Report as of FY2008 for 2006IN187B: "Wireless Monitoring of Purdue's Constructed Wetland"

Publications

- Dissertations:
  - Simond, Claire, “Establishing Water Balance and Effectiveness of a Constructed Wetlands System in Agricultural Settings”, Masters Thesis, Ecole Polytechnique Federale de Lausanne & Purdue University, supervised by David Barry (EPFL) and Chad Jafvert (Purdue).

Report Follows

IWRRC Final Report

Title: Wireless Monitoring of Purdue's Constructed Wetlands

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Funding Period: March 1, 2006 – February 28, 2009

Problem: The purpose of this project was to install water quality monitoring instrumentation and wireless routers at Purdue's constructed wetlands and maintained by Purdue University undergraduate students enrolled in the EPICS course: Constructed Wetlands/Water Quality. The constructed wetland cells are on Purdue University's ASREC (Animal Science Research and Education Center) farms.

Research Objectives: This projects focus is on: (1) employing innovative wireless continuous monitoring strategies for assessing water quality at remote locations, (2) training undergraduate students in sensor and wireless technologies as they relate to environmental assessment and protection, and (3) leveraging project infrastructure and results to attract additional resources to the State of Indiana to monitor environmental parameters at a broader scale (i.e., watershed level).

Methodology: Monitoring hardware and instrumentation was purchased in late spring of 2006, and arrived in the middle of the fall semester. This was too late in the semester for undergraduate student involvement. However, in the spring semester, the instruments were set-up and evaluated within the laboratory, testing the probes and wireless communication software and hardware. Initial work was begun at the constructed wetlands to instrument this site. The EPICS class constructed 2 flumes that were installed at the effluent of the wetlands to measure flow. Ultrasonic level sensors were installed above each flume to measure the height of water behind the hydraulic jumps, from which the flow rate (gal/sec) is calculated. These data are collected at 1 minute intervals on a Campbell Scientific CR1000 datalogger. The datalogger is powered by a 7 amp-hr battery and 10 Watt solar panel. Sometime this summer (2009), this datalogger will become part of a larger wireless network the PI has installed at the ASREC farms. In addition, the EPICS class

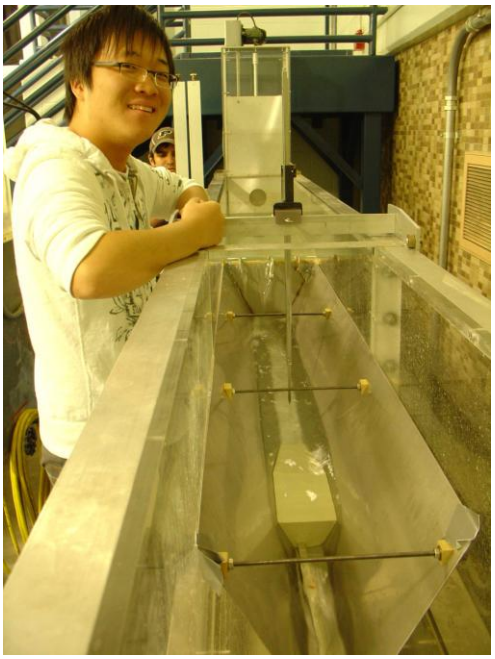

Figure 1. EPICS students measuring flow in one of the 5-ft stainless steel flumes (within a larger flume) before installing it at the wetlands.

helped install a weather station (ET106 from Campbell Scientific) at the constructed wetland – the data from this site is part of the larger wireless network the PI has installed at the ASREC farms. The data are transmitted via RF radios at 15 minute intervals from the weather station to an internet router installed at the Aquaculture Center (http://www.ag.purdue.edu/ansc/Pages/AquaUnit.aspx). From here the data are transmitted back to a server on Purdue's main campus from which the most recent 48 hrs of data are available on a web page at http://128.46.174.145/. The weather station is shown in Figure 2.

Principal Findings:

Summary: Water quality monitoring instrumentation has been installed at a constructed wetlands located on Purdue University's Animal Science Research and Education Center (ASREC) farms. At the wetland, the flow rate of water into and out of the wetland cells is monitored via weir boxes (inflow) and flumes (outflow), and a weather station has been installed. Undergraduate students enrolled in a service learning course entitled: "Constructed Wetlands/Water Quality" have worked with the Tippecanoe County Soil and Water Conservation District to implement the project. Students in the course have helped to design and install the stations.

Figure 2. The Campbell Scientific weather station. Recent data are available at http://128.46.174.145/ under the Weather Station tab.

Results and Significance: One of the objectives of this project was to leveraging project infrastructure and results to attract additional resources to the State of Indiana to monitor environmental parameters at a broader scale (i.e., watershed level). In 2007, Jafvert was co-PI on a $700K project funded by the U.S. EPA STAR program entitled: "Fate of hormones in tile-drained fields and impact to aquatic organisms under different animal waste land-application practices". The design of all six monitoring stations for this project parallels the design of the stations at the constructed wetlands and Wabash River sites (same dataloggers, wireless communication system, probes, etc.). The knowledge gained in designing and constructing these stations was instrumental in writing the proposal, and has been critical to the success of this current EPA project. The flow from these stations are available at the web site: http://128.46.174.145/. An additional proposal has been submitted to the National Science Foundation (NSF) for establishing a real time monitoring station on the Wabash River, using similar technologies deployed at the wetlands with addition of a continuous nutrient analyzer. A masters student from the Federal Polytechnical School at Lausanne (Ecole Polytechnique Federale de Lausanne), Claire Simond, visited Purdue University for a six month period to conduct her masters research study at the wetlands. PI Jafvert was her advisor during this time period. As a result, she became familiar with the hardware and

software at the wetlands, and utilized these instruments during her masters research project, which she successfully defended in June 2008.

Major Conclusions: The major conclusions of this study are (1) deploying monitoring instrumentation for assessing water quality at the constructed wetlands was feasible and enhanced the wetlands significantly as a research study area, (2) training undergraduate students in sensor and wireless technologies as they relate to environmental assessment and protection was accomplished, and (3) leveraging project infrastructure and results to attract additional resources to the State of Indiana to monitor environmental parameters at a broader scale (i.e., watershed level) was highly successful, and it is anticipated that future success will also ensue. In addition to these results that stem directly from the original projects objectives, an M.S. thesis study was completed with the resources provided by this project. The master's project was intended to improve our general understanding of constructed wetlands systems. During this project a water balance was established, in which components were measured or estimated. Inflows, outflows, precipitation and net infiltration were measured at the site, while net change in storage was assumed to be zero and evapotranspiration (ET) was estimated using combination and empirical equations. Penman Estimator equation was chosen as the most convenient method to estimate ET, as it depends only on the weather station (placed at the site) data. Chloride tracer tests were performed in one of the three surface flow cells to evaluate its hydraulic characteristics. Figure 3 shows some tracer test results. Plug-flow modified by dispersion and Tanks-in-series with a delay models were fit to the experimental data.

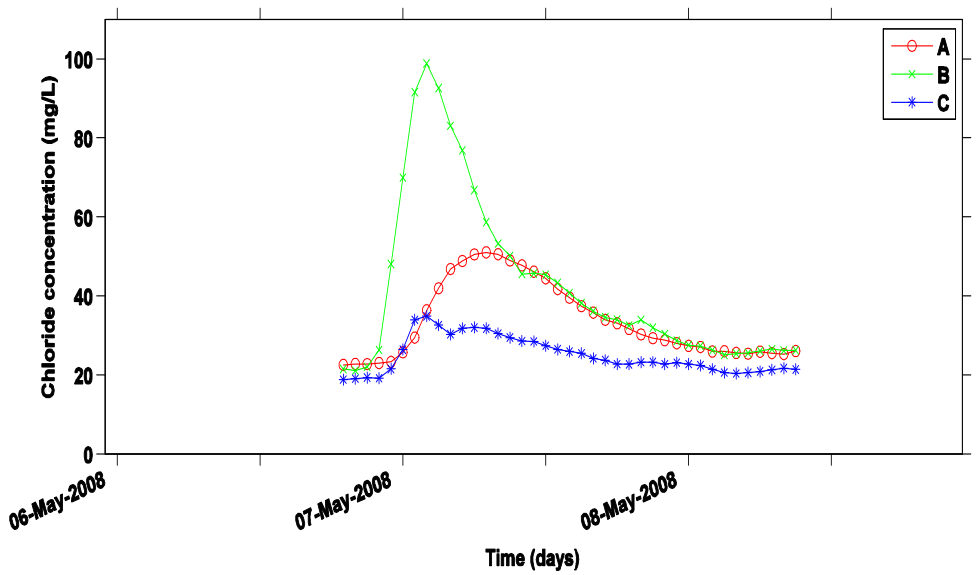

Figure 3. Chloride concentrations measured at the outlet of a surface flow cell in the three discharge pipes (A, B and C) to the next cell in series. Samples were collected with ISCO automated samplers, and chloride concentration was measured by Ion Chromotograph.

Hydraulic characteristics were estimated using the experimental data, and were compared to evaluate the suitability of the models to reproduce the tracer tests. Both models proved

to be adequate for simulating the chloride breakthrough curves. The impact of the water balance components on the wetland hydraulic was assessed by correlating the shape of the tracer test curves with rainfall and evapotranspiration. It was deduced that the water balance components did not significantly affect tracer tests. The possibility of using resazurin as a tracer to deduce microbiological activity and solute transport was evaluated and the results were encouraging. Nitrate concentration was also monitored to evaluate the efficiency of the surface flow cell for reactive nitrogen removal. One-half of the inlet nitrate concentration was removed by the time the water researched the outlet.

Publications:

1. Data from the site are available at: http://128.46.174.145/

2. Information about the EPICS course is available at: http://epics.ecn.purdue.edu/cwwq/

3. Simond, Claire, "*Establishing Water Balance and Effectiveness of a Constructed Wetlands System in Agricultural Settings*", Masters Thesis, Ecole Polytechnique Federale de Lausanne & Purdue University, supervised by David Barry (EPFL) and Chad Jafvert (Purdue).

Students: The service learning course EPICS: Constructed wetlands/Water Quality had enrollments of 13, 14, and 12 students in Spring 2007, Fall 2007, and Spring 2008, respectively. Several of the students in this course worked on various aspects of this project, including analysis of grab samples for E. coli, suspended solids, and nitrate, wireless communication, and calibration of flumes and weirs. Claire Simond, a masters student at Ecole Polytechnique Federale de Lausanne (The Federal Polytechnical School at Lausanne