of the current lake management tools available to managed lakes. LakeScan™ can help and inform in the selection of the best tool for a given problem.

~ Only LakeScan™ provides the kind of seasonal and yearly data that can truly evaluate the outcome and consequences of Lake Management Program Actions.

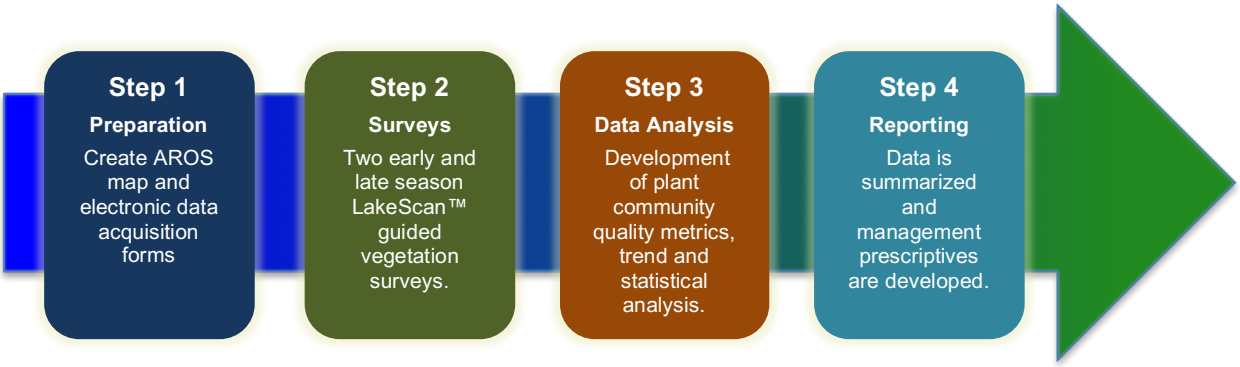
~ Respected LakeScan™ scientists insure access to the latest and best technologies. This approach is critical in the fight against invasive species impacts, toxic bluegreen algae blooms, and issues related to herbicide and harvesting resistance.

METHODS

The LakeScan™ / Aquest Approach

Category 700 Submersed Aquatic Plant Community Monitoring and Analysis

Aquest will employ a four-step approach to understand Wabeek Lake and provide management guidance.



Step 1: Preparation

LakeScan™ guided vegetation surveys are based on a system where the lake is divided into observation sites. Each of the Wabeek Lake 242 aquatic resource observation sites is georeferenced and placed on a map that serves to guide field personnel as they record critical information at each one of these places in the lake. AROS are not randomly scattered, but are purposefully placed to identify distinct biological zones and habitats in the lake. The information collected at each site can be weighted to reflect the relative importance of different areas in a lake. The LakeScan™ guided submersed aquatic vegetation survey is comprehensive.

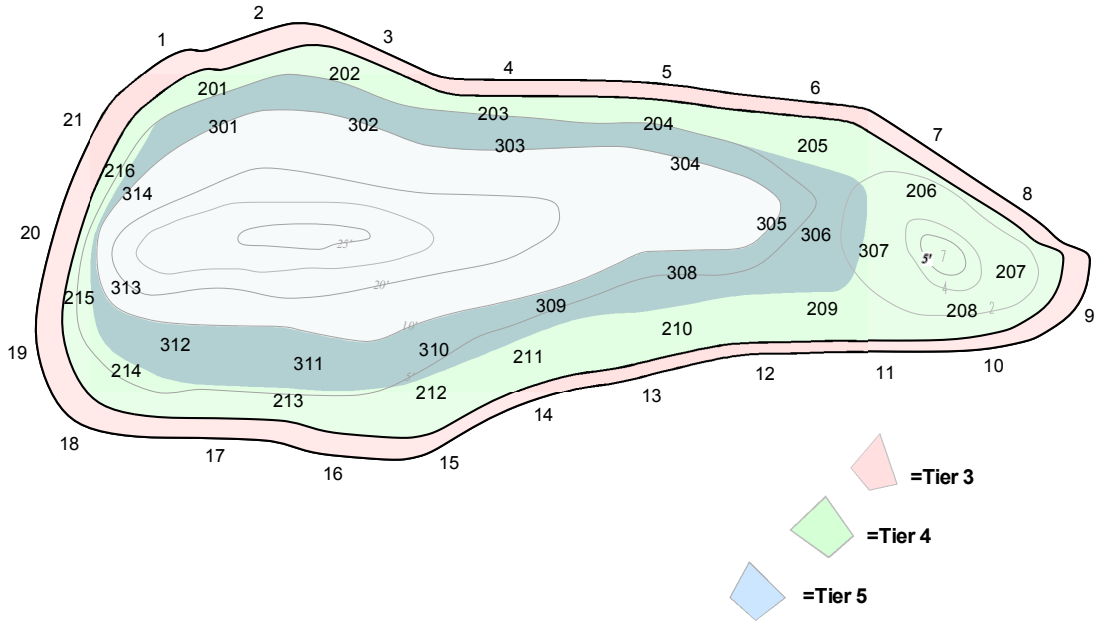
Step 2: The LakeScan™ Cat 700 Aquatic Vegetation Survey

Field personnel record the density, distribution, and relative position in the water column, of each plant species in each AROS. The perceived nuisance level of each AROS is also recorded and offending plant species are identified. Certain plant species are only present in either the early or late summer. Consequently, two surveys are usually conducted each season to obtain a more complete analysis of the vegetation in the lake. Assessments are made from a boat by visual observations, rake (frodis) toss and plant retrieval, advanced hydroacoustics (sonar), and using an under-water video camera. Each one of these devices and methods seems to reveal a different "picture" of the plant community and consequently, they are necessarily combined to provide proper assessment of the plant community. Data are recorded on a tablet computer and are sent to the "cloud" immediately at the end of the survey.

AROS

An AROS (Aquatic Resource Observation Site) is merely a point location in a lake, pond, reservoir, or running water resource. These points are assigned a number and are often georeferenced. Various observations can be made at each point site. Areas are often assigned to each AROS, but these might vary with how data is considered at each of the AROS.

Wabeek Lake LakeScan™ AROS (Aquatic Resource Observation Site) map. Observation data is collected from each AROS. The colored areas represent distinct biological tiers where distinct biological communities are found.



Step 3: LakeScan™ Data Collection and Compilation

AROS Tiers

Aquatic resources support a variety of distinct habitats that vary according to depth distance from the shore. AROS are grouped in distinct tiers labeled from 1 to 8.

Tier 3	**Near shore**
Tier 4	**Just off shore but distinct from Tier 3**
Tier 5	**The "drop off" zone where depth descends quickly to the bottom of the lake.**
Tier 6	**Narrow channels where there is little flow and the area is similar from shore to shore.**
Tier 7	**Submerged "off shore islands".**
Tier 8	**Flowing water where plants lay over because of consistent flow.**

Aquest will utilize LakeScan™ metrics and analysis tools to develop a complete and comprehensive – numbers-based analysis of lake conditions. These values and metrics will be used to characterize the special characteristics of the different vegetation tiers (i.e. near-shore, off-shore, drop offs, submerged islands) and in areas of the lake where different management objectives might be applied according to perceived need, shoreline development, and regulations. The AROS in treatment zones can be aggregated to provide appropriate analysis of the impacts of management interventions applied to each area. The perceived nuisance level of each AROS is also recorded and these can be used to understand variations in nuisance conditions from early to late season and from year to year. Responsible lake management demands much more than a mere summary of the percent occurrence of plants scattered around a lake and maps that depict the location of those plants at a single date or point in time. Management projects that are based on these scant data are conducted more like an aimless game of "Whack a Mole". Established goals, realistic and relevant data collection, numerical analysis, and the expert interpretation of those data are necessary to develop proper lake management plans. Lake associations, special assessment districts, townships, towns, and counties must have these kind of data to demonstrate due diligence and the appropriate stewardship of assessed dollars.

Why is Monitoring So Important?

Accountability, Liability, Compliance, and Cost

Most lakes are public resources or they are shared by multiple individuals. Unlike a individually owned, private pond, commonly held aquatic resources require competent, relevant, and independent management guidance. An independent lake management consultant is necessary for numerous reasons. 1. Monitoring by a professional and independent lake management consultant provides access to the broadest range of lake management technologies. The aquatic resource will be managed better. 2. Monitoring is necessary to reduce the public perception issues and the legal and fiduciary liabilities that are assumed by those who are paid and who volunteer to oversee lake management programs. 3. Regulators are not "the enemy". However, they are required to prove that the management programs that they permit do no harm to the environment. Changes in permitting requirements on a Federal level will certainly demand compliance with more rigorous monitoring programs as a conditions of permit issuance. 4. Proper monitoring, by a lake management consultant that is not tied to an application company can reduce cost by detecting failed management outcomes and ensuring that only the most necessary management objectives are applied each year.

Performance

An independent lake management consultant is not affiliated with any company or corporation that manufactures or applies any of the herbicides, mechanical devices, or systems that are used to management aquatic nuisance conditions. An independent consultant can provide unbiased guidance to design the best lake improvement projects that provide the greatest benefits to the lake ecosystem and for those that use and appreciate these valuable aquatic resources.

Administration Responsibility and Liabilities

Michigan law provides statutory authority to establish various governmental mechanisms for the governance and administration of programs intended to protect and potentially improve lakes and other water resources. Surprisingly, these programs were often conducted without any formal measurement of success or ancillary consequences. Large sums of public monies were spent with not reasonable measure of the "health of the ecosystem". Most everyone in America is very aware of how people on both sides of the political spectrum are unified in their desire and demand for greater accountability from the public official who oversee and administer a broad range of programs. Project outcomes are as important in aquatic ecosystem management as are health outcomes in human and veterinary science. Imagine how ridiculous it would be to visit your physician with a persistent abdominal problem and he or she responds with only a prescription and does not perform a thorough examination or even ask pertinent questions. Sadly, this has been the state of water resource management in Michigan and elsewhere for decades. When sampling is done, it is often focused on improper or irrelevant measures. All too often traditional water quality measures are provided as "substantiating data" to support weed control programs even if these data are as relevant as a brain scan may be to gastrointestinal illness. Occasionally the percent occurrence of plant species is presented with some relative measure of density. But, these data cannot provide a meaningful measure of lake health. People have the right to neglect their personal health - as unwise as that might be. But those who administer publically funded programs have a responsibility to those who are assessed and that everything is being done to ensure that project outcomes are being adequately and reasonably assessed. Failure to provide professional guidance for the management of a publically held resource significantly increases the legal and fiscal liability of the public and private officials that administer lake improvement programs.

Regulatory Requirements

Recent changes in aquatic herbicide application permitting systems acknowledge the critical need for professional, third party assessment of aquatic ecosystems and management outcomes. Regulators are exposed to the same labilities as lake improvement program administrators (even volunteers) when they appropriate funds for programs where there is no oversight or reasonable measure of success. There are new federal mandates (NPDES) that are now being applied to lake management programs throughout the U.S. that require that monitoring be a part of any management program. It will no longer be possible to base most lake management programs program on simplistic anecdotal comments about lake condition. Most lakes will be required to provide some cursory measures of success and responsible program management. It has been said that the LakeScan™ program should be applied to every lake in the State; but the program is still in development and not ready to roll out to all but a select group of lakes. Fortunately, Wabeek Lake is one of those lake and administrators, stakeholders, volunteers, lake association members, and even regulators can all be assured that everything is being done to satisfy the most stringent regulatory legal requirements associated with an effective lake management program.

Fiscal Responsibility

Not only does monitoring demonstrate responsible program management, but it can also be used to ensure that a lake is managed in an ecologically responsible manner. This can save money. Often, monitoring "pays for itself" with the cost savings that occur because of judicious monitoring and data analysis. A properly managed lake becomes more stable and stability helps to reduce the cost of management. It's certainly a lot more than "go out and kill the weeds". Wabeek Lake has always been a "leading lake" in the identification of problems and development of viable solutions. Residents of Wabeek Lake should be proud that they have also been distinguish as one of the first LakeScan Lakes in America and already can meet the requirements of the regulatory community. Furthermore, the data provided in these reports are a testament to the generally effective management program that has been founded on empirical and reliable data.

Step 4: Records and Reporting

Empirical data is critical to create a effective lake management plans. Imagine an office visit where the physician simply looked at your throat, eyes, and in your ears and proclaimed that you needed surgery. No blood sample, no blood pressure monitoring, no data from x-ray images, no comparisons to prior health data – that simply doesn't make any sense. Too often lake management programs are similarly based on simplistic observations, scant data, and simplistic maps that cannot be reviewed in historical or regional perspectives. A quick observational tour of a lake can help to resolve some specific and immediate questions, but cannot be used to evaluate the impacts of long-term, year-after-year, management plans. Maps can be used to illustrate a "point", but cannot generate the kind of numerical rigor that is necessary for administrative bodies and government units to demonstrate that they are doing their "due diligence". Sometimes a listing of species present and relative proportions of species at a few randomly selected sites along randomly placed transects in a lake are used to evaluate lakes in a similar manner to the way that some studies are done in terrestrial ecology. However, these methods do not apply to aquatic ecosystems because they fail to recognize how aquatic plants grow in aquatic ecosystems where critical habitats can change quickly on a relatively small spatial scale. LakeScan™ metrics can be used to effectively meet these challenges because they can be applied to unique areas of the lake, such as critical nearshore areas or areas of the lake where the depth drops off steeply. The diversity of plant communities is believed to a key determinant of ecosystem stability. But, realistic planning and evaluation cannot be reasonably accomplished without empirical data that is based on rigorous sampling and analysis and that is tailored to the specific characteristics of aquatic ecosystems. These data are presented in LakeScan™ reports and can be used to determine if lake management goals are being approached and if the objectives of the program are helping to meet those goals.

AROS MZL

Different areas of a lake require different management objectives. A "varied approach is required to protect ecosystem stability and to satisfy State and Federal regulations.

MZL 1	**Highly targeted and selective plant management. Only the most invasive species will be managed in these areas.**
MZL 2	**Highly targeted management but some non-target impacts are acceptable if the impact is short-lived and there is rapid recovery of non-target plants.**
MZL 3	**Limited broad spectrum plant control. Some species may not drop from the water column, even though they show signs of injury.**
MZL 4	**No "holds barred" management of swimming areas and around boat moorings.**

Part 2

Executive Data Summary

2016

Category 700: LakeScan™ Analysis Highlights – the 2016 Plant Community.

Background: The LakeScan™ method uses 8 different measures of the plant community to determine the condition of this critical part of the lake ecosystem. These measures or metrics were applied to individual or distinct areas in the lake including biological tiers, management zones, or treatment zones (where applicable). These data were also used to consider groupings of plant species that differ in quality, invasiveness, and impact on ecosystem stability. For example; plant community biodiversity is calculated "with weed species" and "without weed species". These data were also used to compare conditions that are surveyed at different times of the year – early and late summer. All of these are used to formulate the most appropriate management plan for the plant community and to make certain that any management interventions result in no further degradation of the lake ecosystem. These data are also necessary to satisfy some regulatory conditions. A typical LakeScan™ report is over 100 pages, but is presented in an easy to understand, graphical format. Readers are encouraged to read the entire annual LakeScan™ report for this and other lakes. The following is a very small part of the analysis used to evaluate the Wabeek Lake plant community, but does provide a general overview of conditions.

LakeScan™ Category 700 (plant and weed community) monitoring and analysis was begun in 2005 on Wabeek Lake. Wabeek Lake is currently one of nearly three dozen Michigan inland lakes where LakeScan™ is used to monitor conditions and evaluate the results of the management program. It is the smallest of these lakes and it has been determined that it may be inappropriate to compare Wabeek Lake to the larger lakes in this cohort. Anecdotal evidence suggests that Wabeek Lake is in considerably better condition than nearby lakes of similar size. This can be attributed to the adoption of a goal directed and effective management program.

Ebrid milfoil (Eurasian watermilfoil and northern x Eurasian watermilfoil hybrids) and starry stonewort are among the most notorious Michigan aquatic invasive species and these have infested Wabeek Lake. If it were not for a largely successful lake management program, conditions in this lake would not be suitable for any recreational use. Furthermore, these species threaten the diversity of species and critical habitats in the lake. Loss of any of these key attributes can seriously destabilize the ecosystem and the fishery.

Most Wabeek Lake plant community metric values met or exceeded expectations in 2016. One of the objectives of future management programs will be to attempt to improve the biodiversity of the plant community by encouraging the spread of more desirable plant species throughout the lake. The quality of plants in this lake is still considered to be good so it is conceivable that biodiversity can be improved without creating greater nuisance values. It is also abundantly clear that these good LakeScan™ metric values are likely to be heavily influenced by the presence or absence of invasive species and could decline rapidly if these species are not successfully suppressed by targeted and highly selective plant species management strategies and technologies. Watermilfoil and starry stonewort have been and are still the greatest threat to ecosystem stability in Wabeek Lake. Every year is different for Michigan inland lakes, and it is virtually impossible to predict which of these two invasive species may dominate the summer season in Wabeek Lake.

Nearly all LakeScan™ metrics are trending in a positive direction since LakeScan™ monitoring was begun. These data seem to suggest that the lake should be capable of meeting biological diversity target values. Careful monitoring and prudent management is necessary to measure these trends and find ways to improve metric values.

A Graphic Review of Selected LakeScan™ Metrics Used to Evaluate Lake Conditions in Wabeek Lake

Table ESP2-1.0 Selected LakeScan™ metric values and target values, 2016. Yellow backgrounds are used to highlight metric target values that have not been met or exceeded. Yellow is "not good". However, these values may be typical for Wabeek Lake.

2016 LakeScan™ Metrics and Targets

	2016 Values	Target Values
Species Richness	13	12
Morphotype	9	12
Mean Weighted C	5.6	5.0
Whole Lake BioD	28	30
Whole Lake BioD T2+	18	25
MorphoD	75	70
Weediness	3.8	5.0
Mean Perceived Nuisance	0.7	0.5

Table ESP2-2.1 Historical perspectives are provided in the following two tables. The upper table illustrates data from 9 monitoring years that began in 2006. Mean metric values and the range of values measured during those years are provided in this table.

Historical Averages
Total Years = 11

	Species Richness	Morpho-types	Weighted Mean C	Whole Lake BioD	BioD T2+	MorphoD	Lake Biovol ft3/acre ft	Weediness	Mean PNL
Wabeek Lake 2016	13	9	5.6	28	18	75	283	3.8	0.7
Target Values	12	8	5.0	30	25	70	283	5.0	0.5
Historical Average	12	8	4.0	21	13	55	277	5.3	0.4
Historical Metric Range	10 to 13	7 to 10	2.9 to 5.6	14 to 28	9 to 18	43 to 75	147 to 428	3.8 to 6.0	0.0 to 1.1

Table ESP2-2.2 Historical perspectives on selected LakeScan™ metric data collected during the previous five years. Mean metric values represent a sum of all relevant data or a mean value derived from observations collected at several vegetation community surveys that were conducted throughout each summer/growing season.

Annual Data Comparisons

	Species Richness	Morpho-types	Mean C	Whole Lake BioD	BioD T2+	MorphoD	Lake Biovol ft3/acre ft	Weediness	Mean PNL
2012	10	8	2.9	14	10	43	147	6.0	
2013	12	10	3.3	20	12	61	320	5.9	
2014	13	8	3.9	24	14	50	209	5.4	
2015	10	7	4.2	16	9	44	428	5.4	1.1
2016	13	9	5.6	28	18	75	283	3.8	0.7

Table ESP2-3.0 Historical LakeScan™ data trend analysis for 9 years of selected metric data.

TREND ANALYSIS

Species Richness	+
Morphotype	-
Mean Weighted C	+
Whole Lake BioD	+
Whole Lake BioD T2+	+
MorphoD	+
AROS BioVol	+
Weediness	-

CATEGORY 700 ISSUES AND ANSWERS, 2017

ANTICIPATED ISSUES	ANSWERS
Most LakeScan™ metric values were better than expected in Wabeek Lake in 2016 considering the prevalence and dominance of starry stonewort and ebrid milfoil. Wabeek Lake is in good condition, but only as a result of effective plant community management. Most of the metric values are trending in a positive direction since LakeScan™ monitoring began in 2005. Invasive species continue to be a serious threat to the lake, but effective management has protected the lake and continue to improve conditions.	*Ebrid milfoil and starry stonewort will continue to threaten the community diversity, critical habitat values, ecosystem stability, and recreational value of the lake. Targeted management must be continued to protect the lake and prevent a deterioration of conditions. However, a very goal directed management program will be required to prevent the lake from becoming more like local lakes.*
Ebrid watermilfoil and starry stonewort have all emerged as dominant plants and have grown to serious nuisance levels in different years. The dominance of each of these species can vary wildly from year to year. It has been virtually impossible to predict which species will be the dominant nuisance each year, but action is required to prevent any further loss of any of the other 11 species that inhabit the lake.	*Careful monitoring is required. The dominant weed species is likely to vary each year. Annual management objectives must be based on the conditions that are presented in the early summer of each year. There is also concern for the emergence of increasing herbicide resistance in the Wabeek Lake watermilfoil population. Adjustments must also be made to address these emerging threats.*

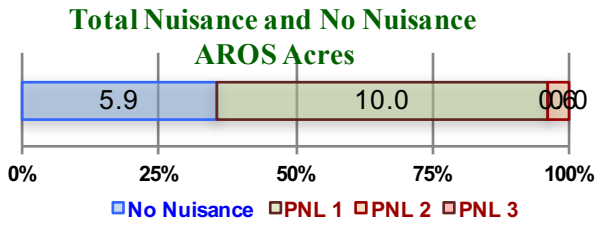
Category 750: LakeScan™ Management Objectives

Perceived Nuisance Index, "PNL" Index and Invasive or Nuisance Species.

Background: There are several species that typically become a nuisance in Michigan's inland lakes. These species are usually targeted for very selective control to prevent them from becoming an aesthetic or recreational nuisance. However, they are also targeted for control when they grow at a level that threatens other more desirable plant species. Species that are nearly always targeted for control are referred to as T1 species in LakeScan™ parlance.

Wabeek Lake 2016: 13 different plant species were observed in Wabeek Lake in 2016. Nuisance aquatic plant conditions were only observed in nearly two thirds of all lake observations sites (AROS). Ebrid milfoil and starry stonewort are the most "threatening weeds" in the lake; however, starry stonewort was not observed to be a serious nuisance. The management program has effectively suppressed the production of ebrid milfoil and starry stonewort, but these efforts have very little impact on weedy hybrid pondweed. Pondweed production needs to be closely monitored and production needs to be encouraged to increase the biodiversity metrics in the lake.

% AROS Acre	PNL Level	Perceived Nuisance Level Description	Total AROS Acres
36%	PNL 0	*"No Nuisance"*	6
61%	PNL 1	*"Ecological Nuisance"*	10
4%	PNL 2	*"Equivocal Nuisance"*	1
0%	PNL 3	*"Obvious Nuisance"*	0



Effective and targeted ebrid milfoil control and suppression of other emerging invasive plant species should help to move the lake toward meeting optimal lake quality criteria. Unfortunately, certain invasive and nuisance native plant species receive some protection from the MDEQ. Control may not be permitted for some of these species, depending upon the year and the location of the offending species.

Eurasian Watermilfoil and Hybrids (Ebrids):

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for a long time (since the late 1980's). University of Connecticut professor Dr. Don Les was the first to determine that there were indeed, Eurasian watermilfoil and northern watermilfoil hybrids in Michigan based on samples sent to his Connecticut lab by Dr. Douglas Pullman, Aquest Corp. in 2003. Experience has proven that it is usually not possible to determine the milfoil observed is either Eurasian or hybrid genotype. However, because they play such similar roles in lake ecology, they are simply "lumped together" and referred to collectively as ebrid milfoil. Ebrid milfoil is a very common nuisance in many Michigan inland lakes.

Wabeek Lake 2016: Ebrid milfoil was not the dominant weed in Wabeek Lake in 2016 but was present at levels that required intervention. It could have been described as a nuisance in 14 acres. It was found in 6 acres where it was not considered to be growing a obvious nuisance levels but this is emblematic of the success of the management program. Ebrid milfoil dominance varies considerably each year as demonstrated in Table 704. Since the ebrid milfoil genotypes are likely to evolve and change over time, continued monitoring and prudent management is required to protect the stability of the Wabeek Lake aquatic macrophytes flora and to detect the emergence of herbicide resistance.

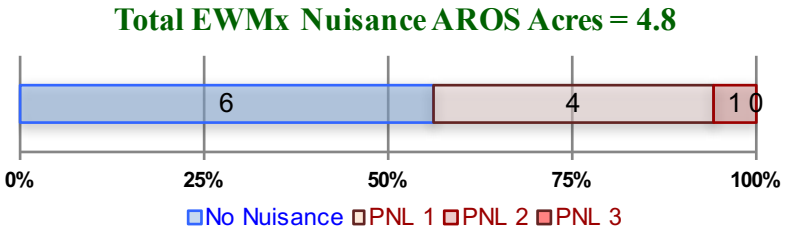


Figure 704. Ebrid milfoil (Eurasian water milfoil + Eurasian and northern watermilfoil hybrids = Ebrid) recorded in the AROS of Wabeek Lake. Nuisance acres are represented by pinks and reds and total nuisance acres are noted in the title. The blue bars represent AROS acres where EWMx was observed, but was not considered to be present at any nuisance level. AROS are assigned to all of the plant productive and potentially plant productive parts of the lake.

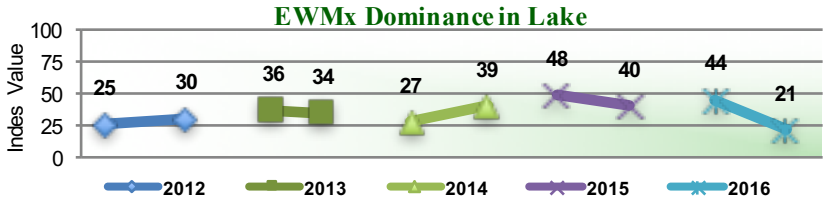
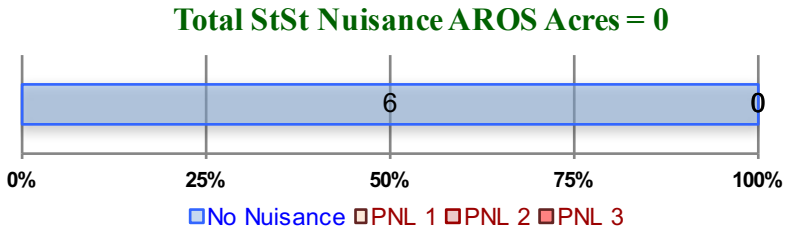


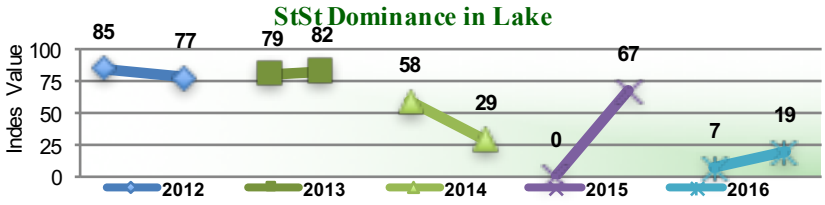
Figure 705. Ebrid milfoil (Eurasian water milfoil + Eurasian and northern watermilfoil hybrids = Ebrid) dominance recorded in the AROS of Wabeek Lake. AROS are assigned to all of the plant productive and potentially plant productive parts of the lake.

Prescriptives: Ebrid milfoil can grow to significant nuisance levels throughout much of Wabeek Lake. It is an ever-present threat to the biological diversity stability of the lake ecosystem. Species selective, systemic herbicide combinations have been used to successfully suppress the nuisance production ebrid milfoil in Wabeek Lake and support the production of a more desirable flora. Milfoil community genetics are dynamic – not static, and careful monitoring is needed to adapt to the expected changes in the dominance of distinct milfoil genotypes. Some of these genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective.

Starry Stonewort

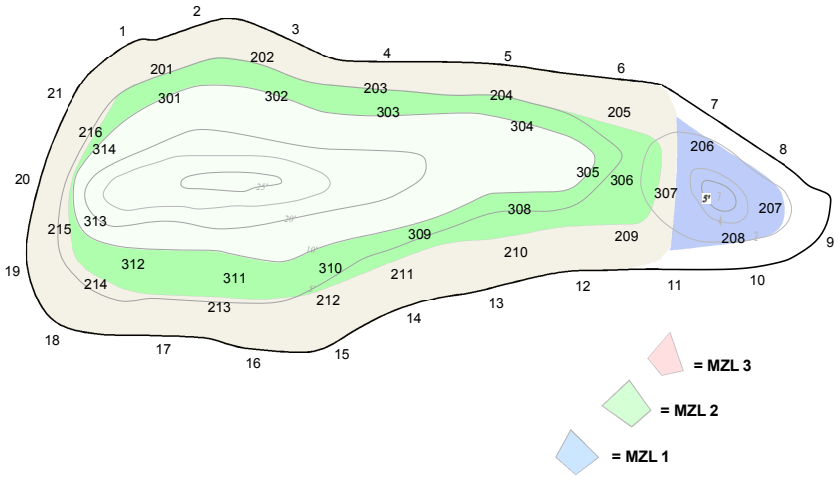
Background: Starry stonewort invaded North American inland lakes after becoming established in the St. Lawrence Seaway/Great Lakes system. It has probably been present in Michigan's inland lakes since the late 1990's but was not positively identified until 2006 by Aquest Corporation Lobdell Lake, Genesee County, MI. Since then, it has been discovered in lakes all over Michigan. The most important characteristic of this species is that it is predictably unpredictable. It is truly an opportunistic species and will bloom AND crash and impose a very significant and deleterious impact on many ecosystem functions. Bloom and crash events are unpredictable and can happen at any time of the year. Some years it can become a horrendous nuisance while it can be inconspicuous in others. It can comingle with other similar species and be very difficult to find when it is not blooming.





Wabeek Lake, 2016: The percent AROS occurrence of starry stonewort was the lowest level that have been observed since it was first found in the lake in 2010. The mean percent AROS occurrence has been 81% since it invaded the lake. The dominance of this species varies wildly from year to year. Starry stonewort and ebrid milfoil colonize the deeper and central areas of the lake where most native Michigan plant species are usually absent. However, it could easily grow to nuisance levels in 2017 and required species targeted management.

Prescriptives: Starry stonewort is capable of growing to extreme nuisance levels in Wabeek Lake even though it was not observed as a significant nuisance in 2016. It is surprisingly easy to kill, but very difficult to treat. It grows so rapidly that mechanical methods of control are strongly discouraged. First, starry stonewort can regrow so rapidly after cutting that it can be nearly impossible to keep up with the nuisance production this fast growing plant. Mechanical controls can also help to disperse and spread starry stonewort throughout inland lakes when the plant is fragmented. It is even more disturbing that desirable plant species are more susceptible to mechanical control strategies than starry stonewort and mechanical controls can thereby select for the dominance of starry stonewort over a much more desirable flora. Starry stonewort is susceptible to most selective algaecides, but the dense mats of vegetation are very difficult to penetrate and provide reasonable biocide exposure. Consequently, multiple algaecide applications may be required to "whittle down" dense starry stonewort growth if the mats reach sufficient height. This is referred to as "hair cut" treatment.



Wabeek Lake Management Zones (MZL):

These are areas where different management objectives are established. These objectives range from highly species selective management intervention strategies and technologies (MIST) to fairly broad spectrum control that might be considered desirable in a swimming area or marina. The selection and designation of the areas is based on the ecological significance of the area and State regulatory policy. MZL 4 areas are the most aggressively managed areas in lakes, but MZL 3 is the most aggressively managed area in this lake. Lake access is critical in MZL 3 areas and selectivity is a subordinate priority. Only T1 (Target 1) species, such as milfoil, curly leaf pondweed, and starry stonewort are targeted in MZL 2 areas, but there may be some temporary impacts on desirable plants. Only the most highly selective management agents are applied to MZL 1 and the objectives in these areas are to focus on only a single species or two.

Management Interventions Strategies and Technologies (MIST)

Weed growth typically reaches nuisance levels around the Memorial Day Holiday in Wabeek Lake. Species selective herbicide combinations are applied to the lake to target invasive species and encourgage the development of a biologically diverse, desirable, native plant community. Different areas of the lake are treated each year and the total area to be treated also varies.

Estimated Management Cost, 2017

The following budget estimate is a "worst case" scenario estimate. Actual costs are based on total area treated and are typically one half of the proposed estimate. Administrative and permit costs are not included in this analysis.

Projected Lake Management Cost Estimates, 2017

Task Description	Total Events	Unit Cost	Total Cost
Cost of Services			
Management Intervention Services			
Ebrid Milfoil Management (Contacts)	2 Events (20 total acres)	$5,800	
Starry Stonewort	2 Event2 (20 acres)	$11,700	
Algae Management	Multiple (10 acres)	$850	
			$18,350
Monitoring and Management Guidance			
LakeScan™ Analysis (Vegetation) and Preseriptives	2 LakeScan Surveys	$4,022	$4,022
	Communications		
TOTAL			**$22,372**