Wakulla County Septic Tank Study
Phase II Report on Performance Based Treatment Systems

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<u>Results at a Glance</u>

1. 70 mg-N/L is a reasonable estimate of total nitrogen concentration in wastewater discharged from Wakulla County households to their septic systems.

2. The average septic tank effluent concentration from Performance Based Treatment Systems (PBTS) sites was 30 ± 11 mg-N/L. While this is a 50-60% N reduction from wastewater inputs, PBTS effluent concentration is greater than the 10 mg-N/L target in Wakulla County Ordinance 2006-58. This ordinance was based on testing of treatment systems under controlled conditions, with much lower nitrogen concentrations in the influent than observed during this study.

3. Results of this study indicate that PBTS installed in Wakulla County reduced nitrogen 50-60% from input concentrations when properly maintained.

4. In a previous Wakulla County study, the average conventional septic tank effluent TN concentration was 64 ± 13 mg-N/L. The effluent from PBTS is thus less than half (45%) of the effluent from a conventional septic system.

5. A large percentage of systems in Wakulla County were non-operational or performing poorly due to compliance, operation, and maintenance issues.

6. Results do not indicate a significant difference in TN removal between drip and conventional drain fields.

7. N-attenuation in the drainfield is 30%. Since PBTS effluent is 45% that of a conventional septic system, N-flux to the aquifer from a conventional septic tank is 44 ± 24 grams N per day (32±17 lbs/yr) versus 20 ± 16 grams N per day (16±14 lbs/yr) for a PBTS.

<u>Executive Summary</u>

Under normal conditions, conventional septic tanks provide minimal treatment of nitrogen – most occurring within and beneath the drainfield. However, in karst regions of Florida the soil can be very well drained and low in organic carbon, resulting in a nitrogen flux to ground water. Advanced pre-dispersal treatment may be needed when soil conditions cannot provide adequate overall treatment. Performance based treatment systems (PBTS) are engineered to provide this additional treatment of nitrogen from the wastewater before it is discharged.

The purpose of this study is to evaluate the effectiveness of PBTS installed and operated at residences in the Wakulla Springs basin. Advanced treatment of nitrogen for new and repaired OSTDS became a requirement for Wakulla County residents in County Ordinance 2006-58, passed in October 2006, and is being considered by Leon County as well as other counties with karst features. The Wakulla County ordinance states that "only performance-based septic systems that *can* produce a treatment standard of 10 mg/L nitrogen shall be installed in new construction and as replacements when older systems fail or are replaced". Approved PBTS from three manufacturers have been installed: MicroFAST by Bio-Microbics, Inc., HOOT Series-AND by HOOT Aerobics Inc, and Singulair 960 by Norweco, Inc. (referred to hereafter in this report as FAST (10%), HOOT (60%), and Norweco (30%)). As of July 2010, approximately 200 PBTS have been installed in Wakulla County under the new ordinance.

The initial results from 8 PBTS tank effluent indicated the systems were not achieving the 10 mg-N/L goal but rather about 30 mg-N/L. The study was expanded to include the sampling of effluent from 27 additional PBTS and resulted in the inspection of 59 PBTS in Wakulla County. This report was prepared to convey results of the Phase II study, and to specifically provide information on the TN removal effectiveness of the treatment systems being evaluated; provide the findings of the wider inspection and sampling of PBTS, which included over half of the systems installed in Wakulla County as of October 2008; and provide results on the attenuation of nutrients by conventional drainfields and drip systems.

In the CSM study, the average conventional septic tank showed a TN-reduction of about 9 ± 19%. A conventional OSTDS provides for some attenuation of nitrogen through ammonia volatilization and the removal of solids. Anderson (2006) as a rule of thumb recommended a figure of 10% reduction for a conventional septic tank. For PBTS systems, the reduction value of 50-60% is consistent with other studies, assuming the systems are installed and maintained correctly. The discrepancy between the test-center based design concentration standard (10 mg/L) and actual in-the-field results is due to lower influent concentrations used in the testing facility. Higher effluent concentrations in septic waters relative to the testing water may be due to water saving devices such as low flush toilets and low volume showerheads.

Of 59 PBTS inspected, 23 (39%) were not operating as designed. Many of the systems (22) were not in operation, either because their electrical switches had been turned off or because the wires to the control boxes had never been connected. Not operating or installing the systems as designed could be in violation of the homeowners' septic tank permits with the county health department.

Due to high variability, neither of the wastewater disposal methods (conventional drainfield or drip irrigation) had a significant advantage over the other for nitrogen removal. A drip system with unchecked unruly vegetation appeared to perform better than systems over a conventional lawn.

<u>Other Stuff</u>

(p. 16) In Florida, advanced treatment to reduce nitrogen is required for permanent OSTDS installed in the Florida Keys, where limestone is at the surface, lots are small, and the nearby coral reef system is threatened. Advanced waste treatment is also required by local ordinance in Collier and a coastal area of Franklin County, Florida. Also in some karst areas of Florida, a larger drainfield is required when shallow discontinuous limestone is encountered during site evaluation. In some cases, a mounded system is used to raise the disposal point well above the limestone, which is often the more cost-effective solution. In October 2006, an ordinance was passed by the Wakulla County Commission to require performance based treatment systems (PBTS) for nitrogen removal (Ordinance 2006-58) and similar ordinances have been proposed for Leon and Marion counties.

(Page 18) Performance based treatment systems are defined by the Florida Department of Health (FDOH) as "a specialized onsite sewage treatment and disposal system designed by a professional engineer with a background in wastewater engineering, licensed in the state of Florida, using appropriate application of sound engineering principles to achieve specified levels of CBOD5 (carbonaceous biochemical oxygen demand),TSS (total suspended solids), TN (total nitrogen), TP (total phosphorus), and fecal coliform found in domestic sewage waste, to a specific and measurable established performance standard". At least five PBTS had successfully reduced effluent TN concentrations to below 10 mg-N/L during the NSF/ANSI testing as listed in the FDOH data base and are approved by FDOH for installation in Florida.

(Page 18) de-nitrification is a goal of performance-based systems to achieve N reduction. To be effective, the septic systems should cycle the wastewater from anaerobic conditions, to aerobic, and then back to sub-oxic/anaerobic conditions. Further nitrogen removal then occurs as the wastewater enters the drainfield and percolates through the unsaturated soil column.

(Page 19) All three of the PBTS evaluated in this study employ similar processes and principles to achieve the three stages of the nitrogen cycle that reduce the nitrogen to acceptable levels – namely ammonification, nitrification and de-nitrification. Raw sewage flows into a pre-treatment chamber, which acts as a small septic tank. Here, solids settle out and ammonification occurs in anaerobic conditions as bacteria convert organic nitrogen into ammonia and ammonium ion. Total Kjeldahl nitrogen is the combination of ammonia, ammonium and organic nitrogen. The predominant form of nitrogen in the wastewater is ammonia as it flows out of the anaerobic pre-treatment chamber into the treatment chamber. A blower or aerator creates an aerobic environment in the treatment chamber, where in the presence of the proper bacteria, ammonia is converted into nitrite and then nitrate. This process is called nitrification. Length of treatment time, oxygen levels and the population and health of the nitrifying bacteria determine the extent of nitrification. The design of the treatment chamber is the major difference between the three systems, but they are all engineered so the wastewater is exposed to both aerobic and anaerobic conditions to allow for nitrification followed by de-nitrification. De-nitrification is the process of nitrate being converted to nitrogen gas in the presence of de-nitrifying bacteria. These bacteria require high carbon content and low dissolved oxygen. In HOOT, Norweco and some configurations of FAST systems, the treated effluent then flows into a dosing tank where it its then pumped to a conventional drainfield or drip irrigation bed. Further de-nitrification is accomplished by having a portion of the pumped effluent directed back to the pre-treatment chamber. This re-circulation is required in HOOT and Norweco systems in order for them to achieve their performance objective. Although FAST systems can be installed with re-circulation, it is not required.

(Page 32) De-nitrification may be somewhat limited underneath a drainfield in the soil and the subsurface aquifer in the Wakulla County. De-nitrification requires nitrate and organic matter as well as anaerobic conditions. Beneath a thin topsoil layer, the soils are sandy and very low in organic content and conditions are aerobic. As currently installed, conventional systems and most drip drainfields are below the more carbon-rich layer and the root zone of plants that could utilize the nitrate. In a PBTS, de-nitrification may occur in the treatment tank and perhaps in the post-treatment tank. Further de-nitrification occurs as a portion of the effluent is recirculated back to the anaerobic pretreatment tank. These nitrogen transformations are critical to reduce environmental nitrogen loading especially in sensitive receiving environments.

(Page 37) Normally, little nitrogen reduction occurs in a conventional septic tank. The primary processing of nitrogen is ammonification, the bacterial conversion of organic nitrogen to ammonia and ammonium ion. Some of the ammonia species are reconverted back to organic nitrogen via cell growth, but a net increase in ammonium concentration occurs in the septic tank. The nitrogen removal from wastewater in a conventional septic tank occurs through ammonia volatilization and sedimentation of undigested organic matter, which is removed by periodic septic pump outs.

(Page 50) Table 16 shows that amount of N removed by advanced systems is quite variable, averaging 58.9 percent but with a standard deviation of 28.5 percent. These systems can remove over 70 percent when dealing with lower influent concentrations of N.

(Page 53) Of the 59 sites visited, 36 (61%) were in compliance. Of the 36 functioning systems inspected, we sampled 27 (75%), 3 (8%) had no sampling access, and 6 (17%) were not sampled for other reasons. Once a functioning system was found, sampling the effluent was often a challenge. This was unexpected because biannual maintenance that occurs under these permits includes visual inspection of the PBTS effluent, which would not be possible without an access port. For some sites, the sampling team found it very difficult to gain access to the effluent. At several sites the pump tank lid was dug up and opened. Locating the pump lid was also a challenge at a few sites. Due to the difficulty the team had in obtaining samples, it became obvious that the effluent at some sites was not being inspected by the maintenance contractors. At other sites, the vent pipe had to be cut and then repaired in order to take a sample.

(Page 57) PBTS are not popular with some septic installers and many homeowners, which may be reflected by the high percentage of systems with non-compliance issues. Sampling many of these systems was difficult and in a few cases not possible. Tanks lids were located and dug up, vent piping cut, and some sampled with a peristaltic pump from the system. Other systems were found that were not fully installed (they were unwired) in occupied houses. Maintenance records indicate the effluent from these systems has been inspected and the systems were noted as operational. It appears some holders of the maintenance contracts (installers) were not fulfilling their obligations at the time. The most prevalent issue identified in the site visits was that homeowners had simply turned off power to the systems. These homeowners may be motivated to turn off power to their PBTS because of electrical costs, noise and/or odor issues.

(Page 59) The much larger La Pine National Demonstration Project conducted in Oregon by the US Geological Survey several years ago demonstrated the difficulty of attaining an effluent TN goal of 10 mg-N/L using most PBTS. For the La Pine study, the 5 systems that consistently produced effluent concentrations lower than 30 mg-N/L used different technologies than the PBTS installed in Wakulla County. The NITREX system, the only system to meet the 10 mg-N/L goal, uses a different treatment strategy which involves the addition of a carbon source in another treatment chamber after nitrification. One Passive Nitrogen Removal system recently proposed by the University of Central Florida also utilizes an added carbon source, a layer of reactive media that would be installed beneath the drainfield. This approach has the potential to reduce the TN concentration in the effluent by approximately 70%.

(Page 61) Drainfields with pressurized drip emitters can enhance plant uptake of nitrogen by distributing the effluent closer to the root zone.

(Page 99) Thus the typical N-flux to the aquifer from a conventional septic tank is 44 ± 24 gram N per day (0.088 lbs per day). For a PBTS the value is 20 ± 16 gram N per day (0.044 lbs/day).