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Annual Report: Urbanization Impacts on NH Streamwater Thermal Loading

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1. Problem

Research suggests that watershed urbanization may have a significant impact on the thermal regime of the stream that drains the impacted area (Krause et al. 2004, Wheeler et al. 2005). Paul and Meyer (2001) list urbanization as a major cause of impairment in streams and rivers, second only to agriculture. In studies dating from the late 1960's, documented urbanization impacts to stream temperature include increases of 5-6°C (Pluhowski 1968, Pluhowski 1970).

Recent research indicates that impervious areas may increase stream temperature following a rainfall event (Nelson and Palmer 2007, Herb et al. 2008, Thompson et al. 2008). In addition, stream crossings, such as culverts, are also suspected to impact stream water temperature. Though temperature impacts are not yet documented, stream crossings impact the macroinvertebrate community (Khan and Colbo 2008) and the geomorphic properties downstream of the crossing. Both are indicative of a change in the thermal regime of the stream.

2. Objectives

The purpose of this research is to study the impacts on urbanization on small streams as they relate to water temperature, with a particular focus on the effects of stream crossings and impervious surfaces. The overall objective will be met by addressing the following three specific objectives:

Objective 1: To develop a database of thermal impacts from storm runoff that includes temperature measurements for typical New Hampshire streams.

Objective 2: To determine the timing and magnitude of thermal differences upstream and downstream of storm runoff.

Objective 3: To model culvert and impervious area impacts on stream temperature.

3. Methods

The overall approach is to monitor temperature upstream and downstream of the stormwater contributing feature. High resolution profiles of temperature using Fiber Optic Distributed Temperature Sensing (FODTS) and ancillary meteorological and vegetation shading data will be measured during one intensive field campaign (IFC). These data will be used to develop a database of thermal impacts from storm runoff that includes temperature measurements for typical New Hampshire streams (Objective 1).

3.1. Continuous Stream Monitoring

Experimental data necessary to test the hypotheses are currently being collected within multiple study streams, at urbanized reaches within the streams. The target streams include mainly 1st and 2nd order streams that have a wide range of impacts (Table 1). Each study site has

a unique combination of impervious area, stream crossings, land use, and riparian zone. Study streams all are within close proximity of a road crossing. Impervious area within the study reaches ranges from 4% to 47%.

At the 10 study sites listed in Table 1, hydrologic instruments have been installed to monitor stream temperature upstream and downstream of potential thermal inputs continuously for at least one year. Several sites have multiple sensors that are being used to measure additional downstream locations. To the extent possible, ancillary measurements including stream stage or flow will be monitored. Atmospheric conditions are being obtained from NOAA's Durham sites.

Table 1: Study locations throughout Southern New Hampshire.

Stream Name	Location	Impervious Area (%)	Road Crossings	Watershed Area (km^2)[mi^2]	Deployment Date
Berry Brook	Dover, NH	47	4	1.06 [0.409]	2/2009
College Brook	Durham, NH	30	7	1.83 [0.705]	12/2007
Reservoir Brook	Durham, NH	27	9	1.53 [0.590]	2/2009
Hodgson Brook	Portsmouth, NH	37	10	9.63 [3.718]	7/2008
Wednesday Hill Brook	Lee, NH	13	1	1.14 [0.441]	7/2007
Bow Brook	Concord, NH	N/A*	13	4.26 [1.646]	7/2008
Gerrish Brook	Dover, NH	6	2	4.06 [1.569]	7/2008
Oyster River	Madbury, NH	N/A*	20	25.4 [9.824]	12/2007
Lee Five Corners Brook	Lee, NH	10	4	1.61 [0.623]	4/17/09
Chesley Brook	Lee, NH	N/A	N/A	N/A	4/17/09

*Impervious surface data were not available for the entirety of these watersheds

3.2. Stream Thermal Sampling IFCs

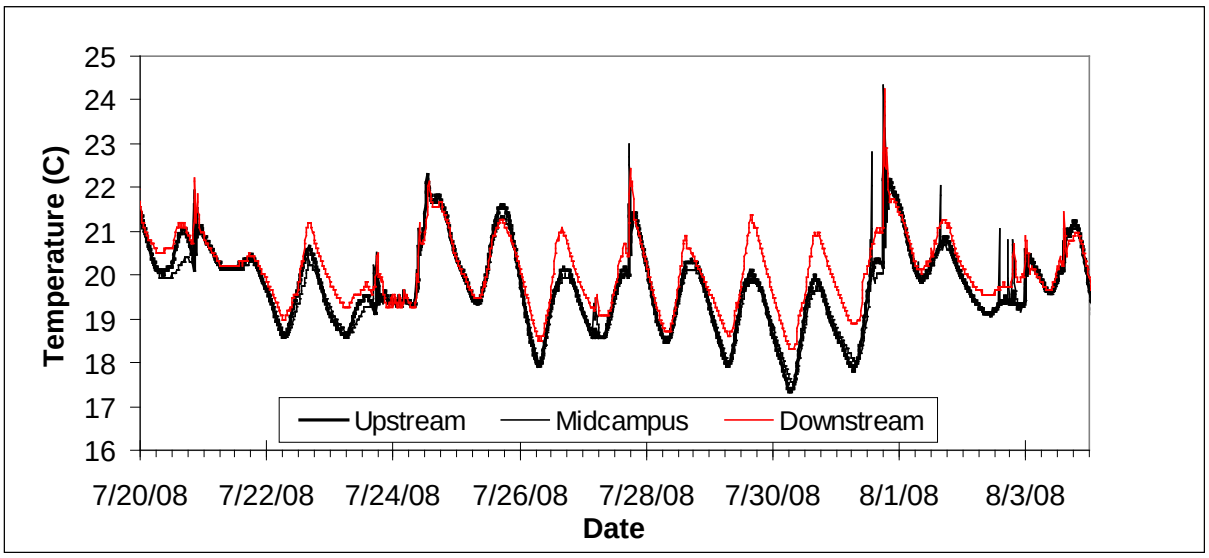
One IFC is planned in Hodgson Brook for July 2009. The July period will collect streamflow during the warm summer season when the impervious surfaces are likely to provide maximum thermal input to the streams and will likely coincide with early low flow periods within the stream. During the IFC, a seven day FODTS survey will be conducted along with enhanced temperature, water level, and streamflow measurements. During the IFC, a series of temperature measurements will be made along the cable with a 1 m spatial, a 1 minute temporal resolution, and a 0.1°C accuracy. Additional temperature sensors and calibrations will be conducted to calibrate the cable's offset and gain.

4. Major Findings and Significance

As stated earlier, data collection from multiple sites for this research is still underway. Temperature data has been collected from over 10 streams throughout the study area in accordance with the methods laid out in the previous section. Figure 1 shows an example of the daily average temperature observations. For this College Brook site, the upstream and downstream sites are roughly 1 km apart, and travel through a heavily urbanized section of the UNH campus. This summer, additional study sites will be added in collaboration with New Hampshire Fish and Game.

Preliminary results suggest differences in year-round temperature regimes based on urbanization. Statistical tests on the Berry Brook and College Brook temperature data show that there is a significant difference (α=0.01) between the upstream (non-urban) and downstream (urbanized) temperature for two parameters. The parameters tested were the mean daily temperature difference (upstream vs. downstream), and the diurnal temperature range (upstream vs. downstream). In College Brook, the temperature was found to be warmer in the downstream location. In Berry Brook, the analysis of the mean upstream and downstream temperatures was inconclusive. In Both Berry Brook and College Brook, the downstream location was found to have a larger diurnal temperature range (daily maximum temperature – daily minimum temperature) than their respective upstream locations.

Figure 1: Stream temperatures in College Brook, Durham, NH



5. Publications, Presentations, and Awards

Lemay, G. and Jacobs, J.M. “Impacts of Culverts and Impervious Areas on Stream Temperature in Coastal NH Streams” North Atlantic Chapter of the Society for Environmental Toxicology and Chemistry Annual Conference. Durham NH. June 10-12, 2009.

Jacobs, J.M. “Stream Temperature What’s Hot, What’s Not!” Natural Resources Seminar. University of New Hampshire. April 24, 2009. Invited Speaker.

Lemay, G. and Jacobs, J.M. “Impacts of Impervious Areas and Culverts on Stream Temperature” Lamprey River Symposium. University of New Hampshire. January 16, 2009.

Jacobs, J.M. “Lamprey River Tributaries” Lamprey River Symposium. University of New Hampshire. January 16, 2009.

Jacobs, J.M. “Stream Temperature Tricks and Treats”, EPA Regional Science Council. November 5, 2008. Boston, Massachusetts. Invited Speaker.

Jacobs, J.M. “Environmental System Characterization Using Temperature Measurements”, New England Regional Temperature Meeting. July 24, 2008. Turners Falls, Massachusetts. Invited Speaker.

Jacobs, J.M. “Fiber Optics Distributed Temperature Sensing: Technology and Scientific Inquiry” Environmental Research Group Seminar. University of New Hampshire. March 7, 2008. Invited Speaker.

Jacobs, J.M. “Stream Temperature Sensing: Technology and Scientific Inquiry” Department of Civil and Environmental Engineering Seminar. Tufts University. April 15, 2008. Invited Speaker.

6. Publications from Previous N/A

7. Outreach or Information Transferred

In addition to the presentations during the past year, numerous extension opportunities have occurred. They are briefly summarized below.

Organization	Topic
NH Fish and Game	Collaboration of monitoring efforts and review of NH coldwater fish datasets
MA Fish and Wildlife	Information exchange and development of collaborative agreements
USEPA Region I	Relationship between instream flow, water quality efforts and stream water temperature
Office of Water Resources	Groundwater depletion effects on stream temperature
MA Dept of Conservation and Recreation	
MA Riverways Group	Groundwater depletion effects on stream temperature
Hodgson Brook Watershed Group	Development of collaborative efforts in the watershed. Site potential for FODTS study
UNH Statistical Hydrology Course	Data were used in the PIs’ Statistical Hydrology course in Spring 2009 (12 graduate students)
Hodgson Brook Watershed Group	Development of collaborative efforts in the watershed. Site potential for FODTS study

8. Students Supported

This project is partially supporting Gary Lemay, a Masters student in Civil Engineering. Additional students have gained research experience through this project including graduate students Danna Truslow and Nick DiGennaro and undergraduations Logan Kenney (Civil Engineering), Rusty Jones (ESci), and Heidi Borchers (Environmental Engineering). Project participants who are not students include Matt Lavigne.

The IFC portion of the project is planned for July 2009. In addition to G. Lemay, graduate students James Sherrard and Carrie Voyuvich will participate in the experiment and be trained in FODTS best methods.

9. References

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