AN ASSESSMENT OF NITROGEN CONTRIBUTION FROM ONSITE WASTEWATER TREATMENT SYSTEMS (OWTS) IN THE WEKIVA STUDY AREA OF CENTRAL FLORIDA

Elke L. Ursin[1] and Eberhard Roeder[2]

ABSTRACT

Nitrogen from wastewater can be one contributor to water quality problems. The onsite sewage, or septic tank discharge, part of this source has been hard to assess due to institutional, technological, and economic constraints. The water for the Wekiva River in Central Florida comes from rainfall runoff as well as several aquifer fed springs, for which nitrogen pollution of ground water is important. This paper will discuss the Florida Department of Health's Wekiva Study that was completed in the first half of 2007 in response to a legislative mandate to address nitrogen contamination of ground water by onsite wastewater treatment systems (OWTS). The study included tasks ranging from field sampling around drainfields to locate and measure the nitrogen plume, estimating how much nitrogen is released into the environment and how much reaches the ground water, to assessments of nitrogen releases from all sources, and management options. The field work results showed that effluent plumes can be identified in the ground water and that approximately one-half to one-third of the nitrogen released from the septic tank reaches the ground water. While soil types were a good indicator of how nitrogen behaves once it leaves the OWTS, variability and limited extent of nitrogen removal indicated that soils cannot be relied on solely to nitrify/denitrify the effluent. To determine the relative significance of OWTS nitrogen contributions, the amount of nitrogen from all sources was evaluated. Approximately 6% to 12% of the nitrogen from all sources came from onsite systems. To reach springs protection levels all sources of nitrogen must be addressed. To reduce the amount of nitrogen in the study area from OWTS, the Department proposed that existing systems should be upgraded to current setback requirements to seasonal high water table and surface water and that new systems should meet a 70% reduction in nitrogen pretreatment performance standard. A strong maintenance and management program is key to ensuring performance results are sustained.

INTRODUCTION

Protection of public health and the environment is a priority for the Florida Department of Health (FDOH). Onsite Wastewater Treatment Systems (OWTS) are a permanent solution to

---

[1] Elke L. Ursin, Environmental Health Program Consultant, Florida Department of Health, Tallahassee. 4052 Bald Cypress Way, Bin #A-08, Tallahassee, FL 32399-1713. Elke_Ursin@doh.state.fl.us

[2] Eberhard Roeder, P.D., P.E., Professional Engineer III, Florida Department of Health, Tallahassee. 4052 Bald Cypress Way, Bin #A-08, Tallahassee, FL 32399-1713. Eberhard_Roeder@doh.state.fl.us

wastewater treatment in many locations throughout the State of Florida. Approximately one-third of the population of Florida utilizes an OWTS for wastewater treatment, creating one of the largest artificial ground water recharge sources in the state. Ninety percent of the water used for drinking comes from the ground water (Florida Department of Environmental Protection, 2006). It is necessary to take care of this resource to protect public health and the environment.

Excessive nitrogen can have negative effects on public health and the environment. There are various sources of nitrogen pollution: fertilizer from both agricultural and residential land uses; atmospheric deposition; agricultural sources such as livestock, feedlots, and manure; wastewater treatment plants; drainage wells; OWTS; and other sources such as sinking streams. The combined affect from all these sources add up to the total nitrogen load that travels to ground and surface waters.

A focus of recent research on OWTS in the State of Florida has been on the contribution of nitrogen to ground water and surface water bodies. Research has shown that properly installed and maintained OWTS effectively reduce the concentration of pathogens found in normal wastewater, but that nitrogen is reduced to a lesser extent (Ayres Associates, 1993; Sherblom 1998). A recently completed FDOH study looked at how quickly and far effluent and nitrogen from conventional OWTS moves in a karst environment (Florida Department of Health, 2004; Roeder et al, 2005). Karst features are found throughout the state of Florida and are characterized by conduits in the underlying limestone. The study found that effluent tracers moved very quickly and nitrogen concentrations remained high in wells in the effluent plume, illustrating the conduits between the ground surface and the surficial aquifer in karst environments that make them more sensitive to nitrogen pollution.

As the population of Florida increases, development in the state increases. This increase in development has led to an increase in the number of new OWTS and a corresponding increase in the amount of nitrogen contributed by OWTS to the ground water. The largely spring-fed Wekiva River in Central Florida (Figure 1) is an area that is currently evaluating nitrogen impacts from all sources of nitrogen, including OWTS. The Wekiva River Basin ecosystem has been recognized as a valuable natural resource with nineteen springs fed by the Floridan Aquifer. This is a karst environment where the ground surface and the underlying aquifer are interconnected and sensitive to nitrogen pollution (Cichon et al. 2005).

In response to proposed increases in development, the Wekiva River Basin Coordinating Committee (WRBCC) was established in 2003 by then-Governor Jeb Bush. This committee, which included various stakeholders in the area, was tasked to develop recommendations on how to protect the Wekiva River through sound development decisions.

Figure 1. Wekiwa Springs State Park, Source Water for the Wekiva River

The local water management district, St. Johns River Water Management District (SJRWMD) found that the nitrogen levels in the Wekiva River were elevated levels of nitrogen as compared to spring-fed streams without development and to be ecologically imbalanced (Mattson et al., 2006).

By setting total maximum daily loads (TMDL's) EPA has set goals of up to 95% reduction in nitrogen output for springs contributing to the Wekiva River (US EPA 2005). These reductions would allow the nitrogen levels in the river to return to ecologically healthy levels. The SJRWMD report set a pollution load reduction goal to reach up to an 85-percent reduction in the nitrate levels for the springs that contribute the most flow to the river (Mattson et al., 2006).

The WRBCC delineated the Wekiva Study Area (WSA) in August of 2003 (Figure 2) as a planning and legislative approximation of the land area that contributes surface and ground water to the Wekiva River system. The Wekiva Study Area consists of 475 square miles and includes parts of Orange, Seminole, and Lake Counties located in Central Florida. According to information developed by counties and the Florida Department of Environmental Protection, the study area contains over 55,000 OWTS.

The 2006 legislature tasked FDOH and its onsite sewage research review and advisory committee (RRAC) with assessing whether OWTS in the WSA are a significant contributor of nitrogen to ground water as compared to other sources, and if so to recommend cost-effective strategies to reduce this impact. The project was split into four tasks: field work, literature review of expected nitrogen reduction in the drainfield, estimation of nitrogen inputs from all sources in the Wekiva Study Area, and recommendations of a range of cost-effective solutions to reduce the nitrogen impact. The first three tasks were accomplished in cooperation with outside contractors.

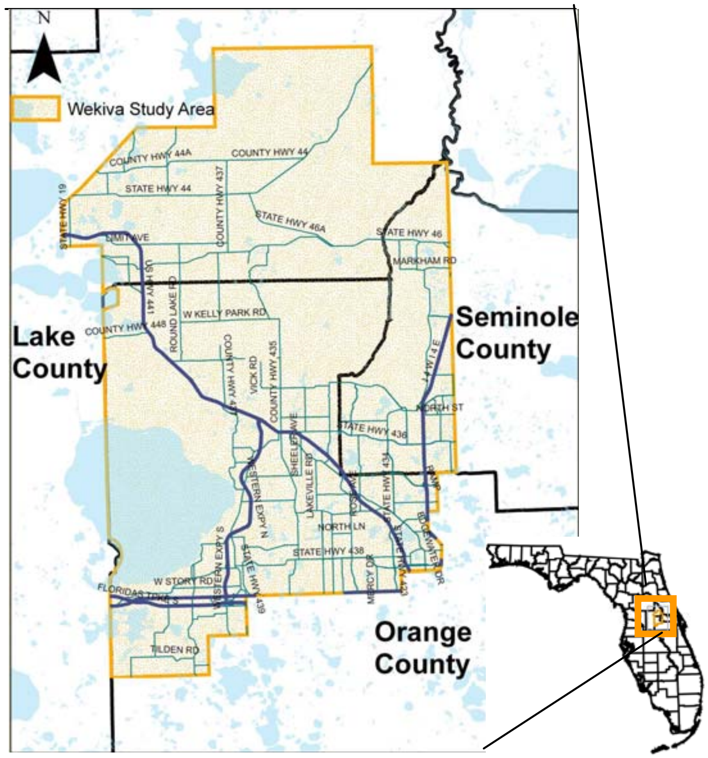

Figure 2. Wekiva Study Area of Central Florida

METHODS

Task 1: Field work

This task was to determine what amount of nitrogen one OWTS contributes to the ground water through performing detailed field sampling. Three systems in the WSA were sampled to determine how much nitrogen comes out of the septic tank, and how much makes it to the ground water. Samples were analyzed in the septic tank and under the drainfield at the top of the ground water table. The effluent plume was also identified as it moved away from the source.

Each of the selected sites met several requirements that included: having one site in each of the three effected counties, a water table that was reachable with the equipment used to sample the ground water, a variety of different water table conditions, minimum and maximum age criteria for the system, the lot size had to be large enough to contain the nitrogen plume, the household fertilizer usage had to be minimal, no availability of reclaimed water for irrigation, and the property was a single-family residence. A Florida licensed master septic tank contractor and county health department staff performed site evaluations for each of the sites to determine the size and location of the existing system. A diagram outlining the field work approach can be seen in Figure 3.

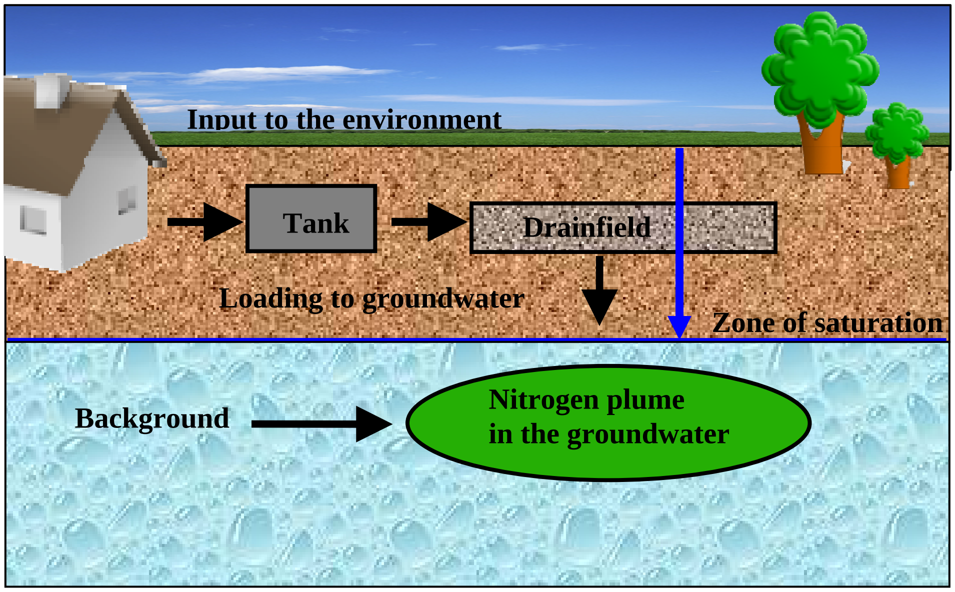

Figure 3. Wekiva Study Field Work Approach

In determining how much nitrogen is released into the drainfield from the septic tank, effluent samples were taken within the solids deflection device at the outlet of the tank. These effluent grab samples were taken at three separate times during the field sampling period and were evaluated for total Kjeldahl nitrogen (TKN), total nitrogen (TN), $CBOD_5$, total suspended solids (TSS), total phosphorus (TP), and several other field parameters. The effluent strength was multiplied with measured flow rates for each house to determine the amount of nitrogen that was discharged to the drainfield.

The ground water flow direction and ground water elevation were estimated utilizing piezometers. Samples of the ground water were taken by direct push technology in strategic locations to best capture the horizontal and vertical extent of the effluent plume in the shallow aquifer and record background concentrations. The field parameters measured were electrical conductivity, dissolved oxygen (DO), pH, temperature, turbidity, oxidation reduction potential (ORP), chloride, total iron, and ferrous iron. The ground water samples were analyzed by a laboratory for total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO_3-N), and total nitrogen (TN). A subset of the samples were analyzed for $CBOD_5$, total suspended solids (TSS), total phosphorus (TP), fecal coliform bacteria, and for nitrogen isotopes to help determine human or other animal versus inorganic sources such as fertilizers. The soil grain size distribution and soil organic content (SOC) was also measured at each of the three sites.

Task 2: Literature review of expected nitrogen reduction in the drainfield

This task was to determine what performance boundaries and categories should be considered to determine what amount of nitrogen one system could contribute to the environment. The denitrification process was broken down to the basic requirements to determine what categories would be important to complete the conversion. Two performance boundaries were considered: what leaves the last treatment component prior to the drainfield and what enters the ground water after treatment in the drainfield and the soil.

Task 3: Estimation of nitrogen input and load in the Wekiva Study Area

This third task was to determine an estimate of the nitrogen input and load in the Wekiva Study Area from OWTS. An input is defined as the amount of nitrogen that is released into the environment. An example would be the amount of nitrogen from a bag of fertilizer applied to the ground surface. A load is the amount of nitrogen that reaches the ground water. An example would be the remaining nitrogen from a bag of fertilizer that reaches the ground water after the plants and the soil have utilized (denitrified) portions of the nitrogen that was originally considered an input. In order to determine the relative significance of the input and load contributions from OWTS in the WSA, the contributions from other nitrogen sources were required. Slightly before FDOH's effort, a contractor for FDEP also performed a literature review study on the nitrogen inputs to the soil from various sources, and this information was used. That study (Tucker and Bidlin, 2007) looked at various sources of nitrate in the Wekiva River Basin and Springshed. This area was slightly larger than the WSA which FDOH addressed. FDEP used total nitrogen (TN) data when nitrate data was not available or reported, and assumed it to be a surrogate for nitrate (Table 1).

Table 1. Nitrogen sources, nitrogen type, and method of calculation considered in FDEP and FDOH studies

Nitrogen Source	FDEP Study	FDOH Study
Industrial, Commercial, and Domestic wastewater from Centralized wastewater facility effluents	• Used nitrate • Reclaimed water used for irrigation, assumed to replace fertilizer use	• Used total nitrogen • Review of FDEP system permit records in WSA, including nitrogen in reuse water, using the actual discharge by the concentration
OWTS effluents	• Used total nitrogen • Obtained estimates from previous FDOH studies	• Used total nitrogen • Used estimates based on the results of this FDOH study
Fertilizer: agricultural (row crop, citrus, nurseries, pasture), residential, golf course, and 'other' (ball fields, roadside, etc.)	• Used total nitrogen • Recommended application rates on pervious land area	• Used total nitrogen • Recommended application rates on pervious land area
Livestock	• Used total nitrogen • Literature values for feedlots and pasture land	• Used total nitrogen • Literature values for feedlots and pasture land
Atmospheric deposition	• Used nitrate • Utilized US EPA's Clean Air Status and Trends Network rural wet nitrate deposition data for the Indian River Lagoon	• Used total nitrogen • Urban literature values for Orlando area for wet deposition, and 30% of total for dry deposition

A second estimate of nitrogen input contributions was obtained by modifying two aspects of the estimate. First, the actual sales of fertilizers in the area and their distribution between farm and non-farm uses were considered. These data are collected by the Florida Department of Agriculture and Consumer Services by county and showed that, given the area of the Wekiva Study Area and the three counties, only about half as much nitrogen was sold as first estimated based on recommended application rates. Secondly, the inputs of nitrogen by OWTS measured in the Wekiva Study Area during Task 1 were included, which were larger than initially assumed.

For FDOH's assessment, inputs and loads were scaled down from the Wekiva River Basin to the Wekiva Study Area utilizing much of the same methodology as FDEP. Total nitrogen values were used for all sources (Table 1). The results of Task 2 were used to obtain a more refined estimate for nitrogen input and loading from onsite systems.

There are over 55,000 onsite systems in the Wekiva Study Area (Figure 4). Both FDEP's study and this study assumed a contribution of 30 lbs/nitrogen leaving the septic tank annually for a typical system. Utilizing GIS, the number of septic systems located in each soil map unit was counted. The estimated nitrogen removal potential from Task 2 was applied to each point to determine a total nitrogen loading estimate for the Wekiva Study Area.

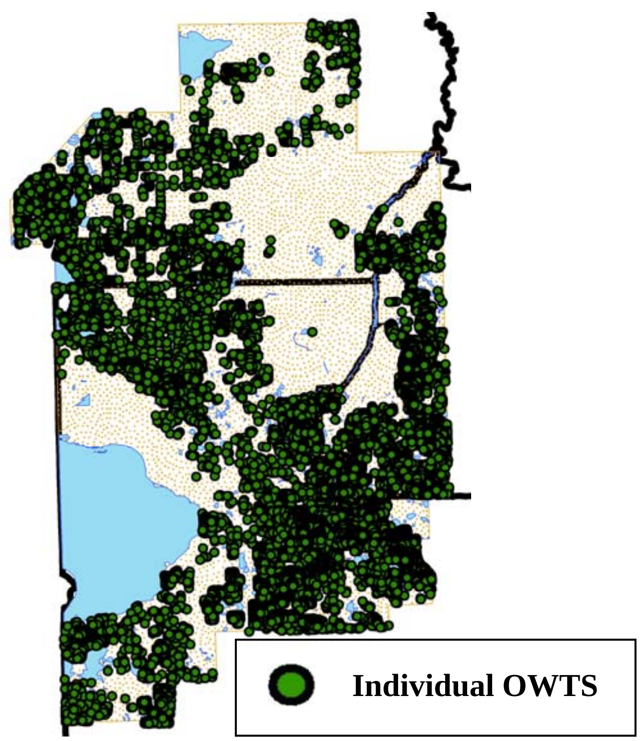

Figure 4. Distribution of Onsite Wastewater Treatment Systems in the Wekiva Study Area

Task 4: Cost-effective solutions to reduce the nitrogen impact

This task was to find cost-effective solutions to reduce any impacts from nitrogen in the WSA. Cost information on construction, operation, and maintenance was gathered from each county in the WSA. The framework built on EPA's voluntary onsite management guidelines (US EPA 2003). Some of the strategies that were researched were providing funding mechanisms for cost-effective projects, to keep the nitrogen loadings the same or lower, evaluating watershed impacts, establishing routine maintenance and inspection programs, and keeping an inventory of location and condition of all systems.

RESULTS

Task 1: Field work

The sample results helped to describe how ground water with an effluent influence behaves as it moves both horizontally and vertically. The wastewater effluent plume in two of the three sites was found not to move in the apparent direction of ground water flow. One possible reason for this could be the underlying discontinuous layers of clay in the soil.

The estimated nitrogen input per capita leaving the septic tank varied between 7.3 and 14.7 pounds per person per year. This can be compared to previous literature ranges from between 7.3 to 17.5 pounds per person per year (Crites et al., 1998) and 4.8 to 13.7 pounds per person per year (US EPA, 2002). The average household size of 2.6 in the Wekiva Study Area leads to an estimated input of a typical septic system of 29 lbs/year.

The nitrogen plumes were identified at all three sites, and electrical conductivity was found to be the best tracer to determine the extent and direction of movement of the effluent plume. All three sites found nitrogen concentrations exceeding 10 mg/L to depths of approximately ten to fifteen feet below the ground water table. Plumes traveled horizontally. Reduction in concentrations as a result of either denitrification or dilution was observed directly below the drainfield and diminished at further distances. Anderson (2006) summarized earlier literature and estimated that between 50 to 90 percent of nitrogen from onsite systems is loaded to the ground water. The field study found, based on the concentration reduction between septic tank effluent and shallowest ground water samples, that approximately one-half to three-quarters of the nitrogen input from the septic tank was loaded to the shallow ground water (Figure 5).

On a per capita basis, the mass loading of nitrogen to the ground water ranged from 3.95 to 9.65 pounds per person per year. This resulted in a mid-range of about 17 lbs nitrogen per year per system.

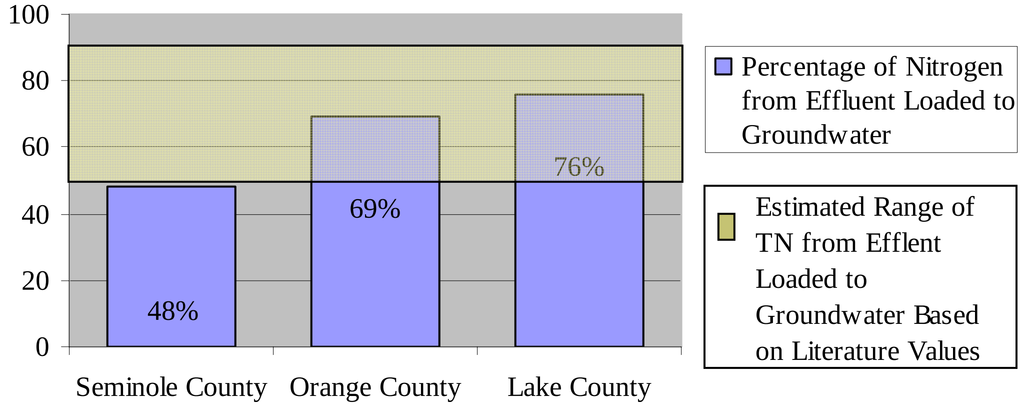

Figure 5. Percentage of Nitrogen from Effluent Loaded to the Ground Water in the Wekiva Study Area from each of the Field Sites

Task 2: Literature review of expected nitrogen reduction in the drainfield

The results of the literature review indicated that two of the main factors influencing nitrogen loading to ground water are the level of pre-treatment prior to release to the drainfield, and the soils underneath the drainfield.

If the amount of nitrogen is reduced in pre-treatment, then the corresponding nitrogen load to the ground water is also reduced. There are two ways to reduce the nitrogen in pre-treatment: by reducing the amount of nitrogen in the raw wastewater coming in, and by adding additional treatment processes prior to release in the drainfield. Nitrogen levels can be reduced up to 75-percent in pre-treatment with commonly available technologies.

Soil factors that appeared important for nitrification/denitrification were depth to the zone of saturation, organic content in the soil, and drainage class. In Florida, some of the requirements for a new drainfield include that it cannot be installed lower than 30-inches below the ground surface, a 24-inch separation is required from the bottom of the drainfield to the estimated wet season zone of saturation, and the organic horizon of the soil is required to be removed. The literature survey indicated that the depth to the zone of saturation under the drainfield can influence the amount of nitrogen that is loaded to the ground water. A traditional drainfield could have a nitrogen removal range between 0 – 35-percent. Having a mounded drainfield increases the nitrogen removal potential, and having a low-pressure dosed system or a sand filter increases this potential further.

The amount of organic content in the soil can aid in denitrification by feeding heterotrophic bacteria which convert nitrogen in nitrified wastewater to nitrogen gas. The drainage class describes how quickly water moves in the soil. For excessively drained well aerated soils, in which a majority of the OWTS in the WSA are installed, plenty of air is available to nitrify the effluent but these types of soil do not provide much organic matter to denitrify the nitrified effluent, and also have a very short retention time. For poorly drained soils that are oxygen deficient there is plenty of organic matter to denitrify the effluent, but if the effluent is not nitrified first it cannot be denitrified. Therefore, it is important to assure conversion of nitrogen to the nitrate form to allow denitrification, such as by maintaining at least a two foot separation from the bottom of the drainfield to the estimated seasonal high zone of saturation.

The literature survey showed that soils cannot be completely relied on to nitrify and denitrify. The best conditions for denitrification are that the zone of saturation is no deeper than 3.5-feet below grade and that there is a good chance of finding organic content in the soil. The estimated nitrogen removal potential in soils found in the Wekiva Study Area based on this classification ranged between 0 – 100-percent with an average of 33-percent.

Task 3: Estimation of nitrogen inputs in the Wekiva Study Area and determination of significance

An estimate was calculated for each individual nitrogen source, and is shown in Figure 6. The estimates were based on the calculation methods outlined in Table 1 for FDOH. In this scenario 71% of inputs are estimated to come from fertilizer sources, and 6% of inputs are estimated to come from onsite systems.

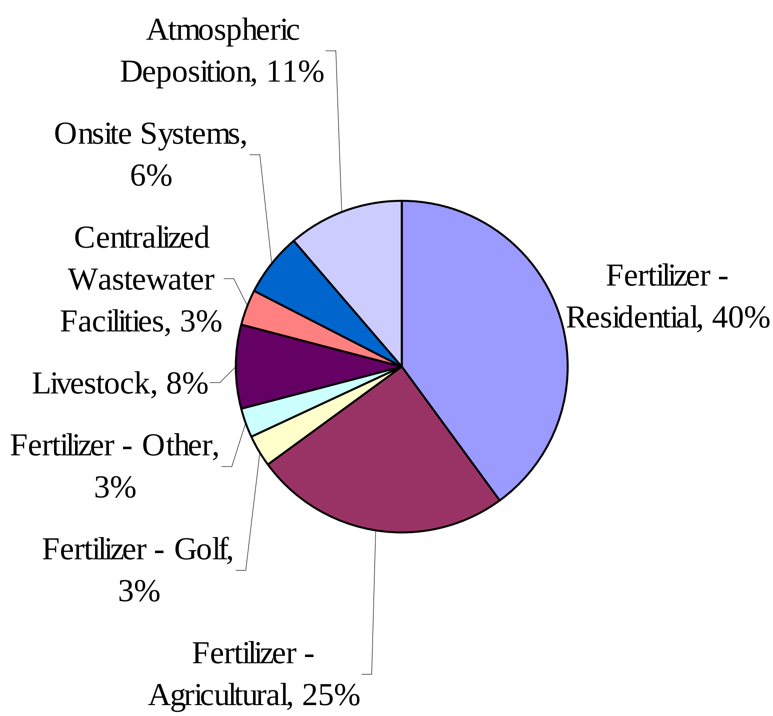

Figure 6. Nitrogen Inputs to the Wekiva Study Area by Source from FDOH Report Utilizing Recommended Application Rates for Fertilizers, Total is 18-Million Pounds per Year

The revised estimates, including fertilizer sales information (about half) and the results of the field study on inputs from onsite systems (29 vs. 20 lbs/year), is shown in Figure 7. 54% of nitrogen inputs are estimated from fertilizer and 12% from onsite systems.

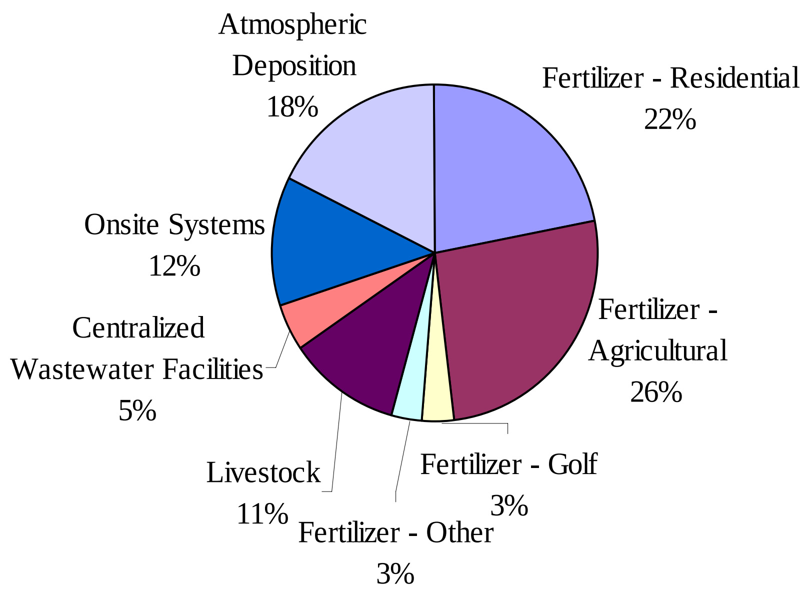

Figure 7. Revised Nitrogen Inputs to the Wekiva Study Area by Source. Changes are Due to Consideration of Fertilizer Sales and OWTS Field Measurements (29-Pounds per Year per System), Total is 13-Million Pounds per Year

The loading to ground water from OWTS was calculated based on the information gathered in Task 2 and overlaying it with soil GIS information specific for the WSA. A comparison between the calculated inputs and the medium soil-specific loading estimates indicated an 18% reduction in the nitrogen between the septic tank and the ground water table. The resulting average load for systems in the Wekiva Study Area (16 lbs/yr) is similar to the average load estimated from the observed OWTS nitrogen inputs and somewhat larger observed nitrogen losses (40% on average) during the field work (17 lbs/yr). Within the time frame of the study methodological issues about how to estimate ground water contributions by other sources were not resolved.

In order to determine whether OWTS are a significant contributor of nitrogen to the ground water the criteria used to determine *significance* need to be defined. Two approaches were considered: determining if the contribution is significant as compared to other sources, or determining if the contribution is significant to reach springs protection levels. The first approach was precluded because no consensus on the nitrogen contribution to loads from other sources was reached. Therefore, the approach was taken to look at springs protection levels. That nitrogen pollution of the ground water and surface water in the Wekiva Study Area occurs has been demonstrated by work leading to pollution load reduction goals by St. Johns River Water Management District (SJRWMD) and total maximum daily loads by the Florida Department of Environmental Protection (FDEP). There is no one entity that is the main contributor of nitrogen in the WSA. Instead, many people, though classified into broad categories, contribute small amounts of nitrogen individually that cumulatively result in the estimated inputs and loadings. Nitrogen impacts overall are significant so all contributing sources will need to do something to meet these goals.

Task 4: Cost-effective solutions to reduce the nitrogen impact

In order to determine the most cost-effective solution to reduce the impact of nitrogen, given that it is a cumulative impact, there has to be a mechanism to prioritize and categorize. One method of categorization would be to look at nitrogen that is entering the environment. This would result in fertilizers being the main contributor, next would come atmospheric deposition, and then wastewater. The focus could also be on the different land uses from which the nitrogen originates. The largest human influenced land use in the WSA is residential followed by agricultural, so addressing nitrogen from residential and agricultural land uses would be most important.

An important component to any program is developing a funding mechanism. Two funding mechanisms were proposed: establishment of a grant program to solicit cost-effective nitrogen reduction projects from any nitrogen source funded by all source contributors, and establishment of wastewater management entities that are funded by onsite system owners to reduce nitrogen load. The first mechanism will require a great deal of cooperation between all nitrogen source contributors and may lead to the most cost-effective way to reduce nitrogen impacts as a whole. The latter of the two can be an existing utility, new management entity, or a county health department that provides grants or loans to upgrade systems. This mechanism can provide the most cost-effective wastewater solutions to reducing nitrogen, or if used in conjunction with the first mechanism, can provide the best option to resolving the nitrogen issue in the WSA.

The costs to system owners will vary on which strategies are implemented. If everyone on an OWTS in the WSA contributes $60 per year per system, this could fund an area-wide grant program for nitrogen reduction, such as upgrades to wastewater treatment plants. If this cost is increased to $200 per year per system a program to upgrade failing systems to provide nitrogen reduction by pretreatment could be implemented. Alternatively, each system owner will be individually responsible for nitrogen reduction.

Another important component for a comprehensive program to reduce nitrogen impacts is to have an accurate inventory of all OWTS. This helps to identify sensitive or densely populated areas that may be better suited for connection to centralized sewer. A large number of OWTS in the WSA were installed prior to the current rule requirements, which in some soil types makes it very likely that they were not installed with a proper separation to the ground water table, increasing the nitrogen load.

A further consideration is the rate at which upgrades to existing OWTS are implemented. One option, which is currently followed in Florida, is that upgrades are only required whenever the system needs a new, repair, or modification permit after failure or changes to the original permit conditions. Another option could be a requirement to upgrade every system within a certain number of years.

Reducing nitrogen loads from OWTS will grow in importance because the Wekiva Study Area is growing in population leading to additional OWTS. These new OWTS add to the existing load. New systems can be installed with reductions in the amount of nitrogen they discharge. Compared to an aerobic treatment unit (ATU)-requirement without specifying nitrogen reduction levels, a more cost-effective level of nitrogen reduction for OWTS is 70%. Existing systems that are in need of repair or modification can be upgraded to meet current setback standards. This results in some reduction of nitrogen loads from systems that are currently so close to the ground water that no reduction occurs. Based on soil types and ages of buildings, about 5-10% of systems in the WSA could be in this category, in which no reduction of input occurs instead of approximately 40% found during the field work.

Figure 8 illustrates the impact of different management strategies on nitrogen loads from OWTS in the future based on permitting trends in 2000-2005.

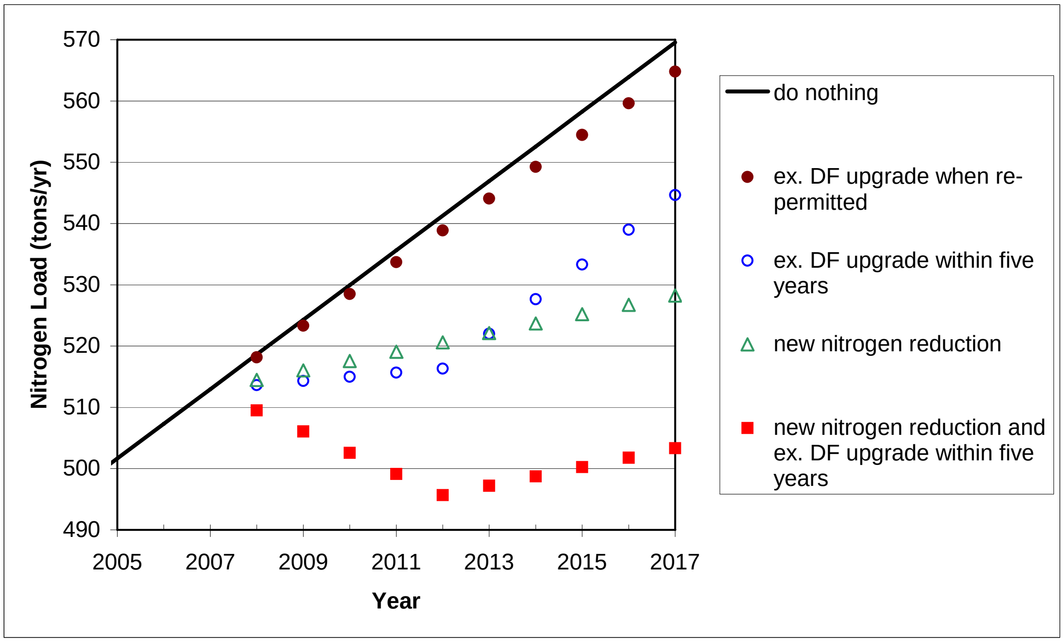

Figure 8. Nitrogen Load Projections for the Wekiva Study Area from Onsite Wastewater Treatment Systems

DISCUSSION

The amount of nitrogen pollution in the WSA was assessed in this study. In forested areas, where the major source of nitrogen is atmospheric deposition, the background levels were generally 0.1 mg/L (Tucker and Diblin, 2007). Field work performed in this study showed background nitrogen levels in residential areas to have an average concentration of 1-2 mg/L. Approximately ten times this level was found in the well defined effluent plume underneath OWTS.

By necessity, an estimate of inputs and loads based on average behavior allows for some variation in the determined input and load contribution from onsite systems. This assessment does not include processes once it is in the ground water prior to discharge at the spring. The FDEP estimate of loads was based on an average of literature values and came to 14 pounds per year per system. The Task 1 field work estimate was based on an average of three sampled sites and came to 17 pounds per year per system. The Task 2 and Task 3 estimates were based on soils and system construction and came to 16.3 pounds per year per system.

Medium density residential, with 2-5 dwelling units per acre, is where most of the OWTS are located in the Wekiva Study Area. This type of land use is increasing, whereas agricultural types are deceasing. This study finds that the contribution of nitrogen from OWTS in medium density residential areas to the underlying aquifer is significant. The relative impact of OWTS as compared to other sources has not been determined, but when comparing to springs protection goals efforts should be made to reduce nitrogen from OWTS as well as other sources of nitrogen. All nitrogen contributors must work together to reduce impacts. The combined effect of fertilizers reveals that they are a major source of nitrogen pollution in the WSA. Onsite systems are not the major source of nitrogen input, but are similar to livestock and centralized wastewater. The solution to reducing nitrogen impacts to the ground water and the springs is to address all sources, with fertilizers being one of the most critical to tackle. FDEP is planning to conduct a field assessment to determine impacts from the residential use of fertilizer in more detail in the next year.

The soil cannot be relied on by itself to significantly reduce nitrogen levels. Adding a mechanism to reduce nitrogen prior to discharge to the soil can be an effective method of achieving nitrogen reduction goals. A previous FDOH study in the Florida Keys (Anderson et al., 1998) demonstrated that nitrogen can be reduced significantly through implementation of performance based standards. Proper operation and maintenance is critical to ensure that these systems continue to perform at the intended levels.

Several recommendations have been made as a result of the study. One is to set a nitrogen discharge fee for all sources to fund cost-effective projects. This will allow for a cost-effective method to target key issues. The establishment of a maintenance program is another recommendation. This program can either be similar to the US EPA Model 4 program (US EPA 2003) where a utility collects fees to provide maintenance, repairs, upgrades, and sewer connections; or to require that all systems have an operating permit, and be inspected and pumped a minimum of once every 5-years. A portion of any fees can be used to fund a grant program for low-income home-owners. Another recommendation is to eliminate grandfathering provisions for older systems as it relates to minimum lot sizes and surface water setbacks. All existing systems needing repair or modification should be upgraded to new system requirements for separation to water table and surface water setbacks. New systems add nitrogen and nitrogen reducing systems will help reduce this. All new systems should be performance based with nitrogen reduction to a level of 10 mg/L or a 70% reduction of nitrogen from raw wastewater as compared to treated wastewater. All onsite systems should be inventoried to help locate areas with older systems closer to the water table and assess the overall impact. The prohibition of land spreading of septage is another recommendation. Finally, the economic feasibility of sewering high density areas should be considered. Implementation of these recommendations will reduce OWTS impacts in the Wekiva Study Area.

This study combined information gathered through reviewing existing literature and field work to evaluate how nitrogen behaves in OWTS, the soil, and the ground water; and what the overall contributions of nitrogen by OWTS to groundwater are. As a result of this study, rule language has been proposed to achieve the recommended changes.

ACKNOWLEDGMENTS

The Florida Department of Health would like to thank the following people for their hard work and valuable insight on this project: the FDOH Research Review and Advisory Committee; Mark Mechling with Ellis & Associates, Inc.; Dr. Richard Otis with Otis Environmental Consultants, LLC; Dr. Linda Young with the University of Florida, Dr. William Tucker with MACTEC; Rob Mattson with the St. Johns River Water Management District, the staff at the Department of Environmental Protection, Damann Anderson with Hazen and Sawyer; and the many other people that contributed. Their assistance was invaluable.

LITERATURE CITED

Anderson, D.L., M.B. Tyl, R.J. Otis, C. Hamilton, T.K. Stevik, P. Fourie. 1998. *Florida Keys onsite wastewater nutrient reduction systems demonstration project*. Final report to the Florida Department of Health with funding from US EPA cooperative agreement X994393-93-0. Tallahassee, FL.

Anderson, D.L. 2006. *A Review of Nitrogen Loading and Treatment Performance Recommendations for Onsite Wastewater Treatment Systems (OWTS) in the Wekiva Study Area*. Report prepared for the Florida Home builders Association. Hazen and Sawyer, P.C. Tampa, FL.

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. Tallahassee, FL.

Crites, R. and G. Tchobanoglous. 1998. *Small and decentralized wastewater management systems*. WCB McGraw-Hill. Boston, MA.

Florida Department of Environmental Protection. 2006. *Integrated water quality assessment for Florida: 2006 305(b) report*. Tallahassee, FL.

Florida Department of Health. 2004. *Manatee Springs onsite sewage treatment and disposal system study: phase I*. Final report to EPA Gulf of Mexico Program under cooperative agreement MX984888. Bureau of Onsite Sewage Programs, Eberhard Roeder comp. Tallahassee, FL.

Florida Department of Health. 2007. *Nitrogen impact from onsite sewage treatment and disposal systems in the Wekiva Study Area*. Report to Governor Charlie Crist compiled by

Briggs, G.R., E. Roeder, and E.L. Ursin. Tallahassee, FL. http://www.doh.state.fl.us/environment/ostds/wekiva/task.htm

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: report to the Florida Department of Environmental Protection by the St. Johns River Water Management District. Palatka, FL.

Roeder, E., C.H. Harden, J. Chanton, and M. Hooks. 2005. Where does it go? Effluent transport in karst observed at two onsite sewage systems. In: Proceedings of the NOWRA Annual Meeting. NOWRA, Edgewater, MD.

Sherblom, P. 1998. *Lysimeter research management and support.* Report to the Florida State Department of Health Onsite Sewage Program under contracts LPB85 and LPD01. Tallahassee, FL.

Tucker, W.A. and M. Diblin. 2007. *Phase 1 report Wekiva River Basin nitrate sourcing study*. Prepared for the Florida Department of Environmental Protection and the St. Johns River Water Management District by MACTEC, Newberry, FL.

US EPA. 2002. *Onsite wastewater treatment systems manual.* EPA/625/R-00/008. US Environmental Protection Agency, Office of Water. Washington, D. C.

US EPA. 2003. *Voluntary guidelines for management of onsite and clustered (decentralized) wastewater systems*. EPA/832/B-03/001. US Environmental Protection Agency, Office of Water. Washington, D. C.

US EPA. 2005. *Total maximum daily load (TMDL) for nutrients in Wekiwa Spring (WBID 2956C), Rock Springs Run (WBID 2967), and Volusia Blue Spring (WBID 28933), Middle St. Johns River Basin, Florida.* Report by U.S. Environmental Protection Agency Region 4, Atlanta, GA. vi, 17 pp., 1 Appendix.