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### Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds

New Hampshire Water Resources Research Center (NH WRRRC)

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## **Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds**

### **Statement of Critical Regional or State Water Problem**

New Hampshire's surface waters are a very valuable resource, contributing to the state's economic base through recreation (fishing, boating, and swimming), tourism and real estate values. Many rivers and lakes also serve as local water supplies. New Hampshire currently leads all New England states in the rate of development and redevelopment (2000 Census). The long-term impacts of population growth and the associated changes in land use to New Hampshire's surface waters are uncertain. Of particular concern are the impacts of non-point source pollution to the state's surface waters (e.g. septic, urban run off, road salt application, deforestation and wetland conversion). Long-term datasets that include year-to-year variability in precipitation, weather patterns and other factors will allow adequate documentation of the cumulative effects of land use change and quantification of the effectiveness of watershed management programs.

### **Statement of Results or Benefits**

The proposed project will provide detailed, high-quality, long-term datasets which will allow for a better understanding of the impacts of land use change and development on surface water quality. This could occur through the development, testing and refinement of predictive models, accurately assessing the impacts of watershed management practices, and potentially early warning of dramatic changes to surface water quality in the region resulting from rapid development.

### **Objectives of the Project**

This project allows for the continued collection of long-term water quality data in New Hampshire. It will use UNH staff, students and volunteers from local communities to collect samples from the College Brook watershed (Durham, NH), the Lamprey River Watershed, and the Ossipee River Watershed.

Water samples will be collected from the following sub-projects.

The **College Brook** watershed, which is dominated by the University of New Hampshire, receives a variety of non-point pollution from several different land uses. Suspended sediments (TSS), pH, conductivity, biological oxygen demand (BOD) and nutrient concentrations ( $\text{Cl}^-$ ,  $\text{SO}_4^{-2}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{+2}$ ,  $\text{Ca}^{+2}$ ,  $\text{NO}_3$ ,  $\text{NH}_4$ ,  $\text{PO}_4$ , DOC, TDN,  $\text{SiO}_2$ ) will be measured to assess water quality. Samples from 7 sites will be collected monthly throughout the year. Sampling of College Brook began in 1991. Sample collection will be done by UNH staff and/or students. The Water Quality Analysis Lab at UNH will analyze these samples as part of the non-federal match.

The **Lamprey River** has been sampled weekly and during rain events since October 1999. Samples are analyzed for total dissolved nitrogen (TDN), nitrate ( $\text{NO}_3\text{-N}$ ), ammonium ( $\text{NH}_4\text{-N}$ ), DON, DOC and orthophosphate ( $\text{PO}_4\text{-P}$ ). Additionally, samples collected since October 2002 are also analyzed for dissolved inorganic carbon (DIC), pH, conductivity, dissolved oxygen (DO), temperature, total suspended sediment, particulate

carbon, particulate nitrogen, silica and major anions and cations. In January of 2004, we began routine sampling of additional Lamprey sites for nitrogen, phosphorus and DOM. Since November of 2003, weekly bulk precipitation samples have been collected at numerous locations throughout the basin for analysis of nitrogen, phosphorus, DOM, major cations and anions and silica. Several homeowners have been monitoring precipitation volume throughout the basin since October 2003.

Precipitation and stream sampling was scaled back in FY05. Precipitation data from FY04 indicates that chemistry does not vary significantly spatially, therefore we'll only sample from one collector on an event basis. Homeowners will continue to monitor precipitation gages throughout the watershed as precipitation amount is spatially variable. The frequency of stream sampling will be curtailed to monthly (instead of weekly) for 10 of our sampling sites. The remaining 3 streams will continue to be sampled weekly. These water samples will be analyzed by the Water Quality Analysis Lab at UNH.

Volunteers of the Green Mountain Conservation Group will sample streams within the **Ossipee watershed** of New Hampshire. Samples will be collected every 2 weeks from May to November, and monthly during the winter months. There will be approximately 340 samples collected. Water chemistry ( $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{+2}$ ,  $\text{Ca}^{+2}$ ,  $\text{NO}_3$ ,  $\text{NH}_4$ ,  $\text{PO}_4$ , DOC, TDN) will be measured on selected samples by the WQAL as part of the non-federal match. WRRC staff will assist in data interpretation.

## **Principal Findings and Significance**

### College Brook

Previous work on College Brook in the early 1990's (McDowell unpublished) shows that the UNH campus had a severe impact on water quality and was negatively affecting stream biota and the integrity of downstream ecosystems. By any yardstick, campus operations could not be considered sustainable. There was clear evidence that the UNH incinerator was causing excessive organic matter loading, resulting in high biochemical oxygen demand (BOD) and low dissolved oxygen (DO) in stream water. Since the incinerator has been closed, BOD and DO are no longer at levels detrimental to instream biota. Our monthly sampling regime was scaled back beginning October 2006 to the 3 stations that have historically shown the greatest changes, and we eliminated the BOD and TSS measurements (both which change little over the reach since the incinerator was closed). The most downstream sampling location is now closer to where the stream empties into the Oyster River in an effort to better quantify inputs to the Great Bay estuary. Analyses of samples collected thru 2006 has been completed and we are in the process of updating our website

[http://www.wrrc.unh.edu/current\\_research/collegebrook/collegebrookhome.htm](http://www.wrrc.unh.edu/current_research/collegebrook/collegebrookhome.htm).

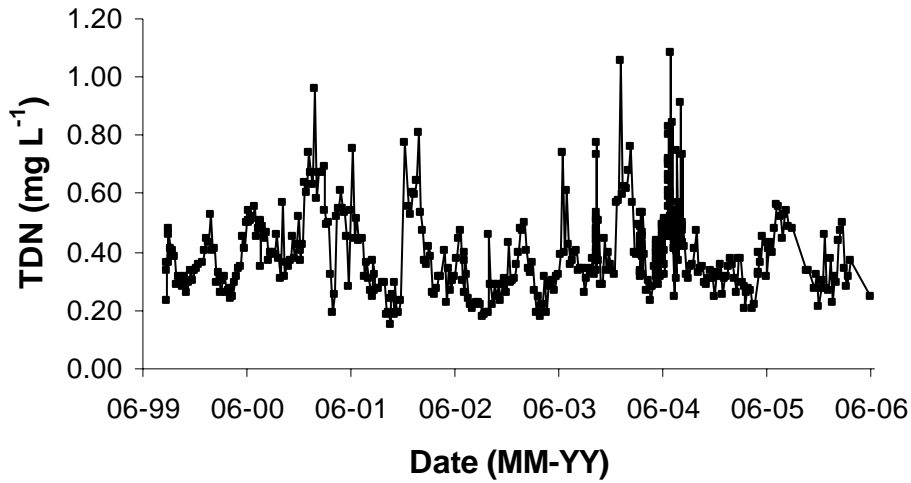
Data from 2000-2006 indicates that the stream is strongly impacted by road salt at its origin, which is essentially a road-side ditch leading to a wetland area. Average Sodium and Chloride concentrations appear to have jumped after year 2000 and remained reasonably constant since then. Concentrations tend to decline downstream. Dissolved Oxygen (DO) is lower at the upstream stations. This difference is presumably due to hydrologic properties of the upstream sampling location which resembles a wetland (i.e.

slow flow, higher organic matter). DO increases downstream as flow becomes faster and re-aeration higher.

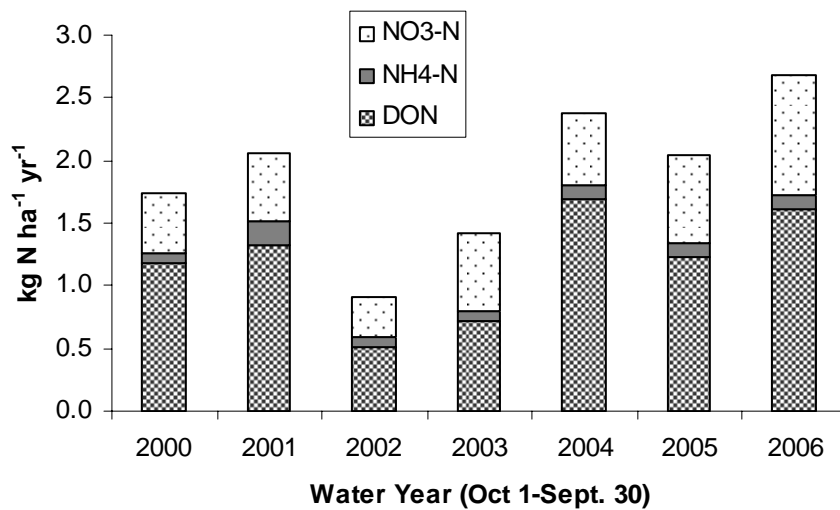
#### Weekly Lamprey Sampling and the Lamprey River Hydrologic Observatory

The Lamprey River watershed is a rural watershed located in southeastern NH and is under large development pressure as the greater area experiences rapid population growth. Our goal for the long-term Lamprey water quality monitoring program is to document changes in water quality as the Lamprey watershed becomes increasingly more developed and to understand the controls on N transformations and losses. We have continued to sample the Lamprey River at the USGS gauging station in Durham, NH (referred to as “LR 73.3”), the North River at the former USGS gauging station in Epping, NH (NR 26.9) and a small tributary to the Lamprey River in Lee, NH (WHB 1.03) for DOC, DON, NO<sub>3</sub>-N, NH<sub>4</sub>-N, PO<sub>4</sub>-P, TDP, TP, Na, Ca, Mg, K, Cl, SO<sub>4</sub>, SiO<sub>2</sub>, pH, DO, temperature and conductivity on a weekly basis. In addition to these parameters, station LR 73.3 is also sampled for DIC, TSS, Particulate C and Particulate N. The USGS discontinued the operation of the North River gauging station in October 2006 and since then we have been recording weekly stage height and calculating flow based on the USGS rating curve. We are able to record stream flow at WHB 1.03 using an electronic distance meter in combination with a rating curve that we have developed for this site. We have also developed a stream flow model for WHB 1.03 where daily discharge can be estimated from meteorological measurements (such as precipitation and temperature) and this model is useful for estimating historic flows. We continue to collect precipitation at Thompson Farm (UNH property located in Durham, NH) to document nitrogen inputs to the basin and work with NOAA/AIRMAP in an attempt to link to precipitation chemistry to air mass chemistry.

Results of stream chemistry to date show an increase in peak springtime TDN concentration in the Lamprey from 2000 -2004, but lower springtime TDN concentrations since 2004 (Figure 1). Lamprey TDN export is dominated by DON export and the highest TDN flux recorded to date was during 2006 (Figure 2). This high export likely associated with the May 2006 hundred year flood given that the runoff from the Lamprey in 2006 (1056 mm/yr) was twice the long-term average (approximately 500 mm/yr). The variation in DON concentration and export throughout the Lamprey basin is related to % wetland cover and even though NO<sub>3</sub>-N does not dominate TDN, variation in NO<sub>3</sub>-N concentration and flux is linked to watershed human population density. Results of precipitation monitoring show that wet deposition is the largest input of N to the Lamprey watershed and precipitation chemistry can be linked to air mass chemistry. DOC and TDN in precipitation are related to biogenic air mass sources, NH<sub>4</sub>-N, NO<sub>3</sub>-N and SO<sub>4</sub>-S are related to urban/industrial air masses and Na and Cl are weakly related to ocean aerosols.



**Figure 1.** Nitrate concentrations over time in the Lamprey River at the USGS gauging station in Durham, NH.



**Figure 2.** Annual export of dissolved nitrogen species from the Lamprey watershed.

Other ongoing research in the Lamprey watershed involves examining potential nitrogen loss in riparian zones. We have two well fields installed within 10 m of two small streams. In one of the riparian zones, there is a large reduction in NO<sub>3</sub>-N (approximately 4.5 mg NO<sub>3</sub>-N upslope to 0.2 mg/L NO<sub>3</sub>-N near the stream) and an increase in NH<sub>4</sub>-N (approximately 0.02 mg NH<sub>4</sub>-N upslope to 0.2 mg/L NH<sub>4</sub>-N near the stream) over a small distance (approximately 10 m). Nitrate addition experiments have been conducted to evaluate the potential for denitrification loss of N but the results of this study are still preliminary.

### Ossipee River watershed sampling

Collaboration with the Green Mountain Conservation Group and their sampling of the Ossipee River watershed has continued to be beneficial. Volunteers sampled streams within the watershed every 2 weeks from May to November, with approximately 340 samples collected from 14 sampling locations. Many presentations were made to planning boards, conservation commissions and other local government groups (see Publication, presentations and awards section below). Data have been used to heighten awareness of the impacts of excessive road salting and snow dumping in local streams. Communication with local road agents has led to the remediation in one development where road salting was an issue. Samples collected and data generated from this funding have shown an improvement in water chemistry following reduced salting and snow dumping.

### **Material in Preparation:**

McDowell, W.H., M.L. Daley, B. Sive, R. Talbot. Factors controlling atmospheric deposition at a coastal suburban site. *Journal of Geophysical Research (Atmospheres)*.

### **Conference Proceedings & Abstracts**

Daley, M.L., McDowell, W.H., T.E. O'Donnell, and L.A. Buyofsky. 2006. Biogeochemistry of a Suburban Basin. *2006 Watershed Conference*. Concord, NH. November 2006.

Daley, M.L., McDowell, W.H., T.E. O'Donnell, and L.A. Buyofsky. 2006. Biogeochemistry of a Suburban Basin. *State of the Estuaries Conference*. Portsmouth, NH. October 2006.

Gettel, G.M., W.H. McDowell, and O. Pisani. 2006. Using fluorescence to understand the role of carbon quality in nitrogen dynamics in a rapidly suburbanizing watershed in southeastern New Hampshire. *Annual meeting of Northeastern Regional Research Collaborative*, Durham NH October 2006.

Gettel, G.M., W.H. McDowell, and O. Pisani. 2006. Using fluorescence to measure carbon quality at watershed scales and implications for nitrogen retention in a rapidly suburbanizing watershed. *Annual NABS Meeting*, June 2006, Anchorage, Alaska.

McDowell, W.H. 2006. Biogeochemistry of suburban basins. *Boston University*. November, 2006.

McDowell, W.H. 2006. Biogeochemistry of suburban basins. *University of Florida*. November, 2006.

McDowell, W.H. 2006. Biogeochemistry of suburban basins. *China*. April, 2006.

**Dissertations and Theses:**

Buyofsky, L.A. May 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed. *Masters Thesis*, University of New Hampshire, Durham, NH.

**Information Transfer:**

McDowell, W.H. & Associates 2006. Lamprey River Hydrological Observatory: an “invisible” part of Lee. *Lee Town Crier* 26, Fall 2006.

Presentations made by the Green Mountain Conservation Group staff.

3/10/2006 OWC Workshop w/ Board & Town Rep’s (GIS, land use planning, watershed planning)

3/24/2006 Natural Resource Based Planning Workshop (regional meeting, Tamworth)

4/8/2006 Water Quality Monitoring Program & Training

4/21/2006 Groundwater Conference

5/3/2006 Tamworth Learning Circle School program (RIVERS)

5/17/2006 Sandwich Elementary School program (RIVERS, macro)

5/18/2006 NRBP Workshop (regional workshop, GIS, watershed planning w/ SPNHF)

5/20/2006 Community School program (WQM)

5/25/2006 Calumet School Program (OLT)

6/1/2006 Calumet Program (OLT)

6/2/2006 Calumet Program (OLT)

6/6/2006 Calumet Program (OLT)

6/8/2006 Summer Camp Program (OLT, Deep Water - Directors)

6/9/2006 Calumet Program (OLT)

6/21/2006 OWC Workshop Madison (GIS, land use planning, watershed planning)

7/4/2006 Calumet Program (OLT)

7/18/2006 Calumet Program (OLT)

7/22/2006 Watershed Weekend (water quality, land use planning, wildlife)

7/25/2006 OWC Workshop Ossipee (GIS, land use planning, watershed planning)

7/27/2006 OWC Workshop Effingham (GIS, land use planning, watershed planning)

8/1/2006 Calumet Program (OLT)

8/2/2006 Valley Vision/TV taping WQM program at Camp Huckins

8/12/2006 SPNHF Workshop – Green Mountain Hike (land use change, land conservation)

8/15/2006 Calumet Program (OLT)

8/23/2006 Macro Training (expansion of WQM program)

8/30/2006 Wetlands Forum (land use planning, protecting water quality in watershed)

9/11/2006 Sandwich Program (RIVERS, macro)

9/21/2006 TNC Moth Program in Pine Barrens  
10/5/2006 Land Celebration (land use planning, watershed protection)  
10/11/2006 Calumet adult program - Watershed Presentation & WQM  
10/18/2006 Ossipee Central School (OLT/Lake/NPS program)  
10/19/2006 Ossipee Central School (OLT/Lake/NPS program)  
11/2/2006 Calumet adult program - Watershed Presentation & WQM  
11/17/2006 State of the Watershed  
12/8/2006 OWC Workshop (regional workshop, natural resource guidebook, watershed protection)  
1/18/2007 OWC Workshop Dark Skies/Stars Program (intro. to GMCG & wqm program)  
2/10/2007 Tracking (wildlife habitat protection, pine barrens, watershed protection)  
2/14/2007 UNHCE Conservation Easement workshop(land conservation, intro. to GMCG as a land trust)  
2/21/2007 Green Yards (water quality protection, junkyard monitoring)