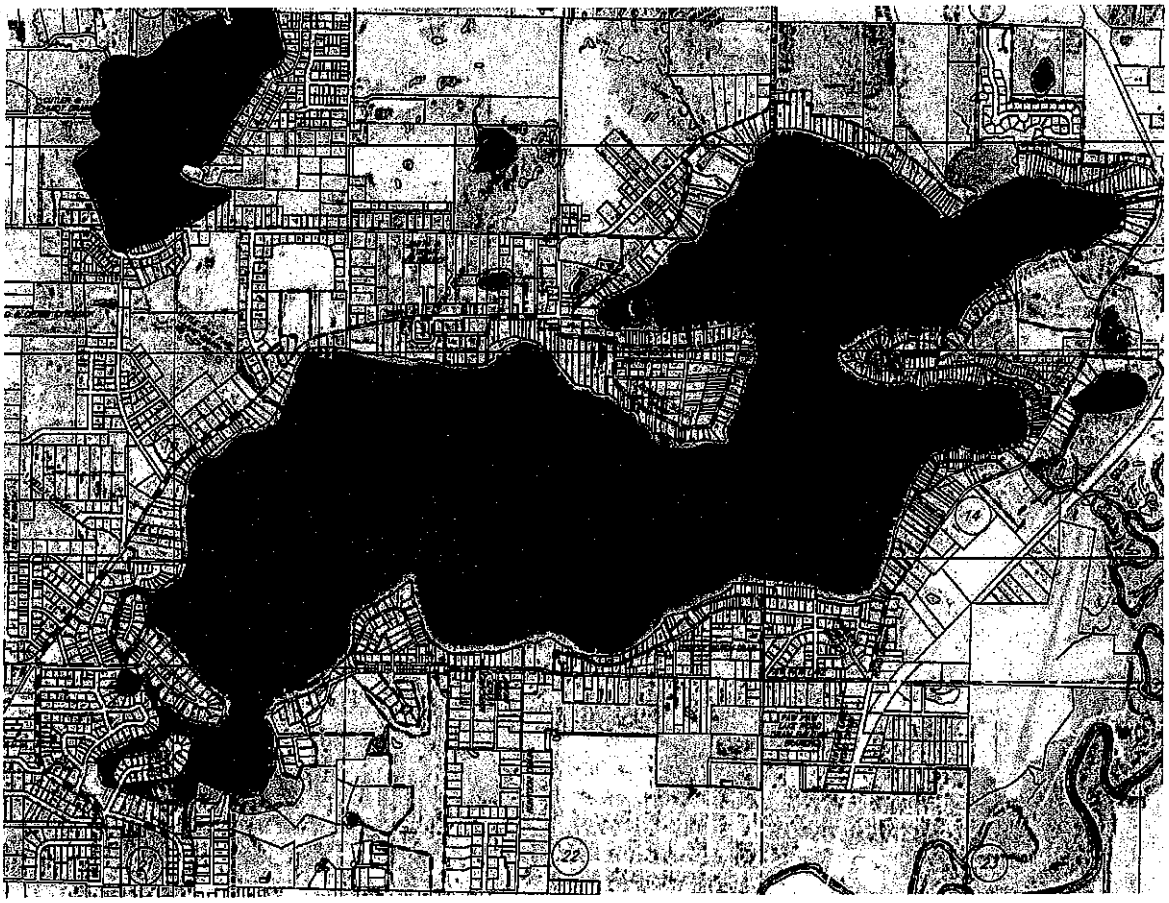
Paw Paw Lake
Lake Improvement Plan

Coloma and Watervliet Townships
Berrien County, Michigan



Submitted to:
The Coloma and Watervliet Township Boards
Lake Restoration Advisory Committee

May 2, 2016

Table of Contents

Submitted by:
Spicer Group, Inc.
1400 Zeeb Drive
St. Johns, MI 48879

GEI Consultants of Michigan, Inc.
806 Hastings Street, Suite M, Box 14
Traverse City, MI 49686

1. Introduction

Spicer Group, Inc (Spicer) and GEI Consultants of Michigan (GEI) were retained by the Lake Restoration Advisory Committee (LRAC) to assist in developing a lake improvement plan that lays out the framework for better understanding, assessing and selecting methods for improving the natural resources and water quality of the lake. In 2012 a 5-year lake management plan was adopted and implemented to address concerns with the invasion of Eurasian milfoil (*Myriophyllum spicatum*) across the lake coupled with the apparent high concentration of phosphorous being released from bottom sediments into the water column exacerbating nuisance growths of aquatic weeds and algal blooms.

Implementation of this plan provided for the lake-wide herbicide treatment of Eurasian milfoil in 2012 with Sonar (Fluridone). Coupled with subsequent spot treatments in 2013-2015, these treatments have proven effective in stopping and controlling the spread of this non-native nuisance plant species across the lake. The plan also included implementation of a pilot aeration project in the northern lobe of the lake to reduce the release of phosphorous into the water column and to reduce the accumulation of bottom sediments. To date the results of that pilot project are still under review and will be evaluated as part of this proposed lake improvement plan.

This lake improvement plan will assess the effectiveness of the actions taken under the previous watershed and lake management plans[1] for Paw Paw Lake and look for ways of improving upon their successes and shortfalls. The budget for this plan is based on a 7-year cycle to account for anticipated maintenance of equipment, retreatment of the lake for Eurasian milfoil, monitoring, and implementation of the plan objectives and actions. This plan is intended to be a working document that can be utilized beyond that time period. An additional component of this plan is inclusion of public education and outreach by providing informational brochures, workshops and meetings along the lakeshore to help both lakefront and non-lakefront owners understand what actions are being taken by LRAC and what actions they can take.

[1] Paw Paw Lakes and Watershed Study (Feb 2008) and Paw Paw Lake Restoration Plan (May 2010)

2. Improvement Goals

The current lake improvement plan spans a 5-year period (2012-2016) and has already included conducting a lake-wide treatment of Eurasian milfoil and installation of aeration in north lobe of the lake as a pilot-study. Those actions were implemented to address the primary goals set by the LRAC in 2012 which included controlling the spread and dominance of Eurasian milfoil across the lake and to implement and evaluate aeration in reducing sediment accumulation and release of nutrients from bottom sediments (reducing availability in the water column for aquatic plants to use) and its potential use across the entire lake.

Over the past year LRAC and its consultants have met to discuss the status and effectiveness of the current lake improvement plan. The group worked to identify, assess and focus the goals and objectives of this plan down to a manageable number realistic with the time and resources available for accomplishing these goals and their objectives. The primary improvement goals for this Lake Improvement Plan are:

- **Manage and Control Invasive and Nuisance Species**
  - One of the greatest threats to Michigan's inland lakes and its associated aquatic resources is the uncontrolled spread of invasive and nuisance species (inclusive of non-native and exotic species) which can compete with native species for food and space, affect the natural balance of aquatic ecosystems, and significantly impact resource use (MDEQ et al., 2013; Michigan Sea Grant, 2012).
  - There are numerous cases in the Great Lakes region where invasive species such as zebra mussels (*Dreissena polymorpha*), round goby (*Neogobius melanostomus*), and Eurasian milfoil have upset the natural balance of the aquatic communities resulting in poorer fishing opportunities, decreased abundance of fish prey (e.g., invertebrates) and spawning habitat, decreased recreational opportunities, and decreased waterfront property values, among other impacts (Lovell, 2005; Rosaen et al., 2012; MDEQ et al., 2013).
  - As of September 2015, an additional 10 aquatic plant and 7 fish/aquatic animal species are listed on MDNR's invasive species "watch list" (MDNR, 2015), indicating the potential for colonization by other species in the future.
  - The LRAC has received numerous complaints pertaining to invasive and nuisance species and recognizes the importance of managing and controlling invasive and nuisance species, whether plant or animal, to not only sustaining but improving the species composition of the lake.

- **Improve Overall Water Quality and Water Clarity – Halt/Reverse Lake Degradation**
  - This goal stems from numerous complaints and concerns brought to the LRAC with respect to algal blooms, decreased visibility, and nuisance smells across the lake. These have increased in number, frequency, duration, and occurrence during summer months when lake use is highest. Objectives and actions to measure and address these issues and to meet this goal are of primary importance to the LRAC.
  - The effectiveness of the pilot aeration project has been questioned along with its possible contribution to the increased turbidity (decreased water clarity). Use of this alternative to reduce sediment and nutrients within the water column and bottom sediments for plants will be assessed along with other alternatives to achieve this goal.

- **Improve Fisheries, Wildlife, Recreational and Aesthetic Values of the Lake**
  - Addressing the objectives and taking action on the two aforementioned goals will assist in achieving this goal. This biotic and human-oriented goal was identified as a separate goal to draw attention to the lake's natural resources and the values they provide to both landowners and non-landowners on the lake. People value the lake slightly different from one another; one person may value the fishing opportunities of the lake over that of their neighbor who may never fish the lake but instead enjoys the serenity of seeing the clear blue waters of the lake throughout the non-winter months. The LRAC decided that each of these users of the lake need to have their interests understood and accounted for in a comprehensive lake management or improvement plan.

Objectives were identified that could be measured and used to determine if the goals of the plan were being met – specifically answering the questions "Is what we're doing really protecting, managing, and improving the natural resources and water quality of the lake?" The objectives that were identified to help measure if the goals are being met are:

- Reduce Percent Cover of Invasive and Nuisance Species
- Reduce Total Phosphorus in the Water Column
- Reduce Algal Blooms
- Decrease Nutrient Inputs into the Lake
- Increase Percent Cover and Diversity of Native Vegetation
- Document and assess existing resources and fish and wildlife habitat, along with recreational and aesthetic values associated with the lake to identify areas of potential improvement, enhancement or restoration

Descriptions of these objectives inclusive of a list of actions that have been identified to be implemented with the Lake Improvement Plan are provided in the proceeding section *3. Objectives and Action Items* of this plan.

3. Objectives and Action Items

To meet the goals and objectives outlined in the preceding sections of this plan, numerous action items will need to be completed throughout the proposed management period. Many of the action items can effectively contribute to more than one of the objectives and not just the one objective that it may be listed under (and wherein a description for that action item is presented).

3.1 Reduce Percent Cover of Invasive and Nuisance Species

This objective relates most directly with the goal of "*Managing and Controlling Invasive and Nuisance Species*". However it also contributes to the other two goals by reducing threats to native plant and animal communities which provide a greater array of wetland functions and values, and habitats for aquatic and terrestrial biota (as compared to invasive species). If left unchecked invasive species can become dominant outcompeting native species, reducing plant and animal diversity which in turn reduces fish and wildlife resources, and ultimately a reduction in recreational, economic and aesthetic values to the lake.

Percent cover of invasive and nuisance species is a metric routinely obtained by field biologists and consists of estimating the amount of vegetative cover within a given area that is covered by native vs. non-native species (i.e. invasive and nuisance species). A metric value for the entire lake or specific sections of the lake can be obtained by using data collected during the Aquatic Vegetation Assessment Sites (AVAS) survey of the lake. AVAS surveys are typically required to be included in MDEQ aquatic nuisance control permit applications and are highly recommended to be completed both in the early summer and last summer (coinciding with both pre- and post-herbicide treatments). They are used to obtain a full understanding of what plant species you have in the lake (noting that some species are not fully represented until later in the growing season) and to assess the effectiveness of herbicide or other weed control measures that were implemented. To help achieve this objective or metric the following action items have been included into the Lake Improvement Plan:

- Continue to implement, monitor, assess, and improve upon current Aquatic Nuisance Weed Management Program (ANWMP).
    - Continue to assess and utilize qualified consultants to provide the services required by the ANWMP.
    - Utilize a 3rd party consultant/aquatic biologist to annually conduct AVAS surveys to aide in assessing the effectiveness of ANWMPs and to

recommend additions or changes to help in meeting the Plans objectives for decreasing percent cover of invasive and nuisance species. The use of 3rd party consultants to review the work performed by and outcomes of these contractors ensures that results are reviewed and assessed scientifically without bias, while also enabling recommendations for corrections or future applications to be presented without bias.

- Continue to implement, monitor, assess, and improve upon current Aeration Pilot Program (APP) and research and evaluate new aeration technologies.
    - Continue to assess and utilize qualified consultants to provide the services required by the APP.
    - Utilize a 3rd party consultant(s) to periodically and annually review the services of the APP contractor to ensure applications and maintenance are provided as required by contract. The consultant(s) will also assess the effectiveness of the APP and recommend additions or changes to help in meeting the Plans objectives. The use of 3rd party consultants to review the work performed by and outcomes of these contractors ensures that results are reviewed and assessed scientifically without bias, while also enabling recommendations for corrections or future applications to be presented without bias.
    - Continue to use a 3rd party consultant to annually conduct bathymetric surveys to aide in assessing the effectiveness of the APP.

- Research, evaluate and implement existing and other technologies/methods for controlling native, non-native, invasive, nuisance, and exotic species.
    - Boat washing station(s) – identify % that will use them, cost, $ source through grants.
    - Surveys of aquatic biota for early detection of potential species

- Provide educational materials to the public and riparians' about the benefits/values of identifying and controlling invasive, exotic and non-native species while maintaining native vegetation where possible through the use of buffer strips and not mowing or maintaining a lawn to the waters' edge.
    - Educational brochures, materials and workshops for riparian owners and the general public will be developed to provide information on identifying, controlling and managing invasive plant and animal species. Emphasizing what they can do to help whether they are on the lake or within the watershed.

3.2 Reduce Total Phosphorous in the Water Column

This objective relates most directly with the goal of *"Improving Overall Water Quality and Water Clarity – Halt/Reverse Lake Degradation"*. However it also contributes to *"Managing and Controlling Invasive and Nuisance Species"* by reducing the amount of

available nutrients in the water column for these overly aggressive and high nutrient tolerant species to utilize (which outcompete native species). Reducing total phosphorous in the water column will limit the available nutrients for adverse growth of algae and nuisance plants which will in turn provide clearer water.

Measuring total phosphorous in the water column has been part of past monitoring practices, is a requirement of MDEQ monitoring, and is therefore recommended to continue being part of the water quality monitoring program that commences in the spring and ends in the fall of each year. This metric is obtained by taking water samples at various depths within the water column and sending those samples to an analytical laboratory. Results are then provided back to the consultants for comparison to other samples taken at different depths, locations in the lake, and to prior years at the same locations and depths. To help achieve this objective or metric the following action items have been included into the Lake Improvement Plan:

- Continue to implement, monitor, assess, and improve upon current Aeration Pilot Program (APP) with specific attention to the effectiveness of bio-augmentation.
    - Evaluation of alternative design and operational methods associated with aeration that will be explored include, but are not limited to, the following:
        - Raising of the diffusers off of the bottom of the lake to align them more into the laminar flow and cycling of water within the lake
        - Adjusting air pressure either up or down to increase effectiveness of aeration and reducing re-suspension of sediments that have been alleged to be the source of decreased clarity in the lake.
        - Increasing or grouping of the number of diffusers
        - Installing alternative diffusers that emit different sizes of bubbles
        - Assessing alternative methods for measuring the success of this technology
    - Evaluation of the effectiveness of bio-augmentation will examine, but is not limited to, the following:
        - Composition of microbes within the bottom sediments – to which there may be sufficient microbes already in the bottom sediments that additional microbes do not need to be injected.
        - Value added of the microbes being injected – do they complement or deter the functioning of the microbes already present in the bottom sediments. This will help answer the question "Is bio-augmentation cost effective?"
        - Evaluation of alternative 'mixes" of microbes to more effectively reduce bottom sediments

- Continue to obtain and assess water quality data, inclusive of dissolved oxygen, total phosphorous, specific conductivity, pH, turbidity, visibility and temperature coupled with adding in 2016 the collection of chlorophyll *a* and water column

samples for determining BOD (biological oxygen demand). The latter will be used to help assess the effectiveness of the ANWMP and APP.
    - Prepare a monitoring plan that can evaluate the effectiveness of the actions implemented. This may result in reducing or expanding upon the current water quality parameters.

- Identify, assess, and take appropriate corrective actions on erosion, point and non-point sources of sediment and nutrient discharges into or within the lake and its tributaries
    - Coordination with the Berrien County and VanBuren County Drain Commissioner Offices for assessment of tributary drains to the lake
    - Coordination with the Department of Public Health on potential faulty septic systems and illicit discharges to the lake
    - Coordination with United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) on programs for controlling agricultural runoff and other potential point and non-point sources of discharge to the lake

- Research, evaluate and implement other technologies/methods for reducing phosphorous inputs into the lake or within the water column or bottom sediments
    - Evaluation of alternative methods for the removal of phosphorous will be explored include, but are not limited to, the following:
        - Aeration
        - Alum
        - Drawdowns
        - Dredging
        - Filtering, extraction or removal of nutrients from the water surface and water column using various technologies
        - Construction of wetland biofilter at the lake and outlet of the Branch and Derby Intercounty Drain
        - Watershed management practices

- Create and provide educational programs to better inform the public and lake riparians' on how to identify, eliminate or better control point and non-point sources of runoff (e.g. sediment, nutrients, pollutants) into the lake
    - Educational brochures, materials and workshops for riparian owners and the general public will be developed to provide information on identifying sources of nutrients and how to manage them. Emphasizing what they can do to help whether they are on the lake or within the watershed.

- Provide educational materials to the public and riparians' about the benefits/values of maintaining native vegetation buffer strips and not mowing or maintaining a lawn to the waters' edge to help reduce nutrient loading to the lake

- Educational brochures, materials and workshops for riparian owners and the general public will be developed to provide information on establishing and maintaining native vegetative buffer strips and other ways to reduce nutrient loading to the lake. Emphasizing what they can do to help whether they are on the lake or within the watershed.

3.3 Reduce Algal Blooms

This objective relates to two goals – one being the goal of *"Improving Overall Water Quality and Water Clarity – Halt/Reverse Lake Degradation"* and the other to *"Improve....Aesthetic Values of the Lake"*. The "pea green soup" appearance of algal blooms occurring across inland lakes throughout Michigan and the Midwest is well documented. Nonetheless it is an important issue that the LRAC intends to address by this plan. Reducing the amount of available nutrients in the water column at various times of the year for the various species which are present is opined by many to help in addressing this problem (Sea Grant 2012b, USEPA 2016)

Measuring the success of reducing algal blooms in the lake will be accounted for by tracking the number, frequency and density of algal blooms that occur throughout the year as observed and called in by people around the lake. Efforts set forth in the actions below will strive to reduce the number, frequency and duration of those blooms while also obtaining a better understanding of, but not limited to, why they are occurring at various times of the year, what species are involved and what herbicides or methods can be used to reduce their occurrence.

Identification of algal species, their densities, and ways to control them will be done in the lab and through literature reviews. To further help achieve this objective or metric the following action items have been included into the Lake Improvement Plan:

- Continue to implement, monitor, assess, and improve upon current Aquatic Nuisance Weed Management Program (ANWMP).

- Research, evaluate and implement other technologies/methods to reduce algal blooms and other mechanisms that contribute to their periodic spikes
    - Evaluation of methods/measures to control algal blooms will include, but is not limited to, the following:
        - Alum
        - Algalcides
        - Aeration
        - Watershed management practices
        - Filtering, extraction or removal of nutrients and/or algal cells from the water surface and water column using various technologies

- Create and provide educational programs to better inform the public and lake riparian's on how to identify, eliminate or better control point and non-point sources of runoff (e.g. sediment, nutrients, pollutants) into the lake
    - Educational brochures, materials and workshops for riparian owners and the general public will be developed to provide information on identifying point and non-point sources of runoff and how to manage them. Emphasizing what they can do to help whether they are on the lake or within the watershed.

- Continue to obtain and assess water quality data, inclusive of dissolved oxygen, total phosphorous, nitrogen, and temperature coupled with adding in 2016 the collection of chlorophyll *a* and water column samples for determining BOD.
    - Prepare a monitoring plan that can evaluate the effectiveness of the actions implemented. This may result in reducing or expanding upon the current water quality parameters.

3.4 Decrease Nutrient Inputs into the Lake

This objective relates primarily to the goal of *"Improving Overall Water Quality and Water Clarity – Halt/Reverse Lake Degradation"*. Decreasing nutrient inputs into the lake will require examination of many potential point and non-point sources of runoff or pollution. Some may be apparent from overland runoff from agricultural fields and residential lawns to direct discharges from stormwater outfalls and tributaries. These apparent visible sources may be less of a factor than the less apparent and often non-visible to the naked eye sources such as discharges from failed septic systems or illicit discharges from businesses and residential home. This objective and its actions will require coordination with local county and federal agencies to seek assistance in not only identifying but also controlling and managing these inputs. To help achieve this objective or metric the following action items have been included into the Lake Improvement Plan:

- Identify, assess, and take appropriate corrective actions on erosion, point and non-point sources of sediment and nutrient discharges into or within the lake and its tributaries
    - Coordination with the Berrien County and VanBuren County Drain Commissioner Offices for assessment of tributary drains to the lake
    - Coordination with the Department of Public Health on potential faulty septic systems and illicit discharges to the lake
    - Coordination with United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) on programs for controlling agricultural runoff and other potential point and non-point sources of discharge to the lake

- Create and provide educational programs to better inform the public and lake riparians' on how to identify, eliminate or better control point and non-point sources of runoff (e.g. sediment, nutrients, pollutants) into the lake
    - Educational brochures, materials and workshops for riparian owners and the general public will be developed to provide information on identifying point and non-point sources of runoff and how to manage them. Emphasizing what they can do to help whether they are on the lake or within the watershed.

- Provide educational materials to the farming community about the benefits of maintaining vegetative buffer strips along creeks, rivers and drains that may traverse their fields and how these can reduce overland runoff of their valuable soils, fertilizers and crops into these watercourses.
    - Educational brochures, materials and workshops for riparian owners and the general public will be developed to provide information on establishing and maintaining native vegetative buffer strips and other ways to reduce nutrient loading to the lake. Emphasizing what they can do to help within the upper portions of the watershed.

- Monitor the Paw Paw Lake Watershed and Tributaries for Nutrients
    - Develop a monitoring plan in coordination with the Berrien and VanBuren County Drain Commissioner Offices to regularly assess the watershed.

3.5 Increase Percent Cover and Diversity of Native Vegetation

This objective relates most directly with the goal of "*Managing and Controlling Invasive and Nuisance Species*". However it also contributes to the other two goals by increasing the percent of native species which in turn reverses lake degradation and increases fish, wildlife, recreational and aesthetic values. As already noted in Objective 3.1 Reduce Cover of Invasive and Nuisance Species, if left unchecked invasive species can become dominant outcompeting native species, reducing plant and animal diversity which in turn reduces fish and wildlife resources, and ultimately a reduction in recreational, economic and aesthetic values to the lake.

Percent cover of natives species is a metric routinely obtained by field biologists and consists of estimating the amount of vegetative cover within a given area that is covered by native vs. non-native species. This metric is obtained at the same time as the percent cover of invasive and nuisance species previously identified in Section 3.1. A metric value for the entire lake or specific sections of the lake can be obtained by using data collected during the Aquatic Vegetation Assessment Sites (AVAS) survey of the lake. As previously noted AVAS surveys are typically required to be included in MDEQ aquatic nuisance weed applications and are highly recommended to be completed both in the early summer and last summer (coinciding with both pre- and post-herbicide treatments) to obtain a full understanding of what plant species you have in the lake

(noting that some species are not fully represented until later in the growing season) and to assess the effectiveness of your herbicide or other weed control measures that were implemented. To help achieve this objective or metric the following action items have been included into the Lake Improvement Plan:

- Continue to implement, monitor, assess, and improve upon current Aquatic Nuisance Weed Management Program (ANWMP).
    - Continue to assess and utilize qualified consultants to provide the services required by the ANWMP.
    - Utilize a 3rd party consultant/aquatic biologist to annually conduct AVAS surveys to aide in assessing the effectiveness of ANWMPs and to recommend additions or changes to help in meeting the Plans objectives for increasing percent cover and density of native species. The use of 3rd party consultants to review the work performed by and outcomes of these contractors ensures that results are reviewed and assessed scientifically without bias. While also enabling recommendations for corrections or future applications to be presented without bias.

- Research, evaluate and consider reintroduction of native vegetation in strategic locations around the lake (township sites, access points). Includes providing educational materials to the public/riparian's on the lake to encourage private native plantings, reduce mowing, and use of fertilizers.
    - Explore and assess the cost effectiveness of re-introducing native species back into areas eradicated of non-native species (i.e. invasive and nuisance species).
    - Provide educational materials to the public and riparian's about the benefits/values of using native species and altering some lawn maintenance activities to reduce nutrient runoff and loading to the lake. Educational brochures, materials and workshops for riparian owners and the general public are being developed on identifying, controlling and managing invasive plant and animal species (under another objective and which will used to also to provide information). These same materials and workshops will also focus on the use of native species. These materials and workshops will emphasize what people can do to help whether they are on the lake or within the watershed.

3.6 Document and assess existing resources and fish and wildlife habitat, along with recreational and aesthetic values associated with the lake to identify areas of potential improvement, enhancement or restoration.

This objective relates most directly with the goal of *"Improving Fisheries, Wildlife, Recreational and Aesthetic Values of the Lake"*. However it also contributes to *"Managing and Controlling Invasive and Nuisance Species"* in that some of the potential areas will focus on those areas of the lake where habitat is degraded and can be improved or enhanced and to which will likely include those areas infested with or dominated by invasive species.

Documentation and assessment of existing resources, inclusive of fish and wildlife, and their habitats can be obtained by conducted visual surveys around the perimeter of the lake and any adjacent wetland complexes. Reconnecting wetlands to lakes has been a successful restoration tool for improving fisheries resources, especially with respect to providing spawning, nursery, rearing and feeding habitats for fish which may have once been connected but have been lost due to roadways and developments. To help achieve this objective or metric the following action items have been included into the Lake Improvement Plan:

- Research and consider Installation/placement of fish and wildlife habitat and/or structures
    - Assess existing fish communities and habitat use areas of the lake for exploring locations and methods for improving habitat or access to other areas that may be obstructed by culverts, road crossings, etc.
    - Coordinate with MDNR Fisheries Division on habitat and locations for selected species to ensure our efforts complement with those of the agencies.

- Provide educational materials to the public and riparian's about the benefits of maintaining buffer strips and native vegetation for reducing nutrient loading to the lake as well as improving fish and wildlife habitat
    - Educational brochures, materials and workshops for riparian owners and the general public will be developed to provide information on establishing and maintaining native vegetative buffer strips while also emphasizing the benefits to improving fish and wildlife habitat.

3.7 Evaluate and develop appropriate metrics to measure the success of the Plan Objectives

To ensure the goals and objectives of the Lake Improvement Plan are pursued and achieved in a resource, timely and cost effective manner the actions and metrics for measuring the success of those actions need to be evaluated and modified where appropriate. Just because those same actions and metrics were used in the past

doesn't mean they are appropriate for achieving the current goals and objectives and more importantly addressing and complying with state permit conditions. Under this objective the plan proposes to compile and evaluate both historic and current data and the methods used to obtain that data to determine if more resource, timely and cost effective methods may be used to obtain or reach the same or better data or result, respectively.

Part of this objective also includes presentation of the data, results, discussions, recommendations, successes and shortfalls of the actions implemented on an annual basis to the LRAC so they can keep the public informed of the progress and effectiveness of the plan.

4. Planning Budgets

2016 Lake Improvement Plan Budget

Paw Paw Lake Improvement Plan
2/18/2016

Annual Analyses	2017	Annual Recurring Costs for 7 Year Cycle (2017-2023)	7-YEAR TOTAL	7-YEAR Cost/Year	7-YEAR Cost/ Resident/Year
Weed Control	$ 50,000.00	$ 50,000.00	$ 350,000.00	$ 50,000.00	$ 50.00
Monitoring					
Bathymetric	$ 9,000.00	$ 7,000.00	$ 51,000.00	$ 7,285.71	$ 7.29
AVS	$ 10,000.00	$ 8,000.00	$ 58,000.00	$ 8,285.71	$ 8.29
Water Quality	$ 15,000.00	$ 15,000.00	$ 105,000.00	$ 15,000.00	$ 15.00
Reporting	$ 30,000.00	$ 30,000.00	$ 210,000.00	$ 30,000.00	$ 30.00
Meetings	$ 7,500.00	$ 3,500.00	$ 28,500.00	$ 4,071.43	$ 4.07
Permitting	$ 5,000.00	$ 2,000.00	$ 17,000.00	$ 2,428.57	$ 2.43
Maintenance	$ 10,000.00	$ 7,500.00	$ 55,000.00	$ 7,857.14	$ 7.86
SUBTOTAL	$ 136,500.00	$ 123,000.00	$ 874,500.00	$ 124,928.57	$ 124.93

Preliminary Improvement Actions	2017	Annual Recurring Costs for 7 Year Cycle (2017-2023)	7-YEAR TOTAL	7-YEAR Cost/Year	7-YEAR Cost/ Resident/Year
Aeration					
Evaluation	$ 2,500.00	$ 2,500.00	$ 17,500.00	$ 2,500.00	$ 2.50
Invasives/Exotics/Natives/Algal blooms					
Evaluation	$ 3,500.00	$ 3,500.00	$ 24,500.00	$ 3,500.00	$ 3.50
Phosphorous inputs/uptake/reduction					
Evaluation	$ 2,500.00	$ 2,500.00	$ 17,500.00	$ 2,500.00	$ 2.50
Fish and Wildlife Habitat					
Evaluation	$ 8,000.00	$ 1,000.00	$ 14,000.00	$ 2,000.00	$ 2.00
Education					
2 Workshops for Riparians	$ 35,000.00	$ 10,000.00	$ 95,000.00	$ 13,571.43	$ 13.57
1 Workshop for General Public	$ 10,000.00	$ 2,000.00	$ 22,000.00	$ 3,142.86	$ 3.14
Drain inputs, evaluation and					
Evaluation and Recommendations	$ 15,000.00	$ 15,000.00	$ 105,000.00	$ 15,000.00	$ 15.00
Monitoring watershed and tributaries	$ 10,000.00	$ 10,000.00	$ 70,000.00	$ 10,000.00	$ 10.00
Implementation of Aeration, Invasives /Exotics/Natives, Phosphorous Inputs & Uptake, Fish & Wildlife, and Algal Blooms	$ 250,000.00	$ -	$ 250,000.00	$ 35,714.29	$ 35.71
SUBTOTAL	$ 336,500.00	$ 46,500.00	$ 615,500.00	$ 87,928.57	$ 87.93

	2017	Annual Recurring Costs for 7 Year Cycle (2017-2023)	7-YEAR TOTAL	7-YEAR Cost/Year	7-YEAR Cost/ Resident/Year
TOTAL OF SERVICES	$ 473,000.00	$ 169,500.00	$ 1,490,000.00	$ 212,857.14	$ 212.86

*Assumes 1,000 full assessments

5. Literature Cited and Reference Materials

Lovell, et al. 2005. The Economic Impacts of Aquatic Invasive Species: A Review of the Literature. Agricultural and Resource Economics Review 35 (1):195-208.

Michigan Department of Environmental Quality. 2013. Michigan's Aquatic Invasive Species
State Management Plan 2013 Update.

Michigan Department of Natural Resources. 2015. Invasive Species Watch List. Updated 9/15/15: http://www.michigan.gov/documents/dnr/InvasiveSpecies-WatchList_498319_7.pdf

Michigan Sea Grant. 2012a. Aquatic Invasive Species in Michigan, Fact Sheet.

Michigan Sea Grant. 2012b. Harmful Algal Blooms – The Beach Manager's Manual. MICHU-12-502. 8 pages.

Paw Paw Lake Foundation (PPLF). 2008. Paw Paw Lakes and Watershed Study. Prepared by Spicer Group, Inc. Feb 2008.

PPLF. 2010. Paw Paw Lake Restoration Plan. Prepared by Spicer Group, Inc. and JFNew, May 2010.

PPLF. 2011. Water Quality Assessment. Prepared by Cardno JFNew. October 2011

Rosaen, et al. 2021. The Costs of Aquatic Invasive Species to the Great Lakes States. Anderson Economic Group LLC. East Lansing, MI 48823

USEPA. 2016. Nutrient Pollution Policy and Data - Control and Treatment of Algal Blooms. Website accessed on February 18, 2016. http://www.epa.gov/nutrient-policy-data/control-and-treatment