Accomplishments
Committee members were active in researching TMDL planning and assessment tools and processes, as evidenced by numerous publications, workshops, and research projects detailed below. One of the most important results of this committee is a collection of papers that is being developed on the topic of tools used in the assessment and implementation of TMDLs. This collection of refereed papers will synthesize current research for a broader audience. Publication in Transactions of the ASAE, which is expected in 2006, will ensure a wide distribution of the results of this important work.

The annual meeting was held in Beltsville MD on October 11-12, 2005. Speakers from USDA ARS, USEPA Office of Wetlands, Oceans, and Watersheds, and USDA CSREES provided useful information in defining the need and uses of assessment tools for watershed and water quality planning. Meeting attendance was good, with 32 participants from around the U.S. Discussions were held on four topics of importance in TMDL tool development and assessment: (1) Biological Indicators, (2) Model Uncertainty, (3) Use and Misuse of Models, and (4) Sediment Modeling. Results are provided in the attached meeting minutes.

The Web page for the S-1004 committee at [http://www3.bae.ncsu.edu/s1004/](http://www3.bae.ncsu.edu/s1004/) includes meeting minutes, annual reports, and links to the s1004 listserv, which is the committee’s primary communication method ( [http://www3.bae.ncsu.edu/s1004/members/listserv-info.html](http://www3.bae.ncsu.edu/s1004/members/listserv-info.html)).

Individual State reports are below.

Maryland (Submitted by Adel Shirmohammadi): We have performed an extensive sensitivity analysis on SWAT’s parameters using data from a small agricultural watershed (850 acres) in the piedmont region of Maryland. We have also performed an extensive calibration and validation of the model with 9 years of hydrologic and water quality data for the same watershed. Our current activities concentrate on performing risk associated with parameter uncertainty and subsequent effect on model output. This aspect of our activity uses Latin Hypercube Sampling technique with constrained Monte Carlo approach to develop output probability distribution with respect to parameter uncertainty reflected by different distribution functions such as log normal, normal, and beta distributions. In this context we have also evaluated the SWAT model’s capability in simulating the NRCS approved BMPs and associated risk with model outcome for each BMP impact. In other words, the level of certainty in pollutant reduction capability of a given BMP has been evaluated. We have been collecting and analyzing hydrologic and water quality data in a small watershed (850 acres) located in the piedmont region of Maryland. There are three major dairy operators in this watershed, thus application of animal waste to the land is a common practice. Land use is comprised of dairy, beef, alfalfa, corn silage/corn grain, and soybeans. Soils are diverse, but the dominant soil series is the Penn silt loam series. Monitoring was performed using US-EPA’s National Watershed Water Quality Monitoring Design consisting of both paired watershed and upstream-downstream monitoring design. Data has been collected since 1994 and
the watershed was designated as one of the national watershed water quality monitoring projects in 1995. Data collected from this watershed has been instrumental in the evaluation of the SWAT model and its output uncertainty due to input variability.

On small plot size (20’ x 40’) lysimeters, we have also been collecting data on pathogen (E.Coli, and Salmonella) transport through both bare and grassed covered surfaces. Sampling has been performed such that to evaluate the effective width of Vegetated Filters in order to keep the pathogens out of our streams and water bodies. This project is a cooperative project with USDA-ARS scientists from Environmental Quality Lab and the Animal Pathogen Lab. A transport modeling component is also associated with this project. Data obtained in this project may be helpful in development and testing of bacteria sub-component in SWAT model.

Impact:

1) Our monitoring in small watershed in the Monocacy Basin resulted in the motivation of land owners (e.g., farmers) to apply for several cost-shared BMP programs through USDA-NRCS. Three slurry storage systems (2 slurry storage tanks each with a capacity of about 520,000 gallons and 220, 000 gallon, respectively) and a concrete lined slurry storage basin were implemented using EQUIP program under USDA-NRCS. Additionally, 20 acres of riparian zone (40 feet on each side of the stream) was implemented using funds from CREP (Conservation Reserve Enhancement Program) of USDA-NRCS. These BMPs have helped and will help to reduce the sediment and nutrient loadings to the Warner Creek that drains to Monocacy River.

2) Our monitoring program has provided educational benefits to both farmers in the watershed and the neighboring farms, students from the University of Maryland, scientists from both University of Maryland and many international countries such as Sweden, Russia, Moldova, Uzbekistan, Romania, etc… Our findings had also been published in refereed journals and been presented in many national and international conferences, thus having wide educational benefits.

3) Our monitoring and modeling efforts have helped to asses the strength and weaknesses of a widely used model such as SWAT for simulating hydrologic and Water Quality response of watersheds. We believe that our efforts will help the users of SWAT model in the development of TMDL plans for their watersheds. Certainly, our work on the development of uncertainty for model outputs due to uncertainty in model inputs is gaining lots of attention as was addressed in the 3rd. TMDL conference in Atlanta, Georgia. This has also led us to submit a multi-state proposal on the development of uncertainty for Margin of Safety (MOS) in TMDL development the recent NRI watershed Processes Grants.

Texas (Submitted by Wes Rosenthal and Ali Saleh): A web-based tool has been developed for EPA Region 6 personnel. It combines GIS layers (elevation, topo maps, digital ortho photos, wetland inventory) and allows the user in ARCView to determine hydrologic flows around wetlands. The software will help EPA personnel to evaluate flows around wetlands and determine if they are jurisdictional. The software will help EPA save thousands of travel dollars to sites in Texas and Louisiana to determine if they fall under their jurisdiction. The tool can be applied to determine if BMPs will affect wetlands in TMDL watersheds.
Models such as SWAT and APEX are only capable of simulating a limited number of BMP scenarios individually. In this study, the SWAPP (SWAT/APEX Programs) program is developed to facilitate the simultaneous use of these two models. The SWAT (version 2000) and APEX (version 2110) models were utilized within the SWAPP program. The SWAT alone (SWAT-A) and the combined SWAT and APEX models within the SWAPP program were calibrated and verified against the historical measured data collected within the UNBR watershed. The results obtained from three sites within the UNBR watershed show that the pattern (model efficiencies) and average monthly values of flow and loadings predicted by the SWAPP were generally similar and in some cases closer to the measured values as compared to the SWAT-A. By using the SWAPP program one is able to simulate management scenarios at the field level, such as multicropping or filter strips by utilizing APEX, whereas SWAT alone currently has limited capability to simulate those practices. In addition, the SWAPP could be used to convert SWAT data files, generated from Geographical Information System (GIS) layers, to APEX data files format.

**Virginia:** (Submitted by Brian Benham): The Center for TMDL and Watershed Studies at Virginia Tech (http://tmdl.bse.vt.edu) continued its commitment to improve the quality and effectiveness of watershed planning processes, including TMDLs and expand the professional expertise needed for their development, evaluation, and implementation by publishing two journal articles, a book chapter, and two Virginia Cooperative Extension publications, and by conducting 5 bacterial and biological (benthic) impairment TMDL studies for the state of Virginia, presenting several papers and workshops at professional meetings, and developing and releasing the Bacteria Source Load Calculator software.

**Impact:**
Several of the TMDL studies conducted by the Center this past year presented opportunities to develop or improve approaches used for TMDL development.

**Beaver Creek in Rockingham County, VA.** Issues: significant historical change in pollution contributors and consideration of spatial variation in water quality.

Careful investigation of the biological impairment showed that it was caused by a fishery no longer in operation. We prepared a detailed analysis of the fishery’s contribution to the impairment and worked with the Virginia Department of Environmental Quality (DEQ) to remove this segment from the impaired waters list after 4 unimpaired benthic samples were recorded. Beaver Creek was rather unique in that it contained a spring contributing about 5/6 of the total flow at the watershed outlet. The flow from the spring entered the main channel downstream of the impaired monitoring station. The spring flow contributed almost no bacteria to the creek. We realized that this meant a TMDL developed for the watershed outlet would not bring the monitoring station located above the confluence into compliance with bacteria water quality standards, and developed two TMDLs – one for the area upstream of the spring confluence, and one for the watershed outlet. This should allow water quality standards to be met at both the monitoring station and the watershed outlet.

**North River in Rockingham and Augusta Counties, VA.** Issue: previously approved bacteria and benthic TMDLs already exist for the majority of the watershed.

Investigation of the previously developed benthic TMDLs showed that the pollutant reductions called for in these TMDLs are adequate to address the benthic impairment in the main
channel of the North River. We completed a stressor analysis that supports the reclassification of this segment to category 4A – impaired, but not needing a TMDL because one or more TMDLs for the identified pollutants have already been completed and approved by EPA. Three-quarters of the North River watershed had previously developed bacteria TMDLs in place. Many of these upstream areas did not have flow gaging stations and thus were not calibrated for hydrology, and several of the previously developed TMDLs were developed under an older, less restrictive standard. We developed methods to appropriately represent the areas of the watershed with previously developed TMDLs in each stage of modeling (hydrology calibration, water quality calibration, and allocation). These methods allowed us to appropriately represent the entire watershed while targeting our current TMDL development efforts on the portion of the watershed without a previously developed TMDL in place.

The Bacteria Source Load Calculator (BSLC) was developed and released by the Center for TMDL and Watershed Studies to assist TMDL developers when generating bacterial loadings to watersheds from livestock, human, and wildlife sources. The BSLC is useful for anyone faced with developing a TMDL for a water body impaired by bacteria (pathogens). The calculator generates input files for NPS and direct NPS bacterial loads required by the HSPF model. The calculator requires user inputs of animal numbers, land use, and stream access on a sub-watershed level. Default production rates are provided but can be changed by the user. This software greatly speeds up the process of generating fecal coliform numbers, land use, and stream access on a sub-watershed level. The BSLC is written in Visual Basic for Applications and is based on a Microsoft Excel spreadsheet, which allows for widespread compatibility with potential users. The BSLC reduces the time, and cost, needed to develop bacteria impairment TMDLs. The flexibility the BSLC provides enables the user to perform more accurate bacteria load source characterizations.

**Georgia: USDA-ARS, SEWRL (Submitted by David Bosch):** The Ann-AGNPS and SWAT watershed models were tested using data collected on the Little River Watershed. The utility of the models for TMDL development in the Southeast was evaluated. To date, comparisons between observed and simulated streamflow data indicate the models provide reasonable hydrologic accuracy for the region. The simulations also indicate a need for improved representation of riparian buffers in the models. Impact: These comparisons help to provide credibility to many TMDL plans being developed within many states throughout the Southeastern Coastal Plain region.

**USEPA (Submitted by Clay Ogg):** A paper was published about new modeling breakthroughs which may be helping states overcome the technical barriers which in the past prevented them from tracking the performance of TMDL and other watershed programs. The barriers stem from the large number (over 20,000) of impaired watersheds, and the costs of developing models for each watershed, as well as the costs of monitoring streams to measure performance. Breakthroughs result from the ability of very fast computers to do site-specific modeling of fields, for thirty years of storm events, and the aggregation of the pollutant loadings to thousands of watersheds.

**Arkansas (Submitted by Indrajeet Chaubey):** A decision support system was developed for the Beaver Lake watershed located in northwest Arkansas. The Beaver Lake is a multi-use reservoir
and supplies drinking water to more than 300,000 residents in northwest Arkansas. The DSS can be used to make watershed management decisions to protect long term quality of the lake while ensuring economic development in the watershed. In addition, development of two other DSS in Eucha-Spavinaw watershed and in L’Anguille watershed is currently in progress. Help was provided to the Arkansas Natural Resources Commission to perform watershed modeling for identifying ‘hot spots’ for flow, sediment, nutrients and pesticides in priority watersheds. The ANRC is using the modeling results to target implementation of BMPs in the watershed. In addition, the ANRC has also used the modeling results to identify priority watersheds for 2004-2008. Three training sessions for using Soil and Water Assessment Tool (SWAT) model have been attended by more than 60 people from various state and local agencies in Arkansas. At least six field days and educational tours of experimental watersheds have been conducted to educate stakeholder on linkages among farm level activities and their impact on watershed scale water quality. More than 300 people have attended these field trips.

**Florida and North Carolina** (submitted by Rafael Muñoz-Carpena and John Parsons): A new procedure for designing vegetative buffer strips (VFS) as best management practices for sediment runoff control within the TMDL process has been proposed. This procedure is based on one of the computer models included in the project proposal, VFSMOD-W. The objective of the design procedure is to obtain the optimal filter length to filter a given percentage of the maximum runoff sediment event (defined by the TMDL) generated for a certain design storm (defined in terms of return period). The procedure considers several design parameters specific to the application location: i) design storms (usually 1, 2, 5 and 10 year return periods) for the area; ii) soil types present in the area; iii) disturbed land conditions including crops and practices; iv) vegetative filter types recommended for the area; v) field and filter slopes. A new release of the model was produced this semester that incorporates this new feature and updated documentation. (http://www3.bae.ncsu.edu/vfsmod). In a further cooperation with colleagues at USDA-ARS-Beltsville, the model is being evaluated as a tool to optimize buffer-grass criteria as part of national P-Index evaluations (Sadegui et al, 2005). The model is currently being developed and tested to include surface phosphorus runoff filtration from disturbed mining areas of Central Florida where P loading can result in TMDL surface water impairments. The Central Florida region of Polk County provides over 75% of the US phosphate needs and approximately 25% of the world’s supply. During 2001, 22.1 million metric tons of phosphate rock were extracted from 4,522 acres of land in this region. Years of mining have left vast tracks of land in need of restoration to minimize the potential for phosphorous pollution from this enriched lands into water bodies. Recently, public attention has been directed to possible links between high phosphorous loads in the Peace River that transverses the region and appearance of red tide blooms in FL Gulf region. New field research (2004-2006) has been initiated in the area to further develop and test VFSMOD-W.

FHANTM and ACRU2000 evaluation is continuing in order to determine these models' applicability for TMDL development in the Lake Okeechobee basin. The models are being tested using data from ongoing BMP demonstration projects on beef ranches in south Florida. FHANTM was calibrated using runoff and water quality data from a 16-pasture research study conducted from 1998 through 2003. Data from 1998-2001 were used in the calibration phase. Data from the same pastures for 2002-2003 were used as an independent verification of the model's performance in predicting runoff and nitrogen and phosphorus loadings from the pastures. Statistical analyses of the model results indicated that FHANTM v2.0 is sufficient for use on site-specific applications.
on the basis of annual runoff for all four pastures simulated and for annual phosphorus loads on
two pastures. It is also sufficient for site-specific use on one pasture for annual nitrogen loads. In
terms of the remaining pastures for monthly runoff, annual and monthly phosphorus loads, and
annual and monthly nitrogen loads, the model is mainly sufficient for screening purposes.
Management activities performed on the pastures could not be represented adequately with the
model. The ACRU2000 model has potential to better represent management activities and spatial
differences that may have caused some of the simulation difficulties with FHANTM. Modification
of ACRU2000 to implement the changes needed to improve its performance on these sandy, flat,
high-water-table pastures is currently nearing completion. Measurement of pasture runoff and
water quality data are continuing in support of this model evaluation research and to evaluate
additional BMPs on another ranch to provide larger watershed-scale research data for use in
continuing model evaluation on a larger ranch scale.

Tennessee (provided by Daniel Yoder): Aided by researchers at Tennessee, the USDA-NRCS has
completed implementation of the RUSLE2 soil erosion model in its 2500+ field offices throughout
the U.S. and its territories and protectorates. This model is being used an estimated 2000-5000
times a day in these field offices for conservation planning as well as for estimating the impact of
management practices on soil health through the NRCS Soil Conditioning Index, which has been
packaged in the RUSLE2 interface. While many of these calculations are not directly linked to
TMDL estimates, they have been used in some TMDL analyses. For example, the Wisconsin
DNR has completed several TMDL analyses using previously-calculated RUSLE2 results as to
determine the sediment contribution from various land areas in their watersheds.

In addition, RUSLE2 is now available as a stand-alone dll, or program that can be called by other
programs. It is currently being used in this way by University of Wisconsin researchers and
Extension personnel working with the SNAP nutrient management model, as well as by the
Manure Management Planner model developed at Purdue. These models make use of erosion
estimates provided by RUSLE2, as well as the access RUSLE2 has to the extensive management
database developed by USDA-NRCS, which contains some 10,000 management, field operation,
and vegetation descriptions. The intention of USDA-NRCS and USDA-ARS is to use RUSLE2 in
this way in the next version of AnnAGNPS, which would be used on a watershed basis.

Alabama (Includes Auburn and Alabama A&M, submitted by M.S. Kang, T. Tsegaye, W.
Tadesse, I. Abdi, and D. Spencer):
The Auburn group initiated a couple of TMDL related project in Alabama. The first project
involves identifying hydrologically-active areas (HAA) in a cattle-grazing pasture in the Sand
Mountain Region of north Alabama. With this project we hope to address phosphorus and
pathogen related problems associated with land-applied poultry litter to the pasture field. The goal
is to minimize the water quality impacts from land application of poultry litter. The second project
involves development of a comprehensive best management practice (BMP) database for Alabama
and implementation of this database as an add-on tool for the SWAT (Soil and Water Assessment
Tool) model. Once fully developed, the add-on tool can be used to evaluate the effect of various
BMPs on streams of Alabama and other southern states.
Impacts of the S-1004 Project

1. The runoff-contributing area project will help minimize water quality impact of land-applied poultry litter in the Sand Mountain region of Alabama.

2. The BMP database and the add-on tool will help model reduction in pollutant loads from various BMPs and will help optimize BMPs implementation in Alabama and other southern states.

The Alabama A&M group monitored the water quality of streams in the Flint River watersheds in northern Alabama for the past two years as a part of the ongoing TMDL related research. The water quality indicator variables of interest included total phosphorus (TP), total nitrogen (TN), cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), zinc (Zn), coliform bacteria (CF), biological oxygen demand (BOD5), dissolved oxygen (DO), temperature, turbidity, pH, and chlorophyll. A study of sediment transport modeling using the AGNPS model has been completed for the Flint River watershed. The watershed was subdivided into 400 m x 400 m grid cell, which are basic operational resolution for the AGNPS model. The runoff and sediment estimates for different rainfall events were computed for each cell. Results also showed that model simulation were improved when composite runoff curve number was generated using the land use/cover data obtained from the satellite image. Further analysis was carried out for estimation of concentration of non-point source pollutants such as nitrogen and phosphorus. The model was also effectively used to prioritize several sub-watersheds in the Flint River for the potential severity of water quality problems, to pinpoint critical areas within a watershed which contribute pollutants, and to evaluate the effects of best management practices (BMP). The GIS representation of model input and output also facilitated examination of a wider range of alternatives than would be possible by using a standard method.

Kansas (Submitted by Philip Barnes): We have completed two long term monitoring during the past year. The first project included data collected during the period from 1997 through 2004 on the Big Blue River watershed drainage into Tuttle Creek Reservoir near Manhattan, Kansas. The States of Kansas and Nebraska have signed a compact that addresses both water quantity and quality issues. Because the water in Tuttle Creek Reservoir is used as a drinking water supply in Kansas it must meet the water use quality standards for Kansas. During this monitoring period the inflow and reservoir have not met the standard for the herbicides atrazine and alachlor. Twenty one locations were monitored for flow and herbicide concentrations during this seven year period. With this data daily loading data was calculated to assess sources of the herbicide pollution. The final report titled “Joint State Atrazine Big Blue River Monitoring Project”, (A Cooperative Joint State Monitoring Project Section 104(b)(3) of the Clean Water Act, EPA Assistance Agreement No. CP997369), show herbicide contamination throughout the watershed. But the largest loading occurred in a four county region along the state line. The predominant crop using these herbicides grown in this region is grain sorghum. During 2005, this watershed received an EPA Targeted Watershed Grant. The project is a collaborative effort between the two states to address multi-jurisdictional water quality problems of excessive sediment runoff, nutrients, herbicides and bacteria. It will demonstrate a process for achieving water quality goals in a large agricultural watershed by targeting and implementing best management practices in critical sub-watersheds. EPA grants funds will be used to implement existing watershed management plans, install no-till systems, establish riparian buffer strips and other conservation measures, and enhance educational
efforts. Market-based incentives will be used to encourage and support landowner adoption of best management practices.

The second project included data collected during the period 2002 through 2004 on the Fall River watershed. This data was collected in part for a Kansas Watershed Restoration and Protection Strategy (WRAPS) Development for the Fall River/Verdigris Basin (EPA Assistance Agreement NPS K3-023). This study examined the effects of headwater impoundments on water quality, stream fluvial geomorphology, and aquatic diversity. Three final reports present information on a paired watershed study to address these issues. The reports include (1) Impact of Watershed Development for the Fall River Watershed Water Quality Assessment by Philip Barnes with Kansas State University; (2) Fall River Watershed Joint District No. 21 Fluvial geomorphology Report by Brock Emmert with The Watershed Institute in Topeka, Kansas; and (3) Effects of Headwater Impoundments on Intermittent Streams in the Flint Hills, Kansas by Nate Davis with Kansas Department of Wildlife and Parks in Pratt, Kansas.

Impact:

1) Monitoring of the Big Blue Watershed has reduced the area of concern to four counties upstream of Tuttle Creek Reservoir. Implementation of practices in these counties should reduce loading of sediments, nutrients, bacteria and herbicides to meet TMDL requirements for Kansas drinking water.

2) Monitoring of the Fall River Watershed indicates that watershed dams can be effective in reducing sediment, nutrient, and bacterial contamination of water below these structures. But these structures can have a dramatic impact on the channel geomorphology below a structure and can reduce the aquatic diversity in the stream below these structures.

Impacts of the S-1004 Project

3. This project is increasing knowledge concerning the appropriateness of various TMDL development tools for application in agricultural watersheds.

4. The utility of current models used for TMDL development in agricultural watersheds is being improved, and biotic and economic factors are being incorporated into several models that do not currently include them.

5. Methods for modeling key TMDL parameters, including sediments, biological indicators, and dissolved oxygen are being synthesized to aid decision-makers in improving TMDLs.

Publications

Refereed Journals


**Book Chapters**


**Non-Refereed and Extension Publications**


