FLORIDA DEPARTMENT OF HEALTH

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task D.3

Selection of Existing Data Sets for Model Calibration

Final Report

June 2009

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In association with

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Prepared for:

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In support of the Florida Onsite Sewage Nitrogen Reducing Strategies (FOSNRS) Study, a simple tool evaluating flow and transport in groundwater to produce output predictions for nitrogen concentration or mass flux is being developed. The overall purpose of this tool is to simulate aquifer nitrate concentrations down gradient from onsite sewage treatment and disposal systems (OSTDS). The modeling tool will be a spreadsheet-implemented, multidimensional, transient analytical solution to the advection dispersion equation with reactions. While the aquifer model to be used has not yet been formally determined, it will likely be a modification or combination of the models presented by Domenico (1986) and Galva (1987). These models assume a planar source of nitrate below or at the water table, and account for relevant advection-dispersion-reaction processes. This initial version of the model will not contain a detailed expression for vadose zone transport processes. Rather, the model will use a simple term for vadose zone attenuation that will be determined by comparing source loading rates (the OSTDS source term) to concentrations at the water table (the aquifer source term). The development of a detailed vadose zone soil treatment model will be completed in the future.

The output of the aquifer model will be concentration as a function of *x, y, z*, and time, C(*x, y, z, t*), where C(*x, y, z, t*) is the computed concentration at a given point defined spatially by (x, y, z) and temporally by time *t*. For this model, the required input is the initial source concentration (C_0), groundwater velocity (v), dispersivity (α) terms that are multiplied by velocity to calculate dispersion coefficients, first-order nitrogen transformation rate constants (λ) and rectangular source dimensions. Measured concentrations at the water table below the OSTDS surface footprint will be the primary means to determine C_0 (initial concentration) for model input. However, we will also use loading information from the surface OSTDS sources, along with simple formulations to account for unsaturated soil treatment, because this is information that is more typically available. It is a goal of future work associated with this project to develop a robust soil treatment model that can be linked to an aquifer model. However, performance evaluation and calibration are not being conducted for that linked model as part of this task.

To evaluate the aquifer model performance, we endeavor to conduct simulations of flow and transport at actual sites, and compare the model results to existing field data. This model evaluation process can be useful for understanding treatment processes in the

vadose zone, but calibration of a vadose-zone treatment model is not an objective of this task. Candidate data sets should provide:

- groundwater velocity, or at a minimum, parameters that allow for calculation of velocity, such as hydraulic conductivity, porosity, and measured head values for determining site-specific horizontal gradient (porosity values could be estimated and this would not introduce unacceptable error);

- temporal and spatial concentrations at monitoring points downgradient from the source; and

- source information, (i.e., number of septic tanks and location, surface-expression shape of the source zone, and loading rates for the septic systems. Loading rates can be estimated from statistical distributions provided by McCray et al. (2005), but would add additional uncertainty to the model-performance evaluation).

The process of identifying candidate data sets for the model evaluation involved analyzing over 25 studies and reports to ascertain if the desired data listed above were available in the study. In some cases, studies were identified that at the very least contained appropriate nitrate concentration data and information concerning the site characteristics. In these cases, it would be possible to use literature values for other parameters not specifically measured. In choosing primary data sets, preference was given to studies with the most complete characterization and monitoring.

Parameters for which no data are available can be estimated via calibration. However, only a certain number of parameters can be uniquely calibrated (the exact number depends on the data set). If all model parameter values cannot be confidently obtained via available data, unique calibration, or independent estimation, then a model uncertainty analysis can be implemented to evaluate the model performance.

The literature review completed in support of model development yielded a number of studies and reports that contain data sets that likely satisfy the above criteria (although, one cannot be certain until the model-performance evaluation is completed). The top candidate study is described first, followed by several alternates. While the primary study data are adequate for model calibration, the model can be verified against another data set for a site with different characteristics. In this way, the ability of the model to simulate flow and transport for various conditions can be demonstrated.

Primary Candidate Studies

1. Indian River Lagoon Study

This study was initiated to assess the impacts to water quality from OSTDS in the Turkey Creek sub-basin in the Indian River Lagoon. Specifically, the study sought to determine the impacts from wastewater practices to nearby canals. Three sites that consisted of residences that used OSTDS were used for sampling. This included the sampling of 25 monitoring wells, 12 piezometers and surface water quality points performed over 14 different events between February 1990 and March 1992. Additionally, two separate tracer tests using bromide were done, and the septic tank effluent was measured for quality and quantity. The resulting data set includes data for nitrate concentrations in groundwater and surface water, STE data and hydraulic parameters. Additional data is available for precipitation and seepage, which is useful for estimating source loading.

2. St. George Island

In the St. George study (Corbett and Iverson, 1999; Corbett et al., 2002), groundwater flow was monitored down gradient of three residences served by OSTDS. Conservative tracers were used to determine groundwater flow velocity, hydraulic conductivity, and dispersivity at the three sites (Corbett et al., 2000). Twelve monitoring wells and 13 multi-level samplers were installed at Site 1, seven wells and eight multi-level samplers at Site 2, and seven wells and seven samplers at Site 3. The total groundwater flux into the adjacent bay was estimated using two different techniques, which agreed well with each other. Nutrient concentrations (total nitrogen, ammonia, nitrite and nitrate) were measured in all samples collected. Nutrient samples were collected monthly for over one year at all sites. In addition, rainfall data was collected over the sampling period (Corbett and Iverson, 1999; Corbett et al., 2002).

3. St. Johns County, Florida

The objective of this study was to delineate the impacts to groundwater below and downgradient of an OSTDS in Florida. The primary constituents of concern were household cleaning products, but data was also collected for nitrate, chloride, and subsurface characterization. The site consisted of a single family home in St. Johns County, Florida. Subsurface characterization data is available through well logs and completion data, and grain size analysis. Groundwater was monitored at multiple monitoring points in three separate events and consisted of groundwater elevation data (providing gradient and flow direction), and constituent analysis for nitrate, chloride, and phosphorus among others. Additional data was collected for STE quality and quantity over several events as well.

4. Wekiva Nitrogen Source Study

A study designed to estimate the nitrogen loading contribution from OSTDS in the Wekiva watershed in central Florida was performed by multiple researchers for the Florida Department of Health (FDOH) (Briggs et al., 2007; Roeder, 2008; Aley IV et al., 2007). The overall objectives of the study is to assess the significance of the nitrogen impacts to groundwater and surface water as part of the Wekiva Parkway and Protection Act and recommend strategies to reduce these impacts. Groundwater field data were collected from three sites in the study area. Nutrient loading from OSTDS into the groundwater were calculated, after which it was determined whether OSTDS were a significant source of nitrogen to groundwater relative to other sources (Briggs et al., 2007; Roeder, 2008). Three nitrogen plumes were also investigated in great detail. Several monitoring wells/piezometers were installed and samples for nitrogen species and other parameters were collected (Aley IV et al., 2007). However, sampling was limited to one event per site.

Alternate Candidate Studies

1. Lake Okeechobee

The Lake Okeechobee study investigated the impact of high-density OSTDS installations on water quality along the northern periphery of Lake Okeechobee in central Florida. Monitoring wells, lysimeters and piezometers were installed at several sites for the investigation of the groundwater flow, height of water table, and quality of leachate from OSTDS as it entered the aquifer and down gradient of the soil treatment unit. Both nitrogen and phosphorous data were collected over the course of one year (ESE, 1993).

2. Other Studies

Additional studies were identified as potential candidates for verification and calibration data. Other studies described above were chosen as primary candidates, mostly because the research was conducted in Florida. However, other available studies contain data that could be used for model verification. These include studies by LaPointe et al (1990), Robertson et al (1991) and Morgan et al. (2008). An additional study by Katz et al (publication pending) could provide a useful database, however the study is currently under USGS review and the complete dataset is not available at this time.

Recommendation

In identifying studies for calibration data sets, preference was given to studies performed in Florida. Additionally, most of the data sets contain data that has been collected over a period of time acceptable for verification of the modeling tool's ability to simulate tran-

sient conditions (in most cases, at least one year). Table 1.1 summarizes the types of data available in the primary and alternate data sets.

The Indian River Lagoon study and the St. George Island studies are the leading candidates as they both contain extensive data related to the input and calibration parameters needed to test and validate the modeling tool being developed. Temporal data is available for hydraulic parameters, source orientation and loading, and source area and down gradient nitrogen concentrations in *x, y, z* orientations. Both studies have multiple sampling points both downgradient and in the source areas.

Our goal is to use the primary data sets for model performance evaluation. However, one cannot predict whether model calibration will be successful for any particular model or data set until the process is complete. In this case, another data set may be applied to the model for further verification and testing. For this reason, several data sets were chosen as alternatives in the event more data is required to assess model performance. This memo satisfies the deliverable D.3 to choose a data set for preliminary model-performance evaluation of a simple aquifer-modeling tool.

Table 1.1
Summary of type of data available for previous Florida Nitrogen Studies

Study	Hydraulic Parameters				Nitrogen Conc. (x,y,z,t)	Source Data			Additional Data
	GW Velocity	K	Gradient	Porosity		OSTDS Location	Footprint	Loading Rates	
Indian River Lagoon Study (Aley, et al., 2007)	X	X	X	X	X	X	X	X	climate data, surface water data, tracer test data
St. George Island (Corbett, et al 1999)	X	X	X	X	X	X	X	X	precipitation, tracer study results
St. Johns County, Florida	X	X	X	X	X	X	X	X	tracer test results, grain size analysis
Wekiva Nitrogen Study Area (Aley, et al 2007)	X	X	X	X		X	X	X	climate data
Lake Okeechobee (ESE 1993)	X	X	X	LV	X	X	X	X	surface water data
Florida Keys (LaPointe et al 1993)	n/a	n/a	n/a	LV			X	n/a	gw flow*, surface water data
La Pine, Oregon (Morgan, et al 2007)	X	X	X	X	X	X	X	X	
Ontario, Canada (Robertson et al, 1991)	n/a	X	X	LV	X	X	X	X	tracer study, model-generated dispersivity values

n/a = not available
K = hydraulic conductivity
LV = literature values based on site characteristics and/or CFD
** measured with in situ flow meter*

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