2009 VIRGINIA WATER RESEARCH CONFERENCE

Concurrent Session II

(A) Assessing Stream Flows in a Changing Climate
(B) Monitoring Watershed Characteristics and Changes
(C) Connecting Nutrient Cycling and Water Quality (Part 2)

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(A) Assessing Stream Flows in a Changing Climate

1) Using Field Measurement of Velocity to Study Erosion Processes in a River -- John Petrie, *Department of Civil and Environmental Engineering, Virginia Tech*

(2) Investigate Relationships Between Water Quality Violations and Streamflow Changes -- Ram Gupta, *Virginia Department of Conservation and Recreation*

(3) Evaluating the Erodibility of Cohesive Riverbanks with the Jet Erosion Test -- John Petrie, *Department of Civil and Environmental Engineering, Virginia Tech*

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USING FIELD MEASUREMENTS OF VELOCITY TO STUDY EROSION PROCESSES IN A RIVER

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The spatial distribution of velocity in a river influences both the channel morphology and ecology. Velocity characteristics, specifically secondary currents, in meander bends have been shown to have a strong effect on bank erosion. This study describes the use of field measurements of velocity to study erosion processes. The acoustic Doppler current profiler (ADCP) represents an important new technology for measuring three-dimensional velocity profiles in rivers. While typically used for measuring discharge, time-averaged velocity profiles and turbulence statistics obtained with ADCPs have recently been reported. The fixed-vessel approach to obtaining velocity time series with an ADCP is reviewed here and data analysis techniques are presented. Some potential uses of ADCP data are discussed and include determination of boundary shear stress and calibration of computational fluid dynamics models. Field measurements from two sites on the lower Roanoke River are used as examples. These

measurements were obtained for two different discharges; one close to the mean annual flow and the second during typical flood control operations. The relationship between the velocity characteristics and observed erosion at the sites is discussed.

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INVESTIGATE RELATIONSHIP BETWEEN WATER QUALITY VIOLATIONS AND STREAMFLOW CHANGES

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The capacity of the earth's atmosphere to trap solar radiation and increase global temperature has now become the topic of intense concern to agriculture and water resource communities. The belief that global warming will continue is now widely recognized by scientists and policy makers. Precipitation has been found to increase in U.S. by 5 to 10% over the 20th century (Intergovernmental Panel on Climate Change, IPCC, 2001), and is predicted to continue to increase in many regions. Few studies have predicted specific precipitation changes across the U.S. These include 25% increase in the Northeast and 10 to 30% increase in Midwest and Pacific Northwest.

Water quality impairment is predicted to increase under climate changes (IPCC, 2001). Specifically, precipitation is expected to occur more frequently through high intensity rainfall events, causing increased surface runoff and erosion. Sediment and nonpoint source pollutants will be transported into stream and groundwater systems, resulting in deteriorated water quality. Water quality will also be affected in areas receiving less precipitation, as pollutants become more concentrated. Studies have shown that the majority of water quality violations (i.e. bacteria), including extreme violations, are related to extreme runoff events, specifically the high and low flow conditions. Thus, it is essential to understand the impacts of various flow condition changes on water quality impairment, as well as develop mechanisms to address those impacts. The present study investigates the impact of flow conditions on potential changes in maximum value of water quality violation parameter (i.e., bacteria) and discusses these impacts for a few impaired stream segments within Commonwealth of Virginia. How these scenarios might be integrated with water quality improvement plans needs further investigations.

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EVALUATING THE ERODIBILITY OF COHESIVE RIVERBANKS WITH THE JET EROSION TEST

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Erosion rates for natural cohesive soils depend on both the complex inter-particle forces within the soil and the applied shear stress by the moving fluid. Due to the difficulty in describing these parameters theoretically, empirical methods are typically used to determine soil erodibility. To analyze erosion of cohesive riverbanks on the lower Roanoke River in North Carolina, jet erosion tests were performed at field sites. The jet erosion test scours the soil by applying a constant head water jet and the measured scour depth and time period provide empirical estimates of soil erodibility parameters. The erodibility parameters assume an excess shear stress model with a linear relationship between erosion rate and applied shear stress. The advantages of the test are (1) it is performed at the site, negating the need for sample removal, (2) it can be performed on steep slopes such as those typical of many riverbanks, and (3) the results are easy to interpret with a spread sheet program. The general testing procedure and analysis is reviewed and the implications of the underlying model discussed. The results from the Roanoke River are presented and erosion rates are compared with soil properties determined from other in situ and laboratory tests. Integration of jet erosion test results with numerical modeling of river flows is also discussed.

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(B) Monitoring Watershed Characteristics and Changes

(1) Analysis of Continuous Water Quality Monitoring Data from the Tidal Freshwater Potomac River -- Christian Jones, *Potomac Environmental Research and Education Center, George Mason University*

(2) An Analysis of the Upper Stroubles Creek Watershed Characteristics Using Geospatial Technologies -- Tiffany Sprague, *Department of Biology, James Madison University*

(3) Rainfall Interception in Tropical Forest Ecosystems: Tree Plantations and Secondary Forest -- César Jiménez-Rodríguez, *Instituto Tecnológico de Costa Rica*

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ANALYSIS OF CONTINUOUS WATER QUALITY MONITORING DATA FROM THE TIDAL FRESHWATER POTOMAC RIVER

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Recent advances in water quality monitoring have facilitated "continuous monitoring"-- the acquisition of basic water quality variables at fixed locations at short intervals over extended periods. Several fixed monitors have been sited in the tidal freshwater Potomac River over the past few years. We focus our analysis on a monitor on the tidal Occoquan River at the Belmont Bay development in Woodbridge, Virginia. Temperature, conductivity, dissolved oxygen, pH, turbidity and chlorophyll were collected at 15 minute intervals during the fall of 2008 and the spring and summer of 2009 using a YSI 6600 extended deployment sonde. Results of time series analysis indicate that, on a short term basis, conductivity shows a semidiel pattern, presumably driven by tidal excursion. On the other hand, dissolved oxygen, pH, and temperature exhibited a simple diel pattern driven by the daily light and temperature cycle. Patterns in turbidity and chlorophyll were not as apparent. Longer term patterns were related to longer term climatic factors such as large runoff events and seasonal progressions of light and temperature. Results from this site were compared with data from other continuous monitors in the tidal freshwater Potomac to determine the generality of the observed patterns.

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AN ANALYSIS OF THE UPPER STROUBLES CREEK WATERSHED CHARACTERISTICS USING GEOSPATIAL TECHNOLOGIES

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Urbanization alters physical characteristics of watersheds and, in many cases, changes the stream's natural flow direction and intensity and impacts the stream quality. The alterations are multifaceted and range from changing the size and slope of the watershed to changing the stream habitat. Understanding how changes affect the health of the watershed is important in determining how to correct the detrimental effects of urbanization. Changes to watersheds are established in many ways and the goal of this research is to investigate the changes in watershed characteristics using geospatial technologies.

An NSF REU research project, conducted during the summer of 2009, evaluated the changes caused by urbanization in the Upper Stroubles Creek Watershed in Blacksburg, Virginia. Technology used to compare these characteristics included GIS, LiDAR, GPS measurements and aerial photos. Physical characteristics analyzed included channel length, width and depth, stream source, watershed elevations, slopes, area and perimeter.

This paper will review the techniques used in the lab and in the field for the delineation of the various watershed characteristics. It will then review the results of the comparative analysis between the field data and the data delineated from the electronic and archival sources.

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RAINFALL INTERCEPTION IN TROPICAL FOREST ECOSYSTEMS: TREE PLANTATIONS AND SECONDARY FOREST

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A study was conducted in the tropical lowlands of Costa Rica, at La Selva Biological Station, to evaluate the rainfall interception of two forest plantations of *Vochysia guatemalensis* Donn. Sm. *Vochysia ferruginea* Mart. and one secondary forest. Daily measurements of gross rainfall, throughfall and stemflow were taken during the peak of the rainy seasons of 2004 and 2005 (August to November). The estimated throughfall expressed in percentage of the total gross rainfall for the secondary forest, Botarrama plantation and Cebo plantation were: 76%; 87,6% and 92,1% respectively. The estimated stem flow in percentage of gross rainfall was of 3% for *Vochysia ferruginea* and of 3,4% for *Vochysia guatemalensis.* Steamflow for the secondary forest was omitted due to the forest structure, composition and high density of palms trees that makes stemflow measurements a difficult task. This study shows that forest structure and composition of studied ecosystems have different degrees of influence in rainfall interception losses. Complex forest structure and composition such as tropical secondary forest intercept more rainfall than forest plantations. This information is important for selection of reforestation species in watershed managements programs as well as in evaluating the hydrological environmental service of these ecosystems.

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(C) Connecting Nutrient Cycling and Water Quality (Part 2)

(1) Streamside Management Zones Minimize Nutrient Fluxes From Forest Fertilization in Piedmont Streams -- John Seiler, *Department of Forest Resources and Environmental Conservation, Virginia Tech*

(2) The Soil Nitrogen Source to Streamflow During Snowmelt is Affected by Soil Freezing -- Sheila Christopher, *Virginia Water Resources Research Center, Virginia Tech*

(3) The Use of Floating Aquatic Plants for Phytoremediation of Eutrophic Waters -- Louis Landesman, *Virginia State University*

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STREAMSIDE MANAGEMENT ZONES MINIMIZE NUTRIENT FLUXES FROM FOREST FERTILIZATION IN PIEDMONT STREAMS

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State Forestry Best Management Practices (BMP) recommend Streamside Management Zone (SMZ) of varying widths based on limited data with regard to nutrient fluxes from silvicultural activities. Studies in Agricultural environs show increases of nitrogen (N) and phosphorus (P) in streams following fertilization. However, little information exists regarding the effectiveness of recommended SMZ widths for controlling nutrient fluxes following forest fertilizer application. We hypothesized that N and P levels would decrease on the soil surface, forest floor, and soil subsurface in forested SMZs as distance from the harvest boundary to the stream increased. Furthermore, we hypothesized that wider, unthinned SMZ's would better prevent nutrients from reaching the stream than narrower and/or thinned SMZ's. Diammonium Phosphate (DAP) and UREA were applied to subwatersheds of 2-3yr old loblolly pine (*Pinus taeda*) upslope from SMZ study areas in Buckingham Co., VA. Three replications of four SMZ treatments (30.5m, 15.2m unthinned, 15.2m thinned, and 7.6m) were studied using surface water collectors, cation/anion exchange membranes, lysimeters, and stream grab-samples. Measurement stations were spaced symmetrically across the SMZ from the uphill SMZ edge to streamside with grab samples being collected approximately 20m upstream and downstream of the fertilized area. Results show that stream water quality is basically unaffected by fertilization at all SMZ width treatments. However, we caution that these results were collected during a relative dry period and that other studies on the same sites indicate that 7.6m wide SMZs may be too narrow to fully provide other riparian functions, such as sediment trapping.

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THE SOIL NITROGEN SOURCE TO STREAMFLOW DURING SNOWMELT IS AFFECTED BY SOIL FREEZING

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Although climatic models of north temperate ecosystems predict greater amounts of winter precipitation in the future, reductions in snowpack are likely to occur due to the increased importance of thaws, sleet, and rain-on-snow events. Without an insulating snowpack, more frequent freeze-thaw cycles will occur and could affect nutrient cycling. Changes in snowpack dynamics, may affect soil and ground water sources in watersheds and the amount and timing of nutrient transport during spring snowmelt. We examined nitrogen (N) dynamics during late winter and spring snowmelt in the 696 ha Point Peter Brook watershed (PPBW), in western, N.Y. during 2007 and 2008. Contrary to what has been observed during late summer/early fall hydrologic events, in this watershed, near-surface soil water was an important source of nitrate during springmelt. To test the effects of soil freezing on *in situ* rates of soil nitrate production (nitrification), a snowpack manipulation study was conducted in winter 2007-2008. We established reference and snow manipulation treatment plots. One pair of treatment and reference plots was located in the riparian zone of PPBW while another pair was located on the hillslope. The treatment plots at both landscape positions had significantly greater N mineralization than reference plots. No treatment effect was observed for nitrification in the riparian plots while the hillslope treatment plot had a smaller nitrification rate than the reference hillslope plot. As climate change alters temperate forested ecosystems, especially during winter, the effect of soil freezing should be considered when evaluating changes in sources and export of N during spring snowmelt.

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THE USE OF FLOATING AQUATIC PLANTS FOR PHYTOREMEDIATION OF EUTROPHIC WATERS

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Over the last 40 years a great deal of research has been published on the use of floating aquatic macrophytes to treat wastewater both from point sources (feedlots, food processing plants) and non-point sources. These plants can recover nutrients such as nitrogen and phosphorus from eutrophic surface waters. They can also remove or accumulate metals, radionuclides and other pollutants in their tissues. Examples of floating aquatic macrophytes include *Eichhornia crassipes* (water hyacinth), duckweed (*Lemnaceae* family), *Azolla caroliniana* (water fern), *Pistia stratiotes)*, (water lettuce), *Hydrocotyle umbellate, (*pennywort) and *Salvinia molesta* (giant salvinia).

Considerable research has been carried out in recent years on the use of these floating aquatic macrophytes to treat wastewater by recovering nutrients present in these waters while at the same time providing a useful product in return. This article will discuss various types of floating aquatic macrophytes and the uses that have been found for their harvested biomass. These floating aquatic plants often act as invasive species and can reproduce asexually as well as sexually. This review will summarize some of the published work done using these plants to phytoremediate natural, domestic and agricultural wastewaters.