Lake Champlain Basin Program

Technical Report No. 2

Design and Initial Implementation of a Comprehensive Agricultural Monitoring and Evaluation Network for the Lake Champlain Basin

Prepared by
NY-VT Strategic Core Group

for
Lake Champlain Management Conference

February 1993

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Design and Initial Implementation of a Comprehensive Agricultural Monitoring and Evaluation Network for the Lake Champlain Basin

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Historical Perspective

The Pollution Prevention, Control and Restoration Plan drafted by the Plan Formulation Team of the Lake Champlain Management Conference states that eutrophication studies conducted on Lake Champlain since 1979 have led to the conclusion that phosphorus levels in the Lake are currently too high and should be reduced.

In the Lake Champlain Basin, some of the decrease in water quality has been attributed to nonpoint source (NPS) pollution from agricultural sources (See Appendix A: Lake Champlain "Level B Study"). The amount of this agricultural contribution is thought to vary tremendously between tributaries and among different lake regions. In spite of the work which has already been done on the subject, there is still a lack of scientific information, understanding, and agreement regarding agriculture's contribution to the water quality problems of Lake Champlain and its tributaries.

Since the 1970s, interested farmers have been actively installing recommended Best Management Practices (BMPs) to reduce or prevent agricultural NPS pollution. About $12 million dollars in federal cost-sharing assistance and $5 million of farmers' funds have been invested in implementation of BMPs in numerous accelerated water quality projects.

The rationale behind this major investment of human and financial resources has always been that BMP installation reduces or prevents agricultural NPS pollution and will eventually achieve significant, measurable reductions in critical pollutant concentrations in Lake Champlain, in much the same way that implementation of point source controls in other lake systems has achieved substantial reductions.

Past monitoring and evaluation studies connected with these implementation programs have shown some edge of field reductions for certain practices and some in-stream reductions for certain pollutants; however, significant reductions in levels of nutrients, especially phosphorus, have not been observed in the Lake. Although the reasons for this lack of response are obscure, it is clear that the technology for reducing or preventing agricultural NPS pollution needs more research and development.

The complexities of the relationships between agricultural land use, the physical environment, and water quality became more apparent. Researchers, managers, and farmers pondered about the proportion of nonpoint source pollution affecting Lake Champlain which is attributable to agriculture, the pollution potential between alternative agricultural activities, and the water quality effectiveness of agricultural treatment measures.

A Plan For Action

In 1991, the Lake Champlain Management Conference authorized the formation of a bi-state technical forum called the Strategic Core Group (SCG) to develop and initially implement a plan for a comprehensive agricultural monitoring and evaluation network (the "Network") for the Lake Champlain drainage basin. The SCG consists of representatives from the States of New York and Vermont interested in agriculture and water quality (See Appendix D for a complete list of the SCG).

Following intensive review of the present state of our knowledge regarding agricultural NPS pollution and Best Management Practices (BMPs) in the Lake Champlain basin, the SCG has identified and developed, through a consensus-based process, a framework of proposed research, monitoring, and evaluation activities for the Network. These proposed activities are organized in this strategic planning document (the "Plan") into a set of functionally interdependent objectives, goals, and action items.

The Network is envisioned as a <u>step</u> toward an eventual comprehensive agricultural nonpoint source <u>program</u> for the Lake Champlain Basin. This Plan for the Network identifies some tools to help answer some of the vexing questions and issues surrounding agricultural NPS pollution. The Network is designed to integrate a set of research, monitoring, and evaluation activities into a managed process to determine, validate, and demonstrate how agricultural activities can be most effectively managed to reduce or prevent agricultural nonpoint source pollution.

As the public invests money in land treatment programs in anticipation of a positive response in water quality, answers to these questions are needed to enable resource management agencies to assist the Basin's agricultural community in their efforts to reduce pollutant contributions and prevent future water quality problems.

The Network calls for four major initiatives:

1) A dynamic process to set Basin-wide priorities at the watershed and farm levels for on-going and future planning and implementation efforts. The process will incorporate current and future information from agricultural resource inventories, water quality monitoring, BMP effectiveness studies, and basic research on the magnitude and behavior of agricultural NPS pollution.

2) Investigations (often requiring an interdisciplinary approach) of agricultural system variables and relationships to improve our understanding of the types, sources, generation, movement, transport, storage, and transformation of agricultural NPS pollutants.

3) Tracking and water quality monitoring of implementation that occurs through existing or new programs to establish cause and effect relationships between changes in land use/farm management and changes in water quality.

4) A partnership of agriculture, science, and management interests to manage the overall process and enhance acceptance of new recommendations and/or technologies.

To advance these four initiatives, the SCG has identified and developed a series of twenty-five goals and sixty-eight proposed, supporting action items (all goals and action items are described in Section IV of this Plan). The twenty-five goals are interconnected scientifically and temporally. Information from some of the goals is needed before progress on later goals can be made.

Because of these interrelationships, only priorities for goals for 1993 and 1994 have been established. Future priorities should be determined and adjusted by an interdisciplinary/interagency advisory group using the cumulative knowledge which results from completed and on-going projects in the Basin and applicable studies from other areas.

The twenty-five Network goals and sixty-eight action items are organized in Section IV of this Plan into the following subject areas or issues:

1) **Identification and Prioritization of Critical Areas:** Because money will continue to be available and spent in the Lake Champlain Basin to implement management practices to reduce or prevent agricultural NPS pollution, a process is needed to set Basin-wide priorities at the watershed and farm levels for on-going and future planning and implementation efforts. This process must be dynamic and incorporate current and future information from agricultural resource inventories, water quality monitoring, BMP effectiveness studies, and basic research on the magnitude and behavior of agricultural NPS pollution.

2) **Agricultural NPS Pollutants:** Eutrophication resulting from excessive phosphorus levels is one of the chief water quality concerns in Lake Champlain. For this reason, phosphorus and sediment head the list of agricultural NPS pollutants of greatest concern. Other important agricultural NPS pollutants are pesticides, nitrogen, pathogens, and organic matter. Improved understanding of the sources and behavior is needed. While the greatest water quality benefits will probably be derived from focusing efforts on phosphorus, other agricultural NPS pollutants also need to be addressed in a comprehensive agricultural monitoring and evaluation network in order to determine the magnitude and extent of their impacts on lake water quality.

3) **Farm Management Systems/BMPs:** Improved understanding of farm management systems and BMPs is needed to keep more nutrients and other agricultural chemicals on the farm and out of surface water and groundwater. Agricultural systems are more complex than natural systems; they have all the attributes of natural ecosystems plus the confounding factors of our efforts to manage those systems for our own purposes. These confounding factors include economic, sociological, and political elements. These factors need to be recognized and evaluated in designing farm management systems and BMPs to reduce or prevent agricultural NPS pollution.

4) From Edge of Field to the Lake: Significant gaps in our understanding of agricultural NPS pollution revolve around the processes and factors which affect the movement, transport, storage, and transformation of pollutants in the areas called the "flow collector" (i.e., the intervening area between the edge of a farm or field and the beginning of a stream) and within the streams ("in-stream"). These phenomena need to be better understood in order to design effective agricultural NPS management programs.

Unless a pollutant source area such as a barnyard or cropland field is immediately adjacent to the Lake, pollutants leaving the edge of a field or bottom of the root zone must be transported some distance across or through some terrestrial and/or aquatic system(s) before delivery to the Lake. This transport provides opportunities for changes to occur in the amount, form, or timing of pollutants delivered to the Lake; and these processes may be physical, chemical, or biological in nature and are poorly understood. It is known that under most circumstances, something less than 100 percent of the mass of a pollutant leaving a field will be delivered to the receiving water, although different pollutants may behave quite differently.

Once a pollutant enters a stream, it is difficult to determine its exact fate, and, thus, its ultimate impact on Lake Champlain. After it leaves the land, a number of processes can act to alter its form and cause it to be retained in the stream system or eventually be delivered to the lake. Although we have little control over these in-stream processes, we need to understand how they operate in order to make informed land management decisions for the purposes of water quality improvement.

5) Development of Management "Tools": Typically, a natural resource manager does not have an adequate understanding of business administration and economics, a business manager does not have an adequate understanding of science, particularly ecology, and neither may understand the political realm. Modeling, the development of simplified representations or simulations of more complex systems, offers managers and policy-makers an activity or "tool" which can integrate information from a variety of disciplines and sources in order to make informed and appropriate decisions.

With these constraints and limitations clearly in mind, validated models can serve as useful tools for the wise management of agriculture to reduce or prevent agricultural NPS pollution. The development of models (or methods) for the Network is envisioned as an on-going process with continuous feedback loops which incorporate useful information into the models from the study of natural processes at the farm/field-scale and watershed-scale, the effects of farm management, and the tracking and monitoring of water quality changes.

This major activity will require the efforts and cooperation of many people from a wide variety of disciplines. Many of the action items outlined in this document will be the building blocks of such a model or method. Model development provides a logical, phased process for collaborative problem-solving that flows from understanding agricultural NPS pollution (and the effects of farm management) to quantification of system variables and relationships to validation of results with actual measurements to meaningful analyses of the problem to building mutually satisfactory solutions.

6) **Partnership of Management, Science, and Agriculture:** The many interrelated and diverse activities of the Network will require a long-term team effort from many individuals with a wide range of backgrounds and interests. Success will be dependent on close cooperation and communication between the scientists who are performing the needed research and evaluation, the management and planning personnel who are responsible for program implementation, and the farming community which will be asked to adopt the BMPs and other new technologies.

7) **Tracking Impacts of Implementation Efforts on Water Quality:** Evaluating water quality changes due to agricultural implementation efforts is an obvious component of an agricultural monitoring and evaluation network and one that should begin now and continue into the future. Water quality monitoring may take place at many different scales, from individual farm fields to tributary streams to entire river basins. At any scale, monitoring programs should be specifically designed to assess the impacts of implementation on water quality as well as to track changes in land use and management. The level that this evaluation effort requires will be dependent upon the level of implementation. If targeting and larger-scale implementation is envisioned in the future, then the evaluation effort must be appropriately scaled to ensure that the public and private investment in implementation measures is producing the desired results.

In conclusion, this Plan is envisioned as a fluid, dynamic, working document, not a report to end up on the shelf. This is eleventh iteration or revision of the Plan since the Strategic Core Group began their discussions in August of 1991, and there are likely to be more revisions in the future as the Agricultural Advisory Council puts the Plan to work in developing RFPs from its conceptual elements. As elements of the Network are developed, implemented, analyzed, and reported, the character of the Network should parallel our progress toward our goals. Answers to the questions we have now may reveal new questions for tomorrow. Along the way, at any one moment in time, a living plan based on a managed process should serve as the "blueprint" for guiding our inquiries into the problem before us.

The Strategic Core Group recommends that the Lake Champlain Management Conference take the following actions to support initial implementation of the Network:

1) Ask the Secretary of Agriculture to allocate (or re-direct) resources to assist with Network implementation.

2) Support increased funding for implementation of on-farm management practices which are effective in preventing or reducing agricultural nonpoint source pollution.

3) Request the Commissioners of the NY Department of Environmental Conservation, NY Department of Agriculture and Markets, VT Department of Environmental Conservation, and VT Department of Agriculture, Food, and Markets to convene a Lake Champlain Basin Agricultural Advisory Council (AAC) for the purpose of overseeing and coordinating the implementation of the Network.

4) Release the funding (FY91 and FY92) for the Manure Injection Request for Proposals.

5) Direct the AAC to recommend priority areas/action items where more RFPs need to be developed for Network implementation.

I. INTRODUCTION

The Setting

Lake Champlain, one of the largest freshwater lakes in the United States and a major natural resource of the Northeast, drains a basin of some 8200 square miles (5.25 million acres). The lake and its basin are shared among the two states of New York and Vermont and two nations, the United States and Canada (Quebec Province). Approximately a half million people live in the basin, and the population of the area is increasing. Sixty per cent of the basin area is forested while 20 per cent of the land area is agricultural including an estimated 2900 active farms (2000 in Vermont and 900 in New York). The Lake Champlain basin has thirty-three tributaries with drainage areas greater than ten square miles.

Complexity and Variation

The draft Pollution Prevention, Control and Restoration Plan prepared by the Plan Formulation Team of the Lake Champlain Management Conference states that eutrophication studies conducted on Lake Champlain since 1979 have led to the conclusion that phosphorus levels in the Lake are currently too high and should be reduced. Phosphorus levels in portions of the Lake are as high as the most eutrophic parts of the Great Lakes during the 1970s. Eutrophication of the open water areas of the Lake is the result of the cumulative impact of many individually small phosphorus sources, both point and nonpoint.

In the Lake Champlain Basin, some of the decrease in water quality has been attributed to nonpoint source (NPS) pollution from agricultural sources (See Appendix A: Lake Champlain "Level B Study"). The amount of this agricultural contribution is thought to vary tremendously between tributaries and among different lake regions. In spite of the work which has already been done on the subject, there is still a lack of scientific information, understanding, and agreement regarding agriculture's contribution to the water quality problems of Lake Champlain and its tributaries.

Agencies in both states, NY DEC and VT ANR, and in the federal government, USDI/USGS and USEPA, are continuing to monitor the quality of the lake water and a number of major tributaries to the lake. While a great deal is known about the quality of the lake and tributary waters, far less is understood about the processes by which pollutants find their way to the Lake.

Legislation

In November 1990, Congress passed the "Lake Champlain Special Designation Act of 1990" as an amendment to the "Federal Water Pollution Control Act" (33 U.S.C. 1251 et seq.). The Lake Champlain Act created the Lake Champlain Management Conference to develop "a comprehensive pollution prevention, control, and restoration plan for Lake Champlain".

The Act also instructs the Secretary of Agriculture to designate Lake Champlain as a special project area under the Agricultural Conservation Program (ACP) and mandates the development of "a comprehensive agricultural monitoring and evaluation network for all major drainages within the Lake Champlain Basin". The Act allocated resources to support this development, but does not specify the nature or composition of the "comprehensive agricultural monitoring and evaluation network".

Planning for the Network

In 1991, the Lake Champlain Management Conference authorized the formation of a bi-state technical forum called the Strategic Core Group (SCG) which consists of representatives from New York and Vermont interested in agriculture and water quality (See Appendix D for a complete list of the SCG). The SCG has identified and developed a framework of proposed research, monitoring, and evaluation activities that comprise a comprehensive agricultural monitoring and evaluation network (the "Network") for the Lake Champlain drainage basin. These proposed activities are organized in this strategic planning document (the "Plan") into a set of functionally interdependent objectives, goals, and action items designed to ensure the long-term success of the Network in serving the water quality efforts of resource management agencies and the agricultural community.

This Plan has been developed through a process of group consensus which was facilitated by a coordinator and in which the representatives and alternates of the SCG participated. During a series of monthly meetings, problems and needs were identified and solutions were developed. These meetings between scientists and managers created an unprecedented forum for communication and collaboration for addressing the issue of agricultural NPS pollution in the Lake Champlain Basin.

The SCG formed five smaller workgroups of specialists to address specific issues such as prioritization, critical agricultural pollutant sources and behavior, management tools and models, and network structuring and continuity. The goals and action items identified and developed by the five workgroups were then reviewed, refined, and agreed upon by the full SCG. This consensus-based planning process required a large commitment of time and effort on behalf of the SCG representatives and alternates. Consensus was employed over quicker decision-making models, such as voting, because the participants realized that their full support and commitment will be crucial to the long-term success of the Network.

Demonstration and Evaluation of Best Management Practices

Funding was also authorized for the initial, limited implementation and demonstration of Best Management Practices (BMPs) on farms in the Lake Champlain Basin as one part of the effort to improve understanding about the effectiveness of recommended practices in reducing agricultural NPS pollution. Two BMP demonstration and evaluation projects are described in Appendix C.

Previous Management Efforts

Since the 1970s, when organized efforts to deal comprehensively with eutrophication issues in Lake Champlain began, interested farmers have been actively installing recommended BMPs to control or reduce agricultural NPS pollution either as voluntary participants in various state and federal land treatment implementation programs (described in more detail in Appendix) or on their own.

About $12 million dollars in federal cost-sharing assistance and $5 million of farmers' funds have been invested in BMP implementation in accelerated water quality projects. $5.5 million was spent on monitoring and evaluation associated with the St. Albans RCWP and the LaPlatte River Watershed projects. This totalled 387 contracts which is about one-third of those farms with a significant water quality problem. In addition, about $1 million each year has been spent on BMP implementation under ACP.

The rationale behind this major investment of human and financial resources has always been that the BMP installation reduces or prevents agricultural NPS pollution and will eventually achieve significant, measurable reductions in critical pollutant concentrations in Lake Champlain, in much the same way that implementation of point source controls in other lake systems has achieved substantial reductions. However, significant reductions in levels of nutrients, especially phosphorus, have not been observed in the Lake.

Extensive monitoring associated with agricultural BMP implementation programs in two Vermont watersheds has not shown dramatic phosphorus loading reductions to the Lake as a result of these efforts. Although some water quality improvements at the edge of field and in some tributaries were suggested by the data, the technology for reliably reducing or preventing phosphorus runoff from agricultural nonpoint sources in the Lake Champlain Basin clearly needs more research and development.

The Future

No biological system has yet yielded itself to complete human control, and the complex interactions which affect the generation, transport, transformation, and delivery of agricultural NPS pollution (and other NPS) presage the difficulties of developing effective reduction or prevention measures. Many important climatic and environmental variables will remain free from our influence.

Our ability to "measure" the impacts of any management strategy will be hindered by the dispersed temporal and spatial nature of agricultural NPS pollution. Measuring changes in pollutant loadings at a watershed mouth is not equivalent to measuring the outfall of a discharge pipe because our knowledge of, and our ability to manage, up-stream variables (land uses, climate, soils, generation and behavior of NPS pollution) is currently more limited than our knowledge of processes producing point source pollution. "Reducing" or "preventing" agricultural NPS pollution, thus, becomes a more realistic objective than "controlling" it.

In spite of these difficulties and uncertainties, it still makes sense to try to reduce pollutant loadings from all nonpoint sources, including agriculture.

Although smaller, the farm is, in its own way, a system with a complexity equal to that of the Lake. In addition to better information regarding the effectiveness of BMPs in reducing or preventing agricultural NPS pollution, effective management strategies in the future will require better knowledge concerning 1) the temporal and spatial character of the sources of agricultural NPS pollution, 2) the magnitude and behavior of critical agricultural pollutant loadings from each source; and 3) the ability to predict the response of the Lake as a whole to changes in pollutant loadings.

The Plan

The following sections of this Plan provide the background and details for a Comprehensive Agricultural Monitoring and Evaluation Network (the "Network") for the Lake Champlain Basin and its tributaries.

Section II discusses the premises which form the foundation for the design of the Network as outlined in this document.

Section III summarizes the overall objective and the major operational and technical objectives of the Network.

Section IV provides background and reasons for the research, monitoring, and evaluation activities needed for the Network. Specific goals designed to contribute towards accomplishing the major operational and technical objectives of the Network are described as well as the actions items needed to achieve these goals.

Conclusions and a summary form Section V.

Additional relevant information is found in Appendices A through E.

Appendix A: Addresses the issue of agriculture and NPS pollution in the Basin. The current state of our knowledge is described, and summaries are provided on studies in progress which have been designed to add to that knowledge. Also, past and current implementation programs and projects are reviewed to provide an overview of the efforts made to date by resource managers and farmers to reduce or prevent agricultural NPS pollution.

Appendix B: Provides a preliminary listing of management practices for agriculture that will reduce pollution in the Lake Champlain Basin . Also included in this list are innovative water quality management practices which are being evaluated in other parts of the country and are thought to have application in the Basin.

Appendix C: Contains summaries of the two BMP demonstration and evaluation projects currently in progress: 1) Phosphorus Management Using Manure and Perennial Forage Grasses, and 2) Topdressed Manure for Established Alfalfa.

Appendix D: Lists the representatives and alternates of the Strategic Core Group.

Appendix E: Gives an explanation of terms and acronyms used in this document.

II. BACKGROUND FOR DEVELOPMENT OF THE NETWORK

The design and development of the Network which is described in this Plan is based upon a number of premises listed below which follow from past studies and experience:

1) There is a lack of understanding and agreement regarding agriculture's contribution to the water quality problems of Lake Champlain and its tributaries. Some of the decrease in the Lake's water quality has been attributed to agricultural NPS pollution. The magnitude and extent of the water quality problems in the Lake and its tributaries have spatial and temporal variability, as do the size and character of agricultural operations. Although the relative contributions of the various agricultural and non-agricultural nonpoint sources of pollutants within the basin are not adequately established (but they need to be for a rational approach to a basin-wide management program), there is still good reason to try to decrease the agricultural contributions. **The activities of the Network, while focused primarily on agriculture, are intended to be closely coordinated with other efforts to assess and reduce the magnitude and impact of nonpoint pollution from non-agricultural sources.**

2) Simple counts of BMPs implemented are of limited utility in establishing relationships between land use and water quality. Better information on soils, climate, management activities, changing patterns of land use, and other farm practices is essential in order to understand the complex interactions that affect the generation, transport, transformation, and delivery of agricultural nonpoint source pollutants. This information will represent an enormous increase in the size and complexity of the data base on the agricultural resource in the Basin. **The Network includes activities designed to efficiently manage the size and spatial and temporal variability of the agricultural resource data base and provides the mechanism to incorporate this information into analysis and decision-making processes.**

3) Better information on the sources, behavior, and magnitude of agricultural NPS pollution and the effectiveness of Best Management Practices (BMPs) in reducing or preventing agricultural NPS pollution is essential to establish relationships between agricultural land, management practices, and water quality. **The Network contains activities to improve understanding of farm/field level natural processes which influence the nature of agricultural NPS pollution and the effects of farm management/BMPs.**

4) Although we have evidence of the effectiveness of some individual BMPs, more information is needed regarding the effectiveness of integrated management systems of site-specific BMPs and other management practices which are thought to have potential as BMPs. **The Network includes projects designed to determine the water quality effectiveness of selected BMPs, research studies to determine the sources, magnitude, and behavior of critical agricultural pollutants, and activities to integrate this information into management models or methods applicable to farm and watershed scale issues and problems.**

5) The physical, chemical, and biological processes that operate to store, release, and transport pollutants in small watersheds and large basins are not instantaneous. The

implementation of on-farm BMPs will most likely be followed by a period of time before pollution reduction in streams or in the Lake is realized. Similar time-lags can be expected whenever any changes in nonpoint management programs or environmental policies are made. Thus, lake water quality and its eutrophication effects will change gradually over time as determined by the nature of the basin. **The Network emphasizes a set of interrelated activities designed to understand and quantify the dynamic nature of watershed processes.**

6) There are insufficient funds and personnel available through existing programs to plan, design, and install integrated complements of Best Management Practices on every farm in the Basin. **The Network contains activities designed to more accurately target critical areas of agricultural NPS pollution at the watershed and farm levels so that limited dollars can be allocated in a manner which will result in the maximum water quality benefits.**

7) Improving our ability to reduce or prevent agricultural NPS pollution will require the coordinated efforts of specialists from a wide variety of natural resource fields. **The Network provides a mechanism to ensure that the various studies are carried out by interdisciplinary teams of investigators with appropriate backgrounds to assess current knowledge, conduct field research, and develop and verify methodologies for management.**

8) Finally, a unified, collaborative approach to problem-solving will produce better results than a fragmented approach. **The Network lays the foundation for building an unprecedented level of communication, cooperation, and coordination between the scientific, management, and agricultural communities.**

III. NETWORK OBJECTIVES

Overall Objective

The overall objective of the Comprehensive Agricultural Monitoring and Evaluation Network (the "Network") is to determine, validate, and demonstrate how agricultural activities at the basin, watershed, and field levels can be most effectively managed to reduce or prevent agricultural nonpoint source water pollution in accordance with implementing environmental policies and ensuring a viable agricultural economy. This Plan outlines activities and a process for building the Network and achieving this overall objective for the Basin.

There are two major operational objectives of the Network:

1) To establish a process for prioritizing agricultural implementation efforts to assure that funds are spent in a way that will result in the best ratio of pollutant reduction per dollar spent.

2) To promote cooperation and collaborative problem-solving between scientists, resource managers, and the agricultural community by providing an organizational structure to facilitate these efforts.

There are four major technical objectives of the Network:

1) To improve understanding of agriculture's contribution to the water quality problems of Lake Champlain.

2) To improve understanding of the chemical, physical, and biological processes affecting the magnitude and behavior of critical agricultural nonpoint source pollutants at the farm and watershed levels.

3) To integrate the understanding of critical agricultural nonpoint source pollutant generation, delivery, and transport processes (spatial and temporal) into a validated, quantitative management model(s) or method(s) applicable to farm and watershed scale issues and problems.

4) To improve on-farm management capabilities for phosphorus and nitrogen from organic and commercial sources.

IV. PLAN FOR THE DEVELOPMENT OF THE NETWORK

This section outlines an interrelated framework of proposed activities that define a comprehensive agricultural monitoring and evaluation network (the "Network") for the Lake Champlain drainage basin. The Network activities are presented in a format which describes specific goals followed by one or more action items needed to achieve those goals. Introductory narrative, in most cases, precedes each goal to provide background or explain the major issues behind the goal.

This set of goals and action items embodies the collective opinion of the participating members of the Strategic Core Group as to what is needed to determine, validate, and demonstrate how agricultural activities can be most effectively managed to reduce or prevent agricultural NPS pollution. There are still many gaps in understanding the agricultural system and the relationships of important variables. The investigations described in this section attempt to cover the full range of those gaps. The constraint imposed by limited financial and human resources requires that investigations be concentrated initially on those areas that current knowledge indicates are the most important. As new information comes to light, however, priorities should be reviewed and fine-tuned. Priority goals for immediate action are followed by the designation: ***HIGH PRIORITY***

While individual action items (boxed) point to discrete gaps in our knowledge base regarding agricultural NPS pollution, it make sense to enhance Network implementation by designing projects which integrate the study elements or concepts from related or complimentary action items.

Also, since most of the activities suggested in this document (including current knowledge assessment, field research, and model development and verification) need to be carried out by interdisciplinary groups, RFPs should encourage the formation of teams of investigators with appropriate backgrounds. Also, the interrelated nature of these activities suggest that various investigations could be conducted in conjunction with each other, where appropriate, to maximize the utilization of existing funds.

A. Identification and Prioritization of Critical Areas

Because money will continue to be available and spent in the Lake Champlain Basin to implement management practices to reduce or prevent agricultural NPS pollution, a process is needed to set Basin-wide priorities at the watershed and farm levels for on-going and future planning and implementation efforts. This process must be dynamic and incorporate current and future information from agricultural resource inventories, water quality monitoring, BMP effectiveness studies, and basic research on the magnitude and behavior of agricultural NPS pollution.

A Basin-wide, general characterization or summarization of the agricultural resource is needed. This activity has a low priority relative to other Network goals; however, it has never been completed for the entire Lake Champlain Basin and would be useful in guiding the efforts of planners and managers in reducing or preventing agricultural NPS pollution and in other related Basin projects.

A higher priority goal is the preliminary identification and prioritization of critical areas of agricultural NPS pollution at the watershed and farm levels to target the efforts of present implementation programs. After this preliminary prioritization, the priorities must be reviewed and adjusted as new information from other studies becomes available which will increase the accuracy of the predictions and as future BMP implementation reduces agricultural NPS pollution.

Models or methods used for prioritization must be validated by comparing predicted loading of agricultural nonpoint source pollutants with results from actual monitoring studies (results which are not used for purposes of model development). This validation activity and the prioritization process are essential for the long-term success of a strategy to reduce or prevent agricultural NPS pollution.

Finally, agricultural activities and land use can change significantly over time. Changes in the number of farms, farm ownership, farm and field management, cropland acres, livestock numbers, and the composition and distribution of livestock populations may have important water quality implications for nonpoint source control priorities of management programs. Improved methods for keeping pace with the changing nature of agriculture are needed.

Goal I: Provide a Basin-wide, general characterization of the agricultural resource in the Lake Champlain Basin.

Action Item I.1: Conduct an inventory of all farms (dairy and non-dairy) within the basin with 10 or more animal units or 25 or more cropland acres to obtain specific numerical estimates for parameters a, b, c, and d listed below. This information should be incorporated into a Geographic Information System and made accessible to federal, state, and local agencies.

a. Location (with stream overlay)
b. Farm operation type
c. Farm size (number of animal units, cropland ac.)
d. Manure handling

Goal II: Provide a Basin-wide, preliminary identification and prioritization of the critical areas of agricultural NPS pollution at the watershed and farm levels.
*****HIGH PRIORITY*****

Action Item II.1: Collect farm-specific information from a statistical sample for all watersheds from the population of farms identified in Goal I for the categories listed in "a" through "k" below to allow prioritization of watersheds. These data should eventually be incorporated into the GIS system and made accessible to federal, state, and local agencies. A significant "marketing" effort should be made to enlist the cooperation of landowners.

a. Number & type of animal units
b. Field use (row crops, hay, pasture,...)
c. Soils
d. Drainage (surface & subsurface)
e. Waste management (manure & milkhouse)
f. Nutrient management (soil/manure testing)
g. Pesticide management
h. Barnyards
i. Streams, streambanks, riparian zone
j. Field management (tillage type, direction, timing, residue, water control structures)
k. etc. (list not necessarily inclusive)

Action Item II.2: Conduct a **preliminary** prioritization of critical areas of agricultural NPS pollution at the watershed level using information collected in Action Item II.1 above and an appropriate model or method.

Action Item II.3: Collect information for "a" through "k" above (after completing Action Item II.2) for any uninventoried farms in high priority watersheds to allow prioritization of farms using an appropriate model or method.

Goal III: Improve the accuracy and usefulness of the agricultural resource database.

Action Item III.1: Establish a process for updating agricultural resource inventories.

a. Update basin-level and watershed-prioritization data every 5 years (5-year updates of SCS "river basin" inventories with SCS as lead).

b. Update farm-level data on an on-going basis utilizing the potential of existing SCS computer technologies (e.g., CAMPS).

Action Item III.2: Investigate the potential of new technologies/methods (such as remote sensing imagery, image processing technologies, and GIS technologies) to maintain an accurate, up-to-date agricultural resource inventory.

Goal IV: Improve understanding of agriculture's relative contribution to the water quality problems of Lake Champlain and its tributaries through coordination with other studies and inventories.

Action Item IV.1: Encourage inventories of other nonpoint sources to be designed in a manner that would enable valid comparisons with the data from the agricultural resource inventory.

Action Item IV.2: Encourage the identification and coordination of the GIS data layer needs for all inventories and studies within the Basin to ensure that the information developed is transferable.

Action Item IV.3: Coordinate the comparison of loadings from agricultural nonpoint sources to estimated loadings from other nonpoint sources on watershed and basin levels.

B. Agricultural Nonpoint Source (NPS) Pollutants

General Discussion

Clean water is the foundation of Lake Champlain's economic, recreational, and cultural values. The main water quality problems in the Lake arise from the presence of four types of pollutants: nutrients (especially phosphorus), toxic substances, sediment, and pathogenic organisms. The beginning of this section focuses on the most important research needs for the agricultural NPS pollutants considered to have the potential for significant impact on Lake water quality.

Eutrophication resulting from excessive phosphorus levels is one of the chief water quality concerns in Lake Champlain. For this reason, phosphorus and sediment (which may carry attached phosphorus) head the list of agricultural NPS pollutants identified in priority order below. While the greatest water quality benefits will probably be derived from focusing efforts on phosphorus, other agricultural NPS pollutants also need to be addressed in a comprehensive agricultural monitoring and evaluation network in order to determine the magnitude and extent of their impacts on lake water quality.

In general, agricultural NPS pollutants can occur in either the dissolved or particulate phase in the aquatic environment. Pollutants may be chemically bound to sediment and organic matter by sorption reactions, or exist within the structure of particulate matter. Many aquatic pollutants may easily change their form depending on changes in water chemistry and physical properties. Changes in dissolved oxygen, pH, water temperature, ionic content, and mechanical disturbance may all change the relative proportions of pollutants.

How does a common and primary plant nutrient like phosphorus become a critical agricultural NPS pollutant? How do phosphorus and other substances on the land contribute to water quality problems in Lake Champlain? The fate of nutrients and pesticides in the environment is dependent on a variety of dynamic and cyclic factors.

Precipitation in the form of rain or snow will have varying amounts of pollen, dust, combustion by-products, and the natural elements from various atmospheric gases. This precipitation, which is also acidic, will deliver various elements directly into a waterbody or onto the land as it falls. The concentrations of these elements can also change (i.e., phosphorus concentrations generally increase) as rain falls through a crop or forest canopy.

After precipitation hits the ground, it is partitioned into surface storage or movement (runoff) and infiltration (or evaporation). Land surface conditions such as permeability and slope are primary factors which determine whether rain will pond, evaporate, infiltrate, or runoff. For example, an impervious, paved, or frozen surface on a slope will direct all the rain into surface runoff in contrast to a partially dry, permeable, and level gravel soil with a residue cover which should allow all the rain to infiltrate. When rain reaches the ground surface, any nutrients, pesticides, and other materials present come into contact and mix with it. Those materials which readily dissolve go into solution and can be transported in the runoff or infiltrating water. Furthermore, the energy from falling rain can dislodge particles (which may have various materials attached to or incorporated into them) and, these entire particles can be suspended and transported with the moving water. As surface water accumulates and gains runoff momentum, it too will have the energy to dislodge and transport even larger particles. This energy in runoff water causes sheet, rill, and gully erosion processes to occur in the field. Consequently, surface water runoff is a primary pathway from the point of rainfall impact to the edge of a field whereby nutrients and pesticides are gathered in solution and/or by attachment or incorporation in suspended particles and transported in the moving water. The surface water runoff, and all which it contains, is a main source of recharge for streams and lakes.

Infiltration, the passage of water into the soil surface, and percolation, the movement of water through the soil profile, are the sources for soil moisture to sustain the growth of plants and of groundwater supply for wells, springs, and the base flow of streams. The amount of precipitation which infiltrates is a function of soil physical characteristics (texture and porosity), the cover on the soil surface, and other factors such as soil moisture content, temperature, and the intensity of rainfall. Nutrients and pesticides on the soil surface which easily dissolve in rainfall and small suspended soil or organic particles can move downward with infiltrating water. Since infiltrating water tries to find the easiest path into the ground, preferential flow occurs. Preferential flow is relatively rapid water movement into soil cracks, wormholes, and large pores or channels or it is the preferred movement of wetting fronts. The amount of preferential flow depends on the size and quantity of the macropores, their continuity and on soil hydraulic properties. With preferential flow, dissolved nutrients, pesticides and fine particles can move quickly, and without any significant alteration, through a macropore and deep into the soil profile and into groundwater.

Infiltration also involves a more gradual downward water movement through all the pore spaces in the soil matrix. This gradual water movement also depends on the properties of the soil. This matrix flow creates more opportunity for mixing or filtering of the water as it moves through the voids and around the soil particles. Depending on the concentration of nutrients, pesticides, and the soil conditions, this mixing and filtering may help to remove some nutrients or pesticides from the water (the soil adsorbs them).

Thus, water which infiltrates and percolates through the soil to the bottom of the root zone may take different pathways. Depending on the pathway taken and what is encountered, the percolating water may be cleaner or further degraded after it has passed through the soil root zone. Water percolating through the soil eventually reaches physical barriers which causes the water to saturate (fill) the voids in the soil forming watertables or groundwater. The barriers could be rock, dense soil layers, or even an existing watertable and it could be near the surface or deep below the surface. The barriers could be natural or artificially-made. Once a soil is saturated, the groundwater mass also moves in a path of least resistance resulting in recharge to pumped wells, flow into subsurface drains, the formation of seeps and springs, and recharge into streams and lakes. Depending on the geometry of the barriers, the groundwater may be at the soil surface, it may come back to the surface very close to where the water initially infiltrated, it could travel long distances, then resurface, or it may never resurface through any natural means. Nevertheless, the quality of the groundwater exhibits characteristics of the soil and rock minerals through which it has traveled and can thus change significantly from one location to the next. Since the subsurface is highly variable and difficult to visualize and observe, the exact pathway of infiltration, the extent of mixing, and the location and effect of various barriers are difficult to measure and predict.

The following six categories of agricultural NPS pollutants are discussed in order of the significance of their impact on the water quality of Lake Champlain:

1. Phosphorus

Phosphorus Sources on the Farm

Agricultural sources of phosphorus in the Lake Champlain Basin generally fall into four main categories: a) Animal Waste, b) Vegetation, c) Agrichemicals, and d) High-phosphorus Soils.

a) **Animal Wastes:** The predominant type of animal waste is dairy manure. However, there may also be locally important concentrations of veal, horse, sheep, beef cattle or poultry. Other sources of animal phosphorus are treated human waste (sludge or septage) that is land applied. Milkhouse waste is also a source of phosphorus (most of the phosphorus in milkhouse waste is probably from cleaners, not milk solids).

b) **Vegetation:** Phosphorus is present in both living and dead vegetation. Harvested crops, crop residues and feed crops in addition to non-cultivated plants (weeds, tree leaves, etc.) are all sources of phosphorus on agricultural land.

c) **Agrichemicals:** Commercial fertilizer is the main phosphorus source in this class. Also included are support products such as detergents to clean milking systems. Phosphorus in detergents is banned in New York. A similar ban exists in Vermont, however, agriculture is exempted.

d) **High-Phosphorus Soils:** Soils with high phosphorus levels coupled with soil erosion may be able to supply large amounts of phosphorus to runoff and ultimately to Lake Champlain. This process may be enhanced by additional applications of fertilizer and manure to these soils.

Phosphorus in Aquatic Systems

Phosphorus in aquatic systems occurs almost solely as phosphate and consists of particulate and dissolved fractions. Physical and chemical treatments of water samples prior to colorimetric analysis are often used to categorize the forms of phosphorus. The dissolved and particulate fractions are analytically approximated by separation through a 0.45 micron membrane filter. Particulate fractions are associated with mineral phases of soil and rock, detritus particles, or as nucleic acids, enzymes, etc. in the bodies of organisms. Dissolved phosphorus can occur in an inorganic (most importantly orthophosphate) or organic form. Reactive phosphorus is that portion of the total phosphorus in solution or suspension that is immediately available for biological uptake.

Phosphorus cycling in the aquatic environment is controlled by both chemical and biological processes. The exchange of phosphorus between bed sediments and overlying waters is a major component of the cycle and often results in a net phosphorus sink to the sediments. Exchange across the sediment interface is regulated by mechanisms associated with: mineral-water equilibria; sorption processes; oxidation/reduction interactions dependent on oxygen supply; and biological activity. Phosphorus exchange between suspended sediment and surrounding waters is controlled largely be equilibria and sorption processes. Uptake and release by aquatic macrophytes and benthic organisms can be important in stream reaches with significant littoral vegetation.

(If the reader is interested in a more detailed explanation of these processes, please refer to: Wetzel, Robert G., 1975, Limnology, Philadelphia: W.B. Sanders Company)

Goal V: Improve our understanding of the on-farm sources, characteristics, and movement of phosphorus in the plant-soil-water system. *****HIGH PRIORITY*****

V.A: Determine the relative importance and variability of surface, subsurface, and lateral movement of phosphorus from the standpoints of soil type, climate, and season.

Action Item V.A.1: Determine the amounts of runoff versus tile drainage versus subsurface recharge to streams (and the amount of phosphorus accompanying the various flow paths) for the major soil types.

Action Item V.A.2: Determine the differences in soil phosphorus dynamics of manure-phosphorus versus inorganic fertilizer-phosphorus (do they behave similarly with regard to runoff, movement into and through the soil to tile drains?).

V.B: Evaluate the relationships between soil test phosphorus and potential phosphorus movement to surface and groundwater.

Action Item V.B.1: Conduct laboratory studies to correlate concentrations derived from soil tests for phosphorus availability currently used in the Lake Champlain Basin plus selected other tests with the amount of phosphorus desorption/dissolution occurring under various soil/solution ratios. These studies should be carried out using a high percentage of the important agricultural soils in the Basin.

Action Item V.B.2: Conduct a field study to sample phosphorus in runoff and tile drainage from a variety of soils in the basin and compare with soil test levels in fields and results of the laboratory studies.

Action Item V.B.3: Summarize current soil test results for phosphorus (UVM/Cornell).

V.C: Determine the "safe" phosphorus level in Lake Champlain Basin soils which will result in "acceptable" levels of soluble-phosphorus runoff:

Action Item V.C.1: Combine results of stream and lake studies (which will determine "safe" phosphorus loading rates from the watershed) and results of studies described under Goal V.B above to perform sample calculations using soils in a particular sub-watershed. Determine the "safe" soil phosphorus levels using the information in the various studies. Expand results to other subwatersheds in the Basin.

V.D: Determine the quantity of phosphorus (via runoff and sediment) delivery that occurs from major soil types in the Lake Champlain Basin.

Action Item V.D.1: Conduct a multi-year field study which includes using information available from soil surveys, routine field inspection, and monitoring. In addition to the determination of actual quantities of runoff and sediment delivery at each major field site, infiltration rates and saturated hydraulic conductivities should be measured at different times of the year. Soil moisture, rainfall, evaporation, and temperature should be monitored at each major site during the study.

V.E: Determine long-term averages for phosphorus export to surface waters from important agricultural soils in the Lake Champlain Basin:

Action Item V.E.1: Develop monitoring stations for key agricultural soils to measure phosphorus export in runoff and sediment delivery over a period of at least 10 years. These fields (or portions of fields) must be carefully selected to represent widespread soil/cropping conditions in the Basin and all agricultural practices should be monitored. These sites should be instrumented to continuously monitor weather and soil water contents along with runoff and phosphorus concentrations.

2. Sediments

Agricultural sources of sediment in the Lake Champlain Basin are a result of land disturbance and are a product of water or wind erosion. Removal of riparian vegetation and free access of livestock to streams can cause streambank erosion. Tillage systems used to produce crops cause disturbance of the upper layers of soil and makes the soil more susceptible to erosion. Depending on the type of tillage and the type of soil, the soil could be susceptible to overland flow erosion (sheet and rill), concentrated flow erosion (ephemeral gully and gully), and wind erosion.

Other agricultural pollutants, such as phosphorus, organic material, and toxic substances, can be attached to and transported along with sediment.

Goal VI: Update and improve our understanding of the magnitude and location of agriculturally-induced field and streambank erosion in the Basin.

Action Item VI.1: Conduct an inventory (or update existing inventories) of agriculturally-induced streambank erosion in the Basin.

Action Item VI.2: Determine the relative significance of cropland erosion in the sedimentation and eutrophication of Lake Champlain by utilizing existing inventories of cropland erosion and information developed from Goal V.

3. Pesticides

Like nutrients, pesticides may occur in solution or be adsorbed onto soil and organic matter. Additionally, they may be chemically or microbially degraded to more toxic, less toxic, or non-toxic forms. In general, the form a pesticide takes upon entering the aquatic environment depends on the characteristics of the pesticide (most importantly its solubility), the characteristics of the adsorbent with which it has had contact (organic matter content, clay content, particle size, etc.), and the ambient stream conditions.

Use of pesticides in agriculture is mainly associated with corn production in the Basin. Corn production, of which the majority is silage, is by far the largest user of pesticides in both Vermont and New York. In Vermont 60 percent of all pesticides applied by commercial applicators are applied to field corn production. The majority of these chemicals are six herbicides used for weed control. Other agricultural crops which result in intensive pesticide use include apples, Christmas trees, and, to a lesser extent, vegetable production. These crops differ from corn production in that they tend to have more than one application of pesticide per year. Apples, for example, have to be treated five to seven times annually in order to control the array of insect and disease problems which affect the crop. These applications also differ in that they are generally applied to the foliage of the crop rather than to the soil. Many herbicides now used for corn production leach readily. A pesticide monitoring program conducted by the Vermont Department of Agriculture has shown that 5 percent of the wells tested had detectible levels of herbicides (samples are analyzed for atrazine, cyanzine, metolachlor, alachlor, pendimethalin, and simazine) in them. This monitoring program has been conducted for the past six years on private water supplies (drilled or driven point wells, dug wells, springs, ponds, etc. used for human or livestock consumption or irrigation) in agricultural areas. Surface water quality has not been monitored.

Recent changes in the atrazine label prohibit fall application of this herbicide, testament to the problems inherent in late-season application of persistent herbicides. Pesticides should be applied according to label instructions, including time of application. Postemergent applications are becoming increasingly popular, and many permit the elimination of a pesticide application if the target pests are not present.Band or directed applications concentrate the pesticide where the material is most needed and can result in a reduced amount of chemical. Broadcast applications are more susceptible to loss by erosion.

By relying on a variety of methods of pest control including crop rotation, cultivation (when appropriate), scouting, and careful timing, both the amount and frequency of application can be reduced.

Genetic resistance to one or more pests is increasingly common in new crop cultivars. Resistant cultivars are often more effective in preventing the effects of insects or diseases than are pesticides. Insect and weed parasites are also used to reduce the need for chemicals.

Goal VII: Improve our understanding of the magnitude, transport, and transformation of pesticides used by agriculture in the Basin.

Action Item VII.1: Summarize and report pesticide use by certified commercial and private applicators in New York and Vermont.

Action Item VII.2:

a. Conduct a study to determine what quantities and types of pesticides used on agricultural land are being delivered to the waters of Lake Champlain.

b. Encourage a study to determine the behavior of the pesticides (identified in "a" above) and their impacts on humans health and biota, if agricultural pesticides are reaching Lake Champlain.

Action Item VII.3:

a. Review results (when available) of current Cornell University study on pesticide discharge from tile drains in orchards (study being conducted outside of Basin).

b. Conduct a similar study within the Basin, if the Cornell study indicates a problem.

4. Nitrogen

Nitrogen can be found in natural waters in both organic and inorganic forms in either dissolved or particulate phases. Nitrogen interactions in the aquatic environment are more varied and complex than those for phosphorus. The nitrogen cycle is largely biochemical (biological) involving nitrogen fixation, nitrification, and denitrification. Fixation occurs when specific bacteria and algae assimilate atmospheric nitrogen. Nitrification is the biological conversion of organic and inorganic nitrogenous compounds from a reduced state to a more oxidized state, such as the conversion of ammonia (NH_3) to nitrates (NO_3). Denitrification is the opposite process, conversion of compounds from an oxidized to a reduced state, ultimately ending with the release of molecular N_2 as a gas.

Nitrogen species of major interest in the aquatic environment are dissolved molecular N_2, nitrate, ammonia, and organic nitrogen. Organic nitrogen occurs in such natural materials as proteins, peptides, nucleic acids, urea, and in numerous synthetic organic substances. Dissolved organic nitrogen often constitutes a major portion of the total soluble nitrogen in fresh waters. Ammonia is the end-product of decomposition of organic matter. Analytically organic nitrogen and ammonia can be determined together and are referred to "kjeldahl nitrogen".

The soluble inorganic species of nitrate and nitrite are produced through nitrification. Nitrite is an intermediate oxidation state of nitrogen, both in the oxidation of ammonia to nitrate and in the reduction of nitrate (NO_3). Algae can utilize either inorganic or organic forms of nitrogen with NO_3-nitrogen and NH_3-nitrogen being used preferentially.

Nitrogen on the Farm

Agricultural sources of nitrogen include the same sources as for phosphorus with the addition of several others:

a. Dairy and poultry manure
b. Sludge/septage
c. Fertilizer nitrogen
d. High N levels in soils (sod & organic matter)
e. Silage storage and feeding of livestock
f. Atmospheric deposition
g. Nitrogen fixation by legumes (e.g. alfalfa)

While nitrogen is suspected of being chiefly an on-farm issue and localized groundwater issue, there is a need for more information on this nutrient as it relates to the water quality of Lake Champlain.

Goal VIII: Assess the impact that nitrogen from agricultural sources may have on the water quality of Lake Champlain.

Action Item VIII.1: Determine if excessive nitrogen levels are occurring and causing water quality problems in Lake Champlain.

Action Item VIII.2: Assess what portion of the nitrogen is being contributed by agriculture, if nitrogen is found to be a significant contributor to the water quality problems of Lake Champlain.

5. Pathogens

Pathogen sources from agriculture are from animal waste. Bacteria and parasites such as giardia are the major forms of pathogens in animal waste. Agricultural nonpoint sources of pathogens are significant with respect to drinking water supplies and water contact recreation.

Goal IX: Determine if bacteria and other organisms from agricultural sources are causing problems for the water contact recreation and water quality of Lake Champlain.

Action Item IX.1: Review the information on pathogens from NYC watershed project when it becomes available and determine if it is applicable to the Lake Champlain Basin.

6. Organic Matter

Many forms of organic matter may originate from agriculture. If this organic matter is deposited directly into a water body, it may exert a biochemical oxygen demand (BOD) that could reduce the oxygen level to critical limits and cause fish kills. Animal waste, silage and silage by-products, and milkhouse waste are examples of agricultural organic matter that could produce a high BOD load.

Goal X: Determine if organic matter from agricultural sources is contributing to water quality problems in Lake Champlain.

Action Item X.1: Conduct an assessment of the risk of this problem, e.g., the proximity of silage storage to streams.

C. Farm Management Systems/BMPs

Farm management systems as BMPs seek to keep nutrients, sediments, and other pollutants on the farm and out of surface and groundwater. The following three management systems/BMPs are considered the most important in terms of potential benefit water quality.

1. Nutrient Management

The timing, amount, type, and method of applying nutrients can affect nutrient losses from leaching, surface water runoff, and soil erosion as well as contributing to improved crop production and reduced costs.

Applying nutrients such as nitrogen close to the time they are needed by plants results in more immediate uptake and therefore less chance for runoff or leaching losses.

Sidedress application of nitrogen on corn results in lower chance of nitrogen leaching and allows best use of the Pre-sidedress Nitrate Test (PSNT). Application of phosphorus in the fertilizer band places the fertilizer below the soil surface where it is less likely to be lost through soil erosion.

Some soil fertility strategies involve building soil fertility to a high level and maintaining it there. This not only costs more than other strategies, but could result in increased water pollution from phosphorus runoff or nitrogen leaching. Relying on soil analyses for fertilizer rates and maintaining moderate levels of soil fertility is a more reasonable strategy.

Many farmers do not give manure proper credit for its fertility value. Manure analysis and calibration of manure spreaders go a long way toward correcting this. Also, there is some evidence that nitrogen in manure will not leach below the bottom of the root zone as readily as the equivalent amount of commercial fertilizer nitrogen and, therefore, is more likely to be utilized by growing crops.

Manure storages should retain not only the solid but the liquid portion of manure (about 10 percent of the nitrogen, 3 percent of the phosphorus, and 20 percent of the potassium in solid manure stacks can be lost in runoff). This means that the storage must have watertight sides and an impermeable bottom; although, in some cases, earthen bottoms are satisfactory. Structures or storages should be constructed so that little or no manure is lost during unloading.

Goal XI: Improve on-farm management capabilities for phosphorus and nitrogen from organic and commercial sources. *****HIGH PRIORITY*****

Action Item XI.1: Conduct a study to correlate phosphorus soil test levels with crop yield response to phosphorus fertilizer on major crops and soils in the Basin.

Action Item XI.2:

a. Obtain information for a statistically accurate sample of farms in the Basin on the quantity of phosphorus import (detergents, feed, minerals, and fertilizers) and phosphorus export (milk, meat, crops). This information will be useful in educating farmers to improve their overall phosphorus budgets.

b. Extrapolate the information from "a" above to obtain a Basin-wide phosphorus input/output budget.

Action Item XI.3: Review previous work and determine phosphorus availability to crops from organic sources (manures, composts, sludges).

Action Item XI.4: Determine the effects of subsurface injection of liquid manure on corn and sod crops and on phosphorus and nitrogen export to surface waters.

Action Item XI.5: Establish a program to reduce nitrogen levels in localized regions where it is a problem (much is already known about how to reduce excessive nitrogen levels), <u>if</u> excessive nitrogen levels are found to be causing water quality problems in Lake Champlain (from Action Item VIII.1).

Action Item XI.6: Conduct a long-term evaluation of the effectiveness of Nutrient Management Plans and associated BMPs which would include analysis of impacts on water quality and farm economics.

2. Farm Water Management

Critical pollutants are commonly transported from the edge of field by surface runoff or the bottom of the root zone into the groundwater. Agricultural management changes that affect water movement or volume can alter the amount of a given pollutant. Practices that prevent excess or clean water from entering contaminated areas serve to better protect surface and subsurface water quality. Diversions, waterways, underground piping, roofing, and gutters are examples of such practices that may be used to safely pass clean water through an agricultural enterprise.

Water cannot be diverted from all agricultural pollutant sources and commonly falls on barnyards, manure piles, and cropland. Water passing through intensively used agricultural areas can carry nutrients, soil, pathogens, and pesticides. Slowing the movement of this water with close growing crops, residues or mulch, filters, or structural storage basins will increase infiltration, decrease surface water runoff, and provide an opportunity for plant uptake. Increased infiltration, however, may increase the amount of contaminants in the groundwater if the pollutants are not utilized by plants or adsorbed on the soil particles.

Goal XII: Summarize and evaluate current knowledge regarding the design and effectiveness of existing methods to treat agricultural NPS surface runoff.

Action Item XII.1: Summarize and evaluate current knowledge about the design and effectiveness of various methods for treating agricultural NPS surface runoff for the following areas:

a. "Clean" water in the vicinity of the farmstead.

b. "Dirty" water (e.g. barnyard runoff and milkhouse wastewater) in the vicinity of the farmstead.

c. Surface runoff from farm fields.

3. Tillage, Residue Management, and Cropping/Grazing Systems

Phosphorus adsorbed to soil particles can be lost from agricultural fields through the processes of runoff and soil erosion. Practices which reduce runoff and soil erosion will, therefore, also reduce phosphorus losses to surface waters. Tillage practices which affect the amount of runoff and the rate of soil erosion are tillage timing (fall versus spring), method (chisel or moldboard plow, no-till), depth, and direction (up and down the slope versus across).

Probably the most important effect of tillage systems is its impact on the amount of residue (corn, hay, cover crop, etc.) remaining on the soil. It is this surface residue that protects the soil from raindrop impact, thus reducing loss of sediment and associated nutrients via erosion and runoff.

Plowing highly erodible soils in the fall can increase soil erosion and phosphorus pollution. On some soils, spring plowing has the potential to reduce erosion. Some relatively flat fields are subject to flooding during spring snowmelt if adjacent to a stream. Plowing these fields in the spring after snowmelt or establishing a cover crop following fall tillage should help reduce phosphorus losses associated with soil erosion. Erosion can also be reduced by practices such as reduced tillage which result in less soil disturbance and plowing across slopes rather than up and down which slows water movement and decreases its erosive capacity.

Tillage can reduce manure losses through incorporation into the soil. This incorporation can be through conventional means such as plowing, or through injection of manure. Application of manure to fields which are ridge tilled or no-tilled can suffer significant runoff losses, especially if the corn was harvested for silage with no cover crop.

The surface of the soil tends to be higher in nutrients under reduced tillage than under conventional plow/harrow systems. This means that, even if runoff is reduced, there may not be a proportional decrease in phosphorus export by using reduced tillage systems.

Establishing a cover crop such as winter rye on erodible land slows water movement and reduces erosion. Oats can also be used as a cover crop and, when planted in early fall, make sufficient growth to reduce erosion. They then winterkill which leaves a seedbed ready for planting the following spring with or without additional tillage.

Unfortunately, in the Basin's short-season climate, post-harvest seedings of cover crops often do not have time for enough growth to provide significant erosion protection in the fall and winter. Seeding rye or oats into the growing crop late in the season can result in more fall growth, but seeding method and successful establishment can be a problem. A promising alternative is interseeding a cover crop such as ryegrass into the crop at the time of N sidedressing and/or last cultivation. The ryegrass can produce good surface cover, as well as N conservation via uptake, in the fall, and the winter-killed residue still provides some surface protection in the spring.

Corn grain residue provides enough protection for most moderately erodible soils. The residue adds organic matter to the soil and improves soil structure. Corn silage management leaves very little residue and increases the need for a cover crop and/or spring tillage to control soil erosion.

Goal XIII: Improve understanding of the effects of tillage and residue management systems on agricultural NPS pollution.

Action Item XIII.1: Conduct a literature review of research dealing with the effects of tillage and residue management systems on agricultural NPS pollution.

Action Item XIII.2: Develop hypotheses concerning the tillage and residue management practices which have the greatest influence on agricultural NPS pollution, based on the results of the literature review in Action Item XIII.1 above.

Action Item XIII.3: Conduct a study to evaluate the effects of tillage and residue management systems (including cover crops) and preferential flow on agricultural NPS pollution and nutrient export to surface waters.

Monocultural row cropping systems adversely affect soil structure and increase the likelihood of nutrient imbalances. Continuous corn fields tend to receive heavy rates of manure to supply high nitrogen levels with a resultant buildup of soil phosphorus levels. Rotations that include sod-type crops provide for a more balanced use of nutrients and results in better soil structure. Improved soil structure allows infiltration of water and dissolved nutrients and reduce nutrient losses in runoff. Proper crop rotation involves a regular and relatively frequent rotation from row crop to sod-forming crop with the number of years in each crop depending on the characteristics of the each field and the farmer's forage needs.

Meadow crops such as grasses and forage legumes have extensive root systems. Grasses have relatively shallow root systems, but are highly fibrous and greatly reduce erosion potential. Legumes have deep tap roots which not only recycle nutrients from deep in the soil but can result in improved water infiltration. Row crops frequently leave insufficient plant residue after harvest which create conditions more susceptible to erosion.

Intensive rotation grazing management with a greater animal density on the land probably has a different influence on runoff quantity and quality than extensive grazing systems. There has been very little work on this issue.

Goal XIV: Improve understanding of the effects of cropping and grazing systems on agricultural NPS pollution.

Action Item XIV.1: Research the effect of cropping and grazing systems on agricultural NPS pollution and phosphorus export in surface and subsurface waters.

D. From Edge of Field to the Lake

Significant gaps in the understanding of agricultural NPS pollution revolve around the processes and factors which affect the movement, transport, storage, and transformation of pollutants in the areas called the "flow collector" (see explanation below) and within the streams ("in-stream"). These phenomena need to be better understood in order to complete the design of effective agricultural NPS pollution management programs.

1. The Flow Collector

Unless a pollutant source area such as a barnyard or cropland field is immediately adjacent to the Lake, pollutants leaving the edge of a field or bottom of the root zone must be transported some distance across or through some terrestrial and/or aquatic system(s) before delivery to the Lake. This transport provides opportunities for changes to occur in the amount, form, or timing of pollutants delivered to the Lake. These processes may be physical, chemical, or biological in nature and are poorly understood, for the most part. It is known that under most circumstances, something less than 100 percent of the mass of a pollutant leaving a field will be delivered to the receiving water, although different pollutants may behave quite differently. The sediment delivery ratio applied to soil loss calculated from the Universal Soil Loss Equation (USDA--Soil Conservation Service) is an example. Storage, even temporary, of dissolved nutrients in a wetland is another example.

The time and space in which such transport attenuation occurs can be divided into two broad compartments: 1) Source-to-stream (the "flow collector" or intervening land area between source and stream) and 2) Stream-to-Lake (in-stream). These two areas must be considered separately for two important reasons. First, movement of pollutants from EOF or BRZ through the flow-collector to a water course may be both an aquatic and a terrestrial process, while in-stream transport will involve primarily aquatic phenomena. Second, management efforts have the potential to influence the source-to-stream process, but have little ability to manipulate in-stream processes. Understanding of source-to-stream processes is thus critical, since this is the focus of many NPS pollution control practices, e.g., diversions, vegetated filter strips, and riparian buffer zones. Understanding of in-stream processes is also essential to enable targeting of critical areas within the Lake Champlain Basin, especially with respect to distance from the Lake, and to predict watershed yields of pollutants under different management scenarios.

Goal XV: Improve understanding of factors controlling pollutant delivery from agricultural land to streams in the Champlain Basin. *****HIGH PRIORITY*****

Factors to be considered include soils, slope, proximity to stream, riparian zone conditions, weather, intervening land use, and artificial drainage.

Action Item XV.1: Conduct a literature review summarizing research results concerning pathways and routing of pollutants from the EOF/BRZ to stream course.

Action Item XV.2: Conduct a review of watershed-scale physical process models that route flow and pollutants through the flow collector, examining and evaluating model algorithms and input parameters used.

Action Item XV.3: Make recommendations concerning the most important factors controlling pollutant delivery from agricultural land to streams in the Basin.

Action Item XV.4: Test the hypotheses from Action Item XV.3 above with actual measurements at the field scale.

Goal XVI: Quantify the behavior and interactions of the most important factors governing pollutant movement from agricultural land to streams in the Lake Champlain Basin. *****HIGH PRIORITY*****

Action Item XVI.1: Conduct field-scale studies to quantify the behavior and interactions of important factors (identified in Action Item XV.3 above) governing pollutant movement in the flow collector. These studies should be based on an input/output mass-balance approach and must address seasonal and hydrologic variation.

Action Item XVI.2: Formulate recommendations for management practices aimed at optimum pollutant control within the flow collector, based on results of studies of important factors governing pollutant movement from agricultural land to streams.

Note: The four action items under Goal XV and the two action items under Goal XVI develop information necessary to achieve Goal XX on page 35.

2. In-stream Processes

Once a pollutant enters a stream, it is difficult to determine its exact fate, and, thus, its ultimate impact on Lake Champlain. After it leaves the land, a number of processes can act to alter its form and cause it to be retained in the stream system or eventually be delivered to the lake. Although we have little control over these in-stream processes, there is a need to understand how they operate in order to make informed land management decisions for the purposes of water quality improvement.

A number of in-stream processes can act to mediate pollutant transformation and transport in the aquatic environment. These processes can be broadly divided into physical, chemical, and biological categories as shown below.

1. <u>Physical (primarily sediment-related)</u>
   Deposition/resuspension within stream channel
   Deposition/resuspension in floodplain
   Deposition/resuspension behind dams and other obstructions

2. <u>Chemical</u>
   Sorption/desorption by suspended & bed sediment (buffering)
   Reactions with organic matter detritus
   Reactions with humic substances

3. Biological

Uptake/release by plants including algae, macrophytes, wetlands
Uptake/release by microbial populations in suspension and in sediment
Uptake/release by animals including benthic invertebrates and fish.
Seasonal variations in relation to critical growth periods, transport, etc.

The effects these processes have on pollutant transport and transformation depend on which mechanisms are operating in a particular stream reach at a particular time. Pollutants delivered from nonpoint sources during spring storm events may be influenced largely by deposition/resuspension within the stream channel and sorption/desorption by sediment in suspension, whereas point source pollutants delivered under low flow conditions during the summer may be most affected by sorption/desorption interactions with streambed sediments and uptake/release by aquatic plants and animals.

It is important to understand and quantify the effects which in-stream residence and transport processes have on pollutants so that critical contributing areas within the Lake Champlain Basin can be identified and targeted for efficient remedial action. The assumption is often made that a smaller proportion of the pollutant load from upstream sources reaches the Lake than from sources close to the Lake because of the longer time and greater distance over which the various in-stream processes can operate to remove pollutants from the system. If this is true, then it would be more cost-effective to manage sources close to the Lake due to their greater delivery ratio. However, if pollutants from up-stream sources reach the Lake in similar proportions, but perhaps take longer to get there, then management priorities may need to focus more on the magnitude of the source, rather than its distance from the Lake, due to the fact that all or most of the load will be eventually delivered. The question of the form of the pollutant, whether it is particulate, dissolved, or immediately bioavailable, would still have to be addressed in either case.

A rational method based on scientific principles is needed which would allow consistent evaluation of pollutant delivery from nonpoint sources with regard to spatial and temporal variation.

GOAL XVII: Improve understanding of in-stream factors affecting pollutant transport and transformation (Phosphorus transport study being proposed this year should help accomplish Action Items XVII.1 through XVII.4 below). ***HIGH PRIORITY***

Action Item XVII.1: Conduct literature review of research dealing with the effects of in-stream processes on pollutant delivery.

Action Item XVII.2: Conduct review of models/algorithms that describe and account for in-stream residence and transport processes.

Action Item XVII.3: Develop hypotheses, based on the above results, as to what factors are most important in governing in-stream pollutant delivery in the Lake Champlain Basin.

Action Item XVII.4: Test the hypotheses with data from field studies that examine in-stream processes.

GOAL XVIII: Quantify the behavior and interactions of the most important in-stream factors affecting pollutant delivery. ***HIGH PRIORITY***

Action Item XVIII.1: Conduct additional field studies to quantify the individual and combined effects in-stream factors have on pollutant delivery.

Note: The four action items under Goal XVII and the one action item under Goal XVIII develop information necessary to achieve Goal XXI on page 35.

E. Development of Management "Tools"

Agricultural systems are complex. They have all the attributes of natural ecosystems plus the confounding factors of our efforts to manage those systems for our own purposes. These confounding factors include economic, sociological, and political elements.

Typically, a natural resource manager does not have an adequate understanding of business administration and economics, a business manager does not have an adequate understanding of science, particularly ecology, and neither may understand the political realm. Modeling, the development of simplified representations or simulations of more complex systems, offers managers and policy-makers an activity or "tool" which can integrate information from a variety of disciplines and sources in order to make informed and appropriate decisions.

The question of the utility and accuracy of models is often raised. Lack of understanding of the nature and purpose of a model often leads to rejection of the model as a useful tool, or, equally likely, unrealistically high expectations of the performance of a particular model and uncritical acceptance of its results.

Models possess a number of attributes that are disconcerting to the nonmodeler. Because reality must be simplified before analysis of a problem is feasible, the process of determining which variables are relevant to a model is simultaneously an advantage and a disadvantage: the problem is made more understandable while, at the same time, other variables have to be omitted. Thus, a model never captures the full reality of a real system, and, therefore, it can never answer all of the questions which we would like to ask of it. The first consideration for understanding and using models is that they are simplifications of real systems.

Models also cause uneasiness because they are not unique and sometimes unvalidated. There is no single correct way to formulate a model for a particular problem. For any given problem, a number of different models can be constructed, all of which satisfy the requirements of the problem and lead to a relatively straightforward analysis. Thus, as nonunique simplifications of real systems, models are easily tinkered with by others and tend to be short-lived. This combination of short life and vulnerability to change can lead to inadequate testing of a model and give rise to the perception that models are unrealistic and lack foundation on "hard" data.

Acceptance and appropriate use of a model depends not only on understanding its nature, but also on understanding its purpose. Models can be constructed for a wide variety of purposes ranging from providing a simple conceptual explanation of a phenomenon to estimating with acceptable accuracy the actual future values of system variable and the effects on these variables of various events or decisions. In general, increasing the expectations for a particular model also increases the level of knowledge required about the relations and functions of system components and the need for quantitative results.

With these constraints and limitations clearly in mind, validated models can serve as useful tools for the wise management of agriculture to reduce or prevent agricultural NPS pollution by integrating the knowledge obtained from interdisciplinary activities. The development of models (or methods) outlined in this section is envisioned as an on-going process with continuous feedback loops which incorporate useful information into the models from the study of natural processes at the farm/field-scale and watershed-scale, the effects of farm management, and tracking and monitoring of water quality changes.

Goal XIX: Develop a validated model/method to assess EOF/BRZ losses of agricultural NPS pollution under various farm management scenarios. *****HIGH PRIORITY*****

Action Item XIX.1: Conduct a literature review and summarize results of research dealing with losses of agricultural NPS pollution at the EOF/BRZ.

Action Item XIX.2: Conduct a review of model/methods that predict losses of agricultural NPS pollution at the EOF/BRZ. Examine and evaluate model algorithms and input parameters.

Action Item XIX.3: Develop hypotheses concerning the most important factors controlling losses of critical agricultural NPS pollution at the EOF/BRZ.

Action Item XIX.4: Test the hypotheses from Action Item XIX.3 above with data from field studies (which was not used in model development).

Action Item XIX.5: Establish the relationships between the economic, social, political, and environmental system variables for agricultural enterprises in the Basin for various management scenarios and for individual BMPs of interest. This activity needs to be conducted in close cooperation with people who are already developing such models. These models (eg., CROPS, PLANETOR) should be utilized, where appropriate.

Goal XX: Develop a validated model or method allowing quantitative assessment of factors important at a specific site in controlling NPS pollutant movement through the flow collector. *****HIGH PRIORITY*****

Note: Goal XV on page 29 and Goal XVI on page 30 feed into Goal XX.

Action Item XX.1: Develop model or method for site-specific assessment of source-to-stream pollutant transport using readily available input parameters.

Action Item XX.2: Field test and verify the method developed in Action Item XX.1 above.

GOAL XXI: Develop a validated model or method that enables quantitative assessment of factors operating in a stream reach that affect NPS pollution delivery from the point of entry into the stream system to the Lake. *****HIGH PRIORITY*****

Note: Goal XVII and Goal XVIII on page 32 feed into Goal XXI.

Action Item XXI.1: Formulate a model or method that, given the amount and form of pollutants entering the stream system from a particular source, will predict the amount and form delivered to Lake Champlain.

Action Item XXI.2: Field test and verify the model/method developed in Action Item XXI.1.

Goal XXII: Integrate the understanding of critical agricultural NPS pollution generation, delivery, and transport processes (spatial & temporal) into a **validated, quantitative** management model or method (a "unified" model/method) applicable to farm and watershed scale issues and problems. ***HIGH PRIORITY***

Action Item XXII.1: Use actual monitoring data collected from Lake Champlain watersheds (and not used in model development) to conduct a formal verification of selected watershed-level model(s)/method as a means of 1) testing the validity of conclusions derived in Flow Collector and In-stream Transport and Transformation studies and 2) as a way to validate a unified model/method for widespread application in the basin.

a. Suggest appropriate usage and improvements to existing models/methods where needed.

b. Identify needed data layers so that model/method will be capable of linking with GIS.

c. Develop an initial protocol for LCMC-funded research/data collection to ensure it could be used for model verification if appropriate.

d. Model/method should be capable of interfacing with the model from the Diagnostic Feasibility Study.

Action Item XXII.2: Establish a process/mechanism, following the preliminary identification and prioritization of critical areas of agricultural NPS pollution at the watershed and farm levels, to incorporate new information (i.e., better inventories, water quality monitoring data, research results, better watershed models, or implementation results) into the model or method so that it will be possible to revise and fine-tune priorities. This activity should start as soon as possible and be on-going.

F. Implementing Network Elements

One of the most significant and often overlooked guiding precepts of environmental management is "everything is connected to everything else", and this principle is certainly true for the elements of the Network, too. The most significant end product of all of the Network activities may be years down the road; however, it will be the result of the accumulation and interaction of many milestones along the way. This section discusses the nature of the relationships and linkages between Network elements and the "ideal" sequencing of their implementation.

1. Relationships of Major Network Elements

Figure 1 shows the simple relationships of the major elements of the Network. The overall goal of improving farm management/BMPs to reduce or prevent agricultural NPS pollution to Lake Champlain is achieved by the integration of three major areas of activity or investigation. First, knowledge of the variables and relationships of the agricultural system must be improved in order to develop more effective BMPs and farm management systems. Second, an improved system for tracking land use practices/BMPs and monitoring water quality should be established so that relationships between changes in land use and changes in water quality can be developed. Last, the many activities that are required to make progress on the first two major elements need to be closely coordinated by an interdisciplinary team of people with backgrounds appropriate to all aspects of the problem--science, management, agriculture, water quality, economics--to enhance the long-term success of the Network and ensure transfer and acceptance of new technologies and management practices that may emerge (or confirmation of old ones).

Figure 2 presents a "flow-chart" analysis of studies or investigations proposed as part of the Network to improve understanding of the relationships of agricultural system variables.

2. Network Timeline and Priorities

Figure 3 displays a timeline for the 25 goals/activities outlined in this document that comprise the Network. All of the goals are related to one another directly or indirectly to some degree, either parallel in time or in time sequence. Information from some is essential to others before progress can be made. Because of these cross-connections and complexities, it is a very difficult task to say with certainty what the relative, long-term priorities are across all of these twenty-five goals. However, priorities for immediate action are indicated by an asterisk (*).

Concerns surrounding phosphorus and interest in Farm Nutrient Management rank very high, but so do many others including a unified model, preliminary identification and prioritization of critical areas of agricultural NPS pollution, the Ag Partnership, monitoring and tracking implementation efforts, and the flow collector and in-stream unknowns. At the moment, our best hope for improving water quality in Lake Champlain lies in focusing efforts on phosphorus and Farm Nutrient Management; however, in the long-run, our ability to affect positive water quality results will be significantly strengthened by also devoting attention to many of the other Network goals/activities.

Please Note that the order in which the various goals are listed in Figure 3 (from I to XXV) **does not** indicate either a time-sequence or priority ranking.

3. Partnership of Management, Science, and Agriculture

The many interrelated and diverse activities of the Network will require a long-term team effort from many individuals with a wide range of backgrounds and interests. Success will be dependent on close cooperation and communication between the scientists who are performing the needed research and evaluation, the management and planning personnel who are responsible for program implementation, and the farming community which will be asked to adopt the BMPs and other new technologies.

Goal XXIII: Create a partnership of management, science, and agriculture which will maintain communication, cooperation, and coordination for implementation of Network elements and continue a collaborative problem-solving approach to reduce agricultural NPS pollution. ***HIGH PRIORITY***

Action Item XXIII.1: The Commissioners of Vermont's and New York's agricultural and environmental agencies should convene a Lake Champlain Basin Agricultural Advisory Council (AAC) to advise state and federal agencies charged with implementing components of the Network as funding becomes available.

The AAC should be:

a. Composed of current representatives of the SCG plus representatives from Farm organizations, Farmers, and agri-business.

b. Expected to meet quarterly.

Figure 1. Relationships of Major Network Elements

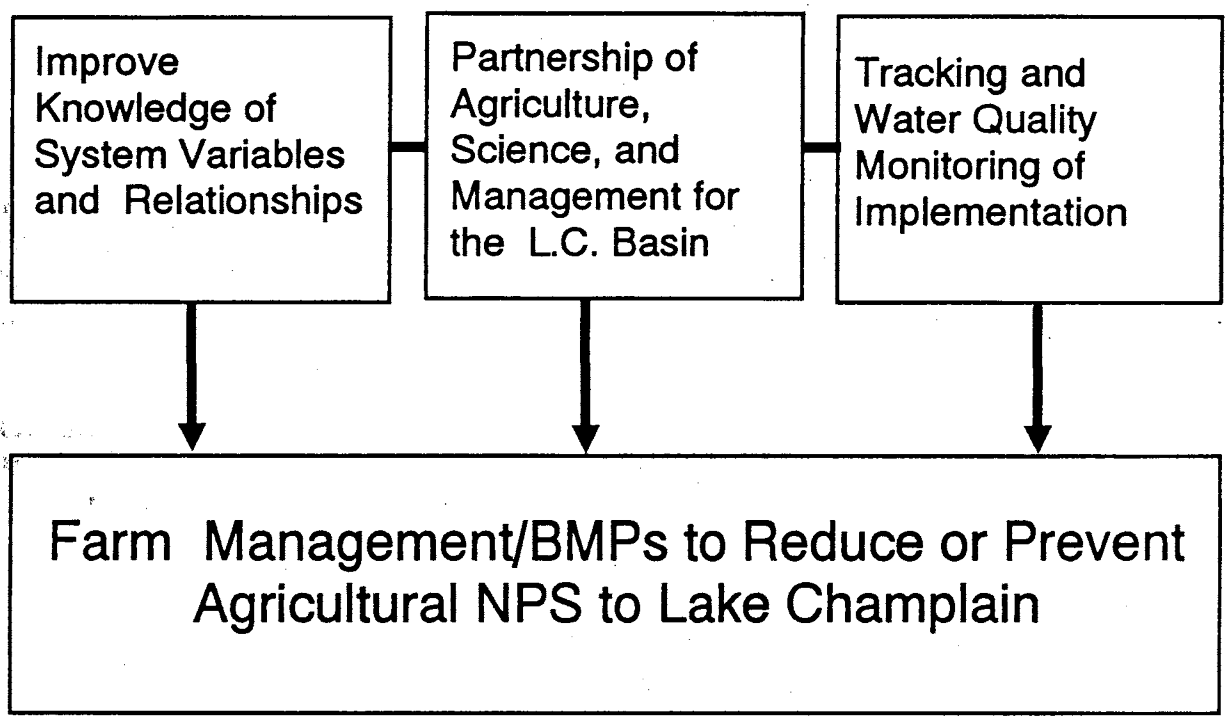


Figure 2. Relationships of Agricultural System Variables

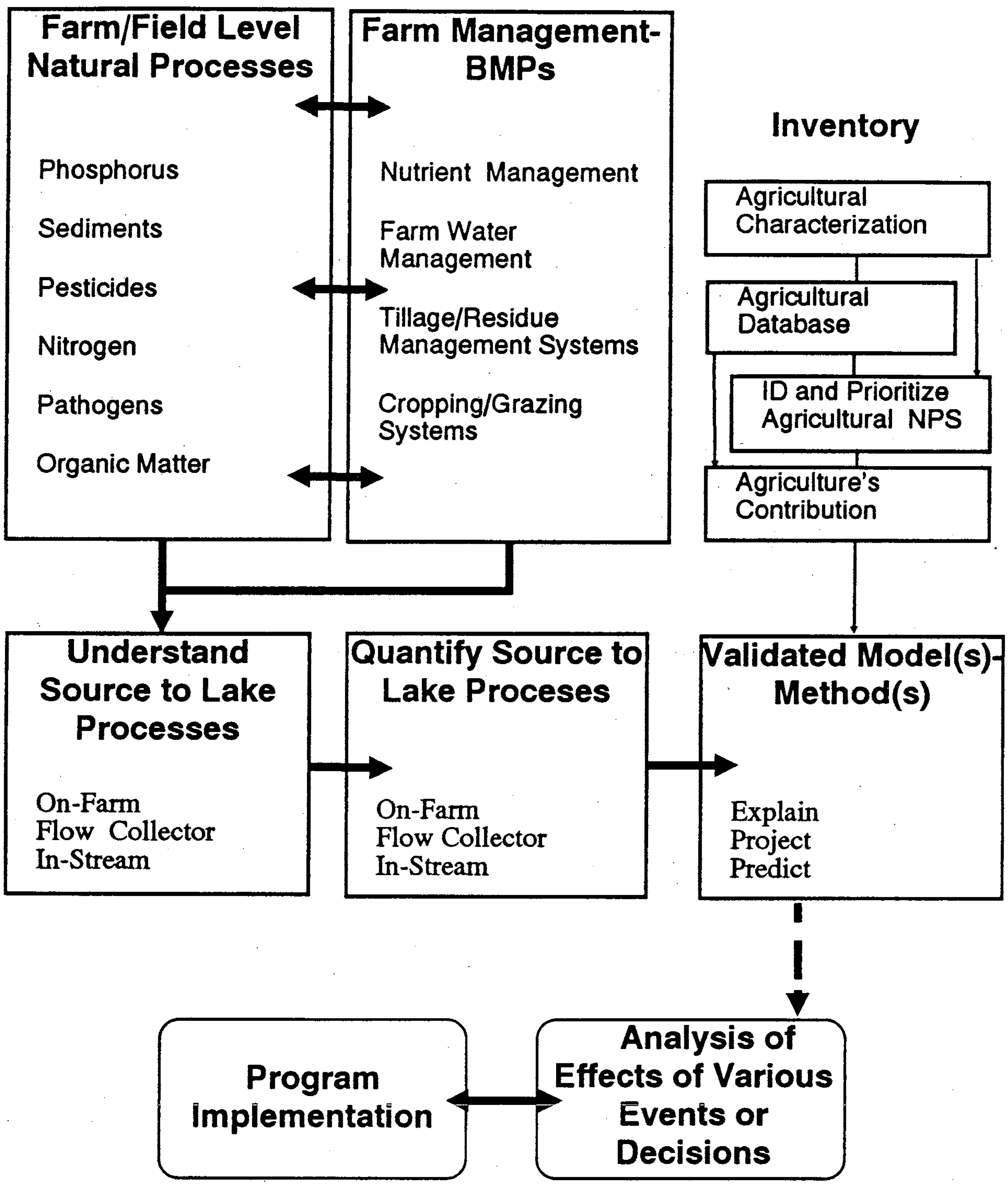
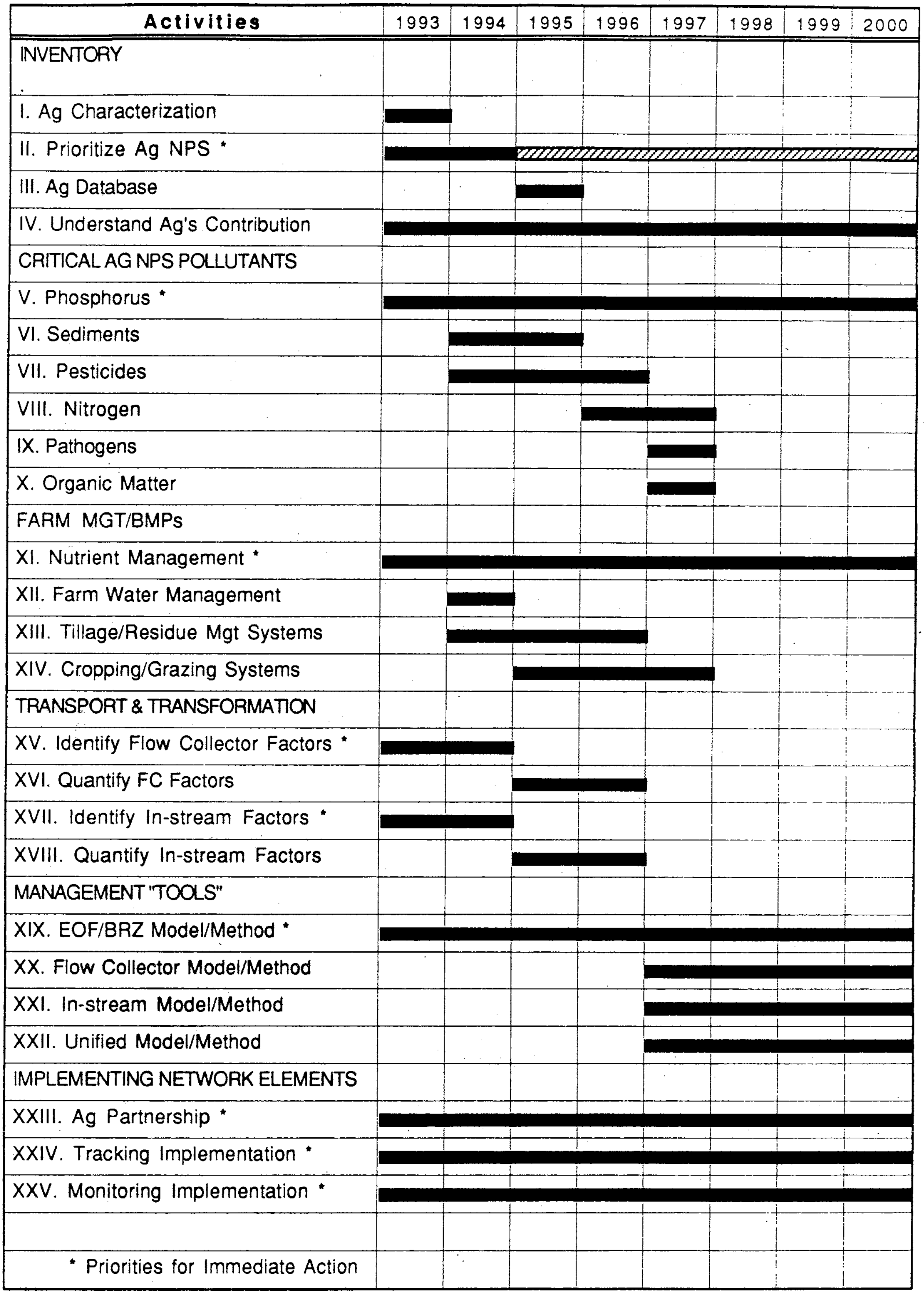


Figure 3. Network Timeline and Priorities



Action Item XXIII.2: Establish a part-time staff position to coordinate and facilitate activities and functions of the AAC with funding for the first two years provided by the LCMC. Estimated Cost: $20,000 per year for 2 years

Action Item XXIII.3: Develop a Memorandum of Understanding among the AAC member organizations which details roles and responsibilities to:

a. Coordinate and evaluate the progress and success of projects at the federal, state, university, and consultant levels which have been funded as a result of Network recommendations.

b. Serve as an advisory group to federal and state agencies for a long-term program for reducing agricultural NPS pollution in the Lake Champlain Basin.

   1. Maintain working relationships
   2. Reduce overlap of programs
   3. Improve effectiveness/efficiency of programs
   4. Maximize pollution reduction/cost ratio
   5. Coordinate NY and VT agricultural NPS pollution programs in the Lake Champlain Basin.

c. Ensure that the science and technologies being developed are adopted by managers and incorporated into management programs.

d. Encourage user group acceptance and implementation by effective flow of data and information.

e. Develop and implement a long-term funding plan for the Network.

Action Item XXIII.4: Conduct a formal annual review of the Network activities with participation from personnel from appropriate regional and national level offices (especially USEPA and SCS) who have the necessary technical knowledge and policy understanding.

4. Tracking Impacts of Implementation Efforts on Water Quality

Evaluating water quality changes due to agricultural implementation efforts is an obvious component of an agricultural monitoring and evaluation network and one that should begin now and continue into the future. The level that this evaluation effort requires will be dependent upon the level of implementation. If targeting and larger-scale implementation is envisioned in the future, then the evaluation effort must be appropriately scaled to ensure that the public and private investment in implementation measures is producing the desired results.

Goal XXIV: Develop and implement a system capable of tracking agricultural implementation efforts so that this information can be used to help establish relationships between changes in water quality (Goal XXV below) and agricultural implementation efforts. *****HIGH PRIORITY*****

Action Item XXIV.1: Develop a system (or modify existing system) to report water quality practices (cost-shared and non-cost-shared) on a hydrologic unit basis (11-digit hydrologic units). This system should 1) be capable of interfacing with the agricultural resource database; 2) bring together all the sources of information on water quality practice implementation (i.e., SCS, ASCS, and 319 programs, etc.); and 3) provide a database for use with the EOF/BRZ model/method described in Goal XIX.

Action Item XXIV.2: Report SCS and SCS water quality practices on a hydrologic unit basis. Include other formal non-USDA implementation programs (e.g., 319 program in VT and NY) and non-cost-shared implementation (e.g. farmer, contractor). This action item is related to XXIV.1 above.

Action Item XXIV.3: Modify the existing ASCS/SCS farm follow-up system to better monitor the maintenance and application of cost-shared practices. For farms with long term contracts with ASCS or SCS, the annual compliance inspection should be increased to include more than one annual farm visit.

Goal XXV: Develop and implement a system capable of detecting changes in water quality resulting from implementation. The system should relate land use changes to changes in water quality and, thus, be useful in determining cause and effect relationships. *****HIGH PRIORITY*****

Action Item XXV.1: Establish site-specific water quality monitoring programs in conjunction with BMPs or groups of BMPs which require monitoring to assess their efficacy to reduce agricultural NPS pollution. Demonstration of these BMPs should be included as an element of this activity.

Action Item XXV.2: Establish a water quality monitoring program (such as a paired watershed design) to assess the relationships between agricultural land treatment and changes in water quality on a watershed scale. A program such as this must be based on and conducted in a watershed where agricultural land treatment or agricultural land use changes are expected to occur on a significant scale and where these treatments will be properly tracked.

Action Item XXV.3: Continue water quality monitoring at the mouth of each river basin tributary to Lake Champlain in order to help assess the long-term effects of agricultural NPS pollution treatment efforts and other NPS pollution treatment efforts in the Basin.

Action Item XXV.4: Use results from monitoring to assess the accuracy of model predictions or estimates at the farm and watershed levels.

5. Modeling as a Unifying Process

Goal XXII outlines the concept of integrating the understanding of critical agricultural NPS pollution generation, delivery, and transport processes into a validated, quantitative management model or method applicable to farm and watershed-scale issues and problems.

This major activity will require the efforts and cooperation of many people from a wide variety of disciplines. Many of the action items outlined in this document will be the building blocks of such a model or method. Model development provides a logical, phased process for collaborative problem-solving that flows from understanding agricultural NPS pollution (and the effects of farm management) to quantification of system variables and relationships to validation of results with actual measurements to meaningful analyses of the problem to building mutually satisfactory solutions.

Information gained from investigations of farm/field natural processes, farm management/BMPs, and source to lake processes is essential raw material for fashioning a meaningful model. The application of the model or method then results in some of the significant outputs or products envisioned as part of the Network such as:

1) Prioritizing watersheds and farms (within high priority watersheds) based on contributions to agricultural NPS loadings to Lake Champlain.

2) Recommending the most effective BMPs for water quality improvement on a Basin-wide scale and within high priority watersheds.

3) Recommending BMPs at the farm level for cost effectiveness and pollution reduction/prevention.

4) With coefficients derived from farm field experiments:

   a. Estimating NPS loadings from unmonitored watersheds.

   b. Contribute to answering the question of what levels of agricultural NPS reduction are achievable.

With these technical outputs established, the model can also be utilized in a broader context to examine the social, economic, and political implications of alternate management decisions and provide a sound basis for acceptance of recommended actions. Model analyses have potential to:

1) Redirect federal, state, and local staffing and resources to increase implementation in the Basin.

2) Expand NPS program funding allocations made by federal agencies for the Basin.

3) Identify the need for new programs or gaps in existing programs and use this information to leverage new sources of funding.

4) Educate landowners concerning the results of implementing BMPs: on-farm costs/benefits and off-site water quality improvements.

6. Cost Estimates for Specific Network Elements

Table 1 below shows cost estimates for specific Network elements. These cost estimates must be considered preliminary and subject to change as individual RFPs are developed.

Table 1. Cost Estimates for Specific Network Elements.

Network Element	Page	Est. Cost	Time Frame	Who
Prioritize Ag NPS Goal II	11	$150,000/yr	FY 1993-94	RFP or Work Plan
Soil-P Concen. vs. Soluble-P Movement Action Item V.B.1	17	$55,000	FY 1994-95	RFP
Soil-P vs. Crop Yield Action Item XI.1	24	$50,000	FY 1993-94	RFP
Farm Input/Output P-Budgets Action Item XI.2	24	$55,000	FY 1993	RFP
Identify Flow Collector Factors Goal XV	29	$75,000	FY 1993	RFP
Quantify Flow Collector Factors Goal XVI	30	$100,000/yr	FY 1994-95	RFP
In-stream P Transport and Transformation Processes Goals XVII+XVIII	32	$95,000/yr	FY 1992-93	RFP
Network Coordination (AAC) Action Item XXIII.2	42	$20,000/yr	FY 93-94-95	Work Plan
Manure Injection Action Item XI.4	24	$67,500/yr	FY 1993	RFP

V. SUMMARY AND CONCLUSIONS

In the Lake Champlain Basin, some of the decrease in water quality has been attributed to nonpoint source pollution from agricultural sources (Lake Champlain "Level B Study"). The amount of this agricultural contribution is thought to vary tremendously between tributaries and among different lake regions. In spite of the work which has already been done on the subject, there is still a lack of scientific information, understanding and agreement regarding agriculture's contribution to the water quality problems of Lake Champlain and its tributaries.

In addition to the unanswered questions outlined above concerning the location, magnitude, and water quality impacts of agricultural NPS pollution, there is also the large question surrounding the effectiveness of farm management and BMPs in reducing or preventing NPS water pollution from agriculture.

Since the 1970s, interested farmers have been actively installing recommended BMPs to reduce or prevent agricultural NPS pollution, and about $12 million dollars in federal cost-sharing assistance and $5 million dollars of farmers' funds have been invested in implementation of BMPs in numerous accelerated water quality projects.

Past monitoring and evaluation studies connected with these implementation programs have shown some edge of field reductions for certain practices and some in-stream reductions for certain pollutants; however, significant reductions in levels of nutrients, especially phosphorus, have not been observed in the Lake. Although the reasons for this lack of response are obscure, it is clear that the technology for reducing or preventing agricultural NPS pollution needs more research and development.

The Network is envisioned as a <u>step</u> toward an eventual comprehensive agricultural nonpoint source <u>program</u> for the Lake Champlain Basin. This Plan for the Network identifies some tools to help answer some of the vexing questions and issues surrounding agricultural NPS pollution. The Network is designed to integrate a set of research, monitoring, and evaluation activities into a managed process to determine, validate, and demonstrate how agricultural activities can be most effectively managed to reduce or prevent agricultural nonpoint source pollution.

The Network calls for four major initiatives:

1) A dynamic process to set Basin-wide priorities at the watershed and farm levels for on-going and future planning and implementation efforts. The process will incorporate current and future information from agricultural resource inventories, water quality monitoring, BMP effectiveness studies, and basic research on the magnitude and behavior of agricultural NPS pollution.

2) Investigations (often requiring an interdisciplinary approach) of agricultural system variables and relationships to improve our understanding of the types, sources, generation, movement, transport, storage, and transformation of agricultural NPS pollutants.

3) Tracking and water quality monitoring of implementation that occurs through existing or new programs to establish cause and effect relationships between changes in land use/farm management and changes in water quality.

4) A partnership of agriculture, science, and management interests to manage the overall process and enhance acceptance of new recommendations and/or technologies.

To advance these four initiatives, the SCG has identified and developed a series of twenty-five goals and sixty-eight proposed, supporting action items (all goals and action items are described in Section IV of this Plan). The twenty-five goals are interconnected scientifically and temporally. Information from some of the goals is needed before progress on later goals can be made.

Because of these interrelationships, only priorities for goals for 1993 and 1994 have been established. Future priorities should be determined and adjusted by an interdisciplinary/interagency advisory group using the cumulative knowledge which results from completed and on-going projects in the Basin and applicable studies from other areas.

Concerns surrounding the behavior of phosphorus and interest in Farm Nutrient Management rank very high, but so do many others including a unified model, preliminary identification and prioritization of critical areas of agricultural NPS pollution, the Agricultural Partnership, monitoring and tracking implementation efforts, and the flow collector and in-stream unknowns. At the moment, our best hope for improving water quality in Lake Champlain lies in focusing efforts on phosphorus and Farm Nutrient Management; however, in the long-run, our ability to affect positive water quality results will be significantly strengthened by also devoting resources to many of the other Network goals/activities.

Finally, this Plan is envisioned as a fluid, dynamic, working document, not a report to end up on the shelf. This is tenth iteration or revision of the Plan since the Strategic Core Group began their discussions in August of 1991, and there are likely to be many more in the future as the Agricultural Advisory Council puts the Plan to work in developing RFPs from its conceptual elements. As elements of the Network are developed, implemented, analyzed, and reported, the shape of the Plan should parallel our progress toward our goals. Answers to the questions we have now may reveal new questions for tomorrow. Along the way, at any one moment in time, however, the Plan should serve as the "blueprint" for guiding our inquiries into the problem before us.

APPENDIX A

NONPOINT SOURCE POLLUTION AND AGRICULTURE

1. State of Our Knowledge

Beginning in the 1970's, coordinated efforts were first initiated to describe the nature, magnitude, and extent of agricultural nonpoint source water pollution in the Lake Champlain Basin. The following reports represent the collective "state of our knowledge" on this subject. In spite of the large amount of information produced by these studies and assessments, much of it is of a qualitative rather than quantitative nature.

a. Basin Level

"Level B Study" (1979)

A report entitled "Shaping the Future of Lake Champlain: The Final Report of the Lake Champlain Basin Study" (May 1979) represents the completion of a two-year effort by the states of New York and Vermont, with assistance from the New England River Basins Commission, and is a comprehensive plan addressing the critical water and related land resource problems facing the Lake and its drainage basin. Eutrophication caused by excessive loading of phosphorus was identified as an issue of special concern.

At the completion of the Level B Study, phosphorus loadings to Lake Champlain from point and nonpoint sources were considered to range from 536,000 to 804,000 kilograms (590.8 to 886.2 tons) per year. On an average basis, the annual phosphorus load to Lake Champlain, the annual phosphorus load to Lake Champlain was considered to be 636,000 kilograms (701 tons).

Close to forty-eight percent of the annual phosphorus load to Lake Champlain was attributed to municipal and industrial point sources. Of this point load, 73 percent was attributed to the Vermont region of the Basin, 25 percent to New York, and 2 percent to Quebec.

The remainder of the annual phosphorus load to the Lake (52 percent) was attributed to nonpoint sources. Of this nonpoint load, 60 percent was attributed to Vermont, 32 percent to New York, and 8 percent to Quebec. Agriculture, particularly runoff associated with animal wastes, was identified as the largest source of nonpoint phosphorus.

Table 2 summarizes by region the relative contributions of the various phosphorus source categories to the total annual phosphorus load to the Lake.

Table 2. Relative contributions of the various phosphorus source categories to the total annual phosphorus load to Lake Champlain.

Region	Source Category	
	Point	Nonpoint
Vermont	35 percent	31 percent
New York	12 percent	17 percent
Quebec	1 percent	4 percent
Totals	48 percent	52 percent

The Level B report identified the need for implementation of "manure management systems" on basin farms especially in priority watersheds (LaPlatte, St. Albans, Winooski River valley, and Great Chazy), the monitoring of selected tributaries for water quality trend assessment (LaPlatte, Winooski, Lamoille, and Saranac), and the initiation of watershed project actions or studies (LaPlatte, St. Albans, Winooski, and Great Chazy). Also recommended for Vermont was "a statewide agricultural runoff study to identify areas with severe runoff problems, recommend BMPs, estimate implementation costs and evaluate the impacts of practices on Vermont agriculture."

The Level B report did not, however, quantify or compare phosphorus loads between the tributaries draining into the Lake, quantify pollutant loadings from nonpoint sources within the basin, or discuss other potentially important agricultural nonpoint source pollutants (such as sediment, nitrogen, pathogens, and pesticides).

b. New York

New York Erosion and Sediment Inventory (1974)

The USDA Soil Conservation Service and the Soil and Water Conservation Districts in New York conducted this inventory to estimate soil erosion and sediment delivery on county and watershed levels. Watershed boundaries coincided with the present 11-digit hydrologic unit area boundaries. Estimates were developed for the major land uses, roadbanks, and streambanks.

The Study revealed that construction sites have the highest erosion rate in tons per acre of any land use. However, in terms of total quantity or erosion, cropland needing treatment accounts for one-third of the state's annual soil loss. Streambank erosion is second to cropland in terms of total; quantity of erosion accounting for 20 percent of annual soil loss. The other agricultural sources considered in the study (i.e., cropland--adequately treated and pasture land) showed low per acre rates, but accounted for approximately 12 percent of the total soils loss per year due to the magnitude of the activity across the state.

A review of the sub-watersheds in the Lake Champlain Basin indicates that these percentages are not representative of the basin. Cropland needing treatment accounted for less than 10 percent of the total erosion in most of the larger sub-watersheds.

Streambank erosion was a more significant factor with rates between 20 and 30 percent in a number of sub-watersheds. There were 3 sub-watersheds in which more than 50 percent of the total annual erosion load was the result of streambank erosion. In many sub-watersheds woodland erosion contributed a very high percentage of the total sediment load. This can be explained by the extent of forested land in these sub-watersheds.

New York Nonpoint Source Assessment Report (1989)

In response to the requirements of Section 319 of the Federal Water Quality Act of 1987, New York completed a Nonpoint Source Assessment Report in February, 1989. The report identifies waterbodies in the state affected by nonpoint source pollution. The surface water information in the report was obtained from the 1988 Priority Water Problem List (PWP) prepared by the Division of Water.

The Assessment Report listed 66 segments in the Lake Champlain Basin with water quality problems. The majority of these segments were smaller ponds and lakes in the higher elevations of the basin that were affected by acid rain. The Assessment only identified one segment in the Basin affect by agriculture. This segment was a 15-mile reach of the Bouquet River where sandy sediments from farms and road sanding caused a severe impairment to fish propagation.

New York Priority Water Problem List (1991)

The Priority Water Problem List (PWP) is the Division of Water's official record of waterbodies with water quality problems in New York State. The most recent update of the PWP was completed in 1991.

The process used for this updating of the PWP incorporated input from county nonpoint source surveys conducted by Soil and Water Conservation Districts. Through this process, new segments with water quality problems were identified and additional information was obtained from some of the existing problem segments. The total number of recorded segments in the Lake Champlain Basin increased from 66 in 1988 to 79 in 1991.

On the 1991 updated list, agriculture is one of the more significant source categories listed for PWP segments within the Lake Champlain Basin. Agriculture is listed as the primary source category on 12 waterbody segments within the Basin. The effects on designated uses of these waterbodies ranged from precluded to stressed. The most significant geographic areas of agricultural impacts appear to occur in northern Clinton County, northern Washington County, and in scattered areas near the Lake Champlain shore between Willsboro and Rouses Point.

New York 305(b) Report (1992)

Section 305(b) of the Water Quality Act of 1987 requires states to biennially report to EPA on the quality of all navigable waters. The report must include analysis of the extent to which waters provide for the protection of fish and allow recreational activities in and on the waters. The Department of Environmental Conservation has the responsibility of producing this report for New York. The 1992 305(b) Report has been completed. The section of the report dealing with the Lake Champlain Basin states that, with some exceptions, water quality is generally good to excellent throughout the Basin. The report states that Lake champlain proper is large and deep and, for the most part, is of excellent water quality. However, some shallow bays are subject to nutrient enrichment which causes eutrophic conditions that are primarily attributable to nonpoint sources, including leaching from on-site disposal systems and contaminated storm runoff.

The only agricultural issue identified for the New York portion of the Basin was that agricultural runoff causes water quality concerns in the Great Chazy and Little Chazy Rivers.

c. Vermont

Agricultural Runoff in Selected Vermont Watersheds (1982)

This study was initiated in 1979 with the expressed support of the Vermont Agency of Environmental Conservation (AEC). The purpose was to provide needed agricultural nonpoint source loading and control information for 15 Lake Champlain watersheds, 2 Lake Memphremagog watersheds, and 2 smaller lake watersheds. The report includes an analysis of soil erosion, agricultural waste, estimated costs for BMP treatment of each watershed, and the economics of representative farm enterprises under various levels of BMP implementation. Vermont AEC incorporated recommended priorities for watershed implementation into their state water quality management plan for agriculture.
For the study watersheds draining into Lake Champlain, the recommended ranking for NPS management efforts is as follows:

1. Lower Lake Champlain
2. Lower Winooski River & Shelburne Pond
3. Malletts Bay & Browns River
4. Dead Creek - Otter Creek
5. Lemon Fair River
6. Rock River & Pike Creek
7. Little Otter Creek
8. Tyler Branch
9. Lewis Creek
10. Black Creek
11. New Haven River
12. Trout River

13. Mid Otter Creek

For the 13 watersheds listed, agriculture is reported as the single largest source of total phosphorus load and dairy farming is identified as the most significant agricultural nonpoint source of nutrient loadings to water courses. Five basic sources of phosphorus loadings on dairy farms are cited: field spread manure, barnyards, manure stacks, milkhouses, and soil erosion.

The report predicted that most agricultural nonpoint source phosphorus could be controlled by concentrating management efforts on dairy farms.

Vermont Nonpoint Source Assessment Report (1988)

The Vermont Nonpoint Source (NPS) Assessment Report was completed by the T Department of Environmental Conservation in August 1988 in response to federal Clean Water Act amendments. The VT NPS Assessment Report received approval by the Environmental Protection Agency in March 1989.

Based on an extensive water quality information gathering process, nonpoint source pollution was identified as the most widespread source of water pollution in Vermont. Agricultural runoff was "the most extensive source of nonpoint pollution having a major impact" throughout the state. NPS pollution from agricultural sources that resulted in designated use impairment was found to occur in each of the seven Vermont river basins draining into Lake Champlain.

Although the Assessment Report was the first statewide and comprehensive documentation of impairments and threats caused by nonpoint source pollution, the Report did not reveal the magnitude or variation in nonpoint pollutant loading from agricultural sources or quantify nonpoint source contributions from any of the river basins draining to the lake. In addition, while the report defined the location and extent of use impairment caused by nonpoint sources, it did not define the portions of agricultural watersheds creating significant pollution problems.

Vermont 305(b) Report

Section 305(b) of the federal Clean Water Act requires each state to submit a biennial report to the US Environmental protection Agency which describes the quality of navigable waters. Beginning in 1988 with the Department's use of a water quality information database (known as the "Waterbody System"), causes and sources of designated use impairment have been inventoried and can be easily characterized.

Table 3 contains information taken from the most recent state biennial assessment report (April 1992) related to identified surface water use impairment caused by agricultural nonpoint sources for Vermont tributaries to Lake Champlain.

Table 3. Basin, Waterbody, and Use Impairment Information for the Seven Vermont River Basins Tributary to Lake Champlain.

Basin	Assessed Rivers & Streams in Basin (miles)	Basin River & Stream Waterbodies (#)	River & Stream Waterbodies in Basin w/ Impairment from Ag NPS (#)[2]	Approx. Extent of Basin Impacted by Ag NPS (miles)[2]
Poultney-Mettowee	180.2	5	4	43.5
Otter	483.0	18	5	80.3
Lower L. Champlain Direct	30.6	4	1	4.0
Upper L. Champlain Direct	137.8	12	5	39.5
Missisquoi	325.9	8	7	43.0
Lamoille	399.6	22	10	134.7
Winooski	576.3	20	6	91.3

2 Column does not include identified threats to use support from agricultural nonpoint sources.

LaPlatte River Watershed Project and St. Albans Bay Rural Clean Water Program - Final Reports (1991)

Between 1979 and 1990 two major watershed studies were carried out within the Vermont portion of the Lake Champlain Basin. The USDA-SCS LaPlatte River Watershed Project was implemented under Public Law 83-566 and the St. Albans Bay Watershed Project was implemented under the Rural Clean Water Program. The goal of both projects was to achieve watershed protection and water quality improvement through land treatment and animal waste Best Management Practices (BMPs).

Streams draining these predominantly agricultural watersheds frequently violated water quality criteria for bacteria. Observed areal nitrogen and phosphorus loading rates in these watersheds were higher than averages cited for agricultural land across the U. S. and in the Great Lakes Basin.

Comprehensive water quality monitoring and evaluation (CM&E) was conducted at both projects to evaluate and document changes in surface water quality resulting from the BMP implementation. Results of these monitoring studies include a database on streamflow, precipitation, and water quality parameters, as well as various data relating to agricultural practices, the spatial and temporal distributions of these practices, and other land uses within the watersheds.

Edge of field studies (such as manure application and milkhouse wastewater treatment) showed a reduction in nutrient and sediment export with BMP implementation. However, studies at a watershed level were unable to explain why a reduction in pollutants at the edge of field (EOF) did not result in a corresponding improvement in stream or lake water quality.

Overall, the monitoring programs show that implementation of agricultural BMPs does have the potential for reducing the amount of agricultural pollution to surface waters. A number of hypotheses were put forward to explain the lack of an observed water quality response to BMP implementation:

1. The timing and/or level of BMPs may have been inadequate to produce detectable changes in water quality over the highly variable natural background water quality levels.

2. Additional or different practices may need to be implemented (such as riparian zone management) and special field nutrient management activities may be needed to minimize overall nutrient application to farm fields.

3. Because of the processes affecting the attenuation, transport, and storage of sediments and nutrients through the flow (stream) corridor, a substantial time lag may exist between BMP implementation and improvements in water quality in streams or the lake.

In addition, it is possible that changes in manure and milkhouse waste practices will only result in a small change in total pollutant loading to streams because a) they represent a small percentage of the total pollutant loading and/or b) the cumulative pollutant loading from surface runoff and subsurface losses over the winter, spring, summer, and fall seasons may not have been significantly different.

2. Studies in Progress

Lake Champlain Diagnostic Feasibility Study (1991-1993)

The Lake Champlain Diagnostic Feasibility Study is a 3-year effort by the Vermont and New York Departments of Environmental Conservation to obtain scientifically sound and up-to-date estimates of phosphorus loading rates to Lake Champlain and to develop a whole-lake water quality model linking the phosphorus loads to eutrophication conditions in individual lake segments.

One of the major technical objectives of the study is to use the phosphorus budget and modeling results to establish a preliminary phosphorus load allocation for the mouth of each tributary. These river mouth allocations will then be sub-allocated among the point and nonpoint sources, one of which is agriculture. Phosphorus control strategies will be developed wherever the need for loading reductions is indicated by the allocation process.

Nonpoint Source Assessment RFP

The Lake Champlain Management Conference has agreed to provide $57,000 in FY 92 funds available for a nonpoint source assessment RFP. The purpose of this one-year project is to provide the information needed to begin to assess the comparative magnitudes of major nonpoint sources of water pollution for the Lake Champlain Basin and its subwatersheds. This project will be conducted as a characterization study to identify what data are available, what interpretations could be made from the data, and what data are necessary for more refined estimations.

In-Stream Phosphorus Transport, Attenuation, and Transformation Study (Contract to be awarded by LCMC)

The purpose of this project is to provide sufficient scientific information for the development of policy tools to enable informed decisions as to the importance of distance from the lake, and other factors, in determining which sources of phosphorus should be targeted for treatment efforts.

Specific project objectives are:

1. Improved understanding of the processes governing in-stream transport, transformation, cycling, storage, an release of phosphorus. It is intended that the proposal should address the relative importance of adsorption and desorption; chemical transformation; conversion from organic to mineral phosphorus; sediment dynamics; and the physical and chemical conditions and limits under which these processes occur.

2. To understand the transportation processes and transformations between total and bio-available fractions of phosphorus.

3. To develop the conceptual framework for a science-based tool for estimating the attenuation rate to Lake Champlain of phosphorus released to surface water at any given location in the lake basin as well as estimating how long it will take before reductions in nutrient inputs to a river at a given location in the watershed will result in reduced mass loadings of phosphorus to the lake at the river's mouth.

Lake Champlain River Basin Study

The Soil Conservation Service is conducting this agricultural resource inventory which is designed to support existing conservation programs by estimating the extent and location of agricultural nonpoint source pollution on the New York side of the Basin. General farm data and data for prioritizing watersheds within the Basin will be collected by SCS field personnel during 1992 and 1993. Data will be averaged and grouped for input into standard sediment and nutrient estimation models such as Erosion-Productivity Impact Calculator--Water Quality Version (EPICWQ) and Barnyard Runoff Nutrient Yield (BARNY).

Vermont Sensitive Area Study

Initiated in FY 1991 by the Vermont Soil Conservation Service, this study will evaluate the existing hydrologic and stream morphology condition of the Ball Mountain Brook and tributaries in the Town of Stratton. This will become the basis for a pilot project to provide modeled hydrologic and stream data. The State of Vermont and towns can then use this information to consider options for managing development in the higher elevations of the Green Mountains. The Sensitive Area Study will also evaluate individual farm nonpoint source pollutant loadings in the Lake Champlain Basin. It will estimate phosphorus loading rates by farm, based on existing management practices. These results will become important to managers; enabling them to prioritize nonpoint source projects in the Basin.

3. Implementation Programs and Projects

To date, a large amount of effort and money has been expended in the Lake Champlain Basin to reduce or prevent agricultural nonpoint source pollution at the farm level. Most of this work has been accomplished through the implementation of federally funded land treatment programs made available to farmers on a voluntary basis. Some farmers have also installed much needed conservation practices on their own without federal assistance. This section contains summaries of the major work accomplished so far in the Basin.

Public Law 83-566

Public law 83-566 (PL 83-566) authorizes the United States Department of Agriculture to plan an conduct project activities for flood prevention, water quality improvement, and soil resource protection. Based on the watershed priorities established in the Agricultural Runoff in Selected Vermont Watersheds study, the USDA-Soil Conservation Service has been working with local sponsors to implement agricultural water quality improvement projects in watersheds under 250,000 acres in size.

Under PL 83-566 water quality and water resource problems are identified, plans are formulated, money is appropriated, and treatment solutions are implemented. The completed and operational PL 83-566 water quality protection projects listed below address the problems of agricultural nonpoint source runoff, cropland erosion, lack of animal waste management, turbidity and excessive sedimentation of tributary streams, and accelerated eutrophication in Lake Champlain:

LaPlatte River Watershed (1979-1990)
Lower Otter and Dead Creek Watershed (1981-1992)
Black River Watershed (1982-[on-going])
Lemon Fair River Watershed (1985-[on-going])
Lower Winooski River Watershed (1985-[on-going])
Barton and Clyde Rivers Watershed (1987-[on-going])

To reduce or prevent nonpoint source pollution, farmers in these watersheds have voluntarily installed a variety of Best Management Practices including: Waste Management Systems (e.g., Waste Storage Facilities, Waste Utilization, Barnyard Runoff Management, Milkhouse Waste Management Systems); Conservation Cropping Systems (e.g., Stripcropping, Contour Farming, Diversions, Waterways); Critical Area Planting; Pasture and Hayland Management; Permanent Conversion to Hayland: Wildlife Upland Habitat Management; Streambank Protection; and Logging Road Erosion Control.

Water Quality Special Projects

The USDA-Agricultural Stabilization and Conservation Service (ASCS) has been in the cost-sharing business with farmers since 1936. The ASCS Agriculture Conservation Program (ACP), through its funds, help landowners to install conservation practices that combat soil erosion and improve water quality. A yearly allocation of funds is distributed to all counties within the Basin. Technical assistance for ACP is provided by USDA-Soil Conservation Service and New York and Vermont State Forest Services.

The goal of a Water Quality Special Project (WQSP) is to accelerate cost sharing for ACP implementation within a hydrologic unit or aquifer recharge area to address an agricultural nonpoint source pollution problem that adversely affects surface or ground water, as identified by local or state agencies. Conservation practices installed are similar to those under the PL 83-566 project mentioned above.

Ongoing WQSP's in the Basin include the Lower Lake Champlain, the Grand Isle, and the Lower Missisquoi River. The Lower Lamoille River and the Lake Champlain Basin were approved as WQSP's in 1992. ASCS authorized $400,000 for the Lower Lamoille WQSP. Currently, no funds have been authorized for the Lake Champlain Basin WQSP.

Hydrologic Unit Areas

The Goal of the Hydrologic Unit Area is to provide technical, financial, and educational assistance to implement a program within a hydrologic unit or aquifer recharge area to solve an agricultural nonpoint source water quality problem identified in a state's Water Quality Assessment Report or Management Plan approved under Section 319 of the Water Quality Act or in the state's ground water strategies.

Technical assistance is provided by the SCS and the Cooperative Extension Service. Financial assistance, if available, is provided by ASCS.

The Lower Missisquoi is the only active Hydrologic Unit in the Lake Champlain Basin and occupies the same watershed area as the Lower Missisquoi WQSP. To improve the quality of the Lower Missisquoi River watershed's surface and groundwaters, the following five-year objectives have been identified:

> Minimize impacts of agriculture on surface and groundwater quality by improving management of crops, soils, nutrients, pesticides, and agricultural wastes.
>
> Evaluate selected nutrient and pest best management practices (BMP's) in terms of agronomic effectiveness, farmer acceptance, economic return, and water quality impacts.

Develop a public information and education program to maintain public awareness and educate them on ways they can contribute to water quality improvement.

Survey groundwater and surface water quality within the project area.

Rural Clean Water Program

From 1980 to 1990 a Rural Clean Water Project (RCWP) was underway around the St. Albans Bay. ASCS cost-shared with farmers to install Animal Waste Management Systems and Sediment Retention Structures in this predominantly dairy-oriented agricultural watershed. SCS provided technical services, Extension conducted informational and educational activities, the Economic Research Service analyzed economic impacts of practices, and the University of Vermont carried out monitoring and evaluation (see under "State of Our Knowledge", page 11).

Resource Conservation and Development Areas

Resource Conservation and Development (RC&D) areas are multi-county areas organized by local leaders and supported by SCS to promote community growth through the conservation and wise use of natural resources. Water quality activities are of high priority and include projects such as animal waste management, tours and demonstrations, and stream corridor management. The RC&D areas on the New York side of the Lake Champlain Basin are the Greater Adirondack RC&D area and the Black River/St. Lawrence RC&D area. On the Vermont side of the Basin, the areas are the North Vermont RC&D area and the George D. Aiken RC&D area (covering the southern half of Vermont).

Agricultural Conservation Program

The purpose of ASCS's Agricultural Conservation Program (ACP)is to assist farmers and landowners with the installation of conservation practices to benefit water quality, soil conservation, forestry, and wildlife. Cost sharing funds are provided on a wide variety of conservation practices. Farmers, in particular, have benefited from ACP assistance to install practices such as manure storages, barnyard runoff control, diversions, stripcropping, and streambank protection for soil erosion and runoff control and improve water quality.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is an ASCS program created by the Food Security Act of 1985 (and amended by the Food, Agriculture, and Trade Act of 1990) that will allow farmers who are cropping highly erodible land to "set it aside" (i.e., establish a soil-conserving crop on it) for a period of ten years and, in return, receive about 50 dollars per acre per year for not cropping this land. Program funds are expected to be available in fiscal year 1993. Over 35 million acres nationwide have already been entered into the program. As part of a specially designated CRP area in Clinton County, New York, ASCS allows farmers to set aside non-highly erodible land if it will benefit water quality.

Section 319

Section 319 of the federal Clean Water Act was created in 1987 for the purpose of reducing pollution from nonpoint sources (NPS). Use of Section 319 funds by the states can only be applied for implementation of NPS controls <u>after</u> EPA approved each state's Nonpoint Source Assessment Report and NPS Management Program. Section 319 implementation funds have only been available for three years.

New York

As part of the January 1990 Nonpoint Source Management Program, the New York Department of Environmental Conservation and the New York State Soil and Water Conservation Committee have encouraged all counties in New York to develop County Water Quality Strategies. These locally-developed action plans will provide a coordinated approach to water quality implementation at the grassroots level. Starting in 1992, the Strategies have also begun to provide a basis for funding specific water quality implementation projects. State-wide, approximately $300,000 will be distributed to match locally-supported efforts identified in the Strategies.

Vermont

Recent Section 319 projects in Vermont include installing and evaluating the water quality effectiveness of two milkhouse waste water treatment systems using an organic matter filter bed and support for review and evaluation of the fifteen Best Management Practices utilized in the St. Albans Bay RCWP.

Additional projects now getting under way involve 1) supporting a crop management service for farmers in Chittenden and Washington Counties (ie., the Winooski River basin); 2) a streambank stabilization project with a local group in an agricultural environment; 3) an Agricultural Watersheds BMP implementation and effectiveness monitoring project focusing on livestock exclusion and intensive rotational grazing; 4) planning for a shoreland management conference (1993); and 5) support for GIS activities involving the Vermont Departments of Agriculture and Environmental Conservation.

Information and Education Programs

The Cooperative Extension Service provides information and education on many aspects of agricultural nonpoint source pollution in critical targeted areas and throughout the rest of the Basin. Activities include conducting tours of manure storages, manure spreader calibration demonstrations, monthly newsletter articles on relevant topics, radio tapes, and workshops on various aspects of farm management which impact water quality. Emphasis is placed on helping farmers develop nutrient management plans for manure and fertilizer.

For the Lower Missisquoi River Hydrologic Unit, Extension developed a computerized manure management worksheet and crop nutrient budget kits, established the Lower Missisquoi Crop Management Services, surveyed present farming practices and attitudes on water quality, and set up five field trials for the Pre-sidedress Nitrogen Soil Test (PSNT), a manure management trial for fall versus spring manure application, and a cover crop study on nitrate leaching potential. Extension has also provided public information and education on agricultural nonpoint source pollution through fact sheets, meetings, newspaper articles, radio talk shows, and an agricultural best management practice curriculum for local vo-ag high school students.

From 1986 to 1990, Extension conducted the Field Nutrient Management Project on eleven farms as part of the St. Albans Bay Rural Clean Water Program to promote and assist in the implementation of best management practices for fertilizer and manure. The objective was to reduce phosphorus loading while, at the same time, maintain or increase economic returns to the participating farmers. Whole farm nutrient management plans were developed for each farm.

Nitrogen Soil Testing: a Tool for Improving Water Quality Through Reduced Nitrogen Loading is a pilot project currently being conducted by Extension to design, test, and use a model of the Pre-sidedress Nitrate Soil Test (PSNT) can be implemented in Vermont and other states in the Northeast.

Extension has provided resource and program support for various integrated crop management programs (ICM) including ASCS Special Practice-53, a program to reduce pollution of water through reduced use of pesticides and nutrients; the Winooski Conservation Crop Management Service, and the farmer-owned and operated Champlain Valley Crop Management Association.

Pesticide Applicator Training is an on-going program to update farmers and commercial applicators on pest management and proper pesticide use, specifically targeted pesticides and water quality.

APPENDIX B

Preliminary Listing of Management Practices for Agriculture

The following is a preliminary list of management practices that will reduce pollution to Lake Champlain. Brief descriptions of some management practices are given. This list is considered "preliminary" because the on-going process of evaluating the effectiveness of management practices will yield new information requiring the periodic updating of the list. "Best Management Practices" are the most effective, practical management practices which have been selected to protect or improve water quality in a specific problem setting.

I. Integrated Crop Management

A. Nutrient Management

1. Fertilizer Management
   a. Apply nutrients as need indicated by soil tests.
   b. Band apply all Phosphorus fertilizer unless the soil is very deficient.
   c. For corn, apply some Nitrogen fertilizer in band at planting and then sidedress more if soil test indicates need.

2. Manure Management
   a. Storage/treatment system (liquid, semi-solid stack, compost windrow) designed to eliminate runoff or contain it within a field.
   b. Use manure nutrient analysis, together with soil tests, to select manure application rates.
   c. Methods - Inject or incorporate manure as soon as possible - Top-dress sod crops when runoff chances are minimal (immediately after first and second cut).
   d. Avoid spreading on snow or frozen ground.

B. Integrated Pest Management

1. Biological Controls

2. Cultural Practices

3. Resistant Crop Varieties

4. Scouting

5. Trap Crops

6. Pesticide Management
   a. Computerized application.
   b. Evaluation of Site-Specific leaching and Surface Loss Potential.
   c. Pesticide Storage and Handling Facility
   d. Proper Equipment Calibration
   e. Proper Timing of Pesticide Application
   f. Read and Follow the Label Directions

C. Runoff and Erosion Control for Sensitive Sites

1. Residue and Soil Surface Management
   a. Use conservation tillage (chisel, no-till, ridge-till) **together with:**
   b. High residue or surface cover cropping [cover crops (interseeded in row crops if possible) and rotations with sod crops or crops leaving high quantities or residues following harvest].

2. Contour Cropping

3. Stripcropping

4. Grassed Waterways, Diversions, Terraces

5. Hayland Management

6. Planned Grazing Systems

7. Subsurface Drainage

8. Water and Sediment Control Basin

D. Record Keeping

II. <u>Riparian Zone and Stream Management</u>

A. Forest Buffer

B. Restoration

III. <u>Clean Water Management</u>

A. Diversions, Grassed Waterways, and Terraces

B. Eavestroughs

C. Piping

D. Storage/Slow Release

E. Surface and Subsurface Drainage

IV. <u>Runoff and Animal Waste Treatment</u>

A. Milkhouse Waste Management

1. Filter Strips
2. Organic Matter Filter Beds
3. Liquid Manure Pit

B. Barnyard Runoff Management

1. Filter Strips
2. Clean Water Management
3. Water and Sediment Control Basin
4. Barnyard Paving and Regular Clean-up

C. Constructed Wetlands

D. Aerobic Lagoons

APPENDIX C

BMP Demonstration and Evaluation Projects (FY 91)

PHOSPHORUS MANAGEMENT USING DAIRY MANURE AND PERENNIAL FORAGE GRASSES

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Overview of Project

Eutrophication of surface water often is blamed on soluble phosphorus or phosphorus bound to sediment eroding from agricultural land. Proper commercial fertilizer and dairy manure management are necessary to minimize the potential for phosphorus eutrophication of Lake Champlain by dairy farms.

Dairy farmers in the Northeastern U.S. are faced with finding a method of disposing of excess nutrients in manure. Many farmers make daily applications of manure on fields close to the barn, and also apply manure to alfalfa fields during the last several years of the stand. Recently, farmers have been applying light applications of manure to new and young seedings of alfalfa. This practice can result in severe weed infestations and reduce the life of the alfalfa stand. Much of the soil resource in the Lake Champlain basin is not suited for alfalfa production. Many dairy farmers persist in attempting alfalfa seedings on marginal land because of their need for a high quality dairy feed.

Perennial grasses grown on soils not suited for alfalfa have a number of advantages over alfalfa. They are better suited for erosion control, usually are more persistent, and are able to utilize large amounts of phosphorus and nitrogen. Unfortunately, grasses are seen as inferior quality forage for lactating dairy cows. It is possible to produce high quality forage from grasses and at the same time safely dispose of dairy manure, and the key is proper management of the grass species.

Project objectives are to 1) quantify the potential of perennial forage grasses to utilize phosphorus, and 2) demonstrate the economic benefits of grass for nutrient management and for high quality forage production on dairy farms.

Summary of Work (through December 31, 1992)

Two farms were selected, based on appropriate forage stands and soil phosphorus level (obtained through soil analysis). The Ted Marsh farm in Westport, NY, and the Jim Hockney farm in Morrisonville, NY both have fields with soil phosphorus levels at less than 1 ppm.

Spring growth of grass was harvested from all treatment areas on June 15 and 16, 1992. Sites were staked out and manure spreaders were calibrated. Dairy manure was applied in three strips (replicates), with three adjacent no-manure strips. Rate of application was monitored before and after entering each strip. Approximately 20 tons of manure was applied per acre. Analysis of the manure is reported in Table 4. The entire test area was fertilized with 150 lbs K_2O per acre and 75 lbs N per acre. Within each of these six trips, a series of smaller areas was set up and 0, 10, 20, 40, 80, and 120 lbs per acre of phosphate (P_20_5) was applied. Statistically, this is a randomized complete block design with a split-plot feature.

Conditions during the summer were good for grass growth, and a harvest was taken on July 30, 1992, from both sites. The Essex County site yielded an average of 1.6 tons per acre (12% moisture) compared to 1.3 for Clinton County. This compares to yields on untreated areas that averaged 0.49 tons per acre in Essex Co. and 0.41 tons per acre in Clinton Co. Manure resulted in significantly higher yields in Essex Co., but not in Clinton Co. A yield response was found to phosphorus in Clinton Co., but not in Essex Co., indicating that the Clinton Co. site has less available phosphorus compared to the Essex Co. site. Preliminary forage quality results show an increase in crude protein content of forage due to manure at both sites and a considerable increase in forage quality (fiber and digestibility analyses) in treatment areas, compared to samples taken from untreated areas.

Economic analysis is underway to compare the return per acre for the following options: 1) all grass, 2) all grass with manure applied, 3) alfalfa-grass mixture, and 4) pure alfalfa. All four options will include budgets for both a high level of management and an average level of management on a moderately productive soil type.

Elemental analysis of forage samples showed that concentration of phosphorus in farmers' samples was very low, particularly in Clinton county, indicating a very low level of available P in the soil. Although 1 lb P per acre is the lowest possible reading for a soil test (both sites), it is clear that soil conditions in Clinton county result in a much lower level of available P, compared to Essex county. The farmer's untreated field in Essex county had almost double the P concentration in the forage at the time of the July harvest, compared to Clinton county. More than twice as much P was removed per acre in Essex county compared to Clinton county.

The very low availability of P in Clinton county resulted in a significant response to P fertilizer at the July harvest. The response continued up to 120 lbs P_2O_5 per acre, with more than a 7 fold increase in the amount of P removed by the hay crop, compared to the farmer's field. Even with a 1 lb P per acre soil test in Essex county, the soil could provide enough P to meet plant needs. The Clinton county yield response up to 120 lb P_2O_5 per acre does not mean that much P would be recommended for maximum growth. It does indicate that most of the P applied was fixed by the P-deficient soil and was not readily available for plant growth.

Results indicate that the P soil test is not particularly sensitive at low levels of available soil P. Available soil P was considerably different at the two sites, one soil requiring P for high yields while the other soil required no P for high yields.

Table 4. Manure Analysis (pounds per ton)

	Clinton County	Essex County
Total Nitrogen	10	11
Ammonia Nitrogen	4	4
Organic Nitrogen	6	7
Phosphate (P_2O_5)	4	4
Postash (K_2O)	7	10
Percent total solids	10.7	16.6

Table 5. Digestibility (IVDMD), Neutral Detergent Fiber (NDF), and Crude Protein (CP) in samples taken July 30, 1992

	Clinton County		Essex County	
	Manure	No Manure	Manure	No Manure
IVDMD (% DM)	68.4	64.1	69.0	66.5
NDF (%DM)	57.7	59.3	59.3	60.3
CP (%DM)	21.4	17.3	17.0	14.4
Farmers' Untreated Samples				
IVDMD (%DM)	55.6		68.3	
NDF (%DM)	64.1		54.7	
CP (%DM)	12.9		13.8	

IVDMD and CP differences between manure and no manure within a site are significant at P = 0.05 for Clinton Co. and P = 0.10 for Essex Co.

TOPDRESSED MANURE FOR ESTABLISHED ALFALFA

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Background

For many years farmers have been told that the best place for dairy manure is on fields which will be planted to corn, or on established grass meadows. Alfalfa was considered a poor choice for manure because as a legume it produces its own nitrogen. However, in spite of increased used of manure storages many farmers find it necessary to find a place to spread manure during the growing season. Since it is impossible to spread manure over corn which is 8-9 feet tall in August, farmers are increasingly looking at established alfalfa fields as a potential site for dairy manure. Previous studies have established that alfalfa makes good use of the phosphorus and potassium in manure, but the nitrogen in the manure does not contribute to yield increases. What, then, happens to manure N? Does it leach into groundwater and become a pollutant? Does soil compaction by the manure spreader significantly affect alfalfa yields?

Methodology

A 15-acre alfalfa field at Miner Institute will be used for the study. It is drained by a series of underground tiles, each with its own outlet. Dairy manure will be spread by a Badger manure spreader. There will be two rates of manure: 15 and 30 tons/acre, plus an unmanured control area. Leachate from treated and untreated areas will be collected and analyzed. Alfalfa tissue analyses also will be done on manured and unmanured plots. Manure spreader wheeltracks will be marked following manure application, and alfalfa yields will be calculated from both wheeltrack and "uncompacted" areas.

Deliverables

1) Evaluation of the effects on water quality of two rates of topdressed cow manure. Are nitrate-N concentrations in the leachate of manured areas over the EPA maximum of 10 ppm?

2) Evaluation of alfalfa tissue analyses for two rates of cow manure and an untreated control.

3) Evaluation of the effects of manure spreader wheel traffic on alfalfa yield.

4) The results will be publicized through farmer meetings and the Miner Institute Farm Report, a monthly newsletter mailed to about 900 farmers and agribusiness representatives.

Progress Report - 1 April to 30 June, 1992

The first set of tile water collections was made on April 20 and submitted to the University of Vermont Agricultural Testing Laboratory for nitrogen analysis. This was to provide baseline levels and to confirm that there were no substantial differences between tile lines. There were not, and nitrate nitrogen levels were all below the EPA maximum of 10 ppm.

The plot area was established on June 15-17, and manure applications were made on June 18. Wheel tacks were staked out in each treatment. A sample of the manure was submitted to the University of Vermont Agricultural Testing Laboratory on June 18th. Applications rates were 3000 to 6000 gallons per acre.

Accurate weather records are being maintained. It should be noted that precipitation has been well below normal since the beginning of May, and no leachate has been collected since April 20.

Progress Report - 1 July to 30 September, 1992

Following the topdressing of dairy manure on June 18, the alfalfa was allowed to regrow until second harvest on July 20. The harvest interval between first and second cutting was 40 days, which is normal and recommended for this area. Plots which had been established following first harvest were harvested on July 20, five replications per treatment. The samples were weighed, dried, and submitted to NYDHIC for nutrient analysis.

The resulting data will be analyzed for the final report. However, a review of the data reveals no consistent differences in nutrient content between manured and unmanured plots. The alfalfa in the 6000 gallons per acre treatment was of higher quality than the control, but the potassium concentrations was higher in the control. There were very few differences in nutrient content between the 3000 gallon per acre treatment and the control.

Alfalfa yield was 7% greater in the 3000 gallon treatment and 44% higher in the 6000 gallon treatment compared to the controls. This data will be analyzed for statistical significance for the final report. Yields were considerably lower in the wheeltracks of both treatments.

We have been unable to collect any water samples because the tile drains have not run since the manure was applied. This is in spite of several significant rainfall events including 1.17" of precipitation over a three-day period on July 4-6, 1.06" on August 1, and 1.70" on August 4-5. Total precipitation for July through September was 90% of normal. The fact that the tiles did not flow during a relatively normal summer is encouraging because it indicates that the nutrients applied via manure remain in the root zone and are therefore available for plant uptake for a considerable time. Crop removal by second and third harvest alfalfa considerably exceeded the nutrients applied by topdressed dairy manure for nitrogen at both rates. Potassium removal considerably exceeded manure input for the 3000 gallon rate, and slightly for the 6000 gallon rate. Phosphorus removal slightly exceeded input for the 3000 gallon rate, but inputs exceeded crop removal for the 6000 gallon rate. This will be discussed more thoroughly in the final report. Future tasks include data analysis and collection of tile drain water for nitrogen and phosphorus analysis.

Progress Report - 1 October to 31 December 1992

Much of the activity during the third quarter of this demonstration project was involved in monitoring tile water flow, collecting water samples from the tiles, analysis of the samples, and interpretation of the data. Because so much time had passed with no tile flow, when on November 3 we finally had tile flow from three of the four tiles involved in the demonstration, we sampled them. There was no flow from the 3000 gallon treatments area, but we were able to collect from both treated and control tiles in the 6000 gallon treatment area. On November 24, following considerable rainfall, we were finally able to collect samples from the 3000 gallon treatment area, but the outlet in the 3000 gallon treatment area (the control outlet) was submerged so we were only able to collect from two outlets. On December 1, the water level had receded enough that we were able to make collections from both tiles in the 6000 gallon treatment area. Finally, on December 8, all systems were go, and we made collections from all four outlets.

It should be noted that the need to take samples from the two treatment areas on separate dates is not a problem from a data analysis standpoint, because from the start we stated that because the 3000 and 6000 gallon treatment areas were of necessity (because of the tile system layout in the field) several hundred feet apart, we would treat the areas as separate demonstration areas and not make direct comparisons between them. We can say, for instance, that while the 3000 gallon treatment level resulted in "x" amount of nitrate and the 6000 gallon level resulted in "y" amount of nitrate, we can't make statistical comparisons, i.e., "6000 gallons of manure results in significantly higher nitrate levels than 3000 gallons."

Because we now have pretreatment nitrate levels for all four outlets, and two and three posttreatment levels for the 3000 and 6000 gallon treatments, respectively, we will not wait until spring to collect any more samples, but will prepare the final report during the final quarter of this project (prior to 3/31/93). The soil in the field is frozen and there is little likelihood of any tile flow between now and the end of March. The final report will include discussion of yield, forage quality, and both nitrate-N and phosphate-P contents of tile effluent.

APPENDIX D

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APPENDIX E

Explanation of CAMEN Terms and Acronyms

Best Management Practices (BMPs):

BMPs are the most effective, practical management practices which have been selected to protect or improve water quality in a specific problem setting.

Comprehensive Agricultural and Monitoring and Evaluation Network (CAMEN):

A framework of proposed research, monitoring, and evaluation activities for the Lake Champlain Basin to determine, validate, and demonstrate how agricultural activities at the basin, watershed, and field levels can be most effectively managed to reduce or prevent agricultural nonpoint source water pollution.

Edge of Field (EOF)/ Bottom of Root Zone (BRZ):

Edge of field is that point where surface water runoff leaves a management unit such as a cropland field, a livestock concentration area, a subdivision tract, etc. Bottom of root zone is that depth in the soil profile of the management unit area below which the indigenous plant root system will not appreciably remove nutrients and other potential pollutants. These two terms are used in combination to identify the functional limit of on-farm, field-scale management practices. This boundary is also the beginning of the Flow Collector.

Flow Collector:

This is the intervening flow path (region) between EOF/BRZ and the stream. There are principally two avenues for pollutant movement: overland flow (diffuse or sheet flow) through various conditions of land use, site physiology, etc., and subsurface paths through various soil, rock, and manmade (subsurface drains) media with reentry into the surface water at the stream.

Nonpoint Source (NPS):

Any source of water pollution that does not originate from a "point" or pipe.

Strategic Core Group (SCG):

The New York/Vermont committee responsible for the design and initial implementation of the Comprehensive Agricultural Monitoring and Evaluation Network (CAMEN) for the Lake Champlain Basin.

RFP: Request for Proposal.

Stream:

Can be loosely defined as being as small as a road ditch, an agricultural surface ditch, or other water conveyance or as large as a river or the lake shoreline itself which would normally receive surface runoff from a flow collector. Man-made structures located within the boundaries of a field, such as grassed waterways or diversion ditches, are not normally considered streams.

Watershed:

As used in this document, a watershed can be loosely defined as an area of land typically, but not exclusively, drained by a perennial stream which discharges enough water to be of interest to persons concerned with measuring changes in water quality that may result over time from changes in management practices. It is large enough to exhibit heterogeneity or variability with respect to slope, soils, and land use (something generally larger than an agricultural "field").