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New Hampshire Water Resources Research Center Annual Technical Report FY 2012

New Hampshire Water Resources Research Center (NH WRRC)

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Annual Technical Report
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Introduction

The New Hampshire Water Resources Research Center (NH WRRC), located on the campus of the University of New Hampshire (UNH), is an institute that serves as a focal point for research and information on water issues in the state. The NH WRRC actually predates the Federal program. In the late 1950s Professor Gordon Byers (now retired) began a Water Center at UNH. This Center was incorporated into the Federal program in 1965 as one of the original 14 state institutes established under the Water Resource Research Act of 1964. The NH WRRC is currently directed by Dr. William McDowell with administrative and technical assistance from Associate Director Ms. Michelle Daley and Mr. Jody Potter. The NH WRRC is a standalone organization, in that it is not directly affiliated with any other administrative unit at UNH, and it reports to the Dean of the College of Life Sciences and Agriculture (COLSA). The NH WRRC has no dedicated laboratory or research space, and instead relies on space allocated for the research activities of the WRRC director by COLSA. The NH WRRC does have administrative space on campus, which houses the Associate Director, WRRC files, and short-term visiting staff and graduate students. The WRRC website (www.wrrc.unh.edu) serves as a focal point for information dissemination and includes all NH WRRC publications and results from past research, as well as links to other sites of interest to NH citizens and researchers.

Research Program Introduction

The NH WRRC supported four research projects with its 2012 104b funding:

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

2. Arsenic chemical dynamics in NH groundwater reservoirs: Insights from temporal variability in multi-element signatures of statewide samples

3. Determining the Impact of Coal Tar Based Driveway Sealant on Polycyclic Aromatic Hydrocarbon Concentrations in NH Waterbodies

4. James Hall Vegetated Roof Nutrient Removal Efficiency and Hydrologic Response

The Water Quality Analysis Lab (WQAL) is affiliated with the NH WRRC and facilitates water resources research through technical assistance and sample analysis. The WQAL was established by the Department of Natural Resources in 1996 to meet the needs of various research and teaching projects both on and off the UNH campus. It is currently administered by the NH WRRC and housed in James Hall. The mission of the Water Quality Analysis Laboratory is to provide high-quality, reasonably priced analyses in support of research projects conducted by scientists and students from throughout the University, state, and nation. Past clients have included numerous research groups on the UNH campus, Federal agencies, scientists from other universities, and private firms. Many thousands of analyses are conducted each year.

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

Basic Information

Title:	Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds
Project Number:	2003NH21B
Start Date:	3/1/2011
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	NH01
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Surface Water, Nutrients
Descriptors:	
Principal Investigators:	William H. McDowell

Publications

1. Buyofsky, L.A. 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed. M.S. Dissertation, Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH
2. Proto, Paul J. 2005, The Significance of High Flow Events in the Lamprey River Basin, New Hampshire, for Annual Elemental Export and Understanding Hydrologic Pathways. M.S. Dissertation, Department of Earth Sciences, College of Engineering and Physical Sciences, University of New Hampshire, Durham, NH, 176 pages.
3. Buyofsky, Lauren A. May 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, MS Dissertation, Department of Natural Resources, College of Life Sciences and Agriculture , University of New Hampshire, Durham, NH, .
4. Legere, K.A. September 2007. Nitrogen loading in coastal watersheds of New Hampshire: an application of the SPARROW model. Masters Thesis, University of New Hampshire, Durham, NH. 75 pages.
5. Traer, K. December 2007. Controls on denitrification in a northeastern coastal suburban riparian zone. Masters Thesis, University of New Hampshire, Durham, NH. 97 pages.
6. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
7. Daley, M.L., J.D. Potter, W.H. McDowell. 2009. Salinization of urbanizing New Hampshire streams and groundwater: Impacts of road salt and hydrologic variability. Journal of the North American Benthological Society, submitted.
8. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
9. Daley, M.L., J.D. Potter and W.H. McDowell. 2009. Salinization of urbanizing New Hampshire streams and groundwater: impacts of road salt and hydrologic variability. Journal of the North American Benthological Society 28(4):929-940.

10. DiFranco, E. 2009. Spatial and temporal trends of dissolved nitrous oxide in the Lamprey River watershed and controls on the end-products of denitrification. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 108 pages.
11. Daley, M.L. and W.H. McDowell. In Preparation. Nitrogen saturation in highly retentive coastal urbanizing watersheds. Ecosystems.
12. Daley, M.L. 2009. Nitrogen Sources and Retention within the Lamprey River Watershed and Implications for Management. State of the Estuaries Conference. Somersworth, NH. October 2009.
13. Daley, M.L. 2009. Water Quality of Private Wells in Suburban NH and Impacts of Land Use. Northeast Private Well Symposium. Portland, ME. November, 2009.
14. Daley, M.L. 2009. Spatial and Temporal variability in nitrogen concentrations, export and retention in the Lamprey River watershed. Joint NH Water and Watershed Conference. Concord, NH. November, 2009.
15. Daley, M.L. and W.H. McDowell. 2009. Nitrogen Saturation in Highly Retentive Watersheds? American Geophysical Union Fall Conference, San Francisco, CA. December, 2009.
16. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
17. Daley, M.L., J.D. Potter and W.H. McDowell, 2010, Nitrogen Assessment for the Lamprey River Watershed, Report prepared for the New Hampshire Department of Environmental Services. http://des.nh.gov/organization/divisions/water/wmb/coastal/documents/unh_nitrogenassessment.pdf
18. Dunlap, K, 2010, Seasonal Nitrate Dynamics in an Agriculturally Influenced NH Headwater Stream, M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 102 pages.
19. Galvin, M, 2010, Hydrologic and nutrient dynamics in an agriculturally influenced New England floodplain, M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 94 pages.
20. Daley, M.L., W.H. McDowell, B. Sive, and R. Talbot, In Preparation, Factors controlling atmospheric deposition at a coastal suburban site, Journal of Geophysical Research (Atmospheres).
21. Daley, M.L. and W.H. McDowell, 2010, Landscape controls on dissolved nutrients, organic matter and major ions in a suburbanizing watershed, American Geophysical Union Fall Conference, San Francisco, CA, December, 2010.
22. Davis, J.M., W.H. McDowell, J.E. Campbell and A.N. Hristov, 2010, Hydrological and biogeochemical investigation of an agricultural watershed, southeast New Hampshire, USA, American Geophysical Union Fall Conference, San Francisco, CA, December, 2010.
23. Hope, A.J. 2010. Ecosystem Processes in a Piped Stream. Plum Island Ecosystems Long Term Ecological Research All Scientists Meeting, Woods Hole, MA. April 8, 2010.
24. Hope, A.J. and W.H. McDowell, 2010, Ecosystem Processes in a Piped Stream, Aquatic Sciences: Global Changes from Center to Edge, ASLO & NABS Joint Summer Meeting, Santa Fe, NM, June 2010.
25. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
26. McDowell, W.H., M.L. Daley and J.D. Potter, 2011, Dissolved organic matter dynamics in a suburban basin: wetlands and people drive quantity and quality, North American Benthological Society Meeting, Providence, RI, May 2011.
27. McDowell, W.H. and M.L. Daley, 2011, Net Manageable Nitrogen: Definition and Rationale for a new approach to nitrogen management in moderately impacted watersheds, American Geophysical Union Fall Conference, San Francisco, CA, December, 2011.
28. McDowell, W.H. and M.L. Daley, 2011, Net Manageable Nitrogen: Definition and Rationale for a new approach to nitrogen management in moderately impacted watersheds, National Academy Keck

Futures Initiative Ecosystem Services Conference, Irvine, CA, November, 2011.
29. Daley, M.L. and W.H. McDowell, In Preparation, Nitrogen saturation in highly retentive coastal urbanizing watersheds, Ecological Applications.
30. Baillio, J., 2012, Controls on variability of dissolved greenhouse gas concentration and emissions from small streams in southeastern New Hampshire, MS Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 111 pages.
31. Daley, M.L. and W.H. McDowell, In Preparation, Human impacts on stream nitrogen chemistry and watershed N retention across a wide range of rural to urban catchments, Ecological Applications.
32. Liptzin, D., M.L. Daley, and W.H. McDowell. Accepted. A comparison of wet deposition collectors at a coastal rural site. Submitted to Water, Air, & Soil Pollution. April 2013.
33. Parham, L., 2012, Spatial and temporal variation in degradation of dissolved organic carbon on the main stem of the Lamprey River, MS Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 66 pages.
34. Hope, A.J., W.H. McDowell, W.M. Wollheim, Submitted, Ecosystem metabolism and nutrient uptake in an urban, piped headwater stream, Biogeochemistry.

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, and drinking water supplies. New Hampshire is experiencing rapid growth in several counties and from 1990 to 2004 the state grew twice as fast as the rest of New England, with a state-wide average population increase of 17.2% during that period (Society for Protection of NH Forests 2005). New Hampshire watersheds rank among the most highly threatened watersheds in the nation because of the high potential for conversion of private forests to residential development. In fact, three of the four most threatened watersheds in the US which could experience the largest change in water quality as a result of increased residential development in private forests occur at least partially in New Hampshire (Stein et al. 2009).

The long-term impacts of this rapid population growth and the associated changes in land use on New Hampshire's surface waters are uncertain. Of particular concern are the impacts of non-point sources of pollution such as septic systems, urban runoff, stormwater, application of road salt and fertilizers, deforestation, and wetland conversion. Long-term datasets that include seasonal and year-to-year variability in precipitation, weather patterns and other factors are needed to adequately document the cumulative effects of land use change and quantify the effectiveness of watershed management programs. No other agency or research program (e.g. NH Department of Environmental Services (NH DES), US Geological Survey (USGS) or Environmental Protection Agency (EPA)) has implemented such a long-term program.

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. These surface water datasets could support the development, testing and refinement of predictive models, accurately assess the impacts of watershed management practices on drinking water supplies, assess efforts to reduce surface water quality impairments, and be potential early warning signs of dramatic changes to surface water quality in the region resulting from rapid development. Long-term datasets from this project will be essential to adaptive management strategies that strive to reduce non-point sources of nitrogen pollution in New Hampshire's Great Bay watershed which is currently impaired by elevated nitrogen and in violation of the Federal Clean Water Act. A list of selected recent presentations, publications and press releases that utilize long-term datasets supported by NH WRRC funding for this project is included at the end of this proposal.

Objectives of the Project

This project allows for the continued collection of long-term water quality data in New Hampshire. It will use University of New Hampshire (UNH) staff, students and volunteers from local communities to collect samples from the Lamprey and Oyster River watersheds located in southeast NH and the Ossipee River watershed in central NH. All three watersheds are located in counties experiencing high population growth rates (Figure 1). Both the Lamprey and Ossipee watersheds are predicted to more than double in population from 1998 to 2020 (Sundquist and Stevens 1999). Surface water sites within each of the 3 watersheds and details on long-term datasets collected are described below. Together these 3 watersheds capture a broad range of urban, rural and agricultural land uses as well as a range of forests and wetland cover types.

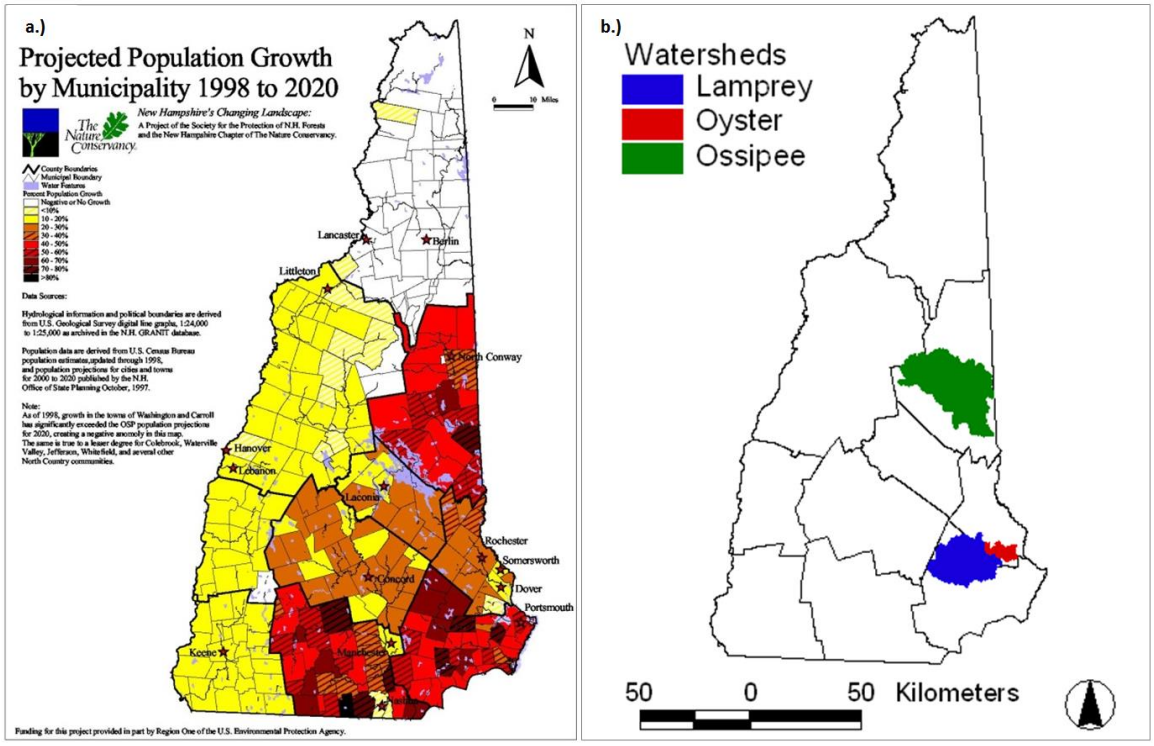

Figure 1. Projected population growth in New Hampshire (Figure from Sundquist and Stevens 1999; A) and study watersheds experiencing high population growth (B).

Methods, Procedures and Facilities

Lamprey River Hydrologic Observatory

The Lamprey River watershed (479 km^2) is a rural watershed located in southeastern NH and is under large development pressure as the greater area experiences the highest population growth in the state. The Lamprey River Hydrologic Observatory (LRHO) is a name given to the entire Lamprey River basin as it serves as a platform to study the hydrology and biogeochemistry of a suburban basin and is used by the UNH community as a focal point for student and faculty research, teaching and outreach. 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.

The Lamprey River has been sampled weekly and during major runoff events since September 1999 at site LMP73 which is co-located with the Lamprey River USGS gauging station (01073500) in Durham, NH. Two additional sites were added to the long-term Lamprey River monitoring program in January 2004. One site (NOR27) was located on the North River, the Lamprey River's largest tributary, less than 1 km downstream from the USGS gauging station (01073460) in Epping, NH. The other site (Wednesday Hill Brook; site WHB01) drains a small suburban area in Lee, NH where residents rely solely on private wells and private septic systems for water supply and waste disposal. A stream gauge at WHB01 is operated by UNH staff and/or students. Sites NOR27 and WHB01 were sampled on a weekly basis through 2010 and in January 2011, the North River sampling frequency (site NOR27) was reduced to monthly because accurate measures of river discharge were no longer possible. Site WHB01 along with LMP73 remain at a weekly and major storm event sampling frequency. Several other sites have been sampled for multiple years on a less frequent basis to assess the spatial variability of water quality in sub-basins with various land uses and development intensities. In the past year, 15 additional sites were sampled on a monthly basis. All LRHO stream water samples are collected by UNH staff and/or students.

Oyster River watershed

The Oyster River watershed (80 km^2) is a small watershed in southeast NH where land use ranges from rural to urban. Two urban sub-basins, College Brook (CB) and Pettee Brook (PB), were selected for long-term sampling in January 2004. Both sub-basins are dominated by the University of New Hampshire (UNH) and receive a variety of non-point pollution from several different land uses. Three sites (CB00.5, CB01.5 and CB03.0) are sampled along College brook which drains the center of campus and one site (PB02.0) is located on Pettee Brook which drains the northern section of campus. Both sub-basins drain areas with high amounts of impervious surface and College Brook also drains the UNH dairy farm and athletic fields. Historic water quality data for these two sites are available from 1991. UNH staff and/or students currently sample these sites on a monthly basis.

Ossipee River watershed

The entire Ossipee River watershed (952 km^2) is classified as rural due to its low but increasing population. Seven sites in the watershed were selected for long-term monitoring in May of 2004. These sites are monitored monthly by volunteers and staff of the Green Mountain Conservation Group (GMCG) and were chosen to capture the areas of concentrated growth and monitor the major inputs and outputs from Ossipee Lake. Additional sites are selected by GMCG for volunteer monitoring during non-winter months (May to November). WRRC staff assist GMCG in site selection and data interpretation. In 2006, the GMCG worked with the Department of Environmental Services to establish a Volunteer Biological Assessment Program (VBAP) for the Ossipee Watershed. Numerous volunteers, including students from five local schools, assist with invertebrate sampling at a total of eleven sites.

Water Quality Analysis

Field parameters (pH, conductivity, dissolved oxygen (DO) and temperature) are measured at all sites. Water samples are filtered in the field using pre-combusted glass fiber filters (0.7 µm pore size), and frozen until analysis of dissolved constituents. Samples collected at all LRHO, CB, PB and the 7 long-term GMCG sites are analyzed for dissolved organic carbon (DOC), total dissolved nitrogen (TDN), nitrate (NO_3-N), ammonium (NH_4-N), dissolved organic nitrogen (DON), orthophosphate (PO_4-P), chloride (Cl^-), sulfate (SO_4-S), sodium (Na^+), potassium (K^+), magnesium (Mg^{+2}), calcium (Ca^{+2}), and silica (SiO_2). Water chemistry is also analyzed on a sub-set of the GMCG seasonal sites and turbidity is also measured in the field at all GMCG sites. Samples collected since October 2002 from LMP73 are also analyzed for total suspended sediment (TSS), particulate carbon (PC), particulate nitrogen (PN) and dissolved inorganic carbon (DIC). All samples are analyzed in the Water Quality Analysis Laboratory (WQAL) of the NH WRRC on the campus of UNH, Durham, NH. Methods for analyses include ion chromatography (Cl^-, NO_3^-, SO_4^{-2} and Na^+, K^+, Mg^{+2}, Ca^{+2}), discrete colorimetric analysis (NH_4, PO_4, NO_3/NO_2), and High Temperature Oxidation (DOC, TDN). All methods are widely accepted techniques for analysis of each analyte.

The WQAL was established by the Department of Natural Resources in 1996 to meet the needs of various research and teaching projects both on and off the UNH campus. It is currently administered by the NH Water Resources Research Center and housed in James Hall. Dr. William McDowell is the Laboratory Director and Mr. Jody Potter is the Laboratory Manager. Together, they have over 40 years of experience in water quality analysis, and have numerous publications in the fields of water quality, biogeochemistry, and aquatic ecology.

Principal Findings and Significance

Lamprey River Hydrologic Observatory

Analysis of samples collected from the LRHO has been completed through 2012 and we are in the process of updating the LRHO website (http://www.wrrc.unh.edu/lamprey-river-hydrologic-observatory). Results of stream chemistry to date show a significant increase in nitrate concentrations during the first 10 years (Water Years (WY) 2000-2009) of monitoring at LMP73 and a slight decrease in nitrate concentrations in recent years, but nitrate levels have not declined to levels initially measured in 2000 (Figure 2). There was no significant change in nitrate concentrations at NOR27 or WHB01 over a shorter time period (2004-2012). We have shown previously that stream water nitrate is related to watershed population density (Daley 2002) and since suburbanization continues to occur throughout the greater Lamprey River watershed, population growth is likely responsible for the increase in stream water nitrate over the 10-year period. The watershed population density increased from 53 to 60 people/km^2 or by 12% from 2000 to 2010 (2000 and 2010 Census). We are unsure if the lower nitrate levels measured in LMP73 during 2010 to 2012 will persist, increase or decrease with changing climate, land use and management in the watershed. Wednesday Hill Brook watershed is near its development capacity, unless the Town of Lee, NH changes its zoning regulations, and the lack of increase in WHB01 nitrate may be due to the limited population growth in this watershed, that this watershed has reached

nitrogen saturation or that the relatively short period of data collection is not reflective of long-term trends. Changes in Lamprey River nitrogen, especially nitrate, can have significant impacts for the downstream receiving water body, the Great Bay estuarine system which is impaired by elevated nitrogen and is currently in violation of the Federal Clean Water Act. The bay is experiencing dangerously low dissolved oxygen levels and a significant loss of eelgrass which provides important habitat for aquatic life. The Lamprey River is the largest tributary to Great Bay, and thus the long-term data provided by the NH WRRC from the LRHO are of considerable interest for watershed management.

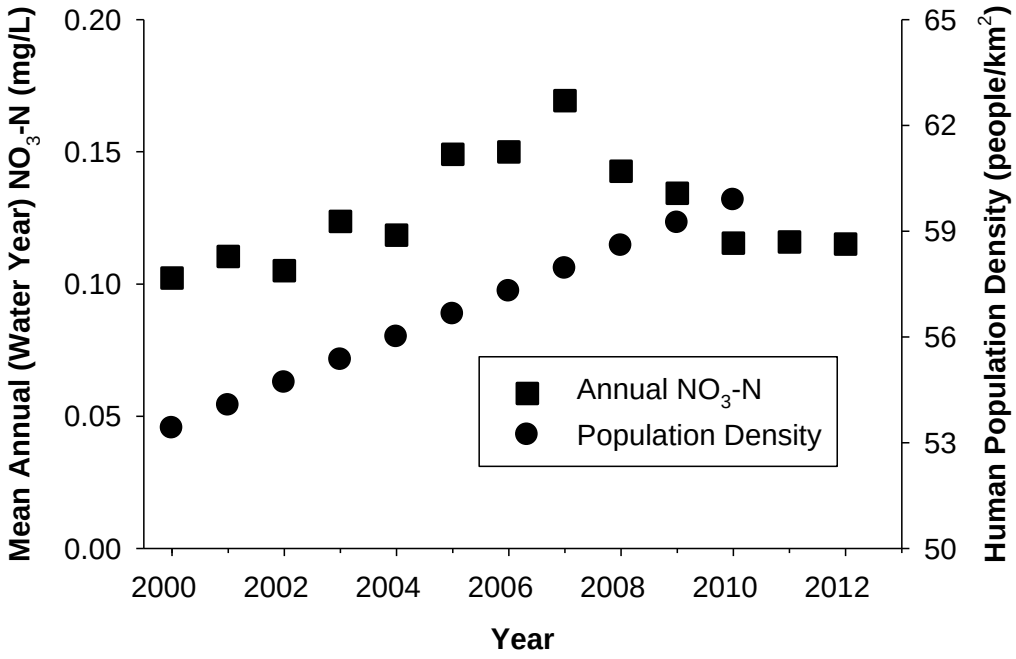

Figure 2. Annual (water year) nitrate concentration and estimated annual human population density from 2000-2010 (2000 and 2010 Census) in the Lamprey River basin. We have applied the Seasonal–Kendall Test (SKT; seasons set to 52) to weekly data from September 1999 through September 2009 and flow-adjusted nitrate concentrations have increased significantly over this time period (SKT $t = 0.28$, $p < 0.01$).

When we combine our specific conductance data (2002 – 2012) with data collected by the USGS (1978 - 1999), we see a long-term increase in specific conductance in the Lamprey River (Figure 3). Sodium and chloride concentrations are directly related to specific conductance ($r^2 = 0.95$, $p<0.01$ for Na^+; $r^2 = 0.93$, $p < 0.01$ for Cl^-) and we conclude that this increase in specific conductance indicates a corresponding increase in NaCl. Sine Na^+ and Cl^- are strongly correlated with impervious surfaces in southeast NH (Daley et al. 2009) and road pavement among southeastern and central NH basins, we conclude that the associated road salt application to these surfaces is responsible for this temporal change in streamwater NaCl.

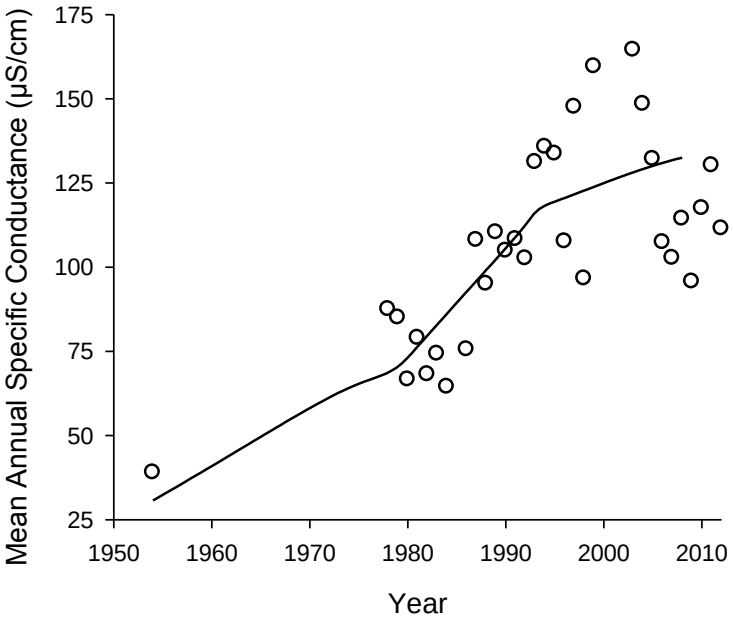

Figure 3. Mean annual specific conductance in the Lamprey River at LMP73 (co-located with the USGS gauging station in Durham, NH. (modified from Daley et al. 2009).

Oyster River watershed

Laboratory analysis of the monthly CB and PB samples is completed through 2012. Recent data show that DO is lowest at the CB upstream station (CB00.5) where it does drop below 5 mg/L (level that is necessary to support in-stream biota) during the summer months. The downstream stations do not drop below 5 mg/L and this difference is due to the hydrologic and biogeochemical properties of the upstream sampling location which has slow stream flow, high dissolved organic matter content and resembles a wetland. DO increases downstream as flow becomes faster and the stream is re-aerated. It is highly unlikely that historical incinerator operations are impacting present day DO levels in this brook as they have in the past.

Data from 2000 until now indicate that the steam is strongly impacted by road salt application at its origin, which is essentially a road-side ditch along the state highway leading to a wetland area, and by road salt applied by UNH and the town of Durham which drains to the middle and lower reaches of the brook. Average sodium and chloride concentrations, as well as specific conductance, appear to have remained reasonably constant since 2001, but are much higher than in 1991 (Daley et al. 2009). Concentrations are highest at the upstream stations and tend to decline downstream as the stream flows through the campus athletic fields and then increase as the stream passes through the heart of campus and downtown Durham. Concentrations are also highest during years of low flow.

College Brook and Pettee Brook have noticeably higher nitrogen concentrations than many other local streams draining less developed or undeveloped watersheds. As College Brook flows from upstream to downstream where it becomes more aerated, ammonium decreases and nitrate increases indicating that nitrification is occurring in the stream channel. However, an increase in dissolved inorganic nitrogen (DIN, the sum of ammonium and nitrate; Figure 4) and total dissolved nitrogen (Figure 5) indicates that there are additional sources of nitrogen entering the stream as it flows downstream

though UNH and Durham. This is possibly from fertilization of the athletic fields, storm water runoff or exfiltration from sewage lines. There is no statistically significant change in DIN or TDN concentrations over time at the station with the longest record (CB01.5).

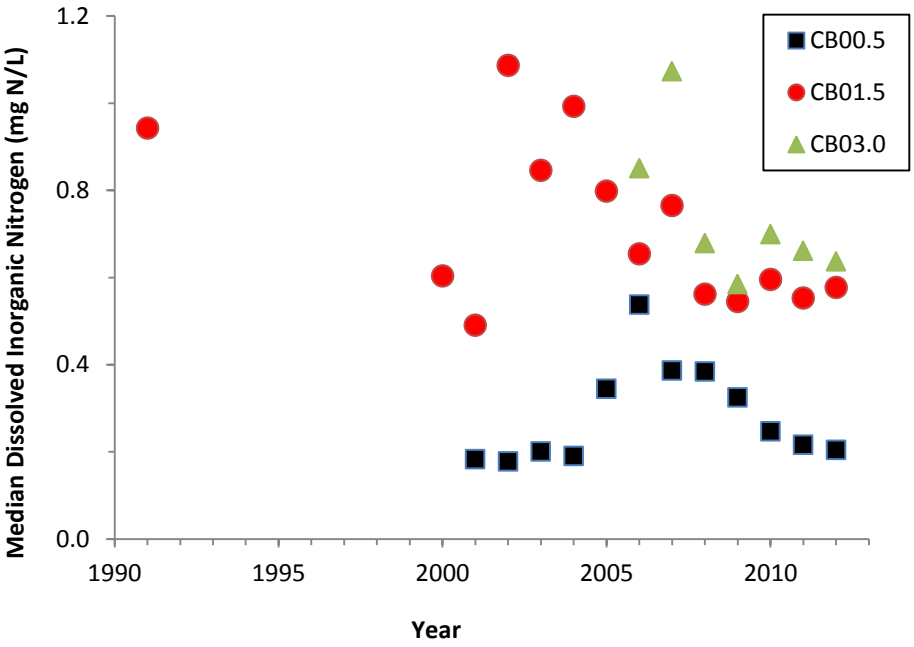

Figure 4. Median annual dissolved inorganic nitrogen (DIN) in College Brook from the headwaters (CB00.5) to the mouth (CB03.0).

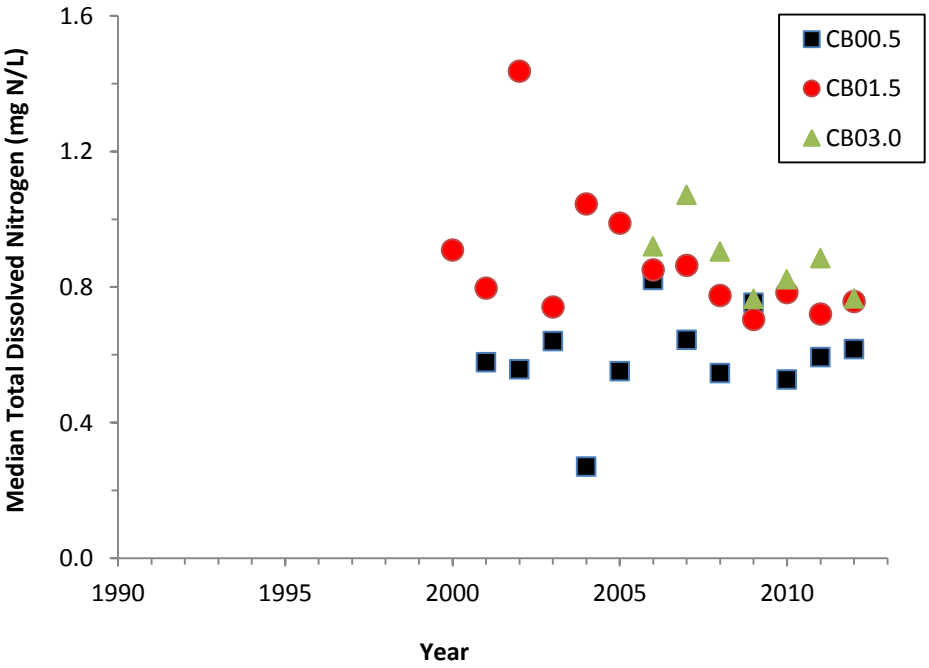

Figure 5. Median annual total dissolved nitrogen (TDN) in College Brook from the headwaters (CB00.5) to the mouth (CB03.0).

Ossipee Watershed

Collaboration with the Green Mountain Conservation Group (GMCG) and their sampling of the Ossipee River watershed provides much benefit to the NH WRRC and the long-term monitoring of rapidly developing suburban watersheds. Volunteers sampled streams within the watershed every 2 weeks from April through October, and monthly winter sampling was conducted by volunteers and GMCG staff at 7 sites. Over 100 samples were collected for analysis in the WQAL and additional field data was collected at over 40 sites throughout 6 towns using the help of many volunteers. Many presentations were made to planning boards, conservation commissions and other local government groups (see information transfer section below). Data have been used to heighten awareness of the impacts of excessive road salting and snow dumping in local streams. The impact of road salting in this central NH watershed is similar to what we see in coastal NH. 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. Data have also been useful in promoting low impact development techniques and best management practices where new development has been proposed in proximity to rivers and streams within the watershed.

Notable awards and achievements

N/A

Number of students supported

Six Master's students (Jason Bailio, Amanda Hope, Lucy Parham, Bianca Rodriguez Nicholas Shonka and Marleigh Sullivan) and 6 undergraduate hourly employees (Matt Bosiak, Sarah Brown, Paige Clarizia, Naomi Odlin, Katie Swan and Sarah Tierney).

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Daley, M.L. May 2002. Export of Dissolved Organic Carbon, Dissolved Organic Nitrogen and Nitrate from the Lamprey River Watershed, New Hampshire: Examining Relationships with Watershed Characteristics. Master's Thesis, University of New Hampshire, Durham, NH.

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Stein, S.M., McRoberts, R.E., Mahal, L.G., Carr, M.A., Alig, R.J., Comas, S.J., Theobald, D.M. and Cundiff, A. 2009. Private forests, public benefits: increased housing density and other pressures on private forest contributions. Gen. Tech. Rep. PNW-GTR-795. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 74 p.

Sundquist D and Stevens M. 1999. New Hampshire's changing landscape. Population growth, land use conservation, and resource fragmentation in the Granite State. Society for the Protection of New Hampshire Forests, Concord, New Hampshire. 110 pp.

Information transfer activities that utilize long-term datasets supported by NH WRRC and matching funds

Publications

Baillio, J., 2012, Controls on variability of dissolved greenhouse gas concentration and emissions from small streams in southeastern New Hampshire, MS Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 111 pages.

Daley, M.L. and W.H. McDowell, *In Preparation*, Human impacts on stream nitrogen chemistry and watershed N retention across a wide range of rural to urban catchments, Ecological Applications.

Hope, A.J., W.H. McDowell, W.M. Wollheim, Submitted, Ecosystem metabolism and nutrient uptake in an urban, piped headwater stream, Biogeochemistry.

Liptzin, D., M.L. Daley, and W.H. McDowell. Accepted. A comparison of wet deposition collectors at a coastal rural site. Submitted to Water, Air, & Soil Pollution. April 2013.

Parham, L., 2012, Spatial and temporal variation in degradation of dissolved organic carbon on the main stem of the Lamprey River, MS Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 66 pages.

Conference Proceedings & Abstracts

Liptzin, D., M.L. Daley, and W.H. McDowell. 2012. A collector comparison for wet deposition at a coastal New Hampshire site. NADP National meeting, Portland, ME, October 2012.

Lombard, M.A., H. Mao, M. Daley, J. Bryce, W.H. McDowell, and R. Talbot. Relationships between mercury and sea salt ion concentrations in rainwater from a marine site. Northeastern Section of the Geological Society of America, Hartford, CT March 2012.

McDowell, W.H. 2012. Consequences of climate and land use change for ecosystems and ecosystem services in New Hampshire. Invited symposium presentation, Ecosummit, Ecological Society of America, Columbus, OH, October, 2012.

McDowell, W.H. 2012. Management of urbanizing watersheds: Central tendencies, outliers, and the art of the possible. Invited presentation, AGU Annual fall meeting, San Francisco, CA. December, 2012.

Presentations

Daley, M.L. and McDowell, W.H. 2012. Nitrogen in the Great Bay and Lamprey Watershed. Lamprey River Advisory Committee. Raymond, NH. March 2012.

Daley, M.L. and McDowell, W.H. 2012. Nitrogen challenges in the Great Bay watershed. Living on Great Bay lecture series: the challenges. Supported by We The People; Sponsored by the Green Sanctuary Project of the first UU Church of Exeter, NH. May 2012.

Daley, M.L. Nitrogen Drivers in the Great Bay watershed. Non-point source nitrogen pathways. Boat Tour of Great Bay. NEIWPCC Annual Nonpoint Source Pollution Conference. Portsmouth, NH. May 2012.

Daley, M.L., McDowell, W.H., Potter, J.D., French, C. and Miller, S. 2012. Nitrogen Sources Collaborative Advisory Board Water Quality Analysis Lab Tour and Field Trip to Great Bay stream sites. Durham and Lee, NH. Durham and Lee, NH. July 2012.

Daley, M.L. 2012. Urbanization and Suburbanization in NH watersheds. University of New Hampshire Watershed Water Quality Management class. Durham, NH. September 2012.

Daley, M.L. 2012. Water Quality Research in the Lamprey River Hydrologic Observatory. University of New Hampshire Approach to Research class. Durham, NH. October 2012.

Daley, M.L. and McDowell, W.H. 2012. Addressing Nitrogen Issues in Great Bay – Non-Point Nitrogen Sources. Co-sponsored by the Oyster River Local Advisory Committee and the Oyster River Watershed Association. Madbury, NH. November 8, 2012.

Daley, M.L. 2012. Ten Years of Water Quality data in the Ossipee Watershed. Green Mountain Conservation Group Community Forum – Looking at 10 Years of Data. Chocorua Village, NH. November 2012.

Daley, M.L. 2012. Watershed management in practice: Great Bay. University of New Hampshire Watershed Water Quality Management class. Durham, NH. September 2012.

Daley, M.L. 2012. Nitrogen in the Great Bay Watershed: Point and Nonpoint Sources (with specifics for the Lamprey River). Newmarket Community Forum on the Health of the Great Bay Estuary. Newmarket, NH. February 19, 2013.

McDowell, W.H. 2012. Hydrofracking, energy, and water quality. Active retirement Association, Durham. NH. October 21, 2012.

McDowell, W.H. 2012. Groundwater and Surface Water Contamination in Suburban Basins. Active Retirement Association, Durham, NH. October 28, 2012.

Press Releases

McDowell, W.H. 2012. Research Profile: Bill McDowell – Protecting Water Quality for Now and the Future. Campus Journal. University of New Hampshire. October 31, 2012.

Green Mountain Conservation Group meetings, workshops and presentations supported by matching funds

2012

March 19th Youth Coalition for Clean Water Steering Committee Meeting
March 29th GET Wet presentation at Ossipee Central School
March Sandwich Students present WQM information to Town Meeting
March 30th Youth Coalition partners with Garden Club on BMP project-Rain Garden
April 21th Water Quality Monitoring 2012 Volunteer Training
April 30th Youth Coalition for Clean Water Steering Committee Meeting
April Training for GMCG Reps to deliver information to town officials about Water Quality
May 10th Source Water Conference in Concord
May 12th Trout workshop and WQ at Sumner Brook Fish farm
May 10th Youth Coalition for Water Quality Steering Committee Meeting
May 24th GET WET well water sampling Effingham
May 30 Release of brook trout
May 31 Alternatives to House hold Chemicals—better ways to protect water quality
June 1st Ossipee Central School GET WET! & water quality presentation
June Ossipee Lake Alliance meeting ---WQM on Ossipee Lake
June 9th Wetland walk with Rick Van de Poll
June Drive Time Radio Program WQM 2012
June 18th Rain barrel workshop

July 2012 Volunteer Lake Assessment Program & WQ Programs with Camps Cody, Huckins, Robin Hood, Marist & Danforth Bay

July 6, 20, Aug. 3 WQ Programs/Ossipee Lake & Tributary testing with Camp Calumet

July 9 River Runners workshop

July (once a week) Madison Library Kids Program on Macroinvertebrates

July 23 Presentation on priorities for water quality protection on Ossipee Lake and prep for possible Watershed Management Plan in 2013

August 4th House Hold Hazardous Waste Day and hand out of GET WET well sampling kits

August 22 GET WET water sampling day at Huntress House (GMCG office)

August 24 VBAP, Trout in the Classroom & WQM Volunteer Training at Community School with NH Fish and Game

Sept 7-30th VBAP Programs & WQM daily with Ossipee Central School, Effingham Elementary, The Community School, Freedom Elementary, Sandwich Elementary School

October 18th Erosion control workshop

November 15 WQM forum

December 6st Student WQM Presentation in Tamworth of VBAP & WQ for 2012

December 8th Trout in the Classroom training

2013

January 19 - 15th Annual meeting and Water Quality presentation

January 22 - Lynn and Eric attended Trout in the Classroom training in Concord

February 16th – Winter tracking workshop held at the GMCG office with Barbara Bald. Seventeen trackers of all ages joined us.

Arsenic chemical dynamics in NH groundwater reservoirs: Insights from temporal variability in multi-element signatures of statewide samples

Basic Information

Title:	Arsenic chemical dynamics in NH groundwater reservoirs: Insights from temporal variability in multi-element signatures of statewide samples
Project Number:	2011NH141B
Start Date:	3/1/2011
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	1
Research Category:	Water Quality
Focus Category:	Geochemical Processes, Groundwater, Toxic Substances
Descriptors:	
Principal Investigators:	Julia G Bryce

Publications

There are no publications.

Year 2 Project Report: "Arsenic chemical dynamics in NH groundwater reservoirs: Insights from temporal variability in multi-element signatures of statewide samples."

PI Julia G. Bryce, USGS Collaborator Joe Ayotte, UNH Staff Florencia Prado

1. Problem and Objectives

The purpose of this project is to measure the concentrations of arsenic, a key regulated contaminant, in public and private groundwater wells distributed across the state of New Hampshire. In the first year of this project, we focused on developing the arsenic method for analysis via hydride generation-high resolution inductively coupled plasma mass spectrometry. We optimized our analytical protocol for "harvesting" arsenic out of water samples originally collected for a MTBE study, and we optimized a set of procedures for investigating "leachable" arsenic from samples of local bedrock. By the end of year two we have prepped nearly 500 samples and run approximately 380. Ongoing analyses of other key geochemical parameters (e.g., Fe and Pb) coupled with additional leaching laboratory experiments manipulating pH provide the opportunity to investigate geochemical controls on arsenic mobility in geochemical environments such as those found in the bedrock-hosted aquifers of southern NH.

2. Methods and Project Activities

Our work is focused on developing analytical protocols to measure arsenic contents in existing samples. Nearly 900 samples exist from sampling campaigns led by J. Ayotte originally designed to study MTBE occurrences in groundwaters sampled from public and private drinking water supplies. Since some of the existing samples are older than recommended "hold" times for water samples, we first needed to ensure no arsenic has been lost from the system, via selective adsorption onto the bottle sides and/or via co-precipitation with other elements. Our approach to ensuring all arsenic is in solution is as follows. First we acidified the samples to 5% nitric acid, and then let sit for several days and shoot and mixed via ultrasonic mixing. We then took a (quantified) cut for which we measured the arsenic concentration. We subsequently transferred the sample to a cleaned bottle and acidified to 10% nitric, let sit, and then ran the results for arsenic concentration. We repeated this last bottle-leaching with 15% nitric.

We have implemented the analysis of arsenic via hydride generator (Klaue and Blum, 1999) plumbed into a high resolution inductively coupled plasma mass spectrometry. Our detection limits are generally $\sim <$ 0.025 μg/kg. We ran two blind standards provided by Joe Ayotte to run every 15-30 samples throughout each run day. We also used standard-sample-standard bracketing with NIST certified reference standard 1643e to correct for within-run drift and also ran standard curves using diluted natural water samples to assess matrix effects. Our lab has participated in the biannual USGS round robin since Fall 2012. We will continue to participate until all 900 water sample analyses have been completed.

In another component of the study, we carried out leaching experiments with chipped bedrock samples to elucidate the geochemical controls on the contributions of

arsenic from metasedimentary bedrock units. Our first analyses in support of these investigations include the analysis of environmentally mobile arsenic in the Kittery formation. Our approach is adapted from that described in Peters and Blum (2003), wherein we used partial leaching in dilute acid to identify the readily mobilized As fractions. In addition to the acid leaching (carried out at pH ≤ 1), we carried out a subsequent study exposing the samples to solutions of elevated pH to test for the role of pH-selective absorption onto minerals on As mobilization (e.g., Peters and Blum, 2003 and references therein).

3. Findings and Future work

In our assessments of accuracy and precision we ran a standard (NIST SRM 1643e, Trace elements in water) and found excellent accuracy and reproducibility. We have also participated in the USGS Round Robin measurements for standards every six months during this study. Following procedures we have developed, we reported our assessment of the standard, which came in below the median value reported for the unknown standard we were assigned. Though it is difficult to address the meaningfulness of the "median" value as it includes several different types of analytical approaches (some of which would not be used validly for samples with As of low abundance), we are continuing to run the standard using other techniques (e.g., standard addition) to ensure that we are accurately measuring sample values. Any offset in our values likely comes from a mismatch between the matrix of the standard we are using and the matrix of unknowns. Accordingly we will be carrying out investigations of the influence of several different "matrix"-modifiers to ensure that our analytical protocols are not impacted by the high abundance of certain elements (e.g., Fe).

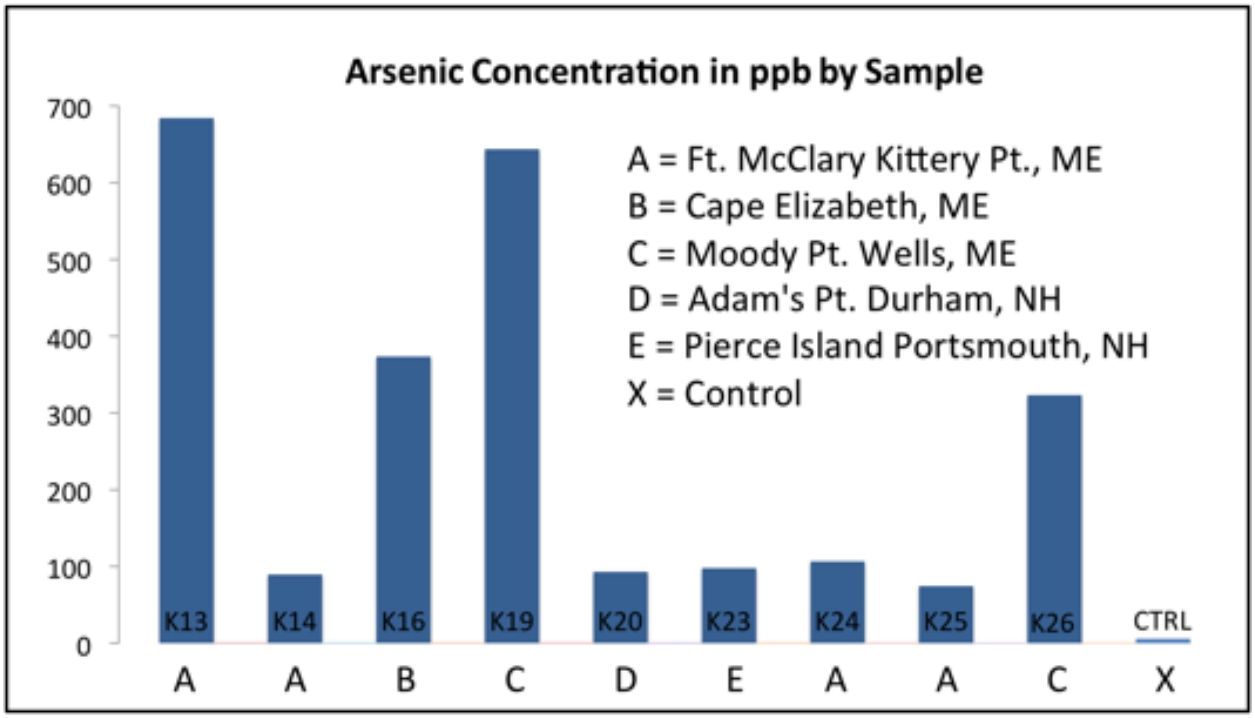
In terms of ensuring that we have no sample biasing issues with the shelf life of our samples, we spent the time on a subset of our samples to ensure we can establish a protocol for future measurements of the remainder of the 900 groundwater samples. Analyses of five samples showed, in cases where the original sample is above the detection limit, that we have a > 99% yield for the total arsenic in the system during the acidification to 5% nitric. Accordingly we will adopt these protocols with the rest of the unknown samples.

Our initial investigations of the environmentally mobile arsenic confirm the extreme range in arsenic that we can find over relatively short spatial scales in metasedimentary bedrock (Figure 1), as well as the strong sensitivity of subsequent arsenic remobilization due to changing pH in oxidizing conditions . We will complement our existing results on the Kittery with leaching studies of additional sub-samples from two existing ~100-foot six-inch drill cores through the Kittery and Elliot formations around the Great Bay in Southeastern NH and potentially from other bedrock units that host samples we have collected in the southern NH region.

The concentrations of arsenic in groundwater from the private and public water supplies measured thus far have been highly variable, with many samples exceeding the EPA-recommended drinking water limit. Two samples exceeded 100 ppb in concentration, well above recommended limits. Later this summer, once we have the majority of the 900

samples, we plan to work together with Joe Ayotte (USGS) to link our geochemical data to geospatial data for presenting the data in a coherent fashion and inform any additional sampling measures.

Figure 1. Arsenic concentrations in bedrock-leaching solutions from the Kittery formation. Note the extreme variability in the arsenic that is potentially environmentally mobile from different localities in the Kittery formation medasedimentary bedrock as well as the variability within individual localities. Forthcoming elemental analyses will help to identify the geochemical processes responsible for these wide variations.



4. Presentation

Results of the bedrock-leaching were presented at the 2012 UNH Undergraduate research project by Mr. John Clark (UNH BA-Earth Sciences Teaching, 2012). Clark started his activities on the project in summer 2011 and continued during the 2011-2012 and 2012-2013 academic years. We are working together to complete the analyses by the end of CY 2013 and hope to work together with USGS to prepare a publication of the results shortly thereafter.

5. Outreach efforts

Clark has finished his professional degree to be a secondary school science teacher, and his involvement in this project has provided him the opportunity to participate in "genuine" scientific research he can model with his future middle school students. He originally participated in this project as part of a summer research internship provided by a National Science Foundation grant for which Bryce is a co-PI. His attraction to the project came

because of his belief that this was a project involving chemistry, public health and the environmental sciences, in such a way that he could engage his future students. His continued involvement during the academic year is a testimony to his long-standing interest.

In the spring, we featured the results of this project in a hands-on lab day for a cadre of high school chemistry and Earth Science teachers separately supported by a Dreyfus Foundation Grant. The teachers were involved in sample collection, ICP analyses, and discussion of USGS studies of As in NH groundwaters, and are working with PI Bryce and Ms. Prado to establish As in groundwater as a unit in their chemistry and Earth Science classrooms.

6. Personnel development- students, faculty and staff

In addition to Mr. Clark, whose analytical efforts were supported by this project, this project is responsible for convincing Ms. Florencia Prado, a talented staff member to enter the Ph.D. program. Prado has developed the analytical techniques and worked with Bryce to supervise and develop Clark's project.

USGS Award No. G11AP20128 Determining the Effectiveness of the Clean Air Act and Amendments for the Recovery of Surface Waters in the Northeastern U.S.

Basic Information

Title:	USGS Award No. G11AP20128 Determining the Effectiveness of the Clean Air Act and Amendments for the Recovery of Surface Waters in the Northeastern U.S.
Project Number:	2011NH164S
Start Date:	3/28/2011
End Date:	4/30/2014
Funding Source:	Supplemental
Congressional District:	
Research Category:	Climate and Hydrologic Processes
Focus Category:	Acid Deposition, Surface Water, Law, Institutions, and Policy
Descriptors:	
Principal Investigators:	William H. McDowell, Steve Kahl

Publications

1. Sanclements, M., G. Oelsner, D. McKnight, S.J. Nelson, J. Stoddard, 2012, New insights into the source of decadal increases of dissolved organic matter (DOM) in acid-sensitive lakes, Environmental Science and Technology, in press.
2. Nelson, S.J., P. Vaux, M.J. James-Pirri, and G. Giese, 2011, Assessment of natural resource conditions in and adjacent to Cape Cod National Seashore, Massachusetts, Natural Resource [Technical] Report NPS/XXXX/ NRXX—20XX/XXX, National Park Service, Fort Collins, Colorado, In press.
3. Kerr, J.G., M.C. Eimers, I.F. Creed, M.B. Adams, F. Beall, D. Burns, J.L. Campbell, S.F. Christopher, T.A. Clair, F. Courchesne, L. Duchesne, I. Fernandez, D. Houle, D.S. Jeffries, G.E. Likens, M.J. Mitchell, J. Shanley, H. Yao, 2011, The effects of seasonal drying on sulphate dynamics in streams across southeastern Canada and the northeastern USA, Biogeochemistry DOI 10.1007/s10533-011-9664-1.
4. Sanclements, M., G. Oelsner, D. McKnight, S.J. Nelson, J. Stoddard, 2012, New insights into the source of decadal increases of dissolved organic matter (DOM) in acid-sensitive lakes of the northeastern U.S., Environmental Science and Technology, 46(6): 3212–3219, DOI: 10.1007/s11356-009-0176-7.
5. Nelson, S.J., P. Vaux, M.J. James-Pirri, and G. Giese, 2012, Natural resource condition assessment: Cape Cod National Seashore, Massachusetts, Natural Resource Report NPS/NER/NRR—2012/605, National Park Service, Fort Collins, Colorado.
6. Kerr, J.G., M.C. Eimers, I.F. Creed, M.B. Adams, F. Beall, D. Burns, J.L. Campbell, S.F. Christopher, T.A. Clair, F. Courchesne, L. Duchesne, I. Fernandez, D. Houle, D.S. Jeffries, G.E. Likens, M.J. Mitchell, J. Shanley, H. Yao, 2011, The effects of seasonal drying on sulphate dynamics in streams across southeastern Canada and the northeastern USA, 111(1-3): 393-409, Biogeochemistry, DOI 10.1007/s10533-011-9664-1.

7. James-Pirri, M. J., S. J. Nelson, and P. D. Vaux, June 2011, Natural Resource Condition Assessment for Saugus Iron Works National Historic Site. Natural Resource Report NPS/NER/NRR—2011/457, National Park Service, Fort Collins, Colorado.

Annual Report to

USGS WRD WRRI, Reston, VA
US EPA, CAMD, Washington DC
and US EPA, ORD, Corvallis OR

June, 2013

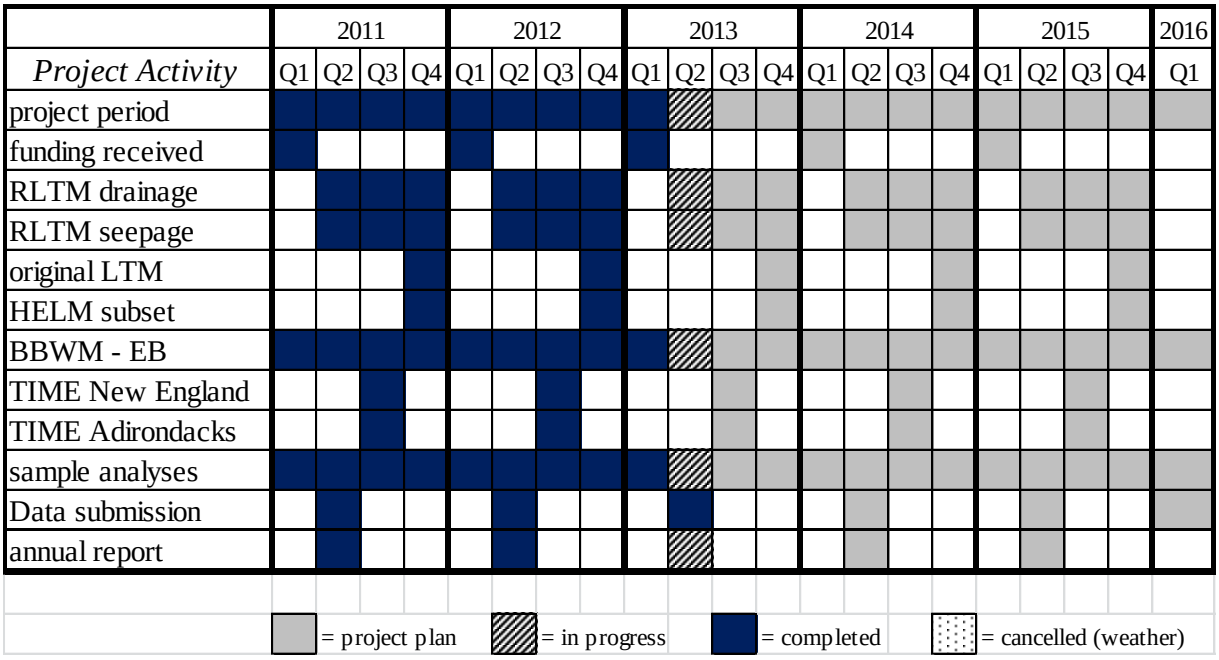
Determining the effectiveness of the Clean Air Act and Amendments on the recovery of surface waters in the northeastern US

IAG 06HQGR0143

Principal Investigators: *William H. McDowell[1], Sarah J. Nelson[2], J. Steve Kahl[1], J. Saros[2]*
[1]Univ. of New Hampshire, [2]Univ. of Maine

Overview of activities during 2012-2013. A schematic summary of progress on the project plan is provided below (Table 1) and discussed on the following pages. We have concluded the first year of five for the most current project agreement, which supports the continuing needs of EPA to assess the effectiveness of the Clean Air Act Amendments of 1990 (CAAA). Field work and data assessment continue on schedule. Project coordination as well as most analytical chemistry, and some field sampling are conducted by the University of New Hampshire. Additional field sampling, data quality assurance, and data reporting are conducted by the University of Maine. This year, the project is leveraging resources through other funded research that supports a Ph.D. candidate and two M.S. students at the University of Maine who are evaluating recent trends in the LTM and TIME lakes' responses to changes in atmospheric deposition, geochemical response to extreme weather events and climate, and changes in lake thermal stratification related to climate change. Two of the projects also include drinking water supply lakes and use the RLTM lakes as context for interpreting patterns in diatom communities and nuisance algae. (See citations for Strock et al., Brown et al., Boeff et al.). TIME lakes data are being used in research funded through USDA-NSRC to Nelson et al., related to mercury in lake water and dragonfly larvae. Additionally, this project continues to fund a portion of the base program of stream chemistry monitoring at Bear Brook Watershed in Maine (BBWM), for the reference watershed, East Bear. BBWM celebrated its 25th anniversary in 2012, and PIs led the international BIOGEOMON conference. BBWM is partway through a three-year NSF DEB grant that is evaluating nitrogen dynamics in both watersheds using ^{15}N tracer studies. The base funding through this IAG project created continuity that was key in securing the NSF award.

Table 1. 2011-2015 Project plan progress to date.



Project background

Objectives. This research is part of EPA CAMD programs that are verifying the effectiveness of emission controls at reducing acidification of surface waters. Our approach is to collect long-term high-quality data that characterize the trends and patterns of response in low ionic-strength surface waters. We have specifically targeted waters that have been classified as being sensitive to acidic deposition and will represent lakes across the Northeast in varying landscape settings. The goals and methods are hierarchical, ranging from intensive site-specific investigations to regional assessment of sites that have been chosen to provide a statistically rigorous sample of regional surface waters. The objectives are to:

1) document the changes and patterns in aquatic chemistry for defined sub-populations and sites that are known to be susceptible to acidification or recovery;
2) evaluate the extent to which changes in surface waters, if any, can be linked to changes in deposition that are driven by regulatory actions;
3) characterize the effectiveness of the CAAA in meeting goals of reducing acidification of surface waters and improving biologically-relevant chemistry in the northeastern US;
4) provide information for assessment of the need for future reductions in atmospheric deposition based on the long-term trajectories of the systems under study; and
5) assess the extent to which increased variability in precipitation events will play a role in the long-term sustainability of CAAA success in these sensitive surface waters. This is leveraged through other funded research.

Approach. The schedule of tasks ranges from weekly to annual, continuing data records that now range from 17 to 30 years. We evaluate chemistry on a weekly basis year-round at the small watershed-scale at BBWM, quarterly in LTM, and annually during the historical index period for the TIME and HELM lakes. These project components provide a *statistical framework* for inferring regional patterns in chemistry using TIME and LTM (and ELS-II under separate funding). The *long-term records* of LTM, HELM and BBWM provide information on seasonal and annual variability, and thus provide a seasonal context for the annual surveys.

Expected Results. This information is needed for EPA to meet its Congressional mandate to assess the effectiveness of the CAAA. The combination of site-specific data within the regional context provides a rigorous assessment of the effects of declining pollutant emissions on SO_4 concentrations, base cation depletion, and changes in N-saturation or DOC contributions to acid-base status. The results are also central to assessing whether additional emission reductions may be needed to produce recovery.

Project Status: Water Chemistry

Field sampling. All project field objectives in 2012 were accomplished as planned. A summary of the annual field schedule for this project is provided below (Table 2).

Table 2. Annual project field schedule for lake sampling

Project	sub-project	n	Times Sampled	Field work	May	June	July	Aug.	Sept.	Oct.
RLTM-Maine										
	seepage	3	3	UMaine	X		X			X
	drainage	9	3	UMaine/UNH	X		X			X
	LTM lakes	3	1	UMaine						X
TIME										
	New England	31	1	UNH			X	X	X	
	Adirondacks	42	1	ALSC			X	X	X	
HELM		25-30	1	UNH						X

Analytical. Analyses are complete for all samples collected through 2012. All laboratory analyses for TIME, RLTM, and HELM are conducted at the University of New Hampshire Water Quality Analysis Laboratory (WQAL) except for aluminum. Total and organic aluminum samples are processed on an ICP at the USDA Forest Service Region 1 laboratory in Durham, NH. All analyses for TIME, RLTM, and HELM continue to be conducted by, or under the supervision of, Adam Baumann as has been the case since 2006. This is changing in 2013, as analyses will now be conducted under the supervision of Jody Potter, the laboratory manager of the WQAL.

Samples from East Bear Brook at BBWM, which are collected on a regular basis year-round, continue to be analyzed at the University of Maine Sawyer Environmental Chemistry Research Lab.

Data reporting. All data collected through 2011 have been delivered to EPA. The next delivery of data to EPA is expected before August 2013, after evaluation of inter-laboratory comparisons and regular QA analyses by UNH and UMaine. Additionally, PI Nelson has been working with EPA-CAMD to improve the legacy database through improved formatting, metadata, and reporting of an expanded and re-checked legacy database.

Presentation of findings. Several publications and presentations continue to result from this project and are listed at the end of this report. Recent leveraged funding is supporting portions of two MS theses and a PhD dissertation at UMaine under the supervision of co-PI Saros, as well as ongoing mercury research by co-PI Nelson.

New developments: During the past year we were able to make routine two new sets of analyses to continue to extract new and innovative information from these study sites. A subset of lakes were analyzed for DOC quality using SUVA and fluorescence (EEMS) analysis, as well as concentrations of the dissolved greenhouse gases (CH_4, CO_2, and N_2O) in surface waters. Moving forward this data will provide valuable insight into changes in organic sources to acid-base status as well as the influence of precipitation event variability on long-term changes in surface water chemistry. Analyses of archived samples from the LTM lakes led to a publication in Environmental Science and Technology (Sanclements et al. 2012), based on carbon quality

measured as fluorescence index. This paper reports that (1) five of the nine lake samples analyzed had increasing DOC trends during 1993-2009, and (2) in these five lakes with increasing DOC, fluorescence indices suggest the source of DOC has become increasingly terrestrially-derived. Research regarding lake thermal stratification by MS student Brown uses these lake DOC patterns to structure the sampling strategy.

Conversations with the Adirondack Lake Survey Corporation (ALSC) at our periodic TIME/LTM cooperators meeting opened conversations about streamlining the collection and analysis of TIME-Adirondack samples. Many years of duplicate analyses provide ample opportunity for interlaboratory comparisons between ALSC and UMaine and UNH that we are hopeful will allow for analytical responsibility to shift mainly to the ALSC lab in the near future.

Data were provided to a team including former EPA-LTM PI Katherine Webster (with P.A. Soranno, K.S. Cheruvelil, E.H. Stanley, J.A. Downing, N. Lottig, and P-N Tan), who are working on the NSF Macrosystems Biology Project "studying large-scale and long-term dynamics of lakes." Data related to the 2004 re-sampling of ELS-II lakes have been transmitted to John Stoddard for use in evaluating zooplankton response to changes in lake geochemistry. Bear Brook data are routinely shared with cooperators across the Northeast, often as part of USDA-NSRC funded research, for use in meta-analyses.

Students and Staff supported

Two undergraduate hourly employees (Matt Bosiak and Katie Swan), one early career research scientist (Adam Baumann) and two early career technicians (Ania Kobylinski and Lisle Snyder) were supported by this project.

Publications using related project information ***(recent publications in bold):***

Sanclements, M., G. Oelsner, D. McKnight, S.J. Nelson, J. Stoddard, 2012. New insights into the source of decadal increases of dissolved organic matter (DOM) in acid-sensitive lakes of the northeastern U.S. Environmental Science and Technology 46(6): 3212–3219; DOI: 10.1007/s11356-009-0176-7.

Nelson, S.J., P. Vaux, M.J. James-Pirri, and G. Giese. 2012. Natural resource condition assessment: Cape Cod National Seashore, Massachusetts. Natural Resource Report NPS/NER/NRR—2012/605. National Park Service, Fort Collins, Colorado.

James-Pirri, M. J., S. J. Nelson, and P. D. Vaux. June 2011. Natural Resource Condition Assessment for Saugus Iron Works National Historic Site. Natural Resource Report NPS/NER/NRR—2011/457. National Park Service. Fort Collins, Colorado.

Kerr, J.G., M.C. Eimers, I.F. Creed, M.B. Adams, F. Beall, D. Burns, J.L. Campbell, S.F. Christopher, T.A. Clair, F. Courchesne, L. Duchesne, I. Fernandez, D. Houle, D.S. Jeffries, G.E. Likens, M.J. Mitchell, J. Shanley, H. Yao, 2011, The effects of seasonal drying on sulphate dynamics in streams across southeastern Canada and the northeastern USA, Biogeochemistry DOI 10.1007/s10533-011-9664-1.

Navrátil, T., S.A. Norton, I.J. Fernandez, S.J. Nelson, 2010. Twenty-year inter-annual trends and seasonal variations in precipitation and stream water chemistry at the Bear Brook Watershed in Maine, USA. Environ. Monit. Assess. 171:3-21.

Norton, S.; Fernandez, I.; Kahl, J.; Rustad, L.; Navratil, Tomas; Almquist, H., 2010. The evolution of the science of Bear Brook Watershed in Maine, USA. Environmental Monitoring and Assessment, 171(1-4): 3-21.

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Rosfjord, C., K. Webster, J.S. Kahl, S.A. Norton, I. Fernandez, and A. Herlihy, 2007. Anthropogenically-driven changes in chloride complicate interpretation of base cation trends in lakes recovering from acidic deposition. Environ Sci Technol, 41:7688 -7693.

Rosfjord, C., J.S. Kahl, K. Webster, S. Nelson, I. Fernandez, L. Rustad, and R. Stemberger, 2006. Acidic deposition-relevant changes in lake chemistry in the EPA Eastern Lake Survey, 1984-2004. Final report to USDA NSRC, Durham, NH. 69 p.

Campbell, J, J. Hornbeck, M. Mitchell, M. Adams, M. Castro, C. Driscoll, J.S. Kahl, and others, 2004. Input-output budgets for inorganic nitrogen for 24 watersheds in the northeastern United States. Water Air Soil Pollut., 151:373-396.

Lawler, J., J. Rubin, B.J. Cosby, I. Fernandez, J.S. Kahl, S. Norton, 2005. Predicting recovery from acidic deposition: Applying a modified TAF (Tracking Analysis Framework) Model to Maine High Elevation Lakes, Water Air Soil Pollut. 164:383-389.

Dupont, J., T. Clair, C. Gagnon, D. Jeffries, J.S. Kahl, S. Nelson, and J Peckenham, 2005. Estimation of critical loads of acidity in the northeastern US and eastern Canada. Environ. Monit. Assess. 109:275-291.

Kahl, J.S., J. Stoddard, R. Haeuber, S. Paulsen, R. Birnbaum, F. Deviney, D. DeWalle, C. Driscoll, A. Herlihy, J. Kellogg, P. Murdoch, K. Roy, W. Sharpe, S. Urquhart, R. Webb, and K. Webster, 2004. Response of surface water chemistry to changes in acidic deposition: implications for future amendments to Clean Air Act. Environmental Science and Technology, Feature Article 38:484A-490A.

Norton, S., I. Fernandez, J.S. Kahl, and R. Reinhardt, 2004. Acidification trends and the evolution of neutralization mechanisms through time at the Bear Brook Watershed, Maine, USA. Water, Air, Soil, Pollution Focus 4:289-310.

Presentations using related project information ***(recent presentations in bold) :***

Nelson, S.J., C. Chen, D.P. Krabbenhoft, J.S. Kahl, B. Zoellick, 2013. Validating landscape models for mercury in northeastern US lakes using dragonfly larvae as mercury bio-sentinels. Accepted for poster presentation at the ICMGP - International Conference on Mercury as a Global Pollutant, July 28- Aug. 3, 2013, Edinburgh, Scotland.

Boeff, K., J. Saros. 2013. Evaluating the Effect of Changing Wind Strength on Thermocline Depth in Maine's Great Ponds. 21st Annual Harold W. Borns Jr. Symposium, Orono, ME, USA, April, 2013.

Brown, R.E., J.E. Saros, S.J. Nelson. Algal community response to increases in dissolved organic carbon in Maine lakes: implications for drinking water utilities. 21st Annual Harold W. Borns Jr. Symposium, Orono, ME, USA, April, 2013.

Strock, K.E., J.E. Saros, S. Birkel, S.J. Nelson, 2013. Exploring the effects of extreme hydrologic events in the northeastern U.S.: Implications for brownification and episodic acidification in Maine Lakes. 21st Annual Harold W. Borns Jr. Symposium, Orono, ME, USA, April, 2013.

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Weiss, Marissa S., Christine L. Goodale, Mary Beth Adams, Ivan J. Fernandez, Serita D. Frey, Gary M. Lovett, and Steven G. McNulty. 2013. Effects of long-term nitrogen addition on soil carbon pools and fluxes in forest soils of the northeastern US. Soil Bio Biochem (in review).

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Fernandez, Ivan J., Madeleine M. Mineau, Kevin S. Simon, and Stephen A. Norton. 2012. The influence of decadal-scale N enrichment on N dynamics and 15N discrimination in a New England Forested Watershed. (Paper 302-2). Presented at the ASA-CSSA-SSSA International Meetings. Cincinnati, Ohio. October 22-25. ASA, CSSA, SSSA, Madison, WI.

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Norton, S.A., I.J. Fernandez, T. Navratil, K.S. Simon, and S. Jain. 2012. The Bear Brook Watershed in Maine (BBWM) at 25: manipulation, monitoring, mechanisms, and modeling. BIOGEOMON 2012, The 7th International Symposium on Ecosystem Behavior. Northport, Maine. ISBN 978-0-87723-108-0. p. 177.

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Determining the Impact of Coal Tar Based Driveway Sealant on Polycyclic Aromatic Hydrocarbon Concentrations in NH Waterbodies.

Basic Information

Title:	Determining the Impact of Coal Tar Based Driveway Sealant on Polycyclic Aromatic Hydrocarbon Concentrations in NH Waterbodies.
Project Number:	2012NH165B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	NH-All
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Water Quality, Sediments
Descriptors:	None
Principal Investigators:	Alison Watts

Publications

There are no publications.

NH WRRC Final Report

Determining the Impact of Coal Tar Based Driveway Sealant on Polycyclic Aromatic Hydrocarbon Concentrations in NH Waterbodies.

Alison Watts and Thomas Ballestero, University of New Hampshire, Dept of Civil Engineering

Problem

Recent studies have found that coal-tar-based pavement is a major source of polycyclic aromatic hydrocarbons (PAHs) to the environment (Mahler et al., 2005; Selbig et al., 2009; Mahler et al., 2010; Watts et al., 2010, UNHSC 2010). The US EPA identifies 16 PAHs as priority pollutants, one of which, benzo(a)pyrene, is also listed as a Persistent Bioaccumulative and Toxic Chemical. PAHs are ubiquitous in the environment, and are one of the compounds most likely to be associated with Tier 1 impacted aquatic sediments. PAHs are released to the environment by many sources, including automotive exhaust, industrial activity and fires. Driveway sealant is applied to the surface of driveways and parking lots as a thin black layer, which wears off and is reapplied every few years. Two types of sealant are commonly used in the US; refined coal-tar-pitch emulsion and asphalt-based emulsion. Although the two sealcoat product types are similar in appearance, PAH concentrations in coal-tar-based sealcoat are about 1,000 times higher than those in asphalt-based sealcoat (Scoggins et al., 2009).

Studies by the University of New Hampshire Stormwater Center (UNHSC), and the United States Geological Service (USGS) have found that stormwater runoff from coal-tar-based sealant contains PAH concentrations one to two orders of magnitude higher than concentrations measured in stormwater runoff from adjacent, unsealed surfaces (Mahler et al., 2005; Watts et al., 2010). Additional work by USGS researchers found that up to 50% of the total PAH load in sediment samples collected from 40 lakes across the country were attributable to the use of coal-tar-based sealant (Van Metre and Mahler, 2010). None of the lakes sampled in this study were located in NH, but coal-tar-based sealant is frequently used in this region, and it is reasonable to conclude that a similar trend may be present. The Piscataqua Region Estuaries Program (PREP) State of the Estuaries 2009 Report identified PAHs as the contaminant which most commonly exceeded threshold values in Great Bay sediments, and noted that concentrations in the Great Bay mussel tissue are increasing. PAH contamination in portions of the Great Bay is partially associated with legacy contamination from former manufactured gas plants (MGPs) (Figure 1),

but may also reflect runoff from increasing urbanization, and associated sealant use, in the region.

Figure 1. Silver colored sheen associated with PAH contamination from coal tar in the Cocheco River, Dover, NH.

This project will evaluate existing and data sets and methods as a first step towards determining whether the use of coal-tar-based sealant is impacting aquatic sediments in New Hampshire. PAH compounds are a class of hydrocarbon compounds composed of 2 or more benzene rings. PAHs analyses most commonly report the 16 compounds identified as priority pollutants by EPA, however extended analyses can identify over 60 parent PAH compounds and alkyl homologs, and the distribution of the compound suite can be used to infer the source process. PAH compound profiles have been used extensively to identify PAH sources in sediments, most commonly associated with allocation of responsibility for industrial contaminants (e.g. Stout et al., 2005, Costa, H. J.; Yunker et al., 2002). These methods have also been used to identify sediments contaminated by PAHs released from coal-tar-based sealant (Mahler and Van Metre, 2005, Watts 2010, Van Metre and Mahler 2010).

Objectives

To validate the use of existing data and statistical methods as effective tools to distinguish PAH

sources in Great Bay sediments, and determine the impact of coal-tar-based sealcoat in urban and suburban sediments in New Hampshire by:

- Developing a consistent database of PAH compounds in sediments in the Great Bay region, using both existing and new data.
- Developing and testing a contaminant mass balance model, and applying the method to each sample set to determine the most probable source of PAHs, and identify shifts in PAH source.

Results and Discussion

Data compilation: Existing data from EPAs National Coastal Assessment (NCA) program, the GulfWatch mussel program, and individual research projects conducted by researchers at UNH was identified and collated. The data was reviewed for consistency and merged into a single, comprehensive database for the statistical analysis and modeling. PAH source profile data was drawn from an extensive database complied by the USGS (Van Metre and Mahler, 2010) augmented with sealant and other coal tar source data collected in NH (Watts et al, 2010, Watts unpublished data). These sample data and source data were evaluated to identify a set of compounds consistently present in all analysis. These compounds were used to develop the CMB model. The compounds selected for the CMB model were; anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[e]pyrene, benzo[b]fluoranthene, benzo[ghi]perylene, benzo[k]fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene and pyrene.

Coastal Assessment sediment data: NCA data is collected every 1-5 years from the top layer of sediment in 71 locations in the Great Bay. The samples are analyzed for 22 PAH compounds. Conventional compound ratio analysis was used to screen the data and determine if there were any significant difference in compound assemblage based on location (Figure 2). No correlation was found with location, but there is a shift in the 2006 data driven primarily by the flouranthene/pyrene ratio (Figure 2). A higher Fl/Py ratio is consistent with inputs of coal tar compounds released during dredging operations in the Cocheco River in 2004-2005.

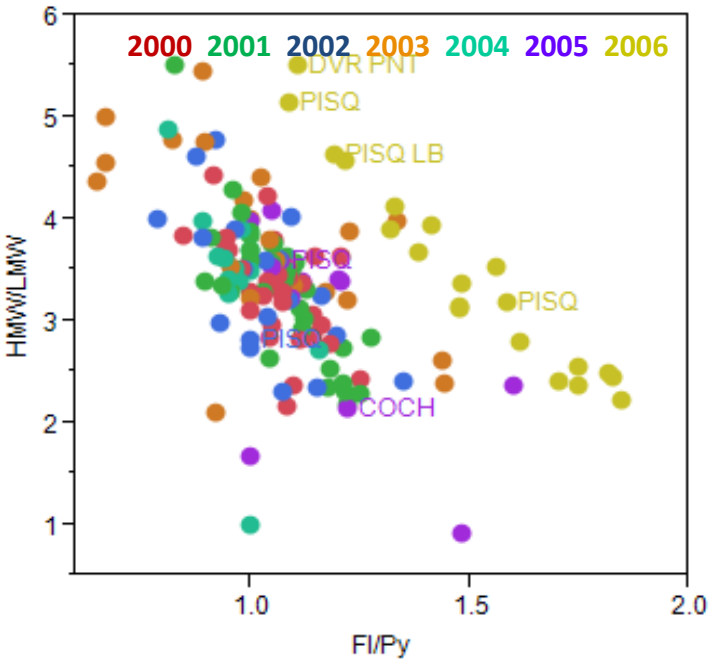


Figure 2. Double ratio plot of flouranthene (Fl)/Pyrene (Py) and high molucular/low molecular weight PAH compounds. Samples were collected at Dover Point (DVR PNT), Pisqcataqua river (PISQ), Little Bay (LB), and the Cocheco River (COCH).

Samples collected from within the Cocheco River before and after dredging show an increase in concentrations (Figure 3), but not a change in source (Figure 4), indicating that erosion of coal tar laden sediments was the primary source of PAHs in the river both prior to, and following, dredging.

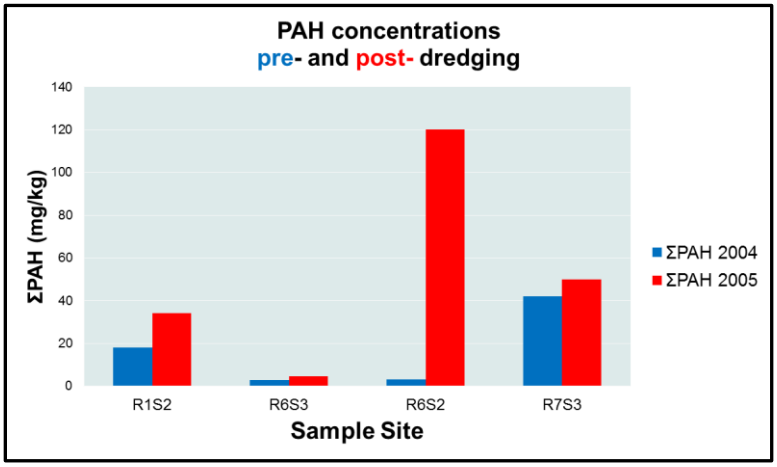


Figure 3. PAH concentrations increased in surface sediment samples collected before and after dredging PAH-contaminated sediments in the Cocheco River.

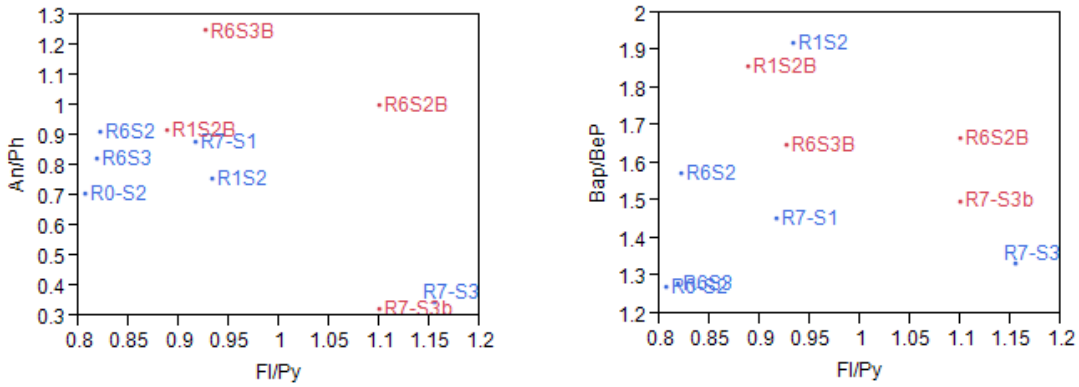


Figure 4. Compounds ratios in pre-and post dredging sediment samples in the Cocheco are similar, indicating that the PAH source did not change.

Regions outside the Cocheco; in the Piscataqua and Little Bay did not experience a measurable rise in concentration (based on the limited data available), but the dominant signature shifted, at least temporarily, from petroleum related sources such as fuel spills, to combustion related sources including coal tar.

Mussel tissue data; Tissue samples are collected by the Gulfwatch program at 21 stations in the Great Bay region, and analyzed for 24 PAH compounds. Compound ratio analysis indicate distinctly different sources of PAH compounds in mussels collected from with Great Bay, Hampton Harbor and South Mill Pond in Portsmouth.

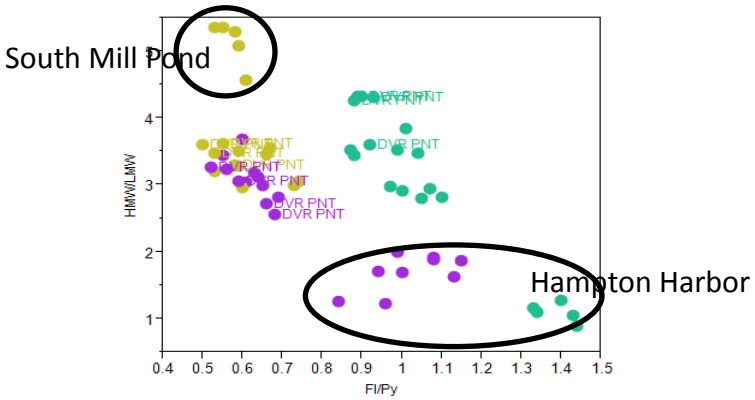
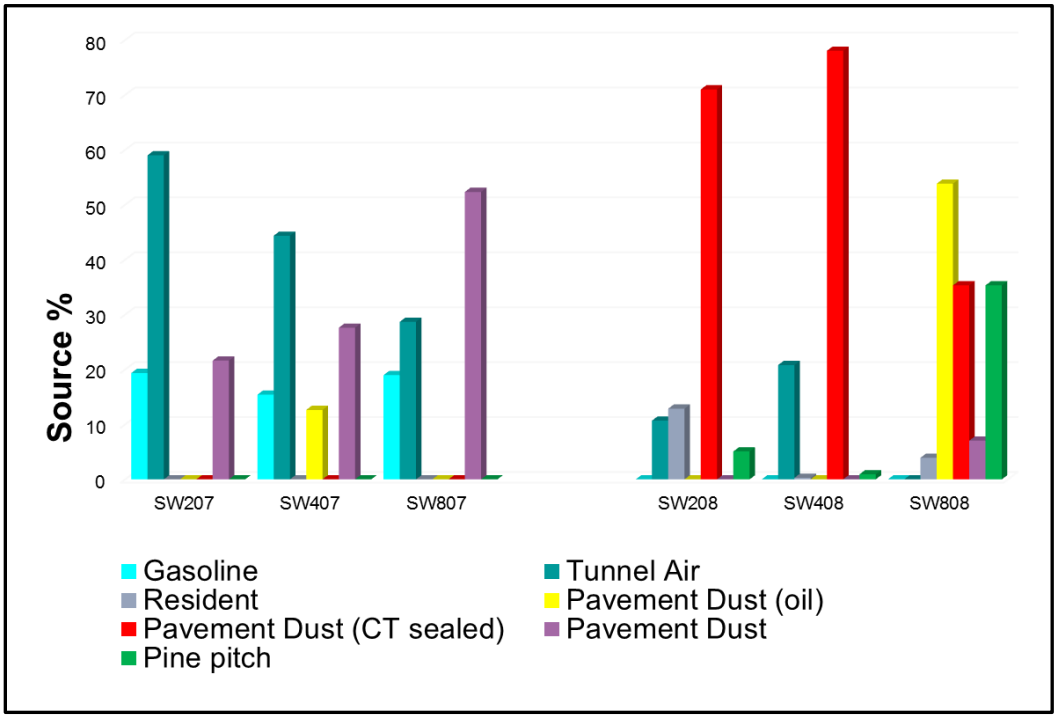


Figure 5. Mussel tissue samples indicate different PAH sources in different water bodies in the Great Bay region.

Source-receptor Modeling: EPA's Chemical Mass Balance (CMB) receptor model consists of a solution to linear equations that express each receptor chemical concentration as a linear sum of products of source profile abundances and source contributions. The CMB model starts with the PAH profiles of known sources and determines the fractional contribution required from each source to reproduce the PAH profile measured in the receptor. The model relies on several primary assumptions; 1) that the PAH profile is constant from source to receptor, and 2) that all potential sources have been identified, and a "fingerprint" profile is available. Chi-square and Pearson correlation will be used to quantitatively evaluate the similarity between source and sediment profiles. Chi-square is calculated as the square of the difference in proportional PAH concentrations divided by the mean of the two values, summed for the total number of PAHs; where lower Chi-square indicates greater similarity. The model is run repeatedly, using various combinations of source profiles, fitting parameters, and estimates of uncertainty to identify a model with the best fit for the source mixtures expected in sediments.

Samples collected at the UNH Stormwater center were used to test the model, and determine if it can effectively differentiate sediments contaminated with coal tar-based sealant from samples not associated with sealant. Samples collected in a stormwater swale prior to sealant application in 2007 were compared to samples collected from the same swale a year later, after coal-tar based sealant was applied to an adjacent parking lot. Figure 6 shows the model results. The model identied tunnel air (automotive exhaust), pine pitch (indicative of wood smoke), and pavement dust as the primary sources of PAHs in the swale prior to sealant, and correctly identified pavement dust from coaltar sealed pavement as a primary source in the post-sealant samples. This exercise confirms the potential for this modeling method to identify locations where coal-tar based sealant is a primary source of PAHs.

Figure 6. EPA Chemical Mass Balance Model of PAH sources in a stormwater swale prior to sealant application (SW207, SW407, SW807 and at the same locations after sealant application (SW208, SW408, SW807). The model correctly identifies the addition of coal-tar-based sealant as the predominant source in 2008.



Principal Findings and Significance

This study confirmed the viability of using PAH compound distributions as a method of identifying PAH sources in Great Bay sediments. We found that:

- Existing national data sets can be used to identify large scale shifts in source, such as contaminants released during river dredging. Specifically, the analysis identified a significant release of PAHs associated with dredging of contaminated sediments in the Cocheco River. This operation increased PAH concentrations in the river downstream of the operation, and impacted (at much lower concentrations) sediments in further reaches of Little Bay.
- Compound analysis can effective identify PAH releases associated with the application of coal-tar-based sealant.
- Existing data sets do not have sufficient spatial resolution to identify the impact of specific practices, such as sealant application, on regional sediments.

A second phase of this study is recommended to extend existing data sets and more fully understand the impact of coal-tar-based sealant on aquatic sediments.

Personnel supported

This project supported 0.8 months of Dr. Watts' time. No students were supported.

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James Hall Vegetated Roof Nutrient Removal Efficiency and Hydrologic Response

Basic Information

Title:	James Hall Vegetated Roof Nutrient Removal Efficiency and Hydrologic Response
Project Number:	2012NH168B
Start Date:	3/1/2012
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	01
Research Category:	Water Quality
Focus Category:	Nutrients, Water Quality, Treatment
Descriptors:	
Principal Investigators:	Robert Roseen, Thomas P. Ballestero

Publications

There are no publications.

James Hall Vegetated Roof Nutrient Removal Efficiency and Hydrologic Response

Project Type: BMP Water Quality and Effectiveness Research
Focus Categories: Effects of urban development and storm water runoff on surface water quality, Non-point source pollution, BMP effectiveness, Education outreach
Keywords: Vegetated Roof, Environmental Education, Water Resources
Project Duration: March 1, 2012 to February 28, 2014 (1 year + a 1 year no-cost extension)

***Agency Funding Requested*:** $7,000.00 Matching Funds: $14,000.00

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Background: The University of New Hampshire Stormwater Center (UNHSC) has been contracted to examine the water quality and hydrologic performance of a EPDM rubber flat compared to that of a vegetated roof. Currently, vegetated roofs are not widely used within New England as a common stormwater Best Management Practice (BMP). However, the incorporation of vegetated roofs into a region's stormwater management plan may be an efficient method of managing flooding issues and reducing nutrient loading to already impacted surfaces waters.

Statement of Critical State Issues: NH faces a host of water resource-related issues, including flooding, drought, non-point source pollution, Lake Eutrophication, erosion and sedimentation, and climate change. Each of these can be related to stormwater runoff and the environmental consequences and management responses. Conventional strategies for managing stormwater discharge such as traditional storm drains and ponds have typically been ineffective at removing nutrients from stormwater runoff. The adverse effects of nutrient pollution on water quality are well documented in state water quality assessments (NITG 2009). The relationship between nitrogen loading, background or historical nitrogen concentrations and dissolved oxygen levels is complex and requires calibrated models to help manage excessive loads (NYSDEC, CTEPA 2000). There is a need to understand the role various Best Management Practices have for nutrient removal in order to help develop estuarine watershed management plans and quantify the impact of the stormwater component of estuarine nitrogen Total Maximum Daily Loads (TMDLs). Total nitrogen is more complex than TSS, Total Phosphorus (TP) and metals because it is not tightly bound to particulates, exists in dissolved inorganic forms, can pass through typical stormwater BMPs, and potentially be introduced into groundwater, stream baseflows and estuarine or coastal waterbodies (PREP 2009).

BMPs have mixed success at removing nitrogen from stormwater. Two primary mechanisms are observed for treatment of nitrogen in stormwater runoff including 1) adsorption and uptake by

vegetated systems (Davis et al 2009), and 2) anaerobic microbial conversion of nitrate to nitrogen gas (Brown and Hunt 2010, Roseen et al 2010). The first mechanism is determined largely by filter media composition, and the second mechanism largely by system configuration and drainage. Traditional stormwater technologies (ponds, swales, hydrodynamic separators) do little to address nitrogen pollution with removal performance observed from zero to at most 33%. Whereas vegetated filter systems, including green roofs, subsurface gravel wetlands, bioretention basins, can have a removal performance as high as 40-95% but are infrequently employed. Bioretention systems are becoming more common as they are relatively simple to build, and provide excellent removal for many stormwater contaminants, including suspended sediments, metals, and hydrocarbons. Tremendous performance variations are observed for different filter medias. Positive nitrogen removal is observed in media systems with low infiltration capacity and low sand content, and neutral or even negative treatment is observed from media with high sand and/or compost contents (FAWB 2008, Davis et al 2009, UNHSC 2010). There is a trend toward the use of rapidly draining medias because they enable smaller filter beds and ultimately reduced cost for construction, however they may be doing little for nitrogen removal. Importantly, filtration medias that are successful at removing nitrogen generally cannot exceed ~40-60% removal from adsorption and vegetative uptake alone.

Statement of Results and Benefits (Research Update):

Limited access and turnover in project staff have delayed deployment of research instrumentation. Installations will be secured over the next reporting period and samples collected analyzed and results interpreted.

Updated Timeline

Timeline:

Task Description	***Start***	***End***	***Status***
Site Assessment	3/1/2013	3/15/2013	Complete
Installation	3/15/2013	4/15/2013	to be completed by 6/15/2013
Initial Sampling	6/15/2013	8/1/2013	On time
Sampling	10/1/2013	1/30/2014	On time
QA/QC and Data reduction	2/1/2014	2/15/2014	On time
Final Report	2/15/2014	2/28/2014	On time

Methods, Procedures, and Facilities:

Research will utilize existing infrastructure within James Hall that splits roof runoff into flat roof and vegetated roof drainage pipes. These piping networks will be employed to sample storm events. Sampling will trigger when an appropriate flow rate is achieved. Once triggered 100 ml aliquots samples will be withdrawn on a flow weighted basis. Every 10 aliquots will be composited within one bottle to represent a specific portion of a storm event. Monitoring equipment from the UNHSC will be used. Storm samples will then be analyzed and further composited to best reflect each storm event. These flow weighted composite samples will then be sent for analysis to the UNH Water Quality Analysis Lab. Hydrologic and analytical results obtained from the laboratory will be evaluated and compiled into a tabular format for further investigation.

Analytical Methods: Analytical testing of water samples will include: total nitrogen and subspecies, total phosphate and subspecies. Analytes and methods are delineated in Table 1. In addition to those analytes listed below, real-time parameters will include pH, dissolved oxygen, conductivity, temperature, turbidity, and flow. Analytical and methods procedures are outlined in the UNHSC Quality Assurance Project Plan, available upon request.

Table 1: Analytes and Analytical Methods.

ANALYTE	METHOD
Nitrate/Nitrite in water	EPA 300.0A
TKN	ASTMD359002A
Ammonia (NH3)	SM4500NH3-D
Total Nitrogen	SM 2540 D
Total Phosphorus	EPA 365.3
Ortho-Phosphate	EPA 300.0A

Expenditures:

To date funds have been used to support staff in developing the research design investigating monitoring locations and setting up equipment. Earnings to date include:

James Houle: $1,890.75
Tim Puls: $1,433.36

Information Transfer Program Introduction

The NH WRRC supported two information transfer projects with its 2012 104b funding:

1. New Hampshire WRRC Information Transfer

2. Participatory Water Quality Assessment Through the NH Lakes Lay Monitoring Program

New Hampshire WRRC Information Transfer

Basic Information

Title:	New Hampshire WRRC Information Transfer
Project Number:	2008NH97B
Start Date:	3/1/2011
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	01
Research Category:	Water Quality
Focus Category:	Management and Planning, Education, Non Point Pollution
Descriptors:	
Principal Investigators:	William H. McDowell

Publications

1. Baillio, J. 2012. 2012. Controls on variability of dissolved greenhouse gas concentration and emissions from small streams in southeastern New Hampshire. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 111 pages.
2. Daley, M.L. and W.H. McDowell, In Preparation, Human impacts on stream nitrogen chemistry and watershed N retention across a wide range of rural to urban catchments, Ecological Applications.
3. Hope, A.J., W.H. McDowell, W.M. Wollheim, Submitted, Ecosystem metabolism and nutrient uptake in an urban, piped headwater stream, Biogeochemistry.
4. Liptzin, D., M.L. Daley, and W.H. McDowell. Accepted. A comparison of wet deposition collectors at a coastal rural site. Submitted to Water, Air, & Soil Pollution. April 2013.
5. Parham, L. 2012. Spatial and temporal variation in degradation of dissolved organic carbon on the main stem of the Lamprey River. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 66 pages.

Information Transfer

Unbridled development and population growth can have detrimental impacts to water resources and ecosystem services. Rapid population growth is occurring in New Hampshire and state regulations, planning board decisions and zoning classifications all attempt to minimize the environmental impact of this rapid population growth. Most land use planning decisions are made at the local level on a town by town basis, often by volunteers who serve on various boards, commissions and committees. Decisions by these various resource managers are often made without a full understanding of the consequences that their decisions will have on water resources or ecosystem services.

This project provided salary for the Center's Director and Associate Director to meet with state representatives, local town officials, watershed groups, school groups, the general public and scientists to discuss WRRC findings that relate to population growth and land use change. The NH WRRC website (http://www.wrrc.unh.edu/) is also used to disseminate information on water resources, and is updated and maintained by salary provided by this project. The time of the Director and Associate Director is increasingly spent discussing current and future research in the Lamprey River Hydrologic Observatory, which is partially funded by the longstanding 104B project "Water Quality and the Landscape: Long-term monitoring of a rapidly developing suburban watershed" and on nitrogen dynamics in New Hampshire's Great Bay watershed. On January 11, 2012 the NH WRRC totally funded and organized the **Sixth Annual Lamprey River Symposium** (see also below). Presentations focused on water quality, hydrology, geomorphology, stormwater, climate and landuse change, aquatic species and habitat, watershed planning and nitrogen cycling in coastal New Hampshire. The symposium attracted approximately 100 attendees, including scientists, regional leaders, town officials, members of state agencies, and federal agencies. The agenda can be found on the NH WRRC Lamprey River Hydrologic Observatory Symposium website. This annual symposium and other discussions in which the Center's Director and Associate Director participate further the research and information transfer goals of the NH WRRC.

2012 Information Transfer Activities Supported by Section 104b Funding and Matching Funds

Data for Public Water Supplies

The NH WRRC's long-term water quality data on the rapidly developing suburban Lamprey River watershed is available to towns as they investigate new potential sources for public water supply. Both Newmarket and Durham, NH have investigated using the Lamprey River to artificially recharge water supply aquifers to meet the town's water supply needs. The NH WRRC has provided both towns and their consulting firm long-term water quality data on the Lamprey River to inform the water supply decision-making processes. As more towns in the future look to the Lamprey for water supply, the long-term dataset provided by the NH WRRC will become increasingly valuable.

Nitrogen Data in New Hampshire's Great Bay watershed

Over the four years, there has been significant focus on nitrogen loading to New Hampshire's largest estuary, the Great Bay estuary, and the impairment to aquatic life it has caused. In August 2009, Great Bay, Little Bay and the tidal rivers were added to the New Hampshire 2008 303d list of impaired waters rendering them in violation of the federal Clean Water Act. Based on the most recent "State of Our Estuaries Report" prepared by the Piscataqua Region Estuaries Partnership (PREP 2013), 32% of the nitrogen entering Great Bay and Little Bay is from point sources; the majority (68%) enters via non-point sources of pollution. The Lamprey River is the largest tributary to Great Bay, and thus the long-term data provided by the NH WRRC from the LRHO are of considerable value for watershed management. The NH WRRC provides the best dataset in NH for assessing the spatial and temporal variability in N concentrations and export in response to suburbanization and changes in land use. These 12+ years of data will be instrumental in assessing the success of current and future efforts to reduce non-point sources of nitrogen pollution reaching Great Bay. There is much interest in LRHO datasets from NH Department of Environmental Services (DES), PREP, the Environmental Protection Agency (EPA) and other municipal, regional, state and federal agents. Many of the presentations and meetings listed below focused on transferring information on nitrogen cycling to stakeholders throughout NH's coastal watershed and beyond. The NH WRRC has received several phone calls to discuss the Great Bay nitrogen issue and also the EPA's draft National Pollutant Discharge Elimination System (NPDES) permits that limit nitrogen in wastewater treatment plant effluent to 3 mg/L in several seacoast communities. The NH WRRC's Associate Director also participated in the Newmarket Community Forum on the Health of the Great Bay Estuary which was intended to inform citizens of the needed wastewater treatment facility upgrades in preparation for the town vote on a warrant article for a new treatment plant.

Symposia, Conferences and Seminars Organized and Funded

The NH WRRC totally funded and organized the "**Sixth Annual Lamprey River Symposium**" held January 11, 2013 in Durham, NH. The symposium is dedicated to exchanging the results of recent research on the water quality, hydrology, water resources issues, and management of the Lamprey River basin. The Symposium is a vehicle for researchers to share data and insights with other researchers, as well as those in the management and policy arena who would benefit from exposure to the latest research on the watershed. The symposium drew approximately 100 attendees, including researchers, legislators, water system operators, town officials, regional leaders and government officials. The symposium contained 13 presentations split up over three sessions. There was a break out session on sensors that collect 'real-time' water-quality data year-round and a poster session during lunch (5 posters and displays were exhibited). The day ended with an open discussion on research priorities in the Lamprey watershed and southeast NH. This event was mostly funded and organized by the NH WRRC. Staff from UNH cooperative extension and Great Bay National Estuarine Research Reserve helped moderate the open discussions and NH EPSCoR assisted with registration and printing. Survey results indicate that 94% of the attendees found the topics covered to be either helpful or very helpful.

The NH WRRC sponsored the "**NH Water and Watershed Conference**" in Plymouth, NH on March 23, 2012. This event was designed to meet the information and networking needs of lake, river, and watershed groups; environmental organizations; volunteer monitors; municipal board and staff members; elected officials; local and regional planners; policy makers; scientists; educators; consultants and students. The was to enhance capacity to understand, protect, and manage New Hampshire's water resources. The NH WRRC co-Sponsored this conference along with Plymouth State University and the Center for the Environment, NH DES, NH Fish and Game, NH Lakes Association, NH Rivers Council, US Geological Survey NH-VT Water Science Center, Weston & Sampson Engineers Inc., White Mountain National Forest, GeoInsight Inc., PP Systems, Sudbury Nurseries West, LLC, YSI, Inc. The conference contained 5 concurrent sessions in the morning and 6 in the afternoon including tropical storm Irene, wastewater and septic infrastructure, outreach, surfacewater nutrients, LID and stormwater management, invasive aquatic plants, Great Bay, drinking water, floodplains, restoration, dams and wetlands. The conference drew over 250 people, including researchers, legislators, water system operators, land use planners, and government officials.

Publications

Baillio, J. 2012. 2012. Controls on variability of dissolved greenhouse gas concentration and emissions from small streams in southeastern New Hampshire. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 111 pages.

Daley, M.L. and W.H. McDowell, *In Preparation*, Human impacts on stream nitrogen chemistry and watershed N retention across a wide range of rural to urban catchments, Ecological Applications.

Hope, A.J., W.H. McDowell, W.M. Wollheim, Submitted, Ecosystem metabolism and nutrient uptake in an urban, piped headwater stream, Biogeochemistry.

Liptzin, D., M.L. Daley, and W.H. McDowell. Accepted. A comparison of wet deposition collectors at a coastal rural site. Submitted to Water, Air, & Soil Pollution. April 2013.

Parham, L. 2012. Spatial and temporal variation in degradation of dissolved organic carbon on the main stem of the Lamprey River. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 66 pages.

Conference Proceedings & Abstracts:

Argerich, A., S.L. Johnson, S.D. Sebestyen, C.C. Rhoades, E. Greathouse, M.B. Adams, D.M. Amatya, J.L. Campbell, G.G. Ice, J.B. Jones, J.D. Knoepp, G.E. Likens, W.H. McDowell, and P.M. Wohlgemuth. 2012. Temporal trends in stream N concentrations and biogeochemical responses to disturbances in long term reference watersheds. National Council for Water Quality Monitoring, Annual Meeting, Portland, Oregon April 2012.

Argerich, S., S.L. Johnson, S.D. Sebestyen, C.C. Rhoades, E.Greathouse, P.M. Wohlgemuth, F.N. Scatena, W.H. McDowell, G.E. Likens, J.D. Knoepp, J.B. Jones, G.G. Ice, J.L. Campbell, D.M. Amatya, and M.B. Adams. 2012. Effects of forest disturbances on stream nitrate concentrations. Annual Meeting of the Ecological Society of America, Portland, Oregon. August, 2012.

Argerich, A., .S.L. Johnson, S.D. Sebestyen, C.C. Rhoades, E. Greathouse, P.M. Wohlgemuth, F.N. Scatena, W.H. McDowell, G.E. Likens, J.D. Knoepp,J.B. Jones, G.G. Ice, J.L. Campbell, D.M. Amatya, and M.B. Adams. 2012. Effects of forest disturbances on stream nitrate concentrations in sites participating in StreamChemDB. LTER All Scientists Meeting, Estes Park, CO, September 2012.

Frey, S.D., R. Bowden, E. Brzostek, A. Burton, B. Caldwell, S. Crow, C. Goodale, S. Grandy, A. Finzi, M. Kramer, K. Lajtha, M. Martin, W. McDowell, R. Minocha, K. Nadelhoffer, S. Ollinger, P. Templer, and K. Wicking. 2012. Temperate forest soils sequester as much carbon as trees in response to nitrogen deposition. LTER All Scientists Meeting, Estes Park, CO, September 2012.

Greathouse, E.A., S.L. Johnson, D. Henshaw, S.D. Sebestyen, C.C. Rhoades, W.H. McDowell, J. Jones, G. Ice, and A. Argerich. Current status of StreamChemDB, a proposed web-accessible database of stream chemistry at U.S. Forest Service Experimental Forests and National Science Foundation Long-term Ecological Research sites. National Council for Water Quality Monitoring, Annual Meeting, Portland, Oregon April 2012.

Liptzin, D., M.L. Daley, and W.H. McDowell. 2012. A collector comparison for wet deposition at a coastal New Hampshire site. NADP National meeting, Portland, ME, October 2012.

Lombard, M.A., H. Mao, M. Daley, J. Bryce, W.H. McDowell, and R. Talbot. Relationships between mercury and sea salt ion concentrations in rainwater from a marine site. Northeastern Section of the Geological Society of America, Hartford, CT March 2012.

McDowell, W.H. 2012. NEON and STREON: Opportunities and challenges for the aquatic community. Annual meeting of the Society for Freshwater Sciences, Louisville, KY. May 2012.

McDowell, W.H. 2012. Consequences of climate and land use change for ecosystems and ecosystem services in New Hampshire. Invited symposium presentation, Ecosummit, Ecological Society of America, Columbus, OH, October, 2012.

McDowell, W.H. 2012. Management of urbanizing watersheds: Central tendencies, outliers, and the art of the possible. Invited presentation, AGU Annual fall meeting, San Francisco, CA. December, 2012.

Wymore, A.S., Z.G. Composn, P. Kein, C.M. Liu, W.H. McDowell, L.B. Price, T.G. Whitham, and J.C. Marks. 2012. Leaf litter phytochemistry influences stream fungi:bacterial ratios,

microbial community structure and ecosystem-level processes. Annual Meeting of the Society for Freshwater Sciences, Louisville, KY. May 2012.

Presentations/Information Transfer

Daley, M.L. and McDowell, W.H. 2012. Non-Point Nitrogen Sources and Transport Pathways in the Great Bay Watershed. NH Water and Watershed Conference. Plymouth, NH. March 2012.

Daley, M.L. and McDowell, W.H. 2012. Nitrogen in the Great Bay and Lamprey Watershed. Lamprey River Advisory Committee. Raymond, NH. March 2012.

Daley, M.L. and McDowell, W.H. 2012. Nitrogen challenges in the Great Bay watershed. Living on Great Bay lecture series: the challenges. Supported by We The People; Sponsored by the Green Sanctuary Project of the first UU Church of Exeter, NH. May 2012.

Daley, M.L. Nitrogen Drivers in the Great Bay watershed. Non-point source nitrogen pathways. Boat Tour of Great Bay. NEIWPCC Annual Nonpoint Source Pollution Conference. Portsmouth, NH. May 2012.

Daley, M.L., McDowell, W.H., Potter, J.D., French, C. and Miller, S. 2012. Nitrogen Sources Collaborative Advisory Board Water Quality Analysis Lab Tour and Field Trip to Great Bay stream sites. Durham and Lee, NH. Durham and Lee, NH. July 2012.

Daley, M.L. 2012. Urbanization and Suburbanization in NH watersheds. University of New Hampshire Watershed Water Quality Management class. Durham, NH. September 2012.

Daley, M.L. 2012. Water Quality Research in the Lamprey River Hydrologic Observatory. University of New Hampshire Approach to Research class. Durham, NH. October 2012.

Daley, M.L. and McDowell, W.H. 2012. Addressing Nitrogen Issues in Great Bay – Non-Point Nitrogen Sources. Co-sponsored by the Oyster River Local Advisory Committee and the Oyster River Watershed Association. Madbury, NH. November 8, 2012.

Daley, M.L. 2012. Ten Years of Water Quality data in the Ossipee Watershed. Green Mountain Conservation Group Community Forum – Looking at 10 Years of Data. Chocorua Village, NH. November 2012.

Daley, M.L. 2012. Watershed management in practice: Great Bay. University of New Hampshire Watershed Water Quality Management class. Durham, NH. September 2012.

Daley, M.L. 2012. Nitrogen in the Great Bay Watershed: Point and Nonpoint Sources (with specifics for the Lamprey River). Newmarket Community Forum on the Health of the Great Bay Estuary. Newmarket, NH. February 19, 2013.

Daley, M.L. shared Daley et al. 2009 "Salinization of urbanizing New Hampshire streams and groundwater: effects of road salt and hydrologic variability" paper with Mike Russo as data to support road salt reductions in the town of Nottingham, NH. December 6, 2012.

McDowell, W.H. 2012. Hydrofracking, energy, and water quality. Active retirement Association, Durham. NH. October 21, 2012.

McDowell, W.H. 2012. Groundwater and Surface Water Contamination in Suburban Basins. Active Retirement Association, Durham, NH. October 28, 2012.

McDowell, W.H. 2013. Overview of the EPSCoR aquatic sensor network. Annual Lamprey River Science Symposium. Durham, NH. January 11, 2013.

Press Releases

Daley, M.L., McDowell, W.H., French, C. and Miller, S. 2012. Scientists around Great Bay collaborate with local citizens to address pollution. Piscataqua Region Estuaries Partnership "Downstream" newsletter. July 26, 2012.

McDowell, W.H. 2012. Research Profile: Bill McDowell – Protecting Water Quality for Now and the Future. Campus Journal. University of New Hampshire. October 31, 2012.

Meetings Attended:

Daley, M.L. 2012. Meet with Durham and UNH officials to discuss possibility of installing in situ sensors in the Lamprey at Wiswall Dam. Durham, NH. March 15, 2012.

Daley, M.L. 2012. Met with NH Senator Jeanne Shaheen staffer Sarah Holmes to discuss water resources and Northern Forest issues in the state and region. Dover, NH. March 28, 2012.

Daley, M.L. 2012. Met Dave Cedarholm at Wiswall dam to discuss site location of in situ sensors. Durham, NH. March 28, 2012.

Daley, M.L. 2012. Attended PREP Technical Advisory Committee / Reserve Advisory Board (TAC/RAB) meeting focused on reviewing draft indicators for the 2012 State of Our Estuaries report. Portsmouth, NH. May 30, 2012.

Daley, M.L. 2012. Attended the Lamprey River New Floodplain Maps workshop. Raymond, NH. June 1, 2012.

Daley, M.L. 2012. Attended the Great Bay National Estuarine Research Reserve (NERR) System Wide Monitoring Program (SWMP) quarterly meeting. Durham, NH. June 14, 2012.

Daley, M.L. 2012. Attended the Water Sustainability in New Hampshire conversation for water professionals. Hosted by the Governor's Water Sustainability Commission. Concord, NH. July 9, 2012.

Daley, M.L. 2012. Attended meeting hosted by Great Bay Municipal Coalition to go over recent study results. Portsmouth, NH. July 19, 2012.

Daley, M.L. 2012. Attended PREP technical advisory committee meeting focused on the State of the Estuaries Report. Portsmouth, NH. July 19, 2012.

Daley, M.L. 2012. Attended Bacteria Source Tracking Workshop. Hosted by NH DES and FB Environmental. Portsmouth, NH. August 8, 2012.

Daley, M.L. and McDowell, W.H. 2012. Attended PREP technical advisory committee meeting focused on the State of the Estuaries Report. Lee, NH. September 26, 2012.

Daley, M.L. 2012. Attended the Stewardship Network in New Hampshire forum. Greenland, NH. September 27, 2012.

Daley, M.L. 2012. Attended the Pawtuckaway Lake Science Roundtable. NH DES. Concord, NH. September 28, 2012.

Daley, M.L. 2012. Meet with Kathy Fallon Lambert (Harvard University), Christopher Neil (MBL) and Anne Giblin (MBL) to discuss legal, advocacy and science issues for Great Bay and potential steps forward. Boston, MA. October 16, 2012.

Daley, M.L. 2012. Attended meeting to discuss Town of Durham and UNH integrated watershed management plan for the Oyster River. Durham, NH. October 17, 2012.

Daley, M.L. 2012. Attended meeting with Green Mountain Conservation Group to discuss analysis of 10 years of water quality data. October 25, 2012.

Daley, M.L. 2012. Attended the Seacoast Science Café: The Health of Great Bay: Great Big Challenges and Great Big Opportunities. Portsmouth, NH. December 5, 2012.

Daley, M.L. 2012. Attended the State of Our Estuaries Conference. Portsmouth, NH. December 7, 2012.

Daley, M.L. 2013. Joined the GMCG Research Committee Meeting via conference call. January 14, 2013.

McDowell, W.H. 2012. Met with Kathy Weathers from the Carey Institute of Ecosystem Studies and Christopher Neill from the Marine Biological Laboratory to discuss nutrient pollution in the Great Bay and how we can better link science and policy throughout the region. September 11, 2012.

Participatory Water Quality Assessment Through the NH Lakes Lay Monitoring Program

Basic Information

Title:	Participatory Water Quality Assessment Through the NH Lakes Lay Monitoring Program
Project Number:	2012NH174B
Start Date:	3/1/2012
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	001
Research Category:	Water Quality
Focus Category:	Water Quality, Non Point Pollution, Management and Planning
Descriptors:	
Principal Investigators:	Jeffrey Schloss

Publications

1. Craycraft, Robert and Jeffrey A. Schloss. 2012. Baboosic Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 138 pps.
2. Craycraft, Robert and Jeffrey A.Schloss. 2012. Bow Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 114 pps.
3. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Chocorua Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 80 pps.
4. Craycraft, Robert and Jeffrey A.Schloss. 2012. Conway Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH.92 pps.
5. Craycraft, Robert and Jeffrey A.Schloss. 2012 Crystal Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 76 pps.
6. Craycraft, Robert and Jeffrey A.Schloss. 2012 Goose Pond Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 78 pps.
7. Craycraft, Robert and Jeffrey A.Schloss. 2012. Great East Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 106 pps.
8. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Kanasatka Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 86 pps.
9. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lovell Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 86 pps.

10. Craycraft, Robert and Jeffrey A.Schloss. 2012. Mendums Pond Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 80 pps.
11. Craycraft, Robert and Jeffrey A.Schloss. 2012. Merrymeeting Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 86 pps.
12. Craycraft, Robert and Jeffrey A.Schloss. 2012. Milton Ponds (Depot, Townhouse and Northeast) Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH..98 pps.
13. Craycraft, Robert and Jeffrey A.Schloss. 2012. Mirror Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 76 pps
14. Craycraft, Robert and Jeffrey A.Schloss. 2012. Naticook Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 80 pps
15. Craycraft, Robert and Jeffrey A.Schloss. 2012. Nippo Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 78 pps
16. Craycraft, Robert and Jeffrey A.Schloss. 2012. North River Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 72 pps
17. Craycraft, Robert and Jeffrey A.Schloss. 2012. Silver Lake (Madison) Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 98 pps
18. Craycraft, Robert and Jeffrey A.Schloss. 2012. Highland Lake (Windham ME) Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 106 pps
19. Craycraft, Robert and Jeffrey A.Schloss. 2012. Squam Lakes Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 160 pps
20. Craycraft, Robert and Jeffrey A.Schloss. 2012. Sunset Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 63 pps
21. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Wentworth and Crescent Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 108 pps
22. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Alton Bay Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 93 pps
23. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Meredith Bay Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 64 pps
24. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Saunders Bay Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 110 pps
25. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Saunders Bay Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 110 pps
26. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Tuftonboro Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 110 pps

27. Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnisquam Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 74 pps

2012NH174B

Participatory Water Quality Assessment Through the NH Lakes Lay Monitoring Program

Problem:

The fresh waters of New Hampshire represent a valuable resource contributing to the State's economic base through recreation, tourism, real estate revenues and taxes. In addition some lakes and rivers serve as current or potential drinking water reservoirs/supplies. For most residents our generally pristine waters help to insure a high quality of life. However, New Hampshire currently leads all of the New England states in the rate of new development and redevelopment (Society for the Preservation of New Hampshire Forests, Governor's Office of Energy and Planning). The long-term consequences of the resulting pressure and demands on the state's precious water resources remain unknown. Of particular concern is the response of our waters to increasing non-point source pollutant loading due to watershed development and land use activities. Local citizens, lake/watershed associations and local decision-makers remain in dire need of additional information required for the intelligent management of our water resources on the local level. State agencies need to be better informed on water quality changes and trends. Limited financial resources do not allow for adequate monitoring of these waters by state or federal agency personnel,

The recent increase of infestations of invasive species such as variable water milfoil as well as the proliferation of blue green bacteria blooms, which can leach dangerous toxins impacting humans and wildlife, has threatened the water quality and has limited or restricted use of NH waters at an increasing rate. There is still no mechanism for successful eradication of milfoil and we are just beginning to understand the conditions that favor blue green bacteria blooms and their ecological impacts through cutting edge research by UNH faculty and students.

Objectives:

The funds provided by the WRRC provided continued partial support of our long term citizen science participatory monitoring effort, the NH Lakes Lay Monitoring Program (LLMP). Additional support for this effort is provided by UNH Cooperative Extension, The UNH College of Life Sciences and Agriculture, USDA National Institute of Food and Agriculture, New Hampshire Department of Environmental Services (NH DES; from US EPA section 319 funding) and from towns, municipalities and lake associations throughout the state.

1- The continued collection and analysis of long-term water quality data in selected watersheds.

2- The dissemination of the results of the analysis to cooperating agencies, water managers, educators and the public on a local, statewide and regional basis.

3- To offer undergraduate and graduate students the opportunity to gain hands-on experience in water quality sampling, laboratory analysis, data management and interpretation.

4- To further document the changing water quality in a variety of watersheds throughout the state in the face of land use changes and best management efforts.

Methods

Lake and stream monitoring through the LLMP generally involved a minimum of monthly sampling starting at spring runoff through to lake stratification and weekly to bi-weekly sampling through to fall mixis. Water clarity, chlorophyll a, acid neutralizing capacity, dissolved organic color, dissolved oxygen and nutrients (total N, total P and nitrate) will be the default suite of parameters measured for lakes while nutrients, turbidity, dissolved organic color and flow will be the parameters of choice for the lake tributary work. On occasion, student field teams traveled to join the volunteer monitors to perform quality assurance checks and do more in-depth analysis and lake profiling. All LLMP field sampling and laboratory analysis follows approved Quality Assurance Projects Plans and Site Specific Project Plans reviewed by NH DES and US EPA New England and are on file with both agencies.

As stated above the primary scope of this project was to maintain the long-term data collection effort of the LLMP and support information transfer for informed local decision making regarding water resources.

Principal findings and significance

Focus of this year's efforts was on the Newfound Lake Watershed and Wentworth Lake

These research findings continued to support an innovative approach used by the Newfound Lake Regional Association to have the watershed towns consider changing their current development ordinances to utilize variable buffer width requirements based on slope. To date 2 towns have incorporated this recommendation and additional towns are considering the measure. For this year specifically, volunteer data were used to help calibrate a watershed land use nutrient loading model as well as a lake response model for the resulting phosphorous nutrient loading.

The Town of Wolfeboro and Lake Wentworth Foundation developed a Watershed Management Plan to protect Lake Wentworth and Crescent Lake. Tributary and in-lake water quality data collected through the NH LLMP were used to calibrate a watershed land use nutrient loading model as well as a lake response model for the resulting phosphorous nutrient loading. The resulting information is being used by the Town of Wolfeboro, the Lake Wentworth Association and the Lake Wentworth Foundation to consider regulation and zoning amendments, to target educational/outreach efforts and to prioritize problem areas for remediation.

Publications and Presentations

<u>Reports:</u>

Craycraft, Robert and Jeffrey A. Schloss. 2012. Baboosic Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 138 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Bow Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 114 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Chocorua Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 80 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Conway Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH.92 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012 Crystal Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 76 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012 Goose Pond Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 78 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Great East Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 106 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Kanasatka Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 86 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lovell Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 86 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Mendums Pond Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 80 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Merrymeeting Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 86 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Milton Ponds (Depot, Townhouse and Northeast) Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH..98 pps.

Craycraft, Robert and Jeffrey A.Schloss. 2012. Mirror Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 76 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Naticook Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 80 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Nippo Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 78 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. North River Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 72 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Silver Lake (Madison) Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 98 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Highland Lake (Windham ME) Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 106 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Squam Lakes Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 160 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Sunset Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 63 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Wentworth and Crescent Lake Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 108 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Alton Bay Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 93 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Meredith Bay Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 64 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Saunders Bay Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 110 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnipesaukee-Tuftonboro Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 110 pps

Craycraft, Robert and Jeffrey A.Schloss. 2012. Lake Winnisquam Annual Lake Report for 2011. New Hampshire Lakes Lay Monitoring Program; UNH Center for Freshwater Biology and UNH Cooperative Extension. Durham, NH. 74 pps

Presentations:

Craycraft, Robert. 2012. Lake Winnipesaukee Cruise water quality talk: water quality sampling and water quality threats. June 24, 2012 Attendance: Approximately 30.

Craycraft, Robert. 2012. Naturally Newfound Fair: Water quality monitoring in the Newfound Lake watershed. June 30, 2012. Attendance: Approximately 300.

Craycraft, Robert 2012. New Hampshire Coverts Project lecture: Water quality overview and threats to New Hampshire lakes. .October 5, 2012. Attendance: 22.

Outreach/Information Transfer

March 23, 2012 –Presented invited opening plenary lecture for Canada Water Day Conference, Dalhousie University, Nova Scotia: "Citizen Science: Participatory Water Resources Monitoring Supports High Tech Analyses". (Jeff Schloss)

April 6, 2012- Guest lecture-for NREN Introduction to Water Resources on the Lakes lay Monitoring Program and NH Lakes. (Schloss)

May 4, 2012- Panel Discussion –Volunteer Monitoring- for the 2012 National Water Quality Monitoring Conference. Portland Oregon. (Schloss)

May 17, 2012- Newfound Lake Project Update- Water Quality Modeling for the Watershed –(Schloss).

June 8, 2012- Landscaping at the Water's Edge Workshop. New England Chapter of the North American Lake Management Association. (Schloss)

June 9th, 2012- Presentation: "Global Change and Our New England Lakes: What can we expect?" New England Chapter of the North American Lake Management Association. (Schloss).

July 3, 2012. Meeting at NH Dept. Of Environmental Services regarding NH LLMP data sharing and the Winnipesaukee Watershed Gateway web site. (Schloss)

September 13, 2012 Newfound Lake Watershed Forestry Roundtable Discussion (Alexandria NH): Discussed water quality sampling results as part of a Newfound Lake sustainable forestry discussion. (Robert Craycraft)

December 6, 2012- Invited presentation "Lessons Learned from a Long-Tern Participatory Water Quality Monitoring Program" Special session on Citizen Science, American Geophysical Union Annual Meeting. San Francisco, CA (Schloss).

Students Supported
While no WRRC support was provided for direct undergraduate student support, the following students were indirect beneficiaries of WRRC support to the NH LLMP:
Undergraduate Students

Casey Chalmers	Environmental Conservation	Junior
Michel Henlou	Environmental Conservation	Senior (Spring 2012 Grad)
Hannah Johnson	Environmental Conservation	Senior (Spring 2013 Grad)
Emma Leslie	Zoology	Senior (Spring 2012 Grad)
Ashley Lupus	Medical Science	Senior (Spring 2012 Grad)
Cara McGuire	Environmental Conservation	Senior (Spring 2012 Grad)
Jessica Waller	Marine Biology	Senior (Spring 2013 Grad)

Graduate Students (directly supported):

Jeff Schloss	Natural Resources and Environmental Studies	PhD candidate

Faculty Staff Supported
Directly: Jeff Schloss- Extension Professor in Biological Science
Indirectly: Robert Craycraft, Educational Program Coordinator, LLMP UNH Cooperative Extension.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	14	0	0	2	16
Masters	6	0	0	0	6
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	22	0	0	2	24

Notable Awards and Achievements

Publications from Prior Years