Nitrogen Impact of Onsite Sewage Treatment and Disposal Systems in the Wekiva Study Area

June 30, 2007

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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.

Introduction

This report was prepared for the Governor, President of the Senate, and Speaker of the House in accordance with the following provisos in the 2006 Appropriations Act:

> From the funds in Specific Appropriation 566, $250,000 in non-recurring tobacco settlement funds are provided to the Department of Health to conduct or contract for a study to further identify and quantify the nitrogen loading from onsite wastewater treatment systems (OWTS) within the Wekiva Study Area. The objectives of the study shall be determined by the department's Research Review and Advisory Committee, which shall also have oversight of the study. The department shall provide a report to the Executive Office of the Governor, President of the Senate, and the Speaker of the House of Representatives no later than June 30, 2007. The report shall assess whether OWTS are a significant source of nitrogen to the underlying groundwater relative to other sources and shall recommend a range of possible cost-effective OWTS nitrogen reduction strategies if contributions are significant.

Onsite Sewage Treatment and Disposal Systems (OSTDS) are an alternative to centralized wastewater treatment systems in the state of Florida. These systems are regulated by the Florida Department of Health (FDOH) under 381.0065, Florida Statutes, to ensure their installation and use does "not adversely affect the public health or significant degrade the groundwater or surface water." Approximately 1/3 of the population of Florida is served by OSTDS. Onsite systems are one of the largest artificial groundwater recharge sources in the state. Approximately 92% of Florida's drinking water comes from the groundwater.

Nitrogen is a common element that occurs in different forms in our environment: nitrate, ammonia, organic nitrogen, and relatively inert nitrogen gas. A brief review of the fate of nitrogen in the environment is given in the task 2 report (Appendix B). Too much nitrogen in an aquatic system can cause ecological changes, such as excessive algae growth, which can affect fish and other aquatic life. Too much nitrate in drinking water causes health effects, particularly in infants. Based on prior research the department has assumed that conventional onsite systems discharge approximately 20 pounds of nitrogen per year to the drainfield, which equates to about four bags of 10-10-10 fertilizer (Anderson, 2006).

Much of Florida's geology is characterized by karst features, limestone that has been partially dissolved to create sinkholes, cracks, and caves. These features are pathways for groundwater and pollutants to enter the aquifer. Spring flows from the Floridan Aquifer contribute 64% of the base flow for the Wekiva River (FDEP 2003). To quantify the vulnerability for contamination of the Floridan Aquifer in the state of Florida, the Florida Geological Survey (FGS) developed a geographic information system (GIS) map that considers karst features, confining layer thickness and soil permeability, and pressure difference between the surficial and Floridan Aquifer. This map is known as the Floridan Aquifer Vulnerability Assessment (FAVA). In 2004, the FGS developed a refined map, the Wekiva Aquifer Vulnerability Assessment (WAVA), specific to the Wekiva area. This map shows three different levels of concern: primary (more vulnerable), secondary (vulnerable), and tertiary (less vulnerable). The areas with very well drained soils generally are in the primary areas and reflect how quickly water from the surface can make it to the aquifer.

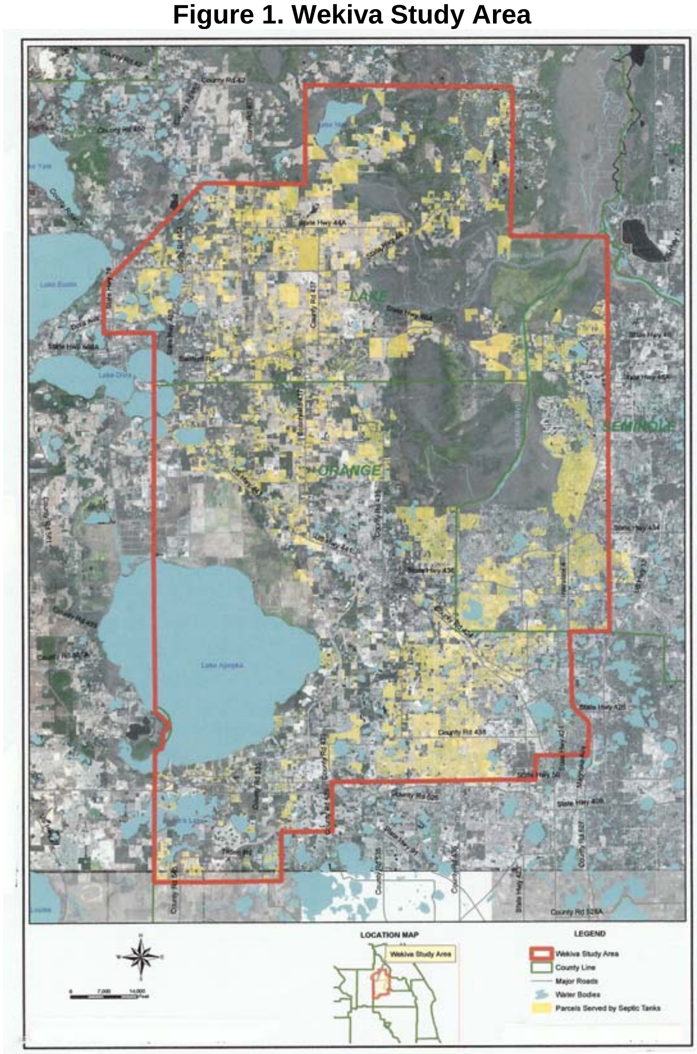
The Wekiva River, located in central Florida, is designated an Outstanding Florida Water, a State Canoe Trail, and has recently been added to the federal Wild and Scenic Rivers program. The majority of the source water for this river is from Wekiwa Springs and Rock Springs.

Background

In June of 2004, the Wekiva Parkway and Protection Act was signed into law, linking the relationship between development of the Wekiva Parkway and the preservation of the Wekiva River System. This act was a regional collaborative approach. Each agency was tasked to look at their specific issues and report their outcomes to the Wekiva River Basin Commission, which was established to ensure implementation of the legislation.

The Wekiva Study Area (WSA) represents an approximation of the area that impacts the Wekiva River System. While not identical to either the area that contributes water to the springs (springshed) or the area that contributes water to the river (watershed) it covers most of those areas (Tucker and Diblin, 2007). The Wekiva Study Area consists of approximately 304,000 acres and incorporates parts of Lake, Orange, and Seminole counties in central Florida as shown in Figure 1.

Figure 1. Wekiva Study Area



The Florida Department of Health was tasked in 2004 to study how effective current onsite system standards are at achieving nitrogen reductions that will protect groundwater quality. The department reviewed past research projects done in the state of Florida. These results indicated that properly sited and constructed conventional onsite sewage systems work very well at removing disease-causing organisms; but that they are less effective at removing nutrients such as nitrogen. A recently completed study at Manatee Springs (FDOH, 2004) indicated this is especially true in karst environments like the WSA.

2006 Study Approach Task Summaries

The 2006 study approach was developed through several public meetings of the department's Research Review and Advisory Committee (RRAC), incorporating input from industry experts and the general public. The project was split into four tasks. The first task and core element was a detailed field sampling (Appendix A) within the WSA to determine the amount of nitrogen that makes it to groundwater from an onsite system. The questions that the field work portion of the Wekiva project addressed were how much nitrogen comes out of a septic tank (input into the environment) and how much nitrogen makes it to the groundwater (load to groundwater). The load to groundwater was accomplished by analyzing samples taken underneath a drainfield at the top of the water table and in the shallow groundwater. Three onsite systems serving single-family residences were assessed. Each site location was within the boundaries of the WSA and chosen based on a comprehensive list of criteria that RRAC developed. Samples were also taken to characterize the effluent plume as it moved away from the onsite system. The field work was designed to give a better understanding of what one onsite system in the WSA contributes to the groundwater and whether this contribution is different from literature values.

A second task (Appendix B) of the project 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 (e.g. drainage class, depth to saturated zone, and soil organic content) and wastewater characteristics (applied nitrogen species) on nitrogen loading to the groundwater. The study resulted in a range of estimated fractions of nitrogen removal as a function of soil characteristics and system type.

In a third task (Appendix C) a refined estimate for onsite systems nitrogen contributions was integrated with the input and loading estimates from other sources (wastewater treatment facilities, residential fertilizers, commercial fertilizers, etc.) Estimates for other sources were based on a recent study for the Florida Department of Environmental Protection and St. Johns River Management District (Tucker and Diblin, 2007) for the combined springsheds and river basins that contribute water to the Wekiva River. The result was an estimate of the fraction of overall nitrogen input that came from onsite systems and how much nitrogen loading to the groundwater came from onsite systems.

The fourth task (Appendix D) consisted of the development and discussion of a range of cost-effective solutions for consideration if contributions of nitrogen from onsite systems were found to be significant. RRAC advised the department staff to prepare a report for this task. Staff presented updates on the progress on this task at RRAC meetings. The RRAC decided at the June 2007 meeting that they would not take action on this task until completion of the second phase of FDEP's study.

Task 1: Multiple Nitrogen Loading Assessments from Onsite Waste Treatment and Disposal Systems within the Wekiva River Basin

The first task was to collect Wekiva Study Area specific field data from groundwater around OSTDS drainfields. The criteria for site selection, as determined by the Research Review and Advisory Committee included one site in each county, a water table shallow enough for sampling, a variety of water table conditions, system age, lot size, minimal use of fertilizer, no use of reclaimed water for irrigation, public water, and a single family residence. Three sites were selected that fully met the criteria with the exception of the Lake County site having an onsite well, which was metered during the study period.

The department obtained several existing geographic information system (GIS) data files which included information on parcels, subdivisions, Wekiva Aquiver Vulnerability Assessment, sewer connections, onsite systems, soil maps, and depth to groundwater. These were combined in a GIS project used by the department to provide a list of potential subdivisions with lots meeting the selection criteria, and given to the provider (Ellis & Associates, Inc.) The provider contacted residents within these subdivisions to solicit volunteers. The estimates from the GIS data were field verified.

The sites were sampled and the methods and results are described in Appendix A. Piezometers were used to measure the groundwater levels and to help select suitable background sampling locations. Direct push technology was used to measure the groundwater quality to identify the wastewater plume both vertically and horizontally. This helped to show how groundwater that has been influenced by wastewater behaved as it moved down-gradient from the source. The effluent in the septic tanks at the three sites that were investigated had concentrations of nitrogen that fell within the expected range. The mass of total nitrogen that flowed into the drainfield was larger than previously estimated for the Seminole and Lake county sites and within the expected range for the Orange County site. If one adjusts the observed nitrogen inputs to the average household size of 2.6, the estimate for the yearly nitrogen input per system becomes 19, 37, and 38 pounds per system in Orange, Seminole, and Lake county, respectively, with a mid-range of about 29 pounds of nitrogen.

Ellis & Associates, Inc. performed mass loading calculations based on observed nitrogen concentrations. These calculations indicated that some nitrogen removal, presumably due to nitrification/denitrification, is taking place. Previous reviews of the literature have indicated that about 50 – 90% of the total nitrogen leaving the onsite system reaches the groundwater as nitrogen load. The Seminole County site was estimated to load 68%, or 9.7 pounds of total nitrogen (TN) per person per year, with 32% being removed. The Lake County site was estimated to load 48%, or 7.1 pounds TN per person per year, with 52% being removed. The Orange County site was estimated to load between 54 - 77%, or between 4.0 – 5.6 pounds TN per person per year, with between 23 - 46% being removed.

In summary, between half and three quarters of the nitrogen from the onsite systems was found in the shallow groundwater. The field results allow an estimate of the nitrogen load that comes from a typical onsite system in the Wekiva Study Area. Using the Ellis & Associates estimate for Lake County as an intermediate case and an average of 2.6 people living in a home, the yearly load of nitrogen to groundwater is about 18 pounds of nitrogen. This is more than the 14 pounds used in the loading estimates by MACTEC (Tucker and Diblin, 2007).

Task 2: Categorization and Quantification of Nitrogen Loading from OSTDS Types

The purpose of this task was to determine which criteria are important to determine loading from onsite systems to the groundwater in the Wekiva Study Area. Two performance boundaries were considered: the end of the last treatment system component prior to discharge to the drainfield, and the groundwater boundary after the wastewater has passed through the unsaturated zone of the soil.

Otis Environmental Consultants, LLC, developed a table, utilizing existing literature data, which outlines the various soil series found in the Wekiva Study Area. This table included the soil's drainage class, the depth to saturated conditions, and the availability of organic materials. The drainage capacity of the soil can be related to how permeable the soil is and how long the soil is likely to remain unsaturated. The drainage classes were subdivided into excessively or somewhat excessively drained, well drained, moderately well drained, and somewhat poorly or very poorly drained. Soils that are saturated do not allow air to get to the wastewater, which does not allow nitrogen to convert from the organic and ammonia forms to the nitrate form. The depth to saturated conditions was split into two categories: less than 3.5 feet and greater than 3.5 feet. The more organic material available to the wastewater, the more likely it is that nitrate will be removed. The estimated total nitrogen removal potential for each of the listed soil series was calculated with this information.

The amount of nitrogen that eventually makes it to the groundwater is dependant on the amount of nitrogen that enters the drainfield. Two factors influence the nitrogen entering the drainfield: the nitrogen content of the raw wastewater and whether there is additional treatment before discharge. Approximately 80% of the nitrogen from raw domestic wastewater comes from toilet wastes. An additional treatment step, such as a specialized aerobic treatment unit, would convert the nitrogen from the ammonia form to the nitrate form. If after such pretreatment and discharge to the drainfield the underlying soils contain organic matter and provide for unsaturated and then saturated conditions, nitrate in wastewater can be more readily converted to nitrogen gas.

Soils that have a very deep water table contribute to very little denitrification due to organic matter being oxidized before it makes it to the groundwater. The wastewater will also not be nitrified well in soils that have a very shallow water table with less than two feet separation from the estimated seasonal high water table. If the soil has both a dry and wet zone there is a greater potential for denitrification. The soils found to have the greatest potential for denitrification were found to be moderately well drained to very poorly drained soils that have a fine loamy texture with clay fines, a shallow water table, and have some organic matter present deeper in the soil profile. If the estimated seasonal high water table is at 3.5 feet below grade or greater, and a two foot separation is maintained from the bottom of the drainfield to the estimated seasonal high water table, then nearly complete denitrification of the nitrogen in the applied wastewater can be expected.

The design of the drainfield also plays an important role in converting the nitrogen. Both the O-horizon and the A-horizon of soils have a high level of organic matter. If the drainfield is installed below the upper soil layers with a high level of organic matter, the system does not benefit from these layers. At-grade and mound systems could possibly utilize this organic matter, but the current department rule requires the removal of these upper layers and any severely limited soils to allow the wastewater to drain.

Appendix B lists the estimated denitrification potential of the soils found in the Wekiva Study Area. A range of removal potentials are given. The estimated total nitrogen removal potential ranged from 0 to 100 percent removal, depending on the soil series, with a median value ranging from 10 to 30 percent removal.

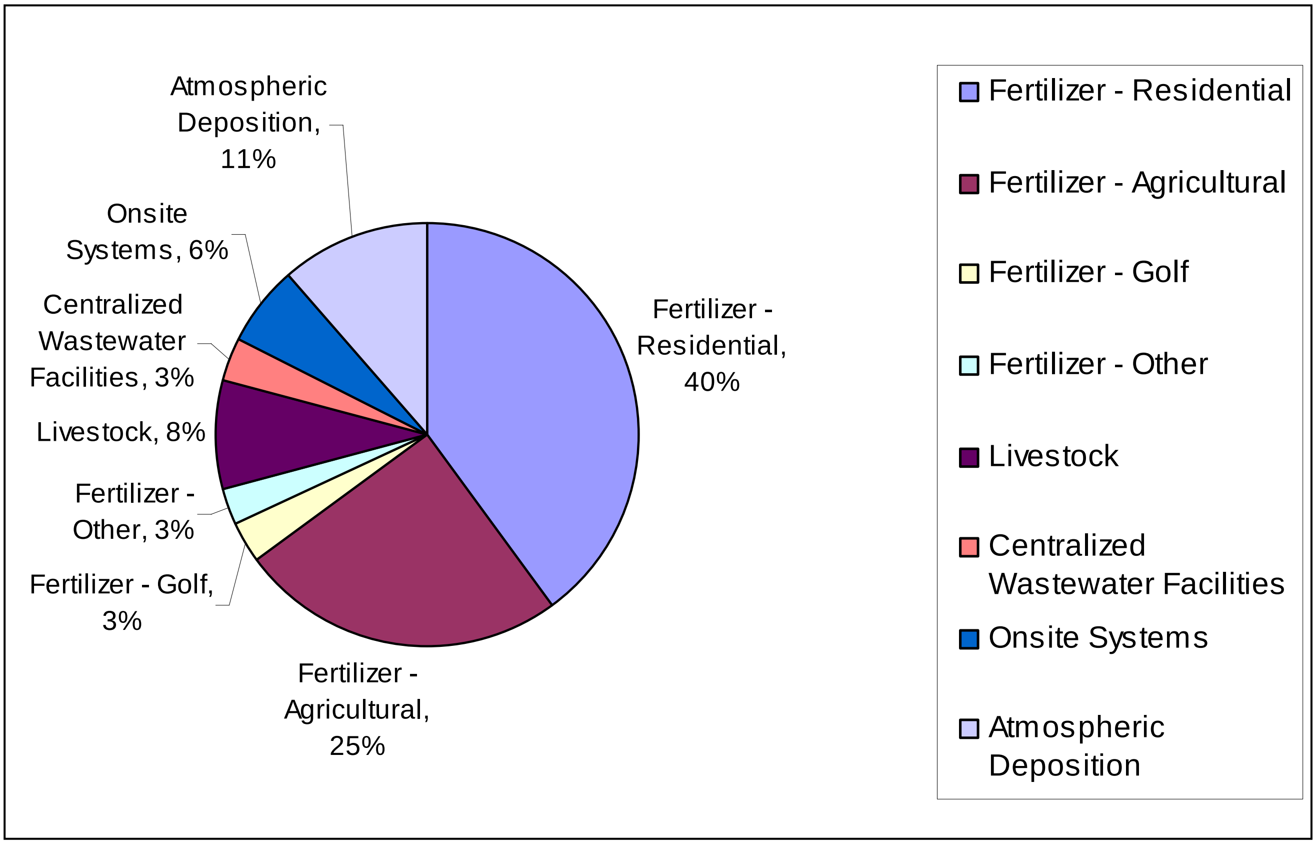
Task 3: Assessment of Contributions of Onsite Sewage Treatment and Disposal Systems Relative to Other Sources

The third task was to determine whether onsite systems are a significant source of nitrogen to groundwater relative to other sources. The provider (Dr. Young of the University of Florida) first determined which categories would be of importance to illustrate the factors that influence nitrogen input and loading to the groundwater. She then worked in coordination with Dr. Otis to determine the selected categories. They were drainage class, water table class, organic matter class, soil series taxonomy, applied nitrogen, and estimated total nitrogen removal potential. Dr. Young utilized existing GIS data to count the number of septic systems in each category. Then, she calculated the nitrogen input from each category and the load to the groundwater.

Dr. Young coordinated with MACTEC, a consultant for the St. Johns River Water Management District, who was tasked to identify and quantify sources of nitrogen loading in the Wekiva River Basin for the FDEP. The Wekiva River Basin has a different boundary than the Wekiva Study Area, so all estimates from MACTEC were adjusted. The MACTEC report (Tucker and Diblin, 2007) considered total nitrogen in their estimates for all sources such as septic systems and fertilizer inputs, but considered nitrate only for atmospheric deposition, effluents from centralized wastewater facilities, and stormwater. Wastewater reuse was assumed to substitute for fertilizer. Based on comments received since the release of the MACTEC report, Dr. Young adjusted the input for atmospheric deposition utilizing total nitrogen data from the Orlando area, included available flow and total nitrogen concentration data for centralized wastewater facilities and incorporated reuse of wastewater in the centralized wastewater estimates. Total nitrogen inputs were estimated to be 18 million pounds per year. Fertilizer was estimated to account for 71 percent of all inputs. Inputs to the environment from onsite systems in this scenario constitute 6 percent of the total.

The estimate of fertilizer inputs was based on recommended application rates, while other inputs were more closely related to literature values of observed inputs. A large difference exists between fertilizer sales data from the Department of Agriculture for fiscal year 2004-2005 and these estimated application rates. About twice as much fertilizer is estimated to have been used than was actually sold in 2004/2005. Based on sales data, the contribution by fertilizer inputs could be overestimated by a factor of two. If adjustments are made based on the sales data this reduces fertilizer contributions to 53% and increases onsite system contributions to 13%. Figure 2 shows the percentage of inputs to the environment using the recommended application rates for fertilizers.

Figure 2. Total Nitrogen Inputs to Wekiva Study Area by Source



MACTEC's approach to determining the loading of nitrogen to groundwater consisted of the following: Literature values of concentrations of shallow groundwater under different land uses, stormwater concentration from different land uses, and wastewater were multiplied by estimated flows for each transport mechanism and then further distinguished by land use. Two concerns in the implementation of this approach were not resolved within the time frame of this study. The MACTEC report was not consistent in its use of nitrate or total nitrogen as a measure of nitrogen concentration and it has been suggested that the groundwater recharge determined from a regional groundwater model was not comparable to stormwater and wastewater flows (Anderson, 2007). The first difficulty could underestimate total nitrogen load estimates, the latter could bias the groundwater recharge estimates in either direction. Dr. Young prepared a draft loading estimate that showed a decreased loading contribution to groundwater by fertilizers relative to inputs, and correspondingly an increase in the importance of wastewater. While the direction of this shift is plausible if one considers that fertilizers are used by plants, the magnitude was subject to criticism. Eventually, RRAC recommended excluding such an estimate of nitrogen loads to groundwater by all sources from this report, and the department has followed this recommendation.

Assessment of Significance of Onsite Sewage Nitrogen Contributions

The department was tasked to assess the significance of onsite systems contributions to the nitrogen problem relative to other sources. The Legislature's appropriation language did not provide criteria for determining significance. In response to technical issues in assessing loading to groundwater, RRAC decided to postpone a decision about significance. The approach taken here leans on concepts related to the development of environmental impact statements according to the national environmental policy act (40 CFR Parts 1500 - 1508 (1987). Significance needs to be evaluated both in regard to contexts and in regard to the intensity or severity of impacts. Several contexts will be considered: the Wekiva Study Area; atmospheric deposition; wastewater as a source category; long distance transport; and medium density residential land use. Eighty percent of onsite systems are located in 2-5 residences per acre medium density residential land use areas (Tucker and Diblin, 2007).

The severity of impacts is related to the vulnerability of the groundwater to nitrogen pollution, the number of contributors of nitrogen, and their amounts. Groundwater and the springs of the Wekiva Study Area are vulnerable to groundwater pollution. This vulnerability is not only potential, as assessed by Cichon et al. (2005), but has already resulted in excessive nitrogen concentrations at the largest springs. In response, the U.S. Environmental Protection Agency has established goals of a 95% reduction in nitrogen for Wekiwa Springs and for Rock Springs Run. Additionally, the Saint Johns River Water Management District has proposed goals for the reduction of nitrogen concentrations: an 82% reduction for Wekiva Springs, an 85% reduction for Rock Springs, a 69% reduction in the upper Wekiva River, and a 36% reduction for the Lower Wekiva River.

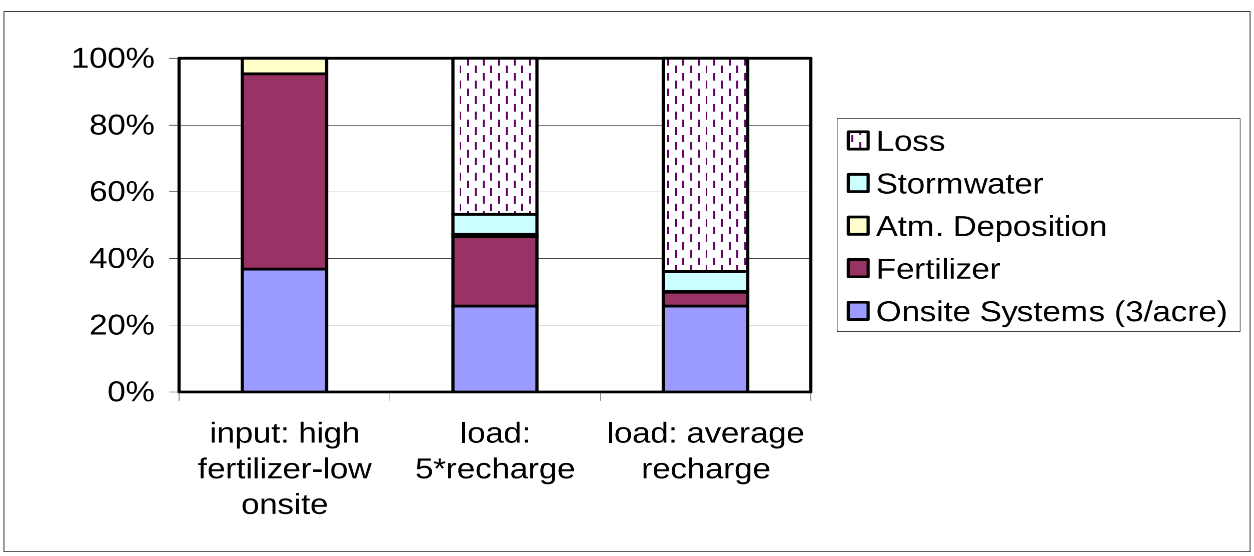
Given that nitrogen impacts overall are significant, the next question is if there are individual entities that make significant and measurable contributions that caused the impacts and may in turn reduce them. The task 3 input analysis shows that no single entity, such as a specific wastewater treatment plant, causes the impact. It is the cumulative impact of many individual nitrogen sources that causes the problem. To address the cumulative impact of these sources it is necessary to categorize and prioritize them. The choice of categories can influence the resulting priorities. For example, if a category focuses on the form in which nitrogen is entering the Wekiva Study Area, the obvious categories would be fertilizer, atmospheric deposition, livestock and wastewater, in that order. If the focus is on the land uses from which nitrogen stems, medium density residential land use classification including fertilizer, wastewater and atmospheric deposition would stand out beyond any other. The categorization chosen by MACTEC and followed here is oriented toward the regulatory framework and agencies that can implement strategies for a particular category. This is the reason for looking at onsite systems separate from centralized wastewater and at agricultural fertilizer separate from other fertilizer. In this situation of cumulative impacts and multiple possible categorizations the implementation of a nitrogen reduction measure by one individual is unlikely to be measurable on the scale of the Wekiva Study Area. Instead it takes the action of many to achieve the desired results. In situations where better management practices of a few regulated categories can achieve the pollution reduction goal cost-effectively, these may be assigned the highest priority. The high nitrogen reduction goals for the Wekiva River system suggest that all sources have to be reviewed to attain these goals, and thus there is no insignificant source. Onsite sewage systems are a source similar in magnitude to centralized wastewater, livestock, and non-residential, non-agricultural fertilizer use. In such a situation, relative magnitude, expected final impacts, and cost-effectiveness can serve as guides for determining priorities for implementing nitrogen reduction projects funded by all.

The intensity of nitrogen inputs from onsite systems can be compared to atmospheric deposition. The input of atmospheric deposition is spread out over a much larger area than the inputs from onsite systems. The intensity appears to have an effect on concentrations and therefore likely the loading of nitrogen in shallow groundwater. While atmospheric deposition in forested areas results in background concentrations of around 0.1 mg/L (Tucker and Diblin, 2007), field work during this study showed that the combination of this source with fertilizer application on lawns resulted in average concentrations around 1-2 mg/L. The concentration observed underneath and in the effluent plume of onsite systems was another order of magnitude higher. The plume was well identifiable in all cases.

Compared to centralized wastewater facilities, the input by onsite systems appears to be larger, even though far fewer people are served by onsite systems. Part of this is due to exports of wastewater to areas outside of the Wekiva Study Area, such as the Conserv II Wastewater Treatment Facility. The main difference can be accounted for by a nitrogen reduction effectiveness of about 75 percent between use and treated effluent discharge. The wastewater treatment plants for which data were available, generally met a total nitrogen effluent standard of 10 mg/L or lower. The difference in nitrogen loading is more difficult to estimate. This is because a large fraction of treated wastewater is not discharged in rapid infiltration basins where nitrogen removal might be similar to drainfields, but reused for irrigation purposes where plant uptake may provide additional nitrogen removal. The Department of Environmental Protection has already implemented a strategy to reduce nitrogen inputs by the wastewater utility category even further by upgrades to higher treatment standards.

Most onsite systems exist in the land use classified as medium density, with 2-5 dwelling units per acre (Tucker and Diblin, 2007). This land use is increasing, while agricultural land uses are in decline. Such a density provides choices between various alternatives of wastewater nitrogen reduction, from individual onsite systems over cluster systems to connection to a main sewer line. For three onsite systems per acre, figure 3 illustrates the relative importance of onsite systems, fertilizer, atmospheric deposition, stormwater and losses based on the same assumptions as the MACTEC report and task 2. Stormwater loads have been adjusted using values provided by Tucker and Diblin (2007) to reflect total nitrogen instead of nitrate. The two load estimates for different recharge rates show that groundwater impacts for other sources (subtracting stormwater) are reduced by at least as much as onsite systems. This initial attempt at a mass balance for nitrogen under a land use illustrates that the contribution to groundwater loading by onsite systems will be relatively larger than their input contribution.

Figure 3. Relative Contribution of Onsite Systems to Nitrogen Inputs to the Environment and Loading to Groundwater in Medium Density Residential Land Uses.



The input assessment here should be complemented by further assessments of loading to the groundwater and eventually to the springs. Such an assessment, for example through a regional groundwater flow and transport model will be most useful to confirm sensitive areas which should have priority for implementation of nitrogen reduction strategies. Such a model is unlikely to discriminate between different sources of nitrogen except to the extent that they stem from areas that differ in vulnerability. The Wekiva Aquifer Vulnerability Assessment allows an initial assessment of where onsite systems are located relative to the vulnerability of the Floridan aquifer. About a third of the onsite systems in the Wekiva Study Area are located in the primary protection zone, and another 60% are in the secondary protection zone. Only relatively few (8%) are located in the tertiary protection zone. This indicates that the location of onsite systems does not generally protect the deeper aquifer from their input.

The discussion above shows that the largest uncertainties of the nitrogen input and loading assessment are in regard to fertilizer. The field work performed by the department's contractor has generally confirmed MACTEC's assumptions about onsite system inputs and loadings (increase by less than 50%) and groundwater concentrations under lawn (decrease by less than 50%). Fertilizer application rates and recharge to the shallow groundwater are topics that should be explored in more detail.

Onsite systems tend to be located in more vulnerable areas and there are indications that they experience less nitrogen removal than sources applied to the land surface. Therefore, their contribution to groundwater loading is likely to be larger and more important than their contribution to nitrogen inputs. The department finds that onsite contributions are a significant source of nitrogen input in medium density residential situations where most of them are located. While the department cannot yet determine the relative contribution of onsite systems to groundwater loading compared to all other sources, based on the nitrogen reduction goals, set by spring water-quality standards, onsite systems do have an impact on the nitrogen loading to groundwater.

Task 4: A Range of Cost-Effective Strategies for Nitrogen Removal

The department was charged to "recommend a range of possible cost-effective OWTS nitrogen reduction strategies if contributions are significant." Because the budget provided by the Legislature was completely allocated to the field work and contribution assessments, RRAC recommended that department staff work on this task. The results of staff efforts on this task are provided in Appendix D of this report. Consistent with RRAC's decision to await further study before contemplating significance of contributions, the committee also decided not to take action on this appendix. RRAC intends to develop a position on the significance of onsite system contributions after this report has been submitted.

A comprehensive onsite sewage treatment and disposal program has to address nitrogen pollution where the contributions of onsite systems are significant in pursuit of the Florida Legislature's intent 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." (381.0065(1), Florida Statutes) Appendix D discusses a range of strategies that complement each other in order to reduce nitrogen inputs and loads in the Wekiva Study Area.

The development of funding mechanisms to select the most cost-effective nitrogen reduction projects in the Wekiva Study Area is of critical importance. Two mechanisms are suggested. The first mechanism is a grant program to solicit cost-effective nitrogen reduction projects from any source in the Wekiva Study Area, funded by payments from dischargers of nitrogen such as onsite system owners. The discharge fee could be initially oriented on costs to remove the first few pounds of nitrogen. This mechanism would allow for continued monitoring of the increasing costs as the loading is reduced toward the target level to meet spring water-quality standards, and would allow for an adjustment of fees. The second mechanism consists of wastewater management entities that are funded by all onsite system owners to reduce the nitrogen load from onsite systems. These entities will be in a position to select the most cost-effective wastewater nitrogen reduction projects to address nitrogen in their service area. Both of these mechanisms could be combined to increase the rate at which nitrogen reduction projects are implemented in order to reach the pollution reduction goal. Costs to the system owners will depend on the extent and speed of nitrogen reduction. Estimates given in section two of Appendix D suggest about $60 per year per system initially for an area-wide grant program, and about $200 per year per system for a program to upgrading failing systems to achieve nitrogen reduction.

In the context of a growing region, limiting the increase of loads by onsite systems to the Wekiva Study Area will be an important program goal. This would require that new systems achieve nitrogen reduction, and that existing systems achieve some reduction, with an average total reduction of 40-50%. An analysis in section 5 of Appendix D for new systems indicates that given a choice of treatment standards that result in 30%, 60% or 70% reduction of nitrogen load, the average installation cost per pound removed is lowest for the 70% standard. The cost-effectiveness of upgrading existing systems to the 70% standard is very similar to that for new construction.

Wastewater management entities can provide grants or loans to support repairs of failing systems and upgrades to new standards. While outside grants and loans can and should support such programs, pooling of the resources within the service area could move such a program forward even in the absence of outside support. These entities, either existing utilities, newly formed onsite wastewater management providers, or county health departments in an expanded role could be funded by an onsite system fee, which would cover costs of this function as well as periodic monitoring, inspection, and inventory of onsite systems.

A key element of a comprehensive onsite sewage program should be an inventory of all onsite systems. This takes on particular importance in the Wekiva Study Area because a large fraction of onsite systems were originally installed before current rules were in effect. Older systems are more likely to not have an adequate separation to the wet season water table. In contrast the field work of Task 1 focused on systems that were installed since current rules were in effect. Lack of adequate separation to the water table will generally lead to less nitrogen reduction before reaching the groundwater and to higher loads of pathogens. An inventory program will provide more complete information about the current status of onsite sewage treatment and disposal systems. Continued evaluation of watershed impacts by onsite sewage treatment and disposal systems, as well as the functioning and performance of individual systems or types of system, is recommended to collect information that can be used to adapt the nitrogen reduction program as needed.

Conclusions

Realizing that the established reduction goals presents a challenge to all contributors the department finds that all contributors must work together to reduce nitrogen inputs and loads. Onsite systems are not the major source of nitrogen contributions but the estimates for them are similar in magnitude to livestock, centralized wastewater, and non-agricultural, non-residential fertilizer use. Fertilizers taken together are a major source in many land uses. The MACTEC report and the attached FDOH task reports provide details on input and loading. Input is the term used here to describe the total amount of nitrogen going into the area, whereas loading is the term used here to describe that portion of the nitrogen input which reaches waters of the area. Only a portion of the nitrogen input to the Wekiva Study Area will reach ground and surface waters. At this point there is no consensus on how much nitrogen is loaded from all sources to the groundwater, but there is an agreement on how the inputs are determined.

There is consensus that the input from onsite systems should be based on the number of systems, average number of persons per household (2.6), and an average input of nitrogen per person per day (20 pounds per year). Using these assumptions, the total nitrogen input to the Wekiva Study Area is estimated to be 1,100,000 pounds per year, representing 6 percent of the estimated nitrogen input to the Wekiva Study Area. However a change in another input value, such as fertilizers, would change this percentage.

The MACTEC numbers were adjusted to reflect total nitrogen for the inputs from all sources. Fertilizer is the major source of nitrogen inputs to the WSA, accounting for 71 percent of all inputs. This estimate was based on recommended application rates and exceeds the amount of fertilizer sold by a factor of two. Among the sources of fertilizer, residential use is the primary factor (40 percent) followed by agricultural use (25 percent). Livestock contributes nine percent of the inputs to the WSA. Onsite sewage treatment and disposal systems constitute about six percent of the inputs to the WSA.

Dr. Richard Otis provided the information for determining the groundwater loadings from septic systems. These loadings were found by multiplying the total nitrogen inputs to the environment by the proportion of that amount anticipated to reach groundwater. That proportion depends on soil drainage, water level class, organic matter class, and soil series (Task 3: Appendix A). For poorly drained soils, the fraction removed depends on the form of applied nitrogen. Which form of nitrogen is appropriate depends upon septic system type. Using this information, the low, medium, and high estimates of groundwater nitrogen loadings from septic systems for each soil series were calculated (Task 3: Table 10).

The adjustments of the inputs to get to loading estimates for sources other than onsite systems beyond the approach taken by MACTEC was beyond the scope of task 3. There is a phase II study in the scoping stages with FDEP to field verify the assumptions made in the MACTEC report. Once the other sources have been verified, the loading estimates from onsite systems can be incorporated into the calculations. The total estimated amount of nitrogen from onsite sewage treatment and disposal systems that is loaded to the groundwater is 900,000 pounds per year. The solution to nitrogen loading in the Wekiva Study Area must address all sources but the most critical issue is fertilizer.

Out of necessity, input and load assessments over such a large area require assumptions about what are typical contributions by any particular source type. The department's Wekiva study has complemented the desk-top assessment of inputs and loadings by MACTEC with field work (Task 1) and more detailed loading assumptions that incorporate soil variability into the loading estimates for onsite systems (Task 2 and Task 3). The more detailed assumptions in task 2 and task 3 result in a average load per system of 15 pounds per year, as compared to 14 pounds per year assumed by MACTEC, and 18 pounds per year from the field work of task 1. The field work found definite nitrogen plumes stemming from onsite systems. Nitrogen concentrations in these plumes exceeded drinking water standards and were far in excess of background concentrations. Nitrogen impacts on springs are determined by the amount of nitrogen that arrives at the spring via groundwater. This is a complex process with some debate over what happens to the nitrogen after it reaches the groundwater and before it reaches the spring.

The nitrogen load from onsite systems is a load that can be reduced significantly as demonstrated by a department research project in the Florida Keys. To reach the goal of reducing nitrogen levels to the levels required by the total maximum daily load, onsite systems, as well as all sources, particularly fertilizer, must be addressed. In addition to performance based treatment systems (PBTS) that reduce the nitrogen load before discharge to the drainfield, older systems, many of which may be in the wet season water table, can also be improved by providing two feet of unsaturated soil beneath the drainfield. Upgrading all existing systems to PBTS providing nitrogen reduction would further reduce the load. Due to the wide variations of factors that impact the effectiveness of nitrogen removal in the soil and the aquifer vulnerability, pre-treatment before discharge is the only reliable option. Routine inspections and maintenance are also critical to ensuring the satisfactory operation of onsite systems.

A large concern in the Wekiva Study Area has been initial installation cost. It is apparent that the largest increase in installation cost stems from the change from a passive system to a mechanical aeration system. Further treatment, excepting carbon additions, requires little additional cost under current market conditions. Consequently, the incremental cost to go beyond an aerobic treatment unit standard to a performance standard of 10 mg/L for nitrogen is low. Due to the variety of field conditions which may be encountered, up-front installation costs can only be estimated to range between $12,000 and $14,000 for a 300 gallon-per-day residential system. In addition to installation costs, performance based treatment systems require a maintenance contract, an operating permit, and have ongoing maintenance and operation costs.

Research Review and Advisory Committee Comments

The Research Review and Advisory Committee (RRAC) was given oversight of this project in accordance with the legislative mandate. The committee has been involved with the development of the scope, the selection of the individual task providers, and discussions on the individual task reports and this final project report. The committee is in unanimous agreement with the following:

1. The final FDOH report shall be amended to use the inputs as presented in Dr. Linda Young's report (Task 3) with the following adjustments: for atmospheric deposition use urban estimates such as those found in the Tampa Bay area rather than the rural estimates used in the MACTEC report, to have the atmospheric deposition number reflect total nitrogen, to add reclaimed/reuse water to the estimates for wastewater treatment plants, and to use total nitrogen numbers for wastewater treatment plants. The Task 3 report shall be modified to reflect these changes. There should be no conclusions on significance of loading until the second phase of the FDEP report has been completed. The loadings should be removed from the FDOH draft report and from Task 3.

2. The RRAC recommends that no action be taken on proposing a range of cost-effective strategies for nitrogen removal (Task 4) at this time.

Recommendations

While the department cannot yet determine the relative contribution of onsite systems to groundwater loading compared to other sources, the department realizes, based on the nitrogen reduction goals, that onsite systems do have an impact on the nitrogen input to groundwater. The following are some strategies that can be implemented to reduce nitrogen input:

Discharge Fee to Fund Projects – 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.

Establishment of a Maintenance Program – The department will provide a legislative proposal for the 2008 session for the Legislature to consider implementing one of the following requirements:

1. Implementation of U.S. Environmental Protection Agency Model 4, The Responsible Maintenance Entity (RME) Operation and Maintenance Model, for the Wekiva Study Area and other sensitive environmental areas in the State of Florida. Wastewater utilities or local governments would be authorized to collect a wastewater service fee from all developed properties in their service areas. For owners of onsite sewage treatment and disposal systems, the fee would be used to provide routine maintenance, repairs, mandated upgrades, or connection to sewer. The fee for onsite system owners would be assessed as if they were connected to sewer. These programs should take the privatization approach to the maintenance of onsite sewage treatment and disposal systems. Under this approach existing registered septic tank contractors, licensed plumbers, or licensed wastewater treatment plant operators would be contracted with for inspection and maintenance services. At a minimum, all systems should be inspected and pumped every five years. A similar program has recently been established in Maryland to protect the Chesapeake Bay. To lower nitrogen contributions, all households are assessed $30/year. For households served by central sewer, this money will be used to fund upgrades to wastewater treatment plants. Of the funds generated by households served by onsite sewage treatment and disposal systems funding can be awarded for agency projects of upgrades, repairs of individual failing systems, and individual upgrades to at least 50% nitrogen reduction.

2. Require an operating permit for all onsite systems and require all onsite sewage treatment and disposal systems to be inspected and pumped out every five years to ensure the system's compliance with 381.0065, Florida Statutes, and rules adopted under that section. Inspections should be conducted by a septic tank contractor licensed under part III of chapter 489. The contractor should be required to furnish the system owner with an inspection report and to file a copy with the Department of Health. The department should be required to adopt by rule the elements of the inspection, the form for the report, and the fee. A portion of the fee should be used to fund and administer a grant program to assist owners of onsite sewage treatment and disposal systems to repair or upgrade a system serving a single-family, owner occupied, residence. Owners with an income equal to or less than 200 percent of the federal poverty level at the time of application would be eligible for a grant. The department should be required to adopt rules establishing the grant application and award process. The amount of the grant should be limited to the cost differential between replacement of the existing system and the upgrade. The grant should be in the form of a rebate to the owner for costs incurred in complying with requirements for onsite sewage treatment and disposal systems. The

department is recommending this be a statewide mandate since the issues raised here are not unique to the Wekiva Study Area.

Eliminate Grandfather Provisions of 381.0065, Florida Statues - - The Legislature should consider eliminating grandfather provisions in 381.0065 in regard to minimum lot sizes and surface water setbacks. The department will provide a legislative proposal for the 2008 session.

Upgrading Existing Systems –Recommend the department amend its rules to require that all existing systems requiring repair or modification meet new system standards for water table separation and setbacks to surface water bodies. Current repair standards are less stringent than new standards. The year of the original installation determines the permitting requirements with regard to the septic tank capacity, drainfield size, separations, and setbacks. All tanks should be assessed during the permitting process for watertightness and replaced where necessary. These changes should apply statewide.

Nitrogen Treatment Levels for New Systems – The department should require that all new systems in the Wekiva Study Area be performance based treatment systems providing nitrogen reduction pre-treatment. Any plan for net reductions in nitrogen loading has to consider additional loading due to growth. While requiring upgrades in repair permits provide an avenue to reduce the impact of existing systems, new systems, even if installed to higher performance standards, add additional load. For the three counties, the five-year average numbers of repairs and newly permitted systems for fiscal years between 2000 and 2005 were determined from the department's county summary data. In order for nitrogen loading from OWTS to remain constant in the three counties a nitrogen reduction by about 41% is necessary for both new and repaired systems. The department recommends a pre-treatment discharge limit of 10 milligrams per liter of total nitrogen for new systems in the Wekiva Study Area. This treatment level could achieve at least 70% reduction of nitrogen inputs from that onsite system.

Onsite System Inventory – The department and local governments should create an inventory of all onsite systems in the Wekiva Area that can be maintained in cooperation between county health departments and county property appraisers.

Prohibition of Land Spreading Septage - 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.

Economic Feasibility of Sewering - 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.

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Definitions

Denitrification – the process of converting nitrogen from the nitrate form to a gas that is released to the atmosphere. This requires food and the absence of fresh air., Generally for drainfields the difference between an input and a load is the amount of nitrogen that has been denitrified or removed by plants or stormwater.

Input – the amount of nitrogen that is released into the environment, for example applying a bag of fertilizer to the ground surface would be considered an input.

Load – the amount of nitrogen that enters the groundwater, for example the remaining nitrogen from a bag of fertilizer that reaches the groundwater after the plants and the soil have utilized portions of (denitrified) the nitrogen that was originally considered an input.

Loss/removal - the difference between input and load. This can be due to denitrification, plant uptake, or runoff with stormwater.

MACTEC – a consultant for the St. Johns River Water Management District, who was tasked to identify and quantify sources of nitrogen loading in the Wekiva River Basin for the Florida Department of Environmental Protection

Nitrate - form of nitrogen that moves easily with water and results from the reaction of ammonia and organic nitrogen in wastewater with oxygen.

Nitrification – process of converting nitrogen from the TKN form into the nitrate form. This requires oxygen and air

Nitrogen - an element that exists in various forms: ammonia, nitrate, organic nitrogen, or gas.

OSTDS – Onsite sewage treatment and disposal system, also referred to as onsite system, onsite wastewater system, and septic system; a system which handles sewage from residential and commercial buildings and generally consists of a septic tank, which collects the wastewater, and a drainfield, which disperses the wastewater from the septic tank into the soil which provides further treatment before contact with groundwater.

OWTS – Onsite wastewater treatment systems; synonymous with OSTDS.

RRAC – Research Review and Advisory Committee; a committee established in Chapter 381.0065(4) (o), Florida Statutes, consisting of nine members that are responsible for advising the department on directions for new research, reviewing and ranking proposals for research contracts, and reviewing draft research reports and making comments. The committee was given oversight of the Wekiva study, which is the content of this report.

WSA – Wekiva Study Area; approximately 304,000 acres that incorporates parts of Lake, Orange, and Seminole counties in central Florida and is an approximation of the area that impacts the Wekiva River System.

Appendix

A. Task 1: Multiple Nitrogen Loading Assessments from Onsite Waste Treatment and Disposal Systems within the Wekiva River Basin

B. Task 2: Estimates of Nitrogen Loadings to Groundwater from Onsite Wastewater Treatment Systems in the Wekiva Study Area

C. Task 3: Assess Contributions of Onsite Wastewater Treatment Systems Relative to Other Sources

D. Task 4: A Range of Cost-Effective Strategies for Nitrogen Removal