Florida Department of Health
Bureau of Onsite Sewage Programs
Research Review and Advisory Committee Meeting

DATE AND TIME: **March 24, 2011 at 9:30 a.m. EDT**

PLACE: Florida Department of Health Southwood Complex
Betty Easley Center
4075 Esplanade Way, Room #178
Tallahassee, FL 32399

Or via conference call / web conference:
Toll free call in number: 1-888-808-6959
Conference code: 1454070
Website: http://connectpro22543231.na5.acrobat.com/rrac/

This meeting is open to the public

AGENDA: FINAL 23MARCH11

1. Introductions and Housekeeping
2. Changes to RRAC Composition
3. Review Minutes of Meeting December 10, 2010
4. Nitrogen Study
    a. Task D modeling amendment discussion
    b. Comments on deliverables and next steps
    c. Status report for Legislature
5. Presentation by Presby Environmental Inc. on passive denitrification processes
6. Research Priorities Workshop
7. Update on Study of Performance of Advanced Systems in Florida
8. Update on Alternative Drainfield Products Study
9. Other Business
10. Public Comment
11. Closing Comments, Next Meeting, and Adjournment

Florida Department of Health
Research Review and Advisory Committee for the Bureau of Onsite Sewage Programs

Draft Minutes of the Meeting held at the Gulf Coast Research and Education Center, Wimauma, FL
December 10, 2010

In attendance:

- **Committee Members and Alternates**:
  - **In person:**
    - Sam Averett (alternate, Septic Tank Industry)
    - Tom Higginbotham (alternate, Division of Environmental Health)
    - Bob Himschoot (member, Septic Tank Industry)
    - Kriss Kaye (alternate, Home Building Industry)
    - Patti Sanzone (member, Environmental Interest Group)
    - Clay Tappan (chairman, member, Professional Engineer)
  - **Via teleconference:**
    - Quentin (Bob) Beitel (alternate, Real Estate Profession)
    - Kim Dove (member, Division of Environmental Health)
    - Carl Ludecke (vice-chairman, member, Home Building Industry)
    - Bill Melton (member, Consumer)
    - Pam Tucker (member, Real Estate Profession)
    - Vincent Seibold (alternate, Local Government)
  - **Absent members and alternates**:
    - John Dryden (alternate, State University System)
    - Geoff Luebkemann (member, Restaurant Industry)
    - Mike McInarnay (alternate, Septic Tank Industry)
    - Susan McKinley (alternate, Restaurant Industry)
    - Jim Oskowis (member, Local Government)
    - Jim Peters (alternate, Professional Engineer)
    - Eanix Poole (alternate, Consumer)
    - John Schert (member, State University System)
- **Visitors**:
  - **In person:**
    - Damann Anderson (Hazen and Sawyer)
    - Josefin Hirst (Hazen and Sawyer)
    - Don Orr (ADS, FOWA)
    - Maria Pecoraro (Rep. Nelson)
    - Steven Rowe (Big River Ind.)
    - Daniel Smith (AET)
  - **Via teleconference:**
    - Sarah Fowler
    - Mary Howard (Orange County Health Department)
- **Department of Health (DOH), Bureau of Onsite Sewage Programs**:
  - **In person:**
    - Elke Ursin, Environmental Health Program Consultant
    - Paul Booher, Professional Engineer
  - **Via teleconference:**
    - Kim Duffek, Environmental Health Program Consultant
    - Eberhard Roeder, Professional Engineer

1. **Introductions** – Eight out of ten groups were present, representing a quorum. Missing the State University System and the Restaurant Industry. Chairman Tappan called the meeting to order at 10:05 a.m. Introductions were made and some housekeeping issues were discussed.

2. **Review of Previous Meeting Minutes** – The minutes of November 5, 2010 were reviewed with some modifications/corrections made.

> **Motion by Bob Himschoot and seconded by Patti Sanzone to approve the minutes as amended. All were in favor with none opposed and the motion passed unanimously.**

3. **Nitrogen Study**

   a) **Unfinished business** – At the November 5, 2010 meeting, RRAC made a motion to send a memo to the Department's budget office regarding the budget numbers for the nitrogen study and to determine what was earmarked to be stricken from the budget. The intent was to clarify what DOH has requested for budget authority for this study. This was discussed internally and clarification was made that historically the mechanism for requesting budget authority for the nitrogen study is through the progress report that is sent to the Florida Legislature and Governor. After discussion with Gerald Briggs, he did not know of anything that would be earmarked as to be stricken in the DOH budget regarding this project. DOH did request budget authority for the remaining balance of the already appropriated funds. As far as is known, DEP submitted for $1-million in their budget for this project. Bob Himschoot wanted to see a breakdown of how much has been budgeted, how much has been spent, and how much is remaining. Damann Anderson indicated that the contract, which is on the Department's website, shows the budget for the project with deliverables and costs. Elke Ursin indicated that along with all invoices that are routed for payment, there is a spreadsheet which shows this information. Clay Tappan indicated that there is a summary table in the draft legislative report showing which deliverables have been completed, which are currently planned, and which are dependent on future funding.

   b) **Discussion on draft legislative report** –The interim legislative report, as outlined in the legislative language in this year's budget, is due on February 1, 2011 and will need to be routed internally at least a month prior to be completed on time. The revised report, based on the last meeting, was discussed. More detail was requested on Table 1 to show the budgeted amount for each of the tasks, how much total budget is currently appropriated, and how much remaining budget is needed. Other topics were discussed regarding modifications suggested to be made to the draft legislative report.

> **Bill Melton made a motion, seconded by Bob Himschoot, to follow the following protocol in getting the legislative report finalized:**
> - **Comments on the report are to be sent to Elke Ursin by close of business Monday December 13th.**
> - **Comments will be compiled along with comments made at this meeting and sent to the RRAC on Tuesday December 14th as two pdf's (a final version and one with tracked changes).**
> - **Votes will be emailed back to Elke Ursin by close of business on Thursday December 16th as either yes, no, or contingent. If a RRAC voting member does not respond this will be considered as a yes vote. Any contingent comments will be sent to RRAC. Once majority approval has been reached, the vote will be final.**
>
> **All were in favor, none opposed, and the motion passed.**

c) **Comment on deliverables and next steps** – Elke Ursin gave an overview outlining what has happened since the last meeting. For Task A, a draft scope for proposed modifications for the Passive Nitrogen Removal Study Phase II (PNRS II) was submitted to staff, an authorization to proceed was given, and the modifications have been completed. Some additional small columns were constructed to provide information for the mini-mound component, and additional sampling will be associated with these columns. There will also likely be a process modeling component for PNRS II as well. Damann Anderson provided some information on how the PNRS II is set-up at the research facility and some of the overall project goals to address some questions from the RRAC. The Task B process forward meeting minutes and final QAPP was submitted to the Department. Home sites are currently being identified for Tasks B & C with plans to install one of the available passive technologies at a home site in Wakulla County. Instrumentation and monitoring of a Task C home site has begun in Wakulla County. The instrumentation and monitoring network for the GCREC mound was completed and monitoring/sampling has begun. The Task D scope and budget is being reworked to align with the QAPP. DOH staff gave the go-ahead to start the soil modeling work as per RRAC direction at a previous meeting.

4. **Research Priorities Workshop** – The basic process to get the ranking done as quickly and efficiently as possible was outlined. Everyone is to brainstorm up to 5 ideas for potential research projects. Then each person will recite his or her responses which will be written down by staff. Then a group discussion will occur to clarify and discuss the potential research projects. Then each person will select and rank the top 5 ideas. Finally, the rankings will be tallied and reported to show the final RRAC selection and ranking for research priorities. During the brainstorming process, RRAC shall consider studies that are related to human health, performance of onsite systems, and environmental impacts from onsite systems. After brainstorming, Elke Ursin asked each RRAC member to list their ideas. Several of the projects were explained in more detail. Eberhard Roeder provided an explanation of one of the projects that had to do with a study that Marion County did regarding the average age of failure for onsite systems based on several data sources and looking back at them now to see how many of these systems have failed. He also provided a more detailed explanation for the "designing for maintenance" project and how that project would be to discover ways that might make it easier to maintain systems that work. After some discussion it appeared as if this project might be more of a TRAP issue for known best management practices (i.e. designing a manhole to grade, putting observation ports in the drainfield). Grouping of some of the listed projects was done as well as listing some additional projects. Bob Himschoot suggested that the list should be narrowed down prior to doing the final ranking and prioritization. Patti Sanzone asked what the DOH timeline is for needing these projects ranked. Elke Ursin indicated that just after the June 10, 2010 meeting a budget was submitted requesting funding for several projects (alternative drainfield project, inventory, etc.) just in case they were voted as priorities, so that the budget would be available. This budget request is a placeholder for the funding, and does not require that any specific project be done. She will submit a budget in April/May for the 2011-2012 fiscal year. After further discussion RRAC directed Elke Ursin to email the revised priority list to the RRAC by Tuesday December 14th and RRAC is to send their top 10 projects back to Elke on Thursday December 16th. Once these projects have been screened, then a revised list will be sent to the RRAC prior to the next RRAC meeting.

5. **Other Business** – Bob Himschoot provided an update of SB 550 and how there are several bills being filed to repeal the bill. There is a coalition between home builders, realtors, Florida Chamber of Commerce, and associated industries (FOWA) proposing to keep the septic tank

pumping and maintenance on a 5-year schedule and removing much of the rulemaking parts and simplifying the bill. Eberhard Roeder gave a quick update on the 319 project indicating that the testing of field procedures will be occurring in the near future. Elke Ursin requested that comments on the Town of Suwannee Journal Manuscript be sent to her as soon as possible. Elke also showed a graph depicting the number of new and repair septic installations on an annual basis. A significant drop in the number of permits has occurred over the past 5 years, as well as a crossing over in 2008 where the number of repairs first starts to outnumber the number of new systems.

6. **Public Comment** – The public were allowed to comment throughout the meeting. There was no additional public comment.
7. **Closing Comments, Next Meeting, and Adjournment** – Potential dates for the next RRAC meeting will be emailed to RRAC members and alternates to determine the next meeting date. It is anticipated that this meeting will occur sometime in March to coincide with the legislative session. The meeting adjourned at 1:30 p.m. A tour of the nitrogen research test center at the Gulf Coast Research and Education Center (GCREC) was conducted after the meeting for all interested parties.

Florida Department of Health
Research Review and Advisory Committee for the Bureau of Onsite Sewage Programs

Final Minutes of the Meeting held at the Betty Easley Conference Center, Tallahassee, FL
March 24, 2011

In attendance:

- **Committee Members and Alternates**:
  - **In person:**
    - Bob Himschoot (member, Septic Tank Industry)
    - Carl Ludecke (vice-chairman, member, Home Building Industry)
    - Bill Melton (member, Consumer)
    - Eanix Poole (alternate, Consumer)
    - Patti Sanzone (member, Environmental Interest Group)
  - **Via teleconference:**
    - Quentin (Bob) Beitel (alternate, Real Estate Profession)
    - Kim Dove (member, Division of Environmental Health)
    - Tom Miller (member, Local Government)
    - John Schert (member, State University System)
    - Clay Tappan (chairman, member, Professional Engineer)
    - David Richardson (alternate, Local Government)
  - **Absent members and alternates**:
    - Sam Averett (alternate, Septic Tank Industry)
    - John Dryden (alternate, State University System)
    - Tom Higginbotham (alternate, Division of Environmental Health)
    - Kriss Kaye (alternate, Home Building Industry)
    - Mike McInarnay (alternate, Septic Tank Industry)
    - Jim Peters (alternate, Professional Engineer)
    - Restaurant Industry (no appointed member/alternate)
- **Visitors**:
  - **In person:**
    - Robert Arredondo (DCA)
    - Keith Hetrick (Broad & Cassel for FHBA)
    - Richard Hicks (DEP)
    - Sean McGuigan (Presby Env,)
    - Steve Meints (Clearstream)
    - Dave Presby (Presby Env.)
    - Lee Rashkin (Presby Env.)
    - Shanin Speas-Frost (DEP)
  - **Via teleconference:**
    - Damann Anderson (Hazen and Sawyer)
    - Kim Dinkins (Marion County)
    - Gina Herron
    - Katherine Lowe (CSM)
    - John McCray (CSM)
    - Maria Pecoraro (Rep. Nelson)
    - Andrea Samson
    - Daniel Smith (AET)
    - Richard Spaulding (DOH)
    - Pam Tucker
- **Department of Health (DOH), Bureau of Onsite Sewage Programs**:
  - **In person:**
    - Eberhard Roeder, Professional Engineer
    - Elke Ursin, Environmental Health Program Consultant
  - **Via teleconference:**
    - Kim Duffek, Environmental Health Program Consultant
    - Paul Booher, Professional Engineer

1. **Introductions** – Nine out of ten groups were present, representing a quorum. Missing the Restaurant Industry. Chairman Tappan called the meeting to order at 9:35 a.m. Introductions were made and some housekeeping issues were discussed.

2. **Changes to RRAC Composition** – Every year around December and January terms expire. The expirations are staggered so that each year 3-4 groups need to be renewed. New appointees include Tom Miller and David Richardson representing local government. Reappointments are Bill Melton and Eanix Poole representing consumers, and John Schert and John Dryden representing the state university system. Leaving the committee is Pam Tucker, Jim Oskowis, and Vince Seibold. The Florida Restaurant Association failed to name replacements for the committee and the two positions remain vacant. Clay Tappan pointed out that there is no replacement right now for the Real Estate Industry member position. Elke Ursin stated that that is correct, and that the alternate, Quentin Beitel, would be the voting member until a new member is appointed. Pam Tucker stated that she is still interested in keeping up with what is happening, but that she could not make another commitment to serve on the panel. Quentin Beitel acknowledged the great work that Pam has done and that she has inspired a lot of people in their industry throughout the state, and there was general consensus from DOH staff and the RRAC that she will be missed.

3. **Review of Previous Meeting Minutes** – The minutes of December 10, 2010 were reviewed.

   Motion by Patti Sanzone and seconded by Bob Himschoot to approve the minutes as presented. All were in favor with none opposed and the motion passed unanimously.

4. **Nitrogen Study**

   a) **Comments on deliverables and next steps** – Elke Ursin presented the overall purpose of the study and presented several updates to each of the tasks.

   Damann Anderson presented on a concern that Representative Nelson had regarding the definition of passive. Representative Nelson expressed concerns regarding the use of pumps for all passive nitrogen reduction systems. Damann stated that pumps would not be required for all these systems, that the definition states there shall be no more than one pump, so if topography allows for it the pump could be eliminated from the design. Damann proposed looking at a gravity system at a home site with available topography in Task B to satisfy these concerns. Bill Melton stated that after reading the Wakulla study report, he would rather not see any pumps at all because of issues that occur if they don't work. Carl Ludecke stated that in some situations you have to have a pump. He said that the systems that are being turned off in the Wakulla study report are the ones with aerators and with gravity flow through the system so when the aerator is turned off the sewage still moves through the system. Damann stated that allowing for the one pump is a similar concept to what is currently required for mound systems throughout the state. Clay Tappan stated that when the original definition of passive was written, including the option for no more than one pump to move effluent was to include systems that would need a pump based on site conditions. Having a pump was not a requirement, but was allowed, if necessary, based on site conditions. There is a difference between pumps required for operational improvement (part of an advanced system, recirculation, etc.) and functional necessity (lift dosing to meet site restrictions). Maria Pecoraro asked if these type of systems would require a generator if there is no power due to a natural disaster and Damann stated that this would be no different than any of the other systems out there currently with a pump. Carl Ludecke stated that the pump does not run constantly, it only runs as the demand is needed. If the power goes out, the tanks and drainfields are built with extra capacity to handle some of the flow. For systems out in rural areas where there is a well for drinking water, when the power goes out the well does not work so there is no flow generated. Damann stated that they are working on developing a system and whether or not a pump is required is a different issue. Maria stated that Representative Nelson's concerns are regarding existing septic systems that have no electricity that might now require electricity if a pump is required. Damann stated that the only places where a pump would be required would be places where a pump would be required anyway for a septic system due to topography or water table setback issues. There were some questions regarding how many systems have a pump and Elke Ursin will provide this information to the RRAC email distribution list shortly after the meeting. Bill Melton asked Damann how much drop in elevation is needed for the system they are working on and Damann stated approximately 6-8 feet.

Quentin Beitel made a motion, seconded by Bill Melton, to require one of the field tests to be a gravity system. All were in favor, none opposed, and the motion passed.

Quentin Beitel asked if there is anything that can be done to clean up the definition of passive. Carl Ludecke said that passive is non-mechanical and there is an exception to allow one pump to move effluent. Eberhard Roeder stated that back when the definition was originally made, mechanical aeration pumps were to be excluded and a pump to allow for distribution and head was allowed. Damann stated that the idea was to have a system that is no more complicated than the systems around today. Maria stated that this definition was crafted 5 years ago during a RRAC meeting. Maria stated there is an issue with nitrogen, but that there needs to be an understanding of what homeowners are going to be able to do in a practical sense. Maria stated some of Representative Nelson's other concerns were that there seemed to be a lack of coordination with other studies going on and that there was not enough research done on different drainfield materials or other media. Clay stated that regarding the issue with lack of coordination, RRAC has had two or three presentations from the University of Central Florida regarding their system and wanted to avoid doing extensive testing on existing products to avoid giving someone a free ride in the application process. Damann stated that this study has researched all sorts of media alternatives, in any number of configurations, and several are being tested at the testing center. Pam Tucker stated that homeowners think that a passive system has no mechanics. Homeowners are fearful of rules that require mechanics. Because the definition is not clear, there is a gap in understanding. Maria agreed with Pam's comments and stated that homeowners are coming to them with these concerns. Keith Hetrick stated that there will be no rulemaking until the study is done. These systems are not complex mechanical systems; these are cost-effective systems for homeowners that do not have a high level of maintenance. Elke Ursin stated that Gerald Briggs had told her that the current draft of the house and senate budget includes a line item for the Nitrogen Reduction Strategies study in the amount of $2,725,000. Rick Hicks stated that there might be a possibility that the definition of passive as it is right now might restrict the funding for this project. Maria stated that Representative Nelson has a concern over the inclusion of pumps on a passive system. He understands the topography and water table restrictions but that a pump cannot be the first option. If the site can utilize gravity flow then that should be the default. Eberhard Roeder stated that this definition has been used all throughout this project and if this definition is changed it may not be consistent with the contract and the competitive instrument used to hire the contractor. Maria stated that the study needs to include non-mechanical systems. Carl Ludecke stated that the study does include this. Damann stated that a passive system is a non-mechanical treatment system however one pump is allowed, but not required, to get the effluent to the treatment system. Maria's concerns were that rulemaking could require that all systems need a pump. Damann stated that the pump would be allowed, but not required. There seemed to be a general consensus that a passive system does not require a pump. Patti Sanzone stated that what this study is looking at is not a conventional system. A conventional system does not do much for nitrogen removal. Damann is trying to get a system to reduce nitrogen that is cost-effective. Damann stated that a mound system with a pump achieves better treatment than a gravity-fed mound system. Patti stated that the study will give us the answers, at this point we do not know what they are. Patti asked Maria if the Legislators have any problem with the current rules when it comes to pumping to a drainfield. Maria stated that they are reviewing those rules, but that a pump should not be mandatory for people that do not need a pump. Patti stated that development in Florida is currently focusing on developing marginal lands, and that these areas often have pumps in order to meet state requirements. Eberhard Roeder stated that the legislative language for this year said that the contract shall remain in full force. Changing the definition of passive may not be allowed. Keith Hetrick suggested changing the definition of passive from "includes no more than one effluent dosing pump" to "allows no more than one effluent dosing pump if necessary". Shanin Speas-Frost asked why this is coming up now when this definition has been around since 2007. Patti Sanzone asked that information from homeowners be passed to DOH so that these issues can be responded to. Andrea Samson is a homeowner in the Wekiva area. She said that homeowners are responding to accusations that their systems are polluting the groundwater. The focus of this study was to substantiate the need for nitrogen removal, and the fate and transport component of this project is critical. Legislators need to be convinced that the study is providing homeowners with nitrogen removal materials that can be used with conventional existing systems. They want solutions that are affordable in response to a demonstrated need. Bill Melton said that the ultimate goal of this project is to find the cheapest, most effective, and most efficient way to achieve nitrogen reduction, but that we do not know what the answer is yet. Maria stated that the legislators all value the work that this committee does. Eberhard Roeder stated that he has a concern regarding recirculating systems in Task A and if the definition is changed this would exclude them from being tested. Keith Hetrick said the main focus and priority for Phase II from the legislative language was developing, testing, and recommending cost-effective passive technology design criteria for nitrogen reduction. He stated that originally what they were referring to in the law was that the focus be on passive technologies that can be retrofitted to conventional systems. If the conventional system has a pump then it would still have a pump. He stated that the original intent was not the whole system, but just the passive technology portion. If we are now trying to alter the original system so that it does not have a pump then that is a much different mission than what was originally discussed. The 2008 language from the law mentions looking at multiple types of nitrogen reducing technologies, and the focus is on the technology to reduce nitrogen. We do not want to do anything to disrupt the contract mid-stream. This is a $5 million project that has been vetted and is on time and on budget and he does not want something to disrupt this. Maria stated that the system needs to be non-mechanical. Patti stated that Keith made an excellent presentation. RRAC is following the law and does not want RRAC or DOH to react to something that may not need to be reacted to without full RRAC involvement. Maria stated that the legislators are reacting to homeowners concerns. Damann said that the project is going to look at a completely passive system as part of this project. Maria will send a draft letter that will ultimately come from the RRAC, to DOH staff clarifying the issue, and will then be sent to the RRAC for their review by Elke.

Elke Ursin prepared a spreadsheet with a funding update on what has been spent to date on the project by task.

b) **Task D modeling amendment discussion** – John McCray, professor with the Colorado School of Mines and department head of the environmental science and engineering division, presented on the proposed Task D amendment. Task D goal is to account for the true treatment that happens in soils. The type of treatment depends on many things such as hydrology and soil type. To simply assume that all of the nitrogen leaving a system makes it to the groundwater is too conservative of an approach. In the end they want to develop a tool that is relatively simple to use to find out treatment performance and impacts to groundwater. The general scope and budget do not change with what they are proposing; instead they propose to move some funds from Phase 3 into Phase 2. He described the difference between a simple model and simple to use tool. The simple to use tool will be more robust. He gave an example of a simple model being like a bicycle: it is relatively easy to see how it works and is easy to use; and a simple to use tool being like a car: it is complicated underneath but is also relatively easy to use. Currently the contract has a simple model and they would like to change it so that it is a simple to use tool that will be built from a complex model. Katherine Lowe with the Colorado School of Mines stated that this type of model can be manipulated in many different ways resulting in numerous changes in the output graphs. This will allow you to determine if the soil system will achieve the treatment that is desired, and will allow the user to see the limitations to achieving that treatment level. John McCray presented the suggested amendment. Phase I will not change. Phase II will go from development of a simple soil model and a complex soil model to starting with the complex soil modeling and then tailoring that to a simple soil tool. Phase III will include a groundwater model and linking it with the complex soil model. By shifting funds into Phase II to cover this amendment, portions of Tasks B and C will go into Phase III. Based on the current schedule it appears that this would be done anyway. Damann stated that based on the work that FSU and DEP are doing, this model will provide the missing soil component in their model. Rick Hicks stated that this soil model tool can give ideas for areas of the state where no additional wastewater treatment is needed if the soil conditions are adequate. It is important to advance this tool sooner rather than later. Quentin Beitel asked who can use the deliverables that come out of this task. Elke Ursin stated that all of the work products as a result of this contract are all public information. Katherine Lowe stated that one of the deliverables includes modifications of a model called STUMOD which is available in the public domain. John McCray said that nothing is proprietary; it is all free information for future development. Eanix Poole asked whether this model could address densities and John McCray stated that the model itself cannot do that, but if used in aggregate (i.e. in as Geographic Information System) it could be done. Rick Hicks asked if this was part of the contract and Katherine Lowe stated that Phase III has a component that interfaces with a groundwater model.

> **Bill Melton made a motion, seconded by Patti Sanzone, to move forward with the Task D amendment to make the contract in line with the Quality Assurance Project Plan. All were in favor, none opposed, and the motion passed.**

c) **Discussion on status report for Legislature** –The status report for the Legislature, as outlined in the legislative language in this year's budget, is due on May 16, 2011 and will need to be routed internally at least a month prior to be completed on time. Elke Ursin presented a draft to the RRAC. She asked what RRAC expected this report to look like and how this can be approved by RRAC in the timeframe available. Quentin Beitel stated the this report should highlight accomplishments, go into detail about where we are in the current phase, support the need for funding, mention that the project will be looking at installing a passive gravity-fed system at a home site, and update the Task D section based on what was approved at this meeting. RRAC discussed modifications to the draft status report and agreed that the final format will be almost identical to the legislative progress report from February with some updates regarding current status and current spending.

Bill Melton made a motion, seconded by Patti Sanzone, to do an email vote for approval of this report similar to the process done for the last legislative report. All were in favor, none opposed, and the motion passed.

5. **Presentation by Presby Environmental Inc. on passive denitrification processes** – David Presby presented on their De-Nyte wastewater denitrification system. He stated that some of the work that is being done on the nitrogen study has been done by him previously. They are located in New Hampshire and Maine and are looking to expand. Their product is a container with a special mix of media that goes underneath the drainfield to reduce nitrogen. A physical demonstration of the product was made. Carl Ludecke asked how this product can get approved in Florida, and Sean McGuigan stated that they met with Roxanne Groover with the Florida Onsite Wastewater Association and submitted information to FDOH for part of the system, but not the De-Nyte system. Once they get their initial product approved then they will apply for the rest of the approvals. They appreciated the opportunity to present to the RRAC.

6. **Research Priorities Workshop** – The basic process to get the ranking done as quickly and efficiently as possible was outlined. During the December 10, 2010 RRAC meeting, everyone brainstormed up to 5 ideas for potential research projects. Then each person recited his or her responses which were written down by staff. Then a group discussion occurred to clarify and discuss the potential research projects. These project suggestions were streamlined into 17 projects which had project descriptions roughly scoped out giving a background, objectives and outcomes, the research approach, any potential collaboration, the duration, the estimated cost, and the ease of implementation. RRAC members submitted their rankings to Elke Ursin, which were tabulated in an Excel spreadsheet during the meeting. The resulting priority list is as follows:

Ranking	Project
1	**Continuation of Inventory of OSTDS in Florida**
2	**Effectiveness of Outlet Filters**
3	**Life Expectancy of Onsite Systems**
4	**Drip Disposal With Septic Tank Quality Effluent**
5	**Correlations Between Water Quality, OSTDS, and Health Effects**

These projects will be presented at the next Technical Review and Advisory Panel for their approval per the statutory requirements. Staff will begin scoping out these projects and will present on them at a future RRAC meeting.

7. **Update on Study of Performance of Advanced System in Florida** – Elke Ursin presented some of the recent progress on this project. A grant amendment was executed to extend the end date to 9/30/2011, allow for the purchase of equipment, and allow the county health departments to assist with the sampling effort. She then provided an update of what has been accomplished by task for this project. The summary report outline and data analysis for the Monroe County project is being done. The basic design for the database is complete and is continuously being updated to streamline data entry. A query and report is being developed to automate the summary statistics. The survey results are being tabulated and analyzed with several cross-tab analysis categories having been sent to the contract provider for them to include in their analysis. For the sampling portion of this project, there have been several developments. The Quality Assurance Project Plan was routed to DEP on January 18, 2011 and DEP responded back on March 18, 2011. Staff sent responses back to DEP this morning prior to the meeting. The contract with the lab has been amended to add more units for sample analysis. Permit file reviews are ongoing with 442 files having been reviewed. The sample set was expanded by 204 systems for a total of 1,000 due to a large number of systems not being an active advanced system. They were either abandoned (many in the Keys fit in this category), a conventional system, connected to sewer, etc. The Monroe County Health Department has agreed to participate in the sampling effort. Charlotte CHD volunteered too. Brevard has declined and we are looking for at least one more county to assist. Debra Roberts, the contract staff working on this project, was on a conference call this morning with the Environmental Health Directors throughout the state to let them all know that we need volunteers. The quality assurance on the data entry is ongoing. Eberhard Roeder went on a quality assurance/training trip to the Keys and sampled several systems and standardized the protocol. DOH staff performed a sampling event on March 22nd in Wakulla. The final task for this project is evaluating management practices, and staff is working on developing a method to choose counties to focus on. One way might be looking at high/low user satisfaction from the user surveys. Another way could be looking at high/low scores on county program evaluations as they related to advanced system scoring categories.

8. **Update on Alternative Drainfield Products Study** – Elke Ursin presented an update of what has been accomplished for this project. For 2010 data, a clean-up was done to make sure the system installation date on the repair form is accurate. The county health departments were notified via email and most errors were data entry errors that involved the system install date being the same as, close to, or later than the application date. Data mining of existing permit data was done to link original installations with corresponding repairs based on geocoded addresses. These were then filtered by those that had product information. The plan is to retrace the steps to ensure data accuracy, and then other data fields will be pulled into the dataset to do a data analysis. Data mining and analysis will continue and will be reported back to RRAC.

9. **Other Business** – No other business was discussed.

10. **Public Comment** – The public were allowed to comment throughout the meeting. There was no additional public comment.

11. **Closing Comments, Next Meeting, and Adjournment** – Potential dates for the next RRAC meeting will be emailed to RRAC members and alternates to determine the next meeting date. It is anticipated that this meeting will occur sometime in April to allow for a discussion of the Nitrogen Study Status Report for the Legislature.

    Carl Ludecke made a motion, seconded by Bill Melton, to adjourn at 2:54 p.m. All were in favor, none opposed, and the motion passed.

ATTACHMENT A-1
REVISED GRANT WORK PLAN

DEPARTMENT OF HEALTH ASSESSMENT OF WATER QUALITY PROTECTION BY ADVANCED ONSITE SEWAGE TREATMENT AND DISPOSAL SYSTEMS: PERFORMANCE, MANAGEMENT, MONITORING

LEAD ORGANIZATION: Florida Department of Health, Bureau of Onsite Sewage Programs (DOH)

COOPERATING ORGANIZATIONS: Monroe County Health Department

PROJECT LOCATION AND WATERSHED CHARACTERISTICS: Monroe County; Statewide
Watershed Name: Florida Bay-Florida Keys
Latitude: 26.00 **Longitude:** 81.00
Hydrologic Unit Code (HUC): 03090203

PROJECT OBJECTIVE(S):
Quantify the reduced loading of contaminants from advanced Onsite Sewage Treatment and Disposal Systems (OSTDS) to the environment; assess the operational status of systems under the current management framework; survey perceptions of user groups regarding the management of such systems; validate elements of a monitoring protocol for consistent assessment of systems; document good management practices.

PROJECT DESCRIPTION:
Problem: Onsite Sewage Treatment and Disposal Systems (OSTDS) are one of the nutrient sources in nutrient impaired watersheds. Estimates of the extent of their contribution to nitrogen loadings for different watersheds in Florida have ranged between less than five and 20%. Conventional OSTDS (septic tank-drainfields) have limited capacity to reduce nitrogen concentrations in water discharged to the drainfields. Because of this, residential density limitations have been used as one approach to meet the nitrate drinking water standard of 10 mg/L, which is not necessarily protective of ecological health. The phosphorus loading from OSTDS has been of most concern in the Florida Keys, where small lots, poor soils, and building practices increase the risks of impacts on surface water.

To achieve higher reductions of nutrient concentrations, additional treatment steps in OSTDS are necessary. Advanced OSTDS can utilize various approaches to improve treatment before discharge to a drainfield, or the drainfield itself can be modified. On occasion, engineers have included the drainfield as part of the treatment process, usually as means to achieve fecal coliform removal. In such cases, the engineer is required to include shallow groundwater monitoring wells in the monitoring plan.

The emphasis of this project will be on assessing the effectiveness of pretreatment before discharge to the drainfield. There are two large permitting categories in Florida onsite regulations that qualify as advanced treatment: Aerobic Treatment Units (ATUs) (Florida Administrative Code 64E-6.012), which are generally permitted based on certification by the National Sanitation Foundation; and performance-based treatment systems (PBTS) (Florida Administrative Code 64E-6, part IV), which are permitted based on design by an engineer experienced in wastewater. A third permitting category, rarely used, consists of engineer-designed alternative systems, such as sand filters.

Advanced systems have been required by local regulations, at least in part, with the objective to reduce nitrogen loading to sensitive areas (Florida Keys, St. George Island, Aucilla and Suwannee River floodplains, and Volusia County). In addition, Florida Administrative Code (FAC) 64E-6 requires advanced treatment, sometimes including nitrogen and fecal coliform removal, for lots where the usually required setback or authorized lot flow restrictions cannot be met.

Advanced systems differ in three aspects from conventional treatment systems that consist of a septic tank with drainfield. The design of advanced systems is more variable than the prescriptive approach for conventional systems. They need more frequent checkups and maintenance, which has been the reason for requiring operating permits for them. The performance expectations are more specific than absence of sewage on the ground surface, while failure definitions for advanced systems are vaguer. The first two issues have been challenges for the permitting process. Site specific performance specifications are not captured completely in the three databases that are used statewide for tracking permits, two that were developed for conventional system permitting for the state, and one that was developed for inspection tracking by Carmody, Inc. The third issue has made it hard to determine how well this aspect of Florida's onsite program is working. Until early 2001, operating permit fees allowed County Health Departments to perform limited sampling. In 2001, the legislature decided to limit operating permit fees. Since then, there has been no systematic statewide assessment of the management and performance of these systems. The proposed project aims to perform such a statewide assessment and develop improvements in the management of advanced systems where indicated.

Project Plan: The project to be performed statewide, and in particular in Monroe County, will evaluate the performance, management, and monitoring of advanced systems in Florida.

TASKS /OUTPUTS /DELIVERABLES:

Task 1: *Monroe County detailed study of diurnal and seasonal variability of performance of advanced systems [Monroe County Project]*

The Department of Health, Bureau of Onsite Sewage Programs (Bureau), has allocated $200,000 of research funds to contribute to the assessment in Monroe County. After two failed attempts to find an outside contractor for this study, both Bureau and Monroe County Health Department (MCHD) staff have decided to implement this study using CHD personnel. No staff salaries are to be paid with the allocated state matching funds for this task.

The Monroe County Health Department staff will select a sample of up to nine nutrient-reducing systems and up to four ATUs. Criteria for inclusion are currency of operating permit, year-round use, and willingness of the system user to participate. As part of this task, Bureau and MCHD staff will develop assessment procedures for the performance of advanced systems, including the sampling and monitoring methodology. Repeated sampling will be performed to characterize the variability of the performance of such systems in detail.

Completion Date: June 2011

Deliverables: Validated sampling procedures; Sampling results from Monroe County; Report containing analyses for diurnal and seasonal variability using Florida Keys data. Work for this task has been completed; Final Report will be submitted by June 2011.

Task 2: *Development of a statewide database of advanced systems based on permit record [Database]*

The primary function of this statewide database will be to store and provide information for this project. A second function will be to serve as an assessment tool of the completeness of the source databases.

Systems to be included will be:
-PBTS (of which nutrient reducing and innovative systems are a subset)
-ATUs (including engineer-designed ATUs with drip irrigation)
-Engineer-designed sand filters and other alternative systems

The methodology for the development of this database is as follows. The database will contain information about permit records, system types, property locations, contact information, components used, maintenance, monitoring, inspection and sampling results, performance specifications, and site locations of systems. Data fields will be based largely on the existing databases: the statewide permitting databases, CENTRAX and CENTRAX-Rehost, and the Carmody Program maintenance database, which is capable of receiving data from CENTRAX. The project database will be compatible with these databases in so far as it will be capable of receiving suitably formatted data dumps from them.

Information will be extracted from these database sources by querying for the system types of interest. The result of merging these records and supplementing the information with any additional records provided by county health department staffs will be a database of all advanced systems identified at the time of completion of the database. All addresses shall be geocoded to the best extent possible in order to allow for mapping and trip planning. Comparison of the results from different databases with each other and with the project database will allow an assessment of relative completeness of records and data fields.

The project database will be used for the tracking of systems during the project and for other tasks, such as for survey mailing addresses and selection of systems to be sampled. The project database also will be available to update the source databases. This update is outside of the scope of this project, because the permitting databases are currently not capable of uploading additional records and the extent of needed data entry is difficult to predict.

This task will be implemented by a contract staff position and possibly an intern with assistance from Bureau and County Health Department staff. For the purposes of budgeting, 1,710 hours of contract staff time at an average of $22.24 per hour is assumed.

Completion Date: August 2011

Deliverables: Description of advanced systems database, including fields and structure; Summary statistics of the results of the data aggregation, such as number of each type system, number of advanced systems by county, etc.

Task 3: *Elucidation of the perceived strengths and areas for further improvement of the current management of advanced onsite system [Surveys]*

Surveys of system owners/users, installers, engineers, manufacturers, maintenance entities and regulators will be used to evaluate the perceptions and experiences with operation, maintenance, performance and other issues relating to advanced onsite systems.

Onsite regulators may be surveyed initially to help in developing the database of advanced systems. Surveying tools may differ by stakeholder group, such as electronic surveys for regulators, phone surveys for maintenance entities, a combination of mail, phone and electronic tools for onsite system users. If feasible, information about county health department, manufacturer or maintenance entity will be linked to responses to assess if strengths or areas for further improvement are statewide or specific to an organization. Differences between county health department, manufacturer or maintenance entities can provide leads to best practices for follow-up during Task 6.

A third party will undertake the implementation of surveys. Questions and the detailed methodological approach will be developed by the vendor in coordination with Bureau staff with some common questions complemented by user group specific questions. The exact number of surveys and the format for distribution will be determined after Task 2. Initial contact has been made with state university system survey labs for purposes of verifying costs and timelines. For budgeting purposes the upper limit of a purchase order was used.

Completion Date: June 2011

Deliverables: Survey forms; raw survey results; Analysis of results

Task 4: *Statewide assessment of operating conditions and performance of advanced onsite systems [Assessment of Operational Status and Performance]*

A random selection of advanced systems will be inspected and sampled in coordination with annual county health department inspections. The systems will be selected based on the Task 2 project database. If manufacturer information and system type are available initially for at least half of the systems, the sampling will be stratified to assure proportional representation of manufacturers and system types. The final subgroup categories and sizes will be determined with input from the DOH Research Review and Advisory Committee (RRAC) and consideration of the results of Task 1. A very general approach could consist of an assessment if differences between two subgroups in exceeding the common concentration median are significant at some level of significance (e.g. 0.05). The group size determines then how large a difference can be detected at that significance level. An example in which two subgroup sizes are equal is: for fifty (50) systems, a difference between 60% exceedance of the median in one group and 40% exceedance in the other group is significant, while for 10 systems, only a difference between 75% and 25% is significant.

A Quality Assurance Project Plan (QAPP) will be developed, with input from the RRAC, based on the results of Tasks 1 and 3. The standardized protocol developed in Task 1 will be modified as needed and used in the sampling and qualitative assessment. Available inspection and sampling records will be added to the project system database. During each inspection, the configuration of the unit will be compared to permit records as available and characterized. Evaluation criteria may include: operating permit status; maintenance inspection status; presence of sewage outside of treatment receptacles; operational status of the unit; and qualitative assessment of effluent. Sampling results of effluent (BOD, TSS, and TN) will be determined for all systems. Fecal coliform and TP will be sampled where lab facilities are close enough to meet holding times. These analyses will allow an assessment of how frequently secondary and advanced secondary effluent concentration standards for fecal coliforms and TP are met. For budgeting purposes, it is assumed that half of all systems sampled will be analyzed for fecal coliform and TP.

The emphasis of the sampling will be on effluent quality. While the final number of samples will depend on budget and time constraints and preferences of the Research Review and Advisory Committee, the initial target will be approximately 700 effluent samples. About 700 effluent samples will allow for 95% confidence that the median is between the 46th and 54th percentile of measured effluent concentrations. To reduce this confidence interval by two percentage points would require nearly doubling the number of samples. About 700 effluent samples also will allow estimation of the 10th and 90th percentile within 2.5%.

In order to determine reduction of contaminants, some measure of influent strength will be necessary. The ability to measure influent strength depends on the presence and accessibility of a settling tank that feeds the treatment unit, which may well only be determined during the site visit. Therefore, influent sampling at this stage will be a convenience sample. These systems also will be noted for inclusion in Task 5. With 100 influent samples, the budget assumption, we can be 95% confident that the true median influent concentration is between the 40th and 60th percentile of the measured influent concentrations. The number of influent samples is smaller than the number of effluent samples, because no treatment-type specific differences in influent strength are expected and effluent concentrations are more important in terms of environmental effect.

To account for systems that cannot be sampled, a total of 750 systems will be selected for assessment. This will increase the likelihood that 700 systems are available for sampling with no delays for additional system selections during the actual sampling procedures.

Several issues may arise, which could result in a modification of this proposed approach and reallocation of proposed budget, which would be undertaken in coordination with FDEP staff. The time required to coordinate inspections with County Health Departments and reach the sites may be so long that less than the anticipated four systems per day can be accomplished. This will depend in part on the balance between counties with few systems and many systems and on access to laboratories. Access to sampling ports may be sparse, resulting in a relatively large number of field visits with a smaller number of samples, or in a much larger fraction of effluent samples than influent samples. If a qualitative method is available and validated that can indicate lack of functioning without sampling, the number of samples for cBOD5 and TSS could be reduced. Effective analytical costs could be higher or lower than the assumptions in the budget. Optimization of travel may result in samples not being randomly distributed over the state and sampling period.

This task will be implemented by trained contract staff and county health department staff in coordination with county health department inspectors and Bureau staff. Bureau staff will be involved in the quality assurance, field sampling, and training for this task. The coordination with county health department inspections will provide contract staff and/or Bureau staff with an opportunity to train county health department staff on effective inspection procedures. Any salaries for Bureau staff involvement in this task will be an unquantified in-kind contribution to this project.

For the purposes of budgeting, 2,214.75 hours of contract staff time at an average of $22.24 per hour is assumed. The contract staff shall hold a current OSTDS certification and also be trained to perform the sampling ($1,841.42 for travel and $1,800.00 contract with MCHD) to provide the training. The budget for sampling is based on estimated costs for 770 samples from 600 systems and an additional 10% QA/QC samples. NELAP-certified laboratory services will be provided by contract with a commercial lab or procured in a set of purchase orders with local labs.

Completion Date: August 2011

Deliverables: QAPP for Tasks 4 and 5; spreadsheet listing permits for Task 4 reviewed by month; Examples of all Task 4 forms used for recording and reporting (i.e. raw field data form, system assessment form, chain of custody form, etc.) and three of each type of form completed with actual Task 4 data; Spreadsheet(s) of the Task 4 tabulated field and sampling data with the data fields required in Attachment H, Section (4)(c) of this agreement, *Quality Assurance Requirements for Federally Funded NPS BMP Monitoring Agreements*, for all of the systems monitored by month

Task 5: *Periodic influent and effluent sampling for a sample of advanced systems [Assessment of Annual Variability of Performance]*

Variability of effluent and influent quality over time will be assessed for a selection of volunteer systems. These systems will be from counties where regular sampling is feasible based on staffing qualifications and numbers of systems. Initial candidates are Lee, Monroe, Charlotte, Brevard, Franklin, and Wakulla counties. Recruitment will begin with the survey in

Task 3. Depending on the level of recruitment, volunteers also will be solicited among systems for which influent samples were taken during the first few months of executing Task 4. All systems will be sampled for BOD, TSS, and TN in effluent and influent, and for fecal coliform and TP for approximately half of the total number of systems sampled with a preference for advanced secondary systems. One of the sampling events at each site can be coordinated with the yearly CHD inspection.

This task will be implemented by trained contract staff and/or county health department staff in coordination with county health department inspectors and Bureau staff. Bureau staff will be involved in the quality assurance, field sampling, and training for this task. Any salaries for Bureau staff involvement in this task will be an unquantified in-kind contribution to this project.For the purposes of budgeting, 613 hours of contract staff time at an average of $22.24 per hour is assumed. The contract staff shall hold a current OSTDS certification. The sampling budget is based on estimated costs for influent and effluent samples for 70 sites. This task will have three separate sampling events for each site in addition to the first sampling event completed in Task 4. If none or few of the volunteer sites were part of the random sample of Task 4, the number of sampled systems may have to be reduced within the overall budgeted cost or an amendment to increase funding may be necessary. NELAP-certified laboratory services will be provided by contract with a commercial lab or procured in a set of purchase orders with local labs.

Completion Date: August 2011

Deliverables: Spreadsheet listing permits for Task 5 reviewed by month; Examples of all Task 5 forms used for recording and reporting (i.e. raw field data form, system assessment form, chain of custody form, etc.) and three of each type of form completed with actual Task 5 data; Spreadsheet(s) of the Task 5 tabulated field and sampling data with the data fields required in Attachment H, Section (4)(c) of this agreement, *Quality Assurance Requirements for Federally Funded NPS BMP Monitoring Agreements*, for all of the systems monitored by month

Task 6: *Documentation of good maintenance management programs by CHD and maintenance entities [Management Practices]*

During Task 2 several county health departments and maintenance entities will be selected to quantify and characterize steps in the management of advanced systems. The counties and maintenance entities will be among those with many systems and/or for which survey results indicated a relatively high satisfaction by user groups. Each selected entity will participate in a characterization of the status of management of advanced onsite systems. The characterization will include: detailed information on the number and types of advanced systems; compliance and enforcement rates; systems used for tracking compliance; the presence and responsiveness of maintenance entities and county health departments; the role of education of stakeholders; and, management costs. The collected experiences and viewpoints from the county health departments' and maintenance entities' staffs will outline strengths as well as areas for further improvement in the management of advanced onsite systems. The experience of these entities will be documented and illustrated in a case studies booklet that will be published on the Department's web site and distributed in limited amounts in hard copy format. If additional publication needs are warranted beyond this project's budget, a separate project with other funding will be used to accomplish the printing.

This task will be implemented by a contract staff position and possibly interns with assistance from Bureau staff. For the purposes of budgeting, 250 hours of contract staff time at an average of $22.24 per hour is assumed.

Completion Date: September 2011

Deliverables: Characterization of outcomes in report format; Booklet written with case studies outlining both strengths and areas for further improvement of the current program and best management practices in advanced onsite systems management uploaded on the DOH web site and printed copies distributed in limited amounts

Task 7: *Project administration*

Administrative responsibilities will include project oversight, financial accounting, invoicing, and grant reporting to the Florida Department of Environmental Protection. The final project report will include: a description of the project; a summary of the survey results; a detailed analysis of how the advanced systems perform as compared to permit requirements; problems encountered during the project; and a detailed financial accounting of the project costs, including grant and match funding. Copies of scientific or technical publications resulting from this project will be included in quarterly reports. Other work products that are to be submitted to FDEP with the final report or as separate items include sampling results associated with this project, copies of related press releases, and meeting agendas, fact sheets or other materials distributed to the public as a direct result of this project.

Completion Date: September 2011

Deliverables: Quarterly progress reports and invoices submitted to FDEP; Preliminary (draft) report; Final project report (five paper copies in addition to an electronic version in either Adobe or Word format); Copies of scientific or technical publications resulting from this project (to be included with quarterly progress reports); All other work products associated with this project

PROJECT BUDGET BY CATEGORY:

Project Funding Category	Section 319 (h) Grant Amount	Matching Contribution	Match Source**
Salaries & Fringe Benefits	$39,933.00	$0	
Travel	$41,818.92	$0	
Equipment	$7,521.00	$0	
Supplies/Other Expenses	$14,770.52	$0	
Contractual Services:			
Task 1 Match Project	$0	$200,000	DOH Headquarters contract with Monroe County Health Department
TCC/Niteline Contract	$106,479.56	$0	
Surveying	$25,000.00	$0	
Monitoring: Training for Contract Staff	$1,800.00	$0	
Monitoring: Laboratory Services	$70,031.50	$0	
Printing / Public Education	$1,000.00	$0	
Total*:	$308,354.50*	$200,000	
Total Project Cost:	**$508,354.50**		

Budget Narrative:
*All items will be billed as cost-reimbursable, not to exceed the total project grant amount.

**Department of Health Septic Tank Research Fund ($200,000) - Not quantified in-kind contributions will include technical assistance and project administration by DOH research staff. For Task 1, the method of procurement for laboratory analytical services was an ITB, resulting in a contract between Monroe County Health Department and a NELAC-certified lab for analyzing samples from the Florida Keys. Funding was given directly to the Monroe County Health Department to manage the Keys project. Final reporting will identify breakdown of match expenditures.

Salaries & Fringe Benefits: for County Health Departments – Funding for salaries will be provided to up to three county health departments to assist with the sample collection. Sampling costs have been estimated by the Monroe County Health Department staff based on their experiences in Task 1. The costs are estimated based on the base salary ($18.90 per hour) plus fringe benefits ($8.10 per hour) for an Environmental Specialist III ($27 per hour for a total of 1,479 hours). Actual costs will vary depending on the actual employee doing the work. Task 4 is estimated to have 400 samples at 3 hours per sample, and Task 5 is estimated to have 3 sampling events of 31 samples each event for a total of 93 samples at 3 hours per sample.

Travel - It is hoped that the Tallahassee contract staff, county health department staff, and/or DOH research staff will be able to collect four samples per day for Tasks 4 and 5. The seventy (70) miles/sample was estimated by assuming approximately 200 miles drive to get to each area of four (4) samples, the desired number to be sampled daily, plus an estimated twenty (20) miles vicinity driving between sampling sites (200/4 + 20). Eighty percent of trips are assumed to be overnight. The number of samples that will have travel calculated does not equal the total number of samples due to the county health departments doing some of the sampling. 520 samples divided by four samples per day equals 130 trips for Task 4 or 104 overnight trips and 26 single day trips. There are to be three sampling events for each of 58 sites in Task 5, resulting in (58 samples divided by four samples per day equals 15 trips or 12 overnight trips and 3 single day trips) x 3 events/site. Overnight trips were based on $36 for meals, $80 per diem, and $115/night for lodging. Single day trips were based on mileage only. It is assumed that lodging costs will not be $115/night on a general basis, thus having funds left for miscellaneous travel expenses, such as for tolls, or variable mileages for trips to different parts of the state. A higher assumed lodging rate is used, because sampling will be done periodically, and some sampling will have to be done during peak tourist seasons. The County Health Department staff performing the monitoring is estimated at 40 miles per trip to take four samples per day. Travel for Task 4 is estimated based on taking 400 samples divided by four samples per day equals 100 trips. There are to be 93 samples in Task 5 divided by four samples per day, which equals 23 trips. These are single day trips and are based on mileage only. Travel for Task 4 will be calculated at: Travel for contract staff and DOH research staff [Mileage (520 samples x estimated 70 miles/sample x $0.445/mile) + Meals ($36/day x 52 days) + Per Diem ($80/day x 52 days) + Lodging ($115/day x 52 days)] + Travel for CHD staff (100 days x estimated 40 miles/day x $0.445/mile). Travel for Task 5 will be calculated at: Travel for contract staff and DOH research staff [Mileage (58 samples x estimated 70 miles/sample x $0.445/mile) + Meals ($36/day x 6 days) + Per Diem ($80/day x 6 days) + Lodging ($115/day x 6 days)] x 3 events/site] + Travel for CHD staff (23 days x estimated 40 miles/day x $0.445/mile). A total of $1,841.42 will be spent on travel for monitoring training for contract staff.

Equipment purchased will be used for Tasks 4 and 5, but the costs are allocated to Task 4 only. Items, such as water samplers and multi-parameter handheld instruments, will be purchased to equip four field sample kits. Specifically, four Global Water Composite/Discrete Water Samplers will be purchased at approximately $1,049.00 each, and two YSI multi-parameter handheld instruments will be purchased at approximately $1,662.50 each.

Supplies/Other Expenses are for Tasks 4 and 5. These are miscellaneous supplies/other expenses not included in other portions of the budget. Items to be purchased under this category include wrenching bars, utility pails, Taylor test kits, small tables, pliers, tile probes, digital cameras, manhole cover picks, tubing, batteries, gloves, storage and garbage bags, cleaning cloths, detergent, hand sanitizers, ice, screws, paper towels, general office supplies, and buffer solutions. Other expenses will include service on equipment and shipping of samples to the lab. A split of 80% for Task 4 and 20% for Task 5 was assigned.

Contractual Services

Contract Staff – Competitively procured state contract with TCC/Niteline; staff's time is 100% on this project; 28 months work at average of $3,802.86/month ($15.38/hour plus fringe benefits and administrative fee); hours are estimated based on work effort anticipated for each task This person will develop a database for the project, collect samples, and conduct case studies of management practices; a contract to conduct the survey task.

Contracts with multiple laboratories to conduct the sample analyses;

Contract with the Monroe County Health Department to train the contract staff on sampling protocols based on the Task 1 methods.

Contract to print and distribute materials created for the public education component of this project.

Contract for Survey – The survey work is being performed by FSU staff under contract to DOH.

Contract for Laboratory analytical costs range from $5 - $25 per analysis. A full suite of analyses on a sample costs $66; without the fecal coliform analysis, the cost is $41. Laboratory Services for Task 4 are calculated as: [(700 effluent samples: 350 @ estimated $41 + 350 @ estimated $66) + (70 influent samples: 35 @ estimated $41 + 35 @ estimated $66)] x 1.1 (for 10% QC samples) = $45,314.50. Laboratory Services for Task 5 are calculated as: [(210 effluent samples: 105 @ estimated $41 + 105 @ estimated $66) + (210 influent samples: 105 @ estimated $41 + 105 @ estimated $66)] x 1.1 (for 10% QC samples) = $24,717.00.

Contract for printing of Case Studies Booklets – Booklets will be either about three to four 8-1/2"x11" sheets folded in half with staples (approximately 12-16 pages in length) or a tri-fold size with several inside pages; printing will be bid out or quotes will be obtained to get the highest number of copies for the allotted money.

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BUDGET BY TASK:

Project Funding Activity	Section 319 (h) Grant Amount: Invoiced Prior to Amendment	Invoiced After Amendment	Total	Matching Contribution: Total	Match Source
Task 1: Monroe County Project (Contractual)	**$0.00**	**$0.00**	**$0.00**	**$200,000.00**	GRANTEE
Task 2: Database Development (Contractual)					
Contract Staff (TCC Niteline)	**$31,703.76**	**$6,326.64**	**$38,030.40**	**$0.00**	
Task 3: Surveys (Contractual-FSU)	**$16,233.44**	**$8,766.56**	**$25,000.00**	**$0.00**	
Task 4: Assessment of Operational Status and Performance					
Salaries/Fringe Benefits					
CHD Staff for Monitoring	$0.00	$32,400.00	$32,400.00		
Contractual Services					
Contract Staff (TCC Niteline)	$35,725.04	$13,531.00	$49,256.04		
Monitoring Training for Contract Staff (Monroe County Health Department)	$1,800.00	$0.00	$1,800.00		
Monitoring: Laboratory Services	$0.00	$45,314.50	$45,314.50		
Travel					
Travel for Monitoring Training for Contract Staff	$1,841.42	$0.00	$1,841.42		
Travel for Monitoring	$0.00	$29,990.00	$29,990.00		
Equipment	$0.00	$7,521.00	$7,521.00		
Supplies/Other Expenses	$1,416.10	$8,602.2410,400.32	$11,816.42		
TASK SUBTOTAL	**$40,782.56**	**$139,156.82**	**$179,939.38**	**$0.00**	
Task 5: Assessment of Annual Variability of Performance					
Salaries/Fringe Benefits					
CHD Staff for Monitoring	$0.00	$7,533.00	$7,533.00		
Contractual Services					
Contract Staff (TCC Niteline)	$0.00	$13,633.12	$13,633.12		
Monitoring: Laboratory Services	$0.00	$24,717.00	$24,717.00		
Travel					
Travel for Monitoring	$0.00	$9,987.50	$9,987.50		
Supplies/Other Expenses	$0.00	$2,954.10	$2,954.10		
TASK SUBTOTAL	**$0.00**	**$58,824.72**	**$58,824.72**	**$0.00**	
Task 6: Management Practices					
Contractual Services					
Contract Staff (TCC Niteline)	$0.00	$5,560.00	$5,560.00		
Printing of Case Studies Booklets	$0.00	$1,000.00	$1,000.00		
TASK SUBTOTAL	**$0.00**	**$6,560.00**	**$6,560.00**	**$0.00**	
Task 7: Project Administration*	**$0.00**	**$0.00**	**$0.00**	**$0.00***	
Total:	**$88,719.76**	**$219,634.74**	**$308,354.50**	**$200,000.00**	
Total Project Cost:		**$508,354.50**			

* Department of Health - DOH research staff salaries and fringe benefits are unquantified in-kind contributions not to be counted toward the match requirements of this Agreement.

PROGRESS REPORT FORM

DEP Agreement No.:	G0239		
Grantee Name:	Florida Department of Health		
Grantee Address:	Division of Environmental Health, 4052 Bald Cypress Way, Bin #A-08, Tallahassee, FL 32399-1713		
Grantee's Grant Manager:	Elke Ursin	**Telephone No.:**	850-245-4070 x 2708
Quarterly Reporting Period:	October 1, 2010 – December 30, 2010		
Project Number and Title:	G0239 Department of Health Assessment of Water Quality Protection by Advanced Onsite Sewage Treatment and Disposal Systems: Performance, Management, Monitoring Project		

Provide a summary of project accomplishments to date. (Include a comparison of actual accomplishments to the objectives established for the period. If goals were not met, provide reasons why.)

- Grant was executed on August 6, 2008.
- Task 1: Monroe County Project (in kind match)
    - Monroe County Health Department was selected to perform the sampling.
    - Sampling protocol report has been completed.
    - Presentations made on some of the preliminary results at the Florida Environmental Health Association's Annual Education Conference in August 2008, at the Water Environment Federation's Annual Technical Exhibition and Conference (WEFTEC) in October 2008, in October 2009, and in October 2010. Copies of the presentations have been submitted with previous quarterly reports.
    - All sampling has been completed for this task. Quality control of collected data has been completed. Sampling results are included in this progress report.
    - The employee who did the sampling for this task trained the new employee hired to do the statewide sampling during the week of August 10, 2009.
    - Reports summarizing this project are expected to reach draft form by the end of the next quarter.
    - *This task is behind schedule. This delay does not result in a delay to the overall project.*
- Task 2: Database
    - Decision to hire an outside contractor for the data gathering and database development was made initially to obtain the most cost efficient solution to obtaining the end result.
    - Request for Quotes was advertised, responses were received and scored, and negotiations with the highest scored applicant were made. The proposed contractor withdrew their proposal.
    - This task is being completed by bureau staff. During the previous quarters it became apparent that the originally anticipated volunteer effort could not be incorporated into the work-flow.
    - Preliminary surveys and telephone inquiries were made to the County Health Departments to determine the method for recording operating permit data. The responses have been tabulated.
    - Data has been gathered from the state databases, county specific databases, and Carmody.
    - Initial assessments have shown that there is very limited overlap between operating permits in the state database and in Carmody, complicating efforts to

develop a comprehensive database with uniform fields. Much time during previous quarters has been spent identifying duplicate data, cleaning up and combining the records. The approach that was taken focused on the physical address of a system as the identifying characteristic. Duplication of addresses (e.g. for repairs) in the state permitting (EHD) database was remedied by selecting generally the most recent permit and combining construction and operating permits. Carmody records were screened to eliminate operating permits from non-advanced systems such as a conventional system for a restaurant or in an industrial/manufacturing zone. EHD and Carmody records were linked to each other based on address and permit information. Approximately 16,000 distinct records were the results of this work. The addresses have been geocoded, which serves as an additional data quality check.

- Data fields and database structure have been selected and designed by DOH and contract staff. The database of the system records is mostly complete. A description of the data fields and structure will be developed over the next quarters. We propose to delay submitting the database descriptions until the database design is complete. The basic database information as outlined in the grant is complete. Supplemental information is being gathered in the database to capture information outside of the general system information that was gathered from the permitting databases. This supplemental information is anticipated to include tables on the permit review, physical evaluation of the system, sample results, construction information, and the county evaluation of management practices.
- Tools and methods to streamline data entry and ensure data quality have been developed. These tools and forms ensure accuracy and consistency with regards to data entry. A significant amount of time in past quarters was spent designing queries and forms to capture system details to assist with data analysis later on.
- For those records where sufficient information existed, treatment component technologies have been categorized and this information linked to the system record based on the type of technology installed. The treatment technologies have been grouped as either: unsaturated fixed media, combined media, and extended aeration. Additionally, aeration technology for combined media and extended aeration was subcategorized into diffuser and aspirator approaches. Records were selected to represent each of the different technology approaches. Numbers of samples for each manufacturer were proportional to the logarithm of the number of systems in the same category. The record selection used a similar approach as the overall random sample, by selecting the records with the lowest n random numbers that fulfilled the criteria Details on this can be found in Table 1.

Technology Approach	Manufacturer	Product	Aeration_sub_type	Product sample	suptype sample	Approach sample
Combined	Bio-Microbics	FAST	Diffuser	35	35	70
	Jet	Jet	Aspirator	35	35	
Extended aeration	Acquired Wastewater Technologies	Alliance	Diffuser	2	35	70
	Ecological Tanks, Inc.	Aqua Aire	Diffuser	2		
	Ecological Tanks, Inc.	Aqua Safe	Diffuser	2		
	Aqua-Klear	Aqua-Klear	Diffuser	4		
	American Wastewater	B.E.S.T. 1	Diffuser	3		
	Acquired Wastewater Technologies	Cajun Aire	Diffuser	3		
	Clearstream	Clearstream	Diffuser	3		
	Delta	DF or UC	Diffuser	3		
	Hoot	Hoot	Diffuser	4		
	Hydro-Action	Hydro-Action	Diffuser	2		
	H.E. McGrew	Mighty Mac	Diffuser	3		
	Consolidated	Nayadic	Diffuser	4		
	Consolidated	Multi-Flo	Aspirator	15	35	
	Consolidated	Enviro-Guard	Aspirator	3		
	Norweco	Singulair	Aspirator	17		
Fixed media	Orenco	AdvanTex		6		70
	Quanics	Aerocell		4		
	Quanics	Biocoir		4		
	Premier Tech	EcoFlo		9		
	EcoPure	EcoPure		8		
	Earthtek	EnviroFilter		14		
	Klargester	Klargester		2		
	Rotodisk	Rotodisk		3		
	Ruck	Ruck		7		
	NoMound	NoMound		8		
	Sandfilter	Sandfilter		5		

Table 1. Technology of Components Sample Selection

- Summary statistics on the database will be developed over the next quarter.
- For this task future quarters will be spent adding data regarding the sampling to be performed in later tasks and continued cleaning up of the records.
- *The task as originally outlined in the grant agreement is mostly complete. Additional work gathering and displaying the supplemental information is delaying completion of this task. The end result will provide more information that was originally anticipated. This task is behind schedule due to the addition of this supplemental information. These delays are not affecting other project tasks.*

- Task 3: Surveys
  - Request for Quotes was sent out to several universities and state contract providers to perform the survey.
  - Two proposals were received and the evaluation was completed with the Florida State University Survey Research Laboratory selected as the successful provider.
  - Development of the six surveys has been completed. There have been several meetings between DOH, DEP, and FSU staff to go over the content of the draft surveys prior to reaching the final version. The surveys ranged from 5 pages long to 10 pages long depending on the user group. The surveys have been submitted in a previous quarterly report.
  - The surveys were sent out to the target interest groups during the beginning of 2010. Some time after the first wave of surveys were mailed out a second round of follow-up surveys were sent out to the non-responders.
  - 100% of the population size will be surveyed for the Onsite Regulators, Installers, Engineers, Manufacturers, and Maintenance Entities. 3,795 of the System Owners have been sampled based on a sampling scheme that was agreed to by all parties. This sampling scheme was designed to send surveys to all identified

innovative system owners, oversample commercial systems with approximately 15% of the surveys, and to oversample PBTS' by a factor of 2 relative to ATUs. The oversampling will serve to provide more data on smaller groups to allow comparison to the large group of residential ATUs.

  - FSU reported that a significant fraction of the surveys were returned as undeliverable. 914 of the system user surveys were returned to the department. Surveys were originally sent to the physical property address in order to capture the user's point of view. The main reasons for the inability to deliver to many of these addresses was because the property was vacant, there was no mail receptacle at the location, that is was not deliverable as addressed, or that the mail was unable to be forwarded. After individually searching each address in the corresponding county property appraiser's database, 825 were resent to the property owner; the remaining 89 addresses could not be located in the property appraiser's database. To date, 101 of these letters with the updated owners address have been returned back as being vacant, undeliverable as addressed, etc.
  - FSU has completed all of the data entry on all of the submitted surveys. Quality assurance on the data will be completed in the next quarter.
  - Data analysis will be done once the data has been QA checked. Preliminary results have been submitted to DOH. Final data analysis will be completed over the next quarter.
  - A DOH intern was utilized to categorize some of the open ended questions on the surveys. Analysis and completion of this review will be completed over the next quarter.
  - *This task is behind schedule to allow for inclusion of as many surveys as possible, and to ensure quality data has been entered. After discussions with the contract provider, an extension to the end date has been given to include more of the surveys that are currently being received and to allow for more time to do QA on the data. The delays associated with this task do not affect the project as a whole.*
- Task 4: Assessment of Operational Status and Performance
  - In November 2008 investigations began into the method of procurement for a contract staff position to complete this task, as well as several other tasks associated with this project. DOH has two contractors that provide contract staff: Tallahassee Community College (TCC) and Nitelines USA, Inc. Initially we anticipated utilizing TCC, but in mid February 2009 TCC informed the grant manager that they are no longer taking on new contracts. The process immediately began to utilize Nitelines as the provider with advertising being done in March 2009, interviews being performed in April 2009, and final selection being completed in May 2009.
  - The contract staff position began on June 1, 2009 with much of their time initially being devoted to development of the project database in Task 2.
  - The draft Quality Assurance Project Plan has been written, presented to the DOH Research Review and Advisory Committee (RRAC), revised, and will be finalized, with an anticipated completion during the next quarter. Delays in getting this QAPP in a final format are to make it as robust and detailed as possible to eliminate any mistakes that could occur later.
  - Contract staff became certified in OSTDS in December of 2009 as stipulated in the grant agreement. Staff has also attended GIS mapping training.
  - Criteria regarding site selection were presented and discussed at the RRAC meeting on December 16, 2009. There were many of pros and cons from the system selection strategies list that RRAC discussed. DOH created a flow chart to

illustrate the site selection process. This flow chart was finalized and was submitted with a previous quarterly report. The main sample selection was done by taking a random sample of the entire population of advanced systems. This sample will give a snapshot of the operational status and management of all systems. A total of 700 systems were selected which included 600 primary sample sites and 100 reserve sites in the event that a primary site is not accessible or no longer exists. In addition to a pure random sample, the site selection has been modified to ensure treatment comparison samples are included (70 each fixed media, combined media, and extended aeration). Overlap with the initial random sample has been maximized, so that a total of 796 sites are currently targeted for assessment.

- The random sample has been pulled and Monroe County was over-represented by 2.7%, which comes to 19 systems. Upon discussions internally and with the grant manager at DEP it was decided to make the representation for Monroe County equal. In summary, the top counties were Monroe with 148 systems, Brevard with 99 systems, Charlotte with 95 systems, and Franklin with 47 systems. A total of 53 out of the 67 counties in Florida have at least one system that will be sampled as part of this project. An illustration of the distribution of sample sites is shown in Figure 1.

Figure 1. Distribution of Sample Sites

- 439 permit files have been gathered out of the 796 with most of the counties having responded to our requests for data and a few still needing further reminders. This data gathering will continue in subsequent quarters. Data entry on 107 permit files has been completed to date. This data entry includes detailed information on the construction permit, the operating permit, and other information. During this gathering, Monroe County provided information that 55 of the 148 selected systems are scheduled to be abandoned due to connection to

sewer. Data entry will not be done for this 55 systems.
  - Contract staff placed initial calls to manufacturers in an effort to locate a contact and learn about specific suggestions for sampling. In the event a question arises while in the field those individuals would be a point of contact. Contract staff has collected product manuals to assist with sampling.
  - An Invitation to Bid for the analytical laboratory services was advertised in December of 2009 and 15 responses were received. A final decision and purchase order was executed during a previous quarter. The selected lab is Florida Testing Services, LLC DBA Xenco Laboratories.
  - *This task is behind schedule due to minimal staff time available, delays getting contract staff hired, and delays in getting the QAPP in a final form. The delays associated with this task do put the project behind schedule. At this point the project appears to be significantly behind schedule and is dependant on when the QAPP is approved by all parties. A grant amendment is being initiated to address this issue. Negotiations with Monroe County Health Department staff are being completed to utilize their staff to help complete the sampling associated with this task and Task 5. Other counties will be contacted over the next quarter to see if the sampling effort could be further spread out to allow for more sampling to be done in a shorter time period.*
- Task 5: Assessment of Annual Variability of Performance
  - The draft Quality Assurance Project Plan is being developed with an anticipated completion during the next quarter.
  - *This task is behind schedule due to minimal staff time available, delays getting contract staff hired, and delays in getting the QAPP in a final form. The delays associated with this task do put the project behind schedule. At this point the project appears to be significantly behind schedule and is dependant on when the QAPP is approved by all parties. A grant amendment is being initiated to address this issue. Negotiations with Monroe County Health Department staff are being completed to utilize their staff to help complete the sampling associated with this task and Task 4. Other counties will be contacted over the next quarter to see if the sampling effort could be further spread out to allow for more sampling to be done in a shorter time period.*
- Task 6: Management Practices
  - Contract staff has been compiling data as it becomes available.
  - Tables, queries, and forms have been created to capture County Health Department management practices and files have been gathered.
  - Contract staff went along with department staff to perform a program evaluation in Gilchrist County. Available files that were selected for sampling for this county were pulled and evaluated.
  - A review will be performed on the last three program evaluation cycles for each of the county health departments. These data have been tabulated and will be evaluated to provide background information on the strengths and weaknesses of each county program.
  - *This task is on schedule.*
- Task 7: Project administration
  - *This task is ongoing and is on schedule.*

Provide an update on the estimated time for completion of the project and an explanation for any anticipated delays.

Currently several tasks are behind schedule due largely to staffing delays and time estimation errors. Development of the project database and the development of the Quality Assurance

Project Plan have taken longer than anticipated to complete and has put the project behind schedule. These delays translate to delays in the completion time of the project. A no-cost amendment to this grant is being initiated to extend the project to September 2011.
Provide any additional pertinent information including, when appropriate, analysis and explanation of cost overruns or high unit costs. None
Identify below, and attach copies of, any relevant work products being submitted for the project for this reporting period (e.g., report data sets, links to on-line photographs, etc.) Copy of sampling results for Task 1 (Monroe County sampling)
Summarize and provide supporting documentation regarding your efforts in meeting the MBE/WBE requirements contained in paragraph 5.B. of the Agreement Nitelines USA, Inc. is a MBE. The contract employee that has been hired is a female of minority origin. The contracted lab, Florida Testing Services, LLC dba Xenco Laboratories, is also a MBE/WBE.

Provide a project budget update, comparing the project budget to actual costs to date.

Budget Category	Total Project Budget	Expenditures Prior to this Reporting Period	Expenditures this Reporting Period	Project Funding Balance
Salaries	$0	$0	$0	$0
Travel	$52,552.50	$1, 841.42	$0	$50,711.08
Equipment	$0	$0	$0	$0
Supplies/Other Expenses	$3,618	$258.41	$1,157.69	$2,201.90
Contractual Services:				
Surveying	$25,000	$16,233.44	$0	$8,766.56
Monitoring	$127,925	$1,800.00	$0	$126,125
Public Education	$5,000	$0	$0	$5,000
TCC/Niteline Contract	$94,259	$55,774.23	$11,654.57	$26,830.20
Total:	**$308,354.50**	**$75,907.50**	**$12,812.26**	**$219,634.74**

This report is submitted in accordance with the reporting requirements of DEP Agreement No. G0239 and accurately reflects the activities and costs associated with the subject project.

Signature of Grantee’s Grant Manager

Date

FLORIDA DEPARTMENT OF HEALTH

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task A.26

PNRS II Test Facility Data Summary Report No. 4

Progress Report

February 2011

44237-001

HAZEN AND SAWYER
Environmental Engineers & Scientists

In association with

COLORADO SCHOOL OF MINES 1874

AET Applied Environmental Technology

OTIS ENVIRONMENTAL CONSULTANTS, LLC

Florida Onsite Sewage Nitrogen Reduction Strategies Study

TASK A.26
PROGRESS REPORT

PNRS II Test Facility
Data Summary Report No. 4

Prepared for:

Florida Department of Health
Division of Environmental Health
Bureau of Onsite Sewage Programs
4042 Bald Cypress Way Bin #A-08
Tallahassee, FL 32399-1713

FDOH Contract CORCL

February 2011

Prepared by:

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Environmental Engineers & Scientists

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PNRS II Test Facility
Data Summary Report No. 4

1.0 Background

Task A of the Florida Onsite Sewage Nitrogen Reduction Strategies Study includes the evaluation of passive treatment systems to remove nitrogen from septic tank effluent. The Passive Nitrogen Removal Study II (PNRS II) is a follow-up to the previous experimental evaluations of passive nitrogen removal technologies conducted in Passive Nitrogen Removal Study I. The objective of the PNRS II study is to extend the two-stage biofiltration process into pilot testing to develop design criteria for subsequent full-scale field testing. A unique test facility was constructed for the purpose of the pilot evaluations. The Task A.15 PNRS II Quality Assurance Project Plan (QAPP) documents the objectives, experimental biofiltration systems, monitoring framework, sample frequency and duration, and analytical methods to be used at the PNRS II Test Facility.

2.0 Purpose

This data summary report documents data that was collected in the PNRS II monitoring and sampling event which was conducted January 13, 2011. The corresponding sample event report was submitted as Sample Event Report No. 4, January 2011, as a deliverable under Task A.25. The monitoring event consisted of an assessment and evaluation of PNRS II operation, measurement of flowrates for all systems and flowrate adjustment if warranted, measurement of field parameters, collection of biofilter influent and effluent samples, and their analyses in a NELAC certified laboratory.

3.0 Materials and Methods

3.1 Project Site

The PNRS II Test Facility is located at the University of Florida Gulf Coast Research and Education Center (GCREC) in southeast Hillsborough County, Florida. The specially designed facility enables the simultaneous operation and performance testing of numerous biofilter treatment trains in parallel using the same wastewater source. The source of the influent wastewater is the septic tank effluent from the existing onsite wastewater system serving the GCREC. Details of the design and construction of the PNRS II test facility were presented previously in Task A.17, A.18, A.19 and A.24 documents.

3.2 Modifications of PNRS II Systems

The results of Sample Event No. 1, 2 and 3 and careful observation of PNRS II systems were used to formulate recommendations for modifications to the test systems at the GCREC pilot facility. The modifications that were made following Sample Event No. 3 are presented in this section. All recommendations were based on the overall goal of PNRS II: to provide functional specifications for modular biofiltration components for passive onsite nitrogen reducing wastewater treatment systems.

3.2.1 Polystyrene Biofilter (UNSAT-PS1) Recycle Rate

In Sample Event 3, the unsaturated single pass biofilter with polystyrene media (UNSAT-PS1) exhibited better nitrogen performance as a recirculating system as compared to the single pass configuration during Sample Event 1 and 2. However, significant effluent NH_3-N remained, so the potential utility of polystyrene media in enhanced nitrogen reduction systems depends on further improving ammonia conversion to nitrate. The characteristics of the polystyrene media and the polystyrene based treatment process appear to function better with high recycle rates. Therefore, the Pump 15 runtime was increased so that the recycle ratio was increased to 6:1 from the previous 3:1 ratio.

3.3 Monitoring and Sampling Locations and Identification

A schematic of the PNRS II test facility is shown in Figure 1. Septic tank effluent (STE) from GCREC is pumped from PNRS II-STE-T1 into the PNRS II systems through four points of entry: Hydro-1, Hydro-2, UNSAT-IS1, and UNSAT-IS3. PNRS II biofilters are grouped into the four types of systems shown in Figure 1. The nomenclature and reactor/sample identification used for the PNRS II test facility sampling events are listed in Table 1. The sample designations listed in Table 1 also largely correspond to the locations at which flow volumes are measured in each monitoring event.

Table 1
PNRS II Sample Identification

Group (Figure 1)	Sample Location	Sample Identification
	STE PNRS II Storage Tank 1	PNRS II-STE-T1
I	Stage 1 Single Pass Biofilters	UNSAT-EC1
		UNSAT-EC3
		UNSAT-CL1
		UNSAT-CL3
	Stage 2 Single Pass Upflow Biofilters	DENIT-SU4
		DENIT-LS3
		DENIT-SU3
		DENIT-LS2
		DENIT-LS4
II	Recirculation Tanks	RC1
		RC2
		RC3
		RC4
		RC5
	Stage 1 Recirculating Biofilters	UNSAT-SA2
		UNSAT-EC4
		UNSAT-CL2
		UNSAT-CL4
		UNSAT-PS1
	Pump 15 Tank	P15
III	Denite Feed Collection Tank	DFT
	Stage 2 Horizontal Biofilters	UNSAT-SU1
		UNSAT-SU2
		UNSAT-LS1
		UNSAT-GL1
IV	In-Situ In-Tank Simulator Single Pass Biofilter	UNSAT-IS1
		UNSAT-IS2
		UNSAT-IS3
		UNSAT-IS4
	In-Situ In-Tank Simulator Single Pass Biofilter Sample Port (below EC & LS mixture and above SU layer)	UNSAT-IS3-SP UNSAT-IS4-SP

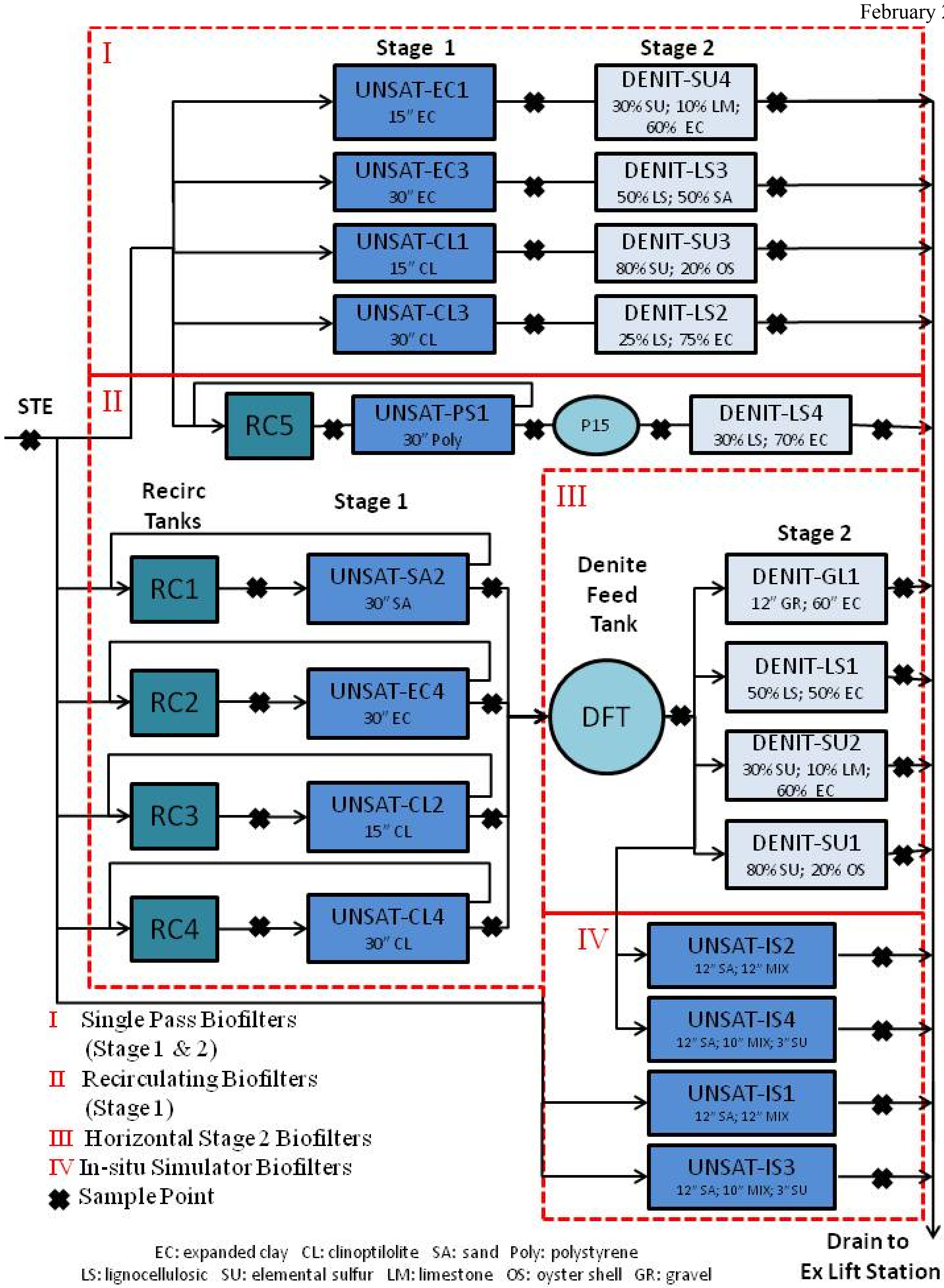

Figure 1
PNRS II Test Facility System Schematic

3.4 Operational Monitoring

Start-up of the PNRS II test facility occurred on May 17, 2010 and all systems have operated continually since that time. The entire facility operation is checked at least once per week and a detailed log of operational observations and activities is maintained. The programmable logic controller (PLC) which controls many of the dosing and pump controls also records pump run times and flow data from flow meters at the facility, and these data can provide useful insight on facility operations.

3.5 Water Quality Sample Collection and Analyses

Influent and effluent water quality samples from the PNRS II test systems for Sample Event 4 were collected January 13, 2011. A sample of STE was collected from the feed line connecting STE Storage Tank 1 (PNRS II-STE-T1) to Hydrosplitter 1 which supplies STE to the single pass Stage 1 biofilters (Figure 1). A manual dose event was initiated on the control panel until sufficient STE sample volume was collected in a clean sample container. Stage 1, 2, and in-situ simulator biofilter and recirculation tank effluents were each sampled by directing the entire flow from the biofilter into a large, clean sample container over a period of time sufficient to obtain the desired sample volume (approximately 3.5 liters). Sample containers were immediately placed in coolers on ice prior to subdivision of the composited sample.

The composite samples in the 3.5 liter sample containers were then subdivided into analysis-specific sample containers. The analysis-specific containers were supplied by the analytical laboratory and contained appropriate preservatives. The analysis-specific containers were labeled, placed in coolers and transported on ice to the analytical laboratory. Each sample container was secured in packing material as appropriate to prevent damage and spills, and was recorded on chain-of-custody forms supplied by the laboratory. Chain of custody forms, provided in Appendix D, were used to document the transfer of samples from field personnel to the analytical laboratory. One chain of custody form was filled out for each set of samples and placed inside the cooler.

Equipment blank, field blank, and field sample duplicates were taken. The equipment blank was collected using a previously cleaned STE sample collection bottle. The bottle was filled with distilled water provided by the laboratory and allowed to sit for eight minutes. The sample containers were then analyzed for the same parameters as the samples. The field blank was collected by filling sample containers with distilled water that had been transported from the laboratory into the field along with other sample containers. The field sample duplicates were collected immediately subsequent to the regular samples. The duplicate sample containers were filled with PNRS II T1-STE effluent, UNSAT-CL3 effluent, UNSAT-EC1 effluent, and UNSAT-CL1 effluent. Additionally, laboratory split duplicate samples were collected immediately subsequent to the regular samples. The laboratory split sample containers were filled with PNRS II T1-STE effluent, UNSAT-EC3 effluent, DENIT-LS1 effluent, UNSAT-IS3 effluent, and UNSAT-IS4 effluent.

Field parameters were measured using portable electronic probes and included temperature (Temp), dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, and specific conductance. Temperature (Temp), dissolved oxygen (DO), and oxidation-reduction potential (ORP) were measured with probe tips placed in flow through samplers located directly in the outlet pipe at each sample location. Specific conductance and pH were measured using external sample collection reservoirs. The influent and effluent samples were analyzed by the laboratory for: total alkalinity, total Kjeldahl nitrogen (TKN-N), ammonia nitrogen (NH_3-N), nitrate nitrogen, (NO_3-N), nitrite nitrogen (NO_2-N), carbonaceous biochemical oxygen demand ($CBOD_5$), total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD), total phosphorus (TP), and fecal coliform (fecal). For some of the denitrification biofilters containing elemental sulfur media, influent and effluent sample analyses were also conducted for sulfate (SO_4) and hydrogen sulfide (H_2S). Table 2 lists the analytical parameters, analytical methods, and detection limits for these analyses.

Table 2
Analytical Parameters, Method of Analysis, and Detection Limits

Analytical Parameter	Method of Analysis	Laboratory Detection Limit (mg/L)
Total Alkalinity as $CaCO_3$	SM 2320B	2 mg/L
Total Kjeldahl Nitrogen (TKN-N)	EPA351.2	0.05 mg/L
Ammonia Nitrogen (NH_3-N)	EPA350.1	0.01 mg/L
Nitrate/Nitrite Nitrogen (NO_X-N)	EPA353.2	0.01 mg/L
Carbonaceous BOD ($CBOD_5$)	SM 5210B	2 mg/L
Total Dissolved Solids (TDS)	SM 2540C	10 mg/L
Total Suspended Solids (TSS)	SM 2540D	1 mg/L
Chemical Oxygen Demand (COD)	EPA 410.4	10 mg/L
Total Phosphorus (TP)	SM 4500PE	0.01 mg/L
Fecal Coliform (fecal)	SM9222D	1 ct/100mL
Sulfate (SO_4)	EPA300.0	0.2 mg/L
Hydrogen Sulfide Unionized (H_2S)	SM4500S F	0.01 mg/L
Sulfide	SM4500S F	0.1 mg/L

3.6 Flow Monitoring

Flow rates for all PNRS II systems were calibrated at initial start-up. The flow rates are then measured and recorded at each sampling event and adjusted as necessary to maintain flow rates consistent with the experimental design following the sampling event. Flow volumes are measured just after sampling and field analyses and represent the flow rates in effect during the water quality monitoring. Flow rates are then adjusted as necessary to correspond to the target flow rates in the experimental design. For this Sampling Event, influent flow volumes were measured on January 17, 2011 and reported in the Sampling Event No. 4 Report. Flow monitoring results are presented in Appendix C.

4.0 Results and Discussion

4.1 Operational Monitoring

Start up of the PNRS II test facility occurred on May 17, 2010. The test systems have been operated continuously since the May 17th start up, with the exception of occasional power interruptions or outages (see operation and maintenance log). The power interruptions were of relatively short duration. For the most part, operation of the pilot biofilters was fully and automatically resumed when power was restored. The only exceptions are the three peristaltic pumps: Pump 5 which supplies the two In-Situ simulators UNSAT-IS1 and IS2, Pump 10 which supplies the two column In-Situ simulators UNSAT-IS3 and IS4, and Pump 11 which supplies the four horizontal flow denitrification biofilters. Initially, the peristaltic pumps displayed an error message and required manual restarting upon disruption of the power supply; their off times were somewhat longer than the other system pumps. The peristaltic pump settings were saved through the power outage, and the same pump operation was resumed once the error code was acknowledged. The peristaltic pumps have since been reprogrammed to start automatically in the event of temporary discontinuance of the power supply. Appendix A provides the operation and maintenance log which includes actions taken since start-up. Appendix B provides summary tables of the PLC recorded data of daily runtimes and flows for the test facility between November 11th and January 12th (Day 178 through Day 240 since start-up) used to check general pump operation and performance.

The recycle rates to the recirculating systems are monitored and recorded in the PLC as Pumps 5, 6, 7, 8, and 15 flows. The data shows that the recycle flows are very close to the initially set 44 gpd rate for Pumps 5, 6, 7, and 8, indicating that the desired recycle ratio of approximately 3:1 is being met. As discussed in Section 3.2.1, the Pump 15 flow rate was increased to 88 gpd rate so that the recycle ratio was increased to 6:1 from the previous 3:1 ratio

4.2 Water Quality Analyses

Water quality analytical results for Sample Event No. 4 are listed in Table 3. Quality Control samples, including field blanks, equipment blanks, and external duplicate and lab split samples are also included in this table. Results for the blanks were examined for obvious problems with sample contamination or improper decontamination of sampling equipment. Duplicate and split samples were examined for reproducibility, and where the differences were significant relative to the sample value, the laboratory was notified and requested to verify accuracy in reporting and reanalysis of the sample was requested if warranted. Significant difference determinations for the various lab analyses were based upon a review of reproducibility data in Standard Methods and EPA guidelines as well as on experience of the project team and data accuracy requirements for this project.

Table 4 shows the results of the QC sampling for this sample event, and a calculation of the percent difference between the sample value and the duplicate/split samples. The sample results that are highlighted in this table were forwarded back to the laboratories for verification and potential reanalysis. Any changes to these data from this verification will be reflected in the next data summary report.

A statistical summary of the water quality data collected to date for the PNRS II systems is presented in Table 5. The following discussion summarizes these results. The laboratory report containing the raw analytical data is included in Appendix D.

Influent Water Quality Water quality characteristics of STE collected in Sample Event 4 remained closer to typical STE composition than were STE samples collected earlier in the PNRS II study. Sample Event 4 STE parameters for TSS, COD, and $CBOD_5$ were still somewhat low, but within the range expected for domestic STE. The measured STE total nitrogen (TN) concentration was 66 mg/L, which is in the range that has been typically reported for Florida single family residence STE. The performance of the various biofilter systems was compared by considering the changes through treatment of nitrogen species (TKN-N, NH_3-N, and NO_X-N), as well as supporting water quality parameters.

Group 1 Single Pass Biofilters Effluent NH_3-N levels were below 2 mg/L for the four Stage 1 single pass biofilters and DO levels were greater than 7.9 mg/L (Table 3). Organic N ranged from 2.3 to 3.5 mg/L in these same four systems. NO_x was significantly increased in all Stage 1 biofilter effluents corresponding to the decrease in TKN.

Effluent NO_X-N was less than 0.13 mg/L in the two Stage 2 single pass denitrification biofilters with sulfur media. The three lignocellulosic biofilters (DENIT-LS2, DENIT-LS3, and DENIT-LS4) exhibited incomplete denitrification with effluent NO_x-N of 41, 43 and 3.4 mg/L, respectively. Although the denitrification performance of the denitrification biofilters was expected to be more or less equivalent to biofilters with sulfur and glycerol electron donor, lignocellulosic biofilter performance continued to be inferior. Possible reasons are lack of reactivity of lignocellulosic material, toxicity (release of toxic material from lignocellulosic material itself), or short circuiting within the biofilters.

The influent to the DENIT-LS4 biofilter was effluent from the recirculation pump tank for the polystyrene biofilter (UNSAT-PS1) which contained 17 mg/L NH_3-N and 12 mg/L NO_x-N. While somewhat successfully denitrifying the relatively low influent NO_x-N, DENIT-LS4 effluent contained 9.5 mg/L NH_3-N. This result again confirms that NH_3-N will be readily transported through anoxic denitrification biofilters which are at the same time capable of achieving significant NO_x reduction.

Group 2 Stage 1 Recirculating Biofilters NH_3-N levels were at or below 0.7 mg/L for the four recirculating Stage 1 biofilters containing clinoptilolite, expanded clay, and sand media, and effluent DO was 7.9 to 11.0 mg/L. Effluent NO_x-N ranged from 25 to 36 mg/L and organic N from 2.0 to 2.4 mg/L for these four recirculating Stage 1 biofilters. The nitrification performance of these biofilters was quite acceptable and TN reduction averaged 51%. The ammonia and DO concentrations in UNSAT-PS1 effluent were 16 mg/L and 5.2 mg/L, respectively, indicating incomplete nitrification. UNSAT-PS-1 also had significantly higher effluent TKN of 17 mg/L.

Group 3 Stage 2 Horizontal Biofilters Influent NOx-N to these biofilters was 29 mg/L. Effluent NO_x-N was 0.35 mg/L and less in three of four Stage 2 horizontal biofilters. The low NO_x-N were accompanied by depressed DO and ORP of -173 to –231 mV. Thus, three of the horizontal biofilters were effective in producing a reducing environment and achieving their NO_x-N reduction goal. DENIT-LS1 exhibited incomplete denitrification, with effluent NO_x-N of 22 mg/L.

Group 4 In-Situ Simulator Systems UNSAT-IS1, UNSAT-IS2 and UNSAT-IS4 exhibited low effluent NO_x-N of less than 0.4 mg/L. UNSAT-IS2 and UNSAT-IS4 exhibited a TN concentration less than 1.3 mg/L. For UNSAT-IS1, the effluent NO_x-N was low but effluent NH_3-N was 58 mg/L indicating incomplete nitrification as seen in Sample Event 2 and 3. UNSAT-IS3 exhibited effluent NO_x-N of 32.3 mg/L indicating incomplete denitrification. In-situ simulator effluent SO_4 concentrations were 7, 250, 120 and 110 mg/L, for IS1, IS2, IS3 and IS4 respectively.

Table 3
Water Quality Analytical Results

Group (Figure 1)	Sample ID	Media Composition	Analytical Laboratory	Sample Date/Time	Sample Type	Temp (°C)	pH	Total Alkalinity (mg/L)	DO (mg/L)	ORP (mV)	Specific Conductance (µS)	TDS (mg/L)	TSS (mg/L)	$CBOD_5$ (mg/L)	COD (mg/L)	TN (mg/L N)[1]	TKN (mg/L N)	Organic N (mg/L N)[2]	NH_3-N (mg/L N)	NO_3-N (mg/L N)	NO_2-N (mg/L N)	NOx (mg/L N)	TIN (mg/L N)[3]	TP (mg/L)	Sulfide (mg/L)	H_2S (mg/L)	SO_4 (mg/L)	Fecal (Ct/100 mL)
	STE Sample																											
	PNRS II STE-Tank 1		Southern	1/13/11 13:15	G	13.7	7.1	380	2.7	-236.5	1,220	470	83	78	230	66.0	66	9.0	57	0.02	0.01	0.03	57.03		16	6.9	13	8,900
	PNRS II STE-Tank 1-D		Southern	1/13/11 13:15	G	13.7	7.1	340	2.7	-236.5	1,220	470	64	85	280	62.1	62	4.0	58	0.05	0.01	0.06	58.06					11,100
	PNRS II STE-Tank 1-D2		Pace	1/13/11 13:15	G	13.7	7.1	351	2.7	-236.5	1,220	570	15.5	87.9	290	61.3	61.1	9.8	51.3	0.12	0.12	0.24	51.54	14.1			17.6	100
	Stage 1 Single Pass Biofilters Effluent																											
	UNSAT-EC1	15" Expanded Clay	Southern	1/13/11 12:05	G	7.8	6.7	160	7.9	36.5	1,110	730	1	2	16	49.1	4.0	2.3	1.7	45	0.11	45.11	46.81				61	3,900
	UNSAT-EC1-D	15" Expanded Clay	Southern	1/13/11 12:05	G	7.8	6.7	180	7.9	36.5	1,110	720	1	2	24	48.2	4.1	2.5	1.6	44	0.11	44.11	45.71					3,000
	UNSAT-EC3	30" Expanded Clay	Southern	1/13/11 12:05	G	6.3	6.8	210	7.9	38.7	1,150	740	1	2	11	47.5	3.5	3.5	0.005	44	0.01	44.01	44.02					4
	UNSAT-EC3-D	30" Expanded Clay	Pace	1/13/11 12:05	G	6.3	6.8	222	7.9	38.7	1,150	914	5	3	16.2	35.8	0.42	0.4	0.020	35.1	0.25	35.35	35.37	5.6			64.4	12
	UNSAT-CL1	15" Clinoptilolite	Southern	1/13/11 11:45	G	8.2	7.2	180	8.8	32.3	1,200	710	1	2	16	33.9	2.7	2.7	0.020	31	0.16	31.16	31.18				59	100
	UNSAT-CL1-D	15" Clinoptilolite	Southern	1/13/11 11:45	G	8.2	7.2	280	8.8	32.3	1,200	700	3	2	20	24.1	2.9	2.9	0.020	21	0.18	21.18	21.20					40
1	UNSAT-CL3	30" Clinoptilolite	Southern	1/13/11 12:05	G	8.3	7.3	300	9.9	20.2	1,300	810	1	2	13	43.8	2.7	2.7	0.016	41	0.07	41.07	41.09					110
	UNSAT-CL3-D	30" Clinoptilolite	Southern	1/13/11 12:05	G	8.3	7.3	280	9.9	20.2	1,300	840	2	2	16	42.9	2.8	2.8	0.018	40	0.06	40.06	40.08					25
	Stage 2 Single Pass Upflow Biofilters Effluent																											
	DENIT-SU4	10% Limestone; 30% Sulfur; 60% Expanded Clay	Southern	1/13/11 9:00	G	7.0	6.8	240	4.2	-99.6	1,350	1,000	2	2	20	1.3	1.2	1.0	0.22	0.10	0.03	0.13	0.35		0.14	0.08	420	3
	DENIT-LS3	50% Lignocellulosic; 50% Sand	Southern	1/13/11 9:00	G	6.6	6.7	240	5.4	-79	1,150	790	1	2	16	45.4	2.3	2.3	0.012	43	0.05	43.05	43.06					1
	DENIT-SU3	80% Sulfur; 20% Oyster Shell	Southern	1/13/11 9:00	G	6.9	6.9	280	2.8	-208.7	1,420	1,000	11	9	50	3.0	2.9	2.1	0.80	0.01	0.04	0.05	0.85				380	6
	DENIT-LS2	25% Lignocellulosic; 75% Expanded Clay	Southern	1/13/11 9:00	G	6.8	7.3	340	5.0	-135	1,300	860	1	2	16	43.8	2.7	2.6	0.085	41	0.07	41.07	41.16					1
	DENIT-LS4	30% Lignocellulosic; 70% Expanded Clay	Southern	1/13/11 9:00	G	7.4	7.3	230	5.2	-98.6	810	460	118	4	22	15.4	12	2.5	9.5	3.1	0.29	3.39	12.89					1
	Recirculation Tanks Effluent																											
	RC1		Southern	1/13/11 11:45	G	7.2	7.2	190	1.6	-0.9	950	520	7	11	37	26.5	12	1.0	11	14	0.53	14.53	25.53					8,200
	RC2		Southern	1/13/11 11:40	G	7.4	7.1	200	2.5	-5	1,000	570	4	9	41	29.2	13	0.0	13	16	0.22	16.22	29.22					9,100
	RC3		Southern	1/13/11 11:40	G	7.4	6.9	220	2.0	-21.7	990	560	13	12	46	28.4	12	1.0	11	14	2.4	16.40	27.40					13,000
	RC4		Southern	1/13/11 12:30	G	8.3	7.3	280	0.4	-121.9	1,050	600	12	9	57	31.5	18	2.0	16	10	3.5	13.50	29.50					8,700
	RC5		Southern	1/13/11 11:10	G	7.9	7.1	220	1.5	-120.7	930	500	17	16	57	36.9	29	6.0	23	6.3	1.6	7.90	30.90					12,700
2	**Stage 1 Recirculating Biofilters Effluent**																											
	UNSAT-CL4	30" Clinoptilolite	Southern	1/13/11 11:15	G	7.9	7.3	170	11.0	55.5	970	660	1	2	13	38.4	2.2	2.2	0.011	36	0.15	36.15	36.16					1
	UNSAT-CL2	15" Clinoptilolite	Southern	1/13/11 9:50	G	6.0	7.0	180	7.9	-88.9	990	600	1	3	16	29.2	2.0	2.0	0.019	27	0.23	27.23	27.25					730
	UNSAT-EC4	30" Expanded Clay	Southern	1/13/11 10:10	G	7.0	6.9	150	10.0	-88.8	960	600	1	2	16	32.9	2.4	2.4	0.038	30	0.50	30.50	30.54					21
	UNSAT-SA2	30" Sand	Southern	1/13/11 10:10	G	6.2	6.8	150	9.6	-70.8	900	550	1	3	16	28.7	3.0	2.3	0.66	25	0.71	25.71	26.37					41
	UNSAT-PS1	30" Polystyrene	Southern	1/13/11 10:15	G	5.8	7.3	200	5.2	-28.5	930	490	9	12	52	28.3	17	1.0	16	10	1.3	11.30	27.30					9,500
	Pump 15 Tank (DENIT-LS4 Influent)		Southern	1/13/11 9:20	G	5.0	7.0	200	6.4	-26.9	900	510	4	10	41	33.2	21	4.0	17	11	1.2	12.20	29.20					3,900
	Denite Feed Tank (Tank 3)																											
	DFT		Southern	1/13/11 10:35	G	6.4	7.0	160	9.8	-40.9	950	590	1	2	46	31.5	2.4	2.3	0.054	29	0.06	29.06	29.11				67	22
	Stage 2 Horizontal Biofilters Effluent																											
3	DENIT-SU1	80% Sulfur; 20% Oyster Shell	Southern	1/13/11 8:00	G	0.2	6.8	220	1.2	-231.2	1,080	760	1	8	22	3.0	2.6	2.1	0.46	0.11	0.24	0.35	0.81				270	5
	DENIT-SU2	10% Limestone; 30% Sulfur; 60% Expanded Clay	Southern	1/13/11 8:00	G	0.3	6.8	200	1.6	-212.2	1,130	740	1	6	24	1.2	1.1	0.8	0.30	0.01	0.05	0.06	0.36		4.3	2.6	300	3
	DENIT-LS1	50% Lignocellulosic; 50% Expanded Clay	Southern	1/13/11 8:00	G	0.3	7.0	190	0.6	-173.1	910	590	1	2	16	23.9	1.8	1.8	0.007	22	0.1	22.10	22.11					1
	DENIT-LS1-D	50% Lignocellulosic; 50% Expanded Clay	Pace	1/13/11 8:00	G	0.3	7.0	219	0.6	-173.1	910	640	5	3	20.5	22.3	0.63	0.6	0.020	21.5	0.12	21.62	21.64	5.2			55.5	
	DENIT-GL1	12" Gravel; 60" Expanded Clay	Southern	1/13/11 8:00	G	0.3	6.6	400	0.9	-208.7	1,000	540	3	17	48	6.5	6.3	0.5	5.8	0.11	0.04	0.15	5.95					1
	In-situ Simulator Biofilters Effluent																											
	UNSAT-IS1 (receives STE)	15" Sand; 12" Mix (45% EC, 35% Ligno, 20% Sulfur)	Southern	1/13/11 10:00	G	1.2	6.7	430	0.4	-141.2	1,200	480	7	65	120	64.4	64	6.0	58	0.08	0.29	0.37	58.37				7	10
	UNSAT-IS2 (receives NO_3)	12" Sand; 12" Mix (45% EC, 35% Ligno, 20% Sulfur)	Southern	1/13/11 8:15	G	6.2	6.8	200	3.9	-234.5	680	710	1	6	18	1.3	1.1	0.6	0.53	0.01	0.21	0.22	0.75				250	1
	UNSAT-IS3-SP (receives STE)	12" Sand; 10" Mix (60% EC, 40% Ligno)	Southern	1/13/11 14:10	G	4.0	7.5	210	12	39.2	980	600	3	2	26	7.7	1.8	1.8	0.036	3.70	2.20	5.90	5.94				130	
4	UNSAT-IS3 (receives STE)	12" Sand; 10" Mix (60% EC, 40% Ligno); 3" Sulfur	Southern	1/11/11 8:20	G	11.6	6.97	300	0.4	136.5	1,331	850	10	2	31	36.4	4.1	2.9	1.2	24.0	8.3	32.30	33.50				120	
	UNSAT-IS3 (receives STE)	12" Sand; 10" Mix (60% EC, 40% Ligno); 3" Sulfur	Pace	1/11/11 8:20	G	11.6	6.97	280	0.4	136.5	1,331	868	10		24.2	41.8	1.9	0.8	1.1	31.3	8.6	39.90	41.00	0.50			116	1
	UNSAT-IS4-SP (receives NO_3)	12" Sand; 10" Mix (60% EC, 40% Ligno)	Southern	1/13/11 14:00	G	5.1	6.60	100	12.0	35.1	1,050	710	1	2	22	52.4	3.5	3.4	0.1	46.0	2.9	48.90	49.00				92	1
	UNSAT-IS4 (receives NO_3)	12" Sand; 10" Mix (60% EC, 40% Ligno); 3" Sulfur	Southern	1/11/11 8:30	G	11.6	7.08	260	1.0	150.4	993	620	7	2	29	1.0	0.87	0.8	0.092	0.11	0.01	0.12	0.21				110	
	UNSAT-IS4 (receives NO_3)	12" Sand; 10" Mix (60% EC, 40% Ligno); 3" Sulfur	Pace	1/11/11 8:30	G	11.6	7.08	264	1.0	150.4	993	637	5.0		29.5	1.1	1.0	0.9	0.052	0.050	0.050	0.10	0.15	3.9			119	1
	Field Blank	Reagent Water	Southern	1/13/11 8:45		5.0	7.0	2	9.8	-54.6	40	10	1	2	10	0.1	0.05	0.05	0.005	0.01	0.01	0.02	0.03					1
	Equipment Blank	Reagent Water - Cleaned STE Bottle #2	Southern	1/13/11 11:30		5.3	7.0	2	9.8	-54.6	40	10	1	2	10	0.1	0.05	0.04	0.008	0.01	0.01	0.02	0.03					1

Notes:

[1]Total Nitrogen (TN) is a calculated value equal to the sum of TKN and NO_x

[2]Organic Nitrogen (ON) is a calculated value equal to the difference of TKN and NH_3

[3]Total Inorganic Nitrogen (TIN) is a calculated value equal to the sum of NH_3 and NO_x

EC: expanded clay, CL: clinoptilolite, PS: polystyrene, SU: elemental sulfur, LS: lignocellulosic, GL: glycerol, OS: oyster shell, NS: sodium sesquicarbonate, GR: gravel

D.O. - Dissolved oxygen

G - Grab sample

Gray-shaded data points indicate values below method detection level (mdl), mdl value used for statistical analyses.

Yellow-shaded data points indicate the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit, value used for statistical analysis.

Table 4
Sample Event No. 4 External QC Sample Results

Sample ID	Total Alkalinity (mg/L)		TDS (mg/L)		TSS (mg/L)		$CBOD_5$ (mg/L)		COD (mg/L)		TKN (mg/L N)		NH_3-N (mg/L N)		NO_3-N (mg/L N)		NO_2-N (mg/L N)		SO_4 (mg/L)		Fecal (Ct/100 mL)	
	Value	% diff	Value	% diff	Value	% diff	Value	% diff	Value	% diff	Value	% diff	Value	% diff	Value	% diff	Value	% diff	Value	% diff	Value	% diff
STE Lab	380		470		83		78		230		66		57		0.02		0.01		13		8,900	
STE Dup	340	-10.5%	470	0.0%	64	-22.9%	85	9.0%	280	21.7%	62	-6.1%	58	1.8%	0.05		0.01	0.0%			11,100	
STE Split	351	-7.6%	570	21.3%	15.5	-81.3%	87.9	12.7%	290	26.1%	61.1	-7.4%	51.3	-10.0%	0.12	MDL	0.12	MDL	17.6	35.4%	100	
EC1 Lab	160		730		1		2		16		4.0		1.7		45		0.11		61		3,900	
EC1 Dup	180	12.5%	720	-1.4%	1	0.0%	2	0.0%	24	50.0%	4.1	2.5%	1.6	-5.9%	44	-2.2%	0.11	0.0%			3,000	
EC3 Lab	210		740		1		2		11		3.5		0.005		44		0.01				4	
EC3 Split	222	5.7%	914	23.5%	5	MDL	3	MDL	16.2	47.3%	0.42	-88.0%	0.020	MDL	35.1	-20.2%	0.25	MDL	64.4		12	
CL1 Lab	180		710		1		2		16		2.7		0.020		31		0.16		59		100	
CL1 Dup	280	55.6%	700	-1.4%	3	N/A	2	0.0%	20	25.0%	2.9	7.4%	0.020	0.0%	21	-32.3%	0.18	12.5%			40	
CL3 Lab	300		810		1		2		13		2.7		0.016		41		0.07				110	
CL3 Dup	280	-6.7%	840	3.7%	2	N/A	2	0.0%	16	23.1%	2.8	3.7%	0.018	12.5%	40	-2.4%	0.06	-14.3%			25	
LS1 Lab	190		590		1		2		16		1.8		0.007		22		0.1				1	
LS1 Split	219	15.3%	640	8.5%	5	MDL	3	MDL	20.5	28.1%	0.63	-65.0%	0.020	MDL	21.5	-2.3%	0.12	MDL	55.5			
IS3 Lab	300		850		10		2		31		4.1		1.2		24.0		8.3		120			
IS3 Split	280	-6.7%	868	2.1%	10	0.0%			24.2	-21.9%	1.9	-53.7%	1.1	-8.3%	31.3	30.4%	8.6	3.6%	116	-3.3%	1	
IS4 Lab	260		620		7		2		29		0.87		0.092		0.11		0.01		110			
IS4 Split	264	1.5%	637	2.7%	5.0	MDL			29.5	1.7%	1.0	14.9%	0.052	-43.5%	0.050	-54.5%	0.050	MDL	119	8.2%	1	
Field Blank	2		10		1		2		10		0.05		0.005		0.01		0.01				1	
Equipment Blank	2		10		1		2		10		0.05		0.008		0.01		0.01				1	

Table 5
Statistical Summary of Water Quality Data

Sample ID	Media Composition	Statistical Parameter	Temp (°C)	pH	Total Alkalinity (mg/L)	DO (mg/L)	ORP (mV)	Specific Conductance (µS)	TDS (mg/L)	TSS (mg/L)	$CBOD_5$ (mg/L)	COD (mg/L)	TN (mg/L N)[1]	TKN (mg/L N)	Organic N (mg/L N)[2]	NH3-N (mg/L N)	NO_3-N (mg/L N)	NO_2-N (mg/L N)	NOx (mg/L N)	TIN (mg/L N)[3]	TP (mg/L)	Sulfide (mg/L)	H_2S (mg/L)	SO_4 (mg/L)	Fecal (Ct/100 mL)
STE Sample																									
STE-Tank 1		n	12	12	10	9	8	12	10	12	12	8	10	12	10	10	3	3	10	9	4	3	4	5	7
		MEAN	23.2		333.5	1.4	-252.8	1077.3	417.7	39.4	71.2	247.6	58.0	59.0	8.0	49.9	0.06	0.05	0.06	47.3	8.8	15.7	8.4	13.9	
		STD. DEV.	5.9		77.6			212.0	89.9	27.7	29.7		20.6	18.9	4.6	19.2	0.05	0.06	0.07	18.3	3.6	0.6	2.9	12.5	
		MIN	13.7	6.4	210.0	0.0	-308.9	649.0	240.0	12.8	22.0	210.0	25.9	25.9	-0.7	20.0	0.02	0.01	0.01	20.0	6.6	15.0	5.4	2.8	80
		MAX	28.3	7.3	430.0	2.7	-230.0	1250.0	570.0	83.0	100.0	290.0	85.1	85.0	15.0	74.0	0.12	0.12	0.24	67.0	14.1	16.0	12.0	33.0	77000
Stage 1 Single Pass Biofilters Effluent																									
UNSAT-EC1	15" Expanded Clay	n	5	5	5	5	4	5	5	5	5	4	5	5	5	5	2	2	5	5	1	3	3	4	3
		MEAN	18.4		152.0	7.4	79.6	1008.4	648.0	1.0	2.0	15.8	46.3	3.9	3.0	0.9	44.5	0.1	42.4	43.4	3.9	0.4	0.0	54.8	
		STD. DEV.	10.1		31.1			221.4	170.4	0.0	0.0		16.3	1.0	0.9	0.8	0.7	0.0	15.3	15.9		0.5	0.03	7.5	
		MIN	7.8	6.7	110.0	6.8	36.5	617.0	350.0	1.0	2.0	10.0	21.2	2.2	2.2	0.01	44.0	0.11	19.0	19.0	3.9	0.1	0.01	46.0	1.0
		MAX	28.6	7.3	180.0	7.9	137.5	1150.0	770.0	1.0	2.0	24.0	66.8	4.8	4.3	1.7	45.0	0.1	62.0	63.3	3.9	1.0	0.1	61.0	3900.0
UNSAT-EC3	30" Expanded Clay	n	5	5	5	5	4	5	5	5	5	4	5	5	5	5	2	2	5	5	2				3
		MEAN	18.2		177.2	7.2	74.9	1079.0	730.8	2.0	2.2	13.3	47.1	2.9	2.4	0.5	39.6	0.1	44.3	44.8	4.8				
		STD. DEV.	11.2		59.9			210.3	194.2	1.7	0.4		24.0	1.7	1.2	1.1	6.3	0.2	22.8	23.7					
		MIN	6.3	6.8	84.0	6.7	38.7	712.0	410.0	1.0	2.0	10.0	21.2	0.4	0.4	0.005	35.1	0.01	19.0	19.0	3.9				1.0
		MAX	29.2	7.3	222.0	7.9	117.0	1250.0	914.0	5.0	3.0	16.2	85.9	4.9	3.5	2.4	44.0	0.3	81.0	83.4	5.6				12.0
UNSAT-CL1	15" Clinoptilolite	n	5	5	5	5	4	5	5	5	5	4	5	5	5	5	2	2	5	5	1	3	3	4	4
		MEAN	19.0		234.0	6.8	71.6	1131.6	686.0	2.6	2.0	16.5	33.2	2.7	2.7	0.013	26.000	0.170	30.5	30.5	8.0	0.5	0.03	51.5	
		STD. DEV.	10.2		36.5			161.4	127.0	2.6	0.0		10.9	0.1	0.1	0.007	7.071	0.014	11.0	11.0		0.5	0.04	11.4	
		MIN	8.2	7.1	180.0	3.5	32.3	857.0	470.0	1.0	2.0	10.0	20.7	2.6	2.6	0.005	21.000	0.160	18.0	18.0	8.0	0.1	0.01	37.0	10
		MAX	29.5	8.3	280.0	8.8	116.2	1271.0	800.0	7.0	2.0	20.0	46.6	2.9	2.9	0.020	31.000	0.180	44.0	44.0	8.0	1.0	0.08	62.0	100
UNSAT-CL3	30" Clinoptilolite	n	5	5	5	5	4	5	5	5	5	4	5	5	5	5	2	2	5	5	1				3
		MEAN	18.8		296.0	8.3	56.2	1248.4	774.0	1.4	2.0	19.5	46.4	3.0	3.0	0.012	40.500	0.065	43.4	43.4	6.8				
		STD. DEV.	9.9		27.0			159.0	126.2	0.5	0.0		22.0	0.6	0.6	0.005	0.707	0.007	22.1	22.1					
		MIN	8.3	7.3	270.0	6.9	20.2	974.0	550.0	1.0	2.0	13.0	22.8	2.7	2.7	0.005	40.000	0.060	20.0	20.0	6.8				3.0
		MAX	28.7	8.6	340.0	9.9	100.5	1388.0	850.0	2.0	2.0	29.0	82.7	4.0	4.0	0.018	41.000	0.070	80.0	80.0	6.8				110.0
UNSAT-PS1 (old)	30" Polystyrene	n	2	2	2	2	1	2	2	2	2	1	2	2	2	2	0	0	2	2	1				1
		MEAN	27.8		220.0	2.6	60.0	804.5	345.0	3.0	4.4	48.0	43.3	34.5	8.3	26.2	0.0	0.0	8.8	35.0	5.9				
		STD. DEV.	1.1		84.9			290.6	106.1	1.4	1.9		25.4	26.2	1.8	28.0	0.0	0.0	0.8	27.2					
		MIN	27.0	7.3	160.0	2.5	60.0	599.0	270.0	2.0	3.0	48.0	25.3	16.0	7.0	6.4	0.0	0.0	8.2	15.7	5.9				930
		MAX	28.6	7.6	280.0	2.7	60.0	1010.0	420.0	4.0	5.7	48.0	61.2	53.0	9.6	46.0	0.0	0.0	9.3	54.2	5.9				930
Stage 2 Single Pass Upflow Biofilters Effluent																									
DENIT-SU4 (old)	80% Sulfur; 20% Sodium Sesqui.	n	2	2	2	2	1	2	2	2	2	1	2	2	2	2			2	2	1	2	2	2	1
		MEAN	27.6		145.0	0.2	-106.6	1162.0	755.0	1.0	3.0	22.0	1.1	1.0	0.8	0.2			0.1	0.3	3.2	1.0	0.3	405.0	
		STD. DEV.	-		7.1			329.5	275.8	0.0	1.3		0.4	0.4	0.2	0.1			0.1	0.2		1.2	0.4	205.1	
		MIN	27.1	6.6	140.0	0.1	-106.6	929.0	560.0	1.0	2.0	22.0	0.8	0.8	0.7	0.1			0.01	0.1	3.2	0.1	0.01	260.0	1.0
		MAX	28.1	7.3	150.0	0.2	-106.6	1395.0	950.0	1.0	3.9	22.0	1.4	1.3	1.0	0.3			0.1	0.4	3.2	1.8	0.6	550.0	1.0
DENIT-SU4 (new)	10% Limestone; 30% Sulfur; 60% Expanded Clay	n	3	3	2	3	3	3	2	2	2	2	2	2	2	2	1	1	2	2		2	2	2	
		MEAN	16		225	4.5	-27	1506	1050	4	2	17	1.1	1.0	0.9	0.2	0.1	0.03	0.08	0.24		1	0.09	490	
		STD. DEV.	-		21			155	71	3	0		0.3	0.2	0.1	0.1			0.08	0.16		0.61	0.01	98.99	
		MIN	7	7	210	1.6	-118	1350	1000	2	2	13	0.9	0.9	0.8	0.1	0.1	0.03	0.02	0.12		0.14	0.08	420	
		MAX	21	7	240	7.8	138	1659	1100	6	2	20	1.3	1.2	1.0	0.2	0.1	0.03	0.13	0.35		1.00	0.09	560	
DENIT-LS3	50% Lignocellulosic; 50% Sand	n	5	5	4	5	4	5	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	19.9		220.0	2.8	56.7	1118.2	670.0	1.3	4.5	18.7	26.5	3.0	2.5	0.4	43.0	0.1	23.5	23.9	3.3				
		STD. DEV.	8.9		16.3			267.1	210.9	0.5	5.0		18.4	1.0	1.2	0.4			18.3	17.9					
		MIN	6.6	6.7	200.0	0.1	-79.0	695.0	370.0	1.0	2.0	11.0	2.0	2.0	1.1	0.0	43.0	0.1	0.01	1.0	3.3				1.0
		MAX	28.1	7.7	240.0	5.4	259.3	1432.0	840.0	2.0	12.0	29.0	45.4	4.3	3.8	1.0	43.0	0.1	43.1	43.1	3.3				1.0
DENIT-SU3	80% Sulfur; 20% Oyster Shell	n	5	5	4	5	4	5	4	4	4	3	4	4	4	4	1	1	4	4	1	3	3	4	2
		MEAN	20.8		245.0	2.2	-220.0	1472.2	952.5	7.5	6.8	38.3	2.4	2.4	1.7	0.7	0.01	0.04	0.04	0.7	6.2	4.7	2.4	430.0	
		STD. DEV.	8.6		50.7			148.7	168.4	7.2	5.2		0.5	0.5	0.5	0.2			0.02	0.2		2.3	1.9	92.0	
		MIN	6.9	6.7	170.0	0.1	-279.6	1257.0	710.0	1.0	2.0	26.0	1.9	1.8	1.2	0.5	0.01	0.04	0.01	0.5	6.2	2.4	0.9	340.0	1.0
		MAX	28.4	7.2	280.0	7.7	-180.0	1655.0	1100.0	16.0	13.0	50.0	3.0	2.9	2.2	0.8	0.01	0.04	0.1	0.9	6.2	7.0	4.5	550.0	6.0
DENIT-LS2 (old)	50% Lignocellulosic; 50% Expanded Clay	n	2	2	2	2	1	2	2	2	2	1	2	2	2	2			2	2	1				1
		MEAN	27.3		375.0	2.1	-11.5	1223.0	680.0	5.0	3.8	24.0	17.5	2.3	2.0	0.3			15.2	15.5	5.7				
		STD. DEV.	0.1		7.1			318.2	240.4	5.7	2.5		20.7	1.2	1.2	0.0			19.5	19.6					
		MIN	27.2	7.8	370.0	0.1	-11.5	998.0	510.0	1.0	2.0	24.0	2.8	1.4	1.2	0.2			1.4	1.6	5.7				1.0
		MAX	27.3	8.1	380.0	4.1	-11.5	1448.0	850.0	9.0	5.5	24.0	32.1	3.1	2.8	0.3			29.0	29.3	5.7				1.0
DENIT-LS2 (new)	25% Lignocellulosic; 75% Expanded Clay	n	3	3	2	3	3	3	2	2	2	2	2	2	2	2	1	1	2	2					1
		MEAN	15.4		330.0	4.5	66.4	1315.7	820.0	1.5	2.0	21.0	31.8	3.3	3.2	0.1	41.0	0.1	28.5	28.6					0.0
		STD. DEV.	7.7		14.1			124.2	56.6	0.7	0.0		16.9	0.8	0.8	0.0			17.7	17.7					0.0
		MIN	6.8	7.3	320.0	4.1	-135.0	1200.0	780.0	1.0	2.0	16.0	19.8	2.7	2.6	0.1	41.0	0.1	16.0	16.1					1.0
		MAX	21.5	7.6	340.0	5.0	263.1	1447.0	860.0	2.0	2.0	26.0	43.8	3.8	3.7	0.1	41.0	0.1	41.1	41.2					1.0
DENIT-LS4	30% Lignocellulosic; 70% Expanded Clay	n	5	5	5	5	4	5	5	5	5	3	4	4	4	4	1	1	4	4	1				2
		MEAN	20.1		264.0	2.3	-49.8	897.4	412.0	24.6	3.8	25.7	31.8	28.5	12.7	15.8	3.1	0.3	3.3	19.2	6.9				
		STD. DEV.	8.3		85.0			197.0	82.9	52.2	3.1		24.8	26.0	14.4	12.1			4.6	12.2					
		MIN	7.4	7.3	180.0	0.4	-137.8	618.0	270.0	1.0	2.0	20.0	14.0	12.0	2.5	5.8	3.1	0.3	0.01	5.8	6.9				1.0
		MAX	28.1	7.6	360.0	5.2	81.0	1120.0	480.0	118.0	9.1	35.0	67.2	67.0	34.0	33.0	3.1	0.3	9.8	33.2	6.9				12.0

Table 5 (con't)
Statistical Summary of Water Quality Data

Sample ID	Media Composition	Statistical Parameter	Temp (°C)	pH	Total Alkalinity (mg/L)	DO (mg/L)	ORP (mV)	Specific Conductance (µS)	TDS (mg/L)	TSS (mg/L)	$CBOD_5$ (mg/L)	COD (mg/L)	TN (mg/L N)[1]	TKN (mg/L N)	Organic N (mg/L N)[2]	NH3-N (mg/L N)	NO_3-N (mg/L N)	NO_2-N (mg/L N)	NOx (mg/L N)	TIN (mg/L N)[3]	TP (mg/L)	Sulfide (mg/L)	H_2S (mg/L)	SO_4 (mg/L)	Fecal (Ct/100 mL)
Recirculation Tanks Effluent																									
RC1		n	4	4	4	3	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	22.2		185.0	1.2	-24.1	899.5	495.0	4.0	5.5	29.3	36.9	15.3	4.8	10.4	14.0	0.5	21.6	32.1	5.8				
		STD. DEV.	11.0		20.8			177.0	112.7	2.6	4.1		12.7	2.4	3.4	3.3			10.9	13.6					
		MIN	7.2	7.2	160.0	0.03	-128.3	637.0	330.0	1.0	2.0	22.0	26.5	12.0	1.0	5.7	14.0	0.5	12.0	17.7	5.8				114.0
		MAX	30.8	7.3	210.0	2.1	57.0	1011.0	580.0	7.0	11.0	37.0	53.0	17.0	9.3	13.0	14.0	0.5	36.0	49.0	5.8				8200.0
RC2		n	4	4	4	3	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	21.9		182.5	1.4	-18.2	932.5	515.0	2.5	5.3	33.3	34.8	16.0	4.4	11.6	16.0	0.2	18.8	30.4	4.2				
		STD. DEV.	10.9		31.0			169.5	117.3	1.3	3.8		7.9	2.6	4.3	4.3			5.7	9.6					
		MIN	7.4	7.1	140.0	0.1	-108.2	679.0	340.0	1.0	2.0	24.0	27.0	13.0	0.0	5.3	16.0	0.2	12.0	17.3	4.2				99.0
		MAX	30.5	7.3	210.0	2.5	58.5	1031.0	590.0	4.0	9.0	41.0	43.0	19.0	9.7	15.0	16.0	0.2	24.0	38.0	4.2				9100.0
RC3		n	4	4	4	3	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	21.5		210.0	1.5	41.6	979.5	515.0	6.5	6.6	48.7	34.1	14.8	5.5	9.3	14.0	2.4	19.4	28.7	6.4				
		STD. DEV.	10.6		41.6			157.1	104.7	4.9	4.7		8.3	3.4	4.2	2.9			9.5	10.3					
		MIN	7.4	6.9	160.0	0.1	-21.7	760.0	360.0	1.0	2.0	39.0	27.0	12.0	1.0	5.5	14.0	2.4	11.0	16.5	6.4				109.0
		MAX	30.2	7.6	260.0	2.3	89.0	1128.0	590.0	13.0	12.0	61.0	45.0	19.0	10.5	12.0	14.0	2.4	33.0	41.7	6.4				13000.0
RC4		n	4	4	4	3	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	21.8		235.0	0.8	0.1	1015.8	552.5	11.8	4.7	37.3	32.9	15.5	5.0	10.5	10.0	3.5	17.4	27.9	6.7				
		STD. DEV.	10.2		44.3			138.9	102.4	7.8	2.9		4.7	3.1	3.9	4.5			7.0	8.0					
		MIN	8.3	7.3	180.0	0.0	-121.9	811.0	400.0	2.0	2.7	26.0	27.0	11.0	2.0	5.5	10.0	3.5	11.0	16.5	6.7				112.0
		MAX	30.4	7.8	280.0	1.9	73.0	1112.0	620.0	21.0	9.0	57.0	38.0	18.0	10.5	16.0	10.0	3.5	27.0	35.4	6.7				8700.0
RC5		n	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2					
		MEAN	15.0		240.0	2.4	-12.4	990.0	490.0	12.5	12.0	59.0	41.0	30.0	4.5	25.5	6.3	1.6	11.0	36.5					
		STD. DEV.																							
		MIN	7.9	7.1	220.0	1.5	-120.7	930.0	480.0	8.0	8.0	57.0	36.9	29.0	3.0	23.0	6.3	1.6	7.9	30.9					
		MAX	22.0	7.3	260.0	3.3	96.0	1050.0	500.0	17.0	16.0	61.0	45.0	31.0	6.0	28.0	6.3	1.6	14.0	42.0					
Stage 1 Recirculating Biofilters Effluent																									
UNSAT-CL4	30" Clinoptilolite	n	4	4	4	4	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	22.1		207.5	8.3	47.9	1011.0	620.0	2.8	2.0	12.3	34.1	2.3	2.3	0.01	36.00	0.15	31.8	31.8	7.6				
		STD. DEV.	9.8		47.9			131.5	93.8	3.5	0.0		16.1	0.2	0.2	0.01			16.2	16.1					
		MIN	7.9	6.7	170.0	7.1	35.5	860.0	480.0	1.0	2.0	11.0	10.3	2.1	2.1	0.005	36.000	0.150	7.9	7.9	7.6				1.0
		MAX	29.3	7.8	270.0	11.0	55.5	1174.0	680.0	8.0	2.0	13.0	45.1	2.6	2.6	0.02	36.00	0.15	43.0	43.0	7.6				1.0
UNSAT-CL2	15" Clinoptilolite	n	4	4	4	4	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	20.8		175.0	6.6	-2.8	955.3	580.0	1.8	2.3	20.7	36.9	2.4	2.4	0.011	27.000	0.230	34.6	34.6	7.1				
		STD. DEV.	10.0		37.9			119.1	95.6	1.0	0.5		17.3	0.5	0.5	0.006			17.0	17.0					
		MIN	6.0	7.0	120.0	5.4	-88.9	781.0	440.0	1.0	2.0	16.0	17.1	2.0	2.0	0.005	27.000	0.230	15.0	15.0	7.1				4.0
		MAX	27.1	7.9	200.0	7.9	50.2	1050.0	650.0	3.0	3.0	24.0	56.3	3.1	3.1	0.019	27.000	0.230	54.0	54.0	7.1				730.0
UNSAT-EC4	30" Expanded Clay	n	4	4	4	4	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	21.3		145.0	7.9	12.2	900.3	562.5	1.3	2.0	13.0	36.3	2.4	2.4	0.02	30.00	0.50	33.9	33.9	3.8				
		STD. DEV.	9.9		12.9			160.3	143.8	0.5	0.0		14.0	0.4	0.4	0.02			13.8	13.8					
		MIN	7.0	6.9	130.0	6.9	-88.8	661.0	350.0	1.0	2.0	10.0	18.9	1.9	1.9	0.005	30.00	0.50	17.0	17.0	3.8				1.0
		MAX	28.5	7.3	160.0	10.0	78.8	1000.0	660.0	2.0	2.0	16.0	52.3	2.9	2.9	0.04	30.00	0.50	50.0	50.0	3.8				21.0
UNSAT-SA2	30" Sand	n	4	4	4	4	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1				2
		MEAN	20.9		122.5	7.6	22.0	846.8	532.0	4.0	2.3	17.0	32.2	3.0	2.6	0.4	25.0	0.7	29.2	29.5	6.3				
		STD. DEV.	10.1		18.9			163.3	139.6	6.0	0.5		10.3	0.6	0.5	0.4			9.7	9.9					
		MIN	6.2	6.0	110.0	6.3	-70.8	604.0	330.0	1.0	2.0	13.0	19.2	2.2	2.2	0.01	25.0	0.7	17.0	17.0	6.3				1.0
		MAX	28.2	6.9	150.0	9.6	89.2	953.0	638.0	13.0	3.0	22.0	41.5	3.5	3.3	0.7	25.0	0.7	38.0	38.7	6.3				41.0
UNSAT-PS1 (new recirc)	30" Polystyrene	n	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2					1
		MEAN	14.8		200.0	6.5	30.8	940.0	520.0	7.0	8.0	45.5	63.2	22.5	4.0	18.5	10.0	1.3	40.7	59.2					
		STD. DEV.	12.7		0.0			14.1	42.4	2.8	5.7		49.3	7.8	4.2	3.5			41.5	45.0					
		MIN	5.8	7.2	200.0	5.2	-28.5	930.0	490.0	5.0	4.0	39.0	28.3	17.0	1.0	16.0	10.0	1.3	11.3	27.3					9500.0
		MAX	23.8	7.3	200.0	7.8	90.0	950.0	550.0	9.0	12.0	52.0	98.0	28.0	7.0	21.0	10.0	1.3	70.0	91.0					9500.0
Pump 15 Tank (DENIT-LS4 Influent)		n	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2					1
		MEAN	12.9		200.0	6.8	-4.1	935.0	530.0	5.0	6.5	37.0	37.6	21.0	4.0	17.0	11.0	1.2	16.6	33.6					
		STD. DEV.	11.1		0.0			49.5	28.3	1.4	4.9		6.2	0.0	0.0	0.0			6.2	6.2					
		MIN	5.0	7.0	200.0	6.4	-26.9	900.0	510.0	4.0	3.0	33.0	33.2	21.0	4.0	17.0	11.0	1.2	12.2	29.2					3900.0
		MAX	20.7	7.4	200.0	7.1	18.8	970.0	550.0	6.0	10.0	41.0	42.0	21.0	4.0	17.0	11.0	1.2	21.0	38.0					3900.0

Table 5 (con't)
Statistical Summary of Water Quality Data

Sample ID	Media Composition	Statistical Parameter	Temp (°C)	pH	Total Alkalinity (mg/L)	DO (mg/L)	ORP (mV)	Specific Conductance (µS)	TDS (mg/L)	TSS (mg/L)	$CBOD_5$ (mg/L)	COD (mg/L)	TN (mg/L N)[1]	TKN (mg/L N)	Organic N (mg/L N)[2]	NH3-N (mg/L N)	NO_3-N (mg/L N)	NO_2-N (mg/L N)	NOx (mg/L N)	TIN (mg/L N)[3]	TP (mg/L)	Sulfide (mg/L)	H_2S (mg/L)	SO_4 (mg/L)	Fecal (Ct/100 mL)
Denite Feed Tank (Tank 3)																									
DFT		n	4	4	4	4	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1	3	3	4	2
		MEAN	20.0		162.5	8.2	15.6	923.5	567.5	1.0	2.0	28.7	28.7	3.0	2.9	0.1	29.0	0.1	25.8	25.8	6.5	0.4	0.0	57.3	
		STD. DEV.	10.0		28.7			123.1	121.8	0.0	0.0		10.8	0.5	0.4	0.1			11.1	11.1		0.5	0.1	9.9	
		MIN	6.4	7.0	130.0	7.3	-40.9	744.0	390.0	1.0	2.0	18.0	19.5	2.4	2.3	0.01	29.0	0.06	16.0	16.2	6.5	0.1	0.01	46.0	1.0
		MAX	28.1	8.1	200.0	9.8	62.2	1020.0	660.0	1.0	2.0	46.0	42.8	3.5	3.3	0.2	29.0	0.1	40.0	40.0	6.5	1.0	0.1	67.0	22.0
Stage 2 Horizontal Biofilters Effluent																									
DENIT-SU1	80% Sulfur; 20% Oyster Shell	n	4	4	4	4	3	4	4	4	4	3	4	4	4	4	1	1	4	4	1	3	3	4	2
		MEAN	20.2		222.5	0.9	-272.8	1248.8	830.0	1.0	19.0	45.0	2.5	2.4	1.1	1.3	0.1	0.2	0.1	1.4	5.0	23.7	10.7	325.0	
		STD. DEV.	13.4		17.1	0.7		165.3	150.1	0.0	8.1		0.4	0.4	0.8	0.9			0.2	0.8		6.1	1.4	97.1	
		MIN	0.2	6.8	200.0	0.1	-317.2	1080.0	660.0	1.0	8.0	22.0	2.0	1.9	0.3	0.5	0.1	0.2	0.01	0.8	5.0	17.0	9.2	230.0	3.0
		MAX	28.0	7.2	240.0	1.6	-231.2	1473.0	1000.0	1.0	26.0	63.0	3.0	2.7	2.1	2.4	0.1	0.2	0.4	2.4	5.0	29.0	12.0	450.0	5.0
DENIT-SU2 (old)	80% Sulfur; 20% Sodium Sesqui.	n	2	2	2	2	1	2	2	2	2	1	2	2	2	2			2	2	1	2	2	2	1
		MEAN	26.4		235.0	0.9	-279.0	1400.0	810.0	1.5	12.5	50.0	4.1	1.5	1.0	0.5			2.6	3.1	4.8	7.1	3.4	305.0	
		STD. DEV.	2.2		35.4			2.8	169.7	0.7	10.7		3.2	0.4	0.2	0.6			3.7	3.0		9.8	4.7	233.3	
		MIN	24.8	7.0	210.0	0.5	-279.0	1398.0	690.0	1.0	4.9	50.0	1.8	1.2	0.9	0.01			0.025	0.9	4.8	0.1	0.0	140.0	1.0
		MAX	27.9	9.1	260.0	1.2	-279.0	1402.0	930.0	2.0	20.0	50.0	6.4	1.8	1.2	0.9			5.2	5.2	4.8	14.0	6.7	470.0	1.0
DENIT-SU2 (new)	10% Limestone; 30% Sulfur; 60% Expanded Clay	n	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2		2	2	2	1
		MEAN	12.9		205.0	0.9	-151.1	1240.0	870.0	4.5	4.0	21.0	1.0	0.9	0.8	0.2	0.01	0.1	0.05	0.2		2.7	1.3	395.0	
		STD. DEV.	17.8		7.1			155.6	183.8	4.9	2.8		0.3	0.3	0.1	0.2			0.02	0.2		2.3	1.8	134.4	
		MIN	0.3	6.8	200.0	0.2	-212.2	1130.0	740.0	1.0	2.0	18.0	0.8	0.7	0.7	0.03	0.01	0.1	0.03	0.1		1.0	0.01	300.0	3.0
		MAX	25.5	7.0	210.0	1.6	-90.0	1350.0	1000.0	8.0	6.0	24.0	1.2	1.1	0.8	0.3	0.01	0.1	0.1	0.4		4.3	2.6	490.0	3.0
DENIT-LS1	50% Lignocellulosic; 50% Expanded Clay	n	6	6	6	6	5	6	5	6	6	4	6	6	6	6	2	2	6	6	2				2
		MEAN	14.7		224.8	0.5	-136.3	927.7	534.0	1.7	11.5	24.6	17.3	1.9	1.6	0.3	21.8	0.1	15.5	15.7	2.8				
		STD. DEV.	12.1		23.5			111.0	101.6	1.6	21.8		12.9	0.8	0.9	0.4	0.4	0.0	12.7	12.4					
		MIN	0.3	6.9	190.0	0.1	-199.7	738.0	370.0	1.0	2.0	16.0	1.5	0.6	0.6	0.005	21.5	0.100	0.01	0.7	0.5				1.0
		MAX	27.3	7.7	250.0	1.1	-15.4	1076.0	640.0	5.0	56.0	44.0	33.7	2.7	2.7	0.8	22.0	0.1	31.0	31.0	5.2				1.0
DENIT-GL1	12" Gravel; 60" Expanded Clay	n	4	4	4	4	3	4	4	4	4	4	4	4	4	4	1	1	5	4	1				2
		MEAN	18.6		417.5	0.8	-187.9	1095.0	665.0	27.0	217.3	312.0	20.3	19.0	9.9	9.2	0.1	0.04	1.0	10.4	2.9				
		STD. DEV.	12.5		181.5			402.9	364.6	48.7	395.4		30.6	31.4	18.1	13.4			2.1	12.7					
		MIN	0.3	6.4	220.0	0.0	-208.7	794.0	380.0	1.0	3.0	22.0	2.0	1.9	0.5	0.9	0.1	0.04	0.04	1.0	2.9				1.0
		MAX	27.8	8.0	660.0	1.5	-174.9	1686.0	1200.0	100.0	810.0	1100.0	66.1	66.0	37.0	29.0	0.1	0.04	4.7	29.1	2.9				800.0
In-situ Simulator Biofilters Effluent																									
UNSAT-IS1 (receives STE)	15" Sand; 12" Mix (45% EC, 35% Ligno, 20% Sulfur)	n	6	6	6	6	5	6	6	6	6	4	6	6	6	6	1	1	6	6	2	5	5	6	3
		MEAN	20.8		306.7	0.8	-73.9	1391.8	783.3	23.8	16.4	82.3	37.2	37.1	2.7	34.3	0.08	0.29	0.1	34.4	1.5	2.1	1.2	304.8	
		STD. DEV.	10.8		111.3			513.7	420.1	43.8	24.2		31.0	30.9	2.7	28.4			0.1	28.5	0.4	2.2	1.1	405.8	
		MIN	1.2	6.4	130.0	0.1	-246.2	1120.0	480.0	2.0	2.0	57.0	0.4	0.4	0.0	0.045	0.08	0.29	0.022	0.1	1.2	0.1	0.01	7.0	1.0
		MAX	29.7	7.1	430.0	2.0	221.6	2438.0	1600.0	113.0	65.0	120.0	75.0	75.0	6.0	69.0	0.08	0.29	0.4	69.0	1.7	4.7	2.8	1100.0	10.0
UNSAT-IS2 (receives NO_3)	12" Sand; 12" Mix (45% EC, 35% Ligno, 20% Sulfur)	n	6	6	6	6	5	6	6	6	6	4	6	6	6	6	1	1	6	6	2	5	5	6	3
		MEAN	21.4		176.7	1.0	-192.8	1474.8	1178.3	48.3	5.5	25.3	1.1	1.0	0.6	0.4	0.01	0.2	0.06	0.5	4.3	0.6	0.1	608.3	
		STD. DEV.	9.1		40.3			1097.7	897.8	45.1	4.5		0.4	0.3	0.3	0.3			0.08	0.3	3.9	0.5	0.3	588.2	
		MIN	6.2	6.1	100.0	0.1	-234.5	365.0	700.0	1.0	2.0	13.0	0.6	0.6	0.4	0.1	0.01	0.2	0.01	0.1	1.5	0.1	0.01	250.0	1.0
		MAX	30.0	6.8	210.0	3.9	-130.0	3506.0	3000.0	108.0	13.0	50.0	1.5	1.5	1.2	0.8	0.01	0.2	0.22	0.9	7.0	1.0	0.6	1800.0	1.0
UNSAT-IS3-SP (receives STE)	Sample Port below 10" Mix (60% EC, 40% Ligno), above 3" Sulfur layer	n	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0				1.0	
		MEAN	4.0		210.0	12.0	39.2	980.0	600.0	3.0	2.0	26.0	7.7	1.8	1.8	0.04	3.7	2.2	5.9	5.9				130.0	
		STD. DEV.																							
		MIN	4.0	7.5	210.0	12.0	39.2	980.0	600.0	3.0	2.0	26.0	7.7	1.8	1.8	0.04	3.7	2.2	5.9	5.9				130.0	
		MAX	4.0	7.5	210.0	12.0	39.2	980.0	600.0	3.0	2.0	26.0	7.7	1.8	1.8	0.04	3.7	2.2	5.9	5.9				130.0	
UNSAT-IS3 (receives STE)	12" Sand; 10" Mix (60% EC, 40% Ligno); 3" Sulfur)	n	4	4	4	4	4	4	3	3	3	3	4	4	4	4	2	2	4	4	1	1	1	4	1
		MEAN	12.7		282.5	0.5	150.6	1390.3	1339.3	8.0	3.0	33.7	38.2	4.2	1.0	3.1	27.7	8.5	34.1	37.2	0.5	1.0	0.01	166.5	
		STD. DEV.	4.3		12.6			82.1	832.0	3.5	1.0		3.4	1.8	1.3	2.5	5.2	0.2	5.1	3.9				83.0	
		MIN	8.7	6.7	270.0	0.4	136.5	1331.0	850.0	4.0	2.0	24.2	34.4	1.9	0.2	1.1	24.0	8.3	28.0	33.5	0.5	1.0	0.01	116.0	1.0
		MAX	18.7	7.0	300.0	0.5	171.2	1505.0	2300.0	10.0	4.0	46.0	41.8	6.4	2.9	6.2	31.3	8.6	39.9	41.0	0.5	1.0	0.01	290.0	1.0
UNSAT-IS4-SP (receives NO_3)	Sample Port below 10" Mix (60% EC, 40% Ligno), above 3" Sulfur layer	n	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	
		MEAN	5.1		100.0	12.0	35.1	1050.0	710.0	1.0	2.0	22.0	52.4	3.5	3.4	0.1	46.0	2.9	48.9	49.0				92.0	
		STD. DEV.																							
		MIN	5.1	6.6	100.0	12.0	35.1	1050.0	710.0	1.0	2.0	22.0	52.4	3.5	3.4	0.1	46.0	2.9	48.9	49.0				92.0	
		MAX	5.1	6.6	100.0	12.0	35.1	1050.0	710.0	1.0	2.0	22.0	52.4	3.5	3.4	0.1	46.0	2.9	48.9	49.0				92.0	
UNSAT-IS4 (receives NO_3)	12" Sand; 10" Mix (60% EC, 40% Ligno); 3" Sulfur)	n	4	4	4	4	4	4	2	2	2	3	5	5	5	5	2	2	5	5	1			5	1
		MEAN	12.5	0.0	251.0	2.9	158.3	778.8	628.5	6.0	2.0	31.2	13.2	1.4	1.3	0.07	0.08	0.03	11.8	11.8	3.9			269.8	
		STD. DEV.	4.2	0.0	35.1			523.1	12.0	1.4	0.0		17.5	0.5	0.5	0.02	0.04	0.03	17.0	17.0				181.7	
		MIN	8.4	7.1	200.0	0.8	150.4	0.0	620.0	5.0	2.0	29.0	1.0	0.9	0.8	0.04	0.05	0.01	0.1	0.2	3.9			110.0	1.0
		MAX	18.3	7.5	280.0	9.0	179.5	1129.0	637.0	7.0	2.0	35.0	43.1	2.1	2.1	0.09	0.11	0.05	41.0	41.0	3.9			490.0	1.0

Notes:

[1]Total Nitrogen (TN) is a calculated value equal to the sum of TKN and NO_x

[2]Organic Nitrogen (ON) is a calculated value equal to the difference of TKN and NH_3

[3]Total Inorganic Nitrogen (TIN) is a calculated value equal to the sum of NH_3 and NO_x

EC: expanded clay, CL: clinoptilolite, PS: polystyrene, SU: elemental sulfur, LS: lignocellulosic, GL: glycerol, OS: oyster shell, NS: sodium sesquicarbonate, GR: gravel

DO - Dissolved oxygen

Gray-shaded data points indicate values below method detection level (mdl), mdl value used for statistical analyses.

Yellow-shaded data points indicate the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit, value used for statistical analysis.

Orange - shaded data points indic

Blue-shaded data points indicate the number is greater than reported value.

Purple-shaded data points indicate results based on colony counts outside the method indicated ideal range.

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4.3 Flow Monitoring

Influent and effluent flows were measured, recorded, and adjusted as necessary to maintain flow rates consistent with the experimental design following the sampling event. Flow measurements and adjustments are made following collection of liquid samples and field parameter analyses.

A flow test was conducted January 17, 2011. These flow measurements are considered to represent those in effect leading up to and during the Sample Event 4. The measured volumes and relative errors between measured and target flow rates are presented in Appendix C, Table 1. For the Group 1 systems, measured STE inputs to four of the five Stage 1 biofilters were within the 15% operational target that is considered acceptable for PNRS II flow rates. The measured influent volume of UNSAT-PS1 was - 24.3% of the target volume. Measured effluent volumes for Stage 1 single pass biofilters (Stage 2 influent) were within 14% of the target volume for four of the five systems (Appendix C, Table 1). The DENIT-LS4 influent pipe was substantially clogged which led to UNSAT-PS1 effluent backing up within the Pump 15 holding tank. Therefore a measurement of influent volume to DENIT-LS4 was unable to be taken.

For the Group 2 systems, all measured STE volumes to the Stage 1 recirculation tanks were within 14% of target volumes. All recycle flow volumes as recorded by the PLC were within 5% of target volumes based on the experimental design recycle ratio of 3.0. The calculated recycle ratios (i.e. recycle flow volume divided by the STE flow volume) for four of the five recirculation systems were within 12% of the target recycle ratio of 3.0. Although the recycle rate to the UNSAT-PS1 was close to target, the recycle ratio was high due to the low influent STE flow that was previously discussed.

For Group 3 systems, the measured influent volumes to the Stage 2 horizontal denitrification biofilters were all within 4% of target.

For Group 4 biofilters, the UNSAT-IS1 and UNSAT-IS2 measured influent volumes were within 15% of target volumes. The UNSAT-IS3 and UNSAT-IS4 measured influent volumes were within 3% of target volumes.

After evaluating the influent flow test results, a few maintenance items were conducted:

- Hydrosplitter 1 petcock valves were adjusted January 18th to provide equal distribution of flow to each of the five Stage 1 biofilters with input volumes as close to the target volume as possible.
- Influent pipe to DENIT-LS4 was unclogged January 18th

The flows were rechecked after modifications to the systems were made and are provided in Appendix C, Table 2. The UNSAT-PS1 measured influent volume is closer to the target as measured on January 18th which will continue to be monitored.

5.0 PNRS II Sample Event No. 4: Summary and Recommendations

5.1 Summary

The results of the fourth sampling event serve to confirm that the experimental systems are functioning as intended and provide the basis upon which to make system adjustments and modifications. The Sample Event No. 4 results indicate that:

- Delivered flowrates to all biofilters continued to be generally within 15% of target;
- Septic tank effluent (STE) quality supplied to PNRS II systems is reasonably characteristic of typical household STE quality due to system modifications;
- Nine out of ten Stage 1 unsaturated biofilters produced effluent NH_3-N of 1.7 mg/L or less;
- Five out of nine Stage 2 saturated biofilters produced effluent NO_x-N of 0.35 mg/L or less;

These results provide continuing support of the nitrogen reduction potential of the PNRS II biofiltration systems. Where expected or desired PNRS II outcomes are not being achieved, they appear to be due to tractable issues can be addressed, as discussed in the following sections.

5.2 Recommendations

Careful observation of PNRS II systems and the results of Sample Events No. 1 to 4 were used to formulate recommendations for adjustments and modifications to the test systems and the GCREC pilot facility. The issues to be addressed, recommended modifications and their rationale, and expected outcomes are presented below. Recommendations are made for each of the PNRS II performance issues that have been identified. It is believed that each issue can be resolved by implementing the recommendations. All recommendations are based on the overriding PNRS II goal of providing functional specifications for modular biofiltration components for passive onsite nitrogen reducing treatment systems. The project team will continuously evaluate all PNRS II results including those that particularly result from implementation of the recommendations and make further adaptations as needed.

5.2.1 Polystyrene Biofilter (UNSAT-PS1)

In Sample Event 4, the unsaturated recirculating biofilter with polystyrene media (UNSAT-PS1) exhibited better nitrogen performance as compared to Sample Event 1, 2 and 3. However, the polystyrene media is not performing as well as the other stage one media and does not appear likely to satisfy the objectives of the project. Therefore, it is recommended to discontinue this system.

5.2.2 Lignocellulosic Containing Biofilters (DENIT-LS1, DENIT-LS2, DENIT-LS3, DENIT-LS4, UNSAT-IS1, UNSAT-IS2, UNSAT-IS3 and UNSAT-IS4)

The three upflow and one horizontal denitrification biofilters with lignocellulosic media continued to show limited NO_x reduction in Sample Event 4. Possible reasons are lack of reactivity of lignocellulosic material, toxicity (release of toxic material from lignocellulosic material itself), or short circuiting as witnessed in the dye test. It is recommended to replace the lignocellulosic material in all the biofilters containing lignocellulosic media with new lignocellulosic material from a different source, and to rebuild these biofilters with special attention to minimizing the potential for hydraulic short circuiting.

5.2.3 UNSAT-IS1 and UNSAT-IS2 Ponding

The UNSAT-IS1 and UNSAT-IS2 biofilters exhibited ponding at the surface during this sample event. Following the sampling event, a clog in the discharge line was detected. It is recommended to replace the discharge PVC piping with clear tubing during the tank cleaning and media replacement to allow better visual inspection for clogs.

5.2.5 Continue to Monitor Quality of STE Supplied to PNRS II Systems

The characteristics of GCREC septic tank effluent in Sample Event 4 continued to be more typical of Florida single family residences than in previous sample events. It seems likely that this was at least partially due to the system modifications that were implemented after Sample Event 2 but prior to Sample Event 3. Continued diligence will be maintained to insure that the PNRS II systems are supplied STE of acceptable characteristics.

5.2.6 Modify Operation

A track record of acceptable performance has been established for many PNRS II systems and increased flowrates are recommended. These are:

Stage 1 Biofilters

- Expanded clay and clinoptilolite media
  - increase loading rates:
    Single pass: 3 gal/ft^2-day to 5 gal/ft^2-day STE
    Recycle: 3 gal/ft^2-day to 6 gal/ft^2-day STE

Stage 2 Biofilters

- Sulfur
  - increase loading rates:
    Single pass coupled: single pass Stage 1 effluent
    5.6 to 9.3 gal/ft^2-day; 25.7 to 15.4 hour mean pore water residence time (MPWRT)
    Horizontal: Stage 1 w/recycle combined effluent
    10 to 20 gal/ft^2-day; 43 to 21.5 hour MPWRT
- Glycerol
  - increase loading rate: 10 to 20 gal/ft^2-day; 43 to 21.5 hour MPWRT

Appendix A: Operation & Maintenance Log

Table A.1
Operation and Maintenance Log

Date	Description
5/17/2010	Start-up
5/20/2010	Pump 1 not in Auto, LL float alarm, refilled Tank 1 to HIGH float
5/24/2010	Glycerol batch #1 prepared (125 mL glycerol; 1875 mL DI water), feed rate ~ 8 mL/dose
5/26/2010	LL float alarm, refilled Tank 1 to HIGH float
6/1/2010	Replaced glycerol tubing
6/4/2010	LL float alarm, refilled Tank 1 to HIGH float, determined that LOW float is faulty
	Revised floats so that old Low Float is now High float
	Revised program installed so that only LOW Float turns on/off Pump 1
6/8/2010	Glycerol batch #2 prepared (125 mL glycerol; 1875 mL DI water), feed rate ~ 8 mL/dose
6/18/2010	Pump 1 screen cleaned with hose
6/21/2010	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
	Pump 8 was on "OFF", turned back to "AUTO"
6/22/2010	Pump 5 had turned off, turned back on at 9:32 am
6/28/2010	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
	Replaced glycerol tubing, kink in top, added elbow
	Russ replaced existing GCREC mound Pump 2 ~ 11:00 am
	All Systems Flow Check
7/1/2010	Sample Event #1
7/2/2010	Pump 1 screen cleaned with hose
7/8/2010	Glycerol tubing had released to bottom of container, replaced with polyethylene tubing
	Tank 1 LOW Float alarm, revised magnet distance to shorten Pump 1 runtime
	Pump 1 screen cleaned with hose
7/12/2010	Pump 5 Error Code 18, cleared alarm and restarted pump
7/14/2010	UPS beeping, problem with receptacle, temporary fix with extension cord
7/15/2010	Electrician fixed receptacle
7/16/2010	Per Dr. Stanley all condensate flow diverted from septic system
	Russ fixed existing GCREC Mound Pump 2 which had not been running
	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
	Glycerol batch #3 prepared (125 mL glycerol; 1875 mL DI water), feed rate ~ 8 mL/dose

Date	Description
7/16/2010	Capillary mat added to PS-1
7/19/2010	IS 1 changed discharge (rotated 180°) now 15 inches of saturation from bottom of tank
7/20/2010	IS 2 changed discharge (rotated 180°) now 15 inches of saturation from bottom of tank
7/26/2010	Removed PS1 capillary mat from inside mesh bag, replaced with new mat on top of bag
	Glycerol batch #4 (70 mL glycerol; 1930 mL DI water), feed rate ~ 10 mL/dose
8/3/2010	Glycerol batch #5 (70 mL glycerol; 1930 mL DI water), feed rate ~ 10 mL/dose
8/4/2010	Cleaned crosses in Stage 1 Recirculating Biofilters
	Added tees to outlet of RC1 and RC4 tanks to alleviate blockage build-up
	Replaced Hydrosplitter 1 & 2 tubing
	Replaced Stage 2 horizontal tubing from Pump 11
	Cleaned Stage 2 horizontal sample ports
	Lowered Pump 1 Low Float 2 wraps to decrease volume in tank(decrease residence time)
8/10/2010	Glycerol batch #6 (70 mL glycerol; 1930 mL DI water), feed rate ~ 10 mL/dose
	Raised Pump 1 Low Float 1 wrap because float down was below the hole
8/12/2010	Revised tubing connection at top of In-Situ simulator tanks to elbow
8/17/2010	Glycerol batch #7 (70 mL glycerol; 1930 mL DI water), feed rate ~ 10 mL/dose
	Added tees to outlet in RC2 and RC3 tanks as well
	Revised RC tanks discharge piping to flexible hose
8/19/2010	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
8/23/2010	Possible leak detected at Recirc Tank #2 for P7
8/27/2010	Glycerol batch #8 (70 mL glycerol; 1930 mL DI water), feed rate ~ 10 mL/dose
8/31/2010	Sample Event #2
9/1/2010	Replaced elbow for Recirc Tank #2 (STE tubing) to fix leak
	All Systems Flow Check
9/7/2010	Glycerol batch #9 (70 mL glycerol; 1930 DI water), feed rate ~ 10 mL/dose
	Removed PS1 capillary mat
9/9/2010	Replaced Pump 5 pump tubing
9/10/2010	Cut the LS4 inlet pipe and used a drain snake to unclog both elbows
9/13/2010	Glycerol batch #10 (70 mL glycerol; 1980 DI water), feed rate ~ 10 mL/dose
9/17/2010	Modified Pump 7 runtime to 15 seconds per dose
9/21/2010	Reconnected the glycerol tubing between bottle and pump head which had separated
	Added sample ports to recirculation pump tank discharge lines for flow measurement
9/28/2010	Glycerol batch #11 (70 mL glycerol; 1930 DI water), feed rate ~ 10 mL/dose
	New clear glycerol bottle with graduated sides, replaced tubing
10/5/2010	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
10/6/2010	Glycerol batch #12 (30 mL glycerol; 1970 DI water), feed rate ~ 10 mL/dose

Date	Description
10/7/2010	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
10/8/2010	Modified Pump 1 discharge pipe to extend through Tank 1 hole in baffle wall
10/11/2010	DENIT-GL-1 nitrified STE influent tubing had disconnected, reattached
	Calibrated IS1 and IS2 tubing
	Calibrated Stage 2 horizontal tubing
10/14/2010	Glycerol batch #13 (30 mL glycerol; 1970 DI water), feed rate ~ 10 mL/dose
	Built new in-situ columns IS3 and IS4
10/15/2010	Unclogged PS1 discharge pipe
	Cleaned Pump 1 intake screen
	Lowered Pump 1 Low Float 1 wrap to decrease volume in tank
10/18/2010	Completed IS3 and IS4 piping, started dosing @ 9:30 am
	Added 3” coarse sand to UNSAT-IS1 for complete nitrification
10/19/2010	Started dye test DENIT-LS2 and DENIT-LS3
	Lowered Pump 1 Low Float 1 wrap to decrease volume in tank
10/20/2010	Calibrated IS3 and IS4 tubing
	Glycerol batch #14 (15 mL glycerol; 985 DI water), feed rate ~ 10 mL/dose
10/22/2010	Moved Pump 1 to effluent baffle tee of existing GCREC Tank 1
	Converted UNSAT-PS1 to recirculating biofilter
10/25/2010	Glycerol batch #15 (15 mL glycerol; 985 DI water), feed rate ~ 10 mL/dose
	DENIT-SU4 media ~5.5" below initial level
	Removed DENIT-SU4, DENIT-SU2 and DENIT-LS2 media
	Cleaned tanks
	Replaced DENIT-SU2 media (30% sulfur, 10% limestone, 60% expanded clay mixture)
	Replaced DENIT-SU4 media (30% sulfur, 10% limestone, 60% expanded clay mixture)
	Replaced DENIT-LS2 media (25% lignocellulosic, 75% expanded clay mixture)
10/27/2010	Glycerol batch #16 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
11/1/2010	Glycerol batch #17 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
11/5/2010	Glycerol batch #18 (13.5 mL glycerol; 986.5 DI water), feed rate ~ 10 mL/dose
11/10/2010	Sample Event #3
11/11/2010	Glycerol batch #19 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
11/18/2010	Glued UNSAT-IS3 and UNSAT-IS4 discharge piping to stop potential leaks
	Glycerol batch #20 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
	Calibrated UNSAT-IS3 and IS4 tubing
11/19/2010	All Systems Flow Check
11/24/2010	Glycerol batch #21 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
11/29/2010	Glycerol batch #22 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose

Date	Description
11/29/2010	Threaded and glued UNSAT-IS3 and UNSAT-IS4 petcock valves
12/1/2010	Tank 1 low-low float alarm activated, high float had activated in Tank 1 preventing Pump 1 to run. Cleared both alarms
12/3/2010	Cleared plug in DENIT-LS4 influent piping
	Replaced Hydrosplitter 1 & 2 tubing
	Replaced Pump 11 pump and system tubing
	Replaced Pump 5 pump and system tubing
	Glycerol batch #23 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
12/7/2010	Hydrosplitter 1 Flow Check
	Calibrated UNSAT-IS3 and IS4 tubing
12/10/2010	Glycerol batch #24 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
12/13/2010	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
12/14/2010	Increased Pump 15 runtime to 6:1 recycle rate
12/17/2010	Glycerol batch #25 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
12/22/2010	UNSAT-IS3 and IS4 effluent samples sent to Southern
12/23/2010	DENIT-LS4, LS2, SU3, LS3, and SU4 effluent sample to Southern
	Glycerol batch #26 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
12/27/2010	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
12/30/2010	Hydrosplitter 1 Flow Check
	Glycerol batch #27 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
	All Systems Flow Check
1/6/2011	Glycerol batch #28 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
1/11/2011	UNSAT-IS3 and IS4 effluent Sample Event #4 samples sent to Southern
	Ponding at surface of UNSAT-IS1 and IS2
	Cleared line blockage at outlet from IS1 and IS2
1/13/2011	Sample Event #4
	Glycerol batch #29 (13.5 mL glycerol; 1973 DI water), feed rate ~ 10 mL/dose
1/14/2011	Stage 2 Profile Samples sent to Southern
1/17/2011	Pump 5 and 11 Error Code 18, cleared alarm and restarted pumps
	All Systems Flow Check
	Cleaned all recirculation system Stage 1 distribution pipes with tap water
	Pump 7 was air locked - restarted
1/18/2011	Hydrosplitter 1 Flow Check - calibration

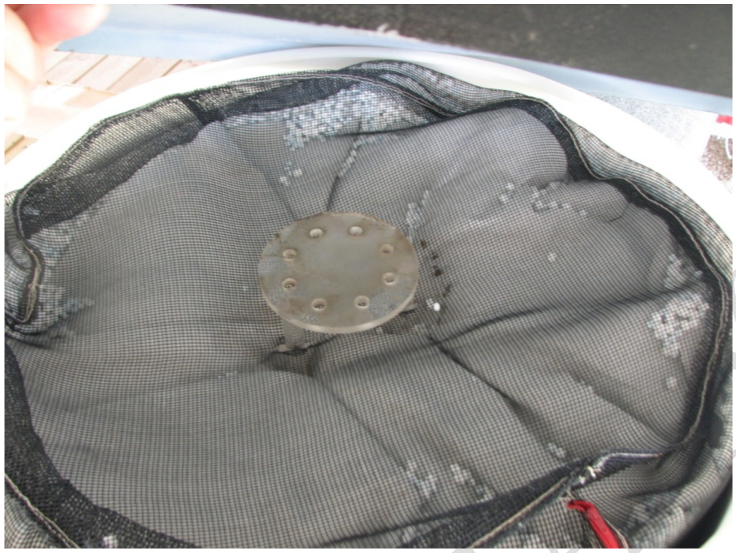

Figure A.1
Capillary Mat Installed above Polystyrene Media 7/16/10

Figure A.2
Revised In-situ Simulators Discharge Piping 7/20/10

Figure A.3
RC1 Outlet Tee 8/4/10

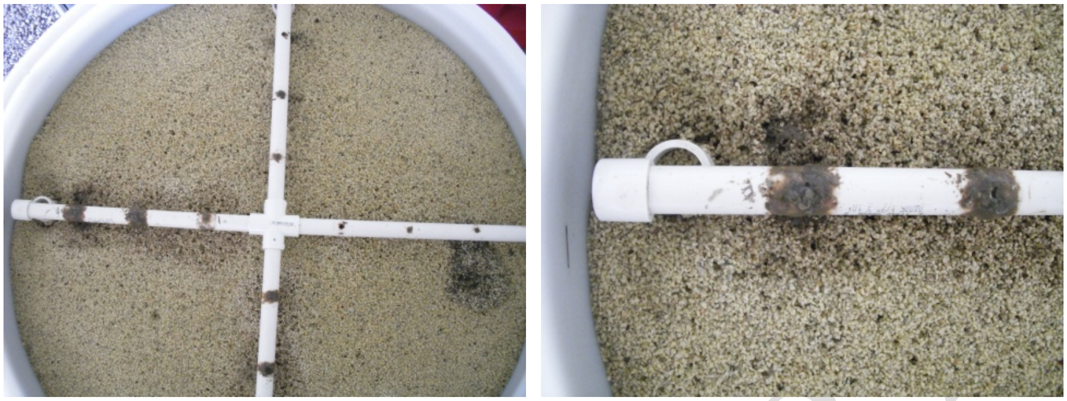

Figure A.4
UNSAT-CL4 before Cleaning 8/4/10

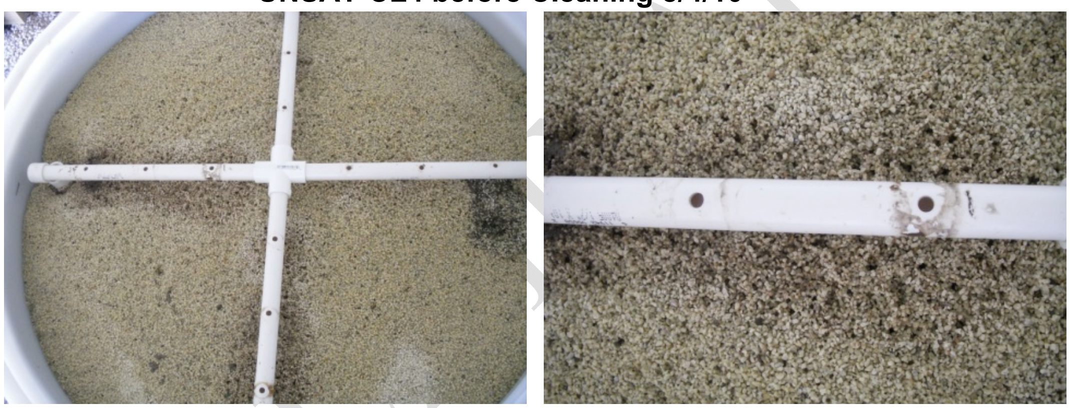

Figure A.5
UNSAT-CL4 after Cleaning 8/4/10

Figure A.6
Unclogging UNSAT-LS4 Influent Pipe 9/10/10

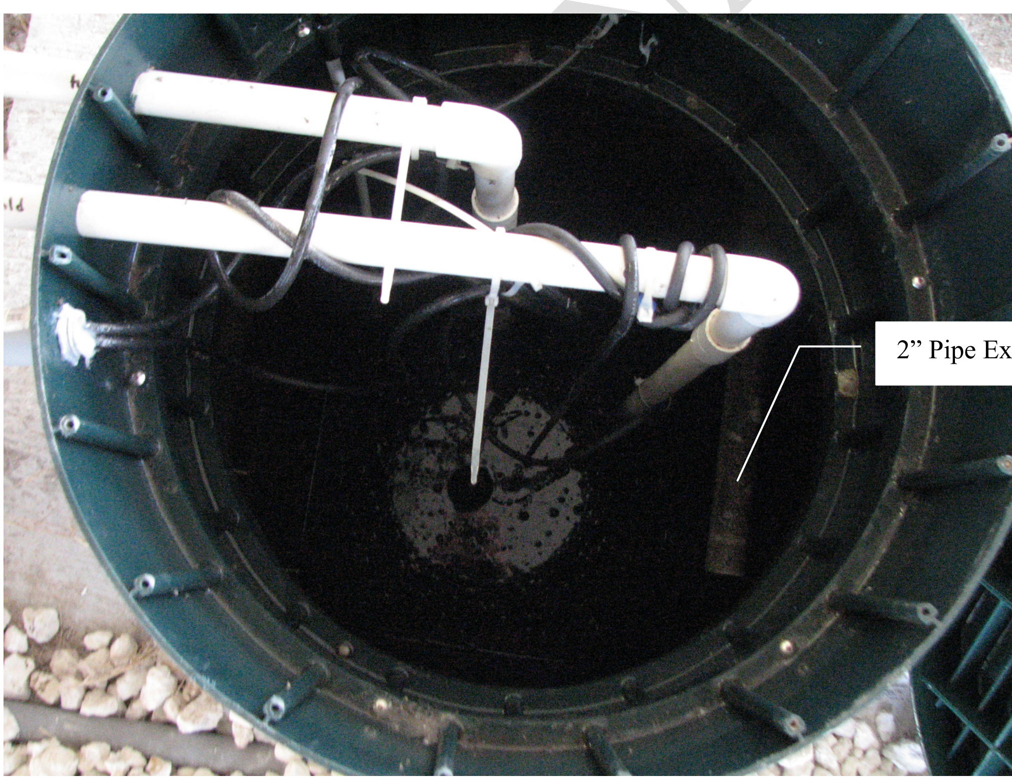

Figure A.7
2” Pipe Extension into PNRS II Tank 1 Pump Chamber 10/8/10

Figure A.8
UNSAT-IS3 and UNSAT-IS4 Columns 10/14/10

Appendix B: PLC Data Tables

Table B.1
Summary of PLC Recorded Daily Flows
(11/11/10 – 1/12/11)

Date Range		Average Recorded Flow (gpd)	Std. Dev.	MIN (gpd)	MAX (gpd)	Target Flow (gpd)	Relative Error[1] (%)
11/11/10-1/12/11	Pump 4 to Hydro 1	70	16.84	0	118	73.7	-5.0%
	Pump 14 to Hydro 2	57	11.40	0	62	58.9	-2.6%
	Pump 6 to Recirc. System 1	41	8.01	0	44	44.2	-7.4%
	Pump 7 to Recirc. System 2	42	8.20	0	45	44.2	-5.3%
	Pump 8 to Recirc. System 3	41	8.05	0	44	44.2	-7.0%
	Pump 9 to Recirc. System 4	41	8.42	0	44	44.2	-8.3%
UNSAT-PS1 Target 3:1 Recycle Ratio							
11/11/10-12/13/10	Pump 15 to Recirc. System 5	40	11.71	0	64	44.2	-10.6%
UNSAT-PS1 Target 6:1 Recycle Ratio							
12/15/10-1/12/11	Pump 15 to Recirc. System 5	91	5.43	89	119	88.4	2.8%

[1]Relative Error = (Recorded Flow – Target Flow)/ Target Flow *100

PRELIMINARY

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Table B.2
Summary of PLC Recorded Daily Runtimes
(1/11/10 – 1/12/11)

Date Range		Average Recorded Daily Runtime (minutes/day)	Std. Dev.	MIN (minutes)	MAX (minutes)	Target Daily Runtime (minutes)	Relative Error[1] (%)
P4 Runtime Target = 31 seconds/dose							
11/11/10-12/6/10	Pump 4 to Hydro 1	11.4	3.6	0.0	13.0	12.4	-7.9%
P4 Runtime Target = 44[2] seconds/dose							
12/8/10-1/12/11	Pump 4 to Hydro 1	18.2	1.1	17.0	24.0	17.6	3.5%
11/11/10-1/12/11	Pump 14 to Hydro 2	10.3	2.0	0.0	11.0	10.4	-1.1%
	Pump 6 to Recirc. System 1	6.1	1.3	0.0	7.0	6.0	1.6%
	Pump 7 to Recirc. System 2	6.1	1.3	0.0	7.0	6.0	1.6%
	Pump 8 to Recirc. System 3	6.1	1.3	0.0	7.0	6.0	1.6%
	Pump 9 to Recirc. System 4	6.1	1.3	0.0	7.0	6.0	1.6%
UNSAT-PS1 Target 3:1 Recycle Ratio							
11/11/10-12/13/10	Pump 15 to Recirc. System 5	6.1	1.9	0.0	10.0	6.0	2.0%
UNSAT-PS1 Target 6:1 Recycle Ratio							
12/15/10-1/12/11	Pump 15 to Recirc. System 5	14.2	0.9	14.0	19.0	14.0	1.2%

[1]Relative Error = (Recorded Runtime – Target Runtime)/ Target Runtime *100
[2]Pump 4 Runtime was increased to increase UNSAT-PS1 STE influent volume to target level

Appendix C: Flow Test Results

Table C.1
Flow Test Results (before flow recalibration)

Group (Figure 1)	Biofilter/Flow	Target Input			Measured Input		Recycle Ratio		
		Target Input Volume	Dose/day	Target Input Volume	Measured Input Volume	Relative Error (%)	Target Recycle Ratio (RR)	Calculated Recycle Ratio (RR)	Relative Error (%)
		(mL/day)	(Dose/day)	(mL/dose)	(mL/dose)	(Measured Input -Target Input) / Target Input * 100	Volume Recycle / Volume STE	Volume Recycle / Volume STE	Measured RR - Target RR / Measured RR * 100
1	**Stage 1 Single Pass Biofilters (Hydrosplitter 1)**								
	Date				1/17/2011 Dose @ 9:00 am				
	UNSAT-PS1	55,656	24	2,319	1,755	-24.3%			
	UNSAT-CL3				2,650	14.3%			
	UNSAT-CL1				2,520	8.7%			
	UNSAT-EC3				2,620	13.0%			
	UNSAT-EC1				2,580	11.3%			
	Mean				2,425	4.6%			
	Stage 2 Single Pass Upflow Biofilters								
	Date				1/17/2011 8:00-9:00 am				
	DENIT-LS4	55,656	24	2,319	Plugged				
	DENIT-LS2				2,580	11.3%			
	DENIT-SU3				2,165	-6.6%			
	DENIT-LS3				2,640	13.8%			
	DENIT-SU4				2,245	-3.2%			
	Mean				2,408	3.8%			
2	**Stage 1 Recirculating Biofilters (Hydrosplitter 2)**								
	Date				(1/17/2011) dose @ 10:30 am				
	RC1 : UNSAT-SA2	55,656	24	2,319	2,000	-13.8%			
	RC2 : UNSAT-EC4				2,080	-10.3%			
	RC3 : UNSAT-CL2				2,290	-1.3%			
	RC4 : UNSAT-CL4				2,260	-2.5%			
	Mean				2,158	-7.0%			
	Stage 1 Recirculating Biofilters (Recycle)				Flowmeter 1/17/2011				
	RC1 : UNSAT-SA2	166,968	24	6,957	6,781	-2.5%	3:1	3.39	11.5%
	RC2 : UNSAT-EC4				6,939	-0.3%		3.34	10.1%
	RC3 : UNSAT-CL2				6,781	-2.5%		2.96	-1.3%
	RC4 : UNSAT-CL4				6,624	-4.8%		2.93	-2.4%
	Mean				6,781	-2.5%		3.15	4.5%
	RC5 : UNSAT-PS1	333,936	24	13,914	14,036	0.9%	6:1	8.00	25.0%
	Stage 1 Recirculating Biofilters (Hydrosplitter + Recycle)								
	RC1 : UNSAT-SA2	222,624	24	9,276	8,781				
	RC2 : UNSAT-EC4				9,019				
	RC3 : UNSAT-CL2				9,071				
	RC4 : UNSAT-CL4				8,884				
	Mean				8,939				
	RC5 : UNSAT-PS1	389,592	24	16,233	15,791				
3	**Horizontal Denitrification Biofilters**								
	Date				1/17/2011 dose @ 10:40 am				
	DENIT-SU1	7,409	24	308.7	311	0.7%			
	DENIT-SU2				311	0.7%			
	DENIT-GL1				298	-3.5%			
	DENIT-LS1				300	-2.8%			
	Mean				305	-1.2%			
4	**In-Situ Simulators**								
	Date				1/17/2011 manual dose				
	UNSAT-IS1 (STE)	14,814	6	2,469	2,590	4.9%			
	UNSAT-IS2 (Nitrified STE)				2,830	14.6%			
	UNSAT-IS3 (STE)	594	6	99	96	-3.0%			
	UNSAT-IS4 (Nitrified STE)				101	2.0%			

Notes: Yellow-shaded cells are measured values; grey-shaded cells are calculated values

Table C.2
Flow Test Results (after flow recalibration)

Group (Figure 1)	Biofilter/Flow	Target Input: Target Input Volume (mL/day)	Target Input: Dose/day (Dose/day)	Target Input: Target Input Volume (mL/dose)	Measured Input: Measured Input Volume (mL/dose)	Measured Input: Relative Error (%) (Measured Input -Target Input) / Target Input * 100	Recycle Ratio: Target Recycle Ratio (RR) Volume Recycle / Volume STE	Recycle Ratio: Calculated Recycle Ratio (RR) Volume Recycle / Volume STE	Recycle Ratio: Relative Error (%) Measured RR - Target RR / Measured RR * 100
	Stage 1 Single Pass Biofilters (Hydrosplitter 1)								
	Date				(1/18/11) manual dose @ 9:55 am				
	UNSAT-PS1				2,645	14.1%			
	UNSAT-CL3				2,420	4.4%			
	UNSAT-CL1	55,656	24	2,319	2,410	3.9%			
	UNSAT-EC3				2,310	-0.4%			
	UNSAT-EC1				2,250	-3.0%			
	Mean				2,407	3.8%			
1	**Stage 2 Single Pass Upflow Biofilters**								
	Date				1/17/2011 8:00-9:00 am				
	DENIT-LS4				Plugged				
	DENIT-LS2				2,580	11.3%			
	DENIT-SU3	55,656	24	2,319	2,165	-6.6%			
	DENIT-LS3				2,640	13.8%			
	DENIT-SU4				2,245	-3.2%			
	Mean				2,408	3.8%			
	Stage 1 Recirculating Biofilters (Hydrosplitter 2)								
	Date				(1/17/2011) dose @ 10:30 am				
	RC1 : UNSAT-SA2				2,000	-13.8%			
	RC2 : UNSAT-EC4	55,656	24	2,319	2,080	-10.3%			
	RC3 : UNSAT-CL2				2,290	-1.3%			
	RC4 : UNSAT-CL4				2,260	-2.5%			
	Mean				2,158	-7.0%			
	Stage 1 Recirculating Biofilters (Recycle)				Flowmeter 1/17/2011				
	RC1 : UNSAT-SA2				6,781	-2.5%		3.39	11.5%
2	RC2 : UNSAT-EC4	166,968	24	6,957	6,939	-0.3%	3:1	3.34	10.1%
	RC3 : UNSAT-CL2				6,781	-2.5%		2.96	-1.3%
	RC4 : UNSAT-CL4				6,624	-4.8%		2.93	-2.4%
	Mean				6,781	-2.5%		3.15	4.5%
	RC5 : UNSAT-PS1	333,936	24	13,914	14,036	0.9%	6:1	5.31	-13.1%
	Stage 1 Recirculating Biofilters (Hydrosplitter + Recycle)								
	RC1 : UNSAT-SA2				8,781				
	RC2 : UNSAT-EC4	222,624	24	9,276	9,019				
	RC3 : UNSAT-CL2				9,071				
	RC4 : UNSAT-CL4				8,884				
	Mean				8,939				
	RC5 : UNSAT-PS1	389,592	24	16,233	16,681				
	Horizontal Denitrification Biofilters								
	Date				1/17/2011 dose @ 10:40 am				
	DENIT-SU1				311	0.7%			
3	DENIT-SU2	7,409	24	308.7	311	0.7%			
	DENIT-GL1				298	-3.5%			
	DENIT-LS1				300	-2.8%			
	Mean				305	-1.2%			
	In-Situ Simulators								
4	**Date**				1/17/2011 manual dose				
	UNSAT-IS1 (STE)	14,814	6	2,469	2,590	4.9%			
	UNSAT-IS2 (Nitrified STE)				2,830	14.6%			
	UNSAT-IS3 (STE)	594	6	99	96	-3.0%			
	UNSAT-IS4 (Nitrified STE)				101	2.0%			

Notes: Yellow-shaded cells are measured values; grey-shaded cells are calculated values

INTERIM STUDY AND REPORT ON PHASE II OF THE FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES STUDY

Bureau of Onsite Sewage Programs

February 1, 2011

Rick Scott
Governor

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INTERIM STUDY AND REPORT ON PHASE II OF THE FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES STUDY

EXECUTIVE SUMMARY

The Florida Legislature has appropriated a total of $2.9 million for Phases I and II of an anticipated 3-5 year project with a total estimated cost of $5.1 million to develop passive strategies for nitrogen reduction for onsite sewage treatment and disposal systems (OSTDS). This report is submitted in compliance with Line Item 486 Section 3, Conference Report on House Bill 5001, General Appropriations Act for Fiscal Year 2010-2011. Currently, this project is in its third year and requires an additional $2.2 million to complete the study.

Funds appropriated and expended to date have established necessary viable protocols and have been appropriately used to test, calibrate and refine technologies and strategies to be tested in the field. Without further funding for the final Phase 3 of the project, necessary and extensive field testing will not occur and, if field testing does not occur, the project will essentially not yield results that can be used to develop viable, cost-effective alternative passive technologies for use by homeowners for nitrogen issues associated with onsite systems.

Regardless of the source, excessive nitrogen has negative effects on public health and the environment. The significance of this innovative project is that it evaluates and develops strategies to reduce nitrogen impacts from OSTDS regulated by the Florida Department of Health (DOH). The goal is to develop systems that are affordable and ecologically protective with reduced engineering and installation costs that assist in sustainable development. This project has been endorsed by Florida TaxWatch as a good use of public funds.

The contractor, in coordination with DOH and the Department's Research Review and Advisory Committee (RRAC), has successfully completed portions of each major task. Work expected to be completed this fiscal year includes: initiating field sampling of passive systems; field sampling of the soil and groundwater under OSTDS at residential homes throughout Florida and at the test facility; and development of both simple and complex soil models.

Further testing is required to verify the results to date and to provide data for development of the specifications for full system designs. The tasks associated with the final phase include: continuation and completion of field monitoring of the performance and cost of technologies at home sites and of nitrogen fate and transport in the shallow groundwater; development of nitrogen fate and transport models that will be calibrated with the field sampling results; and final reporting on all tasks with recommendations on onsite sewage nitrogen reduction strategies.

DOH and its Research Review and Advisory Committee recommend that the Legislature:

1. Provide additional funding and budget authority to DOH in the amount of $2.2 million for the fiscal year 2011-2012 for continuation and completion of the tasks associated with this legislatively mandated study.
2. Provide DOH budget authority for any remaining funds from the 2010 appropriation to carry over to fiscal year 2011-2012.

Continued support for this project will ultimately benefit Florida's approximately 2.7 million onsite system owners by finding cost-effective nitrogen reduction strategies that will improve environmental and public health protection. If fully funded, the results of this project will assist economic growth and jobs creation while producing systems that protect groundwater with both reduced life-cycle costs and lower energy demands.

1 INTRODUCTION

The 2010 Legislature appropriated $2.0 million for Phase II of an anticipated 3-5 year project with a total estimated cost of $5.1 million to develop passive strategies for nitrogen reduction for onsite sewage treatment and disposal systems (OSTDS). This followed an initial appropriation of $900,000 by the 2008 Legislature for the first phase of this study. Currently, this project is in its third year and requires an additional $2.2 million to complete the study. This report is submitted in compliance with Line Item 486 Section 3, Conference Report on House Bill 5001, General Appropriations Act for Fiscal Year 2010-2011, which appropriated the funding for the study.

This study was based on budget language in 2008 (Line Item 1682, House Bill 5001, General Appropriations Act for Fiscal Year 2008-2009) that instructed:

> …the Department of Health to further develop cost-effective nitrogen reduction strategies. The Department of Health shall contract, by request for proposal, for Phase I of an anticipated 3-year project to develop passive strategies for nitrogen reduction that complement use of conventional onsite wastewater treatment systems. The project shall be controlled by the Department of Health's Research Review and Advisory Committee and shall include the following components: 1) comprehensive review of existing or ongoing studies on passive technologies; 2) field testing of nitrogen reducing technologies at actual home sites for comparison of conventional, passive technologies and performance-based treatment systems to determine nitrogen reduction performance; 3) documentation of all capital, energy and life-cycle costs of various technologies for nitrogen reduction; 4) evaluation of nitrogen reduction provided by soils and the shallow groundwater below and down gradient of various systems; and 5) development of a simple model for predicting nitrogen fate and transport from onsite wastewater systems. A progress report shall be presented to the Executive Office of the Governor, the President of the Senate and the Speaker of the House of Representatives on February 1, 2009, including recommendations for funding additional phases of the study.

The 2010 legislative direction (included in Appendix A) specified that the existing contract for this project will remain in full force; that the Department, the Department's Research Review and Advisory Committee (RRAC), and the Florida Department of Environmental Protection (DEP) shall work together to provide technical oversight and that DEP will have maximum technical input; that the main focus and priority for work in Phase II shall be in developing, testing, and recommending cost-effective passive technologies for nitrogen reduction; that field installations for this project will be subject to significant testing and monitoring; and that no state agency shall implement any rule or policy that requires nitrogen reducing systems or increases their costs until the study is complete.

Regardless of the source, excessive nitrogen has negative effects on public health and the environment. The primary motivations for this study are the environmental impacts that the increased levels of nitrogen in water bodies can cause. Programs within DEP identify water bodies impaired by excessive nitrogen, establish targets for maximum nutrient loads, and develop management action plans to restore the water bodies. The relative contribution of OSTDS to total nitrogen impacts varies from watershed to watershed with estimates ranging from below five to more than 20 percent. There is widespread interest in the management of OSTDS and their nitrogen impacts. This project has been endorsed by Florida TaxWatch as a study that is a good use of public funds and that provides homeowners with cost-effective options for nitrogen reduction (email communication from Kurt Wenner to Jerry McDaniel June

2, 2008). The significance of this innovative project is that it evaluates and develops strategies to reduce nitrogen impacts from OSTDS regulated by the Florida Department of Health (DOH). The goal is to develop systems that complement the use of conventional OSTDS and are also affordable and ecologically protective with reduced engineering and installation costs that assist in sustainable development.

The study contract was awarded in January 2009 to a Project Team led by Hazen and Sawyer, P.C., and was based upon an anticipated budget of $5 million over a 3 – 5 year project timeframe, with an additional $100,000 budget to DOH for project management. As a result of the time required for contracting, unspent monies in fiscal year 2008-2009 were budgeted in 2009 to complete the initial tasks of the project. The contract identifies the following tasks:

Task A – Technology Evaluation for Field Testing: Review, Prioritization, and Development: This task includes literature review, technology evaluation, prioritization of technologies to be examined during field testing, and further experimentation with approaches tested in a previous DOH passive nitrogen removal study. Objectives of this task are to prioritize technologies for testing at actual home sites and to perform controlled tests at a test facility to develop design criteria for new passive nitrogen reduction systems.

Task B – Field Testing of Technologies and Cost Documentation: This task includes installation of top ranked nitrogen reduction technologies at actual homes, with documentation of their performance and cost.

Task C – Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater: This task includes several field evaluations of nitrogen reduction in Florida soils and shallow groundwater and also will provide data for the development of a simple planning model in Task D.

Task D – Nitrogen Fate and Transport Modeling: The objective of this task is to develop a simple fate and transport model of nitrogen from OSTDS that can be used for assessment, planning and siting of OSTDS.

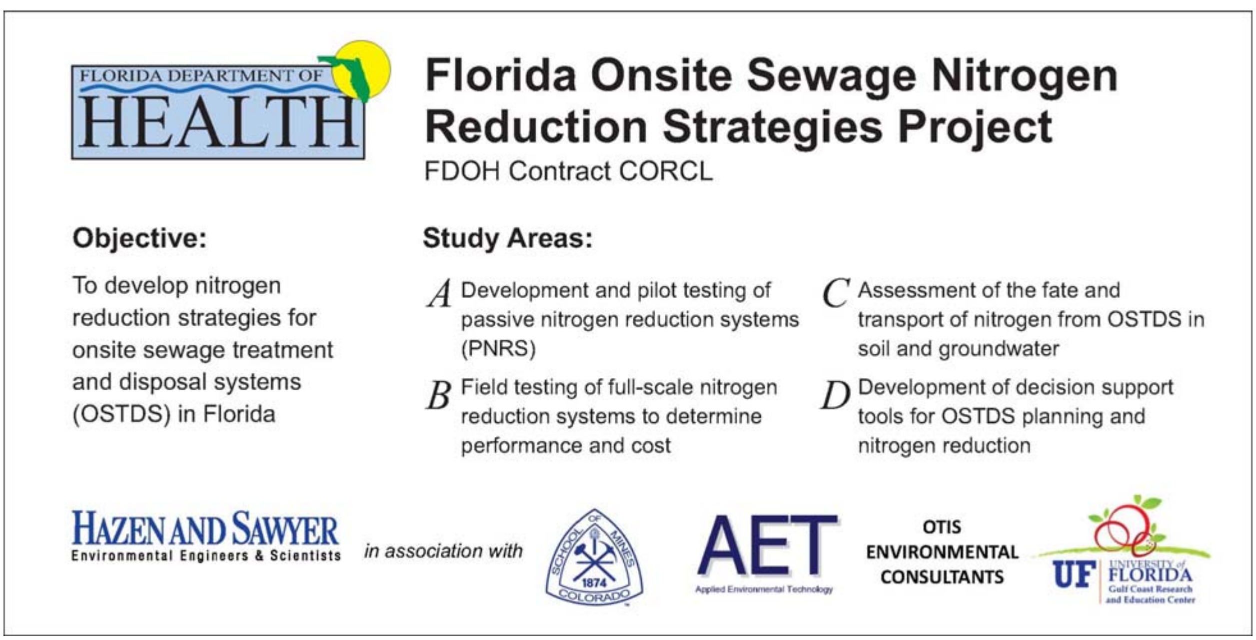

Figure 1. Sign posted at the University of Florida's Gulf Coast Research & Education Center's test facility.

2 PROJECT STATUS

Funding for the first and second phases of this project has been appropriated. A summary of the major project elements and their timing with funding phases is shown in Table 1. The contractor, in coordination with the RRAC and DOH, has successfully completed parts of Tasks A, B, C, and D, including literature reviews; ranking of nitrogen reduction technologies for field testing; design and construction of a test facility for further development of passive technologies; development of quality assurance documents for the test facility work, groundwater monitoring, field testing, and nitrogen fate and transport modeling; and completion of several sampling events at the test facility.

Figure 2. Test facility constructed at the University of Florida's Gulf Coast Research & Education Center.

Current efforts and work expected to be completed this fiscal year include: initiating field sampling of passive systems; installation of field sites at residential homes throughout Florida for the testing of passive systems and to test the soil and groundwater under OSTDS; design and construction of a soil and groundwater test facility; sampling at the soil and groundwater test facility; continued sampling of passive technologies at the test facility; and development of both simple and complex soil models. In particular, the following work by task will proceed with the current funding level:

1. The technology evaluation (Task A) will include a total of 7 sample events at the passive nitrogen test facility, measuring 14 different analytes at 23 sampling points, as well as a final report on the pilot passive nitrogen removal study at the Gulf Coast Research and Education Center (GCREC).
2. For field testing of technologies (Task B), the quality assurance project plan has been finalized. Approximately four onsite systems utilizing various nitrogen removal technologies will be installed at home locations throughout the State of Florida. It is

anticipated that four field system performance monitoring events will be conducted on these systems, measuring 16 different analytes at 8 different sampling points. A life cycle cost assessment template will also be completed.

3. To evaluate nitrogen reduction provided by soils and shallow groundwater (Task C), it is anticipated that a soil and groundwater test facility will be constructed to show how groundwater fate and transport of nitrogen occurs in multiple soil treatment unit regimes. Three sampling events will be completed, sampling six different locations at each site, measuring multiple parameters in the effluent, soil, groundwater, and soil moisture. Instrumentation of the existing OSTDS mound system at the University of Florida's Gulf Coast Research & Education Center (GCREC) in Wimauma, Florida will be done to study how nitrogen behaves in the soil and groundwater. Four sampling events, examining multiple parameters, will be completed at the existing OSTDS mound system at GCREC. At least one soil and groundwater monitoring event will occur at up to four home sites to evaluate nitrogen movement in the soil and groundwater in the field, measuring multiple parameters in the effluent, soil, and groundwater.
4. To address nitrogen fate and transport modeling for Task D, a final quality assurance project plan has been completed, and the first steps are the development of simple and complex soil models to show how nitrogen is affected by treatment in Florida-specific soils.

3 ANTICIPATED PROGRESS IN 2011-2012

During the 2011-2012 fiscal year, additional funding will be critical to complete the tasks associated with the final phase. These include: continuation and completion of field monitoring of performance and cost of technologies at home sites and of nitrogen fate and transport in the shallow groundwater; development of various nitrogen fate and transport models that will be calibrated with the field sampling results; and final reporting on all tasks with recommendations on onsite sewage nitrogen reduction strategies. In particular, the following work by task will occur with the final phase of funding, which is being requested with this report:

1. For Task A, the final task report will be written, which will include a summary of the accomplishments of the passive nitrogen removal test facility.
2. For Task B, it is anticipated that an additional four onsite systems utilizing various nitrogen removal technologies will be installed at home locations throughout the State of Florida, four field system performance monitoring events will be conducted on these systems, and final reporting on all of the field work associated with this task, including life cycle cost assessments, will be completed.
3. For Task C, monitoring events will occur at four home sites to evaluate nitrogen movement in the soil and groundwater in the field, and at six groundwater test areas at the soil and groundwater test facility to show how groundwater fate and transport of nitrogen occurs. Final reporting for this task will be completed.
4. For Task D, shallow groundwater models will be developed, calibrated, and validated, utilizing the results of the field work collected in previous tasks, and a final task report will be written summarizing the results of this task.

Table 1. Summary of Funding Phase Tasks and Associated Number of Deliverables.

	Task	Phase I[a] $900,000 (July 2008-November 2010, completed)	Phase II[a] $2,000,000 (Current Funding, in progress)	Phase III[a] $2,200,000 (Future Funding, yet to be funded)
A	**Task A: Technology Selection & Prioritization**	**$352,144**	**$399,136**	**$35,480**
	Literature review	1		
	Ranking of nitrogen reduction technologies for field testing	1		
	Design and construction of test facility	1		
	Quality assurance project plan	1		
	Monitoring and sample events		7	
	Final test facility report		1	
	Final task report			1
B	**Task B: Field Testing of Technologies**	**$50,202**	**$471,035**	**$559,115**
	Quality assurance project plan		1	
	Installation of ranked nitrogen reduction technologies at 8 field sites		4	4
	System performance monitoring events at 8 sites		4	4
	Life cycle cost assessment template development		1	
	Final life cycle cost assessment report (per system)			8
	Final task report			1
C	**Task C: Evaluation of Nitrogen Reduction by Soils & Shallow Groundwater**	**$216,164**	**$1,027,848**	**$662,940**
	Quality assurance project plan	1		
	Design of test facility	1		
	Construction of test facility		1	
	Monitoring and sample events (6 test areas)		3	3
	Instrumentation of existing OSTDS mound at GCREC facility		1	
	GCREC mound sample events		4	
	Field sites sample events (4 sites)		1	3
	Final task report			1
D	**Task D: Nitrogen Fate and Transport Models**	**$74,357**	**$93,857**	**$639,808**
	Quality assurance project plan	0.5	0.5	
	Simple soil model		1	
	Complex soil model		1	
	Shallow groundwater models for simple and complex soil models			2
	Calibration of models to existing data sets			2
	Uncertainty analysis for models			2
	Validation and refinement of models			2
	Final task report			1
	Project Management (sum of contractor and DOH)	**$119,953**	**$95,304**	**$302,657**
	Contractor project management	$90,695	$77,932	$249,247
	DOH project management	$29,258	$17,372[b]	$53,410[b]
	Total Budget[c]	**$812,820**	**$2,087,180**	**$2,200,000**
	Total Budget Remaining as of November 2010	**$0**	**$2,062,328**	**$2,200,000**

a. Numbers in each subtask represent the numbers of budgeted deliverables.
b. DOH project management costs for Phases II and III are estimated costs.
c. Budgeted totals differ from the legislative funding amounts due to scheduling.

DOH – Department of Health
GCREC – Gulf Coast Research & Education Center
OSTDS – Onsite Sewage Treatment and Disposal Systems

4 FUNDING NEEDS

Activities in fiscal years 2008-2011 have prepared the framework for rapid implementation of all remaining project tasks in fiscal year 2011-2012. Funding for fiscal year 2011-2012 is required to reap the benefits of all previous work and to complete the goals of this project. For the 2011-2012 budget year, $2.2 million dollars is required to fund the completion of this study.

Funds appropriated and expended to date have established necessary viable protocols and have been appropriately used to test, calibrate and refine technologies and strategies to be tested in the field. Without further funding for the final Phase 3 of the project, necessary and extensive field testing, the major portion of Task B, will not occur and, if field testing does not occur, the project will essentially not yield results that can be used to develop viable, cost-effective alternative passive technologies for use by homeowners for nitrogen issues associated with onsite systems.

Project Tasks (described previously) are broken down further into funding phases as follows:

Initial Funding in 2008-2010 (Phase I): $900,000 already appropriated (in 2008 and 2009 state budgets) – status: Largely complete. The initial funding was targeted to prioritize systems for testing, summarize existing knowledge, develop testing protocols, and establish a test facility for detailed soil and groundwater monitoring and for preliminary testing of pilot scale passive nitrogen reduction systems.

Funding in 2010-2011: $2 million already appropriated (in 2010 state budgets) – status: Ongoing. This funding is for field monitoring over at least a one-year monitoring period of performance and cost of technologies at home sites, and of nitrogen fate and transport. This funding will also continue the development and monitoring work at the test facility and continue the modeling work.

Funding in 2011-2012: To adequately fund the final phase of the project, $2.2 million will need to be appropriated during the 2011 legislative session. The preliminary results of the project are encouraging. Further testing is required to verify the results to date and to provide data for development of the engineering specifications for full system designs. The funds will be used to complete monitoring and other field activities, additional testing as deemed appropriate by the Legislature, and final reporting with recommendations on onsite sewage nitrogen reduction strategies for Florida's future.

Further information on this project, including previous legislative reports and detailed project reports, can be found on the Department's website:

http://www.doh.state.fl.us/environment/ostds/research/Nitrogen.html

5 RECOMMENDATIONS

DOH and its Research Review and Advisory Committee recommend that the Legislature:

1. Provide additional funding and budget authority to DOH in the amount of $2.2 million for the fiscal year 2011-2012 for continuation and completion of the tasks associated with the legislatively mandated Florida Onsite Sewage Nitrogen Reduction Strategies Study.
2. Provide DOH budget authority for any remaining funds from the 2010 appropriation to carry over to fiscal year 2011-2012.

This additional funding will be applied to the final phase of the project, primarily continuation and completion of field monitoring of performance and cost of technologies at home sites and of nitrogen fate and transport in the shallow groundwater, development of various nitrogen fate and transport models that will be calibrated with the field sampling results, and final reporting on all tasks with recommendations on onsite sewage nitrogen reduction strategies.

Continued support for this project will ultimately benefit Florida's approximately 2.7 million onsite system owners by finding cost-effective nitrogen reduction strategies that will improve environmental and public health protection. If fully funded, the results of this project will assist economic growth and jobs creation while producing systems that protect groundwater with both reduced life-cycle costs and lower energy demands.

APPENDIX A. 2010 Legislative Language

SECTION 3 – HUMAN SERVICES

486	SPECIAL CATEGORIES		
	CONTRACTED SERVICES		
	FROM GENERAL REVENUE FUND	153,772	
	FROM ADMINISTRATIVE TRUST FUND . . .		337,765
	FROM FEDERAL GRANTS TRUST FUND . . .		348,235
	FROM GRANTS AND DONATIONS TRUST FUND		2,648,438
	FROM RADIATION PROTECTION TRUST FUND		150,000

From the funds in Specific Appropriation 486, $2,000,000 from the Grants and Donations Trust Fund is provided to the department to continue phase II and complete the study authorized in Specific Appropriation 1682 of chapter 2008-152, Laws of Florida. The report shall include recommendations on passive strategies for nitrogen reduction that complement use of conventional onsite wastewater treatment systems. The department shall submit an interim report of phase II on February 1, 2011, a subsequent status report on May 16, 2011, and a final report upon completion of phase II to the Governor, the President of the Senate, and the Speaker of the House of Representatives prior to proceeding with any nitrogen reduction activities.

Section 14. In order to implement Specific Appropriation 486 of the 2010-2011 General Appropriations Act, and for the 2010-2011 fiscal year only, the following requirements shall govern Phase 2 of the Department of Health's Florida Onsite Sewage Nitrogen Reduction Strategies Study:

(1) The underlying contract for which the study was let shall remain in full force and effect with the Department of Health and funding the contract for Phase 2 of the study shall be through the Department of Health.

(2) The Department of Health, the Department of Health's Research Review and Advisory Committee, and the Department of Environmental Protection shall work together to provide the necessary technical oversight of Phase 2 of the project, with the Department of Environmental Protection having maximum technical input.

(3) Management and oversight of Phase 2 shall be consistent with the terms of the existing contract; however, the main focus and priority for work to be completed for Phase 2 shall be in developing, testing, and recommending cost-effective passive technology design criteria for nitrogen reduction.

(4) The systems installed at actual home sites are experimental in nature and shall be installed with significant field testing and monitoring. The Department of Health is specifically authorized to allow installation of these experimental systems. In addition, before Phase 2 of the study is complete and notwithstanding any law to the contrary, a state agency may not adopt or implement a rule or policy that:

(a) Mandates, establishes, or implements any new nitrogen-reduction standards that apply to existing or new onsite sewage treatment systems or modification of such systems;

(b) Increases the cost of treatment for nitrogen reduction from onsite sewage treatment systems; or

(c) Directly requires or has the indirect effect of requiring, for nitrogen reduction, the use of performance-based treatment systems or any similar technology; provided the Department of Environmental Protection administrative orders recognizing onsite system modifications, developed through a basin management action plan adopted pursuant to section 403.067, Florida Statutes, are not subject to the above restrictions where implementation of onsite system modifications are phased in after completion of Phase 2, except that no onsite system modification developed in a basin management action plan shall directly or indirectly require the installation of performance-based treatment systems.

FLORIDA DEPARTMENT OF HEALTH
ONSITE NITROGEN REDUCTION STRATEGIES STUDY

PROGRESS REPORT NO. 9
(January, 2011)

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task A – Technology Evaluation for Field Testing: Review, Prioritization, and Development				
Task A.1, Draft Literature Review Report	Task Complete	Draft literature review report completed on May 19, 2009.	None	N/A
Task A.2, Final Literature Review Report	Task Complete	Final literature review report completed on June 30, 2009. Revised Final report submitted on September 4, 2009.	None	N/A
Task A.3, Draft Classification of Technologies Report	Task Complete	Draft Classification, Ranking and Prioritization report completed on May 19, 2009.	None	N/A
Task A.4, Draft Technology Ranking Criteria Report	Task Complete	Draft Classification, Ranking and Prioritization report completed on May 19, 2009.	None	N/A
Task A.5, Draft Priority List for Testing Report	Task Complete	Draft Prioritization report completed on June 30, 2009.	None	N/A
Task A.6, Technology Classification, Ranking and Prioritization Workshop	Task Complete	Workshop presentation materials were developed. Workshop was conducted on May 28, 2009.	None	N/A
Task A.7, Final Classification of Technologies Report	Task Complete	Final Classification, Ranking and Prioritization report completed on September 24, 2009	None	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task A.8, Final Technology Ranking Criteria Report	Task Complete	Final Classification, Ranking and Prioritization report completed on September 24, 2009	None	N/A
Task A.9, Final Priority List for Testing Report	Task Complete	Final Classification, Ranking and Prioritization report completed on September 24, 2009	None	N/A
Task A.10, Draft Innovative Systems Applications Reports	Not started	No activity	N/A	N/A
Task A.11, Final Innovative Systems Applications Reports	Not started	No activity	N/A	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task A.12, Identification of Test Facility Sites	Task Complete	*USF Lysimeter Station* – A general assessment of lysimeter station rehabilitation needs has been determined and is summarized in a memorandum completed on June 18, 2009. *UF Gulf Coast Research and Education Center* – Preliminary agreement from GCREC to participate on December 22, 2008. A summary of the site conditions and recommendations was sent to Elke and distributed May 19, 2009. On May 28, 2009 the RRAC voted to use the GCREC facility site as the only test facility site. Draft agreement submitted to GCREC on June 8, 2009, and returned to FDOH July 31, 2009 with revisions. Comments from review by FDOH received November 11, 2009. Draft letter of authorization for GCREC sent February 2, 2010 to FDOH. MOU signed June 1, 2010.	Lysimeter station rehabilitation costs alone were likely to be in excess of $60,000, which exceed the total construction budget for the Task A test facility.	We are recommending consolidating our activities to one test facility. We recommended to conduct all test facility activities at GCREC site
Task A.13, Draft QAPP PNRS II	Task Complete	Draft QAPP for PNRS II report completed on June 18, 2009.	None	N/A
Task A.14, Recommendation for Process Forward Meeting	Task Complete	Recommendation for Process Forward meeting held on October 13, 2009. Task completed upon execution of contract amendment in February 2010.	None	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task A.15, Final QAPP PNRS II	Task Complete	Final QAPP for PNRS II report completed on November 24, 2009. Revised and amended for additives rule report completed on February 4, 2010. Amended report for sodium sesquicarbonate media completed on June 4, 2010.	None	N/A
Task A.16 Materials Testing for FDOH Additives Rule	Underway	Florida additive rule for septic system products, evaluation of limestone and oyster shell, report completed on June 30, 2010. Testing of STE, UNSAT-CL4, DENIT-LS1, DENIT-SU1, IS1 and IS3 effluent is underway.	None	N/A
Task A.17, PNRS Specification Reports	Underway	Specification report I completed on May 7, 2010. A revised final report was completed on May 24, 2010.	None	N/A
Task A.18, Test Facility Design 50%	Task Complete	50% revised Design Drawings completed on September 4, 2009.	None	N/A
Task A.19, Test Facility Design 100%	Task Complete	100% Design Drawings completed on December 31, 2009.	None	N/A
Task A.20 PNRS II Test Facility Construction Support & Administration	Task Complete	Construction was started February 15, 2010. 50% construction completed April 2, 2010. 100% construction completed April 30, 2010.	None	N/A
Task A.21 PNRS II Test Facility Construction 50%	Task Complete	Construction was started February 15, 2010, 50% construction progress report completed on April 2, 2010.	None	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task A.22 PNRS II Test Facility Construction 100%	Task Complete	100% construction progress report completed on April 30, 2010.	None	N/A
Task A.23 PNRS II Test Facility Construction Substantial Completion	Task Complete	Construction punch list completed on April 27, 2010.	None	N/A
Task A.24 PNRS II Test Facility Accept Construction	Task Complete	As-built documents completed on May 28, 2010.	None	N/A
Task A.25 Monitoring & Sample Event Reports	Underway	Sample Event Report (SER) No. 1 completed on July 16, 2010. SER No. 2 completed on September 28, 2010. SER No. 3 completed on December 16, 2010. SER No. 4 completed on February 2, 2011.	None	N/A
Task A.26 Data Summary Reports	Underway	Data Summary Report (DSR) No. 1 completed on September 2, 2010. DSR No. 2 completed on October 5, 2010. DSR No. 3 completed on January 20, 2011.	None	N/A
Task A.27 Draft PNRS II Report	Not started	No activity	N/A	N/A
Task A.28 Final PNRS II Report	Not started	No activity	N/A	N/A
Task A.31Change-order Allowance	Underway	FDOH authorized $20,000 for the PNRS II modifications completed December 16, 2010.	None	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task B – Field Testing of Technologies and Cost Documentation				
Task B.1, Identification of Home Sites	Underway	Several home sites in Manasota Key, Wakulla County, Seminole County, Lee County, Hillsborough County and Marion County have been visited to perform preliminary evaluation of sites with homeowners interested in the project. Two Wakulla County homeowner agreements completed on October 5, 2010.	None	N/A
Task B.2, Vendor Agreement Reports	Underway	Started work on vendor agreements.	None	N/A
Task B.3, Draft QAPP for Field Testing	Task Complete	Draft QAPP for field testing report completed on July 16, 2010.	None	N/A
Task B.4, Recommendation for Process Forward Meeting	Task Complete	Conference call meeting was held on October 11, 2010. Meeting minutes were submitted on November 1, 2010.	None	N/A
Task B.5, Final QAPP Field Testing	Task Complete	Final QAPP for field testing report completed on November 1, 2010.	None	N/A
Task B.6 Field Systems Installation Report (per system)	Underway	Started work on field system design at one field site in Wakulla County.	None	N/A
Task B.7 Field Systems Monitoring Report (per event)	Not started	No activity	N/A	N/A
Task B.11, LCCA Template Report (draft)	Not started	No activity	N/A	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task B.12 LCCA Template Report (final)	Not started	No activity	N/A	N/A
Task B.16 Change-order Allowance	Not started	No activity	N/A	N/A
Task C – Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater				
Task C.1, Draft Literature Review on Nitrogen Reduction in Soils & Shallow GW Report	Task Complete	Draft Literature Review on nitrogen reduction in soils and shallow groundwater report completed on June 30, 2009.	None	N/A
Task C.2, Final Literature Review on Nitrogen Reduction in Soils & Shallow GW Report	Task Complete	Final Literature Review on nitrogen reduction in soils and shallow groundwater report completed on November 24, 2009.	None	N/A
Task C.3, Draft QAPP Evaluation of Nitrogen Reduction Provided by Soils & Shallow GW	Task Complete	Draft QAPP on nitrogen reduction in soils and shallow groundwater report completed on October 30, 2009.	None	N/A
Task C.4, Recommendation for Process Forward Meeting	Task Complete	Conference call meeting was held on November 23, 2009. Meeting minutes submitted on November 25, 2009 served as half of the deliverable. Task complete upon completion of contract amendment executed February 2010.	None	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task C.5, Final QAPP Evaluation of Nitrogen Reduction Provided by Soils & Shallow GW	Task Complete	Final QAPP on nitrogen reduction in soils and shallow groundwater report was submitted on December 4, 2009. Determined to be 80% complete on December 23, 2009. Revisions completed February 5, 2010.	None	N/A
Task C.6, S&GW Test Facility Design 50%	Task Complete	Test Facility Design 50% drawings completed on June 30, 2009.	None	N/A
Task C.7, S&GW Test Facility Design 100%	Task Complete	100% Design Drawings completed on December 31, 2009	None	N/A
Task C.8, S&GW Test Facility Design Final	Task Complete	Final S&GW Test Facility Design completed on March 4, 2010.	None	N/A
Task C.9, S&GW Test Facility Construction Support & Administration	Not started	No activity	N/A	N/A
Task C.10, S&GW Test Facility Construction 50%	Not started	No activity	N/A	N/A
Task C.11, S&GW Test Facility Construction 100%	Not started	No activity	N/A	N/A
Task C.12, S&GW Test Facility Construction Substantial Completion	Not started	No activity	N/A	N/A
Task C.13, S&GW Test Facility Accept Construction	Not started	No activity	N/A	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task C.14, Soils & Hydrogeologic & Monitoring Plan for S&GW Test Facility	Not started	No activity	N/A	N/A
Task C.15, Tracer Testing at GCREC	Not started	No activity	N/A	N/A
Task C.16 S&GW Sample Event Report	Not started	No activity	N/A	N/A
Task C.17 S&GW Data Summary Report	Not started	No activity	N/A	N/A
Task C.19 Field Site Selection	Underway	Several home sites in Wakulla County, Lee County, and Marion County have been visited to perform preliminary evaluation of sites with homeowners interested in the project. One Wakulla County homeowner agreement completed on October 5, 2010.	None	N/A
Task C.20 Instrumentation of GCREC Mound System	Task Complete	Instrumentation of GCREC Mound system 100% progress report completed on December 16, 2010.	None	N/A
Task C.21 GCREC Mound Sample Event Report	Underway	GCREC Mound sample event No. 1 conducted December 9-10, 2010.	N/A	N/A
Task C.22 GCREC Mound Data Summary Report	Underway	Started work on data summary report.	N/A	N/A
Task C.23 Instrumentation of Remaining Field Sites	Underway	Started work on instrumentation at one field site in Wakulla County.	N/A	N/A
Task C.24 Field Sites Sample Event Reports	Not started	No activity	N/A	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task C.25 Field Sites Data Summary Report	Not started	No activity	N/A	N/A
Task C.30 Change-order Allowance	Not started	No activity	N/A	N/A
Task D – Nitrogen Fate and Transport Modeling				
Task D.1, Draft Literature Review on Nitrogen Fate & Transport Model Report	Task Complete	Draft Literature Review on nitrogen fate and transport model report completed on June 30, 2009.	None	N/A
Task D.2, Final Literature Review on Nitrogen Fate & Transport Model Report	Task Complete	Final Literature Review on nitrogen fate and transport model report completed on December 4, 2009. Determined to be 80% complete on December 23, 2009. Revised report complete on February 5, 2010.	None	N/A
Task D.3, Selection of Existing Data Set for Calibration Report	Task Complete	Selection of Existing Data Set for Calibration report completed on June 30, 2009.	None	N/A
Task D.4, Draft QAPP N Fate and Transport Modeling	Task Complete	Draft QAPP report completed on April 2, 2010.	None	N/A
Task D.5, Recommendation for Process Forward	Task Complete	Conference call meeting was held on July 13, 2010. Meeting minutes submitted on August 14, 2010.	None	N/A
Task D.6, Final QAPP N Fate and Transport Modeling	Task Complete	Final QAPP report completed on September 22, 2009.	None	N/A
Task D.7 Simple Soil Model Development	Not started	No activity	N/A	N/A

Task	Task Status	Activity this Period	Technical, Schedule, or Budget Problems Encountered	Recommended Methods to Resolve Problems
Task D.14 Complex Soil Model Development	Underway	Started work on complex soil model development.	None	N/A
Task D.29 Change-order Allowance	Not started	No activity	N/A	N/A
Task E – Project Management, Coordination and Meetings				
Task E.1, Project Kick-off Meeting	Task Complete	The project kick-off meeting was held February 27, 2009. Meeting minutes were completed on March 19, 2009.	None	N/A
Task E.2, PM-Project Progress Report	Progress Report 1, 2, 3, 4, 5, 6, 7, 8 - Complete	The January 2011 quarterly progress report (this report) was completed February 28, 2011.	None	N/A
Task E.3, RRAC or TRAP Presentation	Underway	RRAC meeting was attended and a presentation given on July 1, 2009; March 23, 2010; and June 10, 2010. TRAP meeting was attended and a presentation given August 27, 2009. RRAC meeting presentation and tour of GCREC PNRS II facility was given December 10, 2010.	None	N/A
Task E.4 RRAC or TRAP Meeting Attendance	Underway	RRAC meeting was attended December 16, 2009. RRAC meeting was attended November 5, 2010.	None	N/A
Task E.4, PAC Meeting	Not started	No activity	N/A	N/A

FLORIDA DEPARTMENT OF HEALTH

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task B.5

Quality Assurance Project Plan

Final Report

October 2010

44237-001

HAZEN AND SAWYER
Environmental Engineers & Scientists

In association with

SCHOOL OF MINES 1874 COLORADO

AET
Applied Environmental Technology

OTIS
ENVIRONMENTAL
CONSULTANTS, LLC

Florida Onsite Sewage Nitrogen Reduction Strategies Study

TASK B.5
FINAL REPORT

Task B Field Testing Quality Assurance Project Plan

Prepared for:

Florida Department of Health
Division of Environmental Health
Bureau of Onsite Sewage Programs
4042 Bald Cypress Way Bin #A-08
Tallahassee, FL 32399-1713

FDOH Contract CORCL

October 2010

Prepared by:

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AET
Applied Environmental Technology

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Section 1.0
Introduction

1.1 Project Background

Nitrogen is an important concern for water quality and nitrate-nitrogen represents perhaps the most common groundwater pollutant. Animals, crops, ecosystems, and human health can be adversely impacted by the presence of nitrogen in water supplies. The environmental effects of nitrogen on groundwater and surface water can ultimately lead to the degradation of surface waters in watershed systems that have strong groundwater/surface water interactions. Nitrogen that enters surface water bodies via these interactions can lead to algal blooms and eutrophication. These processes lead to oxygen depletion in surface waters which can be harmful to natural aquatic life. In Florida, the protection of watersheds, in particular surface water bodies, has led to the legislation of protection of these areas (i.e., the Wekiva River Protection Act).

The Florida Onsite Sewage Nitrogen Reduction Strategies (FOSNRS) Project is implementing a multi-pronged approach to address nitrogen loading to the Florida environment from onsite sewage treatment and disposal systems (OSTDS). A central component of the FOSNRS project is the experimental evaluation of onsite wastewater nitrogen reduction technologies at field and home sites. A goal of the FOSNRS project is to evaluate technologies that are appropriate for onsite deployment and which achieve a high degree of nitrogen reduction. The classifications of onsite technologies that will be evaluated in Task B have been identified and prioritized in FOSNRS Tasks A.1 through A.9 and include two stage biofiltration using solid phase electron donor media for denitrification, addition of denitrification biofilters to existing aerobic nitrifying systems, and in situ vertical flow biofilters (Hazen and Sawyer, 2009a, 2009b, 2009c, 2009d). Technologies to be evaluated include passive two stage nitrogen reduction systems initially evaluated at bench-scale in the Florida Passive Nitrogen Removal Study (Smith, 2009; Smith, 2008a; Smith, 2008b; Smith et al., 2008).

1.2 Project Scope and Purpose

The overall goal of Task B is to perform field experiments under full scale actual operating conditions to critically assess nitrogen reduction technologies that have been identified in FOSNRS Task A.9. To accomplish this goal several objectives are identified:

1. Identify homeowner test sites and establish homeowner agreements,

2. Identify specific technology vendors and establish vendor agreements,

3. Install technologies at test sites and document installation issues,

4. Document installation costs of technologies,

5. Monitor performance of treatment systems for nitrogen and other water quality parameters and assess performance,

6. Monitor the energy used and other operational costs associated with system operation,

7. Monitor routine and non-routine maintenance costs to support life cycle economic analysis, and

8. Site closure.

To meet these objectives a combination of field testing and monitoring is planned at various residential field sites. Field sites will be selected from regions in north Florida, the Wekiva area, and in other locations on the Florida peninsula. Monitoring at each site will include influent, effluent, and intermediate treatment locations where possible or applicable. The data sets generated will enable quantification of hydraulic, organic, and nitrogen loading rates; average influent and effluent concentrations; removal efficiencies for nitrogen and other parameters; and effluent nitrogen concentrations achieved. Documentation of installation, operation, and maintenance costs will enable comparative life cycle cost estimates to be made. The project approach is described in detail in Section 2.0. Execution of homeowner agreements will initiate in calendar year (CY) 2010 and will continue through CY 2011. Vendor agreements will be pursued in CY 10 through CY 11 and system installation will follow thereafter.

1.3 Project Organization

Task B is comprised of several interrelated subtasks that fall within six primary categories:

1) Selection of field test sites and technologies,
2) Agreements with homeowners and vendors,
3) Installation and operational verification,

4) Field monitoring and laboratory analyses,
5) Performance assessment and reporting, and
6) Site closure.

FOSNRS Tasks B.1 and B.2 of the contract entail establishment of test sites and vendor technology agreements. This Quality Assurance Project Plan (QAPP) under Task B.3 describes the proposed testing and monitoring framework for onsite technologies. While the work described in this QAPP encompasses the entire scope of the FOSNRS project, funding for the entire project has not been totally established. However, the general procedures described in this QAPP will be followed at all field sites. The project work scope is described in Section 2. The methods of data collection and handling to ensure the data quality objectives are met are described in Section 3. Finally, health and safety precautions required during project activities are described in Section 4.

1.4 Key Project Personnel and Responsibilities

A Task B organization chart is shown in Figure 1.1. Mr. Damann Anderson of Hazen and Sawyer is the FOSNRS Manager responsible for project management and oversight. Dr. Daniel P. Smith of Applied Environmental Technology is responsible for scientific and technical oversight. Mr. Anderson and Dr. Smith are co-principal investigators for the overall project. Dr. Smith is the Task B leader responsible for overall Task B operations and activities. The Task B leader is also responsible for ensuring that this project plan is completed and the data quality objectives (DQOs) are met.

Personnel from Hazen and Sawyer and other subcontractors will be responsible for conducting field activities and monitoring. For each field site, a field team leader from Hazen and Sawyer or other subcontractor will be identified and will be responsible for providing daily coordination of field activities, for interfacing with other subcontractors, and for interfacing with the Task B leader. Field personnel involved in onsite operations are responsible for notifying the field team leader of any nonconforming field events or problems and ensuring that all co-workers are aware of such problems. Field personnel are to perform only those tasks that they can do safely and immediately report any accidents and/or unsafe conditions to the field leader and/or Task leader. Field personnel include all individuals performing field tasks and will demonstrate the experience and/or ability to perform the assigned tasks. Equipment operators (e.g., drillers, backhoe operator, etc.) shall be able to verify training and experience for the required capabilities.

Prior to initiating field work, all field personnel will be required to attend a brief site orientation given by the field team leader that will cover the description of work to be performed (task orientation), standard operating procedures (SOPs), QA/QC measures, and safe work practices. In addition, periodic “tailgate” meetings will be held to discuss potential concerns and refresh personnel on work tasks, QA/QC measures, and safe work practices. These field meetings will be documented in the field team leader’s logbook.

All project personnel are responsible for taking all reasonable precautions to prevent injury to themselves and to their fellow employees. The qualifications for key Task B personnel were provided in the proposal (Mr. Anderson, Dr. Smith, and Mr. Harmon Harden).

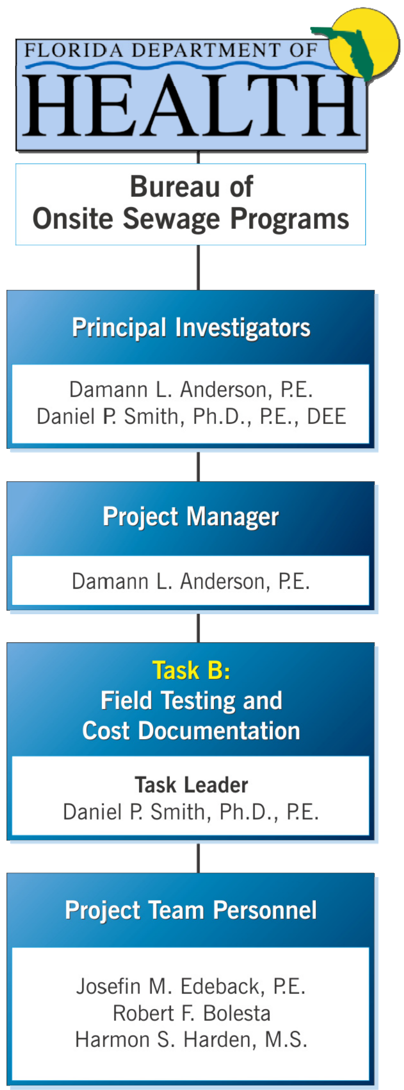

Figure 1-1: Task B Organization Chart

Section 2.0
Task B Description

Field testing will be conducted at residential sites established in various Florida locations. The number of individual installations implemented over the entire project is contingent on the total funding ultimately available. The testing of individual technologies will each be conducted using a general set of activities that are described in this Section. An overview of the technology evaluation process is presented in Table 2.1. The following sections describe the approaches to be taken in implementing the technology evaluation process.

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Table 2.1
Technology Evaluation Process at Residential Field Sites

General Activity	Action	Approach/Activities	Product
Activities Prior to Installation			
1	Identify residential field sites	Availability of sites with homeowners amenable to testing; pre-existing technologies; sensitive sites; geographic distribution; site access; power supply	Establish homeowner agreement
2	Identify specific technology vendors	Task A.9 Technology Prioritization List for Testing; vendor contacts	Establish vendor agreement
3	FDOH notification	Summarize site, technology	Memo to FDOH
Technology Procurement			
4	Procure technology	Vendor contract purchase, component purchase orders, or donation	Purchased, donated or fabricated technology
Installation at Residential Sites			
5	Install technologies at field sites	Site preparation; vendor installation procedures; design of new technologies; site specific features; verify operation; document costs	Documentation of issues with installation and operational verification, costs
Operation and Monitoring			
6	Monitor performance of treatment systems for nitrogen and other water quality parameters	Twelve month or greater period of operation; water quality flowrate or volume; sample influent and final effluent ; sample intermediate treatment steps where applicable; monitor nitrogen species, physical and chemical parameters	Comprehensive datasets
7	Monitor operational costs of system operation	Electrical meter, chemical/additive use, routine operational checks	Documentation of operational costs under actual conditions
8	Track routine and non-routine maintenance	Record keeping of all routine and non-routine operation and maintenance issues	Operation and maintenance under actual field conditions

Table 2.1 (con't)
Technology Evaluation Process at Residential Field Sites

General Activity	Action	Approach/Activities	Product
Performance Assessment			
9	Removal efficiencies; effluent concentrations achieved; water quality parameters	Spreadsheet based data management system; data analysis.	Performance assessment under actual field conditions
Site Closure			
10	Site closure	Provide homeowner with operating instructions or remove technology	Closure agreement; transfer of technology to homeowner or removal

2.1 Activities Prior to Installation

Activities prior to installation include site identification and selection, technology identification and selection, completion of agreements with homeowner and vendor, and notification to FDOH.

2.1.1 Site Identification and Selection

The project team will identify residential field sites that will enable the objectives of Task B to be achieved. Site features to be evaluated include general geographic location, availability of a pool of homeowners who are amenable to testing, site access, pre-existing technologies at site, and energy availability. Practical considerations favor several groups of sites, with individual homeowner sites in each group located in relatively proximate locations. It is anticipated that sites will be identified in the following locations: North Florida (Wakulla County), Central Florida (Wekiva Study Area, Hillsborough County and environs), and South Florida areas (e.g. Lee County). Selection of homeowner sites will be guided by the desire to give preference to evaluating passive type nitrogen reduction systems as per the previous technology prioritization that was conducted and which is summarized in the following Section 2.2.1 (Hazen & Sawyer, 2009c). It is also intended, as a lower priority, to locate sites with pre-existing treatment technologies to which denitrification filters could be added to increase total nitrogen reduction (Hazen & Sawyer, 2009c). In this case, Task B monitoring would be conducted for the entire treatment system including the pre-existing technology.

2.1.2 Technology Identification and Selection

Technology identification will be guided by the recommendations presented in the previous Task A.9 report (Hazen & Sawyer, 2009c) and summarized in Table 2.2. The list of technologies recommended for testing is based on the ranking of technologies that was conducted in Task A.9. However, the actual number and order of system deployments may differ from Table 2.2 due to availability of funding, suitable test sites with amenable homeowners, geographical location of sites, vendor agreements, and readiness of technology. Passive two stage biofiltration systems and in-situ vertical flow systems containing denitrification media are currently being evaluated in PNRS II (Hazen & Sawyer, 2009d). Evaluation of these systems at field sites will be initiated based on PNRS II test results.

Table 2.2
Technologies Recommended for Testing in Task B (from Hazen & Sawyer, 2009c)

System	Technology	Comment
1	Two stage (segregated biomass) system: Stage 1: Biofiltration with recycle (nitrification) Stage 2: Autotrophic denitrification with reactive media biofilter	• Top ranked system capable of meeting the lowest TN concentration standard • Suitable for new systems or retrofit
2	Two stage (segregated biomass) system: Stage 1: Biofiltration with recycle (nitrification) Stage 2: Heterotrophic denitrification with reactive media biofilter	• Top ranked system capable of meeting the lowest TN concentration standard • Suitable for new systems or retrofit
3	Natural system: Septic tank/Drainfield with in-situ reactive media layer	• Lower cost natural system that is untested but appears capable of achieving 75-78% TN removal before reaching groundwater • Suitable for new systems or replacing existing systems at end of useful life
4	Natural system: Primary or secondary effluent with drip dispersal	• Suitable for reducing TN impacts on groundwater through enhanced TN removal and reduced TN loading on soil • Suitable for new systems or retrofit

Table 2.2 (con't)
Technologies Recommended for Testing in Task B (from Hazen & Sawyer, 2009c)

System	Technology	Comment
5	Mixed biomass fixed film system with recycle followed by heterotrophic denitrification with reactive media biofilter	• High performance aerobic treatment with anoxia for enhanced TN removal followed by second stage hetero-trophic denitrification for high nitrogen removal • Suitable for new systems or nitrogen reduction upgrades
6	Mixed biomass fixed film system with recycle followed by an autotrophic denitrification with reactive media biofilter	• High performance aerobic treatment with anoxia for enhanced TN removal followed by second stage autotrophic denitrification for meeting low TN concentration standard • Suitable for new systems or nitrogen reduction upgrades
7	Mixed biomass integrated fixed film activated sludge system: Suspended growth with recycle	• High performance aerobic treatment • Suitable for new systems or nitrogen reduction upgrades
8	Mixed biomass integrated fixed film activated sludge system: Moving bed bioreactor	• High performance aerobic treatment with simultaneous denitrification • Suitable for new systems or nitrogen reduction upgrades
9	Mixed biomass suspended growth system: Suspended growth sequencing batch reactor	• Aerobic treatment • Suitable for new systems or nitrogen reduction upgrades
10	Membrane process system: Membrane bioreactor (MBR)	• Suitable for new systems or nitrogen reduction upgrades
11	Source separation system: Dry toilet (evaporative or composting)	• Eliminates liquid disposal of wastes
12	Source separation system: Urine separating (recovery) toilet	• Innovative system that is capable of removing 70-80% of the household TN at little capital cost • Provides potential for sustainable re-covery of nutrients

2.1.3 Homeowner Agreement

For each test site, a homeowner agreement will be finalized that specifies the terms and conditions under which site testing will be performed. The project team will relay to the homeowner the type of technology, its physical and operational characteristics, and other pertinent features of the systems. The project will generally agree to pay for all expenses related to site preparation specific to the wastewater treatment system, for procurement of technology, installation, operation and maintenance during the study, energy, monitoring, permit fees, design and engineering fees, and maintenance entity fees if applicable. All project payments will terminate upon site closure. Homeowner requirements include site access and spatial needs during testing, non-tampering provisions, and understanding of site closure options.

2.1.4 Technology Vendor Agreement

For each vendor-supplied technology, a vendor agreement will be finalized that specifies the terms and conditions under which the technology will be procured, installed and tested. The vendor agreement must specify exactly what is provided by the vendor and what is not. Vendor will supply written cost estimate including delivery to the site. Vendor requirements include providing full description of technology and requirements for installation, operation and maintenance. Vendors may advise or inspect installation but will not be allowed to independently change or manipulate any aspect of technology once the testing has been initiated. Full or partial equipment donations by vendor will be subject to same rules and considerations as if the equipment were purchased on the open market.

2.1.5 FDOH Notification

FDOH will be notified of individual test site and technology combinations that have been chosen for testing by the project team.

2.2 Technology Procurement

Vendor supplied technology will be procured through purchase agreement as per 2.1.4, paid by project funds. For non-vendor systems, the project teams will purchase materials and components and fabricate technologies for deployment. Detailed cost records will be maintained to enable system cost estimates to be made.

2.3 Installation at Residential Field Sites

Installation activities include site preparation, technology delivery and installation, and verification of operation.

2.3.1 Site Preparation

Site preparation includes site work conducted prior to delivery of the technology to the site and may include providing access, clearing, excavating, leveling, and power supply.

2.3.2 Technology Delivery and Installation

The project team will provide personnel at the site to accept delivery of the technology. Installation will be conducted by licensed septic tank contractors according to vendor recommendations or according to installation requirements formulated by Task B co-PIs for the systems being tested in PNRS II or other non-vendor equipment.

2.3.3 Verification of Operation

Operational verification includes testing of all features pertinent to individual technologies, such as control panels, pumps, and blowers; testing of flow/volume and electrical meters, and, if necessary, manual verification of flows and volumes.

2.4 Operation and Monitoring

The general operating and monitoring schedule is shown in Table 2.3. Operation and monitoring includes monitoring of flowrate or volume treated; energy, chemical, or additives consumption; chemical and microbiological analyses; and routine and non-routine maintenance. The general operating and monitoring schedule is shown in Table 2.3.

Upflow and horizontal denitrification biofilters will have controlled submergence depths which will be maintained by the discharge elevation. Vertical stacked biofilters (In-situ simulators) will also have controlled submergence depths through u tube design. Saturated water levels will be assessed through field monitoring which will be dependent on the technology installed and the need to insure an operation that results in data sets.

Table 2.3
General Monitoring Framework

Task	Nominal Frequency[1]	Actions	Product
Site Inspection	1 time/month	Visual inspection; ascertain operability; odors; read meters; examine drainfield observation ports	Completed inspection checklist; log entries; meter readings
Flow/volume	1 time/month	Record flow/volume meter; make spreadsheet entry	Updated flow/volume records; average daily volume calculation
Energy, chemical, or additives consumption	1 time/month	Record energy meter, chemical or additives use; make spreadsheet entry	Updated energy, chemical or additives records; average daily use and use per volume calculation
Routine maintenance by project personnel or maintenance entity	Per vendor recommendations or recommendations of project team	Perform routine maintenance actions	Maintenance log entries
Non-routine maintenance	As needed	Identify problem and perform non-routine maintenance actions	Maintenance log entries: documented cause of problem, action taken, cost of parts and labor
Chemical and microbiological monitoring	Maximum of 8 full monitoring events, minimum of 1 month between sampling events	Monitor chemical and microbiological parameters in influent, effluent and intermediate process points where applicable; make spreadsheet entries	Data set of chemical and microbiological parameters; log of removal efficiencies and effluent concentrations for total nitrogen, nitrogen species, and other water quality parameters

[1]Frequency of monitoring tasks may be more frequent at start-up. Frequency will be dependenet on technology and the need to insure an operation that results in data sets.

2.4.1 Flow and Volume

A flow/cumulative volume meter will be installed to measure flow to the treatment system. The meter will measure either influent flow to the treatment system or effluent flow from the treatment system. A raw sewage sampling device designed by CSM (Lowe et. al, 2009) will be employed to measure influent raw sewage volume to the septic tank if required.

2.4.2 Energy, Chemical and/or Additives Consumption

Energy consumption will be monitored using an electrical meter installed on the power line to provide cumulative kW-hour used for all energy requiring system components. Any chemical and/or additives use will be tracked by recording the volume or mass of these items supplied for system operation.

2.4.3 Chemical and Microbiological Analyses

The sample collection generally follows the approach that was initially implemented in PNRS I and is being continued in PNRS II. Where possible, monitoring will be based on collecting samples manually through in-line sampler pipes which extend vertically downwards from the effluent pipes and through which sample flows by gravity. Where necessary, samples will be collected using a persistaltic pump. Samples will be collected of the influent to the treatment system, which is onsite primary effluent, also known as septic tank effluent (STE). Influent for treatment technologies that do not utilize a septic tank will be sampled from the primary treatment zone of the unit or if necessary using a "Rotherator" device for influent to the septic tank. Effluent samples (i.e. final effluent) are collected from the final treatment system component (e.g. denitrification biofilter effluent in a two stage passive biofiltration process) and result in the final effluent quality for total nitrogen and individual nitrogen species. Intermediate sample collection can occur from one or more intermediate process points if they are amenable to sampling and enables the performance to be assessed for specific nitrogen species. For example, monitoring the effluent from an aerobic biological process before it enters a denitrification biofilter is used to assess nitrification performance and reduction in $CBOD_5$.

Chemical and microbiological parameters to be analyzed are listed in Table 2.4. The parameter list includes total kjeldahl nitrogen (TKN), ammonia nitrogen (NH_4^+-N), and oxidized nitrogen (NO_3+NO_2)-N for delineation of nitrogen speciation; total and volatile suspended solids (TSS, VSS); bulk organic matter as five day carbonaceous oxygen demand ($CBOD_5$) and chemical oxygen demand (COD); total and orthophosphorus as macronutrient for biological processes; sulfate and hydrogen sulfide (H_2S) for technologies employing sulfur based biofiltration for denitrification; and fecal coliform (fc) and *E. Coli* as microbiological indicators. Supporting inorganic parameters include temperature, pH, alkalinity, dissolved oxygen (DO), and oxidation reduction potential (ORP).

For multiple point monitoring, sample collection will generally be conducted starting with the downstream point and proceeding to the upstream point. This eliminates the effects of upstream sampling on downstream effluent quality. Liquid effluent samples will contact at most one intermediate sample collection bottle before being placed in pre-prepared sample bottles. Field parameters that employ probes may be used if possible by direct probe placement into locations within the process train as opposed to samples collected in external containers. Sample collection, handling and analyses methods will be in accordance with FDEP SOPs and are discussed in Section 3.0. Varied sample collection and additional sample analysis may be conducted for specific research purposes based on ongoing performance monitoring; these may entail additional analytes and/or instrumentation.

Table 2.4
Chemical and Microbiological Parameters

Systems	Sample points	Analytes
All systems	Influent, effluent, intermediate point(s) where applicable	Temperature
		pH
		DO
		ORP
		Alkalinity
		TKN
		NH_4^+-N
		(NO_3+NO_2)-N
		TSS
		VSS
		$CBOD_5$
		COD
		Total phosphorus
		Orthophosphorus
		E. Coli
		Fecal Coliform
Sulfur denitrification biofilters	Influent and effluent	Sulfate
		H_2S

2.4.4 Routine and Non-routine Maintenance

Full documentation will be maintained of routine and non-routine maintenance activities under the actual operating conditions. Routine maintenance refers to scheduled activities that are recommended by the vendor or by the project team for non-vendor systems. Non-routine maintenance relates to equipment breakdowns and malfunctions requiring operator attention.

2.5 Performance Assessment

The performance assessment will be enabled by the acquisition of sufficient data to determine:

- flowrates or cumulative volumes treated;
- concentration of nitrogen species in influent, effluent, and intermediate process points where applicable;
- nitrogen removal efficiencies;
- concentrations of other organic and inorganic water quality parameters in influent, effluent, and intermediate process points where applicable;
- pH, alkalinity, and dissolved oxygen in influent, effluent, and intermediate process points where applicable, and changes of these parameters that occur from influent to effluent of treatment components;
- energy, chemical, and/or additives consumption under actual application conditions; and
- routine and non-routine operational and maintenance requirements.

Successful completion of the monitoring program will provide data sets for each biofilter under the selected design and operation. The datasets will include influent and effluent concentrations of total nitrogen and individual nitrogen species, and the datasets will be used to determine the nitrogen removal efficiencies of individual biofilters and of linked biofilter systems. The data will permit an evaluation of how the treatment technologies perform under given hydraulic and nitrogen loading rates and provide an understanding of the efficacy of nitrogen processing of individual treatment components in multi-step treatment systems. Monitoring of energy, consumables, and maintenance requirements will enable the project team to provide life cycle cost estimates for each system (including costs not related to installation).

Members of the field team will, as a normal part of their daily responsibilities, monitor ongoing work performance by themselves (self assessment) and other project personnel. All project personnel will promptly identify, report, and solicit approved corrections for conditions adverse to quality. All findings and actions concerning equipment problems and nonconformance problems will be documented in field or office logbooks.

2.5.1 Flow and Volume

Flow and/or volume data will be used to estimate average daily volumes, ranges, and variability; hydraulic loading rates; and retention times in treatment systems. These operating features will provide correlative aspects for assessment of nitrogen reduction performance.

2.5.2 Energy, Chemical and/or Additives Consumption

Energy, chemical, and/or additives consumption under actual operating conditions will be used to estimate average consumption and consumption per volume treated. These estimates will be used in life cycle cost estimates for the technology that include both the cost of installation as well as the continuing operational costs that are needed to maintain effective performance.

2.5.3 Chemical and Microbiological Performance

Chemical and microbiological results will be used to assess performance. The concentration of nitrogen species in influent, effluent, and intermediate process points will be used to assess nitrogen removal efficiencies. Other organic and inorganic water quality parameters will also be used to facilitate evaluation of the nitrification and denitrification processes that are occurring.

2.5.4 Routine and Non-routine Maintenance

Documented maintenance requirements for the technology at the residential field sites will be used to develop system maintenance costs. System maintenance costs will be input into life cycle cost estimates that include all costs of system deployment, including initial installation and all recurring and non-routine costs that are needed to maintain effective performance.

2.6 Contingency Measures

An adaptive management strategy will be employed throughout Task B testing. This method is a continuous, integrated process of system monitoring, compilation and evaluation of data, assessing system performance, and making adjustments or modifications that are judged to best serve the overall goals of Task B. The technologies to be tested at residential field sites will be generally well understood and characterized prior to installation. Therefore, the evaluation of technologies at these sites will be one of choosing a design and deployment; then verifying and documenting treatment performance and salient features of operation under that chosen condition. The need for adaptive management decision making will be manifest only in the event of unexpected results and unforeseen outcomes. Examples of modifications could include adjustments in operational strategies, such as modifications of recommended recirculation flowrates; modifications of dosing distribution systems to unsaturated biofilter surfaces; or perhaps other hydraulic modifications. These types of changes will always be evaluated from the perspective of the general desirability of providing continuous datasets under given operational conditions and minimizing manipulation of treatment processes. Operational modifications would then be implemented only if judged to be advantageous to the overall testing objectives.

During Task B, corrective actions may also be required for two other types of problems: analytical or equipment problems and nonconformance problems. Analytical or equipment problems may occur during sampling, sample handling, sample preparation, field measurements, laboratory analyses, and data review. Nonconformance problems may develop at any time during these activities and are often discovered during data review. Analytical laboratory contingency measures are discussed in Section 3.3.

Equipment problems or nonconformance problems should be reported to the Hazen and Sawyer project manager. The field team will then document the condition, its cause, any other related information, and the proposed corrective action. The field team will implement the corrective actions and document them in the field logbook. If appropriate, the field team will ensure that no additional work that is dependent on the nonconforming activity is performed until the corrective actions are completed.

Examples of corrective actions for field measurements include:

- Repeat the measurement to check the error;
- Check for all proper adjustments for ambient conditions, such as temperature;
- Check instrument batteries;
- Recalibrate instrument or device; and
- Replace the instrument or measurement device.

FLORIDA DEPARTMENT OF HEALTH

Section 3.0
Quality Assurance and Quality Control

3.1 Data Quality Objectives (DQOs)

The general quality assurance (QA) objective for Task B is to ensure that the field data collected are of known and acceptable quality. When available, FDEP SOPs will be used for conducting field sampling to ensure that representative data will be collected. Specific Data Quality Objectives (DQOs) for Task B are to:

- ensure that the overall sample collection, preservation, analyses, and data reporting are correct and sufficient to meet Task B objectives;

- characterize the septic tank effluent quality at residential field sites to confirm that it is representative of typical household effluents from Florida residences (Lowe et al., 2009; Lowe et al., 2007);

- provide a systems check by verifying that the expected biochemical reactions are occurring in treatment units, and identify unforeseen operational conditions; and

- produce quality data sets of influent, effluent and intermediate monitoring point water quality that enable critical evaluation of process effectiveness for removal of nitrogen and other constituents.

Of key importance is to define the removal efficiency of total nitrogen; measure concentrations of individual nitrogen species in process effluents; measure effluent levels of biodegradable organics ($CBOD_5$); and to measure levels of water quality parameters that are indicative of favorable environments for nitrogen transforming biochemical reactions and that change as a result of those bioreactions (i.e. pH, alkalinity, dissolved oxygen, oxidation reduction potential). This data will enable critical performance evaluation of the treatment technologies under the regimes in which they are operated.

Data quality indicators will be used to collectively define the quality of the submitted data. These indicators include both qualitative and the quantitative quality control (QC) measures. Task B activities that affect data quality include the sampling methodology, laboratory analyses, and data analyses. The specific methods and quantitative data QA measures (e.g., accuracy, precision, completeness and detection limit) are described in the following sections. In addition, specific qualitative control measures to be used in

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both the field and laboratory are described (e.g., data type, frequency of use, handling of failed QC measures).

3.2. Field Activities

The Task B sampling framework and methodology were described in Section 2. The following descriptions pertain to the field methods to be used. Laboratory activities are described in Section 3.3.

3.2.1 Sample Methods

To preserve the sample integrity, proper sample handling procedures will be employed from the time of sample collection in the field through sample analysis. Table 3.1 lists the FDEP SOPs that are pertinent to Task B. The SOPs will be used by field personnel performing field work for the project.

Table 3.1
List of FDEP SOPs for Task B

SOP	Description
FC 1000	Cleaning / Decontamination Procedures
FD 1000	Documentation Procedures
FQ 1000	Field Quality Control Requirements
FS 1000	General Sampling Procedures
FS 2400	Wastewater Sampling
FT 1000	General Field Testing and Measurement
FT 1100	Field Measurement of pH
FT 1200	Field Measurement of Specific Conductance
FT 1400	Field Measurement of Temperature
FT 1500	Field Measurement of Dissolved Oxygen
FT 1900	Field Continuous Monitoring

3.2.1.1 Sample Collection

As described in Section 2, several different types of samples will be collected in Task B. The monitoring program consists primarily of manually collected samples of treatment system influent (primary effluent, or septic tank effluent), final system effluent, and samples from intermediate process points (Section 2.4.3). Routine monitoring will include several field measurements including temperature, pH, dissolved oxygen (DO), and oxidation-reduction potential (ORP). Sampling methods will be in accordance with FDEP-SOPs (FS 1000). The sample collection frequency and analytes are described below and are summarized in Table 3.2. Associated QC samples are summarized in Section 3.2.1.4.

Table 3.2
Task B Measurements

<table>
<tr><th>Sample frequency</th><th>Systems</th><th>Sample points</th><th>Analytes</th></tr>
<tr><td rowspan="18">One event per two months, maximum of eight full monitoring events</td><td rowspan="16">All systems</td><td rowspan="16">Influent, final effluent, intermediate point(s) where applicable[1]</td><td>Temperature</td></tr>
<tr><td>pH</td></tr>
<tr><td>DO</td></tr>
<tr><td>ORP</td></tr>
<tr><td>Alkalinity</td></tr>
<tr><td>TKN</td></tr>
<tr><td>NH_4^+-N</td></tr>
<tr><td>(NO_3+NO_2)-N</td></tr>
<tr><td>TSS</td></tr>
<tr><td>VSS</td></tr>
<tr><td>$CBOD_5$</td></tr>
<tr><td>COD</td></tr>
<tr><td>Total phosphorus</td></tr>
<tr><td>Orthophosphorus</td></tr>
<tr><td>E. Coli</td></tr>
<tr><td>Fecal Coliform</td></tr>
<tr><td rowspan="2">Sulfur denitrification biofilters</td><td rowspan="2">Influent and effluent</td><td>Sulfate</td></tr>
<tr><td>H_2S</td></tr>
</table>

[1]Intermediate monitoring points will be established based on technology and sampling access

Samples of influent (primary effluent), system final effluent, and intermediate wastewater will be collected in accordance with FS 2400, Wastewater Sampling. The exact sample locations are system dependent and will be established at the time that individual systems are installed. Gravity collection from in line ports will be used where possible and will provide whole effluent collection for a limited time period. Peristaltic pumps will be used as a second option if necessary. Samples will be collected into a single sample container, immediately subdivided into prepared sample storage and preservation containers for different analytes, and placed in a cooler in wet ice. All non-dedicated sampling equipment will be decontaminated (soap wash, triple DI rinse, and acid wash as required) between sampling locations in accordance with FDEP-SOPs (FC 1000) by a NELAC certified analytical laboratory.

3.2.1.2 Sample Handling and Custody

Sample handling procedures include the use of correct sample containers, labeling, documentation, preservation, and transport. Sample bottles will be precleaned and provided by a NELAC certified laboratory; certificates of cleanliness will be maintained in the project file. The bottles will be stored in a secured area to maintain integrity. Preservatives will consist of reagent grade chemicals and will be placed in the bottles prior to sample collection. Selection of sample containers is governed by sample type and size and the required analyses. Each sample aliquot will be labeled with the site ID, sample ID, date, time, and sampler initials and logged into laboratory notebooks. Duplicate samples will be designated with a "D" or "dup" after the last character of the sample designation. Equipment rinsates will be designated with an "ER" after the last character of the last sample collected prior to the equipment rinsate. Field blanks will be numbered consecutively.

Due diligence will be exercised to minimize the time between sample collection at the site and transport to the laboratory for analysis. After the samples have been collected, labeled and preserved, the samples will be placed in a cooler and transported in wet ice to a NELAC certified laboratory for analyses. Sample containers will be secured in packing material as appropriate to prevent damage and spills. Sample delivery will be conducted on a daily basis corresponding to executed sampling event.

A sample will be considered under custody if it is in:

- actual possession of a member of the sampling crew,
- in view of the sampling crew (constituting actual possession by the crew), or
- in actual possession of the sampling crew and locked in a secured area or vehicle in a manner such as to prevent tampering.

Chain of custody forms will be provided by the NELAC certified laboratory and used to document the transfer of samples from field personnel to the certified analytical laboratory. One chain of custody form will be filled out for each set of samples and placed inside the cooler.

The chain of custody form will list the following:

- regional location,

- sampler(s),
- sample identification,
- sample type,
- date and time of collection,
- analyses requested,
- preservative (if applicable),
- signature and date, and
- remarks.

Sample custody for samples received by the analytical laboratory will be performed according to the laboratory procedures. The analytical laboratory will be in compliance with the FDOH Environmental Laboratory Certification Program (ELCP) and ensure that all samples are properly stored, handled, and analyzed within the required holding time (see Section 3.3). The laboratory will be notified of upcoming field sampling activities and the subsequent transfer of samples to the laboratory. This notification will include information concerning the number and type of samples to be shipped, as well as the anticipated date of arrival.

3.2.1.3 Sample Analysis

Tables 3.3 and 3.4 list the analytical methods, target analytes, sample containers, preservatives, and holding times for samples of influent, system effluent and intermediate process points. Constituents of interest will be analyzed following standard methods as described in Table 3.3 (FDEP, 2008; APHA, 2005). Laboratory analysis of the samples shall be performed within the appropriate holding times as specified in individual analysis methods (Table 3.4). Accuracy and precision targets for analytical parameters are listed in Table 3.5. An analytical template showing the total number of samples to be analyzed at a single test site is summarized in Table 3.6 for four system cases: systems with and without an intermediate monitoring point, and systems with and without sulfur based denitrification. For all systems, system influent and final effluent will be measured.

For microbial analyses (E. coli and fecal coliforms), sample aliquots will be collected, placed into sterilized containers, and immediately placed on ice for microbial analyses. Both fecal coliforms and *E. coli* will be enumerated using either a modified version of the enzyme substrate test (APHA Method 9223B, modified by incubation at 45°C), or alternatively the membrane filtration (MF) technique (APHA 2005, Method 9222D). In the modified enzyme substrate test, samples are diluted and added to a chromogenic and flourogenic substrate and the mixture is incubated at 45°C for 24 hours The concentrations of both fecal coliforms and *E. coli* are provided through a most probable number result based on the substrate color change or UV fluorescence. The incubation temperature in the modified enzyme substrate test is 45°C versus the manufacturer's recommendation of 35°C. The higher incubation temperature enumerates only fecal coliforms rather than total coliforms. Several groups have shown that the modified enzyme substrate test results in similar fecal coliform counts when compared to the membrane filtration method (Yakub *et al.*, 2002; Chihara *et al.*, 2005). Studies have shown that sample holding times of up to 24 hours have little impact on bacterial counts or coliphage numbers (Van Cuyk, 2003; Selvakumar *et al.*, 2004). Although effort will be made to minimize the time between sample collection and analyses, sample holding times of up to 24 hour may result.

Table 3.3
Sample Analyses Methods

Parameter	Detection Limits[1]	Method
Flow	Manufacturer Specification	Water meter
Temperature	0.1 °C	DEP FT1400
pH	0.1	DEP FT1100
DO	0.1 mg-DO/L	DEP FT1500
ORP	25mV	Electrode - (APHA method 2580B)
Alkalinity	2.0 mg-$CaCO_3$/L	Titration - (APHA method 2320B)
TKN	0.05 mg-N/L	U.S. EPA 351.2
Ammonia nitrogen	0.01 mg-N/L	U.S. EPA 350.1
NO_x-nitrogen (nitrate + nitrite)	0.01 mg-N/L (nitrate)	U.S. EPA 300.0
TSS (non-filterable residue)	1.0 mg/L	Gravimetrically, dried at 103–105°C - (APHA methods 2540D)
VSS (volatile non-filterable residue)	1.0 mg/L	U.S. EPA 160.4
$CBOD_5$	2.0 mg/L	Carbonaceous 5-day test - (APHA method 5210B)
COD	10.0 mg/L	U.S. EPA 410.4
Total phosphorus	0.01 mg-P/L	Nitric acid-sulfuric acid method - (APHA method 4500-P)
Orthophosphorus	0.01 mg-P/L	U.S. EPA 300.0
Fecal coliform	1Ct/100mL	APHA method 9222D
E. coli	2Ct/100mL	APHA method 9223B
Sulfate	0.2 mg/L	U.S. EPA 300.0
H_2S	0.01 mg/L	APHA method 4500 SF

[1] Detection limits are for wastewater samples. Actual minimum detection limits may vary due to sample concentrations and subsequent dilutions. The detection limit will be reported with the data.

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Table 3.4
Sample Analyses Requirements[1]

Parameter	Minimum Volume (mL)	Container Requirements	Preservative and Holding Time
Flow	NA	NA	NA
Temperature	20	Pre-cleaned plastic or glass	None, analyze immediately
pH	20	Pre-cleaned plastic or glass	None, analyze immediately
DO	20	Pre-cleaned plastic or glass	None, analyze immediately
ORP	20	Pre-cleaned plastic or glass	None, analyze immediately
Alkalinity, total	20	Pre-cleaned plastic or glass	<6^{o}C, 14 days
TKN	100	Pre-cleaned plastic or glass	H_2SO_4 to pH <2, 28 days
Ammonia-nitrogen	25	Pre-cleaned plastic or glass	H_2SO_4 to pH <2, 28 days
NO_x-nitrogen (nitrate + nitrite)	50	Pre-cleaned plastic or glass	<6^{o}C, H_2SO_4 to pH <2, 28 days
TSS (non-filterable residue)	300	Pre-cleaned plastic or glass	<6^{o}C, 7 days
VSS (volatile non-filterable residue)	300	Pre-cleaned plastic or glass	<6^{o}C, 7 days
$CBOD_5$	1000	Pre-cleaned plastic or glass	<6^{o}C, 48 hours
COD	50	Pre-cleaned glass	<6^{o}C, H_2SO_4 to pH <2, 28 days
Total phosphorus	50	Pre-cleaned plastic or glass	<6^{o}C, H_2SO_4 to pH <2, 28 days
Orthophosphorus	25	Pre-cleaned plastic or glass	<6^{o}C, 48 hours
Fecal coliform	100	Sterile plastic or glass	<6^{o}C, 24 hours
E. coli	100	Sterile plastic or glass	<6^{o}C, 24 hours
Sulfate	10	Pre-cleaned plastic or glass	<6^{o}C, 28 days
H_2S	500	Pre-cleaned plastic or glass	NaOH + Zn Acetate, 7 days

1 Requirements are consistent with: FDEP-SOP-001/01, General Sampling Procedures; APHA 2005, Standard Methods; and U.S. EPA Test Methods.

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Table 3.5
QA/QC Targets

Analyte	Precision (%)	Accuracy (%)
Temperature	NA	NA
pH	1	95-105
DO	10	90-110
ORP	20	90-110
Alkalinity	26	80-120
TKN	10	90-110
NH_4^+-N	10	90-110
(NO_3+NO_2)-N	10	90-110
TSS	30	85-115
VSS	22	90-110
$CBOD_5$	25	85-115
COD	32	85-115
Total phosphorus	25	75-125
Orthophosphorus	10	85-115
E. Coli	20	NA
Fecal Coliform	20	NA
Sulfate	10	85-115
H_2S	20	80-120

[1]*NA not applicable*

Table 3.6
Total Monitoring Analyses for System Types

Sample frequency	Analyte	System[1] with sulfur		System[1] without sulfur	
		Influent (STE), final effluent	Influent (STE), final effluent, intermediate point	Influent (STE), final effluent	Influent (STE), final effluent, intermediate point
Eight monitoring events over a 12-16 month period	Temperature	16	24	16	24
	pH	16	24	16	24
	DO	16	24	16	24
	ORP	16	24	16	24
	Alkalinity	16	24	16	24
	TKN	16	24	16	24
	NH_4^+-N	16	24	16	24
	(NO_3+NO_2)-N	16	24	16	24
	TSS	16	24	16	24
	VSS	16	24	16	24
	$CBOD_5$	16	24	16	24
	COD	16	24	16	24
	Total phosphorus	16	24	16	24
	Orthophosphorus	16	24	16	24
	E. Coli	16	24	16	24
	Fecal Coliform	16	24	16	24
	Sulfate	16	16	0	0
	H_2S	16	16	0	0

[1]Total samples to be analyzed for a single test site system.

3.2.1.4 QC Samples

Routine QC checks of sampling and analysis procedures will be in accordance with FDEP-SOP FQ 1000 and consist of two parts: 1) field QC samples; and 2) laboratory QC samples. The number of QC samples collected will be 10% of the total number of samples collected in the overall Task B monitoring. The primary goal of the QC samples is to ensure that all data are of known quality and that the expected quality is appropriate for the desired use of the data. Field QC samples will be collected to ensure proper sample collection and handling. Laboratory QC samples will be analyzed to ensure proper sample preparation and analytical techniques (see Section 3.3). Non-routine QC checks will include laboratory testing as needed to assure SOPs do not affect the sample quality. A summary of the QC samples is presented in Table 3.7.

Field QC samples will include field blanks, equipment rinsates, and duplicates. Field blanks will be collected to ensure that constituents of interest (i.e., nitrogen) are not introduced into the sample collection containers during the normal sampling procedures. Field blanks will be collected by transporting organic-free deionized water to the field along with sample containers, pouring deionized water into sample containers that are identical to sample containers used for analyses, and preserving and transporting field blanks to the analytical laboratory using the same procedure as regular samples. The deionized water and sample containers will all be supplied by the analytical laboratory. Field blanks will be analyzed for the parameters listed in Table 3.5. Equipment rinsates will consist of evaluating the washing and rinsing procedure applied to decontaminate intermediate sample containers and probes. The procedure is 1. wash/rinse with potable tap water three times, 2. rinse with deionized water two times. A sample container subject to this procedure will then be filled with deionized water and the container contents will be analyzed. Equipment rinsate samples will be analyzed for the parameters listed in Table 3.5.

Field duplicate samples will be collected with the regular samples to evaluate laboratory QA/QC. Duplicate analyses will be performed on the parameters listed in Table 3.8, which also lists the criteria for acceptance of duplicate results. Due to the objectives of Task B, the nitrogen analyses will receive a greater percentage of duplicates than other parameters (Table 3.8). Field duplicate collection will consist of a. collection of sample into the common collection container as per normal sampling, b. pouring sample from the common collection container into a sample bottle specific to an analyte, and c. pouring another sample from the same common collection container into a second sample bottle specific to that analyte. Duplicate samples will undergo the same laboratory analyses as regular samples. The identification numbers and locations of the duplicate and regular samples will be maintained in the field logbook. The analytical laboratory will not be provided with knowledge of the identity of duplicate samples (blind test). The majority of duplicated will be *intralaboratory* duplicates in which the duplicate samples are analyzed by the same laboratory. *Interlaboratory* duplicates (split samples) will be used in some cases to compare results from different laboratories.

Table 3.7
Summary of QC Samples Collected and Analyses Conducted

QC Sample	Frequency
Field blank	one per sampling event[1]
Equipment rinsate	one per sampling event[1]
Field duplicate	See Table 3.8[1]
Laboratory blank	per laboratory SOPs
Laboratory spike	per laboratory SOPs
Laboratory duplicate	per laboratory SOPs
Non-routine method check	as necessary

[1]Field QC samples collected will be 10% of total number of samples collected in overall Task B monitoring

Table 3.8
Duplicate Analyses

Analytes	% of Total	Duplicate Acceptance Criteria (% RE)
Alkalinity	6	26
TKN	15	10
NH_4^+-N	15	10
(NO_3+NO_2)-N	15	10
TSS	6	30
VSS	6	22
$CBOD_5$	6	25
COD	6	32
Total phosphorus	6	25
Orthophosphorus	6	10
Sulfate	8	10
H_2S	5	20
TOTAL	100	-

3.2.2 Field Testing

Field testing will include operational monitoring using field instruments. The field equipment for Task B includes flow meters and meters for measuring temperature, pH, DO and ORP. Equipment used in the field will be maintained and calibrated in accordance with the manufacturers' specifications and will conform to FDEP SOPs as listed in Table 3.1. Field instruments will be thoroughly checked and calibrated before they are transported to the field. These instruments will be inspected for damage once they have arrived in the field. Damaged instruments will be immediately replaced or repaired. Service and repair of field instruments will be performed by qualified personnel and will be recorded in the field logbook.

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Calibration or calibration checks of field instruments and equipment will be performed at least daily or at more frequent intervals as specified by the manufacturer. Calibrations may be performed at the start and completion of each test run. However, calibrations will be reinitiated as appropriate after a period of elapsed time due to meals, work shift change, or if damage has occurred. Records of calibration procedures, frequencies, lot numbers of standard reference solutions used as calibration standards, and any repairs or replacements will be recorded in the calibration log and/or field logbook.

3.3 Laboratory Activities

All laboratory activities will meet the minimum QC as specified in the FDEP-SOPs and that meets the National Environmental Laboratory Accreditation Program (NELAP) requirements. However, if a certified laboratory is not identified, a waiver may be requested based on the research nature of this project (DEP 62-160.600 (1)(d) and (3)(f)). Regardless of if a waiver for the laboratory certification is obtained, all laboratories conducting work for this project will operate and maintain a QA Program consistent with NELAP standards. All laboratory methods to be utilized during Task B are standard methods. Should any non-standard laboratory methods be required, an addendum to this QAPP will be prepared.

Analytical methods, target analytes, sample containers, preservatives, and holding times for system influent (primary effluent, aka septic tank effluent), final system effluent, and intermediate sample points are discussed in Section 3.2.1.3 and listed in Tables 3.3 and 3.4. Once samples are received, the laboratory will have a document-control system including: sample labels, analysis logbooks, computer printouts, and raw data summaries. The analytical laboratory will be in compliance with the FDOH ELCP and ensure that all samples are properly stored, handled, and analyzed within the required holding time. A qualitative assessment of each sample container will be performed to note any anomalies, such as broken or leaking bottles and any labeling or descriptive errors. In the event of discrepant documentation, breakage, or any condition that would compromise sample integrity, the laboratory will immediately contact the field team. The samples will be stored at a temperature of approximately <6°C (as applicable) until analyses are performed.

The analytical laboratory will have approved SOPs for preventative maintenance for each instrument system and for required support activity. These records will be reviewed by auditors who perform internal and external system audits of the laboratory. All laboratory instrumentation maintenance and calibration will be performed and documented in accordance with the laboratory SOPs.

Laboratory QC procedures will include split samples, method blanks, spikes, and duplicate samples. The analytical laboratory will be in compliance with the FDOH ELCP and routinely analyze QC samples in accordance with their approved SOPs. Reagent blanks will be run for all appropriate analyses to verify that the procedures used do not introduce contaminants that affect the analytical results. Surrogate spike analysis is used to determine the efficiency of recovery of analytes in sample preparation and analysis. Calculated percent recovery of the spike is used as a measure of the accuracy of the analytical method. A surrogate spike is prepared by adding to an environmental sample (before extraction) a known amount of pure compound similar in type to the one to be assayed in the environmental sample. Surrogate spike recovery must fall within certain limits; if the recovery is not within these limits, corrective action will be implemented. Duplicate samples will be used to confirm laboratory method precision. Replicate samples should have a relative standard deviation as provided in Table 3.5. If the recovery is not within these limits, corrective action will be implemented. Laboratory duplicate samples will be prepared from the same sample in immediate succession with a regular sample.

Corrective actions at the analytical laboratory are required whenever an out-of-control event or potential out-of-control event is noted. Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors and checks the instrument calibration, spike and calibration mixes, instrument sensitivity, and other parameters. If the problem persists or cannot be identified, the matter is referred to the laboratory supervisor, manager, and/or QA department for further investigation. Each certified laboratory has written SOPs specifying the corrective action to be taken when an analytical error is discovered or when the analytical system is determined to be out of control.

3.4 Documentation, Assessment, and Reporting

To ensure representative data is collected to meet the DQOs, the following documentation, assessment, and reporting methods will be performed.

3.4.1. Documentation

Information to be documented will be in accordance with FDEP-SOPs (FD 1000). Logbooks will be used by the project team members and subcontractors responsible for sample collection and analyses. Each team member will be responsible for recording daily activities and/or significant events, observations, and measurements. Enough information will be recorded such that clarification, interpretations, or explanations of the data and activities are not required from the originator of the documentation. Checklists and FDEP forms will be used as appropriate and maintained in the project files. Specifically, forms FD 9000-7, FD 9000-8, FD 9000-9, FD 9000-22, FD 9000-23, and FD 9000-24 are expected to be used. All logbooks will be bound books with entries signed and dated. All field data will be protected to prevent loss. All Task B documentation will be retained for a minimum of 5 years.

Entries in the logbooks will include the following when applicable:

- description of activity,
- date and time,
- location,
- weather conditions,
- names and affiliations of field team,
- work progress,
- test area and operational condition of treatment system(s),
- field measurements and observations,
- equipment maintenance and calibration (Section 3.2.2), and
- any unusual occurrences, depending upon the nature of the occurrence, such as:
    - delays,
    - unusual situations,
    - departure from established field procedures,
    - equipment breakdown and repairs,
    - instrument problems, and
    - accidents.

Minimum information on the sample bottle labels will include:

- unique sample identification number,
- analyses required,
- preservative used (if any),

- name or initial of sample collector(s), and
- date and time of sample collection.

All original data recorded in field logbooks, standard checklists, and sample labels will be written with black indelible ink. If a previously recorded value is discovered to be incorrect or if blank lines are left, the wrong information or blank lines will be crossed through with a single line, the correct value written in, and the change initialed and dated. If the change is made by someone other than the original author or if the change is made on a subsequent day, the reason for the change will be recorded at the current active location in the logbook, with cross reference to the original entry. All monitoring results will be entered into an electronic database such as Microsoft Access or Excel.

Laboratory documentation will be in accordance with FDOH ELCP requirements and at a minimum include:

- project information (e.g., client name, project number, etc.),
- sample information (e.g., source, location of sample, matrix, etc.)
- analysis results (e.g., analyte, result, units, comment, etc.),
- laboratory QC information (e.g., blank results, matrix spike information, RPD, etc.)
- instrumentation/equipment maintenance performed, and
- instrument calibration results.

The laboratory records shall contain sufficient information to allow independent reconstruction of all activities related to generating data that are submitted in data reports to the client (Hazen and Sawyer). All analytical results will be entered into an electronic database such as Microsoft Access or Excel.

3.4.2 Data Assessment

The data collected in Task B will be evaluated for precision, accuracy, representativeness, comparability, and completeness. When using these parameters as indicators of data quality, only precision and accuracy can be expressed in purely quantitative terms. The other parameters are mixtures of quantitative and qualitative expressions. All of these parameters are interrelated and can be difficult to evaluate separately. Primary data will also be graphically examined to identify obvious effects and trends and then subjected to classic statistical analyses, such as multifactor analysis of variance, principal components analysis, and/or multivariate regression analyses (e.g., Snedecor and Cochran, 1980; Minitab, 2000).

3.4.2.1 Precision

Measurements of data precision are necessary to demonstrate the reproducibility of the data. Precision objectives for field instruments are included in the SOPs for the instruments. To the extent possible, one set of field instruments will be used for the duration of the project.

All laboratory measurements will be made with high-purity materials, by knowledgeable laboratory personnel, and following internal QC. Duplicate samples will be collected and analyzed to assess the overall precision of laboratory procedures. Analytical precision may be expressed in terms of the standard deviation or RPD. RPD is calculated as follows:

$$RPD = ((X_1 - X_2)/X_{avg})(100)$$

where:

X_1 = analyte concentration of first sample

X_2 = analyte concentration of a duplicate sample

X_{avg} = average analyte concentration of first and duplicate samples.

3.4.2.2 Accuracy

The accuracy of a measurement is based on a comparison of the measured value with an accepted reference or true value. Accuracy of a procedure is best determined on a known quantity or quality. The accuracy of field measurements will be assessed through the use of calibration standards (e.g., pH standards), by comparing the measurement of a field instrument against a known standard. All calibration and instrument operations will be carried out using traceable standards and specified materials and methods.

Sampling accuracy can be estimated by evaluating the results obtained from blanks. The types of blanks to be used for this evaluation are field blanks and rinsates. The accuracy of laboratory measurements can be expressed as percent recovery (PR) and is calculated as follows:

$$PR = ((A - B)/C)(100)$$

where:

A = spiked sample concentration

B = sample concentration

C = concentration of spike added.

3.4.2.3 Representativeness

All data obtained should be representative of actual conditions. The field procedures and laboratory analyses outlined in Section 2.0 were selected to provide data representative of process conditions. The representativeness of all field data will be qualitatively assessed by determining if the data are consistent with known or anticipated water quality in the treatment system samples and accepted scientific and engineering principles. Field measurements will also be checked for completeness of procedures and documentation of procedures and results.

To preserve the integrity of water quality data, water quality samples will be collected using appropriate collection and handling methods. Field measurements will be conducted either external to the treatment process with samples or if possible by probe insertion into the flowing process water (i.e. a flow-through cell). Additionally, to protect the quality of samples, the sampling equipment and field instruments will be kept clean.

3.4.2.4 Comparability

Consistency in the acquisition, handling, and analysis of samples is necessary so the results may be compared. Factors that will affect comparability are sample collection and handling techniques, sample matrix, field measurement techniques, and analytical methods. Results from two or more sampling events may be compared by specifying and standardizing these factors as much as possible. To ensure the comparability of field measurements made throughout the duration of the project, all field samples will be measured immediately, and the same field instruments and measurement techniques will be used consistently. To ensure the comparability of analytical laboratory results, all samples will be transported to the laboratory promptly to ensure holding times are met, and the instruments and techniques used for sample collection will be used consistently. Calibrations will be performed in accordance with the manufacturer's specifications and/or approved SOPs.

3.4.2.5 Completeness

Field measurements will also be checked for completeness of procedures and documentation of procedures and results. Completeness of field efforts will be defined by comparing the planned scope to the actual field work completed (e.g., by comparing the total number of samples planned to be taken with the number of samples successfully received by the laboratory) and by evaluating the quality of the field work completed (e.g., by establishing that valid field data have been obtained through the use of proper procedures for field measurements and sample collection, etc.).

3.4.2.6 Validation

Field measurements will be made by competent engineers, environmental scientists, and/or technicians. Field data and analytical results will be validated using five primary procedures:

- Routine checks will be made during the processing of data to check for errors in data records.
- Internal consistency of a data set will be evaluated by plotting the data and testing for outliers.
- Comparison checks of related analytical results (e.g., ammonium-nitrogen + nitrate-nitrogen is less than 120% of TKN).
- Checks for consistency of the data set over time will be performed by visually comparing data sets against gross upper limits obtained from historical data sets, or by testing for historical consistency. Anomalous data will be identified.
- Checks will be made for consistency with parallel data sets, that is, data sets obtained from the similar home sites.

The purpose of these validation checks is to identify outliers or anomalies (i.e., an observation that does not conform to the pattern established by other observations). Outliers may be the result of transcription errors or instrumental breakdowns. Outliers may also be manifestations of a greater degree of spatial or temporal variability than expected. After an outlier has been identified, obvious mistakes in data will be corrected. If no plausible explanation can be found for an outlier, it may be excluded, but a note to that effect will be included in data reporting. In addition, an attempt will be made to determine the effect of an outlier when both included in and excluded from the data set.

3.4.3 Reporting

Reports of analytical results for Task B (Deliverable B.7, Monitoring Report) will contain data sheets and the results of analysis of QC samples. Sample reports will include a log of the sample identification numbers designated in the field and the corresponding laboratory sample numbers. Analytical reports will contain the following items:

- project identification,

- sample number,
- sample matrix description,
- date of sample collection,
- location of sample collection,
- date of sample receipt at the laboratory,
- analytical method and reference citation,
- date of analysis (extraction, first run, and subsequent runs),
- individual parameter results,
- quantification limits,
- dilution or concentration factors, and
- corresponding QC report.

Electronic data will be tab-delimited. The final project report will contain a compilation of all the QA/QC data generated, a discussion of out-of-control events, and any corrective actions taken.

3.5 QA Surveillance

The Hazen and Sawyer project manager will be responsible for QA/QC and will ensure compliance with this QAPP. Field surveillances and assessments will be performed by the field leader at the initiation of sampling associated with the controlled test site and again at the initiation of home site sampling. These QA surveillances of the field activities will focus on verifying proper use of field procedures for sample collection and documentation. All surveillances and necessary corrective actions will be documented in the field logbook. QA reports will include a discussion of the methods used for field activities and any items that differ from those described in this QAPP. QA reports will also include a short discussion of the quality of field documentation of data, instrument calibration, corrective actions, and other field information pertinent to the field effort.

Performance audits of the analytical laboratories will be conducted on a regular basis to verify the effectiveness and implementation of the laboratory QA/QC plan as specified in the laboratory SOPs. Results of the internal audits shall be documented and kept on file at the laboratory.

Section 4.0
Health and Safety

4.1 Hazard Assessment

Field activities will consist of test site preparation, installation of treatment technologies, operation and maintenance of treatment systems, water quality sampling and delivery of samples to analytical laboratories. An activity hazard analysis table will be available in the field at all times (see Appendix A). All field activities will be conducted in areas without inherent chemical hazards. Biological hazards are associated with exposure to high concentrations of microorganisms in household sanitation water. The most common bacterial pathogens found in untreated wastewater are *Salmonella* and *Shigella,* while other bacterial microorganisms include *Vibrio*, *Campylobacter*, and *Leptospira* (Bitton, 1999). The following are general personnel hazards with the potential to occur during Task B field work:

1) Infectious disease exposure;
2) Potential for contact with preservation chemicals;
3) Slip, trip, and fall potential;
4) Potential for pinch points and striking objects due to mechanical hazards; and
5) Potential electric shock from improperly grounded equipment.

Proper personal hygiene and use of personal protective equipment (PPE) will significantly reduce or eliminate biological and chemical safety hazards. Constant attention will be given to physical hazards encountered during work activities, which will be most present during installation. Qualifications (i.e., demonstrated experience and ability) with respect to the installation tasks to be performed will be required. Only qualified, competent personnel with prior experience will perform installation tasks. Slip, trip and fall potential during operation, maintenance and monitoring will be minimized by eliminating site or installation features that increase the potential of these mishaps and by conducting site work solely during daylight hours when at all possible.

Biological Hazards Three general categories of pathogenic organisms that may be present in wastewater include bacteria, viruses, and parasites (including protozoans and helminths). The principle pathogenic organisms found in STE and untreated wastewater and the corresponding infectious dose are shown in Table 4.1. Microorganisms of concern commonly found in STE include pathogenic bacteria at sustained high concentrations and virus at highly variable and episodically released levels (Bicki *et al*., 1984; Van Cuyk *et al*., 1999). The most common pathogenic viruses found in groundwater are hepatitis, Norwalk-like agent, echovirus, poliovirus and coxsackie virus. Enteric virus includes 72 types of virus (e.g. polio, echo and coxsackie virus) that can cause gastroenteritis, heart anomalies, and meningitis. The diseases caused by common pathogens in wastewater are summarized in Table 4.2.

Table 4.1
Microorganisms Found in STE and Untreated Wastewater
(in MPN/100mL)

Organism		Conc. in STE	Infectious Dose
Bacteria	Total Coliform	10^6-10^9	NA
	Fecal Coliform	10^5-10^8	10^6
	Clostridium perfringens	10^3-10^5	1-10^{10}
	Enterococci	10^4-10^5	NA
	Fecal streptococci	10^3-10^6	NA
	Pseudomonas aeruginosa	10^3-10^4	NA
	Shigella	10^0-10^2	NA
	Salmonella	10^2-10^4	NA
Protozoa	*Cryptosporidium* oocysts	10^1-10^3	1-10
	Entamoeba cysts	10^{-1}-10^1	10-20
	Giardia cysts	10^3-10^4	<20
Helminths	Ova	10^1-10^3	NA
	Ascaris lumbridcoides	NA	1-10
Viruses	Enteric Virus	10^3-10^4	1-10
	Coliphage	10^1-10^4	NA

(US EPA, 2002; Crites and Tchobanoglous, 1998; Anderson et al., 1994; Brown et al., 1980; Ziebell et al., 1974). The most probable number (MPN) method is not an actual concentration, but a statistical estimate of concentration using serial dilutions. NA: not available

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Table 4.2
Pathogenic Microorganisms Found in STE and Untreated Wastewater
(Lowe et al., 2007)

Organism		Disease Caused	Symptoms
Bacteria	Salmonella typhi	Typhoid fever	High fever, diarrhea
	Shigella	Bacillary dysentery	Dysentery
	Vibrio cholerae	Cholera	Diarrhea, dehydration
	Yersinia enterocolitica	Gastroenteritis	Diarrhea
	E. coli (pathogenic)	Gastroenteritis	Diarrhea
	Legionella pneumophila	Legionnaires' disease	Malaise, acute respiratory illness
	Leptospira spp.	Weil's Disease	Jaundice, fever
	Campylobacter jejuni	Gastroenteritis	Diarrhea
Virus	Adenovirus	Respiratory disease	Diarrhea
	Enteroviruses	Gastroenteritis, meningitis, heart anomalies	Often no symptoms
	Poliovirus		
	Echovirus		
	Coxsackie virus		
	Hepatitis A	Infectious hepatitis	Jaundice, fever
	Norwalk	Gastroenteritis	Vomiting
	Parvovirus	Gastroenteritis	Diarrhea
	Rotavirus	Gastroenteritis	Diarrhea
	HIV	AIDS	
Protozoa	Cryptosporidium parvum	Cryptosporidiosis	Diarrhea, low-grade fever
	Giardia lamblia	Giardiasis	Diarrhea, nausea, indigestion
	Balantidium coli	Balantidiasis	Diarrhea, dysentery, intestinal ulcers
	Entamoeba histolytica	Amoebic dysentery	Diarrhea, dysentery
	Cyclospora	Cyclosporasis	Severe diarrhea, nausea, vomiting, severe stomach cramps

Partially adapted from Bitton (1999) and from Crites and Tchobanoglous (1998)

Cold and Heat Stress Personnel will be monitored for heat stress during all field activities. The length of periods of active work without a break will be adjusted as the weather dictates. Anyone exhibiting signs or symptoms of heat-related illness will be removed to a controlled temperature location immediately.

Noise Hearing protection will be available for all field workers. Hearing protection is required at 85 decibels or above, on the A-weighted scale on a slow response scale as per American National Standards Institute (ANSI).

Electrical All temporary, 120V, single-phase, 15- and 10-ampere receptacles and cord sets will be protected by approved ground fault circuit interrupts (GFCIs) as prescribed in 29 CFR 1926.404(b)(ii). Prior to setting the drilling rig at location for piezometer installation, the field leader will determine the distance to electrical transmission lines. If the voltage of electrical transmission lines is unknown, a distance of 20 ft. will be maintained. If the voltage is known, the equipment will not be operated when any part enters a minimum radial distance of 10 ft. to electrical transmission lines as specified in 29 CFR 1910.181.

Other Physical Hazards Other physical hazards may be present. These hazards may include buried water lines; equipment movement; and equipment malfunctions. Improper lifting of heavy objects will be avoided. Tripping, slipping, and falling hazards and specific hazards pertaining to the operation of the drilling equipment will be evaluated. Equipment guards will be used on any mechanical equipment, as mandated by Occupational Safety and Health Administration (OSHA) regulations, to minimize personnel exposure to moving parts during piezometer installation. OSHA safety mandates and guidelines will be implemented by personnel that work near potentially dangerous drilling equipment.

The following are general health and safety standard operating procedures.

1) Wear designated PPE and safety equipment at all times while in the work area.

2) Do not eat, drink, chew gum or tobacco, smoke, or apply cosmetics in the work area.

3) Do not work with open wounds, including bandaged wounds, or other injuries that could provide a route of entry for possible microorganisms.

4) Prevent spillage. If a spill occurs, contain wastewater and dispose properly.

5) Practice good housekeeping. Keep everything orderly and out of potentially harmful situations.

6) Be familiar with the physical characteristics of the site, including:

   a. nearest emergency assistance;
   b. accessibility to associates, equipment, and vehicles;
   c. communication facilities at and near the site; and
   d. site access and egress.

7) Keep the number of personnel and equipment in the work area to a minimum, but only to the extent consistent with work force requirements of safe site operation.

8) Dispose of all waste generated properly.

9) Report all injuries, no matter how minor, to the field leader.

10) Do not wear loose clothing and jewelry while working with or near drilling equipment.

11) If desired, wear gloves or other equipment for protection against physical hazards in addition to the above-mentioned PPE.

12) Be continually aware of potentially dangerous situations (e.g., presence of strong, irritating, or nauseating odors) and immediately take precautionary measures to ensure the safety of everyone.

4.2. Personal Protection Requirements

During Task B, the primary exposure risk is ingestion through splashes that contaminate food, drinks and/or hands (most common); inhalation of infectious agents or aerosols, and contact with unprotected cuts and abrasions. There is no airborne exposure pathway associated with the microbiological constituents present in residential STE or nitrified effluent. To mitigate these exposure routes for workers, eating, drinking or smoking will be prohibited in the field during monitoring. Good personal hygiene, such as avoiding touching the mouth, frequent hand washing, and use of disposable gloves (latex or nitrile), will be implemented. During routine field activities, personal protection equipment will include long pants, close-toed shoes, and appropriate gloves. Hard hats and safety glasses will be worn when equipment is being set up and when in the proximity of overhead hazards.

The primary potential public health risk associated with this project is the discharge of STE or nitrified effluent to the ground surface or groundwater underlying the site. To mitigate public exposure risk, all STE released to the environment will occur below ground;

there will be no surface application of wastewater effluent. In addition, access to the test site will be controlled (fencing, locking caps on monitoring points, etc.).

4.3 Emergency Response

The following procedures will be implemented in the event of an emergency during field activities. In case of emergency dial 911. The location of the nearest medical facility will be made available prior to field activities. Notify the Hazen and Sawyer project manager of any emergencies. Maps consisting of directions to the nearest medical facility and hospital will be posted at the job-site.

Section 5.0
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FLORIDA DEPARTMENT OF HEALTH

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task C.21

GCREC Mound Monitoring Sample Event Report No. 1

Progress Report

February 2011

44237-001

HAZEN AND SAWYER
Environmental Engineers & Scientists

In association with

COLORADO SCHOOL OF MINES 1874

AET Applied Environmental Technology

OTIS ENVIRONMENTAL CONSULTANTS, LLC

Florida Onsite Sewage Nitrogen Reduction Strategies Study

TASK C.21 PROGRESS REPORT

GCREC Mound Monitoring Sample Event Report No. 1

Prepared for:

Florida Department of Health
Division of Environmental Health
Bureau of Onsite Sewage Programs
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February 2011

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FLORIDA DEPARTMENT OF HEALTH

GCREC Mound Monitoring Sample Event Report No. 1

1.0 Background

Task C of the Florida Onsite Sewage Nitrogen Reduction Strategies Study includes monitoring at field sites in Florida to evaluate nitrogen reduction in soil and groundwater, to assess groundwater impacts from various onsite wastewater systems, and to provide data for parameter estimation, verification, and validation of models developed in Task D. The existing mound system at the Gulf Coast Research and Education Center (GCREC) is being monitored to serve as a bridge between the controlled GCREC pilot-scale testing conducted within the same type of soils and the uncontrolled monitoring at home sites in different soils throughout the state. The Task C.5 QAPP documents the objectives, monitoring framework, sample frequency and duration, and analytical methods to be used at the GCREC existing mound system site. The Task C.20 Instrumentation of GCREC Mound System and Plume Progress Reports No. 1 and 2 document the test area design, number and location of monitoring points, and preliminary sample collection and analyses.

2.0 Purpose

This sample event report documents data collected from the first GCREC mound monitoring and sampling event which was conducted December 9, 2010 – December 10, 2010. This monitoring event consisted of measurement of flowrates dosed to the system, groundwater elevation measured within the standpipe piezometers, measurement of field parameters, and collection of groundwater samples and their analyses in a NELAC certified laboratory.

3.0 Materials and Methods

3.1 Project Site

The GCREC mound is located at the University of Florida Gulf Coast Research and Education Center (GCREC) in southeast Hillsborough County, Florida. The facility is situated on 475 acres of land that were donated by Hillsborough County government. Wastewater from the GCREC research offices and onsite dormitories flow to an existing OSTDS. Lab waste from Facility laboratories is not directed to the OSTDS. This existing

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OSTDS consists of a pressure dosed mound system designed for 2,850 gallons per day. Two septic tanks (2,500 and 1,250 gallons) provide primary treatment followed by a dosing tank (3,000 gallons). The mound drainfield has 4,351 ft^2 of infiltrative area (design hydraulic loading rate of 0.65 gpd/ft^2) with each half of the drainfield receiving alternating doses. As part of this project, two flow meters were installed to monitor the actual daily flow to the drainfield.

3.2 Monitoring and Sampling Locations and Identification

A schematic of the GCREC mound monitoring network is shown in Figure 1. A sampling grid for groundwater screening was developed downgradient of the soil treatment unit. A 25-ft by 25-ft grid was staked then locations surveyed (x, y, and z). Transect lines AA through R are parallel to the southern edge of the mound and increase (higher letter identification) moving southward from the mound. Transect lines 1 through 15 (from east to west) are perpendicular to the southern edge of the mound. Groundwater monitoring points were installed in May, June, and November 2010. Two types of monitoring points were installed using either hand or drilling methods: drive point samplers and standpipe piezometers. Drive point samplers consist of a stainless steel drive tip and attached 1-in. long screen with a protective “umbrella” (to prevent soil entering and clogging the screen), and flexible tubing that extends to the ground surface (Figure 2). Standpipe piezometers consist of either ¾-in., 1¼-in., or 2-in. diameter PVC with 1-ft, 4-ft, 5-ft, or 10-ft long 0.010 slot PVC screens and PVC riser extending to the ground surface (refer to the Task C QAPP and Task C.20 Progress Reports #1 and #2 for additional detail). Figure 3 depicts an installed ¾-in. diameter PVC standpipe piezometer.

The monitoring locations established to date are depicted in Figure 1. Each monitoring location has been assigned a unique identification indicating the type of monitoring point (DP = drive point, PZ = standpipe piezometer), grid location (self explanatory), and depth below ground surface (bottom of the drive point or well screen in feet). For example DP-AA9-14 is a drive point sampler located on the grid at AA9 (see Figure 1) at approximately 14 ft below ground surface. Approximately 145 subsurface monitoring locations have been installed at the site to date.

A total of 62 specific monitoring locations were sampled during this GCREC mound sampling event. The nomenclature and sample identifications for this sampling event are listed in Table 1.

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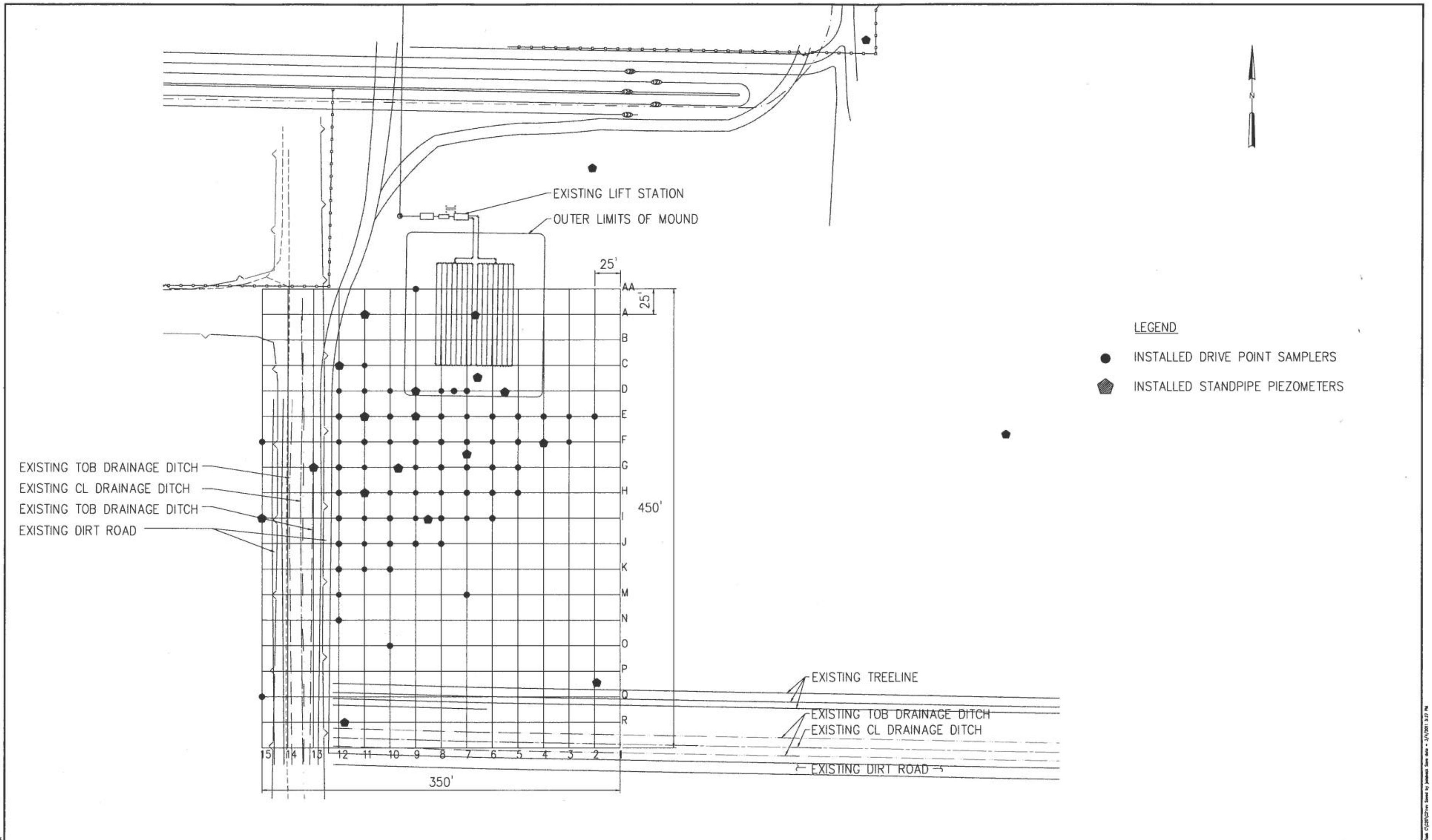

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FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATIGIES STUDY

FIGURE 1
MONITORING PLAN

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

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Figure 2
Stainless Steel Drive Point with Mesh Screen, Umbrella and Tubing

Figure 3
Installed ¾" Diameter PVC Standpipe Piezometer

Table 1
GCREC Mound Sample Identification

	Grid Location	Sample Identification	Notes	Bottom Elevation (ft)
1	EX Lift Station	STE-EX Pump Tank	Wastewater Sample	N/A
2	Bkgd, North	PZ04-BKG-9	1 1/4” Standpipe Piezometer, 4’ screen	118.66
3	Bkgd, North	PZ24-BKG-26	2" Standpipe Piezometer, 5' screen	101.41
4	AA9	DP-AA9-14	SST Drive Point	110.68
5	AA9	DP-AA9-22	SST Drive Point	103.08
6	AA9	DP-AA9-27	SST Drive Point	98.28
7	C12	PZ16-C12-28	3/4" Standpipe Piezometer, 1' screen	94.75
8	D7.5	DP-D7.5-14	SST Drive Point	111.24
9	D7.5	DP-D7.5-20	SST Drive Point	105.31
10	D7.5	DP-D7.5-26	SST Drive Point	99.24
11	D9	DP-D09-6	SST Drive Point	118.35
12	D9	DP-D09-8	SST Drive Point	116.45
13	D9	DP-D09-15	SST Drive Point	109.18
14	D9	DP-D09-21	SST Drive Point	103.18
15	D9	DP-D09-27	SST Drive Point	97.18
16	E12	DP-E12-10	SST Drive Point	113.22
17	E12	DP-E12-15	SST Drive Point	108.66
18	E12	DP-E12-22	SST Drive Point	101.56
19	E12	DP-E12-28	SST Drive Point	95.71
20	F8	DP-F08-14	SST Drive Point	110.43
21	F8	DP-F08-20	SST Drive Point	103.96
22	F8	DP-F08-28	SST Drive Point	96.18
23	F11	DP-F11-11	SST Drive Point	112.68
24	F11	DP-F11-15	SST Drive Point	108.88
25	F11	DP-F11-18	SST Drive Point	105.73
26	F11	DP-F11-21	SST Drive Point	102.93
27	F11	DP-F11-24	SST Drive Point	99.88
28	F11	DP-F11-27	SST Drive Point	96.73
29	F15	DP-F15-14	SST Drive Point	108.82
30	F15	DP-F15-20	SST Drive Point	102.87
31	F15	DP-F15-26	SST Drive Point	96.97

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Table 1
GCREC Mound Sample Identification

	Grid Location	Sample Identification	Notes	Bottom Elevation (ft)
32	G7	DP-G07-13	SST Drive Point	111.63
33	G7	DP-G07-15	SST Drive Point	109.56
34	G7	DP-G07-17	SST Drive Point	106.76
35	G7	DP-G07-21	SST Drive Point	103.31
36	G7	DP-G07-24	SST Drive Point	100.51
37	G7	DP-G07-27	SST Drive Point	97.61
38	G12	DP-G12-15	SST Drive Point	108.37
39	G12	DP-G12-21	SST Drive Point	102.32
40	G12	DP-G12-27	SST Drive Point	96.37
41	I6	DP-I06-14	SST Drive Point	110.24
42	I6	DP-I06-20	SST Drive Point	103.99
43	I6	DP-I06-26	SST Drive Point	97.94
44	I15	PZ17-I15-26	3/4" Standpipe Piezometer,1' screen	97.09
45	J9	DP-J09-14	SST Drive Point	109.61
46	J9	DP-J09-20	SST Drive Point	103.36
47	J9	DP-J09-26	SST Drive Point	97.11
48	J12	DP-J12-15	SST Drive Point	108.26
49	J12	DP-J12-20	SST Drive Point	102.61
50	J12	DP-J12-27	SST Drive Point	96.36
51	M7	DP-M07-15	SST Drive Point	108.975
52	M7	DP-M07-21	SST Drive Point	102.65
53	M7	DP-M07-27	SST Drive Point	96.95
54	N12	DP-N12-14	SST Drive Point	108.4
55	N12	DP-N12-21	SST Drive Point	101.725
56	N12	DP-N12-27	SST Drive Point	95.63
57	O10	DP-O10-12	SST Drive Point	110.71
58	O10	DP-O10-18	SST Drive Point	104.56
59	O10	DP-O10-24	SST Drive Point	98.56
60	Q15	DP-Q15-15	SST Drive Point	108.2
61	Q15	DP-Q15-21	SST Drive Point	102.29
62	Q15	DP-Q15-26	SST Drive Point	96.4

3.3 Soil Characteristics

During the instrumentation of the mound, at five locations (south end of the mound, E9, G10, F4, and west side of the mound), continuous soil cores were collected to determine general soil properties (lithology, soil features, organic matter content, grain size, etc) as summarized in Table 2. However, only at one location, G10, were continuous soil cores collected to the confining Hawthorn clay layer. In addition, handheld methods were used to determine the top of the spodic layer as shown in Figure 4. Cross section A-A' is depicted in Figure 5.

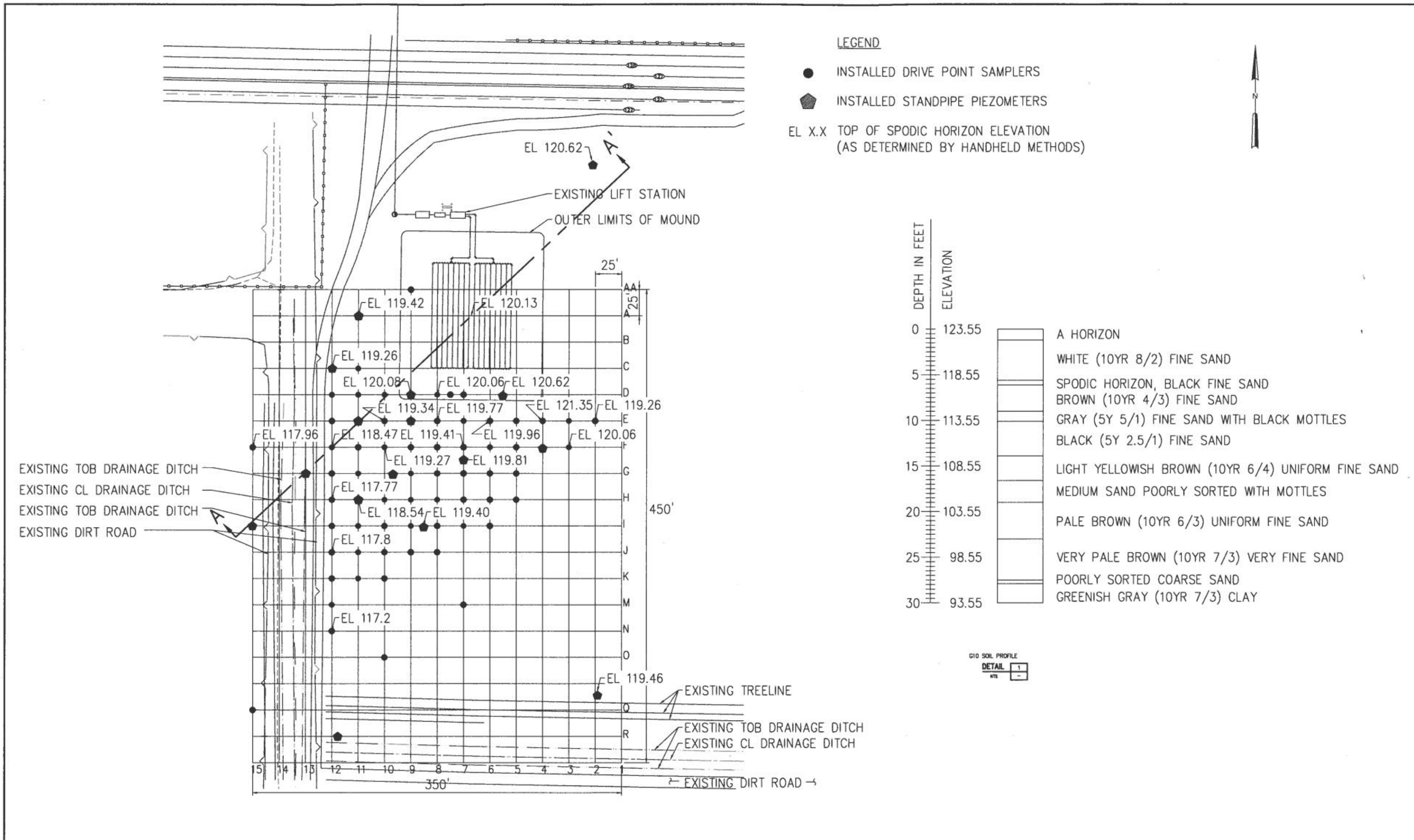

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FIGURE 4
TOP OF SPODIC ELEVATIONS

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

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CONTRACT NUMBER
DRAWING NUMBER

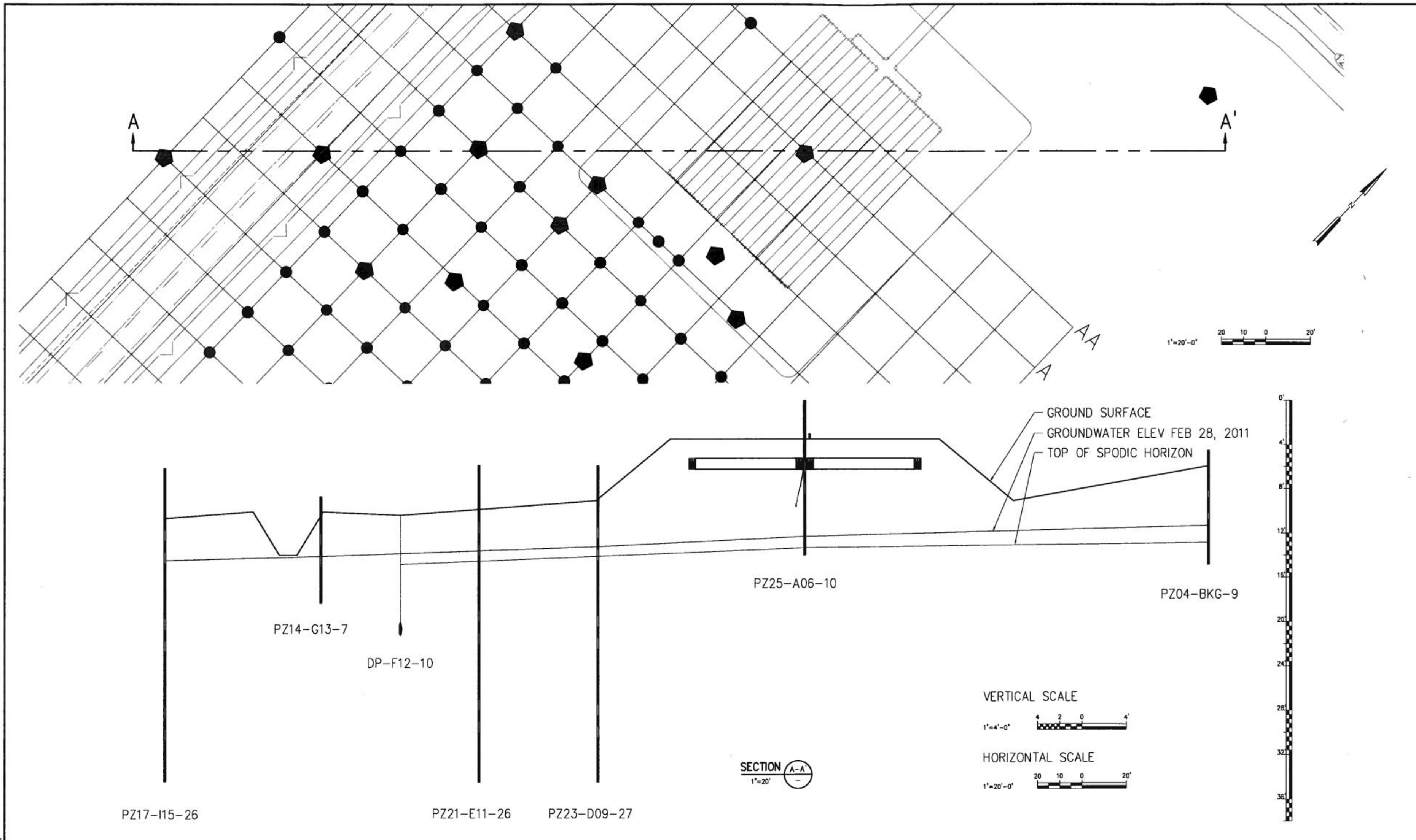

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FIGURE 5
CROSS SECTION A-A'

THE SCALE BAR SHOWN BELOW MEASURES ONE INCH LONG ON THE ORIGINAL DRAWING.

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CONTRACT NUMBER
DRAWING NUMBER

Table 2
June 2010 Small Direct Push Rig (6620 Geoprobe™)
Soil Core Descriptions

Grid Location	Identifier	Surface Elevation (ft)	Depth bgs (ft)	Description
South end of Mound CD6.5	PZ10-CD6-13	129.51	0-0.4’	Grass/fill
			0.4-0.9’	Gray fine sand with yellow and white mottles
			0.9-6.6’	Uniform yellow fine grain sand
			6.5’	Saturation
			6.6-6.7’	Dark brown (10YR 3/3) fine sand
			6.7-10.7’	Light gray (5Y 7/2) fine sand
			10.7-11.5’	Dark brown (10YR 3/3) fine sand
			11.5-12.3’	Yellow (5Y 7/6) fine sand
			12.3-13.45’	Light gray (5Y 7/2) fine sand
			13.45-16.1’	Spodic horizon, dark brown (7.5YR 3/3) fine sand
			16.1-17.4’	Brown (7.5YR 4/4) fine sand
E9	PZ11-E09-10	124.06	0-2.2’	A Horizon top soil
			2.2-2.7’	Pale yellow (5Y 7/3) fine sand with mottles
			2.7-5.8’	Yellowish brown (10YR 5/4) fine sand
			5.8-6.9’	Very dark brown (7.5YR 2.5/3) fine sand
			6.1’	Saturation
			6.9-10.3’	Medium brown (10YR 5/3) fine sand
			10.3-15’	Black (10YR 2/1) fine sand
G10	Abandoned PZ12	123.55	0-1.2’	A Horizon top soil
			1.2-2.8’	White (10YR 8/2) fine sand
			2.8-6.1’	Spodic horizon, black fine sand
			6.1-9’	Brown (10YR 4/3) fine sand
			9’	Saturation
			9-10.1’	Gray (5Y 5/1) fine sand with black mottles
			10.1-13.9’	Black (5Y 2.5/1) fine sand
			13.9-16.6’	Light yellowish brown (10YR 6/4) uniform fine sand
			16.6-19’	Medium sand poorly sorted, well rounded (3mm diameter) with mottles
			19-23’	Pale brown (10YR 6/3) uniform fine sand

Table 2
June 2010 Small Direct Push Rig (6620 Geoprobe™)
Soil Core Descriptions

Grid Location	Identifier	Surface Elevation (ft)	Depth bgs (ft)	Description
G10 (con't)	Abandoned PZ12	123.55	23-27.5'	Very pale brown (10YR 7/3) very fine sand
			27.5-27.9'	Poorly sorted coarse sand
			27.9-30.0'	Greenish gray (Gley1 6/5GY) clay, Hawthorn confining layer
F4	PZ13-F04-8	124.42	0-4.2'	A Horizon top soil
			4.2-4.7'	Pale yellow (5Y 8/4) fine sand with mottles
			4.7-13.5'	Spodic horizon, dark brown sand
			6.3'	Saturation
Westside of Mound		~129	0-7.4'	Mound sand with some mottles
			7.4-8.4'	Dark oxidized sand
			8.4'	Saturation
			8.4-9.4'	Saturated very pale brown fine sand
			9.4-10'	Spodic horizon, dark brown fine sand
			10-12'	Dark yellowish brown (10YR 4/6) fine sand
			12-15'	Dark brown fine sand

3.4 Operational Monitoring

Wastewater flow to the mound system is measured via two (2”) flow meters located on the dose lines to the mound which were installed in December, 2009. The PNRS II test facility programmable logic controller (PLC) records flow data from these meters. Appendix A provides summary tables of the recorded wastewater flow data for the GCREC mound pumps between June 14, 2010 and December 10, 2010 (Day 28 through Day 207 since PNRS II test facility start-up). Prior to July 16, 2010, the GCREC air conditioning systems were discharging considerable quantities of A/C condensate to the sewer, and this flow was rerouted on July 16th. The wastewater flow to the GCREC mound has averaged approximately 1700 gpd since condensate rerouting occurred.

3.5 Meteorological Data

A weather station is located at the GCREC with weather conditions recorded every minute and stored on a private website. Table 3 provides the recorded meteorological data daily averages leading up to and during the sample event. Unseasonably cold weather and very low rainfall characterized the month of December 2010. Only 0.5 in. of rain fell for the month and only 0.03 in. occurred over the 5 day period from December 6-10, 2010. Appendix B provides summary tables of the average monthly recorded meteorological data.

Table 3
Meteorological Data Daily Averages Measured December 6, 2010 – December 10, 2010

Date	Temp Avg 60 cm (°F)	Temp Avg 10 m (°F)	Temp Soil Avg -10 cm (°F)	Dewpoint Avg 2m (°F)	Relative Humidity Avg 2m (%)	Rain Total 2m (in)	Wind Speed Avg 10m (mph)
12-6-10	44.08	43.81	63.34	32.19	66	0	8.7
12-7-10	40.44	40.95	61.3	26.71	62	0	7.22
12-8-10	45.03	45.58	60.32	29.72	59	0	5.6
12-9-10	48.45	48.36	60.71	34.76	62	0.03	6.37
12-10-10	51.85	51.49	60.72	45.45	83	0	6.51

3.6 Groundwater Level Monitoring

The piezometer designations listed in Table 4 correspond to the locations at which groundwater levels are measured. The groundwater level within the standpipe piezometers was measured on December 9, 2010 for this sampling event. Figure 6 shows the surficial groundwater contours on that day.

Table 4
Standpipe Piezometer Groundwater Level Measured December 9, 2010

Fig 4 Identification	Location	Identification	Water Table Elevation (ft)
1	Bkgd, North	PZ01-BKG-9	122.97
2	Bkgd, North	PZ04-BKG-9	121.76
3	Bkgd, North	PZ24-BKG-26	121.46
4	Bkgd, East	PZ05-BKG-9	121.53
5	Bkgd, NW	PZ06-BKG-12	122.09
6	A11	PZ15-A11-6	119.77
7	C12	PZ16-C12-28	119.37
8	CD6.5	PZ10-CD6-13	120.37
9	D5.5	PZ07-D05-7	120.22
10	D9	PZ23-D09-27	119.64
11	E9	PZ11-E09-10	119.57
12	E11	PZ21-E11-26	119.22
13	E11	PZ22-E11-15	119.21
14	F4	PZ13-F04-8	120.16
15	FG7	PZ08-FG7-6	119.65
16	G9.75	PZ19-G10-26	119.18
17	G9.75	PZ20-G10-15	119.17
18	G13	PZ14-G13-7	118.72
19	H11	PZ03-H11-6	119.21
20	I8.5	PZ09-I08-5	119.15
21	I15	PZ17-I15-26	118.26
22	PQ1.75	PZ02-P02-9	118.52
23	R12	PZ18-R12-26	118.22

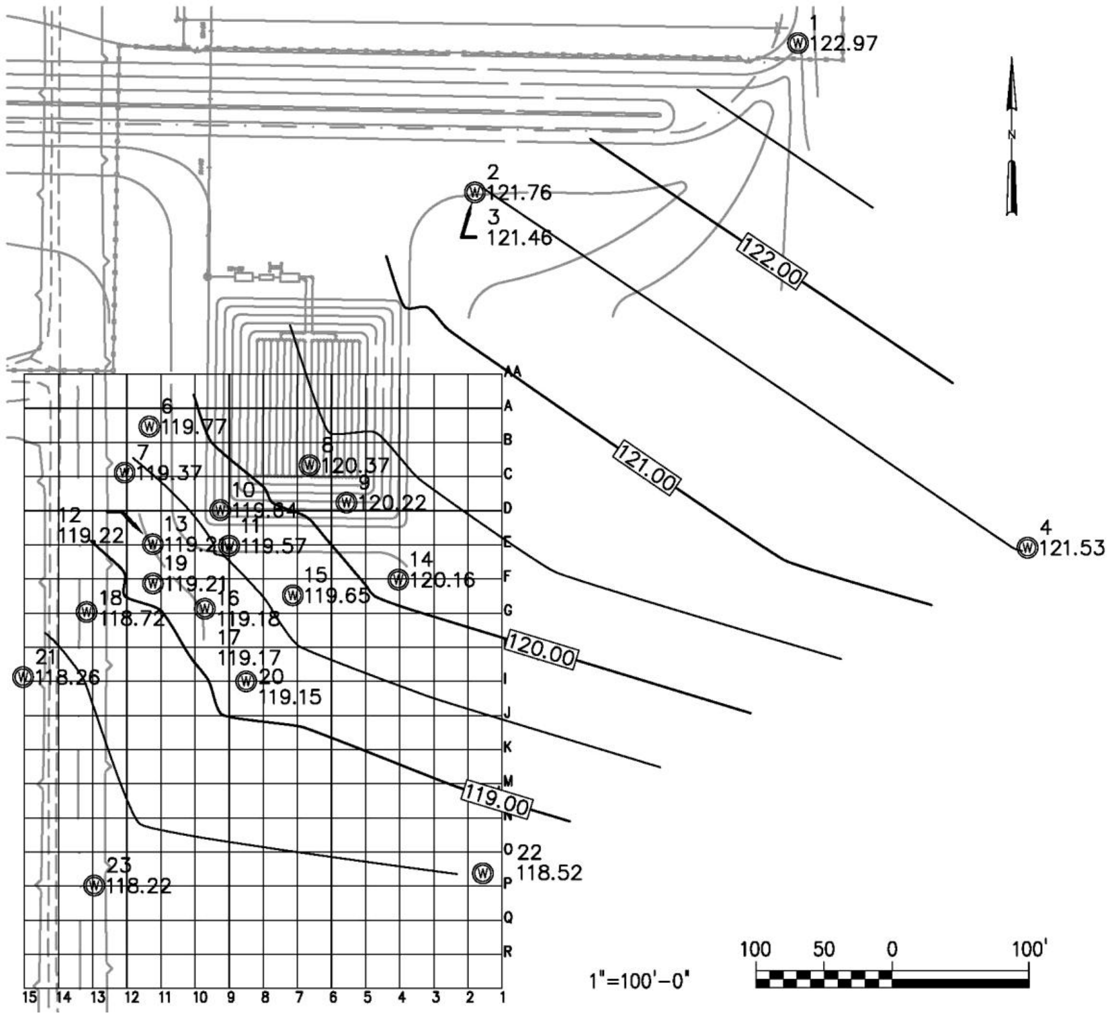

Figure 6
Surficial Groundwater Contours December 9, 2010

3.7 Water Quality Sample Collection and Analyses

Groundwater and effluent water quality samples for the GCREC mound Sample Event No. 1 were collected December 9-10, 2010. A sample of STE was collected from the existing lift station (see Figure 1) which supplies STE to the GCREC mound. STE from the lift station tank was collected directly into the analysis-specific containers supplied by the analytical laboratory using a peristaltic pump.

Groundwater samples were collected using a peristaltic pump attached to either the drivepoint or standpipe piezometer dedicated tubing and directing the sample into the analysis-specific containers after sufficient purging had occurred. The analysis-specific containers were supplied by the analytical laboratory and contained the appropriate preservatives. The analysis-specific containers were labeled, placed in coolers and transported on ice to the analytical laboratory. Each sample container was secured in packing material as appropriate to prevent damage and spills, and was recorded on chain-of-custody forms supplied by the laboratory. Chain of custody forms, provided in Appendix C, were used to document the transfer of samples from field personnel to the analytical laboratory. One chain of custody form was filled out for each set of samples and placed inside the cooler.

Equipment blank, field blank, and field sample duplicates were taken. The equipment blank was collected by pumping deionized water provided by the laboratory through the cleaned pump tubing. These samples were then analyzed for the same parameters as the GW samples. One field blank was collected by filling sample containers with deionized water that had been transported from the laboratory into the field along with other sample containers. A second field blank was collected by filling sample containers with the tap water used for rinsing. The field sample duplicates were collected immediately subsequent to the regular samples. The field duplicate samples taken include:

- DP-D09-15
- DP-F08-20
- DP-F15-20
- DP-G12-15
- DP-J12-20
- STE-EX Pump Tank

Field parameters were measured using portable electronic probes with probe tips placed in a flow-cell device as groundwater was being pumped (see Figure 7). Field parameters include pH, specific conductance, temperature (Temp), and dissolved oxygen (DO).

Field parameter results are listed in Appendix D. The STE and groundwater samples were analyzed by the laboratory for: total alkalinity, total Kjeldahl nitrogen (TKN-N), ammonia nitrogen (NH_3-N), and nitrate/nitrite nitrogen (NO_X-N). Additionally, at some of the locations with elevated conductivity in previous preliminary sampling, total organic carbon (TOC) and dissolved organic carbon (DOC) were included. Table 5 lists the analytical parameters, analytical methods, and detection limits for these analyses.

Once analytical results are obtained from the laboratory, GCREC Mound Data Summary Report No. 1 (Task C22) will be prepared describing the results from this sampling event.

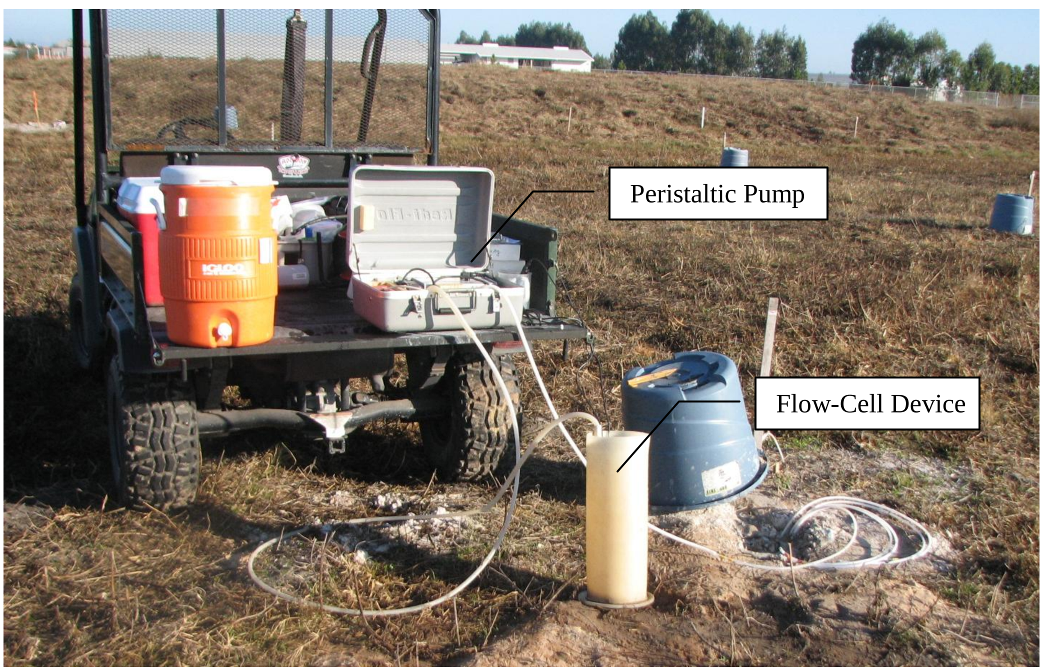

Figure 7
Flow-Cell Device

Table 5
Analytical Parameters, Method of Analysis, and Detection Limits

Analytical Parameter	Method of Analysis	Laboratory Detection Limit (mg/L)
Total Alkalinity as $CaCO_3$	SM 2320B	2 mg/L
Total Kjeldahl Nitrogen (TKN-N)	EPA351.2	0.05 mg/L
Ammonia Nitrogen (NH_3-N)	EPA350.1	0.01 mg/L
Nitrate/Nitrite Nitrogen (NO_X-N)	EPA353.2	0.01 mg/L
Total Organic Carbon (TOC)	SM 5310B	0.5 mg/L
Dissolved Organic Carbon (DOC)	SM 5310B	1.0 mg/L

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Appendix A: GCREC Mound Wastewater Flow Data

Table A.1
GCREC Mound Metered Wastewater Flow Data

Date Range	Flow Meter Totalized Pump 1 to GCREC Mound (avg. gpd)	Flow Meter Totalized Pump 2 to GCREC Mound (avg. gpd)	Total Recorded Flow (avg. gpd)
Before A/C Condensate Diversion			
12/21/10 – 7/16/10	1,650	591	2,241
After A/C Condensate Diversion			
7/19/10 – 1/9/11	789	911	1,700

Table A.2
Summary of Daily Wastewater Flows (PLC Recorded)

	Date Range	Average Recorded Flow (gpd)	Std. Dev.	MIN (gpd)	MAX (gpd)
Before A/C Condensate Diversion					
Pump 1 to Mound	6/14/10 – 7/16/10	5,422	1,565	3,013	9,117
Pump 2 to Mound		-	-	-	-
Sum of Both Pumps		5,422	1,565	3,013	9,117
After A/C Condensate Diversion					
Pump 1 to Mound	7/16/10 – 12/10/10	790	366	284	2,640
Pump 2 to Mound		917	403	291	3,090
Sum of Both Pumps		1,707	749	584	5,730

Table A.3
PLC Recorded Daily Wastewater Flows
(6/14/10 – 12/10/10)

Day Since Start-Up	Date	Pump 1 to GCREC Mound	Pump 2 to GCREC Mound	Sum Pump 1 and 2
28	6/14/2010	PR	PR	-
29	6/15/2010	6,436	0	6,436
30	6/16/2010	5,035	0	5,035
31	6/17/2010	7,841	0	7,841
32	6/18/2010	5,268	0	5,268
33	6/19/2010	3,668	0	3,668
34	6/20/2010	3,013	0	3,013
35	6/21/2010	5,250	0	5,250
36	6/22/2010	5,734	0	5,734

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Day Since Start-Up	Date	Pump 1 to GCREC Mound	Pump 2 to GCREC Mound	Sum Pump 1 and 2
37	6/23/2010	4,672	0	4,672
38	6/24/2010	5,061	0	5,061
39	6/25/2010	5,142	0	5,142
40	6/26/2010	4,546	0	4,546
41	6/27/2010	4,044	0	4,044
42	6/28/2010	7,189	0	7,189
43	6/29/2010	4,739	0	4,739
44	6/30/2010	9,117	0	9,117
45	7/1/2010	PR	PR	-
46	7/2/2010	NR	NR	-
47	7/3/2010	NR	NR	-
48	7/4/2010	NR	NR	-
49	7/5/2010	NR	NR	-
50	7/6/2010	NR	NR	-
51	7/7/2010	NR	NR	-
52	7/8/2010	NR	NR	-
53	7/9/2010	NR	NR	-
54	7/10/2010	NR	NR	-
55	7/11/2010	NR	NR	-
56	7/12/2010	NR	NR	-
57	7/13/2010	NR	NR	-
58	7/14/2010	NR	NR	-
59	7/15/2010	NR	NR	-
60	7/16/2010	NR	NR	-
61	7/17/2010	NR	NR	-
62	7/18/2010	NR	NR	-
63	7/19/2010	NR	NR	-
64	7/20/2010	NR	NR	-
65	7/21/2010	NR	NR	-
66	7/22/2010	NR	NR	-
67	7/23/2010	NR	NR	-
68	7/24/2010	NR	NR	-
69	7/25/2010	NR	NR	-
70	7/26/2010	NR	NR	-
71	7/27/2010	NR	NR	-
72	7/28/2010	NR	NR	-
73	7/29/2010	NR	NR	-
74	7/30/2010	PR	PR	-

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Day Since Start-Up	Date	Pump 1 to GCREC Mound	Pump 2 to GCREC Mound	Sum Pump 1 and 2
75	7/31/2010	485	639	1,124
76	8/1/2010	312	314	626
77	8/2/2010	1,021	1,192	2,213
78	8/3/2010	814	814	1,628
79	8/4/2010	994	825	1,819
80	8/5/2010	842	966	1,808
81	8/6/2010	982	793	1,775
82	8/7/2010	321	316	637
83	8/8/2010	319	463	782
84	8/9/2010	960	808	1,768
85	8/10/2010	780	943	1,723
86	8/11/2010	962	951	1,913
87	8/12/2010	933	776	1,709
88	8/13/2010	936	925	1,861
89	8/14/2010	457	466	923
90	8/15/2010	452	452	904
91	8/16/2010	946	1,363	2,309
92	8/17/2010	986	1,164	2,150
93	8/18/2010	930	1,056	1,986
94	8/19/2010	1,129	945	2,074
95	8/20/2010	782	964	1,746
96	8/21/2010	616	607	1,223
97	8/22/2010	450	456	906
98	8/23/2010	943	926	1,869
99	8/24/2010	1,092	939	2,031
100	8/25/2010	1,092	1,229	2,321
101	8/26/2010	1,242	1,085	2,327
102	8/27/2010	1,073	1,226	2,299
103	8/28/2010	745	742	1,487
104	8/29/2010	749	761	1,510
105	8/30/2010	917	1,204	2,121
106	8/31/2010	900	1,082	1,982
107	9/1/2010	1,053	1,049	2,102
108	9/2/2010	759	1,223	1,982
109	9/3/2010	1,659	1,715	3,374
110	9/4/2010	290	441	731
111	9/5/2010	599	444	1,043
112	9/6/2010	450	593	1,043

Day Since Start-Up	Date	Pump 1 to GCREC Mound	Pump 2 to GCREC Mound	Sum Pump 1 and 2
113	9/7/2010	1,060	909	1,969
114	9/8/2010	1,055	1,383	2,438
115	9/9/2010	746	904	1,650
116	9/10/2010	729	1,062	1,791
117	9/11/2010	284	594	878
118	9/12/2010	289	588	877
119	9/13/2010	899	1,067	1,966
120	9/14/2010	913	1,058	1,971
121	9/15/2010	748	1,043	1,791
122	9/16/2010	896	764	1,660
123	9/17/2010	897	920	1,817
124	9/18/2010	288	588	876
125	9/19/2010	292	437	729
126	9/20/2010	754	901	1,655
127	9/21/2010	881	749	1,630
128	9/22/2010	746	904	1,650
129	9/23/2010	597	752	1,349
130	9/24/2010	891	916	1,807
131	9/25/2010	286	300	586
132	9/26/2010	285	446	731
133	9/27/2010	758	923	1,681
134	9/28/2010	740	1,052	1,792
135	9/29/2010	894	762	1,656
136	9/30/2010	606	896	1,502
137	10/1/2010	750	893	1,643
138	10/2/2010	290	596	886
139	10/3/2010	287	441	728
140	10/4/2010	1,082	903	1,985
141	10/5/2010	911	1,071	1,982
142	10/6/2010	770	1,222	1,992
143	10/7/2010	906	925	1,831
144	10/8/2010	940	905	1,845
145	10/9/2010	291	293	584
146	10/10/2010	295	435	730
147	10/11/2010	732	934	1,666
148	10/12/2010	906	1,054	1,960
149	10/13/2010	934	1,222	2,156
150	10/14/2010	1,201	1,271	2,472

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Day Since Start-Up	Date	Pump 1 to GCREC Mound	Pump 2 to GCREC Mound	Sum Pump 1 and 2
151	10/15/2010	292	739	1,031
152	10/16/2010	573	444	1,017
153	10/17/2010	285	444	729
154	10/18/2010	913	1,223	2,136
155	10/19/2010	1,099	1,274	2,373
156	10/20/2010	1,053	1,081	2,134
157	10/21/2010	915	1,078	1,993
158	10/22/2010	606	932	1,538
159	10/23/2010	435	598	1,033
160	10/24/2010	433	292	725
161	10/25/2010	1,260	1,250	2,510
162	10/26/2010	1,243	1,401	2,644
163	10/27/2010	931	1,246	2,177
164	10/28/2010	1,237	1,246	2,483
165	10/29/2010	930	1,216	2,146
166	10/30/2010	292	589	881
167	10/31/2010	439	291	730
168	11/1/2010	765	1,218	1,983
169	11/2/2010	906	1,058	1,964
170	11/3/2010	909	1,069	1,978
171	11/4/2010	1,060	909	1,969
172	11/5/2010	752	1,083	1,835
173	11/6/2010	446	593	1,039
174	11/7/2010	589	444	1,033
175	11/8/2010	1,067	1,239	2,306
176	11/9/2010	768	1,056	1,824
177	11/10/2010	1,661	1,887	3,548
178	11/11/2010	293	596	889
179	11/12/2010	1,309	1,343	2,652
180	11/13/2010	286	448	734
181	11/14/2010	442	446	888
182	11/15/2010	941	1,436	2,377
183	11/16/2010	1,241	1,103	2,344
184	11/17/2010	1,306	1,827	3,133
185	11/18/2010	1,269	1,459	2,728
186	11/19/2010	895	781	1,676
187	11/20/2010	286	761	1,047
188	11/21/2010	433	446	879

Day Since Start-Up	Date	Pump 1 to GCREC Mound	Pump 2 to GCREC Mound	Sum Pump 1 and 2
189	11/22/2010	744	1,118	1,862
190	11/23/2010	984	1,555	2,539
191	11/24/2010	906	1,073	1,979
192	11/25/2010	291	445	736
193	11/26/2010	440	294	734
194	11/27/2010	438	596	1,034
195	11/28/2010	293	443	736
196	11/29/2010	899	1,088	1,987
197	11/30/2010	1,880	2,048	3,928
198	12/1/2010	2,640	3,090	5,730
199	12/2/2010	892	1,106	1,998
200	12/3/2010	752	1,089	1,841
201	12/4/2010	291	330	621
202	12/5/2010	446	561	1,007
203	12/6/2010	1,116	1,134	2,250
204	12/7/2010	916	938	1,854
205	12/8/2010	1,082	1,284	2,366
206	12/9/2010	771	942	1,713
207	12/10/2010	940	1,280	2,220

[1]NR = No reading
[2]PR = Partial daily flow recorded

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Appendix B: GCREC Weather Station Data

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Table B.1
Monthly Recorded Meteorological Data

Period	60cm T avg (F)	60cm T min (F)	60cm T max (F)	10m T avg (F)	10m T min (F)	10m T max (F)	Tsoil avg -10cm (F)	Tsoil min(avg) -10cm (F)	Tsoil max(avg) -10cm (F)	2m DewPt avg (F)	RelHum avg 2m (pct)	2m Rain tot (in)	2m Rain max over 15min (in)	10m Wind avg (mph)	10m Wind min (mph)	10m Wind max (mph)	WDir avg 10m (deg)	ET avg (in)
Jan-10	53.1	23.97	82.38	53.67	25.75	80.78	59.67	51.13	66.63	44.57	76	3.19	0.57	7.6	0	32.8	348	0.05
Feb-10	53.75	30.84	78.96	53.88	34.39	76.75	59.86	54.32	65.75	43.97	74	2.22	0.47	7.85	0	36.13	348	0.07
Mar-10	59.24	32.89	82.26	59.54	37.02	80.42	62.09	55.31	68.11	48.75	73	6.15	0.44	8.25	0	38.27	289	0.1
Apr-10	69.78	44.74	88.54	70.02	51.53	86.36	70.78	63	75.72	59.5	74	2.79	0.52	7.46	0	44.17	94	0.15
May-10	77.78	62.37	93.63	77.61	65.19	91.15	79.11	73.17	83.97	68.62	77	0.89	0.13	6.75	0	31.1	126	0.18
Jun-10	80.91	65.84	99.09	80.81	68.68	95.32	82.32	76.69	88.63	72.87	80	8.25	1.3	5.85	0	50.47	116	0.19
Jul-10	80.67	68	96.21	80.81	70.7	93.81	82.58	77.49	87.03	74.05	82	7.3	0.48	5.95	0	35.37	103	0.18
Aug-10	80.54	70.59	96.87	80.58	71.64	93.81	82.63	79.11	87.85	75.03	85	13.51	1.74	5.78	0	43.53	154	0.16
Sep-10	78.91	63.43	95.88	79.14	67.87	92.93	80.83	78.17	83.39	72.11	82	3.42	0.55	6.33	0	41.6	84	0.16
Oct-10	71.98	51.24	93	72.84	55.15	90.25	74.97	71.83	78.62	61.55	73	0.01	0.01	5.56	0	32	31	0.11
Nov-10	65.75	39.95	86.77	66.38	41.73	84.13	69.47	64.33	75.34	56.97	76	1.24	0.16	6.52	0	30.53	55	0.07
Dec-10	50.64	22.86	78.37	51.3	27.61	76.46	60.71	54.61	71.33	39.83	71	0.5	0.05	7.33	0	36.77	354	0.04

Appendix C: Field Parameter Analyses

Table C.1
Field Parameter Results
(December 9-10, 2010)

	Sample Identification	pH	Temperature (°C)	Specific Conductance (µS)	Dissolved Oxygen (mg/L)
1	STE-EX Pump Tank	7.33	19.9	1273	0.10
2	PZ04-BKG-9	5.3	21.6	72.9	1.10
3	PZ24-BKG-26	5.1	24.1	296.2	0.70
4	DP-AA9-14	5.1	25.1	281.9	0.89
5	DP-AA9-22	4.9	23.3	318.7	1.04
6	DP-AA9-27	4.8	22.7	293.2	0.84
7	PZ16-C12-28	5.6	27.2	291.8	0.70
8	DP-D7.5-14	7.01	21.2	432	1.10
9	DP-D7.5-20	7.01	22.2	258	2.55
10	DP-D7.5-26	7.01	21.3	295	2.01
11	DP-D09-6	4.82	17.0	363	5.59
12	DP-D09-8	4.65	18.4	380	3.52
13	DP-D09-15	5.30	19.1	433	3.20
14	DP-D09-21	5.78	21.7	300	1.35
15	DP-D09-27	5.97	20.2	270	2.26
16	DP-E12-10	5.48	19.2	491	4.68
17	DP-E12-15	4.88	22.2	550	2.47
18	DP-E12-22	5.00	20.4	464	1.95
19	DP-E12-28	5.17	21.9	297	2.01
20	DP-F08-14	7.04	22.4	1412	6.09
21	DP-F08-20	6.34	23.2	368	1.77
22	DP-F08-28	6.11	23.1	332	1.73
23	DP-F11-11	5.35	19.5	366	5.26
24	DP-F11-15	5.00	22.8	547	3.64
25	DP-F11-18	5.02	23.1	497	2.48

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	Sample Identification	pH	Temperature (°C)	Specific Conductance (µS)	Dissolved Oxygen (mg/L)
26	DP-F11-21	5.02	22.7	458	2.10
27	DP-F11-24	5.00	22.9	475	1.15
28	DP-F11-27	5.19	23.3	297	0.82
29	DP-F15-14	5.10	21.5	408.6	1.11
30	DP-F15-20	4.9	22.1	649	0.62
31	DP-F15-26	4.9	21.8	290.8	0.52
32	DP-G07-13	Dry			
33	DP-G07-15	5.53	21.4	271	3.33
34	DP-G07-17	5.36	21.9	312	2.19
35	DP-G07-21	5.37	22.9	343	1.66
36	DP-G07-24	5.26	22.9	300	1.13
37	DP-G07-27	5.19	22.5	293	1.37
38	DP-G12-15	4.7	22.3	508	0.89
39	DP-G12-21	4.9	22.7	636	0.99
40	DP-G12-27	4.7	23.1	509	0.45
41	DP-I06-14	5.25	20.4	240	1.66
42	DP-I06-20	5.03	21.4	367	1.80
43	DP-I06-26	5.01	21.3	302	2.36
44	PZ17-I15-26	5.7	22.1	294.1	0.52
45	DP-J09-14	4.5	21.9	232.1	3.29
46	DP-J09-20	4.9	23.2	338.1	1.57
47	DP-J09-26	4.9	23.0	298.2	2.51
48	DP-J12-15	4.8	22.1	287.5	1.50
49	DP-J12-20	5.0	22.9	342.9	1.13
50	DP-J12-27	4.8	22.6	307.1	1.14
51	DP-M07-15	4.8	22.2	304	0.80
52	DP-M07-21	4.9	22.5	374.9	0.58
53	DP-M07-27	4.8	22.5	301.5	0.49
54	DP-N12-14	5.0	22.1	163.4	1.28
55	DP-N12-21	4.9	22.3	304.1	1.91
56	DP-N12-27	5.0	21.6	331.6	2.45
57	DP-O10-12	4.3	21.1	186.4	1.31
58	DP-O10-18	4.8	22.2	298.6	0.77

	Sample Identification	pH	Temperature (°C)	Specific Conductance (µS)	Dissolved Oxygen (mg/L)
59	DP-O10-24	4.2	21.8	182.2	0.44
60	DP-Q15-15	4.7	20.7	303.4	2.31
61	DP-Q15-21	5.0	22.6	323.6	1.44
62	DP-Q15-26	5.1	21.5	324	0.96
63	Field Blank - DI	5.71	12.1	1.49	9.44
64	Field Blank - TAP	6.97	9.6	445	11.07
65	Equipment Rinsate	7.2	11.9	13.2	2.31

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Reports for the March 24, 2011 Meeting

Agenda Item	Report Title	Summary
1	Agenda	
1	Map to Physical Meeting Location	
1	How to Connect to the RRAC Web Conference	Instructions to view meeting via web. Use this if calling in to the meeting.
2	Draft Minutes December 10, 2010 Meeting	Minutes from last meeting.
3 b	Nitrogen Study Final Interim Legislative Report February 2011	FYI. Final report submitted on February 1, 2011.
3 b	Nitrogen Study Data Summary Report #4	FYI. **From the contract:** The provider will provide data reports that verify completion of analyses by an analytical laboratory and that include compiled data from field and analytical laboratory analyses in electronic and paper form.
3 b	Nitrogen Study Final Task B Quality Assurance Project Plan (QAPP)	FYI. **From the contract:** The department will gather comments on the draft QAPP from RRAC and any other interested parties and transmit such comments to the provider within one month of receiving the draft. The provider will address these comments in preparing final deliverables within one month of receiving comments.
3 b	Nitrogen study GCREC Mound Monitoring Sample Event Report #1	FYI. **From the contract:** The monitoring framework established at the GCREC will be described in the QAPP including number of sampling points, sampling frequency and duration, and analytical parameters. Monitoring reports, based on the QAPP framework, will be provided that describe site conditions and interim sample results (i.e., compiled data from field and analytical laboratory analyses).
3 b	Nitrogen Study Progress Report	FYI. Progress of study as of January 2011.
5	Research Priorities Worksheets	**Main focus of the meeting. Please review each proposed project and come prepared to discuss and rank these.**
6	Progress Report on 319 Grant on Advanced OSTDS in Florida	FYI. Report submitted to DEP for the October 1, 2010 – December 31, 2010 reporting period.
6	Revised Grant Work Plan fir the 319 Grant on Advanced OSTDS in Florida	FYI. Grant revision and extension.
8	Wakulla County Septic Tank Study	FYI. Final report on the Phase II study that FSU did for DEP. RRAC requested that this report be sent to RRAC once completed.

Research Priorities Ranking Workshop 2011

RRAC Member/Alternate Name:

Number	Project Title	Weight: Choose top five projects (highest priority = 5, lowest priority = 1)
1	**Continuation of Inventory of OSTDS in Florida**	
2	**Grease Sludge Waste Reduction and Reuse Study**	
3	**Correlations Between Water Quality, OSTDS, and Health Effects**	
4	**Introducing and Evaluating Improved Treatment Methods in OSTDS (Other Than Nitrogen)**	
5	**Urine Separation in OSTDS**	
6	**Growth Management and Septic Systems Symposium**	
7	**Linkages Between Optical Brighteners and Other Wastewater Indicators Such as Coliforms and Nutrients**	
8	**Effectiveness of Outlet Filters**	
9	**OSTDS Wastewater Strength & Flow Study**	
10	**Literature Review on Other OSTDS Research**	
11	**Fate and Transport of Nitrogen and Bacteria from OSTDS as it Relates to EPA Nutrient Criteria Rules, TMDLs, and State-Wide Water Quality Rules**	
12	**Pros and Cons of Using Cisterns for Potable Water Use**	
13	**Life Expectancy of Onsite Systems**	
14	**Drip Disposal With Septic Tank Quality Effluent**	
15	**Loading Rates and Effective Soil Depths Between Drip Irrigation, Low Pressure Dosing, Lift Dosing, and Conventional OSTDS**	
16	**Disparities in OSTDS Management**	
17	**Pharmaceuticals, Personal Care Products, and Other Organic Compounds in OSTDS: Occurrence, Persistence, Effects**	

PROJECT DESCRIPTION #1	
Project Title	**Continuation of Inventory of OSTDS in Florida**
Proposed By	Elke Ursin
Background	Having an inventory of OSTDS is the first step to any management program. A snapshot inventory was completed in 2009 per the request of the State Legislature. There has been much interest in these data by DEP, consultants, county health departments (CHD's), etc. This information is quickly outdated if not updated. The original data had many unknown/estimated parcels due to a lack of response for data from many DEP regulated Wastewater Treatment Plants (WWTP's). Part of this project would be to make another attempt at gathering that data.
Objectives and Outcomes	Update the current inventory from 2009 and develop a method to make this process easier for future efforts.
Research Approach	• Merge the existing inventory data into the Environmental Health Database (EHD) which will allow for real-time data updates as permits are entered into the system by the CHD's • Update EHD with Department of Revenue data annually for updated parcel information • Update with DEP data on WWTP's • Send letters to WWTP's to gather their sewer data and update the inventory • Develop and implement a grant program so CHD's can verify and update unknown parcels
Potential Collaboration	Collaborate with DEP on the information gathering for the WWTP's. DEP has indicated they are interested in collaborating. This was not done with the first round of data collection and will likely yield a higher response rate.
Duration	1-2 years
Estimated Budget ($)	$150,000
Ease of Implementation	Medium effort, some work can be contracted out but several components are best handled by staff. Updating EHD can be done through modifying an existing DOH contract, updating DOR and WWTP information could possibly be done through a purchase order (if under $35,000), and the grant program with CHD's to be implemented by staff.
Comments	This project ranks highly with Gerald Briggs, Bureau Chief for the Onsite Sewage Program, as this inventory is the starting point for any onsite sewage management program.

PROJECT DESCRIPTION #2	
Project Title	**Grease Sludge Waste Reduction and Reuse Study**
Proposed By	Elke Ursin
Background	Establishments generating fats, oils, and grease (FOG) such as restaurants and commercial kitchens face particular challenges with their waste and wastewater disposal. Utility-owned centralized wastewater collection systems often have utility-specific requirements to install certain precautions to prevent FOG from entering the collection system. Onsite sewage treatment and disposal systems (OSTDS) are regulated state-wide but have fewer required continued preventative measures. Often these business owners do not have the expertise or resources to know how they can prevent their sewage system from failing by performing simple daily tasks to reduce the amount of FOG entering the system.
Objectives and Outcomes	The objective of this project is to reduce FOG waste and increase reuse among these small businesses by providing technical assistance and education.
Research Approach	• Identify the scale of the problem/opportunity in Florida • Conduct a survey to better understand current practices and opportunities for improvement • Approximately 25 businesses will be selected for a more in depth characterization, which will then lead to recommending and implementing changes in practices, and monitoring the outcomes over time • Provide education and outreach to industry professional organizations as well as to business owners and their employees
Potential Collaboration	Florida Onsite Wastewater Association (FOWA), Florida Environmental Health Association (FEHA), Department of Business and Professional Regulation (DBPR), Orange County Utilities Water Reclamation Division
Duration	1-2 years
Estimated Budget ($)	$150,000
Ease of Implementation	Medium effort, most of the work can be contracted out with staff involvement in project oversight and Florida OSTDS data gathering, procurement of contracts (survey will likely be a purchase order and case-studies will be through an ITN), and contract administration.
Comments	This project was submitted as a grant proposal to EPA's Pollution Prevention Program and was not funded due to the scope being too narrow for the grant program (program looked at number of pounds of pollution prevented). EPA suggested for DOH to do this project first and then come back for funding for implementation, which would be easier for them to fund.

PROJECT DESCRIPTION #3	
Project Title	**Correlations Between Water Quality, OSTDS, and Health Effects**
Proposed By	Eberhard Roeder
Background	Many field studies are very site specific, focusing on single OSTDS. Different approaches can be used to assess quantify broader questions about environmental and public health impacts of OSTDS. A 1999 cohort study on an association of Giardiasis and Shigellosis 1994-1996 with the location of repair permits relative to a cohort of functional (systems without a repair permit) was inconclusive, in part due to small sample sizes. In 2005 several FAMU interns gathered data on the public health effects of OSTDS with a focus on drinking water wells. In another project, reported failures, as indicated by repair permit issuance, of onsite sewage systems statewide show a seasonal pattern, with a peak during the first quarter of a year. Variations in environmental conditions, system usage, funding or reporting are possible explanations.
Objectives and Outcomes	Perform an analysis using a geographic information system (GIS) of any correlations between water quality in drinking water wells, OSTDS, and health effects.
Research Approach	Gather data and put into a GIS database / map. A key question will be what data are available. Analyze the data to see if any correlations exist. Produce a final report.
Potential Collaboration	Environmental Public Health Tracking programs at CDC and DOH may have related databases and project expertise. The Bureau of Water Programs has information on some private wells. A University program with GIS and/or public health expertise
Duration	1-year
Estimated Budget ($)	Depending on the final approach, the budget could be approximately $5,000 if conducted in house to $30,000 if contracted out.
Ease of Implementation	Medium to high effort depending on if the work will be conducted in house or contracted out. Staff involvement will be considerable in either case for project oversight and Florida OSTDS data gathering.
Comments	

PROJECT DESCRIPTION #4	
Project Title	**Introducing and Evaluating Improved Treatment Methods in OSTDS (Other Than Nitrogen)**
Proposed By	Eberhard Roeder
Background	While the research programs focus has recently been on nitrogen treatment effectiveness and fate and transport, other contaminants, regulated and unregulated, are also of concern. There has been very limited interest, development, and evaluation in Florida of new alternatives to current treatment approaches for the following: -Enhancements/alternatives for primary treatment (i.e. septic tank) to remove more cBOD5and TSS. Eventually, can improvements in geometry provide secondary treatment for cBOD5 and TSS without aeration? -Enhancements/alternatives for phosphorus treatment. Treatment in the Keys is based on absorption media. Larger wastewater treatment systems employ other processes that tend to require additives and more intensive operational control. What can be useful for OSTDS? -Enhancements/alternatives for disinfection treatment. Chlorination is codified, and soil treatment has been used in designs for the treatment of fecal coliforms. The former needs ongoing supply and maintenance, the latter may not treat as effectively for viruses as for fecal coliform. Industry has shown very limited interest in pursuing innovative system applications for UV-disinfection, with its own operational challenges. What can be useful for OSTDS?
Objectives and Outcomes	Identify treatment approaches with improved effectiveness Encourage establishment as innovative systems Evaluate performance at field installations in Florida Establish alternatives to currently used technologies
Research Approach	Could be similar to the passive nitrogen study, with a third party organizing the selection, installation, and testing
Potential Collaboration	NSF field testing protocol development
Duration	Several years
Estimated Budget ($)	$500k –several millions
Ease of Implementation	difficult
Comments	

PROJECT DESCRIPTION #5	
Project Title	**Urine Separation in OSTDS**
Proposed By	RRAC / TRAP recommendation
Background	During the July 30, 2008 RRAC meeting and the August 27, 2008 TRAP meeting, presentations were made by Dominique Buhot with Green's Environmental Services on alternative methods to remove nitrate and phosphorus from wastewater using urine separation. RRAC asked the Department to see how this type of treatment and disposal would be possible under current rules. The TRAP was interested in this technology and suggested that the product be presented to the Florida Building Commission.
Objectives and Outcomes	The objective of this project will be to research life cycle / nutrient cycle management for nutrients in OSTDS from sources such as urine, and evaluate energy efficiencies in such approaches.
Research Approach	Perform a literature review of existing technologies, report back to RRAC on a proposed process forward, and develop a scope of work based on RRAC recommendations.
Potential Collaboration	This concept has been discussed in the passive nitrogen study literature review. It was ranked at a low priority, so most likely no further study would be done on this topic within that project. There has been some study of precipitating fertilizer out of fairly concentrated wastewater in the wastewater literature that may be applicable to this.
Duration	6 months for literature review
Estimated Budget ($)	Staff time
Ease of Implementation	Semi-difficult due to limited staff time available to devote to this project in the immediate future.
Comments	

PROJECT DESCRIPTION #6	
Project Title	**Growth Management and Septic Systems Symposium**
Proposed By	Elke Ursin
Background	In January of 2007, DOH and FOWA held a Florida Wastewater Summit that was extremely successful. This project would be to expand the audience to those outside the Environmental Health profession to make individuals more educated on the topic of decentralized systems.
Objectives and Outcomes	Develop an informational education program to county government, real estate industry, builders, planning agencies, and other interested groups on decentralized systems.
Research Approach	Develop overall meeting format, coordinate speakers and agenda, and determine location. Advertise and solicit attendees. Conduct the symposium.
Potential Collaboration	Florida Onsite Wastewater Association (FOWA), Florida Environmental Health Association (FEHA), Florida Home Builders Association, Florida Association of Realtors, Department of Community Affairs, etc.
Duration	1-year
Estimated Budget ($)	$25,000 (could also be grant funded if opportunity exists); possibility of using the existing OSTDS Training Center contract for FOWA to handle registration, etc.
Ease of Implementation	Difficult as it would require much staff time to coordinate and implement.
Comments	There is a potential this might be something that could be grant funded if the opportunity presents itself.

PROJECT DESCRIPTION #7	
Project Title	**Linkages Between Optical Brighteners and Other Wastewater Indicators Such as Coliforms and Nutrients**
Proposed By	Eberhard Roeder
Background	The previous remote sensing project found that wastewater had a characteristic optical signature that could be used to estimate a fraction of sewage equivalent in waters. Very limited work was completed on correlating this fraction to other water quality parameters such as coliforms or nutrients, and was inconclusive.
Objectives and Outcomes	Further characterization of the agent that provides the optical signature, which was not an optical brightener as expected. Validation that a two-wavelength method that was proposed in the previous reports gives similar sewage fraction results as evaluations of the full spectrum. Assessment of the relationships between the sewage fraction estimates based on this method and other water quality parameters. Evaluation of the use of optical assessment in constraining source identification and mass balances of water bodies of concern.
Research Approach	Combined field and laboratory study with statistical analysis Could be combination of a broader survey with assessment efforts at particular water bodies
Potential Collaboration	Coordination with water quality sampling and assessment by other agencies
Duration	1-2 years
Estimated Budget ($)	Depending on extend of coordination and sampling, 100k-300k
Ease of Implementation	Medium (depending on ability to find partners), very limited knowledge base
Comments	

PROJECT DESCRIPTION #8	
Project Title	**Effectiveness of Outlet Filters**
Proposed By	Eanix Poole
Background	The objective/purpose of outlet filters is to retain solids in the tank where further digestion can take place thus "in theory" extending the life of the drainfield because of a cleaner higher quality effluent. Outlet filters first appeared in the rule in 1995 as an alternative to multi-chambered tanks. In 1997, Florida became the first state to require outlet filters in new installations. For several years prior to 1997, outlet tees were required to have a gas baffle to prevent solids being directly discharged to the drainfield (same theory). Economics played a role in this as there was only one manufacturer who made outlet filters and the product was quite expensive. This manufacturer developed a simple, inexpensive, filter targeting the Florida market. Other companies soon developed similar products. The Department developed Approval Standards for Outlet Devices that were incorporated by reference into the rule to ensure minimum design and performance criteria. Other states are now requiring outlet filters and industry has responded with a multitude of products at various price ranges.
Objectives and Outcomes	1. Determine whether outlet filters are performing as expected/described and not causing unnecessary expense to the homeowner as in unnecessary cleanings and or pump outs. 2. Determine average maintenance frequency such as filter cleaning or pump outs. 3. Determine whether Department's Approval Standards for Outlet Filters are adequate.
Research Approach	Phase I. Perform survey in a minimum of 3 counties: one small, one medium, and one large. Take a small sample of installations since 1997 and determine history of maintenance and pump outs. Survey Environmental Health offices and get their input on filter performance. Survey Installer/Pumper Companies to determine their experience with filters. Survey Pumper Companies to determine their perspective. Phase II. Depending on findings of Phase I, may need to field test filters for performance.
Potential Collaboration	Health Departments, Florida Onsite Wastewater Association, Universities, Private Research Contractor
Duration	Survey should be finished within 6 months of work start approval.
Estimated Budget ($)	Phase I: $35,000; Phase II: dependant on results of Phase I
Ease of Implementation	Should be a simple project. Depends on whether the Department chooses to perform or contracts to other entity.
Comments	Filters on the market today are capable of performing for at least five years in a normal usage household without maintenance. It needs to be determined if Florida homeowners are facing unnecessary expenses for more frequent maintenance and or pump outs.

PROJECT DESCRIPTION #9	
Project Title	**OSTDS Wastewater Strength & Flow Study**
Proposed By	Eberhard Roeder / Elke Ursin
Background	Both variability of use and long-term changes of plumbing fixtures and use patterns introduce variations in sewage flow and strength. Residential flow strength may be higher now than previously in Florida due to low flow fixtures and other water conservation activities. A recent WERF-study suggests that this effect appears most clearly for nitrogen, less so for cBOD5 and phosphorus, and least for total suspended solids. Are there parts of the code that should be revised to account for these changes, such as the definition of domestic strength sewage, and estimated sewage flows? Commercial flow strength is also changing due, in part, to changes in grease composition (more vegetable grease and less animal grease).
Objectives and Outcomes	Determine factors that influence excessive wastewater strength and flows that cause systems to become out-of-compliance with the current sizing standards, and develop alternatives to address these factors. The focus will be on generating more information on specific establishment and treatment types.
Research Approach	Determine the effects of water saving fixtures on influent / effluent concentrations and flow amounts for residential and various commercial establishments (sampling of systems that do not have water saving fixtures, then install the fixtures and resample). Compare current commercial sewage strengths with those found in the restaurant study. Determine if current sizing criteria for various establishments (restaurants, convenience stores, etc.) is still adequate. When the sewage waste is separated, do blackwater/graywater concentrations exceed domestic sewage waste concentrations limits? A failure study could also be done for establishments that are shown to exceed current concentration standards. Perform a data analysis of vacation rentals and/or other establishments that have short term overloading. What is the performance of systems under such conditions (peak factor relative to average or median flow); what is the performance of mitigating factors, such as over-design or time-dosing, both under the peak conditions and under average conditions?
Potential Collaboration	Department of Business and Professional Regulation, local governments
Duration	3-years
Estimated Budget ($)	$150,000 (focus on one or two questions)
Ease of Implementation	Medium effort, most of the work can be contracted out with staff involvement in project oversight and Florida OSTDS data gathering, procurement of contract (will likely be an ITN), and contract administration.
Comments	

PROJECT DESCRIPTION #10	
Project Title	**Literature Review on Other OSTDS Research**
Proposed By	Carl Ludecke
Background	Several projects have come to the RRAC's attention over the recent years, which are related to several research projects that the program is conducting or considering conducting. Having a method to regularly keep up with what other people are looking into regarding OSTDS research may help in streamlining DOH's research efforts.
Objectives and Outcomes	Conduct a literature review of current research on OSTDS being conducted, or having been recently completed. Create a method to update this information.
Research Approach	Develop a contact list of other agencies, private companies, colleges, and universities that have or are conducting research on OSTDS. Create a database to hold the contact information, results of inquiries, copies of reports and other related information, and suggested follow-up. Report back to the RRAC on the results of this research and any potential areas that warrant further research.
Potential Collaboration	Multiple other agencies, private companies, colleges, and universities. Information sharing will likely occur, broadening the reach of the research that DOH has done or is conducting.
Duration	6 months
Estimated Budget ($)	$2,000 for copies
Ease of Implementation	Somewhat difficult as it will be time-consuming for staff. No contracts or purchase orders are anticipated to be made.
Comments	Once the initial framework is set-up this type of information gathering on an annual basis will be easier to conduct and will be valuable in prioritizing future research projects.

PROJECT DESCRIPTION #11	
Project Title	**Fate and Transport of Nitrogen and Bacteria from OSTDS as it Relates to EPA Nutrient Criteria Rules, TMDLs, and State-Wide Water Quality Rules**
Proposed By	Kriss Kaye
Background	There have been several developments recently regarding the EPA nutrient criteria rules, TMDLs, and state-side water quality rules. These new developments raise several questions: What is the strength of the effluent at the outlet filter and what is an appropriate constituent level / loading at the property line? How effective is the soil in treating the wastewater? How much phosphorus removal occurs under drainfields? How much groundwater mounding occurs under drainfields that then can impact drainfield performance?
Objectives and Outcomes	Determine how the fate and transport of contaminants of concern relates to current developments regarding the EPA nutrient criteria rules, TMDLs, and state-side water quality rules.
Research Approach	Strength of effluent can be incorporated in one of the other priorities and based on current literature and studies. Nitrogen fate and transport is part of the ongoing passive nitrogen reduction strategies study. This leaves the following questions: -Mounding effects: Survey a sample of systems in high groundwater conditions and compare the results to existing model predictions. -Effects on water bodies: Possible approach might be to sample areas that have recently been sewered to see if there are any advantages of sewering looking at inland / fresh water bodies and compare to the Town of Suwannee and Taylor County study results. (overlap with optical brightener topic) -Fate and transport of phosphorus and fecal coliforms: Literature review and/or site-scale field studies Analyze results and compare with current developments regarding the EPA nutrient criteria rules, TMDLs, and state-side water quality rules.
Potential Collaboration	The test center in Wimauma could be used to help answer some of these questions for the soil conditions present there. Nitrogen fate and transport monitoring and modeling is part of the passive nitrogen strategies study. Could consider collaboration and additional samples. DEP has funded studies that look at similar questions that could provide data.
Duration	2 years
Estimated Budget ($)	$100,000- (estimated assuming one semi-large-scale sampling effort, could vary from literature review to project on the scale of the nitrogen strategies study)
Ease of Implementation	Medium effort, most of the work can be contracted out with staff involvement in project oversight, procurement of contracts (will likely be through an ITN), and contract administration.
Comments	

PROJECT DESCRIPTION #12	
Project Title	**Pros and Cons of Using Cisterns for Potable Water Use**
Proposed By	Kriss Kaye
Background	Recently the code has been modified to allow for the conversion of septic tanks to cisterns in lieu of abandonment for single family residences. The variance committee had been granting numerous variances to allow this, mainly in the Keys, prior to the rule change. Use of a cistern is beneficial for conserving water with the main use of the water being for irrigation.
Objectives and Outcomes	Review the current practice of converting septic tanks to cisterns to ensure public health and the environment are protected.
Research Approach	For all final approved cistern conversions, review lab results, inspection results, and survey homeowners and CHD's to assess the pros and cons. An option would be to fund sampling of the cisterns some time after conversion. Write a report on the findings.
Potential Collaboration	Monroe county Health Department, other health departments where this practice has been implemented.
Duration	1 year
Estimated Budget ($)	$5,000-50k (if contracted out with student involvement)
Ease of Implementation	Medium effort. Data gathering and analysis to be conducted in-house. Survey to be contracted out through a purchase order.
Comments	

PROJECT DESCRIPTION #13	
Project Title	**Life Expectancy of Onsite Systems**
Proposed By	Eberhard Roeder
Background	A summary of three Florida studies (statewide, Marion, Sarasota) in late 1998 found an average age at failure (defined as getting a repair permit) of OSTDS of about 18 years, and described a bimodal failure distribution, with early failures attributed to hydraulic overloading, and older failures attributed to roots. One of the studies saw an increase to about 28 years that was attributed to a change in county ordinances. On the other hand, repair rates of one to two percent would lead to an estimate of 50-100 years as life expectancy. Possibly explaining part of the difference is an observation that average age at failure appears to be higher in areas with older housing stock. Still other observations suggest that tank corrosion varies regionally. So, what is the expected life of an OSTDS? How representative are repair rates for the frequency of failure and non-conformance of OSTDS to standards? Are there categories (which) of systems that get repaired less frequently? Are there factors that are important such as soils, treatment effectiveness, and code conformance?
Objectives and Outcomes	Determine the life expectancy of a septic tank and various kinds of drainfields.
Research Approach	Review of permitting databases. Follow-up on data sources used in 1998 study. Statistical analysis to identify predictors/confounders. Follow-up on the systems that were part of Marion county's assessment (50 systems were tracked in 1992, 1993, and 1996)
Potential Collaboration	Repair evaluation gathering tool by Bureau Statewide or county inspection programs (depending on existence)
Duration	1 year
Estimated Budget ($)	$50,000 (university student project; some field work to assess systems)
Ease of Implementation	Medium (initially heavy involvement in gathering and preparing databases, later depending on who does the work)
Comments	

PROJECT DESCRIPTION #14	
Project Title	**Drip Disposal With Septic Tank Quality Effluent**
Proposed By	Sam Averett
Background	This is being done in other states, with a back washing filtering system. This is generally a more thorough back washing approach than the filter surface flushing that appears to be usually used with more pretreated effluent in Florida.
Objectives and Outcomes	Determine the effectiveness of permitting drip disposal using septic tank quality effluent. Determine maintenance requirements and how these can be assured.
Research Approach	• Perform a literature review to see what research has already been conducted on this topic. • Develop a project plan to address outstanding research issues. One possibility could be to allow several systems to be installed and monitor them yearly and in 5 years If it works allow wide spread use.
Potential Collaboration	The passive nitrogen project anticipates some evaluation of this approach at the test center. The Keys OWNRS-study included a couple of such systems, and perhaps up to half a dozen systems appear to have been permitted this way before pretreatment by PBTS or ATU became standard.
Duration	5 years (could be shorter)
Estimated Budget ($)	Up to $100,000 depending on results of literature review.
Ease of Implementation	Medium effort, most of the work can be contracted out with staff involvement in project oversight, procurement of contracts (will be through an ITN), and contract administration.
Comments	There are several of these units on the market right now; let them into the state and make them warranty the system. If this was approved it could be a less expensive way to upgrade existing systems, and get them out of the water table. Because of the height reduction and footprint, it could be a better choice than a conventional drainfield.

PROJECT DESCRIPTION #15	
Project Title	**Loading Rates and Effective Soil Depths Between Drip Irrigation, Low Pressure Dosing, Lift Dosing, and Conventional OSTDS**
Proposed By	Eberhard Roeder
Background	Drip irrigation, low-pressure-dosed, lift-dosed, and gravity-fed drainfields are sized largely the same, with loading rates and effective soil depths determined based on the material surrounding the infiltrative surface. Some differences are introduced by "rating" alternative drainfield products, by adjustments for pretreatment for slightly limited soils, and by proposals to treat drip systems differently. While there is a general perception that dosing is beneficial for drainfield function, a preliminary assessment as part of a repair data evaluation indicated higher odds of getting a repair permit for systems with a dosing pump. Is there a universal drainfield formula that can be used to consistently evaluate proposed changes to drainfield sizing, so that the odds of failure are uniform?
Objectives and Outcomes	Assess what the effects of dosing are on drainfield function and odds of needing a repair permit Assess the effect of different infiltrative surface architectures on drainfield function and odds of needing a repair permit Assess the effect of different soil profiles on drainfield function and odds of needing a repair permit Assess combined effects
Research Approach	Review of literature and experiences in other states. (contract or in-house) Review of failure evaluations and repair permit information to assess differences in failure rates. (contract or in-house) Modeling studies to assess effect of differences. (contract out) Laboratory / test center / field studies. (contract out)
Potential Collaboration	Alternative drainfield product study
Duration	2 years
Estimated Budget ($)	Can vary widely, depending on extent of scope (5k-millions)
Ease of Implementation	Difficult
Comments	

PROJECT DESCRIPTION #16	
Project Title	**Disparities in OSTDS Management**
Proposed By	Elke Ursin
Background	Populations of demographic (gender, race, age, income, etc.) minorities have been shown to often receive a lower quality of health services. This study will look to identify if there are any such disparities in OSTDS management and upkeep related to demographic characteristics.
Objectives and Outcomes	Identify if there are any disparities in access to wastewater treatment facilities (either central or decentralized) related to demographic characteristics.
Research Approach	Obtain Florida-specific demographic data, OSTDS information (could be linked to the wastewater inventory), and wastewater treatment plant (WWTP) information. Information to look at could include cost of wastewater treatment, sanitary nuisances, location of types of treatment systems, etc. Do an analysis, possibly utilizing a geographic information system (GIS), to determine if there are any correlations between various demographic categories and various wastewater treatment issues.
Potential Collaboration	FDEP, as this will include looking at WWTP's. Possibly Florida Onsite Wastewater Association (FOWA) in gathering cost information and other OSTDS non-permit related questions.
Duration	1-year
Estimated Budget ($)	$30,000
Ease of Implementation	Medium effort, most of the work can be contracted out with staff involvement in project oversight and Florida OSTDS data gathering, procurement of contracts, and contract administration.
Comments	

PROJECT DESCRIPTION #17	
Project Title	**Pharmaceuticals, Personal Care Products, and Other Organic Compounds in OSTDS: Occurrence, Persistence, Effects**
Proposed By	Eberhard Roeder
Background	While wastewater treatment has tended to look at a few bulk contaminants, in recent years concern about the cumulative effects of endocrine disrupting compounds and pharmaceuticals and personal care products have prompted an increasing number of studies. These look at concentrations of compounds in wastewater, treatment effectiveness, and concentrations in water bodies. Another line of inquiry is about the human health effects of the exposure to endocrine disrupters and pharmaceuticals via wastewater discharges. Examples for concentration studies: WERF-study on wastewater composition; USGS studies in Leon and Wakulla counties
Objectives and Outcomes	Summarize current knowledge of fate and transport of such compounds in OSTDS, in the environment, and their likely effects on human health. Fill in gaps through either lab, field, or modeling studies. Contamination sources that might provide particularly high concentrations include hospitals, pharmaceutical manufacturing, and group care facilities.
Research Approach	Literature review to determine next steps
Potential Collaboration	Research program that has an interest in this (?)
Duration	One year
Estimated Budget ($)	$30,000 – (assumes graduate student or similar)
Ease of Implementation	Medium
Comments	

Department of Health
Bureau of Onsite Sewage Programs
Research Review and Advisory Committee

Thursday March 24, 2011

9:30 am - 3:00 pm

Agenda:

- Introductions and Housekeeping
- Changes to RRAC Composition
- Review Minutes of Meeting December 10, 2010
- Nitrogen Study
  - Task D modeling amendment discussion
  - Comments on deliverables and next steps
  - Status report for Legislature
- Presentation by Presby Environmental Inc. on passive denitrification processes
- Research Priorities Workshop
- Update on Study of Performance of Advanced Systems in Florida
- Update on Alternative Drainfield Products Study
- Other Business
- Public Comment
- Closing Comments, Next Meeting, and Adjournment

Introductions & Housekeeping

- Roll call
- Identification of audience
- How to view web conference
- DO NOT PUT YOUR PHONE ON HOLD!!!!
- Download reports:

http://www.myfloridaeh.com/ostds/research/Index.html

Changes to RRAC Composition

Link to current list:
http://www.doh.state.fl.us/environment/ostds/research/index.html

New members (term expires January 2014):

- Local Government: Tom Miller (member) and David Richardson (alternate)

Reappointments (term expires January 2014):

- Consumers: Bill Melton (member) and Eanix Poole (alternate)
- State University System: John Schert (member) and John Dryden (alternate)

Leaving the committee:

- Pam Tucker (realtor), Jim Oskowis (local government), and Vince Seibold (local government)
- Florida Restaurant Association has failed to name replacements for the committee and the two positions remain vacant

Review Minutes of Meeting December 10, 2010

- See draft minutes

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Purpose: Develop passive strategies for nitrogen reduction that complement use of conventional onsite sewage treatment and disposal systems, and further develop cost-effective nitrogen reduction strategies

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Environmental Engineers & Scientists

FLORIDA DEPARTMENT OF HEALTH

Florida Onsite Sewage Nitrogen Reduction Strategies (FOSNRS) Project

Project Status Report

FDOH Research Review & Advisory Committee Meeting

March 24, 2011

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AET
Applied Environmental Technology

Otis Environmental Consultants

44237-001W-

Task D – Current Approach

- General Scope
  - Simple soil model
  - Complex soil model linked to an aquifer model
  - Provide simple to use tool for the assessment of OSTDS treatment performance and impacts to groundwater
- Budget = $808K
  - Phase 1 = $74K; Phase 2 = $94K; Phase 3 = $640K

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Task D – Proposed Approach

- General Scope
  - Simple soil model
  - Complex soil model linked to an aquifer model
  - Provide simple to use tool for the assessment of OSTDS treatment performance and impacts to groundwater
- Budget = $808K
  - Phase 1 = $74K; Phase 2 = $258K; Phase 3 = $476K
- ***No change to general scope or total budget***

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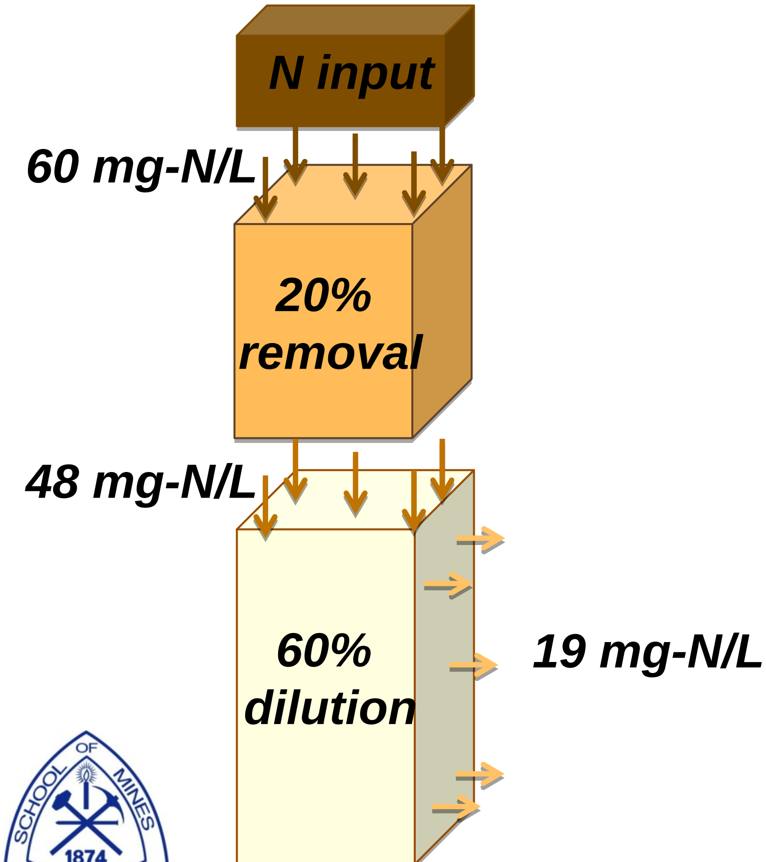
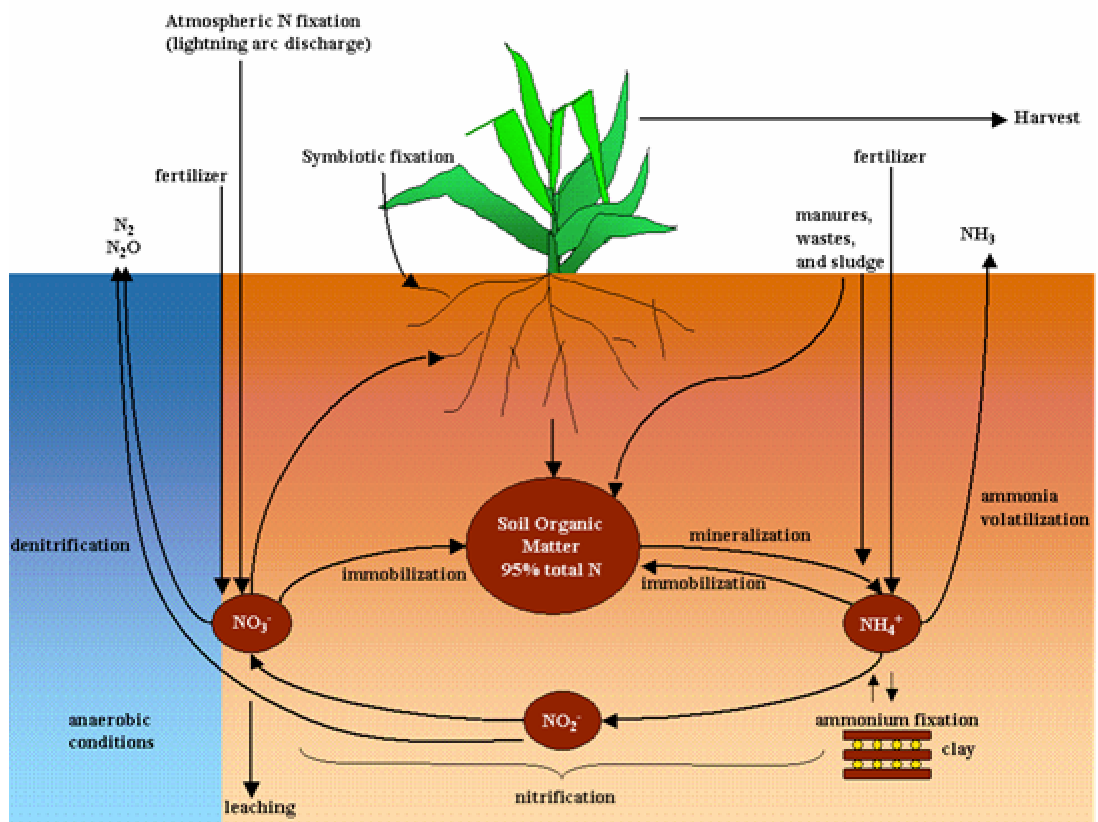
Task D – Soil Model

- Simple model vs. simple to use tool…





Neitsch et al., 2002

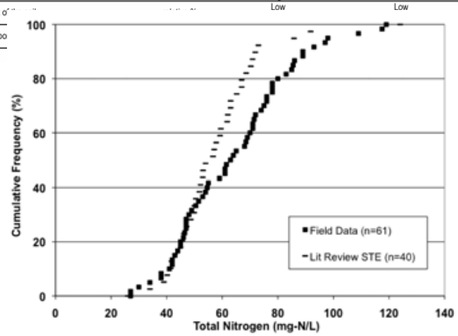
Task D – Soil Model

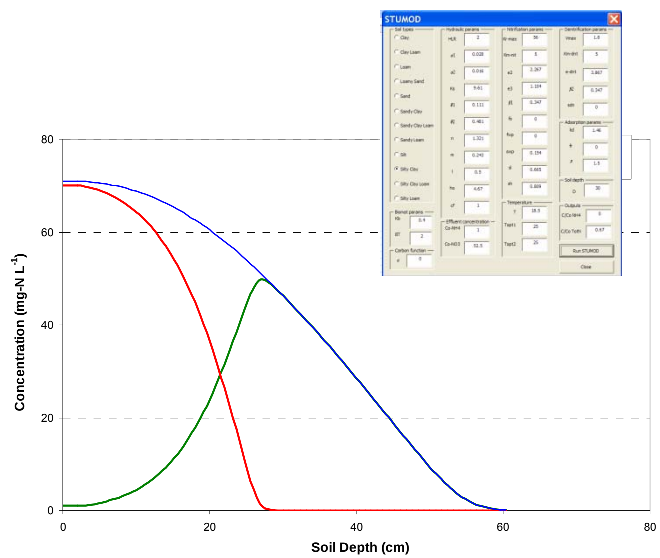
- Simple model vs. simple to use…

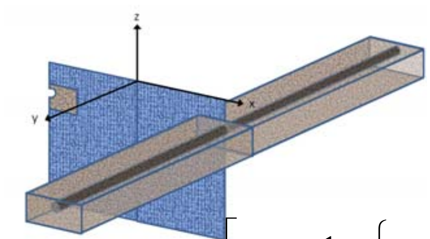
increasing complexity

Tables Graphs	***Spreadsheet Tools***	***Numerical Models***

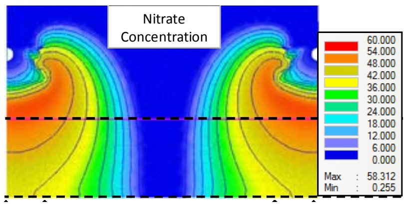
Factors	Units	Expected Field Condition	Resulting Ammonium Sorption
Ammonium-nitrogen concentration of the effluent	mg-N L^{-1}	Low	High
		High	Low
Chemical oxygen demand of the effluent	mg L^{-1}	Low	Low
		High	High
Cation exchange capacity of the soil	meq 100g^{-1}	Low	Low
		High	High
Calcium and magnesium mineral content of the soil	mg L^{-1}	Low	High
		High	Low
Clay content o…		Low	Low
Water filled po…			







$$\psi = c_f\left[\psi_o - z + \frac{1}{\alpha_G}\ln\left\{\frac{v}{K_o}e^{-\alpha_G\psi_o}\left(e^{\alpha_G\psi_o}-1\right)+1\right\}\right]$$



Task D – "Simple" Approach

- Spreadsheet tool based on Wekiva loading estimates (Otis, 2007)
  - spatially averaged % removal in soil
    - water table, drainage, soil texture, and organic matter
  - highly conservative, limited value
- Look-up tables for key Florida conditions
  - numerical models used to estimate performance
  - limited number of runs, easy field reference

Soil Texture	Design HLR (gpd/ft^2)	Effluent Quality	Separation to Seasonal High Groundwater	Estimated Nitrogen Removal
Fine sand	0.8	60 mg-N/L as NH_4^+	12 inches	10%
Fine sand	0.8		24 inches	45%
Fine sand	0.8		36 inches	50%
Fine sand	0.8	30 mg-N/L as NO_3^-	12 inches	10%
Fine sand	0.8		24 inches	30%
Fine sand	0.8		36 inches	30%

Note: Table values are arbitrary and intended to illustrate the type of information and format of look-up values only rather than expected performance or actual modeled conditions.

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Task D – “Complex” Approach

- Spreadsheet model incorporating scientific principals
  - Taylors existing soil model (STUMOD) for Florida specific conditions
    - Simple to use model can be calibrated to site specific data
    - Based on Darcy’s Law and a simplification of the advection dispersion equation
    - Incorporates nitrification and denitrification based on estimates of the water filled porosity
  - Incorporates the effects of evapotransporation and high groundwater tables

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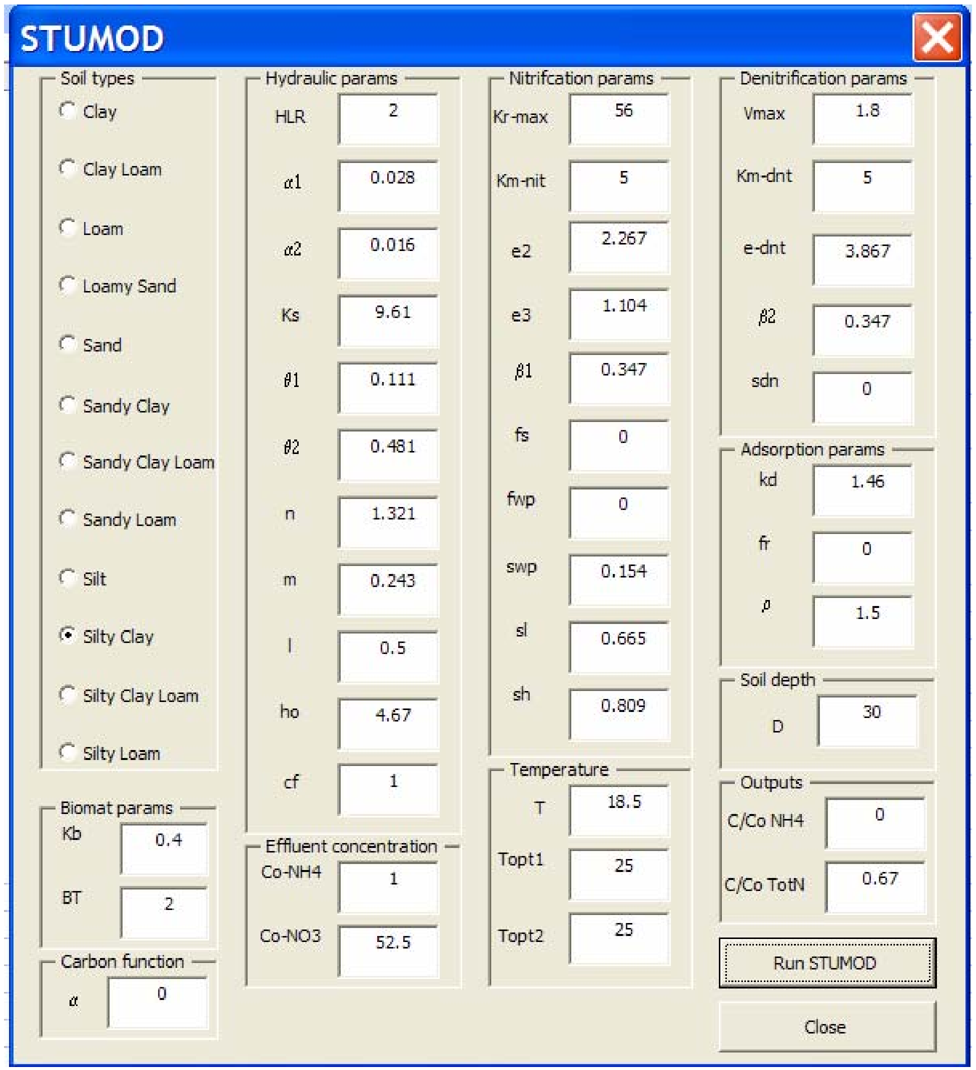
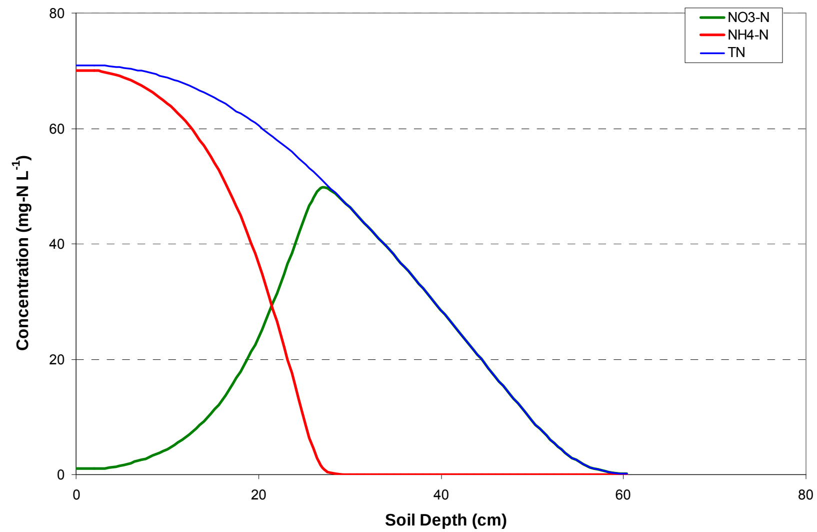
44237-001W-FN

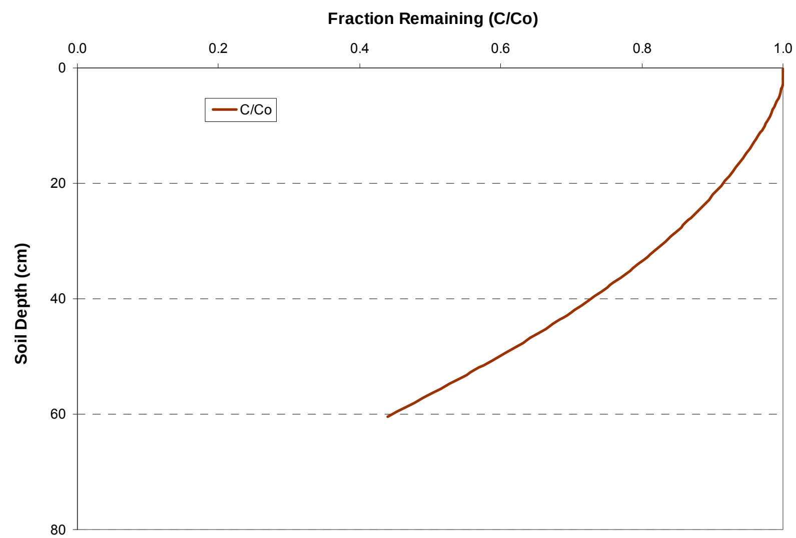
Task D – "Complex" Example

- STUMOD
  - Input parameters:
    - effluent concentration, hydraulic loading rate
    - hydraulic and nutrient transformation calibration parameters
  - Output:
    - expected performance (i.e., constituent concentration) at selected soil depth

Task D – "Complex" Example



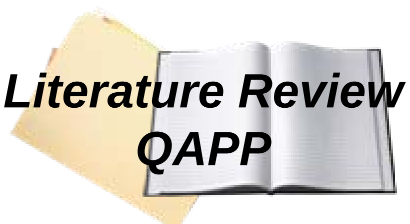




Suggested Task D Amendment

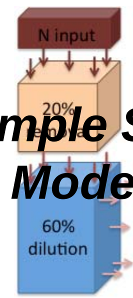
- Current Approach

Phase 1

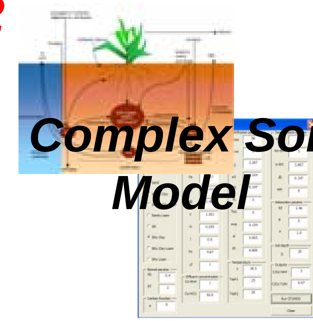


Literature Review QAPP

Phase 2



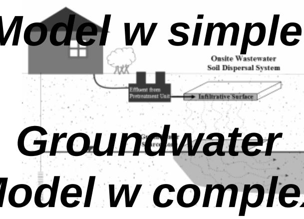
Simple Soil Model



Complex Soil Model

Phase 3

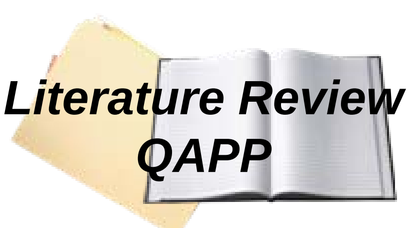
Groundwater Model w simple



Groundwater Model w complex

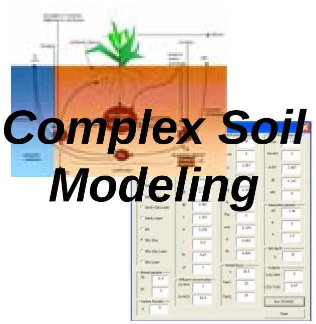
- Proposed Approach

Phase 1

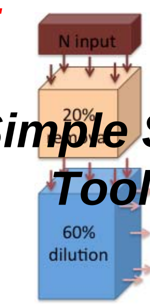


Literature Review QAPP

Phase 2

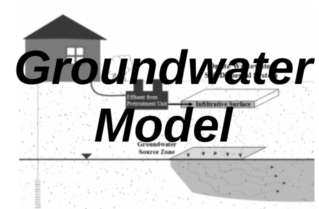


Complex Soil Modeling



Simple Soil Tool

Phase 3



Groundwater Model

Task D Summary

- Task D budget remains at $808K
  - Authorize $163K from Phase 3 as part of Phase 2
  - Delay portions of Tasks B and C from Phase 2 into Phase 3
- Task D deliverables at completion of Phase 2
  - Simple tools
    - tables of selected Florida conditions
  - Complex soil model
    - based on rigorous scientific principles, but simple to use
    - stand alone tool can be used as input to groundwater models

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Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task D modeling amendment discussion

Main reasons for this amendment are:

1. Get the soil model moving ahead, as it is something that is really needed for OSTDS planning, also will be useful to the FDEP/FSU model we saw at the previous RRAC meeting
2. The way the schedule is moving, it appears that we won't get the number of Task B or C sites completed that we thought, so some of this money can be moved to Task D soil modeling to better fit the schedule

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task A

- PNRSII modifications as of the last meeting: increased recycle ratio for the polystyrene biofilter to 6:1 from 3:1
- Fourth sampling event report submitted
  - Systems functioning as intended
  - Flow rates within 15% of target
  - Septic tank effluent quality characteristic of household
  - 9 of 10 Stage 1 unsaturated filters had ammonia of 1.7 mg/L or less
  - 5 of 9 Stage 2 saturated filters had nitrate/nitrite of 0.35 mg/L or less
- Recommend to discontinue polystyrene, replace lignocellulosic material, replace piping with clear tubing to allow better visual inspection for clogs, and increase loading rates for some of the biofilters

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task B

- Currently identifying home sites: two in Wakulla and one in Hillsborough
- Started work on vendor agreements
- Field work begun for permit to install passive technology at a home site in Wakulla

Task C

- Currently identifying home sites: one in Wakulla
- GCREC mound monitoring/sampling has begun, first sample event report submitted
  - 62 monitoring locations sampled
  - Groundwater levels ranged from 118 ft to 123 ft below sea level, which is equivalent to about 4 ft to 9 ft below ground surface
- Instrumentation and monitoring of Tack C home site in Wakulla ongoing

Task D

- Working on contract amendment to align with QAPP
- Started work on complex soil model development

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Passive Definition Concerns – Pumping

- Rep. Nelson expressed concerns regarding use of pumps for all passive nitrogen reduction systems
- Proposed looking at gravity systems at home site with available topography in Task B to satisfy these concerns

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task B – PNRS II Systems Pumped Flow

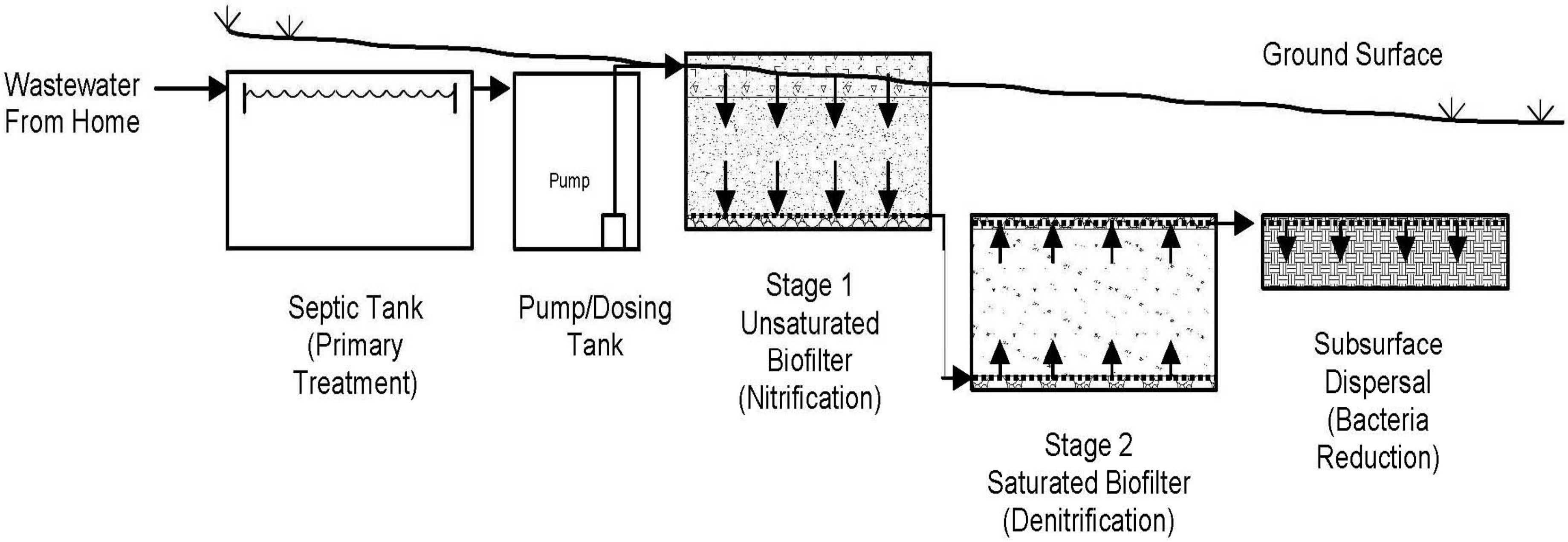

FIGURE 2. Schematic of two-stage, in-tank single pass biofilters for passive nitrogen reduction on relatively flat terrain with high groundwater, requiring a pump.

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task B – PNRS II Systems Gravity Flow

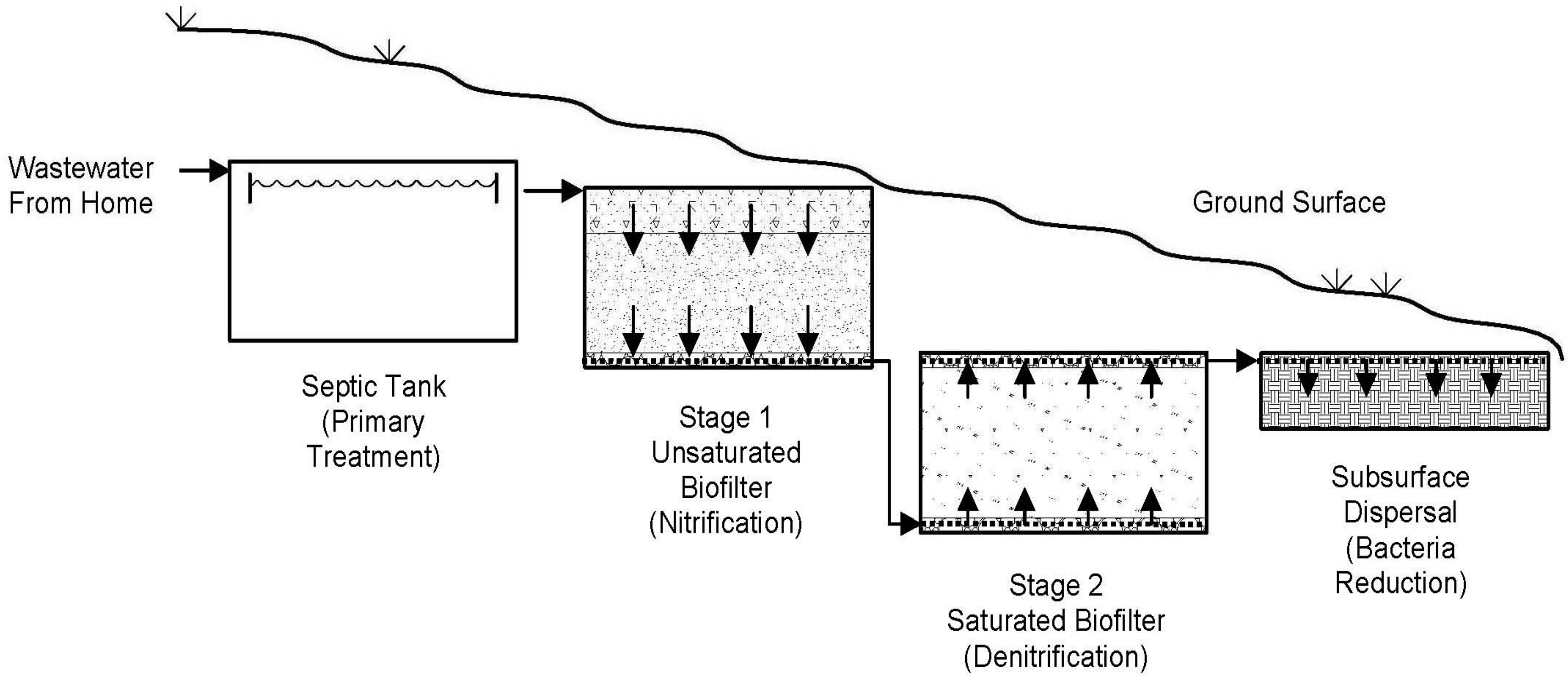

FIGURE 1. Schematic of two-stage, in-tank single pass biofilters for passive nitrogen reduction on sloping ground with gravity flow.

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Status report on nitrogen study due May 16, 2011 (need to route by mid-April)

- What format?
- Modify Interim Report from February 16th
  - Final language will depend on what the Legislature does regarding additional funding
  - Take out recommendations **(switch to draft status report)**
- How to obtain RRAC approval? (email vote?)

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Funding update

	Total Estimated Cost	Allocated Funds	Estimated to be Spent for Phase I	Estimated to be Spent for Phase II	Estimated to be Spent for Phase III	Total Spent as of March 17, 2011	Remaining Unspent Allocated Funds	Remaining Funding Needs
Task A	$786,760	$751,280	$352,144	$399,136	$35,480	$472,559	$278,721	$35,480
Task B	$1,080,352	$521,237	$50,202	$471,035	$559,115	$71,565	$449,672	$559,115
Task C	$1,906,952	$1,244,012	$216,164	$1,027,848	$662,940	$254,201	$989,811	$662,940
Task D	$808,022	$168,214	$74,357	$93,857	$639,808	$90,015	$78,199	$639,808
Task E	$417,874	$168,627	$90,695	$77,932	$249,247	$124,741	$43,886	$249,247
Other Costs Not in Nitrogen Contract (RRAC, etc.)	$100,040	$46,630	$29,258	$17,372	$53,410	$43,788	$2,842	$53,410
Total	$5,100,000	$2,900,000	$812,820	$2,087,180	$2,200,000	$1,056,869	$1,843,131	$2,200,000

Passive Denitrification Processes

Presentation by Presby Environmental Inc.

(limit 15 minutes)

Prioritization of Future Projects

Prioritization Process:

1. (completed at 12/10/10 meeting) Individuals brainstorm up to 5 ideas for potential research projects
2. (completed at 12/10/10 meeting) Round robin - each person recites his or her responses, which are written down
3. Clarification - the group discusses any questions about the proposed projects
4. Selection and ranking - each person selects and ranks top 5 projects in priority order from 5 (highest priority) to 1 (lowest priority)
5. Final selection and ranking - results are tallied and reported

Step 3: Clarification

- Discussion/clarification of proposed projects

Step 4: Selection and Ranking

- Select and rank your top 5 ideas

5 = highest ranking

1 = lowest ranking

Step 5: Final Selection and Ranking

- Tally results, highest total score wins
- Determine final prioritization list and process forward

319 Project on Performance and Management of Advanced Onsite Systems

Purpose: Assess water quality protection by advanced OSTDS throughout Florida

Progress:

- Executed amendment to grant
  - New end date 9/30/2011
  - Allowed for purchase of equipment
  - Allowed for CHD's to assist with sampling
- Monroe County Project
  - Summary report being outlined
  - Data analysis combining all phases to begin

319 Project on Performance and Management of Advanced Onsite Systems

Progress cont. :

- Database
  - Basic design complete, continuously updating forms to streamline data entry
  - 16,802 identified advanced systems in the state
  - Developing query and report to automate summary statistics
- Surveys of interest groups
  - Survey results being tabulated and analyzed
  - Cross-tab analysis categories for analysis developed (next slide)

319 Project on Performance and Management of Advanced Onsite Systems

Some of the questions we're analyzing in the survey:

1. **Owners:**
    - **Age of system vs. whether they have had any problems over the last year**
    - **Age of system vs. overall satisfaction**
    - **Problems over the past year vs. overall satisfaction**
    - **Overall satisfaction vs. the type of system**
    - **Overall satisfaction vs. county**
    - **Cost of permits and maintenance contract vs. overall satisfaction**
    - **How many people use the system vs. problems over the past year**

319 Project on Performance and Management of Advanced Onsite Systems

Some of the questions we're analyzing in the survey:

2. **Maintenance Entities:**
   - What services are covered by the annual contract fee vs. the cost of the maintenance contract
   - Level of interaction with entities vs. the overall treatment performance
3. **Regulators:**
   - Employee years of experience vs. turnover rate
   - Employee years of experience vs. who evaluates permits for advanced systems
   - Size of county vs. the number of systems needing enforcement
   - Size of county vs. customer complaints
   - Size of county vs. overall treatment performance

319 Project on Performance and Management of Advanced Onsite Systems

Progress cont. :

- Sampling
  - QAPP routed to DEP on January 18, 2011, DEP responded on March 18th, anticipate response back to DEP on March 23rd
  - Contract with lab has been amended to add more sample analysis
  - Permit file reviews are ongoing, 442 files have been reviewed
  - Expanded sample set by 204 systems (for a total of 1000 systems) due to a large number of systems (~60%) being not an active advanced system (abandoned, conventional system, connected to sewer, etc.)
  - Monroe County Health Department has agreed to participate in the sampling effort, anticipate Charlotte CHD to volunteer, Brevard has declined, looking for one more county to assist
  - Quality Assurance (QA) on data entry ongoing
  - QA trip to Keys: sampled several systems, standardized protocol
  - Sampling event on March 22nd in Wakulla

319 Project on Performance and Management of Advanced Onsite Systems

Progress cont. :

Management Practices

- Developing method to choose counties to focus on:
  - High/low user satisfaction from the user surveys
  - High/low scores on county program evaluations looking at the advanced systems scoring categories

Alternative Drainfield Products

Problem statement: Since approximately 2004 alternative drainfield products are installed at rates higher than aggregate. System field longevity and effectiveness of minimum drainfield size are untested. Availability of data is limited.

Study history: RRAC directed staff to proceed with performing an evaluation of existing data. Once data gaps are identified, the next phase of the project will be scoped out.

Alternative Drainfield Products

Progress:

- For 2010 data, a clean-up was done to make sure the system installation date on the repair form is accurate.
- CHD's were notified via email. Most errors where the system install date was the same as, close to, or later than the application date were due to data entry errors.

```
SYSTEM FAILURE AND REPAIR INFORMATION

[          ] SYSTEM INSTALLATION DATE            TYPE OF WASTE   [  ] DOMESTIC   [  ] COMMERCIAL
[          ] GPD ESTIMATED SEWAGE FLOW BASED ON     [  ] METERED WATER  [  ] TABLE 1, 64E-6, FAC

SITE         [  ] DRAINAGE STRUCTURES  [  ] POOL     [  ] PATIO / DECK   [  ] PARKING
```

Alternative Drainfield Products

Progress (cont.):

- Data mining of existing permit data was done to link original installations with corresponding repairs based on geocoded addresses (~12,000 records)
- Then filtered by those that had product information (~2,500 records)
- Will retrace steps to ensure data accuracy then will pull in other fields to do data analysis
- Data mining / analysis to continue and will report back to RRAC at the next meeting

Other Business

Public Comment

Next Meeting

Upcoming meeting topics:

- Discussion on process forward for ranked priority project ideas
- Status report on nitrogen study due May 16, 2011 (need to route by mid-April)

Proposed dates for next meeting:

- Suggestions?

Closing Comments and Adjournment

Wakulla County Septic Tank Study

Phase II Report on Performance Based Treatment Systems

FDEP AGREEMENT NO: WM926

The Florida State University
Department of Earth, Ocean and Atmospheric Science

December 7, 2010

Prepared by

Harmon Harden[1], Jeffrey Chanton[2], Richard Hicks[3] and Edgar Wade[4]

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List of Tables

Results at a Glance

1. The average total nitrogen (TN) input value for raw sewage inputs to septic systems was 72.8 ± 39.2 mg-N/L, n=17 from five households served by Performance Based Treatment Systems (PBTS). A companion study by the Colorado School of the Mines (CSM, Lowe et al., 2009) focused on anther six households, with an average of 73.1 ± 50.3 mg-N/L, n = 24. The data indicates that 70 mg-N/L is a reasonable estimate of total nitrogen concentration in wastewater being discharged from households in Wakulla County to their septic systems.

2. The average of monthly septic tank effluent concentration in samples from the 8 PBTS sites monitored in Phase II two of the study was 30 ± 11 mg-N/L. This average effluent concentration is consistent with the effluent concentrations in 27 other PBTS that were also sampled in Wakulla County during this study, which had a average effluent concentration of 29 ± 21 mg-N/L. For all 35 PBTS that were sampled, the average TN concentration was 29 ± 19 mg-N/L. While this is a 50-60% N reduction relative to wastewater inputs, the PBTS effluent concentration is greater than the 10 mg-N/L target effluent concentration included 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. The results of this study indicate that Performance Based Treatment Systems (PBTS) installed in Wakulla County reduced nitrogen 50-60% from input concentrations when properly maintained. Using a raw wastewater input concentration of 70 mg-N/L and the effluent results in bullet number 2 above; the 8 primary study sites yield a TN reduction of 57 ± 16%. For the 27 sites sampled only once, we calculated a TN reduction of 59 ± 30%.

4. In a previous Wakulla County study, conducted by the Colorado School of the Mines (CSM, Lowe et al., 2009), the average conventional septic tank effluent (STE) TN concentration was 64 ± 13 mg-N/L. For all 35 PBTS that were sampled in this study, the average TN concentration was 29 ± 19 mg-N/L. The effluent from PBTS is thus less than half (45%) of the effluent from a conventional septic system.

5. Compliance, operation and maintenance issues in Wakulla County were responsible for a large percentage of systems that were found to be non-operational or performing poorly.

6. Lysimeters and wells placed within pressurized drip drainfield systems and conventional drainfield systems captured roughly 50% septic tank effluent based upon Cl concentration data. In other words, the water collected from these samplers was diluted by 50%, and contained 50% septic water. Median effluent nitrogen attenuation by denitrification, adsorption and plant uptake was 30% in these systems, similar to the 25% reduction observed for conventional systems during Phase I of this study (Katz et a. 2010). Four drip systems and five conventional systems were evaluated. Due to high variability, our results do not indicate a significant difference in TN removal between the drip and the conventional drain fields.

7. As stated above, a previous Wakulla County study (Lowe et al., 2009), found that the average conventional septic tank effluent (STE) TN concentration was 64 ± 13 mg-N/L (Fig. ES-2). For all 35 PBTS that were sampled in this study, the average TN concentration was 29 ± 19 mg-N/L. Our results indicate that N-attenuation in the

$$(1-0.3) * 64 \pm 13 \text{ mg-N/L} = \quad 45 \pm 9 \text{ mg-N/L}.$$

Similarly, a typical PBTS system TN input to the aquifer may be calculated as

$$(1-0.3) * 29 \pm 19 \text{ mg-N/L} = \quad 20 \pm 13 \text{ mg-N/L}.$$

PBTS systems reduce TN input to the watershed by 55%. The effluent from a PBTS is only 45% that of a conventional septic system. Average daily water use for the 11 residences in the Phase I and Phase II study was 988±492 L/d (261±130 gallons per day, Appendix A). Thus the typical N-flux to the aquifer from a conventional septic tank is 44 ± 24 grams N per day (32±17 lbs/yr). For a PBTS the value is 20 ± 16 grams N per day (16±14 lbs/yr).

Executive Summary

A conventional onsite sewage treatment and disposal system (OSTDS) includes a septic tank and drainfield to treat wastewater. Under normal conditions, conventional septic tanks provide minimal treatment of nitrogen. Most of the nitrogen removal associated with a conventional OSDS occurs within and beneath the drainfield. However, in karst regions of Florida the soil can be very well drained and low in organic carbon. These conditions result in a nitrogen flux to ground water. Advanced pre-dispersal treatment may need to be provided 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 2006 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" (Wakulla County Ordinance, 2006). This ordinance applies to the entire county. Approved PBTS from the following three manufacturers have been installed in Wakulla County: MicroFAST by Bio-Microbics, Inc., HOOT Series-AND by HOOT Aerobics Inc, and Singulair 960 by Norweco, Inc. For simplicity they will be referred to hereafter in this report as FAST, HOOT, and Norweco. As of July 2010, approximately 200 PBTS have been installed in Wakulla County under the new ordinance. The general distribution of PBTS installed in Wakulla County by manufacturer is shown in Figure ES-1.

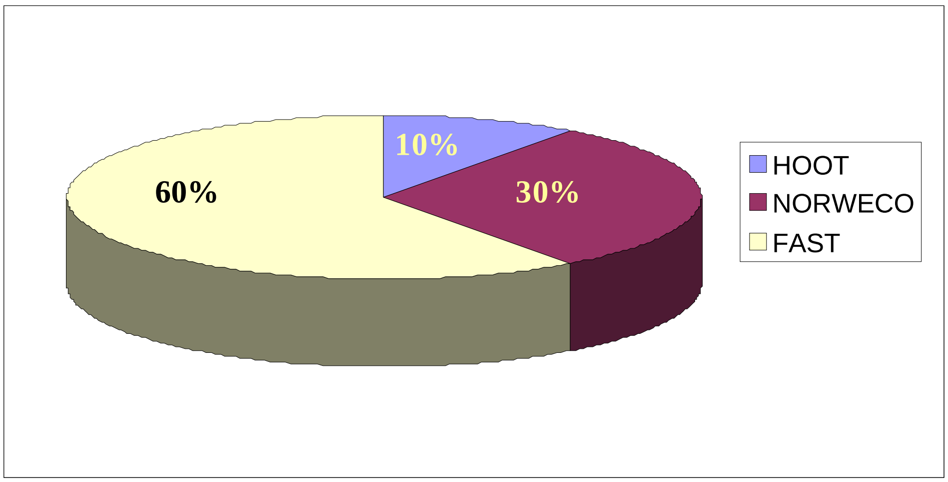


Figure ES-1. The distribution of performance based treatment systems by manufacturer installed in Wakulla County, 10% Hoot, 30% Norweco, 60% Fast.

In May 2007, the Florida State University Department of Oceanography entered into an agreement with the Florida Department of Environmental Protection (FDEP) Ground Water Protection Section and worked cooperatively with the United States Geological survey to evaluate the fate of nutrients discharged by conventional OSTDS in the Wakulla Springs Basin by measurement of nutrients in the septic tank effluent, drainfield pore water and underlying groundwater. This contract was amended in June 2008 to include a second phase, a 1-year-long study of PBTS that were installed under the new ordinance. The scope of work for Phase II used a similar study design, with monthly monitoring of the PBTS and additional sampling of the raw sewage inputs to the systems. The initial results from the 8 PBTS tank effluent indicated the systems were not achieving the 10 mg-N/L goal of the Wakulla County ordinance. Although significant reduction of total nitrogen (TN) was observed, the initial results indicated that the average effluent concentration was approximately 30 mg-N/L. To determine whether the 8 systems being studied were representative of PBTS installed in the area, 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

1. provide information on the TN removal effectiveness of the treatment systems being evaluated;
2. 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
3. provide results on the attenuation of nutrients by conventional drainfields and drip systems.

Effectiveness of the systems being monitored in this study was measured as a percent (%) reduction in the TN concentration of the septic tank effluent, comparing average OSTDS influent concentrations obtained in the county against tank effluent concentrations from the PBTS included in the project, as shown below in Equation 1.

$$\textbf{\% N-reduction} = \textbf{(1 - PBTS effluent /PBTS influent) * 100} \qquad \textbf{(1)}$$

Characterizing the amount of nitrogen going into an individual residential OSTDS (influent) requires multiple samples over a period of time due to the high variability in the composition of the raw sewage. However, understanding the characteristics of the waste stream is crucial in the design of treatment systems, management decisions, and accessing PBTS performance and environmental impacts. As this study was commencing, the Colorado School of Mines (CSM, Lowe et al,. 2009) was finishing a large study focusing on the raw sewage inputs and effluent from conventional septic tanks in three regions of the United States, and a portion of the work was conducted in Wakulla County by a Department of Oceanography researcher. The Phase II raw sewage samples were collected using the same methodology and equipment used for the CSM work.

In this study, raw sewage samples from five households served by PBTS had an average influent concentration of 72.8 ± 39.2 mg-N/L, n=17. The CSM study (Lowe et al., 2009) focused on six other households which produced an average raw TN concentration of 73.1 ± 50.3, mg-N/L, n = 24 (Figure ES-2). As mentioned previously, a large range in raw wastewater TN concentrations is to be expected due to the variety of daily water use activities that can significantly dilute or strengthen the waste stream TN composition for a particular household. Additionally, the number and age of household members and their life styles can affect the TN concentration in the wastewater. For ease of subsequent calculations, a value of 70 mg-N/L was chosen to represent raw wastewater input of TN to septic tanks in Wakulla County.

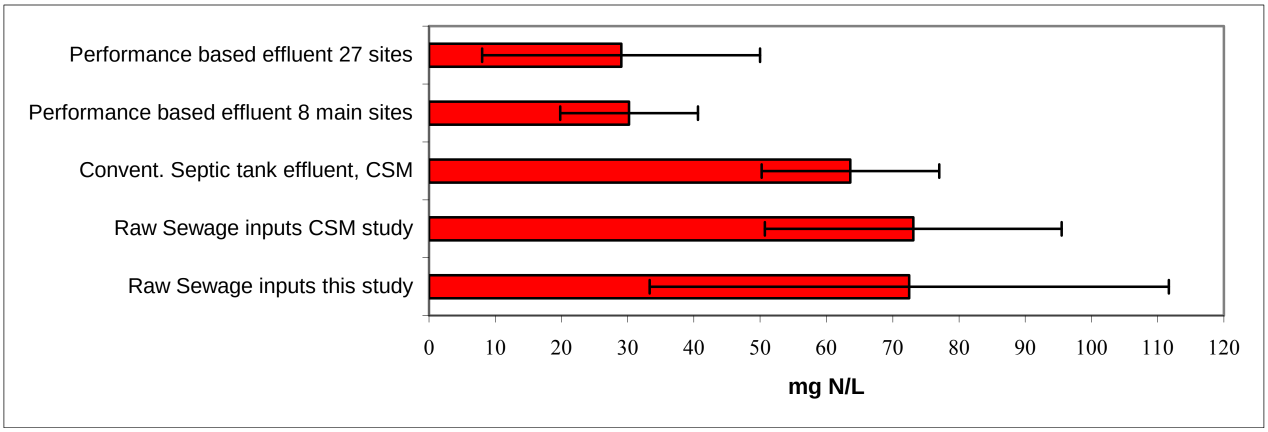


Figure ES-2. Concentration of total nitrogen in septic tank inputs and effluent from conventional and performance based systems.

In the CSM study, the average conventional septic tank effluent (STE) concentration was 64 ± 13 mg-N/L (Fig. ES-2). If 70 mg-N/L is used as a raw wastewater input value, this results in a TN-reduction of 9 ± 19% (Eq. 1) for these conventional septic tanks (Figure ES-3). A conventional OSTDS provides for some attenuation of nitrogen through ammonia volatilization and the removal of solids. According to Anderson (2006), estimates of up to 17% reduction in TN content have been reported by the U.S. Environmental Protection Agency and others. Anderson (2006) as a rule of thumb recommended a figure of 10% reduction for a conventional septic tank. In another study, Xuan et al. (2009) reported a of 24% reduction in TN for a conventional system during the first few months of operation. The La Pine, Oregon survey of 40 conventional systems with 427 samples reported a median TN concentration of 63 mg-N/L for conventional septic tank effluent (La Pine Oregon Demonstration Project, 2006), which is similar to the CSM value of 64 ± 13 mg-N/L.

The average TN concentration from monthly effluent samples collected during the Phase II study of 8 PBTS sites was 30 ± 11 mg-N/L. The results of the Phase II study of the 8 PBTS sites are consistent with the average concentration from 27 PBTS randomly sampled in Wakulla County (29 ± 21 mg-N/L, inFigure ES-2). For all 35 PBTS that were sampled, the average TN concentration was 29 ± 19 mg-N/L. The results are 55% lower than the average TN concentration from conventional OSTDS effluent. However, the observed PBTS TN concentration is greater than the 10 mg-N/L treatment goal in the county ordinance. Using a raw wastewater input concentration of 70 mg-N/L; and the mean effluent value determined in this study, the 8 primary study sites provided a TN reduction of 57 ± 16%. For the 27 sites sampled only once, we calculated a TN reduction of 59 ± 30% (Figure ES-3). From direct measurements of PBTS inputs (raw sewage) and effluent on 5 sites, we calculated an average reduction of 49.2 ± 17.8% (Table 15). These results are similar to results obtained in the larger La Pine National Demonstration Project conducted in Oregon (La Pine Oregon Demonstration Project, 2006).

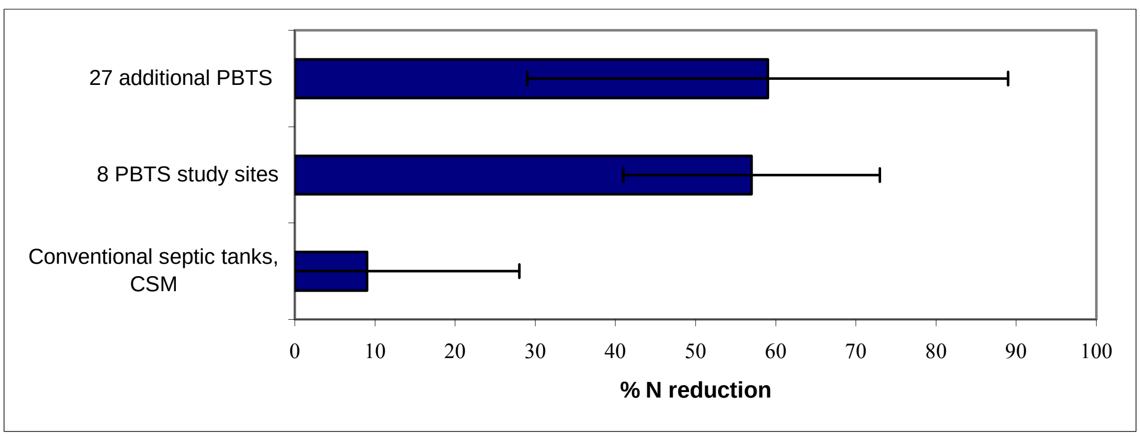


Figure ES-3. Percent Nitrogen reduction from conventional and performance based septic systems. An influent value of 70 mg-N/L was used in calculations.

The average TN effluent concentration of approximately 30 mg-N/L may seem high for systems that achieved a 10 mg-N/L effluent concentration standard during testing, but the percent reduction value of 50-60% is consistent with other studies. The technology employed by all of these three systems has been shown to consistently achieve 50-70% nitrogen reduction when 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 the influent concentrations used in the testing facility. In the test centers measurments (for NSF and others where the testing occurred) from which performance-based designs are based, TN concentrations in the influent was 25-35 mg-N/L, less than half of the actual concentrations in raw sewage measured in these studies specific to Wakulla County and in other studies (approximately 70 mg-N/L). 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.

The sampling of the 27 PBTS sites in addition to the 8 study sites, was conducted with the assistance of the Wakulla County Health Department (health department) and the FDOH Bureau of Onsite Sewage Programs. All of the PBTS systems visited were installed prior to October 2008, to insure at least 6 months between installation and sampling. The distribution of types of PBTS in Wakulla County (ES-1) was also taken into consideration while selecting site candidates. The sampling team encountered several issues of concern regarding the installation, operation and maintenance of many systems. A total of 59 systems were inspected to obtain the 27 samples from properly functioning systems. More site visits would have been required to collect the samples had not health department staff pre-checked sites to eliminate non-operating systems during the last three days due to time constraints of the sampling team. Although not in the study plan, this survey included over half of the systems installed in Wakulla County.

Of a total of 59 PBTS inspected, 23 (39%) of these systems were not operating as designed (Figure ES-4).

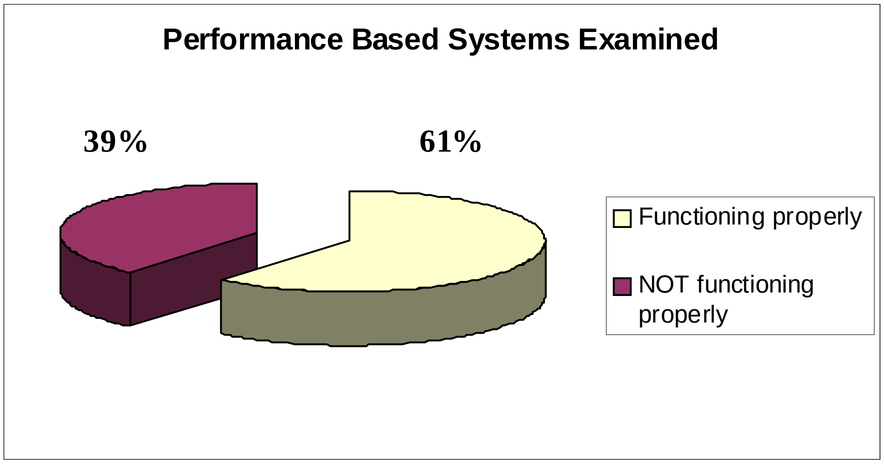


Figure ES-4. Of 59 performance based systems examined in Wakulla County, 36 (61%) were in compliance. 23 systems (39%) were not functioning as performance based systems due to electrical issues, being turned off or other problems.

One widespread problem identified in this study was that many of the systems (22) were not in operation, either because their electrical switches had been turned off or (in three cases) 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.

At another non-compliant site, a plug was missing from the bottom of the system's holding tank, resulting in effluent seeping into the ground and not going to the drainfield. Sampling was further complicated at several sites by the lack of ports or other access points to enable sampling of the system effluent, which is a requirement of the engineering design and necessary for periodic inspections required under their permits. For some systems that were sampled, extraordinary efforts were required to access suitable sampling points. This lack of accessibility seemed to contradict their maintenance records which indicated that effluent was being periodically being inspected by contractors for clarity and odor.

Of the 59 sites visited, it appeared that only 36 (61%) were operating. Of the 36 functioning systems inspected, 27 (75%) were sampled, 3 (8%) had no sampling access, and 6 (17%) were simply not chosen for system type distribution considerations. As a requirement of its permit, a PBTS in Wakulla County is supposed to receive initial and periodic inspections by the septic tank contractor. However, the rigor of some of these inspections would appear to be questionable.

Lysimeters and wells placed beneath pressurized drip drainfield systems and conventional drainfield systems captured roughly 50% septic tank effluent, based upon Cl concentration data. In other words the samples collected by these devices contained 50% waste water and were diluted by groundwater by 50%. Median nitrogen attenuation due to denitrification, adsorption and plant uptake was 30% in these systems. Four drip systems and five conventional systems were evaluated. Due to high variability, our results did not indicate that either of the wastewater disposal methods (conventional drainfield or drip irrigation) had a significant advantage over the other as far as nitrogen removal was concerned. A drip system with unchecked unruly vegetation appeared to perform better than did systems where there was a conventional lawn. We hypothesize that the vegetation roots were deeper in this system and that they were able to access the nitrogen released from the drip line.

For the Wakulla County sites included in the CSM study, the average conventional septic tank effluent (STE) concentration was 64 ± 13 mg-N/L (Fig. ES-2). For all 35 PBTS that were sampled in this study, the average TN concentration for effluent was 29 ± 19 mg-N/L. The PBTS systems reduced N output 57 to 59% based on a raw sewage value of 70 mg-N/L. Our results indicate that the average N-attenuation in the drainfield is an additional 30%. These results indicate that for Wakulla County, a typical conventional septic tank input is 45±9 mg-N/L of wastewater to the aquifer (64* (1-0.3)). A typical PBTS system inputs 20 ± 13 mg-N/L of wastewater to the aquifer (29* (1-0.3)). Average daily water use for the 11 residences in the Phase I and Phase II study was 988±492 L/d (261.0 ± 130.0 gallons/d)(Appendix A). 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).

1 Introduction

1.1 Background and Motivation

Onsite sewage treatment and disposal systems (OSTDS) are an important part of Florida's wastewater infrastructure, serving about a quarter of the state's households (Social Science Data Analysis Network, undated; FDOH, 2007). The proportion of homes served by OSTDS, in comparison to those on central sewer, is much higher in the rapidly growing, formerly rural areas of central and north Florida. These regions include areas where the limestone is close to the surface and characterized by karst features, such as large springs, sinkholes and solution channels that have formed in these shallow limestone layers. These karst features have been shown to rapidly transport contaminants to and in the underlying groundwater (e.g. Price, 1988; Paul et al., 2000; Dillon et al., 1999, 2000: Harden et al., 2008).

Springs in most areas, except in national forests, have experienced degradation in water quality, particularly exhibiting elevated nitrogen concentrations (Florida Springs Task Force, 2006). While other sources such as fertilizer use, stormwater runoff, atmospheric deposition, and wastewater treatment plant discharge also contribute to nitrogen in ground water, the effects of conventional OSTDS, consisting of a septic tank with a drainfield, have become a concern because of the recent trend in high-to-medium density residential development in areas not served by sewer. The EPA has stated "alternative systems may be necessary in karst areas" (EPA, 2006). 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 (FDOH, 2009). 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 (FDOH, 1999). 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.

In May 2007, the Florida State University Department of Oceanography entered into an agreement with the Florida Department of Environmental Protection (FDEP) Ground Water

Protection Section to evaluate the effectiveness and fate of nutrients discharged by conventional OSTDS in the Wakulla Springs Basin. This contract was amended in June 2008 to include a second phase, a 1-year-long field study of the effectiveness of PBTS that were installed under the new Wakulla County ordinance.

Phase I of this study focused on three residential sites with conventional septic tanks and drainfields in or near Wakulla County. Septic tank effluent (STE) samples, pore water samples from lysimeters below the drainfields; and ground water well samples from below the drainfields were collected and analyzed for nutrients, inorganic wastewater tracers, organic wastewater compounds and microorganisms (Katz, et al, 2010). Concurrent with this study, the Department of Oceanography, working with the Colorado School of Mines (CSM, Lowe et al, 2009), conducted a study characterizing raw sewage inputs into septic tanks in comparison to STE from conventional OSTDS. One of the CSM study areas was in Wakulla County and included one of the Phase I sites.

Phase II of this study was focused on assessing the effectiveness and performance issues associated with PBTS that were installed in compliance with the 2006 Wakulla County ordinance. It included collection and analysis of septic tank effluent samples, pore water samples beneath drainfields and ground water samples from adjacent to drainfields. In addition, it included collection of influent samples using the same equipment and methodology employed in the CSM study.

This report includes a comparison between raw sewage inputs to household septic systems from the three studies against the nitrogen content of effluent from both conventional and performance based treatment systems, with the goal of calculating a percent reduction for nitrogen (N) as

$$\textbf{\% N-reduction} = \textbf{(1 - septic tank effluent/septic tank influent) * 100} \qquad \textbf{(1a)}$$

or

$$\textbf{\% N-reduction} = \textbf{(1 - PBTS effluent/PBTS influent) * 100} \qquad \textbf{(1b)}$$

Additionally, Phase II includes an overall assessment of the PBTS in Wakulla County and a survey to assess compliance with the ordinance and random sampling to evaluate TN reduction and system efficiency. The findings of this survey are also included in this report.

1.2 Descriptions of PBTS Installed in Wakulla County

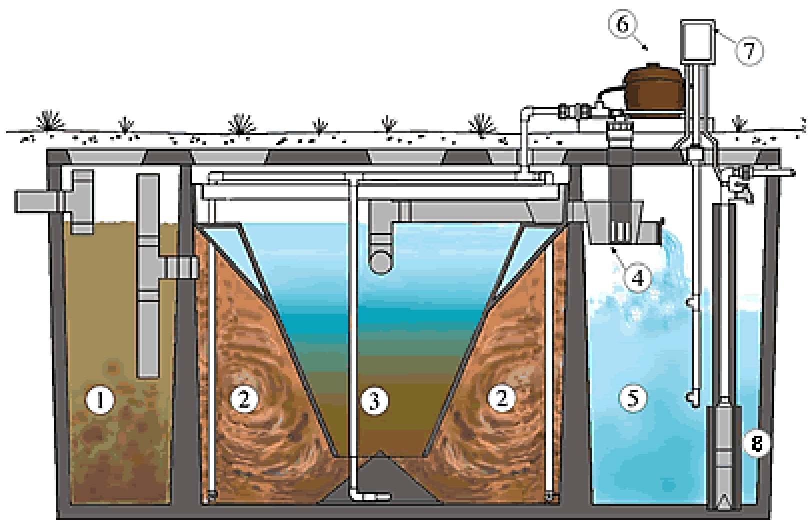
Performance based treatment systems are defined by the Florida Department of Health (FDOH) as "a specialized onsite sewage treatment and disposal system designed by a professional engineer with a background in wastewater engineering, licensed in the state of Florida, using appropriate application of 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." (FDOH, 2009). Nitrogen reduction data for designs currently in use in Florida were obtained concurrently with testing according to the NSF/ANSI Standard 40 plus Nitrogen Reduction or Standard 245 and have been reviewed and approved by the FDOH Bureau of Onsite Septic Systems. 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. Consistent with the performance expectation of the FDOH evaluation process, the Wakulla County 2006 ordinance states that "only performance-based septic systems that *can* produce a treatment standard of 10 mg/L TN shall be installed: in new construction and as replacements when older systems fail or are replaced" (Wakulla County Ordinance 2006-58). Designs based on technologies from the following three manufactures have been installed in Wakulla County: MicroFAST by Bio-Microbics, Inc., HOOT Series-AND by HOOT Aerobics Inc, and Singulair 960 by Norweco Inc. For simplicity they will be referred to as FAST, HOOT, and Norweco in this report.

Raw sewage (influent) that enters the tanks contains nitrogen in the form of mainly organic nitrogen and ammonia. The organic N component is converted to ammonia and ammonium by bacteria under anaerobic conditions. In the presence of oxygen, ammonia (NH_3) and ammonium (NH_4) are then converted to nitrate (NO_3). Nitrate can be converted to di-nitrogen gas (N_2) under sub-oxic/anaerobic conditions by bacteria in the presence of organic matter. Di-nitrogen gas is an inert form of N; all the other forms are bio-active. Thus denitrification 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.

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, ammonification, nitrification and denitrification. Raw sewage flows into a pre-treatment chamber, which acts as a small septic tank. Here, solids settle out and ammonification occurs in the anaerobic conditions as bacteria convert organic nitrogen into ammonia and ammonium ion (ammonification). 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 denitrification. Denitrification is the process of nitrate being converted to nitrogen gas in the presence of denitrifying 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 denitrification is accomplished by having a portion of the pumped effluent directed back to the pre-treatment chamber. This recirculation is required in HOOT and Norweco systems in order for them to achieve their performance objective. Although FAST systems can be installed with recirculation, it is not required. Each system is described in greater detail below.

1.2.1 HOOT and Aerobic Treatment System. Models H-500 and H-600 are typical for residential use and use the same tank.

Septic influent enters the anaerobic pretreatment chamber where initial settling and anaerobic treatment occurs. The wastewater then flows into the aeration chamber. A blower delivers air into the aeration chamber through bubbler stones. The wastewater enters the clarification chamber, which has an open bottom and is inside the aeration chamber. Sludge settles out of the open bottom clarification chamber back into the aeration chamber. Wastewater flows from the clarification tank into a dosing tank. The wastewater is pumped from the holding tank into the drainfield (Figure 1). If the drainfield is a drip system, the pumped effluent passes through a 120-150 micron filter. A portion of the effluent pumped to the drainfield is returned to the pre-treatment tank enhancing denitrification. The recirculation of the effluent back to the pre-treatment tank is the configuration of the HOOT system for which test center data have shown that the 10 mg N/L standard for Wakulla County can be met.



1. Pretreatment tank where influent enters.
2. Aeration chamber where oxygen is pumped into the wastewater.
3. Clarifier chamber where the clear, odorless effluent rises.
4. Chlorinator where the clear effluent passes through for disinfection. *
5. Holding tank for disinfected* effluent ready for discharge (optional).
6. Aerator and pump.
7. HOOT Control Center monitors and controls the system.
8. Discharge Pump

* Not used in the Wakulla Springs basin.

Figure 1-Diagram of the HOOT Aerobic Treatment System from HOOT website. Recirculation of the effluent exiting the system back into the pretreatment tank is not shown.

1.2.2 Norweco Singulair Model 960 with recirculation.

With the Norweco system, wastewater enters an anaerobic pretreatment chamber where settlement and ammonification occur. Wastewater flows into the aeration chamber. Aeration is achieved by a specifically designed aerator. Air enters the aerator through four vents and is drawn down into the treatment tank through the spinning aerator shaft. A control box monitors and turns the aerator on and off at adjustable time intervals which allows for alternating aerobic and anaerobic conditions. Wastewater flows from the aeration chamber to a clarification chamber. The inlet has a pipe that delivers the aerated wastewater near the bottom of the clarification chamber and sludge settles and flows back into the aeration chamber through an opening between the chambers. The remaining wastewater flows into a "Bio-Kinetic" filter, which has optional chlorination and dechlorination (Figure 2). This filter provides non-mechanical flow equalization achieved by a small hole into the filter container, which reduces incoming hydraulic surges from periods of high wastewater flow. Wastewater flows out into a separate pump tank and a pump doses the drip drainfield system after passing through another 120-150 micron filter. If the drainfield is conventional, then there is no secondary filter. As with the HOOT system, recirculation back to the pre-treatment chamber is the configuration of the Norweco system for which test center data have shown that the 10 mg N/L standard for Wakulla County can be met.

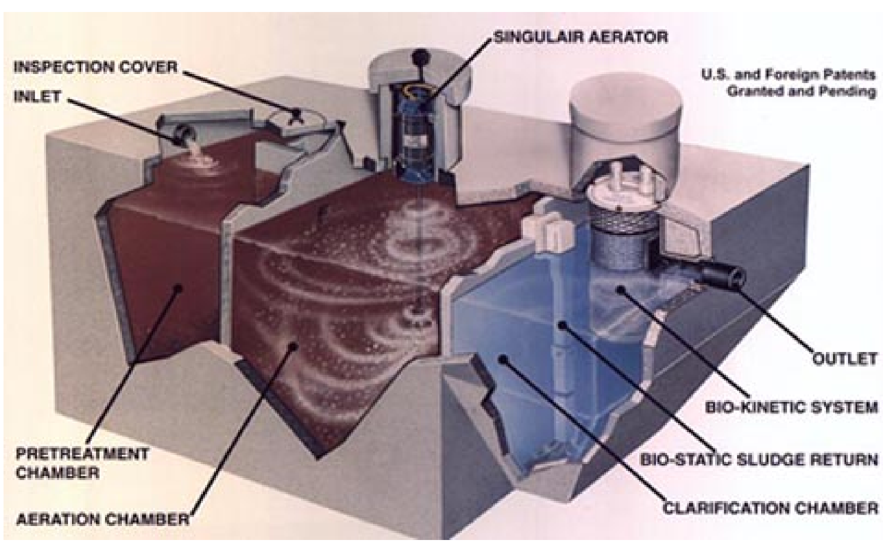


Figure 2. The *Singulair Wastewater Treatment System by Norweco, Inc. From the Norweco website. In Wakulla County a post tank housing a pump is required to allow recirculation back to the pretreatment chamber.*

1.2.3 FAST: Fixed Activated Sludge Treatment, Model MicroFAST 0.5 or 0.75 for typical residence, lager sizes available, a product of Bio-Microbics, Inc.

The FAST system differs from the Norweco and HOOT systems in that it has fixed media for the nitrifying bacteria to grow, whereas bacteria in the Norweco and HOOT systems are suspended in the wastewater. Another major difference between the FAST system and the other two is that the FAST system typically uses slightly modified two-chamber tanks manufactured locally, whereas the chambered tank is part of the HOOT and Norweco systems and supplied by the manufacturer.

Influent flows into an anaerobic settling chamber (pre-treatment chamber) in a two-compartment tank or in a separate "trash" tank. The septic water then flows into another chamber or tank that has the FAST treatment unit installed. The treatment unit sits above the bottom of the tank either on legs or it is suspended from the top. An above ground blower forces air into the FAST chamber drawing water up into the treatment unit and splashing water and air up and over the fixed media. An outlet vent allows air to escape the system to prevent pressurization of the tank. Bacteria fix themselves to the media and consume nutrients as the water circulates through the media. As the bacterial mat ages and accumulates on the media, a sloughing off occurs and dead bacteria settle to the bottom of the tank to be removed by periodic pump outs. An outlet pipe in the treatment unit sends water out to the drainfield system or a dosing tank (Figure 3).

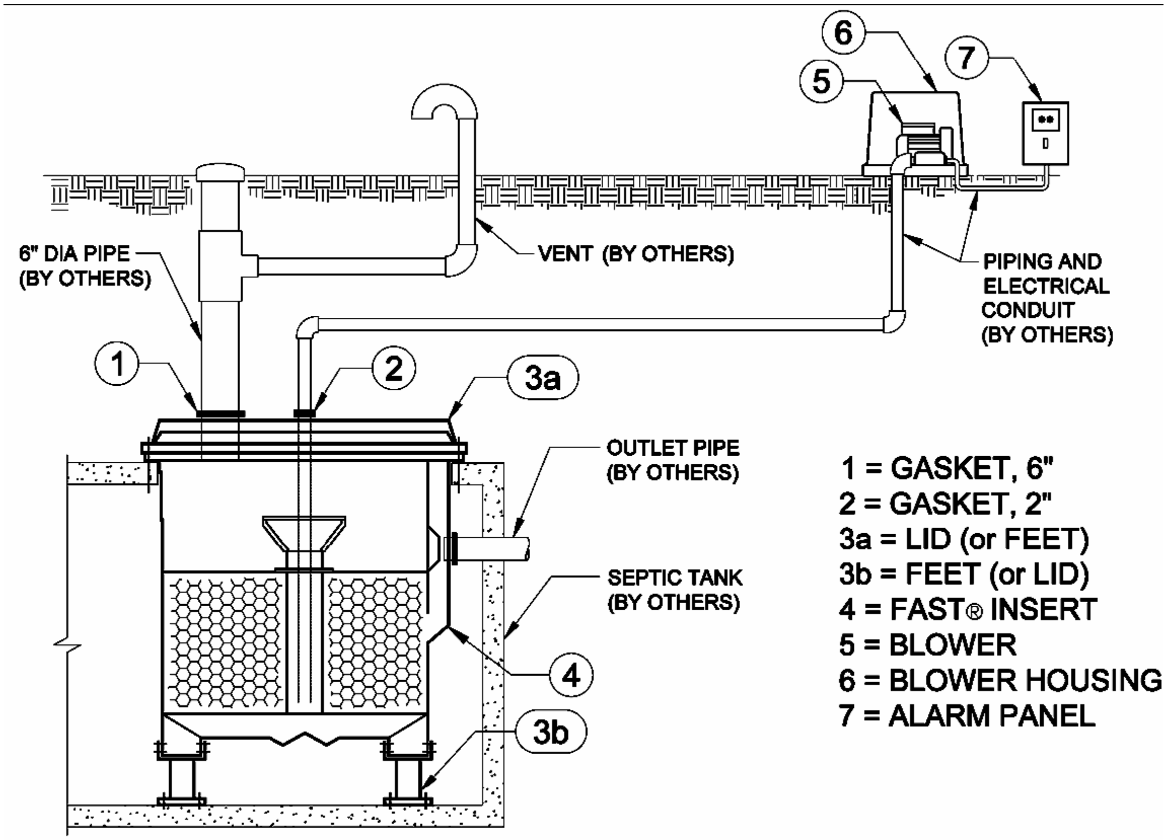


Figure 3. Cross section of the FAST treatment unit installed in the second chamber of two chamber tank or in a single chamber tank that is after a separate pre-treatment tank. The blower, vents and controls are also shown. From the Bio-Microbics website.

The recirculation step described for the HOOT and Norweco systems to enhance denitification is not required for the FAST system. A narrow spill tray allows water splashing up over the fixed media in the treatment to flow back outside the treatment unit but in the treatment chamber. The water outside the treatment unit in the treatment chamber is likely to be anaerobic, providing an environment for denitrification of the aerated wastewater from the spill tray (Figure 4).

Figure 4. A picture of FAST treatment unit being installed into the treatment chamber of a dual chambered tank. The blue fixed media and spill tray are shown.

Not having to recirculate a system's effluent back to a pretreatment chamber allows for the FAST system to be installed without a post chamber or tank housing a pump, as with the HOOT and Norweco systems. If a drip or mounded drainfield systems is necessary, a separate dosing tank or pump tank is added. An additional tank can also be added without the pump to increase the capacity of the system. Because of the added expense of the extra tank and/or pump, most FAST systems have a conventional drainfield that is fed by gravity flow (Figure 5).

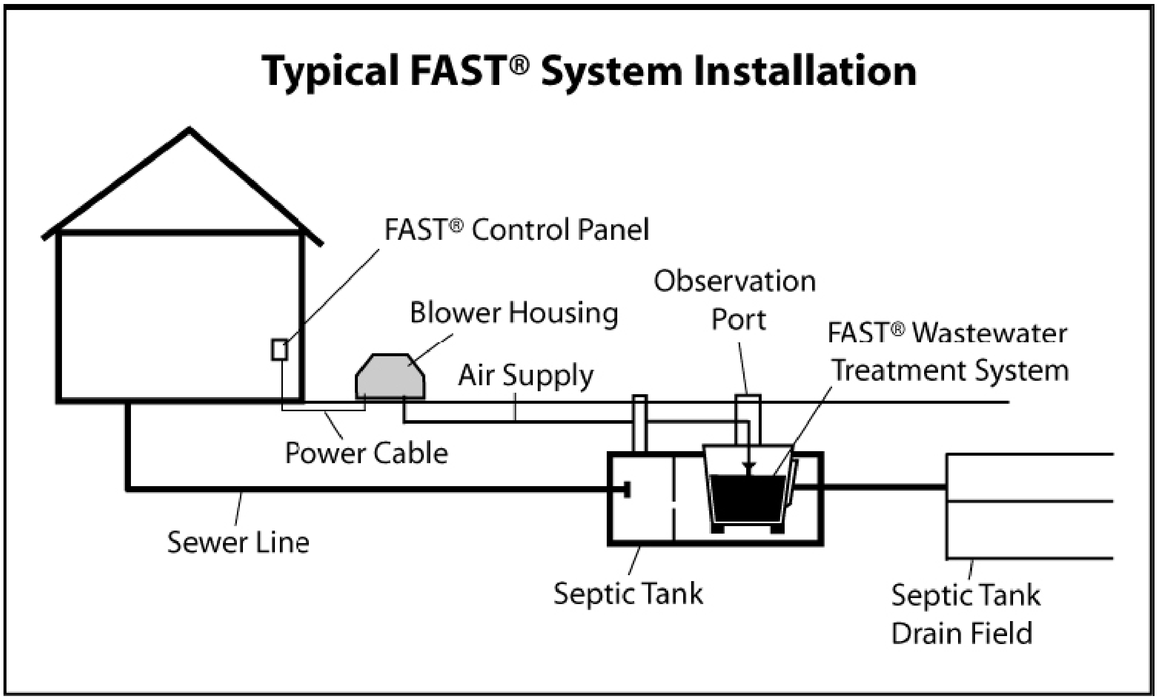


Figure 5. The most common FAST system configuration installed in Wakulla County. From the Bio-Microbics website.

Earlier FAST systems installed in Wakulla County used to include a single 1050-gallon septic tank followed by a 350-gallon pump tank. Competing interests complained to the county health department that these systems were not engineered with an anaerobic tank and therefore were in a different configuration than those certified by NSF/ANSI Standard 40 and Nitrogen Reduction. The FDOH then recommended that the systems be installed with a pre-treatment chamber or tank. As a result, FAST systems are now installed into a two chamber 850-900 gallon tank, the first approximately 350 gallon chamber being anaerobic and the second being the aeration chamber with no pump tank. In some homes, the engineer has added a separate tank post treatment unit. This is also done when drip irrigation is used and there is need for an effluent pump. The most elaborate configuration of a FAST PBTS uses three separate tanks, a pretreatment tank, a treatment tank with the FAST unit installed, and a post treatment or pump tank.

2 Methods

2.1 Phase II Study Sites.

Potential study sites were selected after a review of septic tank permit files at the Wakulla County Health Department. At that time, the files contained records for 105 PBTS systems installed as of 10/27/08 in the county. Potential sites were chosen so that the different types of PBTS systems installed in the county were represented. The drainfield type was also considered in site selection to have an equal representation of conventional and pressurized drip systems. The owners of the candidate sites were then visited by the research team and cooperating sites that were evaluated for accessibility and acceptable soil and water table conditions. Table 1 describes the 8 sites selected for the Phase II study.

Table 1. Site information for the Phase II sites, including system type, drainfield, installation date.

Site ID	PBTS	Drainfield Type	Final Inspection	Household
WSS-1-2	HOOT	Drip, Small Mound	07/03/07	2 adults, 3 children
WSS-2-2	FAST -Dual Chamber	Conventional, gravity	02/02/08	2 adults, 1 child
WSS-3-3	Norweco	Conventional, dose	04/10/08	2 adults
WSS-4-2	FAST- 3 Tanks	Drip, Large Mound	08/18/05	2 adults, 1 child
WSS-5-2	Norweco	Mounded conventional dose	08/20/07	2 adults
WSS-6-2	HOOT	Drip	8/20/07	2 adults, 2 children
WSS-7-2	Norweco	Drip	08/28/08	2 adults, 1 child
WSS-8-2	FAST-Dual & Post Tank	Conventional, gravity	02/08/08	5 adults, 5 children

The locations of the 8 sites in Wakulla County are shown in Figure 6.

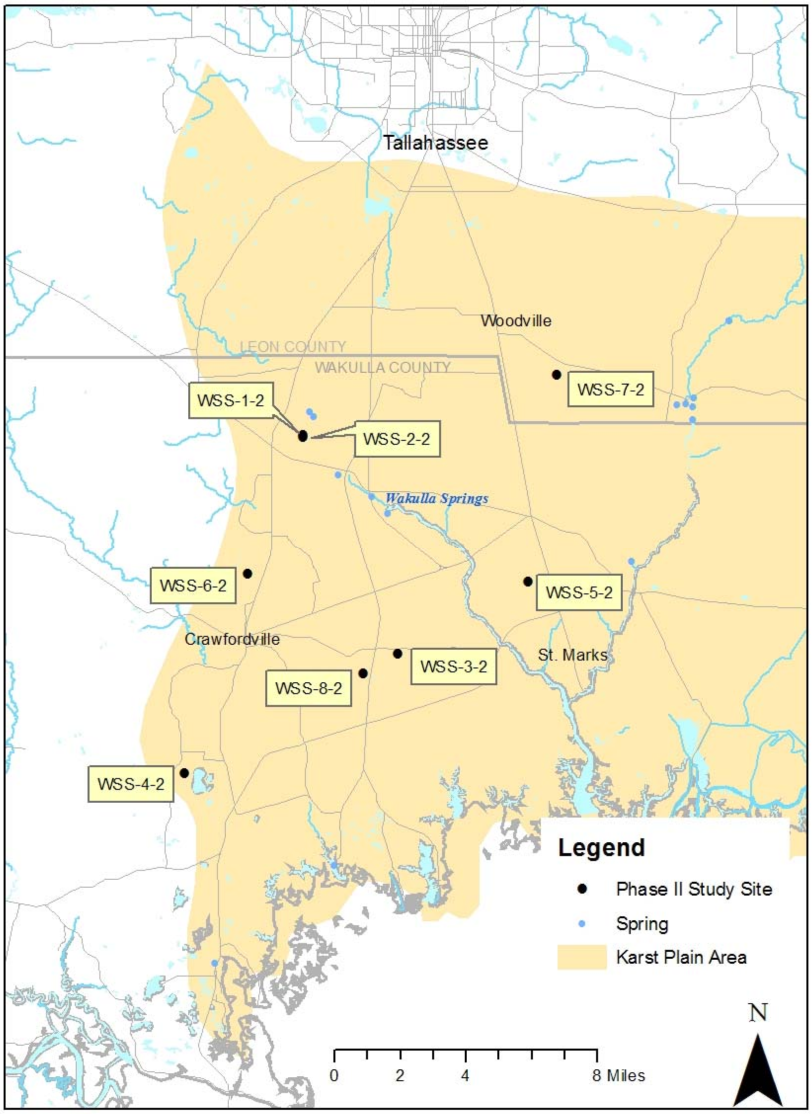


Figure 6. Study Site Locations.

2.2 Raw Sewage Sampling

Flow-weighted 24-hour composite samples of the raw sewage were collected to access the nutrient input to residential septic systems. Raw sewage was homogenized by the sampling pump that was triggered using a water sensor to capture each flow event.

Prior to the first sampling event, the raw wastewater line between the house and septic system was exposed and a collection vessel and associated plumbing installed. Two vertical PVC pipes extended from the collection vessel to the ground surface. One access port was for placement of a float switch which triggered the sampling pump and the other port was for the raw wastewater input to the pump. An additional PVC line extended to the ground surface for the return of wastewater to the septic tank a (Figure 7). After backfilling each site, two irrigation boxes were placed over the access.

Figure 7. Plumbing for sampling raw wastewater about to be installed between the house and septic tank at site WSS-4-2. The water sensor is placed in the 4 inch opening of the 4-way PVC piece. Note the inlet clean out.

The raw sewage sampling device consists of a fabricated system mounted on a wagon that includes an in-line macerating vacuum pump, a power converter, and the waste stream return line with ball valve for sample collection (Figure 8). The entire raw wastewater flow from the home passes through the collection vessel and sampling pump. A float switch in the collection vessel triggers the in-line macerating vacuum pump (Jets Standard As, vacuumerator 15MB). The pump, commonly used in Europe, is designed for collection of toilet waste and is capable of operating either continuously or intermittently at flow rates up to approximately 83 L/min. A ball valve, installed in the discharge line to control wastewater flow to the sampling container, is adjusted to collect approximately 75-150 mL of sample from each 7.5-liter sample event (1-2% of the total flow). The remainder of the homogenized wastewater flow returns to the wastewater line prior to discharge into the septic tank. Prior to collecting raw wastewater samples, the solids in the collection vessel are purged and the vessel is flushed with water. Due to the complex nature of the homogenization apparatus (i.e., vacuum pump, PVC connections and polyethylene tubing) and the variability of the waste stream being sampled (i.e., raw wastewater with high concentrations of the constituents being analyzed for), this system flush also served to decontaminate the homogenization apparatus between sites. Approximately 20 L of tap water was used during the flush. However, if the discharge stream from the wagon visually appeared "dirty", additional clean water was flushed through the system. Finally, prior to sample collection, up to four exchanges of wastewater from the 7.5-L collection vessel were passed through the system.

Figure 8. The sampling pump wagon set-up at a residence to sample raw sewage. The clear hose is the inlet to the pump and the white hose is the return line. The blue cooler holds a glass 2 gallon jar on ice. On the far right, the wire coming out of the PVC pipe is from the water sensor.

2.3 PBTS Effluent Sampling

The technique for sampling effluent varied depending on the type of system. Ideally, effluent would be sampled while flowing in the pipe that leads from the PBTS to the drainfield. In systems that have drip drainfields, the pump has a 120-150 micron filter and the sample is taken post filter. Sites WSS-4-2 and WSS-5-2 both had sampling ports installed in the correct location. For these sites, the pump could be turned on and after waiting at least 1 minute, the sample taken using the installed valve. At sites WSS-2-2 and WSS-8-2, both with gravity fed drainfields, the vent pipe was used as the sampling port. For these, if effluent was not flowing prior to sampling systems without an effluent pump, then flow was induced by adding water to the cleanout in the inlet pipe to the system. Site WSS-3-2 was sampled from a cleanout installed in the pipe from the pump tank to the conventional drainfield. The pump was turned on and the sample taken from then cleanout after flow was established. The remaining sites, WSS-1-2, WSS-6-2, and WSS-7-2, have pumps with filters. The sampling ports were located prior to the filter housing and were not used as the sample should be taken post filter. In addition to the inlet and outlet of the filter, there is a small (1/4 inch) line that is used to re-circulate the filtered effluent back to the pretreatment tank. To sample these systems, the line was disconnected, the pump turned on and after allowing the effluent to flow at least 1 minute, the sample taken.

Analyses and analytical methods for raw sewage and PBTS effluent samples are shown in Table 2.

Table 2. Analytical Methods for Raw Sewage and Septic Tank Effluent Samples

Analysis	Analytical Method	Laboratory Detection Limit
Ammonia Nitrogen	EPA 350.1 Rev. 20.	0.010 mg/L
Total Kjeldahl Nitrogen	EPA 351.2 Rev. 2.0	0.20 mg/L
Nitrate+Nitrite Nitrogen	EPA 353.2 Rev. 2.0	0.004 mg/L
Total Phosphorus	EPA 365.1 Rev. 2.0	0.012 mg/L

2.4 Lysimeter Construction.

Suction lysimeters were used to collect soil pore water from beneath and away from the drain field at each of the sites. Lysimeter bodies were constructed from 2-inch (5.08-cm) PVC pipe. A porous ceramic cup measuring 26 cm (Soilmoisture 0653X07-B01M3) was attached to ceramic cups were attached with epoxy to custom machined bushings made from solid 2 3/8 inch PVC stock. The cup bushing was then glued into a 2 inch PVC coupling and attached to the 2 inch pipe. Another bushing for the 2 valves and sample tube was made for the top of the lysimeter. Two ¼-inch holes were drilled through a piece of the solid PVC stock, both holes were threaded (¼-inch NPT threads) on one side to hold two ¼-inch valves which were fitted with hose barbs. On the other side of the bushing, one hole was threaded and a ¼-inch brass Swagelok connector was used to attach the sample tube, which reached to bottom of the Lysimeter cup. The outside of the top bushing was machined to fit into a 2-inch coupling. The bushing was glued into the coupling and the coupling attached to the lysimeter body. An alternative design was used for 10 of the lysimeters, due to limitations in availability of the machine shop personnel. The bushing for the ceramic cup was replaced by a 2- to 1.5-inch rubber reducer coupling with band clamps and attached with clear water proof adhesive. For the top of the lysimeter, a 2-inch rubber coupling was used to attach the valve bushing to the top of the pipe. Both designs proved effective in the field and allowed for flexibility in the depth of lysimeter placement.

2.5 Lysimeter Installation and Sampling

At each site, two shallow lysimeters were placed so the top of the cup was 2 ft (0.6 m) below the bottom of the drain field or drip irrigation line. This depth was chosen as it is the separation required between the drainfield and the seasonal high water table by the FDOH. Two deep lysimeters were also installed just above the clay or limestone layer where clay or limestone were encountered. In areas where limestone or clay was not encountered, the deep lysimeters where placed approximately 2.5 meters below land surface. In Section 4, the depths of the bottom of drainfield and the lysimeters are given for each site.

The day prior to sampling, a vacuum of 60 KPa was by applied to each of the lysimeters using a peristaltic or hand pump to create a negative pressure in the soil around the ceramic cup and extract pore water. A pore water sample was then taken by opening both valves and withdrawing water from the lysimeter using a peristaltic pump attached to the valve with sample tube.

3 Conventional Septic System and Performance Based Treatment Systems

Nitrogen in raw wastewater is predominately in the reduced forms of organic-nitrogen and ammonium-nitrogen. Conditions in septic tanks, as well as the pre-treatment tanks in PBTS, are generally anaerobic, causing ammonification, the rapid conversion of organic-nitrogen to ammonium-nitrogen, the predominate form of nitrogen in STE. Nitrification occurs with sufficient oxygen and the proper microbial population, converting ammonium-nitrogen to nitrite-nitrogen then nitrate-nitrogen. In a conventional septic system, nitrification occurs in the unsaturated soil within and beneath the drainfield. In a PBTS, the purpose of the blower or aerator is to create an aerobic environment in the treatment chamber so microbial nitrification can occur. Subsequently, if the system provides the proper anaerobic conditions for the nitrified wastewater and the required microbial populations are then present, denitrification converts nitrate-nitrogen to inert nitrogen gas. The denitrifying bacteria require a carbon source and limited dissolved oxygen.

Denitrification may be somewhat limited underneath a drainfield in the soil and the subsurface aquifer in the Wakulla County. Denitrification 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, denitrification may occur in the treatment tank and perhaps in the post treatment tank. Further denitrification 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.

3.1 Raw wastewater nitrogen inputs to residential OSTDS in Wakulla County

To gauge the effectiveness of septic systems in reducing TN, input concentrations as well as system effluent concentrations must be known. In Phase I of this study, raw wastewater was not sampled. Fortunately during that time period, CSM choose Wakulla County as one of their three study regions and 6 sites were sampled quarterly for a year for both raw wastewater and STE. Phase II of this study employed the same equipment (contributed by CSM), sampling techniques, and personnel to sample the wastewater inputs at 5 of the 8 study sites.

Unfortunately, site WSS-8-2 had to be abandoned after three of the monthly sampling events and only one raw wastewater sample was obtained from the PBTS installed at it. The PBTS at Site WSS-4-2 was then outfitted with the raw wastewater sampling apparatus as a replacement. As expected, nitrogen in the raw influent was predominately total Kjeldahl nitrogen (TKN), mostly in the form of organic nitrogen with a smaller component of ammonium (Table 3).

Table 3. Phase II Study Results. Raw sewage TN-inputs to septic tanks. Units of N are in mg-N/L.

Site ID	TN Average (mg/L)	n	%TN as TKN	%TKN as $NH4^+$
WSS-1-2	**55.1 ± 28.2**	**4**	**98**	**16**
WSS-2-2	**96.5 ± 56.2**	**5**	**100**	**20**
WSS-4-2	**54.4 ± 32.7**	**4**	**96**	**16**
WSS-7-2	**77.4 ± 26.1**	**5**	**99**	**5**
WSS-8-2	**70.2**	**1**	**100**	**6**
All Samples	**72.5 ± 38.3**	**19**	**98**	**14**

Notes: Average with standard deviation and number of samples (n) for TN measured at each site. The percentage of TN in the form of TKN and the percentage of TKN in the form of ammonium ion and ammonia is also presented. TKN is the sum of organic nitrogen and ammonia species components of TN. TN is the combination of TKN and nitrate plus nitrite.

Although the TKN percentage of TN was consistently close to 100%, there was a large variability in the TN concentrations (Table 4).

Table 4. Phase II Study Results. TN statistics from the 5 sites at which raw sewage inputs were measured. Units are in mg-N/ L or percent, where noted.

Site ID	Average	Std. Dev.	Low	25^{th} %	Median	75^{th} %	High	IQR	n
WSS-1-2	**55.1**	28.2	**30.4**	32.0	**51.5**	74.6	**87.1**	42.6	**4**
WSS-2-2	**96.5**	56.2	**42.6**	51.0	**78.3**	140.3	**170.2**	89.2	**5**
WSS-4-2	**54.4**	32.7	**24.5**	35.7	**46.6**	65.3	**100.0**	29.6	**4**
WSS-7-2	**77.4**	26.1	**54.7**	59.6	**61.6**	100.7	**110.4**	41.1	**5**
WSS-8-2	**70.2**								**1**
All Samples									
	72.5	38.3	**24.5**	46.8	**61.6**	93.6	**170.2**	46.7	**19**
Statistics for Averages of 4 Phase II sites: WSS-1-2, WSS-2-2, WSS-4-2, WSS-7-2									
	70.9	20.1	**54.4**	54.9	**66.3**	82.2	**96.5**	27.2	**4**

Notes: Only one sample was taken at site WSS-8-2. Due to the high variability in TN values found in raw wastewater, the data from this site was not used in calculating the statistics of the averages of each site. The bottom row is the average of the means of each of the four sites where the most data was obtained. Each site is counted once in this mean, n=4.

The wide range in raw wastewater TN values is not surprising due to variety of daily water use activities that can dilute or strengthen the waste stream concentration for a particular household. Additionally, a household's number and age of members and their life styles can affect the TN concentration in the wastewater. For example, an elderly retired couple's waste stream may be very different than that of a younger couple with children. The CSM data shows a similar wide range in TN concentrations for individual sites (Table 5).

Table 5. CSM Wakulla Results for Raw Wastewater. Statistics for the TN concentrations from the 6 sites at which raw sewage inputs were measured during the portion of the Colorado School of Mines study in Wakulla County. One of the quarterly samples for site F2 is an average of 6 samples taken over a one week period. Units of N are in mg-N/ L.

Site ID	Average	Std. Dev.	Low	25^{th} %	Median	75^{th} %	High	IQR	n
F1	**51.1**	29.1	**22.0**	28.8	**50.3**	72.6	82.0	43.9	**4**
F2	**43.5**	30.31	**10.5**	28.9	**40.0**	54.6	83.4	25.7	**4**
F3	**96.9**	51.4	**37.0**	66.3	**97.8**	128.4	155.0	62.1	**4**
F4	**70.3**	15.1	**50.0**	65.0	**72.5**	77.8	86.0	12.8	**4**
F5	**81.8**	105.8	**23.0**	23.0	**32.0**	90.8	240.0	67.8	**4**
F6	**95.3**	15.5	**74.5**	88.0	**99.3**	106.5	108.0	18.5	**4**
All Samples									
	73.1	50.3	**10.5**	36.5	**72.3**	87.6	240.0	51.1	**24**
Statistics for Averages of 6 Sites									
	73.2	22.4	**43.5**	55.9	**76.1**	91.9	96.9	36.0	**6**.

Notes: The bottom row is the average of the means of each of the six sites. Each site is counted once in this mean, n=6. Units of N are in mg-N/ L.

The Phase II (Table 4) and CSM (Table 5) data for raw wastewater are in good agreement in regard to the averages of the means of each site where 4 or more samples were taken, 70.9 ± 20.1 mg-N/L n=4 and 73.2 ± 22.4 mg-N/L n=6, respectively. This very strong correlation is also seen if the statistics are done using all the samples taken in the Phase II study to date, 72.5 ± 38.3 mg-N/L, n=19 and 73.1 ± 50.3 mg-N/L, n=24 from the CSM study. Both studies also show the high degree of variability in samples. The low value in the Phase II data to date is 24.5 mg-N/L and the high value is 170.2 mg-N/L. The range of values was greater in the CSM study, 10.5 mg-N/L and 240.0 mg-N/L. The higher range and standard deviation of the TN values in the CSM study may be a result of the greater number of samples taken. One of the CSM sites in each region was sampled for 7 consecutive days to access daily variations. The statistics for 6 samples taken over a one week period from a Wakulla County site (F-2) are summarized Table 6.

Table 6. CSM 7 Day Intensive Results. Statistics for the raw wastewater TN inputs to the CSM site F2 which included a 7 day sampling event during the week of April 15 through 21, 2008. Units of N are in mg-N/L.

Measurement Date	**Average.**	**Standard Deviation**	**Median**	**n**
15 April	71.0	0.0		2
16 April	**No sample**			**0**
17 April	94.0	0.0		2
18 April	44.0	2.8		2
19 April	38.5	0.7		2
20 April	149.0	0.0		2
21 April.	104.0	4.2		2
April, 2008 6 days	**83.4**	41.4	**82.5**	**6**
F2-Fall	10.5	0.5		**2**
F2-Winter	35.0	0.0		**2**
F2-April, 2008	**83.4**			**6**
F2-July, 2008	45.0	0.0		**2**
Quarterly Total	**43.5**	30.3	**40.0**	**4**
All F2 samples	**65.7**	43.1	**45.0**	**9**

Notes: The sewage pump was set up on a Monday and first sample was on Tuesday. The Wednesday sample was not taken due to equipment malfunction. The statistics are presented for all samples taken at site F2 as well as the 4 quarterly events, using the average of the 6 daily samples taken during the 3rd quarterly sample even for that value.

The results presented in Table 6 show a wide range of TN values during the weeklong daily sampling and further illustrate the necessity of repeated sampling to accurately access a household's waste stream. It is difficult to sample raw wastewater on a large number of systems due to having to install special plumbing and the time and labor involved, yet having a realistic and reliable wastewater input value is crucial to evaluating the effectives of treatment. The family in this household, at Site F2, is a young working couple with a toddler. The recently released CSM report, *Characterization of Raw Wastewater and Septic Tank Effluent from*

Residential Onsite Sources, discusses regional and demographic variations in detail (Lowe et al., 2009).

3.2 Septic tank effluent (STE) from conventional septic tanks at Phase I Sites.

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 (Washington State DOH, 2005). 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 (Table 7).

Table 7. Phase I Study Results. The STE Average (Ave.) and standard deviation (Std. Dev.), number of samples (n) for TN measured at each site. Units of N are in mg-N/L.

Site ID	TN Average.	TN Std. Dev.	TN Median	n	%TN as TKN	%TKN as $NH4^+$
HK	**30.1**	10.4	**35.0**	3	100	87
LT	**57.2**	4.6	**55.0**	3	100	94
YG (F1)	**47.8**	13.5	**43.5**	3	100	96
All Samples						
	45.0	14.8	**43.5**	9	100	93

Notes: The percentage of TN in the form of TKN and the percentage of TKN in the form of ammonium ion and ammonia is also presented. TKN is the organic nitrogen and ammonia species component of TN. TN is the combination of TKN and nitrate plus nitrite.

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 (Washington State DOH, 2005). The low concentrations or absence of nitrate in raw wastewater and the anaerobic conditions unfavorable to nitrification result in the TN in STE to be virtually 100% TKN (Table 7). Denitrification in wastewater treatment requires anaerobic conditions followed by aerobic conditions and back to anaerobic conditions in the presence of a carbon source.

The TN concentration in STE is less variable than the TN in raw wastewater due to temporal averaging that occurs in the tank. One of the primary functions of a conventional septic tank is to equalize the flow of the wastewater stream and allow for the digestion and sedimentation of wastewater solids. The statistics for the TN concentrations found in the three sites with conventional septic tanks studied in Phase I of this study are summarized below in Table 8.

Table 8. Phase I Study Results. Septic tank effluent (STE) TN statistics for the 3 sites with conventional systems at which STE were measured at the Phase I sites. Site YG and F1 are the same. These samples are grab samples. Units of N are in mg-N/L.

Site ID	Ave.	Std. Dev.	Low	25th %	Median	75th %	High	IQR	N
HK	**30.1**	10.4	**18.1**	26.6	**35.0**	36.0	**37.0**	9.4	**3**
LT	**57.2**	4.6	**54.0**	54.5	**55.0**	58.8	**62.5**	4.2	**3**
YG (F1)	**47.8**	13.5	**37.0**	40.3	**43.5**	53.3	**63.0**	13.0	**3**
Statistics for Means of 3 Sites									
	45.0	13.8	**30.1**	39.0	**47.8**	`52.5	**57.2**	13.6	**3**
All Samples									
	45.0	14.8	**18.1**	37.0	**43.5**	55.0	**63.0**	18.0	**9**

Notes: The second to bottom row is the average of the means of each of the three sites, where each site is counted once, n=3. The bottom row includes the statistics for all samples taken from the three sites

In Phase I, the STE samples were grab samples. In the CSM study the STE samples were 24-hour composite samples. Site YG from Phase I is the same residence as site F1 in the CSM study. In the CSM study (Table 9) the average septic tank effluent was 64 ± 13 mg-N/L. Due to the larger sample size, we consider the CSM study results for STE for conventional septic tanks to be the more representative values. This assertion is supported by the results of the much more comprehensive La Pine study, 66 ± 22, n=427 (La Pine Oregon Demonstration Project, 2006).

Table 9. CSM Study Results. TN statistics of STE measured at the 6 CSM Wakulla County sites with conventional systems. Site YG from Phase I and F1 of the CSM study are the same septic system. Units of TN are in mg-N/L

Site ID	Average.	Std. Dev.	Low	25^{th} %	Median	75^{th} %	High	IQR	n
F1 (YG)	**43.9**	5.3	**38.0**	41.0	**43.5**	46.4	**50.5**	5.4	**4**
F2	**72.8**	7.0	**64.0**	68.1	**71.0**	78.0	**85.5**	9.9	**10**
F3	**68.3**	5.4	**61.0**	66.3	**69.0**	71.0	**74.0**	4.8	**4**
F4	**67.5**	7.9	**59.0**	62.0	**67.5**	73.0	**76.0**	11.0	**4**
F5	**44.3**	4.3	**38.0**	43.3	**45.5**	46.5	**48.0**	3.3	**4**
F6	**70.9**	5.5	**65.0**	68.0	**70.3**	73.1	**78.0**	5.1	**4**
Statistics for Averages of 6 Sites									
	61.3	13.4	**43.9**	50.1	**67.9**	70.3	**72.8**	20.2	**6**
All Samples									
	63.6	13.4	**38.0**	52.6	**68.0**	72.0	**85.5**	19.4	**30**

Notes: The second to bottom row is the average of the means of each of the six sites, where each site is counted once, n=6. The bottom row is the statistics for all samples taken from the six sites

If 70 mg-N/L is used as an input value, this results in an N-reduction of 9 ± 19% in these conventional septic tanks (using Equation 1). The results of Table 8 with an STE of 45 ± 15 mg-N/L indicate a 36 ± 21% reduction. However, the total CSM study found that on average the mean of both raw influent (n=63) and STE (n=61) was ≈ 60 mg-N/L, suggesting little removal of N by a conventional septic tank (Lowe et al, 2009).

3.3 <u>Effluent Nitrogen data from PBTS installed in Wakulla County, Florida 8 main sites.</u>

Effluent from 8 PBTS was sampled as many as 11 times on an approximately monthly basis for a year and analyzed for the nitrogen species, as well as TP and chloride. For this report, nitrogen is the focus. Table 10 summarizes the TN concentration in the effluent, measured at the 8 sites. Site WSS-8-2 was abandoned after the first three samples because the homeowner decided to no longer participate in the study. Only samples from functioning systems in occupied residences are reported. Other deviations from the 11-month sample set were due to system malfunctions, homeowners being on vacation or homeowners moving. During three of the sampling events, site WSS-3-2 was found to be non-functioning. The home owner was notified and the system issue was addressed. At site WSS-7-2 the home owner moved between the PTBS sampling on 09/08/09 and the quarterly sampling on 10/01/09. The homeowners at site WSS-4-2 were out of town during one sampling event and there was no access to the system.

Table 10. Phase II Study Results. TN in effluent from 8 PBTS study sites in Wakulla County, Florida. Units of TN are in mg-N/L.

Site ID	Average	Std. Dev.	Low	25th %	Median	75th %	High	IQR	n
WSS-1-2	**39.6**	17.1	10.5	28.3	**43.1**	53.0	59.0	24.8	**11**
WSS-2-2	**25.2**	2.7	20.8	23.1	**24.5**	27.3	28.9	4.2	**11**
WSS-3-2	**28.2**	13.8	12.7	17.9	**26.6**	33.0	54.2	15.1	**8**
WSS-4-2	**17.3**	9.4	1.3	11.0	**20.4**	25.0	27.2	14.0	**10**
WSS-5-2	**32.2**	10.1	13.2	26.4	**33.0**	38.7	49.4	12.3	**11**
WSS-6-2	**14.5**	9.0	5.3	9.6	**11.2**	16.8	32.1	7.2	**11**
WSS-7-2	**49.2**	17.0	16.3	45.6	**48.1**	57.6	71.3	12.0	**7**
WSS-8-2	**33.7**	3.8	31.0	31.5	**32.0**	35.0	38.0	3.5	**3**
Statistics for Averages of 8 Sites									
	30.0	11.4	14.5	23.2	**30.2**	35.2	49.2	11.9	**8**
All Samples									
	28.7	15.4	1.3	17.3	**26.7**	38.6	71.3	21.3	**72**

Notes: The second to bottom row is the average of the means of each of seven sites. Each site is counted once, n=8. The bottom row is the statistics for all samples taken from the eight sites.

3.4 Daily Variation in Effluent Nitrogen data from PBTS

The short-term fluctuation in effluent concentration was evaluated by sampling effluent from 3 of the PBTS on consecutive days. During 2 of the monthly effluent monitoring events, site WSS-4-2 was sampled on two consecutive days. The deviation between consecutive samples was small and the averages were reported as the monthly TN value Table (11). At sites

WSS-3-2 and site Wss-6-2 the effluent was measured on 5 consecutive days during the December sampling. The agreement between samples at site WSS-6-2 was very close. At site WSS-3-2 the effluent TN was more variable with a low TN of 21 mg-N/L and a high value of 38 mg-N/L. The median of the 5 values at each site was used as the monthly TN effluent measurement (Table 11).

Table 11 Phase II Study Results. Daily variation of TN in effluent from PBTS study sites in Wakulla County, Florida where samples were taken on consecutive days. TN concentration is in mg-N/L.

Site ID		Average	Median	n
WSS-3-2	5 days	26.6 ± 7.4	21.7	5
WSS-6-2	5 days	10.2 ± 0.6	10.2	5
WSS-4-2	2 days	21.9 ± 0.8		2
WSS-4-2	2 days	18.9 ± 0.8		2

3.5 TN in effluent sampled from the 3 Norweco PBTS

The sampling protocol recommended by Norweco for sampling their systems differs from the approach used in this study. We sampled all the systems from plumbing which leads from the last tank in the system and the drainfield. This approach captures the effluent that is actually entering the drainfield at that point in the treatment process. Norweco recommends that the sample be taken as the effluent leaves the ATU portion of the system and flows into the pump tank. This approach avoids any mixing from the effluent that was just treated before it mixes with the treated effluent in the pump tank. Our purpose was to determine the TN concentration as the effluent entered the drainfield at a point in time, while the Norweco approach focuses on how the system is functioning at that point in time. The procedure for collecting an effluent sample recommended by Norweco is difficult because it involves opening the pump tank and placing a bottle on a pole to reach the effluent as it falls into the pump tank. At the 3 sites with Norweco systems, samples using both approaches where taken during 3 of the monthly sampling events. Of these 9 sample comparisons, 5 differed by 5% or less (Table 12).

Table 12. Comparison of the sampling approach recommended by Norweco and the approach used in this study are presented. NOR designates samples taken according to the Norweco protocol and EFF designates samples using the standard sampling procedures followed in this study. Units of TN are in mg-N/L.

Site	Date	NOR	EFF	% Difference
WSS-3-2	**5/1/09**	30.5	54.2	44
WSS-3-2	**6/1/09**	12.7	12.7	0
WSS-3-2	**7/1/09**	39.1	37.0	5
WSS-5-2	**5/1/09**	51.6	49.4	4
WSS-5-2	**6/1/09**	40.5	33.6	17
WSS-5-2	**7/1/09**	23.0	22.3	3
WSS-7-2	**5/1/09**	36.2	44.1	18
WSS-7-2	**6/1/09**	17.1	16.3	4
WSS-7-2	**7/1/09**	56.1	48.1	14

3.6 Effluent Nitrogen data from Performance Based Treatment Systems installed in Wakulla County, Florida, sampling of additional sites in April, 2009.

In an effort to ascertain if the results from the 8 intensive sites were representative of PBTS installed in the Wakulla Springs basin, an additional 27 PBTS systems were sampled in the county in cooperation with the Wakulla County Health Department and FDOH Bureau of Onsite Sewage Programs in April, 2009. Candidate systems were selected from a survey of PBTS permits finalized as of 10/27/08. This survey indicated that of the 105 PBTS installed, approximately 10% were HOOT systems, 30% were Norweco systems and 60% were FAST systems. Sample sites were chosen to reflect this ratio and to also sample each variety of FAST system that was installed.

Of the 27 additional sites sampled during April, 2009, 3 sites had TN effluent concentrations lower than the 10 mg-N/L total nitrogen treatment goal and 5 sites had TN effluent concentrations of 60 mg-N/L or greater, similar to conventional septic system effluent (STE). However, the majority of the sites that were sampled had TN effluent concentrations very similar to those detected in the monthly samples from the PBTS study sites (Table 13).

Table 13. Phase II Study Results. TN in effluent from 27 additional PBTS sites in Wakulla County, Florida sampled in April, 2009. Units of TN are in mg-N/L.

Sample ID	System type	TN.	%TKN
WS-11	HOOT	20.2	6
WS-25	HOOT	40.5	11
WS-26	HOOT	18.1	23
WS-1	Norweco	**72.0**	**86**
WS-10	Norweco	19.2	22
WS-12	Norweco	21.1	100
WS-20	Norweco	23.0	74
WS-24	Norweco	**8.6**	**94**
WS-3	FAST Dual Chamber	26.4	68
WS-5	FAST Dual Chamber	26.1	4
WS-7	FAST Dual Chamber	**67.0**	**21**
WS-8	FAST Dual Chamber	**3.6**	**64**
WS-9	FAST Dual Chamber	**59.5**	**100**
WS-22	FAST Dual Chamber	29.3	8
WS-23	FAST Dual Chamber	14.1	22
WS-14	FAST Dual Chamber + Post Tank	**2.6**	**38**
WS-18	FAST Dual Chamber + Post Tank	20.0	98
WS-21	FAST Dual Chamber + Post Tank	16.2	7
WS-6	FAST Single Chamber +Pre Tank	37.0	100
WS-13	FAST Single Chamber +Pre Tank	**60.0**	**27**
WS-16	FAST Single Chamber +Pre Tank	13.2	24
WS-17	FAST Single Chamber +Pre Tank	32.1	19
WS-2	FAST Single Chamber +Post Tank	20.3	98
WS-15	FAST Single Chamber +Post Tank	**8.6**	**2**
WS-19	FAST Single Chamber +Post Tank	26.4	80
WS-4	FAST Three Tanks	**78.1**	**3**
WS-27	FAST Three Tanks	24.0	8
	Average	**29.2 ± 20.8**	

Notes: ***Data are grouped by system type. The FAST system with a single chamber with the treatment unit plus a post tank is no longer allowed by the FDOH. The FAST Dual Chamber configuration is the most common installation. The TN values below 10 mg-N/L and those above 60 mg-N/L, an estimate TN for conventional systems, are in bold.***

The results from the 27 additional sites confirm that the TN data from the 8 PBTS study sites are representative of functioning systems installed in Wakulla County. Table 14 compares the results from all PBTS sampled to date and also gives statistics for the three types of systems studied. The average effluent concentration for the 35 sites was 29.4 ± 18.8 mg-N/L.

Table 14. Phase II Study Results. TN in effluent from the 8 PBTS sites of Phase II and the 27 additional PBTS sites in Wakulla County, Florida sampled in April 2009. Units of N are in mg-N/L.

Sample Group	Ave.	Std. Dev.	Low	25th %	Median	75th %	High	IQR	n
24 Current Code**	**30.5**	21.5	2.6	17.6	**23.5**	37.9	78.1	20.3	**24**
27 Survey Sites	**29.2**	20.8	2.6	17.2	**23.0**	34.6	78.1	17.4	**27**
8 Main sites	**30.0**	11.4	14.5	23.2	**30.2**	35.2	49.2	11.9	**8**
HOOT	**26.7**	10.5	18.1	19.2	**20.2**	35.6	40.5	16.4	**5**
Norweco	**32.2**	19.9	8.6	20.6	**27.3**	37.7	72.0	17.1	**8**
FAST	**29.2**	20.2	2.6	16.5	**26.2**	33.3	78.1	16.8	**22**
Average of 35 Sites									
Total	**29.5**	18.7	2.6	18.1	**26.1**	35.0	78.1	16.9	**35**

*****Notes: Three of the 27 sites have the FAST unit in a single chamber tank with a post tank, which is no longer allowed by WDOH. These sites are excluded from the 27 Survey Sites in the Table entry "24 Current Code".***

3.7 <u>Evidence of Nitrification and Denitrification in PBTS Effluent</u>

In a properly functioning PBTS, the nitrogen in the wastewater flowing out of the pre-treatment chamber into the treatment chamber approaches 100% organic nitrogen + ammonia (TKN) (Table 6). In the treatment chamber, TKN is to be converted to NO_3 with oxygen through bacterial nitrification. The efficiency of this process is dependent on the amount of dissolved oxygen present as well as the health and vigor of the nitrifying bacteria. Since nitrification of the TKN to NO_3 is necessary before denitrification can occur, the extent of nitrification in this step affects the amount of the nitrogen reduction that can occur through denitrification. Denitrification then occurs as the NO_3 encounters anaerobic conditions in the presence of organic matter. The percentage of nitrogen as TKN versus NO_3 in the PBTS effluent can provide insight into how well a system is functioning, but those findings can also be misleading since the treatment processes for HOOT and Norweco systems involve the recirculation of treated water and mixing of more and less treated wastewater. The study results showed that samples with relatively low TN concentrations could have either very low or higher percentages of TKN in comparison to NO_3. However, samples with relatively high TN concentrations consistently have high percentages of nitrogen as TKN, which may indicate less efficient treatment by the PBTS (Figure 9).

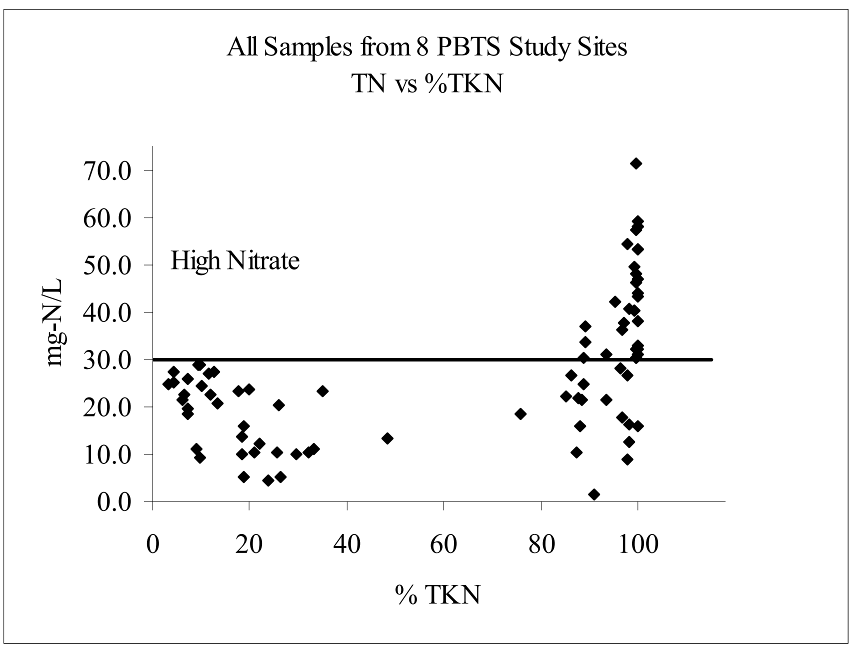


Figure 9. The TN concentrations (y-axis) of all samples from the 8 PBTS study sites plotted against the percentage of nitrogen as TKN. The samples with TN concentrations below 30 mg-N/L had TKN percentages that were either low or high. Samples with TN concentrations above 30 mg-N/L always had a high percentage of nitrogen as TKN.

Effluent samples from systems with low TN concentrations and a high percentage of the nitrogen as NO_3 indicate that these systems are achieving a high rate of nitrification. Most of the nitrogen is converted into NO_3 and as denitrification occurs, lowering the TN, the remaining effluent is predominately NO_3. Samples with low TN concentrations and a high percentage of the nitrogen as TKN indicate systems that have incomplete nitrification followed by denitrification. As denitrification occurs in the partially nitrified wastewater, the NO_3 is consumed, resulting in effluent with a high percentage of nitrogen as TKN. Samples with high TN concentrations and a higher percentage of the nitrogen as TKN in comparison to NO_3 indicate systems that have limited or no nitrification. Any NO_3 that is formed is consumed by denitrification. Since nitrification is limited, denitrification is also limited and the resulting effluent has a high TN that is mostly TKN. These results suggest that the effectiveness of these systems is limited by insufficient aeration. A balance must be struck however, for with too much aeration, denitrification is limited.

The data from site WSS-1-2 illustrates how the performance of an individual system can be improved with monitoring and subsequent adjustments to the system. After the May 2009 sample event, the pressure in the drainfield and recirculation system was reduced. Nitrification was thought to be limited as the recirculation was flushing wastewater through the system too fast. After this adjustment, the TN values were lower with a greater percentage of (NO_3 in the effluent (Figure 10). Apparently additional adjustment was needed, for in September the sytem returned to its previous poor performance.

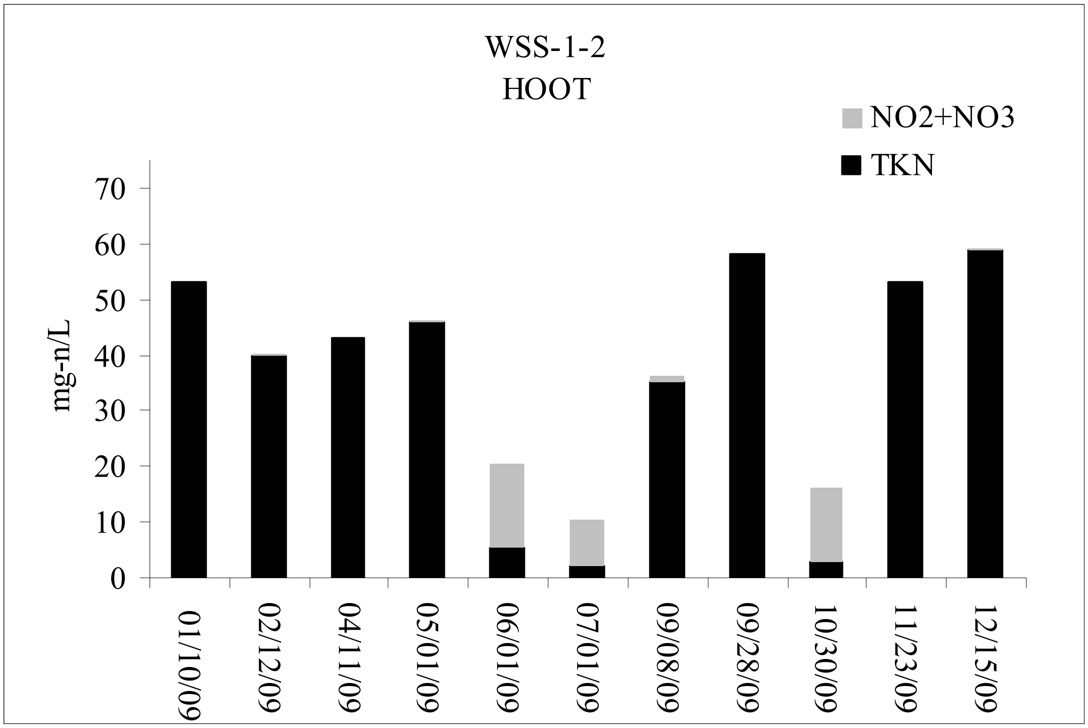


Figure 10. The TN concentrations plotted against the percentage of nitrogen as TKN at site WSS-1-2. In the first 4 samples with relatively high TN values, the nitrogen was mostly TKN. In the following two samples nitrification was apparently much more extensive and the TN concentrations were lower and predominately in the form of NO_3.

The data from the 27 additional sites sampled showed a greater degree of variability in the percentage of TKN in the TN of the systems effluent. As with the data from the 8 PBTS study sites, there are: 1)low TN concentrations with low percent as TKN indicating extensive nitrification and denitrification; 2)low TN concentrations with high percent as TKN indicating incomplete nitrification and denitrification (or mixing of treated water from different stages); and 3)high TN concentrations with a high percentage as TKN indicating limited nitrification and denitrification. Additionally, the data from the additional 27 sites shows a fourth category, 4)systems with samples with high TN with a low percentage as TKN indicating a system that is possibly too aerobic and that is nitrifying the waste stream without the subsequent denitrification step (Figure 11).

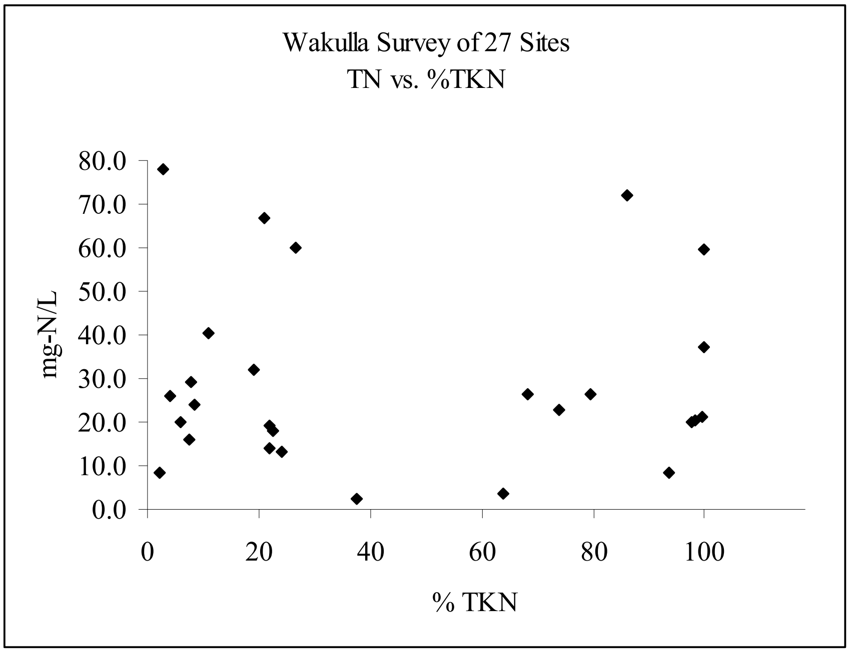


Figure 11. The TN concentrations (y axis) of all samples from the 27 PBTS study sites plotted against the percentage of nitrogen as TKN (x-axis).

3.8 Nitrogen Reduction in PBTS

The reduction of nitrogen by a system can be calculated if both the raw sewage inputs and the effluent output nitrogen concentrations are known. As discussed previously, the nitrogen content of raw sewage is highly variable depending on varying water use and lifestyle of the occupants of a household. The recent measurements suggest that a reasonable estimate for the average TN input from raw sewage in residences in Wakulla County is 70 mg-N/L (Tables 4 and 5). The percent reduction is calculated using this estimate and the actual input values for the study sites where the data is available.

The results of the Phase II study on performance based units are as follows. Effluent from eight Wakulla County PBTS units was sampled on a monthly basis during 2009. STE from the study sites averaged 30 ± 10 mg-N/L (Figure ES-2, Table 10). Of the additional 59 surveyed sites, the effluent of 27 performance based units was sampled. Their average value was 29 ± 21 mg-N/L (Figure ES-2, Table 11). The average concentration for the 35 total sites was 29 ± 19 mg-N/L (Table 12). These values are 45% of the average TN concentration in effluent from conventional septic tanks.

For the 5 sites where the TN of the raw sewage was measured, the percent reduction is calculated using both the measured input TN concentrations and the influent concentration estimate of 70mg-N/L (Table 15).

Table 15. Phase II Study Results. The percent reduction in TN achieved by the PBTS systems at sites where raw sewage inputs were measured is calculated using both the measured raw sewage values and the estimate of 70 mg-N/L. Units of N are in mg-N/L.

Site ID	Input TN Average.	Effluent TN Average.	Average % Reduction	% Reduction 70 Input
WSS-1-2	55.1 ± 28.2, n=4	39.6 ± 17.1, n=11	28.1	43.4
WSS-2-2	96.5 ± 56.2, n=5	25.2 ± 2.7, n=11	73.9	64.0
WSS-4-2	39.1 ± 20.6, n=2	17.3 ± 9.4, n=10	55.8	75.3
WSS-7-2	77.4 ± 26.0, n=5	49.2 ± 17.0, n=7	36.4	29.7
WSS-8-2	70.2, n=1	33.7 ± 3.8, n=3	52.0	51.9
5 Sites with Input Measurements				
	67.7 ±21.8, n=5	**33.0 ± 12.4, n=5**	**49.2± 17.8, n=5**	**52.9 ± 17.7, n=5**
All Samples				
	72.8 ± 39.2, n=17	31.6 ± 16.3, n=42	56.6	54.9
WSS-3-2	NA	31.6 ± 15.3, n=6	NA	54.9
WSS-5-2	NA	34.4 ± 9.5, n=6	NA	50.9
WSS-6-2	NA	19.2 ± 9.3, n=6	NA	72.6

Notes: The second to bottom row is the average of the means of each of the five sites, where each site is counted once, n=5. The bottom row is the statistics for all samples taken from the five sites

For the 27 sites sampled once, we calculate a percent N-reduction of 58.9 ± 28.5% (Figure ES-3, Table 16)

Table 16. Phase II Study Results. Nitrogen reduction at the study sites. Percentages assume an input TN concentration of 70 mg-N/L. For samples with effluent values greater than 70 mg-N/L, the % reduction was assumed to be zero. Units of N are in mg-N/L.

Sample ID	System type	TN.	%Reduction 70 mg-N/L Input
WS-11	HOOT	20.2	71
WS-25	HOOT	40.5	42
WS-26	HOOT	18.1	74
WS-1	Norweco	**72.0**	**0**
WS-10	Norweco	19.2	73
WS-12	Norweco	21.1	70
WS-20	Norweco	23.0	67
WS-24	Norweco	**8.6**	**88**
WS-3	FAST Dual Chamber	26.4	62
WS-5	FAST Dual Chamber	26.1	63
WS-7	FAST Dual Chamber	**67.0**	**4**
WS-8	FAST Dual Chamber	**3.6**	**95**
WS-9	FAST Dual Chamber	**59.5**	**15**
WS-22	FAST Dual Chamber	29.3	58
WS-23	FAST Dual Chamber	14.1	80
WS-14	FAST Dual Chamber + Post Tank	**2.6**	**96**
WS-18	FAST Dual Chamber + Post Tank	20.0	71
WS-21	FAST Dual Chamber + Post Tank	16.2	77
WS-6	FAST Single Chamber +Pre Tank	37.0	47
WS-13	FAST Single Chamber +Pre Tank	**60.0**	**14**
WS-16	FAST Single Chamber +Pre Tank	13.2	81
WS-17	FAST Single Chamber +Pre Tank	32.1	54
WS-2	FAST Single Chamber +Post Tank	20.3	71
WS-15	FAST Single Chamber +Post Tank	**8.6**	**88**
WS-19	FAST Single Chamber +Post Tank	26.4	62
WS-4	FAST Three Tanks	**78.1**	**0**
WS-27	FAST Three Tanks	24.0	66
	Average and Standard Deviation	**29.2± 20.8**	**58.9 ± 28.5**

The average TN value of near 30 mg-N/L may seem high for systems in comparison to the 10 mg-N/L expectation in FDOH and Wakulla County documentation, but the percent reduction value of near 60% indicates these systems are working as designed. This technology has been shown to consistently achieve 50-70% nitrogen reduction when installed and maintained correctly. The discrepancy with the NSF/ANSI standard is that under the controlled testing conditions these systems were fed sewage with TN influent concentrations of 25-35 mg-N/l, which is much lower than many of the influent concentrations measured for actual home septic systems (Table 17). The results of this study indicate that in field settings the PBTS tested generally achieve 50% N-reduction, but they do not achieve 10 mg-N/L in their effluent.

Table 17. Influent and effluent TN concentrations of systems during NSF/ANSI standard testing. Percent reduction of TN is also calculated. Units of N are in mg-N/L

NSF/ANSI Testing	Input TN Average	Effluent TN Average	Average % Reduction
FAST	34.5	9.4	73
HOOT	26.3	9.63	63
Norweco	25	6.8	73

3.9 Survey Results: Frequent non-compliance of PBTS systems.

During the course of sampling these additional PBTS, we encountered issues of concern regarding their installation, operation and maintenance. The most widespread problems were that a large number of systems were being turned off or were not receiving power. Also, a number of sites lacked a sampling port or other access to enable sampling of the system effluent. Out of a total of 59 PBTS inspected, 23 (39%) of these systems were not functioning as PBTS. At 22 of those systems, the treatment units were turned off or not powered. At three of these, the electrical wires were not even connected to the control boxes (Figures 12 and 13). At the other non-compliant site, the pump tank was empty due to a missing plug on the bottom (Figure 14). Other sites considered for this survey were not visited by the sampling team because pre-screening by Wakulla County Health Department staff indicated that those systems were not running (and presumably also not in compliance with their permits).

Figure 12. Picture taken on 04/16/09 of a FAST system with the unwired control box lying on the exposed tank. The system was in use with sewage, but no electricity.

Figure 13. Picture taken on 04/16/09 of Norweco system with the wiring to the control box not connected. There was power to the pump, but not to the aerator control box.

Figure 14. Pictures of the inside of an empty pump tank attached to a functioning FAST system. The installer indicated that a plug at the bottom of the tank came out and has encountered this problem at other sites.

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. With three systems that were visited, the sampling team could find no way to access the effluent. At one of the sites, there was no sample port and when the lid was dug up, the electrical wires were found strung across the pump tank lid making it impossible to open without, cutting or disconnecting the wires (Figure 15).

Figure 15. Picture taken on 04/20/09 of Norweco system with wires strung across the pump tank lid preventing access. No sampling port was installed. Maintenance records indicate the effluent was visually inspected.

At other sites, the vent pipe had to be cut and then repaired in order to take a sample (Figure 16). Despite our difficulties in sampling systems, maintenance records for these sites show that the effluent from the PBTS has been visually inspected. In other instances, the team found that the systems did have sampling ports, but they had been installed in the wrong place in the system to obtain a sample complying with the manufacturer's recommendations.

Figure 16. Picture taken on 04/14/09 of a vent pipe typical of FAST installations. Note the PVC coupling at ground level. In order to take a sample, the pipe was cut and repaired with the coupling. The black piece is a charcoal filter installed due to odor complaints. In this neighborhood, there are 5 systems in a row, backing to another 5 systems. This resulted in 10 systems on 1 ¼ acre which apparently created an odor problem.

The highest TN concentration in the effluent samples from the 27 survey sites and the 8 main study sites was 78.1 mg-N/L. This sample was collected from site WS-4, which has a FAST system configured with three separate tanks with recirculation and a mounded drip irrigation system. This configuration has a separate pretreatment tank, treatment tank, and pump tank and should have been one of the systems, based on the design, to provide optimum TN reduction. However, this system had an ongoing repair problem with a broken pipe that resulted in the system effluent filling the control box and not going to the drainfield (Figure 17). Other repair issues with this system may have been responsible for the elevated TN concentration in the effluent.

Figure 17. Pictures of site WS-4 taken on April 14, 2009. The broken plumbing evident in this picture was also reported in September 2008. The broken pipe caused the effluent to fill the control box instead of going to the drainfield.

3.10 <u>Operation and Maintenance Issues with PBTS</u>

Testing and field research have shown that PBTS can achieve 50 percent reduction of TN from input concentrations. The research from this locality shows that 70 mg-N/L is a reasonable estimate for residential sewage in Wakulla County. The median for all three regions investigated (Florida, Colorado, and Minnesota) in the CSM study was 60 mg-N/L, which is similar. Using the 70 mg-N/L average for influent TN, properly functioning PBTS should have on average effluent TN values below 30-35 mg-N/L. Our October 2008 inventory of septic tank permits in the Wakulla County Health Department files identified 105 PBTS installed in the county at that time. Of these systems, 63 (60%) were visited and 59 of the systems were inspected by the sampling team. Of the 59 systems inspected, 23 (39%) were not being operated properly and were therefore were not sampled because they would not provide representative performance data.. Twenty seven of the systems visited were operating and were sampled. The operational systems had an average TN concentration in the effluent of 29.2± 20.8 mg-N/L. Using 60-70 mg-N/L as an input value for TN, this translates to 50% to 60% reduction, on average.

Of the 27 systems sampled, 13 (48%) had effluent concentrations higher than 30 mg-N/L, and 9 (33%) had effluent concentrations higher than 35 mg-N/L. Five (15%) of the systems sampled appeared to not be functioning properly based on the data because they had effluent concentrations at raw sewage values (60-70 mg-N/L). The compliance issue with the systems that were not in operation is clear-cut but also the systems with elevated TN effluent concentrations could have issues that were not identified in this one sampling episode.

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 theses systems has been inspected and system 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.

3.11 September, 2009 additional site visit observations

Two of the 27 sites were re-sampled in September, 2009 along with an additional 3 systems in close proximity to site WSS-3-2. The two sites were chosen for re-sampling because one was not indicating any treatment over a conventional system in April and the other was performing better than average. The TN concentrations and the percent TKN in these systems are presented in Table 18.

Table 18. Phase II Study Results. Additional PBTS sampling. Two of the 27 sites sampled in April were resampled in September, along with 3 additional sites. Percentages assume an input TN concentration of 70 mg-N/L. Units of N are in mg-N/L.

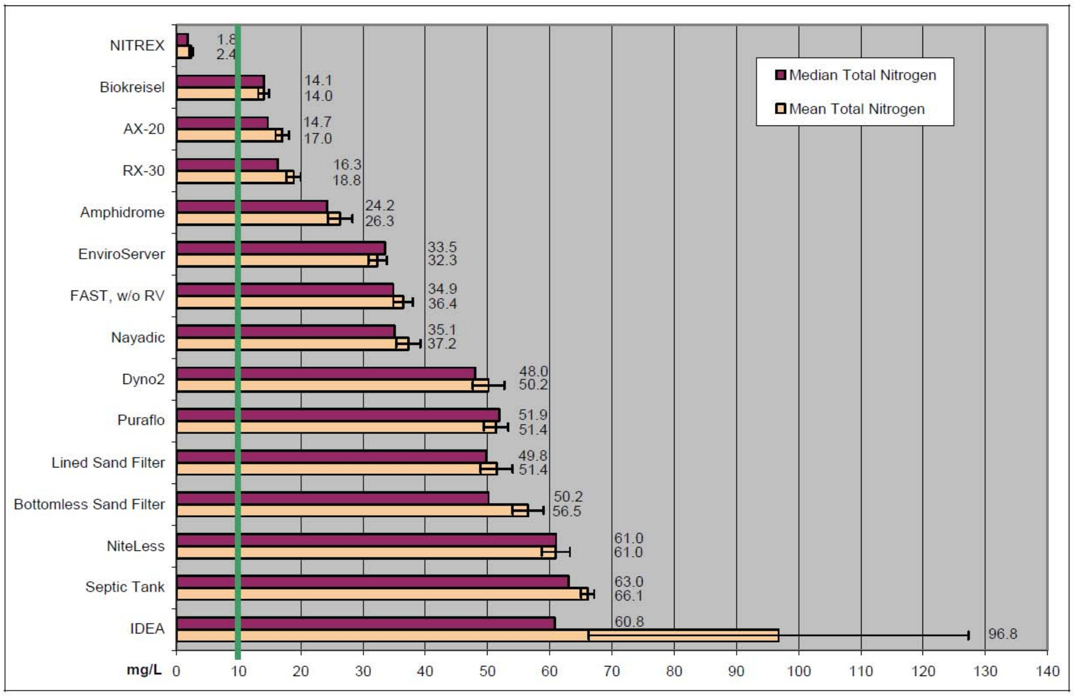
Sample ID	Date	System Type	TN	%Reduction
WS-13	April	FAST Single Chamber +Pre Tank	60.0	14.3
WS-13	September		39.6	43.4
WS-24	April	Norweco	8.6	87.8
WS-24	September		42.5	39.4
WS-28	September	Norweco	25.4	63.7
WS-29	September	FAST Dual Chamber	5.2	92.6
WS-30	September	FAST Dual Chamber	13.8	80.3

The re-sampling of the two systems illustrates the variability that can occur in the performance of nitrogen reduction in these systems. The TN reduction observed in the other three systems sampled was better than average for sites sampled in Wakulla County. Adding these five additional samples the average TN concentration changes slightly to 28.5 ± 19.9 mg-N/L, n=32.

While sampling the three additional sites, two other neighboring sites were inspected and the systems found not functioning, although the switches were turned on. Site WSS-3-2 experienced periodic maintenance issues, of the 11 sampling events, during 3 the system was found not operating. During one of these inspections, the neighboring system of the same type and installation was also not functioning.

3.12 Other research findings

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 (Fig. 18, La Pine Oregon Demonstration Project, 2006).



Notes. The median TN concentration of 63 mg-N/L for effluent from conventional septic systems (STE) shown above is very similar to the values presented in this study. The FAST effluent TN mean concentration of 35 mg-N/L in the La Pine study compares to the FAST effluent results of this study, 26.2 mg-N/L.

Figure 18 Results of La Pine Oregon Demonstration Project, 2006. Only one of the nitrogen reducing systems examined achieved levels of 10 mg-N/L.

Raw sewage inputs were not measured in the La Pine study, instead conventional septic tank effluent and sand filters were used as controls. The effluent TN concentrations in the La Pine study for both conventional septic tanks and the FAST system are very similar to results in this report (Fig. 18). 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. A chart compiled by FDOH summarizing data for PBTS and innovative systems reports nitrogen reductions ranging from 44% to 77% (FDOH, 2008). This excludes NITREX and Puraflo systems, both which utilize an added carbon source for denitrification. The Washington State Health Department also released a study on nitrogen reducing systems reporting reductions of 51% to 64% (WDOH, 2005).

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% (Chang et al 2009). Preliminary results from a pilot test conducted by an FDOH contractor, using another form of reactive media, showed considerable nitrogen removal (Smith et al 2008). FDOH currently has a study under way that includes pilot-scale and then field scale testing of several promising passive technologies to reduce effluent TN concentrations.

4 TN attenuation downstream of the PBTS or Septic Tank: Pressurized Dripfields and Drainfields.

Once the TN loading to the drain field from either conventional or PBTS effluent is known, the treatment of the drainfield and underlying soils can be investigated by examining the TN concentrations in the soil porewater and shallow groundwater beneath the drain field or dripfield. The percent reduction of TN from the systems effluent in the porewater and groundwater can be calculated from just the nitrogen data; however this does not consider dilution effects.

$$\%\ \text{TN Reduction} = [1 - \{TN_{sample}/TN_{medianSTE}\}] \qquad 4\text{-}1$$

To determine the amount of TN attenuation due to adsorption or denitrification, it is essential to know how much the effluent in the porewater and groundwater is diluted. Chloride (Cl) is thought to act conservatively and can be used to calculate the dilution of the effluent. Although evaporation effects are not accounted for, the dilution of Cl is a reasonable estimate of dilution.

$$\%\,\text{TN Attenuation} = \left(1 - \frac{\dfrac{TN_{sample}}{Cl_{sample\,-\,background}}}{\dfrac{TN_{median\,STE}}{Cl_{median\,STE}}}\right) * 100 \qquad 4\text{-}2$$

This calculation corrects for dilution of the septic effluent in the porewater and groundwater. Since the TN and Cl concentrations of the effluent are variable, the median effluent values over the 12 months were used for the loading concentration. Chloride concentrations for the porewater and groundwater samples were corrected for background concentrations. The lowest median value in either a background lysimeter or well was chosen. The source of Cl in the septic tank effluent was due either to residential use of chlorinated city water (site 3 and 6, Appendix A), household use of cleaners and detergents containing chlorine, household use of chlorine bleach and dietary salt.

It is important to know how much a sample is diluted as well as the amount of nitrogen attenuation. This can help determine whether a lysimeter or well is sampling the main effluent plume or sampling toward the edges or even outside the plume.

$$\%\,\text{Cl dilution} = \left(1 - \frac{\left(Cl_{sample} - Cl_{background}\right)}{Cl_{medianSTE}}\right) * 100 \qquad 4\text{-}3$$

4.1 TN Attenuation in Phase II PBTS with pressurized drip drainfields

Drainfields with pressurized drip emitters can enhance plant uptake of nitrogen by distributing the effluent closer to the root zone. Plant cover and depth of installation are critical factors that can affect the uptake of nitrogen. Without filtration, effluent from conventional septic systems tends to clog the emitters due to high BOD and thus pressurized drip systems are not used with conventional septic tanks in Florida, although they are in some states. Effluent nitrogen in a properly functioning PBTS should have a low BOD, allowing for shallow dispersal and plant uptake. Wakulla Basin PBTS study sites with drip drainfields were WSS-1-2, WSS-4-2, WSS-6-2 and WSS-7-2. Drip lines for these systems were 8 to 12 inches (20 – 30 cm) below the soil surface.

Site WSS-1-2

Site WSS-1-2 has a small mound (less than 0.5 m) with a pressurized drip system. The ground cover is part of a maintained lawn and the drip lines at the location of the lysimeters are 20-25 cm below surface. The shallow lysimeters were installed so the top of the 9 inch (23 cm) cups were approximately 2 ft (0.6 m) below the drip lines (Table 19).

Table 19. The depth from surface is given for the bottom of the drainfield (DF Bottom), the top of the lysimeter cup (Top of Cup) and the bottom of the lysimeter cup (Bottom of Cup)

WSS-1-2	Description	DF Bottom	Top of Cup	Bottom of Cup
S-L-1	**Shallow**	8 in (20 cm)	33 in (84 cm)	42 in (107 cm)
S-L-4	**Shallow**	10 in (25 cm)	35 in (89 cm)	44 in (112 cm)
D-L-2	**Deep**	10 in (25 cm)	71 in (180 cm)	80 in (203 cm)
D-L-3	**Deep**	8 in (20 cm)	91 in (231 cm)	100 in (254 cm)
BG-L	**Background**		66 in (168 cm)	75 in (191 cm)
OM-L	**Off Mound**		53 in (135 cm)	62 in (157 cm)

The drainfield well was located approximately 6 ft (2 m) from the drainfield. The off mound lysimeter (OM-L) was located next to the drainfield well. The background well and lysimeter were located near the front of the property, up gradient from the septic system. The median Cl concentration of the background well was chosen as the $Cl_{background}$ term in both the Cl dilution and TN attenuation calculations. Both the background lysimeter and the off mound lysimeter had elevated Cl concentrations during the February sampling event (Table 20).

Table 20. The Cl and TN concentrations of the background well (BG Well), the background lysimeter (BG-L), and the lysimeter located off the drainfield mound (OM-L), next to the drainfield well. Concentrations of Cl and TN are given in mg/L and mg-N/L, respectively. The mean, standard deviation (SD), and median of the four sampling events are given.

WSS-1-2	BG Well		BG-L		OM-L	
	Cl	**TN**	*Cl*	**TN**	*Cl*	TN
02/25/09	*2.5*	**0.2**	*6.9*	**0.2**	*9.2*	**0.2**
06/16/09	*2.9*	**0.2**	*0.61*	**0.4**	*1.5*	**0.2**
09/28/09	*3.3*	**0.3**	*1.8*	**0.4**	*0.76*	**0.2**
12/15/09	*3.4*	**0.3**	*2.5*	**0.3**	*1.5*	**0.1**
Mean	***3.0***	**0.2**	***3.0***	**0.3**	***3.2***	**0.2**
SD	*0.4*	0.0	*2.7*	0.1	*4.0*	0.0
Median	***3.1***	**0.3**	***2.2***	**0.3**	***1.5***	**0.2**

The effluent TN from the HOOT system at WSS-1-2 was variable, ranging from 11 to 59 mg-N/L. The fluctuating TN input into the drainfield makes any seasonal change in the effectiveness of the drainfield difficult to discern.

Calculations for TN reduction in the lysimeters and drainfield well are made using the median of the effluent (Eff) TN concentrations. TN reduction includes the effect of dilution, while attenuation refers to the reduction without dilution. The table below (Table 21) gives the TN concentrations and the percent reduction of TN including any dilution. The negative values for EFF indicate that on some sampling dates the sampled STE (septic tank effluent) was greater than the median STE value, as seen in Figure 19. The negative value for D-L-3 on December 15, 2009, indicates that the TN in the lysimeters was above the median STE value.

Table 21. The TN in mg-N/L and the percent TN reduction (Red) including dilution is given for each of the four sampling events and the median values for the PBTS effluent (Eff), the shallow lysimeters (S-L-1, S-L-4) and the deep lysimeters (D-L-1, D-L-3). The median TN of the effluent was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 11 effluent sampling events.

WSS-1-2	2/25/09		6/16/09		9/28/09		12/15/09		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
Eff	**40.2**	*7%*	**20.3**	*53%*	**58.1**	*-35%*	**59.0**	*-37%*	**43.1**	*0%*
S-L-1	**28.7**	*33%*	**15.8**	*63%*	**34.2**	*21%*	**33.1**	*23%*	**30.9**	*28%*
S-L-4	**16.0**	*63%*	**5.4**	*87%*	**26.9**	*38%*	**11.7**	*73%*	**13.9**	*68%*
D-L-2	**33.1**	*23%*	**13.2**	*69%*	**26.9**	*38%*	**42.9**	*0%*	**30.0**	*30%*
D-L-3	**38.8**	*10%*	**12.1**	*72%*	**18.6**	*57%*	**44.5**	*-3%*	**28.7**	*33%*
DF Well	**26.4**	*39%*	**17.2**	*60%*	**11.3**	*74%*	**23.4**	*46%*	**20.3**	*53%*

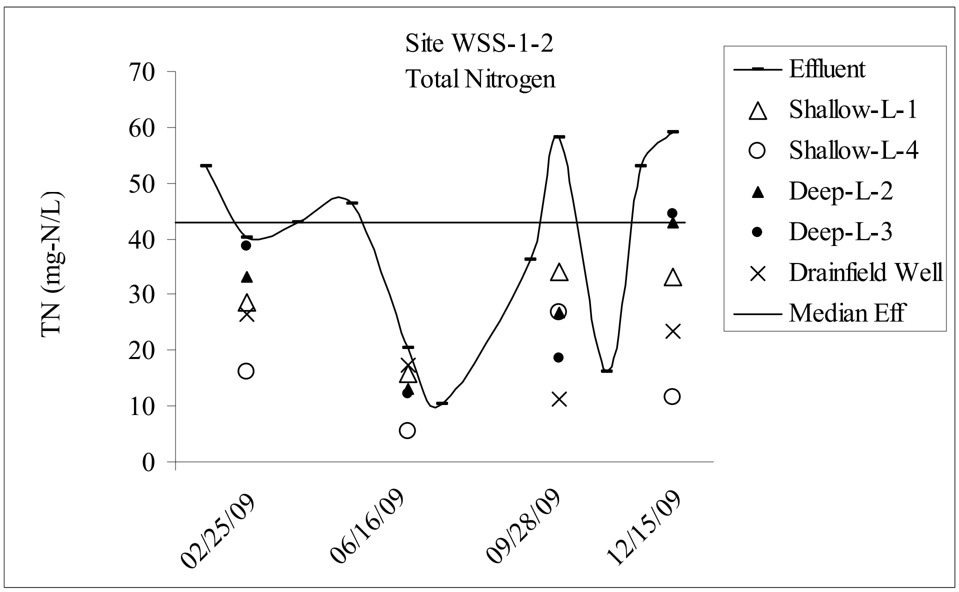


Figure 19. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and drainfield well at site WSS-1-2. Sampling dates for effluent that included lysimeters and wells were on 02/25/09, 06/16/09, 09/28/09, and 12/15/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

The drainfield well is in the main effluent plume as indicated by the Cl dilution, ranging from 23 to 48 %, and a larger range of TN attenuation from 3 to 63 %. Little to no attenuation was observed in the lysimeters during the February sampling. In June, significant attenuation was observed in all lysimeters. In the September sampling event, attenuation was less than in June in the lysimeters and greater in the drainfield well. In December, the shallow lysimeters and drainfield well were more heavily diluted than in previous samplings and negative attenuation of TN was observed in the lysimeters and slight attenuation in the drainfield well. The negative attenuation in the lysimeters in December indicates an additional source of nitrogen besides the PBTS effluent. On possible source may be dog waste. Between the September and December sample events the homeowner fenced in their backyard, enlarging the area their two dogs could access to include the area of the drainfield. The fluctuation is shown in Figure 20.

Even with a pressurized drip system which distributes the effluent throughout the drainfield, TN attenuation can greatly differ in different locations in the drainfield. Shallow-L-1 samples that were more diluted (64% and 39%) showed no TN reduction. In the more concentrated samples, diluted by 6% and 11%, TN attenuation was observed (Table 22). The median TN attenuation via denitrification and/or adsorption at this site was 10%.

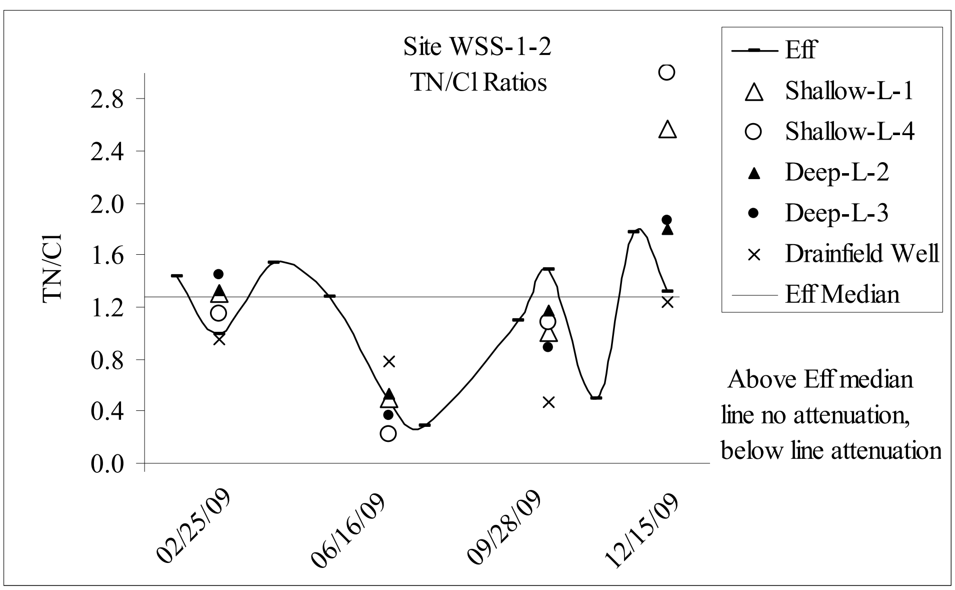


Figure 20. The TN/Cl ratios for the site WSS-1-2. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

Table 22. The percent <u>TN attenuation</u> (TN Atten) calculated from TN/CL ratios which accounts for dilution. The percent of Cl dilution (CL dil) is also given.

WSS-1-2	2/25/09		6/16/09		9/28/09		12/15/09		Medians	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
S-L-1	**-2%**	*39%*	**61%**	*11%*	**21%**	*6%*	**-100%**	*64%*	**10%**	*25%*
S-L-4	**10%**	*61%*	**83%**	*31%*	**16%**	*31%*	**-134%**	*89%*	**13%**	*46%*
D-L-2	**-4%**	*31%*	**59%**	*31%*	**8%**	*36%*	**-40%**	*34%*	**2%**	*32%*
D-L-3	**-12%**	*25%*	**71%**	*9%*	**30%**	*42%*	**-45%**	*34%*	**9%**	*29%*
DF Well	**26%**	*23%*	**39%**	*39%*	**63%**	*34%*	**3%**	*48%*	**32%**	*36%*

Site WSS-4-2

Site WSS-4-2 has a large drainfield mound (greater than 1 m) with a pressurized drip effluent dispersal system. The mound is overgrown with thick untended vegetation. The drip lines are 12 in (30 cm) below the soil surface in the location of the lysimeters. The shallow lysimeters were installed so the top of the 9 inch (23 cm) cups were approximately 2 ft (0.6 m) below the drip lines (Table 23).

Table 23. The depth from surface is given for the bottom of the drainfield (DF Bottom), the top of the lysimeter cup (Top of Cup) and the bottom of the lysimeter cup (Bottom of Cup)

WSS-4-2	Description	DF Bottom	Top of Cup	Bottom of Cup
S-L-1	**Shallow**	12 in (30 cm)	36 in (91 cm)	45 in (114 cm)
S-L-3	**Shallow**	12 in (30 cm)	36 in (91 cm)	45 in (114 cm)
D-L-2	**Deep**	12 in (30 cm)	63 in (160 cm)	72 in (183 cm)
D-L-4	**Deep**	12 in (30 cm)	63 in (160 cm)	72 in (183 cm)
BG-L	**Background**		59 in (150 cm)	68 in (173 cm)

The drainfield well was located on the lip of the drainfield mound. The background well and lysimeter were located near the boundary of the property, up gradient from the septic system. The median Cl concentration of the background lysimeter was chosen as the $Cl_{background}$ term in both the Cl dilution and TN attenuation calculations. The background well had Cl concentrations an order of magnitude greater than the concentrations in the background lysimeter (Table 24).

Table 24. Site WSS-4-2. The Cl and TN concentrations of the background well (BG Well) and the background lysimeter (BG-L). Concentrations of Cl and TN are given in mg/L and mg-N/L, respectively. The mean, standard deviation (SD), and median of the four sampling events are given.

WSS-4-2	BG Well		BG-L	
	Cl	**TN**	*Cl*	**TN**
2/27/09	*7.0*	**0.1**	*NS*	**NS**
6/18/09	*6.5*	**0.1**	*2.7*	**0.1**
10/02/09	*16.0*	**0.2**	*0.7*	**0.1**
12/18/09	*17.0*	**0.1**	*1.8*	**0.1**
mean	***11.6***	**0.1**	***1.7***	**0.1**
SD	*5.7*	0.0	*1.0*	0.0
median	**11.5**	**0.1**	***1.8***	**0.1**

The effluent TN from the FAST system at WSS-4-2 was also variable but generally lower than WSS-1-2, ranging from 1.3 to 27.2 mg-N/L. The fluctuating TN input into the drainfield makes any seasonal variation in the effectiveness of the drainfield difficult to discern (Figure 22).

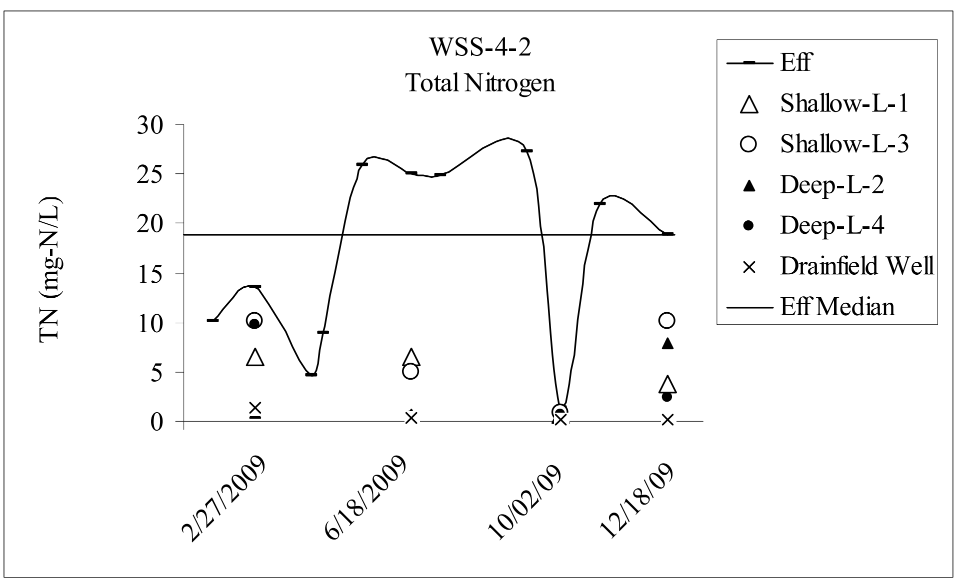


Figure 22. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and the drainfield well at site WSS-4-2. Sampling dates for effluent that included lysimeters and wells were 02/27/09, 06/18/09, 10/02/09, and 12/18/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

Calculations for TN reduction were made using the median of the effluent (Eff) TN concentrations. TN reduction includes the effect of dilution, while attenuation refers to the reduction without dilution. Table 25 shows the TN concentrations and the percent reduction of TN including any dilution. It is unclear why the TN effluent was so low (1.3 mg-N/L) during the 10/02/09 sampling event. The lysimeter and drainfield well values are even smaller indicating that loading to the drainfield was also reduced compared to other sampling events.

Table 25. The TN in mg-N/L and the percent TN reduction (Red) <u>including dilution</u> is given for each of the four sampling events and the median values for the PBTS effluent (Eff), the shallow lysimeters (S-L-1, S-L-3) and the deep lysimeters (D-L-2, D-L-4). The median TN of the effluent was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 11 effluent sampling events.

WSS-4-2	2/27/09		6/18/09		10/02/09		12/18/09		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
Eff	**13.5**	*28%*	**25.1**	*-33%*	**1.3**	*93%*	**18.9**	*0%*	**18.9**	*0%*
S-L-1	**6.5**	*66%*	**6.4**	*66%*	**0.7**	*96%*	**3.8**	*80%*	**5.1**	*73%*
S-L-3	**10.2**	*46%*	**4.9**	*74%*	**0.8**	*96%*	**10.2**	*46%*	**7.5**	*60%*
D-L-2	**0.9**	*95%*	**0.7**	*96%*	**0.4**	*98%*	**7.8**	*59%*	**0.8**	*96%*
D-L-4	**9.8**	*48%*	**0.5**	*97%*	**0.7**	*96%*	**2.4**	*87%*	**1.6**	*92%*
DF Well	**1.4**	*93%*	**0.3**	*98%*	**0.2**	*99%*	**0.1**	*99%*	**0.3**	*99%*

The TN/Cl ratios for the lysimeters and monitoring well over time are shown in Figure 23 and TN attenuation for each lysimeter and the well is summarized in Table 26. . During the February sampling event, the Cl data indicates the lysimeter samples were 0 to 10% diluted compared to the effluent and the drainfield well was diluted by 54%. Significant TN reduction was observed in all samples. Although the amount of dilution varies over the four sampling events, significant attenuation was observed in all samples. The median attenuation via denitrification and/or adsorption for this site was 78%.

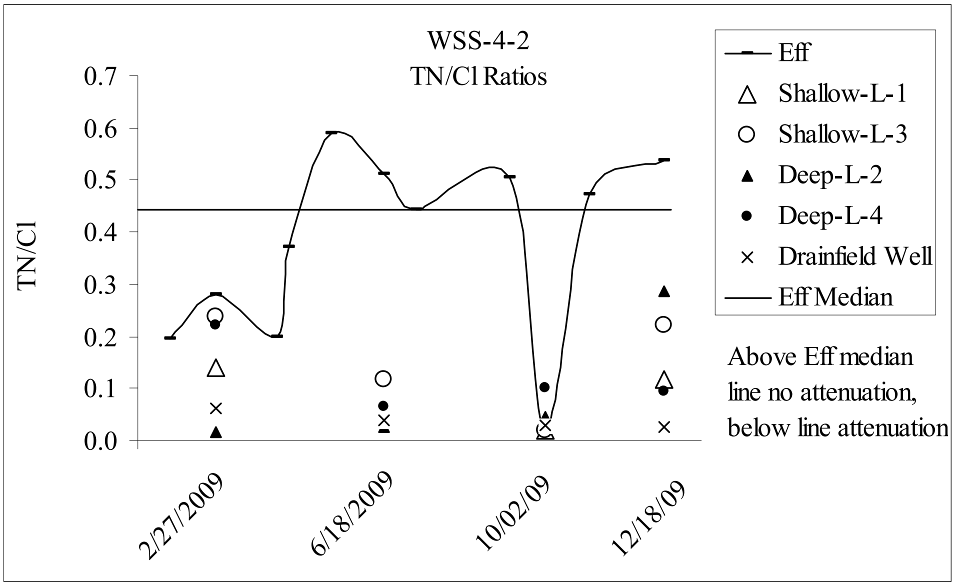


Figure 23. The TN/Cl ratios for the lysimeters and drainfield well at site WSS-4-2. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration of the 11 effluent samples. The graph is corrected for dilution.

Table 26. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given. Not enough sample was available for Cl analysis in S-L-1 on 06/01/09 and is indicated by NS.

WSS-4-2	2/27/09		6/18/09		9/28/09		12/15/09		Medians	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
S-L-1	**69%**	*4%*	**NS**	*NS*	**96%**	*25%*	**74%**	*33%*	**74%**	*25%*
S-L-3	**47%**	*10%*	**74%**	*12%*	**96%**	*10%*	**50%**	*4%*	**62%**	*10%*
D-L-2	**96%**	*0%*	**94%**	*45%*	**90%**	*84%*	**35%**	*43%*	**92%**	*44%*
D-L-4	**50%**	*8%*	**86%**	*84%*	**77%**	*85%*	**79%**	*48%*	**78%**	*66%*
DF Well	**86%**	*54%*	**91%**	*83%*	**93%**	*87%*	**94%**	*89%*	**92%**	*85%*

Site WSS-6-2

Site WSS-6-2 has a pressurized drip drainfield that is at grade, covered by a mowed lawn. The drip lines were 11-13 in (28-33 cm) below the soil surface in the location of the lysimeters. The shallow lysimeters were installed so the top of 9 inch (23 cm) cups were approximately 2 ft

(0.6 m) below the drip lines. Lysimeter S-L-5 was installed after the first sampling event. Installation details of the lysimeters and well are provided in Table 27.

Table 27. The depth from surface is given for the bottom of the drainfield (DF Bottom), the top of the lysimeter cup (Top of Cup) and the bottom of the lysimeter cup (Bottom of Cup)

WSS-6-2	Description	DF Bottom	Top of Cup	Bottom of Cup
S-L-2	**Shallow**	13 in (33 cm)	37 in (94 cm)	46 in (117 cm)
S-L-3	**Shallow**	11 in (28 cm)	35 in (89 cm)	44 in (112 cm)
S-L-5	**Shallow**	13 in (33 cm)	37 in (94 cm)	46 in (117 cm)
D-L-1	**Deep**	13 in (33 cm)	62 in (157 cm)	71 in (180 cm)
D-L-4	**Deep**	12 in (30 cm)	91 in (231 cm)	100 in (254 cm)
BG-L	**Background**		72 in (183 cm)	81 in (206 cm)

The drainfield well was located approximately 3m off the corner of drainfield. The background well and lysimeter were located up gradient from the septic system. Since no sample was obtained in S-L-2 on 02/26/09, this lysimeter was removed, and lysimeter S-L-5 was added prior to next sampling event.

The median Cl concentration of the background well was chosen as the $Cl_{background}$ term in both the Cl dilution and TN attenuation calculations. The background lysimeter had Cl concentrations that were higher and more variable (Table 28).

Table 28. Site WSS-6-2. The Cl and TN concentrations of the background well (BG Well) and the background lysimeter (BG-L). Concentrations of Cl and TN are given in mg/L and mg-N/L, respectively. The mean, standard deviation (SD), and median of the four sampling events are given.

WSS-6-2	BG Well		BG-L	
	Cl	**TN**	*Cl*	**TN**
02/26/09	*4.0*	**0.8**	*37*	**0.4**
06/17/09	*4.2*	**0.9**	*13*	**0.3**
09/29/09	*4.8*	**1.1**	*12*	**0.2**
12/16/09	*4.7*	**1.3**	*5.8*	**0.2**
mean	***4.4***	**1.0**	***17.0***	**0.3**
SD	*0.4*	0.2	*13.7*	0.1
median	***4.5***	**1.0**	***12.5***	**0.3**

The TN concentration in effluent from the HOOT PBTS system at WSS-6-2 was also variable but with a lower median STE TN concentration than both WSS-1-2 and WSS-4-2, ranging from 3.3 to 32.1 mg-N/L. The fluctuating TN input into the drainfield makes any seasonal variation in the effectiveness of the drainfield difficult to discern (Figure 24).

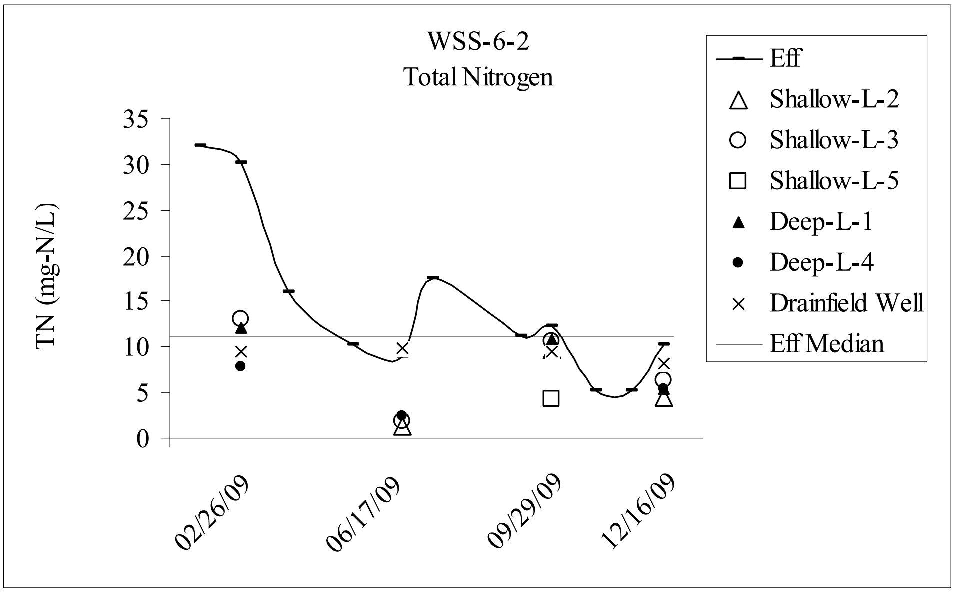


Figure 24. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and drainfield well at site WSS-6-2. Sampling dates for effluent that included lysimeters and wells were on 02/26/09, 06/17/09, 9/29/09, and 12/16/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

The fist two effluent TN concentrations were approximately 3 times higher the median value. The higher input concentrations during and prior to the February sampling event account for the negative percent TN reduction values in these samples (Table 29). Calculations for TN reduction and attenuation were made using the median effluent (Eff) TN and Cl values.

The drainfield well TN concentrations were relatively consistent over the four sampling events, ranging from 9.9 to 8.2 mg-N/L. The June sampling event had the highest drainfield well concentration, yet the lowest lysimeter concentrations of the samples.

Table 29. The TN in mg-N/L and the percent TN reduction (Red) including dilution is given for each of the four sampling events and the median values for the PBTS effluent (Eff), the shallow lysimeters (S-L-2, S-L-3, S-L-5), the deep lysimeters (D-L-1, D-L-4) and the drainfield well (DF Well). The median TN of the effluent was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 11 effluent sampling events. NS indicates not enough sample was in the lysimeter for TN analysis.

WSS-6-2	02/26/09		06/17/09		09/29/09		12/16/09		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
Eff	**30.1**	*-169%*	**9.0**	*20%*	**12.3**	*-10%*	**10.2**	*9%*	**11.2**	*0%*
S-L-2	**NS**		**1.3**	*89%*	**9.7**	*14%*	**4.5**	*59%*	**4.5**	*59%*
S-L-3	**13.1**	*-17%*	**1.9**	*83%*	**10.7**	*5%*	**6.3**	*44%*	**8.5**	*24%*
S-L-5	Not Installed		**1.0**	*91%*	**4.3**	*62%*	**NS**		**2.6**	*77%*
D-L-1	**12.1**	*-8%*	**NS**		**10.8**	*4%*	**5.5**	*51%*	**10.8**	*4%*
D-L-4	**7.9**	*29%*	**2.4**	*79%*	**9.5**	*15%*	**5.5**	*51%*	**6.7**	*40%*
DF Well	**9.4**	*16%*	**9.9**	*12%*	**9.4**	*16%*	**8.2**	*27%*	**9.4**	*16%*

The drainfield well had much higher TN/Cl ratios than the effluent and lysimeters (Figure 25). The Cl dilution percentages indicate 80% or greater dilution of the effluent (Table 30). An additional source of nitrogen, besides the septic system, may be contributing to TN in the drainfield well. Possible sources include fertilizer or the goat waste from the animal pen nearby.

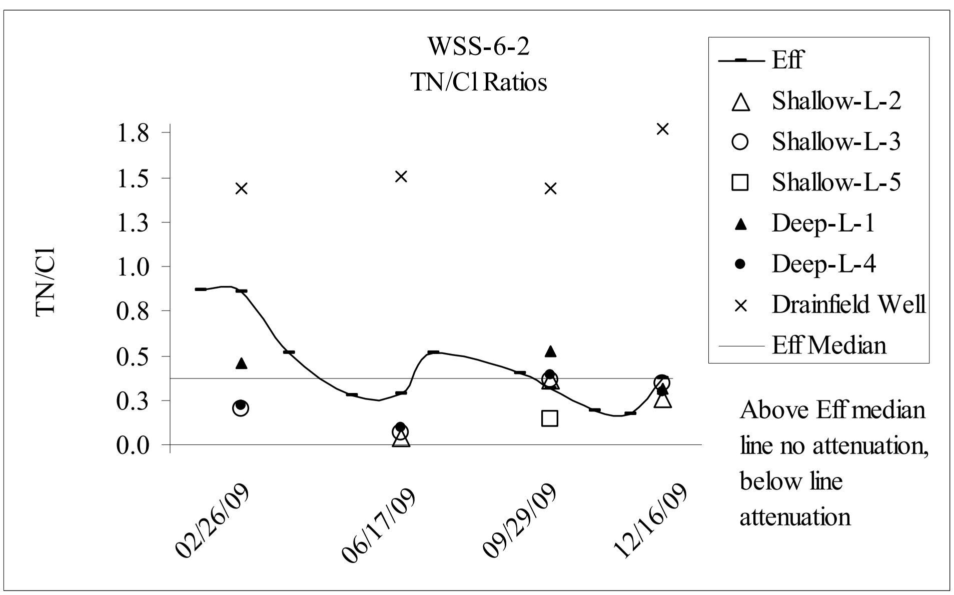


Figure 25. The TN/Cl ratios for the site WSS-6-2. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

Table 30. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios to account for dilution. The percent of Cl dilution (CL dil) is also given. NS indicates not enough sample was in the lysimeter for a sample.

WSS-6-2	2/26/09		6/17/09		9/29/09		12/16/09		Medians	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
S-L-2	NS		**89%**	*8%*	**3%**	*17%*	**31%**	*45%*	**31%**	***17%***
S-L-3	46%	*-102%*	**83%**	*11%*	**4%**	*8%*	**9%**	*42%*	**28%**	***9%***
S-L-5	**Not Installed**		**NS**		**61%**	*8%*	**NS**		**NA**	
D-L-1	**-21%**	*17%*	**NS**		**-39%**	*36%*	**17%**	*45%*	**-21%**	***36%***
D-L-4	**41%**	*-11%*	**74%**	*23%*	**-3%**	*23%*	**22%**	*42%*	**31%**	***23%***
DF Well	**-283%**	*80%*	**-301%**	*80%*	**-283%**	*80%*	**-372%**	*86%*	**-292%**	***80%***

The negative Cl dilution values observed on the 02/26/09 sampling event in two of the lysimeters indicate that the concentration of the effluent in Shallow-L-3 had twice as much Cl than the STE median. The Deep-L-4 had 10% more Cl than the STE median. Although the effluent TN values were higher than normal on and before the 02/26/09 sampling (Table 29), the effluent Cl values were within the range of the rest of the effluent samples. Using the lysimeter data, the overall median N attenuation by denitrification, adsorption or plant uptake for this site was 30%.

Site WSS-7-2

Site WSS-7-2 has a pressurized drip system at grade, covered by a mowed lawn. The drip lines are 10 in (25 cm) below the soil surface in the location of the lysimeters. The shallow lysimeters were installed so the top of 9 inch (23 cm) cups were approximately 2 ft (0.6 m) below the drip lines (Table 31).

Table 31. The depth from surface is given for the bottom of the drainfield(DF Bottom), the top of the lysimeter cup (Top of Cup) and the bottom of the lysimeter cup (Bottom of Cup)

WSS-7-2	Description	DF Bottom	Top of Cup	Bottom of Cup
S-L-1	**Shallow**	10 in (25 cm)	35 in (89 cm)	44 in (112 cm)
S-L-4	**Shallow**	10 in (25 cm)	35 in (89 cm)	44 in (112 cm)
D-L-2	**Deep**	10 in (25 cm)	79 in (201 cm)	88 in (224 cm)
D-L-3	**Deep**	10 in (25 cm)	79 in (201 cm)	88 in (224 cm)
BG-L	**Background**		69 in (198 cm)	78 in (175 cm)

Monitoring wells were not installed at this site because the top of limestone was above the water table and prevented well installation using the direct push system.

The median Cl concentration of the background lysimeter was used as the $Cl_{background}$ term in both the Cl dilution and TN attenuation calculations. Cl and TN concentrations in the background lysimeter are shown in Table 32.

Table 32. The Cl and TN concentrations of the background lysimeter (BG-L) at site WSS-7-2. A background well was not installed. Concentrations of Cl and TN are given in mg/L and mg-N/L, respectively. The mean, standard deviation (SD), and median of the four sampling events are given.

	BG-L	
	Cl	**TN**
02/26/09	*7.9*	**0.2**
06/17/09	*2.5*	**1.6**
10/01/09	*3.1*	**0.6**
12/17/09	*3.1*	**0.2**
mean	***4.2***	**0.7**
SD	*2.5*	0.6
median	***3.1***	**0.4**

The effluent TN concentrations from the Norweco PBTS system at WSS-7-2 were variable, with a median STE TN concentration ranging from 12.0 to 71.3 mg-N/L (Figure 26). This was similar to WSS-1-2. The fluctuating TN input into the drainfield makes it difficult to discern any seasonal differences in the effectiveness of the drainfield. Calculations for TN reduction and attenuation were made using the median effluent (Eff) TN and Cl values.

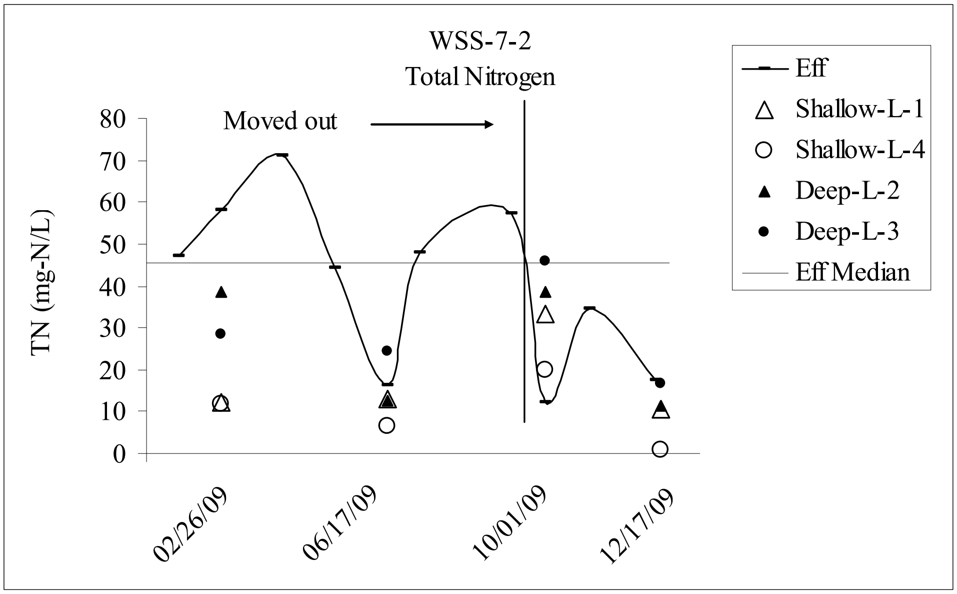


Figure 26. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and drainfield well at site WSS-7-2. Sampling dates for effluent that included lysimeters and wells were on 02/26/09, 06/17/09, 10/01/09, and 12/17/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

At this site, the residents moved out of the house sometime between the 09/08/09 effluent sampling and the 10/02/09 sampling event. The system was not in operation on 10/02/09 and was in operation only intermittently between then and the 12/17/09 sampling event. These fluctuations drop off in effluent concentration are reflected in the data (Table 33).

Table 33. The TN in mg-N/L and the percent TN reduction (Red) including dilution are given for each of the four sampling events and the median values for the PBTS effluent (Eff), the shallow lysimeters (S-L-2, S-L-3, S-L-5) and the deep lysimeters (D-L-1, D-L-4). The median TN of the effluent was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 11 effluent sampling events.

WSS-7-2	2/26/09		6/17/09		10/01/09		12/17/09		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
Eff	**58.0**	*-27%*	**16.3**	*64%*	**12.0**	*74%*	**17.4**	*62%*	**45.6**	*0%*
S-L-1	**12.2**	*73%*	**12.9**	*72%*	**33.1**	*27%*	**10.5**	*77%*	**12.6**	*72%*
S-L-4	**12.0**	*74%*	**6.5**	*86%*	**20.0**	*56%*	**0.9**	*98%*	**9.2**	*80%*
D-L-2	**38.7**	*15%*	**12.7**	*72%*	**38.6**	*15%*	**11.5**	*75%*	**25.7**	*44%*
D-L-3	**28.4**	*38%*	**24.5**	*46%*	**45.7**	*0%*	**16.7**	*63%*	**26.5**	*42%*

On each sampling of the lysimeters, the deep lysimeters had higher concentrations of TN than the shallow lysimeters. Cl was greatly reduced in shallow lysimeters in the December, showing effect of system not being in use since last sampling. The overall median value for TN attenuation for this system (other than by dilution), not counting the December measurements, was negative 6%. Thus, essentially, the system displayed no TN attenuation except by dilution. The TN/CL ratios and the percent TN attenuation are shown in Figure 27 and Table 34, respectively.

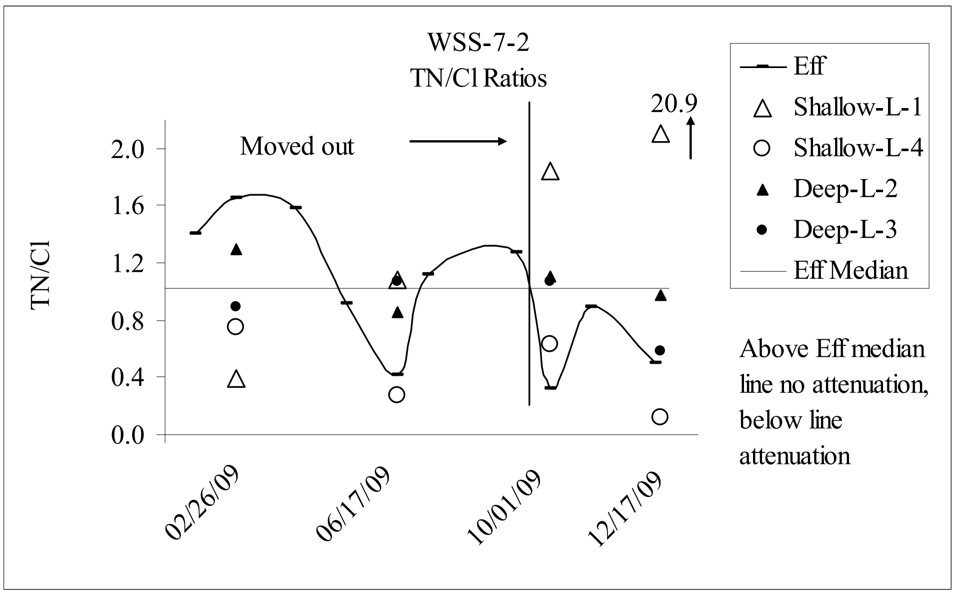


Figure 27. The TN/Cl ratios for the site WSS-7-2. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

Table 34. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given. <u>Since the house was unoccupied, the 12/17/09 sample values were not used in calculating the median values.</u>

WSS-7-2	2/26/09		6/17/09		10/01/09		12/17/09		Medians	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
S-L-1	**61%**	*21%*	**-7%**	*69%*	**-82%**	*54%*	**-1954%**	*99%*	**-7%**	*54%*
S-L-4	**26%**	*59%*	**73%**	*39%*	**38%**	*18%*	**89%**	*80%*	**38%**	*39%*
D-L-2	**-27%**	*23%*	**16%**	*62%*	**-9%**	*11%*	**5%**	*69%*	**-9%**	*23%*
D-L-3	**13%**	*18%*	**-5%**	*41%*	**-5%**	*-10%*	**43%**	*26%*	**-5%**	*18%*

One of the advantages of a pressurized drip dispersal drainfield is that the effluent is dispersed evenly though out the drainfield. Even with this even dispersion, the lysimeter data for all of the drip systems showed considerable spatial variability in both the TN concentrations and percent attenuation. There is also much variability between sample dates at the same lysimeter. It is difficult to make strong conclusions because of the intermittent operation of this system.

4.2 TN Attenuation in Phase II PBTS with conventional drainfields

The conventional drainfields at cooperating sites used in Phase II of this study were all Infiltrator® chamber systems. Infiltrator system drainfields are high density polyethylene arches that interlock to form a continuous drainage area which is open on the bottom. When STE is discharged from a PBTS to a conventional drainfield, it flows into a distribution box and flows down 2-4 chamber lines. The drainfields at the study sites are all relatively new. The greatest amount of the infiltration in newer drainfields occurs at the end closest to the distribution box, but as they age and the underlying soils start to become less permeable near the discharge point, more of the effluent infiltrates further down the chambers. Not knowing where the greatest amount of infiltration occurs can make it difficult to properly locate lysimeters and wells, which is much more difficult than the systems with pressurized drip dispersal systems where infiltration is uniform. It was difficult to obtain representative data beneath the conventional drainfields for this reason. At all three sites with conventional drainfields, the lysimeters had to be relocated after the first sampling round indicated that they were not sampling the main effluent plume.

Site WSS-2-2

Site WSS-2-2 has a conventional drainfield system that is at grade, covered by a mowed lawn. The bottom of the drainfield chambers is 18-19 in (46-48 cm) below the soil surface in the location of the lysimeters. The shallow lysimeters were installed so the top of the 9 inch (23 cm) cups were approximately 2 ft (0.6 m) below the drip lines (Table 35). During the February sampling event, lysimeters S-L-1, D-L-2, and D-L-3 did not have enough water for a sample and were moved and re-numbered prior to the June sampling event. An additional shallow lysimeter (S-L-6) was also installed.

Table 35. The depth from surface is given for the bottom of the drainfield(DF Bottom), the top of the lysimeter cup (Top of Cup) and the bottom of the lysimeter cup (Bottom of Cup)

WSS-2-2	Description	DF Bottom	Top of Cup	Bottom of Cup
S-L-1	**Shallow**	18 in (46 cm)	42 in (107 cm)	51 in (130 cm)
S-L-4	**Shallow**	19 in (48 cm)	43 in (132 cm)	52 in (132 cm)
D-L-2	**Deep**	18 in (46 cm)	65 in (165 cm)	74 in (188 cm)
D-L-3	**Deep**	19 in (48 cm)	91 in (231 cm)	100 in (254 cm)
S-L-5	**Shallow**	19 in (48 cm)	43 in (132 cm)	52 in (132 cm)
S-L-6	**Shallow**	19 in (48 cm)	43 in (132 cm)	52 in (132 cm)
D-L-7	**Deep**	18 in (46 cm)	54 in (160 cm)	63 in (160 cm)
D-L-8	**Deep**	18 in (46 cm)	54 in (160 cm)	63 in (160 cm)
BG-L	**Background**		66 in (168 cm)	75 in (191 cm)

The background well and lysimeter for site WSS-1-2 were also used for site WSS-2-2 also, since the two sites were in close proximity. Table 20 gives the Cl and TN concentrations in the background lysimeter and well used for sites WSS-1-2 and WSS-2-2. The median Cl concentration of the background well was chosen as the $Cl_{background}$ term in both the Cl dilution and TN attenuation calculations. The background lysimeter had Cl concentrations that were higher and more variable (Table 20).

The effluent TN from the FAST PBTS system at WSS-2-2 was relatively consistent compared to the other sites, ranging from 20.8 to 28.9 mg-N/L (Figure 28). Calculations for TN reduction and attenuation were made using the median effluent (Eff) TN and Cl values. This information is provided in Table 36. During the late September sampling event, the lysimeters S-L-5, S-L-6, D-L-7, and D-L-8 had TN concentrations higher than the measured effluent and median effluent.

No attenuation relative to the median effluent TN/Cl ratio was observed in the drainfield well during the four sampling events. Lysimeter samples are very similar to the effluent concentration and show little dilution. The overall TN attenuation at this site was -5%. Essentially the site showed no evidence for N-attenuation via processes other than dilution. This can be seen in Figure 29 and Table 37.

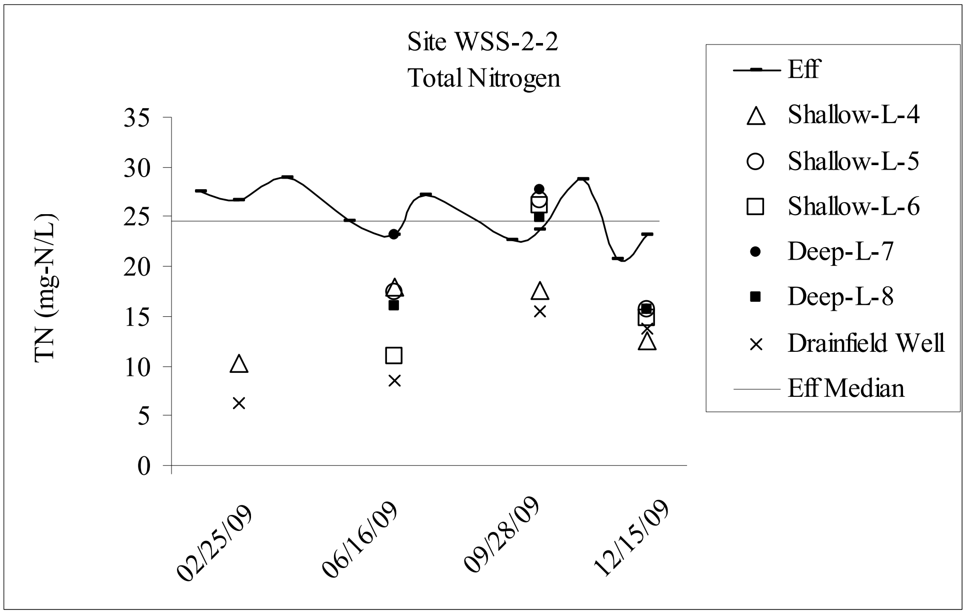


Figure 28. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and drainfield well at site WSS-2-2. Sampling dates for effluent that included lysimeters and wells were on 02/25/09, 06/16/09, 09/28/09, and 12/15/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

Table 36. The TN in mg-N/L and the percent TN reduction (Red) including dilution is given for each of the four sampling events and the median values for the PBTS effluent (Eff), the shallow lysimeters (S-L-4, S-L-5, S-L-6) and the deep lysimeters (D-L-7, D-L-8). The median TN of the effluent was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 11 effluent sampling events.

WSS-2-2	2/25/09		6/16/09		9/28/09		12/15/09		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
Eff	**26.7**	*-9%*	**23.1**	*6%*	**23.7**	*3%*	**23.1**	*6%*	**24.5**	*0%*
S-L-4	**10.4**	*58%*	**18.0**	*27%*	**17.7**	*28%*	**12.6**	*49%*	**15.1**	*38%*
S-L-5	Not Installed		**17.5**	*29%*	**26.7**	*-9%*	**15.8**	*36%*	**17.5**	*29%*
S-L-6	Not Installed		**10.9**	*56%*	**26.1**	*-7%*	**14.8**	*40%*	**14.8**	*40%*
D-L-7	Not Installed		**23.1**	*6%*	**27.6**	*-13%*	**15.6**	*36%*	**23.1**	*6%*
D-L-8	Not Installed		**16.1**	*34%*	**24.9**	*-2%*	**15.7**	*36%*	**16.1**	*34%*
DF Well	**6.3**	*74%*	**8.6**	*65%*	**15.4**	*37%*	**13.8**	*44%*	**11.2**	*54%*

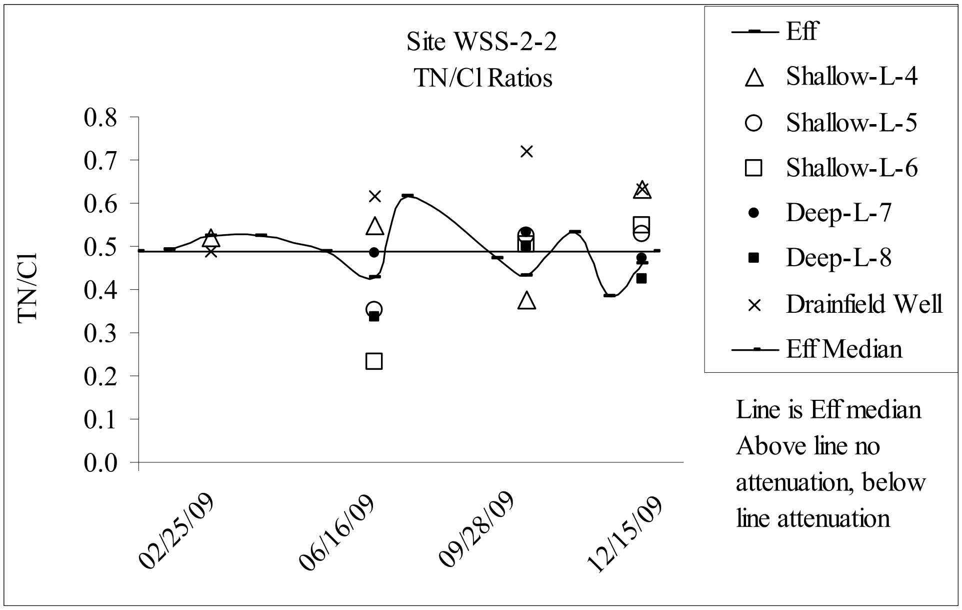


Figure 29. The TN/Cl ratios for the site WSS-2-2. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

Table 37. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given.

WSS-2-2	2/25/09		6/16/09		9/28/09		12/15/09		Medians	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
S-L-4	-3%	62%	**-11%**	*39%*	**23%**	*14%*	**-31%**	*64%*	**-9%**	*51%*
S-L-5	Not Installed		**29%**	*7%*	**-7%**	*6%*	**-9%**	*45%*	**-7%**	*8%*
S-L-6	Not Installed		**53%**	*13%*	**-3%**	*4%*	**-13%**	*51%*	**-3%**	*13%*
D-L-7	Not Installed		**2%**	*11%*	**-9%**	*4%*	**2%**	*40*	**2%**	*11%*
D-L-8	Not Installed		**32%**	*11%*	**-2%**	*8%*	**13%**	*32*	**13%**	*11%*
DF Well	5%	75%	**-24%**	*74%*	**-48%**	*61%*	**-31%**	*60%*	**-27%**	*67%*

Site WSS-3-2

Site WSS-3-2 has a conventional drainfield system that is at grade and covered by a mowed lawn. The bottoms of the drainfield chambers are 29 in (74 cm) below the soil surface in the location of the lysimeters. The shallow lysimeters were installed so the top of the 9 inch (23 cm) cups were approximately 2 ft (0.6 m) below the drainfield chambers (Table 38). The results from the February sampling event indicated that the lysimeters were not in the main septic plume. For the three lysimeters with samples, the TN concentrations were less than 2 mg-N/L and Cl was diluted by 77 to 93%. All four lysimeters were moved prior to the June sampling event in an attempt to find the portion of the drainfield receiving effluent.

Table 38. The depth from surface is given for the bottom of the drainfield(DF Bottom), the top of the lysimeter cup (Top of Cup) and the bottom of the lysimeter cup (Bottom of Cup)

WSS-3-2	Description	DF Bottom	Top of Cup	Bottom of Cup
S-L-2	**Shallow**	29 in (74 cm)	55 in (140 cm)	64 in (163 cm)
S-L-4	**Shallow**	29 in (74 cm)	55 in (140 cm)	64 in (163 cm)
D-L-1	**Deep**	29 in (74 cm)	91.5 in (232 cm)	100.5 in (255 cm)
D-L-3	**Deep**	29 in (74 cm)	92 in (234 cm)	101 in (257 cm)
S-L-6	**Shallow**	29 in (74 cm)	55 in (140 cm)	64 in (163 cm)
S-L-8	**Shallow**	29 in (74 cm)	55 in (140 cm)	64 in (163 cm)
D-L-5	**Deep**	29 in (74 cm)	91.5 in (232 cm)	100.5 in (255 cm)
D-L-7	**Deep**	29 in (74 cm)	92 in (234 cm)	101 in (257 cm)
BG-L	**Background**		69 in (175 cm)	78 in (198 cm)

The background well and lysimeter were located next to an empty parcel near the road of the residence. This site is in Wakulla Gardens, an area with high density (1/8 acre) lots. The drainfield well had lower TN and Cl than the background well. This indicates that the drainfield well was not sampling the septic plume. The background well TN values at this site, 1.8 ± 1.0 mg-N/L, n=4 were much higher than background at sites WSS-1-2 and site WSS-4-2. Table 39 gives the Cl and TN concentrations in the background lysimeter and well used at site WSS-3-2.

Table 39. The Cl and TN concentrations of the background well (BG Well, the background lysimeter (BG-L), and the lysimeter located off the drainfield mound (OM-L), next to the drainfield well. Concentrations of Cl and TN are given in mg/L and mg-N/L, respectively. The mean, standard deviation (SD), and median of the four sampling events are given.

WSS-3-2	Background Well		Background-L		Drainfield Well	
	Cl	**TN**	*Cl*	**TN**	*Cl*	TN
2/27/2009	*14*	**2.1**	*30*	**0.4**	*10*	**0.5**
6/19/2009	*18*	**0.3**	*NS*	**0.4**	*11*	**0.7**
09/29/09	*21*	**2.2**	*NS*	**1.2**	*13*	**1.3**
12/16/09	*19*	**2.6**	*11*	**0.2**	*13*	**1.6**
Mean	***18.0***	**1.8**	***20.5***	**0.5**	***11.6***	**1.1**
SD	*2.9*	1.0	*13.4*	0.5	*1.4*	0.5
Median	***18.5***	**2.1**	***20.5***	**0.4**	***11.8***	**1.0**

The median Cl concentration of the drainfield well was chosen as the $Cl_{background}$ term in both the Cl dilution and TN attenuation calculations for the lysimeter samples.

The effluent TN from the Norweco PBTS system at WSS-3-2 was variable throughout the study (Figure 30). During 3 of the 11 effluent sampling events, the system was not functioning properly. Calculations for TN reduction and attenuation are made using the median effluent (Eff) TN and Cl values. Values calculated for TN reduction are shown in Table 40.

Attenuation of TN, as represented by TN/CL rations are show in Figure 31 ant Table 40. Insufficient volumes of water were in the Deep Lysimeters during the June and September sampling events. On the 09/28/09 sampling event S-L-6 had enough sample for nitrogen analysis but not for chloride. Only lysimeter S-L-6 had enough sample for analysis on 06/19/09, and no chloride samples could be collected from any of the lysimeters on 09/29/09. The drainfield well had lower concentrations of both TN and Cl than the background well, and therefore monitoring well data were not used in the TN/Cl data analysis. The median TN attenuation via denitrification, adsorption or plant uptake at this site was 32%.

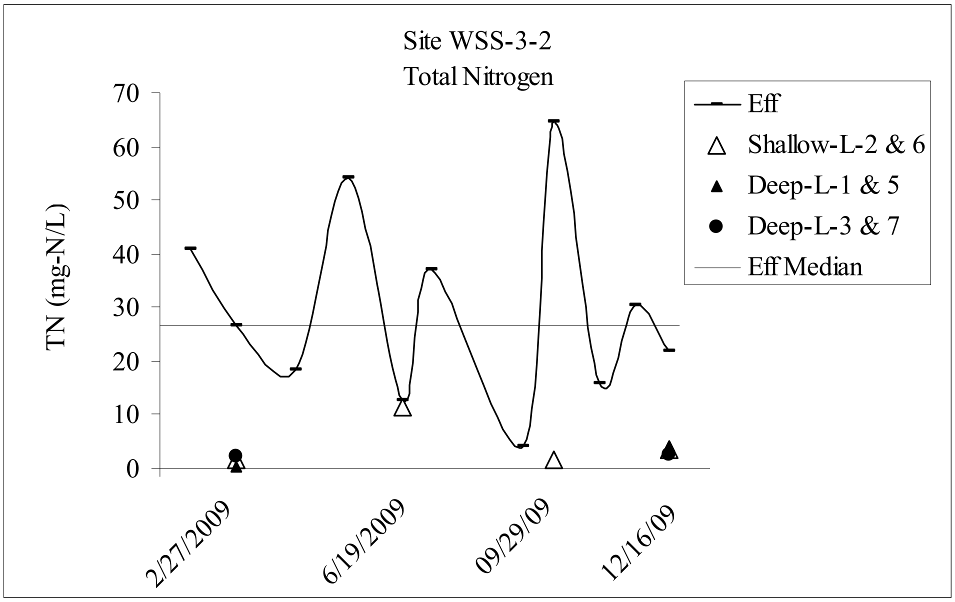


Figure 30. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and drainfield well at site WSS-3-2. Sampling dates for effluent that included lysimeters and wells were 02/27/09, 06/196/09, 09/29/09, and 12/16/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

Table 40. The TN in mg-N/L and the percent TN reduction (Red) <u>including dilution</u> is given for each of the four sampling events and the median values for the PBTS effluent (Eff) and lysimeters. The lysimeters S-L-2, D-L-1, and D-L-3 were relocated and renumbered prior to the 06/16/09 sampling as S-L-6, D-L-5, and D-L-7, respectively. The median TN of the effluent was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 11 effluent sampling events.

WSS-3-2	2/27/09		6/19/09		9/29/09		12/16/09		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
Eff	**26.6**	*0%*	**12.7**	*52%*	**64.7**	*-143%*	**21.7**	*18%*	**26.6**	*0%*
S-L-2 or 6	**1.6**	*94%*	**11.4**	*57%*	**1.6**	*94%*	**3.6**	*87%*	**3.6**	*90%*
D-L-1 or 5	**0.4**	*98%*	**NS**		**NS**		**4.2**	*84%*	**NA**	
D-L-3 or 7	**2.2**	*92%*	**NS**		**NS**		**2.5**	*90%*	**NA**	
DF Well	**0.5**	*98%*	**0.7**	*97%*	**1.3**	*95%*	**1.6**	*94%*	**1.0**	*96%*

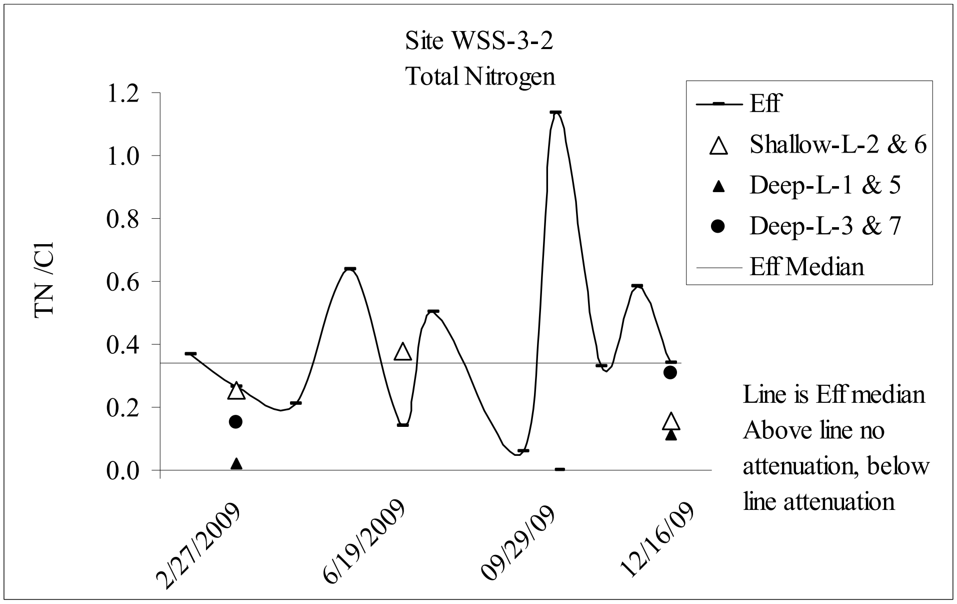


Figure 31. The TN/Cl ratios for site WSS-3-2. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

Table 41. The percent TN attenuation (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given. The median TN attenuation and Cl dilution are calculated from the medians of the TN and Cl values and are not the medians of the given TN Attenuation and Cl dilution.

WSS-3-2	2/27/2009		6/19/2009		12/16/2009		**Medians**	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN att**	*Cl dil*
Shallow-L-2 & 6	**25%**	*93%*	**-11%**	*65%*	**54%**	*73%*	**25%**	73%
Deep-L-1 & 5	**94%**	*77%*	NS		**66%**	*58%*	**80%**	68%
Deep-L-3 & 7	**55%**	*84%*	NS		**9%**	*90%*	**32%**	87%

Site WSS-5-2

Site WSS-5-2 has a mounded conventional drainfield system covered by a mowed lawn. The bottom of the drainfield chambers are 21 in (53 cm) below the soil surface in the location of the lysimeters. The shallow lysimeters were installed so the top of 9 inch (23 cm) cups were approximately 2 ft (0.6 m) below the drainfield (Table 42). During the February sampling event, lysimeters S-L-1, S-L-3, and S-L-4 had barely enough water for a sample. In an effort to find an area of the drainfield with more effluent, these three lysimeters were moved and re-numbered. Limestone prevented the installation of deeper lysimeters and each lysimeter was placed so the top of the cup was 45 in (114 cm) below the ground surface and the bottom of the cup at 54 in (137 cm).

Table 42. The depth from surface is given for the bottom of the drainfield(DF Bottom), the top of the lysimeter cup (Top of Cup) and the bottom of the lysimeter cup (Bottom of Cup)

WSS-5-2	Description	DF Bottom	Top of Cup	Bottom of Cup
S-L-1	**Shallow**	21 in (53 cm)	45 in (114 cm)	54 in (137 cm)
S-L-2	**Shallow**	21 in (53 cm)	45 in (114 cm)	54 in (137 cm)
S-L-3	**Shallow**	21 in (53 cm)	45 in (114 cm)	54 in (137 cm)
S-L-4	**Shallow**	21 in (53 cm)	45 in (114 cm)	54 in (137 cm)
S-L-5	**Shallow**	21 in (53 cm)	45 in (114 cm)	54 in (137 cm)
S-L-6	**Shallow**	21 in (53 cm)	45 in (114 cm)	54 in (137 cm)
S-L-7	**Shallow**	21 in (53 cm)	45 in (114 cm)	54 in (137 cm)
BG-L	**Background**		37 in (94 cm)	46 in (117 cm)

The Cl concentrations in the background well were higher than both the background lysimeter and the drainfield well (Table 43). The elevated Cl in the background well may have been the result of the homeowner washing off the salt (with bleach?) from his boats and other equipment after returning from the coast, in the area near the background well. The median Cl concentration of the background lysimeter was chosen as the $Cl_{background}$ term in both the Cl dilution and TN attenuation calculations.

Table 43. The Cl and TN concentrations of the background well (BG Well), the background lysimeter (BG-L), and the lysimeter located off the drainfield mound (OM-L), next to the drainfield well. Concentrations of Cl and TN are given in mg/L and mg-N/L, respectively. The mean, standard deviation (SD), and median of the four sampling events are given.

WSS-5-2	Background Well		Background-L		Drainfield Well	
	Cl	**TN**	*Cl*	**TN**	*Cl*	TN
2/26/2009	*20*	**0.2**	*7.6*	**0.2**	*8.4*	**3.1**
6/18/2009	*17*	**0.2**	*3.8*	**0.2**	*8.8*	**2.7**
10/01/09	*16*	**0.2**	*2.8*	**0.2**	*9.8*	**3.4**
12/17/09	*13*	**0.2**	*5.5*	**0.1**	*7.2*	**1.0**
mean	***16.5***	**0.2**	***4.9***	**0.2**	***8.5***	**2.5**
SD	*2.9*	0.0	*2.1*	0.0	*1.1*	1.0
median	***16.5***	**0.2**	***4.7***	**0.2**	***8.6***	**2.9**

Total nitrogen concentrations in the effluent, lysimeters and drainfield well are plotted in Figure 32 and the reduction in TN concentrations calculated for the various sampling points are shown in Table 43.

The TN/Cl values plotted for the monitoring points over time are presented in Figure 33. At this site TN reduction ranged from 70% to 91% but this was due to considerable dilution (Table 45). Excluding dilution, TN attenuation ranged from 8% to 76%. The median value for this site was 31%.

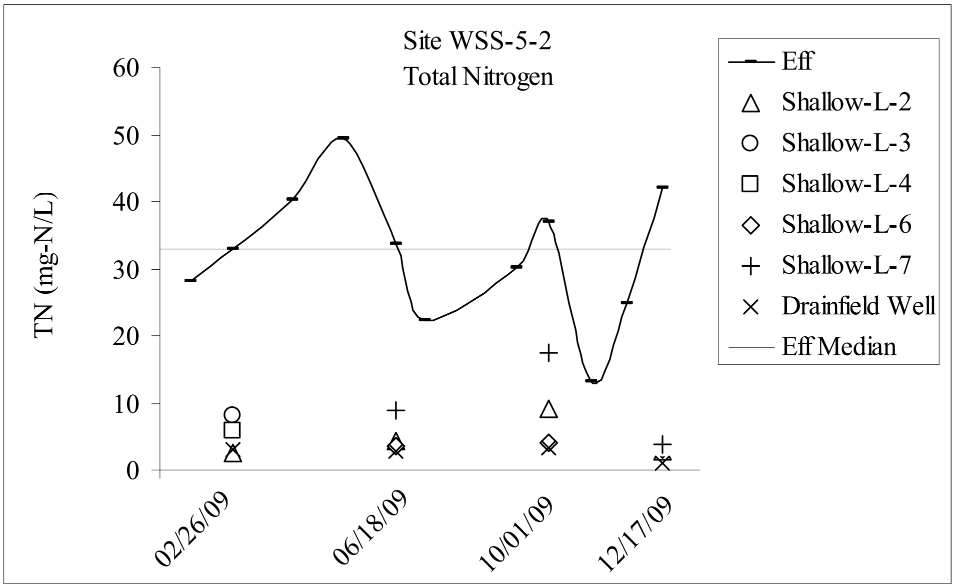


Figure 32. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and drainfield well at site WSS-5-2. Sampling dates for effluent that included lysimeters and wells were on 02/26/09, 06/18/09, 10/01/09, and 12/17/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

Table 44. The TN in mg-N/L and the percent TN reduction(Red) including dilution is given for each of the four sampling events and the median values for the PBTS effluent (Eff), the shallow lysimeters (S-L-2, S-L-3, S-L-5) and the deep lysimeters (D-L-1, D-L-4). The median TN of the effluent was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 11 effluent sampling events.

WSS-5-2	2/26/09		6/18/09		10/01/09		12/17/09		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
Eff	**33.0**	*0%*	**33.6**	*-2%*	**37.0**	*-12%*	**42.0**	*-27%*	**33.0**	*0%*
S-L-2	**2.7**	*92%*	**4.3**	*87%*	**9.2**	*72%*	**2.7**	*92%*	**3.5**	*89%*
S-L-3	**8.1**	*76%*	Removed							
S-L-4	**5.7**	*83%*	Removed							
S-L-5	Not Installed		**9.9**	*70%*	**12.8**	*61%*	**5.1**	*85%*	**9.9**	*70%*
S-L-6	Not Installed		**3.6**	*89%*	**4.0**	*88%*	**3.1**	*91%*	**3.6**	*89%*
S-L-7	Not Installed		**8.9**	*73%*	**17.5**	*47%*	**3.7**	*89%*	**8.9**	*73%*
DF Well	**3.1**	*91%*	**2.7**	*92%*	**3.4**	*90%*	**1.0**	*97%*	**2.9**	*91%*

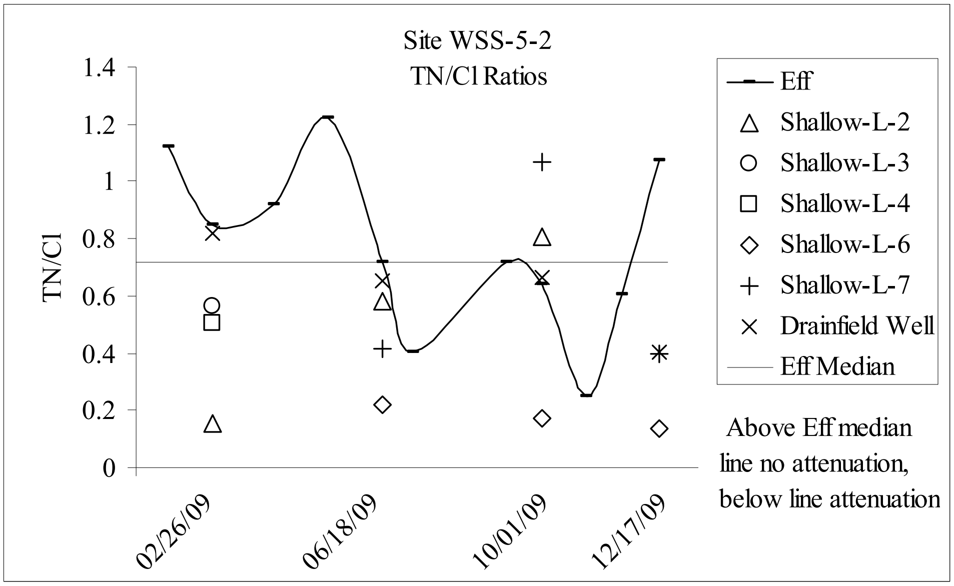


Figure 33. The TN/Cl ratios for the site WSS-5-2. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

Table 45. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given. The median TN attenuation and Cl dilution are calculated from the medians of the TN and Cl values and are not the medians of the given TN Attenuation and Cl dilution.

WSS-5-2	2/26/09		6/17/09		10/01/09		12/17/09		Medians	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
S-L-2	**79%**	*59%*	**19%**	*83%*	**-12%**	*73%*			**19%**	*73%*
S-L-3	**22%**	*66%*	Removed							
S-L-4	**30%**	*73%*	Removed							
S-L-5	Not Installed		**NS**		**-24%**	*66%*	**32%**	*75%*		
S-L-6	Not Installed		**70%**	*61%*	**76%**	*44%*	**81%**	*47%*	**76%**	*47%*
S-L-7	Not Installed		**42%**	*49%*	**-49%**	*61%*	**45%**	*78%*	**42%**	*61%*
DF Well	**-14%**	*91%*	**9%**	*90%*	**8%**	*88%*	**44%**	*94%*	**8%**	*91%*

4.3 TN Attenuation in Phase I Drainfields of Conventional Septic Systems.

The three septic systems studied in Phase I all had conventional septic tanks with at grade conventional drainfields. A full report on Phase I of this study can be found in Katz, et al, 2010. The purpose of including the Phase I data in this report is to allow comparison between the results of Phase I and Phase II studies using the same data analysis techniques.

The lysimeters in Phase 1 were of a similar design as in Phase II, using the same type of 10 inch porous cups. However in Phase I, copper tubing was used instead of PVC pipe and a different manner of attaching the lysimeter cup to the body was employed. Two short lysimeters were installed at each of the three sites so that the 10 in. lysimeter cup was at depth of 36 to 46 inches (92-118 cm) below the surface. At this depth the top of the lysimeter cup was directly beneath the bottom of the drainfield. The long lysimeters were installed so the lysimeter cup was 66 to 76 inches (168-194 cm) below surface. Although four lysimeters were installed at each site, 2 shallow and 2 deep, the two shallow lysimeters were combined into one sample and the two lysimeters were combined for one sample. This was done because of the large sample volume needed for other the parameters being measured by USGS in Phase I.

Phase I Site HK

The HK system served 4 residents and the house was constructed in the 1970s. After the first sampling on 12/17/07, the old drainfield was replaced in January 2008 due to drainfield failure. The new drainfield was in another area of the lot and Infiltrator chambers were installed. The area of the new drainfield was seeded with rye grass that was fertilized with a few handfuls of fertilizer, as reported by the homeowner. Both shallow and deep lysimeters were installed in the new drainfield, while at the old drainfield only shallow lysimeters were installed due to proximity of clay and limestone to the surface in that area. In May 2008, the area was re-seeded with summer grass and approximately 2.3 kg of 10-10-10 fertilizer was applied by the home owner. Additionally, more of the same fertilizer (less than 2 kg) was applied to the garden adjacent to drainfield. The depth of water table during the study ranged from 8.5 to 8.9 ft (2.6 to 2.7 m). The average daily water use during the study period for this site was 430 g/day (1,630 L/d), although after the drainfield was replaced conservation measures reduced the amount of water discharged to the septic system. Figure 34 is a plot of the TN concentrations in the lysimeters and drainfield wells at the HK site.

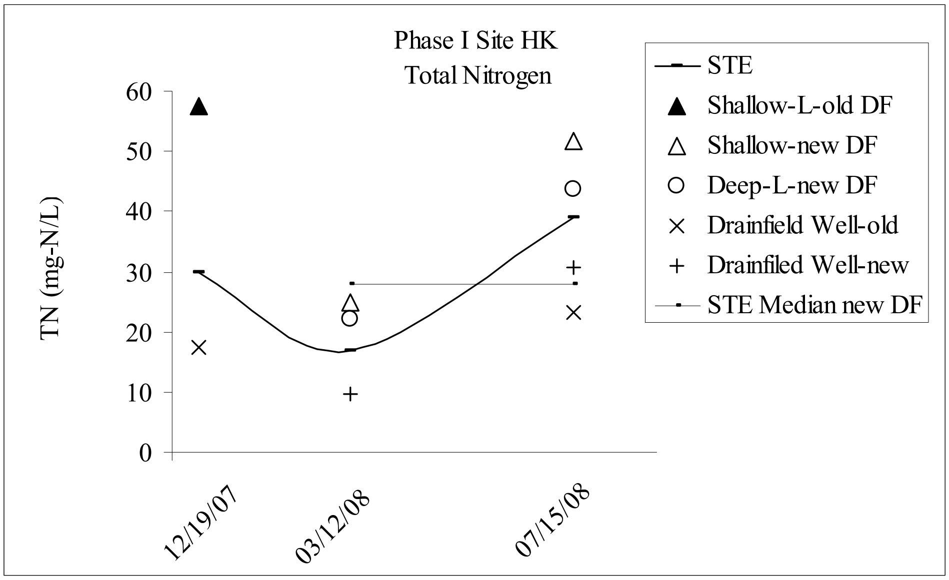


Figure 34. The TN concentrations are given for the Septic Tank Effluent (STE), lysimeters and drainfield well at the Phase I site HK. This graph includes the effect of dilution. After the 12/19/07 sampling event the drainfield at this site was replaced. Both the new and old drainfield wells were sampled on 07/15/08. TN concentrations are in mg-N/L.

The TN concentrations of STE (28.0 ± 15.6 mg-N/L) were about half what is typically found discharged from a conventional septic tank. The higher than average water use most likely diluted the effluent stream. The calculated percent reductions in TN at the various sampling points at this site are shown in Table 46.

Table 46. The TN in mg-N/L and the percent TN reduction (Red) including dilution for the STE, lysimeters and drainfield well is given for each of the three sampling events. The drainfield was replaced after the 12/19/07 sampling event. The TN reduction for 12/19/07 is calculated from the STE TN concentration on that date. The TN reduction for the 03/12/08 and 07/15/08 sampling events was calculated from the average of those two STE measurements.

HK Phase I	**12/19/07**		**03/12/08**		**07/15/08**	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*
STE	**30.0**	*0%*	**17.0**	*39%*	**39.0**	*-39%*
Shallow-L	**57.4**	*-105%*	**25.0**	*11%*	**51.6**	*-84%*
Deep-L			**22.1**	*21%*	**43.6**	*-56%*
DF Well	**17.5**	*38%*	**9.7**	*66%*	**30.6**	*-9%*

The TN concentration in the lysimeters was higher than the measured STE TN concentration on each sampling event. For the 12/19/07 data this was most likely due to the fact that the drainfield was failing in December 2007. On 03/12/08, the STE TN was exceptionally low, less than a third the typical concentration of 60 mg-N/L. Although larger than the measured STE, the lysimeters had TN concentrations of approximately half the concentrations measured on 12/19/07 and 07/15/08. The high TN concentrations measured on 07/15/08 are most likely the result of fertilizer application in May, 2008. The TN/Cl ratios for these samples are plotted in Figure 35.

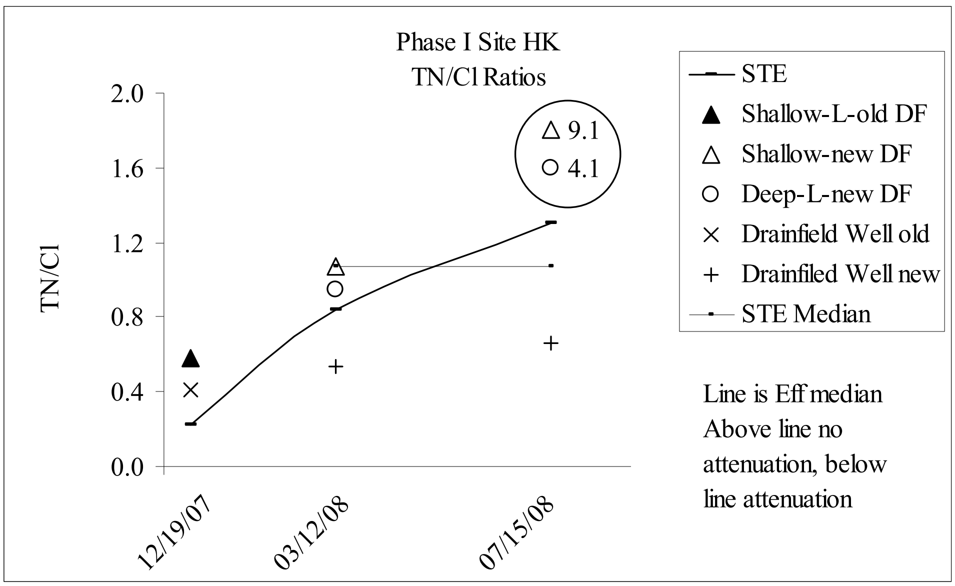


Figure 35. The TN/Cl ratios for site HK. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

The very high TN/Cl ratios in the lysimeters observed on 07/15/08 is most likely due to the addition of fertilizer two months prior. The higher ratio in the shallow lysimeter, indicating a greater increase of TN relative to Cl, supports this as the nitrogen was consumed as it moved downward in the soil. This sh shown in calculated values in Table 47. It is difficult to use the results of this site due to the fertilizer applications. TN was consistently in the lysimeters at higher concentrations than in the STE.

Table 47. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given. The median TN attenuation and Cl dilution are calculated from the medians of the TN and Cl values and are not the medians of the given TN Attenuation and Cl dilution.

HK Phase I	**12/18/07**		**03/13/08**		**07/16/08**	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
Shallow-L	**-161%**	*27%*	**0%**	*7%*	**-745%**	*77%*
Deep-L			**12%**	*7%*	**-279%**	*57%*
DF Well	**-102%**	*71%*	**39%**	*41%*	**33%**	*-71%*

Phase I Site LT

Site (LT) had two to three adult residents who had lived in the house since it was built in 1987. The household utilized the original septic tank and drainfield. The current residents of the house had applied no fertilizers. Depth to groundwater ranged from 3.0-3.6 m during the study. The septic tank effluent (STE) TN from the three sampling events was very consistent, compared to the effluent of PBTS (Figure 36). Average daily water use at the LT site was 394 L/d (104 gal/d).

The percent TN reduction observed in the lysimeters and drainfield well are shown in Table 48. Both the STE TN concentrations (54.0 mg-N/L) and DF well TN concentrations (24 mg-N/L) were relatively consistent over the three sampling events. The lysimeter TN concentrations varied significantly over the three sampling events (Table 48).

The TN/Cl plot in Figure 36 shows the amount of nitrogen attenuation measured by the lysimeters and drainfield wll.

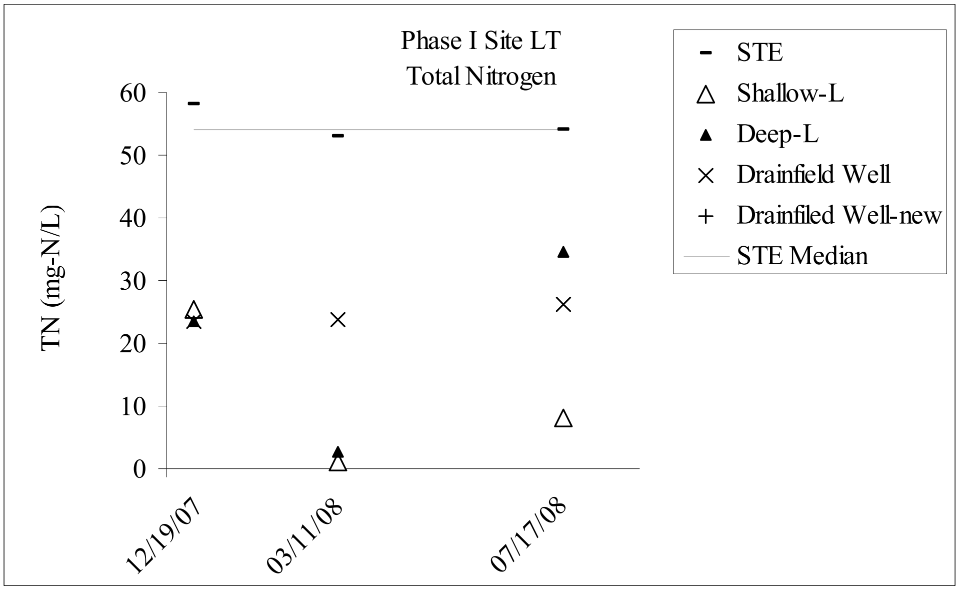


Figure 36. The TN concentrations are given for the septic tank effluent,, lysimeters and drainfield well at site LT. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

Table 48. The TN in mg-N/L and the percent TN reduction (Red) including dilution is given for each of the three sampling events and the median values for the septic tank effluent (STE), the combined sample of both shallow lysimeters and combined sample of the deep lysimeters). The median TN of the STE was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 3 sampling events.

LT Phase I	**12/19/07**		**03/11/0**		**07/17/08**		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
STE	**58.0**	*-7%*	**53.0**	*2%*	**54.0**	*0%*	**54.0**	*0%*
Shallow-L	**25.5**	*53%*	**1.0**	*98%*	**8.1**	*85%*	**8.1**	*85%*
Deep-L	**23.4**	*57%*	**2.7**	*95%*	**34.6**	*36%*	**23.4**	*57%*
DF Well	**23.4**	*57%*	**23.8**	*56%*	**26.2**	*52%*	**23.8**	*56%*

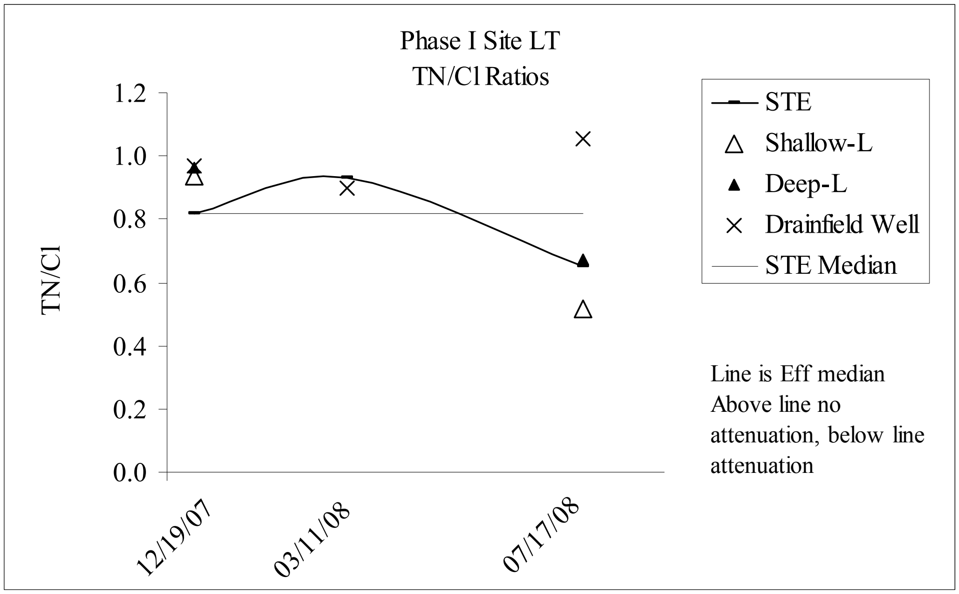


Figure 37. The TN/Cl ratio for the site LT. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

On the 03/11/08 sampling event, the background well Cl concentration was greater than Cl concentration in both the shallow and deep lysimeters, indicating the samples were 100% or more diluted (Table 49). TN attenuation other than dilution was not observed in the drainfield well samples at this site. On the 12/19/07 sampling event, no attenuation other than dilution was observed in either the shallow or deep lysimeters. However, attenuation was observed in both the shallow and deep lysimeters in July. The overall median N attenuation by denitrification/adsorption/plant uptake at this site was 0%.

Table 49. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given. The median TN attenuation and Cl dilution are calculated from the medians of the TN and Cl values and are not the medians of the given TN Attenuation and Cl dilution.

LT Phase I	**12/19/07**		**03/11/0**		**07/17/08**		Medians	
	TN Atten	*Cl Dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
Shallow-L	**-14%**	*62%*	**NA**	*102%*	**36%**	*78%*	**11%**	*78%*
Deep-L	**-18%**	*66%*	**NA**	*100%*	**18%**	*27%*	**0%**	*66%*
DF Well	**-19%**	*66%*	**-10%**	*63%*	**-29%**	*65%*	**-19%**	*65%*

Phase I Site YG

The YG site had two adult residents that have lived in the household for four years, and the house was built around 2003. The original septic tank system was in use at the time of the study. The residents of the house had applied no fertilizers. Depth to the water table ranged from 4.1-4.4 m during the study. The overall median N attenuation at this site attributable to denitrification/adsorption was 66%. Figure 38 shows the TN concentrations over time in the effluent, lysimeters and drainfield well and Table 50 shows the calculated TN reduction at each of the sampling points.

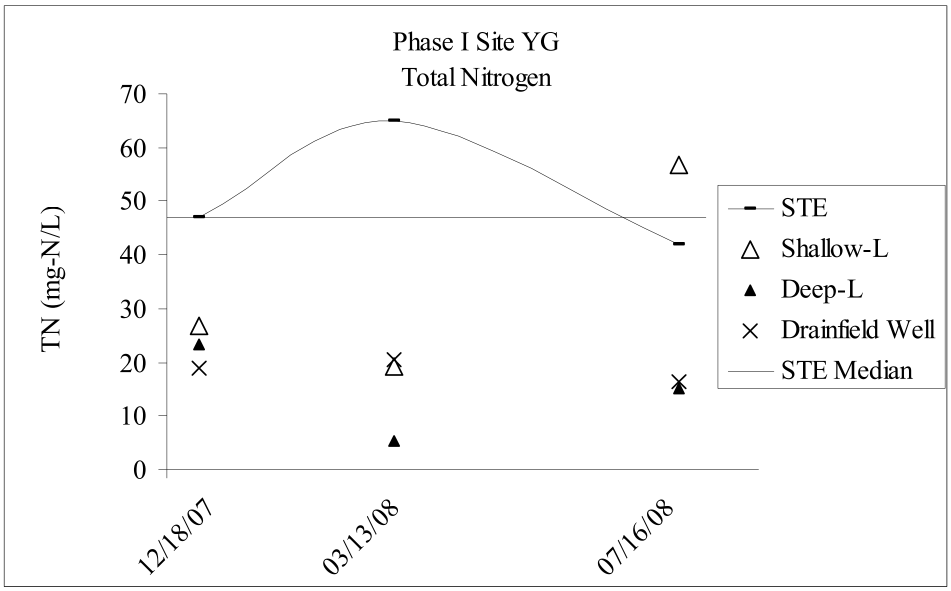


Figure 38. The TN concentrations are given for the PTBS effluent (Eff), lysimeters and drainfield well at site WSS-2-2. Sampling dates for effluent that included lysimeters and wells were 02/26/09, 06/18/09, 10/01/09, and 12/17/09. TN concentrations are in mg-N/L. The graph includes the effect of dilution.

Table 50. The TN in mg-N/L and the percent TN reduction (Red) <u>including dilution</u> is given for each of the three sampling events and the median values for the septic tank effluent (STE), the combined sample of both shallow lysimeters and combined sample of the deep lysimeters). The median TN of the STE was used for the % reduction calculations, thus the % reduction of the effluent for each sampling event indicates the variance from the median of the 3 sampling events.

YG Phase I	**12/18/07**		**03/13/08**		**07/16/08**		Medians	
	TN	*Red*	**TN**	*Red*	**TN**	*Red*	**TN**	*Red*
STE	**47.0**	*0%*	**65.0**	*-38%*	**42.0**	*11%*	**47.0**	*0%*
Shallow-L	**26.7**	*43%*	**19.4**	*59%*	**56.8**	*-21%*	**26.7**	*43%*
Deep-L	**23.3**	*50%*	**5.4**	*88%*	**15.0**	*68%*	**15.0**	*68%*
DF Well	**19.0**	*60%*	**20.6**	*56%*	**16.4**	*65%*	**19.0**	*60%*

Figure 39 shows the TN/Cl effluent concentrations in the lysimeters and drainfield well calculated from measurements taken during the three sampling periods and Table 51 shows the calculated attenuation of nitrogen that occurred at each of the points.

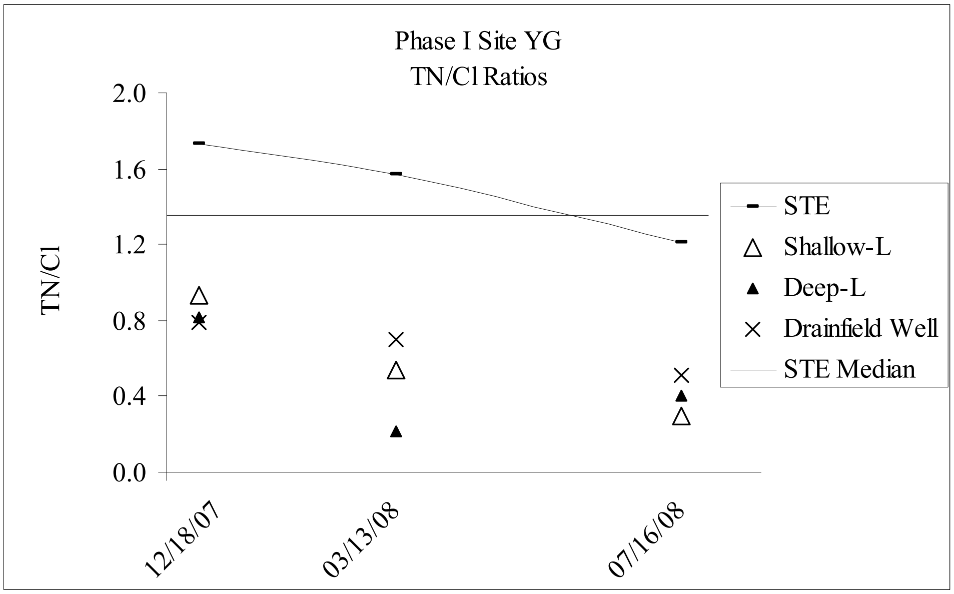


Figure 39. The TN/Cl ratio for the site YG. Samples with TN/Cl ratios smaller than the effluent ratio show attenuation of nitrogen, not including the effect of dilution. Calculations for TN reduction were made using the median effluent TN concentration. The graph is corrected for dilution.

Table 51. The percent <u>TN attenuation</u> (TN Atten) calculated from the TN/CL ratios and therefore accounts for dilution. The percent of Cl dilution (CL dil) is also given. The median TN attenuation and Cl dilution are calculated from the medians of the TN and Cl values and are not the medians of the given TN Attenuation and Cl dilution.

YG Phase I	**12/18/07**		**03/13/08**		**07/16/08**		Medians	
	TN Atten	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*	**TN Atten**	*Cl dil*
Shallow-L	**41%**	*17%*	**66%**	*-4%*	**81%**	*-457%*	**66%**	*-4%*
Deep-L	**48%**	*18%*	**86%**	*29%*	**74%**	*-8%*	**74%**	*18%*
DF Well	**50%**	*31%*	**56%**	*15%*	**67%**	*8%*	**56%**	*15%*

4.4 Dilution in drip systems versus conventional drainfield systems.

Lysimeter and drainfield well samples from PBTS sites with drip systems captured roughly 50% of the effluent, as indicated by the % dilution calculated from the Cl data. At site WSS-1-2, median dilution ranged from 25 to 46% for the lysimeters and 36% for the drainfield well (Table 22). At site WSS-4-2 (Table 26), dilution ranged from 10 to 66% for the lysimeters and was 85% for the drainfield well. At site WSS-6-2, dilution ranged from 9 to 36% for the lysimeters and was 80% for the drainfield well. At site WSS-7-2, dilution ranged from 18% to 54% for the lysimeters. The variation in dilution shows the importance in correcting TN reduction to TN attenuation based on TN/Cl ratios.

For PBTS sites with conventional drainfields, dilution was as follows: at site WSS-2-2, the lysimeters were diluted by 32-64%, the drainfield well by 60%; at site WSS-3-2, the lysimeters were diluted by 73-87%; at site WSS-5-2 the lysimeters were diluted by 47-73%, the drainfield well by 91%; at site HK the lysimeters were diluted by 47-77%; at site LT the lysimeters were diluted by 66 to 78%, the drainfield well by 65%; and at site YG the lysimeters were diluted by 0-18%, while the drainfield well was diluted by 15%. Overall, the dilution factors, as revealed by the Cl data, attest to the importance of correcting the TN data for dilution when figuring N-attenuation.

4.5 TN attenuation in Pressurized drip drainfields compared to conventional drainfields

An objective of this study was to determine if pressurized drip drainfields provided greater TN attention in comparison to conventional drainfields. Our results were not able to discern any difference between the effectiveness of the two types of installation (Table 52). Admittedly the results are subject to considerable variability, however despite the variability two of the drainfields clearly stand out in the data, Site WSS-4-2, and site YG.

Table 52. Median results for TN attenuation (excluding dilution) at the sites. Negative TN values were input as 0 values.

	Drainfield Type	Median	Min-max
WSS-1-2	Drip w/ slight mound	10%	2-32
WSS-4-2	Drip with Large Mound	78%	10-85
WSS-6-2	Drip at grade	30%	0-31
WSS-7-2	Drip at grade	0%	0-38
Median		20%	
WSS-2-2	Conventional at grade	0%	8-67
WSS-3-2	Conventional at grade	32%	25-80
WSS-5-2	Conventional large mound	31%	8-76
LT	Conventional at grade	0%	0-11
YG	Conventional at grade	66%	56-74
Median		31%	
OVERALL MEDIAN for 9 sites		30%	

Site WSS-4-2 was unique in that it was a mounded drip system, but further, the homeowner allowed the vegetation to grow more or less unchecked over the drip lines (Figure 40), as opposed to all other systems which were covered with a mowed lawn. As the drip lines were placed 8 to 12 inches (20-30 cm) below grade, our data suggest that the drip lines may be too deep to be influenced by root uptake from lawn-type vegetation, while the roots of the vegetation at site WSS-4-2 were sufficiently deep to access the drip system. Site YG did not exhibit any surface characteristics that would indicate why its performance was so efficient.

Figure 40. Vegetation growing over drip irrigation at site WSS-4-2.

4.6 Nitrate input to groundwater from septic tanks.

For the Wakulla County sites included in the CSM study, the average conventional septic tank effluent (STE) concentration was 64 ± 13 mg-N/L (Fig. ES-2). For all 35 PBTS that were sampled in this study, the average TN concentration for effluent was 29 ± 19 mg-N/L. The PBTS systems reduced N output 57 to 59% based on a raw sewage value of 70 mg-N/L. Our results indicate that the average N-attenuation in the drainfield is an additional 30%. These results indicate that for Wakulla County, a typical conventional septic tank input is 45±9 mg-N/L of wastewater to the aquifer (64* (1-0.3)). A typical PBTS system inputs 20 ± 13 mg-N/L of wastewater to the aquifer (29* (1-0.3)). Average daily water use for the 11 residences in the Phase I and Phase II study was 988±492 L/d (261.0 ± 130.0 gallons/d)(Appendix A). 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).

Summary of Findings

- The total nitrogen (TN) input value for raw sewage inputs to septic systems was 72.8 ± 39.2 mg-N/L, n=17 from five households served by PBTS. A companion study by the

- The average of monthly effluent samples from the Phase II study of 8 PBTS sites was 30 ± 11 mg-N/L. The results of the Phase II study of the 8 PBTS sites are consistent with the results of the 27 PBTS that were also sampled that was 29 ± 21 mg-N/L. For all 35 PBTS that were sampled, the average TN concentration was 29 ± 19 mg-N/L. This average concentration is a factor of three times greater than the 10 mg-N/L target effluent concentration included in Wakulla County Ordinance 2006-58 which is based on the NSF/ANSI testing standard.

- Performance Based Treatment Systems installed in Wakulla County reduce nitrogen 50-60% from input concentrations when properly maintained. Using a raw wastewater input concentration of 70 mg-N/L and the effluent results in bullet number 2 above; the 8 primary study sites yield a TN reduction of 57 ± 16%. For the 27 sites sampled only once, we calculated a TN reduction of 59 ± 30%. From direct measurements of PBTS inputs (raw sewage) and effluent on 5 sites, we calculate an average % reduction of 49.2 ± 17.8.

- Compliance, operation and maintenance issues in Wakulla County are responsible for a large percentage of systems being non-operational and performing poorly.

- Lysimeters and wells placed within pressurized drip drainfield systems and conventional drainfield systems captured roughly 50% septic tank effluent based upon Cl concentration data. Median nitrogen attenuation was 30% in these systems. Four drip systems and five conventional systems were evaluated. Our results did not allow us to discern greater effectiveness in the drip systems in comparison to the conventional systems.

- For the Wakulla County sites included in the CSM study, the average conventional septic tank effluent (STE) concentration was 64 ± 13 mg-N/L (Fig. ES-2). For all 35 PBTS that were sampled in this study, the average TN concentration was 29 ± 19 mg-N/L. Our results indicate that N-attenuation in the drainfield is 30%. These results indicate that for Wakulla County, a typical conventional septic tank inputs 45±9 mg-N/L of waste water to the aquifer. A typical PBTS system inputs 20 ± 13 mg-N/L of waste water to the aquifer. Average daily water use for the 11 residences in the Phase I and Phase II study was 988±492 L/d (Appendix A). Thus the typical N-flux to the aquifer from a conventional septic tank is 44 ± 24 gram N per day. For a PBTS, the average N flux to the aquifer would be 20 ± 16 gram N per day.

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Appendix A. FDEP Laboratory data of the Septic Tank Effluent, Lysimeters and Wells from Phase II The average daily flow and the load calculations of TN and TP in pounds per year are given. Duplicates are indicated by a "d"

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-1-2 Raw Input	01/28/09	23	5.5	70	0.42	70.4	17	211.5	45.3	10.9
WSS-1-2 Raw Input	02/25/09	24	2.7	29	0.93	29.9	3.1	185.9	16.9	1.8
WSS-1-2 Raw Input d	02/25/09	23	2.7	30	0.93	30.9	3.2	185.9	17.5	1.8
WSS-1-2 Raw Input	04/01/09	15	3	32	0.51	32.5	6.6	231.5	22.9	4.6
WSS-1-2 Raw Input	05/08/09	54	32	86	1.1	87.1	18	155.8	41.3	8.5
WSS-1-2 Trash Tank	03/31/09	25	39	54	0.005 I	54.0	7.8	231.5	38.0	5.5
WSS-1-2 Trash Tank	05/08/09	33	49	72	0.009 I	72.0	10	155.8	34.1	4.7
WSS-1-2 Trash Tank	06/16/09	40	32	36	0.017	36.0	9.8	188.5	20.7	5.6
WSS-1-2 Trash Tank d	06/16/09	39	31	35	0.023	35.0	9.5 A	188.5	20.1	5.4
WSS-1-2 Effluent	01/28/09	37	48	53	0.029	53.0	8.8	211.5	34.1	5.7
WSS-1-2 Effluent	02/25/09	40	34	40	0.24	40.2	7.9	185.9	22.8	4.5
WSS-1-2 Effluent d	02/25/09	41	34	40	0.24	40.2	8	185.9	22.8	4.5
WSS-1-2 Effluent	04/01/09	28	38	43	0.057	43.1	6.7	231.5	30.3	4.7
WSS-1-2 Effluent	05/08/09	36	38	46	0.17	46.2	8.6	155.8	21.9	4.1
WSS-1-2 Effluent	06/16/09	42	3.6	5.3	15	20.3	7.9	188.5	11.6	4.5
WSS-1-2 Effluent	07/09/09	36	0.65	2.2	8.3	10.5	7.8	617.3	19.7	14.7
WSS-1-2 Effluent	09/08/09	33	31	35	1.2	36.2	9.9	194.9	21.5	5.9
WSS-1-2 Effluent	09/28/09	39	55	58	0.12 I	58.0	7.7	194.9	34.5	4.6
WSS-1-2 Effluent	10/30/09	32	2.1	3	13	16.0	6.2	162.0	7.9	3.1
WSS-1-2 Effluent	11/23/09	30	46	53	0.063	53.1	0.72	215.8	34.8	0.5
WSS-1-2 Effluent	12/15/09	45	46	59	0.04	59.0	7.2	231.6	41.6	5.1

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-1-2-Shallow-L-1	02/25/09	25	0.22	1.7	27	28.7	3.8	185.9	16.2	2.1
WSS-1-2-Shallow-L-1	06/16/09	35	0.051	1.8	14	15.8	1.9	188.5	9.1	1.1
WSS-1-2-Shallow-L-1	09/28/09	37	0.01 U	1.2	33	34.2	1.9 A	194.9	20.3	1.1
WSS-1-2-Shallow-L-1	12/15/09	16	0.19 J	1.1	32	33.1	5.4	231.6	23.3	3.8
WSS-1-2-Shallow-L-4	02/25/09	17	0.016 I	1	15	16.0	0.057 A	185.9	9.0	0.0
WSS-1-2-Shallow-L-4	06/16/09	28	0.01 U	1.2	4.2	5.4	0.021	188.5	3.1	0.0
WSS-1-2-Shallow-L-4	09/28/09	28	0.01 U	0.86 I	26	26.0	0.011	194.9	15.9	0.0
WSS-1-2-Shallow-L-4	12/15/09	7	0.012 I	0.7	11	11.7	0.11	231.6	8.2	0.1
WSS-1-2-Deep-L-2	02/25/09	28	0.01 U	1.1	32	33.1	2.3	185.9	18.7	1.3
WSS-1-2-Deep-L-2	06/16/09	28	0.018 I	1.2	12	13.2	2.6	188.5	7.6	1.5
WSS-1-2-Deep-L-2	09/28/09	26	0.01 U	0.89 I	26	26.0	1.6	194.9	16.0	0.9
WSS-1-2-Deep-L-2	12/15/09	27	0.11	0.9 I	42	42.0	3.9	231.6	30.2	2.7
WSS-1-2-Deep-L-3	02/25/09	30	0.045	0.79 I	38	38.0	0.009 I	185.9	21.9	0.0
WSS-1-2-Deep-L-3	06/16/09	36	0.016 I	1.1	11	12.1	1.3	188.5	6.9	0.7
WSS-1-2-Deep-L-3	09/28/09	24	0.01 U	0.63	18	18.6	1.2	194.9	11.1	0.7
WSS-1-2-Deep-L-3	12/15/09	27	0.023	0.52 I	44	44.0	2	231.6	31.4	1.4

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-1-2 DF WELL	02/25/09	31	0.013 I	0.4 U	26	26.0	0.01 I	185.9	14.9	0.0
WSS-1-2 DF WELL	06/16/09	25	0.01 U	0.26 I	17	17.0	0.006 I	188.5	9.9	0.0
WSS-1-2 DF WELL d	06/16/09	25	0.01 U	0.16 I	17	17.0	0.006 I	188.5	9.8	0.0
WSS-1-2 DF WELL	09/28/09	27	0.01 U	0.24 I	11	11.0	0.008 I	194.9	6.7	0.0
WSS-1-2 DF WELL d	09/28/09	27	0.01 U	0.28 I	11	11.0	0.006 I	194.9	6.7	0.0
WSS-1-2 DF WELL	12/15/09	22	0.011 I	0.4 U	23	23.0	0.011	231.6	16.5	0.0
WSS-1-2 DF WELL d	12/15/09	22	0.01 U	0.4 U	23	23.0	0.009 I	231.6	16.5	0.0
WSS-1-2-Off Mound-L	02/25/09	6.9 A	0.05 U	0.2	0.005 I	0.2	0.031			
WSS-1-2-Off Mound-L	06/16/09	0.61	0.01 U	0.36	0.006 I	0.4	0.005 I			
WSS-1-2-Off Mound-L	09/28/09	1.8	0.01 U	0.37	0.023	0.4	0.016			
WSS-1-2-Off Mound-L	12/15/09	2.5	0.01 U	0.26	0.033	0.3	0.004 U			
WSS-1-2 BG WELL	02/25/09	2.5	0.01 U	0.081 I	0.091	0.1	0.03			
WSS-1-2 BG WELL	06/16/09	2.9	0.01 U	0.09 I	0.15	0.2	0.011			
WSS-1-2 BG WELL	09/28/09	3.3	0.01 U	0.095 I	0.17	0.2	0.007 I			
WSS-1-2 BG WELL	12/15/09	3.4 A	0.01 U	0.08 U	0.19	0.2	0.013			
WSS-1-2 BG-L	02/25/09	9.2 A	0.01 U	0.2 I	0.004 U	0.0	0.012			
WSS-1-2 BG-L	06/16/09	1.5	0.01 U	0.23	0.005 I	0.2	0.007 I			
WSS-1-2 BG-L	09/28/09	0.76	0.01 U	0.16	0.005 I	0.2	0.004 U			
WSS-1-2 BG-L	12/15/09	1.5	0.025	0.14 I	0.004 U	0.0	0.004 U			

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-1-2 Well Water	02/25/09	9.2	0.01 U	0.08 U	1.2	1.2	0.011			
WSS-1-2 Well Water	06/16/09	3.6	0.014 I	0.08 U	0.13	0.1	0.02			
WSS-1-2 Well Water	09/28/09	5.5	0.01 U	0.08 I	0.53	0.5	0.017			
WSS-1-2 Well Water	12/15/09	7	0.014 I	0.08 U	0.6	0.6	0.013			
WSS-2-2 RAW Input	01/28/09	68	13	140	0.25	140.3	14	39.1	16.7	1.7
WSS-2-2 RAW Input	02/25/09	50	6.6	78	0.25	78.3	28	63.8	15.2	5.4
WSS-2-2 RAW Input	03/31/09	50	9.2	44	0.13	44.1	4.9	80.8	10.9	1.2
WSS-2-2 RAW Input d	03/31/09	49	8.6	41	0.12	41.1	4.6	80.8	10.1	1.1
WSS-2-2 RAW Input	05/15/09	34	6.9	51	0.005 I	51.0	8.6	66.4	10.3	1.7
WSS-2-2 RAW Input	06/16/09	87	61	170	0.16	170.2	24	82.8	42.9	6.0
WSS-2-2 Trash Tank	03/31/09	52	15	39	0.69	39.7	8.1	80.8	9.8	2.0
WSS-2-2 Trash Tank	05/15/09	45	24	35	0.008 I	35.0	8.7	66.4	7.1	1.8
WSS-2-2 Trash Tank d	05/15/09	45	24	34	0.008 I	34.0	8.9	66.4	6.9	1.8
WSS-2-2 Trash Tank	06/16/09	53	13	22	0.007 I	22.0	10	82.8	5.5	2.5

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-2-2 Effluent	01/28/09	56	0.3	3.5	24	27.5	9.5	39.1	3.3	1.1
WSS-2-2 Effluent	02/25/09	51	17	23	3.7	26.7	7.3 A	63.8	5.2	1.4
WSS-2-2 Effluent	03/31/09	55	0.63 J	2.8	26	28.8	9.6	80.8	7.1	2.4
WSS-2-2 Effluent d	03/31/09	55	0.62	2.9	26	28.9	9.8	80.8	7.1	2.4
WSS-2-2 Effluent	05/15/09	50	0.053	2.5	22	24.5	8.1	66.4	4.9	1.6
WSS-2-2 Effluent	06/16/09	54	0.095	4.1	19	23.1	8.5	82.8	5.8	2.1
WSS-2-2 Effluent	07/09/09	44	0.052	3.1	24	27.1	5.4	66.7	5.5	1.1
WSS-2-2 Effluent	09/08/09	48	0.15	2.7	20	22.7	6	119.2	8.2	2.2
WSS-2-2 Effluent	09/28/09	55	2.2	4.7	19	23.7	6.9	119.2	8.6	2.5
WSS-2-2 Effluent	10/30/09	54	0.094	2.7	26	28.7	6.7	154.0	13.4	3.1
WSS-2-2 Effluent	11/23/09	54	0.33	2.8	18	20.8	0.77	131.1	8.3	0.3
WSS-2-2 Effluent	12/15/09	50	4.2	8.1	15	23.1	6.2	166.6	11.7	3.1
WSS-2-2-Shallow-L-4	02/25/09	23	0.017 I	0.75 J	9.6	9.6	0.006 I	63.8	2.0	0.0
WSS-2-2-Shallow-L-4	06/16/09	36	0.12	1	17	18.0	0.02	82.8	4.5	0.0
WSS-2-2-Shallow-L-4	09/28/09	50	0.01 U	0.66	17	17.7	0.011	119.2	6.4	0.0
WSS-2-2-Shallow-L-4	12/15/09	23	0.016 I	0.55	12	12.6	0.25	166.6	6.4	0.1
WSS-2-2-Shallow-L-5	06/16/09	53	0.12	1.5	16	17.5	4.4	82.8	4.4	1.1
WSS-2-2-Shallow-L-5	09/28/09	54	1.5	4.7	22	26.7	5.2	119.2	9.7	1.9
WSS-2-2-Shallow-L-5	12/15/09	33	0.015 I	0.75	15	15.8	6.1	166.6	8.0	3.1

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-2-2-Shallow-L-6	06/01/09	50	0.11	1.6	9.3	10.9	0.62	82.8	2.7	0.2
WSS-2-2-Shallow-L-6	09/28/09	55	0.01 U	1.1 I	25	25.0	4.5	119.2	9.5	1.6
WSS-2-2-Shallow-L-6	12/15/09	30	0.032	0.75	14	14.8	4.8 A	166.6	7.5	2.4
WSS-2-2-Deep-L-2	02/25/09	11	~	~	~	~	~	63.8	~	~
WSS-2-2-Deep-L-7	06/16/09	51	0.083 I	1.1	22	23.1	5.2 A	82.8	5.8	1.3
WSS-2-2-Deep-L-7	09/28/09	55	0.8	1.6	26	27.6	5.1	119.2	10.0	1.9
WSS-2-2-Deep-L-7	12/15/09	36	0.025	0.59	15	15.6	4.8	166.6	7.9	2.4
WSS-2-2-Deep-L-8	06/16/09	51	0.16	2.1	14	16.1	3.9	82.8	4.1	1.0
WSS-2-2-Deep-L-8	09/28/09	53	0.014 I	0.89	24	24.9	3.6	119.2	9.0	1.3
WSS-2-2-Deep-L-8	12/15/09	40	0.01 U	0.69	15	15.7	6.1	166.6	8.0	3.1
WSS-2-2 DF Well	02/25/09	16	0.01 U	0.08 U	6.2	6.2	0.014	63.8	1.2	0.0
WSS-2-2 DF Well	06/16/09	17	0.088 I	0.28	8.2	8.5	0.02	82.8	2.1	0.0
WSS-2-2 DF Well d	06/16/09	17	0.16	0.52	8.1	8.6	0.037	82.8	2.2	0.0
WSS-2-2 DF Well	09/28/09	24	0.01 U	0.45	15	15.5	0.004 U	119.2	5.6	0.0
WSS-2-2 DF Well d	09/28/09	25	0.013 I	0.4	15	15.4	0.004 U	119.2	5.6	0.0
WSS-2-2 DF Well	12/15/09	25	0.01 U	0.37 I	13	13.0	0.005 I	166.6	6.8	0.0
WSS-2-2 DF Well d	12/15/09	25	0.01 U	0.28 I	14	14.0	0.006 I	166.6	7.2	0.0

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-2-2 Well Water	02/25/09	3	0.01U	0.08 U	0.25	0.3	0.011			
WSS-2-2 Well Water d	02/25/09	3	0.01 U	0.08 U	0.25	0.3	0.01			
WSS-2-2 Well Water	06/16/09	2.6	0.01 U	0.08 U	0.26	0.3	0.008 I			
WSS-2-2 Well Water	09/28/09	2.7	0.01 U	0.1 I	0.26	0.3	0.008 I			
WSS-2-2 Well Water	12/15/09	3.3	0.01 U	0.097 I	0.21	0.2	0.007 I			
WSS-3-2 Effluent	01/28/09	110	31	40	0.71	40.7	9.7	151.0	18.7	4.5
WSS-3-2 Effluent	02/27/09	100	14	26	0.6	26.6	8.4	233.0	18.9	6.0
WSS-3-2 Effluent	04/08/09	88	0.77	14	4.5	18.5	8.2	469.5	26.4	11.7
WSS-3-2 Effluent	05/14/09	85	3.7	53	1.2	54.2	14	360.4	59.4	15.4
WSS-3-2 Effluent	06/19/09	92	1.3	12	0.24	12.2	13	480.1	17.9	19.0
WSS-3-2 Effluent d	06/19/09	92	1.2	13	0.23	13.2	13	480.1	19.3	19.0
WSS-3-2 Effluent	07/09/09	74	14	37	0.039	37.0	11	679.1	76.5	22.7
WSS-3-2 Effluent	09/08/09	68	0.76	4	0.036	4.0	13	98.9	1.2	3.9
WSS-3-2 Effluent d	09/08/09	70	0.66	3.8	0.15	4.0	13	98.9	1.2	3.9
WSS-3-2 Effluent	09/29/09	57	49	64	0.71	64.7	13	98.9	19.5	3.9
WSS-3-2 Effluent	10/30/09	48	0.49	14	1.9 J	14.0	12	147.8	7.2	5.4
WSS-3-2 Effluent	11/23/09	52	0.44	27	3.4	30.4	0.62	148.1	13.7	0.3
WSS-3-2 Effluent	12/14/09	60	5.5	29	1.1	30.1	14	138.1	12.6	5.9
WSS-3-2 Effluent d	12/14/09	60	5.8	44	1.1	45.1	17	138.1	18.9	7.1
WSS-3-2 Effluent	12/15/09	64	6.7	29	2	31.0	14	138.1	13.0	5.9
WSS-3-2 Effluent	12/16/09	66	7.3	19	2.7	21.7	13	138.1	9.1	5.5
WSS-3-2 Effluent	12/17/09	65	7.9	19	2.5	21.5	13	138.1	9.0	5.5
WSS-3-2 Effluent	12/18/09	63	7.7	20	1.4	21.4	13	138.1	9.0	5.5

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-3-2 NOR	05/14/09	87	3.5	26	4.5	30.5	9.8	360.4	33.5	10.7
WSS-3-2 NOR	06/19/09	92	0.8	13	0.19	13.2	14	480.1	19.3	20.5
WSS-3-2 NOR d	06/19/09	92	0.81	12	0.2	12.2	13	480.1	17.8	19.0
WSS-3-2 NOR	07/09/09	74	25	39	0.064	39.1	9.9	679.1	80.7	20.5
WSS-3-2-Shallow-L-2	02/27/09	18	0.01 U	0.64	0.95	1.6	0.04	233.0	1.1	0.0
WSS-3-2-Shallow-L-2	06/19/09	42	0.01 I	1.6	9.8	11.4	0.078	480.1	16.7	0.1
WSS-3-2-Shallow-L-2	09/29/09	7.5	0.01 U	0.59	1	1.6	0.045 A	98.9	0.5	0.0
WSS-3-2-Shallow-L-2	12/16/09	35	0.01 U	0.69	2.9	3.6	0.048 A	138.1	1.5	0.0
WSS-3-2-Deep-L-1	02/27/09	32	0.01 U	0.4	0.005 I	0.4	0.047	233.0	0.3	0.0
WSS-3-2-Deep-L-1	09/29/09	~	0.013 I	0.65	0.53	1.2	0.051	98.9	0.4	0.0
WSS-3-2-Deep-L-1&3	06/19/09	~	0.015 I	1.2	13	14.2	0.11	480.1	20.7	0.2
WSS-3-2-Deep-L-1	12/16/09	48	0.01 U	0.65	3.5	4.2	0.02	138.1	1.7	0.0
WSS-3-2-Deep-L-3	02/27/09	26	0.01 U	0.47	1.7	2.2	0.027	233.0	1.5	0.0
WSS-3-2-Deep-L-3	09/29/09	~	0.01 U	0.38	1.5	1.9	0.028	98.9	0.6	0.0
WSS-3-2-Deep-L-3	12/16/09	20	0.01 U	0.44	2.1	2.5	0.017	138.1	1.1	0.0

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-3-2 DF Well	02/27/09	10	0.01 U	0.08 UJ	0.47	0.5	0.13	233.0	0.4	0.1
WSS-3-2 DF Well d	02/27/09	9.9	0.01 U	0.08 U	0.45	0.5	0.42	233.0	0.4	0.3
WSS-3-2 DF Well	06/19/09	11	0.01 U	0.08 U	0.63	0.6	0.14	480.1	1.0	0.2
WSS-3-2 DF Well d	06/19/09	11	0.01 U	0.08 U	0.67	0.7	0.16	480.1	1.1	0.2
WSS-3-2 DF Well	09/29/09	12	0.022	0.21	1	1.2	0.15	98.9	0.4	0.0
WSS-3-2 DF Well d	09/29/09	13	0.044	0.44	1	1.4	0.14	98.9	0.4	0.0
WSS-3-2 DF Well	12/16/09	13	0.013 I	0.2 I	1.5	1.5	0.13	138.1	0.7	0.1
WSS-3-2 DF Well d	12/16/09	13	0.01 I	0.17 I	1.4	1.4	0.13	138.1	0.7	0.1
WSS-3-2 BG Well	02/27/09	14	0.01 U	0.18 I	1.9	1.9	0.27			
WSS-3-2 BG Well	06/19/09	18	0.01 U	0.17 I	0.1	0.1	0.17 A			
WSS-3-2 BG Well	09/29/09	21	0.01 U	0.16 I	2	2.0	0.11			
WSS-3-2 BG Well	12/16/09	19	0.01 U	0.16 I	2.4	2.4	0.12			
WSS-3-2 BG-L	02/27/09	30	0.01 U	0.4	0.004 U	0.4	0.063			
WSS-3-2 BG-L	06/19/09	~	0.01 U	0.36	0.006 I	0.4	0.089			
WSS-3-2 BG-L	09/29/09	~	0.015 I	0.4	0.08 U	0.4	0.22			
WSS-3-2 BG-L	12/16/09	11	0.01 U	0.16 I	0.008 I	0.0	0.16			
WSS-3-2 City Water	02/27/09	67	0.01 U	0.15 I	0.028	0.0	1.2			
WSS-3-2 City Water	06/19/09	58	0.01 U	0.11 I	0.01	0.0	1.2			
WSS-3-2 City Water	09/29/09	24	0.01 U	0.08 U	0.08 U	0.0	0.91			
WSS-3-2 City Water	12/16/09	35	0.01 U	0.1 I	0.013	0.0	1.1			

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-4-2 RAW Input	04/16/09	19	7.2	23	1.5	24.5	30	296.0	22.1	27.0
WSS-4-2 RAW Input	05/14/09	61	4.9	52	1.7	53.7	8.3	184.3	30.1	4.7
WSS-4-2 RAW Input	10/29/09	23	4.7	37	2.4	39.4	7.7	166.3	19.9	3.9
WSS-4-2 RAW Input d	10/29/09	23	4.8	37	2.5	39.5	7.8	166.3	20.0	3.9
WSS-4-2 RAW Input	10/30/09	38	18	95	5	100.0	7.4	166.3	50.6	3.7
WSS-4-2 Trash Tank	04/16/09	38	25	30	0.012	30.0	7.1	296.0	27.0	6.4
WSS-4-2 Trash Tank	06/18/09	50	56	59	0.01 I	59.0	7.9	89.5	16.1	2.2
WSS-4-2 Effluent	01/28/09	52	0.4	2.6	7.6	10.2	5.3	213.3	6.6	3.4
WSS-4-2 Effluent	02/27/09	48	0.34	2.5	11	13.5	5.5	187.7	7.7	3.1
WSS-4-2 Effluent	04/08/09	23	0.021	1.1	3.5	4.6	2.3	296.0	4.1	2.1
WSS-4-2 Effluent	04/16/09	24	0.072	1.2	7.7	8.9	2.7			
WSS-4-2 Effluent	05/14/09	44	0.11	1.9	24	25.9	5.8 A	184.3	14.5	3.3
WSS-4-2 Effluent	06/18/09	49	0.01 U	1.1	24	25.1	5.8	89.5	6.8	1.6
WSS-4-2 Effluent	07/09/09	56	0.053	0.82 I	24	24.0	5.5	89.8	6.8	1.5
WSS-4-2 Effluent	09/08/09	54	0.078	1.2	26	27.2	4.4	111.0	9.2	1.5
WSS-4-2 Effluent	10/02/09	54	0.084	1.2	0.12 I	1.2	4.9	166.3	0.7	2.5
WSS-4-2 Effluent d	10/02/09	56	0.082	1.2	0.12 I	1.2	4.8	166.3	0.7	2.4
WSS-4-2 Effluent	10/29/09	47 A	0.072	1.5	21	22.5	5.2	166.3	11.4	2.6
WSS-4-2 Effluent	10/30/09	46	0.1	1.3	20	21.3	5.1	166.3	10.8	2.6
WSS-4-2 Effluent	12/17/09	35	0.13	1.3	17	18.3	3.3 A	210.3	11.7	2.1
WSS-4-2 Effluent	12/18/09	35	0.14	1.4	18	19.4	3.5	210.3	12.4	2.2

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-4-2-Shallow-L-1	02/27/09	48	0.052	0.65	5.8	6.5	0.17	187.7	3.7	0.1
WSS-4-2-Shallow-L-1	06/18/09	~	0.02	0.83	5.6	6.4	0.18	89.5	1.8	0.0
WSS-4-2-Shallow-L-1	10/02/09	38	0.01 U	0.49	0.23	0.7	0.17	166.3	0.4	0.1
WSS-4-2-Shallow-L-1	12/18/09	34	0.01 U	0.58	3.2	3.8	0.12	210.3	2.4	0.1
WSS-4-2-Shallow-L-3	02/27/09	45	0.011 I	1.2	9	10.2	0.6	187.7	5.8	0.3
WSS-4-2-Shallow-L-3	06/18/09	44	0.028	0.69	4.2	4.9	0.45	89.5	1.3	0.1
WSS-4-2-Shallow-L-3	10/02/09	45	0.01 U	0.36	0.46	0.8	0.3	166.3	0.4	0.2
WSS-4-2-Shallow-L-3	12/18/09	48	0.01 U	0.39	9.8	10.2	0.18	210.3	6.5	0.1
WSS-4-2-Deep-L-2	02/27/09	50	0.01 I	0.51	0.35	0.9	0.032 A	187.7	0.5	0.0
WSS-4-2-Deep-L-2	06/18/09	28	0.01 U	0.23	0.49	0.7	0.009 I	89.5	0.2	0.0
WSS-4-2-Deep-L-2	10/02/09	9.7	0.01 U	0.27	0.089	0.4	0.014	166.3	0.2	0.0
WSS-4-2-Deep-L-2	12/18/09	29	0.01 U	0.41	7.4	7.8	0.006 I	210.3	5.0	0.0
WSS-4-2-Deep-L-4	02/27/09	46	0.014 I	0.87	8.9	9.8	0.047	187.7	5.6	0.0
WSS-4-2-Deep-L-4	06/18/09	9.7	0.01 U	0.49	0.012	0.5	0.028	89.5	0.1	0.0
WSS-4-2-Deep-L-4	10/02/09	9.1	0.01 U	0.46	0.27	0.7	0.017	166.3	0.4	0.0
WSS-4-2-Deep-L-4	12/18/09	27	0.01 U	0.29	2.1	2.4	0.004 I	210.3	1.5	0.0

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-4-2 DF Well	02/27/09	24 A	0.01 U	0.097 I	1.3	1.3	0.004 U	187.7	0.8	0.0
WSS-4-2 DF Well	06/18/09	10	0.01 U	0.08 U	0.24	0.2	0.004 U	89.5	0.1	0.0
WSS-4-2 DF Well	10/02/09	8.2	0.01 U	0.08 U	0.11	0.1	0.004 U	166.3	0.1	0.0
WSS-4-2 DF Well d	10/02/09	7.9	0.01 U	0.08 U	0.11	0.1	0.004 U	166.3	0.1	0.0
WSS-4-2 DF Well	12/18/09	7.1	0.01 U	0.08 U	0.057	0.1	0.004 U	210.3	0.1	0.0
WSS-4-2 DF Well d	12/18/09	7.1	0.01 U	0.08 U	0.049	0.0	0.004 U	210.3	0.1	0.0
WSS-4-2 BG Well	02/27/09	7	0.01 U	0.08 U	0.02	0.0	0.037 A			
WSS-4-2 BG Well	06/18/09	6.5	0.01 U	0.08 U	0.058	0.1	0.022			
WSS-4-2 BG Well d	06/18/09	6.4	0.01 U	0.08 U	0.055	0.1	0.021			
WSS-4-2 BG Well	10/02/09	16	0.01 U	0.11 I	0.051	0.1	0.048 A			
WSS-4-2 BG Well	12/18/09	17	0.01 U	0.08 U	0.048	0.0	0.013			
WSS-4-2 BG-L	06/18/09	2.7	0.01 UJ	0.08 U	0.006 I	0.0	0.004 U			
WSS-4-2 BG-L	10/02/09	0.69	0.01 U	0.08 U	0.008 I	0.0	0.004 U			
WSS-4-2 BG-L	12/18/09	1.8	0.01 U	0.084 I	0.005 I	0.0	0.004 U			
WSS-4-2 Well Water	02/27/09	7.1	0.01 U	0.1 I	0.004 U	0.0	0.068			
WSS-4-2 Well Water d	02/27/09	6.9	0.01 U	0.092 I	0.004 U	0.0	0.068			
WSS-4-2 Well Water	06/18/09	6.7 A	0.01 U	0.08 U	0.004 I	0.0	0.069			
WSS-4-2 Well Water	10/02/09	7	0.01 U	0.08 U	0.004 U	0.0	0.055			
WSS-4-2 Well Water	12/18/09	6.5 A	0.01 U	0.097 I	0.004 I	0.0	0.058			

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-5-2 Trash Tank	04/08/09	44	37	46	0.03	46.0	7.7	353.9	49.6	8.3
WSS-5-2 Trash Tank	06/18/09	48	42	49	0.011	49.0	9.9	539.0	80.4	16.2
WSS-5-2 Trash Tank d	06/18/09	48	42	48	0.01	48.0	9.8	539.0	78.8	16.1
WSS-5-2 Effluent	01/28/09	25	17	27	1	28.0	7	10.4	0.9	0.2
WSS-5-2 Effluent	02/26/09	39	26	33	0.027	33.0	5.9	10.4	1.0	0.2
WSS-5-2 Effluent	04/08/09	44	30	40	0.36	40.4	6.9	353.9	43.5	7.4
WSS-5-2 Effluent	05/13/09	41	38	51	0.74	51.7	8.4	615.8	97.0	15.7
WSS-5-2 Effluent	05/15/09	40	38	47	0.015	47.0	8.4	615.8	88.1	15.7
WSS-5-2 Effluent	06/18/09	47	27	30	3.6	33.6	8.8 A	539.0	55.1	14.4
WSS-5-2 Effluent	07/08/09	55	17	19	3.3	22.3	7.8	802.2	54.4	19.0
WSS-5-2 Effluent d	07/08/09	55	17	19	3.3	22.3	7.9	802.2	54.4	19.3
WSS-5-2 Effluent	09/08/09	42	26	30	0.13	30.1	6.5	100.3	9.2	2.0
WSS-5-2 Effluent	10/01/09	58	31	33	4	37.0	7.8	148.9	16.8	3.5
WSS-5-2 Effluent	10/30/09	53	2.1	6.4	6.8	13.2	8.3	148.9	6.0	3.8
WSS-5-2 Effluent	11/23/09	41	17	22	2.8	24.8	0.7	114.2	8.6	0.2
WSS-5-2 Effluent	12/17/09	39	28	37	2	39.0	6.3	269.8	32.0	5.2
WSS-5-2 Effluent d	12/17/09	39	30	43	1.9	44.9	6.2	269.8	36.9	5.1
WSS-5-2 NOR	05/13/09	40	41	51	0.64	51.6	8.3	615.8	96.8	15.6
WSS-5-2 NOR	06/18/09	47	29	35	5.5	40.5	10	539.0	66.4	16.4
WSS-5-2 NOR	07/08/09	56	18	19	4	23.0	8.1	802.2	56.1	19.8

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-5-2-Shallow-L-1	06/18/09	~	0.01 U	0.81	9.1	9.9	0.14	539.0	16.3	0.2
WSS-5-2-Shallow-L-1	10/01/09	19	0.01 U	0.78	12	12.8	0.089	148.9	5.8	0.0
WSS-5-2-Shallow-L-1	12/17/09	15 A	0.01 U	0.35	4.7	5.1	0.036 A	269.8	4.1	0.0
WSS-5-2-Shallow-L-2	02/26/09	22	0.01 U	0.95	1.7	2.7	0.033	10.4	0.1	0.0
WSS-5-2-Shallow-L-2	06/18/09	12	0.01 U	0.29	4	4.3	0.013 AJ	539.0	7.0	0.0
WSS-5-2-Shallow-L-2	10/01/09	16	0.01 U	0.26	8.9	9.2	0.004 U	148.9	4.2	0.0
WSS-5-2-Shallow-L-2	12/17/09	3.9	0.01 U	0.17 I	2.5	2.5	0.005 I	269.8	2.2	0.0
WSS-5-2-Shallow-L-3	02/26/09	19	0.011 I	0.85	7.2	8.1	0.42	10.4	0.3	0.0
WSS-5-2-Shallow-L-3	06/18/09	21	0.01 U	0.76	2.8	3.6	0.1	539.0	5.8	0.2
WSS-5-2-Shallow-L-3	10/01/09	28	0.01 U	0.8	3.2	4.0	0.051	148.9	1.8	0.0
WSS-5-2-Shallow-L-3	12/17/09	27	0.01 U	0.49	2.6	3.1	0.016	269.8	2.5	0.0
WSS-5-2-Shallow-L-4	02/26/09	16	0.011 I	0.83	4.9	5.7	0.07	10.4	0.2	0.0
WSS-5-2-Shallow-L-4	06/18/09	26	0.01 U	1.6	7.3	8.9	0.13	539.0	14.6	0.2
WSS-5-2-Shallow-L-4	10/01/09	21	0.01 U	1.5	16	17.5	0.061	148.9	7.9	0.0
WSS-5-2-Shallow-L-4	12/17/09	14	0.01 U	0.3	3.4	3.7	0.027 A	269.8	3.0	0.0

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-5-2 DF Well	02/26/09	8.4	0.01 U	0.08 U	3	3.0	0.004 U	10.4	0.1	0.0
WSS-5-2 DF Well	06/18/09	8.8	0.01 U	0.08 U	2.6	2.6	0.004 U	539.0	4.4	0.0
WSS-5-2 DF Well d	06/18/09	8.7	0.01 U	0.08 U	2.6	2.6	0.004 U	539.0	4.4	0.0
WSS-5-2 DF Well	10/01/09	9.8	0.01 U	0.08 U	3.3	3.3	0.004 U	148.9	1.5	0.0
WSS-5-2 DF Well d	10/01/09	9.7	0.01 U	0.08 U	3.3	3.3	0.004 U	148.9	1.5	0.0
WSS-5-2 DF Well	12/17/09	7.1	0.01 U	0.081 I	0.94	0.9	0.004 U	269.8	0.8	0.0
WSS-5-2 DF Well d	12/17/09	7.3	0.01 U	0.13 I	0.91	0.9	0.004 U	269.8	0.9	0.0
WSS-5-2 BG Well	02/26/09	20	0.01 U	0.18 I	0.004 I	0.0	0.005 I			
WSS-5-2 BG Well d	02/26/09	20	0.01 U	0.3	0.009 I	0.3	0.043			
WSS-5-2 BG Well	06/18/09	17	0.01 U	0.16 I	0.055	0.1	0.004 U			
WSS-5-2 BG Well	10/01/09	16	0.01 U	0.19 I	0.004 U	0.0	0.004 U			
WSS-5-2 BG Well	12/17/09	13	0.01 U	0.16 I	0.005 I	0.0	0.004 U			
WSS-5-2 BG-L	02/26/09	7.6	0.01 U	0.12 I	0.043	0.0	0.008 I			
WSS-5-2 BG-L	06/18/09	3.8	0.01 U	0.18 I	0.006 I	0.0	0.004 U			
WSS-5-2 BG-L	10/01/09	2.8	0.01 U	0.18 I	0.004 U	0.0	0.004 U			
WSS-5-2 BG-L	12/17/09	5.5	0.01 U	0.14 I	0.004 U	0.0	0.004 U			
WSS-5-2 Well Water	02/26/09	3.8	0.01 U	0.29 J	0.006 I	0.0	0.007 I			
WSS-5-2 Well Water	06/18/09	4	0.01 U	0.08 U	0.006 I	0.0	0.013			
WSS-5-2 Well Water	10/01/09	4.1	0.01 U	0.17 I	0.013	0.0	0.013			
WSS-5-2 Well Water	12/17/09	3.9	0.01 U	0.12 I	0.017	0.0	0.011			

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-6-2 Trash Tank	03/31/09	35	23	30	0.008 I	30.0	6	893.4	81.6	16.3
WSS-6-2 Trash Tank	06/17/09	32	4.9	30	0.004 I	30.0	6.3	357.7	18.6	7.9
WSS-6-2 Effluent	01/28/09	37	24	32	0.074	32.1	6	164.5	16.1	3.0
WSS-6-2 Effluent	02/26/09	35	25	30	0.14	30.1	6.4	224.6	20.6	4.4
WSS-6-2 Effluent	03/31/09	31	13	16	0.02	16.0	5 A	893.4	43.6	13.6
WSS-6-2 Effluent	05/14/09	37	6.5	9	1.3	10.3	4.7	841.8	26.4	12.0
WSS-6-2 Effluent	06/17/09	32 A	5.9	8.8	0.21	9.0	4.9	357.7	9.8	5.3
WSS-6-2 Effluent	07/09/09	34	14	17	0.57	17.6	5.3	1056.7	56.5	17.0
WSS-6-2 Effluent	09/08/09	28	1.9	3.7	7.5	11.2	3.9	533.9	18.2	6.3
WSS-6-2 Effluent	09/29/09	39	1.5	2.7	9.6	12.3	3.5	533.9	20.0	5.7
WSS-6-2 Effluent	10/30/09	28	0.18	0.99 J	4.3	4.3	3.5 A	240.3	3.9	2.6
WSS-6-2 Effluent	11/23/09	31	0.27	1.4	3.9	5.3	3.5	275.1	4.4	2.9
WSS-6-2 Effluent	12/14/09	23 A	0.05	0.91	8.3	9.2	2.7	239.6	6.7	2.0
WSS-6-2 Effluent	12/15/09	25	0.18	1	10	11.0	3	239.6	8.0	2.2
WSS-6-2 Effluent	12/16/09	27	1.7	3	7.1	10.1	3.2	239.6	7.4	2.3
WSS-6-2 Effluent	12/17/09	27	0.9	3.3	7	10.3	3.4	239.6	7.5	2.5
WSS-6-2 Effluent	12/18/09	45	0.27	1.3	8.3	9.6	3.4	239.6	7.0	2.5
WSS-6-2 Effluent d	12/18/09	45	0.27	2.4	8.3	10.7	3.6	239.6	7.8	2.6

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-6-2-Shallow-L-2	02/26/09	50	~	~	~	~	~	224.6	~	~
WSS-6-2-Shallow-L-2	06/17/09	34	0.015 I	0.91	0.34	1.3	0.2	357.7	1.4	0.2
WSS-6-2-Shallow-L-2	09/29/09	31	0.01 U	0.47 J	9.2	9.2	0.52	533.9	15.7	0.8
WSS-6-2-Shallow-L-2	12/16/09	22	0.01 U	0.44	4.1	4.5	0.67	239.6	3.3	0.5
WSS-6-2-Shallow-L-3	02/26/09	69	0.024	1.1	12	13.1	0.034	224.6	9.0	0.0
WSS-6-2-Shallow-L-3	06/17/09	33	0.01 U	0.85	1	1.9	0.024	357.7	2.0	0.0
WSS-6-2-Shallow-L-3	09/29/09	34	0.01 U	0.69	10	10.7	0.02	533.9	17.4	0.0
WSS-6-2-Shallow-L-3	12/16/09	23	0.01 U	0.62	5.7	6.3	0.038 A	239.6	4.6	0.0
WSS-6-2-Shallow-L-5	06/17/09	~	0.019 I	0.95	0.007 I	1.0	0.069	357.7	1.0	0.1
WSS-6-2-Shallow-L-5	09/29/09	34	0.05 U	1.1	3.2	4.3	0.049	533.9	7.0	0.1
WSS-6-2-Deep-L-1	02/26/09	31	0.01 U	2.3	9.8	12.1	0.18	224.6	8.3	0.1
WSS-6-2-Deep-L-1	09/29/09	26/24	0.014 I	0.76	10	10.8	0.06	533.9	17.5	0.1
WSS-6-2-Deep-L-1	12/16/09	22	0.01 U	0.47	5	5.5	0.06	239.6	4.0	0.0
WSS-6-2-Deep-L-4	02/26/09	40	0.015 I	1	6.9	7.9	0.14	224.6	5.4	0.1
WSS-6-2-Deep-L-4	06/17/09	29	0.01 U	0.36	2	2.4	0.024	357.7	2.6	0.0
WSS-6-2-Deep-L-4	09/29/09	29	0.01 U	0.39	9.1	9.5	0.03	533.9	15.4	0.0
WSS-6-2-Deep-L-4	12/16/09	23	0.01 U	0.25	5.2	5.5	0.022	239.6	4.0	0.0

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-6-2 DF Well	02/26/09	11	0.012 I	0.29 I	9	9.0	0.014	224.6	6.3	0.0
WSS-6-2 DF Well d	02/26/09	11	0.02 I	0.19 I	9.4	9.4	0.015	224.6	6.6	0.0
WSS-6-2 DF Well	06/17/09	11	0.01 U	0.08 U	9.8	9.8	0.004 I	357.7	10.8	0.0
WSS-6-2 DF Well d	06/17/09	11	0.01 U	0.08 U	9.8	9.8	0.016	357.7	10.8	0.0
WSS-6-2 DF Well	09/29/09	11	0.01 U	0.08 U	9.3	9.3	0.004 U	533.9	15.2	0.0
WSS-6-2 DF Well d	09/29/09	11	0.01 U	0.09 I	9.4	9.4	0.004 U	533.9	15.4	0.0
WSS-6-2 DF Well	12/16/09	9.2	0.01 U	0.17 I	8	8.0	0.015	239.6	6.0	0.0
WSS-6-2 DF Well d	12/16/09	8.9	0.01 U	0.14 I	8	8.0	0.017	239.6	5.9	0.0
WSS-6-2 BG Well	02/26/09	4	0.012 I	0.08 U	0.69	0.7	0.004 U			
WSS-6-2 BG Well	06/17/09	4.2	0.01 U	0.08 U	0.86	0.9	0.004 U			
WSS-6-2 BG Well	09/29/09	4.8	0.01 U	0.08 U	0.97	1.0	0.004 U			
WSS-6-2 BG Well	12/16/09	4.7	0.01 U	0.13 I	1.2	1.2	0.004 U			
WSS-6-2 BG-L	02/26/09	37	0.01 U	0.43	0.004 U	0.4	0.016			
WSS-6-2 BG-L	06/17/09	13	0.01 U	0.29	0.014	0.3	0.021			
WSS-6-2 BG-L	09/29/09	12	0.01 U	0.13 I	0.08 U	0.0	0.004 U			
WSS-6-2 BG-L	12/16/09	5.8	0.022	0.19 I	0.007 I	0.0	0.004 U			
WSS-6-2 City Water	02/26/09	12	0.01 UJ	0.19 I	0.38	0.4	0.024 A			
WSS-6-2 City Water	06/17/09	9.1	0.01 U	0.08	0.39	0.5	0.027 A			
WSS-6-2 City Water	09/29/09	9.4	0.01 U	0.08 U	0.37	0.4	0.018 A			
WSS-6-2 City Water	12/16/09	11	0.01 U	0.11 I	0.36	0.4	0.011			

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-7-2 RAW Input	01/28/09	55	3.1	100	0.74	100.7	12	271.6	83.3	9.9
WSS-7-2 RAW Input d	01/28/09	55	2.8	100	0.72	100.7	12	271.6	83.2	9.9
WSS-7-2 RAW Input	02/26/09	28	2.5	54	0.73	54.7	5.3	448.9	74.8	7.2
WSS-7-2 RAW Input	04/08/09	30	3.4	59	0.59	59.6	6.7	156.3	28.3	3.2
WSS-7-2 RAW Input	05/13/09	69	6.8	110	0.4	110.4	11	187.9	63.1	6.3
WSS-7-2 RAW Input	06/17/09	33	4.9	61	0.59	61.6	7.5	211.0	39.5	4.8
WSS-7-2 Trash Tank	04/08/09	45	45	65	0.088	65.1	6.7	156.3	31.0	3.2
WSS-7-2 Trash Tank	06/17/09	38	7.5	20	0.065	20.1	6.9	211.0	12.9	4.4
WSS-7-2 Effluent	01/28/09	34	33	46	0.045	46.0	6.8	271.6	38.1	5.6
WSS-7-2 Effluent d	01/28/09	33	30	48	0.14	48.1	6.5	271.6	39.8	5.4
WSS-7-2 Effluent	02/26/09	35	31	58	0.017	58.0	7	448.9	79.3	9.6
WSS-7-2 Effluent	04/08/09	45	44	71	0.26	71.3	7.7	156.3	33.9	3.7
WSS-7-2 Effluent	05/13/09	48	14	44	0.068	44.1	11	187.9	25.2	6.3
WSS-7-2 Effluent	06/17/09	39	7.3	16	0.32	16.3	7.1	211.0	10.5	4.6
WSS-7-2 Effluent	07/09/09	43	39	48	0.12	48.1	7.1	208.7	30.6	4.5
WSS-7-2 Effluent	09/08/09	45	46	57	0.21	57.2	7.7	142.5	24.8	3.3
WSS-7-2 Effluent	10/01/09	38	5.8	8.8	3.2	12.0	7.8	54.8	2.0	1.3
WSS-7-2 Effluent	10/30/09	39	35	34	0.57	34.6	7.3	54.8	5.8	1.2
WSS-7-2 Effluent	12/14/09	35	7	11	6.2	17.2	6.6	1.3	0.1	0.0
WSS-7-2 Effluent	12/15/09	35	6.7	11	6.5	17.5	6.7	1.3	0.1	0.0

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-7-2 NOR	05/13/09	47	14	36	0.18	36.2	10	187.9	20.7	5.7
WSS-7-2 NOR	06/17/09	39	7.6	17	0.051	17.1	7.3	211.0	10.9	4.7
WSS-7-2 NOR	07/09/09	44 A	41	56	0.055	56.1	8.4	208.7	35.6	5.3
WSS-7-2-Shallow-L-1	02/26/09	34	0.33	1.2	11	12.2	0.01	448.9	16.7	0.0
WSS-7-2-Shallow-L-1	06/17/09	15	0.018 I	0.93	12	12.9	0.011	211.0	8.3	0.0
WSS-7-2-Shallow-L-1	10/01/09	21	0.012 I	1.1	32	33.1	0.011	54.8	5.5	0.0
WSS-7-2-Shallow-L-1	12/17/09	3.6	0.01 U	0.86	9.6	10.5	0.014	1.3	0.0	0.0
WSS-7-2-Shallow-L-4	02/26/09	19	0.039	0.96	11	12.0	0.01	448.9	16.3	0.0
WSS-7-2-Shallow-L-4	06/17/09	27	0.015 I	1.3	5.2	6.5	0.038	211.0	4.2	0.0
WSS-7-2-Shallow-L-4	10/01/09	35	0.019 I	1	19	20.0	0.015 A	54.8	3.3	0.0
WSS-7-2-Shallow-L-4	12/17/09	11	0.015 I	0.85	0.072	0.9	0.008 I	1.3	0.0	0.0
WSS-7-2-Deep-L-2	02/26/09	33	0.062	0.69 I	38	38.0	0.005 I	448.9	52.9	0.0
WSS-7-2-Deep-L-2	06/17/09	18	0.011 I	0.67	13	13.7	0.004 U	211.0	8.8	0.0
WSS-7-2-Deep-L-2 d	06/17/09	18	0.012 I	0.73	11	11.7	0.004 U	211.0	7.5	0.0
WSS-7-2-Deep-L-2	10/01/09	38	0.01 U	0.63 I	38	38.0	0.004 U	54.8	6.4	0.0
WSS-7-2-Deep-L-2	12/17/09	15	0.01 U	0.5	11	11.5	0.004 U	1.3	0.0	0.0
WSS-7-2-Deep-L-2 d	12/17/09	15	0.01 U	0.58	11	11.6	0.004 U	1.3	0.0	0.0

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-7-2-Deep-L-3	02/26/09	35	0.068	0.43 I	28	28.0	0.004 U	448.9	38.8	0.0
WSS-7-2-Deep-L-3	06/17/09	26	0.01 U	0.47 I	24	24.0	0.004 U	211.0	15.7	0.0
WSS-7-2-Deep-L-3	10/01/09	46	0.01 U	0.7 I	45	45.0	0.007 I	54.8	7.6	0.0
WSS-7-2-Deep-L-3	12/17/09	32	0.01 U	0.67	16	16.7	0.004 U	1.3	0.1	0.0
WSS-7-2 BG-L	02/26/09	7.9	0.011 I	0.21	0.035	0.2	0.05			
WSS-7-2 BG-L	06/17/09	2.5	0.01 U	0.2	1.4	1.6	0.021			
WSS-7-2 BG-L	10/01/09	3.1	0.01 U	0.4	0.18 I	0.4	0.031			
WSS-7-2 BG-L	12/17/09	3.1	0.01 U	0.23	0.018	0.2	0.019			
WSS-7-2 Well Water	02/26/09	3.8	0.01 U	0.08 U	0.77	0.8	0.012			
WSS-7-2 Well Water d	02/26/09	3.7	0.01 U	0.08 U	0.77	0.8	0.012			
WSS-7-2 Well Water	06/17/09	4.1 A	0.01 U	0.08 U	0.48	0.5	0.011 A			
WSS-7-2 Well Water	10/01/09	3.5	0.01 U	0.14 I	0.53	0.5	0.01 I			
WSS-7-2 Well Water d	10/01/09	3.5	0.01 U	0.13 I	0.54	0.5	0.009 I			
WSS-7-2 Well Water	12/17/09	3.5	0.01 U	0.091 I	0.33	0.3	0.024			
WSS-8-2 RAW Input	01/28/09	180	4.3	70	0.18	70.2	18	320.3	68.4	17.5
WSS-8-2 Effluent	01/28/09	140	25	38	0.007 I	38.0	8.5	320.3	37.0	8.3
WSS-8-2 Effluent	02/27/09	170	19	31	0.024	31.0	6.1	233.8	22.1	4.3
WSS-8-2 Effluent	04/08/09	140	21	32	0.016	32.0	7.0 A	195.5	19.0	4.2

Appendix A (continued).

Sample	Date	Chloride (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	Total P (mg-N/L)	Avg Daily Flow (g/day)	TN (lb/yr)	TP (lb/yr)
WSS-8-2-Shallow-L-4	02/27/09	57	0.015 I	0.66	11	11.7	0.007 I	233.8	8.3	0.0
WSS-8-2 DF Well	02/27/09	30	0.01 U	0.08 I	6.4	6.4	0.14 A	233.8	4.6	0.1
WSS-8-2 BG Well	02/27/09	7	0.01 U	0.08 U	0.62	0.6	0.11	233.8		
WSS-8-2 City Water	02/27/09	54	0.01 U	0.17 I	0.089	0.1	1.2	233.8		

A - Value reported is the mean of two or more determinations
I - The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.
J - Estimated value
U - Material was analyzed for but not detected. The reported value is the method detection limit for the sample analyzed

Appendix B. FDEP Field data for the drainfield wells, background wells, and residential water source from Phase II

Sample	Sample Date	Purge Time	Initial Depth to Water (ft)	Final Depth to Water (ft)	Total Well Depth (ft)	Temp (Cº)	pH	Sp Cond	DO mg/L	DO %sat
WSS-1-2 DF WELL	02/25/09	10 min	10.50	17.45	18.05	22.19	7.71	567	8.43	96.9
WSS-1-2 DF WELL	06/16/09	10 min	10.10	16.30	17.05	22.79	7.32	503	6.79	78.9
WSS-1-2 DF WELL	09/28/09	10 min	10.70	11.90	17.05	24.58	7.62	530	4.93	59.3
WSS-1-2 DF WELL	12/15/09	10 min	8.20	18.90	17.05	22.48	7.27	581	5.54	63.9
WSS-1-2 BG WELL	02/25/09	10 min	11.90	12.85	20.90	21.49	8.53	200	7.57	85.7
WSS-1-2 BG WELL	06/16/09	10 min	11.75	19.40	20.90	23.75	8.83	211	8.72	103.1
WSS-1-2 BG WELL	09/28/09	10 min	11.40	19.70	20.90	24.11	8.97	216	4.31	51.3
WSS-1-2 BG WELL	12/15/09	10 min	8.90	20.70	20.90	22.73	8.82	225	5.38	62.4
WSS-1-2 Well Water	02/25/09	10 min	~	~	~	21.49	7.47	359	5.94	67.3
WSS-1-2 Well Water	06/16/09	10 min	~	~	~	22.71	7.55	367	4.25	49.7
WSS-1-2 Well Water	09/28/09	10 min	~	~	~	24.30	8.12	372	5.70	68.1
WSS-1-2 Well Water	12/15/09	10 min	~	~	~	21.67	7.53	374	4.33	49.6

Appendix B (continued).

Sample	Sample Date	Purge Time	Initial Depth to Water (ft)	Final Depth to Water (ft)	Total Well Depth (ft)	Temp (Cº)	pH	Sp Cond	DO mg/L	DO %sat
WSS-2-2 DF WELL	02/25/09	10 min	11.50	17.10	17.75	20.78	7.33	427	1.44	16.1
WSS-2-2 DF WELL	06/16/09	10 min	10.85	10.85	16.85	20.97	6.79	623	1.01	11.4
WSS-2-2 DF WELL	09/28/09	10 min	10.55	11.60	16.90	23.93	7.08	776	0.59	7.1
WSS-2-2 DF WELL	12/15/09	10 min	8.40	12.40	16.90	23.23	6.93	695	1.14	13.3
WSS-2-2 Well Water	02/25/09	10 min	~	~	~	13.35	7.30	396	5.16	49.4
WSS-2-2 Well Water	06/16/09	10 min	~	~	~	23.21	7.53	375	7.18	84.1
WSS-2-2 Well Water	09/28/09	10 min	~	~	~	23.01	7.68	385	3.77	44.0
WSS-2-2 Well Water	12/15/09	10 min	~	~	~	19.73	7.43	386	4.26	46.7

Appendix B (continued).

Sample	Sample Date	Purge Time	Initial Depth to Water (ft)	Final Depth to Water (ft)	Total Well Depth (ft)	Temp (Cº)	pH	Sp Cond	DO mg/L	DO %sat
WSS-3-2 DF WELL	02/27/09	10 min	18.60	19.10	25.30	21.56	7.71	322	2.11	24.6
WSS-3-2 DF WELL	06/19/09	10 min	18.15	22.10	25.25	21.16	7.52	324	2.12	23.8
WSS-3-2 DF WELL	09/29/09	10 min	16.35	18.30	25.25	22.42	7.51	397	1.86	21.5
WSS-3-2 DF WELL	12/16/09	10 min	15.90	18.50	25.20	22.01	7.32	414	1.76	20.2
WSS-3-2 BG WELL	02/27/09	10 min	18.45	18.50	25.50	21.26	6.93	554	1.85	20.9
WSS-3-2 BG WELL	06/19/09	10 min	17.95	18.60	25.50	21.03	6.97	539	1.66	18.7
WSS-3-2 BG WELL	09/29/09	10 min	16.20	16.40	25.45	21.94	6.97	576	1.79	20.5
WSS-3-2 BG WELL	12/16/09	10 min	15.80	15.80	25.45	22.07	6.90	572	1.74	20.1
WSS-3-2 City Water	02/27/09	10 min	~	~	~	15.62	7.54	528	8.13	82.4
WSS-3-2 City Water	06/19/09	10 min	~	~	~	26.12	7.48	490	5.56	69.1
WSS-3-2 City Water	09/29/09	10 min	~	~	~	26.05	7.58	431	6.76	83.5
WSS-3-2 City Water	12/16/09	10 min	~	~	~	18.68	7.42	441	6.18	66.3

Appendix B (continued).

Sample	Sample Date	Purge Time	Initial Depth to Water (ft)	Final Depth to Water (ft)	Total Well Depth (ft)	Temp (Cº)	pH	Sp Cond	DO mg/L	DO %sat
WSS-4-2 DF WELL	02/27/09	10 min	5.40	5.80	20.40	19.42	5.02	115	3.53	38.9
WSS-4-2 DF WELL	06/18/09	10 min	4.95	7.10	20.30	20.28	5.09	104	2.35	25.9
WSS-4-2 DF WELL	10/02/09	10 min	4.10	7.80	19.35	21.86	5.55	102	0.48	5.4
WSS-4-2 DF WELL	12/18/09	10 min	3.40	7.10	20.35	21.30	5.04	88	0.33	3.8
WSS-4-2 BG WELL	02/27/09	10 min	6.90	18.40	19.05	19.58	5.77	55	6.03	65.8
WSS-4-2 BG WELL	06/18/09	10 min	5.90	18.00	19.05	21.55	5.90	51	6.56	74.4
WSS-4-2 BG WELL	10/02/09	10 min	4.70	18.10	19.05	22.31	6.19	75	6.23	71.7
WSS-4-2 BG WELL	12/18/09	10 min	3.80	18.20	19.05	21.43	5.56	76	7.26	82.1
WSS-4-2 Well Water	02/27/09	10 min	~	~	~	18.71	8.23	187	5.61	60.1
WSS-4-2 Well Water	06/18/09	10 min	~	~	~	23.37	8.35	185	3.78	44.4
WSS-4-2 Well Water	10/02/09	10 min	~	~	~	21.64	8.10	189	4.75	54.1
WSS-4-2 Well Water	12/18/09	10 min	~	~	~	19.46	7.97	187	7.04	76.5

Appendix B (continued).

Sample	Sample Date	Purge Time	Initial Depth to Water (ft)	Final Depth to Water (ft)	Total Well Depth (ft)	Temp (Cº)	pH	Sp Cond	DO mg/L	DO %sat
WSS-5-2 DF WELL	02/26/09	10 min	9.00	9.05	18.95	19.78	7.09	450	4.63	50.7
WSS-5-2 DF WELL	06/18/09	10 min	7.40	7.40	18.90	20.58	7.16	446	2.41	26.9
WSS-5-2 DF WELL	10/01/09	10 min	7.10	7.20	18.90	22.90	7.11	481	2.92	34.1
WSS-5-2 DF WELL	12/17/09	10 min	4.00	4.00	18.90	20.97	6.85	447	3.42	38.4
WSS-5-2 BG WELL	02/26/09	10 min	8.40	9.35	12.65	18.71	6.71	837	0.42	4.5
WSS-5-2 BG WELL	06/18/09	10 min	6.90	6.90	12.60	20.04	6.82	735	0.32	3.5
WSS-5-2 BG WELL	10/01/09	10 min	6.50	6.60	12.60	22.59	6.79	785	0.11	1.4
WSS-5-2 BG WELL	12/17/09	10 min	3.40	3.40	12.60	21.25	6.63	795	0.42	4.8
WSS-5-2 Well Water	02/26/09	10 min	~	~	~	16.21	7.49	413	9.86	100.4
WSS-5-2 Well Water	06/18/09	10 min	~	~	~	23.87	7.36	402	1.96	23.4
WSS-5-2 Well Water	10/01/09	10 min	~	~	~	20.25	7.24	407	5.25	57.9
WSS-5-2 Well Water	12/17/09	10 min	~	~	~	19.28	7.02	398	4.04	43.8

Appendix B (continued).

Sample	Sample Date	Purge Time	Initial Depth to Water (ft)	Final Depth to Water (ft)	Total Well Depth (ft)	Temp (Cº)	pH	Sp Cond	DO mg/L	DO %sat
WSS-6-2 DF WELL	02/26/09	10 min	9.70	9.80	19.10	20.72	4.43	137	1.69	18.9
WSS-6-2 DF WELL	06/17/09	10 min	8.60	9.30	19.05	21.46	4.65	135	1.71	19.3
WSS-6-2 DF WELL	09/29/09	10 min	7.80	9.80	19.05	23.77	4.80	140	1.62	19.2
WSS-6-2 DF WELL	12/16/09	10 min	7.80	8.30	19.05	22.99	4.73	110	2.27	26.4
WSS-6-2 BG WELL	02/26/09	10 min	9.30	10.35	19.15	21.26	4.81	35	3.16	35.6
WSS-6-2 BG WELL	06/17/09	10 min	8.35	11.80	19.10	21.06	5.07	40	2.98	33.4
WSS-6-2 BG WELL	09/29/09	10 min	7.75	10.30	19.10	23.10	5.10	42	2.98	34.9
WSS-6-2 BG WELL	12/16/09	10 min	6.50	9.50	19.15	22.95	4.90	43	2.91	33.8
WSS-6-2 City Water	02/26/09	10 min	~	~	~	14.55	7.50	307	8.74	85.8
WSS-6-2 City Water	06/17/09	10 min	~	~	~	28.18	7.43	341	5.82	74.6
WSS-6-2 City Water	09/29/09	10 min	~	~	~	26.16	7.41	299	7.16	88.5
WSS-6-2 City Water	12/16/09	10 min	~	~	~	17.64	7.33	375	6.89	72.4

Appendix B (continued).

Sample	Sample Date	Purge Time	Initial Depth to Water (ft)	Final Depth to Water (ft)	Total Well Depth (ft)	Temp (Cº)	pH	Sp Cond	DO mg/L	DO %sat
WSS-7-2 Well Water	02/26/09	10 min	~	~	~	20.47	7.08	508	8.83	98.1
WSS-7-2 Well Water	06/17/09	10 min	~	~	~	23.43	6.98	428	6.35	74.6
WSS-7-2 Well Water	10/01/09	10 min	~	~	~	20.42	7.29	449	7.64	84.8
WSS-7-2 Well Water	12/17/09	10 min	~	~	~	15.81	6.97	458	11.69	118.0
WSS-8-2 DF WELL	02/27/09	10 min	16.90	16.90	21.00	20.44	6.86	641	2.98	33.8
WSS-8-2 City Water	02/27/09	10 min	~	~	~	15.69	7.46	480	4.69	47.8
WSS-8-2 BG WELL	02/27/09	10 min	17.75	18.20	25.55	20.80	7.10	371	4.08	45.6

Appendix C. FDEP Laboratory data of the Septic Tank Effluent, Lysimeters and Wells from Phase I. The average daily flow and load calculations of Ortho-P and TN in pounds per year are given. Duplicates are indicated by a "d"

Sample	Date	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	OrthoP (mg/L)	Total P (mg/L)	Avg Daily Flow (g/day)	OrthoP (lb/yr)	TN (lb/yr)
HK Septic Tank Effluent	12/19/07	27	35	0.008	35.0	5.4		500	8.2	53.3
HK Septic Tank Effluent	03/12/08	16	18	0.14	18.1	4.3	5.1	380	5.0	21.0
HK Septic Tank Effluent d	03/12/08	15	18	0.14	18.1	4.3	4.8	380	5.0	21.0
HK Septic Tank Effluent	07/15/08	36	37	0.013	37.0	6.9	7.8	330	6.9	37.2
HK Shallow-L-1 old DF	12/19/07	0.019	0.8	62	62.8	0.93		500	1.4	95.6
HK Shallow-L-2 old DF	12/19/07	0.089	0.8	63	63.8	1.3		500	2.0	97.1
HK Shallow-L-3 old DF	12/19/07	0.11	1	87	88.0	0.9		500	1.4	134.0
HK Shallow-L-4 old DF	12/19/07	0.04	1.2	32	33.2	0.17		500	0.3	50.6
HK Shallow-L-1&2 new DF	03/12/08	0.62	1.3	24	25.3	0.24	0.3	380	0.3	29.3
HK Shallow-L-1&2 new DF d	03/12/08	0.64	1.4	24	25.4	0.24	0.25	380	0.3	29.4
HK Shallow-L-1&2 new DF	07/15/08	0.021	1.6	39	40.6	0.62	0.84	330	0.6	40.8
HK Deep-L-3&4 new DF	03/12/08	0.29	1.2	21	22.2	0.15	0.19	380	0.2	25.7
HK Deep-L-3&4 new DF d	03/12/08	0.4	1.2	22	23.2	0.15	0.2	380	0.2	26.8
HK Deep-L-3&4 new DF	07/15/08	0.024	2	49	51.0	0.46	0.97	330	0.5	51.3
HK DF Well old DF	12/19/07	6.7	5.7	11	16.7	0.042		500	0.1	25.4
HK DF Well old DF	07/15/08	3.6	3.1	20	23.1	0.49	0.54			

Appendix C (continued).

Sample	Date	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	OrthoP (mg/L)	Total P (mg/L)	Avg Daily Flow (g/day)	OrthoP (lb/yr)	TN (lb/yr)
HK DF Well new DF	03/12/08	0.89	1.1	8.1	9.2	0.091	0.14	380	0.1	10.6
HK DF Well new DF d	03/12/08	0.95	1.1	7.7	8.8	0.096	0.14	380	0.1	10.2
HK DF Well new DF	07/15/08	0.01	0.8	30	30.8	0.77	0.96	330	0.8	31.0
HK BG Well	12/19/07	0.01	0.08	0.39	0.5	0.004				
HK BG Well	03/12/08	0.01	0.08	0.56	0.6	0.004	0.02			
HK BG Well d	03/12/08	0.01	0.08	0.56	0.6	0.004	0.02			
HK BG Well	07/15/08	0.1	0.08	0.41	0.5	0.006	0.2			
HK Well Water	03/12/08	0.01	0.08	0.48	0.6	0.014	0.029			
HK Well Water	03/12/08	0.01	0.08	0.48	0.6	0.014	0.022			
HK Well Water	07/15/08	0.01	0.08	0.33	0.4	0.016	0.022			
LT Septic Tank Effluent	12/19/07	56	63	0.008	63.0	14		38	1.6	7.3
LT Septic Tank Effluent d	12/19/07	X*	62	0.007	62.0	13		38	1.5	7.2
LT Septic Tank Effluent	03/11/08	52	54	0.016	54.0	11	12	53	1.8	8.7
LT Septic Tank Effluent	07/17/08	53	55	0.013	55.0	5.9	9.3	63	1.1	10.6
LT Shallow-L-1&2	12/19/07	0.023	1.3	25	26.3	3.3		38	0.4	3.0
LT Shallow-L-1&2 d	12/19/07	0.021	1.1	24	25.1	3.4		38	0.4	2.9
LT Shallow-L-1&2	03/11/08	0.031	0.37	0.5	0.9	1.1	1.1	53	0.2	0.1
LT Shallow-L-1&2	07/17/08	0.012	1.6	6.9	8.5	2.9	3.2	63	0.6	1.6

Appendix C (continued

Sample	Date	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	OrthoP (mg/L)	Total P (mg/L)	Avg Daily Flow (g/day)	OrthoP (lb/yr)	TN (lb/yr)
LT Deep-L-3	12/19/07	0.023	0.74	35	35.7	5.6		38	0.6	4.1
LT Deep-L-4	12/19/07	0.017	1	15	16.0	1.4		38	0.2	1.9
LT Deep-L-3&4	03/11/08	0.037	0.44	2.5	2.9	3.1	3.9	53	0.5	0.5
LT Deep-L-3&4	07/17/08	0.034	1.9	30	31.9	5.2	3.9	63	1.0	6.1
LT DF Well	12/19/07	0.15	0.4	24	24.4	0.15		38	0.0	2.8
LT DF Well d	12/19/07	0.14	0.4	24	24.4	0.16		38	0.0	2.8
LT DF Well	03/11/08	0.042	0.4	25	25.4	0.16	0.17	53	0.0	4.1
LT DF Well	07/17/08	0.019	0.4	27	27.4	0.3	0.3	63	0.1	5.3
LT DF Well d	07/17/08	0.016	0.4	28	28.4	0.3	0.3	63	0.1	5.4
LT BG Well	12/19/07	0.011	1.2	1.1	2.3	0.02		38	0.0	0.3
LT BG Well	03/11/08	0.01	0.08	0.1	0.2	0.004	0.02	53	0.0	0.0
LT BG Well	07/17/08	0.01	0.08	0.098	0.2	0.004	0.033	63	0.0	0.0
LT Well Water	03/11/08	0.01	0.08	1.8	1.9	0.009	0.02	53		
LT Well Water	07/17/08	0.01	0.08	0.42	0.5	0.016	0.024	63	0.0	0.1
YG Septic Tank Effluent	12/18/07	43	48	0.005	48.0	5.8		88	1.6	12.9
YG Septic Tank Effluent d	12/18/07	42	39	0.004	39.0	5.9		88	1.6	10.5
YG Septic Tank Effluent	03/13/08	56	63	0.005	63.0	7.6	8.7	127	2.9	24.4
YG Septic Tank Effluent	07/16/08	39	37	0.006	37.0	1.9	7.4	105	0.6	11.8

Appendix C (continued).

Sample	Date	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	OrthoP (mg/L)	Total P (mg/L)	Avg Daily Flow (g/day)	OrthoP (lb/yr)	TN (lb/yr)
YG Shallow-L-1	12/18/07	0.033	0.4	27	27.4	0.007		88	0.0	7.3
YG Shallow-L-2	12/18/07	0.04	0.57	35	35.6	0.027		88	0.0	9.5
YG Shallow-L-1&2	03/13/08	0.032	0.59	20	20.6	0.024	0.041	127	0.0	8.0
YG Shallow-L-1&2	07/16/08	0.036	2.7	54	56.7	0.049	0.099	105	0.0	18.1
YG Deep-L-3	12/18/07	0.023	0.56	3.5	4.1	0.004		88	0.0	1.1
YG Deep-L-4	12/18/07	0.051	0.4	39	39.4	0.004		88	0.0	10.6
YG Deep-L-3&4	03/13/08	0.028	0.57	5.3	5.9	0.008	0.02	127	0.0	2.3
YG Deep-L-3&4	07/16/08	0.047	1.52	15	16.5	0.004	0.02	105	0.0	5.3
YG DF Well	07/16/08	0.091	0.39	16	16.4	0.018	0.75	105	0.0	5.2
YG DF Well	03/13/08	0.066	0.4	21	21.4	0.016	0.38	127	0.0	8.3
YG DF Well	12/18/07	0.065	0.4	19	19.4	0.025		88	0.0	5.2
YG BG Well	12/18/07	0.015	0.15	0.025	0.2	0.05		88		
YG BG Well	03/13/08	0.01	0.16	0.21	0.4	0.12	0.19	127		
YG BG Well	07/16/08	0.01	0.08	0.4	0.5	0.13	0.15	105		
YG BG Well d	07/16/08	0.01	0.08	0.39	0.5	0.13	0.15			

Appendix D. USGS Laboratory data of the Septic Tank Effluent, Lysimeters and Wells from Phase I. The FDEP TN value and the percent difference are given for comparison. When the FDEP measured individual lysimeters, instead of combining either both short or long lysimeters into one sample, the average of the two values was used in the % difference column. Duplicates are indicated by a "d".

Sample	Date	Cl (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)		TN FDEP (mg-N/L)	% Diff w/ FDEP
HK Septic Tank Effluent	12/19/07	136	25.7	30	<.04	30.0		35.0	15.4%
HK Septic Tank Effluent	03/12/08	20.2	13.8	17	0.2	17.2		18.1	5.3%
HK Septic Tank Effluent	07/15/08	29.9	35.1	39	<.04	39.0		37.0	5.2%
HK Shallow-L-1-4 old DF	12/19/07	103	0.077	0.81	56.6	57.4		62.0	7.6%
HK Shallow-L-1&2 new DF	03/12/08	26.7	0.618	1.7	23.3	25.0		25.4	1.4%
HK Shallow-L-1&2 new DF	07/15/08	9.08	0.056	2	49.6	51.6		40.6	23.9%
HK Deep-L-3&4 new DF d	03/12/08	26.8	0.316	1.2	20.9	22.1		23.2	4.9%
HK Deep-L-3&4 new DF	07/15/08	14.1	<.020	1.7	41.9	43.6		51.0	15.6%
HK DF Well old DF	12/19/07	42.7	6.89	7.6	9.89	17.5		16.7	4.6%
HK DF Well new DF	03/12/08	18.1	0.999	1.5	8.15	9.7		9.2	4.8%
HK DF Well new DF	03/12/08	18.1	0.805	1.2	8.02	9.2		8.8	4.7%
HK DF Well new DF	07/15/08	46.2	<.020	0.26	30.3	30.6		30.8	0.8%
HK BG Well	12/19/07	3.08	0.06	0.15	0.37	0.5		0.5	10.1%
HK BG Well	03/12/08	4.26	<.020	E.08	0.53	0.5		0.6	18.8%
HK BG Well	07/15/08	3.39	<.020	<.14	0.39	0.4		0.5	22.7%

Appendix D (continued).

Sample	Date	Cl (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	TN FDEP (mg-N/L)	% Diff w/ FDEP
LT Septic Tank Effluent	12/19/07	40.6	51.5	58	<.04	58.0	62.5	7.5%
LT Septic Tank Effluent	03/11/08	34.5	48	53	<.04	53.0	54.0	1.9%
LT Septic Tank Effluent	07/17/08	30.9	50.7	54	E.02	54.0	55.0	1.9%
LT Shallow-L-1&2	12/19/07	30	0.037	1.5	24	25.5	25.7	0.8%
LT Shallow-L-1&2	03/11/08	1.6	E.015	0.5	0.47	1.0	0.9	10.9%
LT Shallow-L-1&2	07/17/08	18.3	<.020	1.6	6.49	8.1	8.5	4.9%
LT Deep-L-3&4	12/19/07	27	E.011	1.6	21.8	23.4	25.9	10.0%
LT Deep-L-3&4	03/11/08	2.6	0.024	0.83	1.85	2.7	2.9	9.3%
LT Deep-L-3&4	07/17/08	54.3	0.026	1.4	33.2	34.6	31.9	8.1%
LT DF Well	12/19/07	26.8	0.141	0.29	23.1	23.4	24.4	4.2%
LT DF Well	03/11/08	29.2	0.038	0.19	23.6	23.8	25.4	6.5%
LT DF Well	07/17/08	27.5	0.025	0.19	26	26.2	27.9	6.3%
LT BG Well	03/11/08	2.7	<0.02	E0.07	0.105	0.1	0.2	52.6%
LT BG Well	07/17/08	2.71	<.020	E.13	0.08	0.1	0.2	76.0%

Appendix D (continued).

Sample	Date	Cl (mg/L)	Ammonia (mg-N/L)	TKN (mg-N/L)	Nitrite + Nitrate (mg-N/L)	TN (mg-N/L)	TN FDEP (mg-N/L)	% Diff w/ FDEP
YG Septic Tank Effluent	12/18/07	27.2	39.2	47	<.04	47.0	43.5	7.7%
YG Septic Tank Effluent	03/13/08	41.4	55.6	65	<.04	65.0	63.0	3.1%
YG Septic Tank Effluent	07/16/08	34.7	37.8	42	<.04	42.0	37.0	12.6%
YG Septic Tank Effluent d	07/16/08	34.6	37.5	43.0	<0.04	43.0		13.9%
YG Shallow-L-1&2	12/18/07	31.3	0.021	0.49	26.2	26.7	31.5	16.5%
YG Shallow-L-1&2	03/13/08	38.8	0.105	0.77	18.6	19.4	20.6	6.1%
YG Shallow-L-1&2	07/16/08	196	0.131	4.9	51.9	56.8	56.7	0.2%
YG Deep-L-3&4	12/18/07	31.2	0.044	0.58	22.7	23.3	21.7	6.9%
YG Deep-L-3&4	03/13/08	27.4	E.017	0.45	4.97	5.4	5.9	8.0%
YG Deep-L-3&4	07/16/08	40	0.038	0.61	14.4	15.0	16.5	9.6%
YG DF Well	07/16/08	26.6	0.08	0.29	18.7	19.0	16.4	14.7%
YG DF Well	03/13/08	32.2	0.072	0.14	20.5	20.6	21.4	3.6%
YG DF Well	12/18/07	34.6	0.125	0.21	16.2	16.4	19.4	16.7%
YG BG Well	12/18/07	2.6	<.100	1.2	<.04	1.2	0.2	149.1%
YG BG Well	03/13/08	2.63	<.020	E.08	0.2	0.2	0.4	59.6%
YG BG Well	07/16/08	5.62	<.020	E.14	0.39	0.4	0.5	20.7%