MEMORANDUM
FROM THE
LAKE CHAMPLAIN BASIN PROGRAM

To: **Erik Beck** - IJC Contract Officer's Representative **5 June 2009**
U. S. Environmental Protection Agency
New England Region

From: **Bill Howland**, Manager
Lake Champlain Basin Program
54 West Shore Road
Grand Isle, Vermont 05458

cc: **Willem Brakel,** IJC
Beth Card, NEIWPCC

Re: IJC - New England Interstate Water Pollution Control Commission/Lake Champlain Basin Program Contract, *Missisquoi Bay Basin Project: Identification of Critical Source Areas of Phosphorus Pollution,* **Deliverable: Workshop Report**

Please accept this memorandum and attachments as the deliverable for Task 1, Subtask 1 (9.3.1.1.1) – *Workshop Report* – under the IJC-NEIWPCC contract number 1042-800734.

Summary of Activities

The objectives of the workshop and meeting series were:

- to explore optimal spatial scale and extent, modeling methods, and parameters for the definition, identification and delineation of critical source areas
- to discuss available existing data and gaps in data that would need to be filled
- to assist in structuring and designing the short-term monitoring program and to discuss long term monitoring needs
- to discuss optimal means to compile and analyze information to provide a transboundary understanding of pollutant loads
- to examine the role of spring runoff and flooding on nutrient loads
- to evaluate the recent information compiled by the USDA NRCS Missisquoi Areawide Plan

To meet the objectives, the LCBP convened the following four workshops and two workgroup meetings (please see attached summaries for workshop or meeting details):

- *December 15th, 2008* – LCBP convened the *Workshop on Tributary Monitoring in the Missisquoi Bay Basin* to discuss short and long-term tributary monitoring needs in the Missisquoi Basin. The parameters to be measured, sampling intervals and sampling locations for the short term monitoring program to be funded under the IJC-NEIWPCC contract were discussed at the workshop.
- *January 22nd, 2009* – LCBP convened the *Workshop on Defining Critical Source Areas and Management Needs* to discuss how to define a critical source area and the type of information or outcomes that would be most useful to people working in the Basin to reduce phosphorus pollution.
- *January 23rd, 2009* – LCBP convened a project workgroup meeting. The workgroup debriefed the previous day's workshop, discussed types of approach (strategic and/or tactical) to identifying critical source areas, and the desired outcomes of the identification. The group also discussed the short-term tributary monitoring program and the recommendations from participants at the *Workshop on Tributary Monitoring in the Missisquoi Bay Basin*. The workgroup recommended potential monitoring locations and procedures.
- *March 12th and 13th, 2009* – LCBP convened the *Workshop on Approaches to Identifying Critical Source Areas in the Missisquoi Bay Basin* to review current and previous research on phosphorus pollution and to explore possible modeling approaches to identifying critical source areas. Two keynote speakers, Dr. Andrew Sharpley and Dr. David Dilks, provided an overview of critical source areas and the potential usefulness of models in identifying critical source areas. The first day of the workshop consisted of short presentations on topics including the Vermont Phosphorus Index, The Missisquoi Areawide Plan, the identification of runoff contributing areas, and SWAT modeling in the Rock River Watershed. The second day of the workshop consisted of presentations on the following CSA identification approaches: HSPF, BASINS, SWAT, SPARROW, AVGWLF, LIDAR and High Resolution Mapping, and Spatial Analysis.
- *April 13th, 2009* – LCBP convened a project workgroup meeting. The workgroup discussed the previous workshops and began to outline management and research objectives as well as desired outcomes for the critical source area identification. The group also considered possible approaches, including WMS.
- *April 28th, 2009* – LCBP convened the *Workshop on Data Availability and Data Needs* to review available datasets, to identify additional data needs and to explore transboundary data coordination.

Summary of the Workshop Series

Critical Source Area Identification

A critical source area is defined by the intersection between a phosphorus source and a transport mechanism. Two levels of identification, strategic and tactical, were considered during the workshop series. Strategic level identification would consider the entire basin and would be quantitative in nature. Tactical level identification would consider the farm- or micro-watershed scale and would be relative in nature. Both are valid approaches and would yield information that could be used by managers and others working in the Basin. A basin-wide analysis would be most beneficial for allocating funding between agency programs, while a field-scale approach would be most helpful for

implementing specific management practices on farms. It is hoped that both levels of identification will be addressed by this project.

The critical source area identification could be used to set priorities for management actions and to better allocate funds to management programs. It will also improve the understanding of the sources and transports of phosphorus over land and within the hydrologic network. Desired outcomes include both a relative ranking of types of phosphorus sources as well as physical locations of high phosphorus loadings and transport networks. The final product of this project should be available to all partners and should remain dynamic over time, as new data becomes available.

Multiple modeling approaches were explored during the workshop series. These included HSPF, BASINS, SWAT, SPARROW, AVGWLF, WMS, high resolution mapping, and spatial analysis. These models all appeared valid for this project, depending on the management objectives. Models that require a more detailed temporal scale may better represent important seasonal variations such as spring runoff and flooding events. The best way to determine the appropriate model may be to outline the management or research objectives and desired outcomes in a RFP and have the respondent propose suitable methods.

Data

The LCBP has begun acquiring datasets to help develop a transboundary understanding of pollutant loads and to facilitate the development of a pollutant loading model to identify critical source areas. The data compiled and developed by USDA NRCS for the Missisquoi Areawide Plan including farmstead locations, field crops, and gaps in riparian buffers, has been acquired by the Basin Program and will help the support the identification of critical source areas.

Additional available data was identified by workshop participants and included soils, soil phosphorus, use value parcel identification, town parcels, storm-water infrastructure, and land use/land cover. Some data is currently not available in electronic form and would have to be organized and aggregated by agencies. Other data are subject to confidentiality restrictions. Summarizing or aggregating the data may allow it to be used in this study. Notable data gaps included crop rotation schedules and locations of tile drainage. Additional gaps in data may become apparent once a specific model is chosen.

In many cases data is not consistent between Vermont and Quebec due to resolution and classification differences. For instance, the hydrography data is available at different scales on either side of the border and data are not edge-matched over the border. Integrating cross-border datasets would help to better understand phosphorus loading in the Missisquoi Bay Basin. Other data to be integrated or related include subwatershed boundaries, surface water impairment classification systems, soil types, and phosphorus estimates per animal unit.

Monitoring

Short-Term Monitoring

In consideration of the current basin-wide monitoring programs and recommendations from workshop and workgroup participants, the LCBP has designed a short-term monitoring program that will include tributary monitoring stations and meteorological monitoring stations. LCBP will

establish a minimum of ten monitoring locations within the Missisquoi Bay Basin to be sampled over a two-year period. The increased sampling in the Basin will address the need for more detailed spatial data of tributary nutrient loads and meteorological (precipitation) data.

The monitoring program plans to extend the current long-term monitoring network using similar collection and analysis techniques at the following five tributaries: Hungerford Brook, Black Creek, Tyler Branch, Trout River, and Mud Creek. Installation of a flow gage on the Sutton River also will improve the accuracy of current monitoring. Water quality will include measurements of total and dissolved phosphorus, nitrogen, and suspended sediments.

LCBP will establish a total of four meteorological stations in the Basin. Three meteorological stations will be co-located with stream gages. The fourth meteorological station will be located in East Fletcher, VT.

Long-Term Monitoring
Long-term monitoring stations in the Missisquoi Bay Basin were recently analyzed to determine the phosphorus load from ten sub-basins in the report *Phosphorus Loading to the Missisquoi Bay from Sub-Basins in Vermont and Quebec, 2002-2005* written by Marc Simoneau (MDDEP) and Eric Smeltzer (VTDEC). Adding long-term stations to this program will increase the understanding of pollution sources by allowing the Missisquoi Bay Basin to be divided into more monitored subbasins. In addition, increased long-term monitoring would better support modeling efforts in the future.

Appended Files

1. Summary of the *Workshop on Tributary Monitoring in the Missisquoi Bay Basin*
2. Summary of the *Workshop on Defining Critical Source Areas and Management Needs*
3. Summary of the January 23rd Workgroup Meeting
4. Summary of the *Workshop on Approaches to Identifying Critical Source Areas in the Missisquoi Bay Basin*
5. Summary of the April 13th Workgroup Meeting
6. Summary of the *Workshop on Data Availability and Data Needs*
7. Draft Missisquoi Bay Basin Project Database Summary

Missisquoi Bay Basin Project:
Identifying Critical Source Areas of Pollution

Workshop on Tributary Monitoring in the Missisquoi Bay Basin
Monday, December 15, 2008
10:00 AM – 3:30 PM
Gordon Center House, Grand Isle, VT

Workshop Summary

I. Welcome and Introductions

II. Overview of the Missisquoi Bay Basin Project

Bill Howland, manager of the Lake Champlain Basin Program (LCBP), provided an overview of the Missisquoi Bay Basin Project. The Program received funding from the International Joint Commission (IJC) to identify critical source areas of nonpoint source phosphorus pollution in the Missisquoi Bay Basin of Lake Champlain. The goal of the project is to identify and delineate areas of the Basin that contribute disproportionately large amounts of pollution to Missisquoi Bay, in order to efficiently target limited resources to reduce phosphorus loads.

Three major tasks will be completed as part of the project. The first task is to conduct a series of workshops and meetings to guide the project and development of a request for proposals. The second task is to establish a short-term tributary monitoring program. A minimum of ten new sampling sites will be established and maintained for the duration of the project (two years); data from the monitoring program is intended to assist the identification of critical source areas. The final task of the project is to conduct the critical source area identification analysis. This will be accomplished through a request for proposals and informed by the workshop and meeting series.

III. Monitoring Programs in the Missisquoi

A series of presentations provided background information on the current tributary monitoring programs in the Missisquoi Bay Basin.

Marc Simoneau, Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP), presented the report *Phosphorus Loading to the Missisquoi Bay from Sub-Basins in Vermont and Quebec, 2002-2005*, written in collaboration with Eric Smeltzer, Vermont Department of Environmental Conservation (VTDEC). Using ten sampling stations and nine flow gages, the phosphorus load from ten sub-basins in the Missisquoi Bay Basin was estimated. The results indicate that the phosphorus load to the Bay increased twelve percent, in comparison to the load measured in 1991 (the reference year). The U.S. Army Corp of Engineers' FLUX program was used to extrapolate the 2002 to 2005 basin phosphorus loads under the same hydrologic conditions that existed in 1991. This analysis estimated a decrease in the phosphorus load of 25% at the mouth of the Pike River and 8% at the mouth of the Missisquoi River under the reference year precipitation. The results of this study indicate that wastewater treatment upgrades and watershed management efforts have been beneficial. Additionally, increased precipitation and runoff in recent years has exacerbated pollution in the Missisquoi Bay Basin.

Eric Smeltzer, VTDEC, presented an overview of the tributary monitoring programs conducted in the basin and how they may assist in critical source area identification. Monitoring data can be used to calibrate and validate watershed models and to identify problematic sub-watersheds. Current MDDEP and VTDEC monitoring programs divide the Missisquoi Bay Basin into ten sub-basins, whose phosphorus export rates can be estimated. Increased sampling in the lower Missisquoi River sub-basin would divide it into smaller sub-basins, allowing a more thorough understanding of pollution sources. For example, establishing monitoring on Hungerford Brook, Black Creek, Trout River, and Tyler Branch would increase what is currently known about phosphorus sources to the lower Missisquoi River. The Sutton River, which is currently monitored, would also benefit from the addition of a flow gage.

The Vermont Center for Clean and Clear also conducts concentration-only sampling for a network of 22 sampling stations located in the Rock River Watershed. These stations were simultaneously sampled ten times for total phosphorus, dissolved phosphorus, total nitrogen, and total suspended solids. Preliminary results indicate order of magnitude differences in concentration among the sites. These results suggest that concentration-only sampling can provide a relative ranking of pollution; however, they are limited by the lack of flow data and are thus incomparable to other measurements of load.

Cynthia Scott, Missisquoi River Basin Association (MRBA), presented the volunteer monitoring program coordinated by the MRBA. The water sampling program began in 2005 as an effort to locate areas of phosphorus pollution. Sampling occurs every other Wednesday at 21 sites (five on the Missisquoi River and sixteen located at tributaries) and the State of Vermont's LaRosa Lab analyses the results. The preliminary results for the 2008 sampling season indicate that Mud Creek, Tyler Branch, and Tyler Branch at Duffy Hill Road carry high concentrations of phosphorus.

Aubert Michaud, Institut de Recherche et Développement Agroenvironnement (IRDA), presented an overview of the methodological aspects of a sampling program and the type of sampling needed to support modeling. Tributary monitoring can be used to document fluxes, describe spatial and temporal variability in nutrient concentrations, and develop and validate management tools by combining spatial data and modeling. Monitoring data supports management decisions by determining target loads, critical source areas of pollution, implementation actions, and progress.

Monitoring studies that pair similar watersheds with one controlled and one experimental (added management practice) can assist in the creation of models and the understanding of the effectiveness of a practice. Monitoring data is also useful when it provides a link between the watershed land use and water quality. Sampling that includes flow-stratified measurements of concentration can be used in regression and modeling to determine reliable estimates of loadings across space and time. Measuring conductivity can help estimate stream discharge as well. Watershed-specific hydrological responses and seasonality must also be incorporated in monitoring and modeling.

IV. Transboundary Monitoring Coordination

A facilitated discussion focused on how to coordinate monitoring efforts across the border. The group considered the current monitoring and began to think about increasing collaboration with the new monitoring effort through the Missisquoi Bay Basin Project. The group also considered the availability of Canadian data and obstacles that may prohibit sharing information.

The long-term monitoring has been well coordinated, in particular between MDDEP and VTANR. This monitoring program is the basis for the report on phosphorus loads previously presented by Marc Simoneau. A difference in the calculated phosphorus concentration between VT and QC was due to methodologies and corrected in the report. Other differences in methodologies exist, such as those for measuring phosphorus soil concentrations. In general, different methodologies need to be considered and corrected when sharing and comparing data.

The group expressed interest in having a consistent and common precipitation data set that would be accurate across the entire basin. Data from weather stations in both countries could be compiled to generate a more complete map of the basin. It may be necessary to consider the locations of current meteorological stations and determine if there are any gaps to be filled; for example, there is no meteorological station in the Bay itself.

A map of the basin was created by the LCBP and displays the current sampling stations and designated impaired waters (please see attached map). The group discussed the difficulty of integrating different datasets for the entire basin because of inconsistencies across the border. The LCBP must assure the quality of the data or develop an acceptable integration method and is still in the process of collecting data from the different agencies.

V. International Joint Commission Funded Monitoring Program

Bill Howland, LCBP, reviewed the purpose of the short-term monitoring program funded by the International Joint Commission and handed out an information sheet to help guide the discussion (see attached handout). A minimum of ten new stations will be established and maintained for the duration of the two-year project. Station locations, parameters to be measured, and optimal sampling periods and intervals need to be identified.

The goal of tributary monitoring is to assist in the identification of critical source areas. The following should be considered when designing the monitoring program:

- What are the short- and long-term monitoring needs for phosphorus, nitrogen, and sediment in the Basin?
- What type of data would be most useful to validate and calibrate a basin-wide model?
- What type of information is needed to understand the processes at work in the Basin?
- What monitoring is needed to understand transboundary pollution loads?
- What is the importance of seasonal precipitation and rainfall intensity?

VI. Short and Long-Term Monitoring Needs in the Missisquoi Bay Basin

The group discussed monitoring needs, potential sites, parameters to be sampled, and the optimal sampling periods and intervals. The discussion was intended to guide the tributary monitoring program to be established as part of the IJC funded project.

The group discussed the fundamental problem of designing a program to collect data before the methodology to identify a critical source area is known. The group also considered the fact that the term "critical source area" has yet to be defined for this project; this definition could have implications for the design of a monitoring program.

The group considered the current gaps in monitoring sites as possible locations for new stations. The group also discussed the possibility of improving some of the current sites (such as ones monitored by MRBA and the University of Vermont) so that measurements would be comparable and subject to agreed upon standards. Another suggestion was to classify drainage areas by characteristics (e.g. land use, soil, topography) and then establish a monitoring program that would encompass the variability within the Basin. Similarly, monitoring locations could be placed to capture the specific characteristics of different watersheds. Another approach may be to look at farm- and field-level information and implement edge-of-field sampling.

The group considered the importance of flow data and the possibility of installing automatic samplers. It was also suggested that the resources be used to obtain better spatial data. One possible approach would be to establish some long-term monitoring locations in addition to a short-term synoptic sampling program of twenty or more stations that capture a continuum of watershed characteristics to help in the identification of critical source areas and in model validation. It might also be instructive to examine current land use and changes in land use over time.

VII. Identification of Potential Monitoring Sites

The group recommended the following potential monitoring locations be considered in addition to the current long-term monitoring program:

- Mud Creek
- Black Creek (opportunity to capture flood events) at the mainstem, upper, and lower ends
- Rock River at the international border
- Hungerford Brook

VIII. Thank You and Adjourn

Bill Howland thanked everyone for attending and providing input. It was a productive meeting and the LCBP will consider everyone's input in planning the tributary monitoring program. More workshops focused on guiding the critical source area identification will be scheduled for the winter and spring. The LCBP will send invitations and encourages everyone's participation.

Workshop Attendees

Name	Organization
Erik Beck	Environmental Protection Agency
Phil Benedict	Vermont Agency of Agriculture Food & Markets
Willem Brakel	International Joint Commission
Jeff Comstock	Vermont Agency of Agriculture
Jeff Deacon	United States Geological Survey
Laura DiPietro	Vermont Agency of Agriculture Food & Markets
Fred Dunlap	New York State Department of Environmental Conservation
Ben Gabos	Vermont Agency of Agriculture Food & Markets
Lula Ghebremichael	University of Vermont
David Healy	Stone Environmental, Inc.
Brian Jerose	Waste Not Resource Solutions
Richard Kiah	United States Geological Survey
Paul Madden	Friends of Missisquoi Bay
Don Meals	private consultant
Aubert Michaud	Institut de Recherche et Développement Agroenvironnement
Martin Mimeault	Ministère du Développement Durable, de l'Environnement et des Parcs
Julie Moore	Vermont Agency of Natural Resources
Lin Neifert	United States Geological Survey
Debra Perry	Northwest Regional Planning
Staci Pomeroy	Vermont Department of Environmental Conservation
Kip Potter	Vermont Natural Resources Conservation Service
Jake Riley	VHB Pioneer
Nate Sands	Vermont Agency of Agriculture Food & Markets
Cynthia Scott	Missisquoi River Basin Association
Marc Simoneau	Ministère du Développement durable, de l'Environnement et des Parcs
Eric Smeltzer	Vermont Department of Environmental Conservation
Michael Winchell	Stone Environmental, Inc.
Mike Winslow	Lake Champlain Committee
Jon Winsten	Winrock International/University of Vermont

Lake Champlain Basin Program Staff:
Nicole Grohoski, Colleen Hickey, Bill Howland, Kris Joppe-Mercure, Meg Modley

Missisquoi Bay Basin Project:
Identifying Critical Source Areas of Pollution

Workshop on Defining Critical Source Areas and Management Needs
Thursday, January 22, 2009
10:00 AM – 4:00 PM
Missisquoi National Wildlife Refuge, Swanton, VT

Workshop Summary

I. Welcome and Introductions

II. Overview of the Missisquoi Bay Basin Project

Bill Howland, manager of the Lake Champlain Basin Program (LCBP), provided an overview of the Missisquoi Bay Basin Project. The Program received funding from the International Joint Commission (IJC) to identify critical source areas (CSAs) of nonpoint source phosphorus pollution in the Missisquoi Bay Basin of Lake Champlain. One of the major tasks of this project is to conduct a series of workshops and meetings to guide the project and development of a request for proposals. As part of that series, this workshop, facilitated by Mike Winslow of the Lake Champlain Committee, aims to define CSAs and determine how information generated by CSA identification can be useful to people in the region.

III. What is the definition of a critical source area?

A series of presentations provided definitions of CSAs and was followed by a facilitated discussion about a useful definition for this project. The following questions were asked of the presenters:

1. What is a good two sentence definition of a critical source area?
2. How do you recommend we distinguish between a critical source and a critical source area?
3. What are the 2-3 most important driving characteristics of a critical source area?
4. What should the final product of this project to identify a critical source areas be? (Please think about the spatial scale).
5. What are some limitations to your definition or concept of a critical source area?

Mary Watzin, University of Vermont

A critical source area is defined by the intersection of a phosphorus source and a transport pathway. Soil P concentrations could locate sources, but land management practices and geophysical attributes provide the pathway for P transport. However, there are non-agricultural sources of P that we must also consider. In this case, considering critical sources is unnecessary because knowing what critical sources are is irrelevant without knowing where they are so we can eliminate them. The major limitation in modeling is gathering appropriate data (both geophysical and chemical) for calibration. We are a lacking data on farm practices and urban infrastructure.

The general driving characteristics of a CSA are high erosion, high P concentration, and human management practices. We need to target areas where management is either inappropriate or non-existent. Ultimately, the CSA identification should locate places where landscape features and management practices lead to high P loss. Modeling challenges may require coarse analysis on the

level of sub-watersheds, which will give context within the Basin and could be supplemented with on-the-ground assessment.

Don Meals, independent contractor
A critical source area is defined by the intersection of a phosphorus source and a transport pathway, at the same place and time. CSAs vary with management and hydrology and their identification helps locate Best Management Practices (BMPs), which either change the source of P or interrupt its transport. The major limitation in identifying CSAs is the lack of data on P sources, including P index, soil test P/P_{sat}, management data, and mass balance. Another limitation is the ability to accurately locate runoff contributing areas, which require variable source area hydrology, topographic analysis, field studies/ LiDAR.

Driving characteristics can be split into sources (based on factors such as fertilizer application, soil P concentrations, or land management) and transport mechanisms (e.g. runoff, drainage, impervious surfaces, or hydrological activity). CSA identification should focus on long-term issues, rather than infrequent phenomena like a 25-year storm shortly after manure application. Analysis should begin with determining runoff contributing areas. The end product should be a map that overlays locations of high P with the probability that an area will experience runoff; data should be detailed enough to locate fields.

Aubert Michaud, Institut de Recherche et Développement Agroenvironnement
The definition of a CSA includes the pollution source, its transport mechanism, and its impact on the ecosystem. CSAs differ from critical sources in their inclusion of a spatial aspect and are limited to nonpoint sources; pollution is also variable in space and time and can only be prevented (rather than treated). A CSA analysis should consider multiple spatial scales, mass-balance of point and non-point sources, landscape features, land use, validation from monitoring, and user-driven diagnoses of needed BMPs. This analysis will be limited by the seasonality of P transport, variation in bioavailability of P, ground- and surface-water interactions, and the external and internal loadings.

Driving characteristics of a CSA are landscape (relative position within an area, water table levels, connectivity and density of hydrologic network, soil properties) or land use (management practices, nutrient inputs) related. A tool for identifying CSAs could be either strategic or tactical. A strategic approach would consider the entire basin at a low resolution, be quantitative and validated by models, be informed by hydrological modeling, and would assess BMP efficiency. A tactical approach would consider micro-watersheds at a high resolution, be relative in nature, be informed by remote sensing rather than hydrologic modeling, and support site-specific implementation of BMPs.

Reed Sims, Natural Resources Conservation Service
From a scientific standpoint, a CSA is "a region in which a convergence of environmental stressors causes ecological disruption and the detrimental release of nutrients or toxic substances to a vulnerable hydrological network." Or, more simply, it's "a place where we've messed things up so much, you can't first, swim, or breathe anymore" – the results are what matter to humans and other species. The process of locating CSAs will require breaking the complex picture down into measurable things: legacy P in soil or streambeds, proximity of and protection between certain land uses to the hydrologic network, management practices that alter access to the network, and climate conditions. While we can determine possible CSAs based on P presence and mechanism, we are only predicting their likelihood. Limitations to the analysis will be inadequate data, incorrect

conclusions derived from the inadequate data, government reluctance to point fingers, and how the results apply to conservation efforts.

Driving characteristics of a CSA are human activity in the area, connectedness or proximity to surface water, and topography. Maps showing field and parking lot scale CSAs should be generated in order to help prioritize BMPs that will require farm-by-farm assistance. It should also publicize where CSAs are and provide evidence of their existence (empirical, photographic, or geospatial).

Facilitated Discussion:
Mike Winslow emphasized that there is general agreement that a CSA occurs at the intersection of a source and a transport mechanism, but that management practices also factor into CSAs since they can support or impede transport. The final product of the workshop must be considered during the discussion – we have already identified critical subwatersheds and now need more detailed spatial data. The following topics were discussed:

How should CSA analysis be approached?
It might be most efficient to start with hydrological assessments in the Basin so that we can target areas for which to gather detailed management information (rather than beginning by locating all tiling, for example). A high resolution Digital Elevation Model (DEM) within a meter of vertical error would be necessary to do this effectively. Running this assessment under different water flow scenarios could be a good place to start.

Modeling could also begin with a small watershed to determine landscape characteristics that combine to create CSAs and could then extend to find these characteristics elsewhere in the Basin. Or, we could look at current data to identify critical watersheds to focus on first. In addition to considering the spatial scale of analysis, temporal variations need to be captured when identifying CSAs; a model can function under different weather scenarios or incorporate crop rotation schedules, but this level of detail should not impede its progress.

The model will need to be validated; however, we are not trying to validate what we already know, we are trying to model unknown areas and future problems. Properly documenting animal densities, land use, and physiographic information would create a useful and usable model.

Ultimately, studies should focus on P attenuation: low concentration point sources which are directly discharged may have a higher impact than higher concentration loads that are decreased as they travel across the landscape. The actual P contribution to the Bay from a CSA needs to be considered.

What data should be included?
The locations of direct transport pathways from farmsteads to streams is available but would be enhanced by information on livestock in order to identify CSAs (VAAFM or NRCS may have this data). Information about farm mass balance is necessary to identify farms with manure excess, which would be CSAs – some fields are greater contributors than others so we need to look beyond transport mechanisms. Soil test data should also be included but is collected differently in Vermont and Quebec; fortunately, we know how to compare this data.

In-stream processes, such as hydrological modification, should be included in the analysis, if possible. We could consider geomorphic assessment data to identify unstable reaches as CSAs, but

we also need to address associated land practices. Alternatively, we could identify land-based CSAs and then consider ones adjacent to or upstream of unstable reaches as more critical to address. Although the stream network can act as a CSA in addition to a transport mechanism, in-stream P storage will be difficult to reduce in the short-term, so this analysis might best focus on land-based CSAs.

The analysis might need to consider different forms of P (sediment and soluble), though this can be difficult with models. We will need to choose forms that comply with existing monitoring data and are inexpensive to measure. We must also consider impervious surfaces in addition to agricultural lands because they impact transport (more than they add to the load).

Monitoring is a minor source of data in the Basin compared to remote sensing but should inform the determination of CSAs and be used to assess remediation techniques.

What are the challenges of this analysis?
Using detailed data with general data can affect the accuracy of CSA locations (e.g. LiDAR without field-specific land practices). Detailed land-use information combined with runoff contributing areas would show likely sources of P, but this information is difficult to obtain. However, we do know where farmsteads are and census data of animal densities could show an area's potential as a CSA.

What should analysis results be?
The result could be a gridded index which gives a relative coefficient of P for pixels in the Basin and could be used to target BMPs. The model might be easier for people on the ground to use if it exists for a smaller area than the whole basin, and the frequency with which it is run should be considered.

Generated maps (paper or electronic) should be available to land managers and the public, though we need to be wary of finger-pointing. Should this data be used to limit development or agriculture in identified CSAs? Although this analysis will identify CSAs of pollution, land managers should keep current and potential P sinks in mind in order to reduce the total P load to the Bay. We must also remember that this effort will only identify areas of concern, and that land managers will need to offer incentives in order to obtain land-owner participation in mitigation efforts. How to do this tactical piece is separate from the modeling effort, and will help to narrow a CSA down into more specific and targetable point sources.

Ultimately, we must measure long-term progress in the Bay; we can use monitoring to determine if the correct CSAs have been identified and properly mitigated. It may take a while to see significant improvements. We should determine a time-period (three years was proposed) after which we expect to see ecosystem recovery, due to BMP implementation, and reassess our progress. This assessment might be easiest at the subwatershed level, so it might make sense to begin by targeting investments in a specific watershed.

Since this initiative is funded by the IJC and must focus on the Missisquoi Bay Basin, we are not concerned with the transferability of modeling efforts to other areas.

IV. What type of information would be most useful for people working in the Basin to reduce phosphorus pollution?

A series of presentations by field staff, managers, policy makers, and farm and citizen advocates addressed the types of information they currently use to prioritize their work or could benefit from in the future. These were followed by a facilitated discussion about useful outputs from a CSA analysis. The following questions were asked of the presenters, whose responses are summarized below:

1. What type of information do you currently use to set your priorities for the phosphorus reduction work that you do?
2. What type of information do you wish you had to better target your work?
3. What format and scale of information on identifying critical source areas would be most useful?

Julie Moore, Vermont Agency of Natural Resources
The agency prioritizes BMP projects based on how they will help obtain the lake TMDL goals, landowner willingness, and partnering opportunities (with regional planning commissions and watershed groups, e.g.). Often projects become concentrated because growing local awareness leads to more interest. "Everyone needs to do everything everywhere" … there are no bad projects.

It would be helpful to be able to compare P loads between rivers, urban areas, and agricultural areas. A framework for targeting work beyond just anecdotal evidence would help decision-making. It would also be useful to locate and determine the effects of hydrological modifications.

We need to set interim targets that are challenging and can lead to the final goal of TMDL achievement. The model should assist field staff and must recognize the current mix of regulatory and voluntary programs.

Ben Gabos, Vermont Agency of Agriculture Food and Markets
In order to target areas, Ben uses anecdotal evidence (observations or complaints), aerial imagery, monitoring data, communications between agencies, VT DEC River Management assessments, and the wetland restoration plan. He also assesses landowner interest. Often, responding to one problem can lead to finding more issues, but it also prevents locating others.

It would be helpful to have LiDAR data to locate features such as ephemeral gullies because obtaining accurate soil P data within the Basin is unlikely – landscape features will be problematic regardless of P loads.

Information needs to be given on a field scale and shared so that efforts are not duplicated. Additionally, communication is important because landowners may not be aware of runoff issues because they lease their fields to farmers. Also, choosing priority watersheds would be helpful for field work. Ultimately Ben hopes to use better geographic analysis and CSA identifications to target field work.

Roger Rainville, Farmer's Watershed Alliance
First, farmers must volunteer to have their water quality assessed. The Farmer's Watershed Alliance surveys the farmstead in a few hours using an adapted the EPA's Water Quality Assessment Plan. They focus actions on simple and obvious problems. They must also consider future farm expansion and how those change farm needs as well as the long-term business implications of implementing a BMP. Solutions are prioritized on a first-come, first-served basis.

The alliance would benefit from more outreach to increase farmer awareness of their programs, as well as more funds to help implement projects in this tightening economy. The Alliance also has limited scientific resources but a strong volunteer base.

Brian Jerose, Waste Not Resource Solutions and the Missisquoi River Basin Association
Brian uses visual observations, site visits (farmstead walks or geomorphic assessments), water quality monitoring results, conversations with landowners, and information generated by partner groups or agencies to locate areas of high flow to target for phosphorus reduction initiatives.

It would be helpful to have flow accumulation maps (like have been recently created by the NRCS) to limit field assessments to areas of high runoff potential. Field-level hydrological information (e.g. slope, floodplains, tile drain locations, annual and perennial streams or ditches) and soil physical properties (e.g. porosity and moisture retention of soils, soil type, background levels of nutrients) would also be helpful. Brian noted that areas with tile drainage can be problematic if the soil is saturated or crusted over and that variable soil conditions are the most important during the spring when the ground is bare.

Field-scale maps would be useful to share with farmers, towns, and land managers in order to inform precision agriculture and conservation and should be provided as both geographic files and finalized maps. Information generated from this analysis should be able to help adjust behaviors (economic impact is useful to know), identify the most appropriate lands to be cropped, assist in customizing incentives, and determine places to improve tile drainage networks. This analysis may be limited by money, and so it may have to focus on targeting sub-watersheds so that other groups or agencies can continue their work effectively. In terms of resources and time, is modeling or field studies more effective?

Deb Perry, Northwest Regional Planning Commission
For the Planning Commission water quality is a priority in the context of other community concerns (flooding, recreation value, scenic value, farm vitality, etc.). The planning commission considers the functionality of reaches of waterways based on information from other sources in order to facilitate mitigation projects. They focus on areas when landowners and waterways both benefit or determine suitable landowner compensation, if necessary.

When the commission prioritizes projects, it considers: likelihood of success, restoration to geomorphic equilibrium, location of project within the watershed, landowner willingness, cost effectiveness, visibility and educational value of project, and its ability to leverage other agency funding.

The commission would benefit most if the CSA locations were supplemented with recommended BMPs. It is currently difficult to compare and prioritize projects or do cost-benefit analyses. The regional planning commissions work with communities involved in planning and zoning in order to protect nutrient sinks and avoid development on potential CSAs, so knowing where these areas could be would be useful preventative information. Data generated should be provided as both geographic files and pdf maps. Models also need to be sustainable in the long-term so they can continue to generate results and have input data updated.

Facilitated Discussion:

The state and NRCS will still prioritize their work based on landowner volunteers, so in some ways ranking CSAs may not be that helpful. Perhaps known CSAs could receive greater incentives than other areas. Locating CSAs could help farmers change their practices in target areas, if outreach were done. It might help farmers within CSAs to know that they are not managing their land differently than their neighbors, but rather that the land is more sensitive due to its physical features. The Farmer's Watershed Alliance believes they could get farmer participation without regulations or penalties because their program is confidential and voluntary; however, they don't have the resources to recruit farms, thus knowing the locations of CSAs would make approaching farmers more feasible.

CSA identification will determine long-term issues which are currently only found because of short-term phenomena. In addition to managing for these short-term issues, we should be able to target long-term efforts based on CSA analysis.

While the goal of this project is to inform management and policy and not to decide how CSAs should be targeted by agencies, the group discussed how targeting could occur. Although it may be true that there are no bad projects, there may be ineffective ones. It is necessary to target efforts so that limited money can be spent on the most critical areas. The results of the CSA analysis will need to be considered from a programmatic standpoint, so that issues can be addressed with voluntary state programs. One option may be to set a priority watershed or area for BMPs so that it is obvious to farmers why they are involved in the program; however, we cannot exclude problematic farms in other watersheds. .

The group noted that pollution factors affecting blue green algae growth in the Bay are still unknown – because nitrogen might be the limiting nutrient for its growth, this should be included in the analysis. Phosphorus is more commonly associated with soil whereas nitrogen is with organic matter, thus the sources and transport pathways differ. While this grant requires that we focus on phosphorus it does not preclude us from looking at nitrogen. Additionally, this modeling effort will require that we develop data and methods which may be helpful for considering other nutrient transport.

Given the discussion of data needed and generated by this analysis, the confidentiality of this data was discussed. The NRCS, for example, requires a signed release form in order to share any information that can be traced back to an individual, but summary data can be released. In Quebec, a minimum of four farms are aggregated before farm-scale nutrient data can be shared and soil test data is linked to postal codes (nutrient management plans remain confidential). Unfortunately, very general aggregates may obscure farm-specific management practices and make that aspect of CSA identification very challenging.

It was proposed that we tie soil test data to coordinates but not specific landowners for this analysis or that perhaps we could eliminate landowner liability so that they would be willing to share information. It was suggested that the Farmer's Watershed Alliance could get information from every farm but would landowners of other types would also be willing to divulge their information? The LCBP cannot provide confidential information to the IJC, thus any information used for or generated by the analysis will become public domain. Although it cannot be shared in detail, data from nutrient management plans shows the range and variation between fields and can give a basic idea of P amounts. Perhaps the problem is partly an issue of language – informing farmers that they are in an "environmentally sensitive area" that requires special management rather than that they are

a "critical source of pollution" might avoid an accusatory tone. Also, it is likely that enough places will be identified so that people will not feel singled out.

Surrogate or general data may not allow modeling to be sufficient. It was suggested making landowners partners will help them share their information. Providing incentives for sharing information and committing to help landowners if their land is identified as a CSA may also help. In general, landowners will need incentives (either internal or external) before they factor CSAs into their decisions.

The regional planning commission worked with a model in St. Albans that was created based on stakeholder meetings where people expressed their concerns and connected with each other over the local issues. The model recommended BMPs, some of which were implemented and used as demonstration projects for further implementation. A few years later, the commission wishes that they had a way of updating cost/benefit calculations and other changing variables. The "Don't P on Your Lawn" project is also a good example of successful outreach and education.

The idea that we might not actually have a soil P problem as much as we have an erosion problem was also raised. Nutrient management plans could focus on soil P while the model could locate CSAs based on physical features. If that's the case, then would a map showing areas of concern be sufficient? Flow accumulation data (especially from LiDAR) and tile drainage networks will help target restoration to original hydrology. But, because soil tests are more variable in the short-term, they will help to narrow down current CSAs.

It is also necessary to be mindful of areas of than agriculture, e.g. urban areas, suburban developments, and back roads. The model must also be an accessible and repeatable tool and geographic data should be shared. It was also suggested that the model is only a strategic tool that should help us focus tactical actions in the future.

V. Workshop Summary, Next Steps, and Adjourn

Bill Howland thanked everyone for attending and providing input. It was a productive meeting and the LCBP and project workgroup will meet to discuss the general messages from the workshop and the next steps, in light of these ideas. The next workshop will focus on the application of different models to similar problems as well as research currently being done in the Basin. Throughout this process, the LCBP will refine the requirements of an RFP to carry out the CSA analysis. Additionally, LCBP will draft a QAPP for monitoring stations and host another workshop focusing on available and necessary data. The LCBP will send invitations and encourages everyone's participation.

Workshop Attendees

Name	Organization
Bill Bartlett	
Erik Beck	Environmental Protection Agency
Laura DiPietro	Vermont Agency of Agriculture Food & Markets
Fred Dunlap	NYS Department of Environmental Conservation
Greg Fanslow	University of Vermont, Rubenstein School
Evan Fitzgerald	Fitzgerald Environmental
Sally Flis	Bourdeau Brothers
Ben Gabos	Vermont Agency of Agriculture Food & Markets
Bob Hammerl	Vermont Agency of Natural Resources
Brian Jerose	Waste Not Resource Solutions
Matt Kittredge	Vermont Agency of Agriculture Food & Markets
Mike Kline	Vermont Department of Environmental Conservation
Suzanne Levine	University of Vermont
Paul Madden	Friends of Missisquoi Bay
Don Meals	private consultant
Aubert Michaud	Institut de Recherche et Développement Agroenvironnement
Megan Moir	Vermont Agency of Natural Resources
Julie Moore	Vermont Agency of Natural Resources
Leslie Morrissey	University of Vermont
Eric Perkins	Environmental Protection Agency
Debra Perry	Northwest Regional Planning Commission
Staci Pomeroy	Vermont Department of Environmental Conservation
Kip Potter	Natural Resource Conservation Service
Roger Rainville	Farmer's Watershed Alliance
Mike Rapacz	Conservation Law Foundation
Gary Sabourin	Vermont Department of Forests, Parks, & Recreation
Nate Sands	Vermont Agency of Agriculture Food & Markets
Cynthia Scott	Missisquoi River Basin Association
Reed Sims	Natural Resource Conservation Service
Eric Smeltzer	Vermont Agency of Natural Resources
Chris Smith	US Fish & Wildlife Service
Mary Watzin	University of Vermont
Michael Winchell	Stone Environmental, Inc.
Mike Winslow	Lake Champlain Committee

Lake Champlain Basin Program Staff:
Nicole Grohoski, Colleen Hickey, Bill Howland, Kris Joppe-Mercure, Meg Modley, Michaela Stickney

Missisquoi Bay Basin Project:
Identifying Critical Source Areas of Pollution

Workgroup Meeting on Defining Critical Source Areas and Management Needs
Friday, January 23, 2009
10:00 AM – 3:00 PM
Gordon Center House, Grand Isle, VT

Workgroup Meeting Summary

I. Welcome and Introductions

The Missisquoi Bay Basin Project Workgroup was convened to define the term "critical source area," taking into consideration the discussions of *Workshop 2: Defining Critical Source Areas and Management Needs*. The group will also discuss useful data types and formats to be generated through this project and how to share these with people in the Basin. In addition to these topics, the Workgroup will consider the goals of the short-term monitoring program and possible locations and types of monitoring to be established.

II. What is the definition of a critical source area?

A critical source area (CSA) occurs at the intersection of a phosphorus source and a transport mechanism; the magnitude of this source needs to be considered in order to prioritize action. Knowing the magnitude of the source may not be as useful as determining the potential for load reduction. Also, the magnitude of nutrient export is tied to land use and water networks, so the detail of these data need to be considered.

III. What type of source information would be the most useful to people working in the basin to reduce nonpoint source pollution?

Field-scale information about nutrient sources would be the most useful for people working in the Basin, but this may not be possible to generate because of the sensitivity of farm-level data. This project may require two approaches at different scales with different data inputs – a model might help to identify broader areas of concern, while geographic analysis with remote sensing might help pinpoint individual CSAs. Sampling has helped us locate watersheds of concern, but geographic analysis may help us narrow these areas down even more. In addition to locating the sources and determining their relative magnitude, a model should be able to help assess the efficacy of proposed better management practices (BMPs) and progress in reducing pollutants.

A strategic, or spatially broad, analysis might include:

- a warehouse of spatial data, monitoring results, and BMP efficiencies
- identification and prioritization of significant critical sources, for example: farmsteads, farm fields (crop, pasture, grass with annual tilling), wetlands, back roads, developed land (effective impervious surfaces, residential lawns, construction activities), wastewater, geomorphic/fluvial processes, forestry practices
- identification of significant nutrient sinks, for example: wetlands, floodplains, riparian buffers, forests, fields or other landscape features, detention basins (wastewater treatment facilities, septic systems)

- identification of transport mechanisms, for example: runoff, precipitation, flooding, hydrological modification, tile drainage
- prioritization of management actions or state programs
- creation of a better land use/land cover dataset to identify areas that should be targeted based on knowledge of nutrient sinks and sources

A tactical, or spatially detailed, analysis might include:

- locating erosion susceptible landforms, such as rills and gullies using LiDAR and high-resolution orthophotography
- locating Runoff Contributing Areas (RCAs) in order to isolate areas that may be problematic based on land use

The most useful end result of this project would be a map of the Basin with sources of phosphorus identified as polygons and a model of transportation networks overlayed on the map to locate CSAs. A relative ranking of magnitudes critical source areas should also be included. The analysis must take both agriculture and urban land uses into account. The results should help program managers set priorities for action, provide information for field, and be publicly available.

At a minimum, the request for proposals (RFP) must identify desired outcomes so that respondents can determine the best ways to accomplish these goals. However, providing detailed requirements will help to specify intermediate datasets that might be useful in other projects. It may be valuable to split this project into multiple RFPs, so that different contractors with different skills can be utilized (e.g. enhancing drainage networks and developing land use/land cover data require different skill sets).

IV. Preparation for the next IJC workshop on approaches to identifying critical source areas

Workgroup members discussed the structure of the third workshop in the series. The first day of the workshop will include presentations on recent research that might be pertinent to this project. The second day will include presentations by modelers about the capabilities, limitations, and data requirements of specific models or approaches – including SWAT and SPARROW – and how applicable they might be to this project. This day will be introduced by someone who is familiar with a wide variety of models and can give a general overview of how useful modeling might be, given the available data, resources, and desired scale.

The final workshop on data availability and data needs will be informed by the third workshop, because presenters will discuss specific data requirements for models. These needs can be compared to a summary of the current LCBP database to determine data gaps; workshop participants representing local agencies can identify other available data not yet obtained. Transboundary data assimilation will also be discussed.

V. Short-term Tributary Monitoring

Two basic monitoring methods were discussed at the first workshop: establish rigorous monitoring to supplement the current long-term monitoring network or sample more sites across the entire Basin without flow data to aid in more localized comparisons of possible pollution-contributing tributaries. The Lake Champlain Basin Program (LCBP) also could establish monitoring above and below a Best Management Practice (BMP) to determine its effectiveness, around shifts in land use to determine their effects on water quality, or for a paired-watersheds study. The monitoring program should support

modeling efforts, allow changes in water quality to be tracked in the coming years, and include an efficient means of warehousing and sharing all data collected.

The group decided that the greatest value would be to expand the long-term monitoring network in the Basin. New monitoring sites were identified at the mouths of Hungerford Brook, Black Creek, Tyler Branch, Trout River, and Mud Creek to fill the gaps in the current long-term monitoring program. Data collection and analysis at the new locations would be conducted similarly to the existing long-term monitoring, to allow for a consistent data set. In addition to these new stations, the group identified the need for a flow gage on the Sutton River to increase the accuracy of current monitoring. This gage would be established on the US side of the border.

The group also identified the need for a more in-depth network of meteorological stations. There are no automatic National Weather Service (NWS) stations in the Basin; however, there are NWS Cooperative Observer Program stations in and near the Basin. There are three stations in the Quebec Sector of the Basin. Automatic stations in three or four locations within the basin would add to the current NWS stations in the state. Alternatively, the LCBP could find volunteers and purchase stations to add to the Cooperative Observer Program network. In either case, the LCBP would aim to measure meteorological data under the quality assurance plans used by the NWS. The group recommended looking at future station sites near Swanton, East Fletcher, and Troy and will research the possibility of upgrading current sites in Enosburg Falls, Highgate Falls, and at Jay Peak.

VI. Next Steps and Adjourn

The LCBP will convene two more workshops to discuss approaches to defining critical source areas and to consider data needs to support these possible approaches. In addition, the LCBP will develop a Quality Assurance Project Plan for the short-term monitoring program and determine the specific locations and sampling procedures for monitoring.

Meeting Attendees

Erik Beck, Environmental Protection Agency
Laura DiPietro, Vermont Agency of Agriculture Food & Markets
Julie Moore, Vermont Agency of Natural Resources
Kip Potter, Vermont Natural Resources Conservation Service
Eric Smeltzer, Vermont Department of Environmental Conservation
Mike Winslow, Lake Champlain Committee

Lake Champlain Basin Program:
Nicole Grohoski
Bill Howland
Kris Joppe-Mercure
Meg Modley

Missisquoi Bay Basin Project:
Identifying Critical Source Areas of Pollution

Workshop on Approaches to Identifying Critical Source Areas in the Missisquoi Bay Basin
Wednesday and Thursday, March 12 and 13, 2009
Doubletree Hotel, Burlington, VT

Workshop Summary
Day 1

I. Welcome and Introductions

Bill Howland, manager of the Lake Champlain Basin Program (LCBP), welcomed everyone to the workshop and provided an overview of the agenda.

II. Overview of the Missisquoi Bay Basin Project

Bill Howland, LCBP, provided an overview of the Missisquoi Bay Basin Project. The goal of this project is to identify critical areas contributing nonpoint phosphorus pollution to Missisquoi Bay. Identifying the critical areas will help to target resources to manage the problem. The LCBP is convening a series of workshops to help guide the critical source area identification and the development of a request for proposals. This workshop will provide an overview of recent and ongoing research on phosphorus pollution and explore possible approaches to identifying critical source areas.

III. Key Note Address: *Identifying Critical Source Areas*

Dr. Andrew Sharpley, University of Arkansas

Dr. Sharpley discussed critical source areas and how they can be defined, identified, managed, monitored and assessed. Phosphorus and other nutrients, including nitrogen, are valuable resources, but can become a problem when they runoff the land into our waterways. Soils have a capacity to combine with phosphorus. Research on plots of soil with rainfall simulation helped develop a relationship between soil test phosphorus (STP) and the amount of dissolved phosphorus in the runoff. Breaking the curvilinear relationship with defined thresholds is one way to define soil phosphorus levels and to determine when to add phosphorus to the soil.

A critical source area occurs where there is both a source of phosphorus and a transport mechanism to move the phosphorus to the waterways. The amount of phosphorus lost is a function of both the amount of phosphorus in the soil and the runoff volume. Critical source areas can be identified at different levels of complexity. Management decisions are made at the farm level; therefore, identifying the critical source areas at this level will best help affect the amount of phosphorus runoff.

There are different tools to identify critical source areas at different scales, including phosphorus indices, simulation models and Geographic Information Systems (GIS) overlays. Phosphorus indices are a simple tool for the field scale and help farmers manage their fields. Phosphorus indices examine both the source (soil phosphorus content and added phosphorus) and the transport (runoff potential, erosion potential, leaching potential and proximity to the stream). Simulation models are complex and can be data intensive, but can work at the basin or watershed scale. GIS overlaying is a

simple method for examining potential transport of phosphorus. Overall, selecting the right tool is critical to meeting the research objectives.

Critical source areas change with time and land management. Identifying critical source areas allows for Better Management Practices (BMPs) to be effectively implemented. BMP effectiveness also changes overtime. Documenting changes and adapting management is essential to ensure that the remediation of phosphorus pollution is successful. Monitoring at different levels of complexity is critical to assess change. It is also important to remember that there are legacy effects from phosphorus in soils and sediments being released slowly overtime. Due to these effects, the benefits of land management may not be seen immediately.

It will be important to select the appropriate tool to identify critical source areas for the complexity required by the management objectives, to encourage stakeholders to be involved in the process, and to remember that the research approach will have to develop black and white guidelines to represent a dynamic and variable system.

IV. Presentations on Recent and Ongoing Research

The Vermont Phosphorus Index

Joel Tilley, UVM Soil Test Lab

The Vermont version of the phosphorus index was proposed in July 1999 and is based on the original phosphorus index. It is a tool used to assess the risk or potential for phosphorus runoff from individual fields. It examines source factors including soil test phosphorus, manure and fertilizer, and transport factors (e.g. erosion, surface runoff, subsurface flow, distance to streams and buffers). The index is based on a range of soil and field characteristics and management practices. One limitation of the index is that it is applied to an individual field, and the field is defined by the farmer. Another limitation is due to the fact that transport factors (erosion rate and surface runoff volume) are based on long term averages and may not account for individual high-intensity events.

In Vermont, the phosphorus index is required for all fields with manure application on farms with a Nutrient Management Plan (NMP) under Natural Resources Conservation Service (NRCS) contract. Currently, the phosphorus index is used to estimate phosphorus reductions in a pilot program to test performance-based incentives for agricultural phosphorus reduction.

The Missisquoi Areawide Plan: a watershed approach to improving water quality in Lake Champlain

Presented by Kip Potter, NRCS

The Missisquoi Areawide Plan compiled and summarized existing information on the Missisquoi Watershed, developed new priority data layers, identified priority actions and recommended future actions. Missisquoi Bay is the most eutrophic bay in the lake. The watershed is 68% forested, 21% agriculture and 5% urban. The agricultural land is dominated by dairy operations. According to NRCS Ag Census data, the number of farms and acreage of land in farms has remained fairly constant between 1992 and 2002. However, there were changes in the acreage in pasture versus corn.

NRCS compiled data including locations of farmsteads, corn and hay fields, areas suitable for no-till practices, riparian buffer gaps, potential wetland restoration areas, slopes of cropland fields, and available stream geomorphic assessments. NRCS then evaluated potential BMP effectiveness, examining ten BMPs and combinations of BMPs using RUSLE2 (a soil loss equation) and the Vermont Phosphorus Index. The sediment and phosphorus reductions and overall costs were estimated. Based on testing different scenarios, a set of 13 recommendations were developed, including: completing farmstead identification maps and enhancing a GIS database for the entire subbasin, determining where discharges from farmsteads are occurring and their relative severity, and targeting conservation practices to specific crop fields.

Identifying Critical Source Areas (CSA) in Agricultural Areas: the role of hydrological modelling, aerial imagery, Lidar and Geomatics in general

Presented by Isabelle Beaudin, Institut de recherche et de développement en agroenvironnement inc. (IRDA)

Critical source areas are driven by their position in the landscape; the occurrence of elevated water tables; the connectivity, density and convergence of hydrologic networks; and the soil type and its properties. Land use and management – including cropping practices, addition of phosphorus, and nutrient levels in soil – also drive critical source areas. Critical source areas can be identified at two different levels, strategic and tactical. Strategic level identification is done at the territory or basin scale and is quantitative in nature. Tactical level identification is done at the farm or micro-watershed scale and is relative in nature. Tools for identifying critical source areas at each level of identification differ; hydrologic modeling, such as SWAT, could be used for strategic identification while remote sensing and indexing would be more appropriate for tactical identification. The type of information obtained also differs between the two levels. Strategic identification could yield information to support pollutant targets and the assessment of BMP scenarios. Tactical assessment could yield information to support site-specific diagnoses and custom BMP designs.

IRDA has applied SWAT to the Pike River Watershed, a 600 square-kilometer basin. SWAT was used to characterize the landscape and reproduce the transport of water. It was also used to quantify the amount of phosphorus runoff and to target and predict the effectiveness of BMP scenarios. Monitoring data from the watershed calibrated and validated the model. The results of the model show that there is a high spatial variability in the basin, with 10% of the agricultural areas contributing 50% of the total phosphorus export. BMP scenarios were tested to optimize phosphorus reductions and feasibility of implementation. While the model can determine what is feasible, it does not indicate where the BMPs should be placed at the field scale.

Remote sensing was used to determine the location of vegetation, wet areas, tile drains, and buffer strips. Multispectral imagery can also be used to develop a wetness index, which can help identify areas that are prone to runoff. Techniques that can determine microtopography, including GPS, LiDAR and Corelator 3-D, are also useful for identifying critical source areas. The Phosphorus Export Diagnostic Tool (p-edit), a quantitative phosphorus index for Quebec is currently under development and implementation using readily available information.

In conclusion, identifying critical source areas is only the beginning. Any approach to do so must generate results which can be used to convince extension workers and farmers of the benefits of changing their practices. Such an analysis must result in concerted actions.

SWAT Modeling of Critical Source Areas for Runoff Generation and Phosphorus Transport
Presented by Lula Ghebremichael, University of Vermont

The goal of the project currently underway at the University of Vermont is to identify sources of phosphorus and to explore different management strategies to reduce phosphorus loss. Two modeling approaches are being used for the Rock River Watershed: a farm-scale model (IFSM) and a watershed scale model (SWAT). The farm scale model is being used to identify farm phosphorus imbalances that have a potential to cause elevated soil phosphorus levels. The watershed model is being used to identify critical source areas of phosphorus loss.

The intersection between transport factors and phosphorus source factors create a critical source area. These factors are represented and simplified in the model to estimate or quantify phosphorus loss. For example, SWAT approaches runoff generation using the Hortonian flow (infiltration excess) theory, where the amount of water that does not infiltrate into the ground will be considered runoff. SWAT also takes flow from tile drainage into account and uses equations to represent the cycles of phosphorus.

The SWAT model is being applied to the Rock River Watershed, a small agriculturally dominated subwatershed in the Missisquoi Bay Basin. Stream flow and phosphorus concentration data from monitoring are available for calibration of the model. Preliminary results indicate that SWAT has the potential to identify different source areas for runoff and phosphorus loss. Once source areas are characterized, different management practices will be tested to determine what can be done to reduce phosphorus loss. Data are still being gathered to support the farm-scale model for the watershed.

Case Study: Identification of Runoff Contributing Areas in the Little Otter Creek Watershed Using a Topographic Index
Presented by Don Meals

A critical source area is a land area where a significant phosphorus source and a transport mechanism exist at the same place and at the same time. Phosphorus does not move from the land unless these two factors coincide. This project focused on identifying where transport mechanisms were present in the Little Otter Creek Watershed in Addison County. These areas were termed runoff contributing areas (RCAs). The project was part of a larger effort to target critical source areas for watershed phosphorus management.

The analysis of RCAs was based on the principle that runoff is generated by saturation excess for overland flow. As soil becomes saturated, additional precipitation or emerging interflows generate runoff. The variable source area principle was adopted for this study, where runoff contributing areas vary by storm magnitude and are dynamic overtime. To identify the RCAs a set of design storms and assumptions were developed. Each pixel in a digital elevation model was assigned a probability of contributing runoff based on specific criteria; however, runoff was not routed from pixel to pixel. The results indicated that almost half of the watershed rarely contributed surface runoff and a third of the watershed contributed runoff every three years.

Assessing Nutrient Runoff in the Little Chazy River, northeastern New York: A Synoptic Water Sampling Strategy in Nested Subwatersheds
Presented by David Franzi, SUNY Plattsburgh

The Chazy River is located in Clinton County, NY. The basin is 145 square kilometers and the main channel runs through the towns of Chazy and West Chazy, New York. The project includes studying geomorphology, hydrology and water quality. Preliminary geologic maps of the Little Chazy River watershed have been developed. There are two physiographic regions in the watershed: the St. Lawrence Hills and the Champlain Lowlands. Agriculture is unevenly distributed throughout the watershed.

There are several impoundments in the Little Chazy River. A gaging network determines water flow and synoptic sampling is done over several hours each time samples are taken. Samples are analyzed for nitrogen and phosphorus. Data indicates that stream flow is spatially heterogeneous and seasonally variable. In addition, the spatial variability of nutrient concentrations and loads generally follow the agricultural land use patterns in the watershed.

Nutrient Management Planning in the Missisquoi Bay Basin
Presented by Jeff Carter, University of Vermont Extension

This project was funded through the LCBP, with International Joint Commission funds. The project consists of preparing Nutrient Management Plans (NMPs) that meet the NRCS 590 standard for thirty small farm operations in the Missisquoi Bay Basin. The project encompasses 400 fields and approximately 4,500 acres. The data being gathered as part of this project will help farmers make better management decisions.

Temporal Trends of Risk of Water Contamination by Phosphorus in Agricultural Watersheds of Canada and the Great Lakes Basin: P-balance, P-source and P-transport factors from 1981 to 2006
Presented by Eric van Bochove, Agriculture and Agri-Food Canada

The objective of the National Agri-environmental Health Analysis and Reporting Program (NAHARP) is to develop and provide science-based agri-environmental information to improve decision-making. A technical report, with 25 indicators, will be available soon. Factors including climate, vegetation and soils were considered for 279 agricultural watersheds across Canada.

The Indicator of Risk of Water Contamination by Phosphorus (IROWC-P) was developed for agricultural lands and examines phosphorus source, transport and connectivity to water bodies. The indicator also includes tiles drainage flow and excessive flow factors. Data to support the IROWC-P is available through the Ag Census every five years. The project also examined phosphorus balance and phosphorus enrichment.

Phosphorus source is defined as the phosphorus desorbed from agricultural soils by storm events. Four models were developed for Canada as a function of soil test phosphorus and dominant soil surface texture. The transport hydrology component used meteorological data, crop parameters and soil characteristics. Rainfall and snowmelt runoff are also factored into the model equations. Connectivity to water bodies is also included using a topographic index, a tile drain index and a surface-drainage density index.

Results of the project indicate that the risk of phosphorus water contamination increased in half of the watersheds examined from 1981 to 2006. In addition, regulations, BMPs, and NMPs in Quebec and Ontario led to significant reductions of phosphorus balance since 1996.

V. Thank You and Adjourn

Workshop Summary
Day 2

I. Welcome and Introductions

Bill Howland, manager of the Lake Champlain Basin Program (LCBP), welcomed attendees to the second day of the workshop and provided an overview of the day's agenda.

II. Overview of the Missisquoi Bay Basin Project

Mike Winslow, Lake Champlain Committee, provided an overview of the Missisquoi Bay Basin Project and the previous workshop to determine a definition for a critical source area (CSA). A CSA is the intersection of a transport pathway and a phosphorus source; this project aims to identify these places on the landscape. A useful scale for this identification depends on the user – field-scale data would be helpful for best management practice (BMP) implementation but watershed-scale data might help focus strategic management decisions. An approach to CSA identification will need to function without farm-specific data and consider temporal variations. It must also consider ground and surface water transport and inputs from the urban landscape as well as the agricultural. It may need to differentiate between the various forms of phosphorus and consider the impact of downstream transport and storage. As models are presented in this workshop, we need to focus on which will best address all of these questions and can work within our data constraints.

III. Key Note Address: *Use of Models to Identify Critical Source Areas*
Dr. David Dilks, Vice President of Limnotech, Inc.

Dr. Dilks defined a model as a mathematical description of real world processes that converts inputs about environmental conditions and human activities into outputs about the environmental response, based on what we know or are willing to assume. Its objective is to determine the magnitude and location of nonpoint source loads and how the load might change in the future. Environmental models can be classified as empirical or mechanistic. Empirical models are based on observed data correlated from other similar sites. They are simple to use but have limited accuracy. Mechanistic models are based on mathematically replicating physical processes. They are more complex and potentially more accurate than empirical models.

In order to identify CSAs with a model, one must determine what needs to be modeled and the available model frameworks (models can account for source and/or transport). Models that link sources of P and its potential availability are Unit Area Load, the Simple Method, and the Universal Soil Loss Equation. Transport Models consider that delivery ratios (pollutant delivered: pollutant eroded) vary significantly from site to site. Delivery ratios can be estimated from direct measurements, empirically from watershed characteristics, or from process modeling. Hybrid empirical/mechanistic models that account for both source and transport are SPARROW and "inventory with scoring." Similar mechanistic models include SWAT, HSPF, and GWLF.

When selecting a model, one must consider site-specific characteristics (natural processes, sources, space and time scales, land uses), management objectives (project vision, pollutants of interest, desired precision and scale, critical threshold targets), and project constraints (available data, resources for new data, budget, schedule, modeler experience, computing capacity). One should choose the simplest model that can address management concerns while considering that the accuracy of the model will be constrained by the input data. More complexity does not necessarily

mean more reliability. Reliability can decrease rapidly if complexity is not supported by data or understanding.

After the presentation, Dr. Dilks responded to questions about his example models and principles of modeling. Management needs should be clear to consultants responding to an RFP, so that they can propose an appropriate model. Clearly defined but differing management objectives (strategic vs. tactical) can be handled by a model. There will be uncertainty in the modeling, but it can be improved with the right inputs. However, management decisions can still be made despite uncertainty with the model. Interpreting the outputs of a model to inform action is a policy task. In one watershed, stakeholders were able to choose an optimum scenario based on 19 options rather than having a practice prescribed to them. A phased approach to modeling, that is refined over time based on better data or financial inputs, can be valuable. With this approach, coarse-level decisions can be made with preliminary results and more refined decisions can follow.

IV. Presentations on CSA Identification Approaches

HSPF and BASINS

Rick Baker, Numeric Environmental Services

HSPF is a deterministic model with a public domain source code that is well documented and supported by the EPA. For pervious land, the model can define hydrological response units (HRUs, defined by land uses and soil types) and connectivity to determine effective imperviousness. The model can use detailed meteorological input data, simulate surface and subsurface hydrologic processes, and simulate soil erosion processes (using the Agricultural Runoff Management Model). It can also simulate nutrient transport processes; simple methods involve nutrient transportation within water or soils and complex methods consider how nutrients transform within their chemical cycles. HSPF also simulates nutrients and their transport in rivers and lakes. In general, HSPF is not as data dependent as some other models.

BASINS, or Better Assessment Science Integrating Point and Nonpoint Sources, is an integrated GIS that supports watershed based analysis and TMDL development. It includes national datasets with the option to import local data, tools incorporating analysis techniques for watershed assessment, and models for predictive studies. BASINS, and its integrated HSPF model, are complex and use limited data, so that they can provide various levels of output information.

Mr. Baker then addressed questions about this model and program, as pertinent to this project. Soils may but do not need to be separated into different levels when considering water percolation or subsurface chemical processes. We may have difficulty accurately calibrating this model for the Basin because of inadequate data points. HSPF can take into account the diversity of stream types and systems, such as access to floodplains.

SWAT Model

Mike Winchell, Stone Environmental

SWAT was developed by the USDA. It is a widely used and well supported model and is continually updated (a new version will be released this year). The model simulates surface and in-stream process interactions and both urban and agricultural management practices. It works on a

watershed scale with a daily time-step, and can simulate water, sediment, nutrient, and pesticide transport. One feature of SWAT is that it is driven by varying plant cover because of its affects on soil moisture and surface flow. Required data include topography, land use, soils, weather data, management, channel characteristics, calibration data, and initial soil P conditions.

A SWAT simulation might include subbasin delineation, HRU delineation, weather data definition, running a default model, refining the default inputs to calibrate the model, rerunning the model and beginning to simulate alternative management practices. Challenges include data collection prior to modeling as well as calibration and validation of the model (especially for flow and nutrient concentrations). SWAT can also be integrated with APEX which allows more detailed modeling for smaller areas, such as fields.

Mr. Winchell then clarified that a P load is generated by the model at the HRU level and then transported by a "virtual stream" to the reach. SWAT does not transport P between HRUs. He noted that SWAT uses a modified USLE as an event basis in its process and an intensity distribution for storm events. Cross-border data can be incorporated easily.

SPARROW
Keith Robinson, United States Geological Survey

The SPARROW model (Spatially Referenced Regression on Watershed Attributes) is a statistical approach that relates water quality data to upstream watershed characteristics in a GIS and then uses this relationship to predict water quality in unmonitored waters. The water quality load is the dependent variable and nutrient source data becomes the independent variables (point source, fertilizer use, land use, etc.). The model is empirical with mechanistic features (land and stream transport) and its regression approach uses only variables that are statistically significant. It incorporates climate, geology, soils, hydrology, and slope to simulate transport. Model predictions are in terms of mean annual loads of nutrients and are spatially referenced. Because the model is based on the hydrologic network and predicts loads in stream reaches, it is best calibrated with nested monitoring load measurements. It has generally been used regionally to determine critical watersheds and inform management actions.

The New England SPARROW model generates a total nutrient load for each watershed, estimates the proportion of the load from different sources (agricultural and urban land use, point sources, atmospheric deposition), and locates the sources within the watershed. The model can determine an in-stream nutrient loss rate. In the Basin, it would be possible to refine the existing SPARROW models with more detailed information and use it to predict loads and concentrations. Seasons and related flow conditions could be modeled, depending on available data, but storm events or flooding would be difficult.

An advantage of SPARROW is that it can extend water quality data across a spatial domain. It can help illuminate which local processes affect water quality. The model can also be objectively calibrated using observed data. Unfortunately, the model can only be run for one water quality indicator and the process can be data intensive, especially when defining the dependent variable.

AVGWLF
Becky Weidman, NEIWPCC

AVGWLF (Arc View Generalized Watershed Loading Function) was used to create a watershed scale, calibrated model for New England and New York State with EPA funds. It models the overland flow of nonpoint source pollutants and includes hydrology, landcover, soils, topography, weather, and pollutant discharges. It is possible to use a subset of the existing regional model and then recalibrate with more detailed data. AVGWLF currently comes as a prepackaged model with data and it that requires ArcView 3. The data can be updated and the model will soon be available for public domain software, and called Mapshed. The model was calibrated and verified using water quality and flow data from 22 watersheds. PRediCT is a tool associated with AVGWLF that allows the user to see the effect of different management scenarios in terms of cost-effectiveness.

Some benefits of AVGWLF are that it is data rich and user friendly, included data can be replaced with more detailed or current data, datasets are not confined to political boundaries, the model can be recalibrated, and it can be linked to an in-stream model. However, it can only model nitrogen, phosphorus, sediment, and flow. It may also need to be recalibrated for a specific area.

LiDAR and High Resolution Mapping
Keith Pelletier, UVM Spatial Analysis Lab

The Spatial Analysis Lab plans to use new high resolution imagery and LiDAR to complete an automated feature extraction, which could help with CSA modeling in part of the Basin. Both the current land cover data and digital elevation models for this region are too coarse to do local analyses. The 2008 NAIP 1-meter, 4-band imagery for the state, LiDAR data (which provides both surface elevation and feature height data), and parcel and road vector data will be combined with a set of decision-making rules to generate detailed land cover information. The Lab plans to begin this project in the summer of 2009 and complete it by early fall.

Mr. Pelletier then responded to questions. It might be possible to distinguish between hay and pasture land, depending on the data and the inclusion of additional information. The accuracy of this extraction generally ranges between 95 and 97 percent. The analysis requires a high level of computing power, which the lab is equipped to handle. The Lab will also create a digital surface model of bare ground for the area of the LiDAR data. The Lab does not currently plan to make corrections to the existing water data based on the LiDAR, but it would be possible.

Spatial Analysis
Bill Hegman, Middlebury College

Spatial analysis tools and functions can aide in CSA identification without requiring separate models. Data can be stored in either vector or raster layers; the conversion between these is subject to consideration because of resolution errors. Usually, raster models are used for watersheds because of the continuous nature of data across the landscape. A GIS can apply local functions, in which calculations are independently performed on each cell of a grid; zonal functions, in which a value is determined for a grouping of cells (such as within an administrative boundary); global functions, in which the value of a cell is a combination of cell values from multiple input grids; or neighborhood functions, in which a cell value is a function of the input cells within its specified neighborhood. A majority filter can be used to smooth the boundaries of nominal or ordinal zones and reduce errors.

A GIS program can be used to calculate stream order, runoff accumulation, or flow direction. The resolution of input data will affect the detail of outputs, such as location and shape of stream

channels. A program can also be used to run simple mathematical models such as the USLE or do queries and summaries of both vector and raster data. For this project, one could apply P loading coefficients to particular land uses within a GIS using a raster calculator and then estimate P outputs from subbasins using zonal functions.

V. Facilitated Discussion with Panel of Presenters

Beth Card, NEIWPCC, facilitated a discussion about approaches to identifying CSAs with David Dilks, Rick Baker, Mike Winchell, Keith Robinson, Becky Weidman, Keith Pelletier, and Bill Hegman. The following topics were discussed:

What is the role of the new monitoring sites in modeling?
Data collected now will not be immediately useful, because it must meet quality assurance standards. Deciding who maintains the model and reruns it with incoming data is an important management objective.

The model can estimate the load to the Bay, but can it consider the water quality in the Bay?
HSPF efforts have focused on total P, which is not enough information to determine the effect of the P in the Bay. Modeling will need to be three-dimensional to include P in sediments. Theoretically, we would need information about all forms of P and N for a year to determine how the system works and how P partitions itself. HSPF takes a strong kinetic approach, but it would not be able to determine the quality of the receiving waters.

How can the models account for stream bank erosion?
In some cases, nutrient contributions from eroded sediment outweigh dissolved nutrient contributions. SWAT has been shown to take erosion and sediment into account. It would help to gather background soil P levels, so that stochastic modeling could address certainty and variability. Accurate soil information is difficult, especially in stream banks, because each layer has a different P level. Also, floodplains may contain higher levels of P but are not accounted for by RUSLE because they have a slope of zero.

How do the models handle various land use types?
SWAT focuses on agricultural lands, but it can be used for urban lands as well. However, SWAT will not be able to model urban storm water runoff with a great amount of temporal variability. HSPF has been used more in urban areas that in agricultural ones. It might be a good idea to use a broad model to get a general understanding and then focus on more specific areas with different, appropriate models.

Many models estimate annual loads; what time periods are useful?
There are seasonal variations among nutrients that would not be captured by annual models. The Bay would require seasonal and monthly time steps. More sophisticated models can incorporate multiple limiting nutrients, if necessary. Both SWAT and HSPF are comparably sensitive to storm events, which have a significant impact on pollutant loads.

How does scale affect the different models or approaches?
IRDA has done scale variable work, using models for larger areas and then aerial photography for a more detailed assessment. It might be possible to use one model to consider all scales, but it would be very complex and data intensive.

How does the data intensity of models compare?
SPARROW and SWAT are very data intensive. Flow and consistent independent variable data sets are very important for SPARROW. Detailed information about land use, soil properties, and management practices are necessary for SWAT. AVGWLF used SPARROW data and monitoring results with other data to get a view of watershed issues.

The agricultural and urban hydrologic networks are very different and not well documented (tiling and sewer networks). The SPARROW model would apply different loading coefficients to urban and agricultural lands that would take the effect of these networks into account. HSPF simulates combined sewer overflows (CSOs) in a separate model from the land use model because of they are event-influenced. SWAT can address the fact that more water passes through tiles than over the surface; in the absence of mapped tiles, assumptions can be made about how flow is affected (e.g. row crops are more likely to be tiled). Multispectral imagery may show where tile drainage is located (as done in Canada).

Is there any way to get farm data?
Information can be obtained by county from the Agricultural Census. It might be possible to aggregate this on the subwatershed level. Every field that spreads manure has soil P test data; farmers might be willing to share these if they would not individually be identified. In Canada, a neutral organization collected data from individual farmers and aggregated it in groups no smaller than five farms, thus avoiding confidentiality issues. In Quebec, if the model results go directly back to farmers through extension workers, then farmers are willing to share In the Basin, we may need to make individual agreements in order to assuage people's fears. We need to think about why there were no farmers, crop consultants, or representatives from the Farmers Watershed Alliance at the workshop.

How necessary are models to accomplish project objectives? How will they be accepted by the public?
A model can go beyond what is already known by practitioners, for example, the New England SPARROW model found that there were larger than anticipated N contributions by atmospheric sources. Data generated by models are a good starting point for management decisions, especially when local stakeholders are able to collaborate on model inputs. If everyone participates in and agrees to the process, then the results will have more strength as a basis for action. Political will and broad-based support can build confidence in the model results and prevent finger-pointing. This process should include determining realistic P reduction targets for adaptive management. Also, direct observations should match predicted improvements within a specified time range, otherwise the model has failed and management practices will lose support. It will also be politically important to address both urban and agricultural contributions. Another possibility would be to use multiple models to validate each other.

What is the value of focusing on relative ranking of sources rather than their actual contributions?
A basin-wide ranking of large and small sources of P, as well as a ranking of management responses for these sources, might be feasible. If the initial assumptions are sound, this could be a very effective approach. However, the time-scale of the ranking must be considered – the largest contributor annually may only be active at certain times of year or during certain weather events. The feedbacks between these sources and transport require that a ranking consider physical processes.

It's all about the end product!
We need to remember to pick the model that can best guide management, rather the one that can best simulate a complex watershed. If our goal is to identify CSAs to target phosphorus reduction in the lake, then we need to find a model that will help us manage the lake. For example, if we are concerned about blue green algae, we need to reduce dissolved phosphorus; if tile drainage reduces total P to the lake but not dissolved P, then it is not an effective practice for our goals.

VI. Closing Remarks and Adjourn
Bill Howland thanked everyone for attending and providing input. The accomplishments of this project will be constrained by data but also informed by the knowledge gained from this workshop.

Workshop Attendees

Name	Organization
Caroline Alves	VT Natural Resource Conservation Service
Richard Baker	Numeric Environmental Services
Bill Bartlett	private consultant
Isabelle Beaudin	Institut de Recherche et Développement Agroenvironnement
Tom Berry	The Nature Conservancy
Willem Brakel	International Joint Commission
Dave Braun	Stone Environmental, Inc.
Beth Card	New England Interstate Water Pollution Control Commission
Helen Carr	University of Vermont
Jeff Carter	University of Vermont
Jessica Clark	Milone and MacBroom, Inc.
Brian Cote	Milone and MacBroom, Inc.
Jeff Deacon	United States Geological Survey
David Dilks	LimnoTech, Inc.
Laura DiPietro	Vermont Agency of Agriculture Food & Markets
Scott Fitscher	NY Natural Resource Conservation Service
Evan Fitzgerald	Fitzgerald Environmental
Sally Flis	Bourdeau Brothers
Russ Ford	University of Vermont
Dave Franzi	SUNY Plattsburgh
Nikos Fytilis	UVM-Civil and Environmental Engineering
Ben Gabos	Vermont Agency of Agriculture Food & Markets
Lula Ghebremichael	University of Vermont
Bill Hegman	Middlebury College
Brian Jerose	Waste Not Resource Solutions
Matt Kittredge	Vermont Agency of Agriculture Food & Markets
Stephen Kramer	Miner Institute
Daniel LeBlanc	Ministère du Développement Durable, de l'Environnement et des Parcs
Suzanne Levine	University of Vermont
Paul Madden	Friends of Missisquoi Bay
Bree Mathon	UVM-Civil and Environmental Engineering
Tom McAuley	IJC Ottawa
Don Meals	private consultant
Martin Mimeault	Ministère du Développement Durable, de l'Environnement et des Parcs
Megan Moir	Vermont Agency of Natural Resources
Julie Moore	Vermont Agency of Natural Resources

Leslie Morrissey	University of Vermont
Lin Neifert	United States Geological Survey
Abigail Pajak	Vermont Agency of Agriculture, Food & Markets
Bob Paquin	Senator Leahy's Office
Andrea Pearce	University of Vermont
Keith Pelletier	University of Vermont Spatial Analysis Lab
Staci Pomeroy	Vermont Department of Environmental Conservation
Kip Potter	VT Natural Resource Conservation Service
Rich Redman	NY Natural Resource Conservation Service
Donna Rizzo	UVM-Civil and Environmental Engineering
Keith Robinson	United States Geological Survey
Roy Schiff	Milone and MacBroom, Inc.
Jamie Shanley	United States Geological Survey
Andrew Sharpley	University of Arkansas, Fayetteville
Reed Sims	VT Natural Resource Conservation Service
Eric Smeltzer	Vermont Agency of Natural Resources
Chris Smith	US Fish & Wildlife Service
Ed Snizek	Adirondack Park Agency
Marilyn Stephenson	NY Natural Resource Conservation Service
Ethan Swift	Vermont Agency of Natural Resources
Joel Tilley	University of Vermont Soil Test Lab
Eric Van Bochove	Agriculture and Agri-Food Canada
Peter Van Schaick	
Mary Watzin	University of Vermont
Becky Weidman	New England Interstate Water Pollution Control Commission
Joe Wetzstein	NY Natural Resource Conservation Service
Michael Winchell	Stone Environmental, Inc.
Mike Winslow	Lake Champlain Committee
Eric Young	University of Vermont
Anne Marie Ziros	NY Natural Resource Conservation Service

Lake Champlain Basin Program Staff:
Nicole Grohoski, Bill Howland, Kris Joppe-Mercure, Meg Modley, Michaela Stickney

Missisquoi Bay Basin Project:
Identifying Critical Source Areas of Pollution

Workgroup Meeting
Monday, April 13, 2009
10:00 AM – 2:30 PM
Gordon Center House, Grand Isle, VT

Workgroup Meeting Summary

I. Overview of the RFP Process

Bill Howland, manager of the Lake Champlain Basin Program, provided an overview of the RFP process and the purpose of the day's meeting. The objective of the day was to discuss the previous workshops and their results and begin to develop the management objectives and desired outcomes for the critical source area (CSA) identification. The management objectives, desired outcomes and possible approaches will undergo a peer review conducted by the IJC. Review results will help define the scope of the RFP, which will hopefully be developed and released in early summer. A request for qualifications may be another approach to consider. The workgroup can discuss the RFP development process freely but needs to keep these communications within the workgroup. Everyone should be well informed and active in the RFP development process so that we can be sure that agencies' needs are being met.

Details on the Short-Term Monitoring Program are still being resolved. The USGS will likely run the hydrological and meteorological sites and are able to provide match money to support the program.

II. Critical Source Area Identification

The group discussed the results of the previous workshops and began to outline the required and desired outcomes of the project. In their discussions, the group considered the project's contractual requirements and its utility to practitioners in the Basin. The group also considered the different modeling approaches from the workshop as well as the possibility of using Watershed Modeling System (WMS).

There was agreement among the group that a critical source area is defined by the intersection between a phosphorus source and a transport mechanism. A CSA can be a point or a nonpoint source, and both should be considered. It may be necessary to define different sources so that all will be included in the analysis. Understanding the entire hydrologic channel network is also important; flowing waters other than perennial streams should be considered. Additionally, it would be good to consider the role of in-stream processes. Streams are not currently in equilibrium so currently a lot of internal adjustment is occurring. Knowing the proportion and location of phosphorus storage and phosphorus transport would help to identify the magnitude of in-stream issues. Since phosphorus sinks are assets, should they also be considered in this project?

The scope of the project is not well defined. It is important to determine the regulatory or research objectives, the temporal and spatial scale, the degree of accuracy and precision needed and the desired outcomes or products. The group hopes that both a strategic and tactical approach can be accomplished. A relative ranking to identify types of areas or practices that are generally problematic without placing them on a map may also be helpful to the Vermont Legislature as it

endeavors to budget money appropriately. The quantity of problematic areas within the watershed could also be considered within a strategic approach. The project should remain an analysis project and not a data collection project.

The group discussed the possible lack of detailed data and how extrapolating may cause the model to lose its functionality. The data available may also determine the level/scale of the analysis. In some cases, assumptions will need to be made using empirical or literature information.

The following is a list of desired outcomes and objectives brainstormed by the workgroup:

- Strategic ranking of source practices/processes
    - A detailed list of how factors combine to create sources, e.g. high level stream + adjacent fields + steep slope…
    - Could do an ordinal ranking first and then consider orders of magnitude
- Physical locations of high phosphorus loading (spatial scale – identify this down to a specific spot)
    - This might be more of map interpretation exercise than modeling
    - Annotated maps to help field workers find and evaluate potential CSAs
- Prioritization of different stream transport processes (geomorphology)
- Analysis of the extended stream network to see how it affects CSAs
- Consideration of the magnitude of the problem – we don't know where cost-effective break points are (e.g. is there a certain total amount of land that should be cover cropped that we can target?)
    - This may not be possible in that RFP but maybe this can be generated after the analysis
- Ability to analyze effectiveness of BMP scenarios
- Identification of areas where agency involvement is needed
- Determination of time lag of benefits (divide focus between short and long range outcomes)
- Creation of a model that can be easily updated in the future with better information as it becomes available. The model should be available to all partners and should remain dynamic over time (changing management practices will affect CSA locations).

The group considered how outputs of the analysis could be used and developed the following list:

- Understand phosphorus generation and transport (including patterns of runoff and seasonal flooding)
- Guide where to direct resources on the ground
- Direct financial and personnel resources between programs (considering cost and time effectiveness)
- Set expectations of progress within reasonable time frames for the public and the state legislature
- Test BMP scenarios (should be explicitly specified in RFP if desired)

Refining the outputs of the analysis will be necessary to focus expectations for this project. The group suggested that RFP could define the ideal end product and respondents could determine how much they could do with the amount of data and money available. The model developed should be well documented and usable by others in the future. A workgroup could help guide the contractor in this project and share additional data and management activities.

Next Steps

All desired outcomes will first be included in one RFP. The project could potentially be split into two RFPs, if it is determined to be necessary. The timeline for RFP development and release will depend on the LCBP contract with the IJC. LCBP will write a draft of the management objectives and desired outcomes for the workgroup to review.

III. Upcoming Workshop on Data Availability and Data Needs

The group agreed that the data workshop should consist of facilitated discussions rather than presentations. The LCBP will circulate a spreadsheet of data it currently holds to help guide the discussions. The LCBP hopes participants will come prepared to discuss other sources of data, and potential obstacles or limitations associated with the data.

Meeting Attendees

Laura DiPietro, Vermont Agency of Agriculture Food & Markets
Julie Moore, Vermont Agency of Natural Resources
Kip Potter, Vermont Natural Resources Conservation Service
Eric Smeltzer, Vermont Department of Environmental Conservation
Mike Winslow, Lake Champlain Committee

Lake Champlain Basin Program:

Nicole Grohoski
Bill Howland
Kris Joppe-Mercure

Missisquoi Bay Basin Project:
Identifying Critical Source Areas of Pollution

Workshop on Data Availability and Data Needs
Tuesday, April 28, 2009
10:00 AM – 2:00 PM
Gordon Center House, Grand Isle, VT

Workshop Summary

I. Welcome and Introductions

II. Overview of the Missisquoi Bay Basin Project

Bill Howland, manager of the Lake Champlain Basin Program (LCBP), provided an overview of the Missisquoi Bay Basin Project to date. This workshop is the fourth in the series to guide the identification of critical sources areas of pollution. Previous workshop topics included defining a critical source area (CSA), reviewing possible approaches to CSA identification, and determining short term monitoring needs. The LCBP plans to establish new stream gage and water quality sampling sites as well as meteorological stations in conjunction with the United States Geological Survey (USGS).

This workshop, facilitated by Mike Winslow of the Lake Champlain Committee and Bill Howland, aims to discuss data availability, gaps in existing data, and the coordination of transboundary datasets within the Missisquoi Bay Basin. Participants will be asked to share the types of data their agencies or groups have publicly available for the LCBP and other interested users to acquire. Data requirements for potential models as well as for other research needs will be discussed and later help inform a Request For Proposals for the modeling effort.

III. Data Availability

Nicole Grohoski, LCBP technical associate, presented a spreadsheet of the database of geospatial data currently acquired to support this project. Major sources of data were the Vermont Center for Geographic Information (VCGI), the Missisquoi Areawide Plan, and the Spatial Analysis Lab in addition to water quality monitoring groups who shared sampling locations and parameters. The LCBP will obtain recent orthophotography and LiDAR data soon and looks forward to learning about additional data to acquire. The discussion was structured around different data categories, as outlined below.

Agriculture

At the Vermont Agency of Agriculture, Food & Markets (VAAFM), most collected data is input into spreadsheets and tagged with a Hydrologic Unit Code (HUC), though the scale of this code is not consistent (can be 8-, 12-, or 14-digit). Data that could be aggregated by HUC (depending on time, resources, and current format) and shared include:

- Acreage with VAAFM-funded Nutrient Management Plans (NMPs) with crop type noted
- Acreage in the Conservation Reserve Enhancement Program and contract type
- Farm Agronomic Practice Program annual data (total acres in no-till, cover crop, strip till, etc.)

- Type and number of contracted Best Management Practices (BMPs)
- Medium and Large Farm Operation annual reports (manure transfer and production, animal numbers, number of farms)
- Soil test data (not currently linked to a HUC code and not updated beyond 2007)
- Medium and some Small Farm Operation surveys (farm problems, silage, manure) (available at the 8-digit HUC level)
- Acreage of aeration or injector usage
- Complaints and violations of Accepted Agricultural Practices (linked to 17 basins statewide, not HUC code)
- Number of farms with written and/or updated NMPs
- Annual totals of fertilizer sold by county
- Groundwater nitrate, pesticide, and herbicide concentrations from sampled wells

The Natural Resources Conservation Service (NRCS) can share the following data:

- Crop insurance data, though these can be unreliable
- Watershed planning information
- Type of the BMPs supported by the NRCS (currently not easy to access)
- Areas of concern located by photo-interpretation (gully erosion, livestock fence issues)
- 2008 field locations and crop type in the US Rock River watershed (photo-interpretation)

The University of Vermont Soil Test Lab has soil phosphorus data than can be aggregated by the county, zip code, or town that the farm is in. The sampling methods for these tests vary and results exist electronically as far back as 1992. The test data is accompanied by a field questionnaire, which includes optional reporting on field acreage and cropping. It would also be possible for the lab to consider phosphorus trends by soil type. Additionally, private consultants such as Bourdeau and Bushey have NMPs with data about soils, crops, animal numbers etc. This data is confidential but could be aggregated and shared; individual soil phosphorus tests would require release forms from farmers.

In Quebec, the Department of Agriculture aggregates farm census data such that each grouping has a four-farm minimum. Soil phosphorus data can be accessed by farm postal codes and NMPs are mandatory. Crop insurance plans require digitized farm boundaries which farmers often opt to share.

Boundaries

There is a statewide initiative being led by VCGI to create a parcel boundary dataset. This information could be useful in conjunction with land cover data. As of now, very few towns in the Basin have digital parcel boundaries, though the Natural Resources Conservation District intends to do this.

Conservation

Extents of forestry value-use parcels are being mapped for Franklin County. The rare, threatened, and endangered species dataset is used to guide management decisions and could be combined with model outputs to locate areas of special concern. Internally, the ANR has a more detailed and sensitive version of this dataset that may be accessible in a buffered format (sites of archaeological interest are similar).

Hydrography

In rural areas, locating tile drainage would help to understand the hydrologic network and modifications to it. Some drainage might be visible in photographs or extracted from a summer vegetation index, since its implementation is unregulated and undocumented. Its presence could also be predicted by considering land cover and soil drainage characteristics.

In urban areas, the ANR is compiling information this summer about stormwater infrastructure and practices as well as performing some sewer mapping. Impervious surface recognition will be automated in areas with LiDAR data by the SAL. Locations of stormwater permits and discharge concentrations should also be added to the database. The Environmental Protection Agency (EPA) has an online national database of water treatment plants.

Land Use/Land Cover
The National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program developed a land cover dataset in 2006 and performed change detection analysis. The SAL will also complete land cover mapping for areas with LiDAR data.

Photography
High resolution aerial photos, taken at oblique angles, have also been collected by the Agency of Natural Resources (ANR) over the past three years. These cannot be georectified, but they can be used as a reference for identify CSAs. Historical photos dating back to the 1930s could be scanned and then compared digitally to current photos.

Soils
In Franklin County, soils were classified in the 1940s and 1950s and are not accurate. The NRCS has sampled along the Rock River corridor to better characterize soils and establish a native phosphorus level.

Other Data
Geological information is available through the Vermont Geological Survey. The USGS can provide phosphorus and nitrogen predictions from a 1995 SPARROW model. They also have an enhanced EPA point source database and related nutrient load estimates. National assessments of both streambed sediment quality and agricultural fertilizer and manure application are available. The USGS has estimates of water use by census tract, though this does not include agricultural use, as well as information on where sewer lines extend.

IV. Data Gaps

Mike Winslow facilitated a discussion to identify other data that could be useful for the critical source area analysis. Determining the scale of the analysis would help to understand what assumptions can be made and what data would be helpful to collect. For instance, if we are trying to determine critical subbasins, then the current hydrography resolution is adequate; however, if we are looking for critical fields, LiDAR-derived hydrography would be necessary.

There is currently no data on field crop rotation schedules, which would be useful for understanding land use over time. Depending on the scale of modeling, this information may not be necessary or assumptions may be suitable. If rotations are done between fields, then there is little change in production at the farm level. However, recent data has shown that although the acreage of fields has remained the same, the production of corn and hay has changed, indicating crop rotation. NMPs

require a universal soil loss equation evaluation, which includes a planned field rotation in order to meet tolerable soil loss requirements.

Extending the hydrologic network to include tile drains and ditches and then comparing this network to historical photos would help determine changes in the system.

The Phosphorus Index establishes a relative understanding of field-level transport and source, but that info is owned by the farmer and not available for this effort. It probably does not make sense to aggregate this data because of the way that it is calculated, though aggregating based on land-use type might make sense. Grouping these field-based values can also obscure hydrographic boundaries. Quebec uses a quantitative index which might be helpful in validating phosphorus estimates.

V. Transboundary Data

Bill Howland led a discussion about datasets that would benefit from transboundary data unification and what this process might involve. Access limitations and differences in data type, accuracy, precision, and classification between Quebec and Vermont were considered. It is important that datasets be consistent for modeling, but this data should also be created for use in future, unrelated projects. Considerations were based around different data categories, as outlined below.

Agriculture

Land cover data in Quebec differentiates between crop types and is available in an aggregated basis. Using standard aggregation methods would help with transboundary comparisons. Animal unit data is detailed in Quebec but only available for dairy cows in the U.S.; each country estimates phosphorus outputs per animal unit differently and manure exportation is also an important consideration. NMP requirements and BMP expectations are also not equivalent across the border.

Hydrography

Currently, public hydrography data is at different scales on either side of the border. Quebec is in the process of adding 1:20,000 data to Canada's National Hydrographic Network, and the USGS plans to merge this data with the U.S. National Hydrographic Dataset. The Missisquoi Bay Basin will hopefully become a priority in this national endeavor. Alternatively, the IJC might consider joining U.S. data with the current 1:50,000 Quebec data sooner. If necessary, a contractor may need to edge match datasets for modeling. Having accurate subwatershed boundaries derived from the same elevation model (or ones of the same precision) will be important. Another goal is to standardize stream order classifications and understand how surface water impairment classes relate across the border (Quebec uses a scoring index, but Vermont determines if a stream reach meets defined standards for different types of pollutants).

Land Use/Land Cover

The 2001 SAL dataset covers the entire Lake Champlain Basin, but the 2006 NOAA dataset does not. It is possible to complete a new classification using a common image, so that there is consistency for modeling. Cropping differs from that of the U.S. so creating a common classification system is important.

Soils

Soil surveys differ significantly across the border; on the U.S. side, map units do not capture the true variability of soils in river corridors. Common slope, erodibility, and drainage classifications are needed. The Quebec survey was done in 1991 and has a different resolution than U.S. data. The NRCS may be able to sample soils across the border in order to make comparisons between soil series classifications.

Water Quality Monitoring
Quebec flow gage information is not currently available online; it would useful to have one webpage where monitoring data for the entire basin is available. There has been interest in this from the Quebec side – perhaps the IJC could help in this process. More information about phosphorus loads, by stream segment or subbasin, is also an ongoing goal. Currently, Quebec uses a different test for phosphorus concentration which can be related to Vermont tests, but might be advantageous to harmonize. Considering bioavailable phosphorus and sediment concentrations may also be important. There are also differences in bacteria monitoring and beach closure policies.

Other Data
Right now, the orthophotography cuts off along the border, but the new Department of Homeland Security imagery should correct this issue. Quebec has a comprehensive roads layer similar to the E911 data, though whether or not it contains information on road surfaces is unknown. E911-type point data referencing building locations would be helpful in generating a basin-wide density surface. This data could theoretically be used in conjunction with sewer line extents to determine where septic systems are located.

VI. Next Steps and Adjourn

Bill Howland thanked everyone for attending and providing input. This project database will continue to grow and become more comprehensive in the coming months, based on the information learned here. After datasets are reviewed in accordance with quality assurance protocols, the LCBP will make this data available to the public. The LCBP is considering how to distribute large datasets and how to inform people as new or updated data becomes available. It will notify attendees of the workshop series of data publication when the time comes, as well as provide workshop summaries and attendee lists online.

Workshop Attendees

Name	Organization
Caroline Alves	Natural Resource Conservation Service
Erik Beck	Environmental Protection Agency
Alexandra Dichter	Environmental Protection Agency
Laura DiPietro	Vermont Agency of Agriculture Food & Markets
Sally Flis	Bourdeau Brothers
Lula Ghebremichael	University of Vermont
Alexandra Haselton	VT EPSCoR Streams Project
Bill Hegman	Middlebury College
Buzz Hoerr	VT Citizens Advisory Committee, LCBP Education & Outreach
Richard Kiah	United States Geological Survey
Aubert Michaud	Institut de Recherche et Développement Agroenvironnement
Julie Moore	Vermont Agency of Natural Resources
Lin Neifert	United States Geological Survey
Jarlath O'Neil-Dunne	University of Vermont Spatial Analysis Lab
Kip Potter	Natural Resource Conservation Service
Keith Robinson	United States Geological Survey
Reed Sims	Natural Resource Conservation Service
Eric Smeltzer	Vermont Agency of Natural Resources
Joel Tilley	University of Vermont Soil Test Lab
Carl Waite	Vermont Monitoring Cooperative
Mike Winchell	Stone Environmental, Inc.
Mike Winslow	Lake Champlain Committee

Lake Champlain Basin Program Staff:
Nicole Grohoski, Bill Howland, Kris Joppe-Mercure, Meg Modley

Missisquoi Bay Basin Project:
Identifying Critical Source Areas of Pollution

DRAFT Database Summary

Instructions for Use

The "Data Hierarchy" worksheet is set up to mirror the hierarchical database maintained by the LCBP. Column A lists folders organized by functional group. Columns B-E list either subfolders or enclosed datasets (bolded names represent folders). The first set of subfolders (Column B) usually pertains to the geographic extent of the dataset (e.g. Lake Champlain Basin, VT, QC, etc.). Column F contains a short description of each dataset (or group of datasets); G details the source agency; H gives the latest date through which the data is relevant (year-month-day); I gives the date published; and J records the status of the metadata. The "Acronyms" worksheet explains any acronyms used in data descriptions. Questions about viewing this file can be directed to Nicole Grohoski at ngrohoski@lcbp.org or 802.372.3213 x 20.

Data listed in this workbook will be subject to quality assurance standards before becoming available for distribution by the Lake Champlain Basin Program. If you are interested in obtaining the data listed, please contact the source directly.

Data to be Acquired

Other known data yet to be acquired are listed below. Reasons for absence in database include upcoming release dates, cost and licensing, and undetermined frequency and aggregation of data needed for analysis. Other data to be acquired, but not listed below, are detailed in the Draft Summary of the *Workshop on Data Availability and Data Needs*.

- LiDAR for the western basin in Vermont
    - Products will be provided to the USGS on June 10, 2009.
    - Products include a DEM and contours
- International boundary imagery (Dept. of Homeland Security)
    - Currently in quality control
- Canadian National Hydrographic Network will incorporate 1:20,000 provincial data for Quebec
    - current data is derived from 1:50,000 photography
    - to be completed in 2010, integration by the USGS with the US NHD may occur after this release
- Canadian data available for purchase from geoboutique.mrnf.gouv.qc.ca
    - Includes: orthophotos (21, 30, 56, or 100 cm – not sure what is available for this region)
    - satellite imagery (1:100,000)
    - digital elevation models (1:20,000)
- 1:20,000 Canadian soil data is available for purchase from IRDA.
- The Canadian Insured Crop Database is available for purchase and may include agricultural parcel locations and current crops (http://www.fadq.qc.ca/index.php?id=2173&L=1)
- Measured data will not be obtained until specifications for their use are determined.

- Monitoring data (monitoring locations are detailed in the GIS datasets)
- Meteorological data (National Weather Service or Environment Canada Weather Office)
- Stream flow data (USGS or MDDEP)

Data Gaps

Other data that might be useful for the CSA analysis but that do not currently exist are listed below. Additional data gaps may be recognized once the analysis approach and scale are determined.

- Field crop rotation schedules
- Agricultural ditch and tile drainage network
- Municipal sewage and water networks

DATA HIERARCHY	SUBFOLDER/FILE NAME	SUBFOLDER/FILE NAME	SUBFOLDER/FILE NAME	FILE NAME	FILE DESCRIPTION	data source	relevancy of data	date published	metadata
C:\Data									
\LCBP									
agricultural									
	basin								
		NoTill_Procedures			written procedure to map suitable areas for no-till crop management	NRCS	NA	NA	NA
		crop&hay_allMisq.shp			corn, hay, and other ag fields in MBB digitized from 2003 orthophotography	NRCS	2003	200801	prelim
		MQ_farmsteads.shp			point locations of farmsteads in US MBB digitized from 2003 orthophotography	NRCS	2003	200801	prelim
		NoTillGood_MQ			fields in MBB that are amenable to no-till agriculture	NRCS	based on SSUF	200801	prelim
		StABay_farmsteads.shp			point locations of farmsteads in St Albans Bay Basin digitized from 2003 orthophotography	NRCS	2003	200801	prelim
boundaries									
	basin								
		LCB_boundary.shp			Lake Champlain Basin extent	LCBP			none
		LCB_counties.shp			US counties clipped to LCB extent	LCBP			none
		LCB_towns.shp			US LCB town names	LCBP			none
		LCB_census_towns.shp			US and Canadian LCB towns	LCBP			none
		LCB_sub_basin.shp			Extent of 7 subbasins in LCB	LCBP			none
		QC_LCB_towns.shp			Quebec towns in the LCB (1996 pop)	LCBP			none
	Canada								
		Census_divisions.shp			Statistics Canada county equivalents (Quebec has municipalité régionale de comté)	StatisticsCanada	2006	2006	prelim
		Provinces_line.shp			Canadian province lines	Geobase	200301	200301	x
		Provines_poly.shp			Canadian province polygons (generic Nunavut)	Geobase	200301	200301	x
		Provinces_poly_dtl.shp			Canadian province and oceanic boundaries (detailed N. islands)	GeoGratis	200807	200807	x
	VT								
		VT_admin_bounds.shp			VT state administrative boundaries (Exec Order #7-95)	VCGI	20071231	20080212	x
		VT_counties.shp			VT county boundaries	VCGI	20071231	20080212	x
		VT_LEPCs.shp			VT Local Emergency Planning Committee Boundaries	VCGI	20071231	20080212	x
		VT_line.shp			VT state outline	VCGI	20071231	20080212	x
		VT_poly.shp			VT state polygon	VCGI	20071231	20080212	x
		VT_RPCS.shp			VT Regional Planning Commissions	VCGI	20071231	20080212	x
		VT_town.shp			VT town boundaries	VCGI	20071231	20080212	x
		VT_villages.shp			VT village boundaries	VCGI	20071231	20080212	x
census									
	basin								
		census.dbf			table with populations by decade 1960-2000	LCBP			none
		LCB_census_towns.shp			US and Canadian LCB towns for joining census table	LCBP			none
conservation									
	basin								
		Riparian_Gap_Procedures			written procedures used to create riparian gap files	NRCS	NA	NA	NA
		LCB_QC_pad.shp			CBI/WWF provincially owned protected areas in QC LCB	CBI	1970-2001	200111	x
		LCB_US_pad.shp			CBI/WWF federal/state/local owned protected areas in US LCB	CBI	1970-2002	200111	x
		restorable_wetlands.shp			Prioritization of restorable wetlands in LCB	VT ANR	200808	200702	x
		RiparianGaps_MQ.shp			Gaps in 25' riparian buffers for SGA stream reaches, US MBB	NRCS	2003		prelim

		RiparianGaps_StABay.shp			Gaps in 25' riparian buffers for SGA stream reaches, St. Albans Bay Basin	NRCS	2003	20080902	prelim
	VT								
		RestorWetl_VT.shp			areas classified as restorable wetlands in VT	VT ANR	200808	200702	x
		VT_conslands.shp			VT Conserved Lands Database (w/o proprietary parcels)	SAL	200412	200412	x
		VT_conslands_public_line.shp			line subset of VT CLD (municipal, state, federal, public easements)	SAL	200412	200412	x
		VT_conslands_public_poly.shp			poly subset of VT CLD (municipal, state, federal, public easements)	SAL	200412	200412	x
cultural									
elev									
	basin								
		NEDdem26m			LCB USGS 26.6m 1:24,000 National Elevation Dataset (height in m)	USGS		200208	needs work
	VT								
		contours_100ft.shp			100-foot contour intervals interpolated from USGS 7.5' NED data	VCGI		20021009	x
		contours_50ft.shp			50-foot contour intervals interpolated from USGS 7.5' NED data	VCGI		20021009	x
		vt_dem			VT USGS 26.6m 1:24,000 National Elevation Dataset (height in ft)	VCGI		200210	x
		vt_hillshade			VT hillshade derived from 26.6m NED DEM	VCGI		200210	x
		vthydrodem			VT 10m DEM compliant with VHD (height in cm)	VCGI	2000	200610	x
hydro									
	basin_cartography								
		LCB_huc14.shp			LCB hydrologic unit code 14 designations	LCBP			none
		major_river.shp			LCB major rivers	LCBP			none
		nhd_basinlakes.shp			LCB lakes/ponds from NHD	LCBP			prelim
		nhd_basinrivers.shp			LCB rivers/streams from NHD	LCBP			none
	Canada								
		ondrcarto_l.shp			Ontario drainage system, 1:1,000,000 lines	GeoGratis	200807	200807	x
		ondrcarto_p.shp			Ontario drainage system, 1:1,000,000 polys	GeoGratis	200807	200807	x
		qcdrcarto_l.shp			Quebec drainage system, 1:1,000,000 lines	GeoGratis	200807	200807	x
		qcdrcarto_p.shp			Quebec drainage system, 1:1,000,000 polys	GeoGratis	200807	200807	x
	QC								
		nhn_02og000	many shapefiles (lakes, reservoirs, watercourses (rivers and streams),		1:50,000 National Hydro Network files covering most of MBB	Geobase	199512	200712	x
		nhn_02oh001	many shapefiles (lakes, reservoirs, watercourses (rivers and streams),		1:50,000 National Hydro Network files covering area north of MBB	Geobase	1996	200712	x
	US								
		US_lakes.shp			1:2,000,000 US National Atlas water features (polygons)	Natl Atlas	2002	200512	x
		US_rivers.shp			1:2,000,000 US National Atlas water features (lines)	Natl Atlas	2002	200512	x
	VT								
		basin							
			SGA_MQ.shp		US MBB SGA line data, merged	NRCS/ANR			none
			VT_labeled_rivers.shp		major rivers/streams in VT LCB	LCBP			none
			VT_labeled_water.shp		major lakes in VT LCB	LCBP			none
		state							
			SGA_Data		SGA base data organized into folders by subwatershed (stream reaches, meander centerlines, valley walls)	ANR			none
			WaterHydro_VHD		VHD package of edited NHD files (includes polygon rivers and waterbodies, streams, HUC bounds, code tables)	VCGI	200001	200808	x
			VT_basins_HUC12_line.shp		VT hydrological unit boundaries (12 digit) -line	VCGI	200305	200305	x
			VT_basins_HUC12_poly.shp		VT hydrological unit boundaries (12 digit) -poly	VCGI	200305	200305	x

			VT_basins_HUC8_line.shp		VT hydrological unit boundaries (8 digit) -line	VCGI	200305	200305	x
			VT_basins_HUC8_poly.shp		VT hydrological unit boundaries (8 digit) -poly	VCGI	200305	200305	x
	wetlands								
		VT							
			nwicodes.dbf		NWI codes with enumerated classes and systems				none
			VT_NWI_line.shp		VT NWI quads with codes (line)	VCGI	1983	200403	x
			VT_NWI_poly.shp		VT NWI quads with codes (poly)	VCGI	1983	200403	x
			VT_sig_wetlands.shp		VT Significant Wetland Inventory (generalized type)	VCGI	1975-1978	199610	x
imagery									
	Landsat1991				IDRISI .rst files				none
	Landsat1999								
		p014r029_b123457.img			July 1999 Landsat image of LCB, 30 m, bands 1-5, 7				prelim
		p014r029_b8			July 1999 Landsat image of LCB, 15 m, band 8 (b/w)				prelim
infrastructure									
	VT								
		muni_sewers							
			xsewer.shp		polygon extents for municipal sewage in NWRPC area: x= alburgh, enosburg, fairfax, richford, st albans, or swanton	NWRPC			none
		muni_water							
			xwater.shp		polygon extents for municipal water in NWRPC area: x= alburgh, enosburg, fairfax, richford, st albans, or swanton	NWRPC			none
		VT_dams.shp			Vermont Dam Inventory dam point locations (type and use status)	VCGI	200902	20090226	x
	NY_VT_PCS_locations.shp				NY/VT locations of EPA permitted water discharges extracted from IMS, discharge data can be added (for other EPA data, connect to geodata.epa.gov)	EPA	20090513	20090513	x
lake_champlain									
	bathymetry				LC water depth model interpolated from NOAA chart depth points				needs work
	champlain_contours.shp				bathymetric contours with 10 foot intervals				none
	champlain_depths.shp				NOAA chart depths and points from LCBP data bundle	VCGI		200306	x
	champlain_poly.shp				LC polygon with islands shown	LCBP			none
	champlain_shoreline.shp				LC line outline	LCBP			none
lulc									
	basin								
		LULC_LCB_1992			improved 2001 LULC data for LCB created by UVM SAL (7 classes)	SAL	1992	200703	x
		LULC_LCB_2001			improved 1992 LULC data for LCB created by UVM SAL (7 classes)	SAL	2001	200703	x
		LULC_MQ_corridor.shp			US Missisquoi, North Branch, and Trout River LULC for 800' buffer corridors (14 classes)	SAL	200309	200603	x
	unknown								
		93landcover_scene.mxd							
		basinlu_74			LULC for LCB from Landsat imagery		1974?		none
		basinlu_93			LULC for LCB from Landsat imagery	VCGI	1993?	199801	x
		basinlu_rcl			Reclass of 1993 LULC from 17 to 14 classes		1993?		none
	VT								
		Grasslands.mdb							
			Grasslands		study area: Addison, Chittenden, Franklin, and Grand Isle				
				Crop_DomSoil	Agricultural cover types and dominant soil types (for above)	SAL	2003	200506	x
				Suburban_Pasture	Suburban and pasture fields in above study area	SAL	200309	200603	x
			CropRotation_SoilType		likely crop rotations based on soils for study area	SAL	200604	200604	x
			CropRotationCodes_Domain		crop rotation codes	SAL	NA	NA	NA
			LULC_Domain		Land use/land cover codes	SAL	NA	NA	NA

		IMPERV2001.img			Percent imperviousness based on 2001 National Land Cover Database (30 m res)	VCGI	200310	200309	x
	nlcd_legend.gif				National Land Cover Dataset Classification System legend	NA	NA	NA	NA
modeling									
	Missisquoi_River_92_TP_SPARROW					USGS			
		Metadata			metadata files for shapefiles within this folder	USGS	early 1990s	2004	x
		catchments			Catchment areas of reaches with primary P source noted	USGS	early 1990s	2005	in folder
		reaches			NHD reaches at 1:100k with predicted P load (kg/yr	USGS	early 1990s	2006	in folder
		sources&loads.mxd			Shows NHD reaches with line width increasing with total phosphorus load (kg/yr)	USGS	early 1990s	2007	in folder
		states_ne			outline of New England states for reference in .mxd	USGS	early 1990s	2008	in folder
monitoring									
	basin								
		LC_USGS_ECsites.shp			USGS emerging contaminant monitoring sites in VT	USGS	2006-8	200811	prelim
		LC_USGS_HgSites.shp			USGS mercury monitoring sites in VT	USGS	2008	200811	prelim
		LC_VTUSGS_gages.shp			USGS continuous flow gages in VT	USGS	2008	200811	prelim
		LongTermLakeSites.shp			LCBP Long term monitoring sites on Lake Champlain	LCBP	2008	200802	prelim
		LongTermTribSites.shp			LCBP Long term monitoring sites on LCB tributaries	LCBP	2008	200802	prelim
		WWTF_P_Loads_VT-NY-QC.xls			Annually averaged WWTF phosphorus loads, 1991-2008	ANR	1991-2008	2009	prelim
	Missisquoi								
		Sampling_results							
			MRBA_Monitoring_05-07.xls		Raw and summary data for MRBA sites (05-07)	MRBA	2005-7	200901	prelim
		CC_RockRiverSites.shp			Rock River grab-sample sites (DEC 08)	VT ANR	2008	200811	prelim
		MQ_FlowGageSites.shp			Continuous flow gage locations in MBB (USGS, MDDEP)	DEC/MDDEP	2007	200805	prelim
		MQ_PhosSamplingSites.shp			Phophorus sampling sites in MBB (DEC, MDDEP 2002-5)	DEC/MDDEP	2002-5	200805	prelim
		MRBA_05-07.shp			MRBA grab-sample sites in MBB (05-07)	MRBA	2005-7	200901	prelim
		MRBA_08_sites.shp			MRBA grab-sample sites in MBB (08)	MRBA	2008	200812	prelim
		UVM_Hungerford_Sites			Hungerford Brook gaged stream sampling sites (UVM May-Nov 06)	UVM	2006	200709	prelim
	precipitation								
		precip01_02albers.img			LCB 2001-2 mean annual precipitation in inches	SAL	2001-2	200705	x
		precip_91_albers.img			LCB 1991 mean annual precipitation in inches	SAL	1991	1999	x
		precip_mean_albers.img			LCB long-term mean annual precipitation in inches, 57 stations, 1951-1996	SAL	1951-96	1999	x
		region_precip_stations			stations used to create the precipitation images				prelim
		stations_precip_1995.shp			stations with 1995 min, max, and mean precipitation values				none
		updated_precip			cooperative and automatic weather stations in and near the MBB	NWS/MDDEP/EC'	200902	200901	prelim
	VT								
		2008_303dPartA_line.shp			VT CWA 303d Part A impaired surface streams	VCGI	200810	200811	x
		2008_303dPartA_poly.shp			VT CWA 303d Part A impaired surface lakes	VCGI	200810	200811	x
		2008_priority_waterBtoG_line.shp			VT Priority Surface streams outside of CWA	VCGI	20081001	20090109	x
		2008_priority_waterBtoG_poly.shp			VT Priority Surface lakes outside of CWA	VCGI	20081001	20090109	x
		stormwater_outfalls.shp			Stormwater outfalls associated with 2004 VT Impaired waters list	VCGI	20050405	20050405	x
orthos									
	2008_NAIP_UTM								
		Essex			contains .jp2 orthomosaic for Essex County: 1 m, color IR, 2008 NAIP	USGS	2008	20080921	x
		Franklin			contains .jp2 orthomosaic for Franklin County: 1 m, color IR, 2008 NAIP	USGS	2008	20080921	x
		Grand_Isle			contains .jp2 orthomosaic for Grand Isle County: 1 m, color IR, 2008 NAIP	USGS	2008	20080921	x

		Orleans			contains .jp2 orthomosaic for Orleans County: 1 m, color IR, 2008 NAIP	USGS	2008	20080921	x
	Hungerford_1ft_prerelease	HBSAWS_n_30_2008_1.sid			PRERELEASE Hungerford Brook watershed orthophoto mosaic, 2008 1' color	ANR?	will be replaced		prelim
	NAIP_VTSP				VT color 1m orthos (Mr. sid)	VCGI	various		in folder
	Rock_1ft_prerelease	RRWS_n_30_2008_1.sid			PRERELEASE Rock River watershed orthophoto mosaic, 2008 1' color	ANR?	will be replaced		prelim
	VMP				Vermont Mapping Program bw 0.5m orthos (Mr. sid)	VMP	various		VMP program
	vtortho_vt011.sid				portion of VT LCB bw ortho mosaic (Mr. sid)	LCBP			none
soils									
	VT_SSURGO								
		20_useful_soilattr			DBFs of 20 most common soil attributes compiled for and by VT	VCGI	based on SSUF	200305	x
		soil_vt005			SSURGO spatial and tabular datasets - Caledonia County	NRCS		20081219	x
		soil_vt007			SSURGO spatial and tabular datasets - Chittenden County	NRCS		20080317	x
		soil_vt011			SSURGO spatial and tabular datasets - Franklin County	NRCS		20080317	x
		soil_vt013			SSURGO spatial and tabular datasets - Grand Isle County	NRCS		20080317	x
		soil_vt015			SSURGO spatial and tabular datasets - Lamoille County	NRCS		20080317	x
		soil_vt019			SSURGO spatial and tabular datasets - Orleans County	NRCS		20081219	x
		blank_soildb_VT_2002.mdb			for the import of county SSURGO data	NRCS			
		soil_vt011_streambankerosion.shp			streambank erosion rankings by soil type, Franklin County, VT	NRCS			prelim
		soil_vt015_streambankerosion.shp			streambank erosion rankings by soil type, Lamoille County, VT	NRCS			prelim
		soil_vt019_streambankerosion.shp			streambank erosion rankings by soil type, Orleans County, VT	NRCS			prelim
		Streambank Erosion Hazard Rule Tree.doc			decision flow to determine erosion susceptibility				
topos									
	Canada								
		indexes							
			NTS_index_1mil.shp		Canadian NTS Index 1:1 million scale	GeoGratis	200804	200804	x
			NTS_index_250k.shp		Canadian NTS Index 1:250,000 scale	GeoGratis	200804	200804	x
			NTS_index_50k.shp		Canadian NTS Index 1:50,000 scale	GeoGratis	200804	200804	x
		topos_250k			1 topo tile at 1:250,000 covering QC LCB	GeoGratis	1988	200509	x
		topos_50k			6 topo tiles at 1:50,000 covering QC LCB	GeoGratis	1985-96 (varic	2004-7 (vario	x
	VT								
		VT_100k							
			_VT_100k_topos.lyr		layer file referencing all VT 100k topos	USGS/VCGI	NA	NA	NA
			DRG_standards.txt		Standards for Digital Raster Graphics	USGS/VCGI			
			TOPOxx.TIF		13 VT topo tiles at 1:100 000 scale	USGS/VCGI	various	200009	x
			Topo_index_100k.shp		Index of 1:100 000 topo maps	USGS/VCGI	200009	200009	x
		VT_24k							
			_VT_24k_topos.lyr		layer file referencing all VT 24k topos	USGS/VCGI	NA	NA	NA
			metadata		metadata files for all 1:24,000 topos in folder	USGS/VCGI	various	199811	some missing
			TOPOxxxx.TIF		234 VT topo tiles at 1:24,000 scale	USGS/VCGI	various	199811	some missing
			Topo_index_24k.shp		Index of 1:24,000 topo maps	USGS/VCGI	200009	200009	x
trans									
	QC								
		NRN_QC_rds.shp			National Roads Network QC roads	Geobase	200211	200706	x
	VT								
		bridge_culvert	shapefiles and PGDB		VT bridge and culvert database of transportation structures (Vtrans)	VCGI	20080616	20080616	x
		VT_e911_rds.shp			E911 road centerlines from 1:5000 photos and GPS	VCGI	200601	200601	x
		vt_pavemt_type98.shp			1998 pavement types for select VT roads	VCGI	19980101	20000101	x

		VT_roadbases_2000.shp			2000 roadway base materials for select VT highways	VCGI	2000	20030311	x
		Vtrans_majrds1.shp			VTrans road centerlines -major and minor roads (less reliable naming than e911)	VCGI	200810	200810	x
		Vtrans_majrds2.shp			VTrans road centerlines -major and minor roads (less reliable naming than e911)	VCGI	200810	200810	x
		Vtrans_rds.shp			VTrans road centerlines -all roads including surface info (less reliable naming than e911)	VCGI	200810	200810	x
C:\Projects									
\MBBP_Phos									
data									
	Basin_bounds	Misq_basin.shp			MBB polygon	LCBP		2008	none
		Misq_basin_line.shp			MBB outline	LCBP		2008	none
		Misq_HUC12.shp			MBB HUC12 polygons	LCBP		2008	none
		Misq_HUC12_lines.shp			MBB HUC12 outlines	LCBP		2008	none
		Misq_mask.shp			rectangle of area surrounding, but not including, MBB	LCBP		2008	none
	Basin_water	Misq_QC_lakes.shp			Canadian MBB waterbodies from NHN	LCBP		2008	none
		Misq_QC_streams.shp			Canadian MBB streams/rivers from NHN (with some border corrections)	LCBP		2008	none
		Misq_VT_lakes.shp			US MBB waterbodies from VHD	LCBP		2008	none
		Misq_VT_streams.shp			US MBB streams/rivers from VHD (with some border corrections)	LCBP		2008	none
	Impaired_water	Misq_303d_streams_partA.shp			US MBB streams designated under Part A of CWA 303(d) 2008	VCGI		2008	none
		Misq_303d_streams_partsAC.shp			US MBB streams designated under CWA 303(d) (part A) 2008 or Vermont List of Priority List of Surface Waters (part C) 2008	LCBP		2008	none
		Misq_303d_lakes_partA.shp			US MBB waterbodies designated under Part A of CWA 303(d) 2008	VCGI		2008	none
		Misq_QC_impaired.shp			QC impaired waters 2005-7	MDDEP		2008	none
	Reference_features	Misq_towns.shp			MBB major towns for cartographic use	LCBP		2008	none

ACRONYM	MEANING
MBB	Missisquoi Bay Basin
HUC	USGS Hydrologic Unit Code
NHN	National Hydro Network (Canada)
NHD	National Hydrography Dataset
VHD	Vermont Hydrography Dataset
CWA	Clean Water Act
GNIS	Geographic Names Information System
LCB	Lake Champlain Basin
CBI	Conservation Biology Institute
WWF	World Wildlife Fund
UVM	University of Vermont
SAL	Spatial Analysis Lab
MDDEP	Ministère du Développement durable, de l'Environnement et des Parcs
MRBA	Missisquoi River Basin Association
DEC	Department of Environmental Coservation (Vermont)
USGS	United States Geological Survey
CLD	Conserved Lands Database
NTS	National Topographical System (Canada)
NWI	National Wetlands Inventory (US)
SGA	Stream Geomorphic Assessment
VMP	Vermont Mapping Program
LULC	Land use/land cover
ECWO	Environment Canada Weather Office