Backyard Biological Nutrient Removal: Florida On-Site Sewage Nitrogen Reduction Strategies Study

Damann L. Anderson and Josefin E. Hirst

Approximately 25 percent of the United States and 30 percent of Florida's population rely on on-site wastewater systems (OWS) for wastewater treatment. Nutrient loading from many sources, including OWS, has received increased attention from water quality regulators and the public in many watersheds. Nitrogen in particular is an important nutrient of concern for water quality, and nitrate-nitrogen represents perhaps the most common groundwater pollutant from OWS. The environmental effects of excess nitrogen on groundwater and surface water can ultimately lead to the degradation of water quality, since excess nitrogen loading can lead to algal blooms and oxygen depletion in surface waters, which can be harmful to natural aquatic life. The protection of watersheds and surface water bodies from excess nitrogen loading has led to increasing regulatory actions requiring nitrogen reduction from OWS in areas such as the Florida Keys, Chesapeake Bay, and Cape Cod, to name a few.

In Florida, the degradation of water quality in the many freshwater springs and nitrogen-limited estuarine surface water bodies has led to legislation requiring protection of these areas, including requirements for nitrogen-reducing OWS. The Florida Department of Health initiated the Florida On-Site Sewage Nitrogen Reduction Strategies (FOSNRS) project to research, develop, construct, and test different on-site wastewater treatment systems to address nitrogen reduction from OWS. As part of the FOSNRS project, passive nitrogen reduction systems (PNRS) were developed and pilot tested and are now being evaluated at homes in Florida. The goal of these systems is to reduce nitrogen inputs to watersheds where OWS have been identified as a significant source of nitrogen.

A PNRS system installed in Hillsborough County utilized the two-stage passive biofiltration concept. As shown in Figure 1, primary treated wastewater, or septic tank effluent (STE) from the home's existing septic tank, is discharged to a two-stage treatment system consisting of a first-stage unsaturated porous media recirculating biofilter for ammonification and nitrification, followed in series by a second-stage saturated anoxic upflow porous media biofilter for denitrification. Effluent from the stage-one biofilter was pumped to the stage-two biofilter and also recirculated back to the stage-one biofilter at a ratio of approximately 3:1 recirculation flow R to forward flow Q. The denitrified treated effluent was discharged into the home's existing drainfield. The PNRS system was monitored over an 18-month period, receiving STE with an average total nitrogen (TN) concentration of 54.7 mg N/L. The overall system-treated effluent average TN concentration was 2.5 mg N/L, a reduction in TN of over 95 percent.

Damann L. Anderson, P.E., is a vice president and Josefin E. Hirst, P.E., is a senior principal engineer at Hazen and Sawyer in Tampa.

A second PNRS system was developed and constructed to provide high levels of wastewater treatment, as well as landscape irrigation at a five-bedroom home in central Florida. This system utilized the same two-stage concept, but the first-stage biofilter was constructed in ground over a polyethylene liner rather than in a tank. The system was monitored over an 18-month period, and TN entering the system averaged 50.5 mg N/L. The overall system-treated effluent average TN concentration was 1.9 mg N/L, a reduction in total nitrogen of over 96 percent. This effluent was applied as irrigation water to turf grass at the home via drip irrigation.

In addition to the treatment performance, groundwater quality was monitored at this site before and after installation of the PNRS. Prior to the PNRS installation, a groundwater monitoring network was established, which included over 60 groundwater monitoring wells downgradient of the existing conventional OWS. Figure 2 shows a site plan of maximum TN concentrations at all locations where groundwater samples were obtained during the four sample events (July 2011 through July 2012) taken prior to the PNRS installation. In addition, illustrated in Figure 2 are two transect cross sections A-A' and B-B'. For comparison, Figure 3 depicts the maximum TN concentration at all locations where groundwater samples were obtained during

Continued on page 6

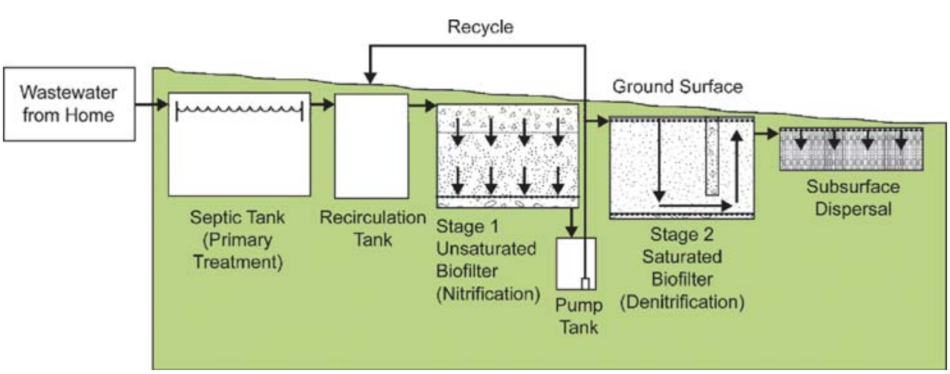

Figure 1. Passive nitrogen reduction system (PNRS) process flow diagram

Continued from page 4

the sample event conducted 468 days following PNRS start-up (Oct. 23 and 24, 2014), along with similar transect cross sections A-A' and B-B'. As shown, a significant decrease in TN concentration in the groundwater plume downgradient of the PNRS system has occurred since PNRS system installation.

While these are preliminary results, they suggest the potential to significantly reduce N input to sensitive watersheds from OWS. Five additional full-scale PNRS are currently under evaluation, and results from these systems will provide key additional data regarding PNRS performance.

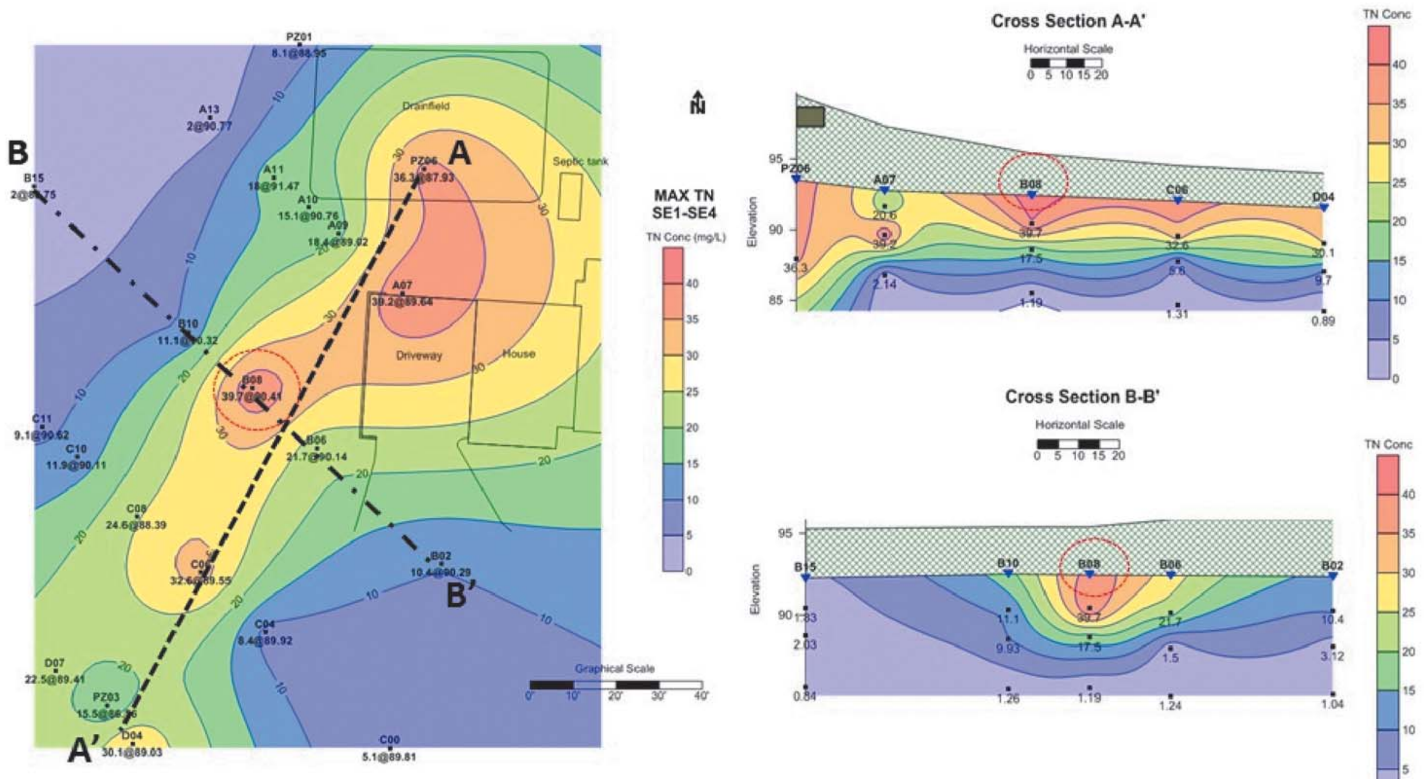

Figure 2. Groundwater monitoring downgradient of the conventional OWS prior to PNRS installation

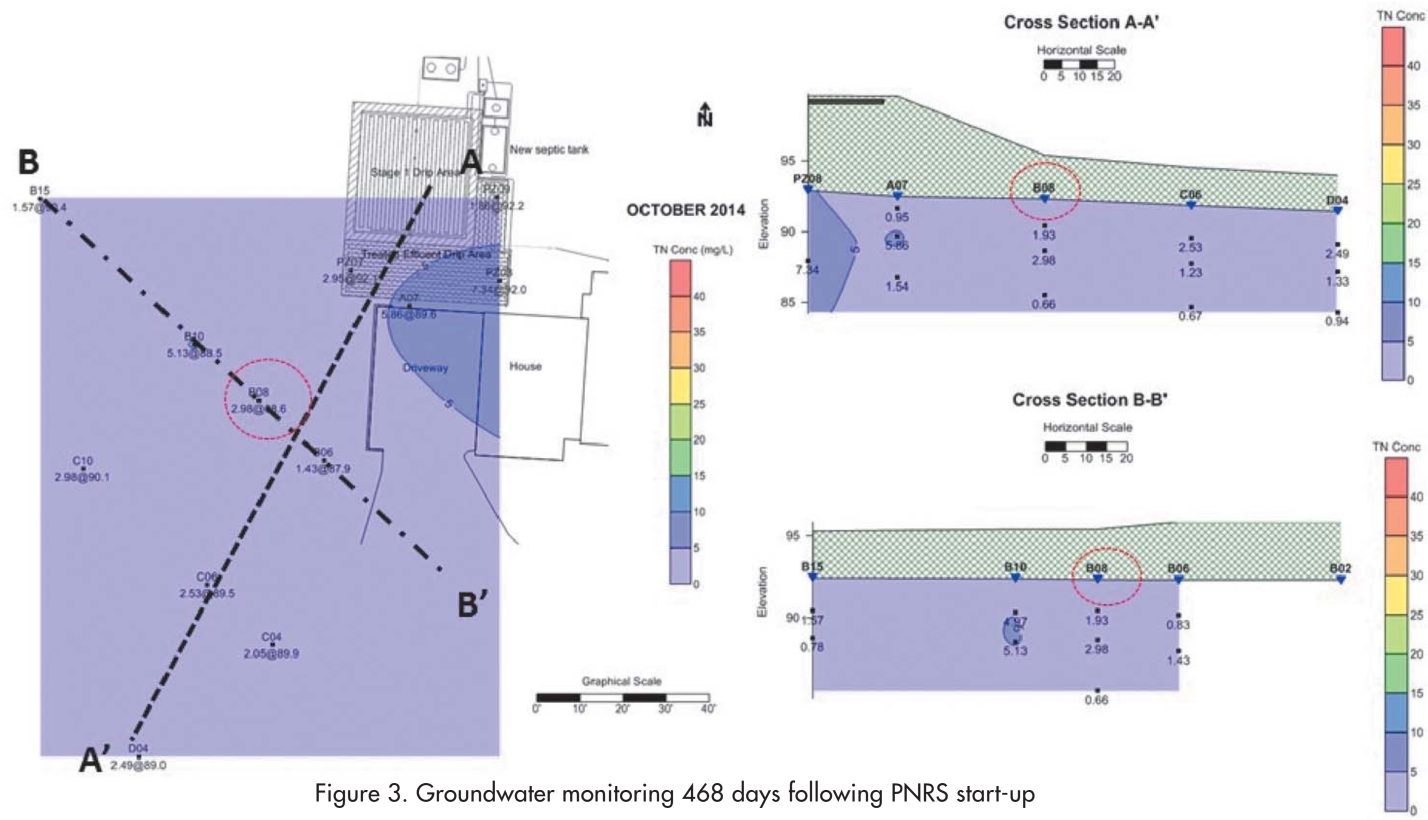

Figure 3. Groundwater monitoring 468 days following PNRS start-up