Report for 2001SC3741B: Non-point Source Runoff and Water Quality in a Rapidly Growing Urban Watershed

There are no reported publications resulting from this project.

Report Follows:

Statement of Critical Regional Water Problem

Between 1970 and 1990, population in Richland county has increased by over 20% (South Carolina Statistical Abstract, 1999), and has been continuing to grow (Dobson et al., 2000). As a result, the potential for introduction of non-point source runoff in various county watersheds has been intensifying. Non-point source pollution encompasses runoff from land surfaces after rain events or snow melts. Various environmentally harmful entities, such as sediments, oil, grease, litter, pesticides, fertilizers, bacteria and nutrients, may be detected in non-point source runoff. These materials find their way to lakes, streams, wetlands, and even groundwater, and gradually deteriorate water quality, leading not only to destruction of wetlands and wildlife habitat, contamination of drinking water, but also to economic losses from diminishing property value and low recreation potential.

This study will focus on the Gills Creek watershed, South Carolina, which is a highly urbanized water system (1,620 people per square mile, DeVier, 1999) located in central Richland County. For a year, the study will monitor and document the impact of non-point source runoff on water quality in the Creek, following rain storm events. We chose the Gills Creek watershed because it has been characterized by poor water quality for over 30 years. This watershed is an important water resource in the South Carolina Midlands, because it is currently classified as FW by the South Carolina Department of Health and Environmental Control (SC DHEC). This classification allows for all major water uses, including supply of drinking water after conventional treatment (DeVier, 1999). Gills Creek flows in the Congaree River. Part of the river's flood plain is occupied by the Congaree Swamp National Monument, which preserves in its wilderness state "the largest intact tract of old-growth bottomland hardwood forest in the United States" (National Park Service, 2000). The monument not only supports a variety of recreational activities (National Park Service, 2000b) but also serves as an International Biosphere Reserve, National Natural Landmark, Wilderness Area, and a Continentally Important Bird Area (National Park Service, 2000a). Moreover, Gills Creek runs through the site of a controversial, 4,600 acre development project that has been proposed by the Burroughs and Chapin Company and will include homes, golf courses and businesses (Davis, 2000; Hill, 2000). It is logical to expect that if the Burroughs and Chapin development proceeds as planned, then Gills Creek water quality will potentially deteriorate further. Thus a detailed baseline investigation of the impact of non-point source runoff on Gills Creek watershed is necessary for the adoption of best management practices for this valuable water resource in Richland County.

Statement of Results or Benefits

Locally, this study will serve a twofold need. First, it will provide a detailed look at the impact of non-point source runoff on water quality in the Gills Creek watershed before the development proposed by the Burroughs and Chapin Company. Second,

should the development proceed, our results will not only serve as a baseline in an environmental monitoring program, but also as relevant material to educate the developers as well as the public- potential property owners.

Regionally, and even nationally, the study will draw attention to the impacts of urban sprawl and development on the nation's water resources, regardless of resource magnitude. development and associated urban sprawl and non-point source pollution are serious problems which have been subjected to continuing policy debate (Dobson et al., 2000). It is conceivable that one possible solution to these problems will be the introduction of federal legislation, in which case, studies like this proposed one will be needed to demonstrate the need for such a measure.

Nature, Scope and Objectives of the Research

The proposed project is field-based, with daily water sampling and physical parameter measurements for a week following rain events in the watershed over the course of twelve months. The project's scope is local-to-regional, as the research focuses on a watershed located in one of the fastest growing areas of Richland county, however, the research addresses a wide spread regional problem, namely rapid and uncontrolled urbanization and resultant deterioration of water quality. The project will aim to:

1) Establish a comprehensive, year-long record of non-point source runoff generated after rain events in the Gills Creek watershed.

The Gills Creek watershed is characterized by an average of 15 storms / year, with precipitation exceeding an inch, and 33 storms / year, with precipitation between 0.5 and 1 inch (South Carolina Department of Health and Environmental Control, 1997). Combined, these yearly frequencies add up to a rate of one storm with precipitation exceeding 0.5 inches occurring approximately once every week. Such high frequency suggests that pollutant may be supplied faster than the watershed can manage to "buffer" them. Specifically, following a rainstorm, one would expect that the concentration of dissolved oxygen in the water column would decrease, while nutrient concentration and biochemical oxygen demand will increase. The concentration of total suspended solids would increase, thus limiting light penetration for photosynthesis and the resultant replenishment of oxygen in the water column. Such conditions place aquatic organisms and plants under certain levels of stress. If conditions in the water column do not return to normal before the next storm, then water quality will deteriorate rapidly.

2) Compare the magnitudes of non-point source runoff generated after rain events to baseline, background levels of non-point source pollution in the watershed in order to quantify the rate of non-point source pollutant input.

This objective has direct implications for the recommendation of best management practices to reduce non-point source pollution in the Gills Creek watershed. Because of the expected high pollutant input rates resulting from frequent rain storms in the area, measures for reduction of non-point source pollution in the watershed will have to include both a decrease in pollutant inputs and an increase of

riparian buffers in the watershed. Because urban development in the watershed would increase the area of impervious surfaces, making it easier for direct introduction of pollutant runoff in surface waters, construction of adequate riparian buffers becomes especially important.

Proposed Timeline of Activities

Even though funding is requested for 12 months only, i.e. for the duration of the field and analytical components of the proposed project, we anticipate that this project will actually be completed in 18 months, with additional six months (no-cost) needed for data interpretation, presentation and publication. The project's field and analytical components will begin in July of 2001, and will end in June of 2002. Samples will be collected daily for a week following rain events in the Gills Creek watershed, and will be analyzed immediately following each sample collection.

Methods, Procedures, and Facilities

Water samples will be collected daily, over the course of 12 months, for a week following rain storm events in the Gills Creek watershed. In addition, physical parameters, such as water turbidity, water and air temperature, as well as meteorological conditions will be recorded. Water samples will be collected using a 1 L stainless steel Kemmerer bottle. Subsamples will be set aside for total suspended sediment, nutrient (ammonia, nitrate-nitrite, and ortho-phosphate), and biochemical oxygen demand measurements. Dissolved oxygen, water temperature, pH and turbidity will be measured directly in the field using a HYDROLAB H2O® multiprobe system. In addition, meteorological conditions will be recorded and rain storm information (type, duration, magnitude) will be gathered from the State Climatology Office.

Our sampling scheme will replicate the three sampling stations in the Gills Creek watershed that are currently monitored by South Carolina Department of Health and Environmental Control (figure 1). Proceeding downstream, station C-068 is located at the dam on Forest Lake. Station C-001 is located in Gills Creek, at the US Highway 76 bridge, and station C-017 is furthest downstream, on Gills Creek, at SC Highway 48 (figure 1). SC DHEC yearly average data indicate that biochemical oxygen demand is highest at station C-001, and lowest at station C-068. Ortho-phosphate concentration is lowest at station C-068, but similar for the remaining two stations (South Carolina Department of Health and Environmental Control, 1997). In addition to these three stations, we will add a fourth one, GC-CR, right at the confluence of Gills Creek and Congaree River (figure 1).

In the lab, total suspended solids will be measured gravimetrically, using a 0.45 µ membrane filter (Metricel). Ammonia, nitrate-nitrite, and ortho-phosphate concentrations will be measured spectrophotometrically. Specifically, ammonia will be measured using the indophenol method outlined by Grashoff (1976); nitrate-nitrite will be measured using the cadmium reduction method, and ortho-phosphate - using the

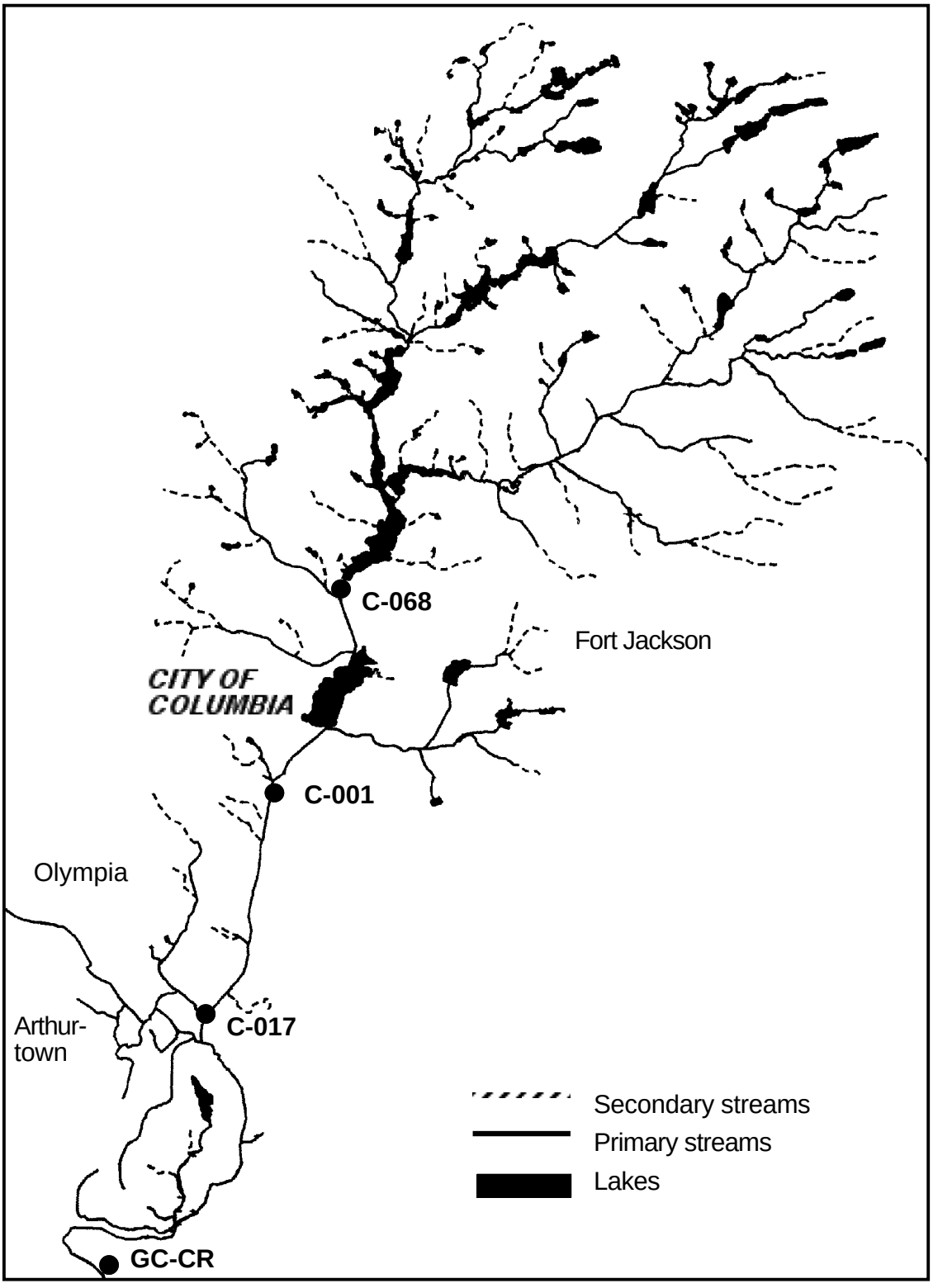

Figure 1. Map of Gills Creek watershed with sampling stations.

Morphy-Riley method (Grashoff, 1976). All data handling and statistical calculations will be performed using Microsoft Excel software.

All sample analyses will be conducted at the Stable Isotope Lab at the University of South Carolina. A HACH DR 2000 direct reading spectrophotometer is available at the lab. A HYDROLAB H2O® multiprobe system will be borrowed from the Bureau of Water, SC DHEC (contact person: Mr. David Chestnut).

Related Research

The South Carolina Department of Health and Environmental Control began monitoring the Gills Creek watershed in 1994, part of an initiative called "The Gills Creek Nonpoint Source Pollution Project", which continued through 1996 (South Carolina Department of Health and Environmental Control, 1997). The goal of the project was to observe non-point source pollution in the watershed in order to recommend appropriate control measures in surrounding communities. Following the completion of the project, which was initiated under the mandate of the 1987 Clean Water Act amendments (DeVier, 1999), SC DHEC has continued monitoring the watershed on a regular monthly basis, including observations of nutrients, dissolved oxygen, fecal coliform bacteria, five -day biochemical oxygen demand, pH, total suspended solid data are available from SC DHEC. We will use these long term data as baseline information in order to compare with the observed values following rain events.

Training Potential

The proposed study has an excellent student training potential, as it will be linked with an established undergraduate research program at the University of South Carolina - Columbia, the Marine and Aquatic Research Experience program (MARE, *mare*, Latin for sea).

MARE is a field-intensive, student-directed program in which teams of undergraduates design and execute their own research agenda, and enlist faculty and technical staff as partners and mentors in their research. Since its inception three years ago, MARE has conducted eight research expeditions on the second largest watershed on the East Coast, Winyah Bay, South Carolina. Over 60 marine science, biology and engineering majors from the University of South Carolina have been involved in these expeditions. Currently the MARE students have organized themselves into geological, chemical, biological and physical thematic research groups. The students have started to accumulate a database of protocols, associated materials and results which have been presented nationally (Benson et al., 2000a,b; Ranhofer et al., 2000; Robinson et al., 2000).

Because the Gills Creek watershed is close to campus, this proposed project will be able to involve students in all research steps: field sampling activities, sample analyses, data interpretation and presentation. Students will also be involved in

preparation of results for publication in refereed journals. Currently, MARE includes approximately 20+ marine science, geography, engineering, biology and geology majors.

For a detailed report of number of students to be trained, please see Appendix C.

References Cited

Benson, K., Fornwalt, B., and D. Volz. 2000a. Nutrient dynamics in the partially mixed estuary of Winyah Bay, SC. *EOS, Transactions of the American Geophysical Union* 81:S87

Benson, K., Armstrong, S., Majzlik, E., and L. Wise. 2000b. An ongoing study into the physical dynamics of the Winyah Bay estuary, South Carolina. *EOS, Transactions of the American Geophysical Union* 81:S276

Davis, M. R. 2000. Development is 'risky,' says FEMA head. *The State*, April 25

DeVier, C. L. 1999. A Study of the Effects of Nonpoint Source Pollution on the Water Quality of the Gills Creek Watershed. Honors Thesis, South Carolina Honors College, University of South Carolina

Dobson, D. L., Oldendisck, R. W., and C. Prince. 2000. Growth in South Carolina. Institute of Public Affairs, University of South Carolina, Columbia, South Carolina

Grashoff, K. 1976. Methods of Seawater Analysis. Verlag Chemie, Berlin

Hill, S. 2000. Sewage plant no rose; officials say no problem. *The State*, September 25

National Park Service. 2000a. Congaree Swamp National Monument [online]. Available Telnet: www.nps.gov Directory: cosw

National Park Service. 2000b. Congaree Swamp National Monument [online]. Available Telnet: www.nps.gov Directory: cosw / pphtml File: activities.html

Ranhofer, M., Morgan, J., Glett, B., and T. Pumphrey. 2000. Geochemical characterization of surface sediments in Winyah Bay, South Carolina. EOS 81:S235

Robinson, C., Heincelman, T., and D. Foy. 2000. The impact of salinity on the distribution of macro-invertebrates of Winyah Bay, South Carolina. *EOS, Transactions of the American Geophysical Union* 81:S82-83

South Carolina Department of Health and Environmental Control. 1997. The Gills Creek Watershed Project: An Urban Nonpoint Source Project, Richland County, South Carolina (February 1994 - September 1996), Final Report. Bureau of Water

South Carolina Statistical Abstract, 1999