# A Proposal to Determine the Seasonal Efficacy of Laminar Flow Aeration as a Treatment for Excessive Sedimentation and Organic Matter Accumulation, Aquatic Vegetation and Algae Growth and Sediment Nutrients in Maple Lake: *In Situ* Effects of Laminar Flow Aeration in Maple Lake, Van Buren County, Michigan.

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## Introduction and Background

### *Maple Lake Sediment Organic Matter*

Sediment samples were collected from Maple Lake on September 2, 2009 by Lakeshore Environmental, Inc. scientists and demonstrated a range in values of organic matter from 1.2% to 56%. Each sediment core sample was maintained in an upright position and kept on ice prior to having the upper 8.0 cm analyzed in the laboratory for fraction of organic carbon (% organic matter) using ASTM Method D2974. The mean concentration of organic matter varied by location throughout Maple Lake, with a mean of 22% in the South Basin, a mean of 14% in the region north of the South Basin, a mean of 27% in the Turtle Bay region, and a mean of 28% in the Central Basin just north of Turtle Bay. The percentage of "fines" was highest in the South Basin at 29% and in the Central Basin at 26%. The distribution of fines within the lake is likely due to the transport of fine particulates to the North Basin of the lake from the South Basin as they enter from the East Branch of the Paw Paw River. Organic matter is likely a product of both external (watershed) inputs from the E. Branch of the Paw Paw River and internal creation from decay of aquatic vegetation. Organic matter is defined as the amount of carbon matter per unit of area and in lake bottom sediments consist of decayed aquatic vegetation and phytoplankton biomass and remnants of other biota from within the lake.

### *Maple Lake Sediment Total Phosphorus*

Phosphorus bound to lake sediments may become "bioavailable" if the sediments are anoxic and phosphorus is released and if sedimentary phosphorus increases the concentration of soluble-reactive phosphorus (SRP) in the sediment pore water. Increases in pore water SRP are attributed to increased rooted aquatic vegetation growth, while increases in available phosphorus in the water column are attributed with increased algal growth and rootless aquatic vegetation growth. The mean concentration of sediment total phosphorus in the South Basin was 402 mg $kg^{-1}$, in the region north of the South Basin was 469 mg $kg^{-1}$, in Turtle Bay was 385 mg $kg^{-1}$, and in the Central Basin north of Turtle Bay was 800 mg $kg^{-1}$. All of these values denote significant quantities of

phosphorus that may become available to the pore water and water column during periods of stagnation when the dissolved oxygen concentration near the sediment-water interface drops close to zero. The result is thick, filamentous and planktonic algal blooms, increases turbidity and subsequent decreased water transparency, accelerated rooted aquatic plant growth, and declines in dissolved oxygen in the water column during evening hours when respiratory demands are high and when the biochemical oxygen demand of the system to degrade excessive biomass is elevated.

### *Laminar Flow Aeration*

## Methods

### *Site –Maple Lake*

Maple Lake is located in sections 1, 11, 12, 13, and 14 (T.3S, R.14W) of the Village of Paw Paw and Paw Paw Township, Van Buren County, Michigan. The lake surface area is approximately 172 acres (Michigan Department of Natural Resources, 2001) and may be classified as a eutrophic lake with one deep basin and a large-sized littoral zone. Maple Lake has a maximum depth of 15.0 feet, and an average depth of 7.0 feet (MDNR, 2005). The lake bottom consists primarily of sandy substrate and organic matter deposits.

Maple Lake has a large, immediate watershed of approximately 62,250 acres (97.3 $mi^2$) consisting of abundant agricultural land which contributes high quantities of fertile sediments and nutrients to the lake. The estimated hydraulic retention time depends on the lake water sources and outlet flow rate, but generally averages 7 days (Southwest Regional Planning Commission 1978). The East Branch of the Paw Paw River enters from the south end of Maple Lake and exits at the north end of the lake where it becomes the South Branch of the Paw Paw River. Additional water enters the lake from Ackley Lake at the northeast corner and from a small drainage area near the east shore of Maple Lake. The East Branch of the Paw Paw River is classified as a second-order designated trout stream and is supplied with cold groundwater and water from Little Paw Paw Lake (Kalamazoo County) and from Mattawan Creek in the Village of Mattawan. The East Branch transports large quantities of sand and silt into Maple Lake since it is approximately 8.4 miles in length and traverses a watershed rich in Houghton Mucks and Glendora Sandy Loams. Briggs Pond which is

located in the Village of Paw Paw, is a sedimentation basin which has accumulated large amounts of sediment that are transported into Maple Lake. The South Branch of the Paw Paw River, which is upstream of the lake, is also a designated trout stream. Excessive sedimentation has led to the accumulation of sediments within Maple Lake, as well as increased turbidity, lower dissolved oxygen levels, high nutrient loading, and overgrowth of submersed aquatic vegetation and filamentous algae. Many of the sediments consist of a high fine fraction and organic matter content since they are derived from a large watershed that is comprised of primarily Adrian and Houghton Muck organic soils. The outlet for Maple Lake contains a hydropower dam which was constructed in 1907 and is located at the north end of the lake.

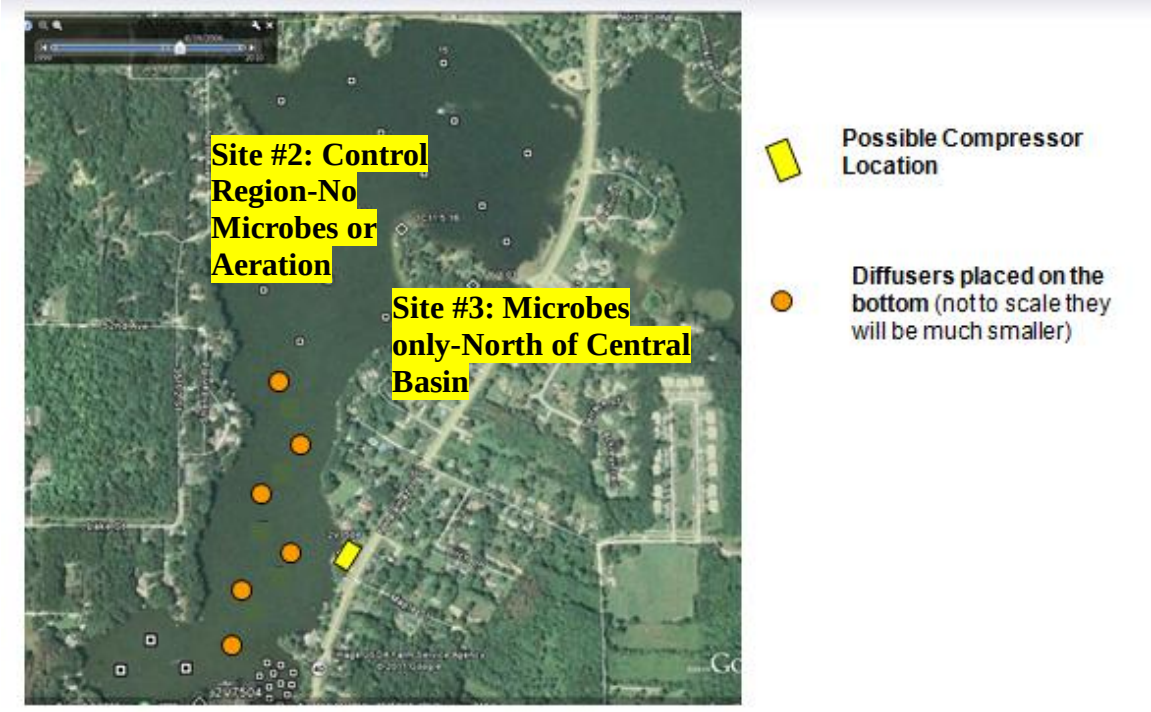
***The Laminar Flow System and Maple Lake***

The Clean-Flo Aeration System utilizes ceramic diffusers which are powered by onshore air compressors. The diffusers are connected via extensive self-sinking airlines which help to purge the lake water of benthic carbon dioxide ($CO_2$), which is a primary nutrient necessary aquatic plant photosynthetic growth and productivity. In addition to the placement of the diffuser units, the concomitant use of non-pathogenic bacteria and enzymatic treatments to facilitate the microbial breakdown of organic sedimentary constituents is also used as a component of the treatment. Although this is a relatively new area of research, recent case studies have shown promise on the positive impacts of Clean-Flo systems on aquatic ecosystem management with respect to sediment organic matter reduction and algal and rooted aquatic plant reductions in aquatic ecosystems (Lakeshore Environmental, Inc 2009-2011 study of Indian Lake, Cass County, MI; Chris Knud-Hansen, Ph.D, Solar-Bee Corporation, personal communication and associated white papers). The philosophy and science behind the Clean-Flo system is to reduce sediment organic matter with the addition of catalysts that help to break down organic matter on the lake bottom under aerated conditions. Sedimentation to Maple Lake should primarily be managed through watershed best management practices (BMP's).

**Evaluation Treatment Design**

***Site#1 –Maple Lake South Basin, Central Basin, and Turtle Bay***

Since a laminar flow system already exists at the South Basin and in Turtle Bay, it is recommended that the area of the Central Basin between the two areas also have laminar flow aeration units installed. This is primarily supported by the sediment and water quality data already collected and also will ensure that the entire South-Central Basin of the lake is thoroughly mixed and obtains benefits from the laminar flow system. It is recommended that all of these regions operate with both the laminar flow system and microbes to achieve the greatest improvements to water quality.

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***Site#2 –Central Basin Control Region***

In order to assess the scientific efficacy of the laminar flow aeration system, a control region must also be selected for measurement of identical variables as those in the "treatment" regions. The purpose of the control area is to provide a measure of baseline conditions in Maple Lake that are not being affected by laminar flow aeration. Through scientific comparisons among the control and "treatment" regions, conclusions can be drawn regarding the efficacy of the system and what impacts are outcomes of the system. It is very important that no herbicide treatments, microbe treatments, or aeration occur in the control zone during the study, as such activities could complicate data collection and yield skewed results.

***Site#3 –North of Central Basin***

The region north of the Central Basin of Maple Lake will serve as the "microbe-only treatment" region which will have the application of microbes, but not aeration. This is necessary to determine if the sediment oxygen conditions are great enough during the treatment season to support a significant decrease in organic matter and changes in other water quality variables due to microbial application alone without supplementation of aeration. Preliminary results from the Indian Lake (2009-2011) study have demonstrated that the addition of microbes and enzymes alone does not contribute to significant reductions in sediment organic matter or sediment depth.

***The Response Variables –***

***Sediment Parameters***

During the evaluation in all regions of the lake (as defined by Site # above), approximately 20 sediment cores will be collected from the vicinity of representative aeration ports (two cores per port) in spring (prior to operation of the laminar flow system) and again in late-summer (likely early October, 2012) after the laminar flow system has been in operation for a few months (presumably beginning in April). In addition to the sediment cores collected at the aeration diffuser ports, 20 additional sediment samples will be collected at each of the Control and Microbe-only areas for comparison. Each of these locations and marked with GPS (accuracy 2.0 feet) to assure consistent sampling among aeration port locations throughout the season. Sediment parameters such as percentage of organic matter, percentage of fine particulates, sediment depth, and sediment total phosphorus will be measured at each of the collected sediment core locations.

### *Aquatic Vegetation and Algal Species Composition*

In addition, aquatic vegetation species and relative abundance will also be measured at each aeration port site and also at each microbe-only and control sampling site. If dense aquatic vegetation is located near the aeration ports, then biomass quadrat samples may also be collected to measure aquatic vegetation per unit of area. This may be useful to measure before and after aeration implementation to assess possible impacts of the aeration system on aquatic plant growth. Algal species composition is a true indicator of water quality and documentation of species community composition is desirable to measure possible impacts of the laminar flow aeration system. Aquatic plant and algal species distribution will then be mapped throughout the study zones of the lake and later used for management purposes.

### *Water Quality Measurements in Maple Lake Study Zones*

Water quality parameters such as water temperature, dissolved oxygen, conductivity, pH, oxidative reduction potential, turbidity, and transparency are all important indicators of ecosystem health and will be measured both in spring and early fall at the study sampling locations. Comparisons can then be made among the control and treatment zones and among seasons to determine possible impacts from the laminar flow aeration system.

### *Water Quality Measurements in E. Branch of Paw Paw River as it enters Maple Lake*

An auto sampler will be placed near the inlet of Maple Lake to continuously sample sediment (total suspended solids) and nutrient loads (phosphorus and nitrogen) that enter the lake over three selected 24-hour periods (preferably after adequate rainfall events). The auto sampler data will then be analyzed in a laboratory and also subjected to loading and runoff models to approximate incoming sediment and nutrient loads to Maple Lake that could potentially compromise the efficacy of the laminar flow system. Loading rates from the model will then be given to determine possible loading consequences over time.

***Statistical Analysis - BACI Design***

The statistical design will follow a BACI (Before, After, Control, Impact) Analysis of Variance (ANOVA) protocol, which factors in population variation within and among treatment and control sites both prior to and after exposure to the treatment implementation (proposed to be an operation season for the laminar flow system), and allows for an accurate assessment of the impacts of a particular treatment method (i.e. the laminar flow aeration) on a specific set of variables (i.e. sediment characteristics, algal species composition, and aquatic plant growth) at all sites after taking into account variation within the natural population. If the laminar flow aeration is successful in the reduction of lake bottom sediment organic matter and/or nutrients, it may be feasible for the Village of Maple Lake and the Maple Lake Association to consider using the laminar flow aeration system throughout the entire lake for further sediment organic matter and/or aquatic plant and algal reduction.

***Cost Estimate for Scientific Evaluation of Laminar Flow Aeration System in Maple Lake***

| ***Proposed Evaluation Parameter*** | ***Estimated 2012 Cost*** |
|---|---|
| Sediment cores (n=20) for Aeration locations Includes sediment % O.M., sediment TP, Sediment depth, % fines, aquatic vegetation, algae composition, boat usage, fuel, labor | $4,500 |
| Sediment samples for Control Region (n=15), Includes sediment % O.M., % fines, organic matter, sediment depth, aquatic vegetation, algae composition, labor, fuel | $3,500 |
| Sediment samples for Microbe-only Region (n=15), Includes sediment % O.M., % fines, sediment depth, aquatic vegetation, algae composition, labor, fuel | $3,500 |
| Autosampler measurements of TSS, TP, TKN at n=2 events (24-hour) in E. Branch of Paw Paw River (near inlet) | $3,000 |
| Detailed report with all 2012 seasonal data and final recommendations on aeration use for Maple Lake/Presentation of report, travel | $2,500 |
| **TOTAL ESTIMATED COST OF EVALUATION STUDY** | $17,000 |

**Professional Services Contract**
**For Laminar Flow Scientific Evaluation Study**
**Of Maple Lake, Van Buren County, Michigan**
**2012**

The Village of Maple Lake Board, hereinafter called the Board, and Lakeshore Environmental, Inc., hereinafter called the "Consultant" agree to the terms of this proposal made on this _____ day of November, 2011.

1. The total cost of the aforementioned Maple Lake study will be a lump sum of $17,000. A payment of 20% of the total project cost is due by January 30, 2012, with an additional 20% due by May 21, 2012 and August 6, 2012. The remainder of the balance will be due by October 26, 2012.
2. For additional evaluation items requested by the Board, the Consultant will be paid at a billing rate of $85 per hour.

IN WITNESS WHEREOF, the Village of Maple Lake Board and Lakeshore Environmental, Inc. execute this agreement.

**Consultant**

By_____
Jennifer L. Jermalowicz-Jones, Water Resources Director
Lakeshore Environmental, Inc.

**Village of Maple Lake Board**

By_____
Village of Maple Lake Board