

## **A Hierarchical Modeling Approach to Evaluate Spatial and Temporal Variability of Wastewater Effluent BOD, TSS and Ammonia**

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**Abstract.** A hierarchical modeling approach is used to account for the spatial and temporal variability of treated wastewater quality as related to discharge permit limits. Together, the simulation captures the spatial and temporal factors associated with facility compliance with discharge water quality limits for three constituents: Biochemical Oxygen Demand (BOD), ammonia, and Total Suspended Solids (TSS) using discharge monthly report (DMR) data from more than 100 facilities with National Pollutant Discharge Elimination System (NPDES) permits across the US. The first level of the hierarchy captures the temporal variability using a Generalized Linear Model (GLM) that relates compliance to plant characteristics such as design capacity, capacity utilization, seasonality and previous month's compliance with permit limits. The residuals from this model are subjected to a spatial model using *Kriging*, in the second level of the hierarchy. The hierarchical model is shown to be a better predictor of NPDES permit compliance than single level GLM counterparts and provides a new approach to incorporating uncertainty into watershed and larger scale planning and regulation of wastewater treatment systems.