An important input variable to the watershed TMDL estimation is the nutrient load, especially nitrate, from the residential septic systems (On-site Wastewater Treatment System) to the nearby surface water body. However, estimating the nutrient load has been a long-lasting challenge. In the past, the load is often obtained by multiplying gross number of septic tanks in the target basin by an average loading from each septic tank. Another way of estimating the load is to use only the estimated number of failed septic tanks, under the assumption that the normally functioning septic systems do not contribute nitrate loads to the natural water system.

Recent studies on septic-tank-generated nitrate and its fate and transport revealed that the above methods may yield erroneous estimate for several reasons. First, the fate and transport of nitrogen from septic systems to surface water body may different for different septic systems. During the anaerobic treatment of wastewater in the enclosed septic tank, the nitrogen containing organic materials is digested, remains largely in the form of TKN and Ammonia, then flows to the drain field, where an aerobic environment may nitrify these compounds to nitrate. Part of the ammonia may volatilize and escape to the atmosphere, and part of the ammonia and nitrate may be taken up by the roots of the sod and nearby bushes and trees. The remaining nitrate leaves the root zone and migrates with groundwater as a solute in groundwater. Therefore, like failed septic tank systems, normally working septic tanks also contribute to natural water systems. Furthermore, recent studies found that denitrification does happen in soil and the surficial aquifer, and the intensity of the denitrification process is related to the organic carbon content in soil and surficial aquifer material. Therefore, there is need for a better method to more accurately estimate the nutrient load from septic tank systems to ground water and receiving surface water bodies. The following sections describe a simplified method for estimating septic tank impacts that takes into account nitrogen attenuation by denitrification. Since this proposal is focused on surficial groundwater aquifer, effect of saturation of vadose zone on nitrification and denitrification is not directly considered. Instead, the effect of saturation on nitrification is indirectly incorporated through the amount of nitrate entering from vadose zone into water table (the NO_3-N concentration at water table ranges from 25 to 80 mg N/L, according to McCray et al., 2005).

Sophisticated numerical models have been developed for modeling detailed physical, chemical, and biological processes controlling nitrogen dynamic cycling (e.g., Maggi et al., 2008; MacQuarrie and Sudicky, 2001; MacQuarrie et al., 2001a, b). However, application of the complicated model for environmental regulation is often not feasible, since running the sophisticated models is demanding in term of time and budget for preparing required data. Also, this complexity of modeling is often not necessary for developing estimates over large areas where a high level of detail in data gathering is not feasible. This proposal is to develop a simplified model that is sufficient and practically accurate enough for planning and management purposes. In addition, we propose to implement it within the GIS framework, i.e., as a GIS plug-in. This will make the model user friendly, greatly reduce the time of preparing and inputting/outputting data, and provide an instantaneous visualization of modeling results. More importantly, using the GIS enables us to incorporate the spatial distribution of septic systems and targeted surface water body, which, as discussed below, is an important factor for estimating the nutrient load. Such visualization is crucial to communicate the scientific results to the general public, the management leadership, the planners and the public officials/decision makers.

While it has been pursued for about a decade to develop simplified and/or GIS-based software for estimating nitrogen loading, the proposed software development in this study is unique,

because it incorporates the denitrification process in groundwater and typical hydrogeological conditions (although with some assumptions). The existing software is either too simple or does not focus on nitrate fate and transport in groundwater. For example, the Septic Dilution Model of the New Jersey Pinelands Commission is designed for a single septic tank, and does not consider spatial distribution of a number of septic tanks. The Watershed Analysis Risk Management Framework (WARMF) developed under sponsorship from the Electric Power Research Institute (EPRI) is focused on watershed management, not the groundwater flow and transport. More importantly, none of them include the denitrification process. We believe that the proposed software development effort is timely and very much needed.