

Report as of FY2007 for 2006MN187G: "Application of Wireless and Sensor Technologies for Urban Water Quality Management"

Publications

Project 2006MN187G has resulted in no reported publications as of FY2007.

Report Follows

Application of wireless and sensor technologies for urban water quality management

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Abstract

The water quality of streams draining watersheds has been degraded by increasing urbanization. The general symptoms of this degradation include more frequent large flow events, reduction in channel complexity, reduced retention of natural organic matter, and elevated concentrations of nutrients. Newly emerging urban water quality threats, including insecticides, herbicides, pharmaceuticals, and estrogens, are known or suspected to damage the health of humans and ecosystems. The restoration and management of streams have traditionally attempted to improve the hydrological and water quality conditions in-stream or in riparian zones. Recent studies have indicated the portion of a watershed covered by impervious surfaces and connected to the stream by stormwater drainage is the primary degrading process of stream ecology and health. These findings suggest that the sustainable restoration and management of stream water quality require quantification of hydrological, chemical, biological, and geomorphological processes, and that these processes must be assessed across a range of scales. Furthermore, interactions among biogeochemical processes across watersheds are either non-linear processes or linear processes dependent on non-linear drivers. The monitoring of such a system inherently requires a change in traditional field sampling strategies. We propose to transform traditional and very limited (in terms of spatial and temporal resolution) field

measurements through the integration of multi-scale, spatially-dense, high frequency, real-time, and event-driven observations by a wireless network with embedded networked sensing.

The goals of the proposed research are to assess the benefits of stormwater best management practices in mitigating the pollutant loads from urban and peri-urban sources, to evaluate the effectiveness of traditional grab sampling in calculating pollutant loads, and to develop correlations to predict the concentrations of non-sensed chemical or biological pollutants. These goals will be achieved by establishing a wireless sensor network capable of monitoring fundamental water quality parameters at high spatial and temporal resolution. It is hypothesized that sensed fundamental water quality parameters can be used for predicting the presence of emerging chemical contaminants in urban streams. It is also hypothesized that the water quality in streams draining similar impervious urban areas is controlled by the mean and variance of effective stormwater residence time. The mean and variance of water residence time, the time it takes urban runoff to travel between the impervious urban land and a receiving aquatic body, will be characterized by radio frequency identification technology (RFID), which will augment the proposed wireless network. Ultimately, data generated from such a monitoring network will enable mechanistically-based scaling and forecasting of water quality in urban streams and rivers. This will transform urban planning practices and management of water quality in streams draining urban land.

Progress

In 2007, the wireless sensor network for water quality monitoring was expanded to include five individual stations, each equipped with a datalogger and radio antenna. In addition to the two existing sensor bundles, three HydroLab sondes (Hach Environmental), two grab samplers (ISCO), and two MicroLab nutrient analyzers (EnviroTech LLC) were added to the network. The network is now capable of measuring temperature, pH, conductivity, dissolved oxygen, turbidity, depth, and nitrate on a continuous basis. Computer code was developed to run the equipment and record data automatically. A wireless cell modem was used to upload the data nightly to a computer located at St. Anthony Falls Laboratory. Remote communications were enabled, which allowed the user to make changes to the sensor network from the laboratory.

Unfortunately, the spring, summer, and fall in 2007 were unusually dry in the Twin Cities area. Thus, with essentially no storm events to monitor, we were unable to deploy along our targeted stream (Shingle Creek). This allowed us extra time, however, to pinpoint our site for BMP testing and monitoring by coordinating with USGS and the consultants responsible for the Single Creek watershed. For the 2008 field season, we have selected to monitor at a golf course in Brooklyn Center, MN. The ponds on the golf course collect stormwater from the surrounding neighborhood and mall parking lots and direct it into Shingle Creek. This site is just upstream from the USGS gauging station for Shingle Creek.

From Nov. 2007-March 2008 various quality assurance exercises were performed in controlled environments to quantify sensor reliability and errors. Within a 20 meter flume, two instrument layouts were studied; first all five instruments were grouped together and second each instrument was longitudinally spaced within the flume. Each set up was subjected to pulse and step inputs of turbidity and conductivity and the observed results were analyzed. Based on flow characteristics of the flume and the implemented inputs, errors associated with each measurement were subsequently quantified. The MicroLab analyzers were also put through a series of calibration exercises and tests.

In the spring, the network was deployed in Shingle Creek to allow continuous monitoring of water quality and BMP performance. Grab samples for the target pesticides, fecal coliforms, and chloride will be taken, as well as samples for sensed variables for verification. These data will be used to determine relationships between sensed parameters and those measured via grab samples. Efforts will be coordinated with activities of the USGS and the local watershed district.

Publications, Presentations, or Published Abstracts:

Publications

Jazdzewski, J. 2007. Stream Water Quality Monitoring Using Wireless Embedded Sensor Networks. M.S. Plan B Thesis, Department of Civil Engineering, University of Minnesota, 44 pp.

Presentations (* indicates student presentation)

Novak, P., J. Jazdzewski, S. Kim, W. Arnold, R. Hozalski, and M. Hondzo. 2007. Wireless Technologies and Embedded Networked Sensing for Urban Water Quality Management. Oral Presentation. Association of Environmental Engineering and Science Professors Interactions at the Interface Conference July 28 – August 1, 2007, Blacksburg, VA.

Hozalski R.M., S-C. Kim, J. Jazdzewski, M. Hondzo, P.J. Novak, and W.A. Arnold. 2007. Wireless Technologies and Embedded Networked Sensing: Application to Integrated Urban Water Quality Management. Oral Presentation. World Environmental and Water Resources Congress 2007, May 15-18, Tampa, FL.

Hondzo, M., W. Arnold, R.M. Hozalski, P.J. Novak, and P.D. Capel. 2006. Wireless Technologies and Embedded Network Sensing: Options for Environmental Field Facilities. Oral Presentation. International Research and Education Planning Visit: Cyberinfrastructure based water research: Towards the next generation of environmental observatories. August 31-September 1, 2006 in Delft, The Netherlands and Sept. 2-3, 2006 in Newcastle upon Tyne (UK).

Arnold, W.A., R.M. Hozalski, M. Hondzo, P.J. Novak, and P.D. Capel. 2006. Wireless Technologies and Embedded Network Sensing: Options for Environmental Field Facilities. Oral Presentation. CLEANER Planning Grant PI meeting. March 2006, Arlington, VA

Kim, S.-C., M. Hondzo, R.M. Hozalski, P.J. Novak, W.A. Arnold, J.D. Jazdzewski, N. Jindal, and P.D. Capel. 2006. Integrated urban water quality management: wireless technologies and embedded networked sensing. Poster presentation. American Geophysical Union National Meeting. December 11-15, 2006, San Francisco, CA.

Jazdzewski, J.D.*, M. Hondzo M., and W.A. Arnold. 2006. Stream water quality monitoring using wireless embedded sensor networks. Poster presentation. Minnesota Water 2006 and Annual Water Resources Joint Conference, October 24-25, 2006, Brooklyn Center, MN.

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Awards and Special Recognition:

None to date.