Tennessee Water Resources Research Center
Annual Technical Report
FY 2008

Introduction

Water Resources Issues and Problems of Tennessee

Tennessee is fortunate to have what many consider to be an abundant and good quality water supply. Historically, federal government agencies, such as the Tennessee Valley Authority (TVA), Corps of Engineers, Soil Conservation Service, U.S. Geological Survey and others, have been the primary contributors to the management and monitoring of water resources. In recent years, however, the State, through the Tennessee Departments of Environment and Conservation, Wildlife Resources, Agriculture and others, have begun to develop a more active and aggressive role in the management and protection of these resources. The State has moved to establish an integrated and coordinated policy and administrative system for the management of water resources in Tennessee

While the situation is improving, there remain many of the additional types of water problems. Although the overall supply of water is adequate, the distribution is still not optimal. Local shortages occur during dry periods. The summer of 2007 was a particularly hot and dry one. During this period over 35 water districts out of a total of 671 public systems in Tennessee experienced lesser degrees of difficulty in supply water. Beginning in 2006 and continuing on through the summer of 2008, Tennessee experienced another major drought period which severely strained the water supplies of many communities across the state. In recent years, many of the small municipal water suppliers and utility districts that rely on wells, springs, or minor tributaries for their water sources continue to face severe water shortage problems. All across the state many private, domestic, and commercial use wells have become severely strained, forcing users to seek alternative sources of water. Providing an adequate supply of water for industrial, commercial, and domestic uses and the protection of these surface and groundwater resources are of major concern in all regions of the state and vital to the economic development and growth of the state.

Groundwater presents a particular challenge in Tennessee. Over 50% of the population of Tennessee depends on groundwater for drinking water supply. In West Tennessee, nearly all public suppliers, industries, and rural residents use groundwater. However, not enough is known about the quality and quantity of groundwater in the state, and consequently, maximum benefit from and protection of this resource cannot be easily accomplished. More information about the quality of the state's groundwater, particularly about the potential impact of recharge areas, is needed in order to develop an effective management and protection program for this valuable resource.

There is also the problem of potential contamination of groundwater from agricultural and urban non-point sources. The "fate and transport" of agricultural chemicals (herbicides and pesticides) and toxic substances in groundwater is a problem area that must be addressed if the state's groundwater protection strategy is to be effective in protecting this vital resource

Although the danger of large-scale, main-stem flooding is controlled by mainstream and tributary dams that have been constructed by TVA and the Army Corps of Engineers, localized flooding and even general flooding in unregulated watersheds remain substantial problems across the state. A lack of effective local floodplain management land-use controls is apparent in West Tennessee, where related problems of excessive erosion, sedimentation, drainage, and the loss of wetlands constitutes what many consider to be the greatest single water resource issue in the state from an economic and environmental point of view. Effective regulation of private levee design, construction, maintenance, and safety is needed.

Water quality problems continue to persist from past industrial practices, from the surface mining of coal and other minerals (especially from abandoned mines), from agricultural and urban nonpoint sources and from improperly planned, designed and operated waste disposal sites. As has been the situation in the past, the state

program for the construction of municipal wastewater treatment facilities and improved operation and management of the facilities have experienced numerous set-backs due to shortfalls in funding and administrative delays. In major urban areas that have combined storm and sanitary sewers, urban storm water runoff causes increased pollution and, during periods of wet weather, bypasses treatment facilities, which allows raw sewage to enter receiving waters untreated. Tennessee cities, both large and small, are concerned about current (and future) impacts of the new NPDES storm water discharge permit requirements on clean up needs and costs. In certain regions of the state, failing septic fields and the practice of blasting bedrock for new septic fields are serious threats to surface and groundwater resources.

There are existing programs which can address many of these problems. However, some problems do not have easy solutions. Additional research can also play a role in understanding and solving these problems, but the greatest impediments are the lack of agreement between competing interests and a shortage of financial support for existing programs. From the viewpoint of the State government, the legal, institutional, and administrative aspects of water management are major concerns. The state is still working to develop new policy and to refine administrative structure for the effective management of its water resources.

To address the problems and issues of effective water resources management in the state of Tennessee, a truly interdisciplinary and well-coordinated effort is necessary. The Tennessee Water Resources Research Center has the capability and organization that can call upon the diverse set of disciplinary expertise necessary to address the key water issues of the state and region.

The Tennessee Water Resources Research Center: Overview of Program Objectives and Goals:

The Tennessee Water Resources Research Center serves as a link between the academic community and water-related organizations and people in federal and state government and in the private sector, for purpose of mobilizing university research expertise in identifying and addressing high-priority water problems and issues and in each of the respective state regions.

The Tennessee Water Resources Research Center, located at the University of Tennessee, is a federally-designated state research institute. It is supported in part by the U.S. Geological Survey of the U.S. Department of Interior under the provisions of the Water Resources Research Act of 1984, as amended by P.L. 101-397 and 10 I - 1 47. The Act states that each institute shall:

I. plan, conduct or otherwise arrange for competent research that fosters the entry of new research scientists into the water resources fields; the training and education of future water scientists, engineers and technicians; the preliminary exploration of new ideas that address water problems or expand understanding of water and water-related phenomena, and the dissemination of research results of water managers and the public.

II. cooperate closely with other colleges and universities in the state that have demonstrated capabilities for research, information dissemination, and graduate training, in order to develop a statewide program designed to resolve state and regional water and related land problems.

In supporting the federal institute mandate, the TNWRRC is committed to emphasizing these major goals:

1. To assist and support all the academic institutions of the state, public and private, in pursuing water resources research programs for addressing problem areas of concern to the state and region.

2. To provide information dissemination and technology transfer services to state and local governmental bodies, academic institutions, professional groups, businesses and industries, environmental organizations and others, including the general public, who have an interest in water resources matters.

3. To promote professional training and education in fields relating to water resources and to encourage the entry of promising students into careers in these fields.

4. To represent Tennessee in the Universities Council on Water Resources, the American Water Resources Association (including Tennessee Section), the Water Environment Federation, the American Water Works Association, the International Erosion Control Association, the Soil and Water Conservation Society, the Lower Clinch Watershed Council, the ORNL-TVA-UT Research Consortium and the National Institutes for Water Resources (NIWR). To work with these and other associations and with state, local and federal government agencies dealing with water resources in identifying problems amenable to a research approach and in developing coherent programs to address them. Particularly, to cooperate with the other state institutes and their regional groupings for assisting the U.S. Geological Survey in developing a national water resources strategy.

In fulfilling the Center's major goals indicated previously, TNWRRC emphasizes the application of Section 104 grant and required matching funds for primarily supporting the research and training/education needs of the state. While the information dissemination and technology transfer portion of the Center's overall program does not receive direct or significant section 104 funding, this is accomplished primarily from the research and training activities of the Center from other funding sources--state, private, or non-profit. The Center recognizes that education and training, research, and information transfer are not independent objectives or are not mutually exclusive. Instead these goals are achieved through the administration of a coordinated, fully-integrated program within the limitations of the resources available to the Center.

Research Program Introduction

None.

Effect of Wastewater Strength on Soil Physical Properties when using Subsurface Drip Irrigation

Basic Information

Title:	Effect of Wastewater Strength on Soil Physical Properties when using Subsurface Drip Irrigation
Project Number:	2008TN52B
Start Date:	3/1/2008
End Date:	8/31/2009
Funding Source:	104B
Congressional District:	TN Second
Research Category:	Water Quality
Focus Category:	Waste Water, Non Point Pollution, Water Quality
Descriptors:	Drip Dispersal, Domestic Wastewater, Decentralized Wastewater Management
Principal Investigators:	John R. Buchanan

Publication

(6) Nature, Scope and Objectives of Research:

The specific objectives of this project were to:

a) Determine whether biomat forms around drip tubing, and to determine whether the quality of the wastewater influences biomat formation around drip tubing.
b) Determine the extent of soil moisture saturation (if any) around the drip tubing.
c) Determine the renovation of the water at various depths below the point of application.
d) Determine the reduction in nutrients, and organic carbon as water moves through the soil.
e) Publish the new information generated by this project.

(7) Methodology and Accomplishments to Date:

Experimental Setup

A consistent supply of primary and secondary treated domestic wastewater was required for this project. Jackson Bend subdivision, located in Blount County, Tennessee, has a decentralized wastewater management system. Wastewater from each home is collected by a Septic Tank Effluent Pump (STEP) system that transfers effluent to a recirculating media filter for secondary treatment. The highly renovated effluent is then subsurface applied using drip irrigation. This location allowed the P.I to collect primary treated water out of the STEP system and collect secondary treated water out of the recirculating sand filter. Two separate subsurface wastewater drip dispersal fields were established. Each field has 305 m of subsurface drip line. Each drip field is composed of 10 parallel rows that are 15.24 m long. The drip lines were plowed-in 0.6 m on center. Specifications for drip line include pressure-compensated emitters rated at approximately 2.27 L/h with the emitters spaced every 0.6 m along the tubing. One drip field received septic tank effluent (primary treatment) and the second field received secondary quality effluent.

Approximately 1,514 L of domestic wastewater per day is applied each day. This includes 757 L of septic tank effluent and 757 L of secondary quality effluent. The dispersal field is 372 m^2, and thus the application rate was 4 $L/m^2/d$.

Data Collection

With Tennessee Water Resources Research Center Program funding, a graduate student was employed to conduct sampling and analyses. Two-inch diameter soil cores were extracted from selected locations within each field. The soil solution from these cores was analyzed for total organic carbon (TOC), total nitrogen, and total phosphorus. A second set of soil cores were extracted and evaluated for saturated hydraulic conductivity.

Soil core samples were taken at two depths, 0.3 and 0.6 m below the drip emitter elevation. Six sets of cores were pulled. Core 1 was at a emitter, core 2 was along the drip tubing, but between emitters, core 3 was at the emitter but between the drip lines (to the right in the direction of flow), core 4 was at the emitter but between the drip lines (to the left in the direction of flow), core 5 was both between emitters and between the drip tubing to the right, and core 6 was between the emitters and tubing to the left. As controls, two cores with samples from 0.3 and 0.6 m were taken from the native soil outside of the drip dispersal area. This procedure was repeated

in both fields: The field receiving primary quality effluent and the field receiving secondary quality effluent.

The goal of the chemical analysis was not to extract all of the carbon, nitrogen and phosphorus out of the sample. Rather, this was an attempt to simulate saturated soil conditions and determine the constituent concentration that would be expected to percolate through to the groundwater. Soil chemical properties were analyzed by drying and then grinding the soil sample. Thirty grams of dry soil was mixed with 20 g of tap water and placed on a shaker table for 24 hours. This mixture was then centrifuged for 10 minutes at 3,500 rpm. A sample of the supernatant was extracted and subjected to chemical analyses.

Data Analysis

All of these samples will be analyzed to look for differences in soil solution quality and water movement as the two types of effluent pass through the soil profile. The null hypothesis is that the soil will be able to renovate and move the septic tank effluent equally well as the secondary-treated effluent. Statistical analysis was performed on the data to verify this hypothesis.

(8) Principal Findings and Significance:

The Jackson Bend site has been in operation since June 19, 2006. In that time, just over 4,300 L of effluent per m^2 has been applied. No significant differences have been found in the data concerning the concentrations of total nitrogen, nitrate-nitrogen, and total carbon from the two fields. There does appear to be a difference in saturated hydraulic conductivity.

Table 1. Results of soil chemical and physical analyses.

Field	Total Nitrogen as N (ppm)	NO3 as N (ppm)	Total Carbon (ppm)	Conductivity (cm/d)
Primary Quality	17.61 mean	6.69 mean	131.19 mean	2.73 mean
	4.82 std dev	0.49 std dev	41.22 std dev	3.15 std dev
Secondary Quality	16.25 mean	5.20 mean	124.19 mean	0.04 mean
	4.52 std dev	0.86 std dev	45.40 std dev	0.06 std dev

The primary goal of this project was (is) to determine whether secondary treatment is needed when the domestic wastewater being applied via subsurface drip irrigation. Subsurface drip irrigation optimizes the wastewater renovation potential provided by the soil. To date, the data seem to suggest that soil solutions beneath the wastewater application areas are not different. This implies that the wastewater constituents are being converted or removed independent of whether the wastewater source has received secondary treatment before subsurface soil application.

(9) Future Research and Funding:

Sampling of these fields will continue. Funding from the University of Tennessee's Institute of Agriculture is being used to continue this effort. It is planned to repeat the above listed

procedure eight more times. The soil is a heterogeneous media. It's physical, chemical, and biological properties can greatly vary both spatially and temporally. The greater the variability, the greater the number of samples required in order to prevent the wrong conclusion from being determined.

A Survey of Bank Erosion in Beaver Creek, Knox County, Tennessee: Correlations of Channel Stability with Force and Resistance Variables

Basic Information

Title:	A Survey of Bank Erosion in Beaver Creek, Knox County, Tennessee: Correlations of Channel Stability with Force and Resistance Variables
Project Number:	2008TN53B
Start Date:	3/1/2008
End Date:	9/31/2009
Funding Source:	104B
Congressional District:	TN Second
Research Category:	Climate and Hydrologic Processes
Focus Category:	Sediments, Surface Water, Ecology
Descriptors:	Bank Erosion, Channel Stability, Siltation, Urbanization, Stream Restoration
Principal Investigators:	Qiang He, John S. Schwartz

Publication

1. Keaney,Bart, Qiang,He, and John,Schwartz,2009, Effects of Watershed Urbanization on Stream Channel Stability in Knox County,Tennessee, "in" Proceeding of the Nineteenth Tennessee Water Resources Symposium, Tennesse Section of the American Water Resources Association, Nashville, TN. pp 2A-26.
2. Keaney,Bart,2009,Stream Channel Stability and Channel Evolution in a Rapidly Urbanizing, Ridge-and-Valley Watershed, Beaver Creek,Knox County, Tennessee,"MS Dissertation", Department of Civil and Environmental Engineering, College of Engineering, the University of Tennessee, Knoxville, TN.,pp. 119.

(6) Problem and Research Objectives:

The State of Tennessee contains many waterbodies that have been identified on the 303(d) list as impaired or threatened, by which they do not meet designated beneficial uses including biological integrity [40 CFR Part 130; TCA §69-3-101 and TDEC Rules Chapter 1200-4]. By far, the majority of streams listed are impacted by excessive sedimentation in channels causing physical habitat degradation, which reduces biological integrity. The Tennessee Department of Environment and Conservation (TDEC) is required by statutes to produce total daily maximum loads (TMDLs) for 303(d) listed streams impacted by siltation and habitat alteration. TDEC has produced sediment TMDLs for the Beaver Creek watershed, Knox County (Lower Clinch HUC). Field observations and output from a completed AnnAGNPS model suggest that bank erosion is a significant contributor.

The nature of this research is to investigate impacts from urbanization on watershed-scale patterns of channel instability. In addition, the proposed research studies how variables associated with force and resistance play into the development of a predictive model for bank erosion potential. The scope of the project is to intensively survey Beaver Creek and major tributaries for bank erosion problems by conducting RGAs. The number of RGAs conducted will be between 50 and 100.

The objectives for this research are:

(a) Evaluate AnnAGNPS model output with respect to identifying locations with bank erosion problems, and

(b) Develop a predictive model for bank erosion potential based on variables associated with channel force and resistance.

(7) Methodology and Accomplishments to Date:

The research being reported here, sponsored in part by the TNWRRC with FY08 and FY09 funding, is to evaluate the AnnAGNPS model output for Beaver Creek, which identified areas with potentially high bank erosion. The field survey carried out in this project using the Rapid Geomorphic Assessment (RGA) technique in Beaver Creek provides the BCTF on prioritization of proposed bank stability projects.

Methodology:

The field survey of bank erosion in the Beaver Creek watershed was performed with three key metrics for each site. These were a Channel Stability Index, water surface slope, and a Modified Wolman Pebble Count. If the bed material at the site was composed entirely of bedrock or of sand or smaller particles, a pebble count was not performed. The latitude and longitude for each site were recorded with a Global Positioning System receiver accurate to 5 meters.

I. Channel Stability Index

The Channel Stability Index is obtained with the Rapid Geomorphic Assessment (RGA) technique developed by Andrew Simon, of the National Sedimentation Laboratory in Oxford, MS, as a tool to allow a quick evaluation of reach-scale stream bank stability to be made in the field. RGA sites were selected using a detailed map of all streams, swales and water conveyances in the Beaver Creek Watershed that was provided by the Knox County Stormwater Department. Channelization was inferred by visual estimation of sinuosity. An effort was made to ensure that sites were somewhat evenly spaced along the length of the stream, to provide data for sites ranging from the headwaters to mouth. Field visits were made to determine whether access to the stream was available and whether there existed a baseflow adequate to perform an RGA.

The Rapid Geomorphic Assessment ranked stream channel stability on a scale from 0 to 36, as measured by a series of 9 quantitative and semi-qualitative metrics. The scores assigned to each metric were summed to obtain the total RGA score. This total score is also termed the "Channel Stability Index". The nine metrics are:

1. Primary bed material. A score between 0 and 4 was given based on the stability of the bed material. 0 was given to bedrock, 1 to boulder/cobble, 2 to gravel, 3 to sand and 4 to silt/clay.
2. Bed/bank protection. A score of 1 was given if no bed or bank protection was present. Two points were given if one bank was protected and 3 points if both banks were. Thus, if a reach had an unprotected bed and two banks protected, the score would be 4. If the bed was protected, the score would be 3.

3. Degree of incision. A score of 0 to 4 was awarded based on the ratio of the bank height (from the toe to the top bank) to the depth of flow at the deepest part of the reach. 0-10% incision was scored 4, 11-25% incision was scored 3, 26-50% incision was scored 2, 51-75% incision was scored 1 and 76-100% incision was scored 4.
4. Degree of constriction. A score of 0 to 4 was awarded based on the ratio of channel width at the head of the reach to the width at the bottom of the reach. 0-10% incision was scored 0, 11-25% constriction was scored 1, 26-50% constriction was scored 2, 51-75% constriction was scored 3 and 76-100% constriction was scored 4.
5. Stream Bank Erosion. Each bank was considered separately. If no erosion was present, it was scored 0. If fluvial erosion was the dominant process, it was scored 1. If mass wasting was the dominant process, it was scored 2.
6. Stream bank instability. If mass wasting was present, whether or not it was the dominant process, the percentage of each bank in the reach on which it appeared was assessed. 0-10% failing was scored 0, 11-25% failing was scored 0.5, 26-50% failing was scored 1, 51-75% failing was scored 1.5 and 76-100% failing was scored 2. This assessment was performed separately for each bank.
7. Established riparian woody-vegetative cover. The percentage of each bank on which woody vegetation was present was considered separately. 0-10% covered was scored 2, 11-25% covered was scored 1.5, 26-50% covered was scored 1, 51-75% covered was scored 0.5 and 76-100% covered was scored 0.
8. Occurrence of bank accretion. The percentage of each bank upon which fluvial deposition was present was considered separately. 0-10% covered was scored 2, 11-25% covered was scored 1.5, 26-50% covered was scored 1, 51-75% covered was scored 0.5 and 76-100% covered was scored 0.
9. Stage of channel evolution. A score between 0 and 4 was awarded based on the stage of channel evolution. Stage 1 was scored 0, Stage 2 was scored 1, Stage 3 was scored 2, Stage 4 was scored 4, Stage 5 was scored 3 and Stage six was scored 1.5.

II. Water surface slope

Slope was measured with a Pentax AL-M4c Autolevel. Frequently, the reach of interest was less than or equal to 100 ft in length, so the slope was measured from points 50 ft upstream and 50 ft downstream of the level, in order to ease calculations. At certain downstream sites, longer reaches were surveyed, to account for the fact that a reach length of six to ten channel widths would be longer than 100 ft. In these instances, the measurements were corrected to provide a percent slope.

III. Modified Wolman Pebble Count

The pebble count procedure was modified from Wolman (1954). A fiberglass tape measure was stretched across a riffle to such a distance that 50 feet were covered (since most reaches would not accommodate a 50ft length of tape directly across the stream, several transects across the same riffle were often used.) Every 0.5 ft the operator lowered his finger straight down and selected the first object he touched. If it was a pebble between 2 mm and 125mm, its size was recorded. If it was a finer particle, it was categorized as clay, silt or sand, depending on feel. If it was larger, it was categorized as cobble, boulder or bedrock, based on visual estimation.

Spatial Analysis:

A digital elevation model of the Beaver Creek watershed area was obtained from the United States Geological Survey National Map Seamless Server. The hydrology toolset incorporated in ESRI's ArcMap 9.3 was used to delineate flow paths as a raster image based on flow accumulation. The latitude / longitude location of each geomorphic assessment site was then plotted onto this map as a point shapefile. The points representing the assessment sites were fitted to the flow accumulation raster so that upstream catchments could be developed. The degree of urbanization in each catchment was determined by overlaying the map with a layer containing the NLCD 2001 Land Cover Classification. "Urbanization" was defined as areas that were labeled 21: Developed, Open Space; 22: Developed, Low Intensity; 23: Developed, Medium Intensity and 24: Developed, High Intensity. The percentage of each catchment that was forested was determined by summing the total of 41: Deciduous Forest and 42: Evergreen Forest. Due to the difficulty of combining the NCLD 2001 Impervious Surfaces raster with the watershed rasters, the area of impervious surfaces was estimated using the "averaging-by-land-use" system used previously in Knox County in the Second Creek watershed and developed by Camp, Dresser & McKee, an environmental consulting firm (Castle, 1996).

Statistical Analysis:

The scores for each metric at each site, as well as the total Rapid Geomorphic Assessment score, the slope, the d50 of the pebble count, the percentage of developed land in the local upstream area and total upstream catchment, the percentage of each catchment that was forested and the percentage of each catchment that was covered by impervious surfaces were used as the input for multivariate statistical analysis using SAS's JMP 7.0.1. The dataset was input as 15 independent and semi-dependent variables and 1 dependent variable. The overall RGA score was taken to be the dependent variable in most analyses, although most of the metrics used to compute the RGA are also controlled, to varying extents, by the same processes as overall channel stability. In particular, the Stage of Channel Evolution, percent of bank failing, degree of incision, bed material and presence of bank accretion were the variables that should have most closely correlated with the overall stability score. Correlations between these variables would not convey information as useful as those between metrics that gave approximations of the processes that control stream channel morphology.

Water surface slope was expected to be a controlling factor for incision, bank accretion, and bed particle size, so these factors were analyzed independently. The presence of vegetation on stream banks was expected to have a strong influence on bank stability, and the RGA allows for each bank to be assessed separately, so the scores for overall stream bank woody vegetation and percentage of stream banks failing, as well as the scores for the left and right banks for both those metrics were analyzed.

Accomplishments:

In total, full assessment were conducted in 57 sites in Beaver Creek watershed with Rapid Geomorphic Assessment (RGA) as well as the slope measurement and pebble count. In addition, there were 34 sites at which only the RGA was conducted.

- Five sites in the Plumb Creek watershed were assessed completely, with one site rated as unstable.
- Four sites in the Meadow Creek watershed were fully assessed, with two sites rated as unstable.
- Eight sites in the Grassy Creek watershed were evaluated fully, with 6 sites rated as unstable
- Eight sites were fully assessed in the Knob Fork watershed, with three sites rated as unstable
- Five sites were fully assessed along Hines Branch, with 1 site rated as unstable
- Fifteen sites were evaluated in the headwaters area, covering several small streams including North Fork, Mill Branch, Willow Fork, Lammie Branch, Kerns Branch, Cox Creek and a stretch of Beaver Creek. Fives sites were rated as unstable.
- Eleven sites were evaluated on the main stem of Beaver Creek downstream of the headwaters area, with 6 sites rated as unstable.

(8) Principal Findings and Significance:

Many rivers and streams in our nation have been identified on the 303(d) list as impaired or threatened as a result of siltation and habitat alteration, and commonly occurring in urbanizing watersheds. Urbanization creates more impervious surfaces that alter the hydrologic regime causing increased storm flow peaks and duration that can lead to excessive stream bank erosion in some locations. Beaver Creek in Knox County, Tennessee has been identified on the state 303(d) list and a sediment TMDL has been proposed by the Tennessee Department of Environment and Conservation (TDEC). In addition, state 319 funds have been awarded to the Beaver Creek Task Force (BCTF) to address the siltation problems. A sediment model for the Beaver Creek watershed completed by the University of Tennessee in 2005, in which the model found bank erosion to significantly contribute to stream sediment loads. However, the model output was never evaluated with a field study to confirm its findings. This study surveyed the extent of bank erosion in the Beaver Creek watershed to evaluate the extent of bank erosion problem. The Rapid Geomorphic Assessment (RGA) developed by the USDA National Sedimentation Laboratory was used to quantify channel stability and bank erosion potential.

RGA analysis found no clear spatial relationship between a study site's position along the stream reach and its stage of channel evolution in this study. Nor was there a clear correlation between the degree of watershed development and channel stability. Previous studies have shown that the presence of vegetative growth on and near stream banks can be one of the dominant controls of bank stability, but this was not the case in this study. Another expected relationship that was not apparent in the data was an influence of slope on

channel incision. Notably, none of the stream channels in the sub-watersheds in the Beaver Creek watershed showed discernable patterns in the stages of channel evolution observed along their courses of flow. The main stem of Beaver Creek did appear to show a pattern of adjustment. The results from this study suggest that the Rapid Geomorphic Assessment is simply not suited to measuring system-wide stream channel stability on the watershed scale under a condition of rapid urbanization. That said, it remains a valuable tool for comparing channel stability at reach-scale sites within a watershed.

Of the 57 sites surveyed for bank stability, 24 were classified as unstable. The study results will provide the BCTF with useful information on prioritization of proposed bank stability projects.

Educational opportunities from the research included support and training of a graduate student, who has graduated with a Master's thesis.

Publications and Presentations Resulting from this Research:

F. B. Keaney, J.S. Schwartz, and Q. He, "Effects of Watershed Urbanization on Stream Channel Stability in Knox County, Tennessee," Proceedings of the 19th Tennessee Water Resources Symposium, Burns, TN, 2009: pp 2A-26.

Platform presentation at the 19th Tennessee Water Resources Symposium, April 15-19, 2009, Montgomery Bell State Park, TN: F. B. Keaney, J.S. Schwartz, and Q. He, "Effects of Watershed Urbanization on Stream Channel Stability in Knox County, Tennessee."

Information Transfer Program Introduction

The major emphasis of the information transfer program during the FY 2008 grant period focused on technical publication support, conference planning/development, and improvement in the information transfer network. The primary purpose of the program was to support the objectives of the technical research performed under the FY 2008 Water Resources Research Institute Program.

The primary objectives, as in previous years, of the Information Transfer Activities are:

-To provide technical and structural support to water researchers performing research under the WRRIP.

-To deliver timely water-resources related information to water researchers, agency administrators, government officials, students and the general public.

-To coordinate with various federal, state, and local agencies and other academic institutions on program objectives and research opportunities.

-To increase the general public's awareness and appreciation of the water resources problems in the state.

-To promote and develop conferences, seminars and workshops for local and state officials and the general public which address a wide range of issues relating to the protection and management of the state's water resources.

During the FY 2008 grant period, a major focus of the information transfer activities was on the participation of the Center staff in the planning and implementation of several statewide conferences and training workshops.

As co-sponsor, the Center was involved in the planning and implementation of the Eighteenth Tennessee Water Resources Symposium, which was held on April 15-17, 2008 at Montgomery State Park in Burns, Tennessee. The goals of the symposium are: (1) to provide a forum for practitioners, regulators, educators and researchers in water resources to exchange ideas and provide technology transfer activities, and (2) to encourage cooperation among the diverse range of water professionals in the state. As with previous symposia, the sixteenth symposium was very successful with over 300 attendees and approximately 68 papers and 16 posters being presented in the two-day period. The event received a good deal of publicity across the state.

The Center also participated in several meetings and workshops across the state that were held to address water related problems and issues such as stormwater management, water quality monitoring, non-point source pollution, water supply planning, TMDL development, watershed management and restoration, multiobjective river basin management and lake management issues and environmental education in Tennessee.

The following is a brief listing of formal meetings, seminars and workshops that the Center actively hosted, supported and participated in during FY 2008:

-East Tennessee MS4 Stormwater Management Working Group, March 26, 2008, June 25, 2008, and October 15, 2008, January 14, 2009 at Ijams Nature Center, Knoxville, TN. TNWRRC and the Tennessee Department of Environment and Conservation sponsored a quarterly meeting of local government officials responsible of implementing local stormwater programs under the MS4 Phase II permit. These meeting are designed to provide local officials with information that will add them in development of their local stormwater

management programs.

-Tennessee Department of Agriculture, Nonpoint Source 319 Program Workshop, Ellington Agriculture Center, Nashville, TN. March 20, 2008.

-Tennessee Wetlands Technical Advisory Task Force meeting, April 28-29, 2008, Nashville, Tennessee. Meeting of government agency staff and technical experts to advise to the State on issues related to the Tennessee Wetlands Management Plan.

-WaterFest, May 2, 2008, Knoxville, TN. An annual community-wide event sponsored by the Water Quality Forum that highlights the importance of our water resources and the activities of the WQF partners to protect and manage those resources. Over 1,200 elementary school age students from the Knox County school systems and schools from the surrounding region attended.

-Fundamentals of Erosion Prevention and Sediment Control Level I Training workshops, sponsored by the Tennessee Department of Environment and Conservation and the Tennessee Water Resources Research Center. A one day course for developers, contractors, road builders and others involved with construction activities across the State. The course was offered on the following dates in FY 2008: March 3, 2009, Cookeville, TN.; March 25, 200, Knoxville, TN.; April 10, 2008, Sevierville, TN.; April 11, 2008, Memphis, TN.; April 22, 2008, Nashville, TN.; May 15, 2008, Chattanooga, TN.; May 22, 2008, Knoxville, TN.; July 29, 2008, Knoxville Utilities Board, Knoxville, TN.; September 4, 2008, Nashville, TN.: September 11, 2008, Knoxville, TN.; September 18, 2008, Memphis, TN.; October 1, 2008, Chattanooga, TN.; October 21, 2009, Lebanon, TN.; November 12, 2008, Johnson City, TN.; December 10, 2008, Nashville, TN.; December 17, 2008, Knoxville, TN.; February 19, 2009, Nashville, TN

-Design Principles for Erosion Prevention and Sediment Controls for Construction Sites Level II workshops sponsored by the Tennessee Department of Environment and Conservation and the Tennessee Water Resources Research Center. A two day training workshops for engineers and other design professionals responsible for the development of Storm Water Pollution Prevention Plans for construction activities. The course was offered on the following dates: April 24-25, 2008, Nashville, TN.; May 6-7, 2008, Knoxville, TN.; October 28-29, 2008, Nashville, TN.; November 20-21, 2008, Memphis, TN.; December 4-5, 2008, Chattanooga, TN.

-Construction Site Inspection as Required by Tennessee's Construction Stormwater General Permit Level I Recertification course sponsored by the Tennessee Department of Environment and Conservation and the Tennessee Water Resources Research Center. This is a half day course which focuses on inspection requirement under the current TNCGP. This course is required for all inspectors of construction sites that have coverage under the TNCGP and serves as a recertification course for those that have completed the Level I Fundamentals course. The course was offered on the following dates: March 4, 2008, Knoxville, TN.; March 12 & 13, 2008, TDOT Region 1, Knoxville, TN.; March 27, 2008, Cleveland, TN.; April 9, 2008, Franklin, TN.; April 23, 2008, Knoxville Utilities Board, Knoxville, TN.; April 30, 2008, Johnson City, TN.; May 13, 2008, Jackson, TN.; May 22, 2008, Ft. Campbell, TN.; May 28, 2008, TDOT Region 3, Nashville, TN.; May 30, 2008, Cookeville, TN.; June 3, 2008, Nashville, TN.; June 5, 2008, Knoxville, TN.; September 25, 2008, Tullahoma, TN.; October 9, 2008, Knoxville, TN.; October, 30, 2008, Nashville, TN.; November 13, 2008, Johnson City, TN.; November 21, 2008, Memphis, TN.; December 9, 2008, Chattanooga, TN.; December 11, 2008, Dyersburg, TN.; January, 24, 2008, TDOT Region 2, Chattanooga, TN.; February, 27, 2008, Nashville, TN.

-Southeast Watershed Roundtable Conference, August 12-14, 2008, Charleston, SC. TNWRRC staff exhibited at the conference attended by over 240 water resource professionals and watershed groups from across the southeast.

-Southeast Stormwater Management Association Conference, October 23-24, 2008, Nashville, TN. TNWRRC is a charter member of SESWA.

-6th Annual Gulf-South Summit on Service-Learning and Civic Engagement through Higher Education March 13-15, 2008, Nashville, TN.

-Adopt-A-Watershed teacher training workshop, June 10-13 2008, Knoxville, TN. This four day workshop sponsored by TNWRRC and partners of the Water Quality Forum trains middle and high school science teachers on how to work with their students to conduct watershed investigations and develop watershed improvement service projects and part of their classroom curriculum. Eight new teachers completed the training course in 2008.

-Knoxville Water Quality Forum, Quarterly meetings, May, July and October 2008 and January 2009. Meeting of government agencies and other organizations to share information and discuss water quality issues in the Tennessee River and it s tributaries in Knox County.

-Little River, French Broad River, Bull Run Creek, Beaver Creek Stock Creek and Emory River Watershed Associations, monthly meetings. Agency staff and community leaders working towards protection of the Little River, Lower French Broad, the Emory/Obed and smaller tributaries watersheds.

-Joint UT-TVA-ORNL Water resources Consortium Seminar Series on timely water resources topics, issues and projects of common interest to the three organizations.

Other principal information transfer activities which were carried out during the FY 2008 grant period focused on the dissemination of technical reports and other water resources related reports published by the Center as well as other types of information concerning water resources issues and problems. A majority of the requests for reports and information have come from federal and state government agencies, university faculty and students, and private citizens within the state. The Center also responded to numerous requests from across the nation and around the world.

Structuring of an Infromation Transfer and Outreach Strategy for TNWRRC Under a New Organizational Framework

Basic Information

Title:	Structuring of an Infromation Transfer and Outreach Strategy for TNWRRC Under a New Organizational Framework
Project Number:	2006TN29B
Start Date:	3/1/2006
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	Second
Research Category:	Not Applicable
Focus Category:	Education, Management and Planning,
Descriptors:	Education, Outreach, Planning, Technology Transfer
Principal Investigators:	Randall Wilson Gentry, Timothy Gangaware

Publication

1. Authur,Roy, Liz Bouldin,2006, The Beaver Creek Watershed Partnership Overview and Watershed Plan,"in" Proceedings of the Sixteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. 2B-13.
2. Hanahan, Ruth Anne, 2006, The Beaver Creek Watershed Partnership: Education and Outreach,"in" Proceedings of the Sixteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville,TN.,2B-14-17.
3. Authur,Roy, Jim Hagarman and Alice Layton,2006, The Stock Creek Watershed Restoration Plan,"in" Proceedings of the Sixteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., 2B-20.
4. Aurthur,Roy,Ruth Anne Hanahan,2007,Watershed Plan Development: Lessons Learned in Beaver Creek, The Good, The Bad, and the Ugly,"in" Proceeding of the Seventeenth TennesseeWater Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., 2B-1-6.
5. Hagerman,James,2007,Modeling Nutrients in an Urbanizing Watershed Using HSPF,"in"Proceedings of the Seventeenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., 1A-1-5.
6. Brotherton, K.M.,2007,The Use of Polacrylamide for Turbidity Control of Construction Site Runoff in East Tennessee, "MS Dissertation," Department of Biosystem Engineering and Soil Science, Insitute of Agriculture, The University of Tennessee, Knoxville, TN., 196 pp.
7. Cantrell, William, John Schwartz, and Ken Barry. 2009, Effects of Watershed Urbanization on Bedload Characteristics,"in" Proceedings of the Nineteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. 2A-26.
8. Baughman, Doug, Roy Arthur, Lisa Bacon, and Rick Brownlow. 2009, Ecological Credit Trading Pilot Study in the Beaver Creek Watershed,"in" Proceedings of the Nineteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville,

TN. 3A-1-9.

9. Dodson, Andrew and Michael Hamrick. 2009. Site Selection, Modeling and Design of Sub-Catchmnet Retrofits for Water Quality and Downstream Channel Protection,"in" Proceedings of the Nineteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. 3A-11.
10. Gibson, Parci. 2009, Rainy Day Brush-Off: Hands On Stormwater Education for Knox County, Tennessee."in" Proceedings of the Nineteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. 3C-1.
11. Davis,Kim, Julie Mawhorter, Tim Gangaware, and Margo Fransworth. 2009, Understanding Priorities, Activities and Needs of Watershed Organizations in Tennessee, Tennessee Water Resources Research Center, the University of Tennessee, Knoxville, TN. pp. 28.
12. Davis, Kim, Julie Mawhorter, Tim Gangaware, and Margo Farnsworth. 2009, Understanding Priorities, Activities and Needs of MS4 Stormwater Programs in Tennessee, Tennessee Water Resources Research Center, the University of Tennessee, Knoxville, TN. pp. 23.
13. Hanahan, Ruth Anne, David Vandergriff, and Melinda Watson. 2009, The Tennessee Yardstick Workbook, University of Tennessee Extension, w219-03/09-09-006, The University of Tennessee, Knoxville, TN. pp. 25.

(13) STATEMENT OF CRITICAL REGIONAL OR STATE WATER PROBLEM(S):
The State of Tennessee (and the southeastern United States region) has many water resources researchers, who participate in a very active and robust research program. The need exists to offer a better coordinated forum for these researchers to interact. Currently, many water rights issues have been elevated in the regional federal district courts. These will be landmark cases, should they proceed, which will define the course of water rights laws in the southeast based upon their precedent. This is one example of the dynamic environment facing water resources decision makers regionally. A more robust forum for information exchange and education is proposed in order to address the multitude of needs in Tennessee.

(14) STATEMENT OF RESULTS OR BENEFITS

The Tennessee Water Resources Research Center (TNWRRC) is a focus area within the Water Resources Science & Engineering group under the newly formed Institute for a Secure and Sustainable Environment (ISSE). Currently, TNWRRC and the Southeastern Water Resources Institute (SWRI) operate under the ISSE Water Resources Science & Engineering group umbrella. The primary goal of this IT project is to implement a synergistic plan for information transfer and outreach, with associated management and planning activities, which would maximize statewide and regional cooperation of stakeholders. The TNWRRC has long been a locus of information for statewide water resources researchers and practitioners. Under this plan, current outreach activities will be strengthened, i.e. Watershed group interactions, statewide workshop for water resources researchers and professionals, new webpage development, and a database for data archival and public access. These activities have provided an improved venue for the interactions of stakeholder water resources researchers and professionals.

Over the three years, TNWRRC has been working within the ISSE framework to develop ties to other potential regional partners. These contacts have included regional watershed groups and other regional WRRIP funded centers within the southeast region. The progress has been slow due to transitional hurdles, but there has been moderate success. TNWRRC staff has worked with the ISSE communication staff to develop a communication outreach plan for TNWRRC. In addition, TNWRRC has been collecting electronic files of publications from previously funded WRRIP projects, report and studies from federal and State government agencies and other water recourses studies of interest that will be used to populate the electronic database that will be part of the new website. We are exploring the possibility of converting past research projects technical reports from paper copy to electronic files, in order to post all project reports and publication into the new database.

Partnerships with a number of watershed stakeholder groups including the Cumberland River Compact, the Beaver Creek Watershed Task Force and the Harpeth River Watershed Association have been established and we are going to work with them to support their education and outreach activities.

(15) NATURE, SCOPE AND ACCOMPLISHMENTS

As mentioned above, the nature of this IT project is to develop better information transfer to state and regional stakeholders. The specific objectives are as follows:

1. Develop a new synergistic information transfer plan for statewide and possible regional stakeholders;
2. Implement a new management, strategy and planning framework for the TNWRRC program that will provide a stronger approach for the new information transfer plan; and
3. Incorporate an over all strategy that will enable more regional collaboration.

These objectives were met through a series of activities or tasks summarized below:

1. TNWRRC will participate in watershed groups and planning efforts;

In the past two years, TNWRRC staff, UT faculty and graduate students have provided technical assistance to non-profit watershed organizations and local governments in the development of watershed restoration plans. To date this effort has resulted in the completion of EPA approved 319 Watershed Management Plans for the Beaver Creek, Stock Creek, Bullrun Creek and Little River watersheds. In addition TNWRRC staff and UT graduate students have provided technical assistance and support to the Lower Clinch River Watershed Council in the development of a NRCS Rapid Watershed Assessment Plan for the Lower Clinch River watershed.

2. Formalize a partnership with the Cumberland River Compact group and facilitate a Targeted Watershed Initiative Grant;

In 2007, EPA Region 4 established the centers of Excellence for Watershed Management Program. The primary goal is to utilize the diverse talent and expertise of colleges and universities across the Southeast to provide hands-on, practical products and services that enhance water quality and quantity, aid communities in creating and implementing locally developed solutions to water issues that affect natural resources and economic sustainability, and promote the growth of watershed stakeholder associations. In February 2008, EPA Region 4 designated the collaborative partnership between the University of Tennessee's (UT) Institute for a Secure and Sustainable Environment (ISSE) and the Cumberland River Compact (The Compact) as the Center of Excellence for Watershed Management in Tennessee.

The new Center for Watershed Solutions (CWS) partnership initiative allows the two partnering organizations to build on their established areas of expertise. UT faculty, staff and students have long been involved in conducting research, supporting information dissemination and technology transfer, and assisting state and local governments in formulating policies to provide Tennesseans with abundant clean water.

The Compact, a nongovernmental organization devoted to education, has a strong reputation for engaging a wide array of stakeholders; citizens, students, community leaders, elected officials and business owners; in creating practical solutions to water challenges affecting the Cumberland River Basin in Tennessee and Kentucky.

The CWS partnership will work with other government agencies to:

- Identify and address the needs of local watershed stakeholders;
- Partner with other education institutions, citizen organizations, and businesses;
- Involve students, staff, and faculty in applying research and conducting activities that provide for water resource management at the watershed scale; and
- Involve the full suite of disciplines needed for comprehensive watershed management.

In 2008, CWS conducted a needs assessment that was the crucial first step in understanding the priorities, activities, and needs of watershed organizations and local government in Tennessee. The CWS will continue to reach out to all stakeholders; businesses, government agencies, academia, developers and citizens; inviting them to help CWS develop new partnerships and initiatives that will ensure the long-term health of Tennessee's water resources.

3. Host a TN water resources stakeholder meeting to identify research priorities and facilitate focused dialogue;

The third stage of the needs assessment process involved gaining input from key agencies and nongovernmental organizations involved in watershed management in Tennessee, In early 2009, a series of information gathering meeting with agency managers who oversee watershed-related functions were held. These discussions focused on understanding each agency's structure and programs for watershed management; learning about priority watershed issues and initiatives where agencies are focusing efforts; and exploring opportunities fro collaboration to address critical needs in the state. The agencies that participated in the initial information gathering sessions included, Tennessee Department of Environment and Conservation, Division of Water Pollution Control; Tennessee Wildlife Resources Agency; Tennessee Department of Agriculture, Nonpoint Source Program; Tennessee Valley Authority, Natural Resources Conservation Service; US Fish and Wildlife Service, US Army Corps of Engineers, US Geological Survey and US Environmental Protection Agency, Region 4.

4. Develop and new webpage for communication and outreach purposes;

A new website for the CWS partnership initiative is under construction and will be partially functional by the end of 2009.

5. Develop a database for Tennessee Water Resources data and information for the public.

ISSE staff in conjunction with faculty for the UT Geography Department and faculty and staff from the UT Institute of Agriculture are exploring the possibility of hosting a GIS based website, where water and natural resources data and information could be made readily available to nongovernmental organization, businesses and the public.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	2	0	0	0	2
Masters	4	0	0	0	4
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	8	0	0	0	8

Notable Awards and Achievements

Publications from Prior Years

1. 2003TN7B ("Evaluation of Pathogen Occurrence and Causation withing the Stock Creek Watershed (Knox County) as a Model for Watershed Restoration") - Articles in Refereed Scientific Journals - Gentry,R.W., A.,Layton, J.,McCathy, L.,McKay, D.,Williams, S.R.,Koirala, and G.S.,Sayler,2007,Efficacy of Bacteroides measurements for Reducing the Statistical Uncertainty Associated with Hydrologic Flow and Fecal Loads in a Mixed Use Watershed, Journal of Environmental Quality, v36, n5, pp. 1324-1330.
2. 2003TN7B ("Evaluation of Pathogen Occurrence and Causation withing the Stock Creek Watershed (Knox County) as a Model for Watershed Restoration") - Articles in Refereed Scientific Journals - Koirala, S.R., R.w.,Gentry, E.,Perfect, J.,Schwartz, and G.S.,Sayler,2008, Temporal Variationand Persistence of Bacteria in Streams, Journal of Environmental Quality, 37(4), pp. 1559-1566.
3. 2003TN7B ("Evaluation of Pathogen Occurrence and Causation withing the Stock Creek Watershed (Knox County) as a Model for Watershed Restoration") - Articles in Refereed Scientific Journals - Bell,A., A.,Layton, L.D.,McKay, D.,Williams, R.W.,Gentry, and G.S.,Sayler,2009, Factors Influencing the Persistence of Fecal Bacteroides in Stream Water, Journal of Environmental Quality, v38, pp. 1-9.
4. 2005TN16B ("Macropores and Colloids: Their Influence on the Quantity and Quality of Recharge") - Articles in Refereed Scientific Journals - Cihan,A., J.S. Tyner, and E. Perfect. 2009. Prediciting relatve permeability from water retention: A direct approach based on fracral geomerty. Water Resources Research, 45, W04404,doi10.1029/2008WR007038.
5. 2005TN16B ("Macropores and Colloids: Their Influence on the Quantity and Quality of Recharge") - Articles in Refereed Scientific Journals - Cihan,A., M. Sukop, J.S. Tyner, E. Perfect, and H. Huang. 2009. Analytical Predictions and Lattice Boltzmann simulations of intrinsic permeability for mass fractal porous media. Vadose Zone J. 8(1): 187-196.
6. 2004TN15G ("Longitudinal fragmentation of stream habitat quality due to watershed urbanization") - Conference Proceedings - Schwartz,John, Andrew Simon, and Lauren Klimetz. 2009, Use of Fish Autecology Data to Link Biological Impairment to Stream Siltation, "in" Proceedings of the Nineteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., 2B-4.
7. 2004TN13B ("An Investigation of Surface-Ground Water Connections at Nonconnah Creek: A Source of Recharge and Potential Contamination for the Memphis Aquifer in Shelby County Tennessee") - Conference Proceedings - Bradshaw, Elizabeth and Daniel Larsen. 2009. Assessment of Groundwater Leakage Through the Upper Claiborne Confining Unit to the Memphis Aquifer in the Allen Well Field, Memphis, Tennessee, "in" Proceedings of the Nineteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN. P-4.