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

DATE AND TIME: **June 10, 2010 at 9:30 a.m. EDT**

PLACE: Gulf Coast Research and Education Center
14625 County Road 672
Wimauma, FL 33598
813-634-0000

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

1. Introductions and Housekeeping
2. Review Minutes of Meeting March 23, 2010
3. Town of Suwannee Study Final Report Presentation
4. Nitrogen Study
    a. Budget proviso language
    b. Comment on deliverables and next steps
5. Discussion on DEP's Wekiva Fertilizer Report
6. Discussion on Continuation of Inventory of OSTDS and relationship to Maintenance and Management Program (SB 550)
7. Update on Study of Performance of Advanced Systems in Florida
8. Alternative Drainfield Products Discussion
9. Discussion on Research Budget
10. Election of Chair and Vice Chair
11. Other Business
12. Public Comment
13. Closing Comments, Next Meeting, and Adjournment

There will be a tour of GCREC facility, after the meeting has adjourned, for all interested parties.

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

Approved Minutes of the Meeting held at the Gulf Coast Research and Education Center, Wimauma, FL
June 10, 2010
Approved by RRAC November 5, 2010

In attendance:

- **Committee Membership and Alternates**:
    - **In person:** Quentin (Bob) Beitel (alternate, Real Estate Profession); David Carter (chairman, member, Home Building Industry); Kim Dove (member, Division of Environmental Health); Bob Himschoot (member, Septic Tank Industry); Kriss Kaye (alternate, Home Building Industry); Carl Ludecke (alternate, Home Building Industry); Jim Peters (alternate, Professional Engineer); Patti Sanzone (member, Environmental Interest Group); and Clay Tappan (member, Professional Engineer)
    - **Via teleconference:** Bill Melton (member, Consumer); and Pam Tucker (member, Real Estate Profession)
- **Not represented**: Restaurant Industry, State University System, and Local Government
- **Visitors**:
    - **In person:** Damann Anderson (Hazen and Sawyer); Blaine Carter (FHBA); Larry Danek (ECT); Josefin Edeback (Hazen and Sawyer); Brian King (York ISG); Don Orr (FOWA); Daniel Smith (AET); Nancy Smith (Orange County Health Department)
    - **Via teleconference:** David Winialski; Mary Howard; Sarah Fowler
- **Department of Health (DOH), Bureau of Onsite Sewage Programs**:
    - **In person:** Paul Booher; Eberhard Roeder; and Elke Ursin
    - **Via teleconference:** Debra Roberts

1. **Introductions** – Seven out of ten groups were present, representing a quorum. Chairman Carter called the meeting to order at 9:38 a.m. Introductions were made and some housekeeping issues were discussed.

2. **Review of Previous Meeting Minutes** – The minutes of March 23, 2010 were reviewed.

    Motion by Bill Melton and seconded by Clay Tappan to approve the minutes as amended. All were in favor with none opposed and the motion passed unanimously.

    Quentin Beitel brought up that alternates cannot vote when the member is present. His comment was noted. Only voting members are allowed to vote.

3. **Town of Suwannee Study** – Elke Ursin presented a brief overview of the status of this project. The final draft report has been submitted. Comments are to be emailed to Elke Ursin by end of June to finalize the report. Larry Danek with ECT presented. The goal of this project was to evaluate the impacts of closing 850 OSTDS in the Town of Suwannee. Baseline data was collected during a study in the winter of 1996. A copy of this presentation is available on the Department's website.

4. Nitrogen Study

Elke Ursin introduced the study and gave an overview outlining what has happened since the last meeting. Damann Anderson presented and the presentation is posted on the Department's website. A background of the study was given, Dr. Smith discussed the second stage of the passive nitrogen removal study, the proposed project scope for Phase I and II were discussed, and at the end of the meeting a tour of the test facility was given.

David Winialski suggested that one of these passive systems could have the maintenance and management done under the new Senate Bill 550 inspection program, so they would only be inspected once every five years. Eberhard Roeder responded by saying that this depends on how the system is classified. If it is classified as a conventional system, then that would be the case, but if it is classified as an advanced system then it would need to meet a more frequent inspection schedule. Damann Anderson said that part of the study will look at this and evaluate this.

David Winialski asked if these systems produce any by-products that would cause environmental problems. Dr. Smith stated that the systems will be designed to keep any discharges below the maximum contaminant level.

David Carter presented the budget proviso language that was approved to be in this year's budget. It gives $2,000,000 to continue the study and requires an interim report on February 1, 2011 and a final report on May 16, 2011. The language also states that DEP is to have maximum technical input. David Carter has asked Elke Ursin to make sure that Jerry Brooks is notified of the RRAC meetings. The language also states that the main focus of the work this year is to focus on developing, testing, and recommending cost effective design criteria. This does not change the contract terms, but emphasizes focusing on passive technologies. Damann Anderson stated that this goes in line with the existing contract. Bob Himschoot asked whether any of the existing approved passive systems will be tested as part of this study, and Damann stated that some will, but not all of them. They will pick the systems that best meet the criteria established in an earlier task. Elke Ursin stated that the way the money was appropriated this year means that the $2,000,000 is available July 1, 2010. Quentin Beitel stated that there was a lot of effort going into getting this money and he wanted to recognize the hard work that went into getting this funding.

Damann Anderson went into detail describing which tasks have been completed, which tasks are proposed for Phase II, and which will remain to be completed in Phase III. Phase I ended on June 30, 2010, Phase II is for this next round of funding, and Phase III is the final phase of funding. Phase II may or may not take 1-year. There was a discussion that tasks A.27 and A.28 (draft and final passive nitrogen reduction systems phase II reports) be moved to Phase II of the project. This will require moving something from Phase II to Phase III. The details will be worked out between Hazen and Sawyer and DOH. Eberhard Roeder asked that D.14 (complex soil model) be moved up to Phase II, and to move task D.10 (multi-source aquifer model) to Phase III. Damann said that he will get with the Colorado School of Mines regarding these changes.

5. Discussion on DEP's Wekiva Fertilizer Report – Elke Ursin presented a brief background on DEP's Wekiva Fertilizer Study. They have completed their study, which focused on residential fertilizer use. The inputs were modified for wastewater treatment facilities and atmospheric deposition per comments from DOH and Damann Anderson. Fertilizer inputs were adjusted based on the findings of the study. They also used Ellis & Associates field data for the OSTDS inputs and loadings which increased the estimate by 45% and 16% respectively. The pie charts showing the nitrate loadings for both the Wekiva Basin and the Wekiva Study Area were discussed. In 2007 the RRAC decided to postpone making a decision on whether the OSTDS contribution of nitrogen to the Wekiva Study Area was significant until the DEP study was done. Now that the study is done it is being brought back to the committee for review and consideration. Damann Anderson said that he is surprised to see the nitrogen contribution from OSTDS so high. He knows of no other study that has demonstrated this. David Carter said that the committee has gone beyond the initial question and that the nitrogen study is looking at this. The committee has decided that septic systems need to do better with nitrogen and that is what the nitrogen study is looking at. He does not think that we need to be doing anything more than what is being done right now. This appeared to be the consensus of the RRAC. No motion was made.

6. **Discussion on Continuation of Inventory of OSTDS and Relationship to Maintenance and Management Program (SB 550)** – Elke Ursin presented a brief overview of SB 550, which requires a 5-year inspection to be done on all systems in Florida. This program has a tie-in with the inventory of all systems in Florida that was completed last year. This inventory presented a snap-shot in time that could be built upon and updated. A website showing the results of this inventory has been developed and should be posted in the near future for the public to access. The RRAC had decided in a previous meeting to start working on a method to continue the inventory and to present this at a future meeting. Elke Ursin presented some proposed next steps, which included updating the Environmental Health Database, updating the data with the latest Department of Revenue information and figuring out a method of automating this task, updating the database with the latest DEP data on permitted wastewater treatment plants (WWTP), resending out letters to the WWTP requesting customer information to update the database, and using county health departments to resolve some of the unknowns. After discussion, it was decided to hold off doing anything until direction is given from Gerald on what would be most beneficial. Scott Carmody gave a brief overview of his database system and mentioned that his program is currently under contract with DEP.

7. **Update on Study of Performance of Advanced Systems in Florida** – Elke Ursin gave an update on the status of this study. The draft summary report for the Monroe County portion of this project is being written. The database is mostly complete and identifies 16,802 advanced systems in the state. Summary statistics are being developed. A description of technologies that the current advanced systems use has been added to the database to make sure different technologies are sampled. Surveys were sent to various interest groups. Approximately 1,000 of the 3,800 surveys were returned as undeliverable due to various reasons such as the house being vacant, or there not being a mail receptacle. DOH staff found these owners' addresses on the property appraisers' websites and resent the letters to these new addresses. The QAPP for the sampling portion of this project is being finalized. The contract with the lab to evaluate the samples has been executed. Permit file reviews on the selected systems is ongoing. An evaluation tool to look at management practices is being developed as this project continues.

8. **Alternative Drainfield Products Discussion** – Availability of data on the longevity and effectiveness of alternative drainfield projects is limited. At the last RRAC meeting staff were directed to come back with a proposed scope of work and budget. Elke Ursin presented a scope of work and wanted to hold off developing a detailed budget until RRAC directs staff on what they would like to see be done. Three different phases were proposed. Phase I would be performing an evaluation of existing data and the cost of this phase would be staff time. Phase II would be

creating an advisory group with product manufacturers, contractors, and CHD's to get an idea of how to gather the information gaps found after Phase I. Phase III would be to go out and gather the data to fill in the data gaps. The RRAC directed staff to wait and see what is going to happen with the SB 550 inspection program.

9. **Discussion on Research Budget** – Fiscal year 2009-2010 budget numbers were presented. There is a significant reduction in the total revenue coming in from the $5 surcharge on new septic permits. In years past this number was around $200,000 and now is around $67,000. The 2010-2011 research budget request was presented. It was decided to keep the alternative drainfield product assessment and inventory phase II studies in the budget.

    Bill Melton made a motion to accept the budget, seconded by Patti Sanzone, and the motion passed.

10. **Election of Chair and Vice Chair** – David Carter is retiring as chair of the RRAC, Carl Ludecke is taking over his spot as the Home Building Industry primary member on the RRAC, and a new chair and vice chair are to be nominated and elected. Pam Tucker nominated Clay Tappan as the chair and Carl Ludecke as the vice chair. Nominations were closed. All were in favor with none opposed. Bill Melton thanked David Carter for all of his years of service stating that he has been remarkably even keeled and easy to deal with. There was a round of applause from those present at the meeting.

11. **Other Business** – Elke Ursin brought up that the pollution prevention grant proposal was submitted on April 5, 2010 and that EPA should make a decision in July. There was a discussion about how to get the Hotel and Restaurant RRAC representatives to attend the meetings.

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

13. **Closing Comments, Next Meeting, and Adjournment** – Clay Tappan thanked David Carter for his dedication to the committee for over a decade. David Carter said that he has enjoyed his time on the committee. The next meeting will be scheduled for sometime in the future, with the date, time, and location being determined via email. The focus of the next meeting will be to discuss the RRAC priorities, the inventory study phase II, and the alternative drainfield products study. Damann Anderson provided some information on the tour of the research facility that occurred after the meeting.

    Carl Ludecke made a motion to adjourn, seconded by Patti Sanzone, and the meeting adjourned.

SECTION 3 - HUMAN SERVICES

485	SPECIAL CATEGORIES ACQUISITION OF MOTOR VEHICLES		
	FROM ADMINISTRATIVE TRUST FUND . . .		80,000
	FROM RADIATION PROTECTION TRUST FUND		130,856
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.

487	SPECIAL CATEGORIES GRANTS AND AIDS - CONTRACTED SERVICES		
	FROM FEDERAL GRANTS TRUST FUND . . .		750,000
488	SPECIAL CATEGORIES RISK MANAGEMENT INSURANCE		
	FROM GENERAL REVENUE FUND	66,504	
	FROM RADIATION PROTECTION TRUST FUND		14,575
489	SPECIAL CATEGORIES TRANSFER TO DEPARTMENT OF MANAGEMENT SERVICES - HUMAN RESOURCES SERVICES PURCHASED PER STATEWIDE CONTRACT		
	FROM GENERAL REVENUE FUND	12,630	
	FROM ADMINISTRATIVE TRUST FUND . . .		18,342
	FROM FEDERAL GRANTS TRUST FUND . . .		9,712
	FROM GRANTS AND DONATIONS TRUST FUND		8,282
	FROM RADIATION PROTECTION TRUST FUND		40,522
490	SPECIAL CATEGORIES STATE UNDERGROUND PETROLEUM ENVIRONMENTAL RESPONSE (SUPER) ACT REIMBURSEMENT		
	FROM GRANTS AND DONATIONS TRUST FUND		534,775
TOTAL:	ENVIRONMENTAL HEALTH SERVICES		
	FROM GENERAL REVENUE FUND	5,436,035	
	FROM TRUST FUNDS		23,407,013
	TOTAL POSITIONS	217.50	
	TOTAL ALL FUNDS		28,843,048

COUNTY HEALTH DEPARTMENTS LOCAL HEALTH NEEDS

APPROVED SALARY RATE 474,197,601

492	SALARIES AND BENEFITS POSITIONS	12,359.00	
	FROM COUNTY HEALTH DEPARTMENT TRUST FUND		652,737,029
493	OTHER PERSONAL SERVICES		
	FROM COUNTY HEALTH DEPARTMENT TRUST FUND		32,697,185

	FROM PERMIT FEE TRUST FUND		1,636,320
	FROM WATER QUALITY ASSURANCE TRUST FUND		1,393,409
1771	OTHER PERSONAL SERVICES		
	FROM ECOSYSTEM MANAGEMENT AND RESTORATION TRUST FUND		358,779
	FROM LAND ACQUISITION TRUST FUND . .		40,000
	FROM MINERALS TRUST FUND		84,045
	FROM NON-MANDATORY LAND RECLAMATION TRUST FUND		59,938
	FROM WATER QUALITY ASSURANCE TRUST FUND		225,168
1772	EXPENSES		
	FROM LAND ACQUISITION TRUST FUND . .		97,750
	FROM NON-MANDATORY LAND RECLAMATION TRUST FUND		494,233
	FROM PERMIT FEE TRUST FUND		463,870
	FROM WATER QUALITY ASSURANCE TRUST FUND		209,928
1773	AID TO LOCAL GOVERNMENTS GRANTS AND AIDS - SUWANNEE RIVER WATER MANAGEMENT DISTRICT - ENVIRONMENTAL RESOURCE PERMITTING		
	FROM WATER MANAGEMENT LANDS TRUST FUND		453,000
1774	AID TO LOCAL GOVERNMENTS GRANTS AND AIDS - WATER MANAGEMENT DISTRICT PERMITTING ASSISTANCE		
	FROM WATER MANAGEMENT LANDS TRUST FUND		100,000
1775	OPERATING CAPITAL OUTLAY		
	FROM MINERALS TRUST FUND		1,132
	FROM NON-MANDATORY LAND RECLAMATION TRUST FUND		40,125
1775A	SPECIAL CATEGORIES TRANSFER TO DEPARTMENT OF HEALTH		
	FROM WATER QUALITY ASSURANCE TRUST FUND		2,000,000

Funds in Specific Appropriation 1775A shall be transferred to the Department of Health to continue the Florida Onsite Sewage Nitrogen Reduction Strategies Study.

1776	SPECIAL CATEGORIES WATER QUALITY MANAGEMENT/PLANNING GRANTS		
	FROM FEDERAL GRANTS TRUST FUND . . .		3,260,043
1776A	SPECIAL CATEGORIES TRANSFER TO DACS GENERAL INSPECTION TF FROM DEP ECOSYSTEMS MANAGEMENT & RESTORATION TF		
	FROM ECOSYSTEM MANAGEMENT AND RESTORATION TRUST FUND		1,666,632
1777	SPECIAL CATEGORIES NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PROGRAM		
	FROM PERMIT FEE TRUST FUND		1,067,293
1778	SPECIAL CATEGORIES CONTRACTED SERVICES		
	FROM MINERALS TRUST FUND		20,000
1779	SPECIAL CATEGORIES HAZARDOUS WASTE CLEANUP		
	FROM WATER QUALITY ASSURANCE TRUST FUND		2,040,964
1780	SPECIAL CATEGORIES RISK MANAGEMENT INSURANCE		
	FROM GENERAL REVENUE FUND	47,108	

FINAL STUDY AND REPORT ON PHASE 1 OF THE FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES STUDY (2008-2010)

Bureau of Onsite Sewage Programs

May 1, 2010

Ana M. Viamonte Ros, M.D., M.P.H.
State Surgeon General

Charlie Crist
Governor

Table of Contents

List of Figures

List of Tables

FINAL STUDY AND REPORT ON PHASE 1 OF THE FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES STUDY (2008-2010)

EXECUTIVE SUMMARY

The 2008 Legislature appropriated $1.0 million for phase 1 of an anticipated 3-5 year project to develop passive strategies for nitrogen reduction for onsite sewage treatment and disposal systems (OSTDS). This report is submitted in compliance with Line Item 471 Section 3, Conference Report on Senate Bill 2600, General Appropriations Act for Fiscal Year 2009-2010, which re-appropriated funding for the study.

The original 2008 legislative direction identified three areas of concern: (1) Quantification of life-cycle costs and cost-effectiveness of passive nitrogen reduction treatment technologies in comparison to more active technologies and to conventional treatment systems; (2) Characterization of nitrogen removal from effluent in the soil underneath the drainfield and in shallow groundwater; and (3) Development of simple models to describe the fate and transport of nitrogen from onsite sewage treatment and disposal systems.

The significance of this project is that it evaluates and develops strategies to reduce nitrogen impacts from OSTDS regulated by the Florida Department of Health (FDOH). Excessive nitrogen can have 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 the Florida Department of Environmental Protection 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.

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. As a result of the time required for contracting, unspent monies in fiscal year 2008-2009 were re-appropriated in 2009 to complete the initial tasks of the project. The contract identifies the following tasks:

Task A includes a 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 includes installation of top ranked nitrogen reduction technologies at actual homes, with documentation of their performance and cost.

Task C 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 is to develop simple fate and transport models of nitrogen from OSTDS that can be used for assessment, planning and siting of OSTDS.

As of March 2010, the contractor, in coordination with the Research Review and Advisory Committee and FDOH, had successfully completed parts of Task A, C, and D, including literature reviews, ranking of nitrogen reduction technologies for field testing, design of a test facility for effluent plume monitoring and further development of passive technologies, and preparation of quality assurance documents for the test facility work and groundwater monitoring to be completed during fiscal year 2010-2011. Installation of the test facility for the evaluation of nitrogen reduction techniques and preparation for field sampling are currently ongoing. Sampling and reporting of results would continue through subsequent years and will require funding for fiscal year 2010-2011. Field-testing of the ranked technologies at home sites (Task B) will also require additional funding.

Recommendations

The FDOH and its Research Review and Advisory Committee recommend the legislature:

- Provide funding and budget authority to the FDOH in the amount of $2 million for the fiscal year 2010-2011 for continuation of the contract and associated tasks.
- Allow the FDOH to carry over remaining funds from fiscal year 2009-2010 to 2010-2011.

Additional resources will be applied to the next phase of the project, primarily 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 also will continue the development and monitoring work at the test facility, and modeling. Additional funding will be needed from the 2011 legislative session to complete monitoring and other field activities, and for final reporting with recommendations on onsite sewage nitrogen reduction strategies.

Detailed nitrogen reduction technology evaluations will be forthcoming as part of this project. However, based on previous research in Florida and the results of the literature reviews completed thus far for this project, the FDOH supports consideration of the following recommendations:

- In nitrogen sensitive areas, requiring lower sewage system densities or better treatment than currently allowed. For example, the current allowances for lots platted before 1972 provide for approximately five typical three-bedroom houses per acre for parcels served by private wells and eight typical three-bedroom houses per acre for parcels served by public water systems.
- A statutory change to allow the use of performance-based treatment systems for establishments other than single family residences without the need for a variance.
- Developing regulations for entities that operate and maintain shared treatment systems (clusters) treating sewage flows within the department's jurisdiction and/or serving an establishment on multiple parcels. This should include requirements for financial assurance, obligations of property owners, and rate setting.
- Identifying funding and cost sharing mechanisms to implement inspection, maintenance or upgrade programs for existing onsite sewage systems.
- Establishing a task force for the study and development of water quality requirements, performance, approval, operation, maintenance and inspection standards for wastewater reuse treatment and waste separation systems, including those that would be constructed within buildings, and delineating the jurisdictional boundaries between the Building Authorities and the Department of Health for such systems.

1 INTRODUCTION

1.1 Legislative Language

This report is submitted in compliance with Line Item 471 in Section 3, Conference Report on Senate Bill 2600, General Appropriations Act for Fiscal Year 2009-2010. The language instructs:

> From the funds in Specific Appropriation 471, $540,000 from the Grants and Donations Trust Fund is provided to the department to continue 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 study and report on February 1, 2010, and a final study and report on May 1, 2010, to the Governor, the President of the Senate, and the Speaker of the House of Representatives prior to proceeding with any nitrogen reduction activities.

The instructions refer to a study that was previously authorized by the legislature. 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.

Both instructions refer to nitrogen reduction and passive technologies or strategies for onsite sewage treatment and disposal systems. The following sections provide background information and discuss several terms that are important for this study.

1.2 General Background

Protection of public health and the environment is the mission of the Onsite Sewage Program of the Florida Department of Health (FDOH). Onsite Sewage Treatment and Disposal Systems

(OSTDS) are a permanent solution to wastewater treatment in many locations throughout the State of Florida. In Florida, an estimated 2.67 million OSTDS are in use statewide, serving approximately a third of the population. They create one of the largest artificial ground water recharge sources in the state. Ninety percent of the water used for drinking comes from ground water. It is necessary to protect this resource to protect public health and the environment.

Excessive nitrogen can have negative effects on public health and the environment. The primary impetus for this study is the increased level of nitrogen in the environment. Increased amounts of nitrogen in surface water bodies can cause eutrophication, which can lead to detrimental effects to sensitive aquatic ecosystems. Nitrogen sources to the environment include: atmospheric deposition; fertilizer from both agricultural and residential land uses; livestock waste; municipal wastewater treatment systems; onsite sewage treatment and disposal systems; and stormwater. The combination of these sources adds up to a cumulative nitrogen load to ground and surface waters. As land uses change and the population and the number of onsite systems increase, the relative contribution of onsite systems to nitrogen sources in an area may change.

Various investigators have evaluated the relative contribution of onsite systems to cumulative nitrogen impacts in specific watersheds and discussed opportunities to reduce this contribution. The FDOH has been most involved in such efforts in the Wekiva Study Area of central Florida and has provided reports on nitrogen and onsite systems to the Governor in 2004 and 2007. An increasing motivation for such evaluations is the need to maintain and restore water bodies to their designated uses, implemented through the total maximum daily load program of the Florida Department of Environmental Protection.

The 2008 legislative language addressed these concerns about the management of impacts from nitrogen discharged from onsite systems on Florida's waters by providing initial funding for a research project. In the same line item, the legislature requested a report on an inspection program to address ongoing maintenance of conventional onsite systems and an inventory of onsite systems in Florida. The 2009 legislative language instructs the FDOH to submit recommendations for passive strategies for nitrogen reduction based on the work accomplished during the project.

1.3 Discussion of Terms

Florida has been a leader in the field of onsite wastewater treatment and disposal system (OSTDS) practices. Conventionally, OSTDS consist of a septic tank and a drainfield. Onsite system construction and use standards in the State date from 1921. A major revision occurred in 1984 from which time onward all drainfields in new onsite system construction had to be installed to provide two feet of separation from groundwater. Figure 1-1 illustrates a conventional onsite system. Research in Florida and elsewhere has shown that OSTDS installed to these modern standards effectively reduce the concentration of pathogens found in normal wastewater, but that nitrogen levels are only reduced to a limited extent.

Mass vs. Concentration of Nitrogen

Mass and concentration of nitrogen in sewage will influence the working of a nitrogen reduction system. The mass of nitrogen to be treated by an onsite system depends on the diet, number, and living patterns of users. On a per capita basis, data allowing estimates of the annual mass of nitrogen leaving septic tanks in Florida have resulted in a range from 7 to 15 pounds of nitrogen per person, with a mid-range value of 11 pounds per capita per year. This estimate is also between the median and mean value of a recent Water Environment Research Foundation (WERF) study that included septic tanks from Florida.

The concentration of nitrogen in sewage depends on the mass of nitrogen generated and the amount of water in which it is diluted. The water usage is again variable and influenced by socioeconomic status. Studies in Florida in the 1980s and 1990s, on which current regulations are based, indicated that a typical total nitrogen concentration leaving a septic tank was just under 40 mg/L. Studies in the last few years, such as the FDOH's Wekiva study in 2007 and the WERF study mentioned before, suggest that typical concentrations have increased to 60 mg/L or even 80 mg/L.

While the concentration appears to have increased, the mass loading of total nitrogen does not appear to have increased, which is consistent with water conservation being the main cause of the concentration increase. Total maximum daily loads are frequently expressed as a limiting concentration. For watershed assessments, such a concentration can be compared to the cumulative mass loading of the pollutant of interest relative to a characteristic flow of the water body of concern. For such estimates the mass loading, i.e. the product of both effluent concentration and flow, from onsite systems is more meaningful than effluent concentrations only. Correspondingly, to address problems of excess nitrogen on a watershed scale, mass loading reductions are more generally applicable than concentration reductions. Therefore, most of this report and most of the reports created by the contractor refer to reductions in mass loading rather than particular concentration values.

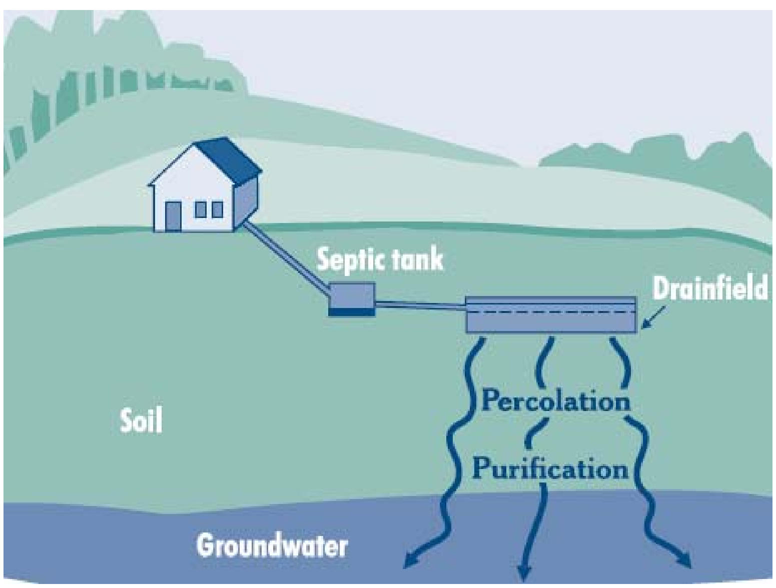


Figure1-1. Conventional onsite sewage treatment and disposal system (septic system) (from http://www.epa.gov/owm/septic/pubs/homeowner_guide_long.pdf).

“Advanced” Treatment Systems

Where local regulations require more treatment or where relatively small lots make it difficult to install a conventional system, more advanced treatment options exist. These fall generally into two permitting categories:

Aerobic treatment units add air to the sewage so that oxygen demanding compounds in the sewage can be digested before the sewage enters the drainfield. Aerobic treatment units are permitted based on a standardized technology test by a third-party that certifies that the technology functions in removing oxygen demanding compounds and solids.

Another permitting category is labeled performance-based treatment systems. A Performance-Based Treatment System is a type of OSTDS that has been designed to meet specific performance criteria for certain wastewater constituents as defined by Section 64E-6.025(10), FAC. It should be noted that nitrogen is only one of the possible constituents in wastewater that can be addressed by performance-based treatment systems, oxygen demand and solids, total phosphorus, or fecal coliforms as pathogen indicator are others. Technologies used in a performance-based treatment system can have a range of complexity and energy intensity. Under current market conditions, most technologies used in performance-based treatment systems have been based on aerobic treatment units and include active aeration, whereby air is introduced into the sewage.

In 2007-2008, the FDOH undertook a study of passive technologies for nitrogen removal. The definition used in that study and since then for “passive” is:

> Passive: A type of onsite sewage treatment and disposal system that excludes the use of aerator pumps and includes no more than one effluent dosing pump with mechanical and moving parts and uses a reactive media to assist in nitrogen removal.

Two elements are of note in this definition. It excludes some approaches to achieving aeration (aerator pumps), one of the processes included in sewage treatment; and it requires a particular approach (reactive media) for nitrogen removal, another process in the treatment of sewage. These elements are based on an understanding that nitrogen removal from wastewater generally occurs in two steps. In the first step associated with aeration, nitrification occurs when nitrogen is converted to nitrate. In the second step, which occurs without air (anoxic conditions), denitrification occurs when nitrate is converted to nitrogen gas that then leaves the sewage. Figure 1-2 illustrates the sequence of processes occurring in a passive system. The same processes can be achieved by other, less passive technological approaches, too. Table 1-1 characterizes the current relationships between conventional, performance-based treatment systems, and passive systems.

Before a new technology becomes classified as performance-based treatment system for nutrient reduction it passes through a period of innovative system testing in Florida. To become an innovative system, a technology has to provide third-party testing data similar to those required for aerobic treatment units. During innovative system testing, a limited number of systems are installed and monitored in Florida. FDOH expects the field testing during Task B of this project to be a useful component of such innovative system testing for some new technologies.

The addition of reactive media, or the dosing of other reactants in non-passive systems, to achieve treatment processes in onsite sewage treatment systems raises the question if such additions themselves can cause ground or surface water contamination. Florida regulations require a review of such compounds and their proposed dosing rates to prevent such contamination.

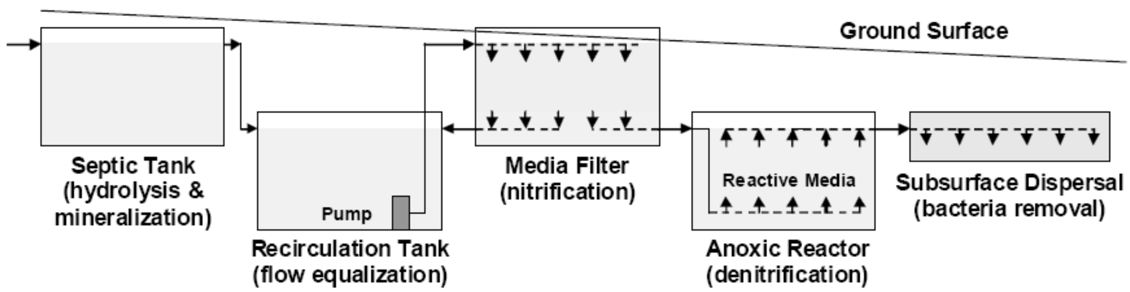


Figure 1-2. Sequence of processes in a passive system (Fig 4.9 of literature review for Task A).

Table 1-1. Relationships between the terms conventional system, performance-based treatment system, and passive system for the purposes of this study.

Characteristic	**Conventional system**	**Performance-based treatment system**	
How important is nitrogen reduction in system?	Nitrogen reduction is coincidental.	Nitrogen reduction is design goal.	
Where does nitrogen reduction take place?	Nitrogen reduction limited in drainfield, site-specific	Denitrification integrated with aeration process	Additional, separate denitrification stage
What treatment processes beyond a conventional system are included?	Not included	Aeration by blowers or similar means	Not included
			Denitrification by dosing reactants
			Denitrification by reactive media
		Aeration by sewage flow over media	Not included
			Denitrification by dosing reactants
			Denitrification by reactive media

"passive system" for the purposes of this study

2 PROGRESS OF THE MULTI-YEAR STUDY THROUGH MARCH 2010

2.1 Contractor Selection

The study legislation was passed and signed into law by the Governor on June 11, 2008. In cooperation with the RRAC, the FDOH developed a request for proposals in the form of an invitation to negotiate (ITN) according to Florida Statute 287.054(3)(a). This ITN was advertised on September 26, 2008 as DOH 08-026 with the title "Florida Onsite Sewage Nitrogen Reduction Strategies Study: Technology Evaluation, Characterization of Environmental Fate and Transport, and an Assessment of Costs". Three teams submitted proposals. During the

RRAC meeting on November 6, 2008, all proposals were ranked, and the proposal by a project team led by Hazen and Sawyer was ranked highest.

The FDOH invited the top-ranked team to begin negotiations. After several negotiation sessions during which aspects of the proposals were clarified and a more detailed scope of work defined, and review of the best and final offer, the FDOH issued an intent to award letter on December 16, 2008, and the contract was executed on January 28, 2009.

The process from signing of the legislation to a completed agreement took approximately six months. This is comparable to the time requirements for soliciting and issuing contracts for smaller projects in the past.

2.2 Summary of Scope and Status for the Multi-Year Study as of March 2010

The resulting contract for the study split the project into five main tasks:

- Task A: Technology Evaluation for Field Testing: Review, Prioritization, and Development
- Task B: Field Testing of Technologies and Cost Documentation
- Task C: Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater
- Task D: Nitrogen Fate and Transport Modeling
- Task E: Project Management, Coordination, and Meetings

For each of these tasks, the contract defines more detailed subtasks and their objectives. The contract anticipates progress by establishing particular milestones at which the gathered knowledge will be used to further refine subsequent work.

The following subsections discuss the status and anticipated progress for the various tasks. Objectives that have been completely or partially accomplished are indicated as such. Reports are available as meeting materials and associated documents on FDOH's onsite sewage research web-page (http://www.myfloridaeh.com/ostds/research/Index.html).

2.2.1 Task A, Technology Evaluation for Field Testing: Review, Prioritization, and Development

The objectives of Task A, Technology Evaluation for Field Testing: Review, Prioritization, and Development, are given in the following listing.

- Perform literature review to evaluate nitrogen reduction technologies -- completed
- Develop technology classification scheme -- completed
- Formulate criteria for ranking of nitrogen reducing technologies for this project -- completed
- Rank and prioritize nitrogen reduction technologies for field testing in this project -- completed
- Conduct technology ranking workshop with RRAC -- completed
- Prepare innovative systems applications for highly-ranked technologies that are not yet innovative systems in Florida
- Conduct technology development in Passive Nitrogen Removal Study II -- design completed, quality assurance project plan completed

2.2.2 Task B, Field Testing of Technologies and Cost Documentation

The objectives of Task B, Field Testing of Technologies and Cost Documentation, are:

- Identify home sites and establish use agreements
- Establish vendor agreements
- Quality Assurance Project Plan
- Install field systems at home sites
- Operate and monitor field systems
- Compile results in report format
- Provide technical description of nitrogen removal technologies
- Acceptance of systems by homeowners
- Conduct Life Cycle Cost Analyses
- Final Report for Task B

As these objectives built on results of Task A, completion of this work is anticipated to begin during the next fiscal year, contingent on additional funding.

2.2.3 Task C, Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater

The objectives of Task C, Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater, are:

- Critical characterization of nitrogen reduction in Florida soils and groundwater (completed)
- Develop Quality Assurance Project Plan -- completed
- Establish a controlled test facility
- Identify home sites and make use agreements
- Instrument field systems at test facility and home sites -- test facility under construction
- Operate and monitor field systems
- Compile data in report format
- Close-out of home sites and controlled test facility
- Provide Final Report for Task C

2.2.4 Task D, Nitrogen Fate and Transport Modeling

The objectives of Task D, Nitrogen Fate and Transport Modeling, are:

- Literature review on fate and transport models -- completed
- Quality Assurance Project Plan
- Space time variable aquifer model with simplified soil treatment
- Development-scale aquifer model creation and calibration
- Space time variable model with complex soil treatment
- Development-scale model with aquifer and soil treatment
- Uncertainty analysis
- Validate and refine models using data from Task C
- Develop decision making framework
- Final Report for Task D

2.2.5 Task E, Project Management, Coordination and Meetings

The objectives of Task E, Project Management, Coordination and Meetings are:

- Conduct project kickoff meeting -- completed
- Prepare progress reports -- four completed

- Make presentations to Research Review and Adivisory Committee and Technical Review and Advisory Panel -- one completed
- Conduct Project Advisory Committee meetings

2.3 Expenditure Status

The proposed cumulative total funds anticipated to be spent on the contract with Hazen and Sawyer prior to the end of the 2009-2010 fiscal year are $774,000. Through February of 2010, Hazen and Sawyer has invoiced for deliverables valued at $375,000. The FDOH has spent about $25,000 through December of 2009 for two RRAC meetings in 2008 and six RRAC meetings in 2009, and other associated costs to discuss the scope of the project, to rank proposals, and to provide input into and updates on the project. It is anticipated at least quarterly RRAC meetings will be required to provide regular updates and guidance on the project.

2.4 Coordination with Advisory Committees of the FDOH

Implementation of this study requires close cooperation with the FDOH's Research Review and Advisory Committee (RRAC), which the legislature charged to control the study.

The RRAC met to discuss this project for the first time on July 30, 2008, in Orlando. One item of discussion was a clarification of roles among: the FDOH that is to contract for the study, provide administrative support to the RRAC, review and accept the deliverables, and provide the report to the governor and legislature; the RRAC which has been tasked with controlling the study; and the contractors that will perform the work, provide reports, and address comments. The RRAC voted unanimously that in controlling the study, RRAC will: rank proposals for contracts, review draft deliverables and provide comments, file a progress report, accept as completed the final report by contractors, and attach comments to the final report. The RRAC provided comments on the draft scope and directed FDOH staff to proceed further with development of a solicitation.

Additional meetings of the RRAC took place on December 02, 2008, when the first progress report for the project was discussed; January 5, 2009; February 3, 2009; May 27 and 28, 2009 when a workshop on prioritization of technologies for testing was held; July 1, 2009, September 10, 2009; and December 16, 2009.

FDOH staff presented a status report on August 27, 2008, to the FDOH's Technical Review and Advisory Panel (TRAP), which advises the FDOH on onsite sewage rule making and policy per 381.0068, F.S. The TRAP voted to approve the project as presented to them and requested they be kept informed on the status of this project. The most recent update occurred at the TRAP meetings on August 27, 2009, and January 28, 2010. FDOH's interim study report was sent to the members of TRAP on February 10, 2010.

2.5 Anticipated Progress in Remainder of Fiscal Year 2009/2010

The tasks associated with this project will have a significant amount of work completed prior to the end of the 2009-2010 fiscal year. The following paragraphs describe the anticipated progress.

For Task A, the completion of construction of the test facility and beginning of testing are anticipated. The quality assurance project plan outlining details of this sub-project has been finalized.

For Task B, preparations for testing at individual homeowner sites will be dependent on anticipated funding for subsequent years.

For Task C, a quality assurance project plan has been completed to outline the monitoring framework for field sites. The monitoring approach takes a three-pronged approach: detailed monitoring, including in the vadose zone, of small-scale drainfields at the test facility; detailed monitoring of a large drainfield at the test facility; monitoring of groundwater plumes at home sites. The design for the test facility will be completed and monitoring will commence. It is anticipated home sites will range across the State of Florida, including north Florida, central Florida (specifically the Wekiva area), and south Florida to capture diversity in site conditions.

For Task D, a quality assurance project plan will be developed to outline steps required to develop a model capable of predicting nitrogen concentrations at a specified location downgradient from the wastewater source. A simple model of nitrogen transport from the drainfield through unsaturated soil to the groundwater will be developed. This model will likely use the approach of specifying removal fractions that are dependent on soil conditions and effluent quality.

3 SUMMARIES OF MAJOR COMPLETED MILESTONES OF STUDY

3.1 Task A Technology Evaluation for Field Testing: Review, Prioritization, and Development

A summary of the literature review findings and recommendations for application of nitrogen reduction strategies in Florida are provided in this section. Subsequent sections that follow include a technology classification scheme to allow comparisons of an array of technologies, a ranking scheme to allow relative rankings of technologies based on criteria such as nitrogen reduction and treatment performance, system reliability and consistency, complexity of operation and maintenance, costs, aesthetics, and stage of development criteria, and a priority listing of the technologies for further testing and evaluation. It should be noted that the weights assigned to various criteria, the scores, and the resulting ranking were developed by the contractor for the specific purpose within this project: the selection of technologies for field testing. Other purposes might warrant other weighting or scoring approaches.

3.1.1 Literature Review (modified, edited and condensed from Section 6 of literature review for Task A)

The goal of the Florida Onsite Sewage Nitrogen Reduction Strategies Study is to develop cost-effective strategies for nitrogen reduction by OSTDS. This literature review provides a review and critical assessment of available literature on nitrogen reduction practices, treatment processes and existing technologies that appear suitable for use in individual home and small commercial onsite sewage treatment and disposal systems (OSTDS). The review catalogued well over 600 papers, proceedings, reports, and manufacturers' technical materials regarding existing and emerging technologies.

3.1.1.1 Categories of Nitrogen Reducing Technologies

A variety of nitrogen reducing technologies can be considered for possible Florida OSTDS applications. The technologies differ in availability of data on their effectiveness, stage of development, treatment approach and other characteristics. To simplify evaluation and provide a framework for further analysis, the available technologies were grouped by the treatment processes used to achieve nitrogen reduction. Four major categories were identified: source separation, biological nitrification/denitrification, physical/chemical, and "natural systems". Each of these categories was broken down further based on distinct process variations within a group (see Figure 3-1). The most prevalent nitrogen reduction processes used for onsite sewage treatment were found to be biological nitrification/denitrification and natural systems. Significant overlap exists between these two process types.

Biological nitrification/denitrification treatment processes are typically contained in treatment vessels, which allow access to observe and modify operation.

"Natural systems" effect treatment from combinations of biochemical processes that occur within the soil matrix and vegetative uptake/evapotranspiration. Conventional onsite sewage treatment and disposal systems and constructed wetlands, which are designed based on mimicking ecological communities, are also included within this group.

Physical/chemical processes, which do not rely on biological processes, are easier to control and are more consistent in treatment achieved, but they require more operator attention and are more costly. Originally thought to be more effective for municipal treatment, they were mostly abandoned as biological processes became better understood and controlled.

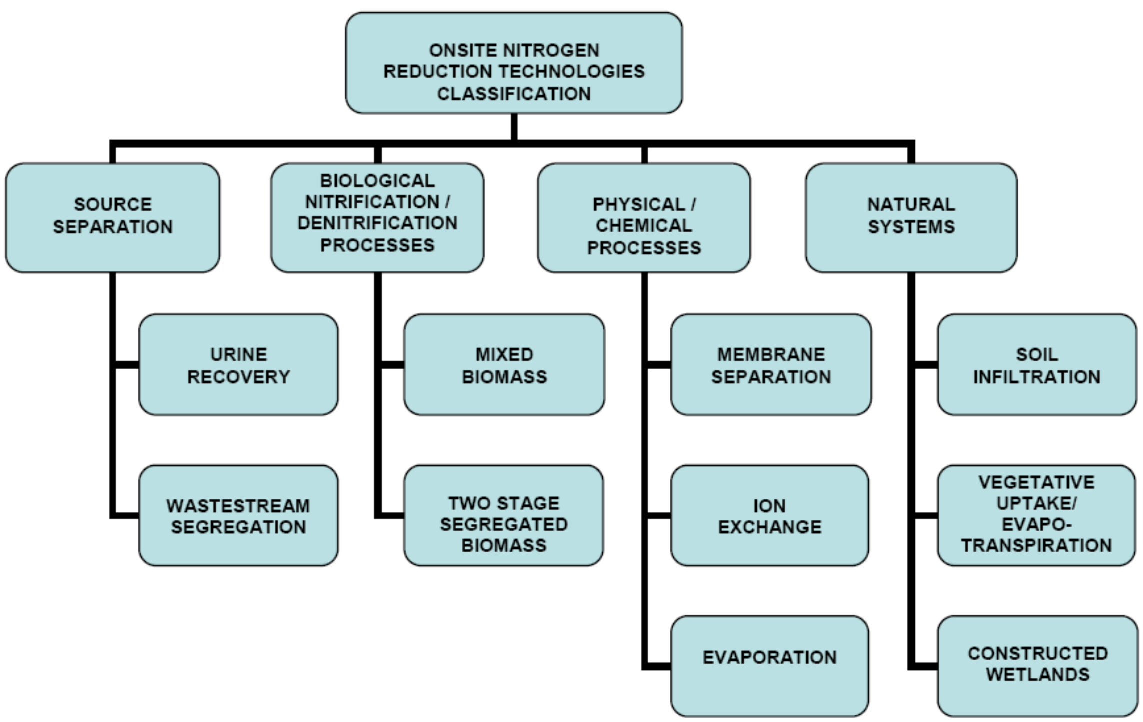


Figure 3-1. Categorization of treatment technologies for nitrogen reduction (Figure 4-1 of the literature review for Task A).

Source separation, on the other hand, is an emerging option for nitrogen removal. A promising practice is urine separation and recovery. Urine recovery can remove 70 to 80 percent of household generated nitrogen by installing urine separating toilets. If the infrastructure for urine collection and use as fertilizer is developed, this offers an effective, reliable and easy to implement option that is low in cost compared to the other identified nitrogen reduction technologies. It also provides a readily available source of fertilizer rich in nitrogen and phosphorus.

3.1.1.2 Process Performance

Data on the performance of OSTDS technologies are available for most biological nitrification/denitrification and natural systems processes. The majority of technologies are proprietary, but some public domain designs exist. Two large groupings of biological nitrification/denitrification processes are distinguished in these technologies: mixed biomass (single stage) and segregated biomass (two stage). The single stage process is the most frequently used process because it relies on organic carbon in the sewage to be the food or electron donor during denitrification as opposed to the two stage process, which requires an external source of food or electron donor. Nearly all of the treatment technologies designed for nitrogen removal can achieve close to 50 percent total nitrogen reduction, but as removal requirements increase, fewer technologies are available. Table 3-1 summarizes the performance capabilities. Ongoing studies by the Florida Department of Environmental Protection, Florida State University and FDOH are generating data that appear to generally agree with the results of the literature review.

Table 3-1. Biological Denitrification Processes and Typical Nitrogen Reduction Limits of OSTDS (modified Table 5-3 of literature review for Task A).

Biological Denitrification Processes and Typical Nitrogen Reduction Limits of OSTDS			
Process	**Mixed Biomass (Simultaneous)**	**Mixed Biomass (with Recycle)**	**Segregated Biomass (Two Stage)**
Electron Donor	Organic carbon from bacterial cells	Organic carbon from influent wastewater	External electron donor (Organic carbon; Lignocellulose; Sulfur; Iron, Other)
Typical N Reductions	40 to 65%	45 to 75%	70 – 96%
Typical Technologies	• Extended aeration • Pulse aeration • Recirculating media filters • Sequencing batch reactors • Reciprocating media beds • Membrane bioreactor	• Extended aeration with recycle back to septic tank • Recirculating media beds with recycle back to septic tank • Moving bed bioreactor	• Heterotrophic suspended growth • Heterotrophic packed bed fixed film • Autotrophic packed bed fixed film

The single stage process has been shown to achieve high removals of nitrogen in municipal wastewater treatment, but for this process the amount of organic carbon reaching the denitrification stage in OSTDS appears to be limiting the amount of nitrogen reduction that can be achieved. This phenomenon can be seen in the performance of OSTDS that use different methods of carbon management in the system. Those nitrogen reducing OSTDS that rely on organic carbon released by dying microorganisms in the active biomass of the system typically achieve 40-65 percent total nitrogen removal, while OSTDS that regularly recycle nitrified wastewater back to the anoxic septic tank to mix with organic carbon present in the raw wastewater typically achieve 45-75 percent total nitrogen reduction.

Segregated biomass or two stage processes, which do not rely on organic carbon in the system but rather add carbon or other food compounds to the denitrification stage from an external source, can achieve nearly complete removal of nitrate by adding carbon into the denitrification reactor. Examples of this approach include two technologies currently in innovative system status in Florida, the passive Nitrex™-reactive media and active dosing with Micro CG™, both of which require nitrifying pretreatment. Another example is the "bold-and-gold"-media that is currently being developed at the University of Central Florida. A segregated biomass (two stage) biological nitrification/ denitrification process would be necessary where strict total nitrogen limits require more than 70 percent removal prior to discharge to the drainfield.

Natural systems, which include the traditional OSTDS, also have inherent performance limitations. Application of septic tank effluent to unsaturated soil results in excellent oxygen demand (cBOD5) and fecal coliform removals. Soils with moderate to high hydraulic permeability with unsaturated (vadose) zones several feet deep below the system infiltrative surface are favored by onsite sewage regulations to achieve such treatment. Such soils are well aerated, which provide efficient and nearly complete nitrification of the influent nitrogen, but as a result of the aerobic soil atmosphere, the vadose zone is unable to retain organic carbon. This is a reason why nitrogen removals in conventional OSTDS are typically less than 40 percent. If aerobic pretreatment and nitrification were to be provided upstream of the infiltration system, slowly permeable soils, shallow organic soils, and soils with shallow perched saturated zones, which typically are restricted for OSTDS, would favor greater denitrification. Infiltration systems, such as mound systems, which could be constructed above the ground surface with the soil's O and A horizons left intact, may provide nitrification through the sand fill and denitrification through the organic layers below, if anoxic.

The effect of timed dosing of septic tank effluent on nitrogen reduction appears to be still subject to discussion. While the project team proposed in their literature review that such drip dispersal could enhance nitrogen reduction because of wetting and drying cycles with alternating aerobic and anoxic soil conditions, they assigned the lowest possible score to the nitrogen reduction performance of dosed septic systems, and the second lowest score to the performance of a drip irrigation system (see Table 3-4 below). Comments received on drafts of this interim report cited studies that did not find an enhancement of nitrogen reduction due to dosing. In reflecting on the cited studies, it appears that an enhancement has more frequently been found in fine-grained material, such as loam, while case studies that have found no enhancement tended to address coarser material such as sand.

Soil infiltration systems, particularly those that use drip dispersal, can also be constructed to create large "footprints" parallel to the lot's contours, which reduce the mass of nitrogen loading per square foot of area to avoid unacceptable concentrations in the underlying groundwater. Like any of the natural systems though, carbon management is problematic and because the discharges are below the ground surface, compliance monitoring is difficult and costly. Therefore, OSTDS are usually only favored where strict nitrogen limits are not required.

3.1.1.3 Emerging Technologies

Few emerging technologies were identified in the literature. Most of those that were identified have been variants to well-established processes. Others that could be considered new technologies for onsite treatment, such as distillation or ion exchange, are early in their development stages and are not yet proven effective.

The most promising new technology for consideration in Florida is urine recovery. This method of nitrogen reduction is already practiced in Scandinavia where urine separating toilets are commercially available. Implementation of this method of nitrogen reduction would be highly effective and far less costly if the necessary servicing and urine reuse infrastructure could be built and public objections to the idea of urine recovery could be overcome or avoided. In addition to ease of use and lower costs, urine recovery also has the added benefit of reducing phosphorus discharges.

3.1.1.4 Establishing Nitrogen Reduction Standards

The need for nitrogen reduction is not likely to be the same for all receiving environments. Therefore, because most nitrogen reduction options are more costly than traditional OSTDS, more complex, and require more attention to operate, the requirements for nitrogen reduction should be carefully considered. The considerations will result in the appropriate treatment requirement and the variations around that standard that will be allowed. Such an analysis should also consider the point of the standard's application. Several options exist. These include the end-of-pipe prior to discharge to the soil, the point below the system where the percolate enters the groundwater, at a property boundary, and/or at a point of use, e.g. a well, or a surface water. End-of-pipe points of application do not account for further treatment that might be attained in the soil. On the other hand, if the monitoring points are at poorly defined locations below the ground surface, compliance monitoring can be more costly and yield ambiguous results.

3.1.1.5 Technology Selection

The wide ranges of technological performance capabilities on the one hand and environmental sensitivities on the other suggest that appropriate solutions may be site-specific. The variety of available nitrogen reduction technologies and performance capabilities allows selection of a system design that can best meet the particular site conditions and nitrogen reduction requirements established for the area. For example, where the density of housing is low and far from high value surface or ground waters, natural systems, such as conventional OSTDS, might be appropriate. In poorly drained soils or where the soil underlying the system contains organic matter, a component designed to nitrify the wastewater before discharging to the soil could be added. In areas where surface waters are not considered threatened, but preventive measures are considered prudent, a technology using a mixed biomass nitrification/denitrification process that is capable of removing at least 50 percent might be most practical. In sensitive areas where protection of ground and surface waters is a high priority, a two stage nitrification/denitrification process could be the only acceptable alternative.

3.1.1.6 Management and Enforcement

Management and proper maintenance and operation of onsite systems are essential. Implementation of nitrogen reduction technologies will expand the FDOH's monitoring and enforcement operations and the owners' responsibilities toward their systems. In Florida, a regulatory framework for aerobic treatment units and performance-based treatment systems already exists that provides a current framework for the management of nitrogen reducing technologies. This can serve as a starting point for further development, which may require statutory changes and funding mechanisms.

The literature review did not address management in much detail. At this point in the study it is unclear if the current framework in terms of regulation or resources will be sufficient for new technologies. The following are some general concepts about management and enforcement from the literature review for Task A.

Thought must be given to how nitrogen reduction standards are to be stated and how compliance monitoring is to be performed. Nitrogen reduction standards may be stated as concentration limits or as percent removals. Nitrogen reduction standards will require water quality sampling to confirm compliance. Alternatively, rather than water quality sampling, compliance could be based on proper technology selection with processes that are known to meet the desired removal and routine maintenance and/or inspections to ensure the technology is functioning as intended. This latter approach to stating standards would likely be much less costly to monitor.

Monitoring of a sample of systems within the watershed rather than individual system monitoring to observe the aggregate impact of OSTDS on water resources could also be an effective alternative. Since impacts to watersheds have many sources and are tracked by multiple agencies, costs of monitoring could be shared between state and local water quality agencies.

Regardless of the choices made, system performance and maintenance tracking, inspections, monitoring and enforcement procedures should be available for deployment prior to permitting nitrogen reduction systems. Needed service provider qualifications and certification programs and sufficient service provider capacity also should be developed before widespread nitrogen reduction system implementation. A public awareness program will be needed also. Without these programs, requirements for nitrogen reduction systems are not likely to achieve the intended goals.

3.1.2 Technology Classification, Ranking and Prioritization of Technologies for Field Testing within this Project

(modified, edited and condensed based on the report for subtasks A7/8/9)

3.1.2.1 Classification

The results of the literature review (discussed in Section 3.1.1) led to development of a scheme for classifying nitrogen reduction technologies to allow comparisons between the many options that are available for use in onsite sewage treatment systems. This scheme consists of four categories for classification: source separation, biological treatment via nitrification/ denitrification, physical/chemical treatment, and natural systems. In most available onsite nitrogen reduction technologies, it is typical that more than one of these processes are operative in any given treatment system. The classification followed largely the pattern developed for the literature review (see Figure 3-1).

3.1.2.2 Ranking Criteria

A simple numerical ranking system was developed to prioritize available nitrogen reduction system categories for testing in this project based on thirteen selected criteria. Each criterion was scored against its particular attribute using a scale ranging from 1 to 5. To account for relative differences in significance of each of the criteria, the criteria were assigned weighting factors indicating relative importance compared to the other criteria. The relative weights of the criteria were determined via a two stage process. First, each criterion was compared to every other criterion by the project team prior to the Technology Classification, Ranking and Prioritization Workshop and then by the RRAC at the workshop. Second, in order to reconcile the differences between the project team and RRAC weights, the weights for each criterion were averaged. Two criteria, construction and operational complexity, were added during the RRAC workshop. During subsequent discussions, RRAC concluded that the weight for energy requirements should be the same as for operation and maintenance cost. Table 3-2 shows the final criteria with their weights.

The scoring systems were created with the full knowledge that data would not be universally available. Scores were made using the given criteria and good engineering judgment, based on the experience of the team where data was not available. Data available for classifications or groupings of technologies were gathered and reviewed by the project team. Given the wide variety of sources and scales, the resulting score was informed by the data but not necessarily based on a particular statistic (such as median or average) of the available data. The criteria departed in one particular way from the results of the literature review. While the literature review summarized performance as a fraction of nitrogen removed, which accounts for the variability of nitrogen concentrations in untreated sewage, the ranking criterion focused on effluent concentrations regardless of the nitrogen concentrations in the influent of the treatment system. Table 3-3 illustrates the scoring system for each criterion.

Table 3-2. Ranking criteria and weighting factors to evaluate technologies for testing (Table 3-1 from classification, ranking, and prioritization report).

Ranking Criteria and Weighting Factors			
Criteria	**Maximum Score S**	**Weighting Factor W**	**Total Possible Score SxW**
Effluent Nitrogen Concentration	5	11	55
Performance Reliability	5	10	50
Performance Consistency	5	9	45
Construction Cost	5	7.5	37.5
Operation and Maintenance Cost	5	7	35
Energy Requirement	5	7	35
Construction Complexity	5	5	25
Operation Complexity	5	5	25
Land Area Required	5	4.5	22.5
BOD/TSS Effluent Concentration	5	3.5	17.5
Restoration of Performance	5	3.5	17.5
System Aesthetics	5	2	10
Stage of Technology Development	5	0.5	2.5
		Total:	377.5

Table 3-3. Score assignments for ranking criteria (after Table 4-2 from classification, ranking, and prioritization report).

Criteria Scores

Criteria Number	Criteria	Score 1	2	3	4	5
1	Effluent Nitrogen Concentration (mg-N/L)	> 30	16 – 30	11 – 15	3 – 10	< 3
2	Performance Reliability	Monthly		Quarterly	Semi-Annually	Annually
3	Performance Consistency	Activated Sludge Nite/Denite	IFAS[2]	MBR/IMB[3]	Fixed Film	Physical/ Chemical & Source Separation
4	Construction Cost ($1,000's) [3)]	>20	16-20	11-15	5-10	<5
5	Operation and Maintenance Cost ($/year) [4)]	>500	401-500	301-400	200-300	<200
6	Energy Requirement (kW-h/year)	>2500	1501-2500	1001-1500	500-1000	<500
7	Construction Complexity	Complex installation, specialized training, sophisticated electrical and controls knowledge req., master septic tank contractor		Some specialized knowledge and training required		Simple to install by any Contractor
8	Operation Complexity	Complex operation with operator training required; Scheduled visits by manufacturer's representative required quarterly		Some specialized operator training required; Scheduled visits by manufacturer's representative required twice per year		Simple operation with limited operator requirements; annual manufacturer's representative scheduled visit
9	Land Area Required (ft2) [5)]	>2000	1001-2000	501-1000	250-500	<250
10	BOD/TSS Effluent Concentration (mg/L)	>50	30/30		20/20	10/10
11	Restoration of Performance	Activated Sludge Nite/Denite	IFAS [1)]	MBR [2)]	Fixed Film	Physical/ Chemical & Source Separation
12	System Aesthetics	Not Acceptable		Perceived Nuisance/ Displeasing		Acceptable
13	Stage of Tech. Development	Conceptual	Experimental	Demonstration	State Use	National Use

1) Integrated Fixed-Film Activated Sludge
2) Membrane Bioreactor
3) Construction cost assumes a standard septic tank cost of $2000 and drainfield cost of $4500 installed.
4) Operation and maintenance cost includes inspections, annual operating permit fee ($100), and maintenance entity, but it does not include power costs.
5) Land area is for a new entire system, and assumed standard septic tank 50 SF and drainfield 400 SF.

More details on the individual criteria and how their scores were determined can be found in the Hazen and Sawyer's report on Technology Classification, Ranking and Prioritization of Technologies. Comments on the report received by FDOH pointed out that the stage of technology development criteria was assigned a very low weight and disagreed with the scoring on this item.

3.1.2.3 Ranking Results to Prioritize Systems for Testing

A summary of the individual criterion scores for physical/chemical, biological, natural systems, and source separation technology classifications is presented in Tables 3-4 and 3-5. While the tables encompass the full range of possible systems contained in the classification, technology classifications that the project team deemed to lack sufficient data to make a criteria ranking determination were left blank. Technologies are summarized in broad categories. Scores for well established technologies reflect typical values from field installations, while scores for more experimental technologies tend to suggest the potential for the technology based on more controlled tests. In addition, the ranking of some of the technologies, in particular soil infiltration with reactive media, reflects the expectations of the project team extrapolated from other technologies more than from actual available data.

The rankings did not include a conventional septic system in which flow to the drainfield occurs by gravity. Such a system is likely to achieve a ranking slightly better than that of a dosed drainfield within the natural system category, based on lower construction and lower electrical costs, and have the same low score on effluent nitrogen concentration. It was not included separately due to the emphasis on prioritizing modifications and alternative technologies for testing during this project.

The top ranked pretreatment or pre-disposal technology classifications for testing (1 and 2) were biological systems with two stage segregated biomass employing autotrophic (chemical-fed) and heterotrophic (carbon-fed) denitrification. These systems are passive, expected to require little operator attention, and expected to provide high reliability. The total scores for autotrophic and heterotrophic denitrification technologies in two stage segregated biomass systems were sufficiently close that they were considered essentially equal. The third and fourth ranked technology classifications were mixed biomass fixed film biological systems with recycle and without recycle, respectively. The total scores for these systems were sufficiently close that they were considered essentially equal. These technology classifications are expected to have the stability advantages that are inherent in fixed film processes.

It is important to note that the natural systems should not be quantitatively compared, using these ranking criteria, to the groups of biological systems detailed in Table 3.4. Primary among considerations supporting this division of technologies is the need to consider separately the elements of each system that performs treatment. The soil infiltration units utilize the soil's ecology and physical characteristics to perform treatment, and all relevant data measures the treatment capacity within the soil to reduce nitrogen. However, it must be kept in mind that the vast majority of biological systems also discharge to the soil. In order to be able to rank each technology fairly, only the nitrogen reduction components were considered. Moreover, management of non-soil based technologies, though more expensive, is simplified because the units can be operated effectively to adjust to varying conditions and serviced easily, which may not be the case with soil-based nitrogen reduction technologies. When malfunctions occur with soil-based technologies, repairs may be necessary and could lead to expensive reconstruction. When the latter is necessary, available land area can become a severe constraint. Finally, while soils provide good treatment over a broad range of conditions, variability of characteristics among soil units can be large, creating significant uncertainty in predicting a soil's nitrogen reduction capacity.

Table 3-4. Project ranking results for pre-disposal treatment technologies based on ranking criteria (after Tables 4-3 and 4-5 from classification, ranking, and prioritization report).

Technology Classification	Criteria 1: Effluent TN Conc. (mg/L)	2: Performance Reliability	3: Performance Consistency	4: Construction Costs ($1000)	5: O&M Cost	6: Energy Req. (kW-h/yr)	7: Construction Complexity	8: Operation Complexity	9: Land Area Req. (ft^2)	10: BOD/TSS Effluent Conc (mg/L)	11: Restoration of Performance	12: System Aesthetics	13: Stage of Technology Development	Total Score
Weighting Factor	11.0	10.0	9.0	7.5	7.0	7.0	5.0	5.0	4.5	3.5	3.5	2.0	0.5	
Physical/Chemical														
Membrane Separation	Not Enough Available Data to Score													
Ion Exchange	Not Enough Available Data to Score													
Evaporation	Not Enough Available Data to Score													
Biological														
Mixed Biomass														
Suspended Growth	3	3	1	2	2	2	3	3	3	4	1	5	5	188.5
Fixed Film														
Fixed Film with recycle	2	4	4	2	3	2	3	3	3	5	4	5	5	235.5
Fixed Film without recycle	1	4	4	2	4	3	3	3	3	4	4	5	5	235
Integrated Fixed Film Activated Sludge	2	3	2	2	2	1	3	3	3	4	2	5	5	183
Two Stage (Segregated Biomass)														
Heterotrophic Denitrification	4	5	4	2	3	2	3	5	3	4	4	5	3	273
Autotrophic Denitrification	4	5	4	2	3	2	3	5	3	5	4	5	3	276.5
Source Separation Systems														
Urine Recovery	Not Enough Available Data to Score													
Wastes Segregation	Not Enough Available Data to Score													

The top ranked "natural system" was soil infiltration with reactive barriers, an approach for which the literature review had gathered little information. The second ranked natural system is traditional trench drainfield with timed dosing of septic tank effluent. However, this system received the lowest treatment score. Application of the ranking system to certain kinds of natural systems can be misleading from a purely quantitative perspective. In this instance, the score is high because of its passive characteristics and low operating costs, but does not address the difficulty of performance monitoring capabilities, the costs associated with correcting poor performance, and the low nitrogen treatment.

Table 3-5. Project ranking results for "natural system" technologies based on ranking criteria (Table 4-5 from classification, ranking, and prioritization report).

Technology Classification	Criteria													Total Score
	1	2	3	4	5	6	7	8	9	10	11	12	13	
	Effluent of TN Conc. (mg/L)	Performance Reliability	Performance Consistency	Construction Costs ($1000)	O&M Cost	Energy Req. (kW-h/yr)	Construction Complexity	Operation Complexity	Land Area Req. (ft^2)	BOD/TSS Effluent Conc (mg/L)	Restoration of Performance	System Aesthetics	Stage of Technology Development	
Weighting Factor	11.0	10.0	9.0	7.5	7.0	7.0	5.0	5.0	4.5	3.5	3.5	2.0	0.5	
Natural Systems														
Soil Infiltration														
With dosing	1	5	4	5	4	5	5	5	3	5	4	5	5	305
With reactive barriers	5	5	4	3	3	5	3	4	5	5	4	5	3	320
With drip dispersal	2	4	4	4	3	5	3	3	3	5	4	5	5	271.5
Annamox	Not Enough Available Data to Score													
Constructed Wetlands														
Subsurface flow with pre-nitrification	3	5	4	2	4	5	3	3	3	3	3	5	5	274

3.1.2.4 Recommendations for Testing

The technology classification ranking provides the basis from which to formulate recommendations for the field testing to be conducted in Task B of the Florida Onsite Sewage Nitrogen Reduction Strategies Study. It is anticipated that up to 12 technologies can be tested, depending on funding and future extensions of the project. In addition to the ranking scores, the criteria used to consider in establishing priorities for testing include representation of several technology classifications, nitrogen effluent performance data, similarity of technologies, and maturity level of technologies. The purpose of prioritization was to select the more promising technologies that may not have sufficient prior testing or may be differently configured to improve performance, and to avoid duplicate testing where substantial experience already exists. The priority list for Task B testing is listed in Table 3.6 and discussed briefly below.

All of the technologies can be employed for new installations. Most of them (except the source separation systems 11 and 12) could possibly be inserted between an existing septic tank and existing drainfield in existing systems, if the existing tank is structurally sound and appropriately sized. This complements and supports the conversion of conventional onsite sewage treatment and disposal systems to nitrogen removal. For systems three and four, a retrofit might involve the addition of pumping and filter mechanisms and the installation of a new drainfield.

The two highest priorities for testing are biological systems with two stage segregated biomass employing autotrophic (system 1) and heterotrophic (system 2) denitrification. These systems are passive and expected to require little operator attention and provide high reliability

The first stage of each is a mixed biomass recirculating biofilter through which nitrification occurs. Significant denitrification also occurs due to the recirculation. The biofilters can employ a variety of fixed film media, many of which are in current use and are described in the literature review. Passive Nitrogen Reduction System Phase II (PNRS II) testing will provide additional data for biofiltration with recycle using clinoptilolite, expanded clay, and polystyrene. The best performing media from PNRS II testing will also be recommended for Task B testing.

The second stage of these hybrid systems will employ autotrophic denitrification and heterotrophic denitrification, respectively. Systems with heterotrophic (carbon addition) denitrification are commercially available. Two such systems, one employing a passive media and one employing more active dosing, already have received an innovative system permit in Florida. Treatment media being developed at the University of Central Florida also fall into this category of heterotrophic denitrification. The project team proposes to use sulfur as medium for autotrophic denitrification. This approach will be further evaluated during PNRS II testing, in continuation of the column studies performed during PNRS I. Comments received by FDOH on drafts of this report suggest a particular need to evaluate the environmental impact of the end products of the autotrophic reactions, such as sulfate.

System 3 is an experimental “natural system” that uses drip dispersal into amended soil of settled or secondary effluent. To enhance denitrification, an in-situ reactive media barrier will be constructed below the drip dispersal tubing. Effluent is dispersed within the root zone and percolates downward through the reactive media barrier containing high water retention materials such as expanded clay and lignocellulosic or elemental sulfur electron donors to support heterotrophic or autotrophic denitrification. The literature did provide few data on the merits of this approach. The design of this system will be based on the results of PNRS II, in which variants of this basic system will be evaluated to determine the design that results in the best nitrogen reduction performance. This system would meet the project definition of passive technology and has the potential to be a low cost in-situ system that can be applied for new installations or retrofits.

System 4 is a “natural system” using drip dispersal of settled or secondary effluent into the soil. By dosing septic tank effluent into the soil on timed cycles, alternating aerobic and anoxic conditions can be created in the soil near each emitter, which may create the necessary conditions for nitrification/denitrification to occur. This intermittent dosing of septic tank effluent has been shown by several studies to reduce the total nitrogen that migrates downward from the point of application. Other studies have shown a limited effect, and the performance score (see table 3-5) for this approach was relatively low. This approach has the potential of being a relatively low cost modification to conventional system that allows the reuse of wastewater for landscape irrigation. Secondary pretreatment is currently required for drip irrigation in Florida and the combination is frequently used in Florida, but a thorough evaluation of the nitrogen reduction benefits of drip irrigation is missing. This approach will also be tested under controlled conditions at the PNRS II test facility in direct comparison to a similarly sized system 3 and a pressure dosed system.

Systems 5 and 6 are similar to Systems 1 and 2, in that they are hybrid mixed/segregated biomass systems with a first stage fixed film bioreactor with or without recycle, followed by a heterotrophic (System 5) or autotrophic (System 6) denitrification filter. Systems 5 and 6 expand the evaluation of the hybrid mixed/segregated biomass systems over that provided by systems 1 and 2 alone.

Systems 7 and 8 are Integrated Fixed-Film Activated Sludge (IFAS) systems. They combine elements of both fixed film and suspended growth microbial communities, resulting in relatively stable treatment processes that achieve more reliable and consistent performance than other mixed biomass processes. Such systems are frequently used as aerobic treatment units in Florida. The performance of one fixed film activated sludge technology (FAST) was previously evaluated under controlled conditions in a study in the Florida Keys that helped to establish nitrogen treatment standards and has been frequently permitted for nitrogen reduction.

System 9 is a suspended growth system, specifically a Sequencing Batch Reactor (SBR). Theoretically, SBR’s should be able to control the loss of carbon better than other mixed biomass systems. While common elsewhere, sequencing batch reactors are largely absent from Florida’s advanced systems.

System 10 is a membrane bioreactor (MBR), which combines suspended growth with a membrane filtration unit. MBR has been applied for onsite treatment of multifamily residential wastewater and is an emerging treatment option for single family home systems.

Systems 11 and 12 are source separation systems. Source separation is an emerging onsite wastewater management option and may become increasingly prevalent in the future in keeping with needs for sustainability and resource recovery. With regard to nitrogen removal, source separation has the potential to be a particularly efficient option since 50 to 75% of household waste nitrogen is from urine. Accordingly, separating the waste streams allows for more efficient, dedicated treatment options for individual components of the wastewater stream. Composting and incinerating toilets can currently be permitted, and the statute for the Suwannee and Aucilla flood plains treats composting toilets similar to a 50% nitrogen reduction system.

Table 3-6. Recommendations for technologies to be tested at the test facility and in field installations (after Table 4.7 from classification, ranking, and prioritization report). The technologies are modular and can be used to complement the conversion of conventional onsite systems to nitrogen removal.

System	Technology	Project Team Comment	Comments on Previous Florida Experience and Testing Approach
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	-Column experiments performed during PNRS I -Further evaluation, including fate of sulfur, planned in PNRS II test facility (Task A)
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	-Innovative System Permit for Nitrex after biofiltration pretreatment, a passive system per project definition -Innovative System Permit for Pura-Flo with Micro CG addition, a biofiltration pretreatment with active carbon dosing -University of Central Florida is developing "bold and gold" treatment media and configurations
3	Natural system: Septic tank/Mound 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	-Initial evaluation, including fate of sulfur, planned in PNRS II test facility (Task A)
4	Natural system: Settled or secondary effluent with drip dispersal	Suitable for reducing TN impacts on groundwater through enhanced TN removal and reduced TN loading on soil	-Secondary effluent with drip is frequently used in Florida, more performance data needed, secondary pretreatment currently required in Florida for drip -Evaluation at PNRS II test facility in comparison to system 3 planned
5	Mixed biomass fixed film system with recycle followed by a heterotrophic denitrification with reactive media biofilter	High performance aerobic treatment with anoxia for enhanced TN removal followed by second stage heterotrophic denitrification for high nitrogen removal	See system 2
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	See system 1
7	Mixed biomass integrated fixed film activated sludge system: with recycle	High performance aerobic treatment	-w/o recycle, common technology for aerobic treatment units (FAST, JET, Bionest) and nitrogen reducing systems (FAST) in Florida -FAST technology, including internal recycle, evaluated during previous Florida Keys test facility study, preceding establishment of Keys nitrogen treatment standard
8	Mixed biomass integrated fixed film activated sludge system: Moving bed bioreactor	High performance aerobic treatment with simultaneous denitrification	-Very limited information from innovative system testing of one particular technology.
9	Mixed biomass suspended growth system: Suspended growth sequencing batch reactor	Aerobic treatment	Common elsewhere, largely absent in Florida
10	Membrane process system: Membrane bioreactor (MBR)		New for single family residences in Florida
11	Source separation system: Dry toilet (evaporative or composting)	Eliminates liquid disposal of toilet wastes	-Several manufacturers approved based on NSF testing/certification -Suwannee/Aucilla statute treats this similar to 50% nitrogen reduction
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 recovery of nutrients	-Requires different plumbing -Need clarification on approval standards

3.1.3 Test Facility Selection

Two sites were evaluated by the provider: the University of South Florida (USF) Lysimeter Facility property and the University of Florida's Gulf Coast Research and Education Center (GCREC) near Wimauma, FL. Salient issues included space availability, site access, wastewater source of sufficient quantity and quality, subsurface hydrology, power supply and security.

Summary (edited from GCREC memo by Hazen and Sawyer)

Based on the cost and time associated with rehabilitating the USF facility, it has become apparent that proceeding with construction of two test facility sites will be costly and time consuming. The current budget in the FOSNRS contract for construction of a test facility at USF does not appear to be sufficient for both the rehabilitation work and the testing facility construction. In addition, the USF Lysimeter station can only be used for pilot tests of treatment technologies and unsaturated zone work, since the water table is extremely deep at the site (>25 ft.) and sufficient area for plume delineation and monitoring is not available. Management of two facilities once operational will also be more difficult and expensive in future phases of the project.

At GCREC, the preliminary soils, wastewater (STE) quality, and groundwater assessment appear to be conducive to performing the proposed work. While the flatwoods type soils at the site have a shallow groundwater that may be more likely to support in-situ denitrification, the soils of the Florida flatwoods land resource area make up approximately 55% of the area of the state, or over 60% if the Everglades land resource area is excluded. In contrast, soils of the central Florida ridge land resource area make up approximately 17% of the area of the state (Ayres Associates, 1987). Also, a site conducive to in-situ denitrification is desirable from a groundwater modeling perspective. To include denitrification in the models developed in Task D, a study site where denitrification can be measured will be more likely to provide the needed inputs and calibration data for model development. If the mechanisms of in-situ denitrification can be identified at the site, then the models developed should be able to predict whether such denitrification is likely to occur at any given site. Additionally, the individual home field sites for Task C will be chosen to include soils of different types, including well drained fine sands typical of the central Florida ridge recharge areas, and the models developed will be tested at these sites.

Treatment technology pilot testing and both the saturated and unsaturated zone investigations could be performed at the GCREC. Therefore, the Project Team recommendation is to conduct all test facility work at the GCREC.

3.1.4 Passive Nitrogen Reduction Study II (Test facility Technology Development and Testing)

The purpose of the PNRS II study is to extend and expand into field pilot testing the previous experimental studies of the two-stage biofiltration process that were conducted in a previous study for the FDOH. PNRS II will perform field testing of prototype passive nitrogen reduction treatment systems using a variety of candidate biofiltration media. The results of PNRS II may be used to develop and implement subsequent evaluations of full-scale systems that will be conducted under Task B of this project. The pilot test systems will consist of various configurations of in-tank biofilters and passive in-situ systems. In-tank systems will primarily employ variants of the two-stage biofiltration concepts elucidated in PNRS I. In-situ technology evaluation will include a drip irrigation system for effluent dosing, with emitters located in shallow root zones.

Two-stage biofiltration evaluation:
Candidate media for evaluation in Stage 1 (unsaturated) biofilters and Stage 2 (saturated) biofilters are listed in Tables 3-7 and 3-8, with physical properties and their sources. Included are media with high water retention and porosity. Stage 1 media includes expanded clay and clinoptilolite. These have greater than 45% porosity and high water retention. Clinoptilolite also contains high ion exchange capacity to retain ammonia ions for enhanced ammonia removal under non-steady flows and higher loading rates. Livlite is an expanded clay with high water retention characteristics. Expanded polystyrene is a very lightweight, readily available, and low cost material that appears to be quite suitable as a biofilter media for aerobic treatment.

The Stage 2 anticipated electron donor media are: elemental sulfur, which will result in an autotrophic denitrification process in the anoxic biofilter; lignocellulosic materials, such as woodchips, which support heterotrophic denitrification; and glycerol, a readily available carbon source for heterotrophic denitrification.

Crushed oyster shells or sodium sesquicarbonate will be used as alkalinity sources in sulfur-based denitrification biofilters, as autotrophic sulfur-based denitrification will consume alkalinity. Expanded shale may be included as a Stage 2 option for its anion exchange capacity to enhance nitrate removal performance. Comments received by the department on the interim report suggested considering the long-term sustainability of materials used in onsite systems.

The biofilter systems will be operated over a twelve month period, dependent on additional funding, during which eight monitoring events will be conducted. A detailed description of analyses is included in the quality assurance project plan (QAPP) document. As outlined in QAPP Table A.1, there are 42 sampling points and a monitoring analyses structure that employs four analytical tiers.

Experimental in-situ simulators:
In-situ testing will be conducted using in-situ simulators as shown in Figure 3-3. The simulators will consist of subsurface drip irrigation application to the root zone of surface vegetation, followed by downward transport through a 12-inch layer of filter sand. Underlying the filter sand is a 12-inch layer of engineered media containing electron donor, which is in turn underlain by natural soil. The test matrix consists of subsurface drip irrigation emitter dosing of primary effluent (i.e. septic tank effluent) or nitrified effluent into the root zone of St. Augustine grass. Other than the pumping of effluent by subsurface irrigation, the in-situ simulators are completely passive systems. An innovative feature of the in-situ simulator design is the use of mixed media in unsaturated mode that contains both a high water retention media (expanded clay) and heterotrophic and autotrophic electron donors. This potential for unsaturated in-situ treatment systems, including plant-assisted nitrogen transformations, has not been examined in Florida with innovative systems of this type but is of potentially high significance.

Table 3-7. Materials for Stage 1 Filters (Table 3.3 of PNRS II QAPP).

Stage 1 Vertical Unsaturated Biofilter Configuration and Initial Operation

Unsaturated Biofilters (Stage 1)					
No.	Media	Biofilter	Media Depth (Inches)	Flow Regime	Recycle Ratio (α)
1	Expanded Clay	UNSAT-EC-1	15	Single Pass	-
2		UNSAT-EC-2		Recycle	3
3		UNSAT-EC-3	30	Single Pass	-
4		UNSAT-EC-4		Recycle	3
5	Clinoptilolite	UNSAT-CL-1	15	Single Pass	-
6		UNSAT-CL-2		Recycle	3
7		UNSAT-CL-3	30	Single Pass	-
8		UNSAT-CL-4		Recycle	3
9	Polystyrene	UNSAT-PS-1	30 (NS)	Single Pass	-
10	Upper: Filter Sand	UNSAT-IS-1	12	Single Pass	-
11	Lower: Expanded Clay, Lignocellulosic, Sulfur	UNSAT-IS-2	12	Single Pass	-

EC: expanded clay, CL: clinoptilolite, PS: polystyrene, SU: sulfur, α: recycle flowrate/forward flowrate, NS: non-stratified

Table 3-8. Stage 2 Saturated Denitrification Biofilter Material, Configuration and Initial Operation (Table 3.6 in PNRS II QAPP).

No.	Electron Donor	Biofilter	Media Composition (by volume)	Initial Surface Loading Rate, gal/day-ft^2	Stage 1 Filter (Table 3-6)
1[1]	Elemental sulfur	DENIT-SU-1	80% SU 20% OS	10.0	2,4,6,8
2[1]		DENIT-SU-2	80% SU 20% NS	10.0	2,4,6,8
3[2]		DENIT-SU-3	80% SU 20% OS	4.7	1
4[2]		DENIT-SU-4	80% SU 20% NS	4.7	7
5[1]	Lignocellulosic	DENIT-LS-1	70% LS 30% EC	10.0	2,4,6,8
6[2]		DENIT-LS-2	70% LS 30% EC	4.7	3
7[2]		DENIT-LS-3	50% LS 60% EC	4.7	5
8[2]		DENIT-LS-4	30% LS 70% EC	4.7	9
9[1]	Glycerol	DENIT-GL-1	100% EC	10	2,4,6,8

SU: elemental sulfur, LS: lignocellulosic, GL: glycerol, OS: oyster shell, NS: sodium sesquicarbonate, EC: expanded clay

1. Fed from common Stage 1 effluent collection tank

2. Directly connected to Stage 1 unsaturated biofilter

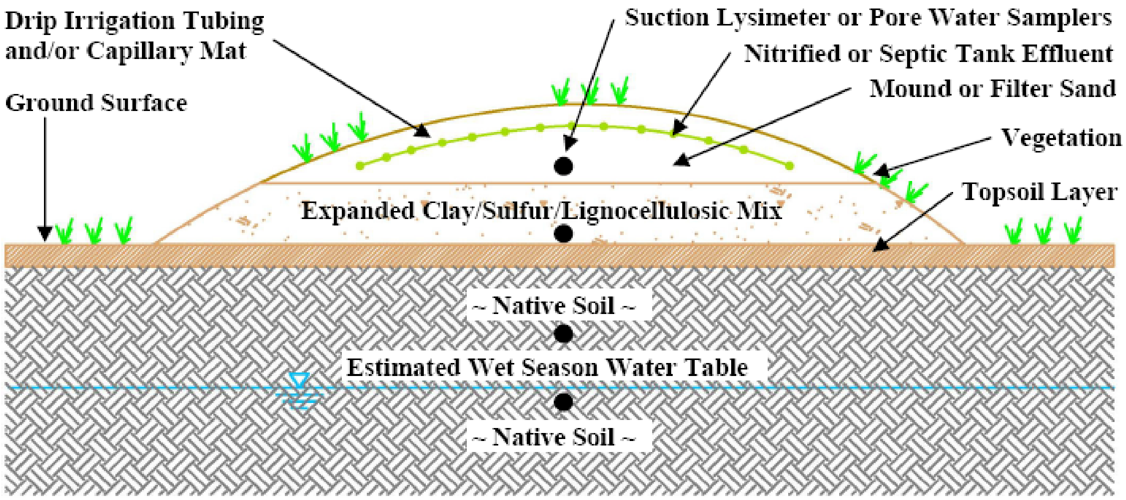


Figure 3-2. Conceptual drawing of in-situ simulators with engineered nitrogen reduction media (Figure 3-2. of Task A QAPP).

3.2 Task C Evaluation of Nitrogen Reduction in Soil and Shallow Groundwater

3.2.1 Literature Review (edited from conclusions of the literature review for Task C)

The literature review revealed numerous factors that may influence nitrogen impacts to groundwater resulting from the use of OSTDS. Transport and fate processes that are present in the OSTDS, vadose zone, and saturated zone all will influence the extent of nitrogen impacts to groundwater. Furthermore, these factors, along with factors related to groundwater/surface water interactions, will also determine if nearby surface water bodies are adversely affected. In doing site assessments, it is therefore important to develop sampling plans that can collect data for a majority of the factors described in the literature. Also, predictive efforts and efforts aimed at reduction of impacts should also consider the findings of the literature review. A brief summary of important points is as follows:

- Some studies identified lot size and location of water supply wells in relation to OSTDS as important factors in determining nitrate contamination to groundwater.
- OSTDS loading rates can significantly impact the performance of the soil and ultimately nitrogen concentrations in the aquifer.
- In certain cases, water table fluctuations may be a larger factor than the loading rate of nitrogen on the overall OSTDS performance.
- Nitrogen reduction in the vadose zone is an important determining factor for nitrate concentrations in the groundwater. This is a complex process dependent on numerous factors that need to be studied in depth.
- Nitrification can be influenced by soil type and appropriate loading of an OSTDS. Some literature indicates that coarse-textured strongly-aggregated soils favor nitrification while finer textured soils lead to the development of anaerobic conditions and inhibit the process.
- Sandy soil aquifers are particularly susceptible to nitrate contamination, particularly in the case of low carbon content aquifers with relatively high groundwater velocities. In these cases, high concentrations and large areas of impact may be expected due to the lack of transformation and the distance nitrate can travel in a short time period.

- Denitrification occurs largely in anoxic soils and groundwaters with adequate carbon sources. In the soil column, denitrification may occur in systems with high or fluctuating water tables that allow the creation of anoxic conditions, providing the organic carbon content of the soil is adequate. In groundwater, dilution is often seen as the dominant mechanism for the reduction of nitrate, although some studies identify denitrification as the dominant factor. This is highly dependent on site-specific characteristics.
- Denitrification, while being a well-understood process, is poorly quantified and not correlated with other site characteristics, especially when considering the saturated zone. This should be a significant topic of further study.
- Some studies identified the relatively high denitrification capacity of river bed sediments, particularly if they contained high levels of organic carbon. This is especially relevant if the protection of adjacent surface water bodies is a key concern.

The literature review suggests reductions in groundwater nitrogen impacts associated with OSTDS are achievable with a few steps. Nitrate is highly mobile in groundwater and the only significant method of natural attenuation is denitrification, a process that the review indicates is not always present in natural aquifers (however, it should be noted that saturated zone denitrification can be enhanced with amendments as a potential treatment process). Therefore, reduction of nitrate contamination may be most efficiently approached in the design and installation processes when considering OSTDS as a treatment alternative. Appropriate land planning and density of OSTDS in new developments is a first step. OSTDS should be placed to maintain a protective distance for downgradient groundwater and surface water resources. Additionally, recognizing the importance of dilution for nitrate concentration reductions, appropriate lot size should be in the design to allow adequate dilution from recharge water. Within the design of OSTDS, appropriate loading rates and an understanding of OSTDS effluent can achieve lower levels of nitrogen entering the subsurface environment.

Additionally, the review indicates the performance value of appropriate treatment units can improve effluent quality by reducing nitrogen prior to infiltration. Additional optimization can be achieved by a thorough understanding of site characteristics and how these may influence OSTDS performance and ultimately nitrogen concentrations in groundwater. Certain water table conditions, soil types, and other subsurface characteristics, such as pH or temperature, can have an effect on the treatment ability of OSTDS by varying oxygen content and redox conditions. If detrimental conditions are seen at a site being considered for OSTDS, other methods of wastewater treatment may be appropriate. This can also be true for areas identified as “high-risk,” such as areas adjacent to a protected water body. Alternatively, it may be possible to amend the site conditions or use an effluent pre-treatment method to improve OSTDS performance. Future work may be needed to examine the data in such studies and make attempts to correlate hydraulic and reactive parameters to observed nitrogen impacts.

3.2.2 Quality Assurance Project Plan (QAPP) for Field Work for Task C

A three-pronged approach is anticipated for the field work.

Detailed monitoring, including the vadose zone, under very controlled conditions will be performed to obtain a side-by-side comparison of drip and low-pressure dosed drainfields that are loaded with either nitrified or septic tank effluent. The in-situ simulators from Task A will be monitored in the same way. Table 3-9 shows the experimental design, and Figure 3-3 shows the cross section of the anticipated drainfields and their monitoring equipment.

Monitoring of a test facility effluent plume in groundwater will be initially performed at a large mound on the test facility. The test facility provides somewhat controlled conditions and the size of the mound will make it easier to find the plume and gather insights on the effects of size. Elements of the groundwater monitoring are outlined in Table 3-10. The monitoring will extend for a year to capture seasonal variability. The location at the test facility where monitoring will take place is shown in Figure 3-4.

Monitoring of effluent plumes in groundwater at individual home sites will utilize the same methodology as the monitoring of the mound at the test facility. It is anticipated that home sites will range across the State of Florida, including north Florida, central Florida (specifically the Wekiva area), and south Florida to capture diversity in site conditions. The monitoring will extend for a year to capture seasonal variability.

Table 3-9. Experimental design of soil and shallow groundwater monitoring (Table 2.2 of Task C QAPP).

Test Area ID	Effluent Quality	Design Hydraulic Loading Rate (gpd/ft^2)	Soil Treatment Unit Design
TA1	STE (septic tank effluent)	0.8	pressure dosed mound
TA2	STE	0.8	Shallow drip dispersal
TA3	nitrified effluent	0.8	pressure dosed mound
TA4	nitrified effluent	0.8	Shallow drip dispersal
TA5	in situ nitrified effluent (Task A)	from PNRS II pilots	mounded drip dispersal over denitrification media
TA6	in situ STE effluent (Task A)	from PNRS II pilots	mounded drip dispersal over denitrification media

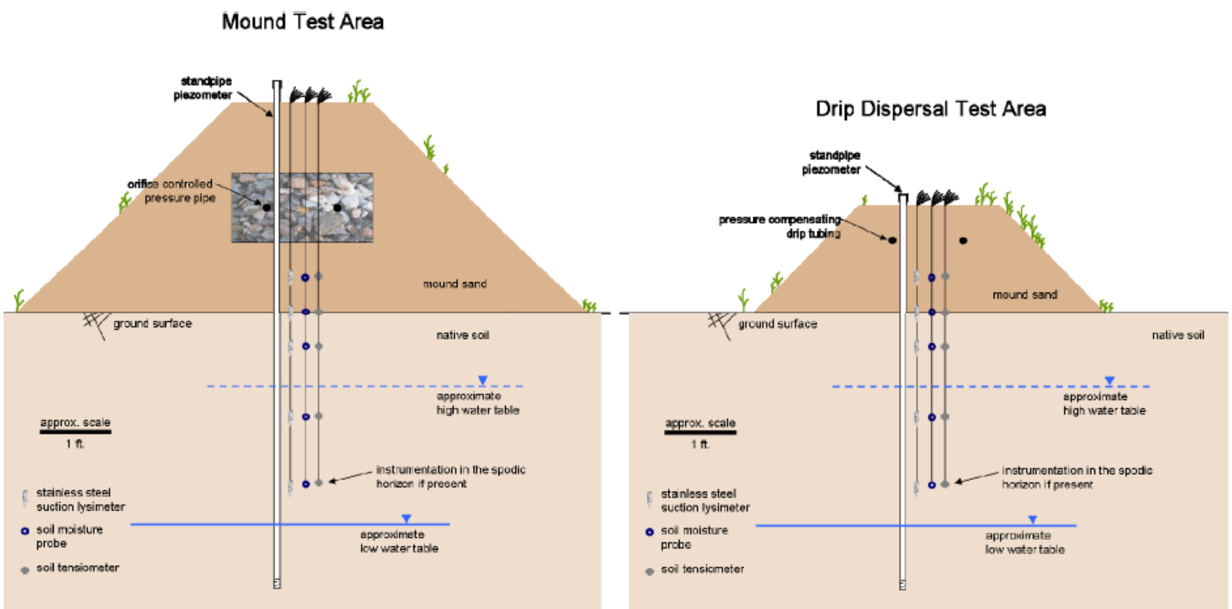


Figure 3-3. Conceptual cross sections of drainfields to evaluate soil nitrogen reduction (Figure 2-2 of Task C QAPP).

Table 3-10. Proposed steps in monitoring the effluent plume of an OSTDS (Table 2-3 of Task C QAPP).

Step	Purpose	Approach	Data to be Collected
1	Plume identification	sampling grid for groundwater screening	in-field measurements of groundwater specific conductance
2	Instrumentation	install multi-level drive point piezometers and shallow standpipe piezometers	soil properties determined from soil borings during standpipe piezometer installation
3	Aquifer characterization	conduct pump test and slug tests on standpipe piezometers	hydraulic gradient, saturated hydraulic conductivity
		baseline tracer test	establish groundwater velocity, dispersivity coefficients, and groundwater dilution
4	Routine monitoring	effluent quality, groundwater concentrations, water levels, climatic conditions	water quality parameters as necessary to determine nitrogen reduction
5	Additional instrumentation, testing, and/or monitoring	as warranted	refine denitrification rates, aquifer properties

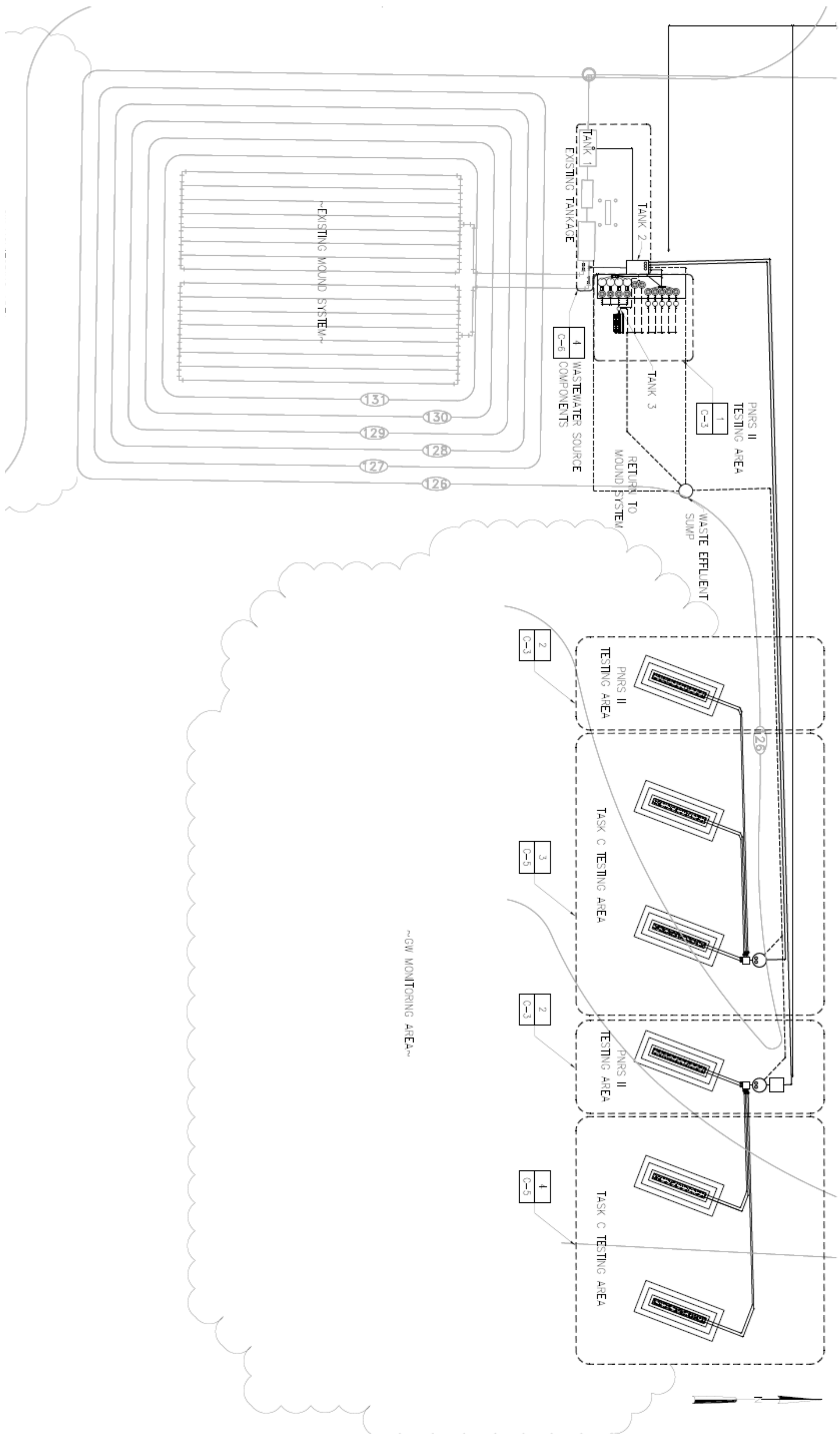


Figure 3-4. Outlay of the groundwater monitoring area at the test facility (Appendix B of Task C QAPP).

3.3 Task D, Nitrogen Fate and Transport Modeling

(edited from conclusions of the draft literature review for Task D)

A review of the literature, the conceptual understanding of the transport of nitrogen as related to OSTDS, and the goals of the project are all taken into consideration when beginning to describe the tool that will be developed. From this, several conclusions and some suggestions for the modeling tool can be developed. The literature review was intended to identify the state-of-knowledge of nitrate fate and transport modeling, identify past models that may provide good templates for the model developed by the FOSNRS Study, and assist in identifying key parameters and processes that need to be represented in a predictive tool.

As with any model development project, the appropriate approach can depend on numerous factors. When conceptualizing a model, several key questions need to be posed, such as:

- Will this model be constructed to represent a specific site of interest or be a predictive tool with broad applicability to a variety of sites?
- What is the desired output?
- What is the most appropriate method of calculating the output?
- Will this model require calibration to existing data sets?
- What, if any, regulatory requirements constrain the model choice?

The modeling tool that is being developed to simulate nitrate fate and transport will require certain features, some of which include:

- Ease-of-use;
- Ability to simulate time-variable OWTS inputs;
- Simulation of transport and fate in both the vadose zone and saturated zones;
- Representation of the numerous advective-dispersive and transformative processes that affect nitrate transport;
- Simulation of temporal and spatial concentrations and mass loading downgradient of the source;
- Include the impacts of seasonal rainfall variation on the source function; and
- Incorporate critical OWTS operating characteristics that strongly influence nitrogen reduction.

Based on the above questions and objectives, many conclusions about the models and model types in the research summary can be made. No simple model (analytical or mass-balance) identified in the literature can currently achieve all of the above-described goals. Also, numerical models are generally not considered a useful tool for system design or regulatory compliance where broad applicability is desired. Thus, development of a new modeling tool is likely required and rigorous numerical modeling may be needed as a first step to determine the most important parameters to include.

A strictly mass-balance modeling approach will likely be inappropriate, as it either does not consider the known physical processes that influence nitrate transport or makes simplifying assumptions about these processes. Furthermore, the output will not satisfy the objectives of the model (time-variable estimations of concentrations at specific spatial points). Nonetheless, these approaches have value in the conceptualization of model inputs and should not be ignored.

Transfer function models have not been widely applied and will likely encounter regulatory resistance, since they are based strictly on probabilities and do not directly consider measured site characteristics.

Both analytical and numerical modeling methods are the most promising approaches when considering the FOSNRS Study model to be developed. These approaches will have wide applicability, regulatory acceptance, and are capable of estimating the important hydrogeochemical properties associated with nitrate fate and transport.

The modeling tool will need to consider transport and transformation (chemical and physical) in the vadose zone, because the nitrogen transformations that occur in this zone have considerable influence on the mass-flux input into the underlying aquifer. This can be a numerical one-dimensional solution of the Richards' Equation. A one-dimensional formulation can likely be implemented in a spreadsheet. Additionally, the modeling will need to consider temporally and spatially variable inputs for multiple OSTDS, as would be found in a community development. This could be addressed through a series of one-dimensional vadose zone models that could provide input to a multi-dimensional groundwater flow and transport model. Both of these studies use the horizontal plane source model or some variation and are also capable of transient simulations. However, the models likely will not be capable of interacting with each other in the vadose zone (i.e., strictly vertical flow is assumed). Nonetheless, the value of including these model features is important when simulating the aerial distribution of OSTDS in a potential housing development and the temporal variation of source input due to changes in wastewater input rate and precipitation recharge. These combined models can likely be implemented in a spreadsheet or using Fortran or C++ programming while maintaining simple and straight-forward input requirements. Of course, no similar model is available to our knowledge, so considerable model research and development must be achieved by this project.

The literature review has suggested the most likely processes and parameters that will need to be considered when developing the modeling tool. The fate and transport of nitrogen products is a result of advective movement, retardation via adsorption, and the transformative processes of nitrification and denitrification. These processes are to be calculated in the model tool via the solutions of the appropriate equations using the necessary parameters, described below. Key parameters to consider for simulation should consist of:

- Physical parameters of the media, such as bulk density, water content, and soil characteristics;
- Advective-dispersive parameters, such as hydraulic conductivity, hydraulic gradient, porosity (or groundwater velocities), and dispersivity values;
- Retardation factor values for ammonium sorption; and
- Rate coefficients for transformative reactions, typically first-order rate constants

A majority of the parameter values needed for model input can be collected during site characterization. In a previous study by members of this project team cumulative frequency distributions (CFD's) were utilized for the estimation of initial parameter values from literature values. This approach results in an uncertain model output where the degree of uncertainty must be quantified. Even if site-specific values are obtained, uncertainty from measurement and subsurface variability remains.

Additionally, many analytical models were found in the literature review (nitrate-specific and general analytical solutions) that are appropriate for the modeling tool, since these can be programmed into a spreadsheet and can be user-friendly. Members of the project team implemented such a spreadsheet approach to develop a nitrogen transport model for the soil underneath a drainfield in a project funded by the Water Environment Research Foundation. This work is nearly completed and future work in the project can build on it.

4 CONCLUSIONS AND RECOMMENDATIONS

The objective of the Florida Onsite Sewage Nitrogen Reduction Strategies Study is to examine nitrogen reduction strategies and technologies for onsite sewage treatment and disposal systems ("OSTDS" also known as "septic tanks") in the State of Florida. FDOH and its Research Review and Advisory Committee (RRAC), with input from the general public, selected a contractor based on the direction given by the Legislature in the 2008 budget proviso and awarded the contract to a Project Team led by Hazen and Sawyer, P.C., in January of 2009. The contract was based upon an anticipated budget of $5 million over a 3 – 5 year project timeframe. The contract divides the project into 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 FDOH 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.

PROJECT STATUS: Funding for the first phase of this project has been appropriated. As of December 2009, the contractor, in coordination with the RRAC and FDOH, had successfully completed parts of Task A, C, and D described above, including literature reviews, ranking of nitrogen reduction technologies for field testing, design and initial construction of a test facility for effluent plume monitoring and further development of passive technologies, and preparation of quality assurance documents for the groundwater monitoring and test facility work to be completed during the fiscal year 2010-2011. Completion of a test facility for the evaluation of nitrogen reduction techniques and preparation for field sampling is planned for later in the fiscal year 2009-2010. Sampling and reporting of results would continue through subsequent years. Funding for fiscal year 2010-2011 is required to field-test the ranked technologies. Field-testing of technologies at home sites (Task B) is on hold pending future funding.

Anticipated Progress in 2010/2011: During the 2010-2011 fiscal year, the tasks associated with this project are anticipated to include a significant amount of treatment and monitoring system installation and sampling. For Task A, the test facility will have been installed and pilot testing will continue for various passive nitrogen removal technologies. For Task B, several onsite systems will be installed at home locations throughout the State of Florida, and monitoring of the performance of these systems in the field will begin. For Task C, instrumentation of home sites that have been selected to evaluate nitrogen movement in the soil and groundwater will occur and monitoring will begin. The installation of a facility to allow side-by-side evaluation of multiple drainfield configurations and the resulting nitrogen groundwater fate and transport in a common environment will have been completed and monitoring will continue. For Task D, an initial simple model will have been developed, and more complex models that allow evaluation of multiple OSTDS, such as on a development scale, will be developed. An alternative, more complex soil transport model that incorporates a more detailed analysis of transport through unsaturated soil will be developed and integrated with the groundwater transport models. These models will in subsequent years be compared to the data obtained during this project.

Funding Needs: Activities in fiscal years 2008-2010 prepared the framework for rapid implementation of a field sampling program in fiscal year 2010-2011. Funding for fiscal year 2010-2011 is required to reap the benefits of this preparation. The remaining years of the project still require funding in order to complete the goals of this project. For the 2010-2011 budget year $2-million dollars is required to fund the continuation of this study.

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

Initial Funding in 2008-2010 (Phase I): Approximately $900,000 already appropriated (in 2008 and 2009 state budgets, see Section 1 of the report) – status: largely complete. The initial funding, as noted in the project status above, has been targeted to prioritize systems for testing, summarize existing knowledge, develop testing protocols, and establish a test facility for detailed soil and groundwater monitoring and preliminary testing of pilot scale passive nitrogen reduction systems.

Funding in 2010/2011: At least $2 million will need to be appropriated during the 2010 legislative session to adequately fund the next phase of the project, primarily 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 of modeling.

Future Funding: Future funding will be needed from the 2011 legislative session 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.

Other ongoing research efforts: This project has the opportunity to build on related current research. These include: evaluation of current technologies by the Department of Environmental Protection and Florida State University, and the Department of Health; technology development and evaluation of treatment media and passive approaches at the University of Central Florida; the development of modeling tools to assess nitrogen removal in the soil underneath a drainfield at the Colorado School of Mines, a project team member; and a proposed national onsite demonstration project in Monroe County. Results of these and other studies will be included in future project reports.

The results of this project will help characterize and refine strategies for cost-effective nitrogen reduction from onsite sewage treatment systems that will protect our environment, as well as, provide cost effective options for citizens of this state.

Recommendations

The FDOH and its Research Review and Advisory Committee recommend the legislature:

- Provide funding and budget authority to the FDOH in the amount of $2 million for the fiscal year 2010-2011 for continuation of the contract and associated tasks.
- Allow the FDOH to carry over any remaining funds from fiscal year 2009-2010 into 2010-2011.

Detailed nitrogen reduction technology evaluations will be forthcoming as part of this project. However, based on previous research in Florida and the results of the literature reviews completed thus far for this project, the FDOH supports consideration of the following recommendations:

- In nitrogen sensitive areas, requiring lower sewage system densities or better treatment than currently allowed. For example, the current allowances for lots platted before 1972 provide for approximately five typical three-bedroom houses per acre for parcels served by private wells and eight typical three-bedroom houses per acre for parcels served by public water systems.

- A statutory change to allow the use of performance-based treatment systems for establishments other than single family residences without the need for a variance.

- Developing regulations for entities that operate and maintain shared treatment systems (clusters) treating sewage flows within the department's jurisdiction and/or serving an establishment on multiple parcels. This should include requirements for financial assurance, obligations of property owners, and rate setting.

- Identifying funding and cost sharing mechanisms to implement inspection, maintenance or upgrade programs for existing onsite sewage systems.

- Establishing a task force for the study and development of water quality requirements, performance, approval, operation, maintenance and inspection standards for wastewater reuse treatment and waste separation systems, including those that would be constructed within buildings, and delineating the jurisdictional boundaries between the Building Authorities and the Department of Health for such systems.

Continued support for this project will ultimately benefit Florida's onsite system owners and will improve environmental and public health protection.

Florida Department of Health
Onsite Nitrogen Reduction Strategies Study

Contract CORCL

PNRS II TEST FACILITY CONSTRUCTION PROGRESS REPORT #3

Date: April 30, 2010
NTP Date: January 29, 2010

Construction of the PNRS II test facility was started February 15th. Below is a list of items completed to date.

I. PNRS II Test Facility Construction JTD

A. Installed Tanks and Accessories

1. Wooden platform has been constructed
2. Flowmeters on existing OSTDS system dose pipes
3. 1050 gallon STE storage tank (Tank 1) and influent pipe
4. (11) Stage 1 Tanks
5. (5) Stage 2 Single-Pass Tanks
6. (4) STE & Recirculation Mixing Tanks
7. (1) Denite Feed Tank
8. (4) Recirculation Pump Tanks
9. Hydrosplitter tee, petcock valves, tubing
10. Geotextile fabric Mirafi FW700
11. Drain pipe
12. Potable water line installed and connected to existing system

B. Pumps and Accessories Installed

1. Installed P2, P3, P4, P6, P7, P8, P9, P14 - Little Giant pumps
2. P5 – In-situ simulation tanks peristaltic pump drive, (2) 1-channel pump heads
3. P10 and P11 - Stage 2 peristaltic pump drive, (2) 2-channel pump heads for stage 2 filter, and (1) 1 channel head for glycerol
4. Installed P4 and P14 pump flow meters
5. Installed P6, P7, P8, P9 recycle pump flow meters

C. Electrical

1. A 15 KVA step-up transformer was installed to the existing 208 volt, 3 phase power feeder to increase the voltage to 480 volt, 3 phase to reduce voltage drop in the 700 foot long feeder. A 15 KVA step-down transformer was installed to feed the existing pump system 120/208 volt power. A second 15 KVA step-down transformer was installed to feed our new system 120/240 volt power.
2. Main Control Panel has been installed.

D. Buildings

1. The storage shed (8' x 16') has been installed near the wooden platform.
2. The 28' x 50' shade cover roof has been installed.

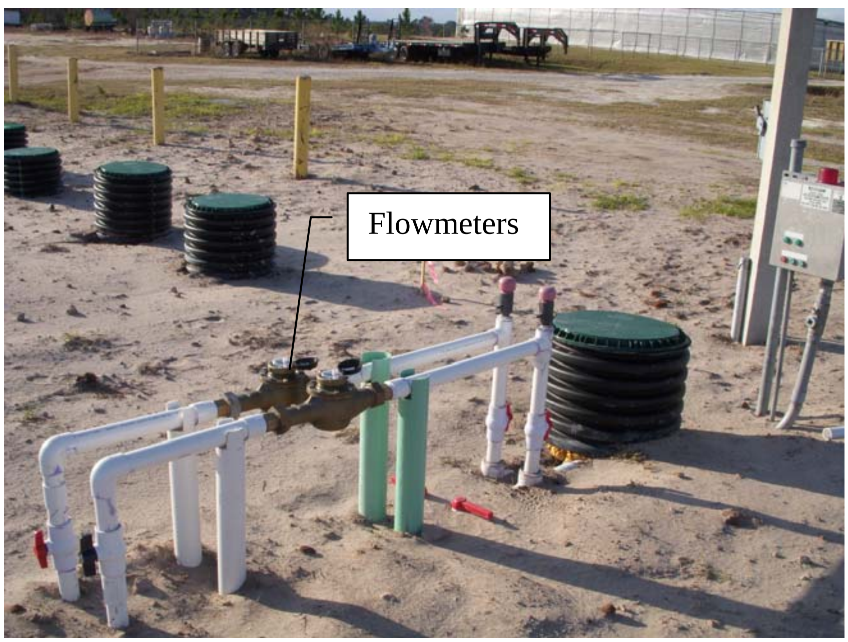
II. Construction Status

The PNRS II pilot test facility construction is substantially complete. Hazen and Sawyer staff conducted a site inspection of the facility on April 26, 2010 and completed a punch list of items for completion by the contractor prior to accepting construction. Storage tank 1 was filled with tap water and all pumps, valves, meters and other equipment were tested. Flow rates were checked, and calibration of flows was begun. The punch list developed is included in Section IV of this progress report. Completion of these items is underway and all items should be complete by mid May.

Start up of the test facility is planned for the week of May 17th. Final calibration of flows to the pilot systems will be completed and the STE supply pump (Pump #1) in GCREC septic tank #2 will be activated, which will then begin supplying wastewater to the system. Water quality monitoring is anticipated to begin in June.

III. Photos Showing Various Components of the Test Facility

1050 Gallon STE Storage Tank 1



Flowmeters for Existing OSTDS System

Wooden Platform North Side

Installing Tanks

Installing Potable Water Line

Mixing Media (Clinoptilolite 8X14 and Oyster Shell)

Media Storage

Gravel at the Bottom of the Tanks

Installing Geotextile Fabric above Gravel at Bottom of Tanks

Installing Media in Tank (UNSAT-EC-3) above Geotextile Fabric

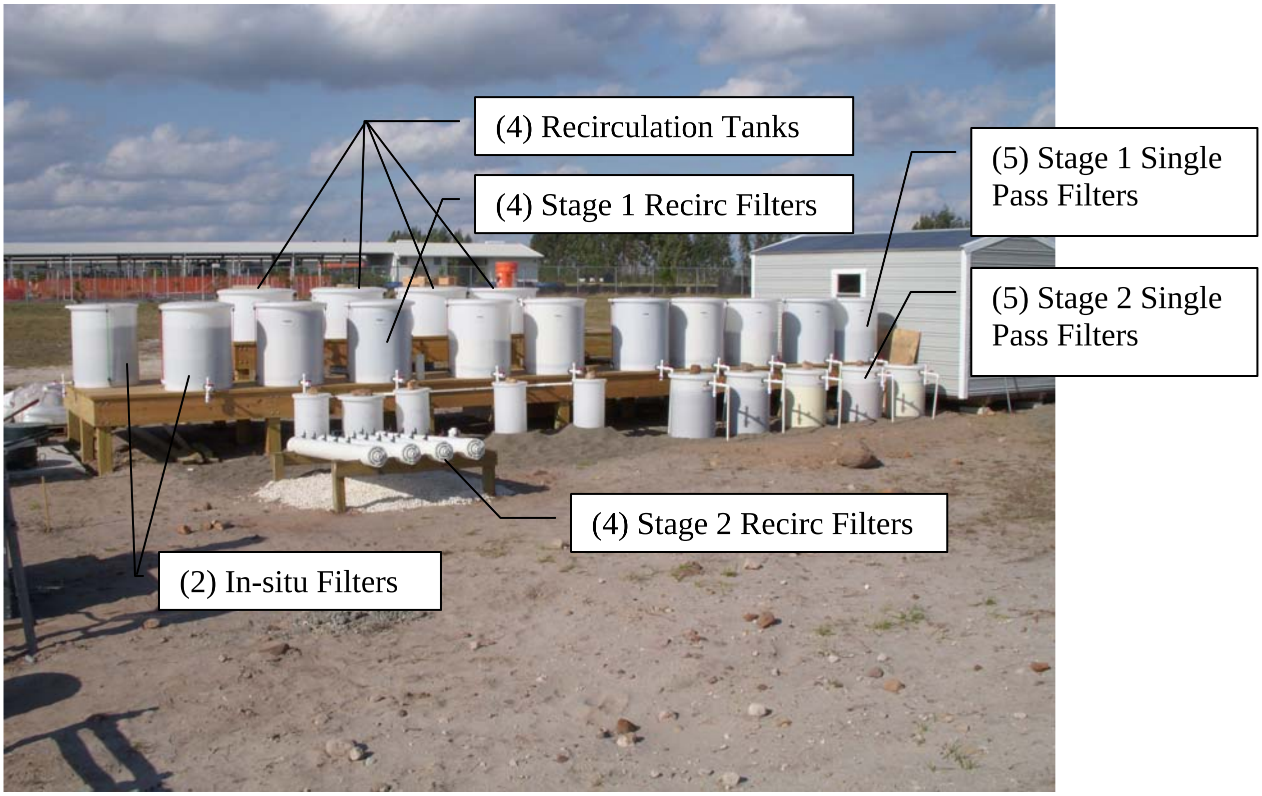
Tamping Media (UNSAT-CL-3)

Installing Sample Piezometers within Stage 2 Upflow Tank (DENIT-LS-2)

Installing Media within 6” x 72” L Stage 2 Filters (DENIT-SU-1)

Storage Shed

New Electrical Transformers


(4) Recirculation Tanks
(4) Stage 1 Recirc Filters
(5) Stage 1 Single Pass Filters
(5) Stage 2 Single Pass Filters
(4) Stage 2 Recirc Filters
(2) In-situ Filters

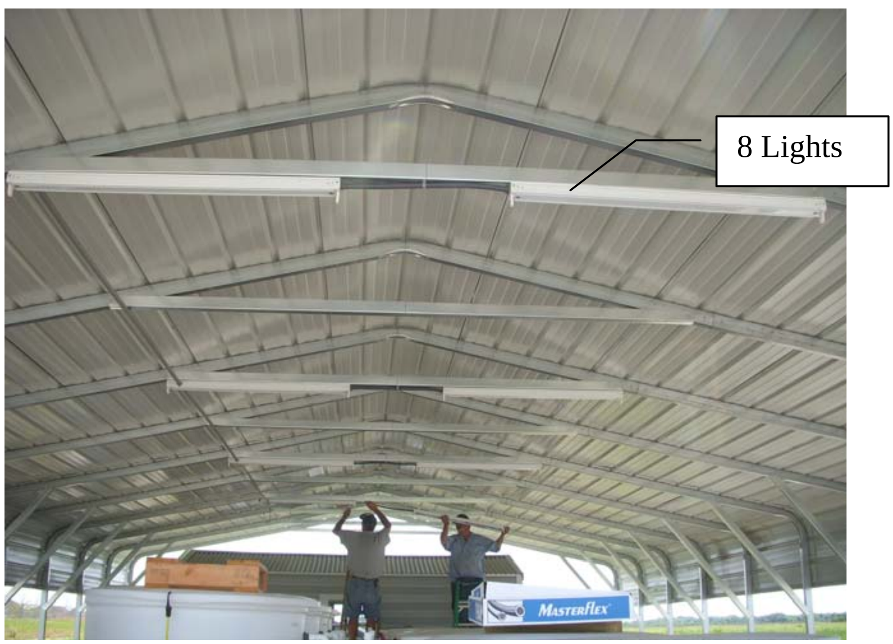
Metal Building Support Beam & Anchors Installed

Metal Building J Frame Installed

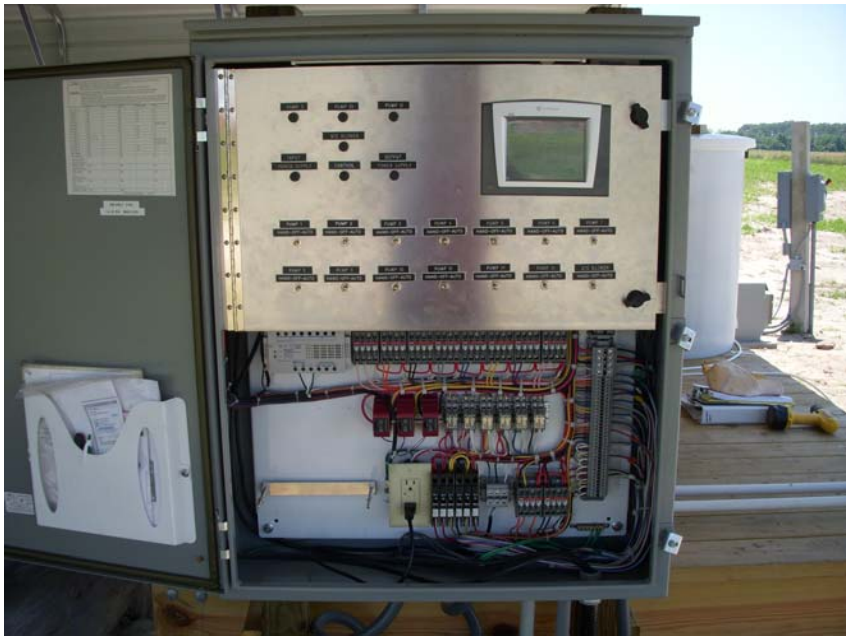
First Roof Panel Installed

Metal Building Roof Panels Almost Complete

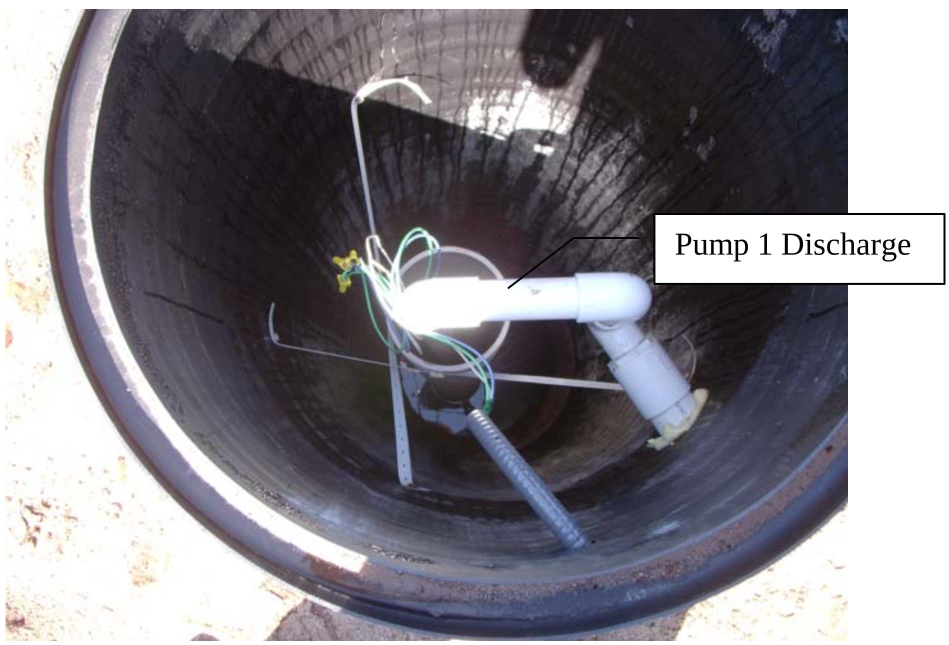
Metal Building Support Beams Almost Complete



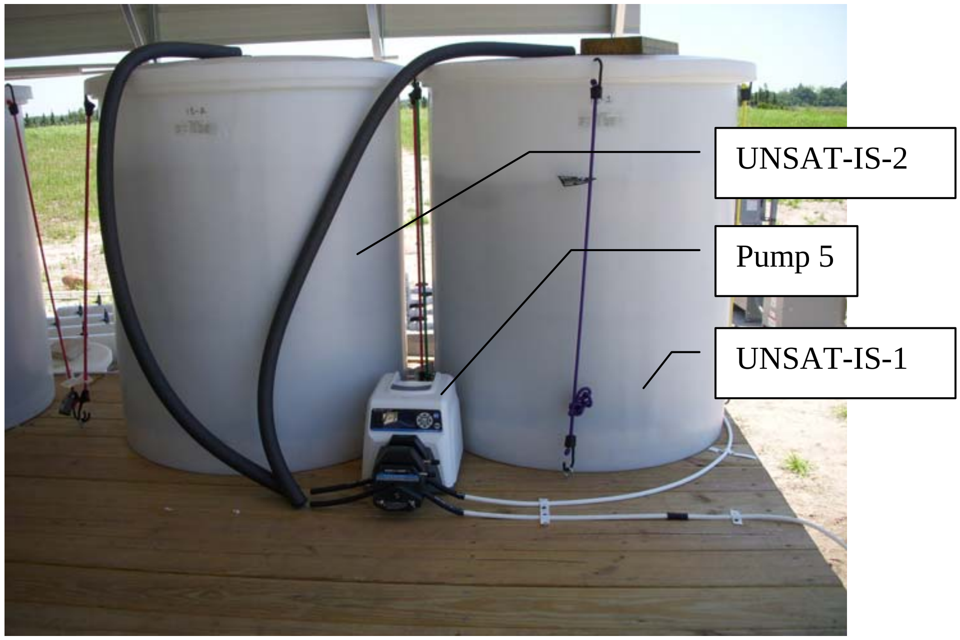
Lights on Metal Building



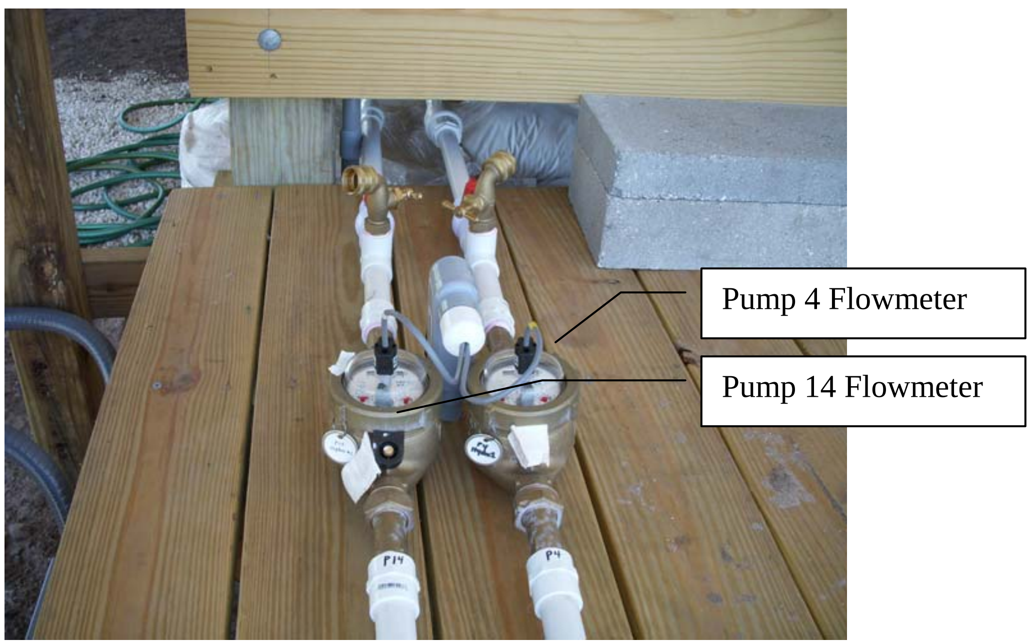
Main Control Panel



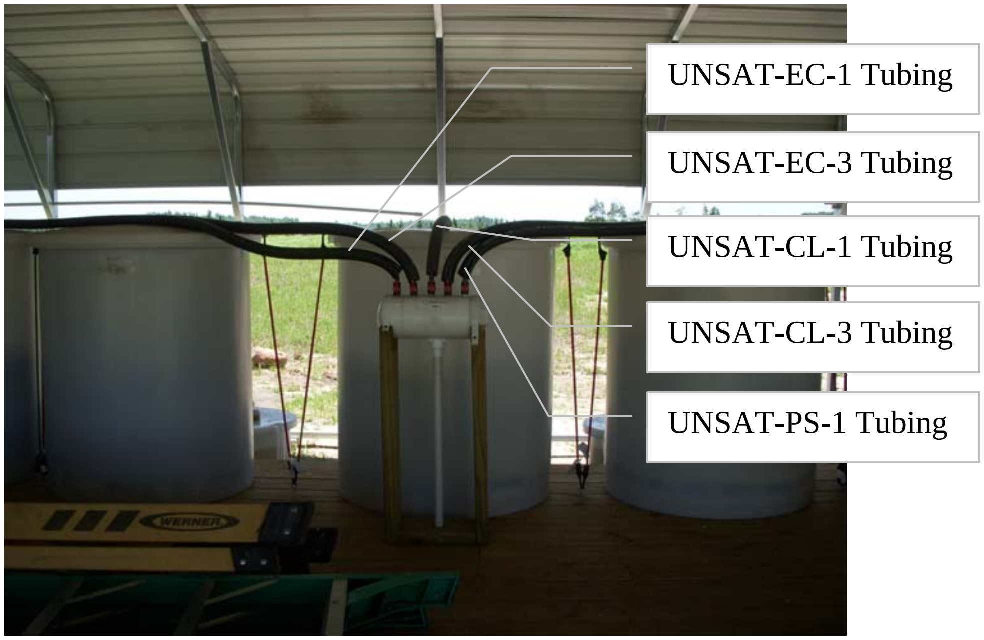
Pump 1 in Existing Tank#2



UNSAT-IS-1 and 2 Biofilters

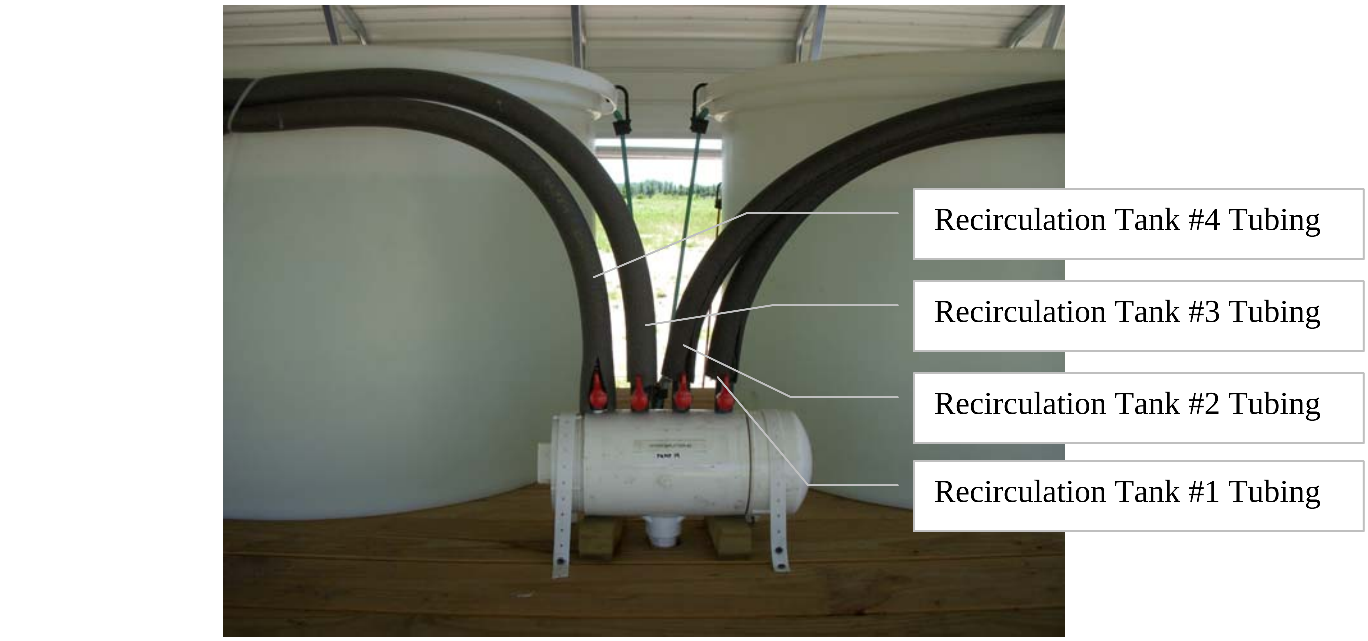


Hydrosplitter Flowmeters

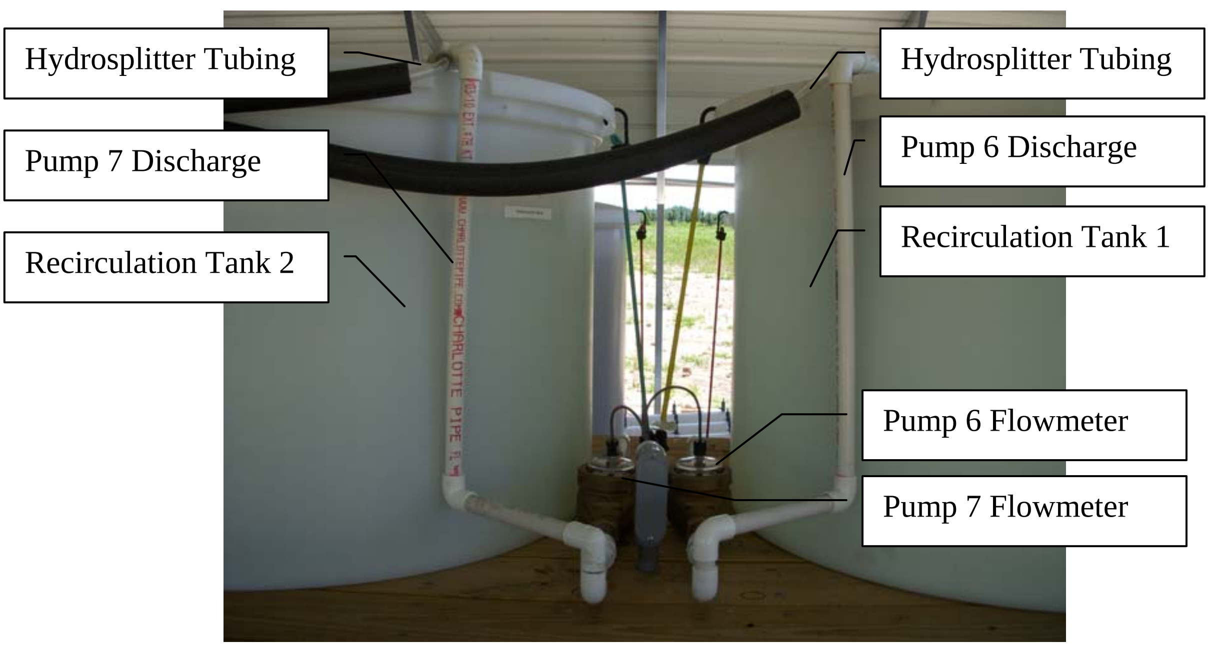


Hydrosplitter #1 (Single Pass Systems)

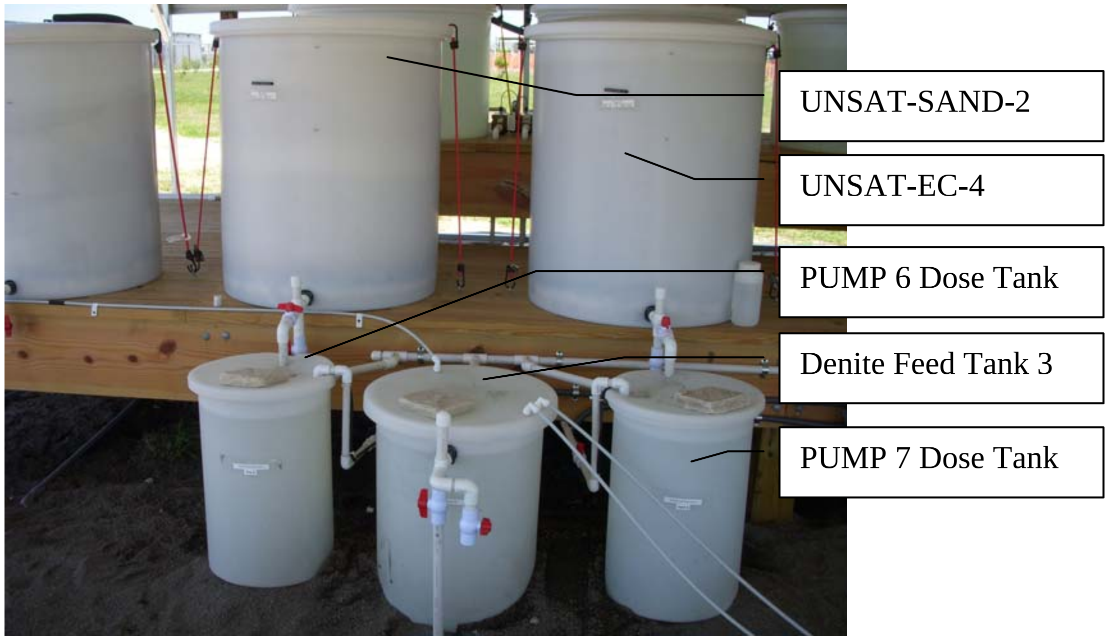
Single Pass Systems



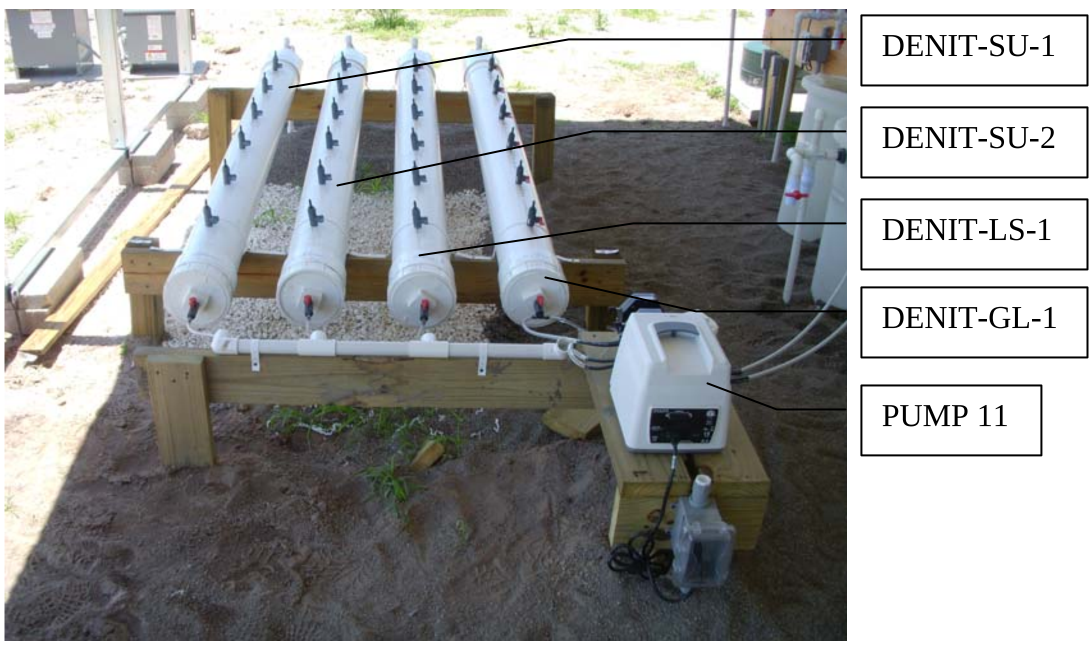
Hydrosplitter #2



Recirculation Systems 1 and 2 (Upstream)



Recirculation Systems 1 and 2 (Downstream)



Recirculation Systems - Stage 2 Filters

Completed PNRS II Test Facility

IV. Punch List

PNRS II TEST FACILITY CONSTRUCTION CONTRACTOR PUNCH LIST

Location	Item	Description	Complete
STE Storage Tank #1	1.	Low Low Float shall be moved to Pump Chamber	04/27/2010
Pump 6 Discharge Line	2.	Install 1/2" ball valve for flow adjustment	04/27/2010
Pump 7 Discharge Line	3.	Install 1/2" ball valve for flow adjustment	04/27/2010
Pump 8 Discharge Line	4.	Install 1/2" ball valve for flow adjustment	04/27/2010
Pump 9 Discharge Line	5.	Install 1/2" ball valve for flow adjustment	04/27/2010
UNSAT-IS-1 and 2 Drain Pipe	6.	Seal connection to main drain line	04/27/2010
DENIT-LS-1	7.	Tighten and seal caps on inlet side (leaking)	05/5/2010
DENIT-SU-2	8.	Tighten and seal caps on inlet side (leaking)	05/5/2010
DENIT-SU-1	8.	Tighten and seal caps on inlet side (leaking)	05/5/2010
HYDROSPLITTER #1	9.	Tighten and re-tape cleanout connection (leaking)	04/27/2010
HYDROSPLITTER #1	10.	Tighten and re-tape petcock valve for UNSAT-CL-1 connection to Hydrosplitter (leaking)	04/27/2010
HYDROSPLITTER #2	11.	Tighten and re-tape cleanout connection (leaking)	04/27/2010
HYDROSPLITTER #2	12.	Tighten and re-tape petcock valve for Recirculation Tank #4 connection to Hydrosplitter (leaking)	04/27/2010
Pump 6 Dose Tank	13.	Glue overflow pipe tee connection to common drain to Denite Feed Tank	04/27/2010
Denite Feed Tank (Tank 3)	14.	Install bulkhead fitting for overflow pipe, pipe and connect to main drain	04/27/2010
Single Pass Stage 2 Biofilters DENIT-LS-4, SU-4, LS-3, LS-2 and SU-3	15.	Provide lid opening for sample tubes	04/27/2010
Single Pass Stage 1 Biofilters	16.	Install splash plates made of plexiglass	TBC
UNSAT-IS-1 and 2 Biofilters	17.	Install splash plates made of plexiglass	TBC
Control Panel	18.	Programming changes to software to revise cycle times to MM:SS input rather than MMM	TBC
Control Panel	19.	Programming change to software to include a reset button to zero all flows, runtimes, etc.	TBC

Nitrogen Impact of Onsite Sewage Treatment and Disposal Systems in the Wekiva Study Area
June 30, 2007

Executive Summary

The 2006 Legislature in Specific Appropriation 566 allotted $250,000 to the Florida Department of Health (FDOH) to assess whether onsite sewage treatment and disposal systems (OSTDS) are a “significant source of nitrogen to the underlying groundwater relative to other sources” within the Wekiva Study Area (WSA) and, if so, “to recommend a range of cost-effective nitrogen reduction strategies.” The department, with direction from the Research Review and Advisory Committee (RRAC), contracted for the assessment in three tasks. The questions were how much nitrogen comes out of septic tank (input) and how much nitrogen makes it to the groundwater (load).

The first task collected field data from groundwater around drainfields from three sites in the area. This task found high concentrations of nitrogen stemming from all three systems and a higher nitrogen input into the environment than expected (29 vs. 20 pounds per system per year) based on previous DOH research. Groundwater monitoring showed that nitrogen movement from onsite systems in the environment is complex. Relying only on the soil for treatment is not a reliable method to achieve load reductions.

A second task reviewed applicable literature to refine the loading estimate to the groundwater from onsite systems. This task developed a classification system to incorporate the influence of soil conditions and wastewater characteristics on nitrogen loading to the groundwater. The study resulted in a range of estimated percentages of nitrogen removal as a function of soil characteristics and system type. The results were generally consistent with the assumptions of the Florida Department of Environmental Protection (FDEP) March, 2007, Phase 1 Report Wekiva River Basin Nitrate Sourcing Study prepared by MACTEC.

The third task was to determine whether onsite systems are a significant source of nitrogen to groundwater relative to other sources. This determination utilized data from the second task and the MACTEC study to estimate inputs to the environment and loading to groundwater from all sources of nitrogen in the area. Fertilizer use accounted for 71 percent of all inputs. Inputs to the environment from onsite systems were estimated to be 6 percent of the total input. This was based on an assumption of 20 pounds of nitrogen per year for 55,000 systems or a total of 1.1 million pounds per year. Based on this input the total estimated amount of nitrogen from onsite sewage treatment and disposal systems that is loaded to the groundwater is about 900,000 pounds per year. MACTEC’s approach to estimating loading to groundwater resulted in an increased fraction of wastewater and a decreased fraction of fertilizer. Due to uncertainty and disagreements about this approach, RRAC recommended to the department that an assessment of loading contributions by all sources not be included in this report

RRAC did not make a final decision on whether the OSTDS are a significant source of nitrogen load to the groundwater because the committee is uncomfortable with the methodologies and assumptions used in the calculations of the MACTEC loading numbers. RRAC decided that verification of the loading contribution from other sources by FDEP was necessary before any decision can be made relative to the significance of the nitrogen contribution from onsite systems in the WSA, and what, if any, cost-effective strategies the committee would endorse.

The U.S. Environmental Protection Agency has established the goal of a 95% reduction in nitrogen concentrations for Wekiwa Springs and for Rock Springs Run. Additionally, the Saint Johns River Water Management District has proposed an 82% reduction for Wekiwa Springs, an 85% reduction for Rock Springs, a 69% reduction in the upper Wekiva River, and a 36% reduction for the Lower Wekiva River. Realizing that these established reduction goals present

a challenge to all contributors the department finds that all contributors must work toward addressing their share of the problem. The contribution of onsite systems to nitrogen inputs to the Wekiva Study Area provides a starting point to determine this share.

While the department cannot yet determine the relative contribution of onsite systems to groundwater loading compared to other sources, the department recognizes onsite systems do have an impact on the nitrogen input to groundwater. Based on the established and proposed nitrogen reduction goals the department recommends the following strategies to reduce nitrogen input from onsite systems:

- The Legislature should consider implementing a nitrogen discharge fee for all sources to fund the most cost-effective nitrogen reduction projects in the Wekiva Study Area to be administered by the Wekiva River Basin Coordinating Committee or other suitable agency.
- The Legislature should consider implementing an onsite wastewater management utility (EPA Model 4) in which operation, maintenance, and inspection of systems are the responsibility of a responsible maintenance entity instead of the individual homeowner. A portion of the funds collected should be used to assist with upgrades of onsite systems or connection to a wastewater treatment facility. Otherwise, require an operating permit for all onsite systems and require all onsite systems be inspected every five years and during real estate transactions. Use a portion of the operating permit fee to fund a grant program to assist low income homeowners with upgrades or sewer connection fees. The department will provide a legislative proposal for the 2008 session.
- The Legislature should consider eliminating grandfather provisions in 381.0065, Florida Statutes, with regard to minimum lot sizes and surface water setbacks. The department will provide a legislative proposal for the 2008 session.
- The department should amend Chapter 64E-6, Florida Administrative Code, to require all systems in need of repair or modification be upgraded to new system water table separation and surface water setback standards.
- The department should require that all new onsite systems in the Wekiva Study Area be performance based treatment systems providing nitrogen reduction pretreatment.
- The department and local governments should create an inventory of all onsite systems in the Wekiva Study Area that can be maintained in cooperation between county health departments and county property appraisers.
- The department should prohibit the land spreading of septage and grease trap waste in the study area. Septage waste would be required to be disposed of at wastewater treatment plants permitted by the Florida Department of Environmental Protection.
- The department recommends that state and local planning agencies evaluate the economic feasibility of sewering areas with existing onsite sewage treatment and disposal systems. Areas with high densities of development will be better suited to central sewering.

Final Report
Wekiva River Basin
Nitrate Sourcing Study

Prepared for:
St. Johns River Water Management District
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Florida Department of Environmental Protection
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MACTEC Project No.: 6063090160A

March 2010

Table of Contents

List of Appendices

Table of Contents (continued)

List of Tables

List of Figures

Table of Contents (continued)

List of Acronyms and Abbreviations

ac	acre
bls	below land surface
BMP	Best Management Practice
CAFO	concentrated animal feeding operations
CASTNET	Clean Air Status and Trends Network
cfs	cubic feet per second
CGW	groundwater concentrations
DIY	Do-It-Yourself
DPT	direct push technology
EMC	event mean concentration
F.A.C.	Florida Administrative Code
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FS	Florida Statutes
ft^2	square foot
GIS	geographic information system
ha	hectare
HNO3-N	nitric acid nitrogen
ICU	Intermediate Confining Unit
in	inches
IRL	Indian River Lagoon
IFAS Extension	Institute of Food and Agricultural Sciences Florida Cooperative Extension Service
lb	pound
kg	kilograms
L	Liters
MACTEC	MACTEC Engineering and Consulting, Inc.
mg	milligrams
MGD	million gallons per day
mi^2	square mile
MT	metric tons
N	Nitrogen
N_2	nitrogen gas
NADP	National Atmospheric Deposition Program
NH_3	ammonia
NH3-N	nitrogen present as ammonia
NH_4	ammonium
NH4-N	nitrogen present as ammonium ion
NO2-N	nitrogen present as nitrite
NO_3	nitrate
NO3-N	nitrogen present as nitrate (often stated as nitrate nitrogen)
NO_x	nitrogen oxides
NTN	National Trends Network
OAWP	Office of Agricultural Water Policy

Table of Contents (continued)

List of Acronyms and Abbreviations (continued)

OSTDS	Onsite Sewage Treatment and Disposal Systems
RIB	rapid infiltration basin
SAS	Surficial Aquifer System
SJRWMD	St. Johns River Water Management District
SRWMD	Suwannee River Water Management District
TKN	Total Kjeldahl Nitrogen is the mass of nitrogen present as ammonia, ammonium, and/or organic nitrogen
TN	total nitrogen
TMDL	Total Maximum Daily Load
μm	microns
UCF	University of Central Florida
UF	University of Florida
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
WAVA	Wekiva Aquifer Vulnerability Assessment
WMM	Watershed Management Model
WSA	Wekiva Study Area
WWTF	Wastewater Treatment Facilities
yr	year

Executive Summary

Description of Project Area

For purposes of this project, "Wekiva Basin" or "basin" refers to the area contributing groundwater recharge[1] to the Wekiva River and its tributaries, and the watershed of the Wekiva River (Figure ES-1). The Wekiva Basin is generally consistent with the Wekiva Study Area (WSA) as defined by F.S. Chapter 369.316, but not identical. The Wekiva Basin has an area of 415,000 acres (ac) [648 square mile (mi^2)], which is 37% larger than the WSA. The portion of the Wekiva Basin that is not part of the WSA is generally to the west and southwest of the WSA, in Lake County, and in areas that are less densely populated.

Project Goals

The Wekiva Parkway and Protection Act of 2004 (Chapter 369, Part III, FS) established the legislative framework for construction of a limited-access expressway across the Wekiva Basin in parts of Seminole, Orange and Lake counties, while providing enhanced protection to the Wekiva River ecosystem. Additional legislation passed in 2006 authorized funds to the Florida Department of Environmental Protection (FDEP) "to determine nitrate impacts to the system". The Wekiva River and Rock Springs Run have been identified as impaired by FDEP, with nitrate as a causative pollutant.

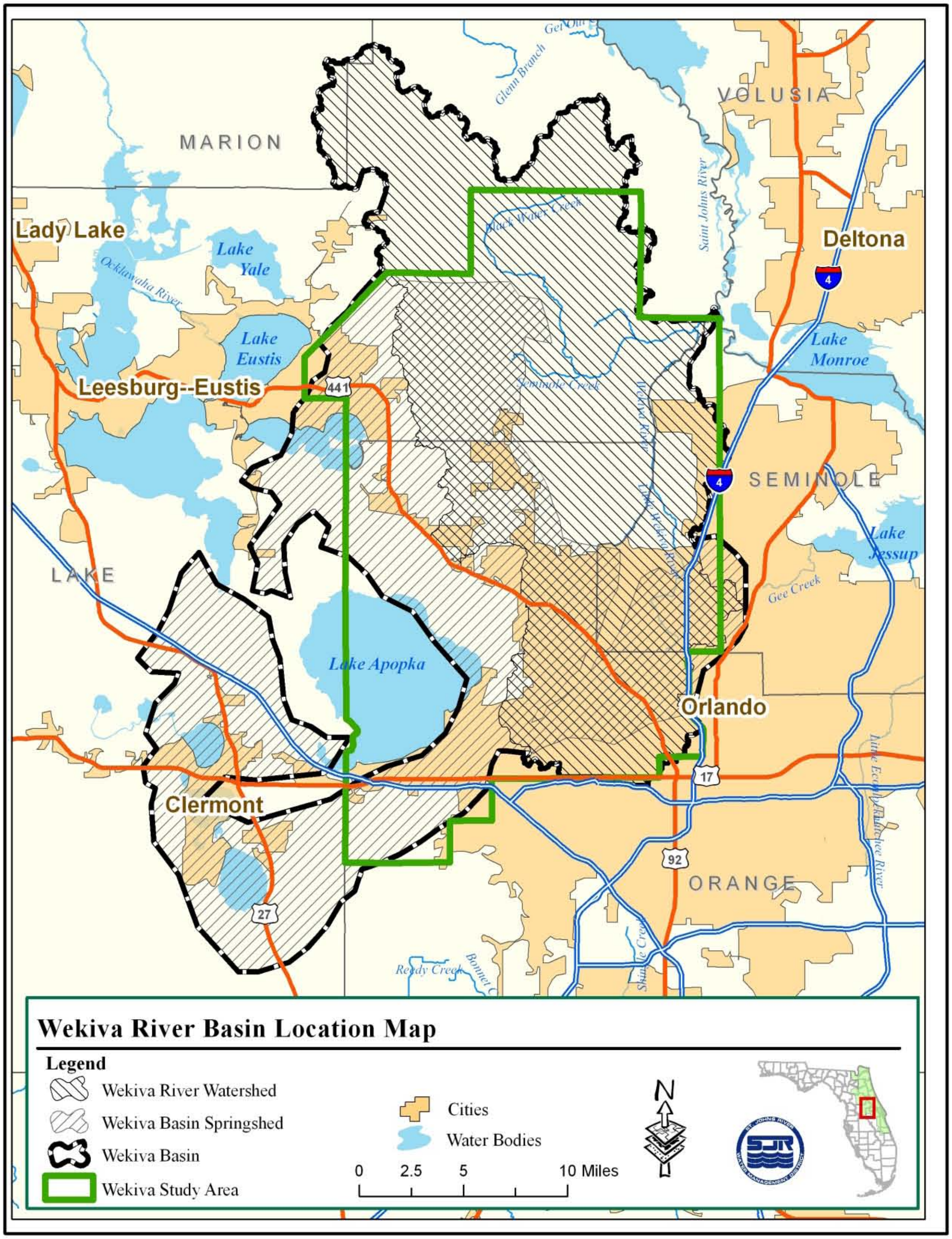
The Nitrate Sourcing Study was performed in two Phases. In Phase I existing information was collected and synthesized to produce a preliminary understanding of nitrate (NO_3) inputs to the basin and loadings to the Wekiva River. In Phase II, FDEP focused on an important area of uncertainty identified by the Phase I study – the effects of residential fertilizer use. To reduce uncertainty associated with this source type, FDEP funded the University of Central Florida (UCF) to survey residential fertilizer practices in the Wekiva Study Area (WSA), and the St. Johns River Water Management District (SJRWMD) to monitor water quality in the surficial aquifer in residential areas within the Wekiwa Springs springshed.

The Florida Department of Health (FDOH) performed companion studies in 2007, including groundwater monitoring in the WSA, focusing on effects of Onsite Treatment and Disposal Systems (OSTDS).

This Final Report presents a best estimate of inputs of nitrogen to the Wekiva Basin and nitrate loadings to the River, incorporating findings from recent state-funded studies within the study area and related technical information. The report also addresses stakeholder comments on the Phase I study.

[1] Recharge is the downward flow of water to a subsurface groundwater aquifer.

Figure ES-1. Project Location



Source: MACTEC and SJRWMD
Created by: JAT Checked by: WAT

Inputs of Nitrogen (Sources of Nitrate)Nitrogen is an important plant nutrient, and a major ingredient in commercial fertilizers. Nitrogen is also associated with human and other animal waste, and is found in raw sewage. Nitrate is a form of nitrogen that is highly soluble in water, so it migrates readily into groundwater. In surface waters, nitrate is a nutrient that can be used as food by algae and other plants, and excessive growth of such plants may cause nuisance conditions in springs, lakes, and rivers, often referred to as eutrophication.

Total nitrogen (TN) input to the Wekiva Basin was estimated for the following source types:

- Wastewater Treatment Facilities (WWTF) (sewer);
- Onsite Treatment and Disposal Systems (OSTDS) (septic systems);
- Fertilizer – Agricultural, Residential, Golf Course, and Other;
- Livestock; and
- Atmospheric Deposition

Nitrate from these sources is delivered to ground or surface waters of the Wekiva Basin by the following transport mechanisms:

- Direct discharge to surface waters (e.g., a wastewater outfall pipe that discharges to a river);
- Generation of stormwater runoff that flows to surface waters (stormwater-direct);
- Generation of stormwater in closed basins, or other stormwater that percolates to groundwater (stormwater-diffuse); and
- Infiltration to groundwater (e.g., the leaching process in which fertilizer applied in excess of crop or turfgrass requirements is carried by infiltrating rainwater to a groundwater aquifer).

Loadings

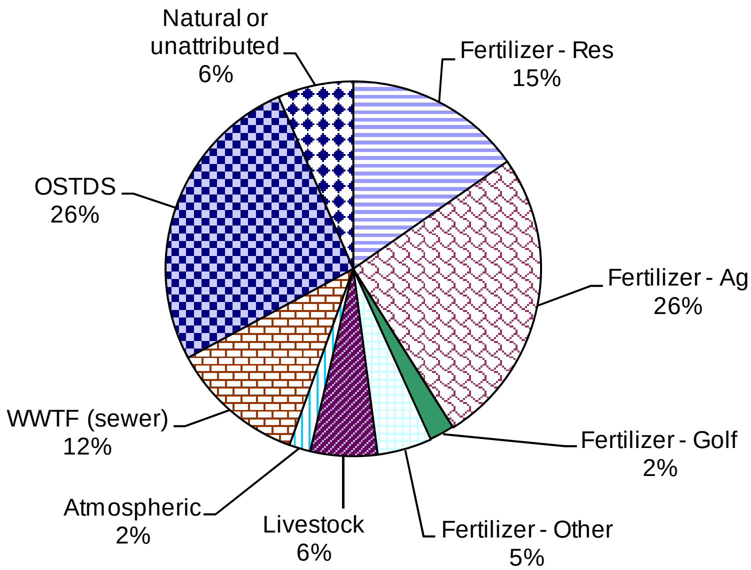
The delivery of nitrate to waters of the Basin by these transport mechanisms is referred to as "loading" in this report. Loadings represent a portion of the TN inputs that actually reach surface waters or groundwater in the Basin as nitrate. To understand the difference between inputs and loadings, as the terms are used here, consider fertilizer use. Inputs represent the total amount of fertilizer nitrogen applied on the land. Some of this fertilizer nitrogen is taken up by plants and incorporated into plant biomass. Not all the fertilizer nitrogen is taken up, however; some is lost during application, and some escapes the root zone, etc. The portion of the applied nitrogen that escapes the soil root zone as nitrate and dissolves in surface runoff or infiltrates to groundwater is a loading.

Results

It was estimated that in 2004, the rate of nitrate nitrogen[2] loading to groundwater and surface water in the Wekiva Basin was 1,800 metric tons per year (MT/yr). Most of this nitrate (about 93%) initially affects groundwater, with only a small amount discharged directly to surface waters. Figure ES-2 illustrates the apportionment of the total estimated loadings by source type.

[2] To compare various chemical forms of nitrogen it is customary to express amounts in terms of the mass of nitrogen in the chemical. For example the mass of nitrogen in nitrate is referred to as nitrate nitrogen or NO3-N

Figure ES-2. Nitrate Loadings to the Wekiva Basin, Partitioned by Source



Source: MACTEC
Created by: SAR Checked by: WAT

Major contributors to total Basin loading include agricultural and residential fertilizer use, OSTDS and WWTF. Fertilizer use comprises about half (48%) of total loadings. Treated domestic wastewater (OSTDS and WWTF) comprises 38% of total nitrate loading. Livestock contribute 6% of the total loading. Approximately 8% of the total loading is natural or cannot be attributed to specific sources.

Residential land uses, which are affected by both fertilizer use, OSTDS, and reused WWTF effluent account for 41% of total loading, while agricultural land uses contribute 33%. Wastewater effluents are the predominant contributor to the utilities land use, which contribute 12% of total loadings of nitrate.

Residential land uses are major contributors to nitrate loadings, in part, because they comprise a large portion (21%) of the Wekiva Basin. Similarly transportation, utilities, commercial, industrial, institutional, and golf course land uses contribute a greater proportion of the nitrate loadings than their proportion of the acreage, while undeveloped land uses that make up more than 50% of the area of the Basin contribute only 6% of the nitrate loading.

Uncertainties

Several of the factors used to estimate inputs and loadings are uncertain, and the procedures themselves do not represent all factors that affect nitrate loadings. Sources of uncertainties are characterized in the report. Phase II investigations were targeted to reduce the most important sources of uncertainty. Results are based on the best available information at this time.

1.0 Introduction and Background

The Wekiva Parkway and Protection Act of 2004 (Chapter 369, Part III, FS) established the legislative framework for construction of a limited-access expressway across the Wekiva Basin in parts of Seminole, Orange and Lake counties, while providing enhanced protection to the Wekiva River ecosystem. Additional legislation passed in 2006 authorized funds to the Florida Department of Environmental Protection (FDEP) "to determine nitrate impacts to the system". Nitrate has been identified as a problem pollutant in springs and spring-run streams in Florida, including the Wekiva River and its main tributary, Rock Springs Run (Mattson, *et al*., 2006; Gao, 2008).

The FDEP contracted with the St. Johns River Water Management District (SJRWMD) to perform this nitrate sourcing work. MACTEC Engineering and Consulting, Inc (MACTEC) assisted the SJRWMD under three different contracts. The study was performed in two Phases. In Phase I existing information was collected and synthesized to produce a preliminary understanding of nitrate sources and loadings in the basin (MACTEC, 2007). In Phase II, FDEP focused on an important area of uncertainty identified by the Phase I study – the effects of residential fertilizer use. To reduce uncertainty associated with this source type, FDEP funded the University of Central Florida (UCF) to survey residential fertilizer practices in the Wekiva Study Area (WSA), and SJRWMD to monitor groundwater quality in the surficial aquifer in residential areas within the Wekiwa Springs springshed. MACTEC conducted the latter study under contract with SJRWMD.

The Florida Department of Health (FDOH) performed companion studies in 2007, including groundwater monitoring in the WSA, focusing on effects of Onsite Treatment and Disposal Systems (OSTDS).

This Final Report presents a best estimate of sources of nitrate to the Wekiva Basin, incorporating findings from these state-funded studies within the study area and related technical information. This report also addresses stakeholder comments on the Phase I study.

1.1 Description of Project Area

For purposes of this project, "Wekiva Basin" refers to (a) the area contributing groundwater recharge[3] to the Wekiva River and its tributaries as delineated by the SJRWMD Division of Groundwater Programs, and (b) the watershed of the Wekiva River (Figure 1-1).

The Wekiva Basin as shown in Figure 1-1 is generally consistent with the WSA as defined by F.S. Chapter 369.316, but not identical. The Wekiva Basin, which includes portions of Lake,

[3] Recharge is the downward flow of water to a subsurface groundwater aquifer.

Orange, Seminole, and Marion Counties, has an area of 415,000 acres (ac) [648 square miles (mi^2)], which is 37% larger in area than the WSA (303,000 ac or 473 mi^2). The population of the Wekiva Basin was approximately 423,000 in 2000, or 9% greater than the population of the WSA (388,000 in 2000)[4]. The portion of the Wekiva Basin that is not part of the WSA is generally to the west and southwest of the WSA, in Lake County, and in areas that are less densely populated. The additional area included within the Wekiva Basin for the purpose of this study is somewhat more rural and agricultural than the portion of the Basin included within the WSA (see Figures 1-2 and 1-3).

Groundwater in the Wekiva Basin generally occurs in three aquifer systems, the Surficial Aquifer System (SAS), overlying an Intermediate Confining Unit (ICU), and deeper, the Floridan Aquifer (McGurk and Presley, 2002). Springs within the basin are primarily fed by the Floridan Aquifer. Surface pollution, for example nitrate from fertilizers, initially enters the SAS, from which it can migrate downward through the ICU to the Floridan. The ICU generally has reduced permeability, which reduces the rate of flow from the SAS to the Floridan; however, the thickness and therefore the degree of confinement varies throughout the basin. The ICU is occasionally absent due to sinkholes and other solution cavities, such that the ICU is "leaky".

1.2 Objectives of Project

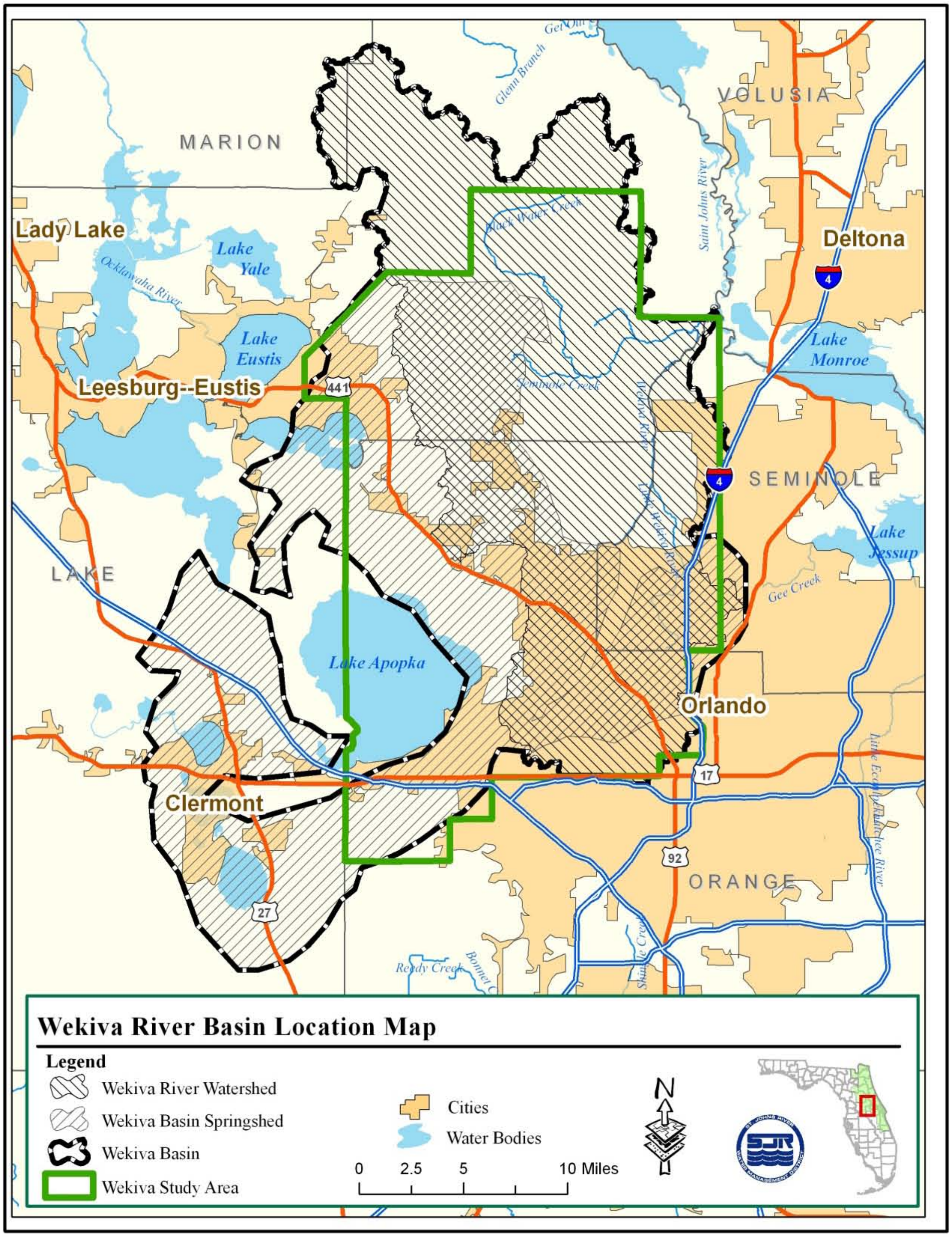
The objectives of this project include:

- Evaluate relevant information developed after publication of the Phase I report in 2007 including Phase II monitoring conducted by FDEP/SJRWMD/MACTEC and FDOH/Ellis & Associates; residential fertilizer practices survey performed by UCF, stakeholder comments on the Phase I report, and other pertinent technical information;
- Revise the Phase I nitrate budget for the Wekiva Basin, as appropriate;
- Apportion the loadings by source type and land use; and
- Prepare a report that summarizes the above.

The base year for estimates provided in this report is 2004 because the estimates are closely related to land use, and the most current land use map available from the SJRWMD at the time of publication characterizes land use in 2004. The estimates do not account for Best Management Practices (BMPs) implemented after 2004.

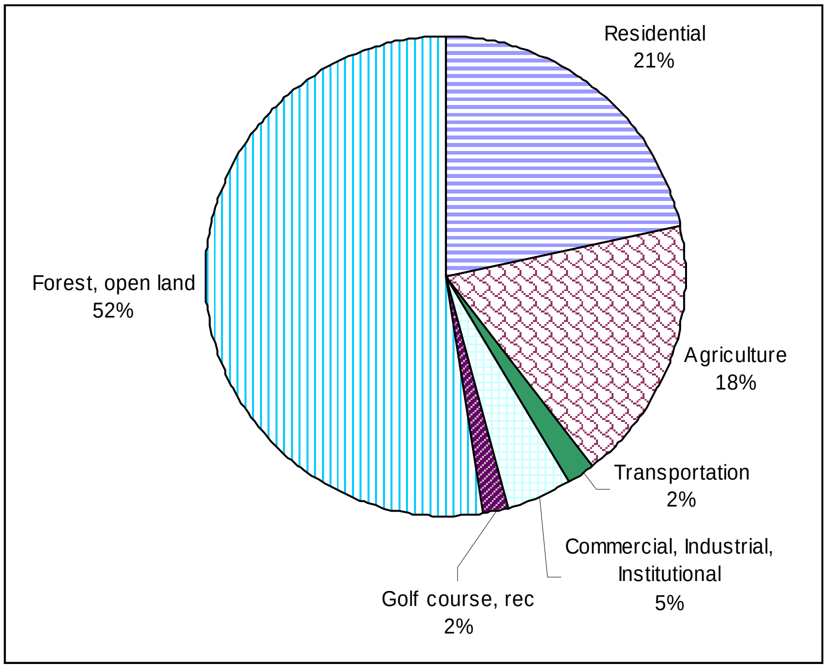
[4] Note: Various statistics presented in this report are based on land use in 2004, while these population statistics are based on the 2000 U.S. census. Population is increasing rapidly in the Basin – acreage in residential land use increased by 10% from 1999 to 2004.

Figure 1-1. Project Location



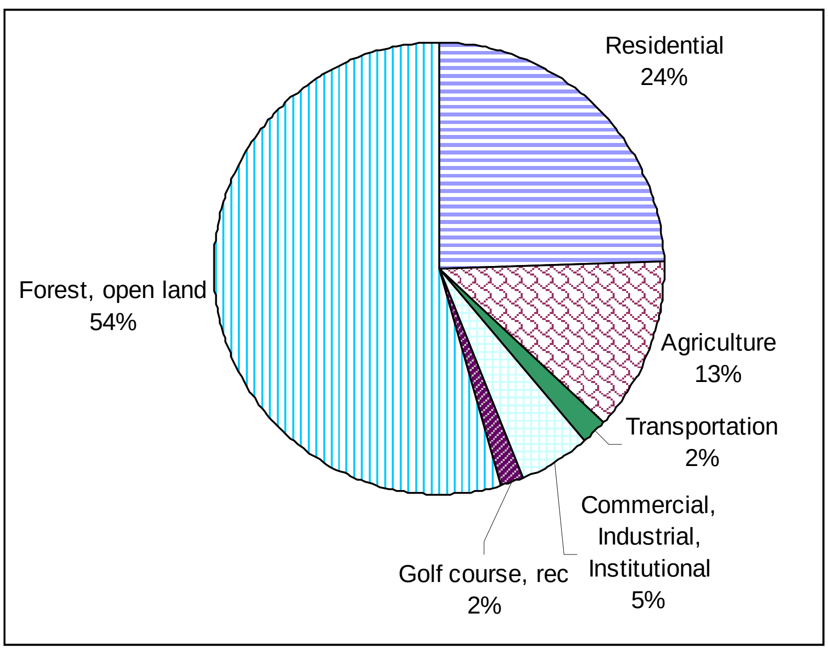
Source: MACTEC and SJRWMD
Created by: JAT Checked by: WAT

Figure 1-2. Land Use in 2004, Wekiva Basin



Source: MACTEC and SJRWMD
Created by: SAR Checked by: WAT

Figure 1-3. Land Use in 2004, Wekiva Study Area



Source: MACTEC and SJRWMD
Created by: SAR Checked by: WAT

2.0 Approach to Nitrate Loading and Partitioning

Existing information and models were collected and synthesized to produce a preliminary understanding of nitrate sources and loadings in the Wekiva Basin.

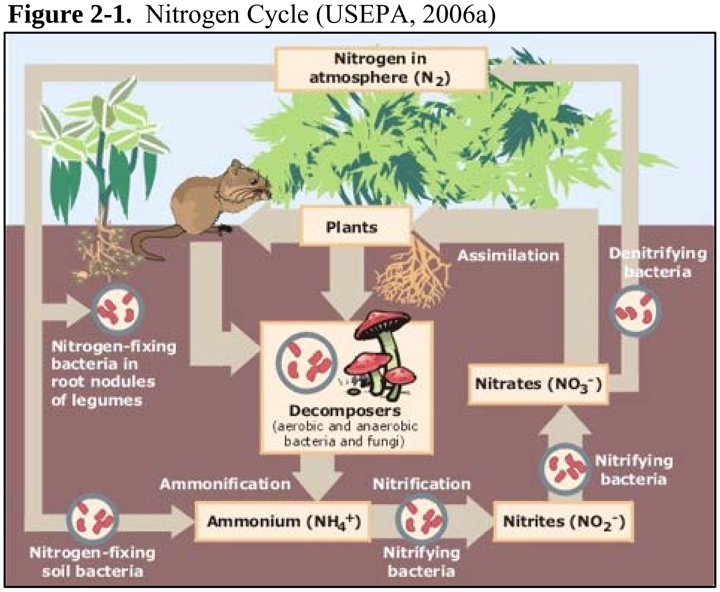
2.1 Review of Available Information

Information sources specified by FDEP and SJRWMD were reviewed. The SJRWMD provided MACTEC with two bibliographic searches conducted by others, and MACTEC identified additional references by review of reference lists of publications reviewed and by keyword search of multiple web-based databases. References identified were then further reviewed for relevance to the project, and copies of technical publications were acquired. The acquired publications were reviewed by the project team to determine their value to the study. In all, approximately 250 technical publications were acquired and reviewed for relevance. The entire list of references consulted appears in Appendix A. Publications actually cited in the report are in Section 4.0 References.

2.2 Conceptual Model of Nitrate Loading to Waters of the Wekiva Basin

2.2.1 The Nitrogen Cycle

Figure 2-1. Nitrogen Cycle (USEPA, 2006a)



Nitrate (NO_3) is an anion that participates in the complex nitrogen cycle (Figure 2-1) in the earth's biosphere (see, for example, Loreti, 1988; the nitrogen cycle is also described on a variety of websites). Nitrate may be either created or destroyed in the biochemically active root zone, in surface water and groundwater.

Nitrogen gas (N_2) comprises about 78% of the atmosphere. Nitrogen is essential for many biological processes, but is not readily available to plants or animals in the N_2 form. In nature, N_2 is converted to biologically usable forms [ammonium (NH_4), nitrate or nitrite (NO_2) ions] by some algae and bacteria, a process called fixation. These anionic forms can be taken up by plants, which convert them to amino acids and proteins, a process known as assimilation; while the reverse decomposition reaction is known as mineralization. Decomposition in anaerobic environments generally yields ammonia (NH_3) or ammonium ions, a process called ammonification. Nitrification is the process whereby microorganisms convert organic nitrogen[5] to nitrate and nitrite. Nitrification is favored in aerobic environments, while ammonification is more likely to occur in reducing environments[6]. Finally, denitrification is a biochemical process that converts nitrate or nitrite ions back to N_2, completing the nitrogen cycle (Cohen, *et* al., 2007). Denitrification depends on the availability of electron donors used by autotrophic bacteria. The electron donors, typically pyrite or ferrous silicates, are rare in the Florida environment. Additionally, when calcium, pH, alkalinity and/or specific conductance are high, denitrification is less likely to occur. All of these parameters are characteristically high in Florida's groundwater. Consequently, denitrification is generally negligible in groundwater in Florida (Cohen, *et* al., 2007). Denitrification has been shown to occur in shallow groundwater in Florida where the water table is near the surface (McNeal, *et al*., 1995; Crandall, 2000).

In soils, organic nitrogen and ammonia are more likely to be associated with solids than nitrate, which is highly soluble and not sorbed to any significant extent (Loreti, 1988). Although ammonium ion is soluble, it is more readily sorbed to soils, and thus not as leachable as nitrate (Cohen, *et* al., 2007). This is one reason that nitrate represents a more significant water quality concern than other forms of nitrogen.

Based on the importance of these processes in the environment, nitrate cannot be considered a conservative (never changing) constituent. Nitrate applied as fertilizer may be assimilated by plants, or denitrified and returned to the atmosphere. Ammonium in fertilizers or in animal waste may be converted to nitrate in soil or water, and so on.

This project did not attempt to quantify these processes in the Wekiva Basin. Certain simplifying assumptions and/or conventions were adopted that partially account for some features of the nitrogen cycle. The target constituent for this study is nitrate. Although it was not feasible to account for all the complex biochemistry of the nitrogen cycle, a limited attempt was made to account for assimilation by plants and other processes that occur in the root zone. Specifically it was not assumed that all fertilizer nitrogen (N) applied to the land surface would reach ground and/or surface water of the Wekiva Basin as nitrate. Specific procedures were adopted that were intended to more realistically account for the inputs, cycling and loadings to water, as described in the following sections.

2.2.2 Conceptual Model

Figure 2-2 presents a conceptual model of nitrate movement from sources (inputs) to loadings to waters of the Wekiva Basin. The model, developed as an organizing concept for this study, defines terms in the nitrate budget of the Wekiva Basin to be quantified in this project.

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[5] Organic nitrogen, such as proteins, amino acids, and urea, includes nitrogen in organic compounds found within living organisms and decaying plant and animal tissues.
[6] A reducing environment is one characterized by little or no free oxygen. In soils, reducing environments are more common in wetlands and where soils are rich in organic matter.

In Figure 2-2, source types of nitrogen are on the left, while the arrows represent transport mechanisms that deliver nitrate to either groundwater or surface waters of the Wekiva Basin. The text summarizes key principals or assumptions that guided the quantification of each term in the nitrate budget.

Inputs of nitrogen from the following source types were quantified:

- Wastewater Treatment Facilities (WWTF)
- OSTDS
- Fertilizer – Agriculture
- Fertilizer – Residential
- Fertilizer – Golf Course
- Fertilizer – Other
- Livestock
- Atmospheric Deposition

For each of these sources, the annual rate of total nitrogen (TN) released to the environment within the Wekiva Basin (inputs) was estimated.

Nitrate from these sources is delivered (loaded) to ground or surface waters of the Wekiva Basin by the following transport mechanisms:

- Direct discharge to surface waters (e.g., a wastewater outfall pipe that discharges to a river);
- Generation of stormwater runoff that flows to surface waters (stormwater-direct);
- Generation of stormwater in closed basins, or other stormwater that percolates to groundwater (stormwater-diffuse); and
- Infiltration to groundwater (e.g., the leaching process in which fertilizer applied in excess of crop requirements is carried by infiltrating rainwater to a groundwater aquifer).

Each of these transport mechanisms was quantified. The delivery of nitrate to waters of the Basin is referred to as "loading" in the remainder of this report. Loadings consistently represent NO3-N[7] loading, not TN. Procedures for each mechanism are described below. Procedures were developed to partition loadings in two ways – by source type and by land use.

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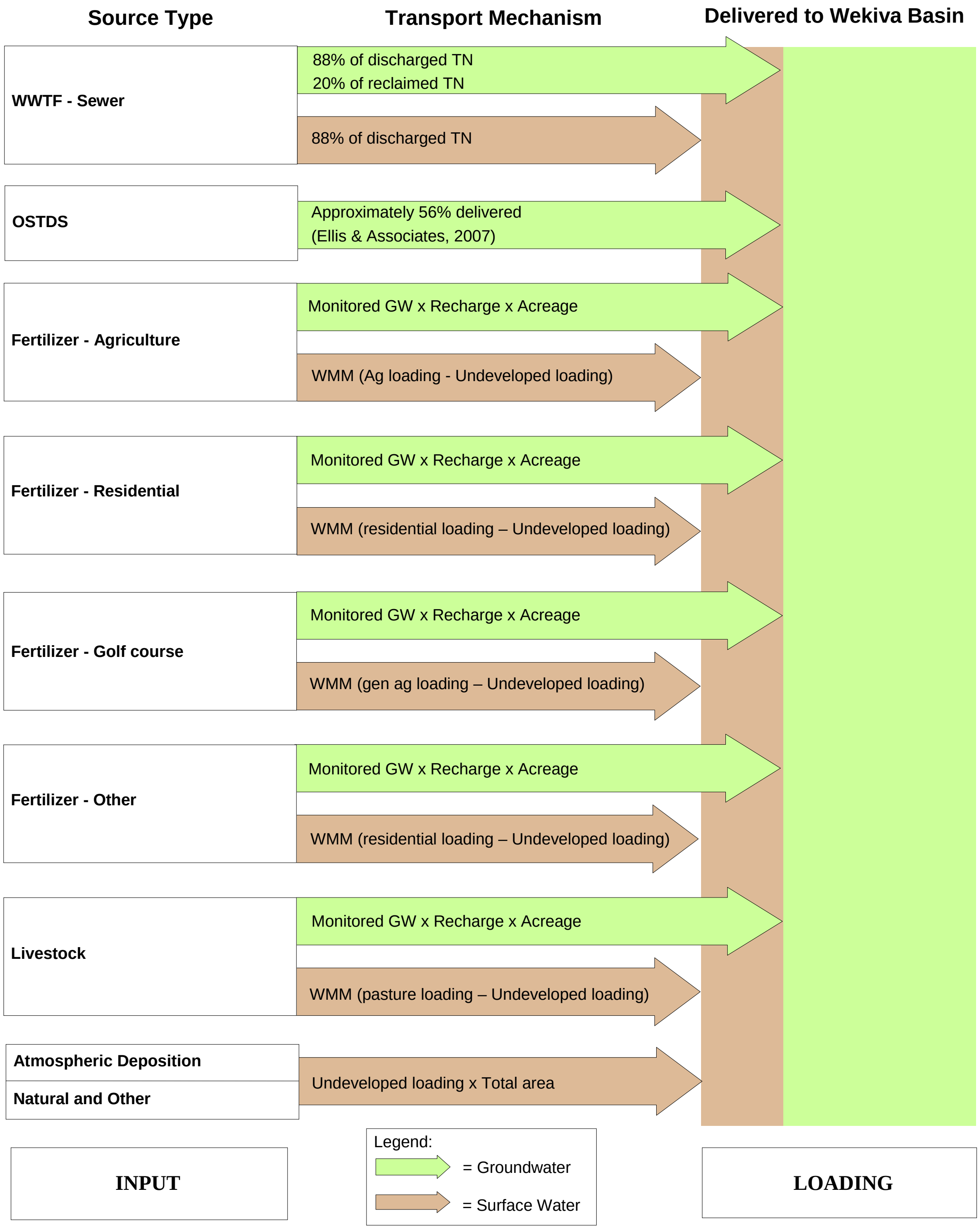
[7] NO3-N is the amount of nitrogen present as nitrate, often referred to as "NO_3 expressed as N" or "nitrate nitrogen". Chemical analyses of nitrate are customarily presented in this form. Although the NO_3 ion has an ionic weight of 62, only 23% of the ionic weight is comprised of nitrogen. Expressing NO_3 mass or concentration in this way permits ready comparison with the mass of other nitrogen containing chemicals, which are customarily also expressed as "N". The analytical method routinely used to measure nitrate actually measures nitrate plus nitrite, however under environmental conditions nitrite is usually a very small fraction of nitrate, so the analyses reported here are based on the assumption that nitrate plus nitrite is equivalent to nitrate.

Figure 2-2. Conceptual Model of Nitrate Inputs to the Wekiva Basin



Note:		
Ag	=	Agriculture
GW	=	groundwater; recharge is the downward flow of water to a subsurface groundwater aquifer
OSTDS	=	Onsite Sewage Treatment and Disposal Systems
TN	=	total nitrogen
WMM	=	Watershed Management Model (used to estimate stormwater loadings)
WWTF	=	Wastewater Treatment Facilities

Source: MACTEC
Created by: WAT Checked by: SAR

2.3 Procedures – Nitrogen Inputs to the Basin

Inputs to the Basin include direct application (use) of fertilizer; animal waste production, which is assumed to be released to the environment; atmospheric deposition (wet and dry); WWTF effluents; and OSTDS discharges. Inputs and loadings per area are presented in this report in metric units of kilogram per hectare per year (kg/ha/yr). Results for the entire Wekiva Basin are presented in metric tons per year (MT/yr).[8]

Appendix D contains a summary of inputs by land use and source type.

2.3.1 Fertilizer Use

The general procedure for estimating fertilizer use was to assume fertilizer is applied at rates recommended by the University of Florida Institute of Food and Agricultural Sciences Florida Cooperative Extension Service (UF/IFAS Extension), with limited modifications if there is evidence that actual usage differs from UF/IFAS Extension recommendations.

2.3.1.1 Residential, Commercial, Institutional and Transportation

Fertilizer use for residential, commercial, institutional, and transportation land uses was estimated using the following equation:

$$Fertilizer\,Use_{LU} = \frac{Pervious\,Fraction_{LU}\ x\ Application\,Rate_{LU}\ x\ Area_{LU}}{CF}$$

Where
- $Fertilizer\ Use_{LU}$ = TN contained in fertilizer applied for a specific land use (LU), totaled for that land use over the entire Wekiva Basin; (MT/yr)
- $Pervious\ Fraction_{LU}$ = Fraction of the land use area that is not paved or under roof;
- $Application\ Rate_{LU}$ = Application rate of TN in fertilizer (kg/ha/yr);
- $Area_{LU}$ = Area within a given land use classification totaled over the entire Wekiva Basin (ha); and
- CF = conversion factor to achieve desired units of measurement, 1000 (kg/MT).

Harper (1994) was used to estimate pervious fraction for each land use. The basis for application rate for each land use follows.

Residential

UF/IFAS Extension recommends application of fertilizer containing 98 to 269 kg TN/ha/yr in Central Florida, depending on the variety of turfgrass (Sartain, 2007). Hipp, *et al.* (1993) and Morton, *et al.* (1988) provide survey and/or anecdotal information that suggest a range from 122 to 450 kg/ha/yr. Of course some homeowners do not fertilize at all, therefore, the lower end of

[8] One kilogram equals 2.205 pounds (lb); one hectare equals 2.472 acres (ac); and one metric ton equals 2,205 lb or 1.102 tons. To convert from metric to English units, multiply the loading rate in (kg/ha/yr) by 0.8920 to yield a loading rate in (lb/ac/yr).

the range is zero. Hodges, *et al*. (1994) surveyed Florida residents and found that 39% do not fertilize. Knox, *et al*. (1995) found that 82% fertilize, averaging three applications per year. Assuming each application is 50 kg/ha, Knox *et al.*'s (1995) findings indicate that most homeowners apply about 150 kg/ha/yr.

As a component of Phase II of this Nitrate Sourcing Study, UCF, under contract with FDEP conducted a survey of homeowners within the WSA to determine their turfgrass management practices and attitudes, including fertilizer use and irrigation practices (UCF, 2009). The UCF survey area was smaller than the WSA, but the surveyed area is expected to be representative of the WSA. Seven hundred forty (740) residents were interviewed by telephone, and 42 of the telephone survey participants were subsequently interviewed in person to determine if they were willing to participate in a Phase II groundwater monitoring program. UCF also conducted a windshield survey of residential subdivisions examining the health of turfgrass landscapes. UCF stratified their data set into two main categories: internal and external fertilizers. Internal fertilizers are those who apply fertilizer themselves (do-it-yourself or DIY), while external fertilizers rely on a commercial lawn service to apply fertilizer. Internal fertilizers generally had more complete knowledge of the rate of fertilizer use than people who relied on a commercial lawn service, but the limited information provided by external fertilizers indicates that commercial lawn services apply more fertilizer, on average, than the DIY residents. About half of all respondents were internal fertilizers (51% including those helped by friends or neighbors). One-third (33%) were serviced by a commercial lawn service, while 16% did not fertilize at all.

The internal fertilizers apply fertilizer 2.88 times per year on average; and UCF estimated, from survey responses, that the average application rate was 0.5 lb TN/1000 square foot (ft^2) per application (UCF, 2009; p. 6). This average practice results in a TN application rate of 70 kg/ha/yr. Thus, the DIY subset applies less fertilizer than recommended by Sartain (2007). External fertilizers reported that fertilizer was applied 4.76 times per year on average, but were generally not aware of the amount applied. The frequency is consistent with the frequency of a "high maintenance program" for St. Augustine grass recommended by Sartain (2007) to "produce an optimum quality turfgrass". Therefore, it is assumed that the commercial lawn service providers are applying at the Sartain (2007) "high maintenance" recommended rate for St. Augustine grass, i.e., 220 kg/ha/yr.

With 51% applying at 70 kg/ha/yr; 33% applying 220 kg/ha/yr; and 16% not fertilizing, the average residential application rate would be 108 kg/ha/yr on pervious surfaces. Although not all residential pervious surfaces are maintained in turfgrass, other residential landscapes include ornamentals which are also likely to be fertilized. Therefore, this rate was assumed to apply to pervious surfaces, rather than the area in turfgrass. The findings of the Phase II UCF survey are generally consistent with results reported by Knox, *et al*. (1995) in a broader survey of Florida residents.

Commercial, Institutional, Recreational, Transportation

Commercial land uses are assumed to apply fertilizer at the average rate recommended for Central Florida turfgrass by Sartain (2007), i.e., 168 kg/ha/yr. Institutional, recreational, and transportation land uses are assumed to receive fertilizer at the residential average rate of 108 kg/ha/yr. A higher rate for commercial properties is expected considering the commercial value of attractive landscaping.

2.3.1.2 Agricultural

Pervious fraction was assumed to be 1.00 for all agricultural land uses. Therefore, fertilizer use for all agricultural land uses was estimated using the following equation:

$$FertilizerUse_{LU} = \frac{Application\ Rate_{LU}\ x\ Area_{LU}}{CF}$$

The basis for application rates for various agricultural land uses are summarized below.

Row Crops

Principal vegetables produced in the Wekiva Basin are cabbage, cucumbers, greens, spinach, sweet corn, eggplant, and peppers [U.S. Department of Agriculture (USDA, 2005)]. The U.S. Environmental Protection Agency (USEPA) (1999) provides average fertilizer use and ranges for each of these crops except greens. The average of these is 180 kg/ha/crop, ranging from 70 to 360 kg/ha/crop. UF/IFAS Extension (Hochmuth and Hanlon, 2000) recommendations for the same vegetables in Florida average 192 kg/ha/crop and range from 100 to 225 kg/ha/crop. Assuming the higher of the USEPA actuals and IFAS recommendations for each vegetable yields 210 kg/ha/crop (average of the seven crops). Kraft and Stites (2003) report that typical application to sweet corn exceeds Extension recommendations in Wisconsin. McNeal, *et al*. (1995) report that typical application rates to peppers, potatoes, and tomatoes substantially exceed UF/IFAS Extension recommendations (300-400 kg/ha/yr typical; 227 kg/ha/yr recommended). These anecdotal reports support using the higher of USEPA actuals or UF/IFAS Extension recommendations.

It is customary to produce two or three vegetable crops per year in central Florida. Therefore, fertilizer application rate per year may be two to three times higher than the application rate per crop. Although it is unlikely that fields consistently produce three crops per year, the anecdotal evidence that actual application rates exceeds UF/IFAS Extension recommendations supports the assumption that three times the fertilizer that would be applied to each crop is applied per year, with the resultant row crop application rate of 630 kg/ha/yr (3 crops/yr x 210 kg/ha/crop).

Field Crops

UF/IFAS Extension recommended fertilization rates for hay are 150 to 180 kg/ha/yr (Mylavarapu, *et al*., 2002). No anecdotal information was found indicating actual use differs. An application rate of 150 kg/ha/yr was assumed for field crops. This rate was also applied to land uses designated “cropland and pastureland.”

Tree Crops, Nurseries, and Ornamentals

In Florida, most land designated as “tree crops” are used for citrus. UF/IFAS Extension (Zekri, *et al*., 2005) recommends 138 to 227 kg/ha/yr for established orange groves. Florida Department of Agriculture and Consumer Services (FDACS) has established 240 kg/ha/yr as a best management practice (BMP) for mature oranges, and 238 kg/ha/yr for grapefruit. MACTEC assumed the upper bound of IFAS recommendations and BMP for oranges will be actual.

This application rate (240 kg/ha/yr) was also assumed for nurseries and ornamentals.

Pasture

UF/IFAS Extension (Mylavarapu, *et al*., 2002) recommends between 56 and 179 kg/ha/yr depending on cattle product pricing, fertilizer pricing, and intensity of use. Sumner, *et al*. (1992) conducted a survey of nine ranches in Florida and found that actual application rates averaged 69 kg/ha/yr. Two of the nine ranches did not fertilize at all. The average of the minimum IFAS recommendation and the nine ranch average, or 63 kg/ha/yr, was assumed to be applied on improved pasture.

2.3.1.3 Golf Courses

UF/IFAS Extension (Sartain and Miller, 2002) recommends application rates for various golf course landscapes:

- Greens – 588 kg/ha/yr;
- Tees – 441 kg/ha/yr;
- Fairways – 294 kg/ha/yr; and
- Rough – 98 kg/ha/yr.

USEPA (2006b) has estimated the portion of golf courses in each of these conditions as:

- Greens – 2.4%;
- Tees – 2.6%;
- Fairways – 28.6%; and
- Rough and other – 66.4%.

Applying these percentages to the recommended application rates indicates that the average application rate on golf courses is 175 kg/ha/yr. No reliable information was identified that actual use differed from UF/IFAS Extension recommendations, so this average recommended application rate was applied to lands used as golf course.

2.3.2 Livestock

Anderson and Cabana (2006) estimate that cattle (including calves) produce on average 56 kg TN/yr. Sumner, *et al.* (1992) and Arthington, *et al.* (2003) indicate that pasture stocking rates in Florida range from 0.27 to 0.40 cattle/ac. USDA (2006) provides a cattle census by county. Given the acreage of pasture and feedlots in Lake, Marion, Orange, and Seminole counties, it appears that the average pasture stocking rate in the Wekiva Basin is approximately 0.3 cattle/ac (approximately 30 cattle/ac in feedlot land uses). The inferred stocking rates are consistent with industry practice, and produce total head of cattle in the counties comprising the Wekiva Basin within 2% of the USDA 1999 cattle census statistics. The inferred number of cattle in the Wekiva Basin is approximately 18,600.

At 0.3 cattle/ac (0.7 cattle/ha) times 56 kg/cattle/yr, livestock waste on pasture land is 41 kg/ha/yr. With 30 head per ac on feedlot land uses, waste production would be 4100 kg/ha/yr. Therefore, animal waste production of TN is:

$$Livestock\ Waste,\ Pasture\ (MT/yr) = \frac{41\ (kg/ha/yr)\ x\ Area\ (ha)}{1000\ (kg/MT)}$$

$$Livestock\ Waste,\ Feedlots\ (MT/yr) = \frac{4100\ (kg/ha/yr)\ x\ Area\ (ha)}{1000\ (kg/MT)}$$

In 2004, approximately 46,000 ac in the Wekiva Basin were used for pasture, while only 160 ac were used for feeding operations. As a result, feeding operations represent a relatively small contribution to inputs of TN in the Basin.

The number of horses stabled in the Wekiva Basin was not readily estimated from sources reviewed, nor was the production of TN per horse. Horses were accounted for in a crude manner, essentially as if they were cattle. Some pastureland is used to support horses, but all was assumed to support cattle. Horse farms were also included in the total area of land treated as pasture, so the total number of animals, modeled as if they were cattle, may include both horses and cattle. Horse farm acreage was also treated as pasture acreage. Although this approach is not ideal it accounts in a crude way for TN inputs from horses as well as cattle.

2.3.3 Wastewater Treatment Facilities (WWTF – sewer)

Most permitted effluent streams have not been required to monitor for TN unless they were discharging directly to surface waters, while most discharges are required to be monitored for NO3-N. As a result, there is a substantial database of NO3-N concentrations in WWTF effluents, but a very limited set of TN concentration results. Following a December 2008 change in FDEP permitting policy, WWTF with permitted discharge exceeding 100,000 gallons per day will be required to monitor for TN if they are in watersheds of water bodies impaired for nutrients or dissolved oxygen, and this requirement will be incorporated in permit renewals. Therefore, more data will be available to estimate TN inputs in the future than were available in preparation of this report.

To estimate TN inputs from this source type, a limited number of effluent samples from the Wekiva Basin that have been monitored for both TN and NO3-N were evaluated to determine a typical ratio of TN:NO3-N in effluents. Wastewater discharges of NO3-N to surface water and groundwater were estimated using monitored discharge rates and NO3-N effluent concentrations obtained from FDEP. Then the ratio of TN:NO3-N was applied to the NO3-N discharge rates to estimate TN inputs to the Basin.

Permitted domestic and industrial wastewater discharge facilities within the Wekiva Basin were obtained from the FDEP Wastewater website (FDEP, 2006). Facilities were segregated into industrial and domestic effluents. Within the Basin there were three (3) industrial dischargers with the potential to emit NO_3 and 53 permitted domestic discharges. Permits were obtained from FDEP for the industrial dischargers. Due to the large number of domestic dischargers, the permitted facilities were sorted by permitted capacity, and the largest 26 facilities were selected for NO_3 loading quantification. These 26 facilities encompassed 99% of the total permitted capacity within the Wekiva Basin. Permits were obtained from FDEP for these 26 facilities.

Permits for the 3 industrial and 26 domestic wastewater facilities were reviewed. Eleven of the 29 facilities are either not required to monitor for NO3-N in effluent, have no available nitrate monitoring data, or have no discharges. The remaining 18 are required to monitor NO3-N concentrations in effluent. For these 18 facilities effluent NO3-N concentrations and actual discharge rates during the period 2004-2006 were obtained from FDEP (Sudano, 2006).

Effluents were segregated by disposal type (e.g., sprayfield, percolation basins, rapid infiltration basins (RIBs), surface water discharge), and subsequently separated into two categories, discharge to surface water or groundwater. In addition, several facilities have a reclamation/reuse disposal system. Inputs of wastewater effluents to groundwater, surface water, and reclaimed/reused were estimated by:

$$Input = \frac{Actual\,Discharge x\; Concentraton\,(NO_3 - N) x\; TN / NO3 - N}{CF}$$

Where *Input* = Wastewater facility effluent (MT/yr);

Actual Discharge = Total annual discharge (L/yr);

Concentration (NO3-N) = Average effluent concentration of NO3-N during 2004 through 2006 (mg/L); and

TN/NO3-N = Ratio of TN:NO3-N in effluents (limited monitoring);

CF = Conversion Factor to achieve desired units of measurement (1×10^9 mg/MT).

Total NO3-N discharged to groundwater from permitted facilities was estimated at 180 MT/yr. Direct discharges to surface water were 9 MT/yr. The amount of NO3-N that is reclaimed/reused was estimated at 109 MT/yr (see Appendix D).

Effluents from two WWTF in the Wekiva Basin have been monitored for TN. These are the two largest NO3-N discharges in the Basin: Orange County's Northwest Water Reclamation Facility, which discharges part of its effluent to a treatment wetland, and the Water Conserv II facility, jointly owned by the City of Orlando and Orange County Utilities. From the Northwest Reclamation Facility, 15 samples were collected during 2005 and 2006 and analyzed for both TN and NO3-N. For Conserv II, one sample was collected in 2009 and analyzed for both parameters. The average TN:NO3-N ratio of these 16 samples was 1.14. This ratio was applied to the NO3-N discharge rates to estimate the total TN input from WWTF of 339 MT/yr.

Industrial wastewater contributes a negligible amount of NO3-N to the Wekiva Basin, at 0.04 MT/yr.

Appendix E contains a summary of the WWTF that were evaluated during this study, and their estimated TN loadings.

2.3.4 Onsite Treatment and Disposal Systems (OSTDS - septic tanks)

FDOH (Roeder, 2006) provided MACTEC with a geographic information system (GIS) map layer identifying the location of all known OSTDS in the WSA. The FDOH OSTDS inventory was developed from 1990 US Census data, FDOH permit files, and consideration of areas served by sewer systems (Roeder, 2006). The primary basis of the FDOH WSA OSTDS inventory was the identification of improved parcels that are not paying for sewer service.

Although there is substantial overlap in the footprint of the Wekiva Basin as defined for this study and the WSA, they are not identical. Therefore, it was necessary to estimate the number of OSTDS in portions of the Wekiva Basin that are not included in the WSA. An estimate was developed under the assumption that the density of OSTDS (OSTDS/ac) was a function of land use. The density of tanks by land use was determined for the WSA, using the FDOH data, and then this same density was assumed in portions of the Wekiva Basin outside the WSA. By this procedure, the number of OSTDS in the Wekiva Basin was estimated to be approximately 65,000. Within the WSA, the FDOH data were used directly. Approximately 85% of the tanks are within residential land use categories, with the largest number in the medium density (2 to 6 dwelling units per ac) residential land use category.

The accuracy of the extrapolation procedure used to estimate the number of tanks in the Basin, but not in the WSA, was evaluated using the same OSTDS densities by land use to estimate the total number of OSTDS in Lake and Orange Counties, and these results were compared with

FDOH estimates of the total number of tanks in each county (using 1999 data for both land use and number of tanks) (FDOH, 2007). This test indicated extrapolation errors of 13% and 4% for Lake and Orange Counties, respectively. Considering these two extrapolation error tests, it appears that the OSTDS density by land use procedure is accurate to about 10%. Since only about 20% of the tanks in the Basin were estimated by the extrapolation method (the rest within the WSA are directly from the FDOH data), the estimate of 65,000 tanks in the Wekiva Basin is expected to be accurate to within about 2%.

Based on monitoring of OSTDS impacts at three locations within the Wekiva Basin, each tank was assumed to release 29 lb TN/yr to the environment (Ellis & Associates, 2007; Roeder, 2008).

2.3.5 Atmospheric Deposition

Deposition of atmospheric nitrogen species has been monitored in Florida by several researchers using differing procedures. TN deposition includes wet and dry deposition. Analytes comprising TN include NO3-N, nitric acid (HNO3-N), ammonia (NH3-N), ammonium (NH4-N), and organic nitrogen. The National Atmospheric Deposition Program / National Trends Network (NADP/NTN) measures wet deposition of nitrate and ammonium at 8 sites in Florida, of which the closest to the Basin is approximately 20 miles southeast at the campus of the UCF in Orlando. USEPA's Clean Air Status and Trends Network (CASTNET) monitors dry deposition of HNO3-N, particulate NO3-N, and particulate NH4-N at three monitoring sites in Florida: one in the panhandle region (Sumatra), one near the Indian River Lagoon (IRL), and one in Everglades National Park. Of these, the IRL site would be expected to be most representative of the Wekiva Basin. The IRL site is at Coconut Point near Sebastian Inlet in northern Indian River County and is 87 miles southeast of Wekiva Springs.

The SJRWMD operated a wet deposition monitoring station at the IRL site using NADP procedures from 2001 through 2006. In addition to nitrate and ammonium, which are monitored by NADP, the SJRWMD also measured organic nitrogen. Results were analyzed by Rogers (2007).

Figure 2-3 presents annual deposition totals for these three stations in Florida from 2001 to 2006. These results combine wet deposition of NO3-N and NH4-N and dry deposition of NO3-N, HNO3-N, and NH4-N at all sites but also includes organic nitrogen at the IRL site. Since 2000, the Florida sites have reported similar TN deposition rates with annual values ranging from 2.6 to 5.1 (kg/ha/yr). The average deposition rate at the IRL site is 3.9 ± 0.4 (kg/ha/yr).

TN deposition rates are expected to be higher in urban areas. Nationwide, approximately half of nitrogen oxide (NO_x) emissions are from mobile sources, e.g., automobiles. Poor, *et al.* (2001) measured TN deposition rates in the Tampa metropolitan area from 1996 to 1999. They observed a deposition rate of 7.3 ± 1.3 kg/ha/yr. In addition to the parameters accounted for at

CASTNET/NADP sites, Poor, *et* al. (2001) determined dry deposition of ammonia. Ammonia deposition over Tampa Bay can be impacted either positively (down) or negatively (up) by the bi-directional flux of the analyte due to air-sea interactions. The dry deposition of ammonia, which Poor, *et al.* (2001) estimate may account for approximately 30% of TN deposition in the Tampa area, can be either increased or decreased by this process depending on the relative concentrations of ammonia in the Bay and the atmosphere. Periods of negative deposition reduced the ammonia dry deposition rate, and therefore the TN deposition rate, by 0.7 kg/ha/yr. Over land, this negative component of deposition would not occur. Their dry deposition procedure also did not account for particles larger than 2.5 microns (μm), while CASTNET devices collect particles as large as 10 μm. Poor, *et al.* (2001) conclude this may result in an underestimate of TN deposition by 0.5 to 1.5 kg/ha/yr. Finally, they did not account for organic nitrogen, which was included in wet deposition measurements conducted by the SJRWMD.

Table 2-1 summarizes TN deposition information from IRL and the Tampa metropolitan area, showing the components of TN that were quantified and the measured deposition rates. None of the monitoring programs captures dry deposition of organic nitrogen, so its contribution remains unknown. Each program has certain distinct deficiencies, which are accounted for as follows:

- Poor, *et al*. (2001) found that dry deposition of NH3-N accounts for approximately 32% of TN deposition in the Tampa Bay area. When considering the common analytes analyzed by Poor, *et al.* (2001) and CASTNET/NADP, the dry deposition of NH3-N equaled 46% of the components quantified at CASTNET/NADP stations. At IRL, these same components (all except organic nitrogen) account for 3.6 kg/ha/yr. Therefore the IRL (rural) value should be adjusted to 3.9 + 0.46 x 3.6 = 5.6 kg/ha/yr. Apply this to rural areas within the Wekiva Basin.
- The Wekiva Basin is primarily land, so the negative impact to NH3 dry deposition observed over Tampa Bay will not occur – add 0.7 kg/ha/yr to Poor, *et al.*'s (2001) results to estimate overland deposition in urban areas of the Wekiva Basin.
- Add 1 kg/ha/yr to the Tampa results to account for particles larger than 2.5 μm.
- Therefore deposition of TN in urban areas within the Wekiva Basin is estimated as 7.3 + 0.7 + 1.0 = 9.0 kg/ha/yr.

The higher urban rate (9.0 kg/ha/yr) is assumed to occur in the following urban land uses: medium and high density residential; transportation, communication, and utilities; and commercial and services. The rural rate (5.6 kg/ha/yr) is assumed to occur in low density residential, agricultural, and undeveloped land uses.

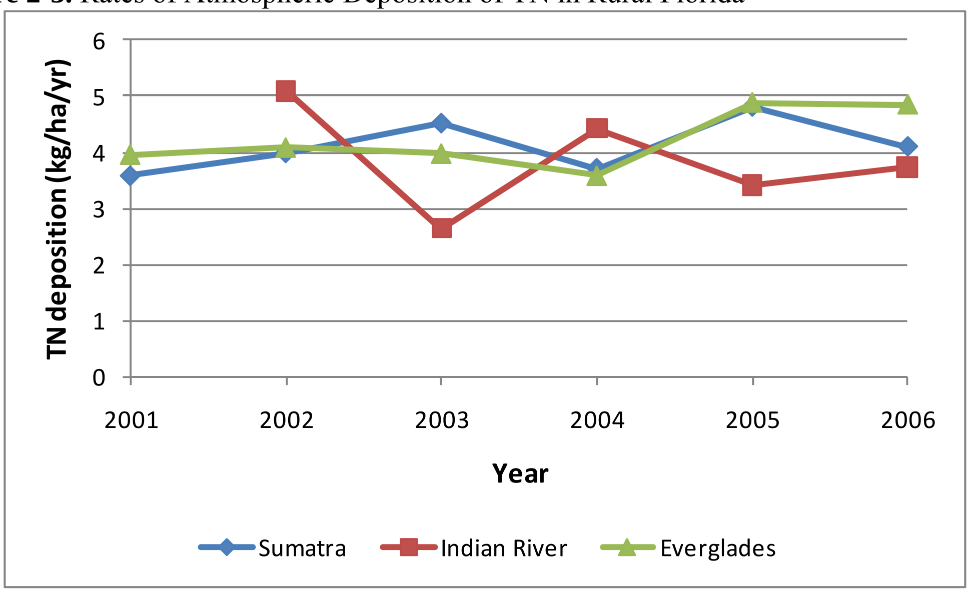
Nitrogen deposition rates could also be higher in agricultural areas where fertilizers are routinely applied, but fertilizer use has been accounted as TN applied, without accounting explicitly for volatile or other application losses. Therefore, if atmospheric deposition rates are higher in and downwind of agricultural areas due to application/volatile losses of applied fertilizer, these amounts are already included in the fertilizer application totals.

Table 2-1. Summary of TN Deposition Rates at Two Florida Sites

Site			IRL	Tampa Bay
Type			rural	urban
Source			CASTNET / SJRWMD	Poor, *et al*. (2001)
Components Quantified	**Dry**	NO3-N	✓	✓
		HNO3-N	✓	✓
		NH4-N	✓	✓
		NH3-N		✓
		Organic N		
		Particles > 2.5 µm	✓	
	Wet	NO3-N	✓	✓
		NH4-N	✓	✓
		Organic N	✓	
Deposition Rate (kg/ha/yr)			3.9	7.3

Created by: WAT Checked by: CMR

Figure 2-3. Rates of Atmospheric Deposition of TN in Rural Florida



Source: MACTEC.
Created by: WAT Checked by: CMR

2.4 Loadings to Waters of the Basin

A portion of the nitrogen released to the environment actually reaches groundwater or surface waters of the Basin. In particular, a significant portion of nitrogen applied to the land as fertilizer is used by plants in the root zone. Denitrification processes also convert NO_3 to N_2, which is released to the atmosphere. A portion of TN in fertilizers and in wastewater effluents is volatilized as ammonia. Consequently, only a portion of the nitrogen input to the Basin will reach ground and surface waters. The nitrate delivered to waters of the Basin will be referred to here as loading.

Available information was sufficient to support estimation and partitioning of loads to groundwater at the water table (generally to the surficial aquifer) and to surface water. The portion of the groundwater load (at the water table) that eventually reaches the Floridan aquifer is expected to be significant (Cohen, *et al*., 2007), but that portion has not been quantified.

The following subsections summarize the procedures and information sources used to estimate loadings, which are primarily based on land use, as well as procedures used to partition those loadings to specific source types.

The primary basis for estimating loadings to waters of the Basin was distinct for the following loading or delivery categories:

- Groundwater recharge as a function of land use,
- Stormwater loadings as a function of land use,
- WWTF (sewer), and
- OSTDS (septic tanks).

Appendix F contains a summary of estimated nitrate loadings by land use and source type.

2.4.1 Groundwater Recharge

Loadings to groundwater associated with various land uses were estimated by multiplying shallow groundwater concentrations (CGW) representative for each land use by the recharge rate (by location) using the following equation:

$$Groundwater\ Loading_{LU} = \frac{Recharge\ x\ CGW_{LU}\ x\ Area_{LU}}{CF}$$

Where $Groundwater\ Loading_{LU}$ = Amount of NO3-N reaching the water table from specific land uses (MT/yr);

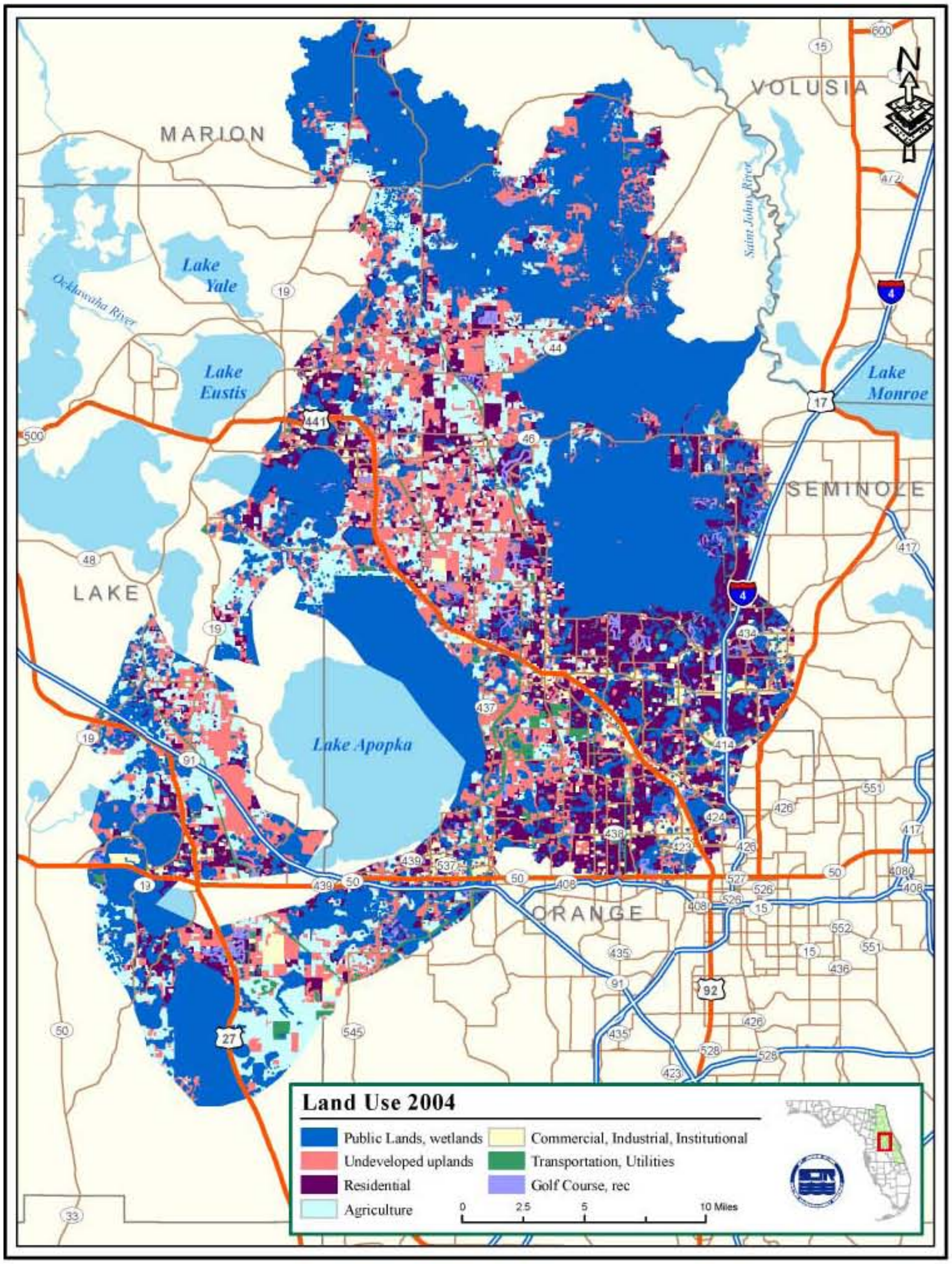
Recharge = downward flow of water to the Floridan aquifer (inch/yr);

CGW_{LU} = Concentration of NO3-N in recharging groundwater, estimated here from concentrations near the water table (mg/L); and

CF = Conversion Factor to achieve desired units of measurement, 3937 (mg inch ha/MT L).

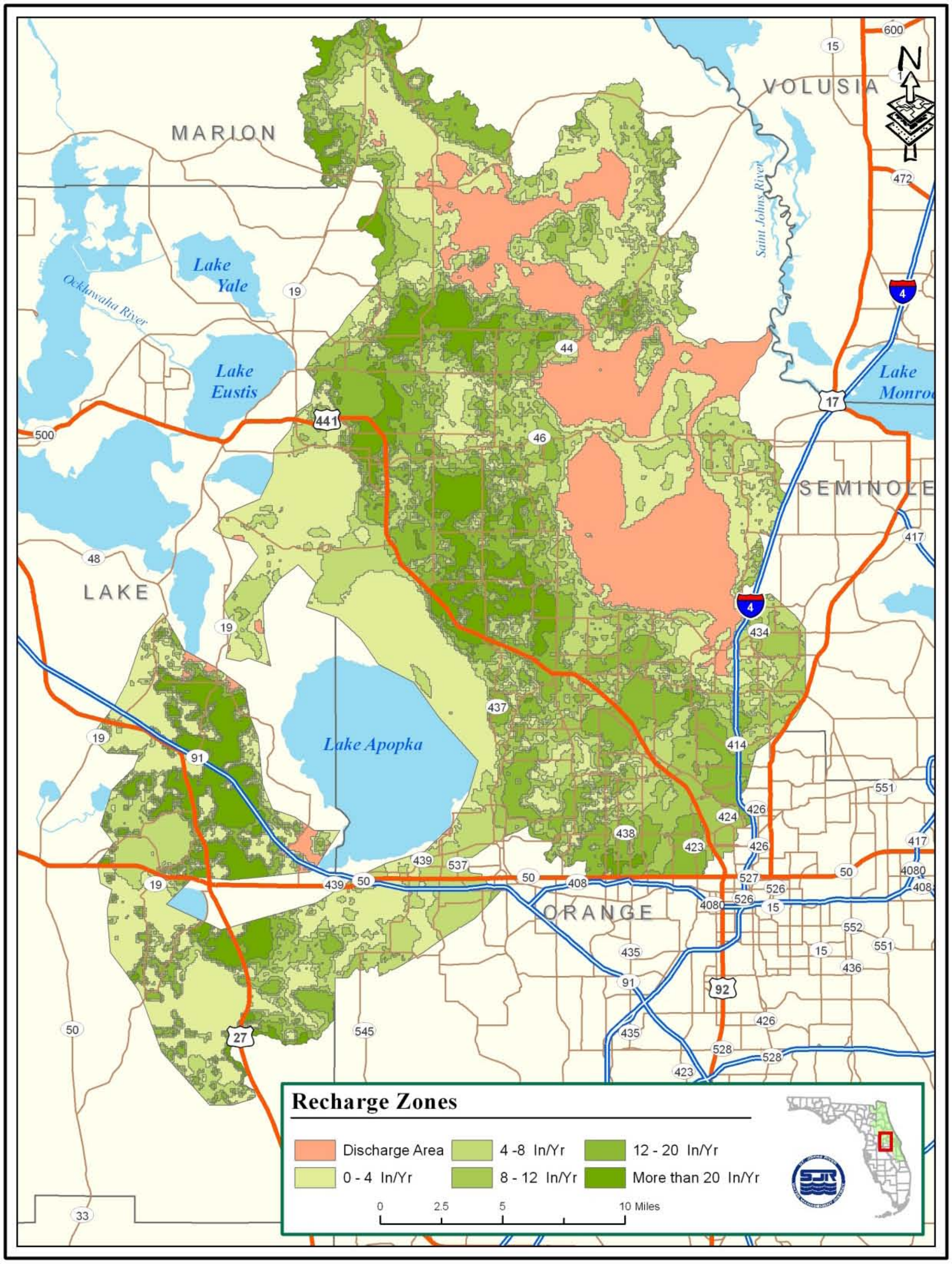
The calculation is performed for each land use category and recharge rate (after overlaying land use and recharge rate using GIS software), then summed across the entire Basin, by land use. Figures 2-4 through 2-6 illustrate the application of this procedure. Figure 2-4 shows land use in the Basin, and Figure 2-5 shows recharge rates. When the two maps are overlaid, using ArcGIS™, a matrix of area by land use and recharge rate was developed, as illustrated in Figure 2-6.

Figure 2-4. Land Use



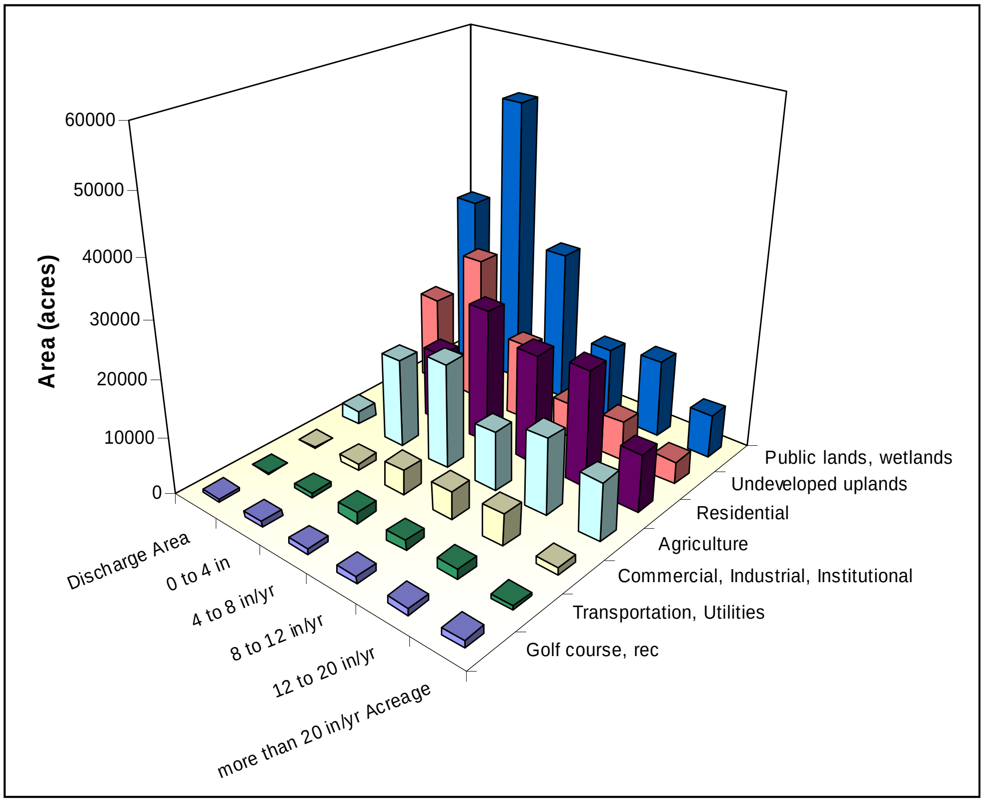
Source: MACTEC and SJRWMD
Created by: NMG Checked by: WAT

Figure 2-5. Recharge Rates



Source: MACTEC and SJRWMD
Created by: NMG Checked by: WAT

Figure 2-6. Acreage by Land Use and Recharge Rate



Note: Golf course, rec = golf courses and other recreational land uses

Source: MACTEC and SJRWMD
Created by: SAR Checked by: WAT

Groundwater recharge rates used as input to the East Central Florida MODFLOW model (McGurk and Presley, 2002) within the Wekiva Basin were acquired from SJRWMD (http://sjr.state.fl.us/programs/index.html). The recharge rate map indicates total recharge within the Basin of approximately 400 cubic feet per second (cfs). This recharge rate compares reasonably with the estimated discharge rate from springs in the Wekiva Basin of approximately 230 cfs, since not all groundwater flowing through the Basin is expected to discharge via springs.

Representative groundwater concentrations for all land uses were estimated from relevant technical literature as discussed in the following subsections. Estimated groundwater concentrations are intended to represent area sources of contamination associated with the land use, not point source contamination due to such sources as OSTDS or WWTF.

Whereas the primary load estimation calculation for groundwater was based on land use, attribution (partitioning) to specific source types was specified according to the primary source presumed to be contributing nitrate to groundwater for each land use. For undeveloped land, the source type was identified as "Natural or Unattributed". For most land uses, the source type was assumed to be fertilizer use. For pasture, groundwater loadings were proportionately assigned to livestock waste and fertilizer use.

2.4.1.1 Residential

The objective of this section is to present procedures used to estimate groundwater concentrations associated with the use of fertilizer in residential areas. Loadings derived using these estimates are attributed to fertilizer use. The residential land use may also be associated with loadings from OSTDS and irrigation with reclaimed effluent, but these loadings are estimated separately (see Section 2.4.4).

The Phase I report (MACTEC, 2007) concluded that field data characterizing groundwater quality in residential areas unaffected by OSTDS were insufficient to reliably estimate the groundwater concentration for residential land uses. To reduce this uncertainty, FDEP conducted a Phase II investigation of groundwater quality in residential areas of the Wekiva Basin that were isolated from known OSTDS (MACTEC, 2009).

Twenty-four (24) shallow wells were installed in residential areas unaffected by known OSTDS. Two (2) shallow wells were installed in undeveloped natural areas on state lands (Wekiwa Springs State Park and Rock Springs Run State Reserve). Wells were completed in the surficial aquifer with depths ranging from 10 to 48 ft below land surface (bls), averaging 21 ft. Most of these wells were sampled four (4) times between October 2008 and July 2009, and samples were analyzed for nutrient constituents of residential fertilizer and other water quality parameters.

NO3-N concentrations in the residential area wells averaged 2.4 mg/L during the study, significantly greater than observed in the natural reference areas (0.3 mg/L). Supplementary analyses of stable isotopes of nitrogen and oxygen in the wells with the highest NO3-N concentrations support the conclusion that these wells were not affected by organic wastewater discharges (MACTEC, 2009). The U.S. Geological Survey (USGS) conducted a companion study, sampling four of the MACTEC Phase II wells in March 2009; approximately one week after one of MACTEC's sampling events. USGS analyzed the same chemical parameters and stable isotopes as MACTEC, but also analyzed for bacteria that may indicate source attribution (Katz and Griffin, undated). Their results for nutrient constituents of fertilizer and stable isotopes of nitrogen and oxygen closely match MACTEC's results. Their microbial data indicates that the MACTEC Phase II wells were not affected by organic wastewater.

One of the MACTEC Phase II wells may be affected by fertilizer use and irrigation practices on an adjacent golf course. This well had the highest NO3-N concentrations observed in this study, averaging 10 mg/L, and was about 125 feet (ft) from a golf course. Excluding this well from the others, for which the primary source of nitrate is residential fertilizer use, the average groundwater concentration (85 samples) in residential areas unaffected by organic wastewater discharges is 2.0 ± 0.2 mg/L.

The Wekiva Phase II results may be compared with a groundwater quality investigation in the springshed of Silver Springs, Marion County, FL (Phelps, 2004). Phelps sampled 17 existing wells in residential areas ranging in depth from 65 to 220 ft bls, averaging 109 ft bls. The author believed that all wells were completed in the upper Floridan aquifer. Concentrations in 18 samples from residential areas averaged 1.2 ± 0.2 mg/L. Phelps' results are generally consistent with the Phase II results from the Wekiva Basin, recognizing that Phelps' wells sampled the upper Floridan aquifer, while MACTEC's Phase II wells sampled the surficial aquifer, which is more directly affected by fertilizer, or other surface sources of nitrate.

Due to a lack of information on groundwater concentrations for commercial and services, institutional, recreational, transportation, communication, and utilities land uses, these land uses were assumed to have similar groundwater concentration to those occurring in residential land uses because significant portions of these land uses are maintained in turfgrass. These combined land uses comprise only 4% of the total area of the Wekiva Basin, while residential land use makes up about 19%. Therefore, errors in estimation of groundwater concentrations under these land uses would not contribute significantly to total uncertainty in nitrate loadings.

2.4.1.2 Agricultural

Representative groundwater concentrations associated with row and vegetable crops, tree crops (citrus), nurseries, pasture, and concentrated animal feeding operations (CAFOs) were estimated from field scale monitoring studies of groundwater concentrations associated with these land uses. Available monitoring studies were reviewed, and well designed studies specific to a given land use from Florida or the Southeastern U.S. were selected to represent the groundwater impacts of these land uses.

Loadings for all agricultural land uses were attributed to fertilizer use, with the exception of pasture and CAFOs. For pasture, approximately 1/3 of the loading was attributed to animal waste and 2/3 to fertilizer use, based on the TN inputs of these two source types to pastureland as detailed in Sections 2.3.1.2 and 2.3.2. All groundwater loadings determined for the feeding operations land use were attributed to livestock waste.

Row and Vegetable Crops

Within the Wekiva Basin, most row and field crop production is in Lake and Orange Counties. About half of the field and row crop production is in hay and other forage, mostly in Lake County; and about half in vegetables (more concentrated in Orange County). Principal vegetables produced are cabbage, cucumbers, greens, spinach, sweet corn, eggplant, and peppers (USDA, 2005).

McNeal, *et al*. (1995) measured shallow groundwater concentrations under vegetable fields and at the downgradient edge of fields in Manatee County. Average monitored groundwater concentrations under fields and at their downgradient edge were 1.3 mg/L for tomato, 1.9 mg/L for pepper, and 1.4 mg/L for all vegetables monitored by McNeal, *et al*. (1995). These concentrations are much lower than those reported for impacts from potatoes and sweet corn in Suwannee County [UF/IFAS and Suwannee River Water Management District (SRWMD), 2006] where concentrations averaged 26 mg/L; cropland in a review of literature on nitrate contamination in the southeastern coastal plain by Hubbard and Sheridan (1989); and under sweet corn in Wisconsin, averaging 20 mg/L (Kraft and Stites, 2003). The Manatee County farms investigated by McNeal *et al*. (1995) were maintained under a high water table condition (about 1 ft bls) with irrigation by shallow ditches throughout the fields. These conditions would favor denitrification of applied NO_3.

To evaluate whether denitrification processes are likely to be important in association with row crop agriculture impacts in the Wekiva Basin, soil types in areas with row crop agriculture land use were assessed. The primary soil characteristic considered was whether the soils were hydric. Such soils occur in wetlands and areas of high water table, and reducing conditions that would favor denitrification are a signal characteristic of hydric soils. It was found that only 12% of row crop agriculture land use occurs in hydric soils within the Wekiva Basin. Consequently, it is assumed that denitrification would not be an important process in fields used for row crop agriculture in the Wekiva Basin, and the results of McNeal, *et al*. (1995) in Manatee County are probably not representative of conditions in row crop land use in the Wekiva Basin. Concentrations observed by UF/IFAS and SRWMD (2006) in Suwannee County and by Hubbard and Sheridan (1989) in the southeastern coastal plain are considered representative, and an average concentration of 23 mg/L NO3-N is assumed under row crops.

Although limited information was identified regarding concentrations under field crops, leaching rates that have been reported from wheat (15 kg/ha/yr; Riley, *et al*., 2001) and alfalfa (7 kg/ha/yr; Randall and Mulla, 2001) are substantially less than those associated with row crops and are consistent with GW concentrations of approximately 4 mg/L.

Tree Crops (Citrus)

In the Wekiva Basin, virtually all land used for tree crops is in citrus. Crandall (2000), Lamb, *et al*. (1999) and McNeal, *et al.* (1995) provide the most thorough and representative data on groundwater concentrations under citrus. Crandall (2000) monitored six groves in Indian River, Martin, and St. Lucie Counties. Lamb, *et* al. (1999) monitored five groves in Highlands County. McNeal, *et al*. (1995) monitored two groves in Manatee County. Each study observed significant NO_3 levels in groundwater collected near the water table and as deep as 10 ft below the water table. In this shallow interval, Crandall (2000) observed an average concentration of 5 mg/L NO3-N in the Indian River groves; Lamb, *et al*. (1999) an average of 11 mg/L; while McNeal, *et al*. (1995) observed an average concentration of 16 mg/L in the Manatee County groves.

Although concentrations observed by Crandall (2000) and McNeal, *et al*. (1995) were similar in groundwater near the water table, the two studies observed distinctly different concentrations at greater depths in the groundwater. McNeal, *et al*. (1995) observed a gradual decline in NO3-N with depth, from 16 mg/L at 10 ft to about 8 mg/L at 19 ft depth. In the Indian River groves, on the other hand, Crandall (2000) observed a marked reduction with depth, declining from an average of 5 mg/L at a depth of 5 ft to 0.8 mg/L at 10 ft and undetectable (<0.02 mg/L) at 20 ft. Crandall (2000) also demonstrated that the process primarily responsible for the reduction was denitrification as evidenced by elevated levels of N_2 gas in shallow groundwater. Apparently conditions favoring denitrification were not in place at the Manatee County groves studied by McNeal, *et al*. (1995). Lamb, *et al*. (1999) monitored one grove on a flatwoods site with concentrations similar to the low lying Indian River groves, three groves on ridge sands (uplands) with concentrations similar to those observed in Manatee County, and one grove that was probably not representative because it had been recently established.

Within the Wekiva Basin, 99% of tree crop land use is on uplands (non-hydric soils). Therefore, the denitrification processes observed by Crandall (2000) are not likely to be important in the Wekiva Basin, so the average concentrations observed by McNeal, *et al*. (1995) and at the three established upland sites monitored by Lamb, *et* al. (1999) were assumed to be representative of tree crop land use in the Wekiva Basin. The grove-weighted average concentration in shallow groundwater at these five groves was 15 mg/L, NO3-N.

It is noted that these studies were conducted prior to the current FDACS BMP for citrus fertilization, and therefore may represent the effect of fertilization at rates greater than the current BMP (see further discussion in Section 3.4.2).

Nurseries

Although very high concentrations (20 to 100 mg/L) of nitrates have been observed in nursery leachates under controlled experimental conditions (McAvoy, *et al.*, 1992; Yeager and Cashion, 1993), a comprehensive monitoring survey of 29 container nurseries in six states, including Florida (Yeager, *et al*., 1993), found groundwater concentrations on and downgradient of nurseries average 6 mg/L, up to a maximum observed concentration of 55 mg/L. It was assumed that a representative groundwater concentration associated with nurseries is 6 mg/L.

FDEP recently investigated a container nursery site in Eustis, FL, due to observations of groundwater contamination by nitrate (Hicks, 2009; Newton, 2010). The Eustis site is within the Wekiva Basin. NO3-N concentrations in eight (8) wells on site and at the site's downgradient boundary averaged 23 mg/L in September 2009. The facility participates in the Container Nursery BMP program and available information indicates it is operating as a typical container nursery in this region. Newton's (2010) observations indicate that the nurseries sampled by Yeager, *et al*. (1993) may not be representative of the groundwater impacts of container nurseries in well drained, sandy soils typical of the Wekiva Basin. Newton's results suggest that the effect of container nurseries in the Basin may be underestimated in the current model. Further investigations are warranted to determine if the levels of groundwater contamination observed at the Eustis container nursery site are representative of this land use within the Wekiva Basin. This concern is addressed further in Section 3.3.2.

Pasture

Limited data are available to estimate groundwater nitrate concentrations under pasture in Florida. Ator and Ferrari (1996) compiled and analyzed groundwater concentrations of NO3-N from more than 850 sites in the Mid-Atlantic Region (including parts of Delaware, Maryland, New Jersey, New York, North Carolina, Pennsylvania, Virginia, and West Virginia) and categorized the sites by land use. The median concentration in pasture lands was 5.5 mg/L, and not significantly different from areas in row or field crops. They concluded that field rotation or the close proximity of crops and pastures within agricultural areas leads to a mixed-agricultural effect on groundwater quality.

The groundwater concentration associated with pasture for the Wekiva Basin was assumed to be 5.5 mg/L.

Concentrated Animal Feeding Operations (CAFOs)

This represents a very limited land use within the Wekiva Basin (< 0.05%), but may have disproportionate nitrate loadings.

Hatzell (1995) monitored groundwater near poultry (broiler) farms in North Central Florida and found that concentrations averaged 13 mg/L.

Woodard, *et al*. (2002) monitored a dairy in the panhandle region of Florida (near Bell) for four years. Dairy effluent was applied to forage crops onsite. Forage crop rotations and application rates were varied in separate plots. Concentration of NO3-N was measured in soil moisture (by lysimeters) and loading rates (kg/ha/yr) were estimated. Soil moisture concentrations are expected to be higher than concentrations in groundwater, which were not monitored. Soil moisture concentrations ranged from about 1 mg/L to 68 mg/L, and averaged 18 mg/L. A bermudagrass-rye rotation was more efficient in N uptake, with an average soil moisture concentration of approximately 6 mg/L, while a corn-sorghum-rye rotation yielded an average leachate concentration of 30 mg/L.

Collins (1995) monitored groundwater at four swine farms in Jackson County, FL. Concentrations ranged from 0.04 to 11 mg/L, averaging 2.8 mg/L.

Although groundwater impacts of these three distinct CAFOs are similar, cattle are the predominant livestock in the Wekiva Basin, so the results of Woodard, *et al*. (2002) for a dairy were assumed to be most representative of CAFOs in the Wekiva Basin, with an average groundwater concentration of 18 mg/L.

2.4.1.3 Golf Courses

All groundwater loadings from golf courses were attributed to fertilizer use.

Groundwater concentrations have been monitored at a number of golf courses nationwide, and leachate quality has been monitored from experimental turfgrass plots designed to simulate golf course landscape management practices. Of the variety of monitoring studies available, the study by Swancar (1996) a USGS study of groundwater impacts of nine central Florida golf courses was used. Swancar's results are generally consistent with results reported outside of Florida (e.g. Flipse and Bonner, 1985; Petrovic, 1995; Branham, *et al*., 1995; Rufty and Bowman, 2004). Concentrations ranged from not detected (< 0.02 mg/L) to 26 mg/L in 228 groundwater samples, averaging 2.6 mg/L. The distribution of concentrations appeared to be lognormal, so the more conservative Land procedure (Gilbert, 1987) was used to estimate the mean concentration. Only data from permanent monitor wells, rather than direct push technology (DPT) samples that were only collected near tees and greens, were used. The conservative estimate of the mean concentration is 8 mg/L.

2.4.2 Stormwater Loadings

The stormwater pollutant loading model developed by CDM (2005) using the Watershed Management Model (WMM) and used to support the WSA Stormwater Master Plan was the primary basis for estimation of stormwater loadings to the Wekiva Basin. The appendix to the WSA Stormwater Master Plan that describes the application of WMM by CDM (2005) is reproduced as Appendix B.

WMM estimates stormwater runoff volumes and pollutant loadings within basins. Inputs include Event Mean Concentrations (EMCs)[9] by land use, annual precipitation, and descriptions of structural stormwater treatment systems or BMPs. CDM modified basin boundaries and mapped BMPs following field investigations. EMCs were identified after a comprehensive literature review and consideration of inputs from Basin stakeholders (e.g., state and local governments). WMM is capable of estimating loads from groundwater (referred to as baseflow), but CDM's (2005) application to the WSA did not account for loadings by baseflow. Their report does not discuss any attempt to calibrate the runoff volumes or loadings.

[9] Event Mean Concentration (EMC) is the average of individual measurements of storm pollutant mass loading divided by the storm runoff volume taken over a storm event (CDM, 2005).

A number of ancillary calculations were performed using the CDM (2005) WMM application to achieve the objectives of this study to:

- Update the loading estimates to the 2004 land use baseline used for this study (the WMM model used to develop the WSA Stormwater Master Plan was based on 1999 land use);
- Extend the WSA results to portions of the Wekiva Basin outside the WSA;
- Partition loadings by land use and source type; and
- Distinguish between direct stormwater loadings to surface waters and diffuse stormwater loadings to groundwater.

The basic approach used in these ancillary calculations was to assume that loadings by land use as determined by the CDM (2005) WMM application were valid. The approach retains the detailed evaluation of WSA hydrology represented by the CDM (2005) WMM application. Sub-basin boundaries, rainfall/runoff relationships, and EMCs by land use were not modified. Acreage in each land use was (a) extended to the Wekiva Basin, and (b) updated to 2004 land use.

WMM does not automatically output totals by land use. Rather it reports total loadings by sub-basin. To determine the loadings by land use, the WSA WMM model was rerun, sequentially "turning on" each land use while turning off all others. These simulations produced results for each land use within the WSA. Next, by a simple ratio, the loading for the Wekiva Basin (2004 land use) could be estimated. These calculations were performed outside the WMM software, in EXCEL™ spreadsheets.

Finally, the sub-basins in the Wekiva Basin were identified as either closed or open. A closed basin is one with no outlet. Closed basins are assumed to deliver their stormwater loadings to groundwater. Open basins are assumed to deliver their loadings to surface waters. Total annual runoff from open basins within the Wekiva River watershed was estimated to be 340 cfs. This flow may be compared with the average discharge of the Wekiva River, which is about 300 cfs. Spring flow to the river is about 230 cfs.

This procedure produced untreated loading (prior to effect of BMPs) and BMP-treated loading by land use for both open and closed sub-basins in the Wekiva Basin. Loading to surface water (stormwater direct) by land use was defined as BMP-treated load from open basins. Loading to groundwater (stormwater diffuse) by land use is untreated load in the entire Wekiva Basin minus loading to surface water. Inherent in this calculation is an assumption that treatment by BMPs reduces the direct loading to surface water, but that all nitrate removed by the BMP goes to groundwater. This assumption is conservative. In fact, some portion of the nitrate load treated by BMPs does not reach groundwater. For example, in wetlands used as BMPs, a portion of the nitrate treatment efficiency represents a true recycling of nitrate into plant biomass and soils. Harper (1988) found that nitrate concentrations in groundwater below detention ponds were similar to concentrations in the ponds (indicating limited treatment effectiveness). Bahk and Kehoe (1997) studied effectiveness of agricultural retention ponds, but their study was not designed to address the question of whether nitrate mass is removed by the ponds. Generally it is found that structural BMPs have limited effectiveness in removal of nitrate mass (e.g., Koob and Barber, 1999; Rea, 2004).

To partition stormwater loadings by source type, it was assumed that nitrate loading from undeveloped lands (e.g., forest, wetlands, and open land) was natural, attributable to atmospheric deposition, or otherwise unattributable. The load from each land use that could be attributed to specific source types is given by [Loading (land use) – Loading (Forest / Open Land)]. WMM was used to estimate the loading from each land use if its land use were changed to Forest / Open Land. The difference between the actual loading and the undeveloped loading was attributed to the most relevant source, e.g., fertilizer use associated with the land use.

2.4.3 Wastewater Treatment Facilities (WWTF – sewer)

All discharges of NO3-N, as estimated according to Section 2.3.3, were assumed to reach waters of the Basin. This represents 88% of the TN inputs. Some nitrate associated with wastewater may be assimilated or denitrified in systems such as artificial wetlands, sprayfields or RIBs; however, the concentrated nature of wastewater disposal facilities minimizes the potential for losses during transport to the water table, and losses were not quantified. Sumner and Bradner (1996) found that denitrification losses were minimal from a RIB in Orange County, FL. Merritt (2006) intensively studied recharge of domestic effluent meeting reclaimed water standards at the City of Orlando Water Conserv II RIB systems in Orange County, FL, which are within the Wekiva Basin. Their study did not specifically quantify denitrification losses, but they performed a variety of dilution and mixing calculations that were based on the assumption that denitrification losses were minimal, and that nitrate could be used as a conservative tracer of effluent impacts. Their results are generally supportive of the assumption used in this study that essentially all effluent nitrate discharged to groundwater via RIBs reaches groundwater. At the Conserv II site, essentially all nitrate also reached the Floridan aquifer. Therefore, based on Sumner and Bradner (1996) and Merritt (2006) studies of RIBs in the Wekiva Basin, all nitrate nitrogen in treated effluent discharged to RIBs is assumed to reach groundwater. This amounts to 88% of the TN discharged by WWTFs from monitoring results reported to FDEP (2006).

York (2007), however, commented on a draft of the Phase I report indicating his opinion that approximately 50% of TN discharged to RIBs is lost, primarily by nitrification/denitrification processes and does not reach groundwater. Dr. York's comments are included as Appendix C.

Reclaimed effluent from several large capacity WWTF in the Basin is reused as irrigation water (slow-rate public access reuse systems). Approximately 37% of permitted wastewater discharges in the Basin were reused as of 2004. Land use within the permitted reuse service areas was quantified. Most of the land in the permitted service areas is classified as residential (36%); commercial, services, transportation, communications, utilities, institutional (16%); agricultural (9%), and recreational, including golf courses (7%). Each of these land uses is assumed, in this study, to receive fertilizer (see Section 2.3.1). In fact, each of these land uses (except residential; see Section 2.3.1.1) is assumed to have fertilizer applications at recommended agronomic rates. If so, the additional nutrients in the reclaimed water would be excess to plant requirements. It is possible that some users understand that reclaimed water has nutrient value, and therefore reduce their rate of fertilizer application. UF/IFAS Extension developed guidelines for using reclaimed water for landscape irrigation (Martinez and Clark, 2009), including recommendations to adjust fertilizer use. For the most part, however, reclaimed water is managed for irrigation value, without consideration of its nutrient value. UCF (2009) found that residents receiving reclaimed water actually applied fertilizer more frequently than those who didn't have access to reclaimed water. Although there remains considerable uncertainty regarding the groundwater impacts of reclaimed water use under actual field conditions, it is assumed here that the ratio of (NO3-N loadings) / (TN inputs) for reclaimed water nutrients is 20% as recommended by York (2007) and approximately the same as the ratio observed for fertilizer use.

Domestic wastewater loadings, excluding effluent reused as irrigation water, were assigned to the land use category of Transportation, Communication, and Utilities (Sewage Treatment).

2.4.4 OSTDS

See Section 2.3.3 for the procedure for estimating the number of OSTDS and their distribution by land use in the Wekiva Basin. Groundwater impacts observed at three OSTDS in the Wekiva Basin, performed by Ellis & Associates (2007) and interpreted by Roeder (2008), are the basis for estimating OSTDS loading per tank.

Ellis & Associates, under contract with FDOH, measured the components of TN [NO3-N, NO2-N, and Total Kjeldahl Nitrogen (TKN)] in septic tank effluent and groundwater below and surrounding their drainfields at three sites in the WSA, one each in Lake, Orange, and Seminole Counties. They estimated the percentage of TN that reached the water table by dividing the maximum observed groundwater TN concentration by the average TN concentration in the septic tank effluent. Since the objective of this study is to determine nitrate loadings to groundwater and related releases of TN, we follow Ellis & Associates (2007) procedure, but divide the maximum observed groundwater NO3-N concentration by the average TN concentration in the effluent to estimate the percentage of TN discharged that reaches groundwater as nitrate.

Results are summarized in Table 2-2. At all sites most of the effluent TN is present as TKN. The water table was higher at the Seminole County site than at the other two sites, resulting in less nitrification occurring prior to the effluent reaching groundwater. At the Seminole County site most of the TN in groundwater was present as TKN. At the other two sites, essentially all TN had nitrified prior to reaching the water table, with all of the TN present in groundwater as NO3-N. The average portion of effluent TN reaching groundwater as NO3-N for the three sites was

56%. With an average TN discharge of 29 lb TN/tank (Section 2.3.4), the estimated loading of NO3-N to groundwater is 29 lb TN/tank x 56% = 16.3 lb NO3-N/tank.

Table 2-2. Fraction of TN in OSTDS Effluent Reaching Groundwater as NO3-N

Site	Maximum NO3-N (mg/L) in Groundwater	Average TN (mg/L) in Effluent	Percent of Effluent TN Reaching Groundwater as NO3-N
Seminole County	24	74	32%
Lake County	22	43	51%
Orange County	59	69	86%
		Average	**56%**

Source: Concentrations from Ellis & Associates (2007); percentages calculated by MACTEC.
Created by: KEM Checked by: WAT

3.0 Estimated Nitrate Loadings

Procedures described in Section 2.0 were applied to estimate TN inputs to the Wekiva Basin and NO3-N loadings to groundwater and surface waters of the Basin.

TN inputs include:

- Application of fertilizer;
- Discharges from WWTF (sewer);
- Discharges from OSTDS (septic tanks);
- Livestock waste; and
- Atmospheric deposition.

NO3-N loadings represent the portion of these inputs that are delivered to groundwater and surface water in the Basin. Loadings are consistently expressed as NO3-N. Loadings were attributed (partitioned) by land use and by source type as described in Section 2.4.

The portion of nitrogen inputs applied as fertilizer that reaches groundwater or surface waters of the Basin as NO3-N is the result of two essentially independent calculations. Nitrogen inputs are based on estimated fertilizer use, while loadings are based on estimated groundwater concentrations and recharge rates (loadings to groundwater) and the results of application of a stormwater loading model (modification of the WMM model application developed by CDM, 2005).

Results of input and loading estimates are presented in the following sections.

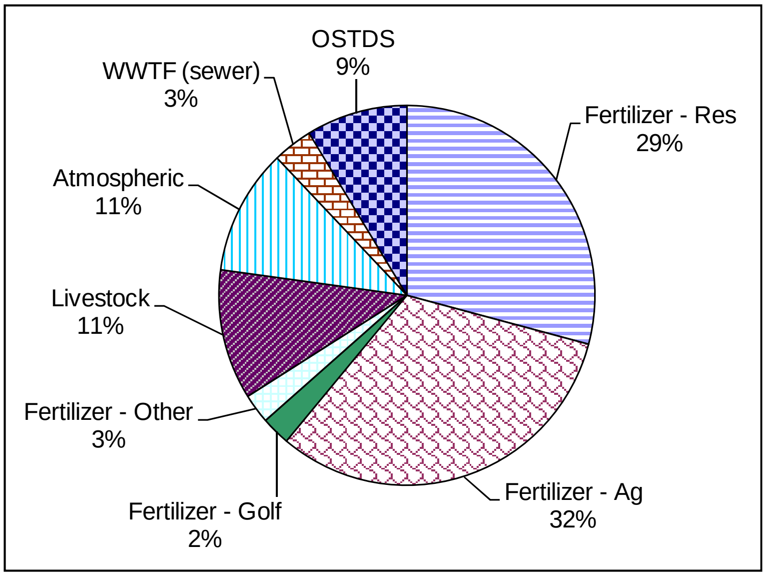
3.1 Inputs of Nitrogen to the Wekiva Basin

The total amount of nitrogen input to the Wekiva Basin is estimated at approximately 9,900 MT/yr. Partitioning of these inputs by source is illustrated in Figure 3-1, which shows approximately 29% of TN input to the Basin results from the application of fertilizer in residential areas; 31% is fertilizer applied in agriculture; 3% fertilizer used on golf courses and 3% other fertilizer use. In all 6,500 MT of TN is applied as fertilizer within the Wekiva Basin annually, accounting for about 2/3 of the TN input to the Basin.

Livestock waste contributes approximately 1,100 MT TN to the Basin annually, or 11% of the total input. Remaining sources are OSTDS, contributing approximately 9% of TN input to the Basin; domestic wastewater, 3%, and atmospheric deposition, 11%.

Some nitrogen inputs have a greater impact on water quality than others. For example, a direct discharge of nitrate to surface water is likely to have a greater impact than an equivalent amount of nitrogen applied as fertilizer on uplands far from streams or springs. Nitrogen applied as fertilizer is used by plants. Nitrogen as ammonia in septic effluents may volatilize to the atmosphere. The next section provides additional information regarding the contribution of each of these nitrogen inputs as nitrate loads to groundwater and surface water of the Basin.

Figure 3-1. Nitrogen Inputs to the Wekiva Basin, Partitioned by Source Type



Notes: Fertilizer – Res = Fertilizer used on residential land uses
Fertilizer – Ag = Fertilizer used on agricultural land uses
Source: MACTEC.
Created by: WAT Checked by: JAT

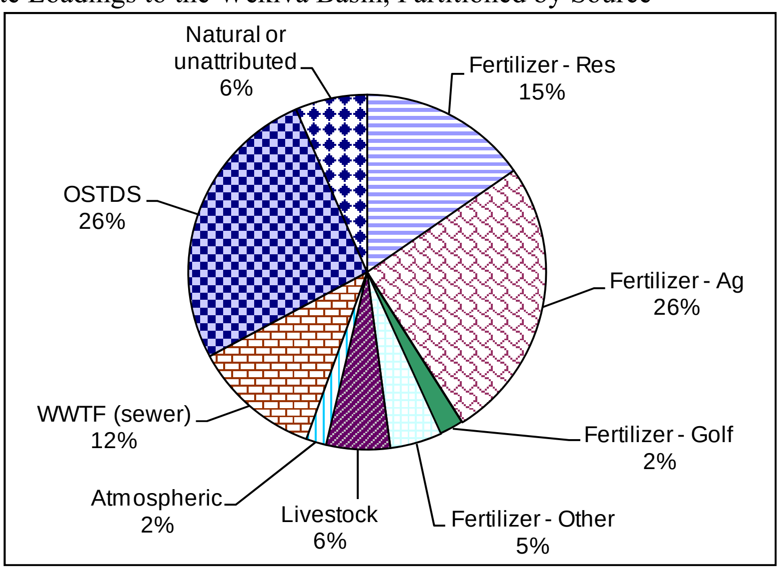
3.2 Loadings to Waters of the Wekiva Basin

Procedures described in Section 2.0 were applied to estimate NO3-N loadings to groundwater and surface waters of the Basin. Total loading of NO3-N to waters of the Basin is estimated to be 1,800 MT/yr. Contrasting this estimate with the nitrogen input to the Basin of 9,900 MT/yr indicates that only 19% of the TN input to the Basin reaches groundwater and surface water as NO3-N. Although the importance of removal processes has not been evaluated quantitatively, it appears that a significant portion of nitrogen input is lost by assimilation (plant uptake), storage as soil organic nitrogen, denitrification, and volatilization to the atmosphere as N_2 or ammonia. Only about 140 MT/yr is discharged directly to surface water in the Wekiva River watershed. The remainder of the loading, i.e., approximately 1,700 MT/yr is a load to groundwater resources. This amount may be compared with the estimated discharge of NO3-N from springs in the Wekiva Basin, which has been estimated to be 232 MT/yr (Gao, 2008).

There are several possible explanations for this discrepancy between estimated groundwater loading and spring discharge. A portion of the nitrate initially discharged to groundwater may be lost by denitrification or other chemical processes, while a portion of the loading may underflow the springs, perhaps eventually discharging to the St. Johns River. Toth (1999, 2003) and Toth and Fortich (2002) demonstrated that water discharging to springs in the Basin reflects impacts from past activities in the Basin. The average age of water discharging from springs is about 20 years, which reflects a mixture of some water that was at the surface recently as well as some older water. Therefore it would not be expected that discharges today are directly related to land use today.

Figure 3-2 illustrates the sources of nitrate loadings. Fertilizer use by agriculture (26% of total loading) and for residential turfgrass (15%) are major contributors, as are OSTDS (26%). Fertilizer use on all land uses comprises 48% of total loadings. WWTF and livestock waste add 12 and 6%, respectively. Approximately 6% of the total loading is apparently natural or cannot be attributed to identified sources. This amount consists of the groundwater recharge and stormwater loadings that would be expected to occur if all land in the Basin were undeveloped. This "natural or unattributed" amount was calculated by setting all groundwater concentrations to 0.1 mg/L, representative of values generally observed in undeveloped areas (Phelps, 2004; MACTEC, 2009)[10], and generating stormwater loadings using WMM in a separate application by changing all upland land uses to an undeveloped classification. Combining this amount with atmospheric deposition (2%, a portion of which is natural) suggests that anthropogenic loadings are about 92% of the total, or that pre-cultural loadings would have been about 1/12th of current loading rates.

Figure 3-2. Nitrate Loadings to the Wekiva Basin, Partitioned by Source

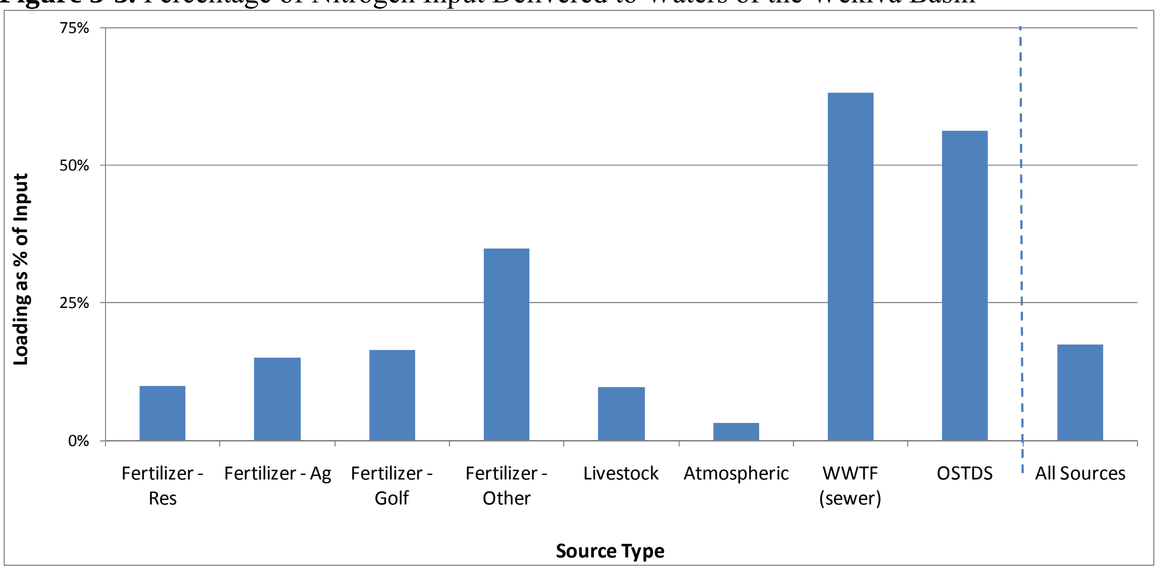


Source: MACTEC
Created by: WAT Checked by: JAT

[10] Note: the natural concentration of NO3-N in the surficial aquifer may be less than 0.1 mg/L. Hicks (2010) summarized data from FDEP's groundwater monitoring database, concluding that median concentrations are 0.02 to 0.05 mg/L. If the lower value had been used in the calculations, they would indicate a greater effect of anthropogenic loadings.

Figure 3-3 shows the percentage of nitrogen inputs that are delivered as nitrate loads to waters of the Basin by source type. It was assumed that all effluent nitrate from permitted wastewater facilities, excluding effluent that is reclaimed or reused, is discharged to waters of the Basin. This amounts to 88% of TN discharged. Effluent TN that is reclaimed or reused was assumed to be processed in the root zone similarly to fertilizer TN, resulting in approximately 20% released to groundwater as NO3-N. Approximately 37% of wastewater effluent TN is reclaimed or reused in the Wekiva Basin. As a result approximately 63% of WWTF effluent TN is estimated to reach waters of the Basin as NO3-N. Approximately 56% of septic tank effluent nitrogen was assumed to reach groundwater as NO3-N (section 2.4.4, based on Ellis & Associates, 2007). The remainder is presumed to be volatilized as ammonia or denitrified and volatilized as N_2 during transport from the drainfield to the water table.

Figure 3-3. Percentage of Nitrogen Input Delivered to Waters of the Wekiva Basin



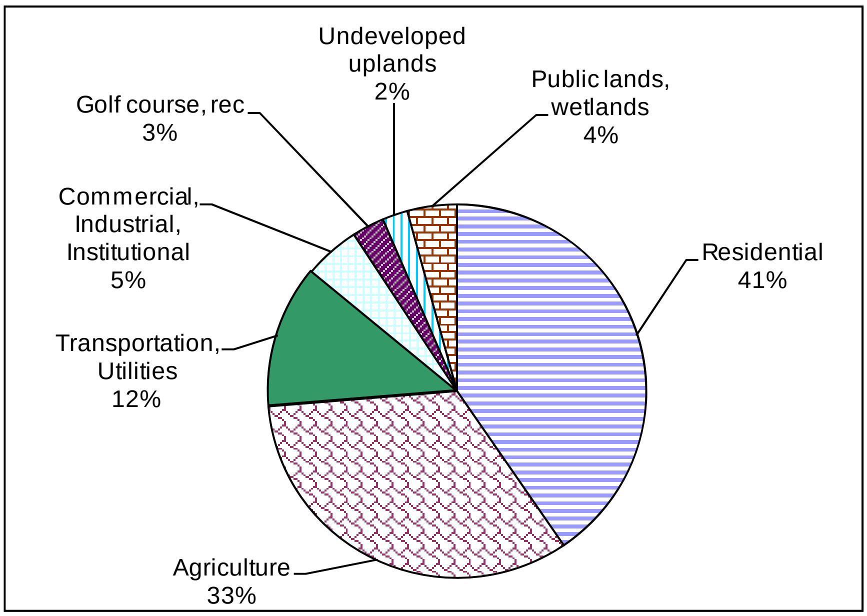
Source: MACTEC.
Created by: JAT Checked by: WAT

The percentage of nitrogen inputs applied as fertilizer that reaches groundwater or surface waters of the Basin as NO3-N (Figure 3-3) is the result of two essentially independent calculations. Nitrogen inputs are based on estimated fertilizer use, while loadings are based on estimated groundwater concentrations and recharge rates (loadings to groundwater) and the results of application of a stormwater loading model (modification of the WMM model application developed by CDM, 2005). Although there is significant potential for errors in both the loadings and the inputs estimated in accordance with Section 2.0, the portion of fertilizer applied that actually reaches ground and surface water is consistent with the literature. For example, leachate and/or runoff losses of NO3-N have been reported to range from 1 to 44% (most results less than 15%) of TN applied as fertilizer to residential turfgrass by Hipp, *et al.* (1993), Morton, *et* al. (1988), Raulerson, *et al*. (2002), and Snyder, *et al*. (1984). This range compares favorably with the portions estimated for residential turfgrass and golf courses in the Wekiva Basin of 10 and

14% respectively. Bottcher and Rhue (2000) estimate NO3-N losses by runoff and leaching of 5 to 30% in agricultural applications, which compares with 20% estimated in the Wekiva Basin.

Figure 3-4 illustrates the partitioning of nitrate loadings by land use. Residential land uses, which are affected by fertilizer use, OSTDS, and reused WWTF effluent, account for 41% of total loading; while agricultural land uses contribute 33%. Wastewater effluents are the predominant contributor to the transportation, communications, and utilities land use which contributes 12% of total loadings of nitrate. In Figure 3-4 the undeveloped sector (as depicted in Figure 1-2) has been disaggregated into two parts, undeveloped uplands (which may be presumed to be developable in the future, and currently contribute 2% to total loading) and those undeveloped lands that are protected from future development, including publicly owned conservation lands, wetlands, and water bodies, which contribute 4% of total Basin loading.

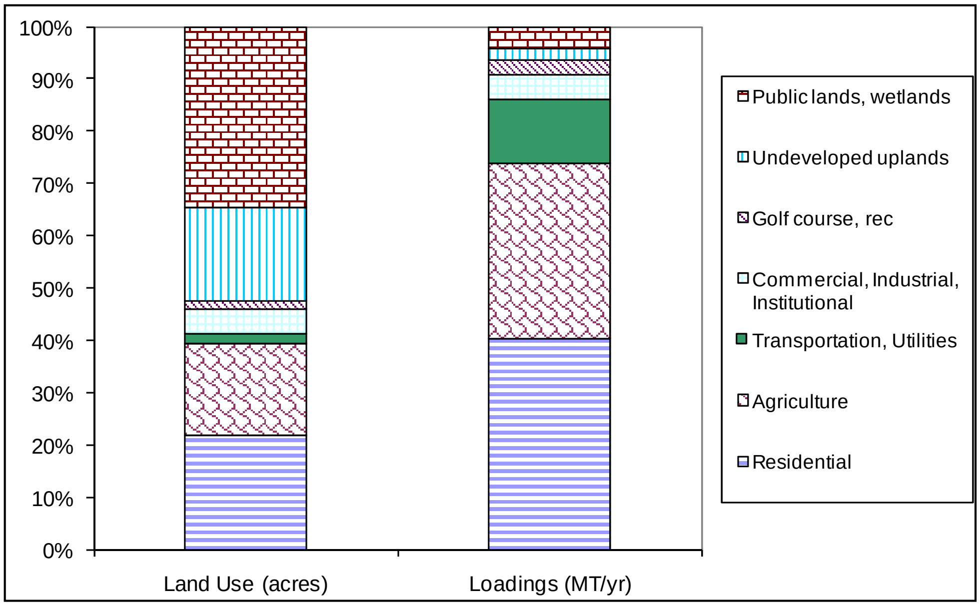
Figure 3-4. Nitrate Loading to the Wekiva Basin, Partitioned by Land Use



Source: MACTEC.
Created by: JAT Checked by: WAT

Residential land uses are major contributors to loadings, in part, because they comprise a large portion of the Wekiva Basin (21%, see Figure 1-2). Figure 3-5 presents information on land use acreage from Figure 1-2, and partitioning of nitrate loadings by land use from Figure 3-4 in a stacked bar chart format. This illustration shows, for example, that although residential land uses comprise 21% of the total area of the Basin, they contribute 41% of the nitrate loadings. Similarly agriculture, transportation, utilities, commercial, industrial, institutional, and golf course land uses contribute a greater proportion of the nitrate loadings than their proportion of the acreage, while undeveloped land uses that make up more than 50% of the area of the Basin contribute only 6% of the nitrate loading.

Figure 3-5. Loadings by Land Use Compared with Proportionate Acreage in Each Land Use



Source: MACTEC.
Created by: JAT Checked by: WAT

Information presented on Figure 3-4 can also be presented in terms of loading rates per area. Residential land uses, in aggregate, yield about 20 kg/ha/yr, while agricultural land uses yield about 21 kg/ha/yr. The loading from specific residential parcels, however, depends primarily on whether they are served by a central sewer system or septic tanks (OSTDS). About half of the aggregate residential loading is from OSTDS, but less than half of residences are on septic systems in the Wekiva Basin, so residential parcels with septic systems have much higher loading rates. Loading rates from undeveloped lands, on the other hand, were estimated to average about 1 kg/ha/yr.

Considering the number of septic systems (65,000), the average number of people served by each OSTDS (approximately 2.5), and the actual discharge rate from WWTF in the Basin (about 48 million gallons per day, MGD), it is estimated that about 160,000 people are served by septic, and 265,000 by central sewer systems. Loadings from OSTDS are estimated at 484 MT/yr, or about 3.0 kg NO3-N/person/yr. Loadings from central sewer average 0.8 kg/person/yr. Therefore, central WWTF reduce 73% more nitrate loading than septic systems.

These loading rates represent conditions in the Basin in 2004. Projections of future loadings were not one of the objectives of this study. Nonetheless, some trends are apparent. From 1999 to 2004, residential land use (and correspondingly the number of dwelling units) increased by about 10% (an increase of about 10,000 ac). During the same five year period, acreage in citrus decreased by 28% (a loss of 5,000 ac). Citrus was converted primarily to residential (1,200 ac); silviculture (1,100 ac); other agricultural uses (800 ac), including pasture (440 ac), and nurseries (140 ac); or abandoned (800 ac). Assuming these trends continue, the percent contribution of residential land uses to nitrate loadings would be expected to increase in the future, with a decrease in the importance of agricultural land uses.

Alternate Analysis – Wekiva Study Area

It is appropriate that this study address all areas contributing water to the Wekiva River. However, it is possible that some administrative actions would only address the Wekiva Study Area considering its special designation by F.S. Chapter 369.316. Therefore the FDEP requested that analogous results be calculated for the WSA. These calculations would also permit more transparent comparison with comparable estimates made by Roeder (2008) for the WSA. Appendix H presents loadings apportioned by major source categories for the WSA only. These estimates were generally made following the same methodology as described in the main body of the report, but limiting the area of interest to the WSA.

Apportionment to major source types is similar in the basin and the WSA. The estimated apportionment to major source types in the WSA, using procedures adopted in this report, are also similar to the apportionment determined by Roeder (2008). OSTDS are a somewhat larger contributor to total loading in the WSA than in the basin, because the density of OSTDS is greater in the WSA (0.17 OSTDS/ac) than in the portion of the basin that is outside the WSA (0.10 OSTDS/ac). Agricultural is slightly more important in the basin than in the WSA, because the areas in the basin that are outside the WSA are generally more agricultural. The total loading of NO3-N estimated in Appendix H for the WSA is similar to, and slightly less, than the loading of TN estimated by Roeder (2008). Overall the procedures used here, when applied to the WSA, produced similar results to those reported by Roeder (2008).

3.3 Uncertainties in Loading Estimates and Limitations of the Selected Procedures

Several of the factors used to estimate inputs and loadings are uncertain, and the procedures themselves do not represent all factors that affect nitrate loadings. Procedures were selected, in part, because available information supported estimation of all quantities specified in the Statement of Work (partitioning by specific source types and partitioning by specific land uses) using those procedures consistently across all source types and land uses.

In the following two subsections limitations of the selected procedures are identified, and uncertainties in input parameters are discussed qualitatively or semi-quantitatively.

3.3.1 Procedural Issues

Procedural issues identified include:

- Definition of the springshed – There are at least three published maps depicting the Wekiva Groundwater Basin and/or the springshed (Toth and Fortich, 2002, Wekiva River Basin Coordinating Committee, 2004). The District has determined that the map used to define the scope of this project is the most reliable. Boundaries of the springshed may change with season, or from year to year. The relative importance of predominantly agricultural areas in the western portion of the springshed would be affected if different assumptions had been made regarding the boundary of the springshed.

- Relative importance of loadings near springs versus loadings far from springs – Although this factor would not affect the estimate of loadings within the Wekiva Basin as defined by this study, not all loadings to the Floridan Aquifer will have an equivalent impact on springs and Wekiva River water quality. Loadings to the Floridan Aquifer that occur near a spring probably have a disproportionately greater impact, and certainly the effects of loading changes in areas near a spring will have a more immediate effect on spring water quality.
- Use of shallow groundwater concentrations and/or leachate concentrations as representative of the quality of recharge to the Floridan Aquifer – By the selected procedure for estimating groundwater loadings (multiplying shallow groundwater concentrations by recharge rates) the ideal groundwater concentration input would be deeper groundwater, the water actually recharging the Floridan. Unfortunately these data are not as readily available as shallow groundwater concentrations, nor could deeper concentrations be attributed to specific sources and land uses. In order to attribute loadings to specific sources and land uses, it was important that the concentrations used as characteristic of a source should clearly reflect the source type. By the time groundwater has recharged to the top of Floridan, in many locations, its concentration represents the combined impacts of multiple land uses, multiple sources, with some dilution and/or other chemical transformations. In this study shallow groundwater concentrations, generally within 20 ft of the water table, were used to estimate concentrations in water recharging the Floridan.
- Primary reliance on UF/IFAS Extension recommended fertilization rates rather than actual fertilizer use – Most researchers and Extension agents generally believe that most farmers apply more fertilizer than the amounts recommended by UF/IFAS Extension. In some cases “over fertilization” has been documented in published reports. For the most part, however, such assertions are not well documented. An alternative approach that was considered was to use fertilizer sales (e.g., by County) as the primary method for estimating fertilizer use. This approach was rejected, however, for several reasons, including (a) difficulty of assigning County-wide fertilizer sales to source types and land uses of interest; (b) recognition that the Wekiva Basin includes small portions of several Counties such that it would be difficult to assign a portion of County-wide sales to the Basin; (c) concern that fertilizer is not necessarily used in the County where it is purchased (one example – large agricultural concerns may use significant quantities of fertilizer purchased elsewhere by corporate purchasing systems).
- Disposal of wastewater treatment residuals was not tracked or accounted for.
- Assumption that structural BMPs (e.g., stormwater detention ponds) simply reroute nitrate from surface water to groundwater, without reducing total Basin loading – Clearly structural BMPs effect some treatment of nitrate, although structural BMPs are less effective for soluble nitrate than for constituents strongly associated with suspended solids, including Total Suspended Solids, Biochemical Oxygen Demand, and Total Phosphate. This assumption is conservative, partially supported by published research, and was made primarily for simplification.

3.3.2 Uncertainties in Input Parameters

All inputs used in estimation of inputs and loadings are uncertain to some extent. Land use designations may not be accurate on a parcel by parcel basis, but the aggregate (total acres by land use through the entire Basin) is probably relatively accurate and not a significant source of uncertainty.

Stormwater loadings (per ac of land use) are the product of stormwater flow for a climatically average year and an EMC (representative concentration of NO3-N in stormwater). Stormwater flow can vary widely from year to year, depending on rainfall rates, but the climatological average is assumed to be reasonably reliable, and not a significant source of uncertainty in this analysis.

EMCs used in this study were developed by CDM (2005) and represent a consensus estimate based on the literature and the input of stakeholders. Information on the uncertainty in EMCs presented by CDM (2005)[11] indicate that the uncertainty in EMCs for the land uses contributing significantly to nitrate loadings in the Wekiva Basin is roughly a factor of 2. The consensus value selected by CDM (2005) was usually near the high end of the range of reported values, suggesting that stormwater loadings are unlikely to be underestimated, but may be overestimated by as much as a factor of 2. Considering that stormwater represents 14% of total nitrate loading in the Basin, the effect of this potential error is that total loadings may be overestimated by 5 to 10%.

The concentrations of NO3-N in recharging groundwater assigned as representative of specific land uses are uncertain. For most land uses these estimates are based on published studies from locations outside the Wekiva Basin, and, in some cases, from outside the state of Florida. Representative data from Florida locations were used if available. Different monitoring studies generally yield fairly consistent results for given land uses, but limitations and variability observed in the data suggest that each land use estimate may not be reliable to much better than ± 50%.

Recent investigation of a container nursery site within the Wekiva Basin (Newton, 2010) indicates that groundwater NO3-N concentrations associated with the nurseries and ornamentals land uses may be higher than the value assumed in this study. Groundwater NO3-N concentrations observed by Newton (2010) at a single site in the Wekiva Basin averaged 23 mg/L in September 2009, while loadings estimates for this land use are based on a representative concentration of 6 mg/L (see Section 2.4.1.2). Each nursery operation is unique, depending on the plants cultivated. The Eustis, FL, operation investigated by Newton (2010) may not be representative of the entire land use. Nonetheless Newton's results indicate significant uncertainty in loadings for this land use, and the potential that its impact has been underestimated in this report. Nurseries apply fertilizer at rates similar to those applied to citrus groves, where representative groundwater concentrations of NO3-N have been observed to be approximately

[11] The information referred to here has been reproduced in an appendix to this report, and can be found in CDM's table E-6. In that table it is shown that CDM (2005) considered a variety of sources of information on EMCs and selected a value based on technical evaluation and a process of consensus building among stakeholders. The values used by CDM (2005) may differ by roughly a factor of 2 from values that have been reported in the technical literature considered by CDM in developing their consensus EMCs.

15 mg/L. If 15 mg/L is representative of the nursery land use, then loadings from this land use would be 150% higher than estimated in this study, and could amount to 7% of total nitrate loading in the Basin. Further investigations of groundwater impacts of container nurseries in the Basin, or similar areas in Florida, may be warranted to reduce this uncertainty.

3.4 Effect of Recently Promulgated Regulations

3.4.1 Wastewater Management Requirements for the WSA (62-600.550, F.A.C.)

In April 2006 FDEP promulgated Chapter 62-600.550, F.A.C., establishing specific wastewater management requirements for the WSA. The purpose of the rule is to reduce nitrate discharges to protect surface and groundwater quality in the WSA. Existing domestic wastewater facilities discharging within the WSA are to comply with requirements of the rule by April 2011. New facilities are to comply immediately.

The approach adopted in 62-600.550 is to target more stringent requirements in portions of the WSA where the Floridan Aquifer is particularly vulnerable to contamination, as defined by the Wekiva Aquifer Vulnerability Assessment (WAVA; Cichon, *et al*., 2005). Cichon, *et al*. (2005) found that the Floridan Aquifer is vulnerable to surface contamination throughout the entire WSA, but further identified areas with relatively greater vulnerability. Areas where the Floridan Aquifer is most vulnerable to contamination are designated the Primary Protection Zone. The Floridan Aquifer is also relatively vulnerable in the Secondary Protection Zone, and least vulnerable in the Tertiary Protection Zone. F.A.C. 62-600.550 requires the most stringent discharge requirements in the Primary Protection Zone, relatively stringent requirements in the Secondary Protection Zone, and less stringent requirements in the Tertiary Protection Zone.

Specifically, in the Primary Protection Zone:

- Expanded rapid-rate or restricted access slow-rate land application systems are prohibited;
- Facilities with a permitted capacity exceeding 0.1 MGD must achieve effluent concentration of 3 mg/L TN in water discharged to rapid rate land applications systems (e.g., RIBs) unless the RIB is used only as backup (<30% of total discharge) to a public access reuse system for which the effluent concentration shall not exceed 10 mg/L TN; and
- Smaller facilities must achieve effluent concentration of 10 mg/L, regardless of disposal method.

In the Secondary Protection Zone:

- Larger facilities (permitted capacity > 0.1 MGD) must achieve effluent concentration of 6 mg/L TN in water discharged to RIBs unless the RIB is used only as backup to a public access reuse system; and
- Other requirements similar to those for facilities in the Primary Protection Zone, except that small facilities have until 2016 to comply.

Facilities do not have to meet these requirements if their effluent contains less than 0.2 mg/L NO3-N. Discharge to surface waters is prohibited except as backup to a public access reuse system. In both the Primary and Secondary Protection Zones, the concentration in effluent supplied to slow rate public access reuse systems must not exceed 10 mg/L TN.

To meet these requirements, several facilities will have to upgrade their treatment systems and/or change their effluent disposal system(s). The need to reduce discharge or modify effluent disposal systems was evaluated by review of effluent concentrations from 2004 through mid-2006. It was assumed that if more than 20% of the historical sample results exceed the revised effluent concentration limits, the facility would upgrade. Further it was assumed the design criterion for upgrades would be that fewer than 20% of discharge measurements would exceed the revised limits, with 95% confidence. Results of this analysis are summarized in Appendix E. The effect of the rule is estimated to be a 56% reduction in TN input and a 68% reduction in loadings within the WSA. Since there are a number of wastewater facilities in the Wekiva Basin that are not within the WSA, and therefore not subject to the requirements of 62-600.550 F.A.C., the overall effect of the required upgrades on effluent loads in the Basin would be a 22% reduction (from 214 to 168 MT/yr). The estimated load reduction is relatively uncertain, based on the analyses performed. The largest discharger in the Basin (Conserv II) is not in the WSA and therefore not subject to the new rule, but has agreed to meet the 62-600.550 requirements for reused water, since the reuse service area is within the WSA. The effect on total loading (entire Basin, all source types) would be a reduction of 3%.

3.4.2 Agricultural BMPs

The Office of Agricultural Water Policy (OAWP) was established in 1995 by the Florida Legislature to facilitate communications among federal, state, local agencies, and the agricultural industry on water quantity and water quality issues involving agriculture. In this effort, the OAWP is actively involved in the development of BMPs, addressing both water quality and water conservation on a site specific, regional, and watershed basis. As a significant part of this effort, the office is directly involved with statewide programs to implement the Federal Clean Water Act's Total Maximum Daily Load (TMDL) requirements for agriculture. The OAWP works cooperatively with agricultural producers and industry groups, the FDEP, the university system, the water management districts, and other interested parties to develop and implement BMP programs that are economically and technically feasible.

BMPs are developed by the Office of Agricultural Water Policy to benefit water quality while maintaining or enhancing agricultural production. The BMP program is completely voluntary, but by implementing the BMPs, landowners are exempted from water quality monitoring requirements and protected from enforcement actions if the water quality standards are not met. Also, those enrolled in the BMP program are eligible for cost-sharing funds used to implement new BMP practices. Finally, the Florida Water Restoration Act includes provisions to require implementation of BMPS if the voluntary programs are not effective in achieving water quality objectives. To take place in the BMP program, one must:

- Do a full assessment of the property using a Decision Tree Flowchart;
- Submit a Notice of Intent to Implement (Outlined in 5M-8.004);
- Implement all applicable BMPs that were needed from the assessment and listed on the Notice of Intent to Implement; and
- Maintain documentation to verify implementation and maintenance of BMPs.

BMPs have been developed for the following agricultural activities:

- Citrus production (BMPs vary by producing region),
- Silviculture,
- Aquaculture,
- Vegetable and agronomic crops,
- Leather leaf ferns,
- Nurseries,
- Forage grass,
- Cow/calf operations, and
- Sod farms.

Considering their importance in the Wekiva Basin, the vegetable and agronomic crop, ridge citrus, and container nurseries BMPs are discussed further below.

Potential Effect of Vegetable and Agronomic Crop BMP

This BMP was promulgated in February 2006, and therefore its effectiveness cannot be determined at this time. The BMP encourages implementation of UF/IFAS Extension recommended fertilization rates. In this study (see Section 2.3.1.2) the assumed application rate is 210 kg N/ha/crop, while UF/IFAS Extension recommended rates are slightly lower at 192 kg/ha/crop. Therefore implementation of the BMP is expected to represent a 9% reduction in fertilizer use from the baseline condition assumed during this study. Extensive guidance is provided regarding water and fertilizer management to reduce nutrient leaching and runoff. Implementation of the BMP would be expected to reduce loadings to surface water and groundwater, but there is no basis to estimate the magnitude of the effect at this time.

Potential Effect of Ridge Citrus BMP

The ridge citrus BMP was promulgated in 2002. The BMP does not require a significant reduction in fertilization rate from the rates assumed as the baseline situation. FDEP, UF/IFAS, and FDACS have conducted research to determine the effectiveness of the BMP.

The primary beneficial effect of the BMP is expected to be the requirement to apply less TN per application, at a greater frequency, than the standard practice of the industry prior to implementation of the BMPs. More frequent fertilization, in smaller amounts, reduces the potential for excessive runoff or leaching if heavy rains follow closely after fertilization, while maintaining, and perhaps enhancing, agricultural productivity. For example, Lamb, *et al*. (1999)

reported an average rate of 257 kg/ha/yr distributed in three applications per year (86 kg/ha/application) on three ridge citrus groves in Highlands County during the period 1988 to 1993. The ridge citrus BMP permits an application rate up to 240 kg/ha/yr[12], similar to rates actually used pre-BMP. Roeder (2008) analyzed data acquired to evaluate the effectiveness of the Ridge Citrus BMP, and found that groundwater concentrations of NO3-N averaged 10 mg/L for facilities implementing BMPs as of 2007, compared with the estimated concentration used in loading estimation in this report of 15 mg/L. FDEP (Brooks, 2008) has verified the effectiveness of the Ridge Citrus BMP, finding that average NO3-N concentrations at 8 groves participating in the BMP program decreased from 11.6 mg/L to 7.8 mg/L from 2004 to 2007, a reduction of 33%. The UF/Citrus Research and Education Center (2007) reports that approximately ½ of citrus acreage is participating in the BMP program as of 2007. Therefore, the effect of the BMP is expected to be less than a 30% reduction in loading rates from the citrus land use under current regulations. If BMP implementation were required under F.S. 403.067(7)(c), available data (Brooks, 2008) indicates that a 33% reduction in loading would be achievable for ridge citrus operations.

Although neither of these BMPs represent a substantial reduction of fertilizer use from the assumed baseline condition, the most critical factor in preventing leaching and runoff to springs and streams is the effective utilization of fertilizer applied by the crop by timing and frequency of fertilizer applications and minimization of irrigation. A small percentage reduction in fertilizer use could result in a much larger percentage reduction in loadings so long as the fertilizer that was applied is used more efficiently by the crop. Increasing the efficient utilization of applied fertilizer is, in fact, a primary objective of the promulgated BMPs so their implementation is expected to result in a more effective reduction in loading than might be indicated by any reduction in fertilizer applied.

Container Nurseries BMP

FDACS promulgated this BMP in August 2007. Its effects have not been evaluated to date. Considering the diversity of container nursery operations, this BMP does not specify a rate of fertilizer application. It addresses a wide range of container nursery operations including nursery layout, container substrate, fertilization management, irrigation, and runoff management. Nutrients are monitored in the container substrate nutrient solution. With respect to fertilization, controlled release fertilizers are to be used on the majority of the nursery, fertilizer is applied at manufacturer's recommended rates or as indicated by substrate nutrient monitoring. Fertilizer use is to be minimized to the amount required for crop production. Acceptable levels of NO3-N in container substrate nutrient solutions range from 15 to 100 mg/L. Since these concentrations exceed Florida groundwater quality standards, minimization of impacts to groundwater requires effective irrigation, leachate, and runoff management.

[12] The allowable application rate varies with age of trees and productivity of the grove. Rates are likely to be limited to 240 kg/ha/yr for mature trees in the Wekiva Basin.

3.5 Summary of Revisions to Phase I Loadings

FDEP's Phase I report (MACTEC, 2007) analyzed available information to develop nitrate loadings to the Wekiva Basin, and made recommendations for Phase II investigations to reduce uncertainties identified by the Phase I study. FDEP's Phase II investigations emphasized the impacts of residential fertilizer use because the Phase I evaluation found that the effects of residential fertilizer use were not well established by field studies. FDEP's Phase II investigations are detailed in MACTEC (2009), UCF (2009), and Katz and Griffin (undated).

In companion studies, the FDOH studied groundwater impacts of OSTDS systems within the WSA. The results of FDOH research were published after publication of FDEP's Phase I report (Ellis & Associates, 2007, Young, 2007, and Roeder, 2008).

The SJRWMD received comments from stakeholders on the Phase I report. Comments were received from Anderson (2007) representing the Florida Home Builders Association, the Florida Onsite Wastewater Association, the Florida Association of Realtors, and the Orlando Regional Realtor Association; and Martinez (2007) and Wible (2007) representing The Scott's Miracle-Gro Company. Stakeholder comments on the Phase I report are reproduced in Appendix G.

This Final report responds to stakeholder comments, and incorporates information developed by the Wekiva Basin studies funded by FDEP and FDOH since publication of the Phase I report, as well as other technical publications not considered by MACTEC (2007). This section summarizes the changes to input and loading estimates made after consideration of stakeholder comments and other new information.

3.5.1 Revisions to Inputs

FDEP's charge from the legislature was to determine nitrate impacts to the Wekiva River and Floridan Aquifer system. Based on this direction, the Phase I estimates were designed to represent nitrate inputs and loadings to waters of the basin. If reliable nitrate data were available for any component of the budget, nitrate data were used. If reliable nitrate data were not available, then total nitrogen data were used. All loadings were quantified as NO3-N, but more than 90% of the inputs were quantified as TN because NO3-N data were not available for most of the inputs (for example, fertilizer use, livestock waste, and OSTDS effluents). As a result the inputs pie charts represented a mixture of NO3-N and TN values. Anderson (2007) commented that "all forms of nitrogen should be considered in quantifying inputs" while Young (2007) commented that MACTEC's (2007) approach "distorts the relative inputs". This report addresses those comments by defining all inputs as TN, resulting in revisions to the WWTF and atmospheric deposition input quantification. Those revisions are reflected in Section 2.3.3 and 2.3.5 of this report.

Anderson (2007), Young (2007), and Roeder (2007) comment that MACTEC (2007) underestimated atmospheric deposition. They present two reasons for their opinions:

- MACTEC (2007) quantified nitrate deposition, not accounting for other forms of nitrogen; this valid point has been addressed as described in the previous paragraph (see Section 2.3.5 of this report); and
- They disagree with use of rural deposition values from the CASTNET IRL site, and recommend use of values obtained in the Tampa metropolitan area.

Atmospheric deposition values have been recalculated in response to these comments, and increased by 120% - an increase of 577 MT/yr. The change primarily results from inclusion of all forms of TN. Deposition rates from both urban (Tampa) and rural (IRL) sites were used in this report. The Wekiva Basin is substantially less urban than either Tampa or the WSA. Urban deposition rates are more appropriate for the WSA (as addressed by Roeder, 2008), while a mixture of urban and rural deposition rates are appropriate for the Wekiva Basin as evaluated in this report.

Martinez (2007) and Wible (2007) commented that residential fertilizer usage rates estimated by MACTEC (2007) were too high, based on county-wide fertilizer sales data and nationwide surveys of residential fertilizer users. Roeder (2008) relied primarily on county-wide fertilizer sales data to develop fertilizer inputs to the WSA. Roeder's analysis assumes that residential fertilizer is applied only to areas managed as turfgrass. This assumption is implausible, since flower beds, ornamentals, and vegetable gardens are routinely fertilized. UCF (2009) found that most residents apply fertilizer at lower rates than were assumed for the Phase I report, a finding that is consistent with the comments of Martinez and Wible. The UCF study also addressed other issues raised by Martinez and Wible. UCF's Wekiva Basin survey should be used, rather than nationwide surveys cited by Martinez and Wible. For example, Martinez, using nationwide survey data, assumed that 50% of residents do not use fertilizer at all, while UCF found that 84% of WSA residents use fertilizer. Disadvantages of using county-wide fertilizer sales as the basis for inputs in this study are presented in Section 3.3.1, and difficulties in use of this type of data are also discussed by Wible (2007). This report has revised the estimates for residential fertilizer use based on the UCF (2009) findings (see Section 2.3.1.1), reducing residential fertilizer inputs (usage rates) by 27%, specifically a reduction of 1,066 MT/yr.

Ellis & Associates (2007) conducted intensive monitoring of OSTDS effluents at three sites in the WSA. This site-specific data, collected to support this study and published after the Phase I report, has been used to revise estimates of OSTDS inputs as detailed in Section 2.3.4. OSTDS inputs were increased by 45% as a result of using site-specific data, an increase of 267 MT/yr.

MACTEC (2007) assumed that nutrients in reclaimed water would "displace" fertilizer use, i.e., that landscape managers (e.g., residents, golf course managers) would apply less TN in fertilizer if they were receiving reclaimed water. Anderson (2007) and Roeder (2008) found this assumption unrealistic. Furthermore, the survey of residential fertilizer users conducted by UCF (2009) found that residents on reclaimed water actually used more fertilizer than those using other sources for irrigation water. In effect, the MACTEC (2007) assumption reduced the apparent contribution of reclaimed water use in the nitrogen budget. In this final report reclaimed water is retained as an input related to the WWTF source category. In addition, as previously discussed, inputs from WWTF are now expressed as TN. The combined effect of these two revisions is to increase WWTF inputs by 79%, an increase of 150 MT/yr.

The estimated fertilizer application rate to tree crops (citrus) was increased from 227 kg/ha/yr to 240 kg/ha/yr, consistent with the Ridge Citrus BMP, correcting an error in the Phase I report. Since nurseries and ornamentals land uses were assumed to received similar fertilization as citrus, this change was also applied to nurseries and ornamentals. The effect is an increase in TN inputs of 6% for these land uses, an increase of 99 MT/yr.

Finally, a computational error reflected in the Phase I report was corrected. The Phase I summary of the agricultural fertilizer inputs did not sum fertilizer use for all agricultural land uses. The nurseries category was incorrectly omitted from the agriculture inputs subtotal. This error has been corrected.

Differences between the inputs estimated in the Phase I report and in this final report are illustrated in Figure 3-6.

3.5.2 Revisions to Loadings

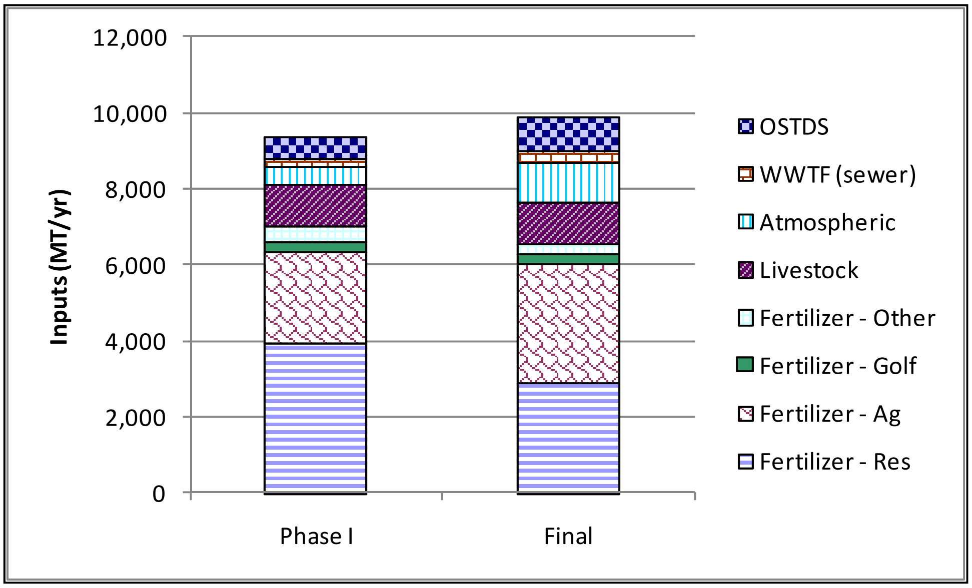
Ellis & Associates (2007) conducted intensive monitoring of OSTDS groundwater impacts at three sites in the WSA. This site-specific data, collected to support this study and published after the Phase I report, has been used to revise estimates of OSTDS loadings, as detailed in Section 2.4.4. OSTDS loadings were increased by 16% (68 MT/yr), compared with Phase I estimates based on national data.

MACTEC (2009) monitored groundwater quality in residential portions of the Wekiva Basin that were isolated from known OSTDS. These site-specific data were used to estimate groundwater quality in residential areas of the Wekiva Basin, resulting in a 33% reduction in NO3-N loading to groundwater associated with residential fertilizer use, a reduction of 98 MT/yr. These revisions, using site-specific data, are also responsive to comments by Wible (2007).

Nitrogen in reclaimed water has now been allocated to land uses receiving the reclaimed water. It is assumed that 20% of the TN in the reclaimed water leaches to groundwater as NO3-N based on York (2007). This represents a similar percentage as other types of fertilizer use. Effectively, this approach treats the nitrogen in reclaimed water as fertilizer, but it is no longer assumed that fertilizer use is reduced on lands receiving reclaimed water. This increased loadings from WWTF by 13% or 25 MT/yr.

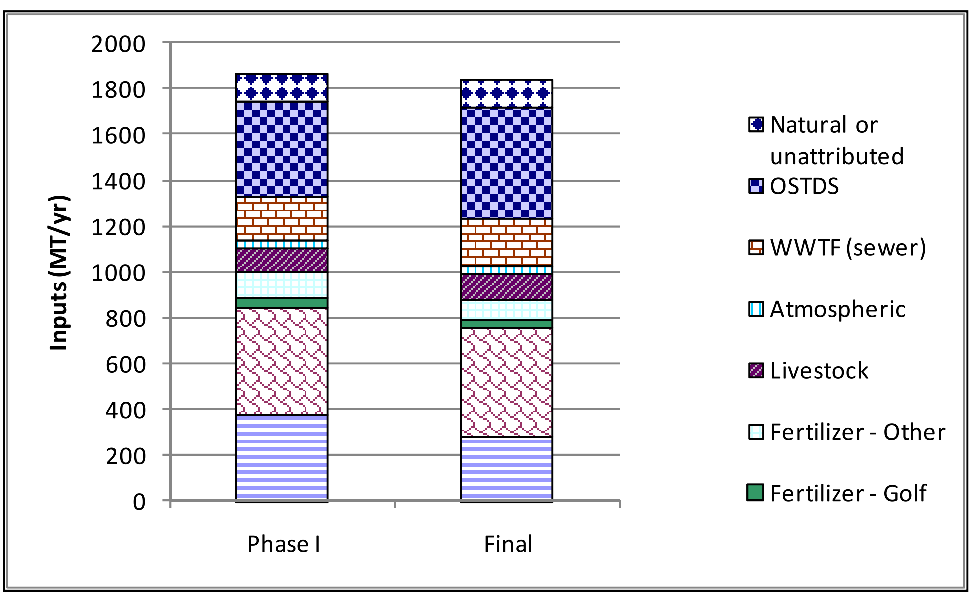
Differences between the loadings estimated in the Phase I report and in this final report are illustrated in Figure 3-7.

Figure 3-6. Comparison of Final Inputs with Estimates from the Phase I Report



Source: MACTEC.
Created by: JAT Checked by: WAT

Figure 3-7. Comparison of Final Loadings with Estimates from the Phase I Report



Source: MACTEC.
Created by: JAT Checked by: WAT

4.0 References

Anderson, C. and G. Cabana. 2006. "Does δ^{15} N in River Food Webs Reflect the Intensity and Origin of N Loads from the Watershed?" Science of the Total Environment, Vol. 367, pp. 968-978.

Anderson, D.L. 2007. Review of Phase 1 Wekiva Basin Nitrate Sourcing Study. Memorandum dated May 23, 2007 to K. Hetrick, E. Vause, T. Goldman, and P. Tucker.

Arthington, J., P. Bohlen, and F. Roka. 2003. "Effect of Stocking Rate on Measures of Cow-Calf Productivity and Nutrient Loads in Surface Water Runoff." AN141, Animal Sciences Department, Florida Cooperative Extension Service, UF/IFAS. Accessed at http://edis.ifas.ufl.edu.

Ator and Ferrari, 1996. *Nitrate and Selected Pesticides in Ground Water of the Mid-Atlantic Region.* USGS Water Resources Investigations Report 97-4139.

Bahk, B. and M. Kehoe. 1997. <u>A Survey of Outflow Water Quality from Detention Ponds in Agriculture</u>. Environmental Section, Southwest Florida Water Management District, 42 p.

Bottcher, D. and D. Rhue. 2000. "Fertilizer Management – Key to a Sound Water Quality Program." UF/IFAS, Circular 816. Accessed at http://edis.ifas.ufl.edu.

Branham, B., E. Miltner, and P. Rieke. 1995. "Potential Groundwater Contamination from Pesticides and Fertilizers Used on Golf Courses." USGA Green Section Record, January/February 1995, pp. 33-37.

Brooks, J. 2008. Letter from Brooks (FDEP) to R. Budell (FDACS OAWP) of November 24, 200,8 presenting FDEP verification of the effectiveness of the Ridge Citrus Nitrogen BMP.

CDM, Inc. 2005. *Wekiva Parkway and Protection Act Master Stormwater Management Plan Support Final Report*. Report for SJRWMD.

Cichon, J.R., A.E. Baker, A.R. Wood, and J.D. Arthur. 2005. *Wekiva Aquifer Vulnerability Assessment*. Florida Geological Survey Report of Investigation 104, 36 p.

Cohen, M.J., S. Lamsal, and L.V. Kohrnak. 2007. Sources, Transport and Transformations of Nitrate-N in the Florida Environment. SJRWMD Special Publication SJ2007-SP10.

Collins, J.J. 1995. *Reconnaissance of Water Quality at Four Swine Farms in Jackson County, Florida, 1993*. USGS Open File Report 95-770, 34 p.

Crandall, C.A. 2000. *Distribution, Movement, and Fate of Nitrate in the Surficial Aquifer Beneath Citrus Groves, Indian River, Martin, and St. Lucie Counties, Florida*. USGS Water-Resources Investigations Report 00-4057, 69 p.

Ellis & Associates, Inc. 2007. Multiple Nitrogen Loading Assessments from Onsite Waste Treatment and Disposal Systems within the Wekiva River Basin. Prepared for FDOH.

Flipse, Jr., W.J., and F.T. Bonner. 1985. "Nitrogen-Isotope Ratios of Nitrate in Ground Water Under Fertilized Fields, Long Island, New York." Ground Water, Vol. 23, No. 1, pp. 59-67.

Florida Department of Environmental Protection. 2006. "Wastewater Treatment Facilities Reports." Accessed at http://www.floridadep.com/water/wastewater/download.htm.

Florida Department of Health (FDOH). 2007. "Onsite Sewage Programs Statistical Data." Accessed at http://www.doh.state.fl.us/ environment/ostds/statistics/ostdsstatistics.htm.

FDOH. 2004. *Wekiva Basin Onsite Sewage Treatment and Disposal System Study*. Bureau of Onsite Sewage Programs, Division of Environmental Health, 21 p.

Gao, X. 2008. Nutrient TMDLs for the Wekiva River and Rock Springs Run. FDEP.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. New York: Van Nostrand Reinhold Company.

Harper, H. 1988. Effects of Stormwater Management Systems on Groundwater Quality, Florida Department of Environmental Regulation.

Harper, H. 1994. *Stormwater Loading Rate Parameters for Central and South Florida*. Environmental Research & Design, Inc. 58 p.

Hatzell, H.H. 1995. *Effects of Waste-Disposal Practices on Ground-Water Quality at Five Poultry (Broiler) Farms in North-Central Florida, 1992-93.* USGS Water Resources Investigations Report 95-4064, 28 p.

Hicks, R. 2010. Personal communication: email of January 27, 2010 to William A. Tucker (MACTEC).

Hicks, R. 2009. Nitrate Contamination of Ground Water by Liner Source Container Nursery (AKA: site #571, Old Post Office Lane Nitrate Study) FDEP Internal Memorandum to J. Brooks and D. Bartlett, August 6, 2009.

Hipp, B., S. Alexander, and T. Knowles. 1993. "Use of Resource-Efficient Plants to Reduce Nitrogen, Phosphorus, and Pesticide Runoff in Residential and Commercial Landscapes." Water Science and Technology, Vol. 28, No. 3-5, pp. 205-213.

Hochmuth, G.J. and E.A. Hanlon. 2000. "IFAS Standardized Fertilization Recommendations for Vegetable Crops." Circular 1152, Florida Cooperative Extension Service, US/IFAS.

Hodges, A.W., J.J. Haydu, P.J. van Blockland, and A.P. Bell. 1994. "Contribution of the Turfgrass Industry to Florida's Economy, 1991-92: A Value-Added Approach." Economics Report ER 94-1., Florida Cooperative Extension Service, UF/IFAS.

Hubbard, R.K. and J.M. Sheridan. 1989. "Nitrate Movement to Groundwater in the Southeastern Coastal Plain." Journal of Soil and Water Conservation.

Katz, B.G., and D.W. Griffin. Undated. Using Geochemical and Microbiological Indicators to Refine the Assessment of Nitrate Sources in the Wekiwa Springs Basin. Draft Data Report submitted to FDEP.

Knox, G.W., G.D. Israel, G.L. Davis, R.J. Black, J.M. Schaefer, and S.P. Brown. 1995. "Environmental Landscape Management: Use of Practices by Florida Consumers." September, Bulletin 307, Cooperative Extension Service, UF/IFAS.

Kraft, G.J. and W. Stites. 2003. "Nitrate Impacts on Groundwater from Irrigated-Vegetable Systems in a Humid North-Central US Sand Plain." Agriculture, Ecosystems and Environment, Vol. 100, pp. 63-74.

Koob, T.L, and M.E. Barber, 1999. WSDOT BMP's for Stormwater Runoff in Confined Spaces, Washington State Department of Transportation Report WA-RD 451.1.

Loreti, C.P. 1988 "Pollutant/Trace Ligands." *Environmental Inorganic Chemistry.* Bodek, I., W.J. Lyman, W.F. Reehl, and D.H. Rosenblatt, eds. New York: Pergamon Press.

MACTEC. 2007. Phase I Report: Wekiva River Basin Nitrate Sourcing Study. Prepared for: SJRWMD and FDEP.

MACTEC. 2009. Final Data Summary Report: Sources of Nitrate in the Wekiva River Basin Phase II. Prepared for SJRWMD and FDEP.

Martinez, C.J. and M.W. Clark. 2009. Using Reclaimed Water for Landscape Irrigation. UF/IFAS AE449. Accessed at http://edis.ifas.ufl.edu.

Martinez, R. 2007. Email correspondence to Robert Mattson. Subject: Fertilizer use in the Wekiva River basin, Florida. Dated: December 10, 2007.

Mattson, R.A., E.F. Lowe, C.L. Lippincott, J. Di, and L. Battoe. 2006. *Wekiva River and Rock Springs Run Pollutant Load Reduction Goals.* SJRWMD, report to FDEP, 70 p.

McAvoy, R.J., M.H. Brand, E.G. Corbett, J.W. Bartok, Jr., and A. Botacchi. 1992. "Effect of Leachate Fraction on Nitrate Loading to the Soil Profile Underlying a Greenhouse Crop." Journal of Environmental Horticulture, Vol, 10, No. 3, pp. 167-171.

McGurk, B. and P.F. Presley. 2002. *Simulation of the Effects of Groundwater Withdrawals on the Floridan Aquifer System in East-Central Florida: Model Expansion and Revision.* SJRWMD, 196 p.

McNeal, B.L., *et. al.* 1995. "Nutrient Loss Trends for Vegetable and Citrus Fields in West-Central Florida." Journal of Environmental Quality. Vol. 24, No. 1, pp. 95-100.

Merritt, M. 2006. Estimates of Upper Floridan Aquifer Recharge Augmentation Based on Hydraulic and Water-Quality Data (1986-2002) From the Water Conserv II RIB Systems, Orange County, Florida. SJRWMD Special Publication SJ2006-SP3. 190 p.

Morton, T.G., A.J. Gold, and W.M. Sullivan. 1988. "Influence of Overwatering and Fertilization on Nitrogen Losses from Home Lawns." Journal of Environmental Quality, Vol. 17, No. 1, pp. 124-130.

Mylavarapu, R., G. Kidder, and C.G. Chambliss. 2002. "UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops." Fact Sheet SL-129, Soil and Water Science

Department, Florida Cooperative Extension Service, UF/IFAS. Accessed at http://edis.ifas.ufl.edu.

Newton, J. March 2010 (in press). Old Post Office Lane Nitrate Study, Eustis, Lake County FL. Preliminary Contamination Assessment Report. FDEP Site Investigation Section Report No. 2010-03.

Petrovic, A.M. 1995. "The Impact of Soil Type and Precipitation on Pesticide and Nutrient Leaching from Fairway Turf." USGA Green Section Record, January/February 1995, pp. 38-41.

Phelps, G.G. 2004. Chemistry of Ground Water in the Silver Springs Basin, Florida, with an Emphasis on Nitrate. USGS Scientific Investigations Report 2004-5144.

Poor, N., R. Pribble, and H. Greening. 2001. Direct Wet and Dry Deposition of ammonia, nitric acid, ammonium, and nitrate to the Tampa Bay Estuary, FL, USA. *Atmos. Environ.* 35:3947-3955.

Randall, G.W. and D.J. Mulla. 2001. "Nitrate Nitrogen in Surface Waters as Influenced by Climatic Conditions and Agricultural Practices." Journal of Environmental Quality, Vol. 30, pp. 337-344.

Raulerson, G.E., *et al*. 2002. "Integration of the Florida Yards and Neighborhoods Program into Stormwater Planning for Nutrient Removal." 7th Biennial Stormwater Research & Watershed Management Conference, May 22-23, 2002.

Rea, M.C., 2004. Pollutant Removal Efficiency of a Stormwater Wetland BMP during Baseflow and Storm Events, Villanova University, Master's Thesis.

Riley, W.J., I. Ortiz-Monasterio, and P.A. Matson. 2001. "Nitrogen Leaching and Soil Nitrate, Nitrite, and Ammonium Levels Under Irrigated Wheat in Northern Mexico." Nutrient Cycling in Agrosystems, Vol. 61, pp. 223-236.

Roeder, E. 2006. FDOH. Personal communication (e-mail), October 26, 2006.

Roeder, E. 2008. Revised Estimates of Nitrogen Inputs and Nitrogen Loads in the Wekiva Study Area.

Rogers, C.M. 2007. CASTNET monitoring activities at Coconut Point (2007). Report to the St. Johns River Water Management District. MACTEC Engineering & Consulting, Inc.

Rufty, T. and D. Bowman. 2004. "Nitrogen Fertilization on Golf Courses: A Water Quality Problem?" North Carolina Turfgrass, May/June 2004, pp. 24-26.

Sartain, J.B. 2007. General Recommendations for Fertilization of Turfgrasses on Florida Soils. SL21, UF/IFAS. Accessed at http://edis.ifas.ufl.edu.

Sartain, J.B. and G.L. Miller. 2002. "Recommendations for N, P, K, and Mg for Golf Course and Athletic Field Fertilization Based on Mehlich I Extractant." SL 191, UF/IFAS. Accessed at http://edis.ifas.ufl.edu.

Snyder, G.H., B.J. Augustin, and J.M. Davidson. 1984. "Moisture Sensor-Controlled Irrigation for Reducing N Leaching in Bermudagrass Turf." Agronomy Journal, Vol 76, pp. 964-969.

Sudano, M. 2006. FDEP. Personal communication (e-mail), November 17, 21, 28, 2006 and December 1, 2006.

Sumner, D.M., and L.A. Bradner, 1996. Hydraulic Characteristics and Nutrient Transport and Transformation Beneath a Rapid Infiltration Basin, Reedy Creek Improvement District, Orange County, Florida: USGS Water-Resources Investigations Report 95-4281, 51 p.

Sumner, S. *et al*. 1992. "Fertilization of Established Bahiagrass Pasture in Florida." Circular 916. Florida Cooperative Extension Service, UF/IFAS, Gainesville.

Swancar, A. 1996. *Water Quality, Pesticide Occurrence, and Effects of Irrigation with Reclaimed Water at Golf Courses in Florida*. USGS, Water Resources Investigation Report 95-4250.

Toth, D.J. 1999. Water Quality and Isotope Concentrations from Selected Springs in the St. Johns River Water Management District. SJRWMD Technical Publication SJ99-2.

Toth. D.J. Water Quality and Isotope Concentrations from Selected Springs in the St. Johns River Water Management District. SJRWMD Technical Publication SJ2003-1.

Toth, D.J. and C. Fortich. 2002. Nitrate Concentrations in the Wekiva Groundwater Basin with Emphasis on Wekiva Springs. SJRWMD Technical Publication SJ2002-2, 76 p.

UCF. 2009. Wekiva Residential Fertilizer Practices. Prepared for FDEP.

UF/IFAS and SRWMD, 2006. *Evaluating Effectiveness of Best Management Practices for Animal Waste and Fertilizer Management to Reduce Nutrient Inputs into Ground Water in the Suwannee River Basin*. Section 319 Nonpoint Source Pollution Control Program, Education/Training Demonstration Project Final Report.

UF Citrus Research and Education Center. 2007. Ridge Citrus Nitrate BMP Verification. http://128.227.177.113/bmp/Background.html, accessed 2/9/2010, last updated 3/2/2007. USDA. 2006. "National Agricultural Statistics Service." Accessed at http://www.nass. usda.gov/ index.asp.

USDA. 2005. "National Agricultural Statistics Service Florida Reports and Statistics." Accessed at http://www.nass.usda.gov/fl/.

USEPA. 2006a. "Mid Atlantic Integrated Assessment: Nitrogen." Accessed at http://www.epa. gov/maia/html/nitrogen.html.

USEPA. 2006b. "Golf Course Adjustment Factors for Modifying Estimated Drinking Water Concentrations and Estimated Environmental Concentrations Generated by Tier I (FIRST) and Tier II (PRZM/EXAMS) Models." Accessed October 2006 at http://www.epa. gov/oppefed1/models/water/golf_course_adjustment_factors.htm.

USEPA. 1999. *Background Report on Fertilizer Use, Contaminants and Regulations*. EPA 747-R-98-003. National Program Chemicals Division, Office of Pollution Prevention and Toxics.

Wekiva River Basin Coordinating Committee. 2004. Recommendations for Enhanced Land Use Planning Strategies and Development Standards to Protect Water Resources of the Wekiva River Basin. 54 p.

Wible, C. 2007. Email correspondence to Robert Mattson. Subject: Fertilizer use in the Wekiva River basin, Florida. Dated: December 13, 2007.

Woodard, K.R., E.C. French, L.A. Sweat, D.A. Graetz, L.E. Sollenberger, B. Macoon, K.M. Portier, B.L. Wade, S.J. Rymph, G.M. Prine, and H.H. Van Horn. 2002. "Nitrogen Removal and Nitrate Leaching for Forage Systems Receiving Dairy Effluent." Journal of Environmental Quality, Vol. 31, pp. 1980-1992.

Yeager, T. and G. Cashion. 1993. "Controlled-Release Fertilizers Affect Nitrate Nitrogen Runoff from Container Plants." Hort Technology, Vol. 3, No. 2, pp. 174-177.

Yeager, T., R. Wright, D. Fare, C. Gilliam, J. Johnson, T. Bilderback, and R. Zondag. 1993. "Six State Survey of Container Nursery Nitrate Nitrogen Runoff." Journal of Environmental Horticulture, Vol. 11, No. 4, pp. 206-208.

York, D. 2007. Nitrogen Removal by Reuse Systems, email communication from York (FDEP) to Richard Drew (FDEP); copy in Appendix C).

Zekri, M., T. Obreza, and A. Schumann. 2005. "Increasing Efficiency and Reducing Costs of Citrus Nutritional Programs." Fact Sheet SL222, Soil and Water Science Department, Florida Cooperative Extension Service, UF/IFAS.

Appendix H

Alternate Loading Estimate for the Wekiva Study Area

Appendix H
Alternate Loading Estimate for the Wekiva Study Area

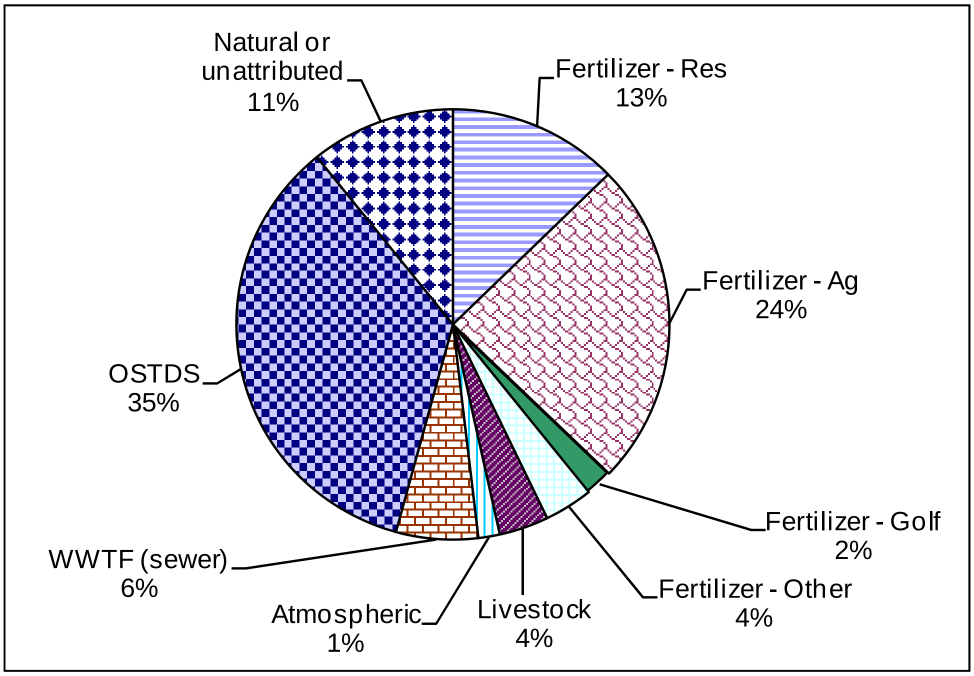
This report focused on estimating sources of nitrate to the Wekiva River Basin, including the watershed of the Wekiva River and the springsheds for springs discharging to the Wekiva River. The basin is generally consistent with the Wekiva Study Area (WSA) as defined by F.S. Chapter 369.316, but not identical. The Wekiva Basin, which includes portions of Lake, Orange, Seminole, and Marion Counties, has an area of 415,000 acres (ac) [648 square miles (mi^2)], which is 37% larger in area than the WSA (303,000 ac or 473 mi^2). The population of the Wekiva Basin was approximately 423,000 in 2000, or 9% greater than the population of the WSA (388,000 in 2000). The portion of the Wekiva Basin that is not part of the WSA is generally to the west and southwest of the WSA, in Lake County, and in areas that are less densely populated. The additional area included within the Wekiva Basin for the purpose of this study is somewhat more rural and agricultural than the portion of the Basin included within the WSA.

It is appropriate that this study address all areas contributing water to the Wekiva River. However, it is possible that some administrative actions would only address the Wekiva Study Area considering its special designation by F.S. Chapter 369.316. Therefore the FDEP requested that analogous results be calculated for the WSA. These calculations would also permit more transparent comparison with comparable estimates made by Roeder (2008) for the WSA. This Appendix presents loadings apportioned by major source categories for the WSA only. These estimates were generally made following the same methodology as described in the main body of the report, but limiting the area of interest to the WSA.

Figure H-1 presents the attribution of nitrate loadings by source type for the WSA. Total loading to the Wekiva River from the WSA is 1,100 MT/yr (compared with 1,800 MT/yr for the entire basin). This estimate of total load compares favorably with the estimate by Roeder (2008). Roeder estimated that 1,150 MT/yr of total nitrogen reach groundwater from the WSA; while the MACTEC procedure finds 1,100 MT/yr of nitrate nitrogen reach surface and ground waters of the basin.

The relative contributions of the major source types are similar to those obtained by Roeder (2008), who estimated total nitrogen loading to groundwater only. The results presented here are for nitrate loading to both surface and ground water discharging to the Wekiva River. Roeder (2008) estimated the OSTDS contribution to nitrogen loading of groundwater of 39%; while in this estimate of nitrate loading to surface and ground water discharging to the Wekiva River, OSTDS contribute 35%. Other meaningful differences include the contribution of livestock and residential fertilizer. Roeder's livestock contribution is 11%, while this estimate is only 4%. Roeder's residential fertilizer contribution is 8%, while this procedure produces an estimate of 13%. Overall the procedures used here produced similar results to those reported by Roeder (2008).

Figure H-1. Nitrate Loadings to the Wekiva Basin from the Wekiva Study Area, Partitioned by Source



Appendix H. Loading Summary

Wekiva River Basin Nitrate Sourcing Study

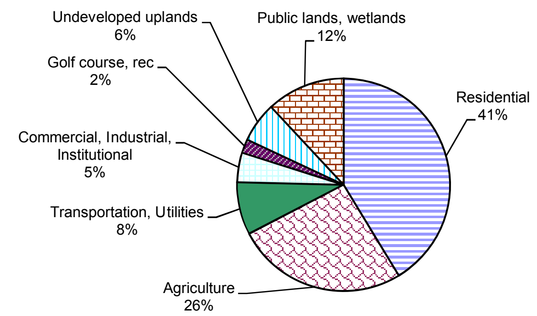
Wekiva Study Area Only

Table 1. Loadings Inputs by Land Use and Source Type

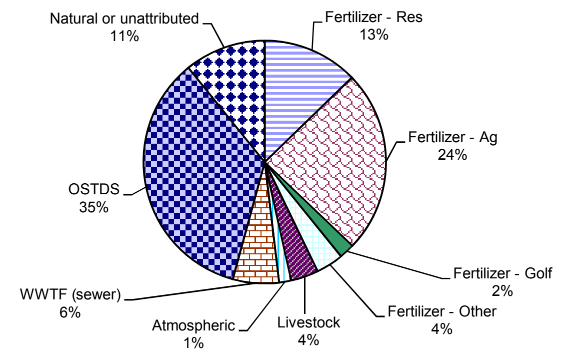
LAND USE	
Land Use Description	**Nitrate in GW mg/L**
Feeding operations	18
Row crops	23
Golf courses	8
Improved pastures, unimproved pastures, woodland pastures, horse farms, cropland and pastureland	5.5
Tree crops	15
Nurseries, vineyards, ornamentals, floriculture, specialty farms	6
Field crops, sod farms	4
Low, medium and high density residential, commercial, institutional, recreational, transportation	2
Industrial, open land, rural areas, upland nonforested, upland forests, water, wetlands, barren land, extractive	0.1
SOURCE TYPE	
Septic Tanks	
Loading Rate lb N/year	16.3
Livestock Waste	
Pasture Cattle/acre	0.3
Nitrate from Cattle kg/year	56
Pasture Fertilizer	
Loading Rate kg/ha/year	63
Atmospheric Deposition	
"Natural" groundwater concentration mg/L	0.1
Domestic Wastewater - Disposed	
to Ground Water MT/year	60
to Surface Water MT/year	10
Loading %	88%
Domestic Wastewater - Reused	
MT/year	31
Reused Water Loading Percent	20%

0

Loadings by Land Use*



* - same figure as Figure 3.4 in Section 3.2.



* - same figure as Figure 3.2 in Section 3.2.

Prepared by: WAT 1/7/10
Checked by: JAT 2/8/10

0

Table 2. Loadings Results by Land Use and Source Type

Loadings by Land Use

Land Use Type	Nitrate in GW (mg/L) (see Table 1)	Recharge Rates (MT/year): No data	Recharge Rates (MT/year): Discharge Area	Recharge Rates (MT/year): 0 to 4 in	Recharge Rates (MT/year): 4 to 8 in/yr	Recharge Rates (MT/year): 8 to 12 in/yr	Recharge Rates (MT/year): 12 to 20 in/yr	Recharge Rates (MT/year): more than 20 in/yr	Subtotal (excluding No Data areas): MT/yr	Subtotal (excluding No Data areas): MT/acre/yr	Concentration Total (including: MT/yr	Concentration Total (including: kg/ha/yr	Weighted Average Recharge Rate: in/yr	OWTS: # Tanks	OWTS: Loading from OWTS (MT/yr)	Domestic Wastewater [(a)]: Reused (MT/yr)	Domestic Wastewater [(a)]: Disposed (MT/yr)	Stormwater: Stormwater - Diffuse (MT/yr)	Stormwater: Stormwater - Direct (MT/yr)	WWTF to Surface Water (MT/yr)	GRAND TOTAL (MT/yr)
1100: Residential, low density - less than 2 dwelling units/acre	2.0	0.00	0.00	0.68	4.50	7.00	13.65	11.14	36.96	2.45E-03	36.96	6.1	11.9	4,859	35.96	0.23		10.85	6.29		90.29
1200: Residential, medium density - 2-5 dwelling units/acre	2.0	0.00	0.00	0.76	9.74	16.54	22.62	7.47	57.12	2.16E-03	57.12	5.3	10.5	35,073	259.55	1.34		21.28	20.48		359.76
1300: Residential, high density - 6 or more dwelling units/acre	2.0	0.00	0.00	0.23	1.75	3.22	6.05	3.06	14.30	2.34E-03	14.30	5.8	11.4	5,499	40.69	0.39		6.31	7.71		69.40
1400: Commercial and services	2.0	0.00	0.00	0.19	1.79	3.08	5.62	1.11	11.79	2.18E-03	11.79	5.4	10.6	1,204	8.91	0.51		4.38	9.04		34.64
1500: Industrial	0.1	0.00	0.00	0.00	0.04	0.08	0.09	0.04	0.25	1.16E-04	0.25	0.3	11.3	380	2.81	0.03		3.32	3.12		9.54
1600: Extractive	0.1	0.00	0.00	0.00	0.01	0.02	0.06	0.03	0.12	1.45E-04	0.12	0.4	14.1	9	0.07	0.00		0.00	0.00		0.19
1700: Institutional	2.0	0.00	0.00	0.03	0.56	0.83	1.79	1.08	4.29	2.53E-03	4.29	6.3	12.3	184	1.36	0.06		3.23	3.52		12.47
1800: Recreational	2.0	0.00	0.00	0.02	0.18	0.44	0.31	0.26	1.22	1.89E-03	1.22	4.7	9.2	37	0.27	0.08		0.00	0.00		1.57
1820: Golf courses	8.0	0.00	0.00	0.17	1.04	3.88	8.49	7.95	21.54	1.15E-02	21.54	28.5	14.0	98	0.73	0.34		1.42	0.79		24.82
1900: Open land	0.1	0.00	0.00	0.01	0.06	0.08	0.17	0.11	0.43	1.22E-04	0.43	0.3	11.9	493	3.65	0.10		0.00	0.00		4.17
2100: Cropland and pastureland	6.0	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.03	3.64E-03	0.03	9.0	5.9	0	0.00	0.00					0.03
2110: Improved pastures (monocult, planted forage crops)	5.5	0.00	0.00	1.58	8.86	10.59	27.02	28.54	76.60	6.94E-03	76.60	17.2	12.3	431	3.19	0.15		4.33	2.90		87.17
2120: Unimproved pastures	5.5	0.00	0.00	0.03	0.02	0.19	1.81	4.38	6.43	1.09E-02	6.43	26.9	19.3	32	0.24	0.01					6.68
2130: Woodland pastures	5.5	0.00	0.00	0.11	1.75	1.96	3.43	3.50	10.74	6.75E-03	10.74	16.7	11.9	35	0.26	0.07					11.08
2140: Row crops	23.0	0.00	0.00	0.13	7.43	0.91	1.13	0.00	9.60	1.55E-02	9.60	38.3	6.6	2	0.01	0.00		0.04			9.65
2150: Field crops	4.0	0.00	0.00	0.21	1.45	1.75	2.86	3.12	9.39	4.62E-03	9.39	11.4	11.2	63	0.47	0.14		0.49	0.78		11.26
2200: Tree crops	15.0	0.00	0.00	1.71	31.50	22.40	45.20	39.96	140.76	1.69E-02	140.76	41.9	11.0	319	2.36	0.09		1.57	0.35		145.14
2300: Feeding operations	18.0	0.00	0.00	0.00	0.39	0.42	1.67	0.00	2.49	2.16E-02	2.49	53.2	11.6	3	0.02	0.01		0.04	0.03		2.58
2400: Nurseries and vineyards	6.0	0.00	0.00	0.01	0.02	0.03	0.29	0.13	0.47	8.97E-03	0.47	22.1	14.5	4	0.03	0.00		1.61	0.22		2.34
2410: Tree nurseries	6.0	0.00	0.00	0.00	0.01	0.08	0.12	0.02	0.24	7.71E-03	0.24	19.0	12.5	2	0.01	0.00					0.26
2420: Sod farms	4.0	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25	8.24E-04	0.25	2.0	2.0	0	0.00	0.00					0.25
2430: Ornamentals	6.0	0.00	0.00	0.48	3.14	5.18	17.00	15.76	41.56	8.56E-03	41.56	21.1	13.9	480	3.55	0.05					45.16
2450: Floriculture	6.0	0.00	0.00	0.00	0.04	0.00	0.15	0.00	0.20	6.44E-03	0.20	15.9	10.4	3	0.02	0.00					0.22
2500: Specialty farms	6.0	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.06	7.46E-03	0.06	18.4	12.1	2	0.01	0.00		0.29	0.10		0.47
2510: Horse farms	5.5	0.00	0.00	0.17	1.03	0.79	1.84	0.83	4.65	5.42E-03	4.65	13.4	9.6	28	0.21	0.02					4.88
2540: Aquaculture*														0							
2600: Other open lands - rural	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	8.45E-05	0.01	0.2	8.2	5	0.04	0.01					0.06
3000: Upland Nonforested	0.1	0.00	0.00	0.03	0.21	0.28	0.68	0.55	1.74	1.27E-04	1.74	0.3	12.3	789	5.84	0.26					7.83
4000: Upland Forests (25% forested cover)	0.1	0.00	0.00	0.03	0.38	0.51	1.07	0.99	2.99	1.28E-04	2.99	0.3	12.4	1,325	9.81	0.70		6.18	7.39		27.06
5000: Water	0.1	0.00	0.00	0.15	0.15	0.14	0.16	0.03	0.64	5.19E-05	0.64	0.1	5.0		0.00	0.22		1.60	2.82		5.27
6000: Wetlands	0.1	0.00	0.00	0.08	0.21	0.13	0.14	0.09	0.64	6.36E-05	0.64	0.2	6.2	479	3.54	0.29		2.24	24.44		31.16
7000: Barren land	0.1	0.00	0.00	0.20	0.02	0.01	0.02	0.02	0.28	2.66E-05	0.28	0.1	2.6	73	0.54	0.09		0.00	0.00		0.91
8000: Transportation, Communication, and Utilities	2.0	0.00	0.00	0.11	1.10	1.96	2.83	1.06	7.07	2.20E-03	7.07	5.4	10.7	58	0.43	0.27	61.60	9.79	12.44	8.80	100.40
										TOTALS	**465**			**51,969**	**385**	**5.46**	**62**	**79**	**102**		**1107**

Loadings by Source Type

Land Use Type	Fertilizer: Residential (MT/yr)	Fertilizer: Agriculture (MT/yr)	Fertilizer: Golf Courses (MT/yr)	Fertilizer: Other (MT/yr)	Livestock (MT/yr)	Atmospheric Deposition (MT/yr)	WWTF (MT/yr)	OSTDS (MT/yr)	Natural or unattributed (MT/yr)	GRAND TOTAL (MT/yr)
1100: Residential, low density - less than 2 dwelling units/acre	43.57					1.85		35.96	8.69	90.06
1200: Residential, medium density - 2-5 dwelling units/acre	76.11					2.86		259.55	19.92	358.43
1300: Residential, high density - 6 or more dwelling units/acre	21.12					0.72		40.69	6.49	69.01
1400: Commercial and services				18.42		0.59		8.91	6.21	34.13
1500: Industrial						0.25		2.81	6.45	9.51
1600: Extractive						0.12		0.07	0.00	0.19
1700: Institutional				8.83		0.21		1.36	1.99	12.40
1800: Recreational				1.15		0.06		0.27	0.00	1.49
1820: Golf courses			22.30			0.27		0.73	1.18	24.48
1900: Open land						0.43		3.65	0.00	4.07
2100: Cropland and pastureland		0.02			0.01	0.00		0.00	0.00	0.03
2110: Improved pastures (monocult, planted forage crops)		48.71			29.87	1.39		3.19	3.86	87.02
2120: Unimproved pastures		3.81			2.51	0.12		0.24	0.00	6.67
2130: Woodland pastures		6.36			4.19	0.20		0.26	0.00	11.00
2140: Row crops		9.57				0.04		0.01	0.02	9.65
2150: Field crops		9.74				0.23		0.47	0.68	11.13
2200: Tree crops		140.72				0.94		2.36	1.03	145.05
2300: Feeding operations					2.47	0.01		0.02	0.07	2.57
2400: Nurseries and vineyards		1.32				0.01		0.03	0.98	2.33
2410: Tree nurseries		0.24				0.00		0.01	0.00	0.26
2420: Sod farms		0.24				0.01		0.00	0.00	0.25
2430: Ornamentals		40.87				0.69		3.55	0.00	45.11
2450: Floriculture		0.20				0.00		0.02	0.00	0.22
2500: Specialty farms		0.24				0.00		0.01	0.21	0.47
2510: Horse farms		2.75			1.81	0.08		0.21	0.00	4.86
2540: Aquaculture*										
2600: Other open lands - rural						0.01		0.04	0.00	0.04
3000: Upland Nonforested						1.74		5.84	0.00	7.58
4000: Upland Forests (25% forested cover)						2.99		9.81	13.57	26.36
5000: Water						0.64		0.00	4.42	5.05
6000: Wetlands						0.64		3.54	26.67	30.86
7000: Barren land						0.28		0.54	0.00	0.82
8000: Transportation, Communication, and Utilities				11.72		0.35	67.80	0.43	17.23	97.53
TOTALS	**141**	**269**	**22**	**40**	**41**	**18**	**68**	**385**	**120**	**1103**

Notes:

* Aquaculture row here is a place holder. No loadings were calculated for aquaculture land use, which is less than 0.005% of total acres.

(a) - Calculated from data in Appendix E, Table 2.

Prepared by: WAT 1/31/10

Checked by: JAT 2/8/10

Wekiva River and Basin Nitrate Sourcing Study
Wekiva Study Area Only

APPENDIX H. WASTEWATER FACILITIES SUMMARY

Table 1. Summary of groundwater, surface water, and reuse Total Nitrogen discharge.

		Current Condition			Implementation of 62-600.550 (WSA only)		
FACILITY ID	NAME	GW DISCHARGE (MT/YR)	SW DISCHARGE (MT/YR)	REUSE (MT/YR)	GW DISCHARGE (MT/YR)	SW DISCHARGE (MT/YR)	REUSE (MT/YR)
FLA010798	OCUD/NORTHWEST WATER RECLAMATION FACILITY	29.6	1.4	0.0	9.6	1.2	0.0
		18.0	0.0	0.0	5.1	0.0	0.0
FLA010818	APOPKA WRF - PROJECT ARROW	1.5	0.0	5.0	0.7	0.0	2.2
FL0036251	WEKIVA HUNT CLUB	6.2	8.8	19.0	1.4	2.0	4.3
FLA010815	OCOEE, CITY OF	1.4	0.0	7.1	1.0	0.0	5.2
FLA010865	ZELLWOOD STATION MHP	1.5	0.0	0.0	0.2	0.0	0.0
FLA010855	COCA-COLA/APOPKA FACILITY	0.0	0.0	0.0	0.0	0.0	0.0
FLA295965	EUSTIS - EASTERN	0.8	0.0	0.0	0.0	0.0	0.0
FLA010541	WEKIVA FALLS RESORT	0.3	0.0	0.0	0.3	0.0	0.0
FLA010851	CLARCONA RESORT CONDO	0.6	0.0	0.0	0.3	0.0	0.0
FLA010833	MONTEREY MUSHROOM FARM (TERRY FARMS)	0.0	0.0	0.0	0.0	0.0	0.0
FLA010498	SEMINOLE SPRINGS ELEMENTARY SCHOOL WWTF	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL DISCHARGE (MT/YR)	**60**	**10**	**31**	**19**	**3**	**12**
	GRAND TOTAL DISCHARGE (MT/YR)		**101**			**34**	
Notes:	WSA Subtotals	60	10	31	19	3	12

MT/YR = metric tons per year

(yellow highlight) = indicates change in amount of groundwater discharge due to implementation of 62-600.550, FAC.

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Checked by: WAT 2/8/10

Wekiva River and Basin Nitrate Sourcing Study
Wekiva Study Area Only

APPENDIX H. WASTEWATER FACILITIES SUMMARY

Table 2. Groundwater, surface water, and reuse nitrate discharge by facility, current condition.

GW DISCHARGE (MT/YR)	SW DISCHARGE (MT/YR)	REUSE (MT/YR)	FACILITY ID	NAME	CAPACITY (MGD)	GROUNDWATER DISCHARGE	ALLOWABLE DISCHARGE (MGD)	ACTUAL DISCHARGE (MGD)	NITRATE CONCENTRATION (MG/L)	TN RELEASE (MT/YR)	SURFACE WATER DISCHARGE	ALLOWABLE DISCHARGE (MGD)	ACTUAL DISCHARGE (MGD)	NITRATE CONCENTRATION (MG/L)	TN RELEASE (MT/YR)	RECLAMATION/REUSE	ALLOWABLE DISCHARGE	ACTUAL DISCHARGE	NITRATE CONCENTRATION (MG/L)	TN RELEASE (MT/YR)	WAVA PROTECTION ZONE	WSA
29.6	1.4	0.0	FLA010798	OCUD/NORTHWEST WATER RECLAMATION FACILITY	7.9	RIBS	4.5	3.3	5.7	29.6	Effluent to Lake Marden	3		0.3	1.4				5.7	0.0	SECONDARY	YES
18.0	0.0	0.0				slow rate restricted public access system (enhanced wetlands)	3	1.762	6.5	18.0											SECONDARY	YES
1.5	0.0	5.0	FLA010818	APOPKA WRF - PROJECT ARROW	4	slow rate restricted public access land application system	2	0.6	1.6	1.5						slow rate public access land application system	4.0	1.99	1.6	5.0	SECONDARY	YES
6.2	8.8	19.0	FL0036251	WEKIVA HUNT CLUB	2.9	RIBS	0.4	0.423	9.3	6.2	surface water discharge Sweetwater Creek/Cove Lake	2.9	0.599	9.3	8.8	slow rate public access reuse system	2.603	1.298	9.3	19.0	SECONDARY	YES
1.4	0.0	7.1	FLA010815	OCOEE, CITY OF	1.6	RIBS	0.35	0.271	3.2	1.4						slow rate public access reuse system 2.25		1.4	3.2	7.1	SECONDARY	YES
1.5	0.0	0.0	FLA010865	ZELLWOOD STATION MHP	0.3	RIBS	0.3	0.137	7	1.5											PRIMARY YES	
0.02	0.0	0.0	FLA010855	COCA-COLA/APOPKA FACILITY	0.255	land application system (spray irrigation field)	0.117	0.053	0.21	0.02											SECONDARY	YES
0.8	0.0	0.0	FLA295965	EUSTIS - EASTERN	0.19	RIBS	0.19	0.022	23	0.8											SECONDARY	YES
0.3	0.0	0.0	FLA010541	WEKIVA FALLS RESORT	0.0990	RIBS	0.099	0.099	2	0.3											SECONDARY	YES
0.6	0.0	0.0	FLA010851	CLARCONA RESORT CONDO	0.08	RIBS	0.08	0.06	6	0.6											SECONDARY	YES
0.0	0.0	0.0	FLA010833	MONTEREY MUSHROOM FARM (TERRY FARMS)	0.076	perc ponds	0.076	0.061	0.3	0.03											SECONDARY	YES
0.0	0.0	0.0	FLA010498	SEMINOLE SPRINGS ELEMENTARY SCHOOL WWTF	0.01	absorption field/drainfield	0.01	0.003	4	0.02											TERTIARY	YES
TOTAL DISCHARGE (MT/YR) 60	10	31		**TOTAL ALLOWABLE DISCHARGE** **TOTAL ACTUAL DISCHARGE**	**22.9220** **12.0780**		11.1220	6.7910				5.9	0.599				8.853	4.688				
GRAND TOTAL DISCHARGE (MT/YR)	**101**																					

Notes:
MT/YR = metric tons per year
MGD = million gallons per day
MG/L = milligrams per liter

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Wekiva River and Basin Nitrate Sourcing Study
Wekiva Study Area Only

APPENDIX H. WASTEWATER FACILITIES SUMMARY

Table 3. Groundwater, surface water, and reuse nitrate discharge by facility from implementation of 62-600.550, FAC (Wekiva Study Area only).

	GW DISCHARGE (MT/YR)	SW DISCHARGE (MT/YR)	REUSE (MT/YR)	FACILITY ID	NAME	CAPACITY (MGD)	GROUNDWATER DISCHARGE	ALLOWABLE DISCHARGE (MGD)	ACTUAL DISCHARGE (MGD)	CONCENTRATION (MG/L)	RELEASE (MT/YR)	SURFACE WATER DISCHARGE	ALLOWABLE DISCHARGE (MGD)	ACTUAL DISCHARGE (MGD)	CONCENTRATION (MG/L)	RELEASE (MT/YR)	RECLAMATION/RE USE	ALLOWABLE DISCHARGE	ACTUAL DISCHARGE	CONCENTRATION (MG/L)	RELEASE (MT/YR)	WAVA PROTECTION ZONE	WSA
	9.6	1.2	0.0	FLA010798	OCUD/NORTHWEST WATER RECLAMATION FACILITY	7.9	RIBS	4.5	3.3	2.1	9.6	Effluent to Lake Marden	3		0.3	1.2						SECONDARY	YES
	5.1	0.0	0.0	FLA010798	OCUD/NORTHWEST WATER RECLAMATION FACILITY	7.9	slow rate restricted public access system (enhanced wetlands)	3	1.762	2.1	5.1											SECONDARY	YES
	0.7	0.0	2.2	FLA010818	APOPKA WRF - PROJECT ARROW	4	slow rate restricted public access land application system	2	0.6	0.8	0.7						slow rate public access land application system	4	1.99	0.8	2.2	SECONDARY	YES
	1.4	2.0	4.3	FL0036251	Sanlando Utilities;'WEKIVA HUNT CLUB	2.9	RIBS	0.4	0.423	2.4	1.4	surface water discharge Sweetwater Creek/Cove Lake	2.9	0.599	2.4	2.0	slow rate public access reuse system	2.603	1.298	2.4	4.3	SECONDARY	YES
	1.0	0.0	5.2	FLA010815	OCOEE, CITY OF	1.6	RIBS	0.35	0.271	2.7	1.0						slow rate public access reuse system	2.25	1.4	2.7	5.2	SECONDARY	YES
	0.2	0.0	0.0	FLA010865	ZELLWOOD STATION MHP	0.3	RIBS	0.3	0.137	1	0.2											PRIMARY YES	
	0.0	0.0	0.0	FLA010855	COCA-COLA/APOPKA FACILITY	0.255	land application system (spray irrigation field)	0.117	0.053	0.21	0.0											SECONDARY	YES
	0.0	0.0	0.0	FLA295965	EUSTIS - EASTERN	0.19	RIBS	0.19	0.022	1.6	0.0											SECONDARY	YES
	0.3	0.0	0.0	FLA010541	Wekiva Falls Resort	0.0990	RIBS	0.099	0.099	2	0.3											SECONDARY	YES
	0.3	0.0	0.0	FLA010851	CLARCONA RESORT CONDO	0.08	RIBS	0.08	0.06	3.3	0.3											SECONDARY	YES
	0.0	0.0	0.0	FLA010833	MONTEREY MUSHROOM FARM (TERRY FARMS)	0.076	perc ponds	0.076	0.061	0.3	0.0											SECONDARY	YES
	0.0	0.0	0.0	FLA010498	SEMINOLE SPRINGS ELEMENTARY SCHOOL WWTF	0.01	absorption field/drainfield	0.01	0.003	4	0.0											TERTIARY	YES
TOTAL DISCHARGE (MT/YR)	**19**	**3**	**12**	**TOTAL ALLOWABLE DISCHARGE** **TOTAL ACTUAL DISCHARGE**		**22.9220** **12.0780**		11.1220	6.7910				5.9	0.599				8.853	4.688				
GRAND TOTAL DISCHARGE (MT/YR)	**34**																						

Notes:
MT/YR = metric tons per year
MGD = million gallons per day
MG/L = milligrams per liter
= change in discharge/concentration from current condition

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Checked by: WAT 2/11/10

Webpage: http://www.dep.state.fl.us/water/wekiva/index.htm

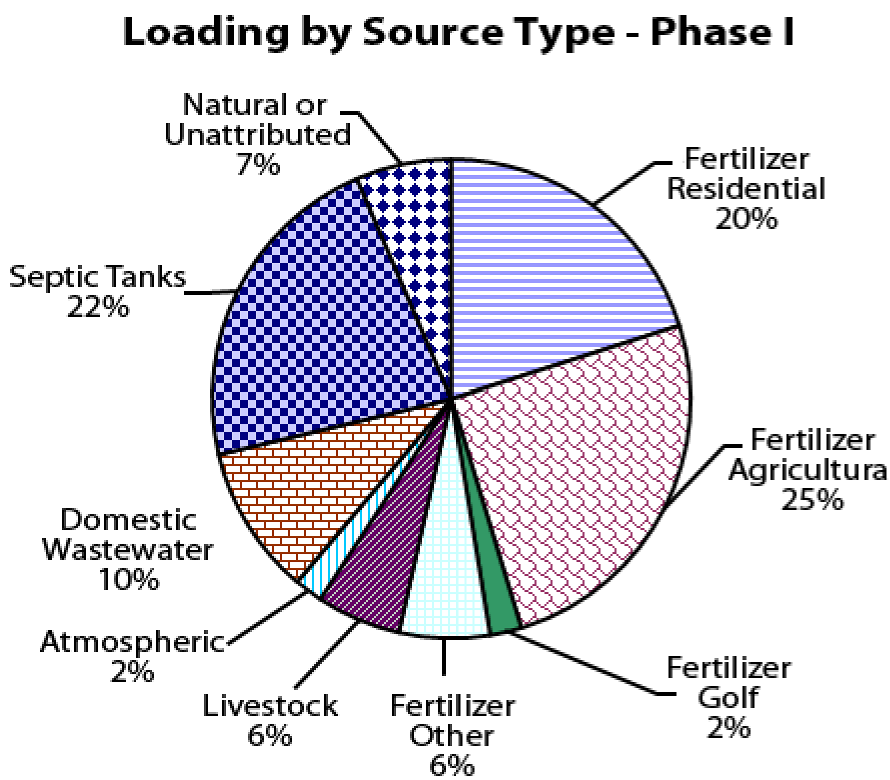
Wekiva Nitrate Sourcing

In the 2006-07 General Appropriations Act, line item 1798, the Florida Legislature established the following requirement for the department:

> "From the funds in Specific Appropriation 1798, $250,000 from the General Revenue Fund is provided to conduct a Wekiva River and Florida Aquifer study to determine nitrate impacts to the system."

The Divisions of Water Resource Management and Environmental Assessment & Restoration have undertaken the required study in conjunction with the St. Johns River Water Management District. It was divided into two phases.

Phase I



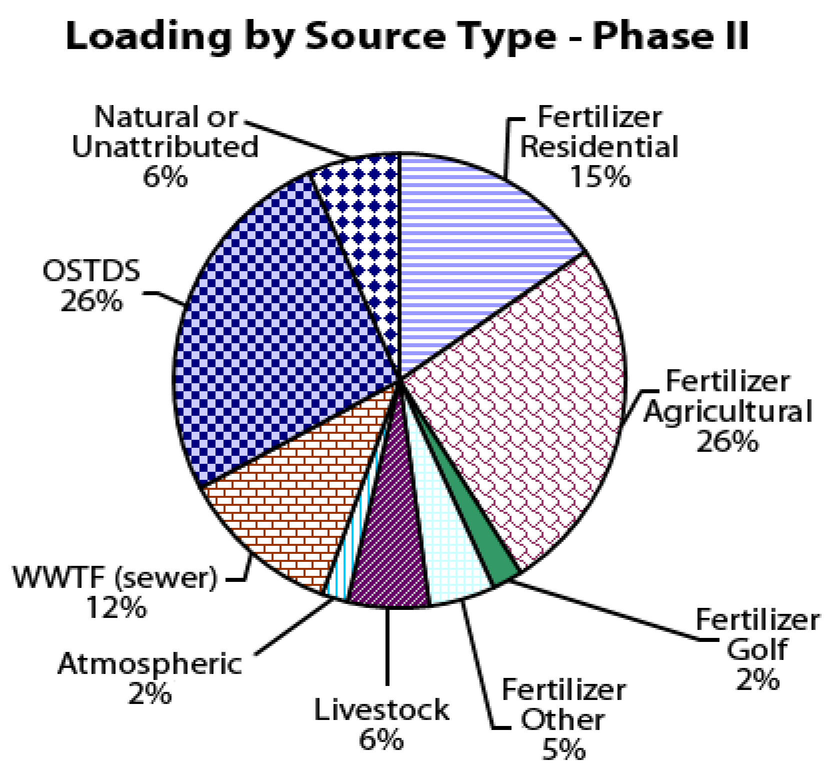
Phase I of the study involved an assessment of available data on nitrate impacts to the Wekiva River and Floridan aquifer system, preliminary identification of relative nitrate contributions to water resources in the area and an identification of data gaps to be filled. The work was performed under contract by MACTEC, Inc., a large consulting company that specializes in a wide variety of scientific and engineering disciplines. MACTEC's findings on the preliminar issues it was contracted to investigate are available in the Phase I Report, Wekiva River Basin Nitrate Sourcing Study, prepared for the department and the St. Johns River Water Management District. (The document is large, with 183 pages of text, graphs, charts and maps, and it will take time to download.)

As noted, the Phase 1 MACTEC report represents a preliminary investigation based on existing data. It is not a final accounting of nitrate impacts in the Wekiva area nor does it reflect final conclusions or recommendations associated with the study the department wa charged with conducting. Phase I estimates of nitrate loadings to the Wekiva Basin, Software.

partitioned by source, are shown in the figure to the right.

Phase II

Phase II of the department's study tested and supplemented the work MACTEC did in Phase I in order to provide an effective assessment of nutrient impacts on water quality i the Wekiva area and inform future public policy decisions at the state, regional and local levels. The final Phase II report can now be downloaded.



Phase II re-visited an important are of uncertainty identified by the Phase I study - the effects of residential fertilizer. To reduce uncertainty associated wit this source type, FDEP funded the University of Central Florid to survey residential fertilizer practices and lawn management activities in th Wekiva Study Area (WSA). I addition, the St. Johns River Water Management District (SJRWMD) conducted field studies of nitrate concentrations in shallow ground water from fertilizer application in residential areas with the Wekiva Springs springshed.

Links to additional reports

Consider the following:

> Nitrate loading from septic tanks has been documented in several parts of Florida, including the Wekiva Study Area. The findings of DEP's Phase I study are generally consistent with the Department of Health Final Project Report, Nitrogen Impact of Onsite Sewage Treatment and Disposal Systems in the Wekiva Study Area, dated June 30, 2007. As well as the more recent Florida Department of Health companion studies in 2008, including groundwater monitoring in the WSA.
>
> Domestic wastewater, a DEP-regulated source, is routinely monitored against specific pollutant limits and therefore has a well known and documentable source contribution.
>
> Agricultural fertilizers have been well studied and reliable data describing nitrate loadings from various agricultural activities is readily available.

The Phase I estimate for source contribution for residential fertilizer changed (compare Phase I chart above to Phase II chart below) as a result of the Phase II study, and the relative impact of other source contributions were adjusted. This Final Report presents a best estimate of inputs of nitrogen to the Wekiva Basin and nitrate loadings to the River, incorporating findings from recent state-funded studies within the study area and related technical information. The report also addresses stakeholder comments on the Phase I study.

If you have questions about the Phase II study, please contact Bonnie Hall at bonnie.hall@dep.state.fl.us.

Domestic Wastewater Treatment in the Wekiva Study Area

DEP's original 2004 study, A Strategy for Water Quality Protection: Wastewater Treatment in the Wekiva Study Area, is also available. This led to development of DEP's specific Wekiva wastewater rules, 62-600.550, Florida Administrative Code.

subsection (5) of that section is renumbered as subsection (6), and new subsections (5) and (7) are added to that section, to read:

381.0065 Onsite sewage treatment and disposal systems; regulation.—

(1) LEGISLATIVE INTENT.—

(a) It is the intent of the Legislature that proper management of onsite sewage treatment and disposal systems is paramount to the health, safety, and welfare of the public. It is further the intent of the Legislature that the department shall administer an evaluation program to ensure the operational condition of the system and identify any failure with the system.

(b) It is the intent of the Legislature that where a publicly owned or investor-owned sewerage system is not available, the department shall issue permits for the construction, installation, modification, abandonment, or repair of onsite sewage treatment and disposal systems under conditions as described in this section and rules adopted under this section. It is further the intent of the Legislature that the installation and use of onsite sewage treatment and disposal systems not adversely affect the public health or significantly degrade the groundwater or surface water.

(4) PERMITS; INSTALLATION; AND CONDITIONS.—A person may not construct, repair, modify, abandon, or operate an onsite sewage treatment and disposal system without first obtaining a permit approved by the department. The department may issue permits to carry out this section, but shall not make the issuance of such permits contingent upon prior approval by the Department of

Environmental Protection, except that the issuance of a permit for work seaward of the coastal construction control line established under s. 161.053 shall be contingent upon receipt of any required coastal construction control line permit from the Department of Environmental Protection. A construction permit is valid for 18 months from the issuance date and may be extended by the department for one 90-day period under rules adopted by the department. A repair permit is valid for 90 days from the date of issuance. An operating permit must be obtained prior to the use of any aerobic treatment unit or if the establishment generates commercial waste. Buildings or establishments that use an aerobic treatment unit or generate commercial waste shall be inspected by the department at least annually to assure compliance with the terms of the operating permit. The operating permit for a commercial wastewater system is valid for 1 year from the date of issuance and must be renewed annually. The operating permit for an aerobic treatment unit is valid for 2 years from the date of issuance and must be renewed every 2 years. If all information pertaining to the siting, location, and installation conditions or repair of an onsite sewage treatment and disposal system remains the same, a construction or repair permit for the onsite sewage treatment and disposal system may be transferred to another person, if the transferee files, within 60 days after the transfer of ownership, an amended application providing all corrected information and proof of ownership of the property. There is no fee associated with the processing of this supplemental information. A person may not contract to construct, modify, alter, repair, service, abandon, or maintain any portion of an onsite sewage treatment and disposal system without being registered under part III of chapter 489. A property owner who personally performs construction, maintenance, or repairs to a system serving his or her own owner-occupied single-family residence is exempt from registration requirements for performing such construction, maintenance, or repairs on that residence, but is subject to all permitting requirements. A municipality or political subdivision of the state may not issue a building or plumbing permit for any building that requires the use of an onsite sewage treatment and disposal system unless the owner or builder has received a construction permit for such system from the department. A building or structure may not be occupied and a municipality, political subdivision, or any state or federal agency may not authorize occupancy until the department approves the final installation of the onsite sewage treatment and disposal system. A municipality or political subdivision of the state may not approve any change in occupancy or tenancy of a building that uses an onsite sewage treatment and disposal system until the department has reviewed the use of the system with the proposed change, approved the change, and amended the operating permit.

(l) For the Florida Keys, the department shall adopt a special rule for the construction, installation, modification, operation, repair, maintenance, and performance of onsite sewage treatment and disposal systems which considers the unique soil conditions and ~~which considers~~ water table elevations, densities, and setback requirements. On lots where a setback distance of 75 feet from surface waters, saltmarsh, and buttonwood association habitat areas cannot be met, an injection well, approved and permitted by the department, may be used for disposal of effluent from onsite sewage treatment and disposal systems. The following additional requirements apply to onsite sewage treatment and disposal systems in Monroe County:

1. The county, each municipality, and those special districts established for the purpose of the collection, transmission, treatment, or disposal of sewage shall ensure, in accordance with the specific schedules adopted by the Administration Commission under s. 380.0552, the completion of onsite sewage treatment and disposal system upgrades to meet the requirements of this paragraph.

2. Onsite sewage treatment and disposal systems must cease discharge by December 31, 2015, or must comply with department rules and provide the level of treatment which, on a permitted annual average basis, produces an effluent that contains no more than the following concentrations:

a. Biochemical Oxygen Demand (CBOD5) of 10 mg/l.

b. Suspended Solids of 10 mg/l.

c. Total Nitrogen, expressed as N, of 10 mg/l.

d. Total Phosphorus, expressed as P, of 1 mg/l.

In addition, onsite sewage treatment and disposal systems discharging to an injection well must provide basic disinfection as defined by department rule.

3. On or after July 1, 2010, all new, modified, and repaired onsite sewage treatment and disposal systems must provide the level of treatment described in subparagraph 2. However, in areas scheduled to be served by central sewer by December 31, 2015, if the property owner has paid a connection fee or assessment for connection to the central sewer system, an

onsite sewage treatment and disposal system may be repaired to the following minimum standards:

a. The existing tanks must be pumped and inspected and certified as being watertight and free of defects in accordance with department rule; and

b. A sand-lined drainfield or injection well in accordance with department rule must be installed.

4. Onsite sewage treatment and disposal systems must be monitored for total nitrogen and total phosphorus concentrations as required by department rule.

5. The department shall enforce proper installation, operation, and maintenance of onsite sewage treatment and disposal systems pursuant to this chapter, including ensuring that the appropriate level of treatment described in subparagraph 2. is met.

6. The authority of a local government, including a special district, to mandate connection of an onsite sewage treatment and disposal system is governed by section 4 of chapter 99-395, Laws of Florida.

(5) EVALUATION AND ASSESSMENT.—

(a) Beginning January 1, 2011, the department shall administer an onsite sewage treatment and disposal system evaluation program for the purpose of assessing the fundamental operational condition of systems and identifying any failures within the systems. The department shall adopt rules implementing the program standards, procedures, and requirements, including, but not limited to, a schedule for a 5-year evaluation cycle, requirements for the pump-out of a system or repair of a failing system, enforcement procedures for failure of a system owner to obtain an evaluation of the system, and failure of a contractor to timely submit evaluation results to the department and the system owner. The department shall ensure statewide implementation of the evaluation and assessment program by January 1, 2016.

(b) Owners of an onsite sewage treatment and disposal system, excluding a system that is required to obtain an operating permit, shall have the system evaluated at least once every 5 years to assess the fundamental operational condition of the system, and identify any failure within the system.

(c) All evaluation procedures must be documented and nothing in this subsection limits the amount of detail an evaluator may provide at his or her professional discretion. The evaluation must include a tank and drainfield evaluation, a written assessment of the condition of the system, and, if necessary, a disclosure statement pursuant to the department's procedure.

(d)1. Systems being evaluated that were installed prior to January 1, 1983, shall meet a minimum 6-inch separation from the bottom of the drainfield to the wettest season water table elevation as defined by department rule. All drainfield repairs, replacements or modifications to systems installed prior to January 1, 1983, shall meet a minimum 12-inch separation from the bottom of the drainfield to the wettest season water table elevation as defined by department rule.

2. Systems being evaluated that were installed on or after January 1, 1983, shall meet a minimum 12-inch separation from the bottom of the drainfield to the wettest season water table elevation as defined by department rule. All drainfield repairs,

replacements or modification to systems developed on or after January 1, 1983, shall meet a minimum 24-inch separation from the bottom of the drainfield to the wettest season water table elevation.

(e) If documentation of a tank pump-out or a permitted new installation, repair, or modification of the system within the previous 5 years is provided, and states the capacity of the tank and indicates that the condition of the tank is not a sanitary or public health nuisance pursuant to department rule, a pump-out of the system is not required.

(f) Owners are responsible for paying the cost of any required pump-out, repair, or replacement pursuant to department rule, and may not request partial evaluation or the omission of portions of the evaluation.

(g) Each evaluation or pump-out required under this subsection must be performed by a septic tank contractor or master septic tank contractor registered under part III of chapter 489, a professional engineer with wastewater treatment system experience licensed pursuant to chapter 471, or an environmental health professional certified under chapter 381 in the area of onsite sewage treatment and disposal system evaluation.

(h) The evaluation report fee collected pursuant to s. 381.0066(2)(b) shall be remitted to the department by the evaluator at the time the report is submitted.

(i) Prior to any evaluation deadline, the department must provide a minimum of 60 days' notice to owners that their systems must be evaluated by that deadline. The department may include a copy of any homeowner educational materials developed pursuant to this section which provides information on the proper maintenance of onsite sewage treatment and disposal systems.

(6) ~~(5)~~ ENFORCEMENT; RIGHT OF ENTRY; CITATIONS.—

(a) Department personnel who have reason to believe noncompliance exists, may at any reasonable time, enter the premises permitted under ss. 381.0065-381.0066, or the business premises of any septic tank contractor or master septic tank contractor registered under part III of chapter 489, or any premises that the department has reason to believe is being operated or maintained not in compliance, to determine compliance with the provisions of this section, part I of chapter 386, or part III of chapter 489 or rules or standards adopted under ss. 381.0065-381.0067, part I of chapter 386, or part III of chapter 489. As used in this paragraph, the term "premises" does not include a residence or private building. To gain entry to a residence or private building, the department must obtain permission from the owner or occupant or secure an inspection warrant from a court of competent jurisdiction.

(b)1. The department may issue citations that may contain an order of correction or an order to pay a fine, or both, for violations of ss. 381.0065-381.0067, part I of chapter 386, or part III of chapter 489 or the rules adopted by the department, when a violation of these sections or rules is enforceable by an administrative or civil remedy, or when a violation of these sections or rules is a misdemeanor of the second degree. A citation issued under ss. 381.0065-381.0067, part I of chapter 386, or part III of chapter 489 constitutes a notice of proposed agency action.

2. A citation must be in writing and must describe the particular nature of the violation, including specific reference to the provisions of law or rule allegedly violated.

3. The fines imposed by a citation issued by the department may not exceed $500 for each violation. Each day the violation exists constitutes a separate violation for which a citation may be issued.

4. The department shall inform the recipient, by written notice pursuant to ss. 120.569 and 120.57, of the right to an administrative hearing to contest the citation within 21 days after the date the citation is received. The citation must contain a conspicuous statement that if the recipient fails to pay the fine within the time allowed, or fails to appear to contest the citation after having requested a hearing, the recipient has waived the recipient's right to contest the citation and must pay an amount up to the maximum fine.

5. The department may reduce or waive the fine imposed by the citation. In determining whether to reduce or waive the fine, the department must consider the gravity of the violation, the person's attempts at correcting the violation, and the person's history of previous violations including violations for which enforcement actions were taken under ss. 381.0065-381.0067, part I of chapter 386, part III of chapter 489, or other provisions of law or rule.

6. Any person who willfully refuses to sign and accept a citation issued by the department commits a misdemeanor of the second degree, punishable as provided in s. 775.082 or s. 775.083.

7. The department, pursuant to ss. 381.0065-381.0067, part

I of chapter 386, or part III of chapter 489, shall deposit any fines it collects in the county health department trust fund for use in providing services specified in those sections.

8. This section provides an alternative means of enforcing ss. 381.0065-381.0067, part I of chapter 386, and part III of chapter 489. This section does not prohibit the department from enforcing ss. 381.0065-381.0067, part I of chapter 386, or part III of chapter 489, or its rules, by any other means. However, the department must elect to use only a single method of enforcement for each violation.

(7) LAND APPLICATION OF SEPTAGE PROHIBITED.—Effective January 1, 2016, the land application of septage from onsite sewage treatment and disposal systems is prohibited. By February 1, 2011, the department, in consultation with the Department of Environmental Protection, shall provide a report to the Governor, the President of the Senate, and the Speaker of the House of Representatives, recommending alternative methods to establish enhanced treatment levels for the land application of septage from onsite sewage and disposal systems. The report shall include, but is not limited to, a schedule for the reduction in land application, appropriate treatment levels, alternative methods for treatment and disposal, enhanced application site permitting requirements including any requirements for nutrient management plans, and the range of costs to local governments, affected businesses and individuals for alternative treatment and disposal methods. The report shall also include any recommendations for legislation or rule authority needed to reduce land application of septage.

Section 36. Section 381.00656, Florida Statutes, is created to read:

381.00656 Grant program for repair of onsite sewage treatment disposal systems.—Effective January 1, 2012, the department shall administer a grant program to assist owners of onsite sewage treatment and disposal systems identified pursuant to s. 381.0065 or the rules adopted thereunder. A grant under the program may be awarded to an owner only for the purpose of inspecting, pumping, repairing, or replacing a system serving a single-family residence occupied by an owner with a family income of less than or equal to 133 percent of the federal poverty level at the time of application. The department may prioritize applications for an award of grant funds based upon the severity of a system's failure, its relative environmental impact, the income of the family, or any combination thereof. The department shall adopt rules establishing the grant application and award process, including an application form. The department shall seek to make grants in each fiscal year equal to the total amount of grant funds available, with any excess funds used for grant awards in subsequent fiscal years.

Section 37. Subsection (2) of section 381.0066, Florida Statutes, is amended to read:

381.0066 Onsite sewage treatment and disposal systems; fees.—

(2) The minimum fees in the following fee schedule apply until changed by rule by the department within the following limits:

(a) Application review, permit issuance, or system inspection, including repair of a subsurface, mound, filled, or other alternative system or permitting of an abandoned system: a fee of not less than $25, or more than $125.

(b) A 5-year evaluation report submitted pursuant to s. 381.0065(5): a fee not less than $15, or more than $30. At least $1 and no more than $5 collected pursuant to this paragraph shall be used to fund a grant program established under s. 381.00656.

(c) ~~(b)~~ Site evaluation, site reevaluation, evaluation of a system previously in use, or a per annum septage disposal site evaluation: a fee of not less than $40, or more than $115.

(d) ~~(c)~~ Biennial Operating permit for aerobic treatment units or performance-based treatment systems: a fee of not more than $100.

(e) ~~(d)~~ Annual operating permit for systems located in areas zoned for industrial manufacturing or equivalent uses or where the system is expected to receive wastewater which is not domestic in nature: a fee of not less than $150, or more than $300.

(f) ~~(e)~~ Innovative technology: a fee not to exceed $25,000.

(g) ~~(f)~~ Septage disposal service, septage stabilization facility, portable or temporary toilet service, tank manufacturer inspection: a fee of not less than $25, or more than $200, per year.

(h) ~~(g)~~ Application for variance: a fee of not less than $150, or more than $300.

(i) ~~(h)~~ Annual operating permit for waterless, incinerating, or organic waste composting toilets: a fee of not less than $50, or more than $150.

(j) ~~(i)~~ Aerobic treatment unit or performance-based treatment system maintenance entity permit: a fee of not less than $25, or more than $150, per year.

(k)~~(j)~~ Reinspection fee per visit for site inspection after system construction approval or for noncompliant system installation per site visit: a fee of not less than $25, or more than $100.

(l)~~(k)~~ Research: An additional $5 fee shall be added to each new system construction permit issued to be used to fund onsite sewage treatment and disposal system research, demonstration, and training projects. Five dollars from any repair permit fee collected under this section shall be used for funding the hands-on training centers described in s. 381.0065(3)(j).

(m)~~(l)~~ Annual operating permit, including annual inspection and any required sampling and laboratory analysis of effluent, for an engineer-designed performance-based system: a fee of not less than $150, or more than $300.

On or before January 1, 2011, the Surgeon General, after consultation with the Revenue Estimating Conference, shall determine a revenue neutral fee schedule for services provided pursuant to s. 381.0065(5) within the parameters set in paragraph (b). Such determination is not subject to the provisions of chapter 120. The funds collected pursuant to this subsection must be deposited in a trust fund administered by the department, to be used for the purposes stated in this section and ss. 381.0065 and 381.00655.

Section 38. Subsection (9) of section 403.086, Florida Statutes, is amended, and subsection (10) is added to that section, to read:

FY 10 Pollution Prevention Grant Program
EPA-HQ-OPPT-2010-03

Fats, Oils, and Grease Waste Pollution Prevention Project

The proposed project will reduce fats, oils, and grease waste and increase reuse. This goal will be accomplished by providing technical assistance and education to small businesses, with a focus on restaurants, which are served by onsite sewage treatment and disposal systems. Effectiveness will be assessed by comparison of before and after intervention.

Total Project Funding: $150,764
Requested Funding: $75,382

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Fats, Oils, and Grease Waste Pollution Prevention Project

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.

The objective of this project is to reduce FOG waste and increase reuse among these small businesses by providing technical assistance and education. To reach this objective, the project will begin by identifying the scale of the problem/opportunity in Florida. Next a survey will be conducted to better understand current practices and opportunities for improvement. Then 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. A final component of this project will be to provide education and outreach to industry professional organizations as well as to business owners and their employees.

Programmatic Capability and Past Performance

FDOH is charged with protecting the health of the public. Basic sanitation is a primary public health function and is vitally important to the health and safety of all Floridians. The onsite sewage program of the department works to ensure properly designed, installed, and maintained onsite sewage systems. FDOH is a statewide operation consisting on 67 individual county health department offices and a centralized headquarters located in Tallahassee. The onsite sewage treatment and disposal program requires close coordination with local building departments and contractors. County-level offices and staff provide for cost-effective, convenient, face-to-face service to the public. Florida continues to be recognized nationally for its onsite systems program. In the fall of 2008, Mrs. Joyce Hudson, Senior Engineer with the U.S. Environmental Protection Agency wrote an article for the National Onsite Recycling Association Onsite Journal and stated "Florida provides for renewable performance-based operating permits for engineered systems as well as maintenance contracts and annual inspections. The state also has one of the best inventory systems among the states reviewed".

The project goals of this proposal are aligned with the statutory mission of the department's research program to research and improve the performance of onsite systems, and to research and reduce the environmental and public health impact of such systems. Our vision is to make the Florida onsite sewage program a model for the nation using research as the cornerstone to develop science-based regulations. Finally, bureau staff members in general provide technical assistance and information to county health department staff, other state agencies, regulated entities, and the general public. This grant will increase our capability of providing this technical assistance as it relates to water quality and public health.

FDOH staff members have the project management experience to successfully execute this project and have a record of past performances with similar grants by EPA and other federal agencies. Project team members have 76-years of combined experience managing grants and contracts. Elke Ursin has been the coordinator for the bureau's research program and managing research grants and contracts since 2006. Dr. Eberhard Roeder is a Professional Engineer III and has been working in designing, implementing, and assessing onsite sewage research projects since 2004. Paul Booher is the programs engineering administrator and has been working with industry managed contracts with government functions since 1969 and currently works for the department in rule promulgation, design, and training for OSTDS systems. Gerald Briggs is the Chief of the Bureau of Onsite Sewage Programs and has been working in the environmental health field for 25 years. This project team has successfully completed four federal grants within the past three years and is currently working on one federal grant. For each of these grants staff successfully managed the agreements and completed each of these projects.

Quarterly reports were submitted on time along with the required MBE/WMBE reports. Final technical reports were submitted within the timeframe allowed under the grant agreement. Each quarterly report adequately documented and reported all progress towards achieving the expected results.

Federal Program Funding Agency	Grant Agreement #	Years	Funding Amount	Grant Title
Environmental Protection Agency 319 Nonpoint Source Management Program	C9-99451505-0 (subrecipient)	July 2008 – present	$308,354.50 federal funding, $200,000.00 match from DOH	Assessment of Water Quality protection by Advanced Onsite Sewage Treatment and Disposal Systems: Performance, Management, Monitoring
National Oceanic and Atmospheric Administration Office of Ocean and coastal Resource Management	NA-08NOS4190415 (subrecipient)	July 2008 – September 2009	$68,000.00 federal funding, $11,800.00 match from DOH	Evaluating the Environmental Impacts of Onsite Sewage Systems in the Town of Suwannee
Environmental Protection Agency Gulf of Mexico Program	MX-96423005-4	September 2004 – July 2009	$90,000.00 federal funding, $22,920.00 match from DOH	Remote Sensing of Onsite Sewage Systems Impacts on Surface Water Quality
Environmental Protection Agency Gulf of Mexico Program	MX-97450302-6	October 2002 – June 2009	$48,150.00 federal funding	Reducing Onsite Sewage Impacts
Environmental Protection Agency Gulf of Mexico Program	MZ-97433201-6	September 2001 – June 2008	$80,000.00 federal funding	Coastal Community Coliform and Nutrient Control

As an additional benefit, the department will draw for review of project reports by the department's Onsite Sewage Research Review and Advisory Committee, which has been in existence since 1986. It consists of representatives from environmental health, the septic tank industry, the home building industry, environmental interest groups, the state university system, professional engineers, the real estate profession, the restaurant industry, local governments, and consumers. This committee advises on directions for new research, reviews and ranks proposals for research contracts, and reviews and comments on draft research reports.

Project Strategy

The focus of this project will be on FOG generated by most food service establishments that prepare hot foods and are served by OSTDS. It is commonly known that it is important to keep FOG out of sewage collection and treatment systems to keep them from failing. Nationally, there appears to be a regulatory trend towards more management of FOG from food service establishments. Such programs in Florida are mainly administered by local utilities, with a focus on maintaining sewer networks. Grease is also a barrier for sewage disposal in onsite systems by blocking the ability for the soil to treat wastewater properly. Sanitary nuisances caused by improperly maintained OSTDS affect public health and the environment through the direct exposure to raw wastewater. Avoiding failure of the sewage system is one incentive for managing FOG.

Historically business owners have had to pay to get rid of FOG. Now with fuel costs soaring, alternative fuels such as biodiesel are becoming more valuable. When business owners are in a position to receive revenue for this "waste" product, it creates a positive incentive for FOG management.

The Florida Department of Health (FDOH) regulates establishments that generate up to 5,000 gallons per day of commercial strength sewage waste served by an onsite sewage system. We estimate that there are approximately 9,700 such food establishments in Florida. In Florida an operating permit is required for the commercial strength sewage waste if there is a change in occupancy or if the OSTDS is installed or repaired. Currently 2,153 (18%) of the existing establishments are being managed by FDOH. Key elements of these regulations are the requirement for outside grease interceptor tanks to collect and retain FOG, and the requirement for an operating permit. This operating permit approach includes an annual inspection to see if the system is still functioning as permitted. The rules in place for the installation of these systems and the management of these systems have not changed much since 1983. In the meantime, there have been changes in business practices. For example, the use of animal fats has decreased and the use of vegetable oil has increased. A byproduct of the project will be a better understanding of the current FOG composition and the development of methods to handle the problem.

The proposed project consists of five major tasks.

Task 1. Identify scale of problem / opportunity in Florida

In this task we will estimate the amount of fats, oils, and grease that are currently wasted and review opportunities based on past and current information to reduce that amount.

This will involve the following subtasks:

a) A determination of the target audience, the number of businesses that are dealing with this issue and are the target audience, will be done first. This will be based on a review of OSTDS permits. Commercial establishments are required to obtain an annual operating permit. This permit, as well as the original construction permit for the onsite system, contains information on the type of business and on design variables. The result will be a tabulation of systems in Florida that are likely to produce FOG.

b) A characterization of FOG quantity and quality will be done and a review of current management practices will be performed. Based on literature reviews and interviews with onsite system owners, installers, maintainers, disposal / reuse companies, and utilities we will develop a characterization of FOG quantity, quality, and management practices. Depending on the information gathered, this may warrant a categorization of businesses into different types. Various treatment approaches, such as waste avoidance, grease interceptors and other methods to capture grease, and additional treatments for high strength waste, and their cost-effectiveness will be examined. Current management practices for waste disposal vs. reuse will be examined. Specifically, we will research how to keep the onsite system working, management programs in other locations, identification of regulatory and nonregulatory barriers and ways to address these barriers, and incentives to pollution prevention,. After the literature review and interviews have been completed, opportunities for solutions will be summarized and factors for a business to consider will be developed.

Deliverables: Summary statistics of the results of the permit review; characterization of outcomes of the literature review and interviews in report format

Task 2. Survey current practices from both businesses on OSTDS and businesses on centralized sewer

In this task we will conduct a survey to targeted user groups in order to identify current business practices in the following manner:

A random sample from the identified target population on OSTDS and a random sample of businesses on centralized sewer will be sent a survey to complete that will summarize their current business practices as they relate to how much grease they generate and what they do with the waste grease. For the businesses on sewer, information may be gathered to allow for comparisons between the differences with or without a management program in place and also for the availability of rendering facilities. 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 1. Initial contact has been made with state university system survey labs for purposes of verifying costs and timelines.

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

Task 3. Case studies / intervention analysis

In this task we will develop individual case studies for approximately 25 systems where we will perform a detailed pre-analysis, recommend changes, implement the changes, characterize the effectiveness of the changes, and analyze the results.

This will involve the following subtasks:

a) An evaluation protocol will be developed based on the results of Tasks 1 and 2. This tool will encompass many different aspects of how to measure variables of interest that characterizes FOG generation and management in an establishment. This will include a Quality Assurance Project Plan (QAPP) for the sampling portion.

b) Approximately 25 food establishment businesses on OSTDS will be recruited by either advertising for volunteers and/or contacting businesses that are currently going through the repair permit process for a failing system. The existing systems will be characterized by sampling and through a detailed usage survey. Changes will be recommended based on the evaluation protocol developed in subtask a). Some examples of changes may include changes in cleaning routines, utilizing pre-rinse stations, installing floor drains, installing under the sink grease separators, increasing the frequency the tanks are pumped-out, monitoring of grease in the interceptor, and/or executing a contract with a grease recycler. These changes will be implemented and then the effectiveness of these changes will be measured after 1-month, 3-months, and 6-months with the option of continued monitoring. A final post survey will be given to measure the likelihood of the business to continue with these practices. The collected data will be analyzed.

c) A final report summarizing results of this task will be developed.

Deliverables: QAPP, usage surveys, sampling, tabulation of sampling results, post surveys, and characterization outcomes in report format

Task 4. Education and outreach

In this task we will perform extensive, broad reaching, education and outreach to targeted business owners as well as to industry associations and periodicals.

This will involve the following subtasks:

a) Presentations will be given at national and statewide industry association conferences such as the Florida Environmental Health Association, the Florida Restaurant and Lodging Association, the Florida Onsite Wastewater Association, the National Onsite Wastewater Recyclers Association, and/or the National

Environmental Health Association. For purposes of the budget, presentations at two statewide conferences and two national conferences are proposed.

b) At least one article will be submitted for publication in a statewide journal such as the Florida Journal of Environmental Health.

c) An informational brochure/fact sheet will be developed outlining the results of the project. This brochure will be sent in hard copy format to all the surveyed businesses on OSTDS and the brochure will be uploaded to the DOH website.

Deliverables: Print-out of all presentations, meeting agenda's, all submitted manuscripts, final brochure

Task 5. Project administration

Administrative responsibilities will include project oversight, financial accounting, invoicing, and grant reporting to the US EPA. The final project report will include: a description of the project; a summary of the survey results; 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 EPA with the final report or as separate items include sampling results associated with this grant 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.

Deliverables: Quarterly progress reports and invoices submitted to EPA; preliminary (draft) report; and final project report (paper copy and an electronic version); 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

This proposal provides a workable framework to address sustainability, business efficiency, and P2 integration activities. The work plan presents a comprehensive and coordinated approach of the issue of FOG pollution prevention starting with identification of the scale of the problem, then moving to identify current business practices, performing detailed case studies to evaluate the effectiveness of strategic changes, and finally performing education and outreach of the results of this project. The end result of this project will include a cost-effective way of meeting or exceeding state regulatory requirements for grease and oil waste.

This project will be consistent with the applicable EPA regulations and grant policies.

The main target audiences for this project are business owners of food service establishments on OSTDS in Florida and their employees. In addition, agencies such as the Florida Department of Business and Professional Regulation (DBPR), Florida Department of Agriculture and Consumer Services, and the Florida Department of Health will be targeted as these regulators have direct contact with the main target audience. Industry professional organizations such as the Florida Environmental Health Association, the Florida Onsite Wastewater Association, and the Florida Restaurant and Lodging Association will also be targeted. The main targeted group will benefit from the P2 technical assistance proposed in this project by being able to implement changes that will extend the life of their OSTDS and to identify potential revenue making options for recycling FOG waste. Once the cost benefits have been developed and presented the target audience will be well prepared to implement these source reduction practices.

At the end of this project, targeted business owners will be provided with useable information to apply common sense practices and simple solutions to effectively reduce and reuse their FOG and increase the lifespan of their OSTDS. Lessons learned from this project will be evaluated to see if any policy changes are necessary to make the results of the project easier to implement. The extensive public outreach and education described in the work plan will allow for the transfer of knowledge among business owners, industry professionals, and regulators.

Threshold Requirements

The following proposal meets the threshold program requirements to receive consideration for funding. Specifically the proposal addresses all five of the national criteria, all four of the Region 4 priorities, meets all three of the P2 programmatic criteria, does not extend beyond 3-years, and consists of outcomes and outputs that align with EPA's strategic plan.

This project addresses all five of the goals of the national focus areas for the P2 plan:

- **Reduce the generation of greenhouse gas (GHG) emissions to mitigate climate change:** Project activities will promote the conservation and recycling of waste grease and oil which can be used as an alternative fuel for cars, for livestock feed, for soap manufacturing, and other uses. These types of establishments are increasingly being paid for this waste product. Biodiesel fuels can be used to offset the demand for petroleum based products which reduces the generation of greenhouse gas emissions.
- **Reduce the manufacture and use of hazardous materials to improve human and ecological health:** Project activities will result in opportunities to reduce the occurrence of sanitary nuisances such as the discharge of raw sewage waste onto the ground surface or into the groundwater. This will affect public health through a reduction of exposure to hazardous sewage wastes and will reduce environmental impacts of untreated sewage entering the groundwater supply.
- **Reduce the use of water and conserve other natural resources to protect ecosystems:** The reuse of waste grease as a natural resource for fuel and other uses allows for the conservation of natural resources. Also, identification and quantification of business practices may lead to options for water conservation that will reduce the amount of waste being generated by the establishment.
- **Create business efficiencies that derive economic benefits and improve environmental performance:** Food service establishments would benefit economically by obtaining cash for their grease as well as providing an avenue to reuse what was originally considered a waste product which improves environmental performance. This grant will identify ways that this type of program could be implemented in Florida for businesses on OSTDS.
- **Institutionalize and integrate pollution prevention practices through government services, policies, and initiatives:** One of the potential end results of this project could be to establish the need and generate language to change the Florida Administrative Code and the Florida Statutes as it relates to the design and management of oil and grease from food service establishments. Government services could be expanded and improved if a grease control training program, inspection program, or surcharge program is initiated.

This grant also addresses all four of the Region 4 priorities. Specifically, this project will integrate P2 and compliance assistance objectives by keeping the OSTDS functioning properly and keeping the grease interceptor functional. Pollution prevention will occur with grease waste avoidance and recovery. This project will maintain and strengthen coordinated state P2 programs by incorporating similar approaches to existing and past Florida P2 programs. Advice will be solicited from the Florida Pollution Prevention Roundtable, Inc. P2 assistance will be directly given to businesses as part of the case studies and public education components of this project which addresses another of the regions priorities. Reuse of grease waste in the hospitality sector provides opportunities for energy conservation and is a renewable energy source which is another Region 4 priority.

This project will align with all three of the programmatic criteria that apply for P2 grants. Methods will be identified to reduce the amount of waste oil and grease prior to treatment and disposal. This will in turn reduce the hazards to public health and the environment. Through proper identification of the problem areas methods can be developed to reduce the release of this pollutant to the environment while providing an economic benefit to business owners through revenue generation (selling of waste oil/grease) and decreased costs (increased system longevity = less repair costs). This project will help businesses identify better environmental strategies and solutions for reducing or eliminating FOG wastes at the source.

This grant will also assist businesses in adopting P2 practices that reduce FOG pollution at the source by supporting business activities that encourage water conservation and recycling of wastewater byproducts.

Environmental Measures

DOH will track and report on expected P2 outcomes and outputs and project activities will directly support one or more of the four strategic targets listed in EPA's 2009-2014 Strategic Plan Change Document.

Project title: Fats, Oils, and Grease Waste Pollution Prevention;
Outputs: The project will perform a preliminary assessment of current business practices to targeted user groups. System performance for 25 food service establishments will be measured, changes will be implemented to apply P2 activities, measurements will occur at 1-month, 3-months, and 6-months after implementation, and a final post survey will be given to measure the likelihood of the business to continue with these practices. Project status will be presented to at least four different state and national groups, published in industry publications, and a final project fact-sheet / brochure will be developed and distributed.
Behavioral measures: Number of business owners that respond to the targeted user group surveys; number of case study business owners that indicate on their post survey that they will continue their P2 efforts
Partners: Florida Environmental Health Association, Florida Onsite Wastewater Association, Florida Department of Health's Research Review and Advisory Committee
Sectors: Hospitality businesses

Data collection description: The P2 measurements will be collected by gathering data from the literature review, pre/post surveys, sampling, and other project activities. The literature review will provide background information for the estimate of the amount of fats, oils, and grease that are currently wasted and review opportunities based on past and current information to reduce that amount. Surveys will be sent to both business owners on OSTDS and central sewer to measure any differences and/or trends. Pre/post surveys will be given to the 25 selected case study sites to measure the differences caused by the implementation of P2 activities. Samples of the effluent pre and post implementation of P2 activities will also be analyzed to determine any differences.

Estimated P2 Outcomes for the Fats, Oils, and Grease Waste Pollution Prevention Project

	Pounds of Hazardous Materials Reduced						Resources Conserved			
P2 Effort	Haz. Inputs	Haz. Waste	Air Poll.	Waste Water	Total Lbs		Solid Waste	MTCO2e	Gallons	Dollars
1. Reduction of FOG in the drainfield				1,313	1,313					
2. Grease recycling									16,219	$649
Total:				**1,313**	**1,313**				**16,219**	**$649**

Descriptions of outcomes:

1. **Reduction of FOG in the drainfield:** The average flow, derived from the FDOH permitting database, of OSTDS generating commercial strength sewage waste in the last two years is 1,639 gallons per day (gpd). Assuming that the calculations used to size the system is 100% more than the actual to cover peak flows; the actual average flow comes to 819.5 gpd. Per a FDOH study done in 2000 (Determination of Properties and the Long Term Acceptance Rate of Effluents from Food Service Establishments that Employ Onsite Sewage Treatment) the median FOG values can be broken out into high (50 mg/L FOG), medium (27 mg/L FOG), and low (9 mg/L FOG) categories. The goal is to have each system improve by one category (go from high to medium or medium to low) which comes respectively to either a 46% or a 67% reduction. Through basic unit conversions, the mg/L can be converted to lbs/gallon, then multiplied by 819.5 gpd, and converted to year to come up with 124.8 lbs/year/system for the high category and 67.4 lbs/year/system for the low category. It is assumed that 15 of the case study systems are currently in the high category and 10 of the case

study systems are in the medium category. The total high category FOG generated by the case study systems comes to 1,872 lbs/year and the total medium category FOG generated by the case study systems comes to 674 lbs/year, which comes to a total of 2,546 lbs of FOG generated by the 25 case study systems. Taking the 47% reduction for the high category systems to move them into the medium category and a 67% reduction for the medium category systems to move them into the low category, the reduction of FOG comes to 861 lbs/year and 452 lbs/year respectively. By summing these two numbers, the total pounds of FOG reduction estimated for this project comes to 1,313 lbs.

2. **Grease recycling:** The total average gallons of waste grease/restaurant/year per the National Renewable Energy Laboratory are at least 2,000 gallons/restaurant/year. There are a total of 25 case study sites proposed with this project. The current volume of grease currently generated by these sites is estimated at 50,000 gallons. The size of the grease recycling container averages 150 gallons and is pumped on average 17.3 times per year. 50% of the grease in these containers is usable for biodiesel or other rendering purposes, and the average price per pound is $0.04. The total grease that could be recycled would be 150 gallons x 17.3 pumpouts a year x 25 systems, which totals 64,875 gallons. Only 50% is useable, so the total potential usable recycled grease is 32,437 gallons, which at $0.04 per gallon comes to $1,297 of potential income to the business owners. The goal is to have 50% of the potential usable grease generated from these facilities recycled, which comes to 16,219 gallons. The goal for direct cost savings to the business owner for the grease waste is $649.

Some other expected outcomes and outputs include:

- Number of dollars saved through pollution prevention improvements listed by categories such as reduced number of pumpouts and reduced likelihood of system failure
- Water pollution measurements such as the number of pounds of TSS / $CBOD_5$ before and after intervention for the case study sites
- Number of workshops, presentations, publications
- Number of readers that were sent publications regarding this project
- Number of fact sheets / brochures developed and distributed
- Estimates of achievable FOG reduction and recycling rates as a result of the research on current and improved management practices

These outcomes and outputs will be measured and tracked as the project progresses and % completion will be submitted along with the quarterly progress reports to EPA. A spreadsheet will be created at the beginning of the project to record the measures and milestones, and will be utilized and updated throughout the project time line.

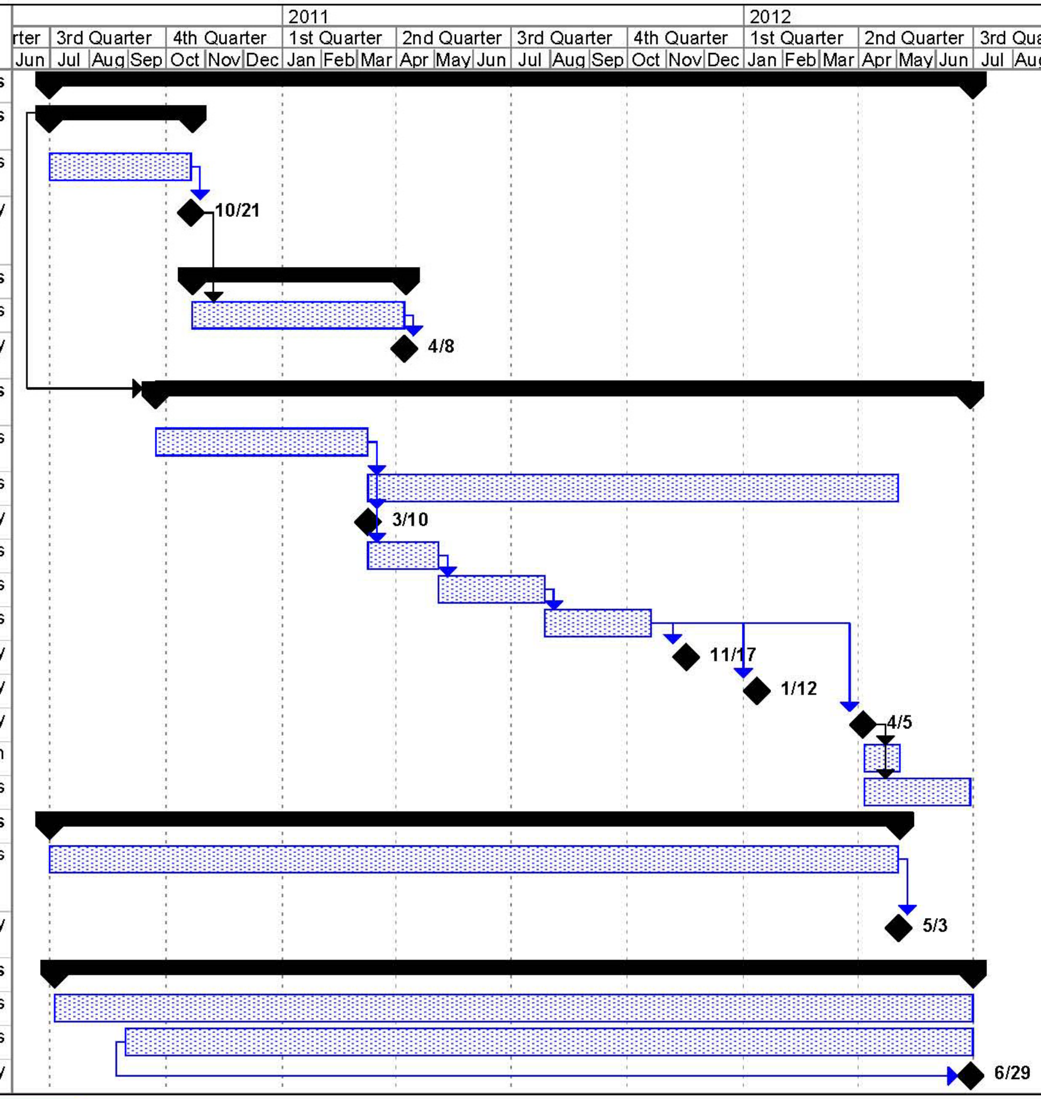
Conclusion

This proposal will allow for cooperation between many of the regulatory agencies that have jurisdiction over the food service establishment. The data collected through this grant will enhance other programs within the Department of Health and may be of interest to other state agencies such as the Department of Business and Professional Regulation, the Department of Environmental Protection, and the Department of Agriculture and Consumer Services.

This project will allow for business owners to better understand ways to prolong the life of their OSTDS, leading to cost savings, and possibly cost reimbursements, in the future.

PROJECT TIME LINE

ID	Task Name	Duration
1	**Project Timeline**	**522 days**
2	**Task 1: Identify scale of the problem / opportunity in Florida**	**81 days**
3	Conduct permit review and literature review	4 mons
4	Summary statistics, characterization of outcomes from literature reviews and interviews	1 day
5	**Task 2: Survey current practices**	**121 days**
6	Conduct surveys	6 mons
7	Survey forms, raw survey results, and analysis of results	1 day
8	**Task 3: Case studies / intervention analysis**	**461 days**
9	Competitively procure contract provider and execute contract	6 mons
10	Conduct case studies	15 mons
11	Develop evaluation protocol	1 day
12	Develop QAPP	2 mons
13	Characterize baseline	3 mons
14	Implement changes	3 mons
15	Measure results Month 1	1 day
16	Measure results Month 3	1 day
17	Measure results Month 6	1 day
18	Post survey for case study sites	1 mon
19	Task report	3 mons
20	**Task 4: Education and outreach**	**481 days**
21	Presentations at industry conferences, publication of articles, informational brochure/fact sheet	24 mons
22	Summary report of education and outreach	1 day
23	**Task 5: Project administration**	**520 days**
24	Quarterly progress reports	26 mons
25	Evaluation of measures	24 mons
26	Final project report to EPA	1 day



Project: Project Timeline
Date: Thu 4/1/10

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

PROJECT BUDGET

Project Funding Category	Detailed Description	Grant Amount	Matching Contribution	Total
Personnel	Program Consultant @ $21.76/hr x 520 hrs	$0	$11,315	
	Engineer III @ $30.82/hr x 440 hrs	$0	$13,561	
	Computer Consultant @ $21/hr x 40 hrs	$0	$840	**$25,716**
Fringe Benefits	Program Consultant @ $286.04/wk x 13 wks	$0	$3,719	
	Engineer III @ $348.54/wk x 11 wks	$0	$3,834	
	Computer Consultant @ $277.10/wk x 1 wk	$0	$277	**$7,830**
Travel	Site Visits to Case Study Locations			
	mileage (25 trips x 514 miles per trip x $0.445/mile)		$5,718	
	hotel ($90/night x 29* nights)		$2,610	
	meals (lunch @ $11 x 29* days + dinner @ $19 x 29* days)		$870	
	per diem ($80/day x 29* days)		$2,320	
	In State Conference Travel x 2 trips x $500/trip	$0	$1,000	
	Out of State Conference Travel x 2 trips x $1500/trip	$3,000	$0	**$15,518**
Equipment		$0	$0	**$0**
Supplies	1000 brochures for community members @ $2 each	$0	$2,000	
	Reports (28 x 50 page reports & 28 x 200 page reports @ $0.10/page)	$0	$700	**$2,700**
Contractual	Scale of Issue Contract with University or Contracted Staff	$12,000	$0	
	Survey of Practices Contract with University or Contracted Staff	$14,000	$8,000	
	Case Studies Competitively Procured Contract	$46,382	$18,618	**$99,000**
Construction		$0	$0	**$0**
Other		$0	$0	**$0**
Total Direct Charges		**$75,382**	**$75,382**	**$150,764**
Indirect Charges	No indirect charges	$0	$0	$0
GRAND TOTAL		**$75,382**	**$75,382**	**$150,764**

*** This estimate is based on a total of 21 one-person trips and 4 two-person trips to total 29 total trips**

Measurement: Expenditures to measure P2 outcomes include personnel costs of $2,675.28 to compile and report on project results listed in the measurement section of this proposal. This includes salary and fringe for the Program Consultant (salary: $21.76/hr x 40 hrs = $870.40, fringe: $286.04/wk x 1 wk) and the Engineer III (salary: $30.82/hr x 40 hrs = $1,232.80, fringe: $286.04/wk x 1 wk).

Florida Onsite Wastewater Association, Inc.

April 2, 2010

Ms. Pamela Swingle
Region 4 Pollution Prevention Program Coordinator
Environmental Protection Agency
61 Forsyth Street SW
Atlanta, GA 30303

RE: EPA-HQ-OPPT-2010-03 – Fiscal Year 2010 Pollution Prevention Grant Program

Dear Ms. Swingle:

It is our pleasure to endorse the Florida Department of Health's (FDOH) efforts to secure EPA funding for the Fats, Oils, and Grease Waste Pollution Prevention Project. Florida's environmental health professionals are often called upon to address the public's concerns regarding the possible association between environmental exposures and health effects. This project can assist with the prevention of sanitary nuisances as well as increase the amount of managed sewage waste.

The Florida Onsite Wastewater Association is involved with every aspect of the onsite industry. We are concerned with the health and well being of Florida residents. Improving the knowledge of people working in the onsite sewage industry as well as our customers is critical to protecting public health and the environment. Management of onsite systems is a key issue that the organization is supporting in Florida's 2010 Legislative Session.

FOWA strongly supports this proposal. Specifically, FOWA will provide support for the education and outreach task of this project. FOWA currently has a class on High Strength Waste and many of the results of this project can be incorporated into the curriculum. We can also provide assistance by publishing articles in our monthly periodical (The VOICE) as well as providing an opportunity for the project staff to present at a future convention and trade show.

Thank you for supporting such an important pollution prevention project.

Sincerely,

Roxanne Groover
Executive Director

Administrative/Business Office
P. O. Box 950368
Lake Mary, FL 32795-0368
Phone: (321) 363-1590 ♦ Fax: (877) 832-9434
Email: admin@fowaonsite.com

Training Center
5115 State Road 557
Lake Alfred, FL 33850-7202
Phone: (863) 956-5540 ♦ Fax: (877) 832-9434
Email: trainingenter@fowaonsite.com

Website: www.FOWAonsite.com

FLORIDA ENVIRONMENTAL HEALTH ASSOCIATION, INC.

An affiliate of the National Environmental Health Association

feha

A non-profit association serving the environmental health profession in the State of Florida

Organized October 12, 1947

April 2, 2010

Ms. Pamela Swingle
Region 4 Pollution Prevention Program Coordinator
Environmental Protection Agency
61 Forsyth Street SW
Atlanta, GA 30303

RE: EPA-HQ-OPPT-2010-03

Dear Ms. Swingle:

Please accept this letter of support for the Florida Department of Health's (FDOH) efforts to secure EPA funding for the Fats, Oils, and Grease Waste Pollution Prevention Project. This project will empower business owners to manage their wastes and will provide for a solid framework for reducing the environmental and public health impacts from failing onsite sewage treatment and disposal systems.

The knowledge gained as a result of this project will assist public health officials, industry experts, business owners, and their employees with pollution prevention activities and will improve on current business practices.

The Florida Environmental Health Association's (FEHA) purpose is to preserve, protect, and improve the quality of life for Florida's residents and visitors. This is accomplished through applying and promoting scientific principles and by educating both environmental health professionals and the public. FEHA publishes a journal which keeps its readers up to date with the latest available information regarding health impacts related to environmental factors. The Journal, the association's website, and FEHA's numerous educational opportunities throughout the year would provide an excellent venue for disseminating the information gathered with this project to a wide audience. We would be pleased to assist FDOH in their efforts to increase their capacity in this area.

Specifically, FEHA will provide support regarding the education and outreach task of this proposal. Examples of what FEHA will support include publishing a manuscript of the project in the Florida Journal of Environmental Health and providing the venue for project staff to present on this project at the associations annual education meeting.

I strongly support this proposal and thank EPA for supporting this important public health initiative. By developing pollution prevention programs such as this one at a statewide level, we ensure a better understanding of the possible benefits of reducing and recycling waste products.

Sincerely,

Scott Turner, MPA, RS
President

1000 Riverside Avenue, Ste. 220, Jacksonville, FL 32204
Official Publication "Florida Journal of Environmental Health"
www.feha.org

Florida Department of
Business & Professional Regulation

Division of Hotels and Restaurants
Bill L. Veach, Director
1940 North Monroe Street
Tallahassee, Florida 32399-1011
Phone: 850.487.1395 • Fax: 850.488.1514

Charlie Liem, Interim Secretary

Charlie Crist, Governor

April 2, 2010

Ms. Pamela Swingle
Region 4 Pollution Prevention Program Coordinator
Environmental Protection Agency
61 Forsyth Street SW
Atlanta, GA 30303

RE: EPA-HQ-OPPT-2010-03 – Fiscal Year 2010 Pollution Prevention Grant Program

Dear Ms. Swingle:

I am writing this letter in support of the Florida Department of Health's (FDOH) efforts to secure EPA funding for a pollution prevention project looking at fats, oils, and grease waste generated by food service establishments on onsite sewage treatment and disposal systems.

The Division of Hotels and Restaurants inspects and regulates over 80,000 hotels and restaurants throughout Florida in order to protect the health and safety of the public. Exposure to raw wastewater from failing onsite sewage treatment and disposal systems is a hazard that should be prevented. The work performed as part of the grant proposal from FDOH will include solutions to reduce and eliminate these types of exposures.

The division is in support of this significant project. It is important to provide business owners with ways to prevent pollution. Thank you in advance for supporting such a critical project.

Sincerely,

Diann S. Worzalla

Diann S. Worzalla, RS. MPA
Deputy Director

Utilities Water Reclamation Division

March 23, 2010

Elke Ursin
Environmental Health Program Consultant
Florida Department of Health, Bureau of Onsite Sewage Programs

Re: **Grease Sludge Waste in Establishments on Onsite Sewage Treatment and Disposal Systems Generating Commercial Strength Sewage Waste**

Regarding your grant proposal, I would be happy to assist you with information on how grease interceptors/traps can reduce the maintenance activities and cost for wastewater systems. I can also provide some visual information on what is actually found in grease interceptors/traps and how lack of interceptor/trap cleaning can cause clogs, which created overflows in facilities and onto the ground which can impact surface and ground water.

I may also e able to assist you with information on oil and grease recycling programs and the products that can be derived from these efforts. Also I will give information on how a maintenance or cleaning frequency monitoring program can reduce overflows and with septic systems drainfield clogging and frequent system repairs.

This information and expertise will be provided in kind with the intent of helping to convey information from an administrator of an existing Fats Oils & Greases program operating within a functioning POW utility reclaimed water division.

The above mentioned services and information will be provided in kind only asking that as a representative of Orange County Utilities that I and my company be mentioned as contributors of information relevant to this project.

If you have any further questions or requests regarding my intent and commitment to assisting with this project please contact me utilizing the information below.

Jorean F. Washington, R.S.
Environmental Specialist II
Orange County Utilities
4760 Sand Lake Rd.
Orlando, FL. 32819
407-254-7750 (Office)
407-254-7780 (Fax)
Jorean.Washington@ocfl.net

DAVID C. CARTER
Consulting Engineers, LLC

(863) 294-6965
FAX (863) 294-7460
dcarte4@tampabay.rr.com

137 Fifth Street, N.W. • Winter Haven, FL 33881

April 2, 2010

Ms. Pamela Swingle
Region 4 Pollution Prevention Program Coordinator
Environmental Protection Agency
61 Forsyth Street SW
Atlanta, GA 30303

RE: EPA-HQ-OPPT-2010-03 – Fiscal Year 2010 Pollution Prevention Grant Program

Dear Ms. Swingle:

Please accept this letter of support for the Florida Department of Health's (FDOH) Fats, Oils, and Grease Waste Pollution Prevention Project. High strength waste has previously been researched by FDOH with assistance by the Research Review and Advisory Committee (RRAC), and it is a component of wastewater that can lead to sanitary nuisances that can negatively effect public health.

FDOH is required by 381.0065(4)(o) of the Florida Statutes to have a Research Review and Advisory Committee, which reviews and ranks proposals for research contracts and reviews draft research reports and makes comments. Our committee is made up of ten representatives from various interest groups such as environmental health, the septic tank industry, the home building industry, environmental interest groups, the state university system, professional engineers, the real estate profession, the restaurant industry, local governments, and consumers.

RRAC will specifically support this project through the contribution of in-kind services. The committee will perform its statutory responsibilities by reviewing and ranking the proposals for any competitively procured contracts and will review and comment to the project staff on project reports.

In conclusion, RRAC supports this proposal as it relates to protecting public health and the environment through pollution prevention activities and we commit to work closely with the project staff to build consensus on the principles of the study and the interpretation of the findings. Please feel free to contact me if further information is needed.

Sincerely,

David C. Carter, P.E.
Chairman

HAZEN AND SAWYER
Environmental Engineers & Scientists

FLORIDA DEPARTMENT OF HEALTH

FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES (FOSNRS) STUDY

UF UNIVERSITY of FLORIDA Gulf Coast Research and Education Center

SCHOOL OF MINES 1874 COLORADO

AET Applied Environmental Technology

OTIS ENVIRONMENTAL CONSULTANTS

RRAC Meeting Presentation

June 10, 2010

1

Agenda

- FOSNRS Study Background
- PNRS II
- Proposed Project Scope – Phase II and III
- Tour of the GCREC Facility

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Environmental Engineers & Scientists

44237-001W-FN

FOSNRS Study Background

- Recent concerns over impacts of nitrogen from Onsite Sewage Treatment and Disposal Systems (OSTDS):
  - Florida Keys
  - Wekiva Study Area
  - Wakulla County
  - Florida's Freshwater Springs
  - Proposed Numeric Nutrient Criteria
- Laws of Florida, 2008-152, directed FDOH to conduct a study to further develop more ***"passive"*** & cost-effective nitrogen reduction strategies for OSTDS
- RFP identified four primary tasks for the study; to be controlled by FDOH Research Review & Advisory Committee

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Environmental Engineers & Scientists

What are "Passive" nitrogen reduction systems?

- Most N-removing onsite systems used in FL are mechanical treatment units utilizing an activated sludge biological process
- "Passive" nitrogen removal OSTDS are similar to conventional onsite systems in their operation and maintenance
- Previous FDOH Study: Florida Passive Nitrogen Removal Systems (PNRS I) Study (Smith et. al., 2008) defined passive systems:
  - Passive nitrogen removal systems are those that *use only one pump and a "reactive media" for denitrification*
  - PNRS I demonstrated effluent TN <10 mg/L

FOSNRS Study Overview
Four Primary Study Areas

- **Task Series A:** Technology evaluation for field testing, Test facility design & construction, Pilot testing of Passive nitrogen removal systems (PNRS II)
- **Task Series B:** Field testing of full-scale treatment technologies, Performance & cost documentation
- **Task Series C:** Evaluation of nitrogen reduction provided by Florida soils & shallow groundwater
- **Task Series D:** Nitrogen fate and transport modeling, Development of decision support tools for OSTDS planning & management

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Environmental Engineers & Scientists

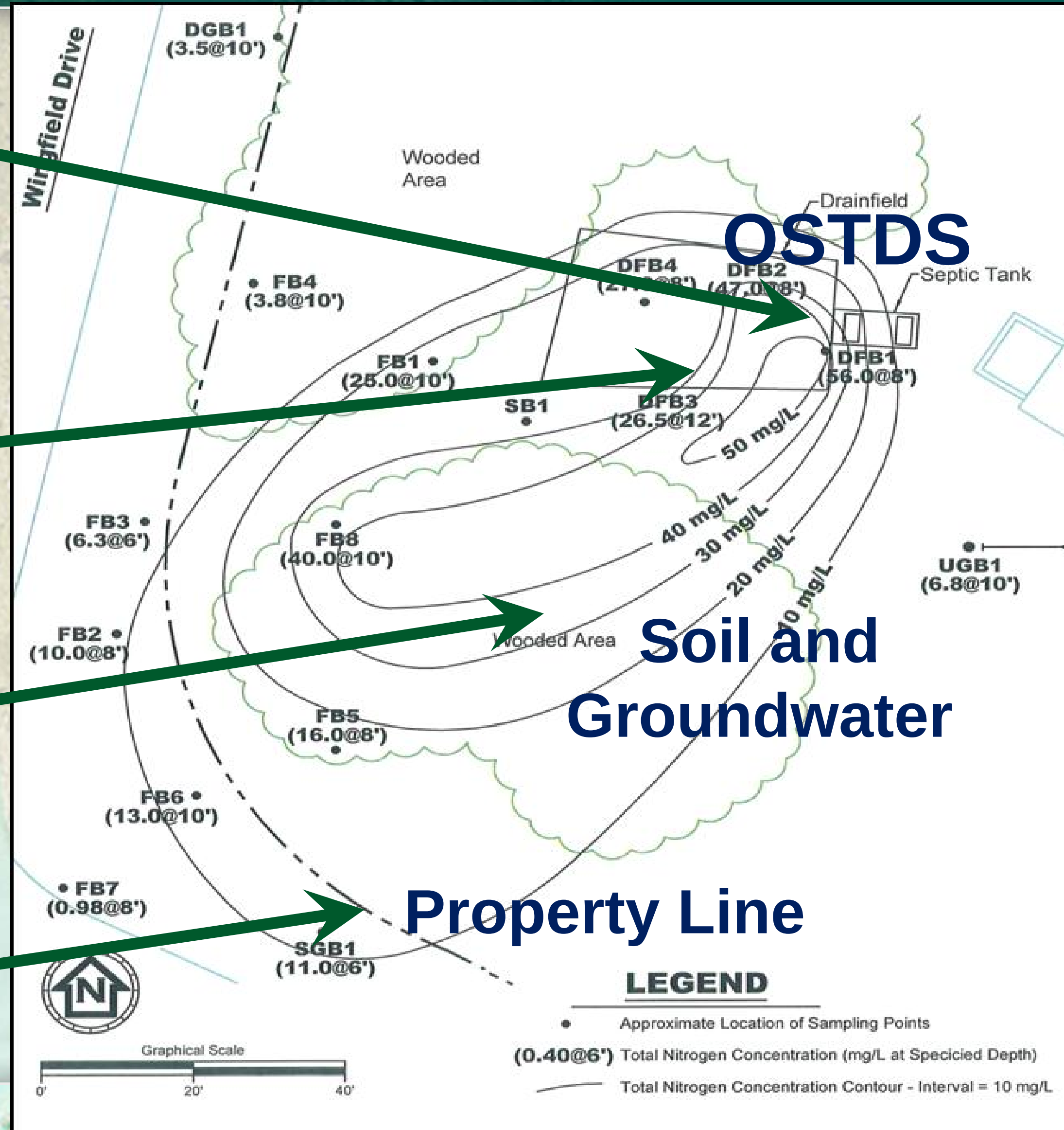
FOSNRS Study Overview
How do tasks relate to N-removal strategies?

Task A Nitrogen treatment and removal options for Florida

Task B Performance verification of nitrogen removal in full scale systems

Task C Evaluation of N reduction in Florida soil and groundwater

Task D Decision support tools for OSTDS planning & mgmt; N-removal goals for Florida



Project Status

- **Project began early 2009**
- **Sub-tasks completed to date**
  - Task A, C and D literature review reports (available at www.doh.state.fl.us/environment/ostds/research/)
  - Task A
    - Draft technology classification, ranking criteria, and priority list for testing
    - PNRS II Quality Assurance Project Plan (QAPP)
    - PNRS II Test Facility Design & Construction
  - Task C: QAPP, Soil & Groundwater Test Facility Design
  - Task D: Selection of existing datasets for model calibration

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Passive Nitrogen Removal Study II
PNRS II (Task A)

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Gulf Coast Research and Education Center

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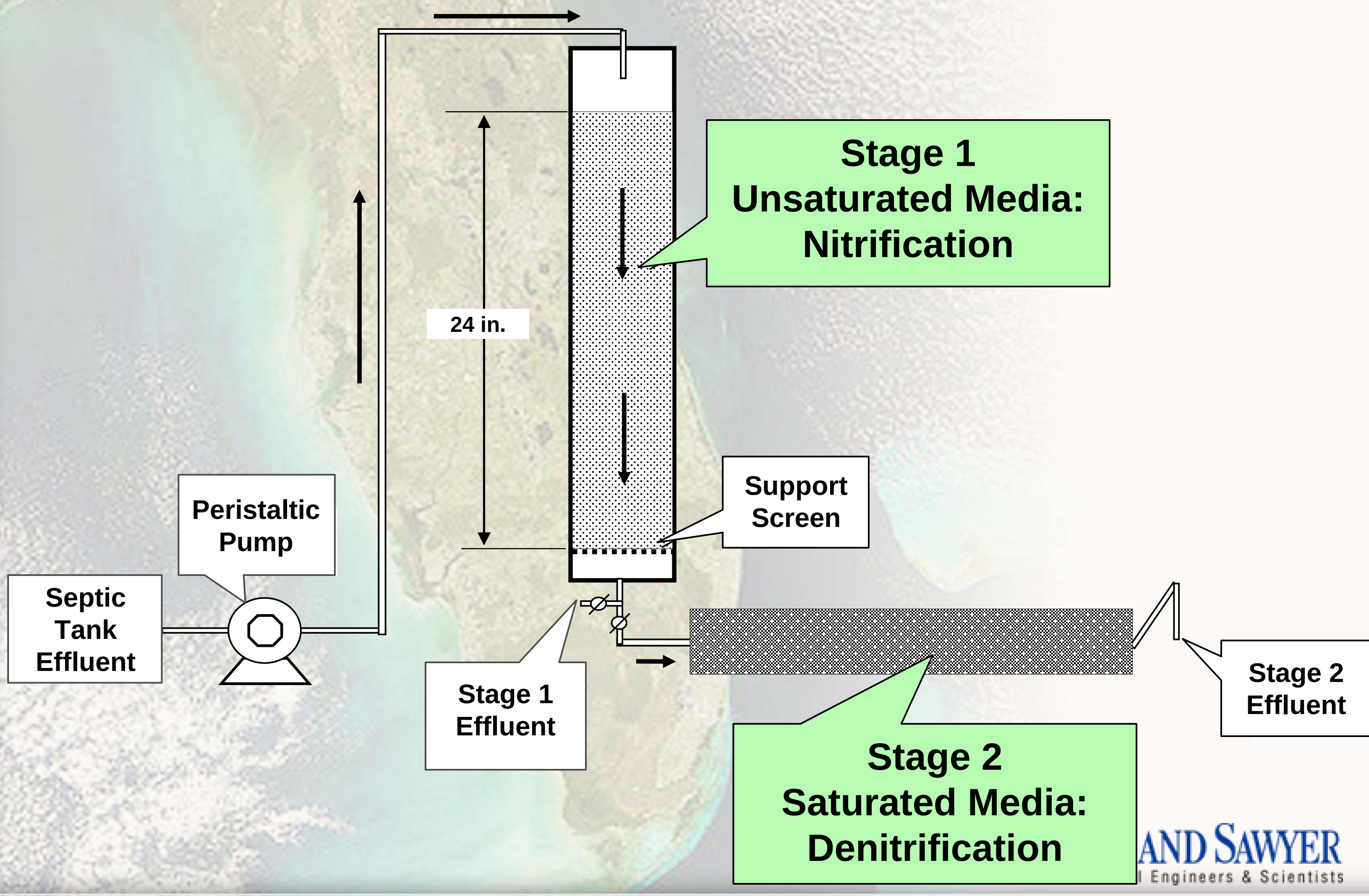
PNRS I: Passive Two Stage Biofiltration (Smith et. al., 2008)



Passive Nitrogen Removal Study I
PNRS I Results

- 8 months operation of bench-scale units at Flatwoods Park, Hillsborough County
- Elemental sulfur as electron donor for denitrification
- 97% nitrogen reduction from septic tank effluent

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Passive Nitrogen Removal Study I
PNRS I Results

- Showed feasibility of passive two stage biofiltration
- One pump, no aerators, reactive media
- Continuous 24/7 operation for 8 months
- Proof of passive 2-stage biofiltration concept provided

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Passive Nitrogen Removal Study II
PNRS II Objectives

- Follow up to PNRS I with larger, pilot scale units and various media
- Develop detailed performance data for passive biofiltration designs
- Produce scalable design data from pilot scale biofilters for subsequent full-scale testing in Task Series B

Passive Nitrogen Removal Study II
PNRS II Approach

- Establish test facility at Gulf Coast Education and Research Center (University of Florida IFAS)
- Test program for in-vessel and in-situ pilot systems
- Operate on septic tank effluent for 12 months
- Various nitrification and denitrification biofilters to be tested

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Gulf Coast Research and Education Center (GCREC)

Source: http://gcrec.ifas.ufl.edu/

- University of Florida, Institute for Food & Agricultural Sciences (IFAS)
- 475 acres of land in SE Hillsborough County
- Facility conducts agricultural research & trials for vegetables, fruit and ornamental plants
- 16 laboratories housed onsite (1 water quality lab)

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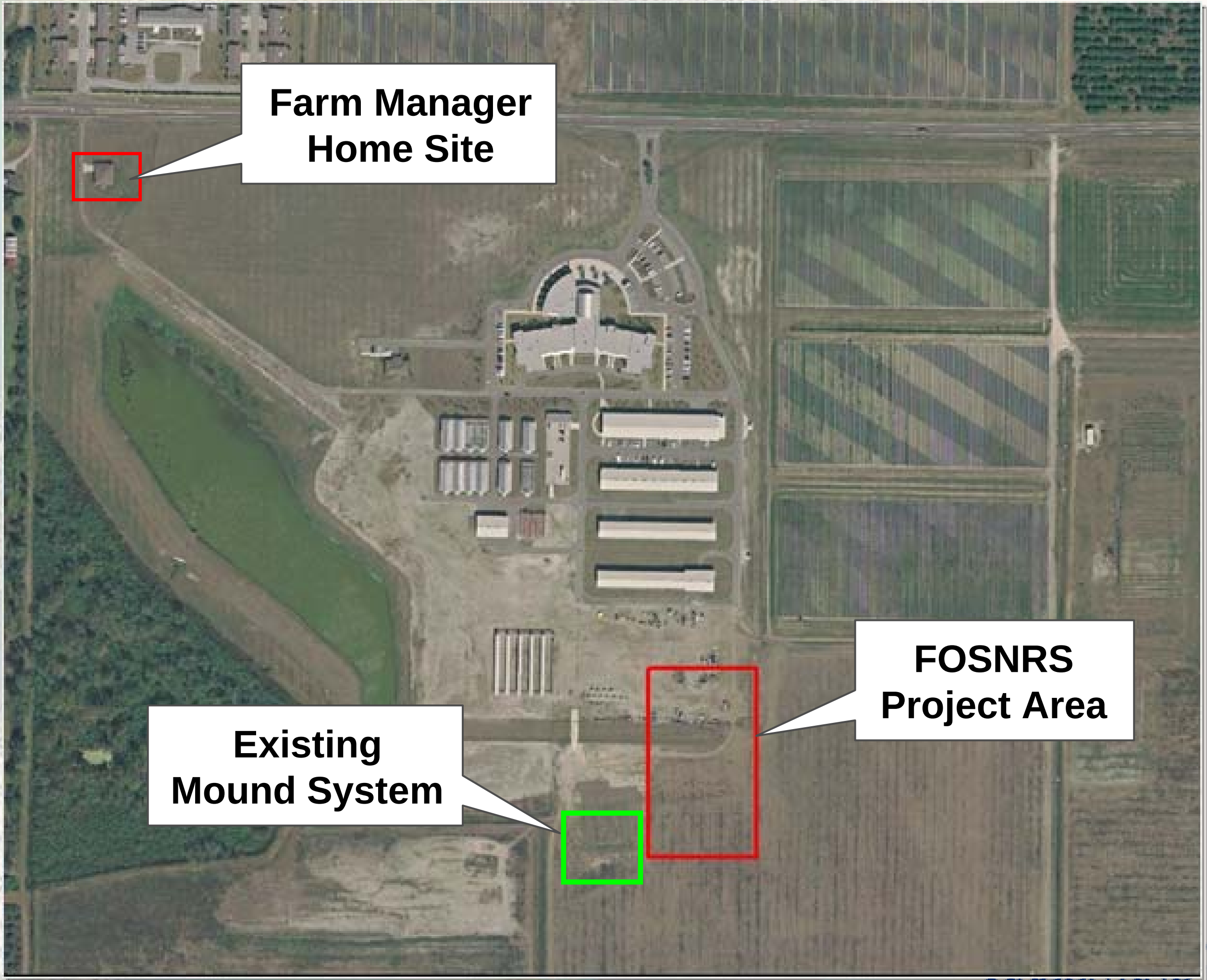
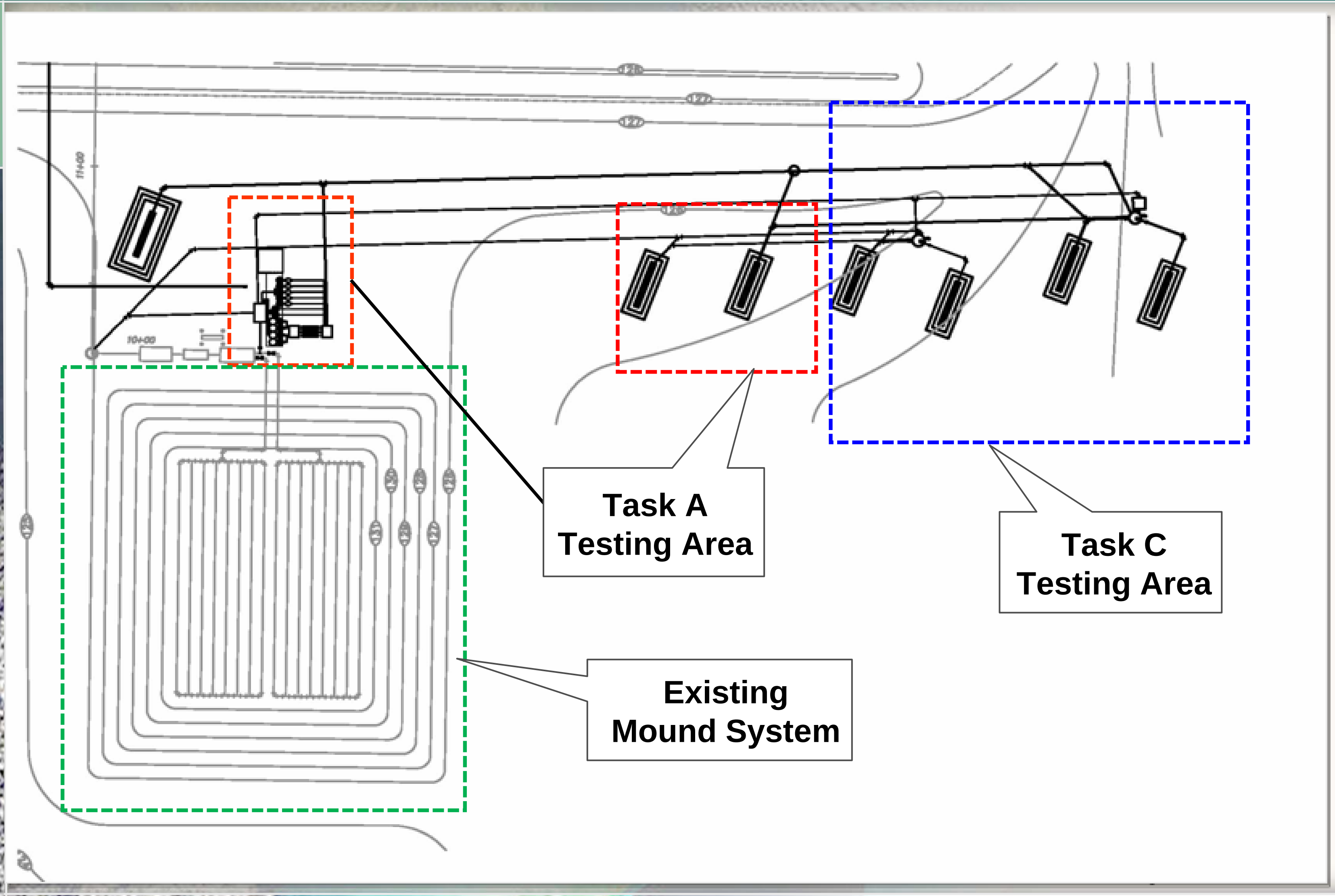
GCREC Facility and FOSNRS Project Area



GCREC FOSNRS Project Area



Passive Nitrogen Removal Study II Significant Features

- Couple first stage recycle (mixed biomass) to denitrification (separate stage biomass)
- Stage 1 unsaturated filter: 2 layer stratification design with 2 media depths
- Evaluate lignocellulosic and sulfur based Stage 2 denitrification biofilters
- Test reactive media in in-ground systems

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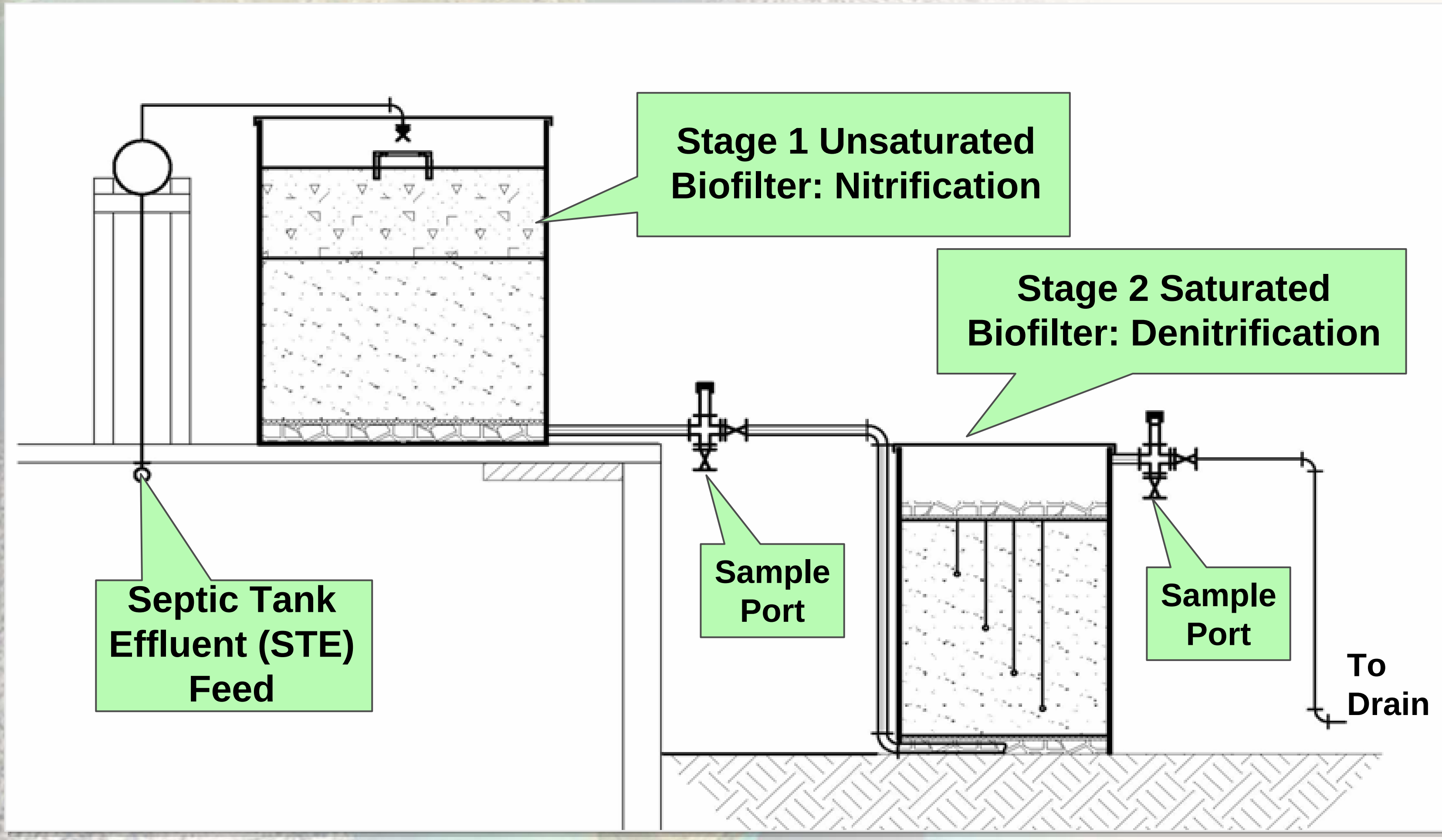
Two Stage Single Pass Biofilters



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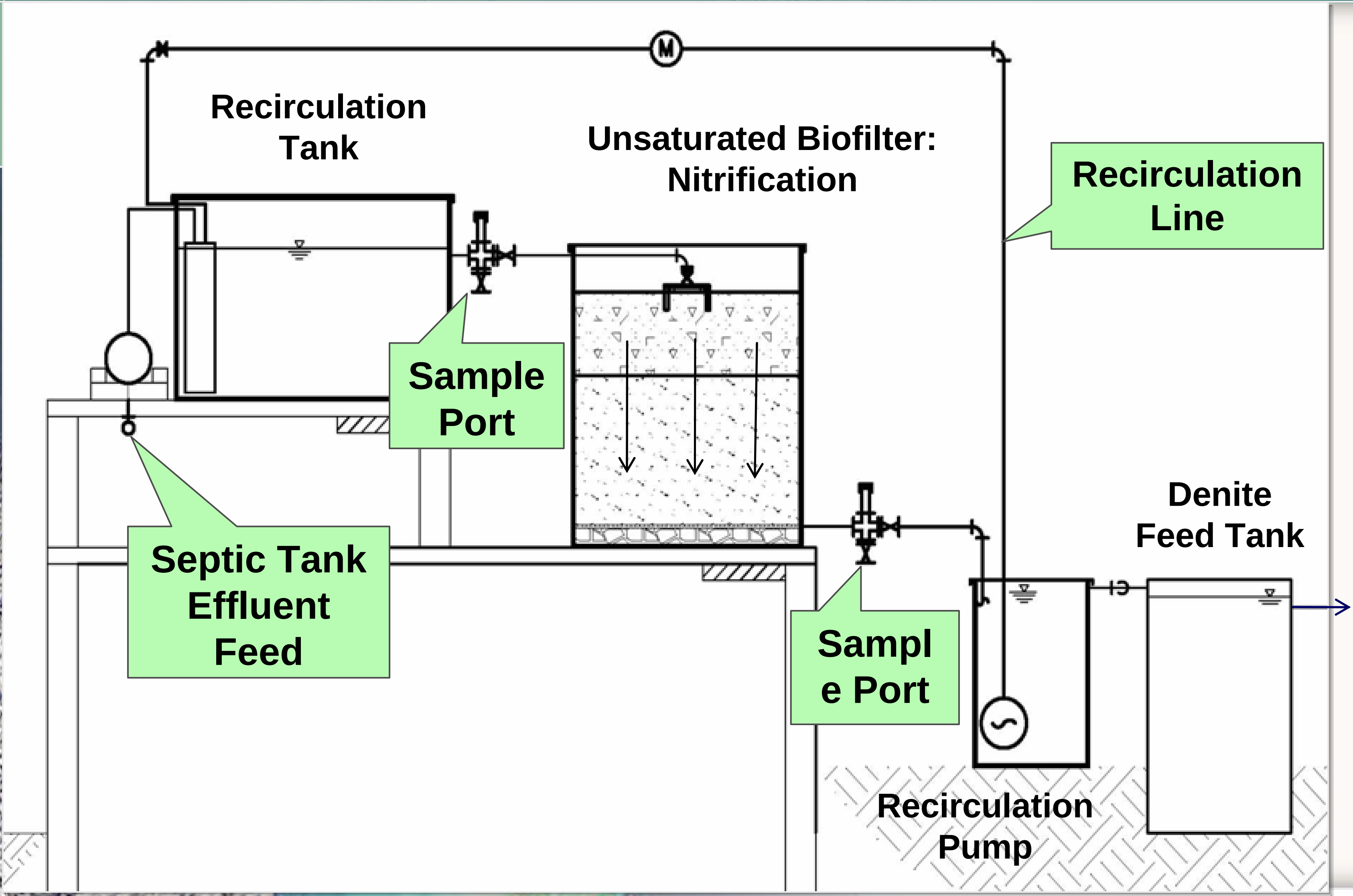
Stage 1 Recirculating Biofilters



Stage 1 Media (nitrification)

Expanded clay

Zeo-Pure clinoptilolite

Expanded polystyrene

Stage 2 Media (denitrification)

Expanded clay

Lignocellulosics

Elemental sulfur

PNRS II Test Facility Construction

Setting up tanks

Mixing media batches

Gravel underdrain

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Placing media in tanks

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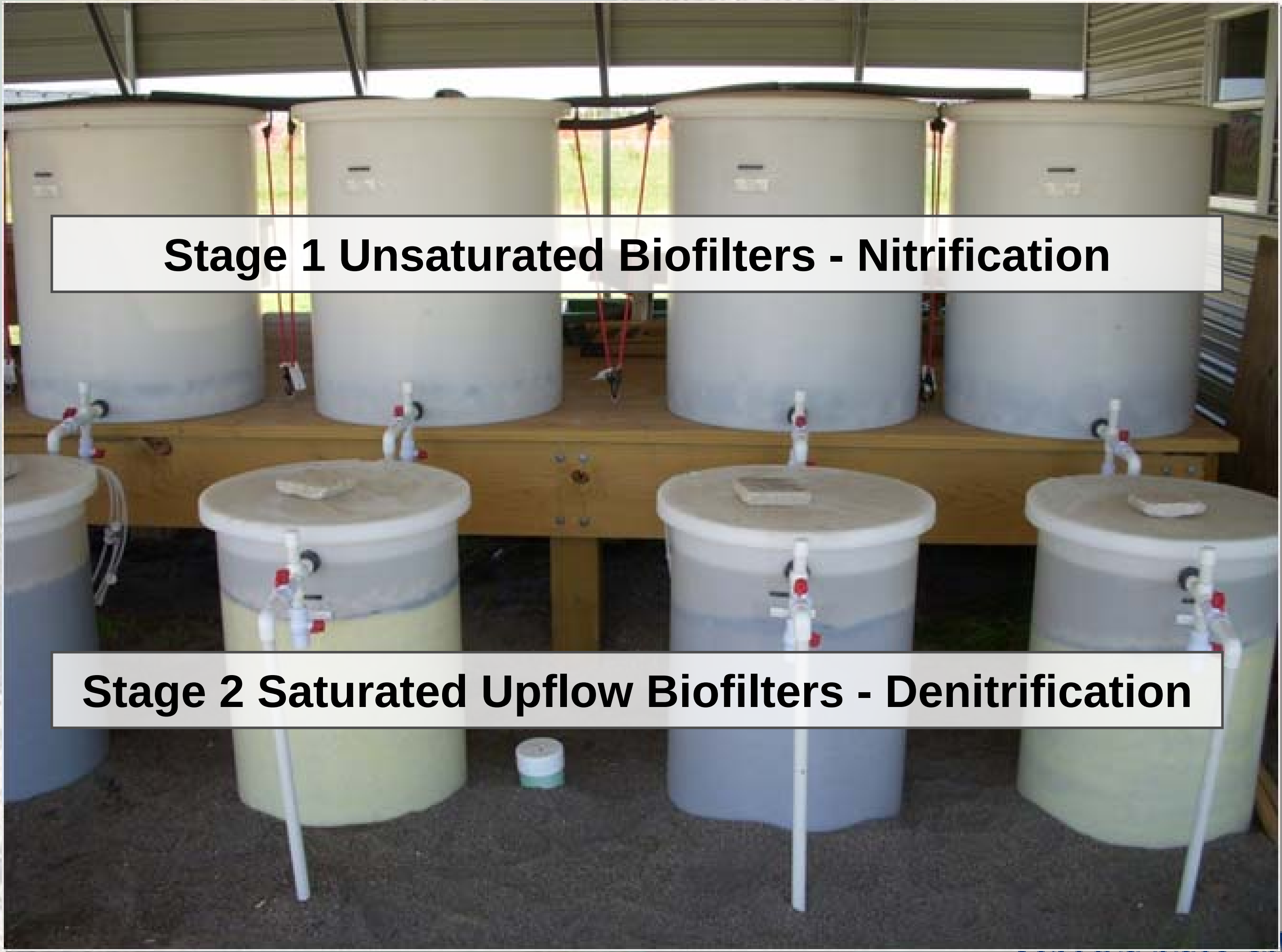
2-Stage Single Pass Biofilters



Stage 1 Recirculating Biofilters & Stage 2 Horizontal Saturated Biofilters

Stage 1 Recirculating Biofilters

Stage 2 Saturated Biofilters

Monitoring & Controls

Flow Monitoring

Control Panel

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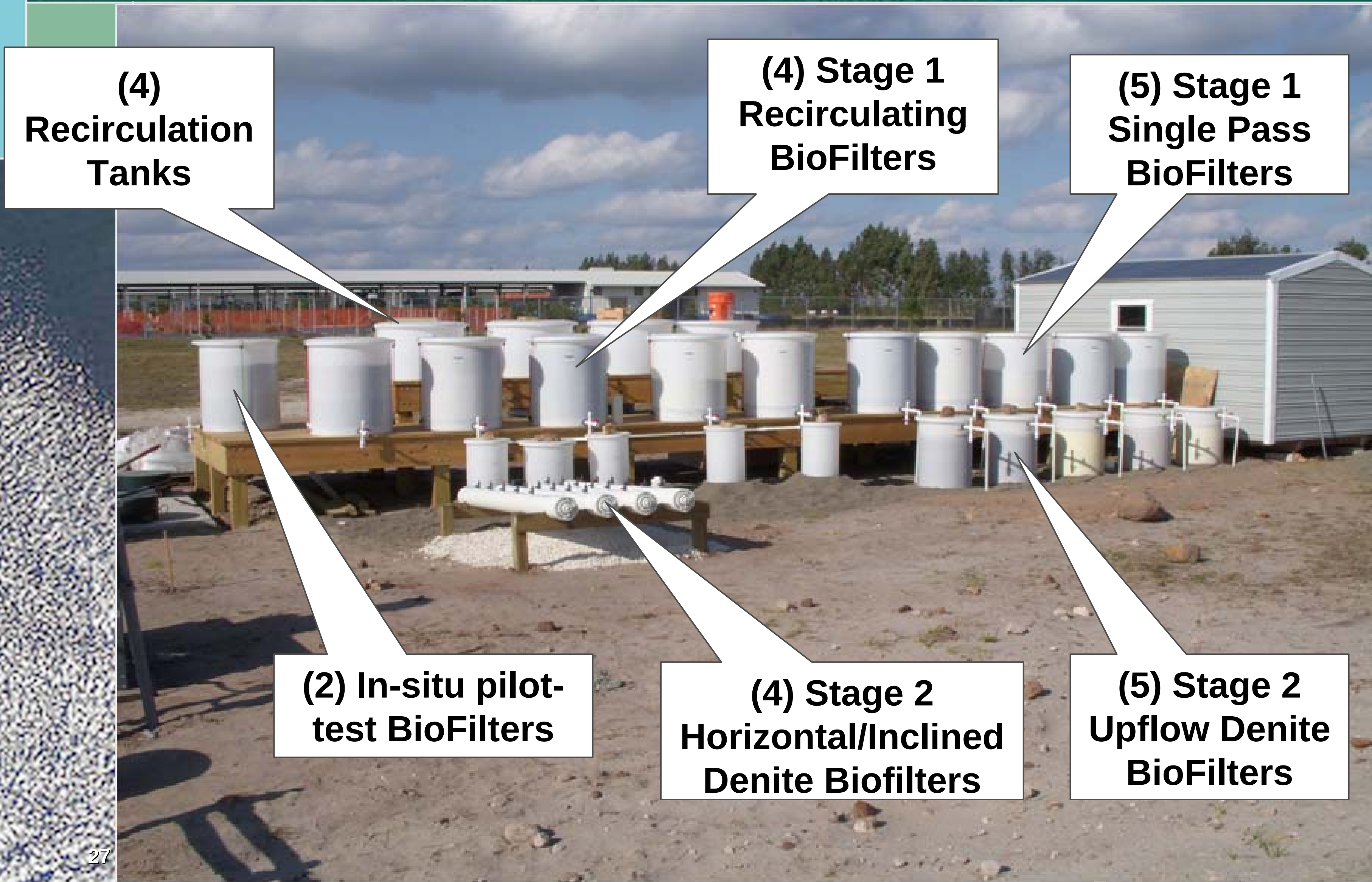
PNRS II Test Facility Nearing Completion

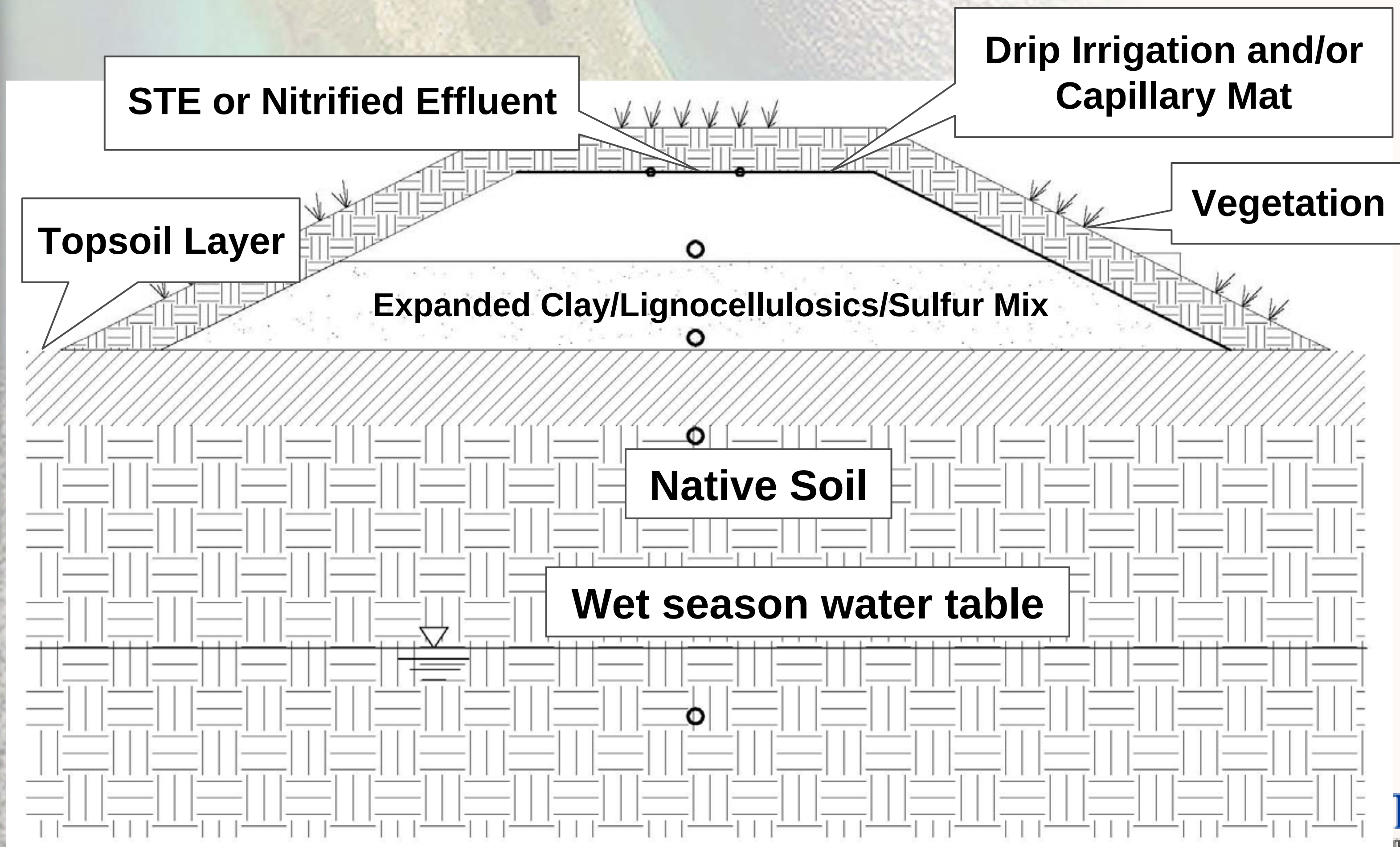


44237-001W-FN

Completed PNRS II Test Facility

Passive Nitrogen Removal Study II

In-Ground Engineered Media Concept



Passive Nitrogen Removal Study II

Application of Technologies

	Passive Two Stage Biofiltration	In-Situ Biofiltration	Passive Denitrification
New or replacement systems	X	X	
Retrofit to existing conventional system	X	X	
Addition to existing aerobic treatment system		X	X

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FOSNRS Summary

- Multi-prong project underway to reduce nitrogen from Florida's Onsite Sewage Treatment and Disposal Systems
- Integrated tasks of:
  - Treatment technology evaluation including new passive systems
  - Full-scale field testing of treatment technologies
  - Monitoring of nitrogen fate and transport in subsurface
  - Modeling and planning tools to support regulatory decision making
- Successful results would allow OSTDS to achieve nutrient removal similar to wastewater treatment plants and play a role in nitrogen reduction in sensitive watersheds

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FLORIDA DEPARTMENT OF HEALTH

Proposed Project Scope
Phase II and Phase III

UF UNIVERSITY of FLORIDA
Gulf Coast Research and Education Center

SCHOOL OF MINES 1874 COLORADO

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Scope – Task A

Task	Phase I	Phase II	Phase III
A.1 Draft Lit Review	1		
A.2 Final Lit Review	1		
A.3 Draft Classification of Tech	1		
A.4 Draft Tech Ranking Criteria	1		
A.5 Draft Priority List for Testing	1		
A.6 Tech Classification, Ranking & Prioritization Workshop	1		
A.7 Final Classification of Tech	1		
A.8 Final Tech Ranking Criteria	1		
A.9 Final Priority List for Testing	1		
A.10 Draft Innovative Systems Application		5	
A.11 Final Innovative Systems Application		5	
A.12 Identification of Test Facility Sites	2		
A.13 Draft QAPP PNRS II	1		
A.14 Recommendation for Process Forward	1		
A.15 Final QAPP PNRS II	1		
A.16 Materials Testing for FDOH Additives Rule	2	2	
A.17 PNRS II Specification Reports	1	1	

Scope – Task A (continued)

Task	Phase I	Phase II	Phase III
A.18 PNRS II Test Facility Design 50%	1		
A.19 PNRS II Test Facility Design 100%	1		
A.20 PNRS II Test Facility Construction Support & Admin	2		
A.21 PNRS II Test Facility Construction 50%	2		
A.22 PNRS II Test Facility Construction 100%	1		
A.23 PNRS II Test Facility Construction Sub. Completion	1		
A.24 PNRS II Test Facility Accept Construction	1		
A.25 Monitoring and Sample Event Reports	1	5	
A.26 Data Summary Report		6	
A.27 Draft PNRS II Report			1
A.28 Final PNRS II Report			1
A.29 Draft Task A Final Report			1
A.30 Task A Final Report			1

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Environmental Engineers & Scientists

Scope – Task B

Task	Phase I	Phase II	Phase III
B.1 Identification of Home Sites		10	
B.2 Vendor Agreement Report		8	
B.3 Draft QAPP for Field Testing	1		
B.4 Recommendation for Process Forward		1	
B.5 Final QAPP for Field Testing		1	
B.6 Field System Installation Report		8	
B.7 Field System Monitoring Report		4	4
B.8 Field System Op., Maintenance & Repairs Report			8
B.9 Technical Description of Nitrogen Reduction Tech. Report			1
B.10 Acceptance of System by Owner Report		4	4
B.11 Draft LCAA Template Report		1	
B.12 Final LCCA Template Report			1
B.13 LCCA Report (per system)			8
B.14 Draft Task B Final Report			1
B.15 Task B Final Report			1

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Environmental Engineers & Scientists

Scope – Task C

Task	Phase I	Phase II	Phase III
C.1 Draft Literature Review on N Reduction in Soil	1		
C.2 Final Literature Review on N Reduction in Soil	1		
C.3 Draft QAPP Eval. of N Red. by Soils & Shallow GW	1		
C.4 Recommendation for Process Forward	1		
C.5 Final QAPP Eval. of N Red. by Soils & Shallow GW	1		
C.6 S&GW Test Facility Design 50%	1		
C.7 S&GW Test Facility Design 100%	1		
C.8 S&GW Test Facility Design Final	1		
C.9 S&GW Construction Support & Admin.		2	
C.10 S&GW Test Facility Construction 50%		2	
C.11 S&GW Test Facility Construction 100%		1	
C.12 S&GW Test Facility Con. Substantial Completion		1	
C.13 S&GW Test Facility Accept Construction		1	
C.14 Soils & Hydrogeologic & Monitoring Plan for S&GW		1	
C.15 Tracer Testing at GCREC		3	
C.16 S&GW Sample Event Reports		6	6
C.17 S&GW Data Summary Report		6	6
C.18 Test Facility Closeout Report			1
C.19 Field Site Selection		8	

Scope – Task C (continued)

Task	Phase I	Phase II	Phase III
C.20 Instrumentation of GCREC Mound System	0.5	0.5	
C.21 GCREC Mound Sample Event Report		3	1
C.22 GCREC Mound Data Summary Report		3	1
C.23 Instrumentation of Remaining Field Sites Report		2	3
C.24 Field Sites Sample Event Reports		4	16
C.25 Field Sites Data Summary Report		4	16
C.26 Draft Site Summary and Close-Out Report			5
C.27 Final Site Close-Out Report			5
C.28 Draft Task C Final Report			1
C.29 Task C Final Report			1

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Environmental Engineers & Scientists

Scope – Task D

Task	Phase I	Phase II	Phase III
D.1 Draft Lit Review on N Fate & Transport Model	1		
D.2 Final Lit Review on N Fate & Transport Model	1		
D.3 Selection of Existing Data Set for Calibration	1		
D.4 Draft QAPP N Fate & Transport Models	1		
D.5 Recommendation for Process Forward	1		
D.6 Final QAPP N Fate & Transport Models		1	
D.7 Simple Soil Model Development		1	
D.8 Non-Steady State Aquifer Model, Simple Soil Model		1	
D.9 Aquifer Model with Averaged Output, Simple Soil Model		1	
D.10 Multi-Source Aquifer Model		1	
D.11 Calibrate Non-Steady State Aquifer Model		1	
D.12 Calibrate Aquifer Model			1
D.13 Calibrate Multi-Source Aquifer Model			1
D.14 Complex Soil Model Development			1
D.15 Non-Steady State Aquifer Model, Complex Soil Model			1
D.16 Aquifer Model with Averaged Output, Complex			1

Scope – Task D (continued)

Task	Phase I	Phase II	Phase III
D.17 Multi-Source Aquifer Model, Complex			1
D.18 Calibrate Non-Steady State Aquifer Model, Complex			1
D.19 Calibrate Multi-Source Aquifer Model, Complex			1
D.20 Uncertainty Analysis for Non-Calibrated Models		1	
D.21 Validate/Refine Non-Steady State Aquifer Model with Task C Data			1
D.22 Validate/Refine Complex Soil with Task C Data			1
D.23 Uncertainty Analysis for Calibrated Models			1
D.24 Validate/Refine Non-Steady State Aquifer, Complex with Task C Data			1
D.25 Decision-Making Framework Considering Uncertainty			1
D.26 Validate/Refine Multi-Source Aquifer Model, Complex with Task C Data			1
D.27 Draft Task D Final Report			1
D.28 Task D Final Report			1

Scope – Task E

Task	Phase I	Phase II	Phase III
E.1 Project Kick-Off Meeting	1		
E.2 PM – Project Progress Reports	6	4	12
E.3 RRAC or TRAP Presentation	2	1	4
E.4 RRAC or TRAP Meeting Attendance	1	1	4
E.4 PAC Meetings		1	3

HAZEN AND SAWYER
Environmental Engineers & Scientists

HAZEN AND SAWYER
Environmental Engineers & Scientists

FLORIDA DEPARTMENT OF HEALTH

Questions?

UF UNIVERSITY of FLORIDA
Gulf Coast Research and Education Center

AET
Applied Environmental Technology

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:	January 1, 2010 – March 31, 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, and in October 2009. Another WEFTEC presentation has been selected for presentation at the 2010 conference.
    - All sampling has been completed for this task. Quality control of collected data was completed this quarter with some minor clarifications still outstanding. Sampling results will be sent in the next quarter once quality control is complete.
    - 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 will be completed by bureau staff with anticipated volunteer assistance. During the last quarter it became apparent that the 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

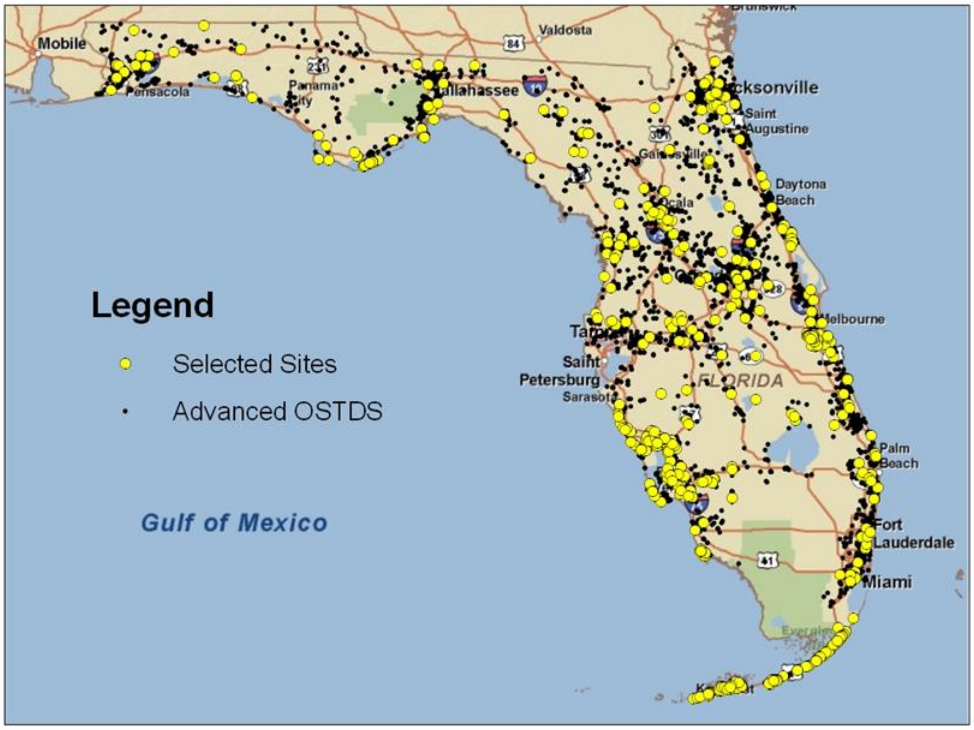
operating permits in the state database and in Carmody, complicating efforts to develop a comprehensive database with uniform fields. Much time during this and the previous quarter has been spent identifying duplicate data, cleaning up and combining the records. The approach taken focused on the physical 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. We are in the process of geocoding them, 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 quarter.
  - 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.
  - This task is behind schedule due to minimal DOH staff time available and delays getting contract staff hired. At this point the delays to the database 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 will range from 5 pages long to 10 pages long depending on the user group. The surveys are included in this 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 are mailed out a second round of follow-up surveys will be sent out to the non-responders. This is to occur during the beginning of the next quarter.
  - 100% of the population size will be surveyed for the Onsite Regulators, Installers, Engineers, Manufacturers, and Maintenance Entities. 3,795 of the System Owners are to be 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 this quarter that a significant fraction of the surveys were returned as undeliverable. The address list stemmed from an earlier interim product of Task 2. Early during the next quarter, we will attempt to update the undeliverable addresses and resend the survey to the corrected address.
  - This task is behind schedule due to several legislatively mandated studies that consumed much of the grant managers time during this quarter and previous

quarters. This task is anticipated to be complete by June 30, 2010. 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 the time 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 early part of next quarter.
    - Contract staff became certified in OSTDS in December of 2009 as stipulated in the grant agreement. Staff has also attended GIS mapping training this quarter.
    - Criteria regarding site selection were presented discussed at the RRAC meeting on December 16, 2009. There were lots 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 is submitted with this quarterly report. The main sample selection will be 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 will be amended to ensure treatment comparison samples are included (fixed media, combined media, and extended aeration). Overlap with the initial random sample will be maximized.
    - 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 below.

Distribution of Sample Sites



- o Permit files have been gathered for Leon and Wakulla Counties. This data gathering will continue in subsequent quarters.
- o 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 will be collecting product manuals to assist with sampling.
- o 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 this quarter. The selected lab is Florida Testing Services, LLC DBA Xenco Laboratories and the final cost for the project sampling is $30,120 which is $97,805 under budget.
- o This task is behind schedule due to minimal staff time available and delays getting contract staff hired. The delays associated with this task do put the project behind schedule. At this point the project appears to be at least 6-months behind schedule and is dependant on when the QAPP is approved by all parties.

- Task 5: Assessment of Annual Variability of Performance
  - o The draft Quality Assurance Project Plan is being developed with an anticipated completion during the early part of next quarter.
  - o This task is behind schedule due to minimal staff time available and delays getting contract staff hired. The delays associated with this task do put the project behind schedule. At this point the project appears to be at least 6-months behind schedule and is dependant on when the QAPP is approved by all parties.
- Task 6: Management Practices
  - o Contract staff has been compiling data as it becomes available.
  - o A supplemental database was created to capture County Health Department management practices and files have been gathered from Wakulla and Leon Counties.

- 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 that have now been resolved. These delays translate to delays in the completion time of the project Once the QAPP has been fully approved, which is anticipated to occur in the next quarter, we will have a better estimate as to how long the project will need to extend.

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.)

- Task 3 Final surveys
- Task 4 Site selection flowchart
- Task 4 Purchase order with Florida Testing Services, LLC dba Xenco Laboratories

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, 342.42	$499.00	$50,711.08
Equipment	$0	$0	$0	$0
Supplies/Other Expenses	$3,618	$125.01	$133.40	$3,359.59
Contractual Services:				
Surveying	$25,000	$1,100.00	$0	$23,900.00
Monitoring	$127,925	$1,800.00	$0	$126,125
Public Education	$5,000	$0	$0	$5,000
TCC/Niteline Contract	$94,259	$20,930.45	$11,486.34	$61,842.21
Total:	**$308,354.50**	**$25,297.88**	**$12,118.74**	**$270,937.88**

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

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

Thursday June 10, 2010

9:30 am – 3 pm

Agenda:

1. Introductions and Housekeeping
2. Review Minutes of Meeting March 23, 2010
3. Town of Suwannee Study Final Report Presentation
4. Nitrogen study
   a) Budget proviso language
   b) Comment on deliverables and next steps
5. Discussion on DEP's Wekiva Fertilizer Report
6. Discussion on Continuation of Inventory of OSTDS and Relationship to Maintenance and Management Program (SB 550)
7. Update on Study of Performance of Advanced Systems in Florida
8. Alternative Drainfield Products Discussion
9. Discussion on Research Budget
10. Election of Chair and Vice Chair
11. Other Business
12. Public Comment
13. 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

Review Minutes of Meeting March 23, 2010

- See draft minutes

Town of Suwannee Study

Purpose: Test the difference in water quality after central sewer has been installed in an area previously served by onsite sewage systems

Progress:

- Final draft report submitted
- Presentation by Larry Danek from ECT
- Comments on report due by end of June

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

Nitrogen Reduction Strategies Study

- Proviso language:

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.

Nitrogen Reduction Strategies Study

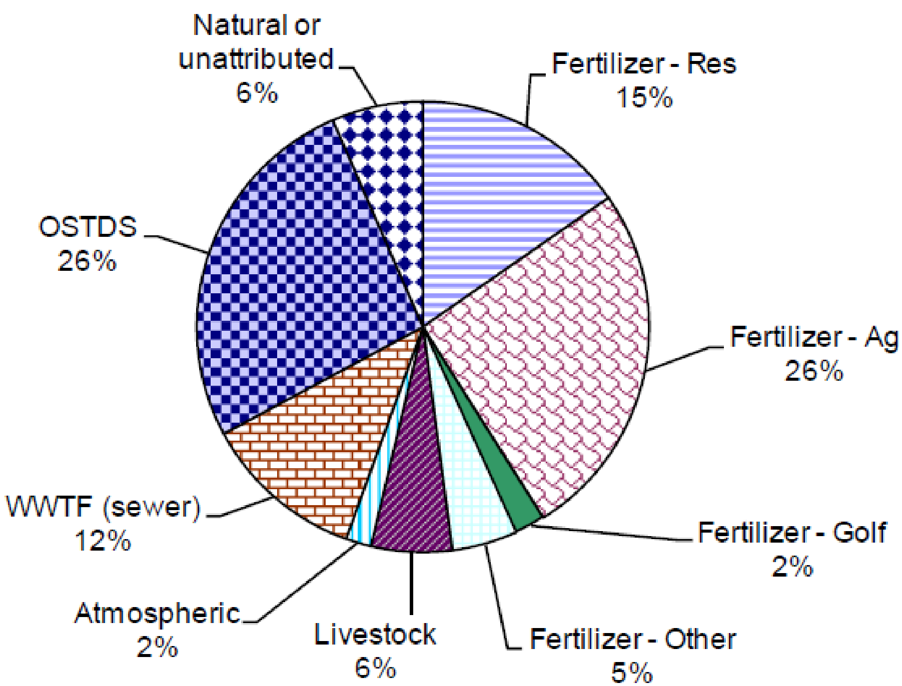
Presentation by Hazen & Sawyer

DEP's Wekiva Fertilizer Report

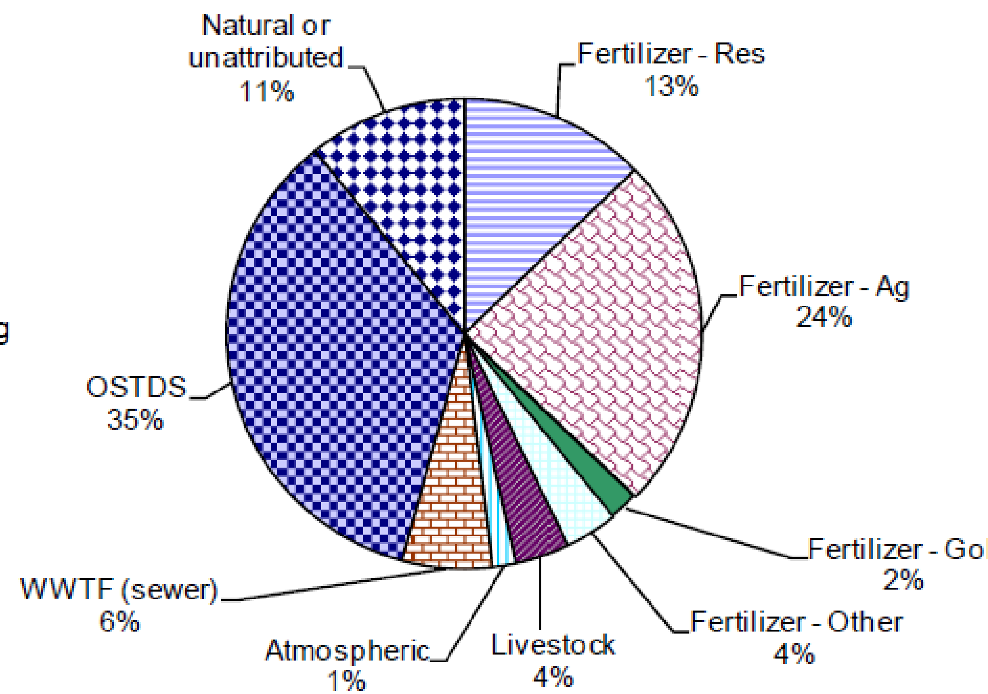
- Wekiva nitrate sourcing study complete
- Focus on residential fertilizer use
- Inputs were modified for WWTF and atmospheric deposition per comments from DOH and Damann Anderson
- Fertilizer inputs were adjusted based on the findings of the study
- Used Ellis & Associates field data for the OSTDS inputs and loadings (increased the estimate by 45% & 16% respectively)

Nitrate Loadings

Wekiva Basin



Wekiva Study Area



DOH number of septic systems were used directly in calculating loadings in WSA, and extrapolated for the basin calculations

DEP's Wekiva Fertilizer Report

- Next steps

New Legislation (SB 550): Maintenance and Management Program

5-year inspection of all systems in Florida

Requiring:

- Pump-out tanks
- Repair failing systems
- Minimum water table separation
  - Before 1983 = 6-inch, if repaired = 12-inches
  - After 1983 = 12-inch, if repaired = 24-inches

FL Wastewater: Results of Inventory

PLEASE NOTE This site is under development and is not available for the general public to view at this time. We are working on making this publicly available.

Continuation of Inventory

- EHD updating
- DOR updating
- DEP data update
- Letters to WWTP
- CHD’s to resolve unknowns

319 Project on Performance and Management of Advanced Onsite Systems

Purpose: Assess water quality protection by advanced OSTDS throughout Florida

Progress:

- Monroe County Project
  - Draft summary report being drafted
- Database
  - Mostly complete
  - 16,802 identified advanced systems in the state
  - Summary statistics to be developed
  - Description of technology used has been added (unsaturated fixed media, combined media, extended aeration)

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		

319 Project on Performance and Management of Advanced Onsite Systems

Progress cont. :

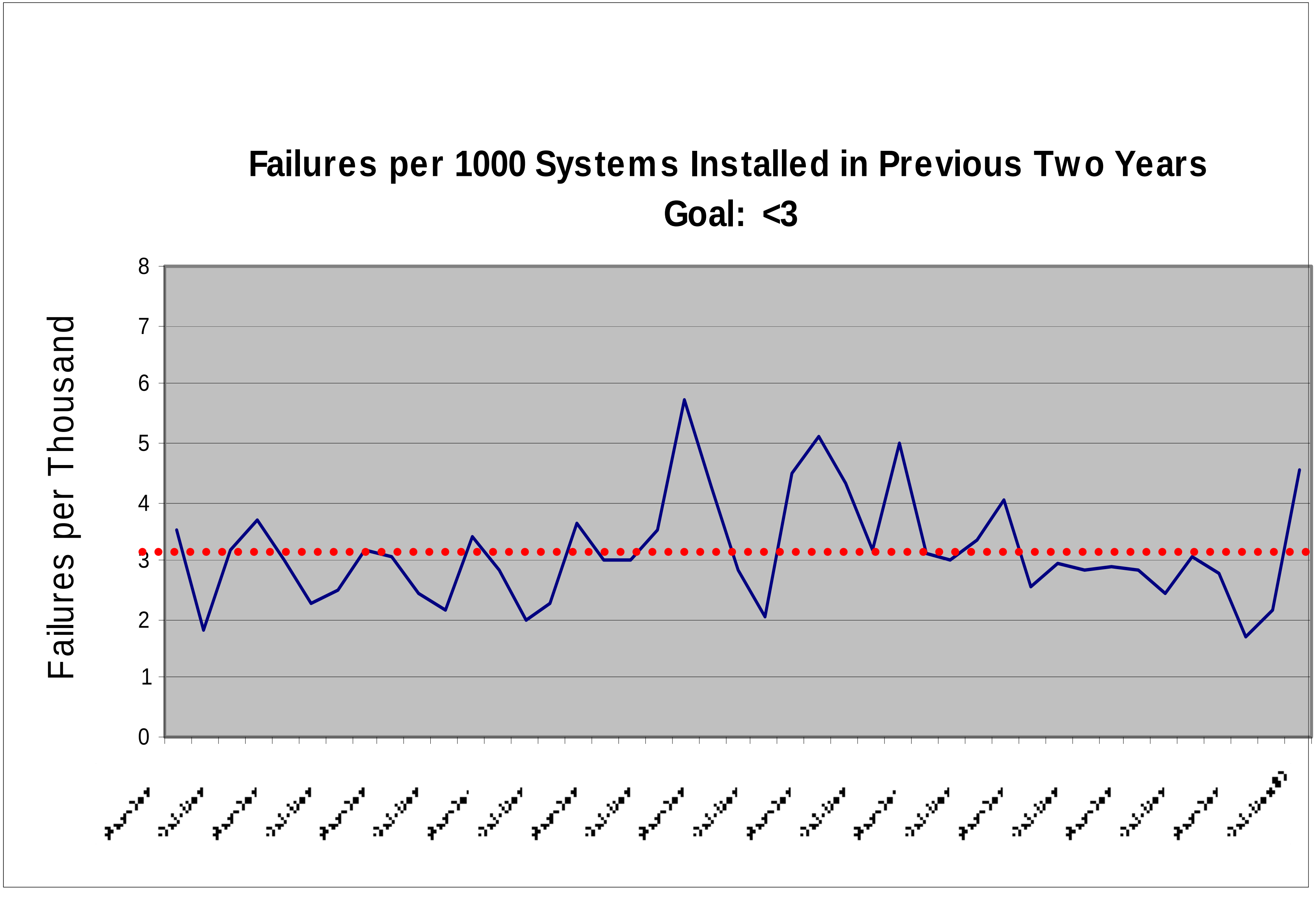
- Surveys of interest groups
  - Surveys have been finalized and mailed to interest groups
  - Approximately 1,000 of 3,800 surveys sent to users were returned as undeliverable, almost all were resent to owner's mailing address
- Sampling
  - QAPP is being finalized
  - Contract with lab has been executed
  - Permit file reviews are ongoing
- Management Practices
  - Evaluation tool being developed to evaluate CHD's

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.

Proposed scope of work:

1. Evaluate existing data (cost will be staff time)
2. Create an advisory group with product manufacturers, contractors, and CHD
3. Fill in blanks from data evaluation by doing detailed surveys on repairs utilizing contractors and CHD staff



Failures per 1000 Systems Installed in Previous Two Years
Goal: <3
Failures per Thousand
8
7
6
5
4
3
2
1
0

Research Budget

For fiscal year 2009 - 2010:

• Beginning Cash Balance	$655,830
• Total Revenue (permit fees)	$ 66,992
• Current Year Expenses	$177,847
• Ending Cash (05/31/2010)	$544,975

B9 Onsite Sewage Research Budget Request

2010 - 2011 Fiscal Year

Salaries	$ 60,000
Expense	$ 25,000
Contracted Services	
a) Alternative Drainfield Product Assessment	$ 40,000
b) Inventory Phase II	$100,000
c) Columbia County River Front Survey	$ 5,000
d) Other	$ 30,000
Subtotal	$175,000
Total	**$260,000**

Grants and Appropriations Onsite Sewage Research Budget Request

2009 - 2010 Fiscal Year

319 Advanced Systems		**$221,490.20**
a) Travel	$50,711.08	
b) Expense	$3,359.59	
c) Contracted Services		
FSU	$7,375.50	
Niteline Contract Employee	$27,119.03	
Lab (Sampling)	$127,925.00	
Public Education	$5,000.00	
Nitrogen Study		**$2,000,000.00**
a) Expense	$50,000	
b) Contracted Services		
Hazen & Sawyer	$1,949,000.00	
F.A.C.	$1,000.00	
Total for all projects		**$2,221,490.20**

Election of Chairman and Vice-Chairman

- Recommendation of nominees
- Vote

Other Business

Pollution Prevention Grant Proposal

Grease Sludge Waste in Establishments on Onsite Sewage Treatment and Disposal Systems Generating Commercial Strength Sewage Waste

- **Objective:** Develop and verify best management practices for grease reduction and reuse in facilities generating commercial strength sewage waste
- Grant proposal submitted on April 5, 2010
- EPA should make decision in July

Public Comment

Next Meeting

Upcoming meeting topics:

- RRAC Priorities
- Inventory study phase II discussion
- Alternative drainfield products discussion

Proposed dates for next meeting:

- Suggestions?

Closing Comments and Adjournment

EVALUATION OF WATER QUALITY AROUND THE TOWN OF SUWANNEE, FLORIDA, AND COMPARISON TO HISTORIC DATA

CONTRACT COQOT—EXTENSION

Prepared for:

FLORIDA DEPARTMENT OF HEALTH

DIVISION OF ENVIRONMENTAL HEALTH
BUREAU OF ONSITE SEWAGE PROGRAMS
Tallahassee, Florida

and

NOAA — NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION — U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC ATMOSPHERIC ADMINISTRATION

Prepared by:

ECT
Environmental Consulting & Technology, Inc.
3701 Northwest 98th Street
Gainesville, Florida 32606
Larry J. Danek, Gary P. Dalbec, and Shirish Bhat

ECT No. 090801-0200

April 2010

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued, Page 2 of 2)

LIST OF TABLES

LIST OF TABLES
(Continued, Page 2 of 2)

LIST OF FIGURES

EXECUTIVE SUMMARY

In 1989 to 1990 *Salmonella* contamination was detected in commercially harvested oysters from an area around the town of Suwannee. The contamination was suspected to be caused and/or contributed to by onsite sewage treatment and disposal systems (OSTDS) in the town. To alleviate the contamination source, plans were approved to abandon OSTDS and route all sewage to a central wastewater treatment plant (WWTP). All OSTDS were closed by March 1998, and the WWTP became operational in October 1997.

The Florida Department of Health and Rehabilitative Services (FDHRS) contracted with Environmental Consulting & Technology, Inc. (ECT), to conduct sampling in 1996 and 1997 in and around the town to evaluate potential differences in water quality immediately before and after construction and operation of the WWTP. A report of this study was issued in 1998. The results of the study suggested the town was not the sole source of *Salmonella*, as this organism was routinely found upstream of the town indicating a potential regional issue.

Unfortunately, the pre- and postconstruction comparisons were somewhat compromised, because in 1997, an El Niño episode persisted during the time of postconstruction sampling, which produced high river flows and potentially introduced other bacterial contamination sources. As such, this weather anomaly affected the postconstruction results and limited the ability to compare with preconstruction data.

In September 2008, the Florida Department of Health (FDOH) received funding to conduct a follow-up study. The intent of the study was to provide an updated evaluation of the environmental impacts of abandoning the OSTDS and sewering the town to a central WWTP. Because of scheduling limitations on the funding, the study was conducted during the summer of 2009, which was not ideal for comparison with the 1996 data that were collected in the winter.

The 1996 and summer 2009 study designs were intended to have common study components to facilitate data comparison. However, in 2009 other analytical parameters were added to provide additional information: total phosphorus, enterococci, and deoxyribonucleic acid (DNA) source (human versus animal) tracking.

The results of the summer 2009 study provided valuable comparisons between pre- and postconstruction water quality data. Statistical techniques were used to separate the changes observed at the river stations (used as controls) and the canal stations. The most notable result was a statistically significant reduction in fecal coliform values observed in the canals between 1996 and the summer of 2009. However, the results of the comparison were somewhat in question, because the studies were conducted during different seasons, which might have biased some of the microbial data.

Fortunately, FDOH received additional funding to repeat the sampling events during the winter of 20009. The sampling was conducted in November and December and aligned with the eight weekly events conducted in 1996. Four river stations, five canal stations, and one monitoring well were sampled. The parameter list for both 1996 and 2009 included fecal coliform, total coliforms, *Salmonella* (presence/absence only), nitrate + nitrite (NO_x), and total Kjeldahl nitrogen (TKN). In addition, enterococci and human gene biomarker (HGB) analyses were added in 2009.

The goal of this study was to evaluate the long-term effects of closing approximately 850 OSTDS in the town of Suwannee and installing a central WWTP. The approach was to sample water quality in the Suwannee River and the canals within the town of Suwannee and compare the results with data collected in 1996 prior to OSTDS closures. The two previous attempts to provide postconstruction data for comparison provided valuable information but were not ideal because of extreme river discharge conditions and seasonality concerns. The current study was conducted during the same season and during comparable river discharge conditions as the 1996 baseline survey conducted prior to septic tank removal. Therefore, this study provides a more defensible data set to evaluate potential improvements in the area 13 years after septic tank closure.

The results did not suggest that there was large improvement in water quality in the canals between 1996 and 2009 that could be attributed to closing the OSTDS. However, several specific observations and some improvements were noted:

- *Salmonella* occurrences were equal to or higher in the river than in the canals in both 2009 and 1996, indicating the canals were not the primary source of *Salmonella*. The percent occurrence of *Salmonella* in the canals was greater in 2009 than in 1996, indicating septic tank closure did not reduce *Salmonella* in the canals.
- NO_x exhibited a strong correlation with river flow and decreased with increasing river flow. TKN increased with increasing river flow, and total nitrogen remained relatively constant. There was consistently more NO_x in the river samples than in the canals; however, there was approximately 7 percent less NO_x measured in 2009 than in 1996.
- The source tracking results (HGB) indicated human material was present approximately 82 percent of the time in the canals (average of two stations) and only 50 percent of the time in the river (Station 10). It appears that, despite septic tank closure, the canals remain a possible source of HGB. Source tracking was not conducted in 1996.
- During the summer 2009 sampling event, HGB was present 38 percent of the time in canals as compared to 50 percent presence in the river.
- The total and fecal coliform values were higher in the canals than in the river in both 1996 and 2009. Fecal coliform decreased from 1996 to 2009 in both the canals and the river stations, whereas total coliforms increased from 1996 to 2009. The higher values in the canals as compared to the river could be from domestic animals or wildlife concentrated near the canals.
- Simple statistical comparison of the 2009 results with the 1996 results indicated there were three statistically significant changes in the measured parameters between 1996 and 2009:
    - There was a 59-percent decrease in fecal coliform in the canals.
    - There was a 230-percent increase in total coliforms in the river.
    - There was a 6-percent decrease in total nitrogen in the river.

All other observed changes in the surface water samples were not statistically significant.

- Additional statistical tests were conducted that evaluated the variability observed in the river stations (controls) and compared that with the variability observed in the canals. The results indicated the magnitude of reduction in fecal coliform concentrations from 1996 to 2009 was unique to the canal stations and could be a possible benefit of closing the OSTDS.
- The monitoring well data indicated dramatic improvement from 1996 to 2009 in most of the parameters. The fecal coliform counts dropped from an average of 232 col/100 mL to nondetectable. The nitrogen parameters all dropped in excess of 82 percent. Since the well was located downgradient of the septic tank drain field, closing the septic tank resulted in marked improvement in the groundwater at this location. However, total coliforms and the percent occurrence of *Salmonella* increased in 2009.
- Comparison of the winter 2009 data with the summer 2009 data indicated that total coliform counts were higher in the summer, but fecal coliform, enterococci, and *Salmonella* occurrences were higher in the winter for both the river and canal stations.

In summary, the results indicated that there was a statistically significant 59-percent reduction of fecal coliform in the canals between 1996 and 2009 that could not be attributed to changes observed in the river stations. There was also an improvement in groundwater measured near a septic tank drain field. No other significant improvements in the water quality of the canals was identified that could be attributed to OSTDS closures.

The winter 2009 study provided a unique opportunity to examine the water quality in the canals and the river around the town of Suwannee 13 years after closure of 850 OSTDS in the area. Rigorous analysis of the data indicated there was a significant reduction of fecal coliform in the canals, but there was not a significant reduction of nitrogen, total coliforms, or occurrences of *Salmonella*, which might have been anticipated. There was a marked improvement of the groundwater near a septic tank drain field.

It is unlikely that additional studies of these parameters would identify further improvements attributable to septic tank removal, since additional improvements were not apparent after 13 years. Although the study plan attempted to isolate the removal of the OSTDS as the only variable for testing between the pre- and postconstruction sampling, it was not possible to control all environmental factors. It is recommended that future studies follow a similar protocol and establish a series of test and control stations that lend themselves to rigorous statistical analysis. Future studies at other sites should again be designed to conduct the pre- and postconstruction sampling during comparable seasonal (temperature) and river discharge conditions. It is also recommended that the additional source tracking techniques such as HGB be used more extensively to help separate human impacts from natural sources.

1.0 INTRODUCTION

1.1 PROJECT HISTORY

A cooperative study by the Florida Department of Natural Resources (FDNR, now the Florida Department of Environmental Protection [FDEP]), the Florida Department of Agriculture and Consumer Services (FDACS), and the U.S. Food and Drug Administration (FDA) in 1990 (Glatzer, 1990), investigated an incident of gastroenteritis in Florida during the fall and winter of 1989 to 1990. At least two of the cases were indicative of salmonellosis. Samples of oysters from Louisiana and Florida were analyzed for *Salmonella*. Approximately 39 percent of the oysters tested positive for *Salmonella*; approximately 90 percent of these oysters were from Suwannee Sound and adjacent areas to the north and south—Horseshoe Beach and Cedar Key, respectively. In addition, *Salmonella* were detected in water samples taken upstream and downstream of the town of Suwannee. Possible sources identified by Glatzer (1990) were the waterfowl and wildlife in the area. In May 1990, FDNR reclassified the oyster areas of Suwannee Sound. This reclassification included changes in closure areas and a new management plan based on rainfall amount.

According to the Florida Department of Health and Rehabilitative Services (FDHRS, 1991), now the Florida Department of Health (FDOH), the town of Suwannee had a total of 717 onsite sewage and treatment disposal systems (OSTDS). Of these, based on agency assessment criteria, seven (i.e., less than 1 percent) systems were considered adequate. The remaining 710 inadequate OSTDS were identified as one of the possible sources for *Salmonella* contamination of the oysters in Suwannee Sound and adjacent areas. Because of the number of inadequate OSTDS, plans were approved to construct a central wastewater treatment plant (WWTP). The facility became operational in October 1997, and connections to the system began immediately. The WWTP is located approximately 2.5 miles northeast of the town and uses primary clarification and aeration basins for treatment of the wastewater. The OSTDS were pumped out and abandoned (filled with sand) at the same time each household was connected to the WWTP system. By the end of November or mid-December 1997, all but approximately 50 of the OSTDS were closed. The remaining 50 OSTDS were closed by March 1998. Instead of the

717 OSTDS initially reported by FDHRS (1991), 850 OSTDS were found; all were properly abandoned.

To investigate the impacts the OSTDS closures and use of a central WWTP would have on surface water around the town of Suwannee, FDHRS contracted Environmental Consulting & Technology, Inc. (ECT), to conduct a water quality study. Sampling was conducted in 1996 prior to the OSTDS closure and again from November 1997 through January 1998 following the OSTDS closure, and a report was issued in 1998 (ECT, 1998). The study included analyses for nutrients, *Salmonella*, and coliforms. Other fecal contaminant indicators were considered for analyses including coprostanol, epicoprostanol, and linear alkylbenzenes (detergent whitener). Of these indicators, coprostanal was selected but provided inconclusive results.

In September 2008, FDOH issued an invitation to negotiate (ITN) titled Evaluation of Water Quality around the Town of Suwannee. The intent of the proposed study was to provide an updated evaluation of the environmental impacts of abandoning the OSTDS and sewering the town to a central WWTP. ECT responded to the ITN and was selected to conduct the study. Sampling for this project was conducted in June and July 2009, and a final report was issued in September 2009.

Because of scheduling issues with funding, the study needed to be conducted in the summer of 2009, which was not ideal for comparison with the preconstruction study that was conducted in the winter (November and December) of 1996. Subsequently, FDOH obtained additional funding to conduct a fourth survey that was completed in November and December 2009. This provided a data set obtained 13 years after the preconstruction survey was completed in 1996 that was completed during the same season. This report provides the results of the winter 2009 study and comparison with the 1996 preconstruction baseline data.

1.2 PROJECT GOALS

The goal of the initial program, as well as the summer 2009 survey, was to evaluate the potential for restoration of commercially viable oyster harvesting in Suwannee Sound following the connection of the town of Suwannee to a WWTP. The specific objectives included:

- Conduct a preliminary online literature search to identify and evaluate various methods for detecting domestic sewage in receiving waters.
- Prepare a plan of study (POS) and quality assurance project plan (QAPP) that would lay out a sampling strategy to meet the goals of the project.
- Conduct preconstruction (of the WWTP) field sampling that would: (1) determine the optimum day of the week to sample, if any; (2) confirm that low tide was the ideal worst-case time to sample; (3) evaluate the various methods selected for detection of domestic sewage; and (4) quantify water quality conditions in the Suwannee River in the vicinity of the town of Suwannee prior to the construction of the WWTP and subsequent abandonment of the OSTDS.
- Conduct postconstruction sampling to determine what changes, if any, resulted from the town of Suwannee converting from OSTDS to the WWTP with land disposal.
- Evaluate the field data and data from other sources in light of the information obtained from the ongoing online literature search and determine if there has been any change in water quality and if the change is statistically significant.

The primary goal of the current project is to generate a comparative water quality database by duplicating the previous study's (1996) weekly sampling effort. The specific sampling approach designed to achieve this goal include:

- Collect samples at the same ten stations (nine surface water and one groundwater) as used in the 1996 to 1998 studies.
- Collect samples over the same duration (eight consecutive weekly events).
- Collect surface water samples during the same tidal cycle (low slack).
- Analyze samples for the same microbiological and nutrient parameters plus the addition of enterococci and deoxyribonucleic acid (DNA) source tracking.

- Use the same surface water sampling and *in situ* data collection protocols. The groundwater sampling technique was revised from using a bailer to use of a peristaltic pump and tubing as required by FDEP.
- Sampling on the same day each week (Monday) as was done during the earlier study.
- Collect data during the same season (November and December) so that water temperature, air temperature, sunlight, and, hopefully, river discharge would be comparable to the preconstruction conditions.

2.0 STUDY COMPONENTS

2.1 <u>SAMPLING EVENTS</u>

2.1.1 SAMPLING SCHEDULE

A total of eight consecutive weekly sampling events were conducted to collect water quality samples and *in situ* data. Prior to the June 2009 sampling, a reconnaissance field trip was conducted jointly by ECT and FDOH project management personnel to inspect current conditions at the proposed sampling locations and confirm station locations. The same stations were used during this study, so an additional reconnaissance trip was not needed.

Sampling was performed on Monday of each week and began on November 9, 2009, and was completed on December 28, 2009. Each weekly sampling event was scheduled so the surface water sampling duration would bracket the projected time of a low slack tide. Tide projections were obtained from an internet Web site (www.saltwatertides.com), which provided daily semi-diurnal tide time projections for the tide at the mouth of the Suwannee River. Based on experienced gained during previous sampling efforts, the total duration for sampling the surface water stations by boat was approximately 2 hours. Therefore, this part of the sampling began 1 hour before the projected time of the low slack tide. Sampling was conducted at low tide to assure samples in the canals collected water issuing from the canals and not water entering from the river.

2.1.2 SAMPLING LOCATIONS

Ten water quality sampling locations consisting of nine surface water stations and one groundwater station were monitored for this project. Figure 2-1 displays the locations of all ten stations. The groundwater station (Station 1) was a shallow well (6 feet below land surface [ft bls]) located on Leon Drive and was the same property as the previous studies. The well was positioned downgradient from an abandoned residential OSTDS site drain-field and installed with a hand auger.

The surface water stations included four stations in the river, including Station 10, located approximately 2 miles upstream of the town, and three other stations located in

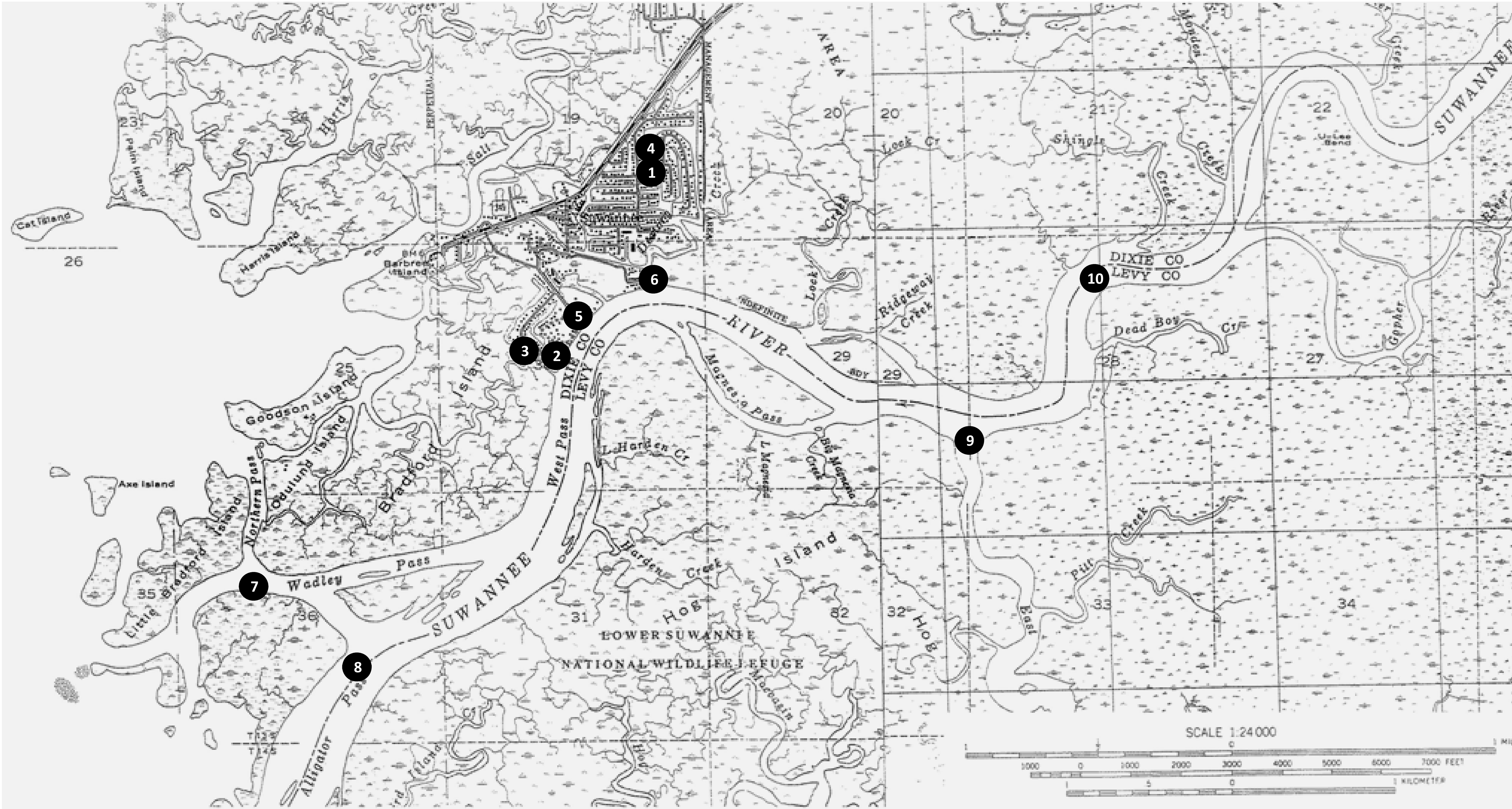


FIGURE 2-1.

SAMPLING LOCATIONS

Source: ECT, 2008.

Environmental Consulting & Technology, Inc.

major passes of the Suwannee River delta, specifically East Pass (Station 9), Alligator Pass (Station 8), and Wadley Pass (Station 7). Stations 2, 3, 4, 5, and 6 were located in the canals. To ensure the same station locations were occupied on each sampling event, the station's latitude and longitude coordinates were programmed during the reconnaissance trip and stored in a global positioning system (GPS) receiver for future navigation to stations. Table 2-1 provides the position coordinates for all stations.

2.1.3 SAMPLING PARAMETERS

Water temperature, specific conductance, pH, and dissolved oxygen (DO) were measured *in situ* at all stations during each survey. The measurements at Station 1 (monitoring well) were done as required by the FDEP standard operating procedure (SOP) for well sampling to demonstrate adequate purging of the well prior to sample collection. Measurements at the surface water stations were made at three depths (surface, mid-depth, and bottom) to document the physical characteristics in the river/canals water column at the time of sampling and assess any stratification. The surface and bottom reading were done 1 foot (ft) below the surface and 1 ft above the bottom, respectively.

Water quality samples were collected from within the first 1 ft of the water column and analyzed for several nutrients and microbiological parameters. Table 2-2 presents a list of the parameters analyzed as well as ancillary information pertaining to the samples.

2.2 SAMPLING AND ANALYTICAL METHODS

2.2.1 FIELD PROTOCOLS

In situ measurements of water temperature, specific conductance, pH, and DO were made at three depths in the water column at surface water stations using a Yellow Springs Instrument® (YSI) Model 556 multiparameter system. During monitoring well purging, turbidity was also measured with a Hach Model 2100P turbidimeter.

In situ measurements at surface water stations were recorded at 1 ft below the surface, mid-depth, and 1 ft above the bottom on standardized forms developed by ECT. Data collection time and depths were also recorded along with the total depth at each station. The total water depth and measurement depths were determined by graduations on the YSI

Table 2-1. Town of Suwannee Water Quality Station Coordinates

Station	Latitude	Longitude
1	29° 18' 55.40"	83° 08' 21.16"
2	29° 19' 15.80"	83° 08' 43.64"
3	29° 19' 16.18"	83° 08' 48.74"
4	29° 19' 57.32"	83° 08' 20.76"
5	29° 19' 23.97"	83° 08' 37.12"
6	29° 19' 30.91"	83° 08' 20.35"
7	29° 18' 28.16"	83° 09' 49.57"
8	29° 18' 11.02"	83° 09' 25.43"
9	29° 18' 55.55"	83° 07' 09.68"
10	29° 19' 29.18"	83° 06' 42.70"

Source: ECT, 2010.

Table 2-2. Town of Suwannee Water Quality Sample Information

Parameter	Analytical Method	Preservation	Holding Time
Total coliform	SM 9222 B	Cool 4°C	6 hours
Fecal coliform	SM 9222 D	Cool 4°C	6 hours
Enterococci	EPA 1600	Cool 4°C	6 hours
Salmonella	SM 9260 B	Cool 4°C	6 hours
Nitrate + nitrite	EPA 353.2	Cool 4°C H_2SO_4 to pH <2	28 days
TKN	EPA 351.2	Cool 4°C H_2SO_4 to pH <2	28 days
DNA source tracking	Human enterococci ID	Cool 4°C	24 hours

Note: °C = degree Celsius.
EPA = U.S. Environmental Protection Agency.
H_2SO_4 = sulfuric acid.
SM = Standard Method (APHA, 1998).
TKN = total Kjeldahl nitrogen.

Source: ECT, 2010.

meter cable, which was attached to a weighted polypropylene line. *In situ* measurements during the monitoring well purging prior to sample collection were done per the requirements in the FDEP groundwater sampling SOP FS 2200 and were recorded along with other SOP required ancillary data/information on FDEP form FD 9000-24.

The *in situ* measurement instruments were calibrated at the beginning and end of each sampling day, and the calibration results were documented on FDEP-generated forms. Per a request from FDOH, all field records included in weekly field data/information packets have been transmitted as a separate electronic data submittal to FDOH, prior to submission of this report.

Per the previous study, surface water samples were collected as surface grab samples from within the top 1 ft of the water column. The sample was collected using an extra precleaned 1-liter sample container provided by the laboratory. This technique is consistent with the surface water sampling FDEP SOP FS 2100, specifically FS 2110(1.1.1). A new sample container was used at each station precluding the need to decontaminate the sampling device between stations and avoiding the potential for station cross-contamination.

Samples were collected using the following steps:

- Samples were collected from the bow of the boat and away from the outboard motor.
- The sampler wore a powder-free shoulder-length glove to submerge the sample container and a standard length powder-free latex glove when handling the sample containers. New gloves were used at each station.
- The 1-liter sampling container cap was removed, and the container was slowly submerged with the opening first into the water.
- The bottle was held with the opening pointed upstream, and water was allowed to fill the container.
- The container was retrieved, and aliquots were dispensed to the individual sample containers for preservation, storage, and shipment to the laboratory.

Please note one modification from the FDEP SOP (FS 2100[1.1.2]) sampling process: the extra sample container used to collect samples was not rinsed prior to sample collection to avoid residuals from surface water sheens and surface floating vegetation that could be caused by multiple container immersions.

Each station's sample kit had one prepreserved container with sulfuric acid (H_2SO_4) for nutrient analyses. Acid preservation is done to maintain sample integrity and requires lowering the sample pH to 2 standard units (s.u.) or below. Adequate preservation was checked during the first two sampling events using color-coded pH sticks. All checks yielded results below 2 s.u. and ranged from 1.0 to 1.6 s.u.

The monitoring well sample was collected with a variable-speed peristaltic pump and tubing. Well purging and sampling was done per FDEP SOP 2200, referencing specific sections of the SOP pertaining to use of a peristaltic pump and other aspects of the SOP addressing the overall purging and sampling process. Per the SOP, general procedures followed included:

- Wearing powder-free latex gloves when handling tubing and sample containers.
- Use of new tubing during each sampling event.
- Controlled pump rate to maintain constant water level in the well and minimize entrainment of solids.
- Use of rolled plastic around the well to prevent pump tubing from contacting surrounding soils when deploying.
- Stabilization of *in situ* parameters within SOP criteria before collecting samples.

Each station's sample container kit was stored in a sealable (e.g., Zip-Loc®) bag prior to and following sampling to prevent station cross-contamination. Samples were placed in ice immediately following collection and until delivery to the laboratory. Samples were delivered to the laboratory within the 6-hour holding time required for the microbiological parameters and accompanied by the laboratory chain of custody form that included the following information:

- Laboratory client name and contact information.
- Project name, number, and location.
- Sample identifications.
- Sample type.
- Date and time of sample collection.
- Number of containers per sample.
- Sample preservation method.
- Parameters to be analyzed.
- Types of samples containers used.
- Name and affiliation of sampler.

2.2.2 LABORATORY METHODS

Table 2-2 summarized the analytical methods used for water quality samples. The sample analyses were conducted by Advanced Environmental Laboratories, Inc. (AEL), Gainesville, Florida, with the exception of DNA source tracking, which was done by Source Molecular Laboratory, Inc., Miami, Florida.

2.3 QUALITY ASSURANCE/QUALITY CONTROL

Prior to initiation of field activities and per Task 1 of the contract, the Quality Assurance Project Plan (QAPP) was updated by ECT and approved by FDOH (ECT, 2010). The document provides methodologies used for water quality sampling, data collection, sample analyses, data review and verification, and reporting.

2.3.1 SAMPLING ACTIVITY

For each of the eight weekly sampling events, a field data/information packet was assembled and completed to provide guidance/details to the sampling personnel to ensure that required activities and necessary documentation were completed per the FDEP SOP employed for project execution. The packet, consisting of reference material and ECT and FDEP standardized forms to document information and data, contained the following:

- A form listing itemization of the various records and logs to be completed during sampling and data collection.
- Identification of the *in situ* parameters to be monitored and procedures to be followed.
- Identification of field personnel, sampling date and time period, and project and site name.
- Equipment checklist.
- Identification of laboratory parameters, analytical method numbers, sample preservation requirements, and sample holding times.
- A daily field activity log.
- A project sampling schedule with sample start times based on predicted time of low slack tide and identification of quality assurance/quality control (QA/QC) samples types (i.e., duplicates, field and equipment blanks) to be collected per trip.
- List of project team member phone numbers.
- List of sampling station coordinates.
- Site map.
- Surface water sampling/in situ data collection form.
- Groundwater sampling form.
- Instrument calibration forms.

As previously discussed, sampling activity prescribed to applicable sections FDEP SOPs, specifically SOP FS 2100 was referenced for surface water sampling and FS 2200 for groundwater sampling. The instruments used to collect *in situ* data were calibrated at the beginning and completion of each sampling day and documented on FDEP-developed forms. The parameters calibrated on each survey were specific conductance, pH, DO, and turbidity. Step one of calibration consisted of measuring and adjusting meter responses to vendor-supplied standards for specific conductance (two standards), pH (three buffer solutions), and turbidity (four primary formazin standards). DO was calibrated following the air calibration procedure in a water-vapor saturated chamber. The DO reading was adjusted to read the correct concentration based on ambient temperature in the calibration chamber and referencing Table FT 1500-1, Solubility of Oxygen in Water at Atmospheric Pressure, in the FDEP SOP FT 1500 for measuring DO. The temperature thermistor on the YSI meter was checked periodically against a National Institute of Standards and Technology (NIST)-traceable thermometer.

Immediately following calibration and to confirm meter accuracy, an initial calibration verification (ICV) was conducted consisting of remeasuring a calibration standard for specific conductance, pH, and DO in the water vapor saturated calibration chamber. Calibration adequacy and meter accuracy were deemed acceptable if the ICV meter responses were within FDEP-stipulated acceptance criteria. For DO, the acceptance criteria is ±0.3 milligrams per liter (mg/L) of the solubility table concentration for the ambient temperature in the calibration chamber during the ICV; specific conductance is within ±5 percent of the standard concentration; for pH within ±0.2 s.u. of the buffer value; and for turbidity, the acceptance criteria ranges from 5 to 10 percent, dependent on the concentration of the standard. At the end of the sampling day, a post- or continuing calibration verification (CCV) was conducted to check on meter reading stability over the course of the sampling day. The CCV responses were deemed acceptable based on the same criteria for the ICV.

The ICV and CCV meter responses were within acceptance criteria for the eight sampling events, with the exception of December 7, 2009 (Event 5), when the 100-nephelometric turbidity unit (NTU) turbidimeter standard read 109 NTU (9 percent), which was marginally outside the acceptance criteria of ±6.5 percent. The reason for the offset is unknown, and the other turbidity calibration responses were within criteria. Also on December 14 (Event 6), the DO CCV reading was 8.30 mg/L and should have been 8.89 mg/L. This response was outside the ±0.3-mg/L criteria but only marginally and was not considered a justification to censure the DO measurements for that event and data were included in the project database.

Per the contract and routine FDEP sampling program requirements, 10 percent of the laboratory samples were QA/QC samples consisting of either a field blank, equipment blank, or field duplicates. Based on ten samples per 8 weeks of sampling, which equates to a total of 80 samples, a minimum of eight QA/QC samples were required for the project. This requirement was met as a total of eight QA/QC samples were collected. Table 2-3 presents a listing, by sampling event, of the types of QA/QC samples generated to satisfy the projects requirements.

The field blank sample was generated by pouring laboratory-provided analyte-free water directly into a set of sample containers to assess the potential for sample contamination from the sampling environment and during handling/transport from the field to the laboratory. The equipment blank was generated by processing analyte-free water through the sampling apparatus (pump/tubing, sample container, and dipper used to collect surface water samples) to simulate sample collection and assess whether the sampling apparatus could contaminate the samples. Duplicate samples were generated by filling two sets of sample containers consecutively at the assign station using the identical sampling procedure.

Table 2-4 presents the results of the field and equipment blank samples collected on sampling Events 1, 2, 3, and 7. Sampling Event 1 equipment blank was generated using the polyethylene sampling bottle used at Station 10. The equipment blank on Event 2 was generated with the polyethylene dipper used to collect the sample at Station 4. The equipment blank on Event 7 was generated using the pump tubing for Station 1. The data for the blank samples were below the analytical method detection limits (MDLs) with the following exceptions: the equipment blank from Event 1 and the field blank for Event 3 for nitrate + nitrite (NO_x) at 0.009 and 0.027 mg/L, respectively, and the equipment blanks from Events 2 and 7 for total Kjeldahl nitrogen (TKN) at 0.18 and 0.14 mg/L, respectively.

Please note the Event 1 equipment blank NO_x value of 0.009 mg/L, which was "I" flagged as being between the MDL and the practical quantitation limit, was less than 1 percent of the associated project sample from Station 10 at 1.15 mg/L. Therefore, any bias from the sampling device was considered inconsequential. Similarly, the NO_x value from the field blank on Event 3 of 0.027 mg/L was only 3 percent of the average NO_x concentration of the samples for Event 3 of 0.812 mg/L. Thus, no significant bias on

Table 2-3. Project Mandated Quality Assurance/Quality Control (QA/QC) Samples

Sampling Event Number	Date	Field QA/QC Sample	Laboratory QA/QC Samples
1	11/09/09	Equipment blank	Laboratory matrix spike and matix spike duplicate
2	11/16/09	Equipment blank	
3	11/23/09	Field blank	
4	11/30/09	Duplicate (Station 5)	Laboratory matrix spike and matix spike duplicate
5	12/07/09	Duplicate (Station 2)	
6	12/14/09	Duplicate (Station 3)	Laboratory matrix spike and matix spike duplicate
7	12/21/09	Equipment blank	
8	12/28/09	Duplicate (Station 10)	Laboratory matrix spike and matix spike duplicate

Source: ECT, 2010.

Table 2-4. Town of Suwannee QA/QC Blank Sample Results

Parameter	Event 1 Equipment Blank	Event 2 Equipment Blank	Event 3 Field Blank	Event 7 Equipment Blank
Total coliform (col/100 mL)	1 U	1 U	1 U	1 U
Fecal coliform (col/100 mL)	1 U	1 U	1 U	1 U
Enterococci (col/100 mL)	1 U	1 U	1 U	1 U
Salmonella	Absent	Absent	Absent	Absent
Nitrate + nitrite (mg/L)	0.009 I	0.003 U	0.027	0.003 U
TKN (mg/L)	0.08 U	0.18	0.08 U	0.14

Note: col/100 mL = colonies per 100 milliliters of sample.
U = analyzed but not detected.
I = value between MDL and practical quantitation limit.

Sources: AEL, 2009.
ECT, 2010.

sample results was attributable to the sampling environment or sample handling and transport.

The TKN concentration for the equipment blank on Event 2 was 0.18 mg/L, which is high relative to the associated project sample from Station 4 at 0.32 mg/L. However, as the Station 4 concentration on Event 2 was the lowest of the eight sampling events, it was not deemed significantly positively biased by the sampling device and was, therefore, not excluded from the project database. The Event 7 TKN value of 0.14 mg/L for the equipment blank sample is approximately 13 percent of the associated project sample from Station 1 at 1.03 mg/L. As the value of 1.03 mg/L was deemed representative of the overall station database for the eight sampling events with an 8-week average of 1.35 mg/L, it was included in the data analyses.

Table 2-5 presents the results of the field-generated duplicate samples collected on four of eight sampling events. Duplicate sample analysis is a means to evaluate analytical data precision or reproducibility as it relates to sample collection and laboratory analysis. Duplicate samples were collected by consecutively filling two sets of sample containers with the same sampling device and using common procedures to handle, store, and transport the samples.

To evaluate the results of the field duplicate samples and per the QAPP, ECT used the laboratory acceptance criteria for the nutrient parameters TKN and NO_x for duplicate analyses of matrix spike and matrix spike duplicate samples. Duplicate sample acceptance criteria is the relative percent difference (RPD) between the two samples and is calculated by dividing the concentration difference of the two samples by the average concentration of the samples and converting the result to a percentage value.

Reviewing Table 2-5 indicates only a single instance where duplicate field sample results did not fall within the acceptance criteria. That was from Event 5 analyses for TKN with an RPD of 18 percent. The reason for the difference in the duplicate sample results is unknown, but the overall project dataset for this parameter is considered valid as the other two field duplicate TKN results are well within acceptance criteria.

Table 2-5. Town of Suwannee QA/QC Field Duplicate Sample Results

Parameter	Event 4			Event 5			Event 8			Acceptance Criteria (%)
	Sample	Duplicate	RPD (%)	Sample	Duplicate	RPD (%)	Sample	Duplicate	RPD (%)	
Total coliform (col/100 mL)	770	770		1,00	616		616	462		
Fecal coliform (col/100 mL)	540	480		55	48		22	21		
Enterococci (col/100 mL)	340	280		21	20		7	8		
Salmonella	Present	Present		Present	Present		Absent	Absent		
Nitrate + nitrite (mg/L)	0.764	0.754	1	0.914	0.934	2	0.405	0.399	1	0 to 10
TKN (mg/L)	0.37	0.40	8	0.37	0.31	18	0.69	0.73	6	0 to 10

Note: RPD = relative percent difference.
col/100 mL = colonies per 100 milliliters of sample.
The RPD is calculated as a percentage by dividing the difference of the two concentrations by the average concentration of the sample and duplicate.

Source: ECT, 2010.

Microbiological analyses methods do not require development of acceptance criteria for duplicate samples. The method includes analyses of duplicates only as a general guide to evaluate consistency in method protocol based on data reproducibility or precision. According to communication with the project contract laboratory, agreement in microbiological duplicate samples values within the same order of magnitude is generally considered adequate. As such, no RPD criteria for microbiological parameters are included in Table 2-6. Based on general acceptance for microbiological duplicates agreeing within the same order of magnitude, the data displayed on Table 2-6 are for the most part good. The total coliform results have a couple of instances of numerical values having considerable differences, specifically Events 5 and 8. However based on the acceptability of duplicate microbiological data agreeing within the same order of magnitude the results were deemed acceptable and included in the data analyses.

One duplicate sample each for source tracking analyses was collected from Stations 2, 5, and 10 during sampling. The Station 2 duplicates both were negative for human DNA in enterococci cultures. The Station 5 duplicates were both positive for human DNA presence, and the Station 10 duplicates were both negative for human DNA presence.

2.3.2 LABORATORY ANALYSES

Microbiology QA/QC procedures used in the laboratory for coliforms, enterococcus, and *Salmonella* included the following:

- Blanks—Pre-, post-, and mid-sample analyses (after every ten samples). The source of positive results in a blank sample are investigated to include reagent water, media, instruments, and general housekeeping adequacy.
- Duplicates—Duplicate analyses are performed weekly, and the precision is calculated per method procedures to assess the overall ongoing laboratory QA/QC program and do not apply to an individual batch of sample results.
- Positive and Negative Controls:
    - Coliforms—Ten positive colonies plus atypical colonies verified by incubation in lauryl tryptose broth/brilliant green lactose bile broth/escherichia coli (LTB/BGB/EC) medias.

- Enterococcus—Ten typical and atypical colonies verified on brain-heart infusion broth (BHIB) + 6.5-percent sodium chloride (NaCl), BHIB at 44.5 degrees Celsius (°C), bile esculin azide (BEA) agar, biochemically with calalase and gram stain.
- *Salmonella*—For positive controls, *Salmonella* organisms are inoculated with urea reagent and incubated. The *Salmonella* colonies should urease negative and remain orange in color. Negative controls are done with S. aureus. The S. aureus culture should urease positive and turn pink in color.

Additional QC measures included temperature monitoring of incubators at the beginning and completion of an incubation period, chlorine residual check of all samples, and a monthly double-count check by a second analyst.

Laboratory QA/QC procedures for DNA source tracking included initial performance recovery (IPR), ongoing performance recovery (OPR), matrix spikes (MS), negative and positive control analysis, method blanks, and media sterility checks. OPR analysis occurs after every 20 field and matrix spike samples or one per week that samples are analyzed. IPR and OPR analyses require preparation of a 100-milliliter (mL) sample of water and seeding it with approximately 20 colony-forming units (cfu) of enterococcal surface protein (ESP) gene-containing Enteroccus faecium (C68) and then processing the samples as outlined in the procedure. IPR is performed with four samples. The method performance is based on a positive polymerace chain reaction (PCR) signal for all Enteroccus faecium (C68) seeded samples. Negative controls are run using sterile reagent water, non-ESP Enteroccus faecium, or autoclaved field samples. All negative control samples should result in a negative PCR signal. Analysis of positive and negative controls is conducted whenever new media or reagent is used. Method blanks are tested to see the sterility of equipment used, and a media sterility check is incubated at 36.5 degrees Celsius (°C) + 1.0°C for 24 + 2 hours and analyzed for growth.

Laboratory chemical analyses QA/QC included daily instrumentation calibration and use of several precision and accuracy evaluation samples to determine the acceptability of each batch of sample analyzed. The types of samples used include method blanks, matrix spike, matrix spike duplicates, and secondary source calibration check standards. The results of these QA/QC samples must meet the laboratory's established acceptance criteria in order for project sample results to be deemed reportable. Table 2-6 provides acceptance criteria for calibration standards, method blanks, matrix spike, and matrix spike duplicates samples as well as other ancillary information on the analytical methods employed for this project.

Another item regarding laboratory QA/QC samples is that the project contract-required matrix spike and matrix spike duplicate samples be designated for this project at a set frequency during the sampling period as follows:

- The first time a sample is collected (Event 1).
- One in each additional 20 samples after the first 20 samples (Events 4 and 6).
- The last time a sample is collected (Event 8).

Matrix spike and matrix spike duplicate samples are included in each batch of samples analyzed during a laboratory work shift. A sample batch may consist of up to 20 samples and may be comprised of samples from a number of different projects and therefore potentially different matrix characteristics. The spiked samples are a means to assess the possibility of positive/negative bias in parameters of interest for this project, TKN, and NO_x, caused by the chemical and/or physical composition of a sample. Typically, samples selected for spiking are arbitrarily selected by the laboratory, unless a client requests their sample(s) be used.

As mentioned, this project required samples from three events be used for the matrix spike and matrix spike duplicates. The laboratory was notified verbally and on the chain-of-custody forms on each event that this project's samples were to be spiked, which were Events 1, 4, 6, and 8.

Table 2-7 presents a listing of chemistry analyses QA/QC sample results that did not meet acceptance criteria and the laboratory's assessment of sample data usability.

Table 2-6. Chemistry Analyses QA/QC Operations Information and Data Acceptance Criteria

Parameter	Number of Calibration Standards	Calibration Acceptance Criteria (%)	Method Blank Criteria	Secondary Standard Recovery Criteria (%)	Matrix Spike Recovery Criteria (%)	Matrix Spike Duplicate Acceptance Criteria (% RPD)	Practical Quantitation Limit (mg/L)	MDL (mg/L)
TKN	6 + blank	90 to 110	<MDL	90 to 110	90 to 110	0 to 10	0.10	0.08
Nitrate + nitrite (NO_x)	9 + blank	90 to 110	<MDL	90 to 110	90 to 110	0 to 10	0.004	0.003

Typical matrix spike concentrations range from 1 to 2 mg/L for TKN and 0.4 to 1 for nitrate + nitrite.

Sources: AEL, 2010.
ECT, 2010.

Table 2-7. Laboratory QA/QC Sample Result Excursion Information

Sample Event	Parameter	Sample Type(s)	Spike Acceptance Criteria (% Recovery)	Spike Recovery (% Recovery)	Duplicate Acceptance Criteria (RPD)	Duplicate Samples Results (RPD)	Laboratory Data Qualifier Code	Code Description/Data Resolution
1	Nitrate + nitrite	Duplicate			0 to 10	50	D-RNG	Concentration difference of sample (0.005 mg/L) and duplicate (0.003 mg/L)is low (0.002 mg/L) compared to MDL (0.003 mg/L)
								Laboratory policy is when difference is low relative to MDL, sample not rerun, and project data deemed acceptable
4	TKN	Duplicate			0 to 10	11	D-RNG	Concentration difference of sample (0.86 mg/L) and duplicate (0.96 mg/L) is low (0.10mg/L) compared to MDL (0.08 mg/L)
								Laboratory policy is when difference is low relative to MDL, sample not rerun, and project data deemed acceptable
4	TKN	Matrix spike	90 to 110	58	0 to 10	2	S-REX	Poor matrix spike recoveries, samples re-extracted and analyzed confirming poor spike recoveries; associated sample results flagged (J4) as estimated values
		Matrix spike duplicate	90 to 110	33			S-CON	
8	TKN	Matrix spike	90 to 110	87			S-REX	Poor matrix recovery; recreated extract and analyzed; poor spike recovery in extract and associated sample result flagged (J4) as estimated value

Sources: AEL, 2009.
ECT, 2010.

Three laboratory values were excluded from the analytical results database as outliers. In all three cases, the values were an order of magnitude either below or above the other values for the particular station and parameter. These values were TKN of 3.83 mg/L at Station 4 on Event 1, NO_x of 0.021 also from Station 4 on Event 1, and enterococci at 1,300 colonies per 100 milliliters of sample (col/100 mL) from Station 8 on Event 1.

3.0 SUPPLEMENTAL DATA

ECT conducted an online search of possible data sources in the project area including state organizations such FDEP, FDACS, Suwannee River Water Management District (SRWMD), and individual research professors at the University of Florida, who have conducted research work in Suwannee Sound. These professors included Dr. Tom Frazer, Dr. Ed Philips, and Dr. Shirley Baker at the Institute of Food and Agricultural Sciences (IFAS). Water quality data were not available from IFAS but were available from the other three state agencies. Additionally, river flow data have been obtained from the U.S. Geological Survey (USGS), which has maintained temporary and ongoing monitoring stations in the lower Suwannee River basin. Precipitation data have also been obtained for the SRWMD station closest to the project area. Section 4.0 of this report summarizes the river flow and rainfall data.

FDACS collects and manages water quality data in and bordering the project area for their Shellfish and Environmental Assessment Section (SEAS) program. Also, FDEP's Storage and Retrieval (STORET) database compiles biological, chemical, and physical data for ground- and surface waters of Florida. Within STORET are 27 monitoring stations in the vicinity of the project area, of which only nine had water quality data. Five of these nine stations are operated by FDACS; the remaining four stations are maintained by SRWMD. Table 3-1 presents information on the nine STORET-listed stations, and Figure 3-1 presents these station locations as well as the ECT stations to illustrate the proximity of the STORET and ECT stations.

Water quality data from FDACS and SRWMD were screened to retain the parameters that are common to this project, including total and fecal coliform, NO_x, and TKN. These data were updated through December 2009. It should be noted that the FDACS fecal coliform data were updated through November 2009 as the agency sampled only from the estuarine portion of the area in December 2009. Enterococci and *Salmonella* were not available from either source. Table 3-2 presents a data inventory for individual parameters for each station and a statistical summary of the updated data record. The table also lists the project stations closest to the STORET stations.

Table 3-1. FDEP STORET Stations in the Vicinity of the Project Area

Station Number	Organization	Station ID	Station Name	Latitude	Longitude	County
1061	FDACS	28SEAS201	South side of Wadley Pass at Junction with northern pass	29° 18' 31"	83° 09' 51"	Dixie
1062	FDACS	28SEAS202	Northern Pass CM #9	29° 18' 55"	83° 09' 48"	Dixie
1109	FDACS	28SEAS244	Confluence of Suwannee River and east passs	29° 18' 54"	83° 07' 11"	Levy
1110	FDACS	28SEAS246	Suwannee River at mouth of channel to Suwannee Shores Marina	29° 19' 31"	83° 08' 20"	Dixie
1084	FDACS	28SEAS428	Southwest of CM #27 and northeast CM #25 in river	29° 18' 10"	83° 09' 20"	Levy
114	SRWMD	SRE080C1	Salt Creek at CM #20	29° 19' 24"	83° 09' 47"	Dixie
180	SRWMD	SUW275C1	Suwannee River at Gopher River	29° 19' 41"	83° 06' 11"	Dixie
182	SRWMD	SUW285C1	Suwannee River #2 east pass near branch off	29° 18' 59"	83° 07' 10"	Dixie
3	SRWMD	SUW305C1	Suwannee River in west pass - SUW190C1	29° 18' 44"	83° 08' 50"	Dixie

Note: CM = channel marker.

Source: ECT, 2010.

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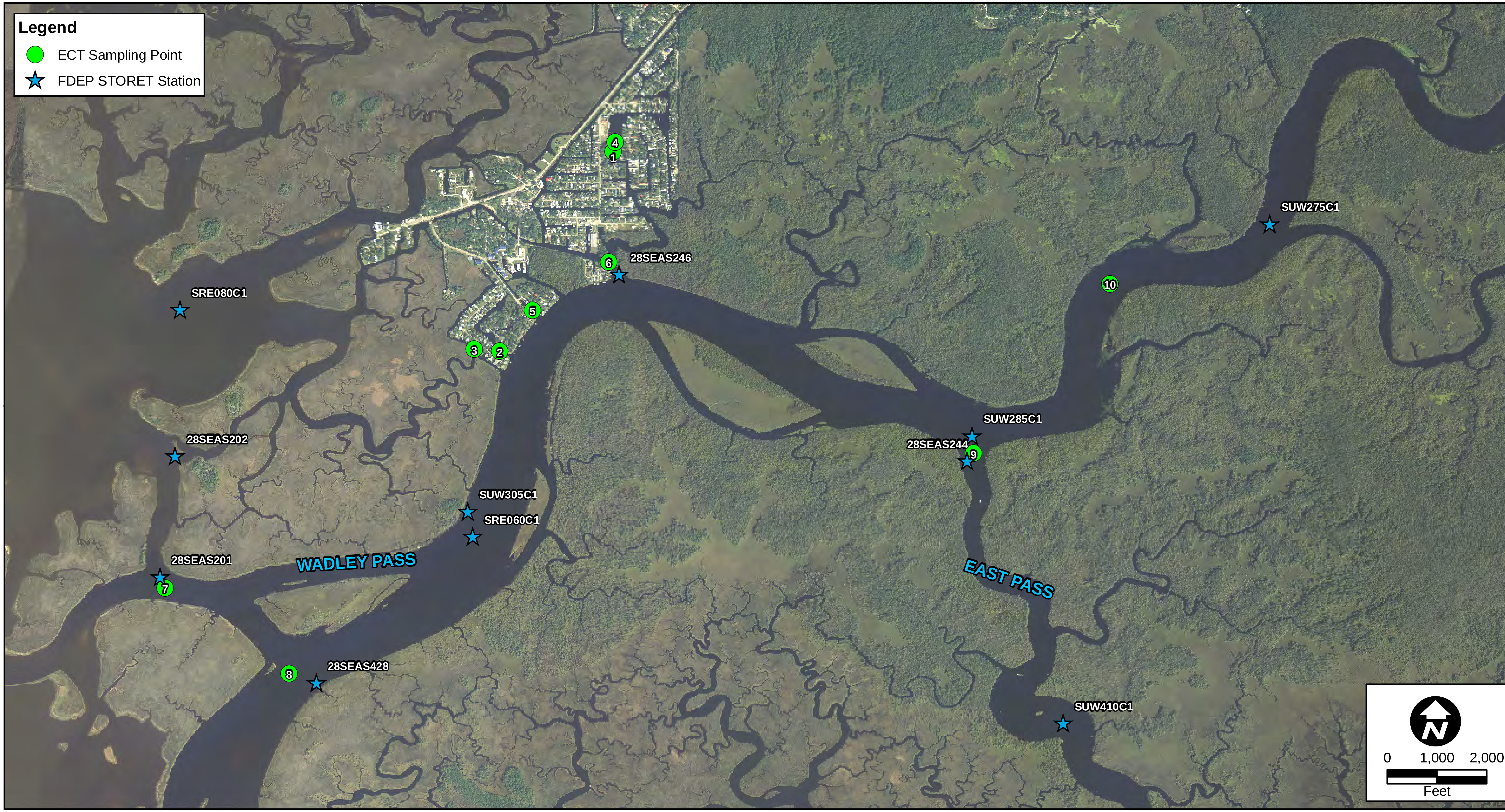

FIGURE 3-1.
STORET AND ECT STATIONS

Sources: NRCS, 2007; FDEP, 2009; SRWMD, 2010; ECT, 2010.

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Table 3-2. Supplemental Water Quality Data

Organization	STORET Station ID	Sampling Period: Begin	Sampling Period: End	ECT Stations	Statistical Summary: Number of Samples	Average	Minimum	Maximum	95th percentile	5th percentile
Fecal coliform (#/100 mL)										
FDACS	28SEAS201	03/07/96	11/05/09	7	162	83	1	920	240	7
FDACS	28SEAS202	09/28/83	11/05/09	—	266	80	1	540	323	7
FDACS	28SEAS244	09/28/83	11/05/09	9	242	69	1	920	217	5
FDACS	28SEAS246	09/28/83	11/05/09	1 to 6	249	111	1	1,600	350	8
FDACS	28SEAS428	03/07/96	11/05/09	8	161	77	1	540	240	8
SRWMD	SRE080C1	10/03/95	04/18/05	—	88	523	9	5,500	1,969	13
SRWMD	SUW275C1	02/11/89	07/18/05	10	71	97	1	1,700	364	1
SRWMD	SUW285C1	10/11/99	07/18/05	9	53	88	1	920	310	7
SRWMD	SUW305C1	02/13/90	07/18/05	7, 8	66	119	1	1,480	536	1
Total coliform (#/100 mL)										
SRWMD	SRE080C1	10/03/95	04/18/05	—	88	569	9	5,500	1,991	18
SRWMD	SUW275C1	02/11/89	07/18/05	10	71	496	1	3,700	2,200	6
SRWMD	SUW285C1	10/11/99	07/18/05	9	54	618	1	6,400	2,280	40
SRWMD	SUW305C1	02/13/90	07/18/05	7, 8	65	766	1	12,000	2,655	12
TKN (mg/L)										
SRWMD	SRE080C1	05/16/96	12/16/09	—	131	0.72	0.05	1.72	1.33	0.25
SRWMD	SUW275C1	02/11/89	12/16/09	10	240	0.56	0.05	5.90	1.13	0.11
SRWMD	SUW285C1	10/11/99	12/16/09	9	138	0.64	0.05	2.22	1.31	0.17
SRWMD	SUW305C1	02/13/90	12/16/09	7, 8	178	0.60	0.05	1.56	1.19	0.14
Nitrate + nitrite (mg/L)										
SRWMD	SRE080C1	10/03/95	12/16/09	—	141	0.33	0.00	0.90	0.80	0.02
SRWMD	SUW275C1	02/11/89	12/16/09	10	246	0.63	0.01	1.35	1.10	0.11
SRWMD	SUW285C1	10/11/99	12/16/09	9	143	0.68	0.00	1.62	1.16	0.16
SRWMD	SUW305C1	02/13/90	12/16/09	7, 8	195	0.56	0.01	1.30	1.02	0.05

Source: ECT, 2010.

Fecal coliform is monitored at nine stations by SRWMD and FDACS in the project area. As shown in Figure 3-1 some of these stations are in close proximity to this project station, and a few are more far afield. For the nine stations, average fecal coliform values range from 77 to 523 col/100 mL. Minimum values are 1 col/100 mL for all except SRE080C1. Maximum counts range from 540 to 5,500 col/100 mL. SRWMD also monitors total coliform in the project area at four locations. Average total coliform counts at these locations range from 496 to 766 col/100 mL. Minimum and maximum values range from 1 to 9 and 3,700 to 12,000 col/100 mL, respectively.

SRWMD also monitors TKN and NO_x at four stations. TKN, a combination of organic nitrogen and ammonia/ammonium nitrogen, has average values from 0.56 to 0.72 mg/L. Minimum values at the four stations are nondetectable concentrations at the detection limit of 0.05 mg/L. Maximum concentrations are from 1.56 to 5.90 mg/L. Concentrations of NO_x, on average, range from 0.33 to 0.68 mg/L. Minimum values are generally below MDLs.

Appendix A provides the complete supplemental water quality data set.

4.0 RESULTS

This section presents the results of the November through December 2009 study. Comparison of these results with the previous studies and assessment of the benefits of closing the OSTDS are presented in Section 5.0.

4.1 RAINFALL AND RIVER FLOW DATA

Approximately 25 miles upstream of the project area, USGS maintains a long-term river stage and flow gauging station near Wilcox, Florida (Station 02323500). Figure 4-1 presents the daily flow hydrograph at this station from October 1941 through December 2009. The highest daily flow observed at Wilcox was 84,700 cubic feet per second (cfs) in 1948. Table 4-1 presents the annual mean discharge values at Wilcox from 1942 to 2009. The annual mean discharge from 1942 through 2009 ranged from 3,275 cfs in 2002 to 24,560 cfs in 1948 (USGS, 2010).

SRWMD has maintained a rainfall gauging station in the vicinity of Wilcox and Fanning Springs (Station 2323500) from 1998 to present. Table 4-2 presents the monthly rainfall total for this period. This project's sampling was conducted between November 9 and December 28, 2009. River daily discharge and rainfall data are presented on Figure 4-2 for the sampling period. The dates of each sampling event are also displayed on this figure. During the sampling period, the highest daily rainfall was 1.0 inch on December 2. Additionally, the cumulative rainfall for November and December 2009 was 5.78 inches. Peak river flow during sampling occurred on the last sampling event on December 28 at 9,540 cfs and gradually increased for the remainder of the month.

4.2 WATER QUALITY DATA

Weekly water quality samples and *in situ* data were collected from November 9 to December 28, 2009. *In situ* measurements included temperature, specific conductance, pH, and DO. Water samples were analyzed for TKN, NO_x, total and fecal coliform, *Salmonella*, enterococci, and DNA human source tracking. The *Salmonella* and the DNA human source tracking analyses were qualitative (presence/absence), not quantitative.

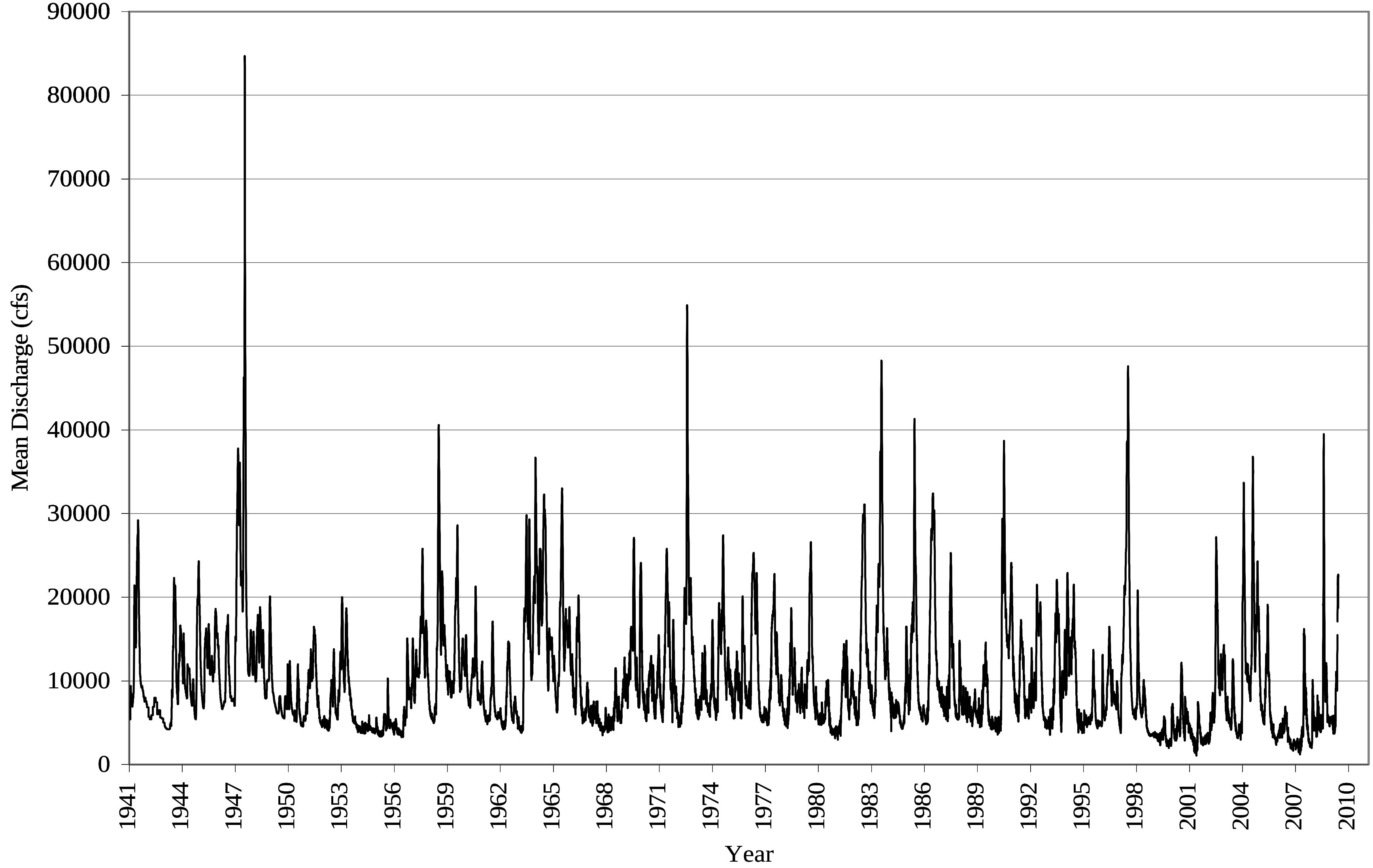

FIGURE 4-1.

SUWANNEE RIVER FLOW NEAR WILCOX AT USGS 02323500
FROM 1941 TO 2009

Sources: USGS, 2010. ECT, 2010.

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Table 4-1. Annual Mean Discharge of Suwannee River near Wilcox at USGS Station 02323500

Water Year	Discharge (cfs)	Water Year	Discharge (cfs)
1942	12,340	1976	9,546
1943	6,229	1977	12,060
1944	9,954	1978	10,870
1945	11,230	1979	8,657
1946	12,500	1980	10,760
1947	9,856	1981	5,612
1948	24,560	1982	8,234
1949	12,980	1983	13,660
1950	7,600	1984	17,140
1951	6,704	1985	6,887
1952	9,179	1986	12,520
1953	7,496	1987	14,310
1954	9,290	1988	9,732
1955	4,291	1989	6,776
1956	4,640	1990	6,875
1957	6,201	1991	14,920
1958	13,210	1992	9,122
1959	13,990	1993	10,330
1960	12,930	1994	10,440
1961	10,590	1995	10,890
1962	7,142	1996	5,970
1963	7,172	1997	8,746
1964	15,050	1998	15,480
1965	19,270	1999	6,415
1966	15,040	2000	3,406
1967	9,549	2001	5,339
1968	5,301	2002	3,275
1969	6,335	2003	10,090
1970	13,300	2004	6,442
1971	9,080	2005	16,310
1972	11,920	2006	6,523
1973	15,560	2007	3,563
1974	8,554	2008	4,678
1975	12,760	2009	7,605

Note: Average annual river flow for period of record = 9,926 cfs.

Sources: USGS, 2010.
ECT, 2010.

Table 4-2. Monthly Total Rainfall at SRWMD Station 02323500 near Wilcox/Fanning Springs

Month and Year	Rainfall (inches)	Month and Year	Rainfall (inches)	Month and Year	Rainfall (inches)	Month and Year	Rainfall (inches)
May 98	0.87	Apr 01	1.38	Mar 04	1.41	Feb 07	1.63
Jun 98	1.73	May 01	0.07	Apr 04	2.06	Mar 07	1.01
Jul 98	1.85	Jun 01	6.08	May 04	1.83	Apr 07	1.07
Aug 98	—	Jul 01	12.14	Jun 04	0.82	May 07	0.46
Sep 98	—	Aug 01	1.76	Jul 04	0.04	Jun 07	6.69
Oct 98	—	Sep 01	7.03	Aug 04	0	Jul 07	5.38
Nov 98	—	Oct 01	0.04	Sep 04	0	Aug 07	6.73
Dec 98	—	Nov 01	0.43	Oct 04	3.73	Sep 07	5.08
Jan 99	—	Dec 01	1.48	Nov 04	2.98	Oct 07	2.51
Feb 99	—	Jan 02	4.07	Dec 04	1.89	Nov 07	1.29
Mar 99	—	Feb 02	0.87	Jan 05	1.13	Dec 07	2.83
Apr 99	—	Mar 02	2.9	Feb 05	1.82	Jan 08	4.1
May 99	—	Apr 02	1.83	Mar 05	3.78	Feb 08	2.78
Jun 99	—	May 02	1.5	Apr 05	5.78	Mar 08	4.85
Jul 99	—	Jun 02	4.45	May 05	4.45	Apr 08	1.51
Aug 99	—	Jul 02	6.05	Jun 05	4.34	May 08	0.9
Sep 99	—	Aug 02	5.98	Jul 05	8.59	Jun 08	5.79
Oct 99	—	Sep 02	5.63	Aug 05	5.39	Jul 08	11.42
Nov 99	—	Oct 02	5.78	Sep 05	1.4	Aug 08	16.1
Dec 99	—	Nov 02	5.47	Oct 05	1.59	Sep 08	1.79
Jan 00	—	Dec 02	8.31	Nov 05	3.07	Oct 08	2.61
Feb 00	—	Jan 03	0.13	Dec 05	7.06	Nov 08	2.12
Mar 00	—	Feb 03	6.96	Jan 06	2.32	Dec 08	0.92
Apr 00	—	Mar 03	6.87	Feb 06	5.11	Jan 09	3.64
May 00	0.25	Apr 03	2.11	Mar 06	0.11	Feb 09	1.61
Jun 00	6.66	May 03	1.46	Apr 06	0.95	Mar 09	4.82
Jul 00	7.27	Jun 03	7.3	May 06	1.89	Apr 09	3.17
Aug 00	1.45	Jul 03	5.93	Jun 06	8.27	May 09	5.22
Sep 00	8.5	Aug 03	5.3	Jul 06	6.44	Jun 09	12.27
Oct 00	0.3	Sep 03	2.52	Aug 06	5.67	Jul 09	7.74
Nov 00	1.24	Oct 03	2.01	Sep 06	2.32	Aug 09	4.33
Dec 00	0.85	Nov 03	1.5	Oct 06	1.36	Sep 09	3.61
Jan 01	1.23	Dec 03	1.18	Nov 06	1.35	Oct 09	3.03
Feb 01	0.38	Jan 04	2.05	Dec 06	4.05	Nov 09	2.51
Mar 01	3.22	Feb 04	7.52	Jan 07	2.72	Dec 09	3.27

Note: — = no data.

Sources: SRWMD, 2010.
ECT, 2010.

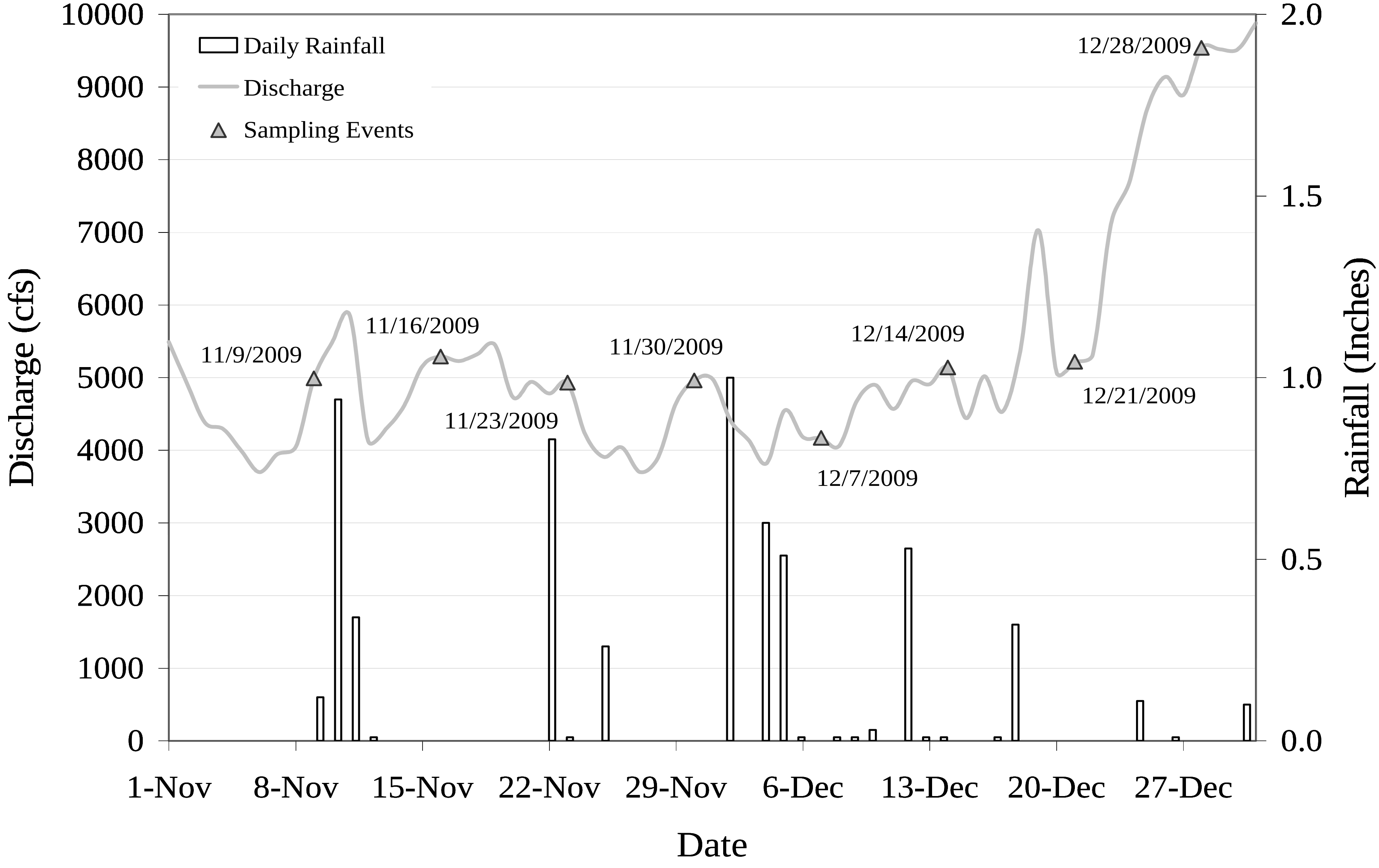

FIGURE 4-2.

SUWANNEE RIVER FLOW, DAILY RAINFALL, AND SAMPLING EVENTS IN NOVEMBER TO DECEMBER 2009

Sources: SRWMD, 2010. USGS, 2010. ECT, 2010.

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The initial presentation of data is provided as statistical summaries and grouped into two categories: canal stations and river stations. The rationale for this grouping is based on the canal stations being near-field relative to the previous locations of the OSTDS and river stations are far-field and include upstream Stations 9 and 10. Canal stations are Stations 2 through 6, and river station are 7 through 10. Additionally, data assessment used this grouping scheme in the earlier study, and this facilitated comparative analyses of the two databases. Station 1 is the monitoring well and has not been included in the station grouping analyses.

Table 4-3 presents *in situ* parameters by station group. Chemical and microbiological water quality sample parameters have been statistically summarized by individual canal and river stations in Tables 4-4 and 4-5, respectively. As shown in Table 4-5, the average values of the upstream stations (9 and 10) were comparable to the values of the downstream stations (7 and 8). Consequently, to aid in statistical comparisons, these four river stations were grouped for comparison with the canal stations (2, 3, 4, 5, and 6). Table 4-6 provides the water quality sample statistical summary for the grouped canal and river stations, as well as the monitoring well station. Tables of the complete raw data set for individual stations are contained in Appendix B. Given the proximity of the well to canal Station 4, water quality results for the well are included in Table 4-4.

4.2.1 IN SITU PARAMETERS

In situ measurements of pH, temperature, DO, and specific conductance were conducted at three depths in the water column: 1 ft below the surface (surface), mid-depth, and 1 ft above the bottom (bottom) at each surface water sampling station. Table 4-3 provides the summary statistics for each of the parameter at the three depths at the river and canal station.

Viewing the surface water *in situ* data both vertically in the water column and spatially within the study area indicates there is no large variation in the measurements. Spatially, the greatest difference when comparing the vertical averages of the canal and river stations is for specific conductance with canal stations at 2,814 microSiemens per centimeter (µS/cm) and the river stations at 1,492 µS/cm. River stations show approximately

Table 4-3. Summary Statistics of *In Situ* Parameters

Parameters	Station	Near-surface			Mid-depth			Bottom			Vertical
		Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Specific conductivity (µS/cm)	Canal	1,964	611	3,773	2,258	634	4,316	4,221	807	9,536	2,814
	River	1,013	315	2,223	1,086	318	2,468	2,376	302	9,868	1,492
DO (mg/L)	Canal	7.34	6.50	9.02	7.18	6.32	8.82	6.89	5.49	8.75	7.14
	River	7.47	6.84	8.21	7.44	6.85	8.20	7.47	6.83	8.20	7.46
pH (s.u.)	Canal	7.73	7.39	8.05	7.70	7.39	8.05	7.62	7.19	8.01	7.68
	River	7.76	7.34	7.92	7.72	7.31	7.92	7.67	7.24	7.90	7.72
Temperature (°C)	Canal	17.93	14.73	20.94	17.90	14.72	20.89	17.42	13.98	21.01	17.75
	River	18.19	15.27	20.74	18.17	15.24	20.75	17.57	13.58	20.78	17.98

Source: ECT, 2010.

Table 4-4. Summary of Water Quality Parameters for Canal Stations

Parameters	Average at Station						Minimum at Station						Maximum at Station					
	Well	2	3	4	5	6	Well	2	3	4	5	6	Well	2	3	4	5	6
Enetrococci (col/100mL)	1	116	101	26	164	171	1	21	12	8	31	13	1	230	230	46	340	280
Total coliform (col/100mL)	845	702	675	539	679	673	1	308	154	154	154	154	2,310	1,230	1,390	2,000	1,540	1,690
Fecal coliform (col/100mL)	1	204	217	101	264	302	1	50	39	53	57	53	1	380	450	260	540	666
TKN (mg/L)	1.35	0.42	0.47	0.63*	0.44	0.41	0.92	0.15	0.19	0.32*	0.20	0.17	2.24	0.72	0.68	0.93*	0.75	0.86
NO_x (mg/L)	0.01	0.77	0.77	0.46†	0.66	0.71	0.00	0.38	0.34	0.26†	0.36	0.36	0.02	0.97	1.00	0.73†	0.88	0.93
Total nitrogen (mg/L)	1.36	1.19	1.24	1.09	1.10	1.12	0.92	0.53	0.53	0.58	0.56	0.53	2.26	1.69	1.68	1.66	1.63	1.79

*Value excluded an outlier of 3.59 from canal Station 4.
†Value excluded an outlier of 0.021 from canal Station 4.

Source: ECT, 2010.

Table 4-5. Summary of Water Quality Parameters for River Stations

Parameters	Average at Station				Minimum at Station				Maximum at Station			
	7	8	9	10	7	8	9	10	7	8	9	10
Enetrococci (col/100mL)	64	37*	32	29	6	4*	6	3	137	94*	52	67
Total coliform (col/100mL)	468	732	366	694	154	154	154	154	1,230	2,310	770	2,160
Fecal Coliform (col/100mL)	168	133	96	84	28	23	24	22	310	320	200	136
TKN (mg/L)	0.34	0.38	0.40	0.36	0.13	0.15	0.04	0.09	0.72	0.63	0.73	0.85
NO_x (mg/L)	0.74	0.80	0.85	0.87	0.32	0.38	0.41	0.41	0.95	1.03	1.09	1.15
Total nitrogen (mg/L)	1.08	1.18	1.25	1.23	0.45	0.53	0.45	0.50	1.67	1.66	1.82	2.00

*Value excluded an outlier of 1,300 from river Station 8.

Source: ECT, 2010.

Table 4-6. Statistics for Water Quality Parameters at Canal, River, and Monitoring Well Stations

Parameters	Size	Average	Standard Deviation	Maximum	Minimum	Remarks
Canal Stations						
Enetrococci (col/100 mL)	40	116	100	340	8	
Total coliform (col/100 mL)	40	654	472	2,000	154	
Fecal coliform (col/100 mL)	40	218	174	666	39	
TKN (mg/L)	39	0.47	0.22	0.93	0.15	*
NO_x (mg/L)	39	0.68	0.24	1.00	0.26	†
Total nitrogen (mg/L)	40	1.15	0.16	1.52	0.80	
Salmonella		Present 62.5% of time (25 out of 40)				
River Stations						
Enetrococci (col/100 mL)	31	40	34	137	3	‡
Total coliform (col/100 mL)	32	565	525	2,310	154	
Fecal coliform (col/100 mL)	32	120	92	320	22	
TKN (mg/L)	32	0.37	0.23	0.85	0.04	
NO_x (mg/L)	32	0.82	0.27	1.15	0.32	
Total nitrogen (mg/L)	32	1.19	0.14	1.54	0.96	
Salmonella		Present 62.5% of time (20 out of 32)				
Monitoring well						
Enetrococci (col/100 mL)	8	1	0	1	1	
Total coliform (col/100 mL)	8	845	860	2,310	1	
Fecal coliform (col/100 mL)	8	1	0	1	1	
TKN (mg/L)	8	1.35	0.43	2.24	0.92	
NO_x (mg/L)	8	0.01	0.01	0.02	0.00	
Total nitrogen (mg/L)	8	1.36	0.43	2.24	0.94	
Salmonella		Present 50% of time (4 out of 8)				

*Statistics exclude a suspected outlier value of 3.83 from a canal station.
†Statistics exclude a suspected outlier value of 0.021 from a canal station.
‡Statistics exclude a suspected outlier value of 1,300 from a river station.

Source: ECT, 2010.

47 percent less conductivity as compared to the canal stations. This is due to the large fresh water flow of the river as well as the residual effects from the more saline flood tides coupled with incomplete flushing of canals during ebb tides. The vertical averages of other three parameters are comparable. Evaluating differences vertically in the water column by comparing the average surface and average bottom measurements for conductance values indicates that the canal stations varied by 53 percent top to bottom (1,964 versus 4,221 µS/cm), and the conductance varied by 57 percent (1,013 versus 2,376 µS/cm) at the river stations. Additionally, pH, temperature, and DO data have only relatively minor differences in the vertical with the largest difference being the DO in the canal station that varied 4 percent, but pH and temperature vertical differences are approximately 1 percent. This uniformity in data indicates waters are well mixed, show no evidence of a prominent salt wedge intrusion during sampling, and support using surface grab samples as a good representation of water quality through the water column.

4.2.2 NUTRIENT PARAMETERS

Nutrient parameters include TKN and NO_x. Total nitrogen was derived by summing TKN and NO_x. Each of these is briefly described in the following subsections and is presented in Table 4-6. The discussion includes comparison with the supplemental data presented in Section 3.0 and specifically on Table 3-2.

4.2.2.1 Total Kjeldahl Nitrogen

The monitoring well TKN concentrations were approximately three times the canal and river average, minimum, and maximum values. The average TKN concentration in the well was 1.35 mg/L compared to canal and river averages of 0.47 and 0.37 mg/L, respectively. The canal and river basic statistics were similar, indicating spatial uniformity throughout the surface water monitoring stations. Project surface water TKN data were slightly lower than the averages of those in the supplemental database for river stations, which range from 0.56 to 0.64 mg/L.

4.2.2.2 Nitrate + Nitrite

The average NO_x was approximately 17 percent higher in the river stations at 0.82 mg/L than the canal stations at 0.68 mg/L. The monitoring well had the lowest NO_x, which averaged only 0.01 mg/L over the sampling period. The maximum river and canal NO_x concentrations were 1.15 and 1.00 mg/L, respectively. The monitoring well maximum concentration was 0.02 mg/L.

The average river NO_x concentration of 0.82 mg/L was slightly higher than the range of average supplemental data river station values of 0.56 to 0.68 mg/L.

4.2.2.3 Total Nitrogen

Total nitrogen was derived by adding TKN and NO_x. Average total nitrogen was similar in both the canal and river stations at 1.15 and 1.19 mg/L, respectively. The monitoring well's total nitrogen average concentration was slightly higher at 1.36 mg/L. The maximum total nitrogen concentration was 2.24 mg/L at the well, compared to 1.52 and 1.54 mg/L at canal and river stations, respectively.

4.2.3 NUTRIENT-DISCHARGE RELATIONSHIP

To explore the relationship between river discharge and nutrient parameters, the surface waters average values for TKN, NO_x, and total nitrogen were determined. These averages were calculated including all of the river stations but excluding the canal stations and monitoring well station. Statistical analysis between the overall average values of the selected water quality parameters and average river discharge for the sampling day revealed a weak positive correlation (R^2 = 0.35) existed between discharge and TKN (i.e., TKN increased with the increase in the discharge), and a weak negative correlation (R^2 = 0.47) existed between discharge and NO_x. Also, a weaker negative correlation (R^2 = 0.29) existed between total nitrogen and discharge. The variations of TKN, NO_x, and total nitrogen with the river flow are presented in Figure 4-3. It is apparent from the figure that in mid-December, when the flow started increasing from its November-December average of 5,300 cfs, TKN increased with the flow, and NO_x decreased with the flow.

Figure 4-4 illustrates the correlation coefficients (R^2), which measure the linear degree of association between the data values.

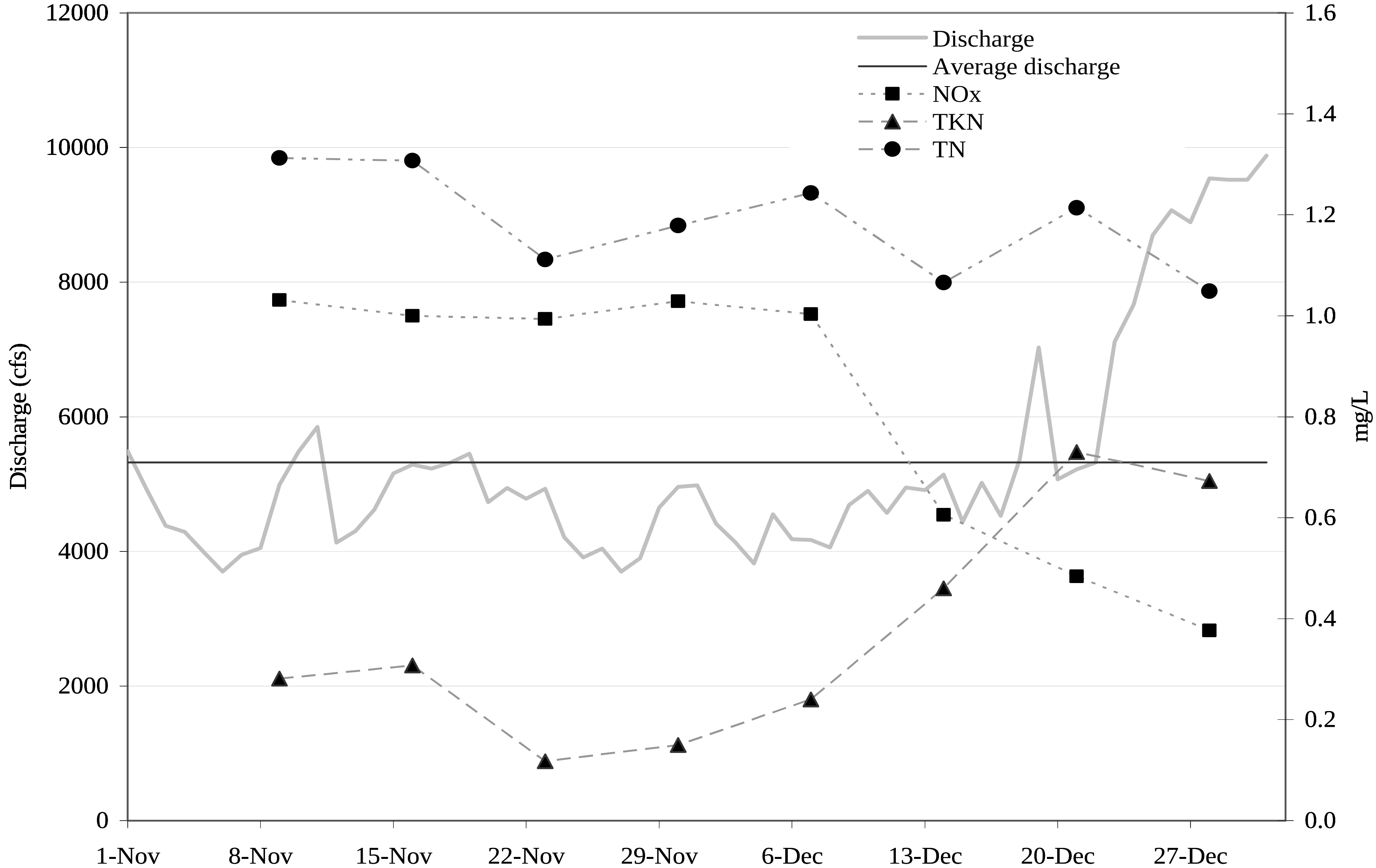

FIGURE 4-3.

VARIATION OF NUTRIENTS WITH THE RIVER DISHCARGE

Source: ECT, 2010.

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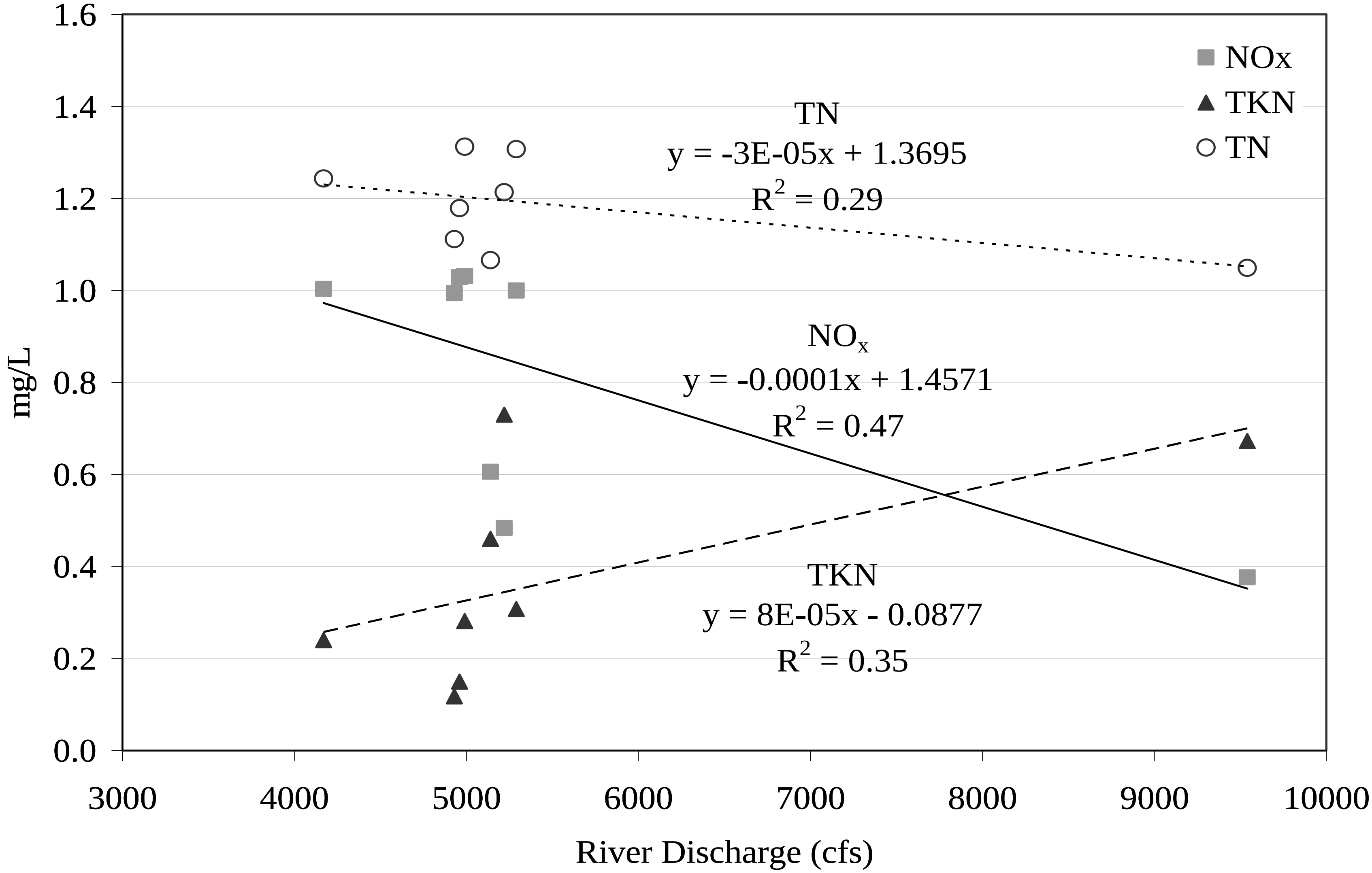

FIGURE 4-4.

RELATIONSHIP BETWEEN RIVER STATIONS NUTRIENT AND RIVER DISCHARGE

Source: ECT, 2010.

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4.2.4 MICROBIOLOGICAL PARAMETERS

Microbiological parameters measured in November through December of 2009 included total coliform, fecal coliform, enterococci, and *Salmonella*. These parameters were expressed in terms of col/100 mL except *Salmonella*, which was reported qualitatively as present or absent. Table 4-6 presents the summary results of the microbiological data.

4.2.4.1 Total Coliform

Total coliform in the monitoring well varied substantially over the sampling duration. Concentrations ranged from a minimum of below detection to 2,310 col/100 mL. The average well total coliform count was 845 col/100 mL. River stations total coliform average was 565 col/100 mL. Canal stations average counts of 654 col/100 mL were less than those found in the well. River and canal stations also had wide variations in counts over the 8 weeks, ranging from 154 to 2,310 col/100 mL. The average river stations value of 565 col/100 mL is similar to supplemental data averages for river stations ranging from 496 to 766 col/100 mL.

4.2.4.2 Fecal Coliform

The average fecal coliform count was highest in the canal stations at 218 col/100 mL, compared to the river and well stations at 120 and 1 (below detection) col/100 mL, respectively. The canal stations also exhibited the highest maximum fecal coliform count, at 666 col/100 mL compared to the river and well maximums of 320 and 1 (below detection) col/100 mL, respectively. The groundwater from the well was below detection for fecal coliform. However, these bacteria were detected in all river and canal station samples over the 8-week sampling period.

The supplemental data average fecal coliform counts was 111 col/100 mL, which is 49 percent less than the project's canal average of 218 col/100 mL. Similarly, the supplemental data average fecal coliform counts range of 69 to 119 col/100 mL compares well with the project's river average fecal coliform count of 120 col/100 mL.

4.2.4.3 **Enterococci**

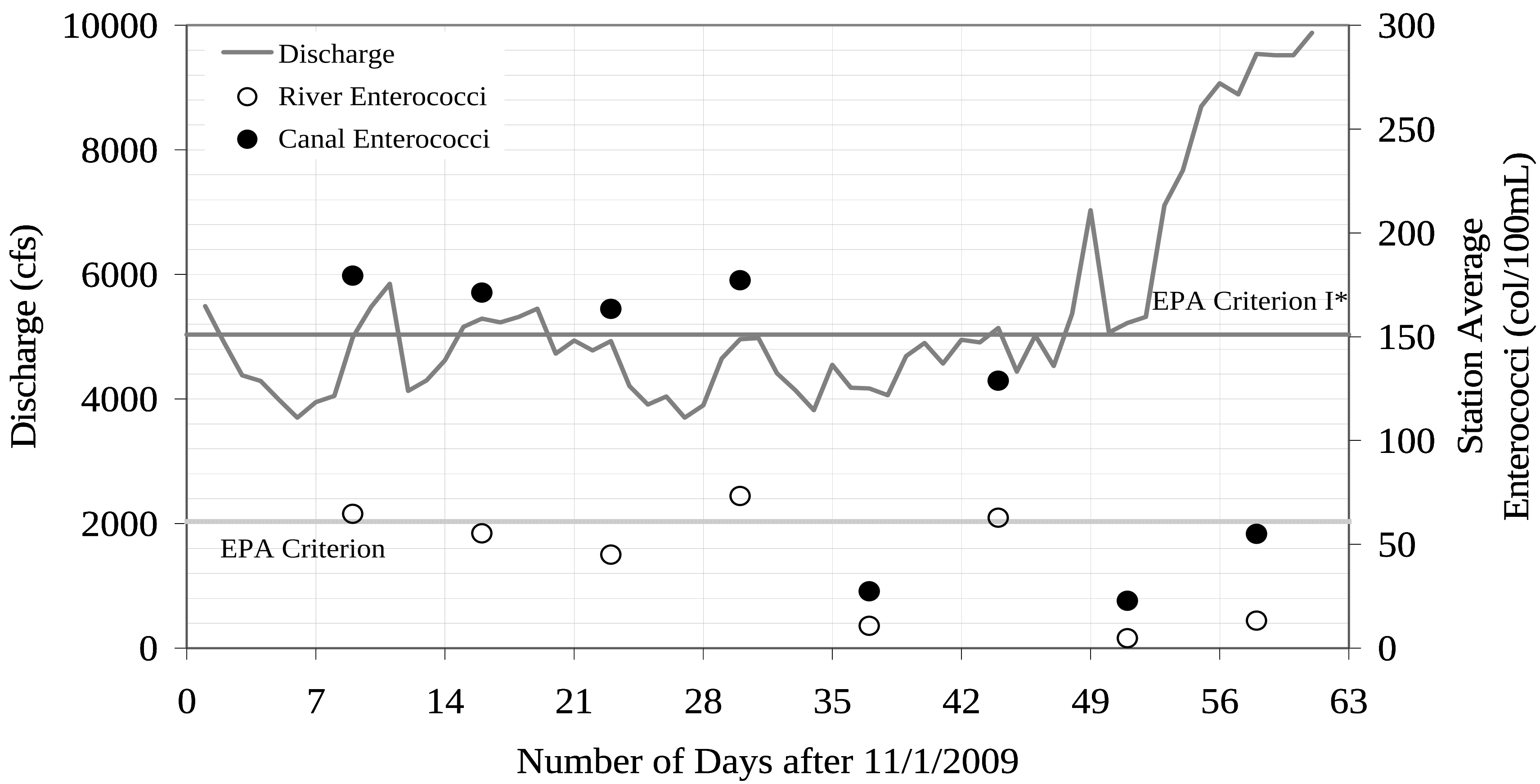
The enterococci bacteria were below detection in the monitoring well. The average well count was 1 col/100 mL (below detection), compared to the canal and river averages at 116 and 40 col/100 mL, respectively. The maximum enterococci count in the canal and river stations were 340 and 137 col/100 mL, respectively.

Figure 4-5 illustrates that the enterococci values were consistently higher in the canal stations than in the river stations. The canal and river stations enterococci values were relatively constant throughout the study except for Week 5 and a decrease in values as the river discharge increased near the end of the study.

The U.S. Environmental Protection Agency (EPA) has four criteria levels for body contact for enterococci levels. The most stringent is for beach areas at 61 counts per 100 milliliters (#/100 mL), and the most tolerant is for infrequent full body contact at a level of 151 #/100 mL. Figure 4-5 presents these values for comparison with the results. As illustrated, the average enterococci values in the river generally comply with the most stringent criteria, but the canal values frequently exceed the least protective criteria.

4.2.4.4 ***Salmonella***

Salmonella were analyzed qualitatively as presence or absence in the samples. *Salmonella* were present in the monitoring well 50 percent (four out of eight) of the time. The percentage of presence of *Salmonella* in the river and canal stations was the same at 62.5 percent. In the river stations, *Salmonella* were present 62.5 percent (20 out of 32) of the time as compared to 62.5 percent (25 out of 40) of the time in the canal stations. Table 4-7 presents the detection of *Salmonella* at each sampling location during the sampling period. The comparable *Salmonella* occurrences in the river suggest that the canals are not the source of *Salmonella*. Also, data in Table 4-7 indicate that the high occurrence of *Salmonella* at Stations 7 and 8 (75 percent) suggests there may be a downstream source of *Salmonella* not associated with the town and canal stations, which in general have a lower percentage of occurrence than Stations 7 and 8. The lowest occurrence of *Salmonella* were during Weeks 7 and 8 when the river discharge increased, suggesting a negative correlation with *Salmonella* and river discharge.



* Single sample maximum allowable Enterococci density for infrequently used full body contact recreation for freshwater (EPA, 1986)

** Single sample maximum allowable Enterococci density for the designated beach area (EPA, 1986)

FIGURE 4-5.

WEEKLY AVERAGE ENTEROCOCCI IN RIVER AND CANAL STATIONS

Source: ECT, 2010.

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Table 4-7. *Salmonella* Results

Station Number	Present (Sampling Weeks)								% Presence
	1	2	3	4	5	6	7	8	
1	✔			✔	✔			✔	50
2		✔	✔	✔	✔	✔	✔		75
3		✔	✔	✔	✔	✔			63
4			✔	✔				✔	38
5			✔	✔		✔		✔	50
6	✔	✔	✔	✔	✔	✔		✔	88
7		✔	✔	✔	✔	✔	✔		75
8		✔	✔	✔	✔	✔	✔		75
9			✔	✔		✔			38
10		✔	✔	✔	✔	✔			63

Sources: AEL, 2009-2010.
ECT, 2010.

4.2.5 MICROBIOLOGICAL PARAMETERS—DISCHARGE RELATIONSHIP

Weak negative correlations were found between total and fecal coliform with the river discharge. As these correlations were insignificant, graphical representation are not included in this report. There also appeared to be a reduction of enterococci and *Salmonella* occurrences as the river discharge increases, as discussed in the previous sections.

4.2.6 SOURCE TRACKING

Water samples from three locations (Stations 2, 5, and 10) were analyzed for *Enterococcus faecium*, esp human gene biomarker (HGB), to track the presence of human fecal contamination as opposed to other animal sources. The stations were selected in consultation with FDOH staff. Samples from Stations 2, 5, and 10 were collected for eight sampling weeks in November and December of 2009. Table 4-8 summarizes the DNA source tracking results. The results showed no consistent patterns within and among the sampling locations.

For example, the first and the third week's samples were all positive for human DNA presence. The second, fourth, and eighth week's sampling had identical results with Stations 2 and 5 results positive for human DNA and Station 10 negative. However, on the fifth week's samples, Stations 2 and 5 were negative. The same stations on the eighth week were positive for human DNA. For the seventh week, Station 2 was negative, whereas Stations 5 and 10 were positive for human DNA. Out of 16 samples collected from two canal stations, 13 samples (81 percent) tested positive for human DNA. Whereas, out of eight samples from the river station, four samples (50 percent) were positive for human DNA. Overall, HGB was detected 71 percent of the time with the canals showing appreciably higher occurrences. At least one station tested positive for HGB during each week.

Table 4-8. DNA Human Source Tracking Analyses Result

Sampling Station	Positive for Human DNA (Sampling Weeks) 1	2	3	4	5	6	7	8	Percent Positive (within stations)
2	✔	✔	✔	✔		✔		✔	75
5	✔	✔	✔	✔		✔	✔	✔	88
10	✔		✔		✔		✔		50
Percent positive (among stations)	100	67	100	67	33	67	67	67	

Sources: Molecular, 2009 and 2010.
ECT, 2010.

5.0 ANALYSIS AND DISCUSSION

The primary goal of the water quality sampling program near the town of Suwannee was to document the water quality effects of installing a central wastewater treatment facility and closing approximately 850 septic tanks. More specifically, the study was to evaluate if closing the septic tanks would reduce pollution and enhance the viability of oyster harvesting in Suwannee Sound. The baseline study for the program was completed in 1996 prior to closure of the septic tanks. The intent was to sample 1 year later to evaluate potential improvements. Unfortunately, the value of the postconstruction sampling was compromised by two factors: (1) the septic tank closure was delayed, and not all tanks were closed prior to the 1997 sampling; and (2) 1997 was an El Niño year, and the river flows were two to three times greater, which affected the results and limited the ability to compare with preconstruction values.

In a continued attempt to evaluate the affects of septic tank closure, FDOH has funded this study to investigate if positive effects are measurable 12 years after the septic tanks were closed. This overall program consisted of two monitoring episodes: May through July 2009 and November through December 2009 (which is discussed in this report). The results of the summer 2009 study were presented in a previous report (ECT, 2009). The results of the 2009 winter monitoring effort were presented in Section 4.0; this section provides a comparison of these results with the 1996 preconstruction data.

5.1 ANCILLARY DATA

For a controlled study it is desirable to keep all variables constant except the study parameter. In this case, the study parameter was the effect of closing septic tanks on water quality. One of the key parameters that could affect or bias the study is river flow. The Suwannee River discharge flow for the sampling periods from 1996 (November through December), 1997 (November through December), 2009 (May through July), and 2009 (November through December) are presented in Figure 5-1 for comparison.

For the baseline or preconstruction year 1996 (November through December), the river flow remained relatively constant. However, in 1997, because of El Niño, the river flow

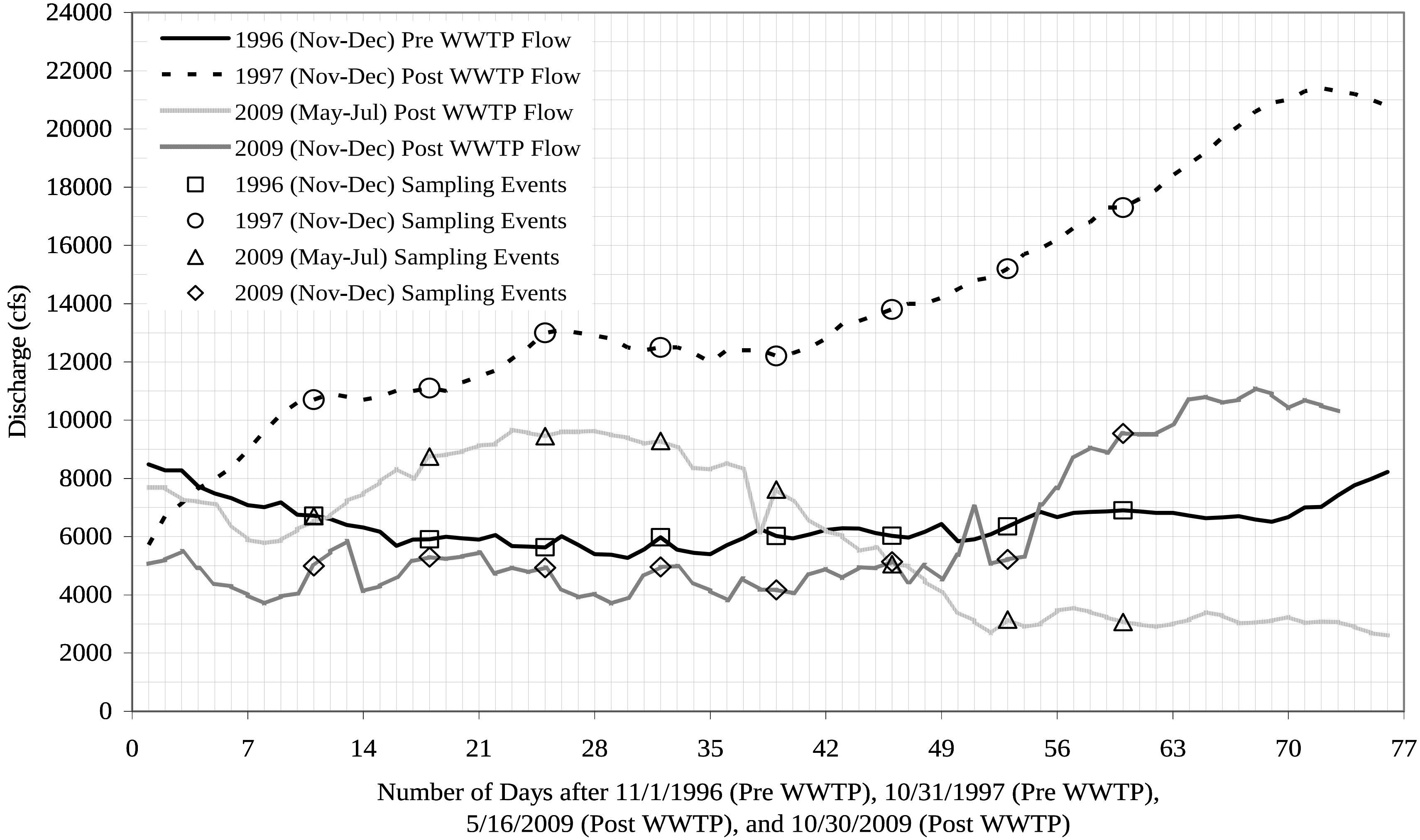

FIGURE 5-1.

RIVER DISCHARGES AND THE SAMPLING EVENTS DURING THE YEARS 1996, 1997, AND 2009 (BOTH SUMMER AND WINTER SAMPLING EVENTS)

Sources: USGS, 2010. ECT, 2010.

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increased sharply, which made it difficult to interpret preconstruction and postconstruction results. The river flow in 2009 was quite variable, but no large flow increases as observed in 1997 occurred. Consequently, the effects of river flow in adding bias to the data were probably small or certainly less than observed in the 1997 results.

The comparison of the 1996 (November through December) and 1997 (November through December) results (ECT, 1998) and the comparison of the 1996 (November through December) and 2009 (May through July) results (ECT, 2009) were provided in the previous reports and will not be repeated in this report. In this section, 1996 (November through December) data (hereafter referred to as 1996 data) are compared with 2009 (November through December) data (hereafter referred to as 2009 data). Comparison of 1996 and 2009 requires evaluation of other parameters that might influence the data comparison. During both sampling events, specific conductivity, DO, pH, and temperature were routinely measured. The results are presented in Figures 5-2 (specific conductivity) and 5-3 (DO, pH, and temperature) and give the vertical average values from measurements made at three different depths for all stations for the entire sampling periods. The results indicate the average specific conductivity in Canal Stations (1,401 µS/cm, equivalent to a salinity of approximately 0.8 parts per thousand [ppt]) in 1996 was less than in 2009 (2,814 µS/cm, equivalent to a salinity of approximately 1.6 ppt), whereas specific conductivity in the river stations in 1996 was higher at 1,653 µS/cm in 1996 as compared to 1,492 µS/cm in 2009. Canal stations' DO in 1996 (6.0 mg/L) was less than that in river stations (7.1 mg/L) in 2009. River stations' DO was also lower at 6.8 mg/L in 1996 as compared to 7.5 mg/L in 2009. An increase in pH was observed in both canal and river stations in 2009 as compared to those in 1996. Temperatures, on the other hand, were slightly lower in 2009 in both the canal and river stations as compared to 1996. These changes, although relatively small, could have an influence on some of the parameters measured, but are probably minor. The variability in these ancillary data is presented to describe and illustrate other parameters that could influence the interpretation of the pre- and postconstruction results.

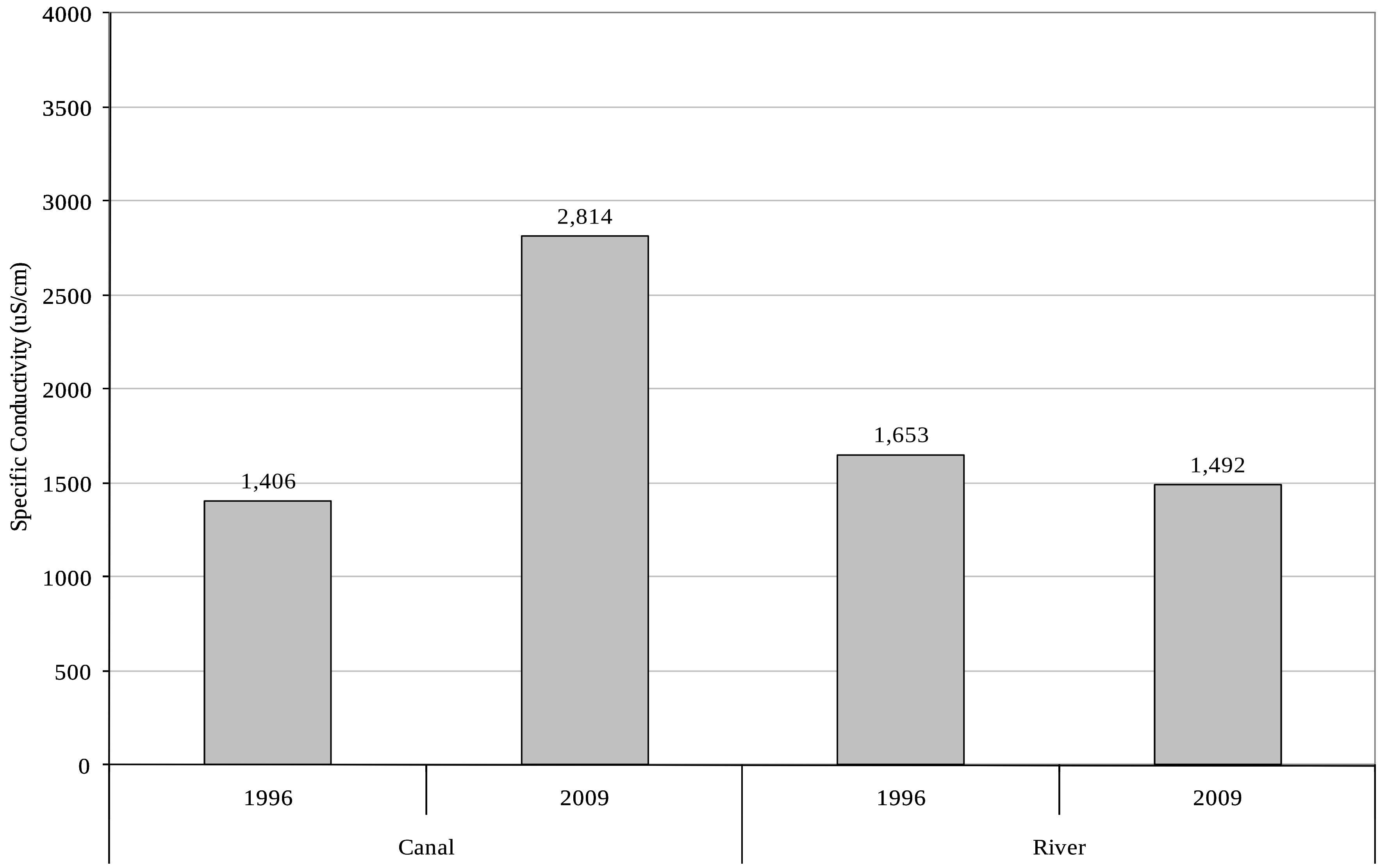

FIGURE 5-2.

COMPARISON OF *IN SITU* SPECIFIC CONDUCTIVITY DATA DURING 1996 AND 2009 SAMPLING PERIODS

Source: ECT, 2010.

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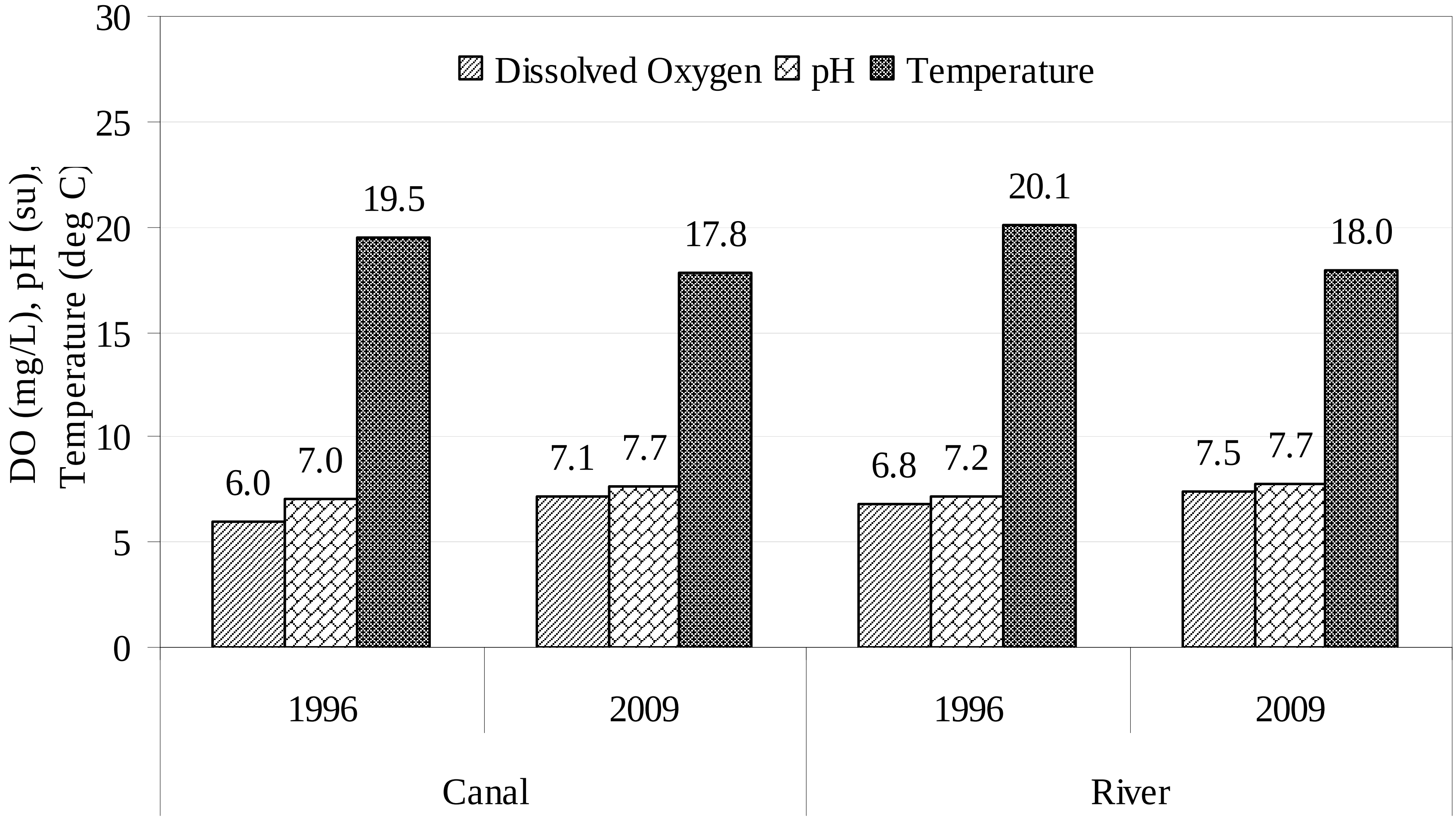

FIGURE 5-3.

COMPARISON OF *IN SITU* DO, pH, AND TEMPERATURE DATA DURING 1996 AND 2009 SAMPLING PERIODS

Source: ECT, 2010.

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5.2 NUTRIENTS

Preliminary examination of the NO_x data for the river stations indicated there was a correlation between NO_x and river flow. The weekly average values for the river stations are plotted against river flow and are shown in Figure 5-4. The figure illustrates the strong correlation (R^2 = 0.78) between river flow and NO_x for 1996 data, whereas the correlation is moderate (R^2 = 0.56) for 2009 data. This is partly because the river flow was relatively constant at approximately 5,000 cfs in 2009 sampling events except for one high flow value. This did not provide a good range of values to examine possible correlations.

To further illustrate the relationship between river discharge and NO_x, the data from the four surveys were plotted and are presented in Figure 5-5. This provided NO_x for a greater range of river discharges and illustrates the strong negative correlation (R^2 = 0.84) of NO_x with river discharge. It is uncertain if this is simply dilution caused by the higher flows or a chemical process.

To further examine the 1996 data and the 2009 NO_x postconstruction data, the average values for the river stations and the canal stations were calculated and presented in Table 5-1. The data for TKN, total nitrogen, and the coliform data are also summarized on this table. Even though there was an overall reduction in NO_x in 2009 as compared to 1996 in both canal and river stations, these differences were 7 percent. Combined all stations reduction of NO_x from 1996 to 2009 was approximately 8 percent.

In 1996, NO_x and total nitrogen in the canal stations were lower but TKN was higher than those in the river stations. Table 5-2 shows these results. Similar results were observed in 2009. However, the TKN concentration in the canal stations in 2009 was 27 percent higher than in the river stations as compared to that in 1996 at only 8 percent. Difference in NO_x concentrations in 1996 and 2009 were similar.

The TKN in the canal stations increased slightly from 1996 to 2009, but the values observed in the river decreased slightly in 2009 as compared to 1996. The increase in canal stations' TKN was offset by the decrease in NO_x such that the total nitrogen remained nearly unchanged between 1996 and 2009 as shown in Figure 5-6. However, both NO_x

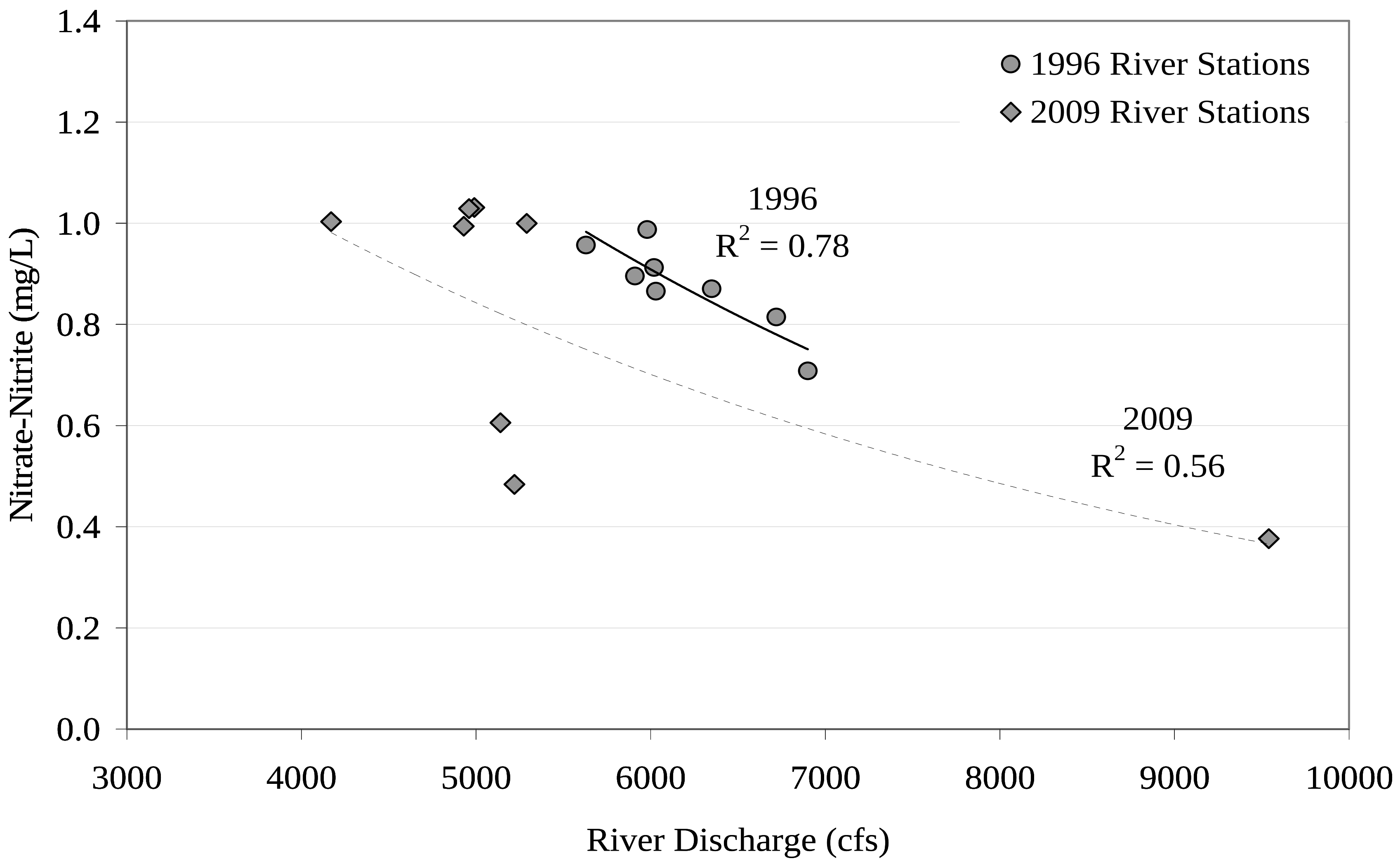

FIGURE 5-4.

NO_x COMPARISON OF RIVER STATION AVERAGES IN 1996 AND 2009

Source: ECT, 2010.

Environmental Consulting & Technology, Inc.

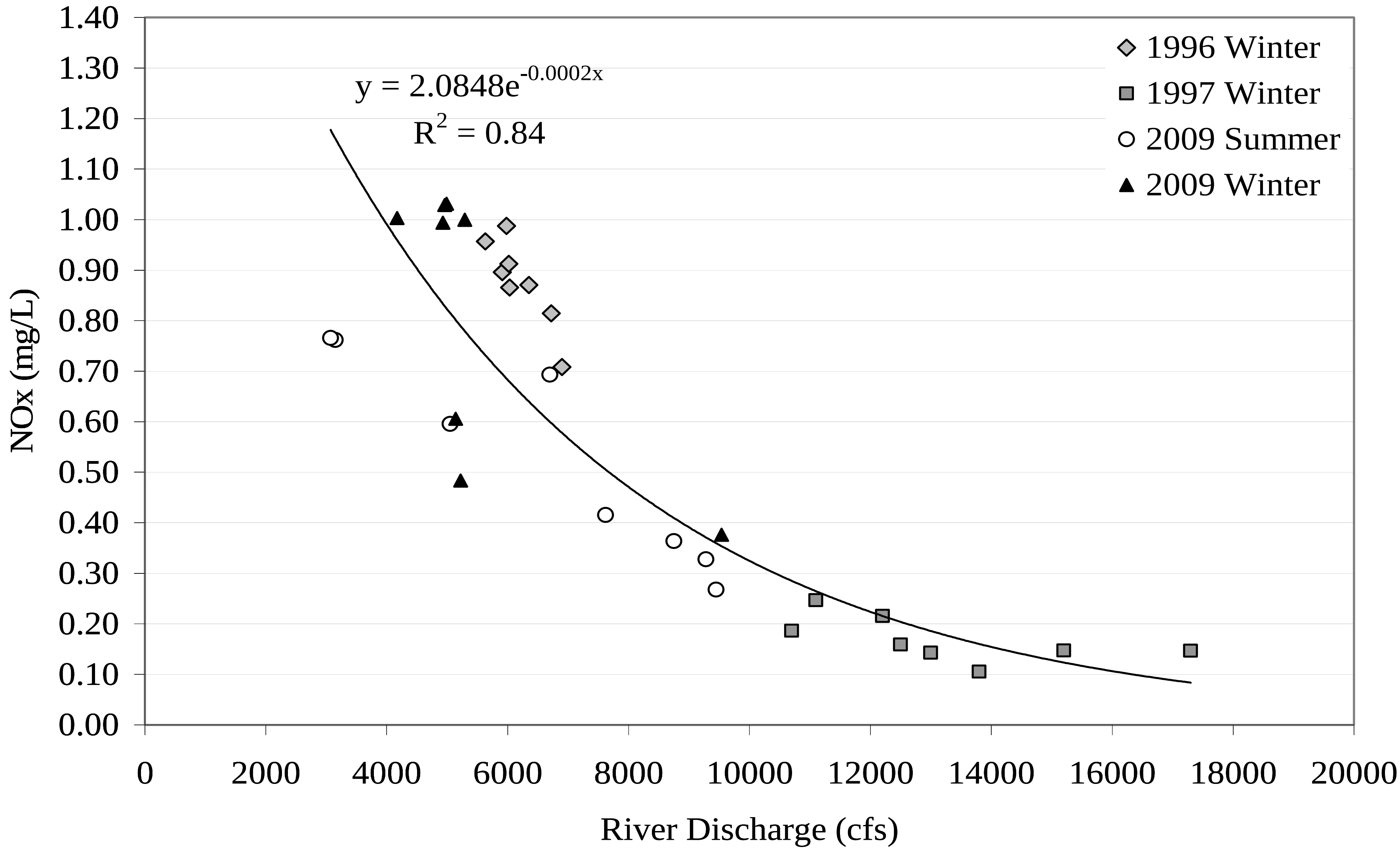

FIGURE 5-5.

RELATIONSHIP BETWEEN NO_x AND RIVER DISCHARGE

Source: ECT, 2010.

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Table 5-1. Changes in Average Concentrations between the 1996 and 2009 Sampling Events

Water Quality Parameters	Average Values 1996	Average Values 2009	% Change from 1996
Canal Stations			
Enetrococci (col/100mL)	—	116	—
Total Coliform (col/100mL)	537	654	22
Fecal Coliform (col/100mL)	537	218	-59
TKN (mg/L)	0.41	0.47*	15
NO_x (mg/L)	0.73	0.68†	-7
Total nitrogen (mg/L)	1.14	1.15	1
Salmonella (% presence)	15	63	320
River Stations			
Enetrococci (col/100mL)	—	40‡	—
Total Coliform (col/100mL)	171	565	230
Fecal Coliform (col/100mL)	170	120	-29
TKN (mg/L)	0.39	0.37	-5
NO_x (mg/L)	0.88	0.82	-7
Total nitrogen (mg/L)	1.26	1.19	-6
Salmonella (% presence)	75	63	-16
Monitoring well			
Enetrococci (col/100mL)	—	1	—
Total Coliform (col/100mL)	234	845	261
Fecal Coliform (col/100mL)	232	1	-100
TKN (mg/L)	7.44	1.35	-82
NO_x (mg/L)	1.88	0.01	-99
Total nitrogen (mg/L)	9.33	1.36	-85
Salmonella (% presence)	0	50	—
All Stations (except Monitoring Well)			
Enetrococci (col/100mL)	—	83	—
Total Coliform (col/100mL)	374	614	64
Fecal Coliform (col/100mL)	374	174	-53
TKN (mg/L)	0.40	0.43	7
NO_x (mg/L)	0.79	0.73	-8
Total nitrogen (mg/L)	1.20	1.15	-4
Salmonella (% presence)	42	63	50

*Average excludes a suspected outlier value of 3.83 from a canal station.
†Average excludes a suspected outlier value of 0.021 from a canal station.
‡Average excludes a suspected outlier value of 1,300 from a river station.

Note: Negative percentage is decrease from 1996 values.
Positive percentage is increase from 1996 values.
Data are presented for river stations, canal stations, monitoring well, and combined river and canal stations (all stations except monitoring well).

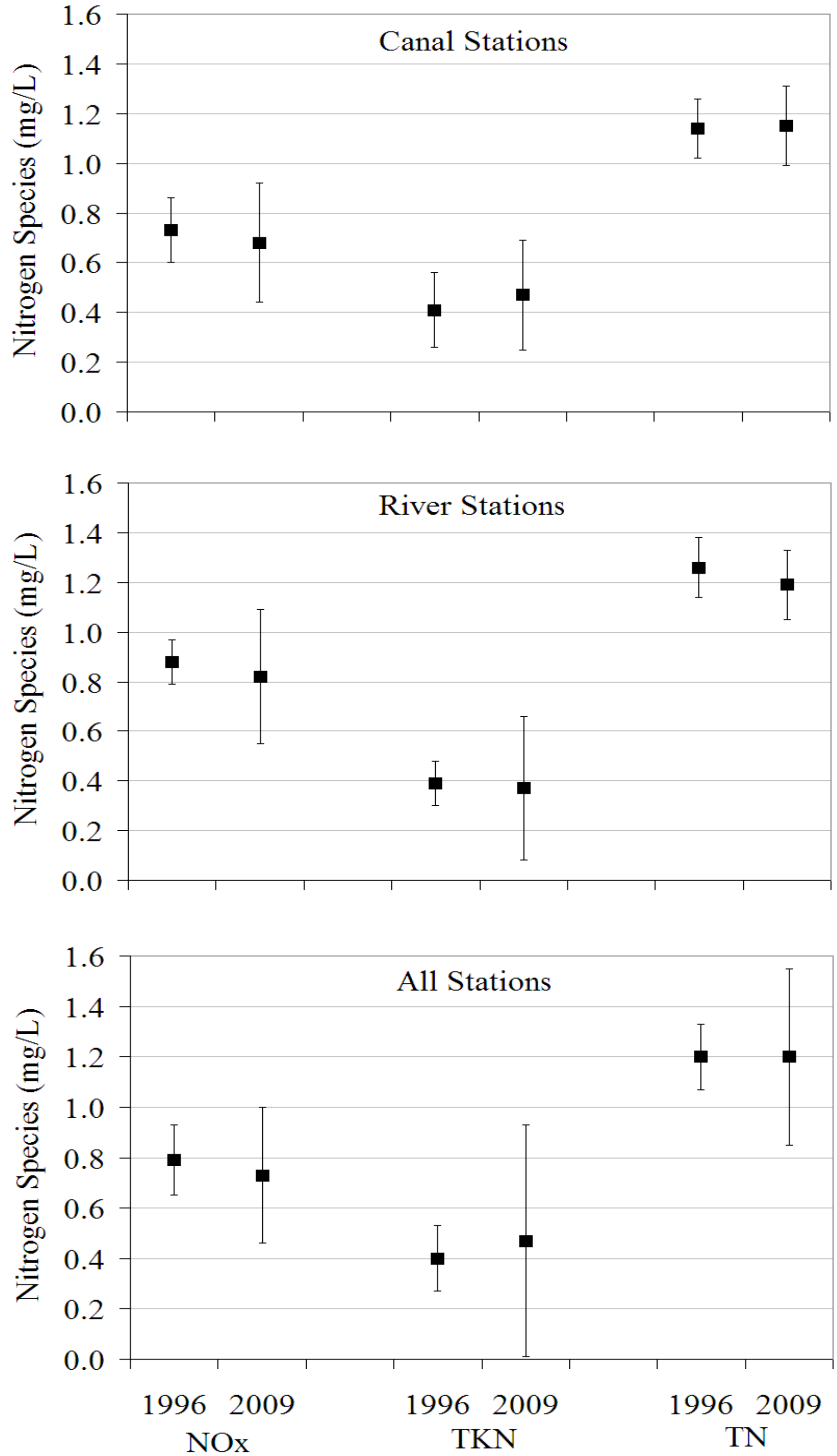
Source: ECT, 2010.

Table 5-2. Difference in Average Concentrations between River and Canal Stations in the Years 1996 and 2009

Water Quality Parameters	1996 River	1996 Canal	Percent Difference	2009 River	2009 Canal	Percent Difference
Total coliform (col/100ml)	171	537	214	565	654	16
Fecal coliform (col/100ml)	170	537	216	120	218	82
TKN (mg/L)	0.39	0.41	5	0.37	0.47	27
NO_x (mg/L)	0.88	0.73	-17	0.82	0.68	-17
Total nitrogen (mg/L)	1.27	1.14	-10	1.19	1.15	-3

Note: Negative percentage is decrease from river station values.
Positive percentage is increase from river stations values.

Source: ECT, 2010.



Note: Average values are shown with ± standard deviation.
All stations exclude monitoring well.

FIGURE 5-6.

COMPARISON OF NO_x, TKN, AND TOTAL NITROGEN BETWEEN 1996 AND 2009

Source: ECT, 2010.

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and TKN in river stations decreased slightly in 2009 as compared to 1996. Station average NO_x concentrations were higher in 2009. TKN and total nitrogen concentrations were lower for 2009. There is no clear indication from these results to attribute improvement of water quality resulting from removal of the septic tanks.

5.3 <u>MICROBIOLOGY</u>

The following section compares the results of the microbiology from 1996 with the recent samples. Source tracking and enterococci analyses were not completed in 1996 and, consequently, are not presented here, but were discussed in Section 4.0.

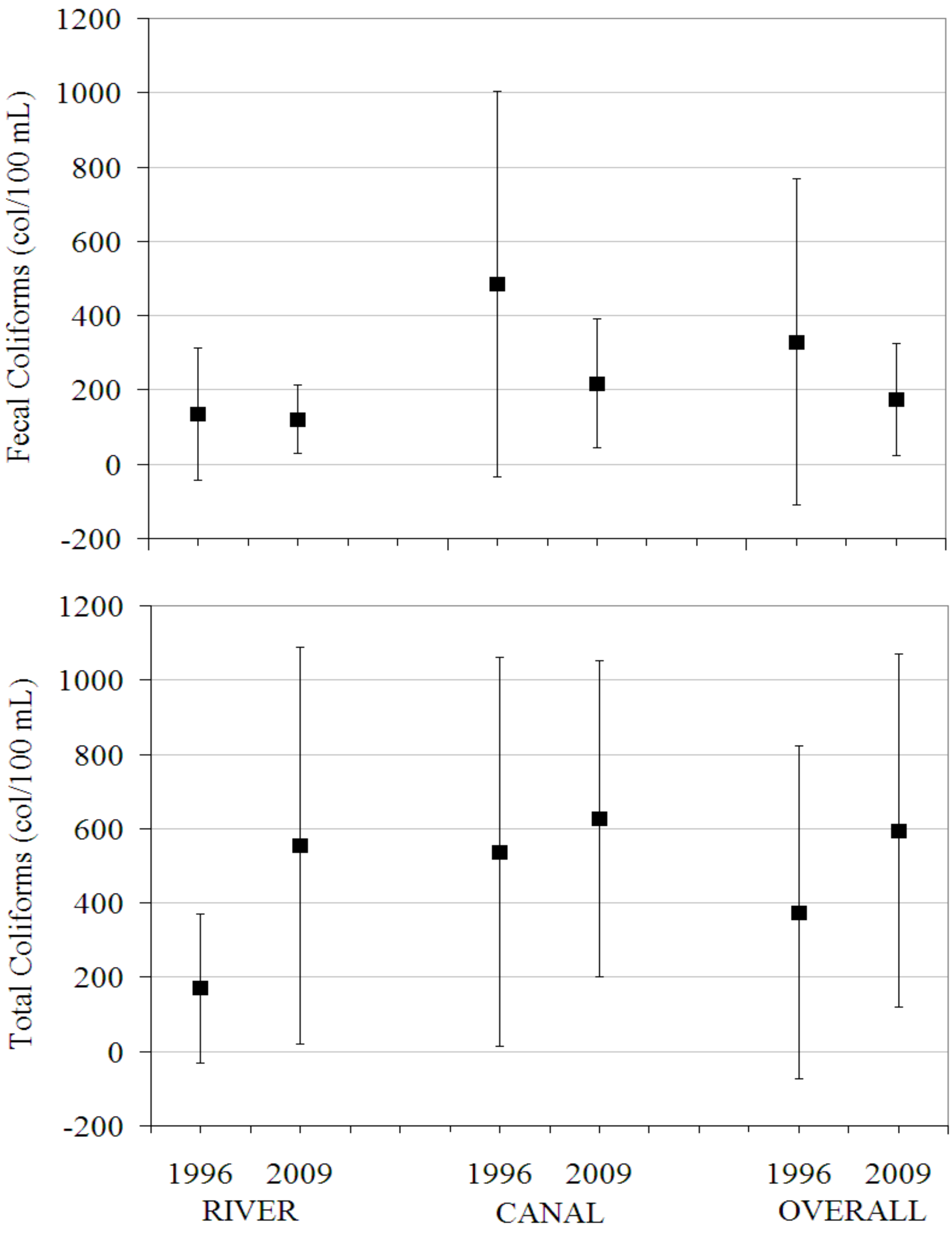
5.3.1 *SALMONELLA*

Salmonella samples were analyzed for presence/absence only, and the 2009 results are presented in Section 4.0. In 2009 *Salmonella* were present in 63 percent of both the river and canal samples. This indicates that *Salmonella* issuing from the canals may not be the primary source of *Salmonella* in the river.

In 1996 *Salmonella* were present in the river stations 75 percent of the time with 100-percent occurrence at Stations 8, 9, and 10 and no occurrence at Station 7. *Salmonella* were present in the five canal stations only 15 percent of the time in 1996. Consequently, the occurrence of *Salmonella* in the river decreased from 75 to 63 percent from 1996 to 2009; however, in the canal stations, the occurrence increased from 15 percent in 1996 to 63 percent in 2009. The results indicate that during both studies the occurrence of *Salmonella* was equal or higher in the river than in the canals. Further, since the occurrences in the canals were higher in 2009 as compared to 1996, there was no observed reduction resulting from septic tank closure.

5.3.2 COLIFORMS

Table 5-1 presents the average observed coliform values for both fecal and total coliforms for 1996 and 2009 and for all river and canal stations. Figure 5-7 illustrates these results. Several key items are apparent in the data. The fecal coliforms are much higher in the canals than in the river in both 1996 and 2009 suggesting that the canals are a source



Note: Average values are shown with ± standard deviation.
Overall values exclude monitoring well.

FIGURE 5-7.

COMPARISON OF FECAL AND TOTAL COLIFORMS BETWEEN 1996 AND 2009

Source: ECT, 2010.

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of fecal coliforms to the river. This is not surprising given the concentration of fish, birds, and other animals in canal areas.

The data also indicate that there was a reduction in fecal coliforms in 2009 as compared to 1996 in both the canals (59-percent reduction) and the river station (29-percent reduction). Fecal coliform reduction in the canals might be attributed to closing of the septic tanks because the reduction is significantly greater than observed in the river.

Fecal coliforms were higher in canal stations in both 1996 (216-percent higher) and 2009 (82-percent higher) as compared to the river stations (refer to Table 5-2). Similar to the fecal coliform data, the total coliform values were higher in the canals in both 1996 (214-percent higher) and 2009 (16-percent higher). Comparison of canal and river stations' total and fecal coliform data indicates that the canals are a source of coliforms to the river. However, contrary to the fecal coliform results, the total coliform counts increased in 2009 at both the river and canal stations. Consequently, closing the septic tanks did not reduce the total coliforms. Closer examination of the 1996 data indicated the total coliform data were abnormally low and are somewhat suspect, so the observed increase from 1996 to 2009 might not be as great.

5.4 STATISTICAL TREATMENT

The primary goal of the 2009 study was to evaluate and document any potential improvements in water quality from closing 850 septic tanks in the town of Suwannee and establishing a central wastewater treatment system. A simple before-and-after comparison was complicated by variations in river flows, rainfall, and water temperatures. Further, similar changes in the test parameters were observed in the river stations as observed in the canal stations. Consequently, separating regional or seasonal changes in the river basin from potential septic tank closure benefits was difficult.

The observed changes between 2009 and 1996 were discussed in the previous sections. The results indicated the differences between the concentrations of canal and river stations for a few of the indicator parameters were reduced in 2009 as compared to 1996 (refer to Table 5-1). To help determine if these differences were attributable to septic tank closure, water quality data from the 1996 and 2009 sampling events were further analyzed using statistical techniques for five indicator parameters including total and fecal coliforms, NO_x, TKN, and total nitrogen. For each sampling week, each indicator parameter was grouped as a canal station or river station. Averages of canal stations and river stations were calculated for each of the parameters and are presented in Table 5-3.

A two-sample (paired) t-test was performed to compare the weekly mean values of water quality parameters for both the canal stations and river stations between 1996 and 2009. Figures 5-5 and 5-6 (presented previously) illustrate the data used for this analysis. Table 5-4 provides the results of the tests.

Of the five parameters tested for the canals, only fecal coliforms were significantly different between the 1996 and 2009 replicate samples (Table 5-4) and showed a 59-percent reduction.

For the river stations, the results indicated that there was a significant increase in total coliform in 2009 as compared to 1996 and also a slight but statistically significant decrease in total nitrogen.

Even though there was a significant reduction in fecal coliforms in the canals from 1996 to 2009, it was not certain if this was the result of septic tank closure or other reasons. To examine this further the changes in the river stations (control stations) were compared to the changes observed in the canals.

In an attempt to assess the septic tank closure contribution to changes in canal water with respect to river water background, the differences between the average concentrations of indicator parameters between the canal and river stations were determined for each of the eight weekly replicate sampling periods. Table 5-3 presents these differences.

A two-sample (paired) t-test was used to compare the eight replicate weekly means of differences for each of the indicator parameters. This analysis was completed to test if there was a significant difference in the observed difference in canal versus river stations

Table 5-3. Weekly Average Value of River and Canal Stations and Their Differences for the 1996 and 2009 Results

Week	Fecal Coliform			Total Coliform			Nitrate + Nitrite			TKN			Total Nitrogen		
Number	River	Canal	Difference	River	Canal	Difference	River	Canal	Difference	River	Canal	Difference	River	Canal	Difference
1996															
1	134	806	672	134	806	672	0.81	0.62	-0.19	0.42	0.53	0.11	1.24	1.14	-0.10
2	498	1,214	716	498	1,214	716	0.90	0.78	-0.12	0.40	0.50	0.10	1.30	1.29	-0.01
3	223	790	567	223	790	567	0.96	0.80	-0.16	0.31	0.29	-0.02	1.27	1.09	-0.18
4	230	534	304	230	534	304	0.99	0.78	-0.21	0.47	0.31	-0.16	1.46	1.09	-0.37
5	166	442	276	166	442	276	0.91	0.77	-0.14	0.43	0.39	-0.04	1.34	1.16	-0.18
6	37	144	107	37	144	107	0.87	0.75	-0.12	0.35	0.38	0.03	1.21	1.13	-0.08
7	35	318	283	39	318	279	0.87	0.73	-0.14	0.30	0.36	0.06	1.17	1.09	-0.08
8	40	52	12	40	52	12	0.71	0.59	-0.12	0.43	0.54	0.11	1.14	1.14	0
Mean	170	538	367	171	537	367	0.88	0.73	-0.15	0.39	0.41	0.03	1.27	1.14	-0.13
2009															
1	216	372	156	1,618	1,508	-110	1.03	0.90	-0.13	0.28	0.43	0.15	1.31	1.33	0.02
2	119	179	60	540	740	200	1.00	0.76	-0.24	0.31	0.31	0	1.31	1.06	-0.25
3	190	302	112	308	678	370	0.99	0.83	-0.16	0.12	0.22	0.10	1.11	1.05	-0.06
4	198	317	119	732	708	-24	1.03	0.78	-0.25	0.15	0.43	0.28	1.18	1.21	0.03
5	41	92	51	424	548	124	1.00	0.87	-0.13	0.24	0.36	0.12	1.24	1.23	-0.01
6	138	338	200	320	493	173	0.61	0.55	-0.06	0.46	0.56	0.10	1.07	1.12	0.05
7	30	55	25	193	308	115	0.48	0.44	-0.04	0.73	0.74	0.01	1.21	1.18	-0.03
8	32	87	55	385	246	-139	0.38	0.34	-0.04	0.67	0.72	0.05	1.05	1.06	0.01
Mean	120	218	97	565	654	89	0.82	0.68	-0.13	0.37	0.47	0.10	1.19	1.15	-0.03

Source: ECT, 2010.

Table 5-4. Differences in Canal Stations and River Stations Mean Values between 1996 and 2009

Parameters	1996 Mean	1996 Standard Deviation	2009 Mean	2009 Standard Deviation	P
Canal Stations					
Fecal coliform	537	523	218	174	<0.001*
Total coliform	537	523	654	472	0.168
NO_x	0.73	0.13	0.68	0.24	0.257
TKN	0.41	0.15	0.47	0.22	0.073
Total nitrogen	1.14	0.12	1.15	0.16	0.844
River Stations					
Fecal coliform	170	200	120	92	0.169
Total coliform	171	200	565	525	<0.001*
NO_x	0.88	0.08	0.82	0.27	0.133
TKN	0.39	0.09	0.37	0.23	0.701
Total nitrogen	1.27	0.12	1.19	0.17	0.011*

*Indicates significant difference.

Note: P = value is the probability of being wrong in concluding that there is a true difference between the groups.

Source: ECT, 2010.

between 1996 and 2009. Of the five parameters tested, fecal coliform, and total coliform were significantly different between the 1996 and 2009 replicate samples (Table 5-5). This difference is the result of a change in the canal values as compared to the change in the river values in the 2009 versus 1996 samples (see Table 5-1).

The significant difference observed in the total coliform data is the result of a large increase in total coliforms in the river from 1996 to 2009 as compared to a relatively small change in the canals. This difference is not the result of large changes in the canals and cannot be attributed to septic tank closure.

However, the significant difference in the fecal coliform is the result of the observed significant decrease in fecal coliform in the canals from 1996 to 2009. The fecal coliform counts in the river stations (controls) changed very little; consequently, the reduction in fecal coliform was unique to the canals and could possibly be attributed to septic tank closure.

5.5 COMPARISON OF THE WINTER AND SUMMERY 2009 RESULTS

Although not an integral component of the study, the results provide a unique opportunity to compare winter and summer data for the study area. Table 5-6 presents the data results (except HGB) for both the summer and winter 2009 surveys, and Figures 5-8 through 5-10 illustrate these results.

A few of the key comparisons include:

- The average water temperature was 17.85°C in the winter and 27.01°C in the summer.
- Total nitrogen concentration is relatively constant, with the NO_x concentration being higher in the winter and TKN being lower in the winter for both the canal and river stations.
- The total coliforms concentration is higher in the summer, and the fecal coliform concentration is higher in the winter for both the canal stations and river stations.
- Enterococci values were slightly higher in the winter.

Table 5-5. Mean and Standard Deviation of the Differences in River and Canal Stations Averages in 1996 and 2009

Parameters	1996 Mean Difference	1996 Standard Deviation	2009 Mean Difference	2009 Standard Deviation	P
Fecal coliform	367	258	97	60	0.023*
Total coliform	367	259	89	171	0.020*
Nitrate + nitrite	-0.15	0.03	-0.13	0.08	0.489
TKN	0.03	0.09	0.10	0.09	0.244
Total nitrogen	-0.13	0.12	-0.03	0.09	0.176

*Indicates significant difference.

Note: P = value is the probability of being wrong in concluding that there is a true difference between the groups.

Source: ECT, 2010.

Table 5-6. Changes in Average Concentrations between the 2009 Summer and Winter Sampling Events

Water Quality Parameters	Average Values—2009		Percent Change from Summer 2009
	Summer	Winter	
Canal Stations			
Enterococci (col/100ml)	73*	116	59
Total coliform (col/100ml)	1,373	654	-52
Fecal coliform (col/100ml)	89	218	145
TKN (mg/L)	0.69	0.47	-32
NO_x (mg/L)	0.39	0.68	74
Total nitrogen (mg/L)	1.07	1.15	7
Salmonella (% presence)	23	63	174
River Stations			
Enterococci (col/100ml)	35	40	14
Total coliform (col/100ml)	841	565	-33
Fecal coliform (col/100ml)	33	120	264
TKN (mg/L)	0.66	0.37	-44
NO_x (mg/L)	0.52	0.82	58
Total nitrogen (mg/L)	1.19	1.19	0
Salmonella (% presence)	47	63	34
Monitoring Well			
Enterococci (col/100ml)	189*	1	-99
Total coliform (col/100ml)	1,690	845	-50
Fecal coliform (col/100ml)	22	1	-95
TKN (mg/L)	1.25	1.35	8
NO_x (mg/L)	0.06	0.01	-83
Total nitrogen (mg/L)	1.31	1.36	4
Salmonella (% presence)	50	50	0
All Stations (except monitoring well)			
Enterococci (col/100ml)	54	83	54
Total coliform (col/100ml)	1,108	614	-45
Fecal coliform (col/100ml)	61	174	185
TKN (mg/L)	0.67	0.43	-36
NOx (mg/L)	0.45	0.73	62
Total nitrogen (mg/L)	1.13	1.15	2
Salmonella (% presence)	33	63	91

*Summer 2009 average value excludes suspected outliers of 1,150 and 2,100 from a canal station and monitoring well, respectively.

Note: Data are presented for river stations, canal stations, monitoring well, and combined river and canal stations (all stations except monitoring well).
Negative percentage is a decrease from summer 2009 values.
Positive percentage is an increase from summer 2009 values.

Source: ECT, 2010.

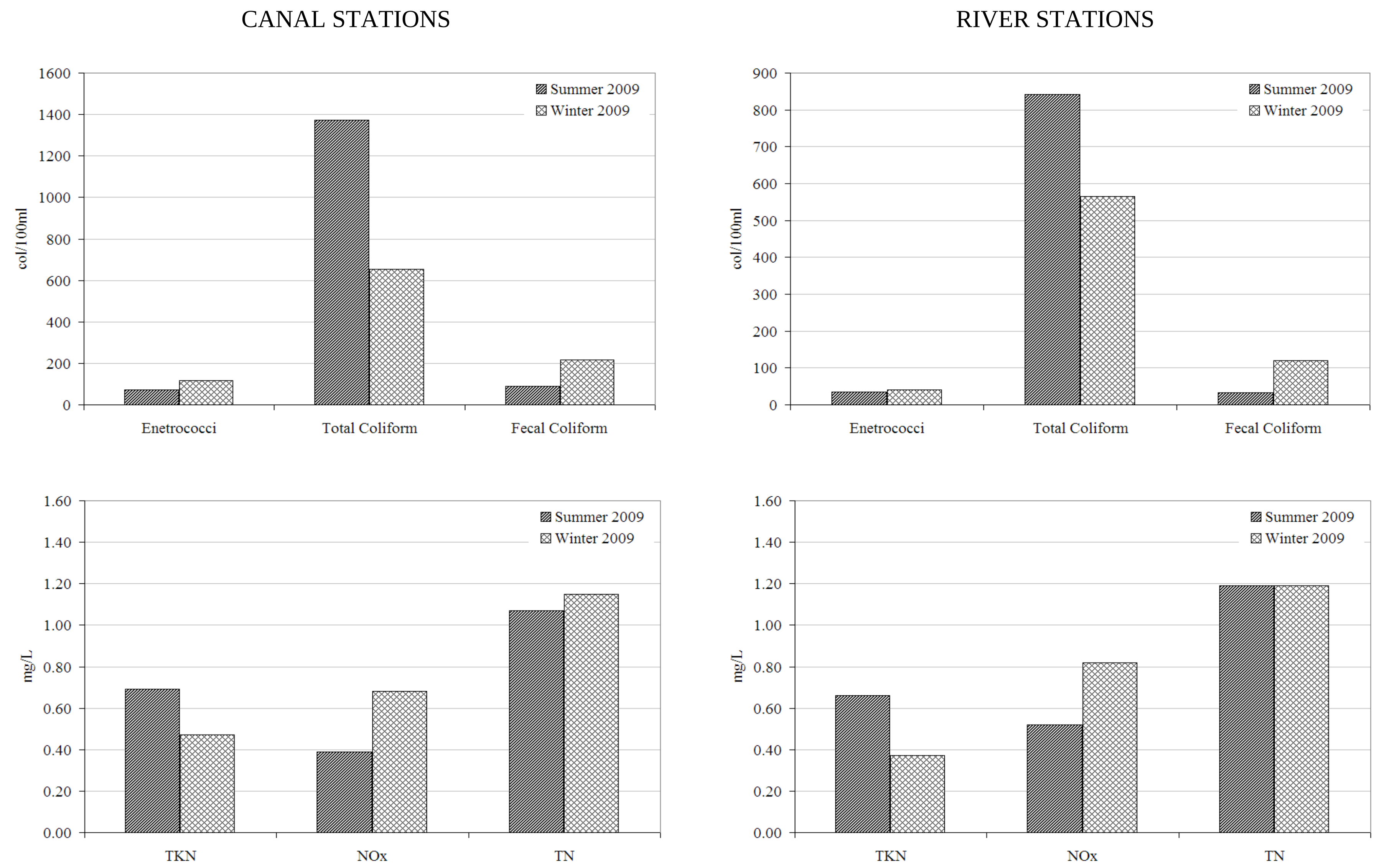


FIGURE 5-8.

COMPARISON OF WINTER AND SUMMER 2009 DATA FOR THE CANAL STATIONS AND RIVER STATIONS

Source: ECT, 2010.

ECT
Environmental Consulting & Technology, Inc.

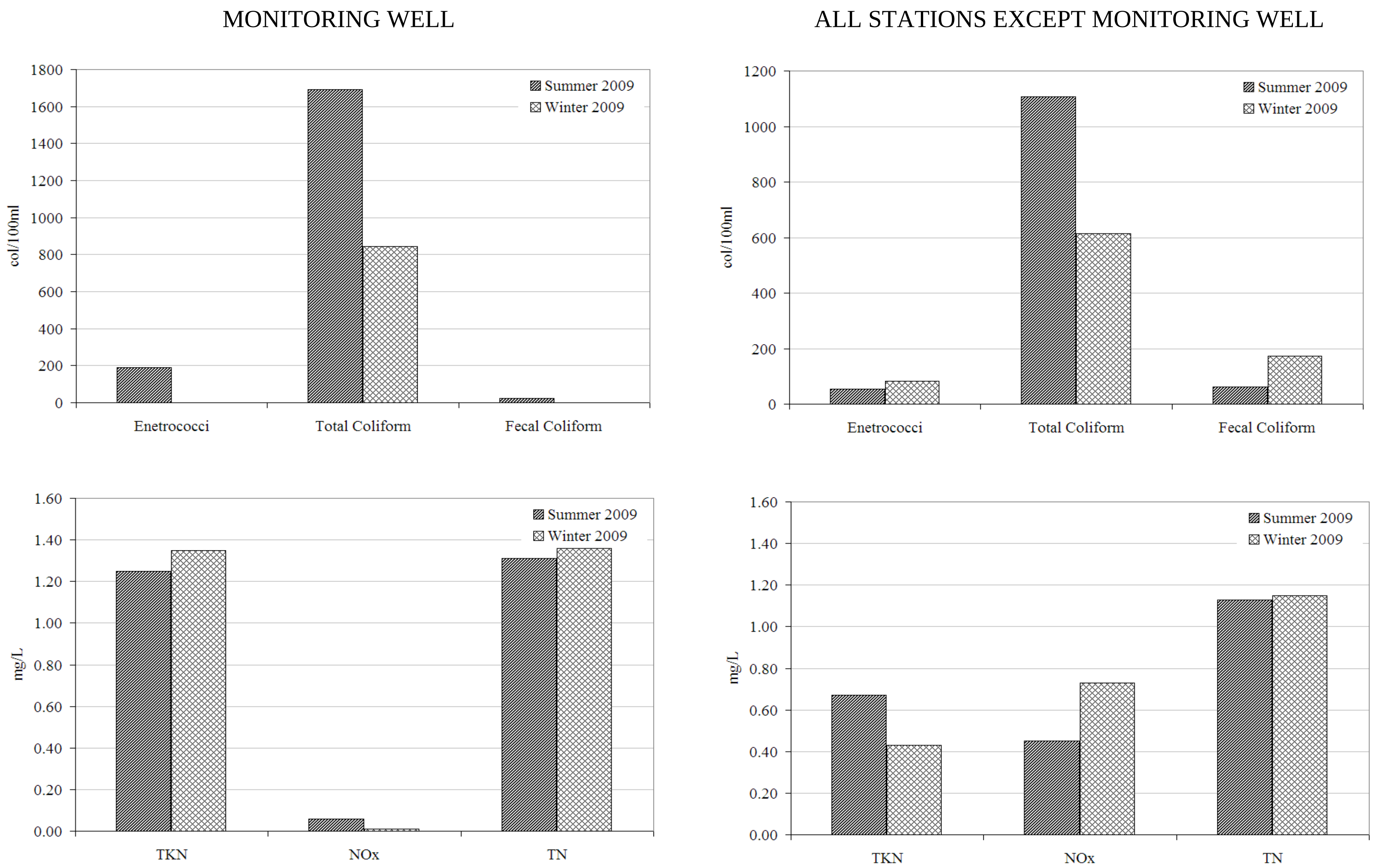
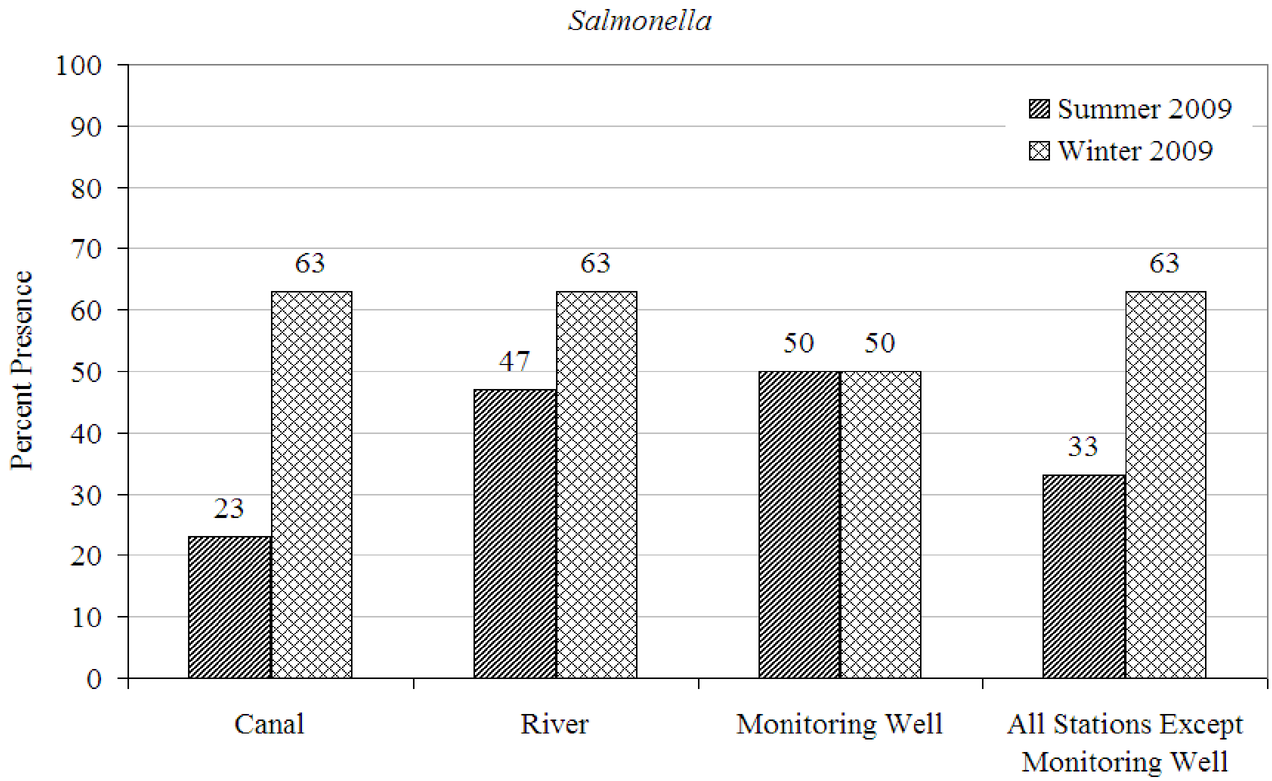


FIGURE 5-9.

COMPARISON OF WINTER AND SUMMER 2009 DATA FOR THE MONITORING WELL AND COMBINED STATIONS

Source: ECT, 2010.

Environmental Consulting & Technology, Inc.



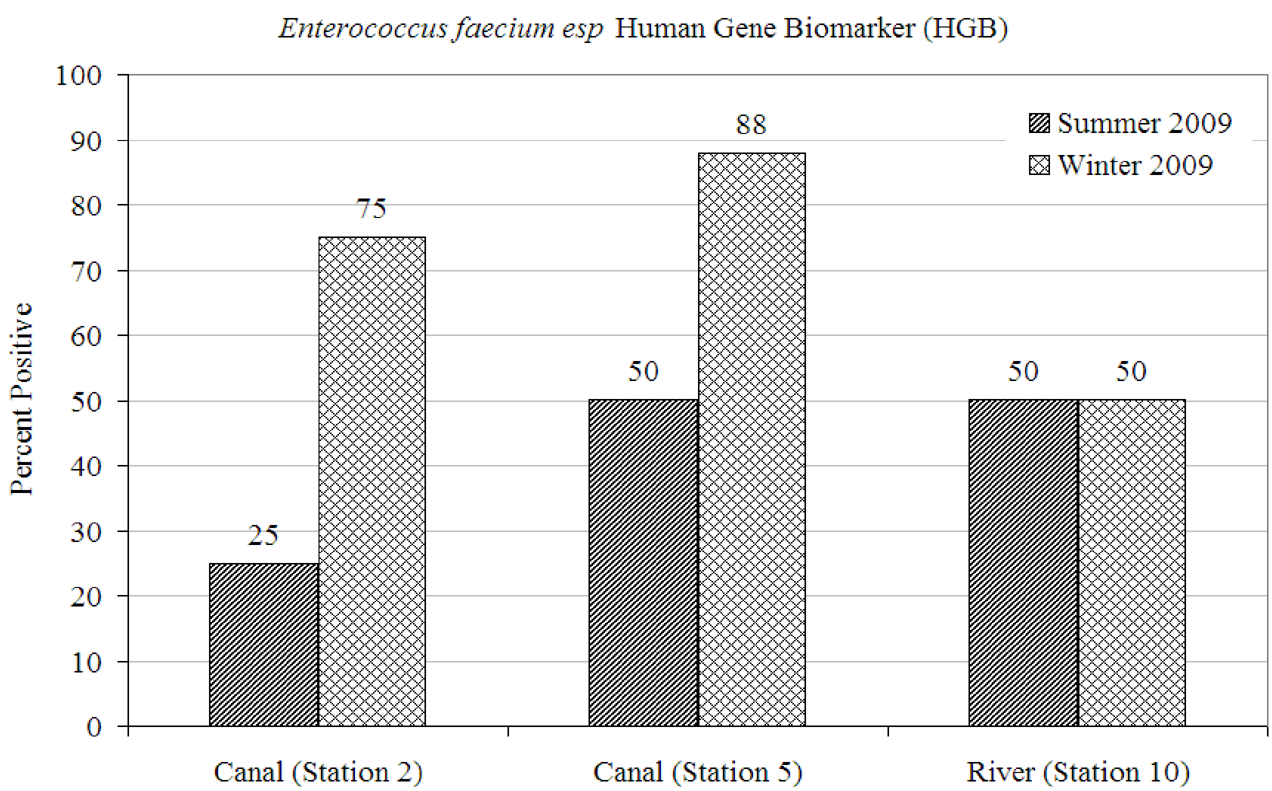


FIGURE 5-10.

COMPARISON OF WINTER AND SUMMER 2009 DATA FOR *SALMONELLA* AND HGB

Source: ECT, 2010.

ECT
Environmental Consulting & Technology, Inc.

- The occurrences of *Salmonella* were substantially higher in the winter, with the winter occurrences nearly twice as high as the summer (33 versus 63 percent, excluding the monitoring well data).
- The occurrence of HGB was the same at the river station (Station 10) for winter and summer but substantially higher in the winter at the two canal stations (average of 82 versus 38 percent).
- At the monitoring well, there were substantial reductions in enterococci, total coliforms, fecal coliform, and NO_x values in the winter as compared to the summer.

In general, the key microbiological parameters concentrations, including enterococci, fecal coliform, and occurrences of *Salmonella*, were higher in the winter.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The goal of this study was to evaluate the long-term effects of closing approximately 850 OSTDS in the town of Suwannee and installing a central WWTP. The approach was to sample water quality in the Suwannee River and the canals within the town of Suwannee and compare the results with data collected in 1996 prior to OSTDS closures. The two previous attempts to provide postconstruction data for comparison provided valuable information but were not ideal because of extreme river discharge conditions and seasonality concerns. The current study was conducted during the same season and during comparable river discharge conditions as the 1996 baseline survey conducted prior to septic tank removal. Therefore, this study provides a more defensible data set to evaluate potential improvements in the area 13 years after septic tank closure.

The results did not suggest that there was large improvement in water quality in the canals between 1996 and 2009 that could be attributed to closing the OSTDS. However, several specific observations and some improvements were noted:

- *Salmonella* occurrences were equal to or higher in the river than in the canals in both 2009 and 1996, indicating the canals were not the primary source of *Salmonella*. The percent occurrence of *Salmonella* in the canals was greater in 2009 than in 1996, indicating septic tank closure did not reduce *Salmonella* in the canals.
- NO_x exhibited a strong correlation with river flow and decreased with increasing river flow. TKN increased with increasing river flow, and total nitrogen remained relatively constant. There was consistently more NO_x in the river samples than in the canals; however, there was approximately 7 percent less NO_x measured in 2009 than in 1996.
- The source tracking results (HGB) indicated human material was present approximately 82 percent of the time in the canals (average of two stations) and only 50 percent of the time in the river (Station 10). It appears that, despite septic tank closure, the canals remain a possible source of HGB. Source tracking was not conducted in 1996.

- During the summer 2009 sampling event, HGB was present 38 percent of the time in canals as compared to 50 percent presence in the river.
- The total and fecal coliform values were higher in the canals than in the river in both 1996 and 2009. Fecal coliform decreased from 1996 to 2009 in both the canals and the river stations, whereas total coliforms increased from 1996 to 2009. The higher values in the canals as compared to the river could be from domestic animals or wildlife concentrated near the canals.
- Simple statistical comparison of the 2009 results with the 1996 results indicated there were three statistically significant changes in the measured parameters between 1996 and 2009:
    - There was a 59-percent decrease in fecal coliform in the canals.
    - There was a 230-percent increase in total coliforms in the river.
    - There was a 6-percent decrease in total nitrogen in the river.

  All other observed changes in the surface water samples were not statistically significant.
- Additional statistical tests were conducted that evaluated the variability observed in the river stations (controls) and compared that with the variability observed in the canals. The results indicated the magnitude of reduction in fecal coliform concentrations from 1996 to 2009 was unique to the canal stations and could be a possible benefit of closing the OSTDS.
- The monitoring well data indicated dramatic improvement from 1996 to 2009 in most of the parameters. The fecal coliform counts dropped from an average of 232 col/100 mL to nondetectable. The nitrogen parameters all dropped in excess of 82 percent. Since the well was located downgradient of the septic tank drain field, closing the septic tank resulted in marked improvement in the groundwater at this location. However, total coliforms and the percent occurrence of *Salmonella* increased in 2009.
- Comparison of the winter 2009 data with the summer 2009 data indicated that total coliform counts were higher in the summer, but fecal coliform, en-

terococci, and *Salmonella* occurrences were higher in the winter for both the river and canal stations.

In summary, the results indicated that there was a statistically significant 59-percent reduction of fecal coliform in the canals between 1996 and 2009 that could not be attributed to changes observed in the river stations. There was also an improvement in groundwater measured near a septic tank drain field. No other significant improvements in the water quality of the canals was identified that could be attributed to OSTDS closures.

6.2 RECOMMENDATIONS

The winter 2009 study provided a unique opportunity to examine the water quality in the canals and the river around the town of Suwannee 13 years after closure of 850 OSTDS in the area. Rigorous analysis of the data indicated there was a significant reduction of fecal coliform in the canals, but there was not a significant reduction of nitrogen, total coliforms, or occurrences of *Salmonella*, which might have been anticipated. There was a marked improvement of the groundwater near a septic tank drain field.

It is unlikely that additional studies of these parameters would identify further improvements attributable to septic tank removal, since additional improvements were not apparent after 13 years. Although the study plan attempted to isolate the removal of the OSTDS as the only variable for testing between the pre- and postconstruction sampling, it was not possible to control all environmental factors. It is recommended that future studies follow a similar protocol and establish a series of test and control stations that lend themselves to rigorous statistical analysis. Future studies at other sites should again be designed to conduct the pre- and postconstruction sampling during comparable seasonal (temperature) and river discharge conditions. It is also recommended that the additional source tracking techniques such as HGB be used more extensively to help separate human impacts from natural sources.

REFERENCES

American Public Health Association (APHA), American Water Works Association (AWWA), and Water Pollution Control Federation (WPCF). 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. APHA, Washington, DC.

Environmental Consulting & Technology, Inc. (ECT). 1998. Evaluation of the Potential for Restoring Commercially Viable Oyster Harvesting in Suwannee Sound. June.

———. 2009a. Evaluation of Water Quality around the Town of Suwannee, Florida, and Comparison To Historic Data; Contract COQOT. Prepared for the Florida Department of Health and the National Oceanic and Atmospheric Administration (NOAA). ECT No. 081081-0300. September.

———. 2009b. Quality Assurance Project Plan for the Evaluation of Water Quality. May.

Florida Department of Health and Rehabilitative Services (FDHRS). 1991. Suwannee River Floodplain Onsite Sewage Disposal System Inventory, Annual Report. Prepared by FDHRS in cooperation with the Suwannee River Water Management District (SRWMD).

Glatzer, M.B. (editor). 1990. Special Study of Incidence of *Salmonella* in Suwannee Sound, October 23 - November 8, 1990. Prepared by the Florida Department of Natural Resources (FDNR), Florida Department of Agriculture and Consumer Services (FDACS), and U.S. Food and Drug Administration (FDA).

Suwannee River Water Management District (SRWMD). 2009. <http://www.srwmd.org/index.aspx?NID=311>. Accessed in 2009.

Tide High and Low, Inc. 2010. <http://www.saltwatertides.com>. Accessed in 2010.

U.S. Geological Survey (USGS). 2009. <http://waterdata.usgs.gov/fl/nwis/dv/?site_no=02323500&referred_module=sw>. Accessed in 2009.

APPENDIX A

SUPPLEMENTAL WATER QUALITY DATA

This data may be accessed at:

https://209.208.21.121/thinclient/login.aspx
(On certificate error, just continue)

Username: 11fdoh081

Password: ect11fdoh081081

APPENDIX B

ANALYTICAL DATA
(NOVEMBER AND DECEMBER 2009)

Town of Suwannee Water Quality Analysis Results
Enterococcus faecium esp Human Gene Biomarker (HGB)
for Human Fecal Contamination*

Sampling Station	DNA Analytical Results*							
	11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
S-2	X	X	X	X	#	X	#	X
S-5	X	X	X	X	#	X	X	X
S-10	X	#	X	#	X	#	X	#

*Detection Method - Polymerase Chain Reaction (PCR) DNA Analytical Technology
HGB Negative
X HGB Positive

Town of Suwannee Water Quality Analysis Results

Station 1

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	U 1	U 1	U 1	U 1	U 1	U 1	U 1	U 1
Fecal Coliforms	colonies/100ml	U 1	U 1	U 1	U 1	U 1	U 1	U 1	U 1
Nitrate-Nitrite	mg/L	0.005 I	0.023	0.022	U 0.003	U 0.003	U 0.003	U 0.003	0.019
Salmonella		Present	Absent	Absent	Present	Present	Absent	Absent	Present
Total Coliforms	colonies/100ml	2310	600	1690	1390	616	U 1	U 1	U 154
Total Kjeldahl Nitrogen	mg/L	1.31	0.92	1.51	1.60	2.24	1.16	1.03	1.01

Station 2

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	210	230	83	128	21	99	30	125
Fecal Coliforms	colonies/100ml	380	220	330	250	55	210	50	140
Nitrate-Nitrite	mg/L	0.966	0.924	0.934	0.971	0.914	0.592	0.490	0.378
Salmonella		Absent	Present	Present	Present	Present	Present	Present	Absent
Total Coliforms	colonies/100ml	1230	616	616	616	1000	616	616	308
Total Kjeldahl Nitrogen	mg/L	0.37	0.17	0.15	0.43	0.37	0.51	0.66	0.72
Human Enterococi ID		Present	Present	Present	Present	Absent	Present	Present	Present

Station 3

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	200	93	230	111	14	120	12	28
Fecal Coliforms	colonies/100ml	420	125	162	450	67	370	39	103
Nitrate-Nitrite	mg/L	0.968	0.927	0.946	1.00	0.921	0.569	0.480	0.340
Salmonella		Absent	Present	Present	Present	Present	Present	Absent	Absent
Total Coliforms	colonies/100ml	1390	1080	462	770	462	616	154	462
Total Kjeldahl Nitrogen	mg/L	0.38	0.59	0.19	0.44	0.40	0.46	0.61	0.68

Station 4

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	46	13	24	27	44	25	8	22
Fecal Coliforms	colonies/100ml	73	160	260	63	83	53	53	61
Nitrate-Nitrite	mg/L	**0.021**	0.481	0.539	0.344	0.731	0.518	0.347	0.261
Salmonella		Absent	Absent	Present	Present	Absent	Absent	Absent	Present
Total Coliforms	colonies/100ml	2000 I	308	1080	154	308	154	154	U 154
Total Kjeldahl Nitrogen	mg/L	**3.83**	0.32	0.40	0.69	0.40	0.93	0.82	0.85

Station 5

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	171	240	230	340	31	180	51	72
Fecal Coliforms	colonies/100ml	330	120	420	540	200	390	57	57
Nitrate-Nitrite	mg/L	0.752	0.669	0.844	0.764	0.875	0.550	0.449	0.358
Salmonella		Absent	Absent	Present	Present	Absent	Present	Absent	Present
Total Coliforms	colonies/100ml	1230	1540	616	770	200	616	308	154
Total Kjeldahl Nitrogen	mg/L	0.51	0.20	0.21	0.37	0.35	0.43	0.75	0.73
Human Enterococi ID		Present	Present	Present	Present	Absent	Present	Absent	Present

Station 6

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	270	280	250	280	27	220	13	28
Fecal Coliforms	colonies/100ml	657	270	340	280	53	666	74	76
Nitrate-Nitrite	mg/L	0.928	0.777	0.863	0.827	0.906	0.544	0.434	0.361
Salmonella		Present	Present	Present	Present	Present	Present	Absent	Present
Total Coliforms	colonies/100ml	1690	154	616	1230	770	462	308	154
Total Kjeldahl Nitrogen	mg/L	0.45	0.26	0.17	0.22	0.27	0.48	0.86	0.60

Station 7

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	101	88	56	82	15	137	6	24
Fecal Coliforms	colonies/100ml	300	128	310	240	28	270	32	34
Nitrate-Nitrite	mg/L	0.920	0.829	0.923	0.953	0.928	0.586	0.470	0.317
Salmonella		Absent	Present	Present	Present	Present	Present	Present	Absent
Total Coliforms	colonies/100ml	1230	462	462	616	308	U 200	154	308
Total Kjeldahl Nitrogen	mg/L	0.29 I	0.25	0.14	0.13	0.27	0.41	0.72	0.64

Station 8

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	**1300**	70	38	94	9	34	4	11
Fecal Coliforms	colonies/100ml	230	126	162	320	64	105	23	35
Nitrate-Nitrite	mg/L	0.965	1.03	0.970	0.993	0.985	0.609	0.482	0.379
Salmonella		Absent	Present	Present	Present	Present	Present	Present	Absent
Total Coliforms	colonies/100ml	2310	1080	154	924	770	154	308	U 154
Total Kjeldahl Nitrogen	mg/L	0.49	0.22	0.15	0.15	0.25	0.49	0.63	0.63

Station 9

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	52	31	44	50	11	51	6	11
Fecal Coliforms	colonies/100ml	200	113	153	126	31	86	24	35
Nitrate-Nitrite	mg/L	1.09	1.06	0.993	1.08	1.04	0.605	0.493	0.405
Salmonella		Absent	Absent	Present	Present	Absent	Present	Absent	Absent
Total Coliforms	colonies/100ml	770	154	154	462	308	462	U 154	462
Total Kjeldahl Nitrogen	mg/L	0.40	0.48	U 0.08	0.15	0.24	0.47	0.72	0.73

Station 10

Water Quality Parameters	Units	Sampling Dates							
		11/9/2009	11/16/2009	11/23/2009	11/30/2009	12/7/2009	12/14/2009	12/21/2009	12/28/2009
Enterococci	colonies/100ml	41	32	42	67	8	29	3	7
Fecal Coliforms	colonies/100ml	135	107	136	107	39	90	39	22
Nitrate-Nitrite	mg/L	1.15	1.08	1.09	1.09	1.06	0.623	0.490	0.405
Salmonella		Absent	Present	Present	Present	Present	Present	Absent	Absent
Total Coliforms	colonies/100ml	2160	462	462	924	308	462	U 154	616
Total Kjeldahl Nitrogen	mg/L	0.18 I	0.28	0.14	0.17	0.20	0.47	0.85	0.69
Human Enterococi ID		Present	Absent	Present	Absent	Present	Absent	Absent	Absent

U = analyte not detected at or above the method detection limit
I = value is between the laboratory method detection liomit and the practical quantitation limit.

Town of Suwannee Water Quality Sampling

Water Quality Parameters: *In-situ* measurement

STATION: S2

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	4	2.5	1	3.0	2.0	1.0	4.0	2.5	1.0	4.0	2.5	1.0	3.5	2.25	1.0	3.5	2.25	1.0	3.25	2.0	1.0	5.0	3.0	1.0
Specific Conductance	umhos/cm	17088	3121	2717	20742	4873	1698	8492	1923	1610	26640	3741	1154	7594	2065	1387	4947	1604	988	1554	736	688	7204	695	605
Temperature	Celsius	21.56	20.94	20.82	19.48	19.21	19.03	20.52	20.85	20.88	16.73	16.51	16.09	15.93	15.75	16.00	16.68	17.14	17.47	14.59	14.16	14.19	14.37	14.12	14.05
pH	su	7.86	7.94	7.95	7.73	7.67	7.88	7.71	8.00	7.88	7.84	7.72	7.69	7.62	7.82	7.82	7.32	7.55	7.53	7.46	7.72	7.65	6.88	7.74	7.64
Dissolved Oxygen	milligrams per liter	6.36	7.32	7.38	6.44	6.56	6.96	6.69	7.05	6.86	7.03	7.00	6.89	7.15	7.47	7.61	5.52	6.23	6.65	6.10	6.96	6.95	4.17	7.29	7.25

STATION: S3

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	4	2	1	2.0	1.5	1.0	3.5	2.25	1.0	3.0	2.0	1.0	2.0	1.5	1.0	2.0	1.5	1.0	3.0	2.0	1.0	4.0	2.5	1.0
Specific Conductance	umhos/cm	2280	2256	2297	1643	1405	1352	2354	2153	1613	1385	1298	1289	1685	1505	1204	1080	850	729	370	363	368	4551	4619	4383
Temperature	Celsius	20.75	20.74	20.74	19.51	19.52	19.54	20.78	20.78	21.04	16.64	16.58	16.52	16.55	16.58	16.56	17.42	17.40	17.40	15.16	15.22	15.24	13.91	13.93	13.94
pH	su	7.84	7.89	7.80	7.75	7.79	7.80	7.79	7.77	7.78	7.64	7.59	7.61	7.78	7.80	7.82	7.52	7.49	7.50	7.63	7.58	7.50	7.20	7.34	7.36
Dissolved Oxygen	milligrams per liter	7.62	7.7	7.65	6.81	6.78	6.77	6.82	6.82	6.96	7.48	7.45	7.39	7.61	7.77	7.72	6.49	6.47	6.48	7.49	7.38	7.27	6.96	7.18	7.08

STATION: S4

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	3	2	1	4.0	2.5	1.0	3.5	2.25	1.0	3.5	2.25	1.0	2.5	1.75	1.0	3.0	2.0	1.0	2.5	1.75	1.0	3.0	2.0	1.0
Specific Conductance	umhos/cm	1193	1192	1191	3529	3013	2965	1854	1856	1862	3240	2952	2692	2948	2067	2051	1106	1059	1022	1391	1392	1390	1059	1060	1060
Temperature	Celsius	21.05	21.04	21.06	19.01	18.68	19.40	20.17	20.44	20.56	16.87	16.55	16.22	15.24	15.17	15.12	17.56	17.71	17.91	14.71	14.74	14.78	13.85	13.86	13.86
pH	su	8.73	8.80	8.82	7.55	7.68	7.99	8.00	8.16	8.22	7.61	7.62	7.96	7.39	7.53	7.55	7.52	7.52	7.52	7.21	7.15	7.16	7.42	7.47	7.51
Dissolved Oxygen	milligrams per liter	14.31	14.08	14.75	6.34	7.33	8.80	8.57	9.30	9.83	4.57	6.43	7.04	6.37	7.34	7.44	6.82	6.39	7.57	6.67	6.71	6.88	7.59	7.84	7.96

STATION: S5

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	3	2	1	2.5	1.75	1.0	3.0	2.0	1.0	3.0	2.0	1.0	2.5	1.75	1.0	3.0	2.0	1.0	3.0	2.0	1.0	4.0	2.5	1.0
Specific Conductance	umhos/cm	9032	8486	8082	7854	7552	7438	3640	3613	3613	3980	3943	3931	2665	2646	2638	1242	1249	1261	606	603	602	780	783	781
Temperature	Celsius	21.15	21.13	21.13	18.96	19.01	19.01	20.78	20.79	20.80	16.59	16.53	16.52	16.45	16.45	16.45	17.54	17.54	17.54	14.54	14.61	14.62	13.89	13.97	13.99
pH	su	7.84	7.82	7.87	7.66	7.58	7.70	7.71	7.67	7.71	7.71	7.69	7.72	7.74	7.76	7.72	7.41	7.39	7.39	7.56	7.49	7.53	7.41	7.41	7.54
Dissolved Oxygen	milligrams per liter	7.39	7.61	7.64	6.23	6.22	6.24	6.81	6.77	6.73	6.59	6.64	6.71	7.57	7.49	7.37	6.41	6.48	6.43	6.85	6.83	6.87	6.88	6.96	6.99

STATION: S6

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	4	2.5	1	4.0	2.5	1.0	4.0	2.5	1.0	3.5	2.25	1.0	3.0	2.0	1.0	3.0	2.0	1.0	3.5	2.25	1.0	5.0	3.0	1.0
Specific Conductance	umhos/cm	1910	1678	1569	2722	1761	1758	1115	1065	801	3927	2950	2804	1414	1195	1126	502	410	375	448	462	475	1074	744	610
Temperature	Celsius	20.53	20.56	20.58	18.47	18.97	19.01	20.43	20.54	20.60	16.06	16.33	16.45	16.03	16.12	16.17	17.53	17.46	17.43	14.84	14.85	14.82	13.90	14.12	14.17
pH	su	7.71	7.75	7.78	7.65	7.67	7.75	7.76	7.71	7.75	7.67	7.71	7.70	7.71	7.70	7.74	7.42	7.37	7.39	7.45	7.46	7.49	7.25	7.45	7.51
Dissolved Oxygen	milligrams per liter	7.12	7.13	7.19	6.00	6.30	6.27	6.56	6.45	6.52	6.70	6.87	6.83	7.09	7.18	7.36	6.12	6.29	6.35	6.51	6.61	6.50	6.95	7.02	7.06

STATION: S7

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	7	4	1	6.0	3.5	1.0	7.0	4.0	1.0	7.0	4.0	1.0	6.0	3.5	1.0	5.5	3.3	1.0	6.5	3.75	1.0	7.5	4.25	1.0
Specific Conductance	umhos/cm	6060	5341	4428	2403	2219	1795	2513	2338	2285	1439	1427	1425	3793	2655	2432	504	488	480	5563	1478	1322	31159	22565	2946
Temperature	Celsius	21.03	20.98	20.93	19.38	19.42	19.46	20.68	20.72	20.77	16.91	16.55	16.56	16.36	16.56	16.59	17.32	17.31	17.31	14.60	15.33	15.36	13.37	13.51	13.63
pH	su	7.90	7.90	7.80	7.56	7.71	7.74	7.77	7.79	7.81	7.69	7.71	7.78	7.81	7.86	7.87	7.47	7.52	7.54	7.34	7.51	7.64	7.60	7.83	8.13
Dissolved Oxygen	milligrams per liter	7.64	7.83	7.91	6.81	6.78	6.77	6.64	6.76	6.89	7.41	7.37	7.44	7.91	8.00	8.00	6.72	6.70	6.62	7.01	6.98	7.12	7.85	7.69	7.51

STATION: S8

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	6	3.5	1	5.5	3.25	1.0	7.0	4.0	1.0	6.0	3.5	1.0	5.0	3.0	1.0	4.0	2.5	1.0	5.5	3.25	1.0	6.0	3.5	1.0
Specific Conductance	umhos/cm	3660	3633	3563	986	973	974	1727	1604	1473	857	851	848	1425	1302	1313	352	350	350	712	646	579	7411	1255	1082
Temperature	Celsius	20.86	20.86	20.86	19.56	19.61	19.61	20.67	20.69	20.78	16.51	16.54	16.58	16.66	16.69	16.68	17.13	17.13	17.13	15.07	15.26	15.31	13.56	13.75	13.81
pH	su	7.82	7.90	7.91	7.81	7.77	7.80	7.78	7.81	7.81	7.78	7.72	7.48	7.85	7.87	7.84	7.58	7.52	7.52	7.61	7.57	7.57	7.38	7.77	7.94
Dissolved Oxygen	milligrams per liter	7.96	7.87	7.89	6.69	6.75	6.78	7.64	7.38	7.39	7.62	7.48	7.51	8.02	8.02	8.03	6.87	6.95	6.96	7.32	7.01	7.11	7.33	7.41	7.36

STATION: S9

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	14	7.5	1	12.0	6.5	1.0	13.0	7.0	1.0	13.0	7.0	1.0	12.0	6.5	1.0	13.0	7.0	1.0	12.5	6.75	1.0	15.0	8.0	1.0
Specific Conductance	umhos/cm	409	409	410	448	446	447	435	425	427	476	478	478	401	401	400	266	266	266	219	217	217	182	175	175
Temperature	Celsius	20.58	20.58	20.58	19.72	19.74	19.74	20.44	20.44	20.45	17.56	17.56	17.55	16.76	16.76	16.76	17.18	17.18	17.18	15.15	15.18	15.18	13.66	13.71	13.71
pH	su	7.87	7.90	7.91	7.77	7.83	7.91	7.82	7.84	7.86	7.82	7.84	7.91	7.90	7.91	7.91	7.28	7.32	7.36	7.50	7.53	7.65	7.55	7.61	7.70
Dissolved Oxygen	milligrams per liter	8.30	8.30	8.32	6.85	6.89	6.93	7.30	7.35	7.33	7.58	7.81	7.77	8.21	8.17	8.21	7.05	7.08	7.06	7.28	7.29	7.23	7.48	7.53	7.53

STATION: S10

Parameters	Date Units	11/9/2009			11/16/09			11/23/09			11/30/09			12/07/09			12/14/09			12/21/09			12/28/09		
Sampling Depth	ft	23	12	1	23.0	12.0	1.0	23.0	12.0	1.0	23	12	1	23.0	12.0	1.0	22.0	11.5	1.0	23.0	12.0	1.0	23.0	12.0	1.0
Specific Conductance	umhos/cm	353	349	348	425	421	421	388	388	387	422	413	410	402	400	398	272	270	269	216	215	214	168	167	166
Temperature	Celsius	20.58	20.57	20.58	19.81	19.88	19.88	20.63	20.58	20.59	17.48	17.57	17.56	16.79	16.79	16.82	17.21	17.18	17.16	15.21	15.20	15.24	13.73	13.74	13.75
pH	su	7.91	7.91	7.93	7.80	7.84	7.97	7.93	7.98	8.00	7.59	7.75	7.97	7.94	7.88	7.96	6.97	6.88	6.98	7.39	7.52	7.72	7.76	7.79	7.88
Dissolved Oxygen	milligrams per liter	8.31	8.33	8.43	7.16	7.04	7.04	7.65	7.63	7.64	7.56	7.66	7.68	8.58	8.47	8.47	7.15	7.15	7.21	7.28	7.24	7.31	7.78	7.78	7.79

Evaluation of Water Quality Around the Town of Suwannee, Florida, and Comparison to Historic Data Contract COQOT

Prepared for:

FLORIDA DEPARTMENT OF HEALTH

Division of Environmental Health
Bureau of Onsite Sewage Programs
Tallahassee, Florida

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June 2010

Project Team

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Agenda

- Project team
- Project goals and objectives
- Project history
- Sampling plan
- 2009 winter results
- Comparison to 1996 winter results
- Comparison of 2009 summer versus winter
- Conclusions
- Recommendations

Project Goal

Evaluate the impacts of closing 850 onsite sewage treatment and disposal systems (OSTDS) in the Town of Suwannee

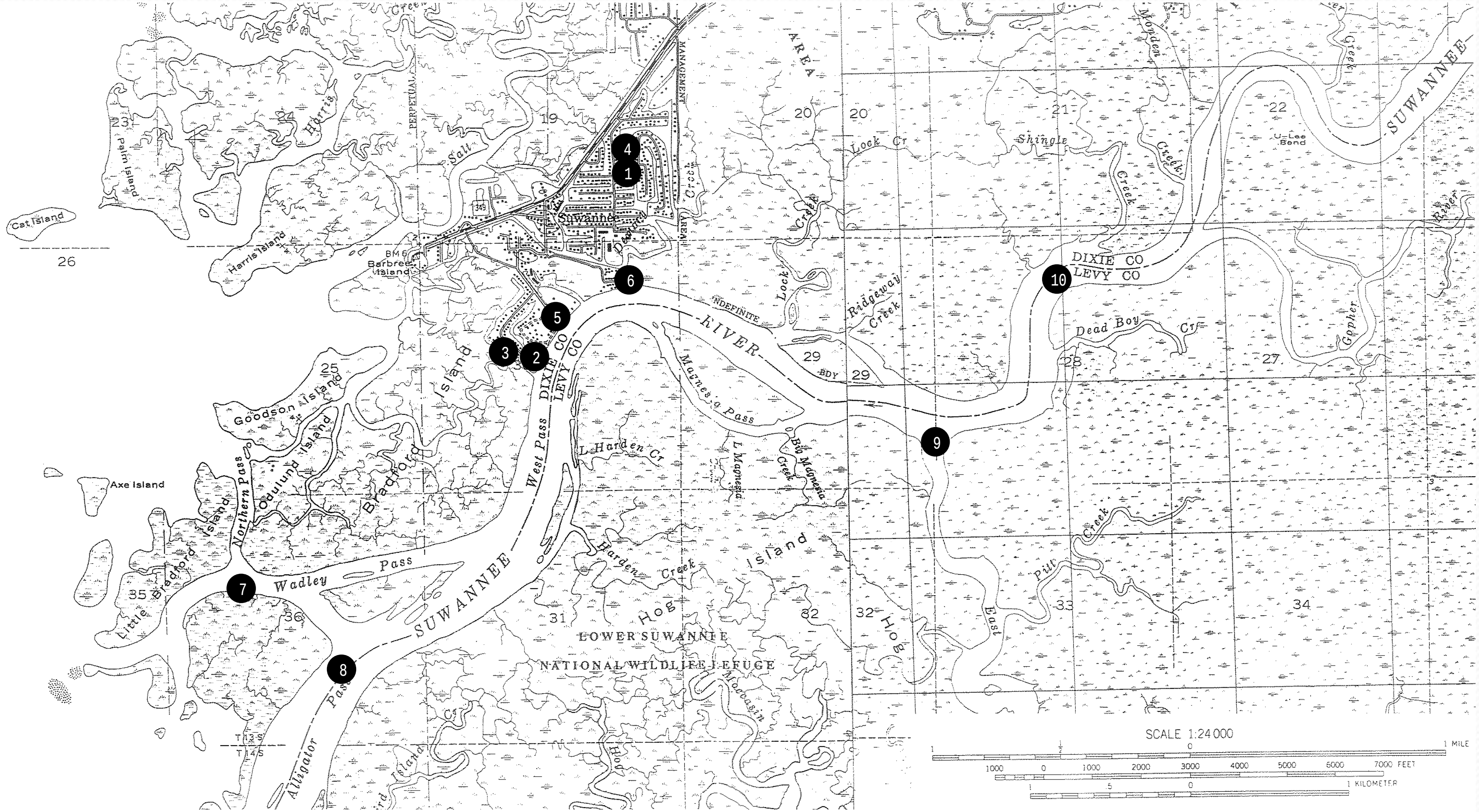
Project Objectives

- Identify and obtain supplemental data
- Repeat the 1996 winter sampling protocol
- Modify the sample parameter list as necessary
- Add DNA source tracking
- Compare river stations with canal stations
- Compare the 2009 winter results with the 1996 winter results
- Compare 2009 summer with 2009 winter results

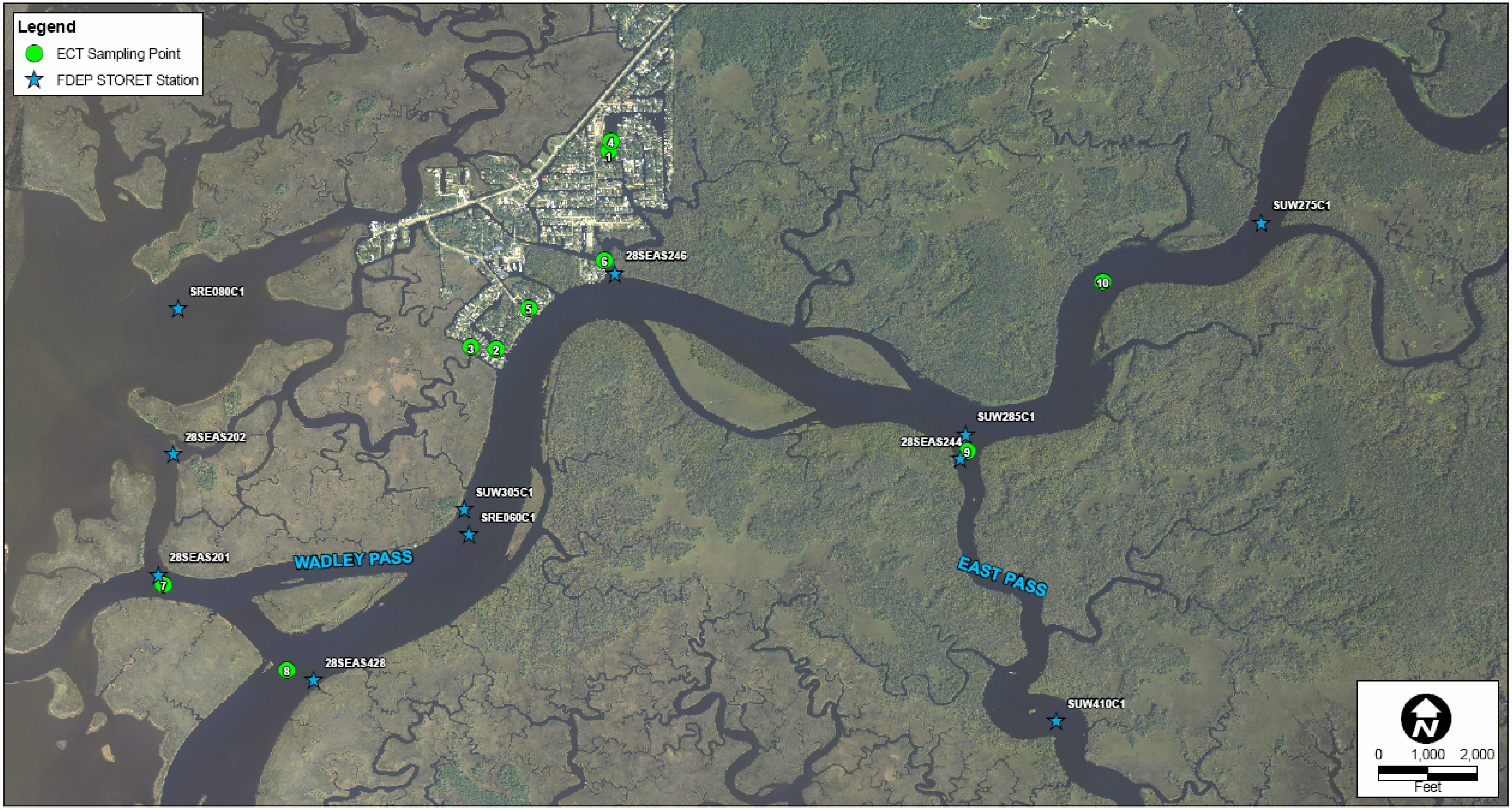
History

- Baseline study conducted in 1996 winter
- OSTDS closed 1997 to 1998
- El niño event in 1997
- Pre- and postconstruction comparisons difficult
- Large changes observed in control stations and canal stations
- Study repeated in 2009 summer and winter

Sampling Plan—Locations



Sampling Plan—STORET, ECT, and USGS Stations



Sampling Plan—Stations

Station 1

Station 2

Sampling Plan—Stations

Station 3

Station 4

Sampling Plan—Stations

Station 5

Station 6

Sampling Plan—Stations

Station 7

Station 8

Sampling Plan—Stations

Station 9

Station 10

Sampling Plan—Components

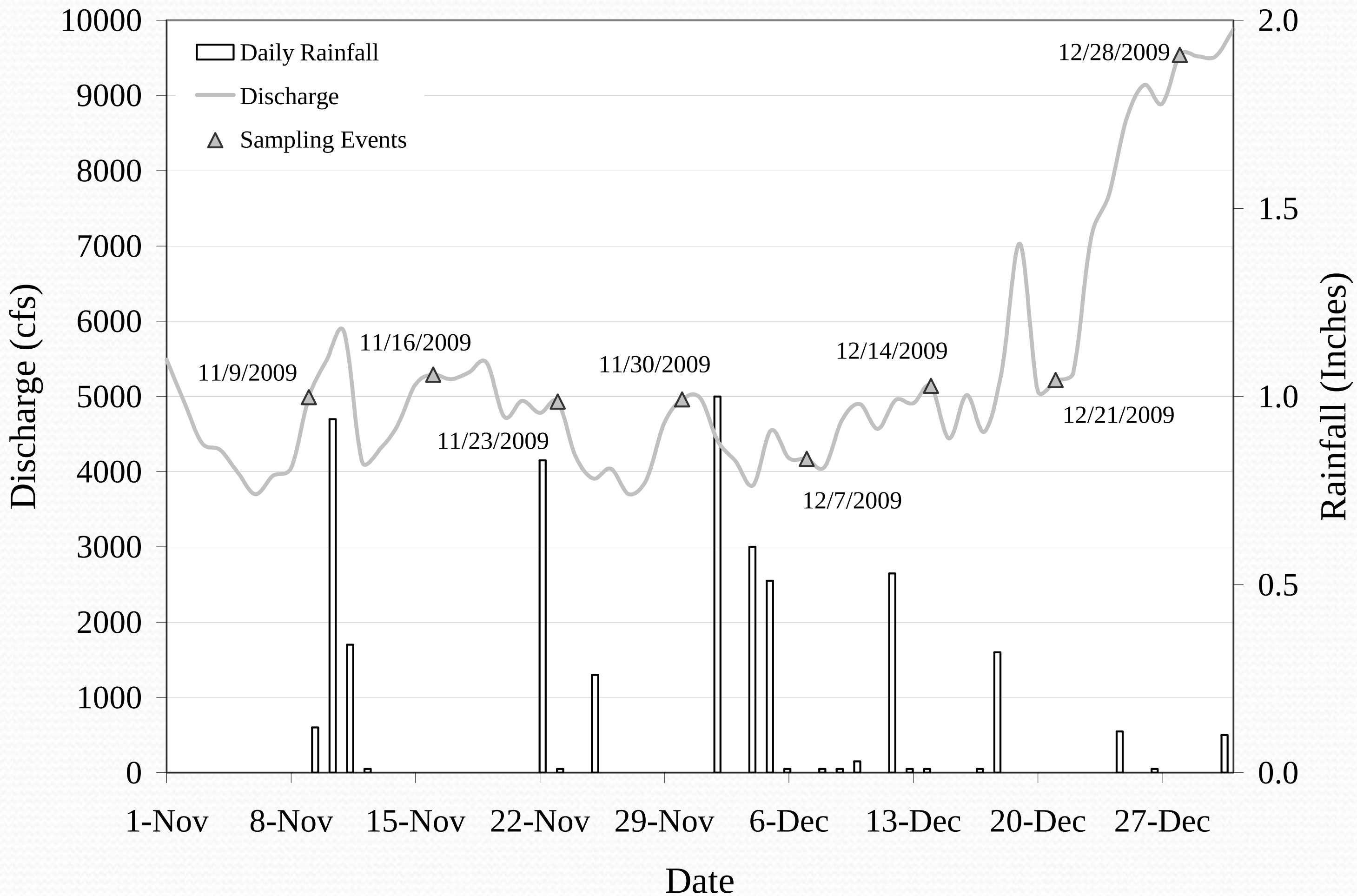
- Quality assurance project plan (QAPP)
- 10 stations: 4 river, 5 canal, 1 well
- 8 weekly events
- Sampled at low tide
- Sampled on Monday
- In situ parameters

Sampling Plan—Parameters

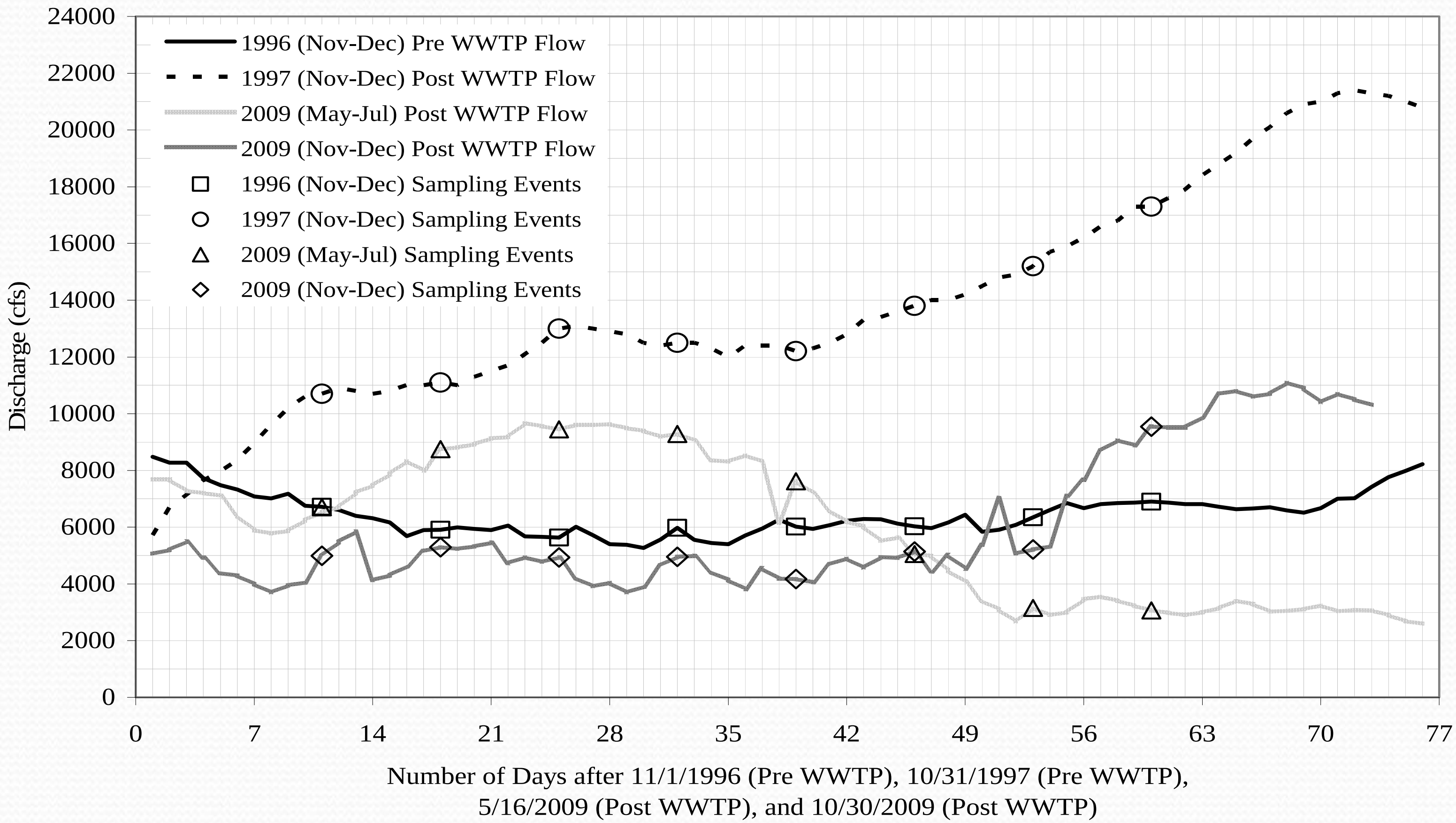
Parameter	Analytical Method
Total coliform	Standard Method 9222 B
Fecal coliform	Standard Method 9222 D
Enterococci	EPA 1600
Salmonella	Standard Method 9260 B
Nitrate + nitrite	EPA 353.2*
Total Kjeldahl nitrogen	EPA 351.2*
DNA source tracking	Human Enterococci identification

*Revision 2.0, 1993.

2009 Results—Flow, Daily Rainfall, and Sampling Events



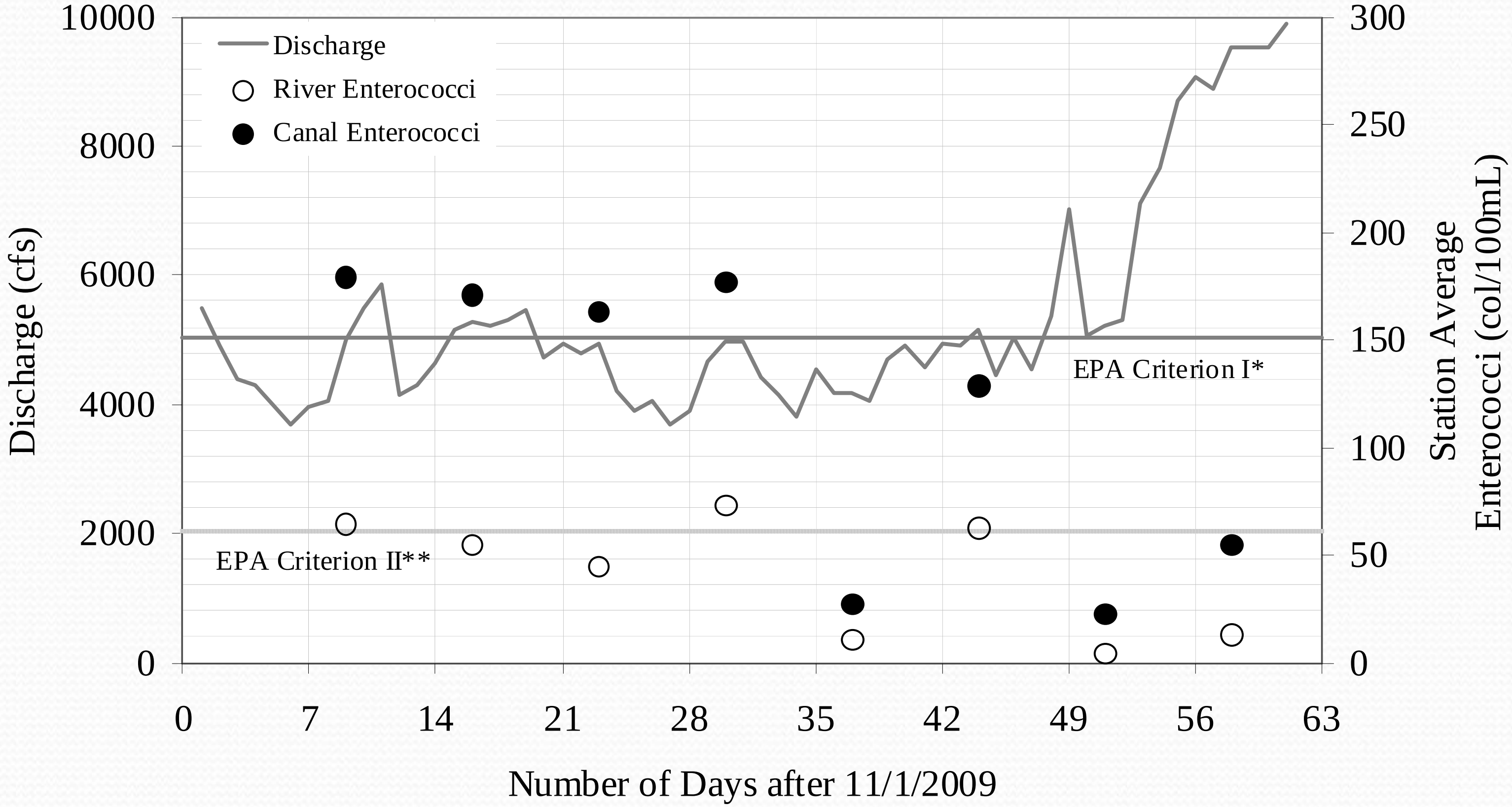
2009 Results—Discharges and Sampling Events (1996, 1997, and 2009)



2009 Winter Results—Water Quality Parameters

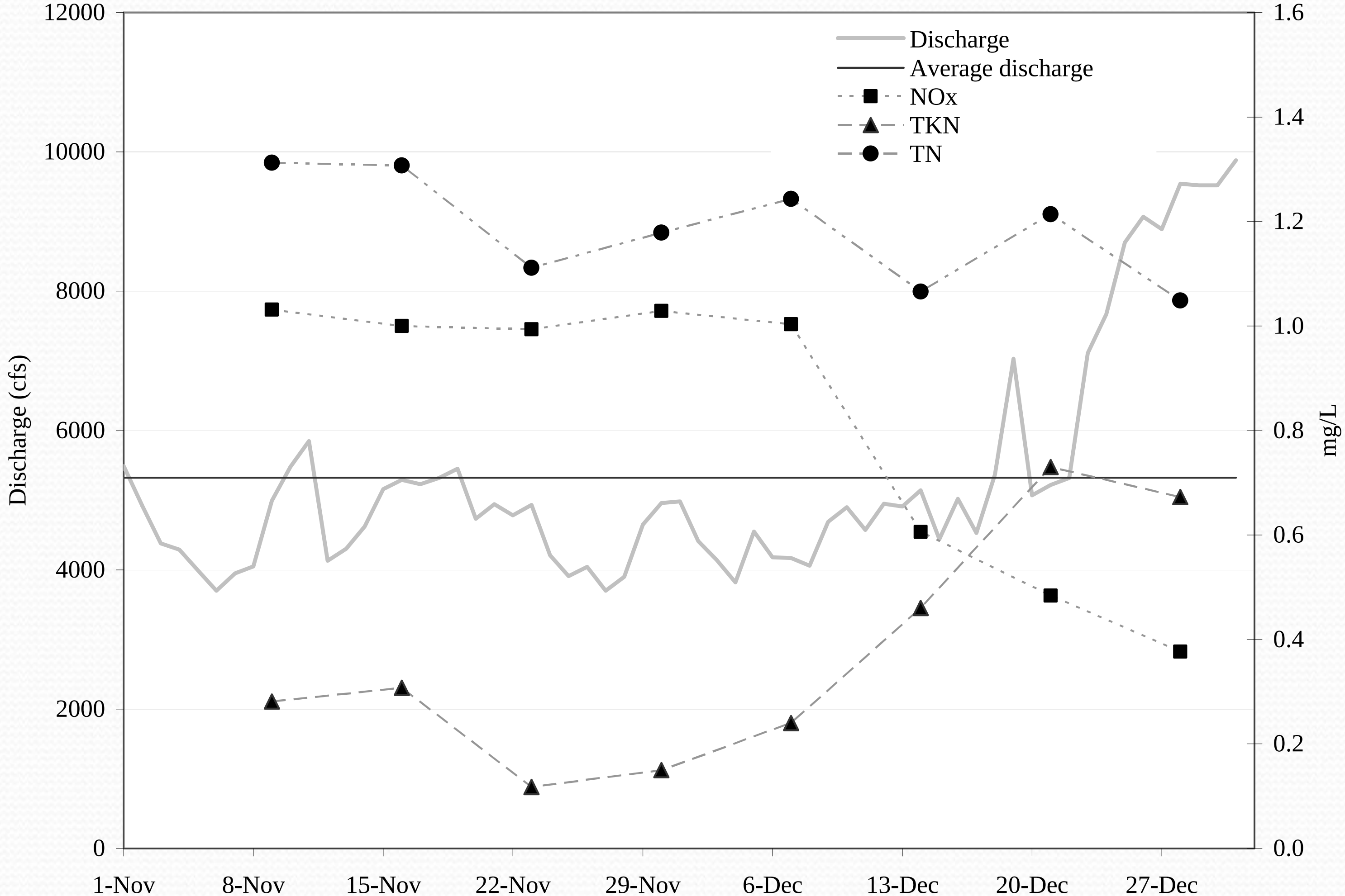
Parameters	Size	Average	Standard Deviation	Maximum	Minimum
Canal Stations					
Total coliform (col/100 mL)	40	654	472	2,000	154
Fecal coliform (col/100 mL)	40	218	174	666	39
Enterococci (col/100 mL)	40	116	100	340	8
Salmonella		Present 62.5% of time (25 out of 40)			
NO_x (mg/L)	39	0.68	0.24	1.00	0.26
Total Kjeldahl nitrogen (mg/L)	39	0.47	0.22	0.93	0.15
Total nitrogen (mg/L) (calculated)	39	1.15	0.16	1.52	0.80
River Stations					
Total coliform (col/100 mL)	32	565	525	2,310	154
Fecal coliform (col/100 mL)	32	120	92	320	22
Enterococci (col/100 mL)	31	40	34	137	3
Salmonella		Present 62.5 of time (20 out of 32)			
NO_x (mg/L)	32	0.82	0.27	1.15	0.32
Total Kjeldahl nitrogen (mg/L)	32	0.37	0.23	0.85	0.04
Total nitrogen (mg/L) (calculated)	32	1.19	0.14	1.54	0.96
Monitoring Well					
Total coliform (col/100 mL)	8	845	860	2,310	1
Fecal coliform (col/100 mL)	8	1	0	1	1
Enterococci (col/100 mL)	8	1	0	1	1
Salmonella	8	Present 50% of time (4 out of 8)			
NO_x (mg/L)	8	0.01	0.01	0.02	0.00
Total Kjeldahl nitrogen (mg/L)	8	1.35	0.43	2.24	0.92
Total nitrogen (mg/L) (calculated)	8	1.36	0.43	2.24	0.94

2009 Results—Weekly Average Enterococci



* Single sample maximum allowable Enterococci density for infrequently used full body contact recreation for freshwater (EPA, 1986).
** Single sample maximum allowable Enterococci density for the designated beach area (EPA, 1986).

2009 Results—Variation of Nutrients

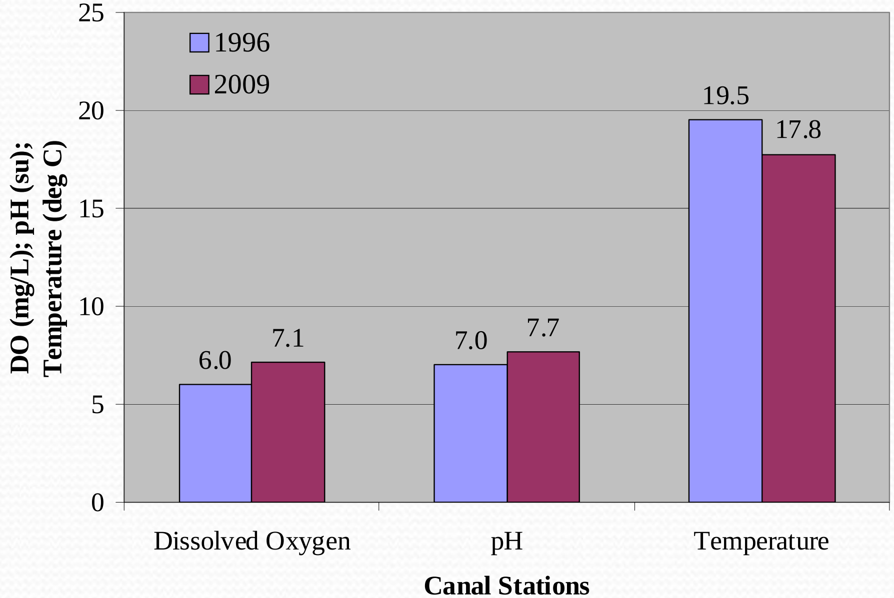


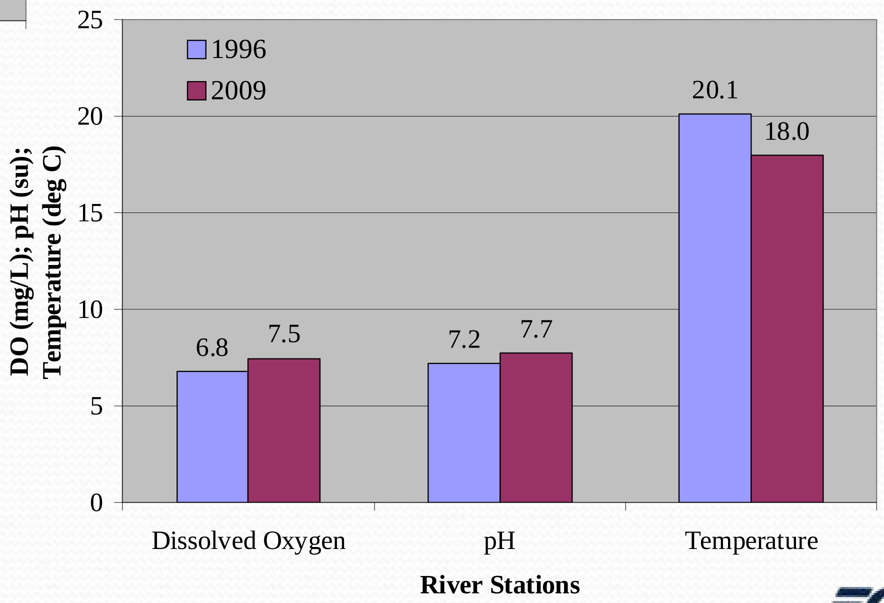
2009 Results—DNA Source Tracking Analyses Results

Winter 2009									
Sampling Station	Positive for Human DNA (Sampling Weeks)								Percent Positive (within stations)
	1	2	3	4	5	6	7	8	
2	□	□	□	□		□		□	75
5	□	□	□	□		□	□	□	88
10	□		□		□		□		50
Percent positive (among stations)	100	67	100	67	33	67	67	67	

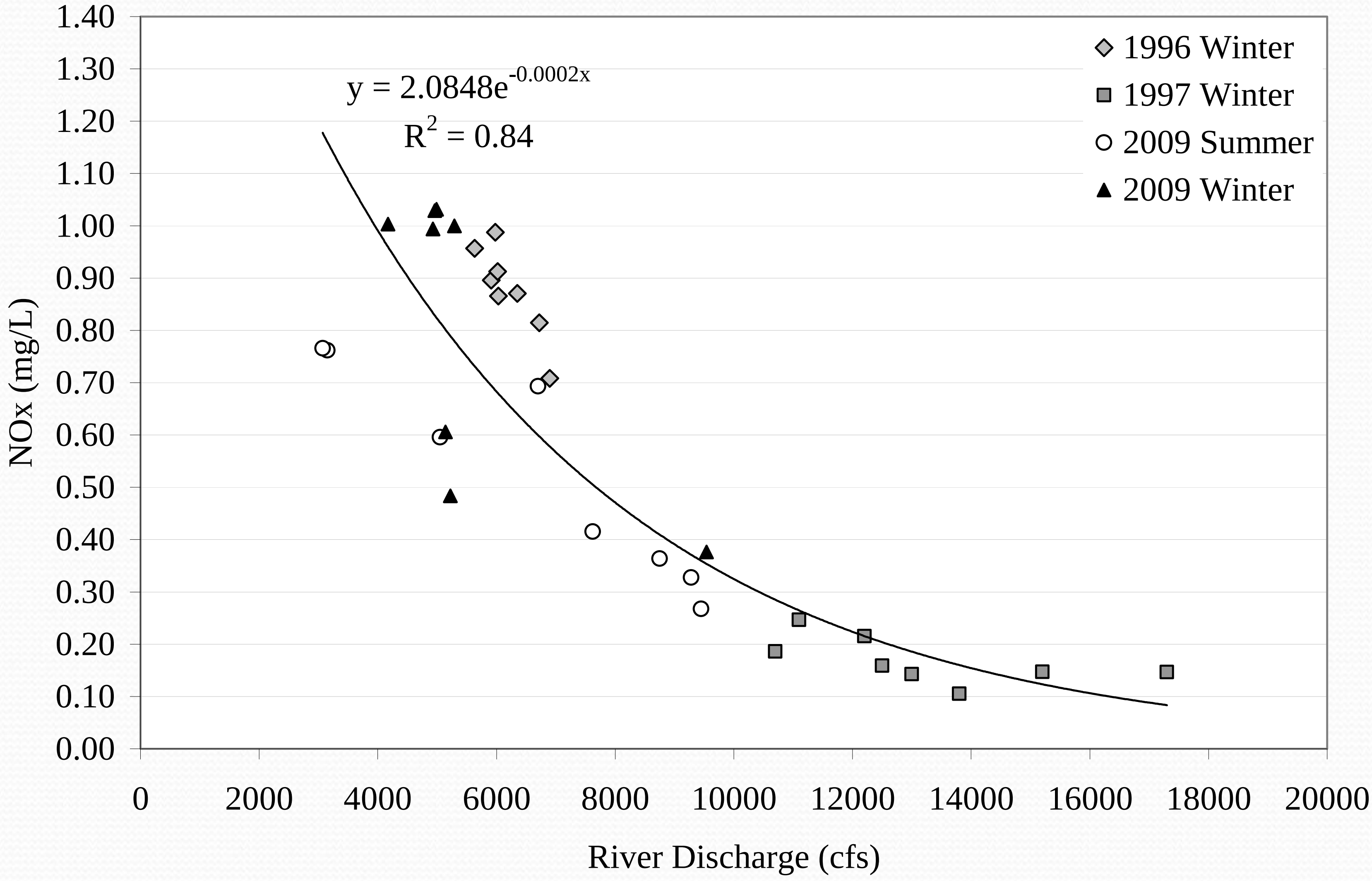
Summer 2009					
Sampling Station	Positive for Human DNA (Sampling Weeks)				Percent Positive (within stations)
	5	6	7	8	
2			□		25
5		□		□	50
10		□		□	50
Percent positive (among stations)	0	67	33	67	

Comparison to 1996 Results—In Situ Data





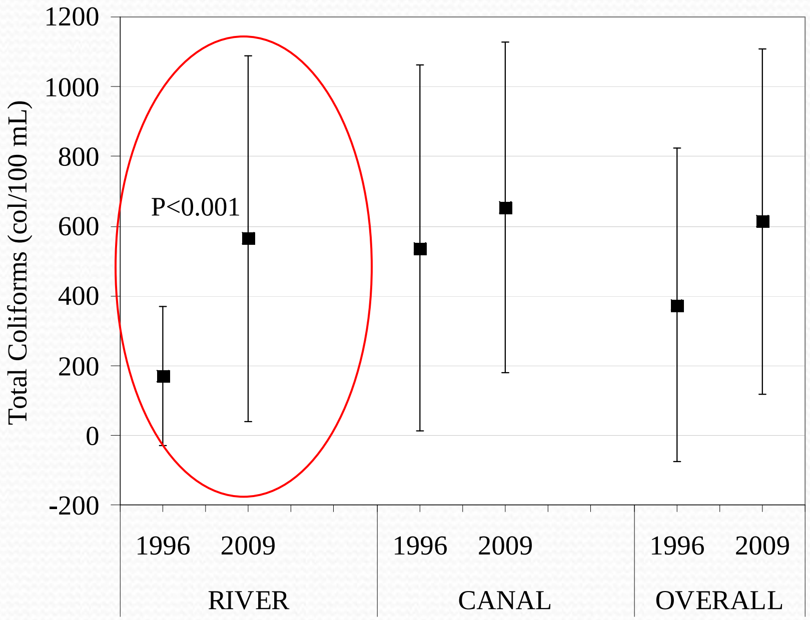
Comparison to 1996 Results—Nitrate + Nitrite



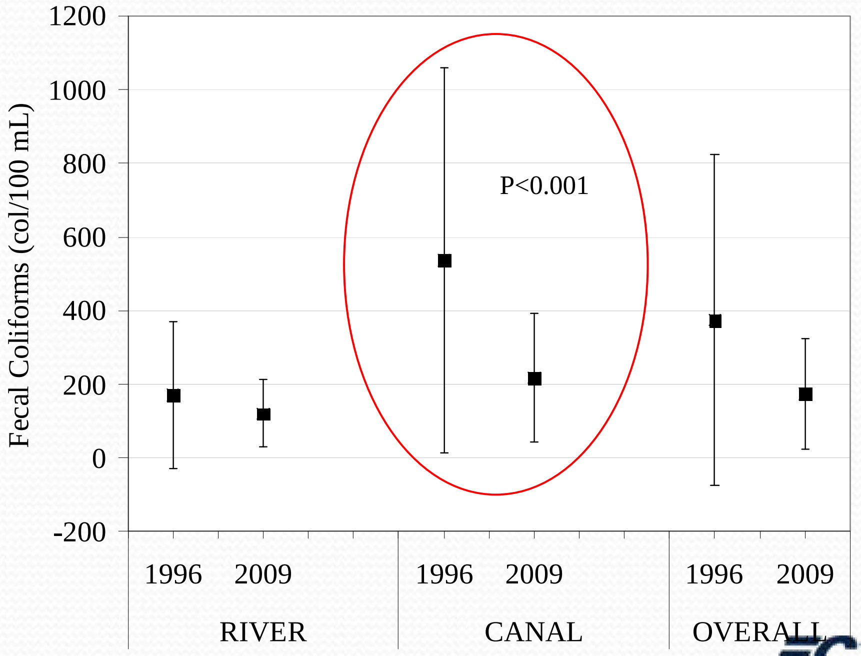
Comparison to 1996 Results—Changes in Average Concentrations: River and Canal Stations

Water Quality Parameters	River Stations			Canal Stations			All Stations		
	1996	2009	Percent Change	1996	2009	Percent Change	1996	2009	Percent Change
Fecal coliform	170	120	-29	537	218	-59	374	174	-53
Total coliform	171	565	230	537	654	22	374	614	64
Nitrate + nitrite	0.88	0.82	-7	0.73	0.68	-7	0.79	0.73	-8
TKN	0.39	0.37	-5	0.41	0.47	15	0.40	0.43	7
Total nitrogen	1.26	1.19	-6	1.14	1.15	1	1.20	1.15	-4

Coliforms

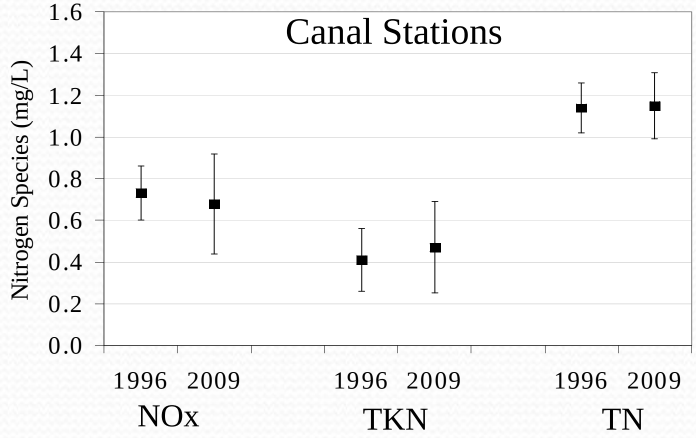


Total Coliforms (col/100 mL)
1200
1000
800
600
400
200
0
-200
P<0.001
1996
2009
1996
2009
1996
2009
RIVER
CANAL
OVERALL

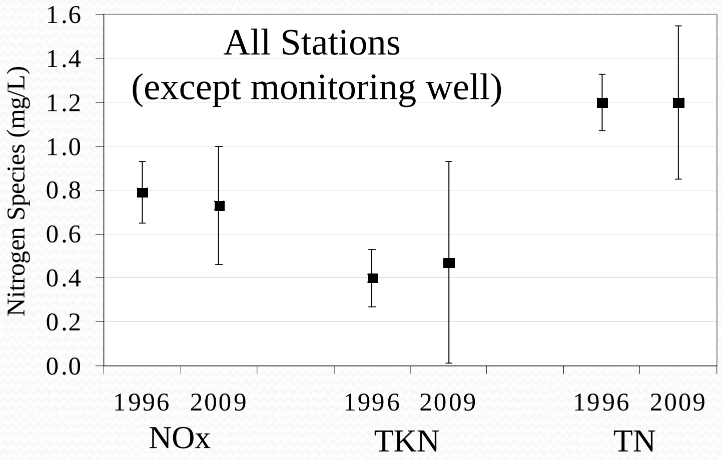


Fecal Coliforms (col/100 mL)
1200
1000
800
600
400
200
0
-200
P<0.001
1996
2009
1996
2009
1996
2009
RIVER
CANAL
OVERALL

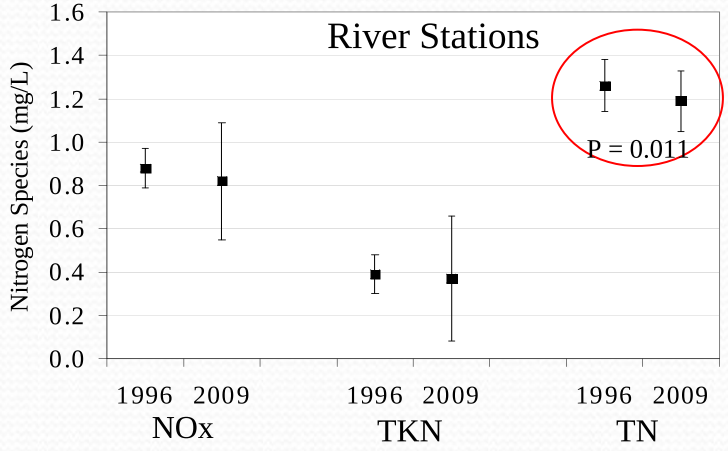
Nitrogen



Canal Stations
Nitrogen Species (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1996 2009
NOx
1996 2009
TKN
1996 2009
TN

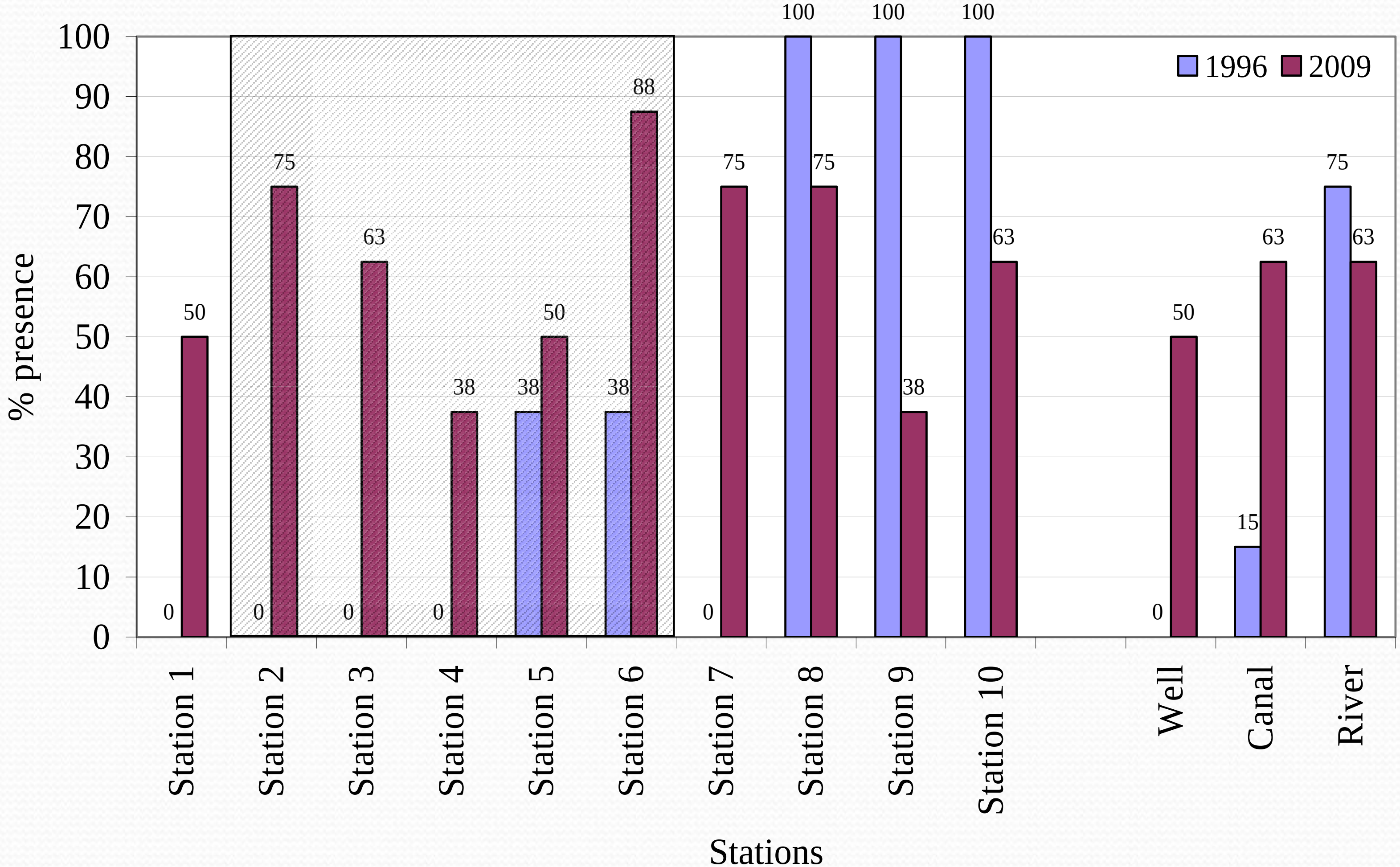


All Stations
(except monitoring well)
Nitrogen Species (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1996 2009
NOx
1996 2009
TKN
1996 2009
TN



River Stations
P = 0.011
Nitrogen Species (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1996 2009
NOx
1996 2009
TKN
1996 2009
TN

Salmonella

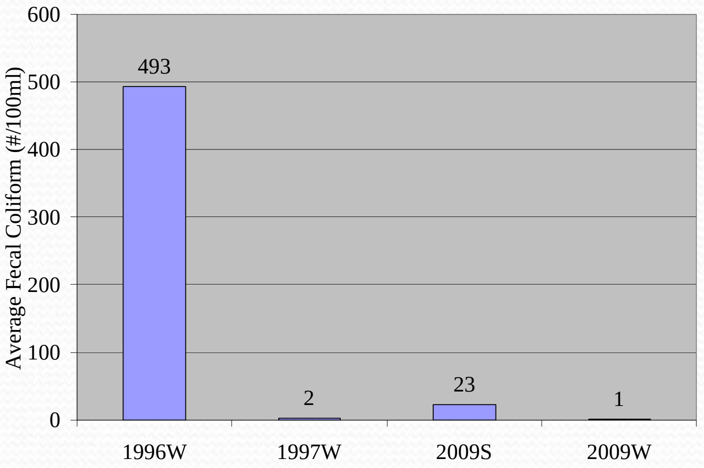


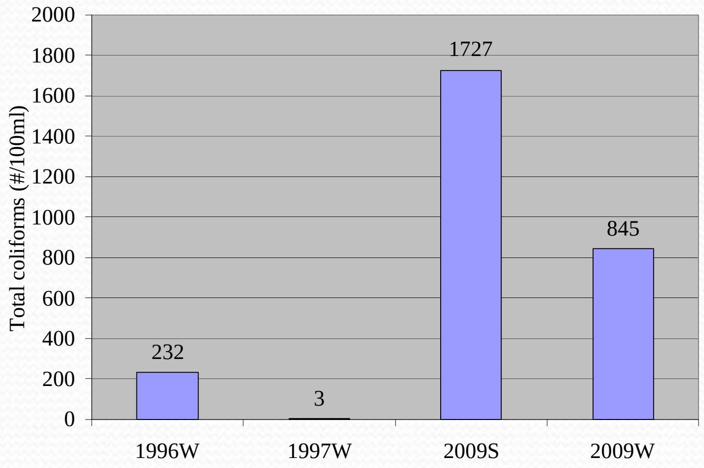
% presence
100
90
80
70
60
50
40
30
20
10
0
1996
2009
0
50
0
75
0
63
0
38
38
50
38
88
0
75
100
75
100
38
100
63
0
50
15
63
75
63
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7
Station 8
Station 9
Station 10
Well
Canal
River
Stations

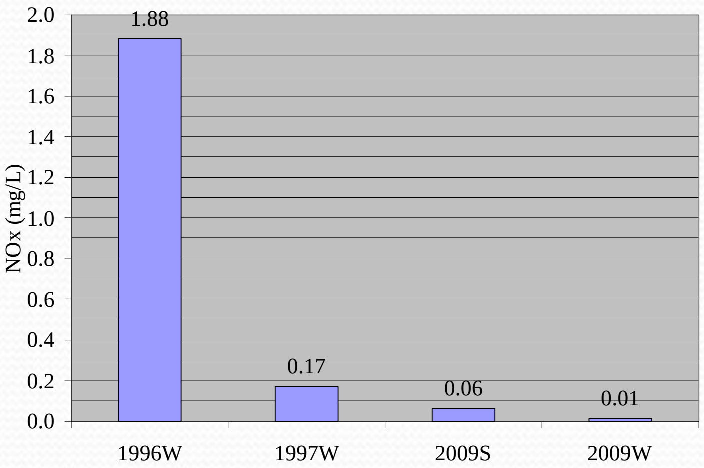
Comparison to 1996 Results—Changes in Average Concentrations: Monitoring Wells

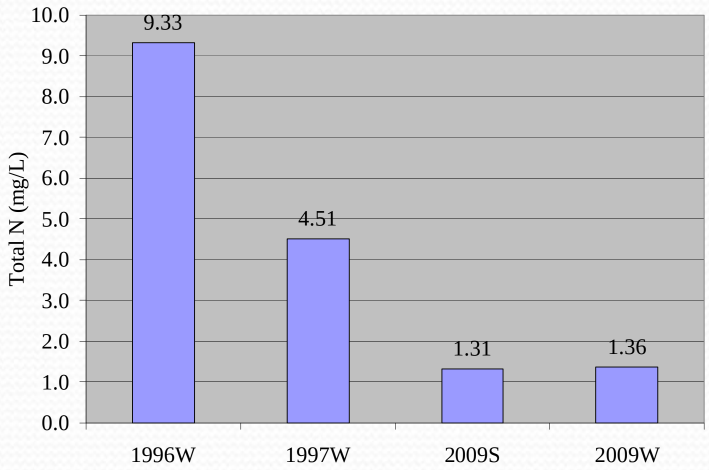
Water Quality Parameters	Monitoring Wells		
	1996	2009	Percent Change
Fecal coliform	232	1	-100
Total coliform	234	845	261
Nitrate + nitrite	1.88	0.01	-99
TKN	7.44	1.35	-82
Total nitrogen	9.33	1.36	-85

Monitoring Well Water Quality Comparison

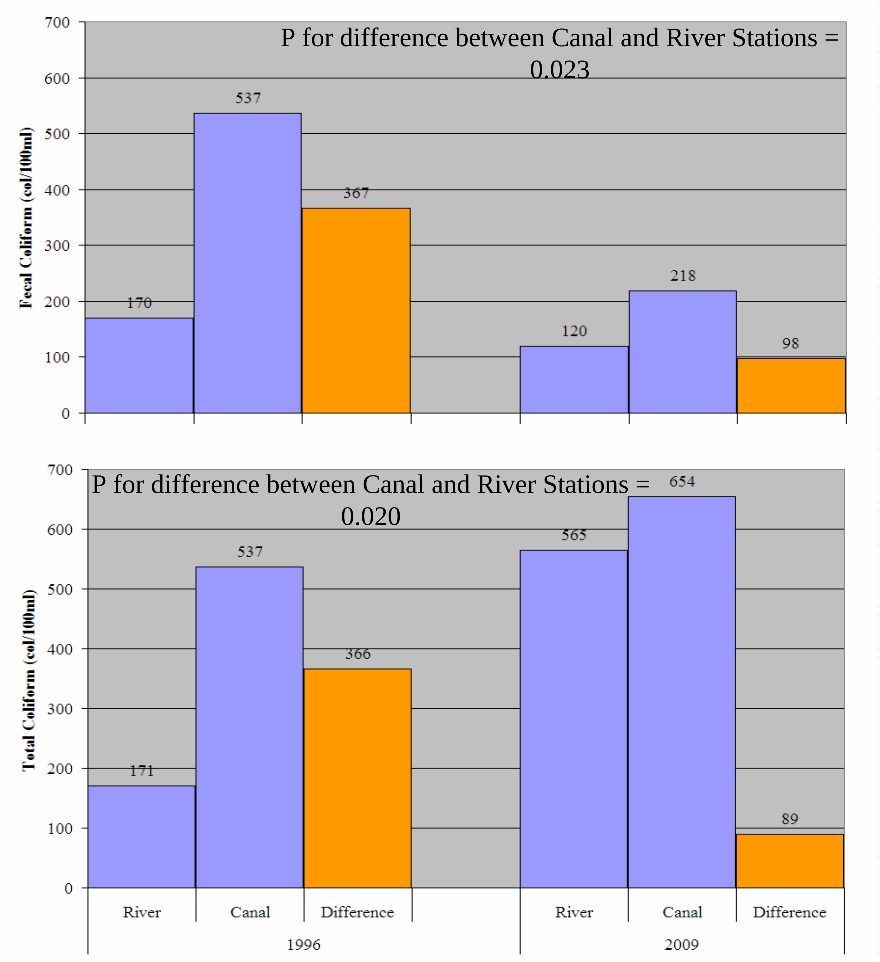




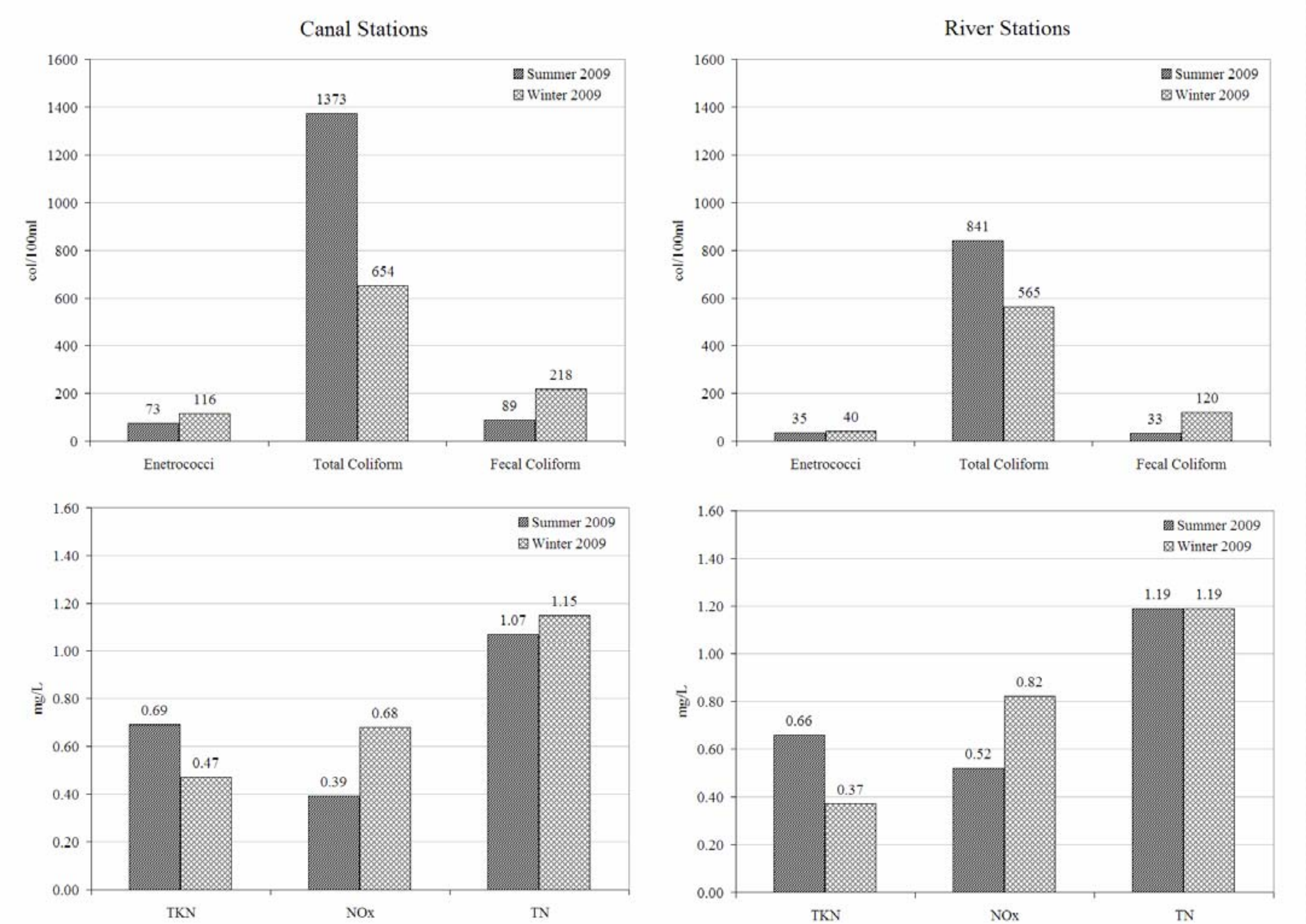




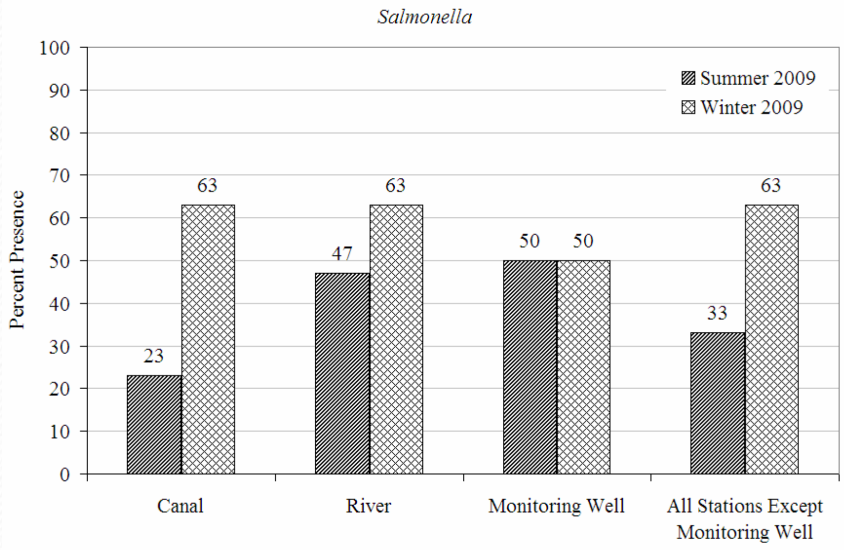
Comparison to 1996 Results—Differences in Canal and River Stations

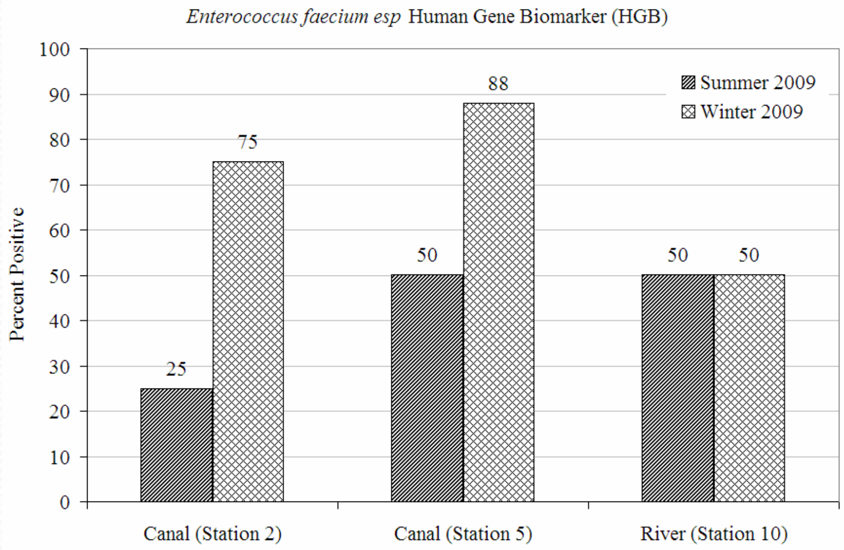


Comparison of Winter and Summer 2009 Data for the Canal and River Stations



Comparison of Winter and Summer 2009 Data for *Salmonella* and HGB





Conclusions

- No large improvement in water quality in the canals between 1996 and 2009.
- *Salmonella* occurrences were equal to or higher in the river than in the canals in both 2009 and 1996, indicating the canals were not the primary source of *Salmonella*.
- NO_x exhibited a strong correlation with river flow and decreased with increasing river flow.
- The source tracking results (human gene biomarker [HGB]) indicated the canals remain a possible source of HGB.
- The total and fecal coliforms were higher in the canals than in the river in both 1996 and 2009.
- There were three statistically significant changes in the measured parameters between 1996 and 2009:
  - Fecal coliform in the canals decreased.
  - Total coliforms in the river decreased.
  - Total nitrogen in the river decreased.
- The magnitude of reduction in fecal coliform concentrations in canal stations from 1996 to 2009 could be a possible benefit of closing the OSTDS.
- The monitoring well data indicated dramatic improvement from 1996 to 2009 in most of the parameters.
- Comparison of the winter 2009 data with the summer 2009 data indicated that total coliform counts were higher in the summer, but fecal coliform, enterococci, and *Salmonella* occurrences were higher in the winter for both the river and canal stations.

Recommendations

- It is unlikely additional studies would identify further improvements attributable to septic tank removal
- Future studies should follow a similar protocol and establish a series of test and control stations
- Future studies should be designed to conduct the pre- and postconstruction sampling during comparable seasonal and river discharge conditions
- Additional source tracking techniques should be used more extensively to help separate human impacts from natural sources

FLORIDA DEPARTMENT OF HEALTH

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task A.17

PNRS II Specification Report I

Final Report

April 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 A.17
FINAL REPORT

PNRS II Specification Report I

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

April 2010

Prepared by:

HAZEN AND SAWYER
Environmental Engineers & Scientists

In Association With:

AET
Applied Environmental Technology

PNRS II Specification Report I

The Florida Department of Health has contracted with a project team led by Hazen and Sawyer, P.C. to continue the study of passive nitrogen removal (PNRS II) under Task A of the Florida Onsite Sewage Nitrogen Reduction Strategies Study (FOSNRS). PNRS II is a follow up to the previous experimental evaluations of passive nitrogen removal technologies conducted by Applied Environmental Technology (AET) under FDOH Contract CORY (Passive Nitrogen Removal Study I). PNRS II will be conducted by staff from Hazen and Sawyer and AET. The FOSNRS Task A.15 Final PNRS II Quality Assurance Project Plan (QAPP) report details the pilot testing plan to evaluate candidate technologies that can be used to remove nitrogen from septic tank effluent with more passive onsite treatment systems. The pilot systems detailed in Tank A.15 consist of various configurations of in-tank biofilters and passive in-situ systems constructed as mound systems. Construction of the PNRS II systems will be completed in two phases, with Phase 1 relating mostly to PNRS II pilot test facilities in-tank biofilters. The passive in-situ systems for PNRS II will be constructed in Phase 2 along with the mini-mounds for Task C. This PNRS II Specification Report is provided under Task A.17 of the FOSNRS Contract and is the first of two specification reports provided for PNRS II construction. This specification report provides details for Phase 1 of PNRS II construction and includes details of design, materials and media procurement and preparation. The PNRS II QAPP should be referred to for additional details on the systems and testing plan.

1.1 Media

PNRS II will perform field testing of numerous onsite wastewater treatment configurations that use biofiltration media to enhance nitrogen reduction. The QAPP for PNRS II lists biofiltration media that will be evaluated in Stage 1 (unsaturated, nitrification) biofilters and Stage 2 (saturated, denitrification) biofilters (PNRS II QAPP Section 3.3). The PNRS II media are listed in Table 1.1 and detailed in the following sections.

Table 1.1
PNRS II Media

Material	Specs	Volume	Unit	Supplier/ Manufacturer	Type or Size Designation	Cost
Clinoptilolite	8x14	17.2	CF	GSA Resources	Sieve size 8 x14	$390 / ton (+$525 to Transport)
Clinoptilolite	16x50	24.5	CF		Sieve size 16x50	$390 / ton (+$525 to Transport)
Expanded Clay	>1.53mm	13.9	CF	Big River Industries	1/8 to 0	$1560 per truckload (44 CY) +$1,300 to Transport
Expanded Clay	<1.53mm	20.4	CF			
Expanded Clay	>1.13mm	7.9	CF			
Expanded Clay	As Is (for In-situ)	240	CF			
Gravel	5x16 >3mm	0.2	CF	National Suncoast Media	#5 x #16 Gravel	Donated
Lignocellulosic	SYP	193	CF	Robbins Products	SYP	Donated
Oyster Shell	>1.13 mm	3.1	CF	Shell's Feed Supply	Crushed	$15 / 50 lbs
Polystyrene		12.3	CF	EZ-Set	EPS	Donated
Sand	0.8-1.2 mm	8	CF	National Suncoast Media	Torpedo Sand	Donated
Sand	0.45-0.55 mm	8.2	CF		Silica Sand	Donated
Sand	As Is (for In-situ)	274	CF	Tampa Groves	Mound Sand	$220/ Truckload (16 CY)
Sodium Sesquicarbonate	>0.85 mm	1.3	CF	Solvay	T-50	Donated
Sulfur	>1.13 mm	10.3	CF	Georgia Sulfur	216	$0.36 / lb + $680 to Transport
Sulfur	As Is (for In-situ)	106	CF			

The media as received from vendors was screened where necessary using mesh screens listed in Table 1.2. Clinoptilolite, lignocellulosic, polystyrene, and sand was used as supplied while elemental sulfur, expanded clay, gravel, oyster shell, and sodium sesquicarbonate was screened to the particle size ranges listed in Table 1.1. Screening was accomplished using square weave stainless steel type 304 wire mesh as specified in Table 1.2. Screens were mounted on a tilting frame device underlain by a collection trough (Figure 1-1). Media to be screened was applied in batches to the surface of the screen, and the screen device was then tilted and vibrated until particles ceased to migrate through the screen.

Table 1.2
Mesh Screen for Media Screening

Screen #	Opening Size (mm/inch)	Mesh Size	Wire Size (inch)	Material	Size (W x L)
1	1.53 mm (0.0603")	12	0.0230"	Stainless Steel 304, Square Weave Wire Mesh	3' x 4'
2	1.13 mm (0.0445")	16	0.0180"	Stainless Steel 304, Square Weave Wire Mesh	3' x 4'
3	0.85 mm (0.034")	20	0.0160"	Stainless Steel 304, Square Weave Wire Mesh	3' x 4'
4	0.23 mm (0.0092")	60	0.0075"	Stainless Steel 304, Square Weave Wire Mesh	3' x 4'
5	3.00 mm (1/8")	1/8"		23 Gauge Steel Wire Hardware Cloth	3' x 4'

Figure 1-1
Media Screening Tilting Frame Device

Various mixtures of the media were prepared for the PNRS II biofilters. Table 1.3 lists the quantities of the screened material used for the various media mixtures. The media mixtures were made in batches onsite prior to placing the media in the test facility treatment tanks. Media mixtures were assembled by adding correct volumes of individual media components to a cement mixer and operating for 20 to 30 seconds. The media mixture was discharged from the cement mixer to a holding bin and the process was repeated until a sufficient volume of the media mixture was produced. Most of the biofilter systems to be tested under the PNRS II pilot study contain one or more of these media mixtures, in various quantities. Table 1.4 and 1.5 provide the details on the mixtures used for each biofilter to be tested.

Table 1.3
Biofilter Media Mixtures

Mixture #	Media ID	Biofilter IDs	Mixture	Media	Total CF	Total Gal
1	Clinoptilolite 8X14	UNSAT-CL-1; UNSAT-CL-3	6.1 CF mixed with 0.45 CF Oyster Shell	Clino 8x14	6.13	45.88
				Oyster Shell	0.46	3.44
2	Clinoptilolite 16X50	UNSAT-CL-1; UNSAT-CL-3	12.3 CF mixed with 0.45 CF Oyster Shell	Clino 16x50	12.27	91.75
				Oyster Shell	0.46	3.44
3	Expanded Clay >1.53 mm	UNSAT-EC-1; UNSAT-EC-3	6.1 CF mixed with 0.45 CF Oyster Shell	E Clay >1.53	6.13	45.88
				Oyster Shell	0.46	3.44
4	Expanded Clay <1.53 mm	UNSAT-EC-1; UNSAT-EC-3	12.3 CF mixed with 0.45 CF Oyster Shell	E Clay <1.53	12.27	91.75
				Oyster Shell	0.46	3.44
5	Expanded Clay >1.13 mm	DENIT-LS-1; DENIT-LS-2	3.23 CF mixed with 3.23 CF Lignocellulosic	E Clay >1.13	3.23	24.14
				Ligno	3.23	24.14
6	Expanded Clay >1.13 mm	DENIT-LS-4	3.69 CF mixed with 1.58 CF Lignocellulosic	E Clay > 1.13	3.69	27.63
				Ligno	1.58	11.84
7	Expanded Clay As Is	UNSAT-IS-1; UNSAT-IS-2	4.4 CF mixed with 3.4 CF Lignocellulosic and 2 CF Sulfur	E Clay As Is	4.42	33.03
				Ligno	3.43	25.69
				Sulfur As Is	1.96	14.68
8	Torpedo Sand	DENIT-LS-3	2.64 CF mixed with 2.64 CF Lignocellulosic	Torpedo Sand	2.64	19.74
				Ligno	2.64	19.74
9	Sulfur >1.13	DENIT-SU-1; DENIT-SU-3	5.16 CF mixed with 1.3 CF Oyster Shell	Sulfur > 1.13	5.16	38.63
				Oyster Shell	1.29	9.66
10	Sulfur >1.13	DENIT-SU-2; DENIT-SU-4	5.16 CF mixed with 1.3 CF Sodium Sesqui-carbonate	Sulfur >1.13	5.16	38.63
				Sodium Sesq	1.29	9.66

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Table 1.4
Stage 1 Biofilter Media Quantities

Biofilter #	Biofilter ID	Media Layer	Mixture ID # (See Table 1.3)	CF	Gal
1	UNSAT-EC-1	Upper 5”	Mixture 3	2.20	16.44
		Lower 10”	Mixture 4	4.24	31.73
2	UNSAT-SAND-2	Upper 10”	Torpedo Sand	4.09	30.58
		Lower 20”	Silica Sand	8.18	61.17
3	UNSAT-EC-3	Upper 10”	Mixture 3	4.40	32.88
		Lower 20”	Mixture 4	8.48	63.46
4	UNSAT-EC-4	Upper 10”	E Clay >1.53	4.09	30.58
		Lower 20”	E Clay <1.53	8.18	61.17
5	UNSAT-CL-1	Upper 5”	Mixture 1	2.20	16.44
		Lower 10”	Mixture 2	4.24	31.73
6	UNSAT-CL-2	Upper 5”	Clino 8x14	2.04	15.29
		Lower 10”	Clino 16x50	4.09	30.58
7	UNSAT-CL-3	Upper 10”	Mixture 1	4.40	32.88
		Lower 20”	Mixture 2	8.48	63.46
8	UNSAT-CL-4	Upper 10”	Clino 8x14	4.09	30.58
		Lower 20”	Clino 16x50	8.18	61.17
9	UNSAT-PS-1	Module	Polystyrene	12.27	91.75
10	UNSAT-IS-1	Upper 12”	Mound Sand	4.91	36.70
		Lower 12”	Mixture 7	4.91	36.70
11	UNSAT-IS-2	Upper 12”	Mound Sand	4.91	36.70
		Lower 12”	Mixture 7	4.91	36.70

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Table 1.5
Stage 2 Biofilter Media Quantities

Biofilter #	Biofilter ID	Media Layer	Mixture ID # (See Table 1.3)	CF	Gal
1	DENIT-SU-1	Mixture 72”	Mixture 9	1.18	8.81
2	DENIT-SU-2	Mixture 72”	Mixture 10	1.18	8.81
3	DENIT-SU-3	Mixture 24”	Mixture 9	5.28	39.47
4	DENIT-SU-4	Mixture 24”	Mixture 10	5.28	39.47
5	DENIT-LS-1	Mixture 72”	Mixture 5	1.18	8.81
6	DENIT-LS-2	Mixture 24”	Mixture 5	5.28	39.47
7	DENIT-LS-3	Mixture 24”	Mixture 8	5.28	39.47
8	DENIT-LS-4	Mixture 24”	Mixture 6	5.28	39.47
9	DENIT-GL-1	Upper 12”	Gravel 5X16 >3 mm	0.20	1.50
		Lower 60”	E Clay >1.13	0.98	7.31

1.2 Construction of Systems

Pilot test systems consist of various configurations of in-tank biofilters and passive in-situ systems. As outlined in the PNRS II QAPP, Phase 1 of construction consists of a total of five two-stage single pass systems, four Stage 1 recirculating biofilter systems followed by four Stage 2 inclined saturated biofilters, and two in-tank in-situ simulators. The passive in-situ systems for PNRS II will be constructed in Phase 2 along with the mini-mounds for Task C.

1.2.1 PNRS II In-Tank Single Pass Biofilters

In the two-stage single pass biofilter process, a first stage unsaturated biofilter is followed in series by a second stage biofilter operated in a water saturated mode. Hydrosplitter 1 applies septic tank effluent to the top of the first stage media in each of the five single pass biofilters. This results in a downward percolation of wastewater over and through the media biofilter bed, through the support screen, and into a ¾” PVC line that conveys biofilter effluent to the directly connected Stage 2 biofilter. The Stage 2 biofilter configurations are 22-inch diameter circular upflow filters of 24-inch media depth. A valve and sample port are located in the line following the Stage 1 and 2 biofilters. The construction of the biofilters consists of a polyethylene tank with cover and underdrain base to support the media.

Table 1.6 details the Stage 1 and Stage 2 media utilized for the directly connected single pass biofilter systems. Figure 1-2 provides an as-built diagram of a single-pass biofilter system. Table 1.7 lists the materials of construction for these systems, as identified on the diagram.

Table 1.6
PNRS II Single Pass Biofilter Media

Single Pass System No.	Stage	Biofilter ID	Media	Media Depth (Inches)	Volume (ft^3)	Supplier (Material/Size)
1	1	UNSAT-EC-1	Expanded Clay >1.53 mm	5	3.3	Florida Rock Industries (1/8 x 0)
			Expanded Clay <1.53 mm	10	4.1	Florida Rock Industries (1/8 x 0)
			Oyster Shell >1.13 mm	~5% of EC Mixture	0.3	Shell's Feed Supply
	2	DENIT-SU-4	Sulfur	24	4.2 (80% of Mixture)	Georgia Sulfur (216)
			Sodium Sesquicarbonate		1.1 (20% of Mixture)	Solvay (T-50)
2	1	UNSAT-EC-3	Expanded Clay >1.53 mm	10	5.3	Florida Rock Industries (1/8 x 0)
			Expanded Clay <1.53 mm	20	8.2	Florida Rock Industries (1/8 x 0)
			Oyster Shell >1.13 mm	~5% of EC Mixture	0.6	Shell's Feed Supply
	2	DENIT-LS-3	Lignocellulosic	24	2.6 (50% of Mixture)	Robbins Products (SYP)
			Sand		2.6 (50% of Mixture)	National Suncoast Media (Torpedo Sand)

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Table 1.6 (con't)
PNRS II Single Pass Biofilter Media

Single Pass System No.	Stage	Biofilter	Media	Media Depth (Inches)	Volume (ft^3)	Supplier (Material/Size)
3	1	UNSAT-CL-1	Clinoptilolite (8 x 14)	5	3.3	GSA Resources (8 x 14)
			Clinoptilolite (16 x 50)	10	4.1	GSA Resources (16 x 50)
			Oyster Shell >1.13 mm	~5% of CL Mixture	0.3	Shell's Feed Supply
	2	DENIT-SU-3	Sulfur >1.13 mm	24	4.2 (80% of Mixture)	Georgia Sulfur (216)
			Oyster Shell >1.13 mm		1.1 (20% of Mixture)	Shell's Feed Supply
4	1	UNSAT-CL-3	Clinoptilolite (8 x 14)	10	5.3	GSA Resources (8 x 14)
			Clinoptilolite (16 x 50)	20	8.2	GSA Resources (16 x 50)
			Oyster Shell >1.13 mm	~5% of CL Mixture	0.6	Shell's Feed Supply
	2	DENIT-LS-2	Lignocellulosic	24	2.6 (50% of Mixture)	Robbins Products (SYP)
			Expanded Clay >1.13 mm		2.6 (50% of Mixture)	Florida Rock Industries (1/8 x 0)
5	1	UNSAT-PS-1	Polystyrene	30	12.3	EZ-Set
	2	DENIT-LS-4	Lignocellulosic	24	1.6 (30% of Mixture)	Robbins Products (SYP)
			Expanded Clay		3.7 (70% of Mixture)	Florida Rock Industries (1/8 x 0)

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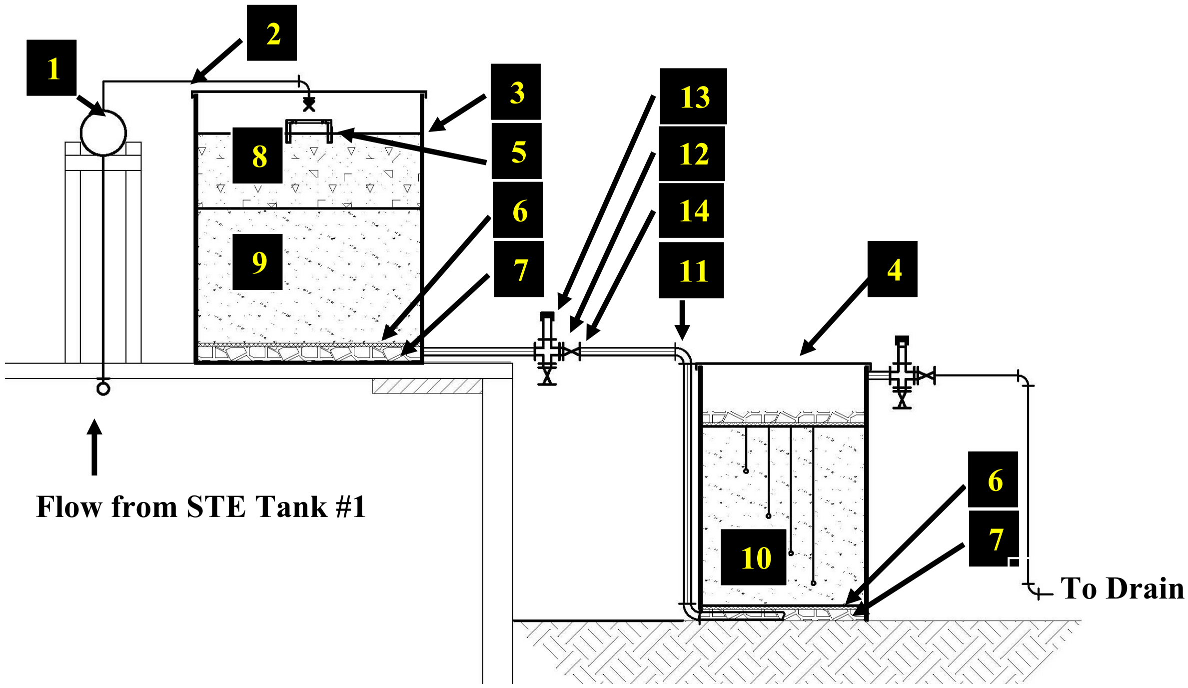

Figure 1-2
PNRS II Single Pass Biofilter System

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Table 1.7
PNRS II Single Pass Biofilter Systems Materials of Construction

Reference No.	Description	Quantity	Unit	Supplier/ Manufacturer	Model #	Specs	Cost
1	Hydrosplitter 1	1	EA	Custom			
2	Hydrosplitter Tygon Tubing 3/8" ID	30	LF	US Plastics	R-3603		$1.33/LF
3	Polyethylene Stage 1 Tank 30" ID x 36" H	5	EA	US Plastics/ TAMCO	4158		$302.74 EA
4	Polyethylene Stage 2 Tank 22" ID x 34.5" H	5	EA	US Plastics/ TAMCO	4032		$95.20 EA
5	Perforated Splash Plate 6" D	5	EA	Plastics America			$37.04 EA
6	Geotextile Fabric FW700	38	SF	F H Moore / Mirafi	FW700		$0.35/SF
7	Gravel ½" Under-drain Material	6.29	CF	Misc. Locations			(see Table 1.1)
8	Stage 1 Upper Media (see Table 1.4)	Varies	CF	Varies	Varies	Varies	(see Table 1.1)
9	Stage 1 Lower Media (see Table 1.4)	Varies	CF	Varies	Varies	Varies	(see Table 1.1)
10	Stage 2 Media (see Table 1.5)	Varies	CF	Varies	Varies	Varies	(see Table 1.1)
11	¾" PVC Pipe	75	LF	Misc. Locations		Sch. 40	$1.56/LF
12	¾" PVC Cross	10	EA	Misc. Locations		Sch. 40	$1.70/EA
13	¾" Cap	10	EA	Misc. Locations		Sch. 40	$0.50/EA
14	¾" Ball Valve	20	EA	Misc. Locations		Sch. 40	$3.05/EA

1.2.2 PNRS II In-Tank Recirculating Biofilter Systems

The two-stage biofilter process will also be tested utilizing recirculation of Stage 1 effluent. A recirculation tank receives STE from Hydrosplitter 2 and recycled Stage 1 effluent which then feeds the Stage 1 biofilter via a gravity line. The first stage biofilter effluent is directed to a dose tank with a submersible pump which recirculates the nitrified effluent at a 3:1 recycle ratio or other ratio as desired. A common Stage 1 effluent collection tank (the denite feed tank) receives the Stage 1 effluent which is not recycled. The construction of the Stage 1 biofilters consists of 30-inch inner diameter polyethylene tanks with covers and underdrain base to support the media. Table 1.8 summarizes the media utilized for Stage 1 of the recirculating two-stage biofilters. Figure 1-3 provides an as-built diagram of a Stage 1 recirculating biofilter system, while Table 1.9 lists the materials of construction for these systems, as identified on the diagram.

Table 1.8
PNRS II Recirculating Stage 1 Biofilters Media

	Biofilter ID	Media	Media Depth (Inches)	Volume (ft^3)	Supplier (Material/Size)	Recycle Ratio (α)
1	UNSAT-SAND-2	Sand 0.8–1.2 mm	10	5.3	National Suncoast Media (Torpedo Sand)	3
		Sand 0.45–0.55 mm	20	8.2	National Suncoast Media (Silica Sand)	3
2	UNSAT-EC-4	Expanded Clay >1.53 mm	10	5.3	Florida Rock Industries (1/8 x 0)	3
		Expanded Clay <1.53 mm	20	8.2	Florida Rock Industries (1/8 x 0)	3
3	UNSAT-CL-2	Clinoptilolite (8 x 14)	5	3.3	GSA Resources (8 x 14)	3
		Clinoptilolite (16 x 50)	10	4.1	GSA Resources (16 x 50)	3
4	UNSAT-CL-4	Clinoptilolite (8 x 14)	10	5.3	GSA Resources (8 x 14)	3
		Clinoptilolite (16 x 50)	20	8.2	GSA Resources (16 x 50)	3

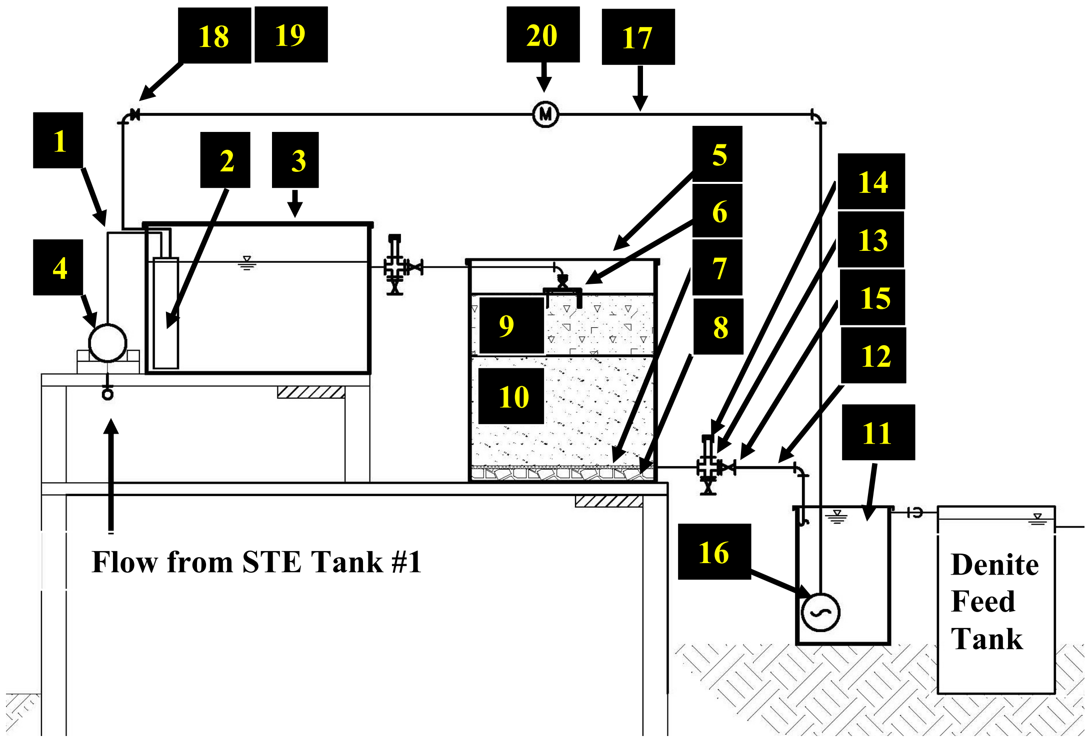

Figure 1-3
PNRS II Recirculating Biofilter Stage 1

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Table 1.9
PNRS II Recirculating Biofilters Stage 1 Materials of Construction

Reference No.	Description	Quantity	Unit	Supplier/ Manufacturer	Model #	Specs	Cost
1	Hydrosplitter Tygon Tubing 3/8" ID	24	LF	US Plastics	R-3603		$1.33/LF
2	4" ID x 18" H Mixing Chamber	4	EA	Misc. Locations		Sch. 40	$12.07 EA
3	Polyethylene Recirculation Tank 36" ID x 24" H	4	EA	US Plastics/ TAMCO	4157		$308.35 EA
4	Hydrosplitter 2	1	EA	Custom			
5	Polyethylene Stage 1 Tank 30" ID x 36" H	4	EA	US Plastics/ TAMCO	4158		$302.74 EA
6	Perforated Splash Plates 6" D	4	EA	Plastics America			$37.04 EA
7	Geotextile Fabric FW700	20	SF	F H Moore / Mirafi	FW700		$0.35/SF
8	Gravel ½" Under-drain Material	3.27	CF	Misc. Locations			(see Table 1.1)
9	Stage 1 Upper Media (see Table 1.4)	Varies	CF	Varies	Varies	Varies	(see Table 1.1)
10	Stage 1 Lower Media (see Table 1.4)	Varies	CF	Varies	Varies	Varies	(see Table 1.1)
11	Recirculation Dos-ing Tank (15 Gallon)	4	EA	US Plastics/ TAMCO	4030		$53.26 EA
12	¾" PVC Pipe	60	LF	Misc. Locations		Sch. 40	$1.56/LF
13	¾" PVC Cross	8	EA	Misc. Locations		Sch. 40	$1.70/EA
14	¾" Cap	8	EA	Misc. Locations		Sch. 40	$0.50/EA
15	¾" Ball Valve	16	EA	Misc. Locations		Sch. 40	$3.05/EA
16	1/6 HP Submersible Pump	4	EA	Sarasota H2O Gardens/ Little Giant	505202	115V	$151.20 EA

Table 1.9 (con't)
PNRS II Recirculating Biofilters Stage 1 Materials of Construction

Reference No.	Description	Quantity	Unit	Supplier/ Manufacturer	Model #	Specs	Quoted Price
17	½" Pipe	80	LF	Misc. Locations		Sch. 40	$1.20/LF
18	½" 90° Bend	16	EA	Misc. Locations		Sch. 40	$0.50 EA
19	½" Ball Valves	4	EA	Misc. Locations		Sch. 40	$2.52 EA
20	½" Flow Meters	4	EA	Misc. Locations		Sch. 40	$137.00 EA

The Stage 1 effluent from the four recirculating biofilters is combined in the denite feed tank. This nitrified effluent is then pumped to Stage 2 inclined denitrification filters. Stage 2 biofilters are maintained in saturated mode by the Stage 2 overflow elevation pipe. The configuration of the Stage 2 biofilters is a 6-inch diameter pipe of 72-inch length which is inclined slightly upward. The media installed in these Stage 2 biofilters is listed in Table 1.10. Table 1.11 lists the materials of construction for these systems, as identified on the as-built diagram provided in Figure 1-4.

Table 1.10
PNRS II Recirculating Stage 2 Biofilters Media

	Biofilter ID	Media	Media Depth (Inches)	Volume (ft^3)	Supplier (Material/Size)
1	DENIT-SU-1	Sulfur >1.13 mm	72” (80% of Mixture)	0.9	Georgia Sulfur (216)
		Oyster Shell >1.13 mm	72” (20% of Mixture)	0.2	Shell’s Feed Supply
2	DENIT-SU-2	Sulfur >1.13 mm	72” (80% of Mixture)	0.9	Georgia Sulfur (216)
		Sodium Sesquicarbonate >0.85 mm	72” (20% of Mixture)	0.2	Solvay (T-50)
3	DENIT-LS-1	Lignocellulosic (SYP)	72” (50% of Mixture)	0.6	Robbins Products (SYP)
		Expanded Clay >1.13 mm	72” (50% of Mixture)	0.6	Florida Rock Industries (1/8 x 0)
4	DENIT-GL-1	Gravel >3 mm	Upper 12” (17% of Mixture)	0.2	National Suncoast Media (Gravel #5 x #16)
		Expanded Clay >1.13 mm	Lower 60” (83% of Mixture)	1.0	Florida Rock Industries (1/8 x 0)

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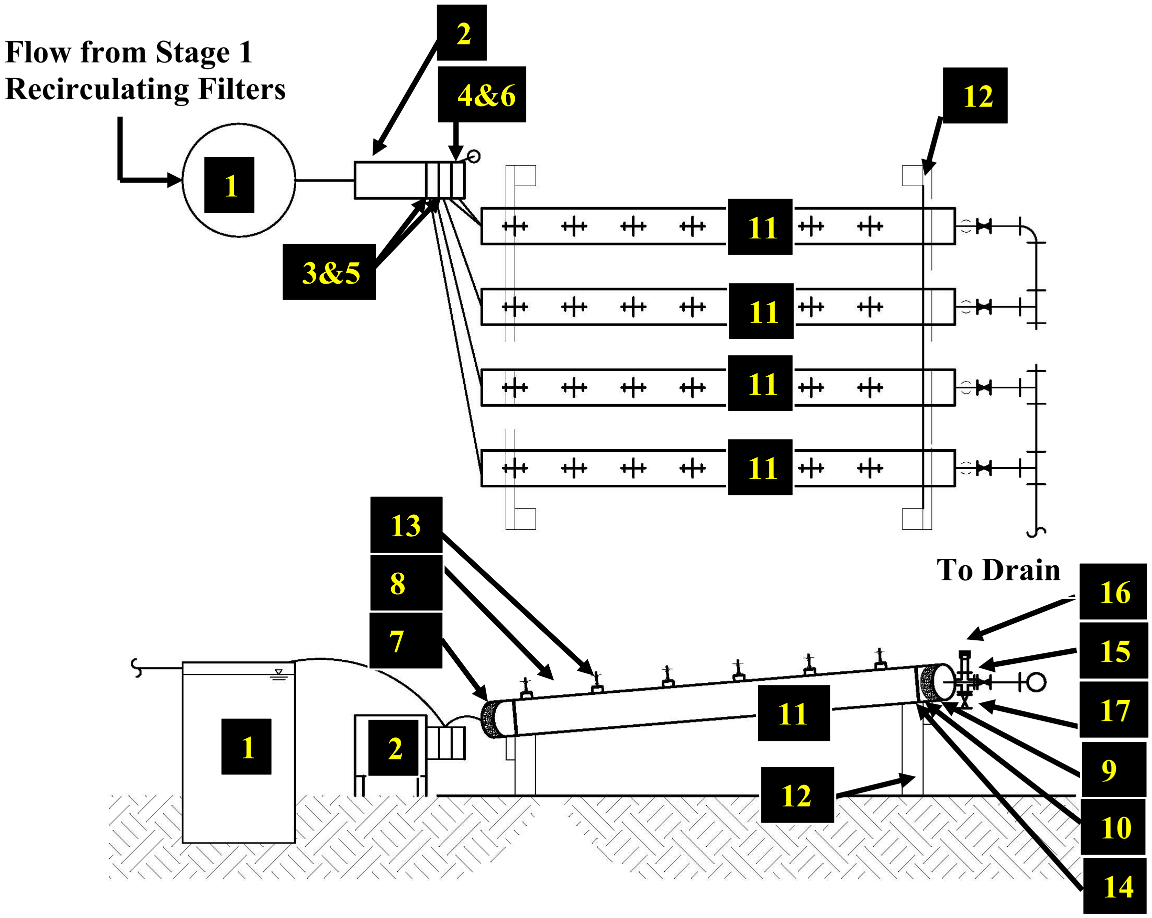

Figure 1-4
PNRS II Recirculating Biofilter Systems Stage 2

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Table 1.11
PNRS II Recirculating Biofilters Stage 2 Materials of Construction

Reference No.	Description	Quantity	Unit	Supplier/ Manufacturer	Model #	Specs	Cost
1	Denite Feed Tank	1	EA	US Plastics / TAMCO	4031	30 gal	$80.25 EA
2	Peristaltic Pump Drive	1	EA	Cole Parmer / Masterflex	R-07523-90		$1,710.00 EA
3	2 Channel Pump Head for Stage 2	1	EA	Cole Parmer / Masterflex	R-77202-50	Easy Load II	$256.00 EA
4	1 Channel Pump Head for Glycerol	1	EA	Cole Parmer / Masterflex	R-77200-50	Easy Load II	$200.00 EA
5	Norprene Pump Tubing L/S 25 for Stage 2	1	EA	Cole Parmer / Masterflex		Norprene 50' L	$46.00/ 50' L
6	Norprene Pump Tubing L/S 13 for Glycerol	1	EA	Cole Parmer / Masterflex		Norprene 50' L	$38.00/ 50' L
7	6" PVC Cap with hole for tubing	8	EA	Misc. Locations		Sch. 40	$15 EA
8	6" PVC (6' segments)	4	EA	Misc. Locations		Sch. 40	$30 EA
9	Gravel ½" Under-drain Material	0.13	CF	Misc. Locations			(see Table 1.1)
10	Geotextile Fabric FW700	4	SF	F H Moore / Mirafi	FW700		$0.35/SF
11	Stage 2 Media (see Table 1.5)	Varies	CF	Varies	Varies	Varies	(see Table 1.1)
12	Wood Frame	1	LS	Misc. Locations			$25.00
13	Sample Port	36	EA	Misc. Locations			$20.00 EA
14	Pipe Strap	8	EA	Misc. Locations			
15	¾" PVC Cross	4	EA	Misc. Locations		Sch. 40	$1.70/EA
16	¾" Cap	4	EA	Misc. Locations		Sch. 40	$0.50/EA
17	¾" Ball Valve	8	EA	Misc. Locations		Sch. 40	$3.05/EA

1.2.3 In-situ In-Tank Simulators Biofilters

Biofilter Systems 10 and 11, Stage 1 biofilters UNSAT-IS-1 and UNSAT-IS-2 respectively, are in-tank analogs of the media to be used in in-situ systems that will be constructed as mound systems at the research facility as part of the Phase 2 construction. System 10 receives primary effluent and System 11 receives nitrified effluent supplied over a capillary seepage mat that has been used for irrigation of agricultural plants by scientists at the University of Florida Gulf Coast Research and Education Center (GCREC). The upper layer of these biofilters is typical mound sand media, and the lower portion of the biofilter consists of an engineered mixed media of expanded clay, sulfur, and lignocellulosic media as listed in Table 1.12. Figure 1-5 illustrates an as-built diagram of the in-situ simulator systems while Table 1.13 details the materials of construction for the systems. System 10 does not include line item No. 8 the capillary seepage mat.

Table 1.12
PNRS II In-Tank In-Situ Simulator Biofilters Media

	Biofilter ID	Media	Media Depth (Inches)	Volume (ft^3)	Supplier (Material/Size)
1	UNSAT-IS-1	Mound Sand	Upper 12”	4.91	Tampa Groves
		Expanded Clay (As Is)	Lower 12”	2.2 (45% of Mixture)	Florida Rock Industries (1/8 x 0)
		Lignocellulosic		1.7 (35% of Mixture)	Robbins Products (SYP)
		Sulfur (As Is)		1.0 (20% of Mixture)	Georgia Sulfur (216)
2	UNSAT-IS-2	Mound Sand	Upper 12”	4.91	Tampa Groves
		Expanded Clay (As Is)	Lower 12”	2.2 (45% of Mixture)	Florida Rock Industries (1/8 x 0)
		Lignocellulosic		1.7 (35% of Mixture)	Robbins Products (SYP)
		Sulfur (As Is)		1.0 (20% of Mixture)	Georgia Sulfur (216)

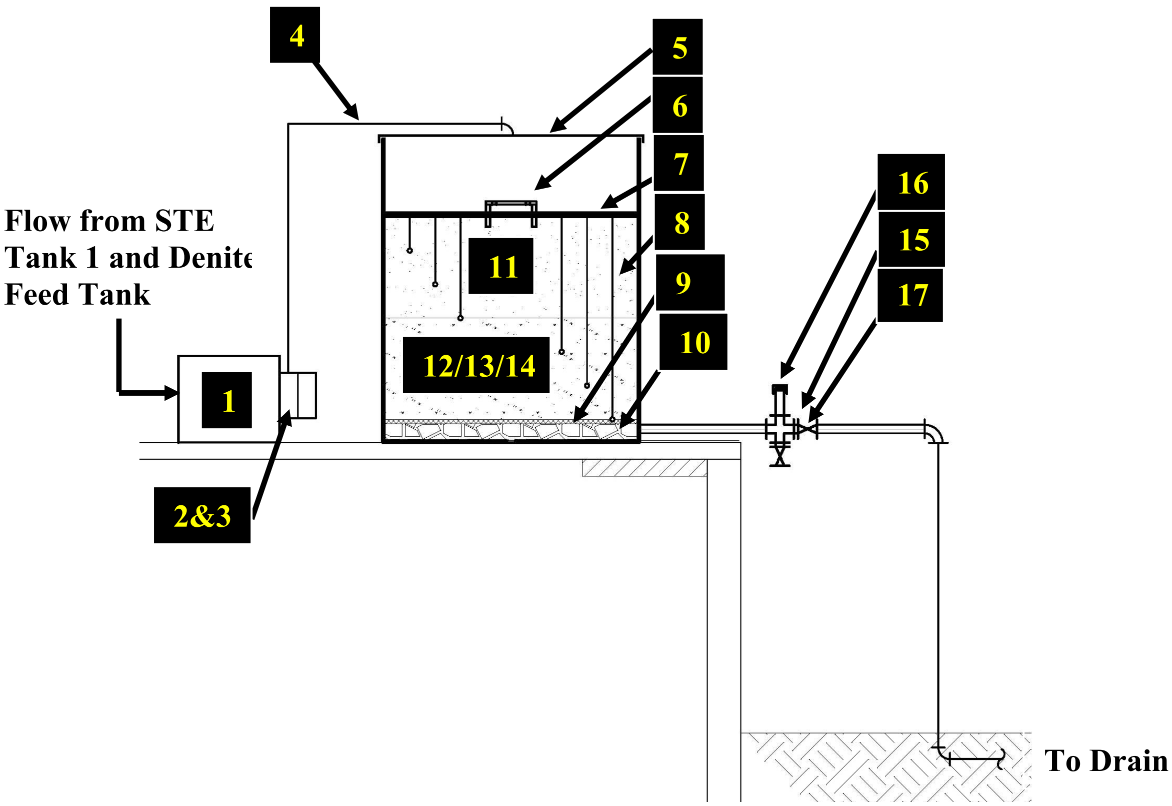

Figure 1-5
PNRS II In-Tank In-situ Simulator Systems

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Table 1.13
PNRS II In-Tank In-situ Simulators Materials of Construction

Reference No.	Description	Quantity	Unit	Supplier/ Manufacturer	Model #	Specs	Quoted Price
1	Peristaltic Pump Drive	1	EA	Cole Parmer / Masterflex	R-07523-90		$1,710.00 EA
2	Pump Head	2	EA	Cole Parmer / Masterflex	R-77200-52		$200.00 EA
3	Masterflex Nor-prene Pump Tubing (A 60 G) L/S 35	1	EA	Cole Parmer / Masterflex	R-06404-35	Norprene 50' L	$102.00/ 50'L
4	Tubing	10	LF	Various			$10/ 50LF
5	Polyethylene Stage 1 Tank 30" ID x 36" H	2	EA	US Plastics/ TAMCO	4158		$302.74 EA
6	Perforated Splash Plates 6" D	2	EA	Plastics America			$37.04 EA
7	Capillary Seepage Mat (UNSAT-IS-2)	1	EA	GCREC			N/A
8	Suction Lysimeters	12	EA	Soil Moisture Equipment	1900L		$75.00 EA
9	Geotextile Fabric FW700	18	SF	F H Moore / Mirafi	FW700		$0.35/SF
10	Gravel ½" Under-drain Material	1.64	CF	Misc. Locations			(see Table 1.1)
11	Sand Media	9.8	CF	Tampa Groves		Mound Sand	(see Table 1.1)
12	Expanded Clay Media	4.4	CF	Florida Rock Industries	Livlite 1/8 to zero		(see Table 1.1)
13	Sulfur Media	2.0	CF	Georgia Sulfur	216		(see Table 1.1)
14	Lignocellulosic Me-dia	3.4	CF	Robbins Prod-ucts	SYP		(see Table 1.1)
15	¾" PVC Cross	2	EA	Misc. Locations		Sch. 40	$1.70/EA
16	¾" Cap	2	EA	Misc. Locations		Sch. 40	$0.50/EA
17	¾" Ball Valve	4	EA	Misc. Locations		Sch. 40	$3.05/EA

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Appendix A
Summary of Media for PNRS II

Table A.1 provides a summary of the quantities of media that were procured for the PNRS II project.

BIOFILTER		Clino		Expanded Clay						#5 x #16 Gravel		Ligno		Oyster shell		Poly.	Sand				Sodium sesqui		Sulfur (216)		
		8x14	16x50	> 1.53 mm	< 1.53 mm	%	> 1.13 mm	%	As Is	%	> 3 mm	%	SYP	%	> 1.13 mm	As Is	%	Torp.	Silica	Mound	%	> 0.85 mm	%	> 1.13 mm	As Is
STAGE 1 BIOFILTERS																									
1	UNSAT-EC-1			3.3	4.1									5%	0.3										
2	UNSAT-SAND-2																	5.3	8.2						
3	UNSAT-EC-3			5.3	8.2									5%	0.6										
4	UNSAT-EC-4			5.3	8.2																				
5	UNSAT-CL-1	3.3	4.1											5%	0.3										
6	UNSAT-CL-2	3.3	4.1																						
7	UNSAT-CL-3	5.3	8.2											5%	0.6										
8	UNSAT-CL-4	5.3	8.2																						
9	UNSAT-PS-1															12.3									
10	UNSAT-IS-1							45%	2.2			35%	1.7							4.9			20%		1.0
11	UNSAT-IS-2							45%	2.2			35%	1.7							4.9			20%		1.0
STAGE 2 BIOFILTERS																									
1	DENIT-SU-1													20%	0.2								80%	0.9	
2	DENIT-SU-2																				20%	0.2	80%	0.9	
3	DENIT-SU-3													20%	1.1								80%	4.2	
4	DENIT-SU-4																				20%	1.1	80%	4.2	
5	DENIT-LS-1					50%	0.6					50%	0.6												
6	DENIT-LS-2					50%	2.6					50%	2.6												
7	DENIT-LS-3											50%	2.6				50%	2.6							
8	DENIT-LS-4					70%	3.7					30%	1.6												
9	DENIT-GL-1					83%	1.0			17%	0.2														
Total Cubic Feet Required		17.2	24.5	13.9	20.4		7.9		4.4		0.2		10.9		3.1	12.3		8.0	8.2	9.8		1.3		10.3	2.0
% Usable When Screening Material		AS IS	AS IS	55%	17%		65%		AS IS		25%		AS IS			AS IS		AS IS	AS IS	AS IS		34%		57%	AS IS
Additional Volume Required				11.4	74.5		4.3				0.6											2.5		7.8	
Extra Safety Factor (30%)		5.2	7.4	7.6	28.5		3.6		1.3		0.2		3.3		0.9	3.7		2.4	2.5	2.9		1.1		5.4	0.6
Total Cubic Feet to Purchase		22.3	31.9	32.9	123.5		15.8		5.7		1.0		14.1		4.1	15.9		10.3	10.6	12.8		4.9		23.6	2.6
Total Cubic Yards to Purchase		0.8	1.2	1.2	4.6		0.6		0.2		0.04		0.5		0.2	0.6		0.4	0.4	0.5		0.2		0.9	0.1