6-1-2013

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.

William H. McDowell  
*University of New Hampshire, bill.mcdowell@unh.edu*

Steve Kahl  
*University of New Hampshire*

Follow this and additional works at: [https://scholars.unh.edu/nh_wrrc_scholarship](https://scholars.unh.edu/nh_wrrc_scholarship)

**Recommended Citation**  
[https://scholars.unh.edu/nh_wrrc_scholarship/31](https://scholars.unh.edu/nh_wrrc_scholarship/31)
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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td>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.</td>
</tr>
<tr>
<td>Project Number:</td>
<td>2011NH164S</td>
</tr>
<tr>
<td>Start Date:</td>
<td>3/28/2011</td>
</tr>
<tr>
<td>End Date:</td>
<td>4/30/2014</td>
</tr>
<tr>
<td>Funding Source:</td>
<td>Supplemental</td>
</tr>
<tr>
<td>Congressional District:</td>
<td></td>
</tr>
<tr>
<td>Research Category:</td>
<td>Climate and Hydrologic Processes</td>
</tr>
<tr>
<td>Focus Category:</td>
<td>Acid Deposition, Surface Water, Law, Institutions, and Policy</td>
</tr>
<tr>
<td>Descriptors:</td>
<td></td>
</tr>
<tr>
<td>Principal Investigators:</td>
<td>William H. McDowell, Steve Kahl</td>
</tr>
</tbody>
</table>

Publications

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\textsuperscript{1}, Sarah J. Nelson\textsuperscript{2}, J. Steve Kahl\textsuperscript{1}, J. Saros\textsuperscript{2}

\textsuperscript{1}Univ. of New Hampshire, \textsuperscript{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 25\textsuperscript{th} 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.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>project period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>funding received</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLTM drainage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLTM seepage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>original LTM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HELM subset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BBWM - EB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME New England</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME Adirondacks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sample analyses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data submission</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>annual report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

= project plan
= in progress
= completed
= cancelled (weather)
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 \( \text{SO}_4 \) 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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RLTM-Maine</td>
<td>seepage</td>
<td>3</td>
<td>3</td>
<td>UMaine</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drainage</td>
<td>9</td>
<td>3</td>
<td>UMaine/UNH</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTM lakes</td>
<td>3</td>
<td>1</td>
<td>UMaine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New England</td>
<td></td>
<td>31</td>
<td>1</td>
<td>UNH</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adirondacks</td>
<td></td>
<td>42</td>
<td>1</td>
<td>ALSC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HELM</td>
<td></td>
<td>25-30</td>
<td>1</td>
<td>UNH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

**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 (CH₄, CO₂, and N₂O) 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):


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


Kahl, J.S., 2005 (invited). The intersection of environmental science and environmental policy. NH Charitable Foundation Lakes Region annual meeting, Meredith, NH, September, 2005.


Kahl, J.S., and Catherine Rosfjord, 2005 (invited). Acid rain and the Clean Air Act in the northeastern US. Annual meeting of the NH-ME Androscoggin River Watershed Council, Bethel, June, 2005


Kahl, J.S., 2004 (invited). The Clean Air Act Amendments of 1990; testing a program designed to evaluate environmental policy. Lecture, Colby College. April, 2004


Recent Bear Brook publications that include “base program” data (East Bear Brook stream chemistry partly funded through this grant):


