

# Tennessee Water Resources Research Center

## Annual Technical Report

### FY 2005

## 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 1980 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. The situation continued to worsen in the late 1980's. Beginning in 1985 and continuing on through the summer of 1988, 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 TWRRRC 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 Ohio River Basin Consortium for Research and Education, the Clinch-Powell River Basin Consortia, the South Atlantic-Gulf regional grouping of state water resources research institutes, the ORNL-TVA-UT Research Consortium and the National Institutes for Water Resources (NIWR) Directors. 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, TWRRRC 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**

# Macropores and Colloids: Their Influence on the Quantity and Quality of Recharge

## Basic Information

<b>Title:</b>	Macropores and Colloids: Their Influence on the Quantity and Quality of Recharge
<b>Project Number:</b>	2005TN16B
<b>Start Date:</b>	3/1/2005
<b>End Date:</b>	2/28/2006
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	TN2
<b>Research Category:</b>	Water Quality
<b>Focus Category:</b>	Water Quality, Water Quantity, Nutrients
<b>Descriptors:</b>	Water Quality, Preferential Flow, Infiltration, Eutrophication, Nutrients, Colloids
<b>Principal Investigators:</b>	John Tyner, Michael Essington, Jaehoon Lee

## Publication

1. Garrett, Tara, J., 2005, Preferential Flow and Colloids: Their Influence on the Transport of Phosphorous, "MS Thesis", Department of Biosystem Engineering and Soil Science, College of Agriculture, The University of Tennessee, Knoxville, TN., pp 108.

**Problem and Research Objective:**

Although Tennessee is water-rich compared to many states, it is still facing the prospect of shortages in both surface and ground water. Due to population growth and water mining, the value of water resources will only continue to grow. Proper management of water resources requires knowledge regarding the recharge rate of aquifers, and the quality of the water recharging the aquifers and streams. Historically, infiltration has been modeled using simple one-dimensional methods, such as the Green-Ampt infiltration model. These methods often underestimate the recharge rate and the risk of infiltrating pollution because they do not include preferential flow, which can be defined as the transport of a portion of water at a much higher rate than the mean velocity. On a microscopic scale, such variation of velocity can be adequately described with a dispersion term. At the macroscopic scale, the variation of flow is more difficult to predict and model.

Preferential flow is often due to macropores, which are continuous pathways through a soil that commonly result from old root canals, earthworms, burrows, insects, or animals. If free water enters the macropores, it flows rapidly downward due to gravity. The macropores are often large enough, such that capillary forces are insignificant. The Reynolds number for macropore flow typically exceeds the laminar flow range, which precludes the use of Darcy's Law to predict its movement. Soil fractures are another source of macroscopic preferential flow, in that the water velocities within the fractures often exceed the laminar range. Fractures can be created during or shortly after deposition of the sediment, as the overburden increases. Soils with expansive clays also contribute to preferential flow as clayey soils are prone to shrink and swell according to water content. Preferential flow due to shrink and swell cycles may be intermittent due to the changing aperture of the fractures.

Beyond the affect macropore flow has on infiltration rate, it also plays a major role in the rapid transport of contaminants. USEPA (1996) perceives eutrophication, which is limited mainly by P in fresh water systems, as the predominant water quality issue facing the United States. Typically, P is thought to be a relatively immobile nutrient within porous media. More recently, examples of P transport within soils with extensive macropore flow have been reported. Macropores enable the majority of the reactive soil matrix to be bypassed, minimizing interaction between the infiltrating water solution and the reactive soil particle surfaces. Once

these sorption sites along the pore walls are filled, the remaining ions are free to move with only minimal retardation.

Potential water contaminants, such as P, can rapidly travel through the macropores to depths of several meters or more. If colloids are present, the problem is exacerbated since the sorbing contaminants attach themselves to mobile colloids. The use of animal manure as a crop fertilizer poses a potential water pollution problem since it typically provides excessive P (based on N crop requirements). Further, animal manure also contains an abundance of colloids and organic forms of P, which are inherently more mobile than orthophosphate.

### **Objectives of Research :**

The research objectives of this project were to :

- (1) determine the influence of preferential flow paths on the transportation of phosphorus (P) through a soil profile.
- (2) determine the effect of fertilizer type (inorganic vs. organic) on the transport of P through a soil profile.
- (3) determine the effect of colloids on the transport of P through a soil profile.

### Research Results and Findings:

Tests from this study included laboratory evaluation of  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{P}_{\text{tot}}$ ,  $\text{P}_{\text{ino}}$ , and  $\text{P}_{\text{org}}$  transport through large, intact soil monoliths under two rainfall intensities. Results from these test provided the following conclusions.

Preferential flow paths enhanced the transport of P through the soil monoliths. Higher concentrations and an early breakthrough of the tracers exiting the columns showed that the amount of P adsorbed by soil particles is reduced by the presence of macropores. High rainfall intensity that creates temporary ponding on the surface and allows water to flow through macropores increases the likelihood that P will be leached through the soil profile. A higher concentration of P was transported rapidly through the monoliths when water was allowed to pond on the soil surface.

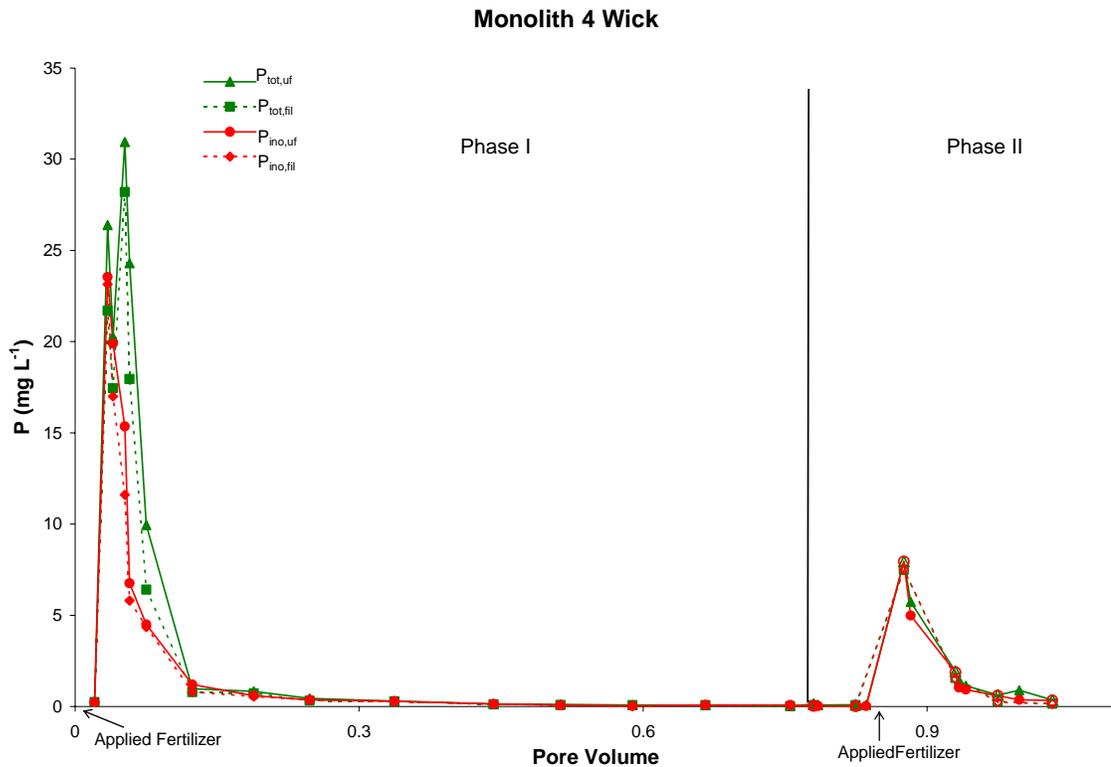


Figure 1. Concentrations of total unfiltered P ( $\text{P}_{\text{tot,uf}}$ ), total filtered P ( $\text{P}_{\text{tot,fil}}$ ), inorganic unfiltered P ( $\text{P}_{\text{ino,uf}}$ ), and inorganic filtered P ( $\text{P}_{\text{ino,fil}}$ ) from monolith 4 treated with diammonium phosphate and urea for Phases I and II, wick. Open dots represents the measurements following rainfall application.

Colloids increased the transport of phosphorous ( $P < 0.05$ ). Fertilizer type (organic/inorganic) did not significantly affect the transport of phosphorous ( $P > 0.05$ ) through the monoliths.

### **Summary**

P was relatively immobile; except where large preferential flow paths were present. Preferential flow enhanced the mobility of P by allowing it to bypass portions of the soil matrix, leading to potential water quality issues in areas with otherwise similar soil composition. Soils that have large preferential flow paths, receiving continuous poultry litter or any other type of organic fertilizer based on N requirements, may discharge significant amounts of P.

# Impacts of watershed urbanization on longitudinal fragmentation of stream habitat quality and fish habitat use

## Basic Information

<b>Title:</b>	Impacts of watershed urbanization on longitudinal fragmentation of stream habitat quality and fish habitat use
<b>Project Number:</b>	2005TN17B
<b>Start Date:</b>	3/1/2005
<b>End Date:</b>	2/28/2006
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	TN2
<b>Research Category:</b>	Climate and Hydrologic Processes
<b>Focus Category:</b>	Ecology, Surface Water, Sediments
<b>Descriptors:</b>	Urbanization, Sediment TMDLs; Habitat Alteration; Biological Integrity; Fis IBI
<b>Principal Investigators:</b>	John Steven Schwartz

## Publication

1. Schwartz, John, S., 2005, Linking ecological response with the dynamics of fluvial processes, habitat maintenance, and sediment characteristics: A framework for sediment TMDL development, "in" Proceedings of the Fifteenth Tennessee Water Resources Symposium, Tennessee Section of American Water Resources Association Nashville, TN., 1A-7-10.
2. Thames, Brantley, A., John S. Schwartz, 2005, Modeling of sediment delivery and channel transport processes: Case study comparison between an urban and non-urban subwatershed, "in" Proceedings of the Fifteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., 2A-7-12.
3. Sain, Robert, Lee., 2006, Characterizing how fish communities and physical habitat structure are affected by urbanization in an East Tennessee watershed, "MS Dissertation", Department of Biosystem Engineering and Environmental Science, College of Agriculture, the University of Tennessee, Knoxville, TN., pp.112.
4. Sain, Robert, L., John S. Schwartz, 2006, Impacts of urbanization on habitat quality and fisheries in a ridge and valley watershed: Implications for stream rehabilitation planning, "in" Proceedings of the Sixteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., 2B-9-14.
5. Bennett, Shannon, E., John S. Schwartz, 2006, Use of a dynamic sediment delivery model for

watershed planning in beaver creek, Knox County, Tennessee, "in" Proceedings of the Sixteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, Tn., 2B-18-21.

### **Water Problems Addressed:**

Many waterbodies in Tennessee are identified on the 303(d) list as biological impaired from excessive sedimentation that causes physical habitat degradation, thereby reducing biological integrity. Most urban streams are listed as biological impaired from a multitude of environmental stressors, including siltation and habitat alteration. The Tennessee Department of Environment and Conservation (TDEC) is required by statute to produce total daily maximum loads (TMDLs) for these 303(d) listed urban streams. However, degradation of stream ecosystems from urbanization is poorly understood. TDEC needs better assessment techniques that can aid in the development of sediment TMDLs, and identify the limitations to ecological recovery in urbanizing watersheds. The focus of this research was to explore relationships among watershed patterns of urban land cover, physical habitat quality, and biological integrity in order to better identify critical stream reaches for conservation or restoration.

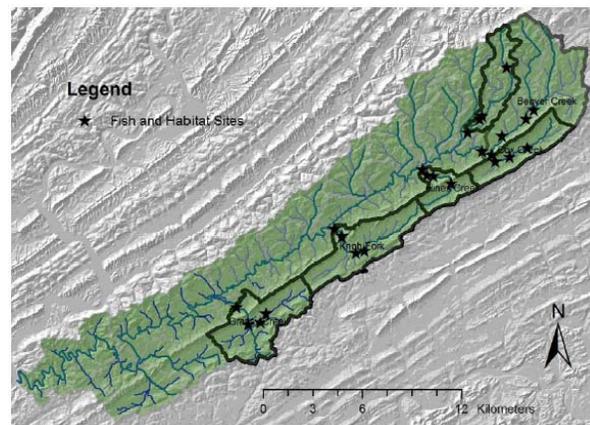
### **Research Objectives of Study:**

The objectives of the study were: 1) determine whether physical habitat structure is altered by urbanization within the context of drainage area, and 2) determine whether fish community structure is altered by urbanization, and whether it is associated with physical habitat alteration. The research was conducted in Beaver Creek, a Tennessee Ridge and Valley stream, Knox County. By interpretation of the results, this study explored qualitatively how reach-scale fragments of poor habitat quality within drainage networks impact fish community structure.

### **Research Results and Findings:**

The study, conducted in Beaver Creek of the Lower Clinch River lies in HUC 06010207 (Lat. 36° 04' 39" and Long. 83° 56' 09"), in which 24 study sites were selected from six subwatersheds with varying ranges of percent urban land cover (Figure 1). Within each subwatershed, four study sites were selected along the longitudinal gradient from headwaters, and downstream usually to the confluence with Beaver Creek main stem. Drainage and land cover characteristics upstream of each site were compiled by ArcGIS software using a land-use layer shape-file, manually created from 2003 KGIS aerial photos. Drainage areas per site ranged from 1.25 to 14.68 mi<sup>2</sup>, but most sites were below 6 mi<sup>2</sup>. The %total urban land cover ranged from 0.26% to 54.23%, and %industrial-commercial land cover ranged from 0% to 16.85%. Total urban land cover included five subcategories, which were high- and medium residential,

Figure 1. Study site locations within the Beaver Creek watershed.



commercial, industrial, and disturbed (exposed soil from human activities). Physical habitat and fish surveys were conducted at each site from June to August 2005. Physical habitat surveys were done according to standard USFS protocols (Overton *et al.* 1997), delineating mesohabitat units in sequence (pool, glide, run, riffle), and characterizing microhabitat quality (unit dimensions depth and width, woody debris, root wads, and bed substrate characteristics) and adjacent riparian cover (contiguous extend, and tree density) recorded per mesohabitat unit. Fish surveys followed standard IBI protocols for the southern Appalachian region (TVA 2005), using a Smith-Root LR-24 backpack shocker and a team of dip netters. Pearson correlations were used to statistically analyze relationships among the study variables. Six major comparisons were evaluated: 1) habitat metrics to drainage area, 2) habitat metrics to %urban land cover, 3) habitat metrics to riparian corridor and in-channel wood metrics, 4) fish metrics to drainage area, 5) fish metrics to %urban land cover, and 6) fish metrics to habitat metrics.

The study found significant positive correlations ( $p < 0.05$ ) between drainage area and average habitat unit width ( $r = 0.57$ ), average habitat unit depth ( $r = 0.64$ ), average pool depth ( $r = 0.71$ ), average riffle depth ( $r = 0.43$ ), and crest to maximum depth ratio ( $r = 0.39$ ). As one would expect, results indicated that habitat unit dimensions increased proportionally with drainage area. However, %length of the different habitat unit types did not correlate with drainage area, which indicates sequence scale is independent of drainage area. These findings are consistent with current geomorphic-habitat literature.

The study found significant negative correlations ( $p < 0.05$ ) between %industrial-commercial land cover and average riffle width ( $r = -0.45$ ) and crest to maximum depth ratio ( $r = 0.47$ ); and ( $p < 0.1$ ) between %industrial-commercial land cover and average habitat unit width ( $r = -0.38$ ) and %length of run ( $r = -0.37$ ). Industrial-commercial land cover represents the greatest degree of imperviousness ( $CN > 98$ ) compared to residential and disturbed lands ( $CN < 90$ ). It appears that some habitat alteration from hydromodification can be inferred from the results. Other researchers have found a loss of mesohabitat structure associated with greater impervious land cover, which typically causes increased peak flows, channel instability, and sedimentation. The relationship between %industrial-commercial land cover and crest to maximum depth ratio would indicate a minor loss of pool-riffle habitat structure possibly from sediment-rich flood waters. However, the negative correlation with this land cover to %length of run is contrary to this finding and current literature when considering impacts from increased peak flows. When considering hydromodification by baseflow degradation rather than increased peak flows this correlation is explainable. It requires evaluating how habitat units are field delineated, in that each unit must be at least equal to the channel width. Runs are typically transitional habitat units between riffles and pools. When baseflow are low relative to normal channel dimensions, field delineation of runs possibly were lumped into pools or riffles because morphologically they lacked sufficient unit length. This possible explanation is supported by the fact that average habitat unit width and average riffle width also decreased with increased %ind.-com. land cover.

The study found significant positive correlations ( $p < 0.05$ ) between the number of riparian trees and %length of riffle ( $r = 0.63$ ) and %occurrence of point bars ( $r = 0.63$ ); and a significant negative correlation ( $p < 0.05$ ) between the number of riparian trees and %length of pool ( $r = -0.46$ ). In addition, significant positive correlations ( $p < 0.05$ ) were found between in-channel average wood volume and average pool depth ( $r = 0.64$ ), average riffle depth ( $r = 0.65$ ), average riffle width ( $r = 0.57$ ), crest to maximum depth ratio ( $r = 0.48$ ), average habitat unit depth ( $r = 0.54$ ), and average habitat unit width ( $r = 0.46$ ). As with average wood volume, similar positive

correlations were found between in-channel number of wood pieces and habitat metrics. A significant positive correlation ( $p < 0.1$ ) was found between %intact riparian cover and in-channel number of wood pieces ( $r = 0.39$ ), but not with the number of riparian trees and in-channel number of wood pieces. Overall, it appears in-channel wood plays an important role in the maintenance of mesohabitat structure, which is consistent with findings by other researchers. This study indicated that the structural role of in-channel wood with mesohabitat heterogeneity is more important to these urban streams, and the larger streams surveyed. Wood recruitment from the riparian corridor appears to be dependent on presence or absence of vegetation rather than the density of trees when a forested corridor exists.

The study found significant positive correlations ( $p < 0.05$ ) between drainage area and fish metrics (percent site abundance of blueside darters, greenside darters, snubnose darters, total darters, mountain shiners, centrarchids, suckers, and specialized insectivores). These correlations between stream size and fish community structure has been recognized by other researchers, in fact are they are accounted for in fish IBI computations.

The study found significant negative correlations between fish IBI scores and %total urban land cover ( $p = 0.006$ ,  $r = 0.29$ ), and %industrial-commercial land cover ( $p = 0.0004$ ,  $r = 0.53$ ). IBI scores ranged from 28 to 50 out of a possible range of 12 to 60 (Figure 2). Significant negative correlations ( $p < 0.05$ ) were found between %industrial-commercial land cover and total% darters ( $r = -0.44$ ) and %specialized insectivores ( $r = -0.45$ ). Similarly, %urban land cover was negatively correlated ( $p < 0.1$ ) with total% darters ( $r = -0.37$ ) and %specialized insectivores ( $r = -0.36$ ). Darters and specialized insectivores are 2 of 12 metrics used in generating an IBI score, and undoubtedly influenced the study's IBI scores. Ecologically, darters and specialized insectivores rely on quality riffle habitat. It appears urbanization impacts riffle quality; however the evidence from the mesohabitat correlations would indicate it is not from total number of riffle per unit length of stream. It is possible that riffle surface area is reduced by urbanization, as observed by the decreased riffle widths in more urban sites. Another possibility is that some quality metric for the riffle habitat unit was not measured.

Several significant correlations were found between fish and habitat metrics ( $p < 0.05$ ,  $p < 0.1$  levels). Greenside darters and blueside darters were positively correlated with average riffle width ( $r = 0.52$ ;  $r = 0.38$ ). Greenside darters were also positively correlated with average pool depth ( $r = 0.37$ ), average riffle depth ( $r = 0.50$ ), crest to maximum depth ratio ( $r = 0.49$ ), average habitat unit depth ( $r = 0.49$ ), and average habitat unit width ( $r = 0.45$ ). Blueside darters were also positively correlated with average pool depth ( $r = 0.43$ ), and average habitat unit depth ( $r = 0.38$ ). Because darters were correlated with both pool and riffle structure, but typically occupy riffles, it appears there is some interdependence of riffle quality with pool structure and elevation differences between juxtaposition units. Omnivores were positively correlated with %length of pools ( $r = 0.43$ ), average pool depth ( $r = 0.49$ ), and average habitat unit depth ( $r = 0.42$ ). Suckers were positively correlated with average pool depth ( $r = 0.36$ ), and average habitat unit depth ( $r = 0.37$ ). Omnivores and suckers appear to prefer deeper pools. Because omnivore and suckers were not correlated with %urban land cover, but darters were correlated, it appears riffle quality degrades initially from the impacts of urbanization.

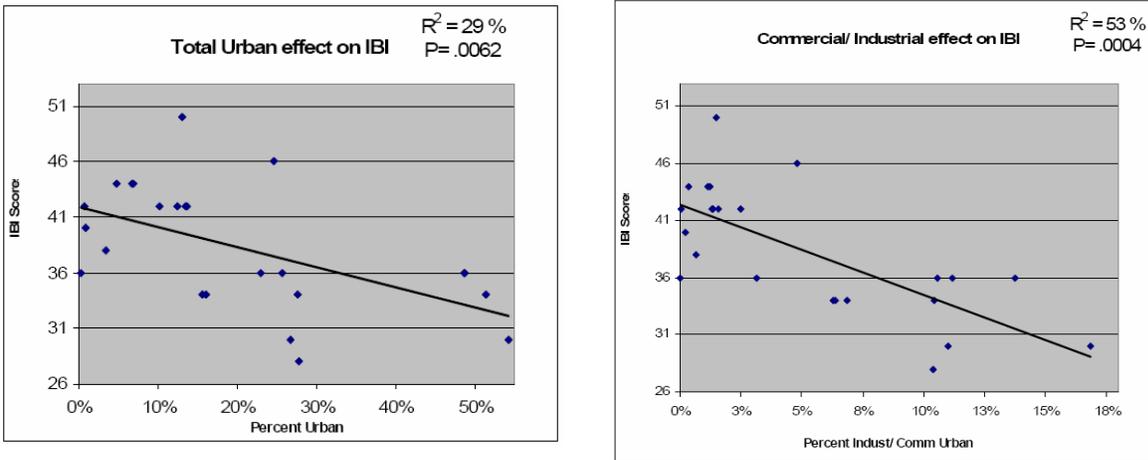


Figure 2. Fish IBI scores versus %urban land cover and %industrial-commercial land cover.

### Summary

This research found %urban land cover significantly altered physical habitat and fish community structure. It appears modified fluvial processes from urbanization initially degrade riffle quality before pool quality when riparian vegetation supplies the channel with large woody debris (LWD). In general, LWD appears to maintain pools by promoting localized scour. Fish community structure was more severely impacted from urbanization in larger streams (drainage areas greater than 2-3 mi<sup>2</sup>) because they naturally support more biodiversity. Additional analyses to support the summary statement can be found in Robert Sain's MS thesis. Stream restoration potential appears to be best by enhancing riffle quality, and hydraulically promoting a heterogenous bed structure provided by pool-riffle structures.

## Information Transfer Program

The major emphasis of the information transfer program during the FY 2005 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 2005 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 2004 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 Fifteenth Tennessee Water Resources Symposium, which was held on April 13-15, 2005 at Montgomery State Park in Burns, Tennessee. The purposes 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 fourteenth symposium was very successful with over 300 attendees and approximately 65 papers and 12 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 2005:

Knox County Site Planning Roundtable meeting held on March 4, 2005, and August 17, 2005, October 19, 2005, November 16, 2005 and December 14, 2005 at UT Faculty Club, Knoxville, TN.

Tennessee Department of Agriculture, Nonpoint Source 319 Program Workshop, Ellington Agriculture Center, Nashville, TN. March 24, 2005.

Tennessee Wetlands Technical Advisory Task Force meeting, April 18-19, 2005, Nashville, Tennessee. Meeting of government agency staff and technical experts to advise to the State on issues related to the Tennessee Wetlands Management Plan.

East Tennessee MS4 Working Group meeting. April 28, 2005, Ijams Nature Center, Knoxville, TN. TNWRRC and the Tennessee department of Environment and Conservation sponsored a monthly 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 stromwater management programs. Additional meetings were held on May 26, 2005, June 30, 2005, September 29, 2005, October 27, 2005, and February 23, 2006.

Kids-In the-Creek, April 29, 2005 Karns Middle School, Knoxville, TN. A watershed experience sponsored by Tennessee Valley Authority, TNWRRC and the CAC AmeriCorps Water Quality Team. An all day event for approximately 70 5th grade students introducing them to watershed science including biological and chemical monitoring and land use impacts on water quality.

WaterFest, May 6, 2005, 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.

Muddy Water Blues, Williamson County AgriCenter, Franklin, TN. May 11-12, 2005. This two day conference was sponsored by the Southeast Chapter of the International Erosion Control Association, TNWRRC and the cities of Franklin, Brentwood, Clarksville and Metro Nashville-Davidson County and Williamson County, TN. The purpose of the conference is to promote state of the art technologies for erosion prevention and sediment control for construction activities. It included and field demonstration of EPSC best managementpractices. Over 400 persons from across the southeast U.S. 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 2005: March 3, 2005, Nashville, TN.; March 22, 2005, Dyersburg, TN.; April 21, 2005, Chattanooga, TN.; May 11, 2005, Franklin, TN. (Muddy Water Blues conf.); May 25, 2005, Chattanooga, TN. (TDOT); June 9, 2005, Franklin, TN.; August 25, 2005, Knoxville, TN. (TDOT); August 30, 2005 Chattanooga, TN. (TDOT); September 20, 2005, Nashville, TN.; September 27, 2005, Knoxville, TN.; October 4, 2005, Sumner County, TN.; October 11, 2005, Chattanooga, TN.; November 1, 2005, Memphis, TN.; November 29, 2005, Tullahoma, TN.; December 1, 2005, Knoxville, TN.; December 8, 2005, Nashville, TN.; January 11, 2006, Sevierville, TN. (Blalock Construction Co.); January 19, 2006, Nashville, TN. (TDOT); February 17, 2006, Knoxville, 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: March 17-18, 2005, Nashville, TN.; March 29-30, 2005, Knoxville, TN.; May 19-20, 2005, Cleveland, TN.; November 2-3, 2005, Memphis, TN.; November 17-18, 2005, Nashville, TN.; December 13-14, 2005, Knoxville, TN.

Nonpoint Source Program Education Working Group, June 7, 2005, Nashville, TN.

Urban Runoff Working Group, June 16, 2005, Nashville, TN.

Adopt-A-Watershed teacher training workshop, June 20-23, 2005, 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 courses in 2005.

Southeast Stormwater Management Association Conference, January 26-27, 2006, Atlanta, GA. TNWRRC is a charter member of SESWA.

Knoxville Water Quality Forum, Quarterly meetings, May, July and October 2005 and January 2006 Meeting of government agencies and other organizations to share information and discuss water quality issues in the Tennessee River and its 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 2005 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.

## Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	6	0	0	0	6
Masters	6	0	0	0	6
Ph.D.	1	0	0	0	1
Post-Doc.	1	0	0	0	1
<b>Total</b>	14	0	0	0	14

## Notable Awards and Achievements

Over the 4-year period, January 2002 through December 2005, the Tennessee Water Resources Research Center (WRRRC) has been very active in coordinating and conducting two levels of erosion prevention and sediment control workshop training courses throughout the State. WRRRC has developed these two courses and has assisted the Tennessee Department of Environment and Conservation (TDEC) in developing the Tennessee Sediment and Erosion Control Handbook. These courses provide training to developers and planners, design engineers, highway and residential contractors, construction inspectors, state & local enforcement officials, and other professionals responsible for all aspects of preparation and implementation of the Storm Water Pollution Prevention Plans (SWPPP) associated with Tennessee's NPDES Construction General Permit requirements. A 1-day, Level 1 course, Fundamentals of Erosion Prevention & Sediment Control for Construction Sites covers local and state regulatory perspectives, SWPPP preparation, basic surface water hydrology processes, fundamentals of soil erosion, and BMP principles, installation, inspection, and maintenance. A 2-day, Level 2 workshop, Design Principles for Erosion & Sediment Control for Construction Sites, focuses on design concepts, hydrologic & erosion modeling, and examples for storm water, erosion and sediment management.

The Tennessee WRRRC staff has provided these courses to many Phase II communities to partially satisfy their MS4 training requirements. These courses also have been offered to TDOT and TDEC officials, utilities, federal agency officials, construction companies, Ft. Campbell base personnel and contractors, storm water and erosion & sediment management specialty conferences, and other organizations to introduce fundamentals and to sharpen advanced understanding of erosion prevention and sediment control practices. To date, 4445 people have been certified by examination for the Level 1 Fundamentals course presented at 77 different times and locations. Over 828 engineers and other professionals have taken the Level 2 design course and earned 11,592 professional development credit hours (PDHs) at 22 places and times. Details of both courses and associated activities for Tennessee's Erosion Prevention and Sediment Control Training and Certification Program for Construction Sites can be viewed on the WRRRC website at <http://www.tnepsc.org/>

In 2003, the Tennessee WRRC, with technical and financial assistance from the Tennessee Department of Agriculture, Nonpoint Source Pollution Program and TDEC's Water Pollution Control Division, developed a Guide to the Selection & Design of Stormwater Best Management Practices (BMPs) for post-construction stormwater management. The manual summarizes major water quality and drainage issues faced by MS4 Phase II communities in Tennessee, drainage law, and 20 structural and non-structural practices for reducing stormwater pollution and managing stormwater runoff from post-development sites. The manual also includes model stormwater ordinances for local community use. Dozens of Tennessee communities affected by the Phase II requirements have used the stormwater practice manual to serve as a resource for understanding the impacts of development on water runoff and for developing their local programs. The manual is available in various formats, including a CD-ROM and a downloadable version on the WRRC's home website at <http://eerc.ra.utk.edu/WRRC.html>

## **Publications from Prior Projects**

1. 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 - Anderson, Jerry, L., 2005, Development of a transducer network in an urban environment, "in" Proceedings of the Fifteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., 1C-14-22.
2. 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 - Larsen, Daniel, Jason Morat, Brain Waldron, Stephanie Ivey, Kerry Anderson, Angela Owen, and Christopher Garner, 2005, Hydrologic assessment of leakage from nonconnah creek to the shallow aquifer in the vicinity of the sheahan well field, Memphis, Tennessee, "in" Proceedings of the Fifteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, Tennessee, 2B-15.
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 - Layton, A.C., D. Williams, V. Garrett, L. Mckay, R.W. Gentry, and G.S. Sayler, 2006, Development of Bacteroides 16S rRNA gene TaqMan™ PCR assays for quantification of fecal source pollution in water samples, Applied and Environmental Microbiology, V72(n6), pp. 4213-4224.
4. 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., J. McCarthy, A. Layton, L. McKay, D. Williams, S. Koirala, and G.S. Sayler, 2006, Escherichia coli Loading at or Near Baseflow in a Mixed-Use Watershed, Journal of Environmental Quality, in press.
5. 2001TN4101B ("Constructed Wetland Cleanup of Pirtle's Container Nursery Runoff") - Conference Proceedings - Stearman, Kim, T. Ramar, D. George, and L. Weathers, 2005, Evaluation of peat moss as a filter media fro the removal of the herbicide simazine, "in" Proceedings of the Fifteenth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Nashville, TN., pp. 2C-27-33.
6. 2003TN7B ("Evaluation of Pathogen Occurrence and Causation withing the Stock Creek Watershed (Knox County) as a Model for Watershed Restoration") - Conference Proceedings - Layton, Alice, Dan Williams, Randy Gentry and Larry McKay, 2006, Bacteroides as an alternative to e.coli as a fecal indicator, "in" Proceedings of the Sixteenth Tennessee Water Resources Symposium, Tennessee

Section of the American Water Resources Association, Nashville, TN., 3C-6-9.