LAKE CHAMPLAIN RESEARCH CONSORTIUM
WATER QUALITY CONFERENCE
SEPTEMBER 29, 2006 AT SAINT MICHAEL'S COLLEGE

PROGRAM

Oral Presentations

9:00 Long-range transport and deposition of atmospheric mercury in the Lake Champlain Basin - Eric K. Miller, Sean Lawson, Melody Burkins, Mim Pendleton, Alan VanArsdale, Jamie Shanley

9:25 Development of a new toxics management strategy for the Lake Champlain Basin, and an evaluation of emerging contaminants in specific lake segments – Neil Kamman, Ann Chalmers, Doug Burnham, Greg Druschel, Nancy Hayden, Meg Modley, Art Stemp, Nat Shambaugh, Mary Watzin

9:50 A reconnaissance of pesticides in the surface waters of the Lake Champlain Basin – Nat Shambaugh

10:15 Break – view posters (titles listed below)

10:30 Toxicity of new generation herbicides versus atrazine: are herbicides responsible for cyanobacterial blooms in Missisquoi Bay, Lake Champlain? – T.J. Basara, T.B. Mihuc, and M.R. Twiss

10:55 Understanding phosphorus dynamics in runoff to Baie Missisquoi, Lake Champlain – Mark Eastman and Chandra A. Madramootoo

11:20 Meeting P target loads for Missisquoi Bay: SWAT-predicted influence of cropping system alterations - Aubert R. Michaud, Isabelle Beaudin, and Julie Deslandes

11:45 lunch and poster session (titles listed below)

12:45 Impacts of uptyping: legal, regulatory and water quality implications of linking reclassification of Vermont's waterways with Basin Plan approval - Rebecca Purdom and Ethan Swift

1:10 The growing hypoxic zone in the northeast arm of Lake Champlain - Eric Smeltzer

1:35 A trophic history of Lake Champlain since European settlement - Suzanne N. Levine, Andrea Lini, Heather D. Burgess, Milton L. Ostrofsky, Peter Leavitt, Lynda Bunting, Daun M. Dahlen, and Neil Kamman

2:00 closing comments and adjournment

Poster presentations

SWAT-modeled influence of landscape and cropping system on phosphorus mobility within the Pike River watershed. - Julie Deslandes, Isabelle Beaudin, and Aubert R. Michaud (IRDA, Québec)

Linking urban land use to stream geomorphology and biotic integrity in the Lake Champlain Basin, Vermont - Evan P. Fitzgerald, William B. Bowden, and Julie Foley (UVM)

Chloride concentrations in Vermont surface waters - Doug Burnham, Jim Kellogg, Rich Langdon, and Angela Shambaugh (Water Quality Division, Vermont Department of Environmental Conservation)

Long-range Transport and Deposition of Atmospheric Mercury in the Lake Champlain Basin

Eric K. Miller (Ecosystems Research Group, Ltd.), Sean Lawson (Vermont Monitoring Cooperative), Melody Burkins (University of Vermont), Mim Pendleton (University of Vermont), Alan VanArsdale (USEPA), Jamie Shanley (USGS)

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Recent emissions-transport modeling conducted by USEPA in support of the Clean Air Mercury Rule (CAMR) depicted rapid deposition of divalent mercury (Hg^{2+}) – also known as reactive gaseous mercury (RGM) – after its release into the atmosphere from major emission sources such as electrical generating units (EGUs). Rapid Hg^{2+} deposition is thought to produce deposition hot-spots immediately downwind of EGUs but to limit the ecological impact on areas like the Lake Champlain Basin which are distant from major emissions sources. Current emission-transport models depict gaseous elemental mercury (GEM) emitted from EGUs as transported long distances and not readily deposited. Model simulations of low deposition rates for GEM and low rates of GEM to RGM conversion in the continental atmosphere have been used to suggest that GEM emissions are environmentally benign and have little impact on ecosystems either local or distant from sources. Model simulations of the behavior of emitted mercury have had an important influence on recent federal rulemaking. However, few observations have been available to evaluate the validity of the model parameterizations and assumptions.

New observations of RGM in air and Hg^{2+} in precipitation at Underhill, Vermont (distant from major sources) suggest that significant long-range transport of divalent mercury occurs frequently in both summer and winter. Air-mass back-trajectories suggest that source regions for elevated RGM and precipitation Hg in northern Vermont are western NY, OH, PA, and NJ where older EGUs are located. The new observations also suggest that conversion of GEM to RGM via ozone oxidation can be significant.

The emission-transport modeling conducted in support of CAMR underestimated the observed wet and dry deposition of Hg^{2+} in northern Vermont. The CAMR modeling also did not quantify GEM deposition to plant foliage, omitting ~1/3 of total mercury deposition and an important pathway for transfer of atmospheric mercury to terrestrial food webs.

Development of a New Toxics Management Strategy for the Lake Champlain Basin, and an Evaluation of Emerging Contaminants in Specific Lake Segments

Neil Kamman (VTDEC), Ann Chalmers (USGS), Doug Burnham (VTDEC), Greg Druschel (UVM), Nancy Hayden (UVM), Meg Modley (LCBP), Art Stemp (NYSDEC), Nat Shambaugh (VTAAFM), Mary Watzin (UVM)

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During 2005 and 2006, the Lake Champlain Basin Program (LCBP) embarked on a revision of the Toxics Substances chapter of *Opportunities for Action* (OFA), the evolving plan for the Lake Champlain Basin, with the goal of developing a toxic substances management strategy for the Basin. In order to develop a renewed strategy, the LCBP Technical Advisory Committee empaneled a subcommittee to review and expande the current listing of priority toxic substances, and to develop management strategies to address them. The subcommittee consists of regional scientists with expertise in the several aspects of aquatic and human ecotoxiclolgy, and pollution control. While the original strategy in OFA identified four broad classes of contaminants, the revised listing articulates seven broad categories. These include bioaccumulating toxics, pesticides, pharmaceuticals and personal care products, trace elements, road salts, cyanobacterial toxins, and other chemicals. Within these, strategies including assessment, regulation, prevention, reduction, remediation are being articulated. Several of the seven contaminant classes contain a wide variety of individual compounds generally referred-to as “new-generation” or “emerging” contaminants. Coincident with the LCBP initiative, the United States Geological Survey has launched a field initiative to measure the occurrence and severity of a large suite of these emerging contaminants. Samples have been collected from a variety of sites including wastewater discharges, major tributaries receiving wastewater effluent and/or agricultural non-point source runoff, lake waters, and lake-bed sediments. In this presentation, the current status of the Strategy revisions will be described, as will the design and preliminary results of the USGS field survey.

A Reconnaissance of Pesticides in the Surface Waters of the Lake Champlain Basin

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As part of an on-going effort to understand the impacts of agriculture on the Vermont environment, the Vermont Agency of Agriculture has been analyzing surface water from the Lake Champlain basin since 2002 for certain pesticides and degradates. Water samples were collected by the VTDEC/LCBP long-term monitoring program staff from various Lake Champlain sites and tributaries. These samples were analyzed for some of the most commonly used pesticides and their breakdown products. Site specific annual variability of pesticide concentrations, as well as relationships with flow and nutrients will be discussed.

Toxicity of New Generation Herbicides Versus Atrazine: Are Herbicides Responsible for Cyanobacterial Blooms in Missisquoi Bay, Lake Champlain?

Tiffany J. Basara (Clarkson University Center for the Environment), Timothy B. Mihuc (Lake Champlain Research Institute at Plattsburgh State University), and Michael R. Twiss (Clarkson University Center for the Environment)

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It is not currently known what causal factor is responsible for the formation of late summertime blooms of toxigenic cyanobacteria in Missisquoi Bay (QC, VT). One hypothesis is that herbicides entering into the water from agricultural lands serve as selective factors for determining phytoplankton community composition. Research suggests that cyanobacteria may be more resistant to herbicides than eukaryotic algae (Fairchild et. al 1998, Seguin et. al 2001, Leboulanger et. al 2001). Acute toxicity tests (96h EC50) were used to assess the relative toxicity levels of “new generation” herbicides (dimethenamid, flumetsulam, mesotrione, nicosulfuron, rimsulfuron) and atrazine, the herbicide used most heavily in this area, to species commonly found in Lake Champlain. The phytoplankton species tested represented Cyanobacteria (*Anabaena*, *Microcystis*), Chlorophyta (*Chlorella*, *Scenedesmus*) and diatoms (*Asterionella*, *Tabellaria*). Toxicity tests assayed five concentrations in quadruplicate and each toxicity test was repeated three to four times. Results show that the new generation herbicides have had limited effects on our test organisms, and the overall 96h EC50 values reveal acute toxicity occurring only at ecologically irrelevant concentrations. However, responses to atrazine show greater sensitivity by the eukaryotic alga (*Chlorella*; 96h EC50 = 0.34 ± 0.01 µM, $n = 3$) compared to the cyanobacteria *Microcystis* (96h EC50 1.04 ± 0.31 µM, $n = 3$) and *Anabaena* (96h EC50 1.36 ± 0.32 µM, $n = 3$). We also analyzed how photosynthetic efficiency of the organisms was affected by the various herbicides, and validated our methods with a potent photosystem II inhibitor, DCMU. This study is important to assessing the aquatic toxicity of new generation herbicides and for determining what, if any, changes need to be taken agriculturally to promote a healthier Lake Champlain ecosystem. Based on our results, we are confident that herbicides are not the leading factor contributing to toxic cyanobacteria blooms in Missisquoi Bay.

Understanding Phosphorus Dynamics in Runoff to Baie Missisquoi, Lake Champlain

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Baie Missisquoi forms the northern extremity of Lake Champlain, in the province of Quebec. The Baie is noted for the very severe problems of blue green algae formation due to pollution from nitrogen and phosphorus in agricultural runoff. The watersheds draining to Baie Missisquoi have very intensive agricultural operations, particularly from swine, poultry and dairy operations. Phosphorus levels in the Pike and Castor river watersheds, in particular, often exceed 3ppb. The Government of Quebec, together with the states of Nw York and Vermont, have therefore signed an agreement to reduce overall P levels in the Lake, and to develop best management practices (BMPs) aimed at reaching targeted P levels in the near future.

In order to develop and promote BMPs, it is necessary to better understand how soil types, runoff, drainage and agricultural practices influence P movement to the Lake. We have therefore established four field sites in the Pike River watershed, on different soil types, and with different cropping systems. The four sites also have different soil P levels. In addition two of the sites have tile drainage and there are two with only surface drainage. This gives an idea as to the effects of drainage system on P movement in surface runoff and tile drain flows.

Our results show that tile drains play a major role in P movement. Over 50% of the total P lost from fields occurs in the tile flow. In addition, the soils with high P levels do not necessarily lead to higher P in surface runoff. We have found that soil type, particularly the macropores in heavier clay soils can induce more P movement to rivers. These results show the importance of proper drainage water management, and the development of techniques to treat and control drainage water. Furthermore, long term crop rotations with pasture, corn and soybeans help to reduce soil P and consequently P in runoff.

This paper will present results of our 5 years of field measurements, as well as results of our SWAT model simulations.

Meeting P Target Loads for Misissquoi Bay: SWAT-predicted Influence of Cropping System Alterations

Aubert R. Michaud, Isabelle Beaudin, and Julie Deslandes (IRDA. Québec)

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An agreement between the governments of the province of Quebec and the state of Vermont calls for a 41% decrease in phosphorus loads reaching Missisquoi Bay, the northern portion of Lake Champlain. The agreement particularly targets the agricultural sector, since 80% of non-point source P inputs to the bay are associated with cultivated lands. In order to identify sustainable cropping practices likely to help meet the target P loads, the SWAT (Soil and Water Assessment Tool) model was employed to assess hydrological performance, erosion processes and phosphorus mobility on the bay's principal tributary, the Quebec portion of the 630 km^2 Pike River watershed. Strong in-watershed spatial clustering of vulnerability to non-point source exports highlights the need for targeted implementation of sustainable agricultural practices and soil conservation works, to derive the greatest environmental benefits. Planting cover crops over the 10% most vulnerable lands would result in a roughly 21% drop in overall P exports at the watershed outlet, whereas the same 10% randomly distributed over the watershed would only contribute to a 6% drop in P exports. The study of different field-scale management scenarios indicated that achieving the targeted 41% reduction in P exports, would require the widespread (half the land devoted to annual crops) implementation of sustainable cropping practices, and the conversion of a specific 10% of the territory to either cover crops or permanent prairie-land. Meeting the P target-loads, as established in the Quebec-Vermont agreement, would require additional investments in the protection of flood-plains and riparian strips, the targeted construction of runoff-control structures, and the rapid soil incorporation of manures on lands dedicated to annual crops.

Impacts of Uptyping: Legal, Regulatory and Water Quality Implications of Linking Reclassification of Vermont's Waterways with Basin Plan Approval

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The State of Vermont, under the direction of the U.S. Environmental Protection Agency, regulates the condition and use of waters in the state based on a waterway classification system dictated by the Clean Water Act and governed by the Water Resources Panel of the Vermont Natural Resources Board. The classification assigned to a water body by the Water Resources Panel is based on a variety of criteria, and can dictate everything from available effluent limitations to stream-side buffer requirements. In addition to water classification, new basin plans being written for watersheds throughout Vermont direct land use and water quality policy. However, in contrast to classifications, which set regulatory requirements for waterways, basins plans address largely nonregulatory features of watersheds, and therefore depend on voluntary compliance by landowners for success.

Current proposals at the state level to reclassify waters as part of the final approval for new basin plans seem to run counter to the grassroots efforts used to facilitate basin planning processes. Additionally, new classifications may be based on presence of a single water quality criterion. This method of reclassification (sometimes called "uptyping") can have significant impacts on both regulated and land use and water quality. This presentation will examine the original proposed typing for waterways in the White River and Poultney-Mettowee basin plans, proposals and justifications by some state officials to uptype waters in those basins. We will also review the legal arguments for and against the state's ability to uptype waters, review potential legal challenges to state action to reclassify (or failure to reclassify) waters within these basins, and the potential result for landowners, researchers, and regulators if the proposed uptying is challenged in court.

The Growing Hypoxic Zone in the Northeast Arm of Lake Champlain

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Long-term monitoring of dissolved oxygen concentrations during the period of 1990-2005 has revealed an expansion of the extent and severity of the hypoxic zone in the hypolimnion of the Northeast Arm (Inland Sea) portion of Lake Champlain. Annual minimum bottom dissolved oxygen concentrations have declined significantly over this time period. Degradation of habitat for fish and benthic organisms and greater internal phosphorus loading are possible consequences of the increased hypoxia. The growing oxygen deficit and a concurrent trend of increasing total phosphorus concentrations indicate an alarming acceleration of eutrophication in this region of the lake. Since the Northeast Arm has a relatively small immediate drainage basin, the major sources of phosphorus must come from the watersheds of adjoining lake segments such as Missisquoi Bay and St. Albans Bay. Evaluating proposed solutions such as phosphorus reduction from adjacent watersheds and multiple causeway removals would benefit from a better understanding of the hydrodynamics of the entire northeast region of Lake Champlain.

A Trophic History of Lake Champlain since European Settlement

Suzanne N. Levine (University of Vermont), Andrea Lini (University of Vermont), Heather D. Burgess (University of Vermont), Milton L. Ostrofsky (Allegheny College), Peter Leavitt (University of Regina), Lynda Bunting (University of Regina), Daun M. DahleN (Paul Smith's College), and Neil KammaN (Vermont Department of Environmental Conservation)

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Lake sediments preserve a treasure trove of biological and geochemical remnants of past communities and environments. To determine what Lake Champlain was like at the time of its "discovery" by Samuel Champlain in 1609 and how it has responded to changing land use, commerce and climate since then, we have begun sediment core collection from various bays and basins of the lake. Cores are analyzed for a large array of indicators of trophic state, including diatom composition, soft algae microfossils, paleopigments, C and N stable isotopes, organic content, phosphorus fractions, total N and biogenic silica. Because Lake Champlain is complex with numerous semi-isolated basins and bays, we plan to collect at least ten cores from different lake regions. To date, we have cored near Port Henry and Savage Island, and in Missisquoi and St. Albans Bays. In addition, we have analyzed sediments from three archived cores (Point Au Roche, Cole and Mallets Bays) for biogeochemical indicators unaltered by drying and storage.

SWAT-modeled Influence of Landscape and Cropping System on Phosphorus Mobility Within the Pike River Watershed.

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Hydrological performance, erosion processes and phosphorus mobility were modelled for the 630 km^2 Pike River watershed, an important Quebec tributary of Lake Champlain. Given the recurring issue of cyanobacterial blooms in the Missisquoi Bay, intervening to reduce the influx of phosphorus to the bay became a priority and led to an agreement between the governments of the province of Quebec and the state of Vermont. The model's parameterisation was supported by a characterisation and spatial representation of agricultural landscapes and production systems according to a field-scale partitioning of cultivated lands into over 2400 hydrological response units, each distinctive in its combination of soil properties, topography, fertilizer inputs, and inclusion within one of 99 sub-watersheds in the region under study. The model's calibration and validation was based on data from four hydrometric stations as well as the monitoring of water quality at the outlet of two small (6-8 km^2) experimental watersheds of contrasting physical attributes. A differential setting of baseline values for the upstream and downstream portions of the watershed led to a better matching of hydrological model output to measured discharge on different branches of the Pike River, as well as a closer reproduction of sediment and phosphorus loads at the outlet of the two reference basins. On a watershed scale, the model-derived sediment and phosphorus loads showed a clear spatial pattern: under present soil and crop management methods, over 50% of modelled phosphorus loads originated over roughly 10% of the watershed's area. Typically, these areas showed high surface runoff depths, high erosion rates or significant phosphorus enrichment of the topsoil.

Linking Urban Land Use to Stream Geomorphology and Biotic Integrity in the Lake Champlain Basin, Vermont

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Urban stormwater runoff is the cause of impairment for 17 small watersheds in Vermont, including 11 in close proximity to Lake Champlain. Concerns over loss of aquatic habitat and increased sediment transport to Lake Champlain led to a collaborative project between the Vermont Agency of Natural Resources (VTANR) and University of Vermont to assess the geomorphic stability and physical habitat condition of 17 small streams in Northwestern Vermont. Characterization of 145 stream reaches followed the Stream Geomorphic Assessment protocol developed by VTANR, which uses a suite of quantitative (e.g., channel geometry measurements, pebble counts) and qualitative (e.g., feature typing) metrics to calculate two indices: Rapid Geomorphic Assessment (RGA) Score and Rapid Habitat Assessment (RHA) score.

From this dataset 17 completely independent reaches (11 impaired and 6 attainment condition) were selected (based upon similar watershed location, substrate, and stream type) to test the hypothesis that urbanization negatively affects physical stream condition. RGA and RHA scores were negatively correlated with percent watershed impervious cover ($p < 0.001$) and declined precipitously at a threshold of ~5% total watershed impervious cover. Other inherent watershed conditions, such as drainage area and slope, interact with the effect of urbanization to magnify channel enlargement and adjustment. Using macroinvertebrate data collected by VTANR in 14 of the 17 study reaches, EPT species richness was found to be negatively correlated with impervious cover ($p < 0.001$), as was overall species richness ($p < 0.05$). A similar threshold of 5 percent watershed impervious cover caused a significant decline in sensitive taxa.

Chloride Concentrations in Vermont Surface Waters

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Chloride concentration in surface waters is an emerging issue in water quality management. Recent studies have documented chloride concentrations exceeding 1000 mg/L in some urban areas of the northeastern United States and Canada. Data from the Lake Champlain Long-term Water Quality and Biological Monitoring Project documents small but steady increases in lake and tributary chloride concentrations since 1992. These concentrations are not biologically significant, but do point to increasing chloride concentrations in the Lake Champlain watershed. Conductivity and chloride data collected by the Biological and Aquatic Studies Section of the VT Water Quality Division indicates that small streams in urban and developed areas of Vermont may be reaching chloride concentrations that are biologically relevant. These data indicate that, while chloride concentrations in large order rivers and Lake Champlain are increasing, they remain at levels below concern. Biota in small order urban streams, however, are experiencing concentrations of chloride that may have deleterious effects.