ABSTRACT

Arabi, Mazdak. Degree Ph.D., Purdue University, August, 2005. A modeling framework for evaluation of watershed management practices for sediment and nutrient control. Major Professor: Rao S. Govindaraju.

Distributed-parameter watershed models are often utilized for evaluating the effectiveness of sediment and nutrient abatement strategies through the traditional {calibrate→ validate→ predict} approach. The applicability of the method is limited due to the effect of spatial aggregation of input data and model uncertainty. In this study, a computational method is presented to determine the significance of these effects in assessing the effectiveness of best management practice (BMPs) in two small watersheds in Northeastern Indiana with the Soil and Water Assessment Tool (SWAT). The role of spatial aggregation is examined by evaluating the effectiveness of BMPs at various levels of watershed subdivision. The results indicated that evaluation of effectiveness of BMPs in the study watersheds was very sensitive to the level of subdivision. It would appear that an average subwatershed area corresponding to approximately 4% of total watershed area is needed to represent the influence of the BMPs in the study watersheds when using the SWAT model. The subsequent uncertainty analysis aims at (i) identifying the hydrologic and water quality processes that control the fate and transport of sediments and nutrients within watersheds, and (ii) establishing uncertainty bounds for model simulations as well as estimated effectiveness of BMPs. The SWAT model is integrated with a Monte-Carlo based methodology for addressing model uncertainties. The results suggested that fluvial processes within the channel network of the study watersheds control sediment yields at the outlets, and thus, BMPs that influence channel degradation or deposition are the more effective sediment control strategies. Conversely, implementation of BMPs that reduce nitrogen loadings from uplands areas such as parallel terraces and field borders appeared to be more crucial in reducing total N yield at the outlets. The uncertainty analysis also revealed that the BMPs implemented in the Dreisbach watershed reduced sediment, total P, and total N yields by nearly 55%, 35%, and 30%, respectively. Finally, a genetic algorithm (GA)-based optimization methodology is developed for selection and placement of BMPs within watersheds. The economic return of the selected BMPs through the optimization model was nearly three fold in comparison to random selection and placement of the BMPs.