South Carolina Water Resources Research Institute Annual Technical Report FY 2004

Introduction

The South Carolina Water Resources Center at Clemson University has completed another year of exciting research projects as well as the provision of water information services to the citizens of South Carolina. Three primary areas of action are included here.

First, the South Carolina Water Resources Center at Clemson University and the Georgia Water Research Institute at Georgia Tech held a workshop focusing on issues related to the Savannah River Basin and assembling information for a potential Water Compact between the States of Georgia and South Carolina. The purpose of the workshop was to discuss water quality and quantity issues related to the Savannah River Basin, and to advise decision makers in both states on a course of action.

The workshop was held at the Georgia Tech Savannah campus outside Savannah, Georgia November, 2004. Over 50 attendees represented the state and federal agencies with management and regulatory responsibilities on the Savannah River, as well as stakeholder groups within the watershed. The agenda included presentations on several issues in the Savannah River Basin, followed by small group discussion and planning. Important topics addressed at the workshop included the impact of both existing and proposed Interbasin transfers on the watershed as well as concerns about pollution, drought management, and plans for bringing Georgia and South Carolina water regulations into harmony.

Second, work is finishing on a multi-year study that SCWRC has participated in with the South Carolina Sea Grant Consortium. This study was named the Land Use - Coastal Ecosystem Study (LU-CES) and included several project teams from Clemson University, the University of South Carolina, the University of Georgia and Georgia Tech. SCWRC’s involvement included developing an urban growth prediction model for coastal South Carolina as well as investigating how the predicted growth might impact various natural and cultural resources.

Finally, SCWRC has moved forward with its work in the Saluda-Reedy Watershed Consortium. The Saluda-Reedy Assessment project brings together an exceptional consortium of talent and organizations to focus on the issues and challenges affecting the Saluda-Reedy basin’s future. This partnership includes truly outstanding resources of universities, government agencies, non-profit organizations, and private sector organizations. These partners have extensive hands-on experience with the specific resources of the Saluda-Reedy Watershed and intimate knowledge of the policy issues and operating political dynamics. In the process of working on these and related issues for many years, the key project team members have gained an in-depth understanding of the resources of the watershed and the tools needed to protect them. In addition, the South Carolina Department of Natural Resources has funded a position within SCWRC for a Reedy River Education Coordinator. This person will take information developed from the Saluda-Reedy Watershed Consortium and share it with stakeholders within the watershed as well as groups of interest across the state and the Southeast.

Research Program

Projects currently underway: Application of Emerging Technologies for Water Quality Monitoring and Data Transfer in the Saluda-Reedy Watershed Funding Agency: USGS/SC Water Resources Center PI: Dr. Christopher Post - Clemson University

Modeling the Impact of Reservoir Management Regimes on Important Ecosystems in the Santee River Basin Funding Agency: USGS/SC Water Resources Center PI: Dr. John M. Grego - University of South Carolina

Reedy River Watershed Education Coordinator Funding Agency: South Carolina Department of Natural Resources Partners: Clemson University Extension Service

"The Saluda and Reedy River Watershed Land Use and Water Quality Assessment" Funding Agency: Proposal submitted to V.Kann Rasmussen Foundation Partners: Multidisciplinary effort at Clemson University, Lander University and Furman University

GIS-based Database Management and Spatial Modeling for Coastal Ecosystems Funding Agency: S.C. Sea Grant LU-CES Program/NOAA Partners: University of South Carolina, NOAA NOS Southeast Fisheries Center

The NY State Wetland Monitoring System: A Remote Sensing Assessment Funding Agency: U.S. Environmental Protection Agency Partners: SUNY-Albany

Forest Fuel Load Classification using Hyperspectral Image Analysis Funding Agency: USDA - U.S. Forest Service Partners: SpectroTech, Inc.

Comparing Forest Fuel Load Classifications of Hyperspectral Image Analysis and Landsat Image Analysis Funding Agency: USDA - U.S. Forest Service Partners: SpectroTech, Inc.

Modeling the Impact of Reservoir Management Regimes on Important Ecosystems in the Santee River Basin

Basic Information

Title:	Modeling the Impact of Reservoir Management Regimes on Important Ecosystems in the Santee River Basin
Project Number:	2004SC9B
Start Date:	3/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	Second
Research Category:	Not Applicable
Focus Category:	Management and Planning, Hydrology, Methods
Descriptors:	Extend Simulation Software, Stochastic Transfer Function Models, Vector ARIMA Time Series Models
Principal Investigators:	John M. Grego

Publication

1. Cai, Zongshou, 2005, "Multiple Input Transfer Function Model with Missing Data, "MS Thesis", Statistics, College of Arts and Sciences, University of South Carolina, Columbia, SC, 63 pp.

Modeling the Impact of Reservoir Management Regimes on Important Ecosystems in the Santee River Basin

Statement of critical regional or State water problem.

With an area of 16,000 mi^2, the Santee River Basin is the second largest Atlantic watershed in the coterminous United States. Although the majority of the basin is located within South Carolina, the basin also includes a North Carolina headwaters region where reservoir management decisions influence conditions downstream. Over the past century the dominant management strategy within the watershed has been the development of hydropower resources. Watershed-wide, all of the basin's major rivers, the Broad, Saluda, Congaree, Catawba, Wateree and Santee, have been altered by the construction of hydropower facilities, including storage reservoirs. As a result, only three unimpounded river segments greater than 3 river-miles in length remain along the basin's significant rivers. Further, the basin's flow regime is now governed largely by the instantaneous value of electricity, which is related to demographic and economic development trends in the state. Historically few, if any, operational rules for reservoirs in the basin have been established specifically to improve ecosystems that have been altered or diminished by departures from the natural hydrology in the basin.

In the period up to 2010, three utilities that operate significant hydropower facilities in the basin will undergo re-licensing processes before the Federal Energy Regulatory Commission (FERC). FERC holds the licensing authority over non-federal hydropower projects with a generating capacity above 5 megawatts. Licenses typically are granted for 30 to 50 years of operation and define operating constraints, often based on meeting water-quality and environmental objectives, which must be met in order to maintain a license. The FERC re-licensing process creates an opportunity to factor management objectives into a license that may have emerged in the decades since the current license was issued. In many river basins, including the Santee, this includes greater consideration of environmental objectives.

Several conservation groups in South Carolina have asserted that ecological interests are under-represented in the licenses currently governing the operation of the Catawba-Wateree Project (operated by Duke Power), the Saluda Project upstream of Columbia (operated by South Carolina Electricity and Gas), and the Santee-Cooper Project (operated the South Carolina Public Services Authority). Ecosystems of interest include the habitat quality and availability in river reaches used for spawning by the endangered short-nosed sturgeon and the biologically important swamplands supported by river stage conditions in the basin, including South Carolina's newly created Congaree National Park.

The wetlands in the Congaree National Park (COSW) represent the last vestiges of a once vast and undisturbed ecosystem, and they function as an outdoor laboratory for the study of physical, biological, and cultural systems and their components. All the benefits derived from the COSW are tied to a highly specialized ecosystem whose unique flora and fauna are sensitive to the extent, duration, and timing of floodplain inundation. Further, the Congaree River's 53 miles provide for sixteen percent of the Santee River basin's 17,600 acres of potential diadromous fish spawning habitat. Given the importance of these resources and the opportunity offered by upcoming FERC re-licensing, research is needed to determine how to characterize the Park's wetlands in the context of a basin-wide hydropower planning model that will be used to explore alternative management regimes that could accommodate new management objects into economically viable hydropower operations.

Statement of results or benefits.

To address re-licensing issues, members of the conservation community in South Carolina are financially supporting the development of a basin-wide hydropower planning tool to assess ecological conditions under several different management regimes, and to thereby describe potentially viable operational changes during FERC re-licensing processes. These organizations have already committed the funds necessary to develop this model and a first phase of model development has been completed for the Santee-Cooper Project which is the furthest along in the FERC re-licensing process. The model currently relies upon historic flow data from the USGS *Wateree at Camden* and *Congaree at Columbia* gauges to provide the inflow that drives project operations. The use of historic data implies that the management regimes of upstream projects will remain unchanged over the life of the new Santee-Cooper license and eliminates the possibility for exploring whether coordinated operations of all projects could enhance the ability to meet South Carolina's increasingly diverse water management objectives.

The model will next be extended basin-wide to cover the Catawba-Wateree and Saluda Projects. At this point the function of the wetlands in COSW becomes an important consideration for two reasons. First, an assessment of inundation at the COSW is one of the more complex metrics which the conservation community wants included in negotiations for FERC re-licensure. The Congaree River has two major, tributaries: the Broad and Saluda Rivers that are regulated by the operations of the Saluda Project. The effects of inflow from these tributaries on floodplain inundation in COSW are not currently well documented or defined, although the effect of upstream river regulation is easily perceptible. Saluda River flows are controlled at Lake Murray, which has a substantial storage capacity (2.1 million acre-feet) in relation to its mean annual flow (1.8 million acre-feet). Although no large storages exist upon the Broad River, the pumping station at the Monticello Project is capable of effectively retaining small to moderate events to augment storages during periods when hydropower is cheap (at night and on the weekend) in order to provide a greater generation during peak demand periods (week-days). Second, the outflow from the wetlands to the downstream Santee-Cooper project is attenuated and potentially depleted by the wetlands. Once again, the relationship between inflow and outflow is not currently well documented. Funds are being sought from the South Carolina Water Resources Center Competitive Grants Program to support the development of a stochastic model of wetlands function in the COSW, and its integration into the basin-wide planning model already under development.

An integral outcome of this effort is the development of reliable performance measures, or metrics, for representing ecological benefits. By comparison, economic metrics are straightforward to develop: powerhouse releases are instantaneous and well defined, as are general market prices. Environmental conditions are seldom as easy to quantify, and are generally based upon both instantaneous and antecedent hydrologic conditions within the system. For instance, providing enough flow to increase fish spawning area achieves little if the additional habitat is allowed to go dry before the fry can hatch. Thus, designing methods to enhance the environment becomes a complex process, highly dependant upon an accurate relationship between in-stream flows and important biological indicators.

In order to clearly understand the relationship between management costs (potentially foregone power production) in order to reach different ecological goals at COSW, it is imperative that a reliable relationship be drawn between managed upstream flows and river elevations at the Congaree Swamp. Development of this model will then be used to enhance the basin-wide model, so that historical gauge data inputs can be replaced with modeled inputs that can then be used to study the entire Santee system under different regulatory schemes.

Nature, scope, and objectives of the research.

The primary goal of the PI's research is to deliver stochastic models for various reaches of the basin-wide model. The Natural Heritage Institute anticipates completion of the basin-wide model using historical streamflows in the second quarter of 2004. As stochastic models are developed, they can be used to study the effect of manipulated input flows for the basin-wide model.

Methods, procedures, and facilities.

Basin-wide methods. Central to this effort is the development of a basin-wide reservoir model, capable of demonstrating operational impacts on both the economics of hydropower generation and the viability of the basin's environmental goals. The principles behind the basin-wide model are relatively simple: a mass balance is maintained between inflows, releases, diversions, and losses at each reservoir; inflows are initially defined by the historic records in the Santee River basin; the timing and quantity of releases is calculated within the model's operational logic to reflect objectives and constraints such as minimum flow requirements and rule curves; lastly, the timing, quantity and duration of releases is used to quantify benefits among the basin's many uses, such as hydropower profits, lake levels, and riverine habitat.

The model will be created using Extend simulation software, a visually communicative, object-oriented programming environment that can easily represent the number of facilities in the Santee River Basin and produce an analytical framework for the analysis of basin-wide planning criteria.

The evaluation of ecologically important metrics within the Congaree National Park and the Upper Santee Swamp requires, first, the development of a reliable and comprehensive model for translating inflow from the Saluda, Broad, and Wateree Rivers into river stages, quantifications of inundated areas, and outflows to Lake Marion, followed by its implementation into the basin-wide planning model environment elaborated above. The proposed approach for this component is an extension of previous work by the PI in the Four Holes Swamp. The Four Holes model used stochastic transfer function models to predict downstream gauge flows from an upstream gauge (the residual standard error in a 1-day ahead forecast was 2.6 cm in a system that could fluctuate by several feet; the residual standard error for a 10-day ahead forecast was 8.1 cm). Four Holes Swamp personnel can use the prediction to study inundation throughout the Four Holes system; as a practical matter, it relieves staff from checking the downstream gauge every day, which was inconveniently located.

Stochastic transfer function models. To allow more flexible modeling of inflows, stochastic transfer function models will be used to model reservoir inflows. This will allow researchers to study the effect of reservoir operations, *as manipulated by the researcher,* beyond conditions available in the historical record. Deterministic transfer function models have long been used by process engineers to study dynamic continuous systems. Discretized versions of these continuous systems can be studied using difference equations.

Typically, an output in these discrete transfer function systems depends on an input variable, a delay between the input and output variable, first- and higher-order differences for the input variable, and first- and higher-order differences for the output variables. Each of these effects can be related to physical characteristics of the system, such as backwater and reservoir effects. While an entirely empirical approach can be taken to stochastic transfer function modeling, it is useful to include known physical effects in the model, so that the model has a theoretical, as well as an empirical, basis.

Transfer function models can be enhanced by modeling residual correlations between the input and output variables using ARIMA (AutoRegressive Integrated Moving Average) Autoregressive terms account for correlations between current stage data and past stage data—multiple AR terms in stochastic transfer function models developed for Four Holes Swamp, for instance, suggested the presence of more than one mechanism for upstream flood events. Moving average terms relate current stage data to past forecast errors. In an earlier project modeling Lake Murray Dam outflows for an analysis of recreational flow on the Saluda River conducted for the River Alliance, moving average terms were needed to compensate for forecasts that tended to underpredict the rapid increase in stage typical of releases from Lake Murray. Integrated terms include first- and higher-order differencing; first-order differencing removes trend effects, while higher-order differencing can be used for smoothing.

Structural similarities between ARIMA and transfer function models facilitate incorporating the stochastic ARIMA models into the deterministic transfer function models. In the case of multiple inputs, stochastic transfer function models can be written as vector ARIMA models. Off-the-shelf software includes numerous useful algorithms and diagnostics for developing single-input stochastic transfer function models. Specialized software packages for multiple-input models are not available, though methodology for vector ARIMA models is well established in the statistical literature.

Related Research.

The first reference contains an in-depth summary of stochastic transfer function modeling, while the second reference extends stochastic transfer function models to multiple inputs using Vector ARIMA time series models. The first reference in particular contains an extensive bibliography on transfer function models.

Box, G.E.P., G.M. Jenkins, and G.E. Reinsel, *Time Series Analysis, Forecasting and Control, 3rd edition,* Prentice Hall, Englewood Cliffs, N.J., 1994.

Astakie, T. and W.E. Watt, Multiple-input transfer function modeling of daily streamflow series using nonlinear inputs, *Water Resources Research, 34,* 2717-2725, 1998.

Application of Emerging Technologies for Water Quality Monitoring and Data Transfer in the Saluda-Reedy Watershed

Basic Information

Title:	Application of Emerging Technologies for Water Quality Monitoring and Data Transfer in the Saluda-Reedy Watershed
Project Number:	2004SC10B
Start Date:	3/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	Third
Research Category:	Not Applicable
Focus Category:	Water Quality, Management and Planning, Education
Descriptors:	Water Quality
Principal Investigators:	Christopher Post, Stephen Klaine

Publication

Application of Emerging Technologies for Water Quality Monitoring and Data Transfer in the Saluda-Reedy Watershed

Statement of critical regional or State water problem:

Water quality in a watershed is ultimately dependent on the policy decisions made within the watershed that shape the landscape. These decisions are often made in the absence of scientific information concerning the critical resources. It is insufficient to monitor water quality and publish papers. If we are to facilitate behavioral and policy changes that result in better water quality than we must present stakeholders and policymakers with accurate, timely information upon which to base their daily decisions.
The Saluda-Reedy Watershed above Lake Greenwood (shown on the map on page 4) is the natural catchment for 1,165 square miles of the Blue Ridge foothills and upper Piedmont of northwestern South Carolina. During the past century, but especially over the last twenty-five years, the Reedy River has been seriously impacted by urban development. This development continues to move down the Reedy River corridor and is now making its way to the Saluda River. Greenwood County and especially Lake Greenwood are experiencing the adverse effects of these rapid changes.
Greenwood, South Carolina is experiencing strong manufacturing expansion, has an emerging biotech industry and will probably become the fastest growing county without a major interstate highway. Greenville's continued growth will depend on the ability to handle its waste, while Greenwood's future depends on a reliable source of drinking water and access to an equitable share of the assimilative capacity of the Saluda and Reedy Rivers. What was once an abundant resource has become the umbilical link of these two growing counties; and the capacity of that resource is finite.
We believe that the delivery of timely information to the policy makers within Greenville will take a large step toward aiding in the development of more environmentally-sound land use policy within the Saluda-Reedy watershed. Technology that reduces the cost and increases the reliability of sensor-based water quality stations will allow for proliferation of the technology in South Carolina and throughout the Nation. Increased frequency of sensor based monitoring will help researchers and stakeholders get a better understanding of how water quality varies over space and time.

Statement of results or benefits

Results of proposed research will evaluate technologies for data transfer from remote sensor locations and also evaluate a new low-cost turbidity sensor developed by the Honeywell Corporation. The most reliable data transfer technique(s) will be used to link to existing sensor sampling stations located in the Reedy River near Greenville, SC with a data warehouse server that provides policy makers with real time information on the water quality of the Reedy River and, most importantly, how this water quality changes as the river flows through Greenville. We anticipate that we will repeat this effort with county and city councils in Laurens and Greenwood counties that lie downstream from Greenville. Through related, concurrent projects we are forming working relationships with policy makers in Greenville, Laurens and Greenwood counties. These projects include Changing Land Use and the Environment (supported by the USDA-NRCS), The Saluda-Reedy Watershed Consortium: Taking Action for Water Quality Improvement and Watershed Management (supported by the V. Kann Rasmussen Foundation), and Satellite Linkages for Real Time Stakeholder Feedback in Watersheds (supported by the American Distance Education Consortium).

Nature, scope and objectives of the research, timeline

The focus of this proposal is both to develop algorithms to test two low cost techniques for data transfer from remote water quality sensor locations (meteor-burst, and cell phone data networks) and to test a promising low-cost sensor for measuring the amount of sediment in river water. Reducing the overall cost of real-time water quality monitoring will increase opportunities to monitor how human activities impact water quality on a watershed scale. Information gained through use of the data transfer techniques and turbidity sensor will be incorporated into an existing dedicated webpage and will also be available to be shared through state, county and city agency and other stakeholder websites.

This project is organized into five major objectives in order to maximize the transfer of the technology to the stakeholders:

1. Develop algorithms to use and test the reliability of Cell phone data networks for transferring sensor data over the Internet to a dedicated data warehouse.
2. Develop algorithms to use and test the reliability of meteor-burst technology for transferring sensor data over the Internet to a dedicated data warehouse. This will require the use of data minimization and compression techniques.
3. Interface and test multiple Honeywell turbidity sensors in order to statistically assess their performance as compared with other existing turbidity sensors and laboratory analyzed samples.
4. Migrate from the existing satellite data transfer technology to cell phone data network and/or meteor-burst technology for two existing sensor sample stations on the Reedy River.
5. Develop web and peer reviewed publications to assist others with using these data transfer techniques and the evaluation of the Honeywell turbidity sensor.

Methods, procedures, facilities

<u>Evaluation of Cell Phone Internet Network for Data Transfer from Sensor Sample Station</u>

High speed data networks are being developed and deployed by the major cellular phone providers and offer the opportunity to connect water quality sensor stations to the internet on a continuous basis and at a relatively low cost. These networks typically offer speeds between 40-60 kbps, with burst capability of approximately 144 kbps, while the next generation network will offer speeds between 300-500 kbps (http://www.verizonwireless.com, http://www.sprintpcs.com). In other words, the current cellular phone data networks are approximately equivalent to dialup modem speeds, while future network speeds will be equivalent to a DSL or office Ethernet connection. Current network speeds should be adequate to transfer sensor data and compressed images from sample locations over the internet to the data warehouse server located at Clemson University, but questions remain about the reliability and usability for the cellular data networks for this application. Availability of the data network varies with the number of users that access the network (SprintPCS technician, personal communication), so the ability to access the cellular phone data network can theoretically vary over time. Also, network speed can also vary with the number of users accessing the network (SprintPCS technician, personal communication). Network availability is high in urban areas and near major interstate roads, but can be limited in rural areas (http://www.verizonwireless.com, http://www.sprintpcs.com).

This proposal will test the network of two major cellular phone providers: Verizon Wireless and Sprint PCS at multiple locations within the Saluda-Reedy Watershed near Greenville, SC. Initial testing will be centered at our real-time sensor locations, one located in the headwaters of the Reedy River above Greenville, SC and one located at the Western Carolina water treatment facility on the Reedy River, south of Greenville, SC. Further testing at other permanent sample sites within the watershed will provide a picture of the applicability of this technology for long-term data transfer. Computer programs will be developed, in JAVA and C++, that both test the quality of the cellular phone network link and optimize the data transmission from the dedicated watershed-based computers that are connected to the sensors to the Clemson University based data warehouse computer. Both dedicated cellular network data cards and connections through cellular phones will be evaluated. The information developed will be useful to a wide range of agencies and individuals as use of Internet-linked sensors and sensor networks become ubiquitous.

Evaluation of Meteor-Burst for Data Transfer from Sensor Sample Station

Meteor-burst technology was developed by the U.S. military in the 1950's and is based on bouncing radio waves off of small meteor particles in the upper atmosphere which are subsequently received by a base station (NRCS, 2003). This technique is a reliable and inexpensive way for remote two-way communication and has a range of approximately 1200 miles (NRCS, 2003). Limitations of this technique include slow data transfer speeds 1-2 kbps and the lack of continuous communication; however communication is usually possible every few minutes when a meteor trail is created in the upper atmosphere (Fukuda, 1996). Computer programs will be developed, in JAVA and C++, to test the use of the meteor burst technology to transfer sensor data to the Internet. NRCS data centers will be used for relay of the sensor information to the internet and subsequently to the Clemson based data warehouse computer (at no cost to this project). This technique will be tested at multiple locations in the Saluda-Reedy watershed and will be compared with the above mentioned cellular data network data transfer technique. Limited bandwidth availability will require the use of data compression techniques and may not allow the transfer of images from dedicated watershed cameras.

Dedicated Use of Cell Phone Data Networks/ and or Meteor-Burst Technology for Existing Sensor Sample Locations on the Reedy River

After the cell phone network and meteor-burst technology has been evaluated either or both technologies will by employed to replace an existing satellite data network for two sensor sample sites, one located in the headwaters of the Reedy River above Greenville, SC and one located at the Western Carolina water treatment facility on the Reedy River, south of Greenville, SC. The satellite system was funded for one year through the American Distance Education Consortium (ADEC). It is cost prohibitive to continue the satellite Internet connection and funding of this proposal will allow for the long-term continued use of the sensor sample stations for scientific monitoring and stakeholder education.

Verification and Calibration of a Honeywell Turbidity Sensor

Use of multiple water quality sensors in a watershed is often limited by the cost of the sensors themselves. Honeywell created the first turbidity sensor for incorporation in dishwashers in 1997 and has recently developed a new high sensitivity turbidity sensor (0 to 100 NTUs, nephelometric turbidity units) that uses a laser diode to estimate the amount of soil particles present in water solution (Ottens and Engler, 2003). Earlier versions of the Honeywell turbidity sensor were not sensitive enough for river water quality use (Personal Communication with K. Engler, December, 2003). This sensor has an approximate cost of $100-$150, which is 10% of the cost of other commercially available turbidity sensors. If this sensor performs well in river water quality monitoring, it could multiply the opportunities for in-situ turbidity sensing because of its low cost. Since this sensor has only been available since December 2003, there is no independent assessment available of the reliability and repeatability of this sensor in a river setting.

This project proposes to test this Honeywell turbidity sensor at an established sensor station in the Reedy River. The established sensor station, located on Western Carolina water treatment facility property, contains a turbidity sensor as well as a LISST-25 laser diffraction sediment load analyzer (from Sequoia Scientific). In addition this location is regularly sampled with an automatic sensor for laboratory analysis of sediment concentration. The combination of established turbidity/sediment sensors and a sampling regime offers an excellent opportunity to test this new sensor.

Related research:

The Changing land Use and the Environment project, supported by USDA-NRCS, focuses on developing cause and effect relationships between land use and water quality in the Saluada-Reedy watershed. As such, this project has established 12 automated water sampling sites within the watershed. These sites automatically sample water from the river during a storm event. Samples are collected manually and taken back to the laboratory for analyses. The Satellite Linkages for Real Time Stakeholder Feedback in Watersheds project, supported by the American Distance Education Consortium, focuses on the equipment and satellite linkages necessary to fully automate two of these sites (one above and one below the City of Greenville on the Reedy River). This automation goes beyond the water sampling to the use of in-stream probes that continuously monitor dissolved oxygen, pH, turbidity, and conductivity.

References

Fukuda, A. 1996. Mobile applications of meteor burst communications. IEICE Transactions on Fundamentals of Electronics Communications and Computer Sciences, E79A (7): 953-960.

NRCS. 2003. Water and Climate Program Products and Services Briefing Book: Data Acquisition Technology. (http://www.wcc.nrcs.usda.gov/publications/Briefing-Book/).

Ottens, G. and K. Engler. 2003. Cooking & Laundry Technology: Laser-Based Turbidity Sensing: Applications include laundry. AM Appliance Manufacture Online. (http://www.ammagazine.com/CDA/ArticleInformation/features/BNP__Features__Item/0,2606,91407,00.html).

Information Transfer Program

We prepared a technical report for Jeffrey Payne of Natural Heritage Institute (NHI) describing our technology, and prediction equations for daily water levels for the gage on the Santee River at Trezevant's Landing using gage data from the Wateree River at Camden and the Congaree River at Columbia. We used the prediction equations to extend estimates of the daily gage data on the Santee River back to the year1939; previously, daily gage data for the Santee at Trezevant's Landing had been available only from 1994 to the present. Hourly prediction equations developed in Zongshou's thesis can be used to study water levels on the Santee under different hydrologic regimes on the Wateree and Congaree and we anticipate making these available to NHI shortly.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	0	0	0	1
Masters	4	0	0	0	4
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	5	0	0	0	5

Notable Awards and Achievements

The South Carolina Water Resources Center at Clemson University and the Georgia Water Research Institute at Georgia Tech co-sponsored a workshop on issues surrounding a potential Savannah River Compact between the states of South Carolina and Georgia. This workshop took place in November of 2004. Over 50 attendees from various state, federal and local agencies as well as various stakeholder groups within the Savannah River basin provided information for discussion.

Information from the South Carolina Department of Natural Resources shows that the Savannah River is the regions major surface water resource, draining an area of more than 10,000 square miles. The river is regulated by 10 hydroelectric projects owned by private utilities. The three major reservoirs are operated by the U.S. Army Corps of Engineers. As population growth and urbanization in the basin continues, competition for use of this resource increases.

Counties within South Carolina have transferred water across political and watershed boundaries for years. In fact, the city of Greenville gets a large portion of its water supply from Lake Keowee. Greenville pulls the water from Lake Keowee in the Savannah River basin for use in the Reedy River and Saluda River basins. Greenville is one basin removed from the Savannah basin, as is Atlanta, so it would seem that one has no more rights to the water than the other. (Greenville's inter-basin water transfer permit allows the city to pull up to 150 million gallons of water per day from Lake Keowee.) As the upstate of South Carolina continues to grow and Atlanta expands in all directions, the Savannah River will be looked at as an answer to future water supply problems for both areas.

However, protecting that supply and meeting the water demands within South Carolina and Georgia takes more than the work of one organization. It takes a concerted group effort. The public as well as local, state and federal government should be working together in this matter. Because water is a limited resource, its the cooperation of individuals and the governmental institutions that will make the difference. The goals for holding the proposed workshop included identifying the key issues for water quantity and quality within the Savannah River Basin, identifying gaps in information necessary for a river compact, and supplying information derived from the workshop to decision makers in both states. Results of the workshop are to be compiled into a white paper and posted on the SCWRC web site.

The SCWRC was pleased to receive a major grant in 2004 from the South Carolina Department of Natural Resources to implement a Reedy River Watershed Education program. The following press release provides a summary of this program.

Reedy River Watershed Education Coordinator Hired

The South Carolina Water Resources Center at the Strom Thurmond Institute on the Clemson University campus welcomes Rebekah Guss as the Reedy River Watershed Education Coordinator. This new position in Cooperative Extension resulted from the identified need for an environmental education program focused on the Reedy River. The South Carolina Natural Resource Trustees allocated funds from the 1996 Colonial Pipeline oil spill settlement to establish this position.

From its source at the junction of two streams near Travelers Rest to its eventual terminus into Lake Greenwood, the Reedy River traverses urban, suburban, and rural landscapes. As a home for wildlife and aquatic creatures, source of drinking water, and repository for storm and waste water the Reedy assumes a diversity of uses. During the industrial era, the river was transformed from a free-flowing water body with reed covered banks to one that was managed with dams and, in many places, denuded of vegetation. The quality of the water and capacity of the river to adapt to storm events declined during this period. The Clean Water Act of 1972 marked an important change for the future of the river. The legislation resulted in improved water quality and increased public awareness.

Recent projects such as the Liberty Bridge in downtown Greenville highlight the importance and beauty of this local natural resource. Despite the strides that have been made in river enhancement, continued efforts are needed to ensure long term water quality and watershed health. As the region continues to grow, so does the potential for storm events and non-point source pollution to impact not only the river, but also surrounding communities.

Ms. Guss, who holds a BS in Environmental Studies from Brown University and an MS in Natural Resources from Cornell University, is eager to apply her experience in environmental education and program coordination to the Reedy River watershed.

She will be working on a number of projects and activities aimed at connecting various stakeholders (e.g., decision makers, residents, and researchers) and facilitating knowledge sharing to promote watershed management. A strong partner in her efforts to initiate an environmental education program will be the Saluda-Reedy Watershed Consortium. This research group represents a collaboration of academic, governmental, industrial, and non-profit entities examining an array of issues in the watershed from the economic impact of water use to the water quality in Lake Greenwood. Ms.Guss will also be working with local organizations to facilitate an array of programming to promote watershed education to a broad spectrum of watershed residents. Upcoming activities include river clean-ups, workshops, educational campaigns, and a paddle festival on the river.

Publications from Prior Projects