Public Service Commission of Wisconsin
& The Statewide Energy Efficiency and Renewables Administration

Environmental and Economic Research and Development Program

Executive Summary

August 2008

Monitoring the Impact of Climate Change on Water Resources in the Northern Highland American Legion State Forest in Wisconsin (NHAL)

Prepared by:
Carl J. Watras, PhD
Wisconsin Department of Natural Resources

This report in whole is the property of the State of Wisconsin, Public Service Commission of Wisconsin, and was funded through the FOCUS ON ENERGY program.

focus on energy[sm]
The power is within you.

Executive Summary

Situated within the northern highland lake district of Vilas and Oneida counties, Wisconsin’s NHAL State Forest contains more than 900 lakes and 126 streams - the largest group of undeveloped waters in Wisconsin. While many water resources in Wisconsin are threatened by over-development, the water resources of the NHAL may be threatened more by climatic changes associated with greenhouse gas emissions and global warming. Changing climatic patterns are expected to result in more frequent heavy precipitation events (and consequent flooding) as well as higher rates of evaporation due to warmer temperatures and shorter periods of ice-cover. Although the net impact of these opposing forces is uncertain, the exchange of water and solutes between lakes, their terrestrial watersheds, and the atmosphere may change in ways that have profound biogeochemical and ecological implications.

The purpose of this project was to develop a reliable, low-cost method to quantify and track these potential climatic impacts. We proposed to evaluate various remote sensing technologies, and then deploy a prototype network of remote sensors within a typical NHAL catchment. The remote sensors would monitor hydrochemical gradients between a small lake, a surrounding wetland and the atmosphere. The prototype network would serve as a model for monitoring efforts across a wide variety of NHAL catchments.

Based on information from remote sensing experts, we elected to develop a wireless platform based on CrossBow’s™ low-power “mote” technology. The CrossBow mote consists of a miniature microprocessor and radio (smaller than a deck of cards) that can

be connected directly to sensors that are embedded in the field. When programmed appropriately, motes can run unattended for months on a few AA batteries. A cluster of motes deployed within a watershed could theoretically form a network that sends data back to a distant base station in near-real time via a single high power radio. In our prototype application, we proposed to interface the mote network with an existing high-power radio network operated by the University of Wisconsin (www.gleon.org). This "piggy-back" approach would minimize costs, conserve power and allow broad dissemination of data via the Internet.

In collaboration with colleagues at UW-Madison, we designed a sensor network that could relay field data from the Crystal Bog catchment back to the UW-Trout Lake Station via the GLEON radio transmitter. An undergraduate student in the Department of Electrical and Computer Engineering built the sensor nodes and programmed the motes. Nodes were designed to record and transmit data on rainfall, lake water and groundwater at three minute intervals. A research specialist at the Center for Limnology facilitated the GLEON interface that coordinated the long distance flow of data.

The network was deployed in the CB catchment at the end of summer 2007, and we began field testing. There were four sensor nodes in the prototype network. One node monitored precipitation; one node monitored lake-water; and two nodes monitored ground-water in the surrounding wetland. The deployment was successful and preliminary results were promising, but not flawless. Power consumption was higher than expected, and data from the lake and wetland nodes frequently had erroneous values.

Further evaluation indicated that subtle hardware malfunctions and software bugs were causing the problems. To resolve these issues, a second one year proposal was submitted to FOE in May 2008. A second phase of the project was initiated in July 2008, with support from FOE.