Demonstration of IFAS Technology for Cold Temperature Nitrification in Lagoon WWTFs at Clare and Ludington, Michigan

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ABSTRACT

The City of Clare pursued an Integrated Fixed-Film Activated Sludge (IFAS) pilot study of the addition of fixed media Webitat™ modules into lagoons with dedicated aeration. The IFAS design was intended to supplement the growth of autotrophic biology for nitrification in order to meet a seasonal effluent ammonia permit limit. The pilot study successfully verified the design nitrification rate of 0.93 pounds of ammonia removed per 1,000 square feet of Webitat media at a minimum wastewater temperature of 9 °C (48 °F) and current average daily flow rate of 0.6 million gallons per day (MGD). The City of Ludington subsequently conducted a similar pilot test of nitrification using IFAS for their lagoon treatment system. The flow rate to the pilot system was doubled three times without any loss of nitrification, verifying the design loading rate.

KEYWORDS

Biofilm, lagoons, Integrated Fixed-film Activated Sludge, IFAS, nitrification

INTRODUCTION

Aerated lagoons are widely used throughout the state of Michigan due to their relatively low costs and minimal maintenance requirements. Although aerated lagoons were not initially designed for ammonia removal many of these facilities have been assigned effluent ammonia limits in recent years. This situation creates an inherent problem in that the aerated lagoons have to operate at a low winter/spring time temperature where nitrification is minimal. Ammonia removal is dependent upon autotrophic bacterial populations which are very slow growing and the reaction rate of nitrification drops exponentially at the very low temperatures that northern lagoons are prone to.

The Cities of Clare and Ludington both have lagoon systems as their primary means of municipal wastewater treatment. They both faced challenges meeting ammonia removal permit requirements in cold temperatures i.e. early spring/late winter. The City of Clare undertook a renovation project, adding fixed media IFAS modules with dedicated aeration to the aerated lagoons to assist in nitrification. The project included a demonstration using the proposed media to ensure desired effluent ammonia levels. When the demonstration project results were successful, the City of Ludington decided to conduct a similar pilot test to move towards renovating their aerated lagoon system. Results from the Ludington demonstration were highly successful, demonstrating high rates of ammonia removal at cold temperatures. The City of Clare will install the full scale media system in the fall of 2011.

Figure 1: City of Clare WWTF

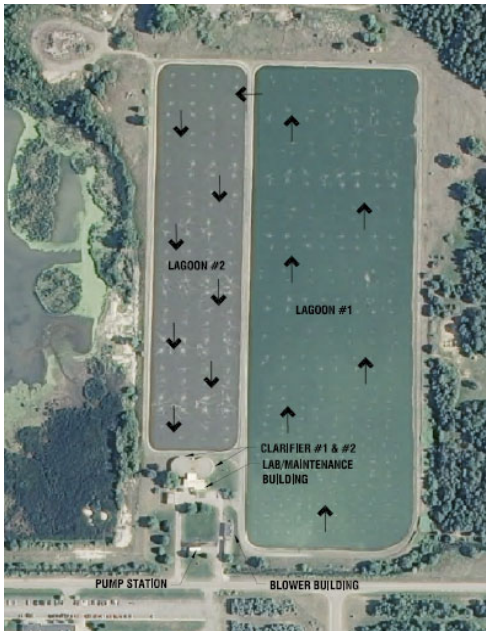

Figure 2: City of Ludington, MI WWTF

BACKGROUND

The current WWTF in Clare was designed and constructed in 1987. The wastewater treatment facility was constructed to treat a waste stream equivalent to approximately 1.3 million gallons per day (MGPD). This large design capacity was due to a dairy related business that contributed high-strength waste (milk) to the system. The dairy business has since been removed from the wastewater treatment facility waste stream and the facility currently approximately 600,000 gallons per day (GPD). The wastewater is collected and transported to the wastewater treatment facility by gravity main as well as several sanitary lift stations. The City of Clare WWTF consists of three aerated lagoons (Lagoons 1 and 3, each with a volume of 7.2 million gallons and Lagoon 2 with a volume of 16 million gallons), operated in series.

In 2008, the Clare WWTF renewed their NPDES permit and a schedule of compliance was issued by the Michigan Department of Environmental Quality (MDEQ) to submit a corrective action plan for effluent ammonia nitrogen violations. The MDEQ NPDES permit states that the WWTF must meet an average ammonia nitrogen effluent limit of 11 mg/l each year, beginning May 1st. The WWTF historicaly has been able to nitrify during the warmest months, but consistently lost nitrification over the winter. This left the WWTF without enough time to warm and recover in order to meet their ammonia permit in May. Figure 3 outlines the seasonal temperature of the wastewater with reference to the summer discharge permit limits.

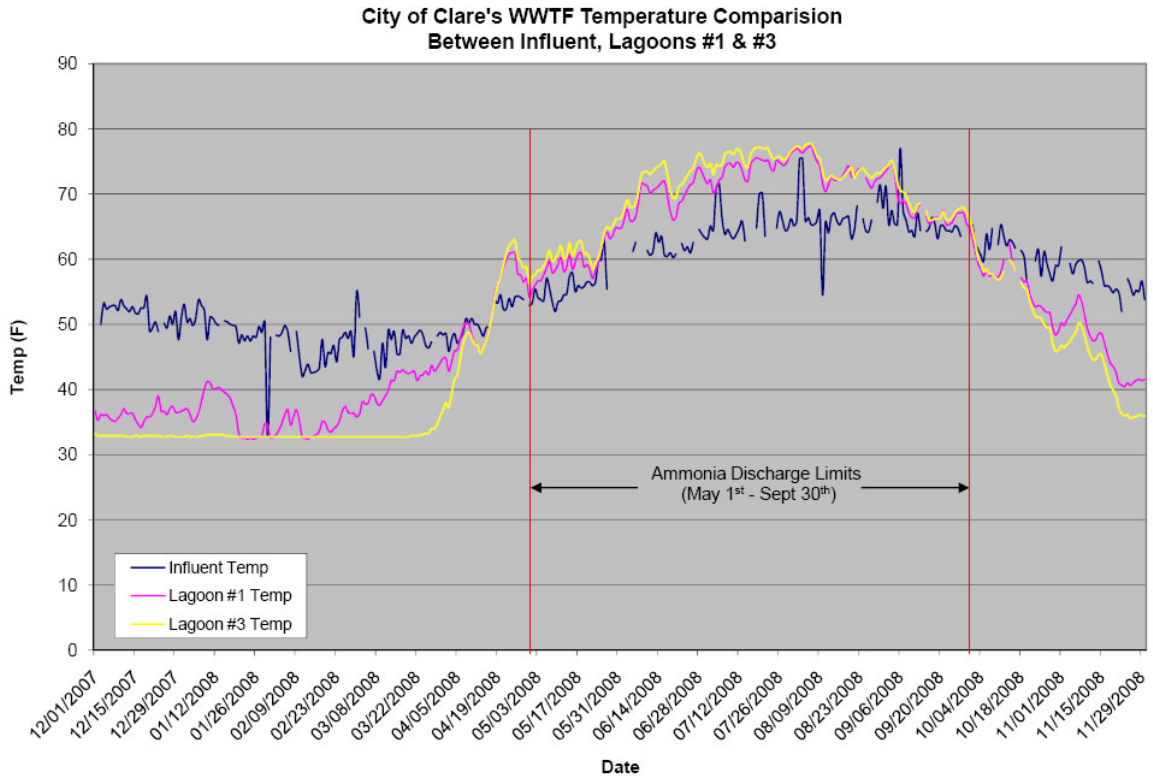

Figure 3: City of Clare's WWTF Temperatures

In 2009, Clare and Gourdie-Fraser, Inc.(GFA) began pursuing a funding source for the Clare WWTF renovation project and submitted a Preliminary Engineering Report (PER) to USDA Rural Development. GFA evaluated several ammonia reduction alternatives and selected the Webitat IFAS Ammonia Nitrification Reduction System as the best cost effective solution pending a pilot study.

Integrated Fixed-Film/Activated Sludge (IFAS) technology has received widespread acceptance in the engineering community as the most economical new way to upgrade wastewater facilities without building new aeration basins or clarifiers. BioWeb is a knit web-like fabric with high surface area designed to be installed directly into aeration basins to create a colony of attached growth biomass in the system. Webitat is a BioWeb™ IFAS system engineered to actively manage the attached biomass environment. Enhanced mixing keeps the biofilm thin and healthy, yielding higher kinetic reaction rates than previously measured in thick biomass. Individual dissolved oxygen control prevents and controls redworms to keep them from stripping the media of biomass. This system is especially useful for lagoon upgrades. The modules can be floated out to specific locations in the lagoon and dropped to sit on the lagoon floor. Webitat modules for lagoons are modified with a flat plate on the bottom with sloped edges to keep the plate from disturbing the lagoon lining or floor. Individual diffusers are included with each Webitat unit that are attached to air lines to provide the media and the lagoon with the aeration and mixing necessary for nitrification.

METHODOLGY

The team set up a pilot study to test the addition of fixed media Webitat modules into the lagoons with dedicated aeration. This treatment train would help supplement the growth of autotrophic biology for nitrification. The objective of the pilot study was to verify that the design nitrification rate of 0.93 pounds of ammonia is removed per 1,000 ft2 of Webitat media at a minimum wastewater temperature of 9 °C (48 °F) and current average daily flow rate of 0.6 million gallons per day (MGD). The study would verify that the full scale fixed media Webitat modules would be capable of removing ammonia in the lagoons to levels that meet or exceed the NPDES permit seasonal (May 1st – September 30th) ammonia limit of 11.0 mg/l.

On April 15th the Webitat pilot was installed near the inlet of Lagoon #1 as shown in Figures 4 and 5. Raw wastewater temperature was monitored in the influent tank. A metering pump pumped out of a screening basket located within the influent tank continuously at approximately 0.5 gallons per hour (gph) into the Webitat reactor. This reactor consisted of a 150 gallon tank and one 6 ft2 Webitat module. The hydraulic residence time in the Webitat reactor was approximately 12 days, representing the residence time of the existing three lagoons at a flow of 1.2 MGD. After treatment in the Webitat reactor, the effluent flowed by gravity into a manhole. A blower and coarse-bubble diffuser system provided aeration and mixing in the Webitat reactor.

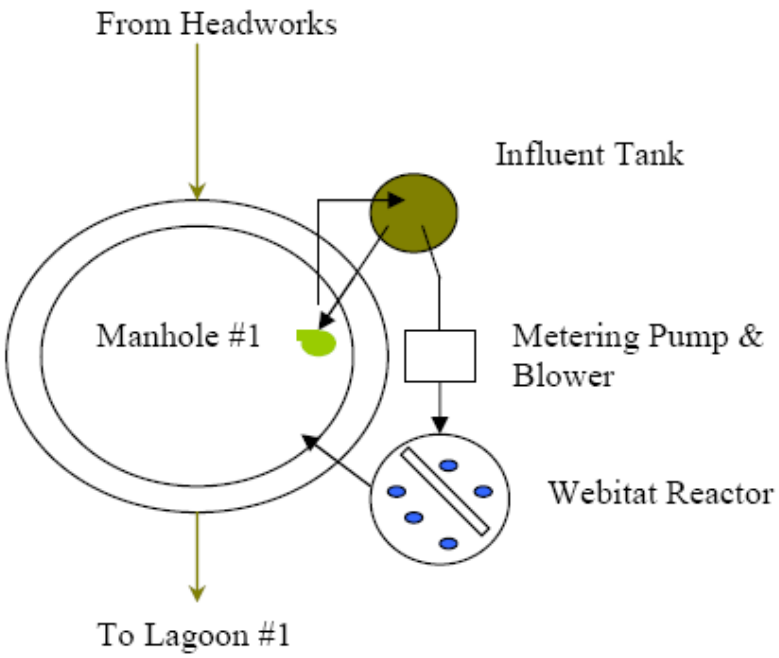

Figure 4: Clare Pilot Plant Configuration

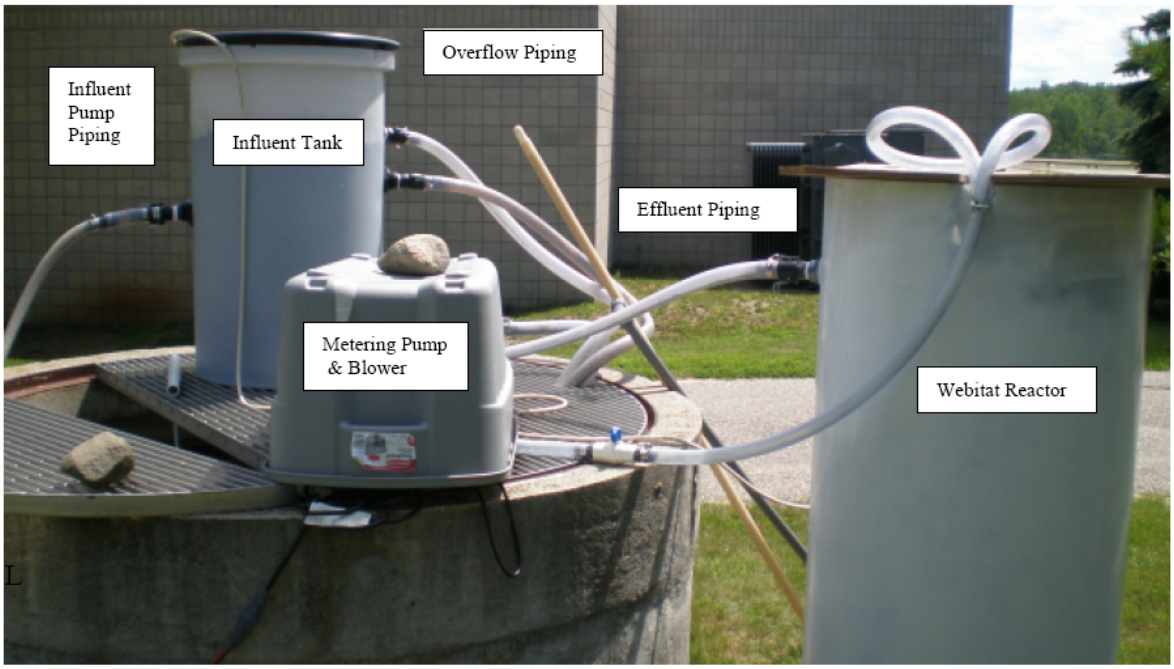

Figure 5: Clare Pilot Plant Set-Up

Clare WWTF staff performed periodic sampling and data collection throughout the pilot study period to measure Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Ammonia Nitrogen (NH3-N), Alkalinity and Total Phosphorus (TP) in the influent and effluent. Temperature, dissolved oxygen and pH were monitored in the influent tank and Webitat reactor.

RESULTS

Figure 6 illustrates the influent and effluent ammonia concentrations in comparison to raw wastewater temperature. Note that the biological growth (start up) of nitrifying bacteria was reached around May 15th as the effluent ammonia concentrations decreased quickly.

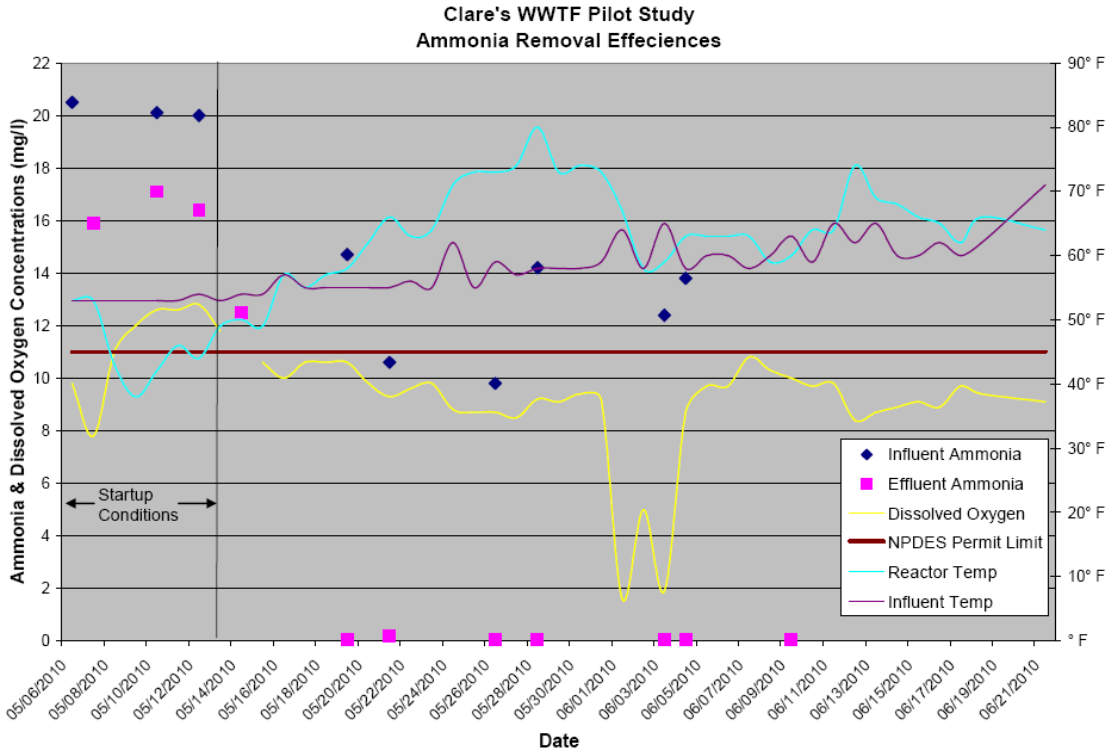

Figure 6: Ammonia Removal Results from Clare Pilot

Due to the time of year that the pilot study was initiated, the average raw wastewater temperature was approximately 58° F. This is significantly higher than the targeted wastewater temperature of 48° F. A temperature correction factor was applied to the laboratory data as shown in Figure 5. The equation used for temperature correction is:

$$BA,8 = BA,T*Ø(T-8) \text{ where } Ø=1.06$$

WERF, 2000. Sen, D.; Copithorn, R.; Randall, C.W.; Jones, R.; Phago, D.; Rusten, B. (2000). *Investigation of*
Hybrid Systems for Enhanced Nutrient Control, Water Environment Federation.

Correcting for flow and temperature produces the following graph for the amount of ammonia removed in Figure 7. Anything above the dash line meets the NPDES permit limit of 11 mg/l effluent ammonia.

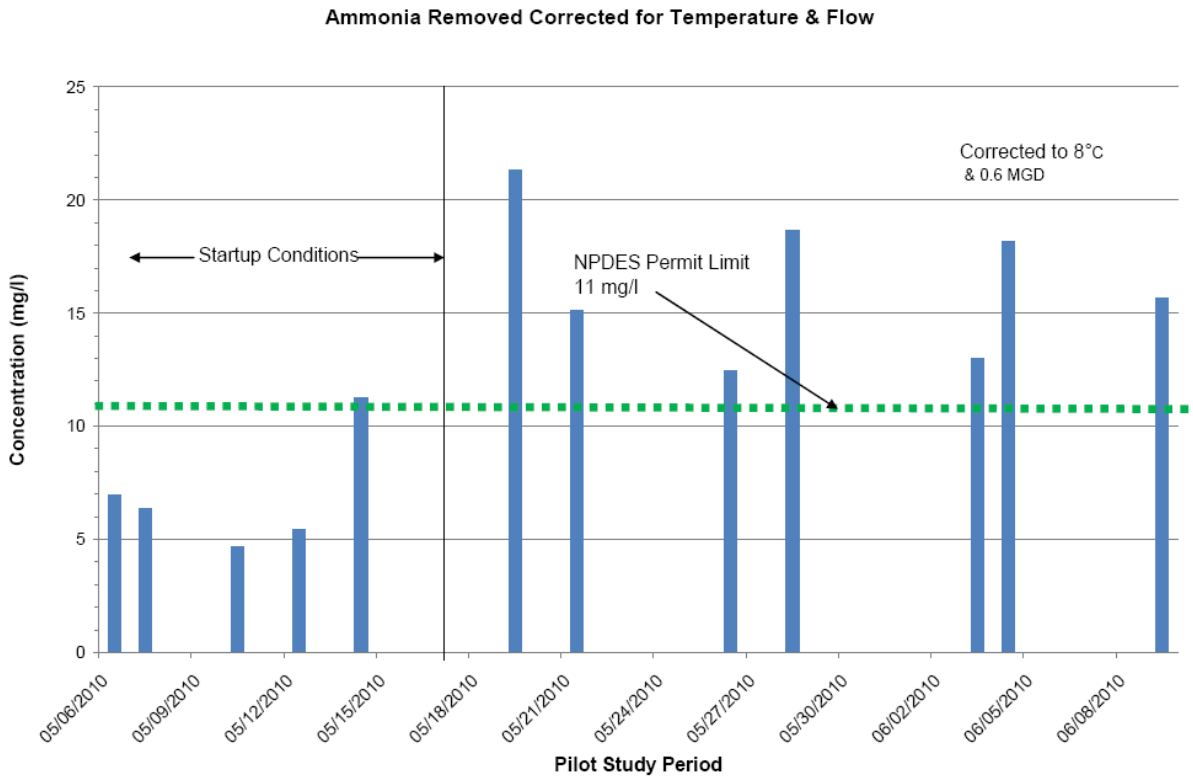

Figure 7: Temp Corrected Ammonia Removal Results from Clare Pilot

After the pilot study at Clare successfully demonstrated that the fixed film media modules would remove ammonia to below the NPDES permit limit of 11 mg/l, the City of Ludington opted to conducted a similar pilot study at their WWTF. The same pilot plant equipment was set up to treat raw wastewater entering the lagoon at the Ludington plant.

Figure 8 depicts the results from the same pilot setup at the Ludington WWTF. Biological growth (start up) of nitrifying bacteria was reached in seven days and effluent ammonia was less than 1 mg/l throughout the sampling period. Once full nitrification was established the flow rate to the pilot was gradually increased from 10 ml/min to 80 ml/min over the course of the 68 day test period. No loss of nitrification occurred and effluent ammonia continued to measure near non-detect, yielding a maximum nitrification rate of .67 lbs NH3-N/1000 ft2/day. Because the test was discontinued without pushing the upper limit of flow before ammonia breakthrough occurred, the real maximum nitrification rate for the system was not determined.

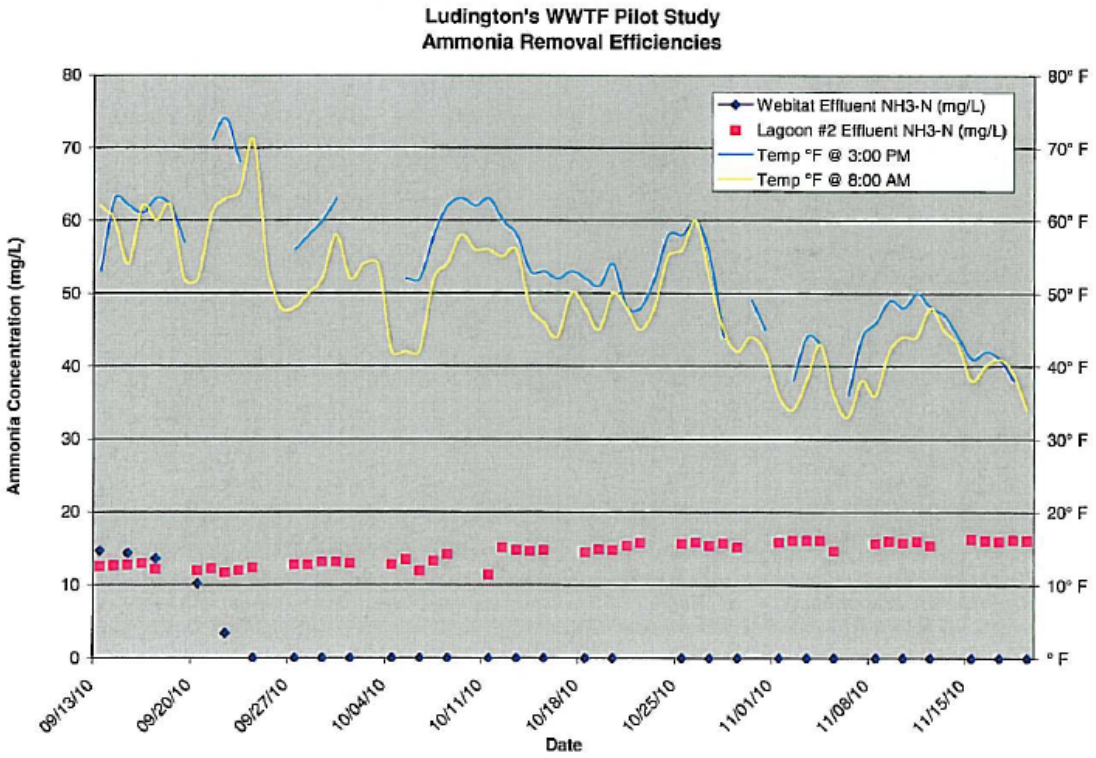

Figure 8: Ammonia Removal Results from Ludington Pilot

CONCLUSION

Because of the wastewater treatment technology involved, a pilot study was successfully conducted by Entex Technologies, Inc. at the City of Clare WWTF to verify their design assumptions for ammonia reduction. The Webitat IFAS system was able to remove the required 11 mg/l NH3-N from the wastewater. The City and their engineer then reviewed all supporting design documents, O&M manuals, references (previous engineers and Webitat clients) and conducted a site visit to Kenosha, WI to view Webitat modules in another aerated lagoon scenario. The full scale upgrade of sixteen fixed media modules into the lagoons is now under construction. Subsequently the City Ludington conducted a similar pilot study which successfully demonstrated full nitrification of the wastewater in a Webitat IFAS system.

Both these pilot tests demonstrate that the use of fixed media IFAS technology in a lagoon is an effective and promising low-cost solution to the rampant problem of poor nitrification at very cold temperatures.