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3:30 PM – 5:00 PM
SESSION 22: Water Quality III

Nutrient Reductions in the Watershed Protection Plan for the Caloosahatchee River - Timothy Liebermann, South Florida Water Mgmt. Dist., Fort Myers, FL

The South Florida Water Management District, along with the Florida Department of Environmental Protection and Department of Agriculture and Consumer Services, was tasked by the Florida Legislature to develop a watershed protection plan for the Caloosahatchee River and Estuary. The purpose of the program is to maximize nutrient-loading reductions to meet anticipated TMDLs; to provide water storage for improving the quantity, timing, and distribution of flows to the estuary; and to establish salinity regimes in the estuary suitable for maintaining a healthy and well-balanced ecosystem. The initial phase of the program has utilized GIS technology and data for the estimation of current nutrient loadings and the potential for reductions in total nitrogen and total phosphorus. Land-use classification and other subwatershed characteristics were compiled. Best-available estimates of unit loadings and runoff for various land-use types were developed. The resulting estimates of nutrient loadings and runoff were adjusted to match available data. Through a public process involving local agencies and interest groups, a set of management measures was screened and optimized for the best combination of reduced peak flows, adequate minimal flows, and nutrient-load reductions. Management measures for nutrient-load reduction included urban and agricultural best-management practices, and individual projects included water-quality treatment areas, filter marshes, managed aquatic-plant systems, restored wetlands, stormwater retrofits, and centralized sewer systems. Loading reductions were estimated and summed for each subwatershed. With implementation of the preferred plan, nutrient loadings within the Caloosahatchee River watershed are expected to decrease by 36 percent for total nitrogen and 38 percent for total phosphorus. Including the estimated inflows from Lake Okeechobee, post-implementation flows to the Caloosahatchee Estuary are estimated to have an average concentration of 1.08 ppm for total nitrogen and 94 ppb for total phosphorus. Some elements of the plan already are being implemented. The plan is expected to be reevaluated every three years. A synoptic water-quality-sampling program was carried out during the 2009 wet season, and the establishment of long-term daily water-quality-sampling stations is planned in 2010 for four sites along the Caloosahatchee main stem. The District is collaborating with FDEP to develop BMAP programs for the new TMDLs.

Land Cover - Nutrient Export Relationships in Space and Time - James Wickham, U.S. Environmental Protection Agency, Research Triangle Park, NC

The relationship between watershed land-cover composition and nutrient export has been well established through several meta-analyses. The meta-analyses reveal that nutrient loads from watersheds dominated by natural vegetation tend to be lower than nutrient loads from watersheds dominated by anthropogenic uses (e.g., urban, agriculture). The meta-analyses suggest that land-cover change should have a detectable and sometimes pronounced effect on nutrient export. The same meta-analyses, however, also reveal considerable intra-site variability in watershed nutrient export. Nutrient export for a single watershed is variable from one year to the next due to a host of exogenous factors. Intra-site variability in watershed nutrient export complicates determination of the effect of land-cover change on nutrient export because it must be taken into account to determine if changes in nutrient export are significant. We incorporated intra-site variability into a statistical simulation model to determine the effect of land-cover change on nutrient export by treating exported loads as distributions, and testing for significant changes in the distributions. The distributions were compiled from over 1200 observations spread across 167 sites in the conterminous United States for total nitrogen (TN) and total phosphorus (TP). Land-cover changes were estimated from the National Land Cover Database (NLCD). Prior to implementing the model, we tested for spatial stationarity in the land cover - nutrient export relationship by testing for ecoregional effects. Ecoregions were not a significant factor, suggesting that the land cover - nutrient export relationship was relatively constant across the conterminous United States. We found a non-linear relationship between land-cover change and statistically significant differences TN and TP distributions. Small amounts of land-cover change produced statistically significant differences in TN and TP distributions when a watershed was dominated by natural vegetation. As the amount of natural vegetation decreased, larger amounts of land-cover change were needed to produce statistically significant shifts in TN and TP distributions. These results suggest that nutrient yields from watersheds dominated by natural vegetation are sensitive to small changes in land cover, and that consistently meeting nutrient export management targets on an annual basis will be difficult in watersheds dominated by anthropogenic uses.

A GIS Methodology to Strategically Place Constructed Wetlands for Nitrate Removal in Tile-Drained Agricultural Watersheds - Margaret McCahon, Purdue University, West Lafayette, IN (co-authors: Indrajeet Chaubey, Jane Frankenberger, Eileen Kladivko)

Intensification of agricultural practices in the Midwest has led to increased nutrient losses in surface runoff and subsurface drainage, potentially impacting the water quality downstream and the problem of hypoxia in the Gulf of Mexico. In heavily tile drained land, characteristic of parts of Indiana, there are considerable nitrogen losses in the form of nitrate. Constructed wetlands have been shown to be an effective practice to reduce nitrate loads leaving Midwestern crop lands. Strategically targeting sites that intercept high nitrate loads and sizing the wetlands according to the characteristics of their contributing areas can maximize nitrate removal while minimizing associated costs and negative impacts on production agriculture. The overall goal of this project was to develop a methodology for targeted wetland placement to remove nitrate from agricultural drainage waters. The specific objectives were to: 1) Determine suitable wetland sites in an 8-digit watershed in Indiana using GIS analysis; 2) Create preliminary wetland designs at each site; and 3) Estimate nitrate removal provided by each design. The GIS methodology for wetland placement selects for regions of high contributing area (500-2000 tile-drained acres) that are on cropland and have a particular topography. Preliminary wetland designs were created in GIS and narrowed based on the relative sizes of wetland (0.5-2% of its watershed), water depth in wetland (no more than 25% of wetland >3 ft deep), and surrounding buffer (ratio of buffer area to wetland must not exceed 4:1). Results included 19 suitable locations for wetland placement in the watershed, requiring 0.1% conversion of land, but treating 3% of the nitrate-rich (tile-drained) waters. With an estimated 33% nitrate removal efficiency, these wetlands would treat one percent of all nitrate exported from tile-drained lands. Strategic placement of wetlands can play a significant role in nitrate removal.

Application of GIS in the Hydrology and Water Quality Modeling Using HSPF in an Estuary Basin In North Florida - Maria Mao, SJRWMD, Palatka, Fl (co-author: Dale R. Smith)

In support of the establishment of Pollution Load Reduction Goals (PLRGs) and Total Maximum Daily Loads (TMDLs) in estuary systems, the St. Johns River Water Management District (SJRWMD) chose the BASINS (US EPA 2001) and hydrological Simulation Program, FORTRAN (HSPF) to simulate runoff and pollution loadings in the Northern Coastal Basin (NCB). The scope of this to develop HSPF hydrology and water quality models to estimate current surface runoff and nutrient loading into Intracoastal Waterway and Tolomato-Matanzas estuary, the North of NCB. The models generated time series of runoff, sediment, and nutrient loads which would be used as inputs to the NCB hydrodynamic/water quality model. The developed HSPF watershed models were used to evaluate the effects of the currently Best Management Practice (BMP). Besides the GIS features provided by the BASINS software, GIS applications/products were used in various aspects of the modeling development in this study. Hourly area-averaged NEXRAD Radar rainfalls were retrieved for each catchment (basic pervious and impervious modeling unit) using a District developed GIS Tool. HEC-GeoRAS was used to generate detailed stage-storage-discharge relationship in one tributary (Moses Creek). The District estimated BMP coverage map based on GIS analyses were adopted as the current BMP distribution for modeling. Three upland HSPF (Pablo Creek, Moultrie Creek, and Moses Creek) hydrologic models were calibrated with the measured discharges. The bimonthly water quality monitoring at Moultrie Creek at State Road 207 were available for water quality model calibration. The water quality constituents simulated included sediment (TSS) and inorganic nutrients (NOx, TAM, PO4), and BOD/organic matter loads. The simulated annual loading rates were within the range of literature-based target loading rates. The simulated instream water quality concentrations generally agreed with the observed concentrations. Regional calibrated HSPF hydrological and water quality model parameters were applied to the other five tributaries that had no observed data for calibration. The HSPF simulated sediment and nutrient loadings, and contributions from current, pre and post BMP implementation were displayed graphically on a GIS layer. The importance and benefits of integrating GIS application and technique with watershed modeling were demonstrated in the study.

Application of NHDplus for SPARROW Nutrient Modeling of the Northeastern and Mid-Atlantic Region of the United States - Richard Moore, U.S. Geological Survey, Pembroke, NH (co-authors: Richard B. Moore, Craig M. Johnston, Richard A. Smith)

SPARROW (Spatially Referenced Regressions on Watershed Attributes) nitrogen and phosphorus models have been developed by the National Water Quality Assessment program of the U.S. Geological Survey for 6 major regions throughout the Unites States. One of these 6 regions includes the Northeastern/Mid-Atlantic area (Chesapeake Bay drainage northward to Gulf of Maine drainage). This SPARROW model utilizes the National Hydrography Dataset Plus (NHDPlus) data as the basis for the stream network in the model. NHDPlus is a set of geospatial data built upon the 1:100,000-scale NHD. It includes: 1) a set of attributes for stream network navigation, 2) a National seamless database of topographically derived catchments, and 3) estimates of mean annual stream flow and velocity. Additional attributes were assigned to each stream segment, called flowlines, as part of the SPARROW modeling effort. These include monitored stream nutrient loads (the dependent variable in the SPARROW models) and numerous predictor variables. Updated geospatial data, and stream-monitoring records from local, State, and other federal agencies were used for this effort. Within the Northeastern/Mid-Atlantic SPARROW model area there are 187,171 stream segments that have been modeled. The nitrogen SPARROW model has been used to examine loads to the major estuaries, while the phosphorus SPARROW model has been used to examine the relative sources and loads to large lakes/reservoirs throughout the study area. These SPARROW nutrient models can be used to aid in the identification of receiving waters where excess nutrients may create a water-quality concern.