Vermont Water Resources and Lake Studies Center

The University of Vermont

Program Evaluation Report Fiscal Years 2008 - 2010



Submitted by:

Breck Bowden, Director

To:

Office of External Research Water Resources Discipline U.S. Geological Survey

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Preface

The Vermont Water Resources and Lake Studies Center receives an annual Federal matching grant as authorized by §104 of the Water Resources Research Act of 1984 (Public Law 98-242) as amended by Public Laws 101-397, 104-147, 106-374, and 109-471. §104 of the Act requires that the Secretary of the Interior "conduct a careful and detailed evaluation of each institute at least once every 3 years to determine that the quality and relevance of its water resources research and its effectiveness at producing measured results and applied water supply research as an institution for planning, conducting, and arranging for research warrants its continued support under this section." The U.S. Geological Survey (USGS), Department of the Interior, administers the provisions of the Act. This evaluation report describes, in the format prescribed by the USGS, the research, training, and information transfer activities supported by the §104 grants and required matching funds in fiscal years 2008 through 2010. Prior to 2008, the Act required an evaluation of the program at least once every 5 years. The last evaluation was conducted in 2007, covering fiscal years 2003 through 2007.

Vermont Water Resources and Lake Studies Center EVALUATION REPORT FY 2008 - FY 2010

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Introduction

During the evaluation period, FY2008-2010, the Vermont Water Resources and Lake Studies Center worked in collaboration with the River Management Program in the Department of Environmental Conservation (Vermont Agency of Natural Resources or VT ANR). In recognition of substantial state matching support provided by the River Management Program, the Vermont Water Center RFP each year was designed to specifically address several broad aspects of river management that are of direct interest to the Department of Environmental Conservation.

The Water Resource Issues and Problems of Vermont

Proposals on any topic relevant to the mission of the Water Center were considered. However, with input from the VTANR and Advisory Board for the Vermont Water Center, the RFP contained guidance for proposals that would

1. 1. advance scientific understanding that helps quantify the contribution of sediment and nutrients derived from fluvial processes in Vermont's rivers;

2. 2. establish the socio-economic justifications, costs, and benefits associated with or represented by river corridor protection in Vermont; and

3. 3. contribute to Vermont's river corridor management, restoration, and protection infrastructure. Within these broad areas several questions of particular interest were identified. We sought proposals that would strengthen and help validate Vermont's fluvial geomorphic-based model for describing sediment regime departures from reference or equilibrium conditions, which strongly influence the magnitude of sediment and nutrient production, transport, and attenuation or storage on a watershed scale. Suggested research areas of particular interest included proposals to

A. build on the existing ANR stream geomorphic assessment protocol, develop techniques for systematically identifying critical in-stream source areas, meaning those segments of the river system that contribute a disproportionate amount of the total P/sediment load

B. quantify how sediment and nutrient reductions may be achieved by managing river systems toward equilibrium conditions, and alleviating constraints to sediment load attenuation at a watershed scale,

C. examine and quantify the P and sediments available to be mobilized by fluvial processes and represented in various legacy sediment accretions in the Northern Lake Champlain watershed,

D. quantify sediment and P production in selected meso/macro scale examples and relate to the extant of fluvial geomorphic evolution or adjustment processes and the driving forces and stressors for such adjustments,

E. collect new and/or use existing data to test fluvial-geomorphic-based models currently being applied by the River Management Program and generate innovative new map products, or

F. place fluvial adjustment processes and sediment/P production rates on a geologic time scale/continuum such that a comparison of rates of sediment/P delivery to receiving waters can be made.

Proposals were also solicited to address socio-economic analyses which would build upon the Vermont River Management Alternatives White Paper and other VT DEC River Management Program fact sheets and papers published by the VTANR River Management Program and available at http://www.anr.state.vt.us/dec/waterq/rivers.htm. Suggested research areas included projects to:

A. identify/test/validate innovative voluntary landowner and municipal incentives that could be created in Vermont to enhance participation in river corridor protection initiatives,

B. quantify the socio-economic costs and benefits of river corridor protection, or

C. identify economic factors that have driven river and river corridor management historically (nineteenth and twentieth centuries) as compared with current day economic drivers and develop ways to use this information in way to that might influence public perception/values.

Institute Mission and Vision: An Overview

The goal of the Vermont Water Resources and Lake Studies Center during the review period has been to encourage, fund, execute, and communicate objective and competent research to assist in the solution of high priority water resources problems in Vermont.

In 2006, the Center entered an exciting new partnership with the Vermont Agency of Natural Resources to focus on issues related to River Corridor Management. This partnership complements the Center's efforts to produce new knowledge and tools to help resource managers, policy makers, and local residents understand how to better manage our valuable water resources. Additional funding and support has come from the Lintilhac Foundation and from Shelburne Farm, a public outreach and education organization in Shelburne, Vermont that promotes better farming practices in the New England region.

Section 104 Objectives

1. 1. To encourage and support basic and applied research directed at Vermont's critical water quality and quantity issues.

2. 2. To transmit, through workshops, annual meetings and printed literature, information on water resources statewide.

3. 3. To promote education in water resources

Allocation of Federal Grant and Matching Funds Among Program Activities: FY2008 through FY2010			
Activity	Percent		
Research	40		
Information Transfer	10		
Education	40		
Administration	10		
Other (please specify)	0		

Total 10)0
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Administration and Coordination

Institute Directors during Evaluation Period

Name	Academic Discipline	Term
William Bowden	Watershed Science and Planning	2008-2010

Advisory Committees

William Bowden, University of Vermont, 2008-2010

Doug Burnham, Vermont Agency of Natural Resources, 2008-2010

Craig Heindel, Hendel & Noyes, 2008-2010 Crea Lintilhac, Lintilhac Foundation, 2008-2010

Eric Smeltzer, Vermont Agency of Natural Resources, 2010

Mary Watzin, University of Vermont, 2008-2010

Mike Winslow, Lake Champlain Committee, 2008-2010

The committee meets approximately twice per year, once to discuss the upcoming RFP announcement and once to review the proposals. These meetings are either in person or via teleconference.

Research Proposal Review and Selection Process

Each proposal submitted to the Water Center for consideration are reviewed for technical merit and relevance to the state needs. Proposals were evaluated by the Vermont Water Center Advisory Committee. The Advisory Committee meets to discuss the proposals and select proposals to be included in the final submission to the USGS. The Director may ask for modifications to proposed objectives and budgets based on input from the Advisory Committee and the Director's perceptions of the strategic need of the Center.

Peer Review of Institute Publication

The Vermont Water Center encourages its principal investigators to publish their Section 104 research results in technical journals that receive peer review, primarily becuase these journals are typically trusted sources that have wide distribution. Though we require a final report for each project, we do so primarily to ensure that there is full documentation of the activities and results from each project funded by Center. These final project reports are retained and posted on our Center website. In many cases final reports are required by collaborating agencies, e.g., VTANR. In these cases the reports are reviewed by agency staff before they are accepted and posted.

Number of Principal Investigators Supported, by Rank and Year

Principal Investigators on Research Projects
Supported by §104 Grants and Matching
Funds, by Academic Rank and Year: FY2008
through FY2010Academic Rank2008200920102010

Assistant Professor and below	4	3	3
Associate Professor	2	1	4
Professor	1	2	1
unknown	0	0	0
Total	7	6	8

Significant Impact

Awards

Research, Information Transfer, and Education

• Drs. Donald Ross (Plant and Soil Science) and Eric Young (previously Plant and Soil Science) examined sources of inorganic and organic forms of phosphorus in riparian soils. More than half of the phosphorus present in the soil was organic. Phosphorus in riparian soil runs the risk of running off into the stream, and organic P is potentially bioavailable, meaning that it can be transformed into an inorganic form that is immediately available to algae. Streambank erosion of this organic, bioavailable P may be confounding efforts to reduce phosphorus management in the Lake Champlain basin.

Dr. Hill (College of Engineering and Math Sciences) examined how microorganisms alter the forms of phosphorus in soils and sediments over time. Some forms, such as orthophosphate, are more available to cyanobacteria and crop plants. An ability to measure such bioavailability is needed in order to improve crop soil fertility as well as decrease the phosphorus in runoff from agricultural fields. The present soil analysis methods are not sufficient, and so a modified method was developed that is a robust, efficient, and sensitive phosphohydrolase based assay. Using the modified method, poultry manure-ammended Vermont soil was investigated, with the ability to track three forms of phosphorus over time and confirm the observed proportions of phosphorus with ³¹P-NMR spectroscopy.

• Drs. Lovell (Plant and Soil Science) and McIntosh (Rubenstein School) conducted water quality studies investigating the relationship between farming practices and runoff from Shelburne Farms, a 590-ha pasture-based dairy farm on the shores of Lake Champlain. Shelburne Farms has several BMPs (rotational grazing, livestock exclusion, nutrient management planning) implemented in their practices to reduce agricultural runoff. The project investigated how well BMPs are at reducing nonpoint source pollutants and determine other practices that may be necessary. The results from the study suggest that balancing water quality protection and dairy farming may continue to pose challenges at Shelburne Farms. However, the results also indicate that adopting additional site-specific BMPs could further reduce agricultural nonpoint source pollution.

Drs. Morrissey (Rubenstein School) and Rizzo (College of Engineering and Math Sciences) used remote sensing to quantify sediment loading mobilized by streambank erosion to better understand nonpoint sources of sediment and phosphorus. The analyses were able to provide consistent, accurate, and relatively low cost information on stream geomorphic change and sediment loading over time at reach and watershed scales. The ability to systematically quantify sediment loading due to streambank erosion throughout the Lake Champlain basin and also provide a watershed-scale approach that can aid adaptive management efforts.

• Dr. Eppstein (Computer Science) developed an automated method for optimizing multiple BMP placement and sizing to meet TMDL targets. A process-based hydrologic model was integrated into a multi-scale, multi-objective evolutionary algorithm in order to evolve populations of potential watershed management practices. Optimized for multiple objectives, the method is able to run multiple potential solutions that will enable decision makers to understand trade-offs between cost and performance so they can select the design that best meets their short and long term needs.

Budget Information

104 Program Federal and Required Matching Funds

Total Federal and Required Matching Funds Available to the Vermont Water Resources and Lake Studies Center under §104 of the Water Resources Research Act of 1984

	2008	2009	2010	Total Federal	Total Match	Total Funds
104(b) Total Federal	\$92,335	\$92,335	\$92,335	\$277,005	X	Х
104(b) Total Match	\$261,716	\$260,436	\$193,829	X	\$715,981	Х
104(b) Total Funds	\$354,051	\$352,771	\$286,164	X	Х	\$992,986
104(g) Total Federal	\$0	\$0	\$0	\$0	X	Х
104(g) Total Match	\$0	\$0	\$0	X	\$0	Х
104(g) Total Funds	\$0	\$0	\$0	X	Х	\$0
Total	\$354,051	\$352,771	\$286,164	\$277,005	\$715,981	\$992,986

Discretionary Base Funding

Appropriated or Other Discretionary Funds						
Available to the Institute: FY2008 through						
FY2010						
	2000	2000	2010	1		

Source of Discretionary Funds 2008 2009 2010 Other Water Resources Research Funding

Total and Average Value of V Resources Grants, Contracts Cooperative Agreements in Wh Institute Had a Major Role Dur Evaluation Period: FY2008 th FY2010	Water 5, and nich the ring the rough
Total Value of Awards, in dollars	\$569,067
Number of Awards	4

Average Value of Awards \$142,267

Please list in the table below the <u>10 largest</u> grants (other than section 104 grants), contracts, and cooperative agreements for which the Director or staff of the institute played a major role in assembling the proposal or otherwise obtaining the grant or contract. Include the dollar amount of the contract, grant, or cooperative agreement, the year that it was initiated, and the source of the funds. USGS-Water Resources Research Institute Internships and funds from other federal agencies passed through to your institute by the USGS should be included here.

The Ten Largest Water Resources Grants, Contracts, and Cooperative Agreements in Which the Institute Had a Major Role during the Period of the Evaluation: FY2008 through FY2010					
Title/Topic Source of Fundings Year Initiated Amoun					
Water Center Supplemental Funds	VT ANR	2008	\$216,000		
Flow Monitoring Project	VT ANR	2009	\$268,067		
Water Center Supplemental Funds Lintilhac Foundation 2008 \$50,000					

Water Center Supplemental Funds	Shelburne Farms	2008	\$35,000
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Research

Summary of Research Projects

Number of Research Projects and Percentage of Research Funds, by Research Category: FY 2008 through FY 2010			
Research Category	Number	Percent of Funds	
Biological Sciences	0	0	
Climate and Hydrologic Processes	0	0	
Ecological Processes	0	0	
Engineering	1	11	
Ground-water Flow and Transport	0	0	
Social Sciences	0	0	
Water Quality	10	89	
Not Applicable	0	0	
Research Projects			

Project Total Title PI Number budget Treatment Solutions to Reduce Nutrient and Bacterial Inputs to Lake Sarah Lovell 2008VT32B \$81,761 Champlain at Shelburne Farms Tracing sources of eroded sediment with atmospherically produced Mandar 2008VT34B \$92,178 10-Be Dewoolkar Soil phosphorus landscape variability and soil mapping in a stream **Donald Ross** 2008VT35B \$81,732 Improvement of Phosphorus Load Estimates through the use of 2008VT36B Jane Hill \$67,842 Enzyme-Hydrolysis Measures of Phosphorus Bioavailability Treatment Solutions to Reduce Nutrient and Bacterial Inputs to Lake 2008VT32B Sarah Lovell \$82,430 Champlain at Shelburne Farms Improvement of Phosphorus Load Estimates through the use of 2008VT36B Jane Hill \$67,583 Enzyme-Hydrolysis Measures of Phosphorus Bioavailability Quantifying Sediment Loading due to Stream Bank Erosion in Leslie Impaired and Attainment Watersheds in Chittenden County, VT \$82,448 2009VT44B Morrissey Using Advanced GIS and Remote Sensing Technologies Estimating Soil Phosphorus Concentrations along Erodible Stream 2009VT45B Donald Ross \$72,201 Corridors in Chittenden County, Vermont Quantifying Sediment Loading due to Stream Bank Erosion in Leslie 2009VT44B Impaired and Attainment Watersheds in Chittenden County, VT \$76,579 Morrissey Using Advanced GIS and Remote Sensing Technologies Estimating Soil Phosphorus Concentrations along Erodible Stream 2009VT45B **Donald Ross** \$73,378 Corridors in Chittenden County, Vermont Advanced Computational Methods for Designing Stormwater Margaret 2010VT50B \$81,883 **Management Practices** Eppstein

Research Publications

Besaw, L.E. 2009. Advances in Artificial Neural Networks with Applications in Surface and Subsurface Hydrology. Ph.D. Dissertation, Civil and Environmental Engineering, University of Vermont, Burlington, Vermont.

Besaw, L.E., D.M. Rizzo, M. Kline, K.L. Underwood, J.J. Doris, L.A. Morrissey, and K. Pelletier. 2009. Stream Classification Using Hierarchical ArtificialNeural Networks: A Fluvial Hazard Management Tool. Journal of Hydrology. 373:34-43. doi:10.1016/j.jhydrol.2009.04.007

Kominami, H. 2009. Synthesizing Summer Water Quality Monitoring Data from Shelburn Farms (2004-2008). Shelburne Farms Technical Report. University of Vermont Plant and Soil Science Department, 35pp.

Besaw, L.E., D.M. Rizzo, P.R. Bierman, and W. Hackett. 2010. Advances in Ungauged Streamflow Prediction Using Artificial Neural Networks. Journal of Hydrology. 386(1-4): 27-37.

Borg, J.L. 2010. Streambank Stability and Sediment Tracing in Vermont Waterways. M.S. Dissertation. Civil and Environmental Engineering, University of Vermont, Burlington, Vermont.

Johnson, N.R. and J. E. Hill. 2010. Phosphorus Composition of a Poultry Manure-Amended Soil Via Enzymatic Hydrolysis: Demonstration of a High-throughput Method and Hints on Enzyme-labile P. Soil Science Society of America Journal. 74(5): September-October issue.

Kominami, H. 2010. Water Quality Monitoring, Siting Composting Areas, and Start-up Performance of a Stormwater Treatment System at Shelburne Farms, a Pasture-based Dairy Farm on the Shores of Lake Champlain, Vermont. M.S. Dissertation. Plant and Soil Science, University of Vermont, Burlington, Vermont.

Ishee, E.R. 2011. Characterizing Phosphorus in Eroding Streambank Soils in Chittenden County, Vermont. M.S. Dissertation. Plant and Soil Science, University of Vermont, Burlingotn, Vermont.

Johnson, N.R. 2011. Soil Organic Phosphorus Classification Using High-throughput Enzymatic Hydrolysis. M.S. Dissertation. Civil and Environmental Engineering, University of Vermont, Burlington, Vermont.

Garvey, K.M. 2012. Quantifying Erosion and Deposition Due to Stream Planform Change Using High Spatial Resolution Digital Orthography and LIDAR Data. M.S. Dissertation. Natural Resources, University of Vermont, Burlington, Vermont.

Giles, C.D. 2012. The Role of Plant and Bacterial Organic Anion Production in the Bioavailability of Myo-inositol Hexakiphosphate: Implications for Soil Phosphorus Cycling and Agricultural Nutrient Matigation. Ph.D. Dissertation. Civil and Environmental Engineering, University of Vermont, Burlington, Vermont.

Young, E.O., D.S. Ross, C. Alves, and T. Villars. 2012. Soil and Landscape Influences on Native Riparian Phosphorus Availability in Three Lake Champlain Basin Stream Corridors. Journal of Soil and Water Conservation. 67(1): 1-7. Doi:10.2489/jswc.67.1.1

Chichakly, K.H., W.B. Bowden, M.J. Eppstein. 2013. Minimization of Cost, Sediment Load, and Sensitivity to Climate Change in a Watershed Management Application. Environmental Modelling & Software. 50:158-168.

Young, E.O., D.S. Ross, B.J. Cade-Menun, C.W. Liu. 2013. Phosphorus Speciation in Riparian Soils: a Phosphorus-31 Nuclear Magnetic Resonance Spectroscopy and Enzyme Hydrolysis Study. Soil Science Society of America Journal. doi:10.2136/sssaj2012.0313

Borg, J.L., P.R. Bierman, M.M. Dewoolkar. Meteoric 10Be Adhered to Suspended Sediment: Source and Transport Dynamics in a Large New England Watershed. In revision, Journal of Geophysical Research – Earth Surface.

Giles, C. D., B. Cade-Menun, and J.E. Hill. (under review) The Inositol Phosphoates in Soils and Manures: Abundance, Cycling, and Measurement.

Hill, J. 2009. Spatial and Temporal Timing of Organic Phosphorus Transformation Under Till and No-till Conditions for a Poultry Manure-applied Vermont Soil. In Prep.

Young, E. O., D.S. Ross, C. Alves, and T. Villars. 2011. Influence of Soil Series on Phosphorus Forms and Availability at Two Riparian Sites in the Lake Champlain Basin (Vermont). In revision.

Information Transfer

Project Number	Title	PI	Total budget
2008VT39B	Information Transfer Activities	Breck Bowden	\$9,271
2008VT39B	Information Transfer Activities	Breck Bowden	\$28,368
2008VT39B	Information Transfer Activities	Breck Bowden	\$29,561
Audio-Visual P	roductions		

None

Newsletter

Reflections on Water Newsletter:

2008 – published once in July and is available on the Vermont Water Resources and Lake Studies Center, announced via e-mail (<u>http://www.uvm.edu/rsenr/vtwater/newsletter/Reflections_July_2008.pdf</u>)

2009 – published twice during the year, available on the Vermont Water Resources and Lake Studies Center website, announced vie e-mail (<u>http://www.uvm.edu/rsenr/vtwater/newsletter/Reflections_January_2009.pdf</u>) and <u>http://www.uvm.edu/rsenr/vtwater/newsletter/Reflections_June_2009.pdf</u>)

2010 – newsletter was not published this year.

Conferences

Lake Champlain: Our Lake, Our Future 2008, June 8-9, 2008, Burlington, Vermont. The conference was managed by the Lake Champlain Research Consortium and the Lake Champlain Basin Program with additional co-sponsorship by the Vermont Agency of Natural Resources, ECHO Lake Aquarium and Science Center, Lake Champlain research Institute, Lake Champlain Regional Chamber of Commerce, and The Nature Conservancy.

http://academics.smcvt.edu/lcrc/Program%20(2A)%20with%20Abstracts.pdf

Lake Champlain: Our Lake, Our Future 2010, June 7-8, 2010, Burlington, Vermont. The conference was managed by the Lake Champlain Research Consortium with additional co-sponsorship by the Lake Champlain Basin Program, the USGS, and the Vermont Agency of Natural Resources.

http://academics.smcvt.edu/lcrc/2010%20Conference/Program%20-%20FINAL%20(complete).pdf

Internet Services

The official Web site of the Vermont Water Resources and Lake Studies Center, hosted by The University of Vermont, appears at <u>http://www.uvm.edu/rsenr/vtwater/</u>.

Information Transfer Publications

IT Publication Type IT Publication Citation

Education

Number of students supported by

base-level grants						
Educational Level	2008	2009	2010	Total		
Undergraduate	0	4	4	8		
Masters	4	4	2	10		
Ph.D.	0	1	2	3		
Post-Doc.	0	0	0	0		
Total	4	9	8	21		

Number of Theses
and Dissertations
Resulting from
Student Support:
FY2008 through
FY2010Master's Theses6Ph.D. Dissertations2

Theses and Dissertations

Student Grants-in-Aid and Summer Fellowships

Additional Information for the Evaluation Panel

Attachments

Attachment A: Individual Project Descriptions

'Treatment Soluti ...': 2008VT32B Research Description

Title	Treatment Solutions to Reduce Nutrient and Bacterial Inputs to Lake
	Champlain at Shelburne Farms
Project Number	2008VT32B
Start Date	3/1/2008
End Date	2/28/2009
Research Category	Water Quality
Focus Categories	Water Quality; Non Point Pollution; Agriculture
Principal Investigators	Sarah Lovell; Alan Mcintosh

Ecological and social functions of Lake Champlain are increasingly threatened by high concentrations of contaminants such as phosphorus which promotes the growth of algae and aquatic plants. Of the 80% of phosphorus entering the lake from non-point sources, approximately 55% is contributed by agricultural activities (Lake Champlain Steering Committee, 2003). Animal waste from agricultural livestock also contributes to harmful strains of bacteria that threaten the health of individuals swimming at public beaches or drinking the water. At Shelburne Farms, a non-profit education center and working dairy farm located directly on Lake Champlain, water quality was monitored in 2004, 2005, and 2007 to determine concentrations of nutrients and bacteria entering Lake Champlain. The results indicate unacceptable levels of phosphorus and E. coli enter the lake in runoff from agricultural areas during storm events. Shelburne Farms intends to serve as a model of environmental stewardship by considering ecological, practical, and cost-effective remediation strategies that will improve the water quality of runoff entering the lake and to provide an education function in demonstrating new treatment technologies. This project will require a multi-scale approach considering: 1) the watershed scale, to develop an ArcGIS flow path model to characterize the relationship between surface flow from the farm landscape into Lake Champlain; 2) the farm scale, to consider land use structure and livestock management activities; and 3) the site scale, to develop a design for a system to treat contaminated runoff from key areas. The focus of this initial effort will be the implementation of a bioretention system designed to treat runoff from the dairy barnyard source area. We hypothesize that bioretention systems designed for agricultural runoff in primary source locations are ecological, practical, and cost-effective solutions for reducing phosphorus and E.coli concentrations to acceptable standards, decreasing the contribution to surface water sources such as Lake Champlain. We will test this hypothesis by designing and installing a site-specific bioretention system for runoff from the dairy barnyard and manure storage facilities focusing on ecological, practical, and cost-effective technologies to reduce nutrient and bacteria loads entering Lake Champlain. The system design will be based on a model of surface flow from the dairy barnyard to the wetland. We will monitor total phosphorus (TP), total suspended solids (TSS), and E. coli from runoff at input and output points along multiple stages of the bioretention system using a standardized sampling protocol. Soils and vegetation will be analyzed in the bioretention system and the downstream wetland to determine the potential for long-term nutrient retention and pathogen transport. This project will be used to educate the public about opportunities to improve the health of Lake Champlain through innovative, yet practical solutions for stormwater management on farms.

Funding		
Funding Period Federal §104 Funds Required §104 Matching Fund		
FY2008	\$13,314	\$68,447

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications	
Publication Type	Publication Citation
	Lovell, S. Taylor, Johnston, D.M. Creating multifunctional landscapes – How can the field of ecology inform the design of the landscape? Frontiers in Ecology and the Environment. In press. Online: http://www.esajournals.org/archive/1540-9295/preprint/2009/pdf/10.1890_070178.pdf
	Taylor Lovell, S., Sullivan, W.C. 2006. Environmental benefits of conservation buffers in the United States: Evidence, promise, and open questions. Agriculture, Ecosystems & Environment 112(4):249-260.
	Sullivan, W.C., Anderson, O.M., and Taylor Lovell, S., 2004. Agricultural buffers at the rural-urban fringe: an examination of approval by farmers, residents, and academics in the Midwestern United States. Landscape and Urban Planning 69:299-313.
	Taylor-Lovell, S., Sims, G.K., and Wax, L.M. 2002. Effects of moisture, temperature, and biological activity on the degradation of isoxaflutole in soil. Journal of Agricultural and Food Chemistry 50:5626-5633.
	Taylor-Lovell, S., Sims, G.K., Wax, L.M., and Hassett, J.J. 2000. Hydrolysis and soil adsorption of the labile herbicide isoxaflutole. Environmental Science and Technology 34:3186-3190.

'Tracing sources ...': 2008VT34B Research Description

Title	Tracing sources of eroded sediment with atmospherically produced 10-Be
Project Number	2008VT34B
Start Date	3/1/2008
End Date	2/28/2009
Research Category	Engineering
Focus Categories	Sediments; Geomorphological Processes

Principal Investigators Mandar Dewoolkar; Paul Bierman

A growing concern over the past few decades in the Lake Champlain region is the eutrophication of Lake Champlain which may trigger increasing amounts of algae and potentially toxic cyanobacteria while disturbing the ecosystem balance of the Lake. High phosphorus levels in the Lake are held responsible for this occurrence. With over 7,000 miles of streams and rivers feeding the Lake, significant amounts of nutrient-bearing sediments are discharged each year. High phosphorus levels allow the algae to flourish because it is often the limiting nutrient for growth. Similar concerns exist in other regions. In order to mitigate the problem, one needs to get to the roots of it; yet, the source of nutrient-enriched sediment entering Lake Champlain is poorly constrained. Understanding where sediment and its particle-associated nutrients come from is critical for informed and effective land and water management. We propose a proof-of-concept study, in essence a test case, to determine whether the rare isotope, Beryllium-10 (10-Be), can be used to fingerprint the source of fine-grain, particle reactive sediment transported by the Winooski River and deposited in Lake Champlain. In order to test the efficacy of 10-Be for tracing the source of sediment entering the Lake Champlain Basin, we propose to collect and process a number of samples of sediment from a suite of geomorphic/human impact settings as well as from spring snow-melt flows during which the bulk of sediment transport occurs. We will focus on the Winooski Basin as it is large, well-characterized, and amenable to event-based sampling. The proposed distribution of samples is designed to allow us to estimate both the mean and spatial/temporal variability of 10-Be concentration in fine grain sediment. The primary benefit of the proposed research will be the first-ever application of atmospherically produced 10-Be as a tracer of sediment sourcing and movement in the glaciated Northeast. It is anticipated that once tested, the proposed approach can be extended to include additional watersheds leading to basin-scale generalized conclusions, getting at the broader root-level questions from where is nutrient-enriched sediment coming. This will eventually allow managers to identify where and when nutrient-loaded sediment is delivered to the channel; thus, there exists the possible benefit of directly targeting for remediation areas contributing the most substantial nutrient load, a cost effective strategy. Graduate student research training is another substantial benefit of the project we propose; particularly valuable will be the cross-disciplinary training of an engineering MS student in cutting-edge geochemical laboratory and analysis methods.

Funding		
Funding Period Federal §104 Funds Required §104 Matching Funds		
FY2008	\$23,738	\$68,440

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications

Publication TypePublication CitationAwards and Achievements

'Soil phosphorus ...': 2008VT35B Research Description

Title	Soil phosphorus landscape variability and soil mapping in a stream
Project Number	2008VT35B
Start Date	3/1/2008
End Date	2/28/2009
Research Category	Water Quality
Focus Categories	Nutrients; Non Point Pollution; Water Quality

Principal Investigators Donald Ross; Eric Young

Sediment and associated phosphorus (P) inputs from agriculture, riparian stream bank erosion, and fluvial processes are thought to be major contributors of P loading to Lake Champlain. Soil properties impose important constraints on the transport and cycling of P in riparian zones. In many Vermont (VT) stream corridors, stream bank erosion itself can be a significant source of P. Research in progress indicates that soil P availability varies significantly among floodplain map units in VT. Thus, soil variability and the associated P content of riparian zones are both critical for developing tools to improve water quality. Our project will quantify and map relationships among soil map unit properties and P availability in a riparian corridor located in the Northern Lake Champlain watershed. The objectives of the project are to: (i) Describe the spatial variability of P and map unit properties among the soils, and (ii) Evaluate the extent of sampling/site characterization needed to achieve a given level of map unit accuracy and expected soil P content within a defined riparian corridor section. The research will also determine the adequacy of the soil survey to depict soil variability and P contents, and identify appropriate levels of soil characterization for modeling and management efforts. A site will be selected to encompass a broad range of floodplain map units and to provide the Vermont Agency of Natural Resources with data to support their management efforts. Objective one will be met by remapping the soils at the site using traditional and geostatistical methods. After the soils have been remapped, a grid-based soil sampling approach with nested subsampling will be applied to capture small- and larger-scale variation in chemical and physical properties. Soil P pools, organic carbon, minerals, texture, and other properties will be analyzed at the UVM Agricultural and Environmental Testing Lab. Predictive maps (ordinary kriging) of P pools, drainage, texture, organic carbon and other covariates will be developed. Additional laboratory experiments will evaluate organic and inorganic P solubility in subsamples from the predominant map units. Results will also include soil series-specific estimates of P content and a statistical analysis of soil properties influencing P availability. Comparisons among the soil survey map, the high order remapping, and the interpolated maps will assess map unit accuracy with respect to different sampling schemes. Results from this project will be integrated with water quality management efforts in the Northern Lake Champlain Basin to help guide prioritization and implementation of best management practices.

Funding		
Funding Period Federal §104 Funds Required §104 Matching Fund		
FY2008	\$7,390	\$74,342

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Pub	licat	tions
1 40	neu	

Publication Type	Publication Citation
	Young, E., O., D.S. Ross, C. Alves, and T. Villars. 2009. Influence of soil series on phosphorus forms and availability at two riparian sites in the Lake Champlain Basin (Vermont). In revision.
Annanda and Aak	la contra de la co

'Improvement of P ...': 2008VT36B Research Description

Title	Improvement of Phosphorus Load Estimates through the use of Enzyme-Hydrolysis
The	Measures of Phosphorus Bioavailability
Project Number	2008VT36B
Start Date	3/1/2008
End Date	2/28/2009
Research Category	Water Quality
Focus Categories	Sediments
Principal Investigators	Jane Hill

Microorganisms alter the forms of phosphorus forms in soils and sediments over time. Prediction of this labile phosphorus is complex and not well understood. This proposal endeavors to aid in the prediction of phosphorus migration off-site through the application of enzymatic assays to assess the labile nature of phosphorus in soils and sediments. Enzyme hydrolysis assays have been applied to dairy manures with success. An intensive assessment of soils and sediments from a variety of soil types will be conducted. This study will 1. Adapt the enzyme assay soils and sediments samples and 2. Provide an option for soil scientists who wish to use a labile phosphorus measure in the Vermont Phosphorus Site Index as well as other models of phosphorus transport.

Funding		
Funding Period	Federal §104 Funds	Required §104 Matching Funds
FY2008	\$35,323	\$32,519

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications		
Publication Type	n Publication Citation	
	Hill, Jane, 2009. Spatial and temporal timing of organic phosphorus transformation under till and no-till conditions for a poultry manure-applied Vermont soil. In Preparation.	
	Hill, Jane. 2008. Lake Champlain Watershed: from the Missisquoi Bay to the Lake (Poster; October 2008)	
	Hill, Jane. 2009. Oral presentation accepted for the American Chemical Society annual meeting August 16, 2009 in Washington D.C. (session: organic phosphorus transport, fate, a impact on the Chesapeake Bay).	
	Johnson, Nicholas R., and J.E. Hill, August 2009. Phosphorus composition of wet and dried poultry litter-amended soil by enzyme hydrolysis and solution 31P-NMR. 238th ACS National Meeting Presentation.	
	Johnson, N.R. and Hill, J.E. 2010 (accepted) Phosphorus composition of a poultry manure-amended soil via enzymatic hydrolysis: demonstration of a high-throughput method and hints on enzyme-labile P Soil Science Society of America Journal	

	Giles, C.D., Cade-Menun, B., and Hill, J.E. (under review) The Inositol Phosphates in Soils and Manures: Abundance, Cycling, and Measurement.
	Hill, J.E., 2009, Phytate: Movement and Transformation in the Landscape, Great Lakes Phosphorus Forum,Poster, July.
	Giles, Courtney D., Barbara Cade-Menun, and J.E. Hill, 2009, Phosphorus mobility and transformation in a poultry manure-amended soil tracked over time and depth, Presentation, August.
	Johnson, Nicholas, Barbara Cade-Menun, and J.E. Hill, 2009, Hydrolysis as a Tool for Measuring Bioavailable P in Dairy Manure Storage and Treatment Systems, Presentation, November.
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'Information Tran ...': 2008VT39B Information Transfer Description

Title	Information Transfer Activities
Project Number	2008VT39B
Start Date	3/1/2008
End Date	2/28/2009
Research Category	Not Applicable
Focus Categories	

Principal Investigators Breck Bowden

The Vermont Water Resources and Lake Studies Center information transfer activities.

Funding		
Funding Period Federal §104 Funds Required §104 Matching Funds		
FY2008	\$6,160	\$3,111

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications		
Publication Type	Publication Citation	
	There are no publications specific to this project. However, papers presented at the conference supported by the Vermont Water Center in 2010 will be published in a special issue of the	
	Journal of Great Lakes Research, expected in late 2011.	

Awards and Achievements

'Treatment Soluti ...': 2008VT32B Research Description

T:4 1	Treatment Solutions to Reduce Nutrient and Bacterial Inputs to Lake
Thie	Champlain at Shelburne Farms
Project Number	2008VT32B
Start Date	3/1/2009
End Date	2/28/2010
Research Category	Water Quality
Focus Categories	Water Quality; Non Point Pollution; Agriculture
Principal Investigators	Sarah Lovell: Alan Mcintosh

Ecological and recreational functions of Lake Champlain are increasingly threatened by high concentrations of contaminants such as phosphorus which promotes the growth of algae and aquatic plants. Of the 80% of phosphorus entering the lake from non-point sources, approximately 55% is contributed by agricultural activities (Lake Champlain Steering Committee, 2003). Animal waste from agricultural livestock also contributes to harmful strains of bacteria that threaten the health of individuals swimming at public beaches or drinking the water. At Shelburne Farm, a non-profit education center and working dairy farm located directly on Lake Champlain, water quality was monitored in 2004, 2005, 2007, and 2008 to determine concentrations of nutrients and bacteria entering Lake Champlain. The results indicate unacceptable levels of phosphorus and E. coli enter the lake in runoff from agricultural areas during storm events. Shelburne Farm intends to serve as a model of environmental stewardship by considering ecological, practical, and cost-effective remediation strategies that will improve the water quality of runoff entering the lake and to provide an education function in demonstrating new treatment technologies. This project will require a multi-scale approach considering: 1) the watershed scale, to develop an ArcGIS flow path model to characterize the relationship between surface flow from the farm landscape into Lake Champlain; 2) the farm scale, to consider land use structure and livestock management activities; and 3) the site scale, to develop a design for a system to treat contaminated runoff from key areas. The focus of this initial effort will be the implementation of a vegetative treatment system (VTS) designed to treat runoff from the dairy barnyard source area. We hypothesize that vegetated treatment systems such as vegetated gravel wetlands designed for agricultural runoff in primary source locations are ecological, practical, and cost-effective solutions for reducing phosphorus, nitrogen, total suspended solids (TSS), and E.coli concentrations, decreasing the contribution to surface water sources such as Lake Champlain. We will test this hypothesis by installing a site-specific vegetated gravel wetland for runoff from the dairy barnyard and evaluating the performance for treating dairy barnyard runoff by comparing concentrations of total phosphorus (TP), total suspended solids (TSS), and E. coli from the influent and effluent of the system, adjusting for flow rates, over a one-year period. The practicality of the system will be assessed by documenting costs, space requirements, and maintenance, to share with farmers and agricultural agencies. We will explore the transferability of the system to other dairy farms by conducting interviews and site analyses of the dairy barnyards of 16 participating farmers. This project will be used to educate the public about opportunities to improve the health of Lake Champlain through innovative, yet practical solutions for stormwater management on farms.

Funding			
Funding Period	Federal §104 Funds	Required §104 Matching Funds	
FY2009	\$13,315	\$69,115	

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		

Post-Doctoral

 Publications

 Publication Type
 Publication Citation

 Awards and Achievements
 Publication Citation

'Improvement of P ...': 2008VT36B Research Description

Title	Improvement of Phosphorus Load Estimates through the use of Enzyme-Hydrolysis
THE	Measures of Phosphorus Bioavailability
Project Number	2008VT36B
Start Date	3/1/2009
End Date	2/28/2010
Research Category	Water Quality
Focus Categories	Sediments
Principal Investigators	Jane Hill

Microorganisms alter the forms of phosphorus forms in soils and sediments over time. Prediction of this labile phosphorus is complex and not well understood. This proposal endeavors to aid in the prediction of phosphorus migration off-site through the application of enzymatic assays to assess the labile nature of phosphorus in soils and sediments. Enzyme hydrolysis assays have been applied to dairy manures with success. An intensive assessment of soils and sediments from a variety of soil types will be conducted. This study will: 1. Adapt the enzyme assay soils and sediments samples and 2. Provide an option for soil scientists who wish to use a labile phosphorus measure in the Vermont Phosphorus Site Index as well as other models of phosphorus transport.

Funding		
Funding Period	Federal §104 Funds	Required §104 Matching Funds
FY2009	\$40,005	\$27,578

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications		
Publication Type	Publication Citation	
	Johnson, Nicholas R., and J.E. Hill, August 2009. Phosphorus composition of wet and dried poultry litter-amended soil by enzyme hydrolysis and solution 31P-NMR. 238th ACS National Meeting Presentation.	
	Johnson, N.R. and Hill, J.E. 2010 (accepted) Phosphorus composition of a poultry manure-amended soil via enzymatic hydrolysis: demonstration of a high-throughput method and hints on enzyme-labile P Soil Science Society of America Journal	
	Giles, C.D., Cade-Menun, B., and Hill, J.E. (under review) The Inositol Phosphates in Soils and Manures: Abundance, Cycling, and Measurement.	
	Hill, J.E., 2009, Phytate: Movement and Transformation in the Landscape, Great Lakes Phosphorus Forum,Poster, July.	
	Giles, Courtney D., Barbara Cade-Menun, and J.E. Hill, 2009, Phosphorus mobility and transformation in a poultry manure-amended soil tracked over time and depth, Presentation, August.	

Johnson, Nicholas, Barbara Cade-Menun, and J.E. Hill, 2009, Hydrolysis as a Tool for
Measuring Bioavailable P in Dairy Manure Storage and Treatment Systems, Presentation,
November.

'Information Tran ...': 2008VT39B Information Transfer Description

Title	Information Transfer Activities
Project Number	2008VT39B
Start Date	3/1/2009
End Date	2/28/2010
Research Category	Water Quality
Focus Categories	Education; Management and Planning; Methods

Principal Investigators Breck Bowden

The Vermont Water Resources and Lake Studies Center information transfer activities.

Funding		
Funding Period	Federal §104 Funds	Required §104 Matching Funds
FY2009	\$11,705	\$16,663

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications		
Publication Type	blication Type	
	There are no publications specific to this project. However, papers presented at the conference supported by the Vermont Water Center in 2010 will be published in a special issue of the	
	Journal of Great Lakes Research, expected in late 2011.	

Awards and Achievements

Title	Quantifying Sediment Loading due to Stream Bank Erosion in Impaired and Attainment Watersheds in Chittenden County, VT Using Advanced GIS and Remote Sensing		
	Iechnologies		
Project Number	2009VT44B		
Start Date	3/1/2009		
End Date	2/28/2010		
Research Category	Water Quality		
Focus Categories	Non Point Pollution; Sediments; Geomorphological Processes		

'Quantifying Sedi ...': 2009VT44B Research Description

Investigators

Principal Leslie Morrissey; Donna Rizzo; Donald Ross; Eric Young

Stream erosion is one of the most important yet least understood nonpoint sources of sediment and phosphorus (P) threatening the impairment of surface water quality and aquatic habitats within the Lake Champlain basin. High spatial and temporal variability and the difficulties of quantifying erosion rates at watershed scales, however, have severely limited understanding the role and relative contribution of stream bank erosion to water quality degradation. Previous research has not provided the quantitative basis required to weight the importance of stream bank erosion relative to other sediment and P sources at watershed scales or the information needed to address within watershed variability in stream bank erosion over time. To address these issues, we propose to quantify the sediment loads mobilized by stream bank erosion over the past decade (1999-2008) in 15 Chittenden County watersheds by combining very high spatial resolution aerial and satellite imagery, LIDAR-derived elevation data, advanced digital image processing, GIS analyses (e.g. flow accumulation modeling) and field sampling. The proposed research will: 1) develop an automated approach to quantify changes in stream geomorphology over time (e.g. channel migration and bank height), 2) quantify sediment loading to the channel and identify critical source areas that may contribute a disproportionate amount of the total sediment load to streams, 3) address the impact of impervious surface areas on stream stability, and 4) derive remote sensing products indicative of stream stability to complement existing ANR stream geomorphic assessment protocols (e.g. steep banks, change in sinuosity over time, valley and channel slope). Our research will focus on 15 watersheds in Chittenden County, VT of which ten are listed on the state's 303d list of impaired waters due to urban stormwater or agricultural runoff and six, including an area draining to the non-impaired reaches of the LaPlatte River, are identified as attainment watersheds. The watersheds chosen for study were selected given long-standing focus on sediment, P or fecal contamination within each system, their contribution to water quality in their respective receiving waters (e.g. Shelburne Bay, Burlington Bay, Malletts Bay and the Winooski River), and to represent a variety of anthropogenic and natural stressors over which the extent of stream bank erosion can be evaluated. Verification of specific products, such as areas of active erosion and bank heights used in estimating soil volume loss, will be verified relative to VT ANR Stream Geomorphic Assessment data and targeted field surveys. The proposed effort differs markedly from previous studies in the Lake Champlain basin by taking advantage of watershed-scale synoptic observations over time and detailed elevation measures offered by remote sensing. In addition, our analyses could serve as a baseline against which future estimates of channel stability and erosion could be evaluated and as a means to constrain subsequent sediment and P loading estimates due to stream bank erosion. More importantly, this effort represents not only a significant step towards the development of a systematic approach to quantify sediment loading to the channel due to stream bank erosion throughout the Lake Champlain basin and elsewhere, but also a watershed-scale approach that could greatly aid adaptive management efforts.

Funding				
Funding Period	Funding Period Federal §104 Funds Required §104 Matching Funds			

FY2009	\$19,859	\$62,589
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Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications			
Publication Type	Publication Citation		
	Garvey, K.M., L. A. Morrissey, D. Rizzo, and M. Kline, 2010, Streambank Erosion in Chittenden County, VT: Application of Very High Resolution Remote Sensing and GIS Modeling, Lake Champlain 2010 Conference: Our Lake, Our Future, Lake Champlain Research Consortium, June 7-8, 2010, Burlington, VT.		
	Garvey, K.M., L. A. Morrissey, D. Rizzo, and M. Kline, 2010, Quantifying Sediment Loading due to Streambank Erosion in Impaired and Attainment Watersheds in Chittenden County, VT, Vermont Geological Society Winter Meeting, Feb. 6, 2010, Norwich, VT.		
	Ishee, E. and D. Ross, Contribution of streambank erosion as a non-point source of phosphorus to Lake Champlain from streams in Chittenden County, VT. American Society of Limnology and Oceanography Conference, Feb 13-18, 2011, San Juan, Puerto Rico.		
	Garvey, K.M. Streambank Erosion in Chittenden County, VT: Application of Very High Resolution Remote Sensing and GIS Modeling. MSc Thesis expected in August 2011.		
	Pelletier, Keith C., 2011, Use Of Very High Resolution Remote Sensing To Estimate Sediment Loading Due To Stream Channel Migration, The Rubenstein School of Environment and Natural Resources, The University of Vermont, Burlington, Vermont. 139 Pages.		

'Estimating Soil ...': 2009VT45B Research Description

Title	Estimating Soil Phosphorus Concentrations along Erodible Stream Corridors in	
	Chittenden County, Vermont	
Project Number	2009VT45B	
Start Date	3/1/2009	
End Date	2/28/2010	
Research Category	Water Quality	
Focus Categories	Nutrients; Non Point Pollution; Water Quality	
Principal Investigators	Donald Ross; Leslie Morrissey; Eric Young	

Phosphorus (P) loss from stream bank erosion is thought to be a major and underestimated contributor of P loading to Lake Champlain. Soil variability strongly influences the chemical and physical properties of riparian areas. Results from our recent research funded by the UVM Water Resources and Lake Studies Center demonstrated that riparian soil P concentrations varied significantly by soil type, texture (e.g., sand, silt, and clay distribution), and drainage at three riparian sites in the Lake Champlain Basin (Lewis Creek, Rugg Brook, and Rock River), suggesting that detailed soil maps may be used to estimate P concentrations. Parent material and drainage vary widely in Vermont's riparian landscapes, making it difficult to produce accurate soil maps. Since drainage and texture are the two main factors that determine soil types, traditional and novel mapping techniques show promise for estimating riparian soil P availability. Building on our previous research, this project will combine high-order soil mapping and soil testing to estimate P levels at riparian sites in Chittenden County, VT. This approach will generate soil-specific P concentrations for each of the study sites. Year one of the project will focus on mapping and sampling along Allen Brook and Indian Brook, where historical channel migration measurements have occurred. In year two, additional sites will be selected to include the dominant riparian soils in the county and represent the impaired and attainment streams proposed for detailed stream bank erosion mapping by co-investigator Morrissey. We will also partner with the Vermont EPSCoR Streams Project to access riparian sites along the LaPlatte River, Potash Brook, and others. The applicability of our approach to other stream corridors in VT will be evaluated by how well soil type and other properties predict P concentrations at sites sampled in year two. The use of Artificial Neural Network modeling will be explored in the future with collaborator Dr. Donna Rizzo, College of Engineering and Mathematical Sciences. Critically, when coupled to historical measurements of streambank erosion, results from this project will provide improved estimates of P mobilized by fluvial systems and contribute to a greater understanding of P dynamics in the Lake Champlain Basin.

Funding		
Funding Period	Federal §104 Funds	Required §104 Matching Funds
FY2009	\$1,478	\$70,723

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications	
Publication Type	Publication Citation

Garcia, Angel, 2010, Understanding the Relationships between Beaver Dams and the Movement of Phosphorus through Allen Brook, Chittenden County, VT, Universidad Metropolitana 2nd Annual Vermont EPSCoR Streams Project Symposium, Apr 19, 2010 Burlington, VT.
Thomas, Maya, 2010, Riparian soil phosphorus and stream channel migration at Allen Brook in Chittenden County, VT, UVM Student Research Conference, April 22, 2010, Burlington, VT.
Alves, Caroline, 2010, Examining phosphorus contributions from alluvial soils - a comparison of three Vermont river corridors, (USDA-Natural Resources Conservation Service). Lake Champlain 2010 Conference: Our Lake, Our Future, Lake Champlain Research Consortium, June 7-8, 2010, Burlington, VT.
Young, Eric, Don Ross, Caroline Alves, and Thomas Villars, 2010, Spatial variability of riparian soil phosphorus at a site along the Rock River, Vermont, Lake Champlain 2010 Conference: Our Lake, Our Future, Lake Champlain Research Consortium, June 7-8, 2010, Burlington, VT.
Valentin, Dorielys 2010. Examining Effects of a Capped Landfill on Groundwater and Alluvial Soils near Indian Brook in Essex, VT. (Universidad Metropolitana). Ana G. Méndez University System 2010 Research Symposium, Sep 10-11, 2010, San Juan, Puerto Rico.
Ishee, Eulaila and Don Ross. 2011. Contribution of streambank erosion as a non-point source of phosphorus to Lake Champlain from streams in Chittenden County, VT. American Society of Limnology and Oceanography, Feb 13-18, 2011, San Juan, Puerto Rico.
Valentin, Dorielys. 2010. Examining effects of a capped landfill on ground water and alluvial soils along Indian Brook in Essex, VT. (Universidad Metropolitana). Third Annual Vermont EPSCoR Streams Project Symposium, Apr 26, 2011, Burlington, VT.
Valentin, Dorielys M., 2010, Examining Effects of a Capped Landfill on Groundwater and Alluvial Soils Near Indian Brook in Essex, VT, ANA G. MÉNDEZ UNIVERSITY SYSTEM (AGMUS) 2010 Research Symposium, San Juan, Puerto Rico, Page 38.
Young, Eric, Don Ross, Caroline Alves, and Thomas Villars, 2011, Influence of soil series on phosphorus forms and availability at two riparian sites in the Lake Champlain Basin (Vermont). J. Soil Water Conserv.: In Press.

'Information Tran ...': 2008VT39B Information Transfer Description

Title	Information Transfer Activities
Project Number	2008VT39B
Start Date	3/1/2010
End Date	2/28/2011
Research Category	Water Quality
Focus Categories	Education; Management and Planning; Methods

Principal Investigators Breck Bowden

The Vermont Water Resources and Lake Studies Center facilitates information transfer in a variety of ways. The Center produces a web-based newsletter that highlights emerging research funded by the Center or relevant to water resources management in Vermont. The Director of the Water Center sits on the Lake Champlain Basin Program's Technical Advisory Committee (TAC) and regularly brings information from Center-funded projects to the attention of the TAC. The Center regularly supports seminars, workshops, and conferences relevant to water resources management issues in Vermont. Examples include specialty workshops designed to showcase emerging results from Center-funded projects. At other times the Center supports meetings that address topics that are directly relevant to the Center's mission. In 2010 the Water Center will co-sponsor a biennial conference on science relevant to the management of Lake Champlain and its basin. The conference will be managed by the Lake Champlain Research Consortium with addition co-sponsorship by the Lake Champlain Basin Program, the USGS, and the Vermont Agency of Natural Resources, to name a few. The center will consider offering a second, advanced technology workshop on optical sensors used to measure and monitor dissolved organic matter and nitrate in freshwaters. The first such workshop was held in Vermont in July 2009 with great success. Scientists and staff from the Sacramento, CA office of the USGS were key partners in the workshop, which was cosponsored by the Consortium of Universities for the Advancement of Hydrologic Scientists, Inc. (CUAHSI). We are currently gauging whether there is sufficient call for a second workshop in 2010-11.

Funding		
Funding Period	Federal §104 Funds	Required §104 Matching Funds
FY2010	\$14,915	\$14,646

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications		
Publication Type	Publication Citation	
	There are no publications specific to this project. However, papers presented at the conference	
	Journal of Great Lakes Research, expected in late 2011.	

	Quantifying Sediment Loading due to Stream Bank Erosion in Impaired and Attainment
Title	Watersheds in Chittenden County, VT Using Advanced GIS and Remote Sensing
	Technologies
Project Number	2009VT44B
Start Date	3/1/2009
End Date	2/28/2011
Research Category	Water Quality
Focus Categories	Non Point Pollution; Sediments; Geomorphological Processes

'Quantifying Sedi ...': 2009VT44B Research Description

Principal Investigators Leslie Morrissey; Donna Rizzo

Stream erosion is one of the most important yet least understood nonpoint sources of sediment and phosphorus (P) threatening the impairment of surface water quality and aquatic habitats within the Lake Champlain basin. High spatial and temporal variability and the difficulties of quantifying erosion rates at watershed scales, however, have severely limited understanding the role and relative contribution of stream bank erosion to water quality degradation. Previous research has not provided the quantitative basis required to weight the importance of stream bank erosion relative to other sediment and P sources at watershed scales or the information needed to address within watershed variability in stream bank erosion over time. To address these issues, we propose to quantify the sediment loads mobilized by stream bank erosion over the past decade (1999-2008) in 15 Chittenden County watersheds by combining very high spatial resolution aerial and satellite imagery, LIDAR-derived elevation data, advanced digital image processing, GIS analyses (e.g. flow accumulation modeling) and field sampling. The proposed research will: 1) develop an automated approach to quantify changes in stream geomorphology over time (e.g. channel migration and bank height), 2) quantify sediment loading to the channel and identify critical source areas that may contribute a disproportionate amount of the total sediment load to streams, 3) address the impact of impervious surface areas on stream stability, and 4) derive remote sensing products indicative of stream stability to complement existing ANR stream geomorphic assessment protocols (e.g. steep banks, change in sinuosity over time, valley and channel slope). Our research will focus on 15 watersheds in Chittenden County, VT of which ten are listed on the state's 303d list of impaired waters due to urban stormwater or agricultural runoff and six, including an area draining to the non-impaired reaches of the LaPlatte River, are identified as attainment watersheds. The watersheds chosen for study were selected given long-standing focus on sediment, P or fecal contamination within each system, their contribution to water quality in their respective receiving waters (e.g. Shelburne Bay, Burlington Bay, Malletts Bay and the Winooski River), and to represent a variety of anthropogenic and natural stressors over which the extent of stream bank erosion can be evaluated. Verification of specific products, such as areas of active erosion and bank heights used in estimating soil volume loss, will be verified relative to VT ANR Stream Geomorphic Assessment data and targeted field surveys. The proposed effort differs markedly from previous studies in the Lake Champlain basin by taking advantage of watershed-scale synoptic observations over time and detailed elevation measures offered by remote sensing. In addition, our analyses could serve as a baseline against which future estimates of channel stability and erosion could be evaluated and as a means to constrain subsequent sediment and P loading estimates due to stream bank erosion. More importantly, this effort represents not only a significant step towards the development of a systematic approach to quantify sediment loading to the channel due to stream bank erosion throughout the Lake Champlain basin and elsewhere, but also a watershed-scale approach that could greatly aid adaptive management efforts.

Funding			
Funding Period	Funding Period Federal §104 Funds Required §104 Matching Funds		

FY2010	\$23,345	\$53,234

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications		
Publication Type	Publication Citation	
	Ishee, E. and D. Ross, Contribution of streambank erosion as a non-point source of phosphorus to Lake Champlain from streams in Chittenden County, VT. American Society of Limnology and Oceanography Conference, Feb 13-18, 2011, San Juan, Puerto Rico.	
	Garvey, K.M. Streambank Erosion in Chittenden County, VT: Application of Very High Resolution Remote Sensing and GIS Modeling. MSc Thesis expected in August 2011.	
Pelletier, Keith C., 2011, Use Of Very High Resolution Remote Sensing To Estimate Sediment Loading Due To Stream Channel Migration, The Rubenstein School of Environme and Natural Resources, The University of Vermont, Burlington, Vermont. 139 Pages.		

'Estimating Soil ...': 2009VT45B Research Description

Title	Estimating Soil Phosphorus Concentrations along Erodible Stream Corridors in
The	Chittenden County, Vermont
Project Number	2009VT45B
Start Date	3/1/2010
End Date	2/28/2011
Research Category	Water Quality
Focus Categories	Nutrients; Non Point Pollution; Water Quality
Principal Investigators	Donald Ross; Leslie Morrissey

Phosphorus (P) loss from stream bank erosion is thought to be a major and underestimated contributor of P loading to Lake Champlain. Soil variability strongly influences the chemical and physical properties of riparian areas. Results from our recent research funded by the UVM Water Resources and Lake Studies Center demonstrated that riparian soil P concentrations varied significantly by soil type, texture (e.g., sand, silt, and clay distribution), and drainage at three riparian sites in the Lake Champlain Basin (Lewis Creek, Rugg Brook, and Rock River), suggesting that detailed soil maps may be used to estimate P concentrations. Parent material and drainage vary widely in Vermont's riparian landscapes, making it difficult to produce accurate soil maps. Since drainage and texture are the two main factors that determine soil types, traditional and novel mapping techniques show promise for estimating riparian soil P availability. Building on our previous research, this project will combine high-order soil mapping and soil testing to estimate P levels at riparian sites in Chittenden County, VT. This approach will generate soil-specific P concentrations for each of the study sites. Year one of the project will focus on mapping and sampling along Allen Brook and Indian Brook, where historical channel migration measurements have occurred. In year two, additional sites will be selected to include the dominant riparian soils in the county and represent the impaired and attainment streams proposed for detailed stream bank erosion mapping by co-investigator Morrissey. We will also partner with the Vermont EPSCoR Streams Project to access riparian sites along the LaPlatte River, Potash Brook, and others. The applicability of our approach to other stream corridors in VT will be evaluated by how well soil type and other properties predict P concentrations at sites sampled in year two. The use of Artificial Neural Network modeling will be explored in the future with collaborator Dr. Donna Rizzo, College of Engineering and Mathematical Sciences. Critically, when coupled to historical measurements of streambank erosion, results from this project will provide improved estimates of P mobilized by fluvial systems and contribute to a greater understanding of P dynamics in the Lake Champlain Basin.

Funding			
Funding Period Federal §104 Funds Required §104 Matching Funds			
FY2010	\$11,348	\$62,030	

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications		
Publication Type	Publication Citation	

Valentin, Dorielys 2010. Examining Effects of a Capped Landfill on Groundwater and Alluvial Soils near Indian Brook in Essex, VT. (Universidad Metropolitana). Ana G. Méndez University System 2010 Research Symposium, Sep 10-11, 2010, San Juan, Puerto Rico.
Ishee, Eulaila and Don Ross. 2011. Contribution of streambank erosion as a non-point source of phosphorus to Lake Champlain from streams in Chittenden County, VT. American Society of Limnology and Oceanography, Feb 13-18, 2011, San Juan, Puerto Rico.
Valentin, Dorielys. 2010. Examining effects of a capped landfill on ground water and alluvial soils along Indian Brook in Essex, VT. (Universidad Metropolitana). Third Annual Vermont EPSCoR Streams Project Symposium, Apr 26, 2011, Burlington, VT.
Valentin, Dorielys M., 2010, Examining Effects of a Capped Landfill on Groundwater and Alluvial Soils Near Indian Brook in Essex, VT, ANA G. MÉNDEZ UNIVERSITY SYSTEM (AGMUS) 2010 Research Symposium, San Juan, Puerto Rico, Page 38.
Young, Eric, Don Ross, Caroline Alves, and Thomas Villars, 2011, Influence of soil series on phosphorus forms and availability at two riparian sites in the Lake Champlain Basin (Vermont). J. Soil Water Conserv.: In Press.

'Advanced Computa ...': 2010VT50B Research Description

Titlo	Advanced Computational Methods for Designing Stormwater Management
THE	Practices
Project Number	2010VT50B
Start Date	3/1/2010
End Date	2/28/2011
Research Category	Water Quality
Focus Categories	Water Quality; Sediments; Hydrology

Principal Investigators Margaret Eppstein

High-levels of phosphorus loading to Lake Champlain have been linked to algal blooms and to eutrophication of sections of the lake. Previous research suggests that runoff from impervious surfaces in developed areas around the lake have accelerated runoff and increased sediment and phosphorus loading, leaving many watersheds impaired and the Lake threatened. There is, therefore, considerable interest in designing cost-effective strategies for reducing sediment and phosphorus loading. In addition, it will be important to design strategies that are robust to anticipated changes in precipitation patterns resulting from global climate change. To this end, we are integrating a process-based hydrologic model into a multi-scale, multi-objective evolutionary algorithm in order to evolve populations of potential watershed management practices. The solutions along the resulting Pareto front will enable watershed managers to assess the trade-offs between cost, effectiveness, and uncertainty when selecting best management practices (BMPs) for watershed management. We will also do a nonlinear analysis of characteristics of solutions along and orthogonal to the Pareto front in order to try to identify patterns from which we could extract fundamental design principles that would allow for direct design of effective solutions. We expect that results from this research will contribute to the understanding of watersheds as complex systems and will provide useful information to managers and policy makers who must decide how to allocate scarce resources for stormwater management most effectively.

Funding			
Funding Period Federal §104 Funds Required §104 Matching Funds			
FY2010	\$31,000	\$50,883	

Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post-Doctoral		

Publications	
Publication Type	Publication Citation
	Four publications are anticipated from this project and are in various states of preparation and review. We will report more fully on the fate of these publications in the 2011 Annual Report.