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Aeration Case Study: Eliminate Accumulated Sediment

A report commissioned by an independent party (in Michigan, USA) demonstrates the reduction of organic lake bottom sediments after the installation of a properly designed aeration system.

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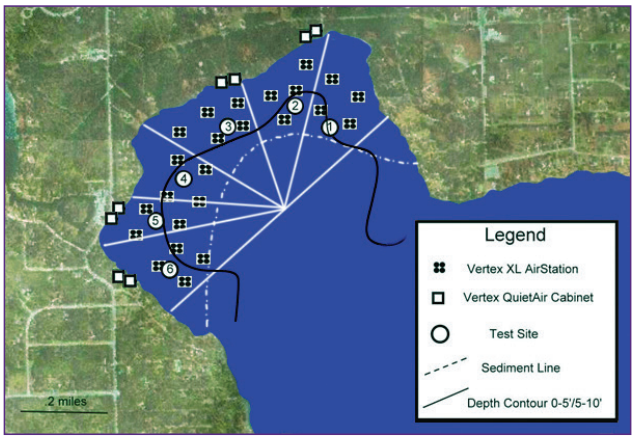
East Twin Lake is a shallow lake in Montmorency County. The lake, along with its Association sister West Twin Lake, form the heart of Lewiston's determined return to the glory days of its timbering heritage at the turn of the last century. East Twin covers about 900 acres of surface area with 9,300 perimeter feet of shoreline. The lake contains roughly 192 million gallons of water.

Lewiston's timbering times gave this bucolic area its identity, and perhaps more. Almost 100 years since the fires which destroyed the lumbering mill housed on the banks of the East Twin Lake, lake users confronted the timbering past as water levels receded in 2000. Boaters were frequently surprised by a sudden bump as they glided boats across the water. The bump was from the remaining upright pillars that supported a small gauge railroad track that extended far into the lake.



Site map of sediment location, depth contours, sampling locations and Vertex aerator placements

A community project removed over 90 dangerous timbers from the lake in 2002. In clearing the lake from these obstructions, discussion turned to the noticeable levels of sediment in East Twin Lake, primarily concentrated at its west side. Was this sediment a sawdust gift from our timbering forefathers that was stored on our sandy-bottomed lake? In 2002, we were determined to come to the aid of our upper mesotropic lake. We were not satisfied seeing our lake filled with unsightly and increasing sediment.

East Twin is a relatively shallow lake. Depths range four to eight feet, with some areas no deeper than about 26 feet. The lake bottom is primarily a hard sandy surface. During a period of low water levels, the high sediment level at the western end of our lake became more prominent. The sediment occupied as much as six of the eight feet of depth in many locations. These levels were unacceptable to boaters, water enthusiasts, and fishing aficionados. Our problem area is located at the western end of our lake. This area consists of 160 acres of surface area. An existing island on our lake and a sand bar, which traverses from the island to the northern shoreline, roughly contains it.

How could we rid our lake of this unacceptable sediment? Once we confronted this question, our goal developed. We were determined to improve water quality/clarity, improve property values, and increase lake enjoyment, by decreasing the sediment level.

Studying Our Sediment Problem

Our suspicions that the sediment was submerged sawdust from the timbering operations were unfounded. One of our initial tasks was to determine the composition of our sediment. There were two primary reasons for this work. First, we wanted to ensure that the material was not toxic or harmful if we disturbed the substance. We also recognized that removing a dangerous substance could be very costly, and perhaps beyond a volunteer reach. Second, we wanted to learn the sediment composition in order to design an effective decomposition program.

We engaged the services of a water testing company who analyzed samples of our muck. The sampling study revealed that our sediment consisted of natural organic material including, but not concentrated with sawdust. Armed with this information, we turned to the selection of removal options.

> ***How many years of water quality problems, particularly those associated with cyanobacteria will we need before governments take a serious look at phosphorous laden sediment, and then take serious action to remediate the problem?"***
>
> - Twin Lakes POA

Determining our Options

Undesired sediment could be removed by dredging. We learned that dredging involves two costly steps: the removal process and the disposal process. While removing the sediment could be achieved at considerable expense, securing nearby elevated land to store the material posed a financial burden beyond our means.

Adding biologic agents, tiny bug-like microbes, was another possible solution. The prospect of dumping drums of biologic agents into the lake and charging these agents with the task of eating our muck was cast aside. This also is an expensive process that must be continually repeated. A certain risk that we might be introducing an unknown harmful agent to our waters also dissuaded us from this approach.

We chose to use aeration. Adding oxygen to our lake would act similar to a bubbler in our childhood fish tank. Bubbles would circulate water, aerobic activity would thrive, water clarity would improve, and water quality would be enhanced.

Organizing Our Resources: People and Money

The initial study and project determination was made by a small core group of lake supporters spearheaded by Alan Kiriluk, an ardent lake supporter. This group formulated a proposal to identify, fund, and solve our lake's sediment issue. The issue was publicized through our lakes' association newsletter and presented in an hour-long forum at our association's annual meeting in 2003.

The approximate 90 lake supporters received a detailed proposal describing the method of attacking the sediment issue and the level of financial support needed to begin the project. The financial projection assumed that monetary support of all lakefront owners would not be received. The financial targets were built based upon participation of only 30% of lakefront owners and a small group of lake access users. We determined that we would gladly confront the issue of having raised too much money, rather than not enough.

The lake association endorsed the project. Mailings were distributed to all lakefront and lake access property owners requesting their financial support of $5.14 per linear feet of lakefront owned or for back lot owners a flat amount of $257. Most importantly, we indicated that if our target of $50,100 was not raised by a date certain four months later, the project would be stopped and all funds would be returned. Coupling this deadline with a specific proposal and solid information were critical to the project's success. Through personal solicitations, newsletter articles, and direct mailing, approximately $60,000 was raised within a four-month period to meet the project's deadline.

Engaging Professional Services

We determined that an aeration system must be professionally installed and maintained. Several methods of artificial aeration exist. Air can be introduced to a lake by injecting air in the lake, mechanically mixing the water, or agitating the water with paddles or fountains. We chose to inject air into the lake through the use of submerged diffusers that are fed air pumped by shoreline compressors through heavy tubing resting on the lake bottom.

A national company skilled in aeration systems for industrial and large residential projects, Vertex Water Features, was chosen to assist our efforts through their local affiliate Tri-County Aquatics, Inc. Further study and design worked was performed.

Our aeration effort is concentrated in the lake's west end where the sediment problem was most prominent. We contracted for the purchase and installation of eight land-based compressors that would each feed three diffuser units. Each diffuser unit consists of four rubberized membranes containing multiple tiny holes. In total, the four compressors would feed 24 diffuser units consisting of 96 membrane bubblers.

Our total project cost was $44,000.00 in 2004 with an anticipated six to seven thousand dollar professional maintenance and utility expense annually.

Legitimizing the Organizational Effort

The East Lake Aeration Association, LLC was formed with the State of Michigan. Insurance coverage was obtained in the unlikely event unforeseen problems developed. Three property owners and our local township were solicited to house the compressor units on the shoreline of their property. Arrangements were made to bring electrical supply to each compressor unit.

Application was made with Michigan's Department of Environmental Quality (DEQ). Securing the permit to conduct the aeration program was an extensive process. We were required to establish the authority to place the aeration units within the riparian interests of adjoining property owners. We were also required to present the detailed locations of the proposed units and their impact on the lake and its fish population. The DEQ conducted additional study in coordination with the DNR fishery experts, before approving the permit.

The permit was granted. Installation was completed in July 2004 when the aeration units were turned on.

How Does Aeration Work? What Does it Accomplish?

We knew that the sediment levels in our lake created low oxygen levels in the muck. When low oxygen levels are present the water's condition is anaerobic. This is undesirable. When aerobic conditions exist, tiny aerobic organisms can exist to naturally eat up or decompose the sediment at faster rates. This was desired.

Initially, most people believe that the air introduced into the lake supplies the requisite oxygen to create aerobic activity. This belief is not correct. The aeration units pump air into the membranes that create columns of bubbles that circulate the lake's water from bottom to top. When water is exposed to the atmosphere it is oxygenated from a process called diffusion. The chief operative characteristic of our aeration units is actually water circulation.

Our aeration units operate once the lake ice disappears in April and are turned off when the ice reappears in November. The diffuser units and the air hose tubing remain in the water year round; nothing is removed.

When activated, the units operate continuously day and night. The operating units are housed in protected metal cabinets and contain two 1/3 hp compressors. The units are quiet and trouble-free. In total, the units are connected to 12,000 feet of self-weighted bottom line tubing that remains at the lake's bottom. On only one known occasion, a low drafting boat pulled the tubing, with no apparent damage to the boat or tubing. The tubing is connected to 24 diffuser units that each creates four columns of tiny bubbles at the water's surface. The 24 diffuser units are situated in specifically designed locations. The units are not moved. On rare occasions, a unit placed in shallow water surfaces. When this occurs, the unit is weighted and returned to the bottom. On average we have replaced one diffuser unit each season that becomes

damaged by ice or contact with a boat if surfaced. When operating, the diffusers present no risk or interference with normal water activities.

The diffuser system circulates over 200 million gallons of water daily. This water circulation allows the biologic oxygen demand (BOD) to reach levels necessary for aerobic activity to occur in the lake. BOD is widely used in environmental engineering practice to determine the amount of oxygen water requires for the sediment breakdown process. Before the aeration program began, the heavy sediment areas were anaerobic.

In other words, the lake was relatively stagnant, holding increasing amounts of suspended muck, with no aquatic organisms existing to eat up the unwanted sediment.

Is Aeration Working? Yes. Is our Sediment Gone? No.

We still have sediment in our lake, but less than before. In our initial project proposal we forewarned everyone that the aeration approach did not seek quick or dramatic results. We entered this program with eyes wide open and spirits prepared for long-term results only. We hoped to reduce our sediment levels by 6 inches per year.

We appear to be exceeding our conservative projections. Testing results are demonstrating continual drops in the undesired sediment levels. After two and a half years of operation, tests are revealing approximately two feet less of sediment in our lake. These tests are conducted 4 times per year in the same locations. Data retrieved from the tests demonstrates reduced sediment levels. These are encouraging results.

Anecdotal reports of lake users have been positive. Increased wildlife has been identified, perhaps attracted by the sediment particles being pushed to the surface. Improved water clarity has also been noted with some west end lake users now being able to see their sandy bottom.

Observations at the 10 Year Mark from TriCounty Aquatics

The average muck depth has gone from approximately 4.3ft to 1.5ft over the past ten years; giving a yearly average reduction of 3.36". It is important to note, however, that most of this reduction occurred within the first 6 years after the installation of aeration. Average muck levels from 2009 to present, have shown little reduction in muck depth and seem to have stabilized. This stabilization could potentially be explained by the fact that some compounds that form during the decay processes (lignocellulose) can become almost chemically inert, where breakdown rates are extremely slow depending on the microbial community.

It is important to understand that previous assessments on the lake's dissolved oxygen levels at the sediment water interface showed that the lake's microbial community was in a predominantly anaerobic state. This is because when oxygen concentrations fall below 2 mg/L (which was observed), the rate of aerobic oxidation is reduced significantly. Anaerobic bacteria can oxidize organic matter without the use of oxygen, but the end products include compounds such as hydrogen sulfide (H2S), ammonium (NH4), and methane (CH4), which are toxic to many organisms. The process of anaerobic decomposition is also much slower than that of aerobic decomposition and can potentially explain why the lake was accumulating more muck than it was reducing. Having increased oxygen at the sediment water interface most likely caused a shift in the microbial community, increased and expanded the range for desirable benthic macro-invertebrates (i.e., Shredders & Grazers), and improved overall sediment chemistry (i.e., changes in redox state). All of these factors could account for the high reduction rates seen from 2004-2009 and no net gain in muck from 2009 to present.

It can be expected that the lake will regress back into its previous state of accumulating organic muck if the aeration system is turned off. In order to maintain the benefits associated with increased oxygen at the sediment water interface and prolong the lake's "life", it is recommended that the current aeration systems remain running (24hrs/day). Although future operation will come with annual maintenance and operational costs, it is expected that the benefits would outweigh the cost.

It is also recommended that the lake's current sediment monitoring program be continued. This will allow for best management practices into the future that are based off actual data not anecdotal observations.

East Twin Lake Sediment, BOD and Oxygen Results

In July 2004, eight Vertex Air 3 XL systems were installed by Tri-County Aquatics in a 160 acre cove of an 900 acre lake. At the time of installation, muck measurements with a “sludge judge” were taken at six locations to determine the amount of muck on the bottom. Three of the sites showed levels of 6 and 7 feet of muck and the average for all 6 sites was 4.3 feet of muck. Oxygen readings were taken at the surface and at the bottom to assess the quality of the water. The dissolved oxygen at the surface was 4.0 mg/l while the oxygen level at the bottom was 2.0 mg/L, which is virtually an anoxic environment. A water sample sent to a lab to determine the BOD (Biological Oxygen Demand) returned results of a BOD of 58 mg/L, which was much higher than the available oxygen in the water could oxidize and reduce.

Tri-County Aquatics, Inc, the installer of the aeration system located within East Twin Lake in Lewiston, MI, has been performing multiple sediment readings at six locations within the lake, in order to track aeration’s effect on reducing muck.