Bioremediation of Occom Pond at Dartmouth College Clears Water

Location: Occom Pond, Dartmouth College, NH

Background

Pine Park is a ninety-acre forest of 125-year-old pine trees at Dartmouth College. This park begins at the north end of campus, along the edge of the Hanover Country Club golf course, and extends along the Connecticut River from Ledyard Canoe Club northward. The trees were saved from the Diamond Match Company in 1900 by local residents who later turned the land over to the College and to the Town of Hanover.

The park is a pristine area where forest and river ecosystems interface, home to a rich mix of water and forest wildlife. Many trails that wind through the woods provide` excellent walking, cross-country skiing and jogging often with a spectacular sense of isolation from the human world.

This site includes a 10-acre pond designed to add to its enjoyment.

Unfortunately the pond had not been well maintained. It had built a large layer of bottom sludge; the water had turned murky, and algae contributed to surface scum, and a malodor had developed.

With limited budget and the size of the pond it was doubtful if it could ever be returned to its pristine state.

Fig. 1: *This picture taken May 15, 2006 shows the turbidity of the water.*

Fig. 2: *Also taken of the pond surface on May 15, 2006 this picture is a close up showing turbidity and surface scum.*

Objective:

The College worked with Ecological Laboratories (ELI) to develop a biological augmentation program using MICROBE-LIFT® technology to clean the pond. The purpose of the program was to speed the biological degradation of all accumulated organic matter within the pond's ecosystem: along the shore (littoral zone), on the surface of the open water (limnetic zone), and the bottom sediment (benthic zone).

The program called for a year-long treatment initiated during the summer months.

Program goals include:

1. Reduce bottom solids 6-18" over a 12 month period
2. Assist in controlling green water water events, in combination with pond management steps
3. Reduce pond malodors
4. Achieve a reduction of at least 20% in BOD, COD, and SS
5. Reduce pond nutrient concentrations
6. Improve water quality and clarity

Treatment was implemented from May 24 to October 13 in 2006 by a very competent Dartmouth team led by Stephen Glaholj and Robert Thebodo. **Ecological Labs** worked closely with the team to assure success.

Modifications to the program were made by **EL** as necessary based on weather and results. Dosage was reduced during heavy rainfall in May, June, and July while increased rates were applied in August and September when rainfall was lower. Data was tracked for the first six months of the program.

Results Achieved:

During the first phase of the bioaugmentation program from May to October 2006, the Occom Pond area experienced heavy rainfall with a reported 8 to 9 inches above average rainfall (reference "Rainfall in Lebanon, NH") The heavy rainfall impacted water volume and organic content as expressed by BOD, COD, SS, and TSS, and increased nutrient levels through excessive run-off from the surrounding area. There were no buffer zones to protect the pond from fertilizer and pesticide run-off.

Occom Pond's bottom solids level and percent organic content were determined at various points as indicated in the sediment chart. The first recorded baseline start points were incorrect due incorrect use of the sludge judge. Therefore bottom solids data review should be compared to the high data points shown about May 20th. This data point represents true baseline levels as determined prior to the first treatment on May 24th. Thereafter, solids data was compiled and monitored twice a month following the start of treatment.

Data indicates that bottom solids were reduced significantly during the treatment phase. This was accomplished in spite of excessive rainfall.

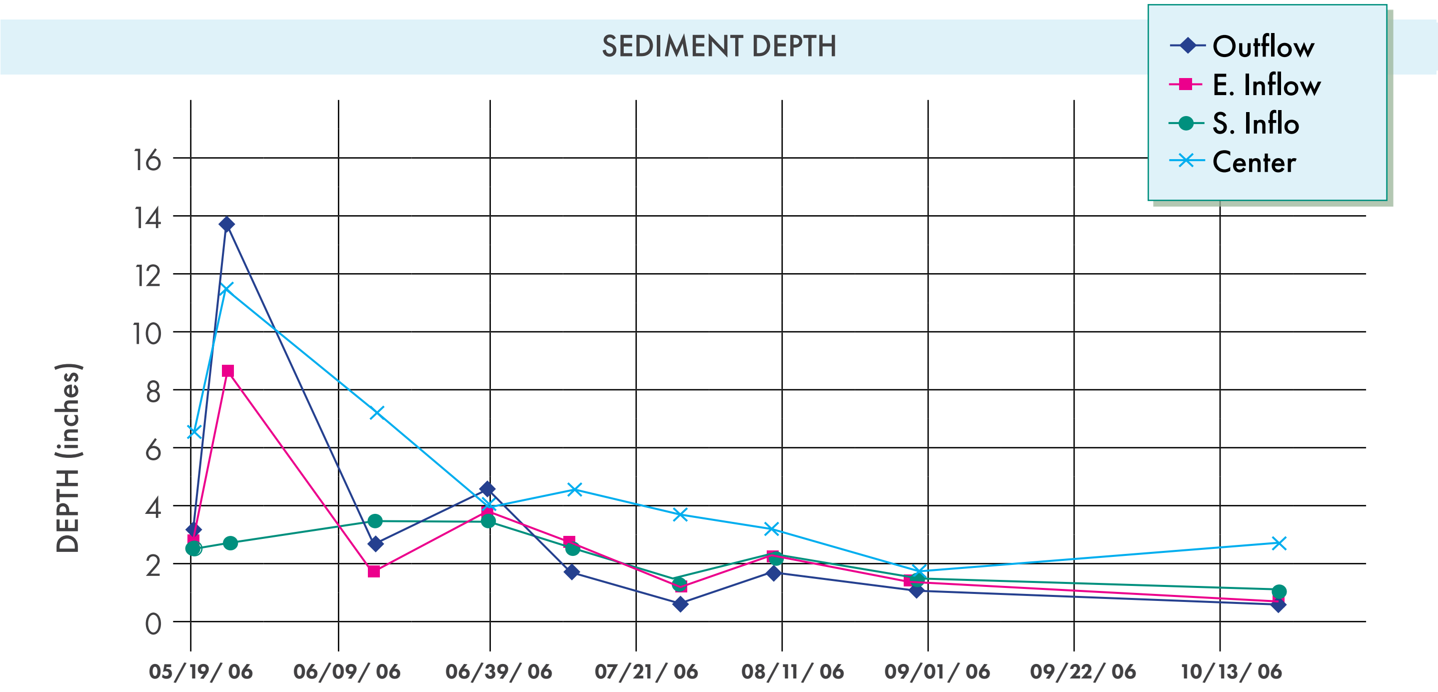


Chart 1: *This graph shows the reduction in sediment in bi-monthly recordings throughout the treatment program. The first data point was incorrect due to improper use of the sludge judge, making the second data point the true baseline.*

Microbial metabolism will continue to breakdown organic solids until mineralization is achieved, leaving only the inorganic portion of the sludge. The percentage of organic solids in the sludge determines the potential for biological removal. The data below indicates the organic portion of Occom Pond sediment is high, thus, the potential for a successful biological removal of sludge is high. **ELI** estimates that it is reasonable to expect up to 6 to 12 inches of removal per year depending on temperature and other environmental factors.

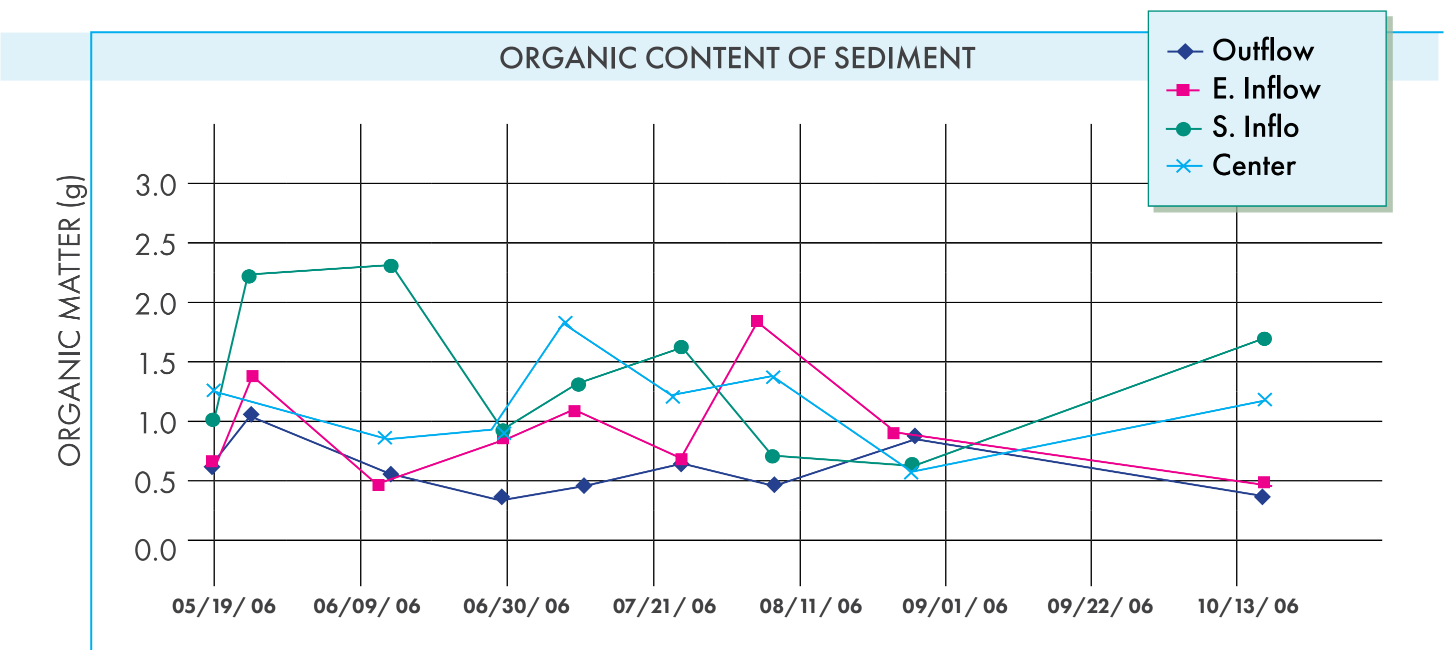


Chart 2: *Sediment is high, thus, the potential for a successful biological removal of sludge is high.*

During the biological oxidation of sludge organics, by-products will be released to the water column increasing the organic loading (BOD, COD) on the microbes in the water phase. This release may temporarily increase BOD results until the microbial activity from the bioaugmentation program balances.

The spikes in BOD in the above graph also coincide with high rainfall as the influent water carries organics in both particulate (settleable) and soluble form. The South influent zone indicates that the heavy rain events may have contributed unusually high organic matter to both pond water and sludge.

Nutrients were also tracked in the water phase. Ammonia levels are primarily developed by biological breakdown of organics containing nitrogen releasing ammonia or deamination. Various microbial metabolic processes can convert ammonia to nitrate, a form that can be utilized by plants or microbes or microbes can convert it completely to nitrogen gas whereby it is returned to the atmosphere. Since the Occom Pond has excess nutrients, microbial action is necessary to remove nitrogen.

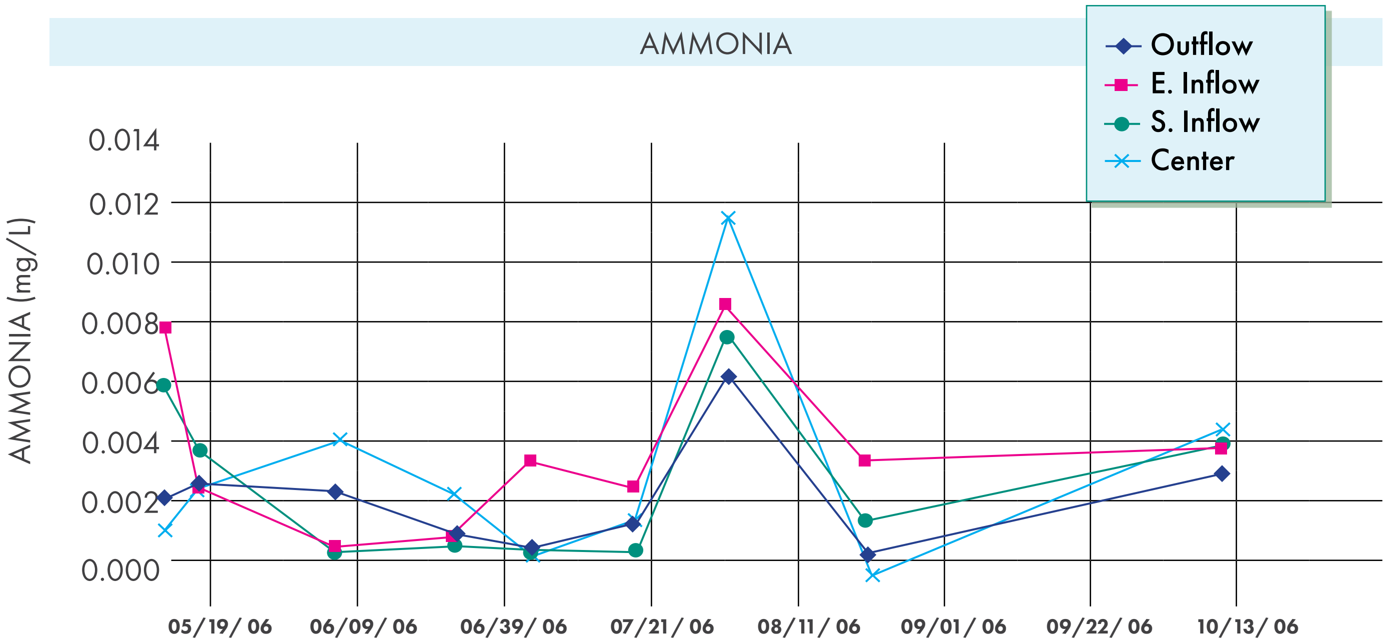


Chart 3: *Ammonia spikes occur after bioaugmentation in August and September.*

Aside from the normal pathway of oxidizing ammonia, nitrate builds to excess due to fertilizer run-off. Surface waters collect fertilizer and deposit it in ponds, rivers, and other waterways. Locations close to residential homes, golf courses, or farms are particularly vulnerable. As seen by the graph below, initial stages of high rainfall concentrates the nitrate contamination.

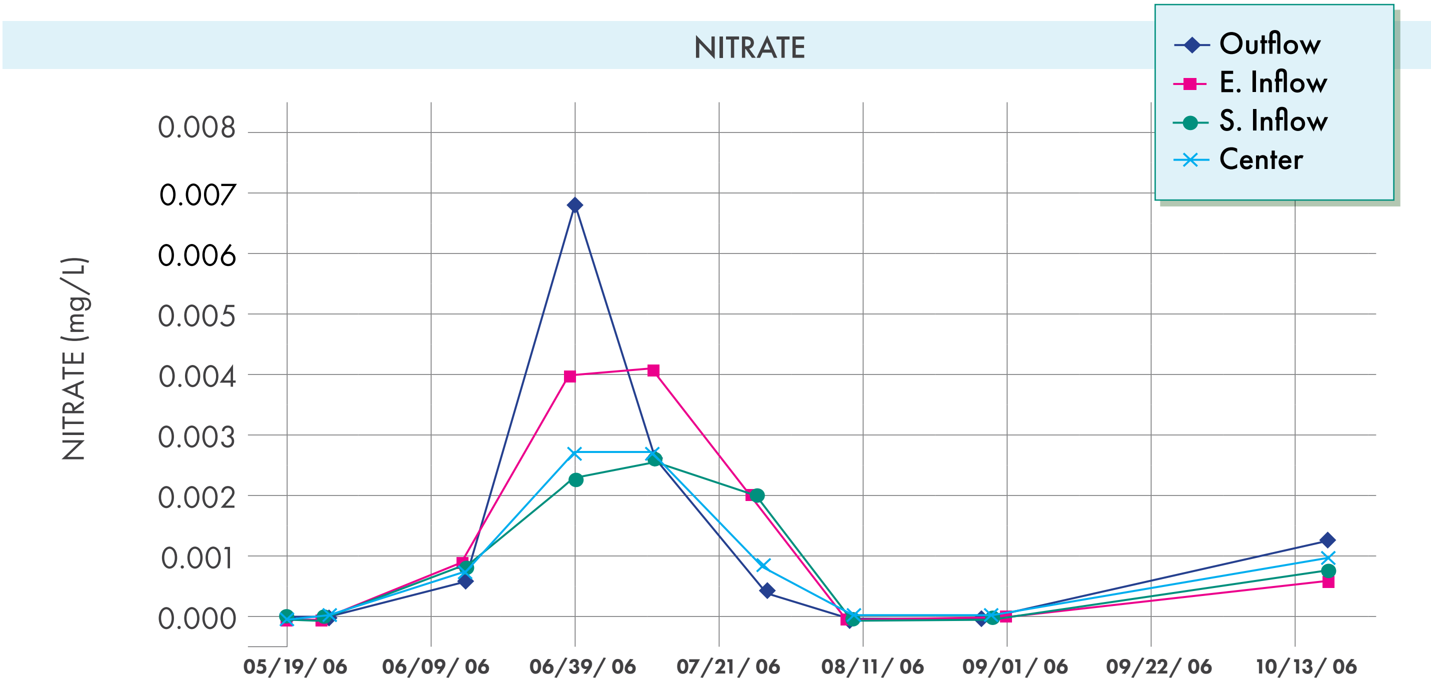


Chart 4: Initial stages of high rainfall concentrates the nitrate contamination.

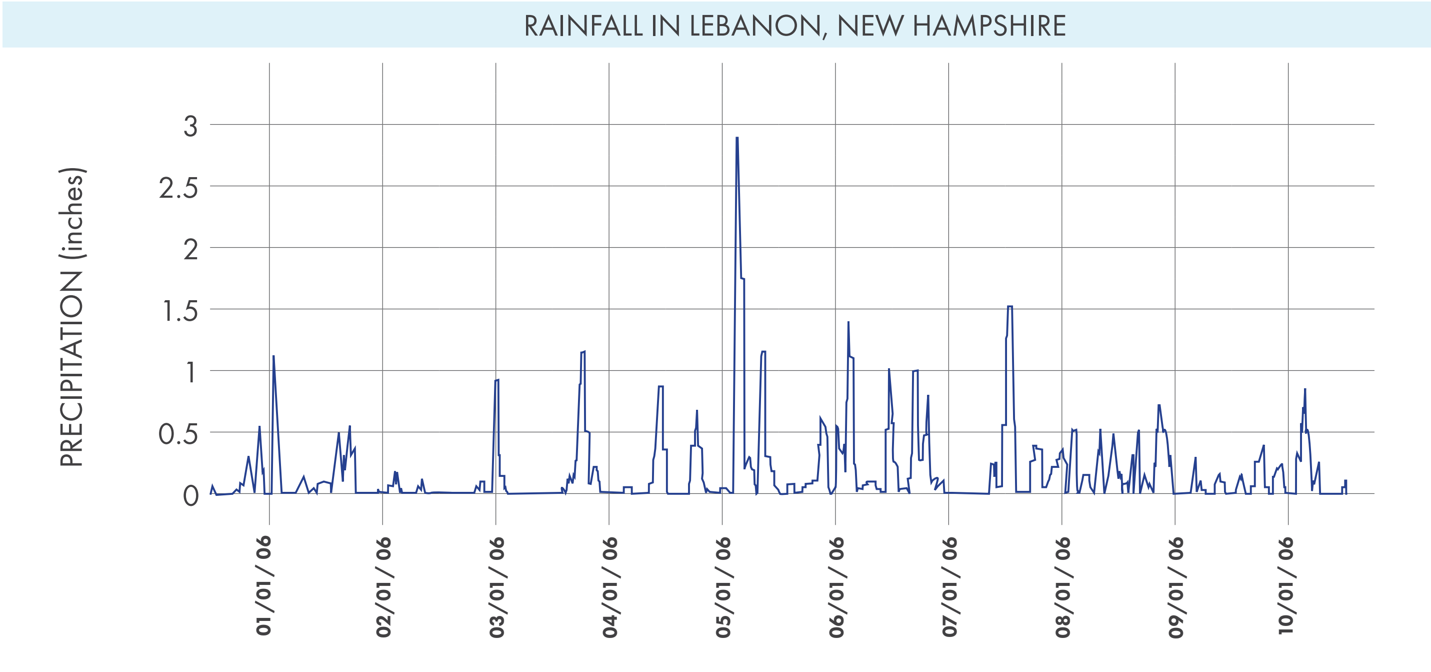


Chart 5: *Note how the spike in rainfall correlates to the spike in nitrate concentration in the pond.*

A high nitrate level is a problem because it encourages green water events and excess bottom plant growth leading to eutrophication. Microorganisms capable of denitrification utilize nitrate for a terminal electron acceptor in place of oxygen releasing nitrogen gas. This occurs in the anaerobic sludge zones often producing bubbles on the water's surface where gas is released.

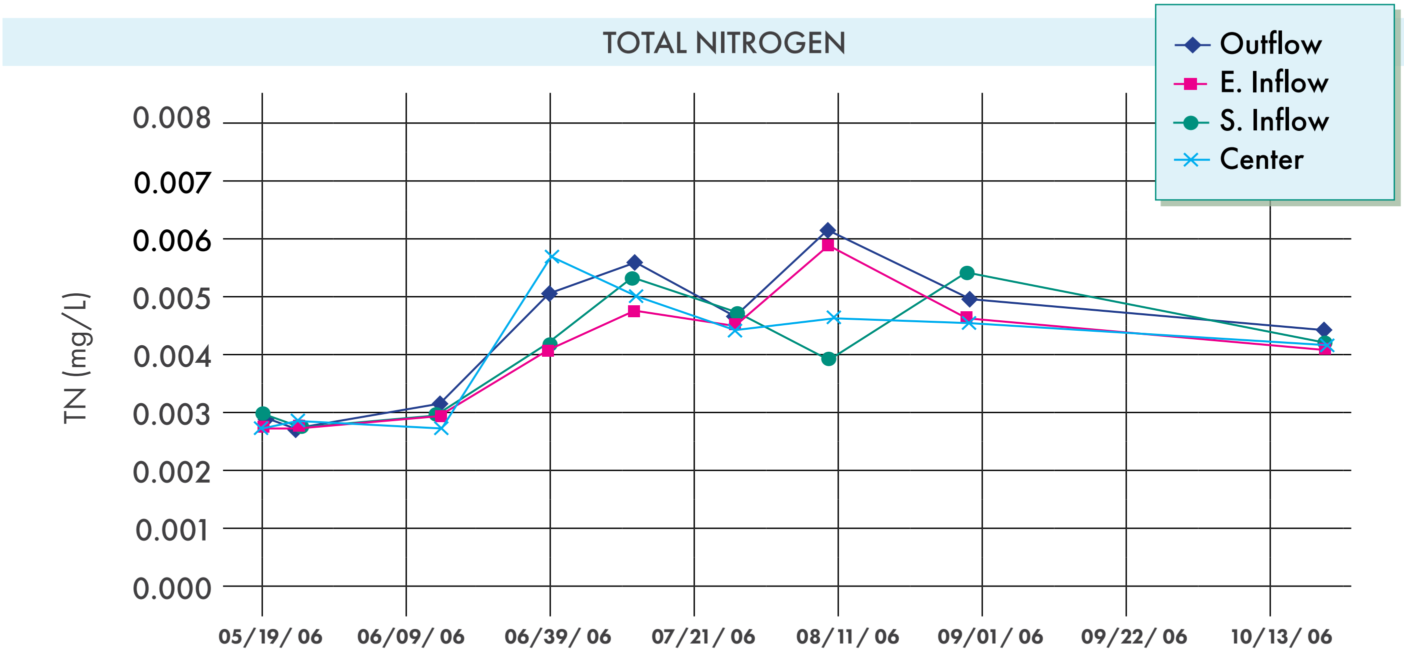


Chart 6: *Total nitrogen includes all forms of nitrogen: ammonia, nitrite, and nitrate plus the nitrogen in organic compounds. This curve shows the influence of the peaks in both nitrate and ammonia*

Phosphorus is another nutrient of concern as it is also a primary contributor to green water events. Occom Pond sits in a bowl in close proximity to a golf course and borders home sites. These factors contribute to pond phosphate levels via fertilizer run-off. There is no buffer system to contain run-off which would ameliorate these factors.

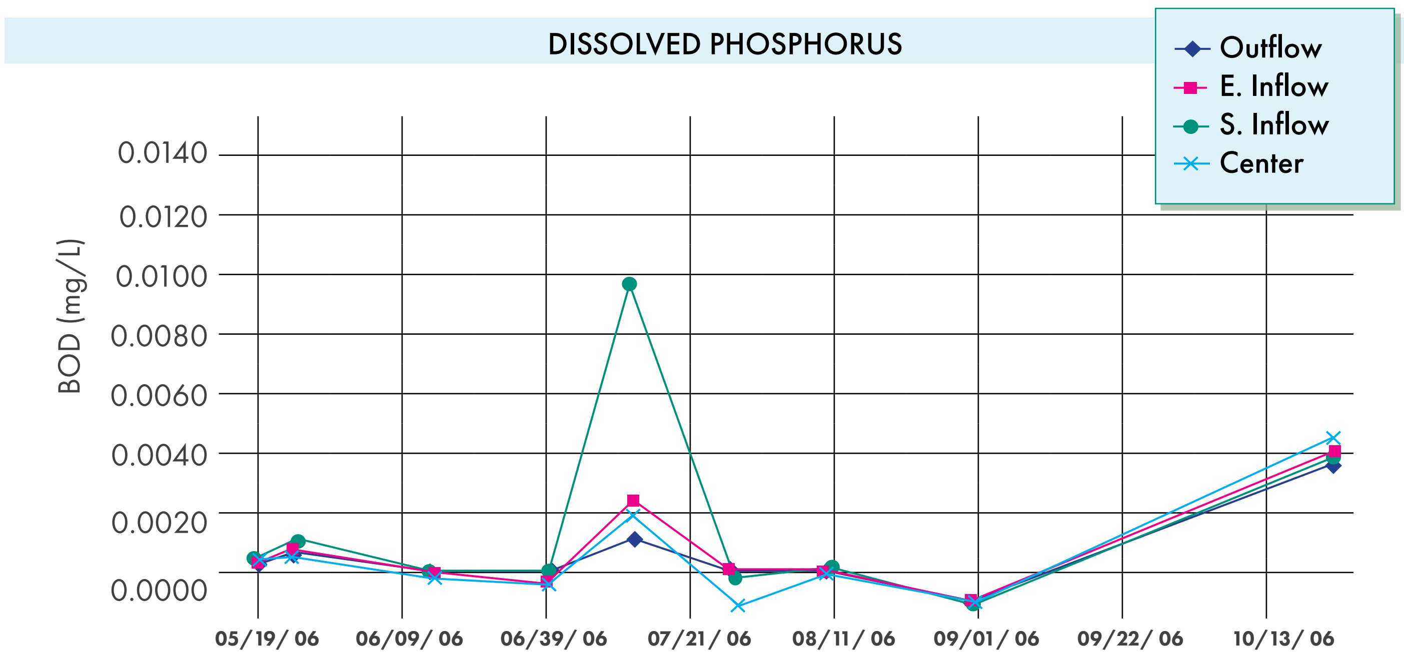


Chart 7: *Phosphorus also shows a peak that coincides with heavy rainfall.*

To compensate for heavy rainfall the augmentation treatment program was modified monthly with dosages changes as necessary to assure long-term effectiveness of the project.

Biochemical Oxygen Demand (BOD) or organic contamination of water results from a number of factors: a) soluble organic matter released from bottom solids, b) conversion of some COD or slow to degrade material to degradable material based on capabilities of selected microbes, and c) organic matter coming into the system in the influent waters or other natural sources such as animal waste. This chart shows increased deposit of organic matter with heavy rainfall peaking on June 30th.

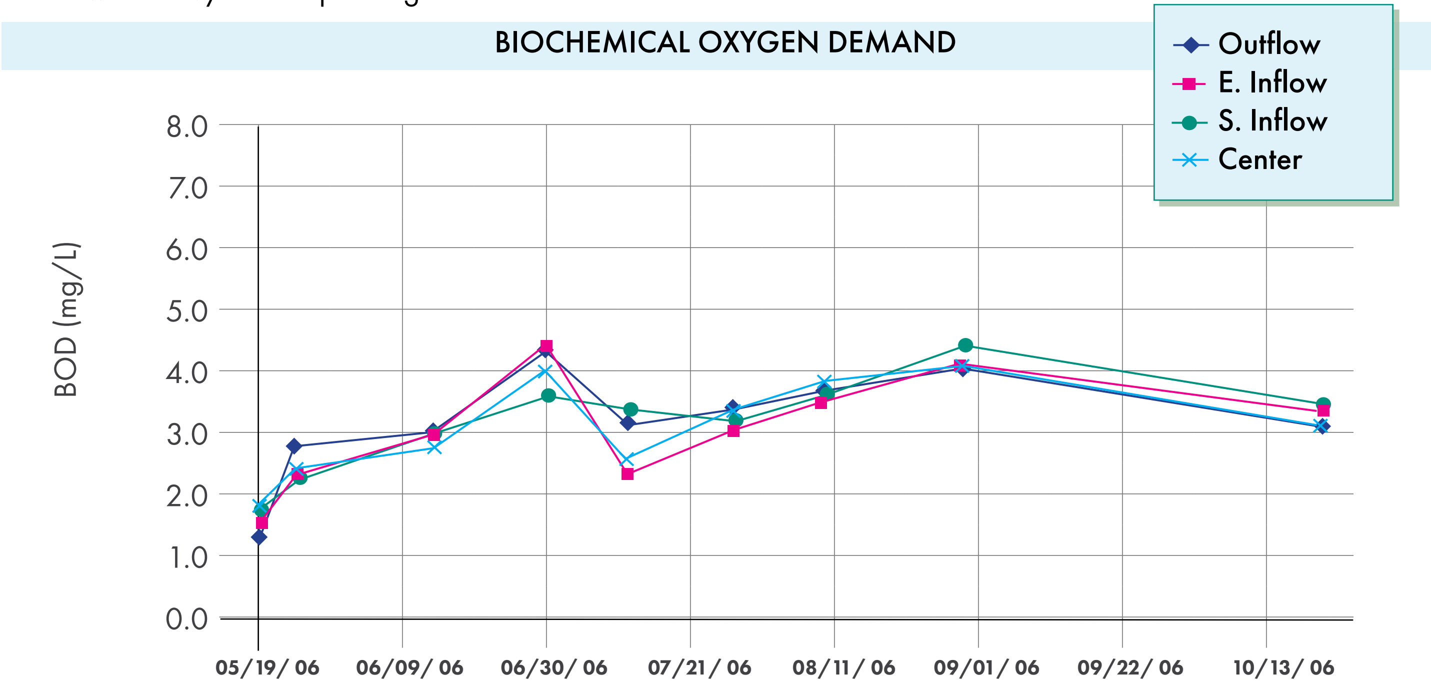


Chart 8: *Biochemical Oxygen Demand (BOD) shows increased deposit of organic matter with heavy rainfall peaking on June 30th.*

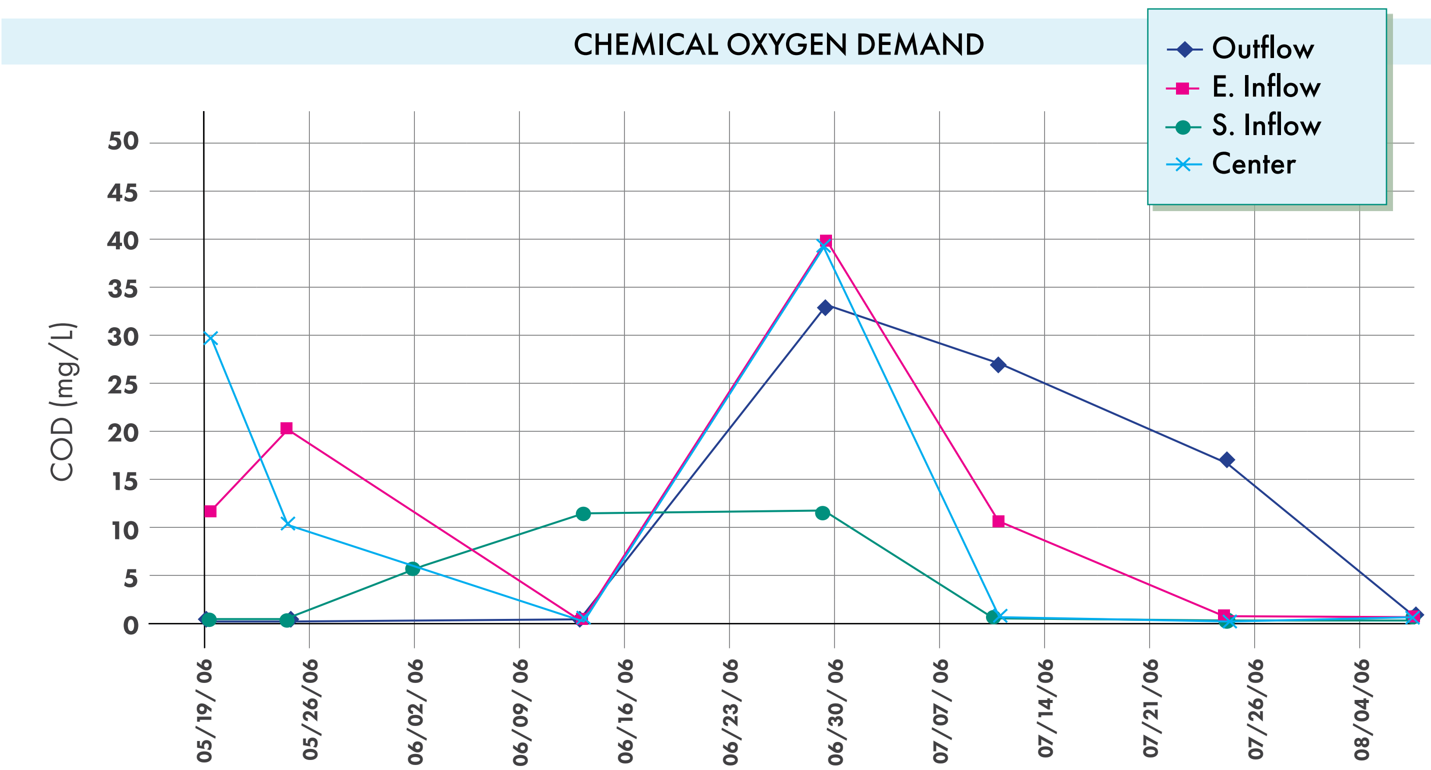


Chart 9: *Chemical Oxygen Demand (COD) shows an increase in influent in heavy rains that then decreases in the outflow as microbial action degrades the organics.*

Chemical Oxygen Demand (COD) is a measurement that includes the biologically degradable material (BOD) plus the non-biodegradable organics that usually require strong chemicals to breakdown. The COD in Occom Pond controlled largely by the introduction of slow-to-degrade and non-biodegradable matter via rain events and the increase in COD mirrors the increase in rainfall. There is also a reduction in the non-biodegradable fractions as the result of high rate microorganisms converting slow-to-degrade compounds to BOD followed by biological oxidation.

Conclusions and discussion:

This first phase of treatment with MICROBE-LIFT® technology was designed to span a period of twelve months. This report summarizes the first six months of treatment with a significant data collection plan. The goals were enhanced water quality, odor reduction and a primary goal of achieving a reduction in the level of bottom solids.

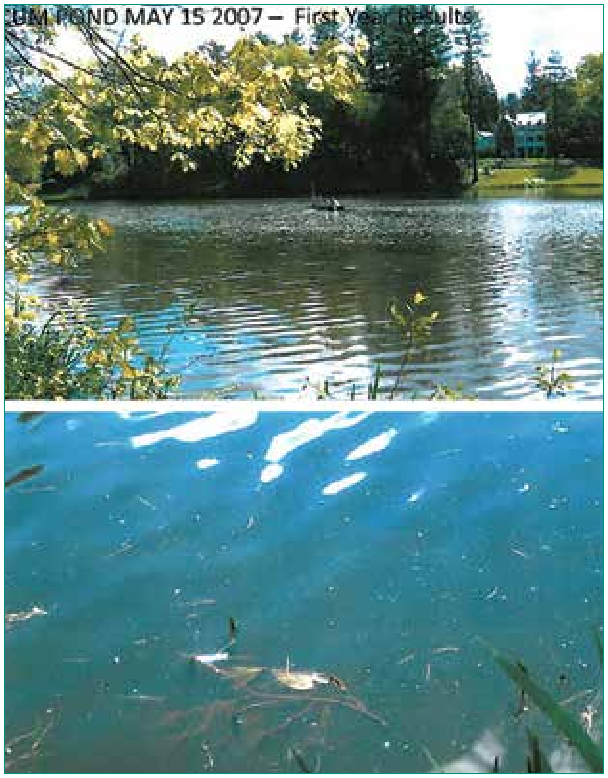
During this first six-month treatment, the augmentation program was negatively impacted by above average rainfall. The heavy rain events were countered by revisions in the treatment programs via changes in the application rates and time of application to assure the most effective treatment.

Based on the data collected, the bioaugmentation program has progressed at a satisfactory rate. Most impressive was the bottom solids reduction while still improving the water quality. In addition, the program achieved odor reduction by eliminating the hydrogen sulfide and other septic odors, and controlled the development of surface scum when compared to the pond history before treatment.

The data was so encouraging that the college made a commitment to continue the program for two years. The results follow:

Fig 3: *Recap: Water condition at the start of the program, May 14, 2006 prior of treatment*

Fig 4: ***Year one:*** *May 15, 2007 after one year of treatment*



SECOND YEAR RESULTS

Fig 5: Year 2: *May 15, 2008*
After two years of treatment
the pond water is very clear.

Fig 6: *This pond has been returned to its pristine condition with two years of treatment with* MICROBE-LIFT® *technology. In fact, the water is so clear that one can even see the stocked goldfish as evident in the picture below.*

MICROBE-LIFT® products act by restoring the natural microbial balance in ponds metabolizing excess nutrients that encourage green water events, eliminating sulfur and other unpleasant odors, and degrading the organics that cause turbidity, toxicity, and oxygen depletion. A MICROBE-LIFT® treated pond is a clean, stable ecosystem that supports fish and other wildlife growth.

For more information on MICROBE-LIFT® Technology contact
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www.EcologicalLabs.com
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