The Rt. Hon. Joe Clark, P.C., M.P.
Secretary of State for External Affairs

Canada

Le très hon. Joe Clark, C.P., député
Secrétaire d'État aux Affaires extérieures

OTTAWA, Ontario
K1A 0G2
April 21, 1987

Dear Mr. Bissonnette:

Pursuant to paragraph 4(b) of the Phosphorus Load Reduction Supplement to Annex 3 of the 1978 Canada-U.S. Great Lakes Water Quality Agreement, I am pleased to submit the Canadian plan to reduce phosphorus loadings to Lake Erie.

The Canadian Phosphorus Load Reduction Plan was developed by the Federal/Provincial Phosphorus Task Force, under the direction of the Board of Review, which implements the Canada-Ontario Agreement Respecting the Great Lakes Water Quality. This plan is embodied in the 1986 Canada-Ontario Agreement on Southwestern Ontario Soil and Water Quality Enhancement.

In the two agreements, the Government of Canada, in cooperation with the Province of Ontario, agreed to develop and undertake specific measures to reduce phosphorus loadings to Lake Erie by 300 tonnes per year over five years, ending in March 1991. Although some water quality monitoring work has now been deferred until the fall of 1987, the other aspects of the plan related to the reduction of the phosphorus load to Lake Erie are on schedule.

Mr. Pierre-Andre Bissonnette, Q.C.
Chairman, Canadian Section
International Joint Commission
Berger Building, 18th Floor
100 Metcalfe Street
Ottawa, Ontario
K1P 5M1

As a result of further consultations with the Government of the United States, it was determined that total annual phosphorus loadings (approximately 7430 tonnes) to Lake Ontario are in excess of the target level (7000 tonnes) established by the Phosphorus Reduction Supplement.

We have thus agreed upon a further joint reduction in loadings over the term of the plan by the amount of the excess, 430 tonnes. In our view, which is supported by the Government of Ontario, current and projected phosphorus control programs for Lake Ontario will achieve this additional reduction as a matter of course. In the context of the review of the Great Lakes Water Quality Agreement, a scientific assessment of Lake Ontario nutrient conditions will also be undertaken.

Yours sincerely,

Joe Clark

Proposed
Canadian Federal / Provincial
Phosphorus Load Reduction Plan for the Great Lakes

April 1985

Prepared by the Federal/Provincial Phosphorus Task Force under the direction of the Canada-Ontario Board of Review for submission to the International Joint Commission in compliance with the Supplementary Agreement between Canada and the United States on Great Lakes Water Quality, 1983.

Federal / Provincial Phosphorus Load Reduction Plan for the Great Lakes

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Executive Summary

In October 1983, Canada and the United States formally agreed to the "Phosphorus Load Reduction Supplement" to Annex 3 of the 1978 Canada-United States Great Lakes Water Quality Agreement. The agreement calls for certain specific measures to protect the upper Great Lakes and a broad range of measures to further reduce phosphorus loading to the lower Great Lakes.

The requirements of the "Phosphorus Supplement" will be implemented in Canada under the Canada-Ontario Agreement Respecting Great Lakes Water Quality. To this end, a Federal/Provincial Phosphorus Task Force was created by the Board of Review under the Agreement with representation from the Federal Departments of Agriculture, Environment and Fisheries and Oceans, and the Provincial Ministries of Agriculture and Food, Environment, and Natural Resources to develop a phosphorus management and implementation plan. A brief description of the proposed Canadian phosphorus load reduction plan is as follows.

In the Upper Great Lakes further phosphorus controls are required at municipal wastewater treatment facilities discharging more than 1 mgd. This will require capital expenditures (for phosphorus removal) at four locations (Sault St. Marie, Sudbury, Kincardine and Port Elgin).

In accordance with the Great Lakes Supplemental Agreement 1983, United States and Canada are committed to the development and implementation of a plan to further reduce the annual phosphorus loading to Lake Erie by 2,000 tonnes. The proposed Canadian plan for Lake Erie addresses a 100 tonne phosphorus reduction from municipal and industrial sources and for a 200 tonne reduction from agricultural cropland sources of phosphorus. A major emphasis is to be placed on agricultural sources since major reductions have been made from municipal and industrial sources.

Municipal sources of phosphorus would be reduced by 30 tonnes/ year (approximately 10% reduction) by reducing the effluent concentration from 1.0 mg/L to 0.9 mg/L. Industrial sources of phosphoruswould be reduced by 95 tonnes/year (approximately 33% reduction) when discharges of three companies are brought into compliance with existing requirements.

Cropland sources of phosphorus to Lake Erie would be reduced by 200 tonnes (approximately 10% reduction) through adoption of improved soil management and conservation practices on those farms located in priority drainage areas. A 0.5 kg/ha reduction of total phosphorusover 400,000 hectares (approximately 30% of improved cropland) of cropland would achieve the program objective. Agriculture Canada and the Ontario Ministry of Agriculture and Food are prepared to implement a set of coordinated, parallel activities with farmers, farm and other organizations in the problem areas directed toward developing and implementing appropriate solutions.

The plan for Lake Ontario is based upon a revised annual overall phosphorus target reduction of 430 tonnes per year to be achieved by both countries. The final allocation of the 430 tonnes between the two countries has not yet been decided. In Canada, it is proposed that the reduction be made by continuation of existing municipal and industrial phosphorus control programs and the expected adoption of similar agricultural cropland measures as are proposed for the Lake Erie drainage basin.

Environment Canada and the Ontario Ministries of Environment and Natural Resources would implement an environmental monitoring and modeling program to evaluate the effectiveness of the phosphorus control measures on nonpoint sources of pollution and to provide a basis for program review. It is proposed that the components of theenvironmental monitoring and modeling program be used to show that the Canadian phosphorus management plan has achieved the target load reductions required in Annex 3 of the 1978 Great Lakes Water Quality Agreement.

The proposed phosphorus load reduction plan would cost federal and provincial agricultural agencies $6 M/year over a five year period. Funds to support the environmental monitoring and modeling requirements of the plan would cost federal and provincial environmental agencies approximately $600K/year over the five years of the study.

2.0 Introduction

In the early 1960s it was recognized that nutrient enrichment of the Great Lakes was being accelerated by human activities and was leading to reduction in water quality for municipal water supplies and recreation as well as degradation of fish habitat. Total phosphorus was established as the nutrient responsible for the accelerated enrichment process. The Great Lakes Water Quality Agreement (1972) between Canada and the United States committed the governments to remedial programs.

The greatest phosphorus pollution problems have occurred in the lower Great Lakes. Lake Erie was particularly polluted with phosphorus as a result of its shallow depths and several large urban centres on its shores. During the late 1960's parts of the lake were pronounced 'dead' where oxygen had dropped to such low levels that the water was virtually devoid of normal animal life. Beaches were fouled with algae and the sport and commercial fishery declined. One species, blue pickerel, important to the commercial fishery became extinct.

Phosphorus pollution was one of the main problems tackled under the 1972 Great Lakes Water Quality Agreement between Canada and the United States. Both countries launched major programs to improve sewage treatment and reduce the amount of phosphorus flowing into the lakes. In the Canadian Great Lakes Basin, over $1.8 billion in federal and provincial funds have been spent on the construction and modernization of sewage treatment facilities.

Laundry detergents once contributed a major portion of the phosphorus in municipal sewage. Since 1970, legislation in Canada has restricted the amount of phosphorus permitted in laundry detergents.

Despite the tremendous strides which have been made in improving sewage treatment in the Great Lakes Basin, excess phosphorus remains a problem in some areas. Both Canada and the United States are now taking steps to control the other major sources of phosphorus pollution such as agricultural and urban runoff.

In October 1983, Canada and the United States formally agreed to the "Phosphorus Load Reduction Supplement" to Annex 3 of the 1978 Canada-United States Great Lakes Water Quality Agreement. The agreement calls for certain specific measures to protect the upper Great Lakes and a broad range of measures to further reduce phosphorus loading to the lower Great Lakes.

Through the agreement, phosphorus load reductions have been allocated between the two countries to satisfy loading targets. For Lake Erie, the agreement requires further load reductions of 2,000 tonnes per year. This further reduction has been allocated such that the Canadian share is 300 tonnes while the corresponding United States share of the program will require an annual reduction of 1,700 tonnes. The proposed target load reduction for Lake Ontario is 430 tonnes.

The requirements of the "Phosphorus Supplement" will be implemented in Canada under the Canada-Ontario Agreement respecting Water Quality. To this end, a Federal/Provincial Phosphorus Task Force was created with representation from the Federal Departments of Environment, Fisheries and Oceans, and Agriculture, and the Provincial Ministries of the Environment, Agriculture and Food, and Natural Resources.

The purpose of this report is to describe the Canadian Phosphorus Load Reduction Plan for the Great Lakes that has been produced to meet Canadian commitments under the Canada-United States Great Lakes Water Quality Agreement of 1978 and the Phosphorus Load Reduction Supplement of 1983.

3.0 Benefits of Phosphorus Control

The first phase of the phosphorus control program in the Great Lakes Basin, including phosphorus reductions at both sewage treatment plants and in detergents, has produced a variety of benefits through the period 1970-1984.Foremost among these are rejuvenation of recreational fisheries in many parts of the Great Lakes and recreational benefits to shoreline users as a result of reductions in *Cladophora* outbreaks to manageable proportions. Improvements in water supplies have not given large savings in terms of water treatment costs, but, in a few cases, very expensive public works programs have been avoided since water quality was improved. To date, the direct users of the Great Lakes waters have benefited most from phosphorus pollution control efforts. Further details of these benefits are included in Appendix 1.

Further major phosphorus reductions to the Great Lakes will have to address the second major source of phosphorus pollution: agricultural runoff. One of the most compelling arguments for controlling phosphorus runoff from agricultural land is the extension of benefits from the Lakes to the land basin where issues such as fish habitat degradation, soil erosion, soil degradation and associated lost crop productivity can be addressed simultaneously. It is fortuitous that in determining benefits to farmers most phosphorus control programs can be considered as soil conservation programs. The soil management practices that reduce phosphorus pollution from cropland are the same practices that will reduce cropland soil erosion and associated soil degradation.

Over the past 20 years increasingly intensive crop production has led to a significant productivity gain in southwestern Ontario. This intensification, while providing short term gains, has led to the reduction of long-term resource productivity through serious soil erosion and degradation. Recent studies have projected the annual costs of erosion, including crop yield reduction, nutrient and pesticide losses to be approximately $68 million with more than 80% of the economic losses in the southwestern part of the province.

Conservation tillage and fertilization practices offer the greatest potential for reducing phosphorus outputs from cropland over the next several years with practices which will return short and longterm benefits to farmers. Available information indicates that on many soils, conservation farming practices immediately reduce input costs while spreading labour demand through reduced tillage operations, with no, or less than off-setting, yield reductions. The potential longterm gain from reduction in fertilizer and pesticide loss is estimated at S31 million annually while the potential from crop yield increase due to improved soil quality is estimated at $25 million annually.

Additional savings can be made through reduced fields operations and the reduced overhead costs of carrying the smaller machinery inventory required for conservation farming. This reduction in inventory would be realized over a period of years as conventional tillage and planting equipment is traded for fewer pieces of more costly conservation equipment and the current larger tractors are traded for fewer, less costly, smaller tractors. Estimates of annual savings in tillage and planting costs exclusive of labour savings vary widely but are estimated at $5 million. Ownership costs on the lower stock of tractor, tillage and planting equipment are estimated at $46 million annually, lower than for the comparable conventional equipment complement by the end of five years.

Ontario's agri-food industry is the largest in Canada, accounting for almost 27% of the country's farm cash receipts and producing 25% of Canada's feed grains, approximately 50% of Canada's fruit and vegetables and one-third of the country's livestock and livestock products. Nearly 45% of Canada's value-added in food processing is achieved in Ontario plants.

Ontario's place in Canadian agriculture is highly dependent upon the productivity of its agricultural heartland in southwestern Ontario. It is the primary source of raw materials for the Ontario food processing industry. Maintenance of its productivity is essential to Ontario continuing to enjoy a competitive advantage in primary and processed food markets and to be competitive in markets at home and abroad.

In addition to direct agricultural benefits, there will be savings associated with soil and water conservation to governments which must allocate significant portions of current budgets (approximately $21 million per year) to maintenance of public works, municipal drain maintenance, cleaning culverts, dredging harbours and rehabilitating degraded fish habitats.

While phosphorus control programs are directed at curtailing eutrophication of the Great Lakes, most remedial measures remove other pollutants such as sediment, microbiological contamination, trace metals, and toxic chemicals to varying degrees. Further details on the benefits of phosphorus control policies and programs are included in Appendix 1.

4.0. Phosphorus Management for the Upper Great Lakes

The following table summarizes the phosphorus target loads for the Upper Lakes and associated phosphorus load reductions agreed to in the 1978 Great Lakes Water Quality Agreement.

Basin	Phosphorus Load (tonnes/year)	
	Target Load	Reduction
Lake Superior	3,400	200
Lake Huron	2,800	200
Georgian Bay	600	30
North Channel	520	30

Load reductions for the Upper Lakes can be accomplished by achieving a 1 mg/L phosphorus effluent concentration (on a monthly average) at municipal waste treatment facilities discharging more than one million gallons per day.

In the early 1970s the Province of Ontario prepared the ground work for the implementation of phosphorus removal facilities at waste-water treatment plants throughout the Upper Great Lakes Basin. The implementation for the Provincial Upper Great Lakes Phosphorus Removal Program began in December 31, 1973.

At present, 60 municipal wastewater treatment plants in priority areas of Lakes Superior and Huron have phosphorus removal equipment installed and operational.

With the signing of the Canada-United States Supplementary Agreement in October 1983, requiring all municipal wastewater treatment facilities 1.0 mgd and greater to implement phosphorus removal, four additional facilities in Ontario now require phosphorus removal (Sault St. Marie, Sudbury, Kincardine and Port Elgin).

The installation of phosphorus removal equipment at these four facilities will result in a further phosphorus reduction of approximately 185 kg per day (67 tonnes per year).

A brief summary of the phasing of the phosphorus management plan for the Great Lakes is included in Appendix 2.

5.0 Phosphorus Management Plan for Lake Erie

5.1 Preliminary Evaluation of Phosphorus Reduction Options

In accord with the "Phosphorus Load Reduction Supplement of the Great Lakes Water Quality Agreement" the federal and provincial governments of Canada are committed to the development and implementation of a plan to reduce the annual loading of phosphorus to Lake Erie by 300 tonnes.

To develop the Lake Erie phosphorus load reduction plan, all major sources of phosphorus inputs and the relative costs of control programs were considered. The following table illustrates the relative costs of phosphorus reduction options and the aggregate benefits.

Phosphorus Source	Relative Phosphorus Reduction Costs $/Tonne	Aggregate Benefit
Industrial	0	95 tonne phosphorus reduction; removal of associated pollutants e.g. metals, organics;
Municipal	(Effluent Quality 1.0 mg/L to 0.8 mg/L) 10 x 10^3 chemical cost only	54 tonne phosphorus reduction; removal of associated pollutants, e.g. metals, organics;
	(Effluent Quality 0.8 mg/L to 0.5 mg/L) 5 x 10^3 chemical cost only. One time cap. cost of 87 x 10^6	81 tonne phosphorus reduction; removal of associated pollutants;
Detergent	0	small potential phosphorus reduction; no further reduction recommended at this time;
Urban Runoff	500 x 10^3	5 tonne phosphorus reduction; removal of associated metals, bacteria, organics; improved fish habitat; reduced municipal treatment costs; one time capital cost expenditure;
Agricultural Runoff	30 x 10^3	400 tonne phosphorus reduction; improved farm profits; reduction of soil degradation, erosion/sedimentation; fish habitat improvement; control of associated pollutants e.g. pesticides; improved stream water quality; five year extension education/demonstration program;
Livestock	600 x 10^3	180 tonne phosphorus reduction; improved manure management; controlled cattle access to streams; improved water quality (esp. during low flows); one time capital cost.

Industrial phosphorus reductions have been the object of ongoing provincial programs. Analysis of data indicated that bringing several industries into compliance with existing phosphorus standards would result in a phosphorus load reduction of about 95 tonnes. Since the existing provincial program will result in these reductions, no further expenditure of funds is required.

In considering municipal phosphorus sources, it was learned that a 0.8 mg/L effluent objective would require a significant change in Ontario policy but could be achieved in most instances with minimal capital construction requirements, the added cost being related to increased chemical and sludge disposal costs.

Any further reduction in municipal effluent objective below 0.8 mg/L phosphorus would necessitate capital expenditures for effluent filtration or increased sludge handling capabilities, and increased costs for chemical and sludge disposal. The capital cost of providing effluent filtration to reduce effluent phosphorus concentration in municipal discharges to Lake Erie from 0.8 to 0.5 mg/L is estimated at $87 million. To this cost must be added expenditures for increased sludge handling in addition to an increased chemical cost of $5,000 per ton of phosphorus removed to achieve an annual phosphorus loading reduction of 81 tonnes.

The potential for further phosphorus reduction through the further reduction of detergent phosphorus levels was considered but not recommended at this time.

Urban sources of phosphorus to Lake Erie were considered but were not judged to be high enough (5 tonne reduction) to warrant a relatively large expenditure of new funds in the basin. An existing provincial program will result in some phosphorus load reduction from the source.

Livestock sources of phosphorus in the Erie basin were relatively high (180 tonnes) but were relatively expensive to control. The Ontario Ministry of Agriculture and Food have an existing program (grants to support manure storage and control manure runoff to streams) that will contribute to controlling the problem.

Since the potential for phosphorus reduction (700 tonnes) in Lake Erie far exceeded the required phosphorus reduction (300 tonnes), it was possible to select a combination of the most cost effective phosphorus control alternatives.

It also afforded the possibility of considering auxiliary benefits associated with the control of various sources. For example, the control of phosphorus from agricultural runoff has the added benefits of reducing the significant soil erosion and degradation problems that are facing farmers.

On this basis it was decided to develop a phosphorus management plan for Lake Erie that addressed municipal and industrial sources of phosphorus for a 100-tonne reduction and agricultural cropland sources of phosphorus for a 200-tonne reduction.

5.2 Municipal and Industrial Implementation Programs

In the Lake Erie Basin, Ontario must further remove some 300 tonnes of phosphorus each year. This can be accomplished by reducing agricultural, industrial and municipal phosphorus inputs. Potential reductions from agricultural inputs are estimated at 200 tonnes/year (approximately 10% reduction) while municipal and industrial input reduction are estimated at 30 (approximately 10% reduction) and 95 (approximately 33% reduction) tonnes/year respectively.

5.2.1 Municipal Programs

In the Lake Erie Basin it is proposed that municipal phosphorus inputs be reduced by 30 tonnes per year by reducing the effluent concentration to 0.9 mg/L total phosphorus from the existing 1.0 mg/L. The 0.9 mg/L effluent concentration is, on an aggregate average basis, presently being achieved by municipal sewage works in. the Lake Erie Basin. Implementation of the requirement will be achieved on a voluntary basis rather than by mandatory policy requirements. Municipalities operating facilities at, less than the 1.0 mg/L total phosphorus will be encouraged to continue to do so. Studies will be carried out to assess operating conditions and to provide technical assistance to operating authorities in an effort to ensure that an effluent concentration less than 1.0 mg/L effluent can be maintained or further improved. Operation of facilities presently not meeting the1.0 mg/L objective will have their operations reviewed by the Ministry of Environment. If necessary, technical advisory services staff of the Ministry will assist in the evaluation. In certain instances consulting firms may be hired to solve site specific problems.

5.2.2 Industrial Programs

Phosphorus levels in Ontario's industrial effluents are subject to Ministry of the Environment "Guidelines for the Control of Industrial Phosphorus Discharges in Liquid Effluents (October, 1976)". The main control statement in the document is as follows:

> The effluent objective for industrial phosphorus discharges should be 1mg/litre maximum total phosphorus; PLANTS WITH DISCHARGES LESS THAN 4.54 kg/day (10 lb/day) TOTAL PHOSPHORUS SHALL BE EXEMPTED FROM THESE GUIDELINES.

In general, phosphorus concentration from industry in the Lake Erie Basin are well below the objective of 1.0 mg/L. Further loading reductions from industrial sources are possible in the Lake Erie Basin. For example, International Minerals and Chemicals in Port Maitland discharges to the Grand River a loading which is approximately 236 kg/day in excess of requirements placed on it (1980-1983 data).

Control of another 23 kg/day is possible because of excesses being discharged by:

Chrysler Canada (Windsor)	19.0 kg/day
Omstead Foods (Wheatly)	4.6 kg/day

All these controls will represent a further reduction of approximately 95 tonnes/year of the industrial phosphorus loading to the Erie Basin. Compliance to these controls was expected to be achieved in late 1984.

5.3 Agricultural Implementation Program

5.3.1 Objectives

A southwestern Ontario soil and water enhancement plan has been developed to reduce phosphorus loading to Lake Erie by 200 metric tonnes/year (approximately 10% reduction) by 1990 from non-point agricultural cropland sources, and to increase the productivity of the primary agricultural sector in southwestern Ontario by reducing or arresting soil erosion and degradation. To meet these objectives, approximately 8,000 farmers cropping 400,000 hectares (approximately 30% of improved cropland) of land contributing high phosphorus loads to streams must adopt appropriate conservation cropping practices.

5.3.2 Program Approach

Reduction of phosphorus loading to Lake Erie from cropland sources, and improved long-term soil productivity, can be accomplished by widespread adoption of improved soil management and conservation cropping practices on those farms in priority areas draining into Lake St. Clair and Lake Erie. A 0.5 kg/hectare reduction of total phosphorus loading of these lakes, over 400,000 additional targeted hectares of cropland, will achieve the water quality program objective. Simultaneously, the conservation practices applied to achieve the reduction in phosphorus loading will enhance long-term soil productivity.

Adoption of such practices would require a significant change in thinking on the part of 8,000 farm operations, resulting in changes in cropping patterns and practices, and changes in machinery complements. These in turn will require changes in capital investment and cash flow. All of these changes must be made by the farm operators themselves. Conservation cropping will result in a smaller machinery complement, and lower production cost with minimal, if any, yield reduction.

Governments could provide leadership, can develop, evaluate, demonstrate and extend conservation cropping technology and through compensation, remove the risk for early use of these new technologies thus encouraging their adoption by innovative farmers in strategic locations in the priority phosphorus pollution areas. Government action would therefore be directed toward changing the attitudes and perceptions of conservation practices, augmenting conservation knowledge, lowering risk, transferring technology, offsetting structural costs, improving communication and testing alternatives. Evaluation and demonstration of technologies would replace here say with facts reducing farmers' perception of the risks involved, encouraging change.

It is recognized that the conservation effort and investment on the part of farm operators must continue beyond the termination of this program. This five-year program effort is therefore directed toward enhancing the ability of funding programs to build up a stock of technology that could be extended to farmers now and in the future, concurrent with strengthening the extension and professional, staff development effort required to achieve a "take-off" level of interest and action in the priority areas. These enhanced programs could terminate at the end of five years, with government expenditures returning to normal, but giving assurance that the tools are available to maintain or even further reduce phosphorus levels and enhance soil quality in the years beyond 1990.

Agriculture Canada and the Ontario Ministry of Agriculture and Food would provide leadership to southwestern Ontario farmers by carrying out a set of co-ordinated, parallel activities with farmers, farm and other organizations in the priority areas directed toward developing and extending appropriate technology. These activities would include: targeting and prioritizing of high-priority areas; strengthening of the current effort dedicated to identifying and evaluating effective soil and water conservation cropping practices; strengthening the availability and quality of technical soil and water expertise available to producers; demonstrating soil conservation cropping practices on commercial farms in priority areas; evaluating and demonstrating soil and water conservation in small pilot , watersheds; providing financial assistance for installation of soil conservation devices; and for communications and for the evaluation of the agricultural source phosphorus reduction program.

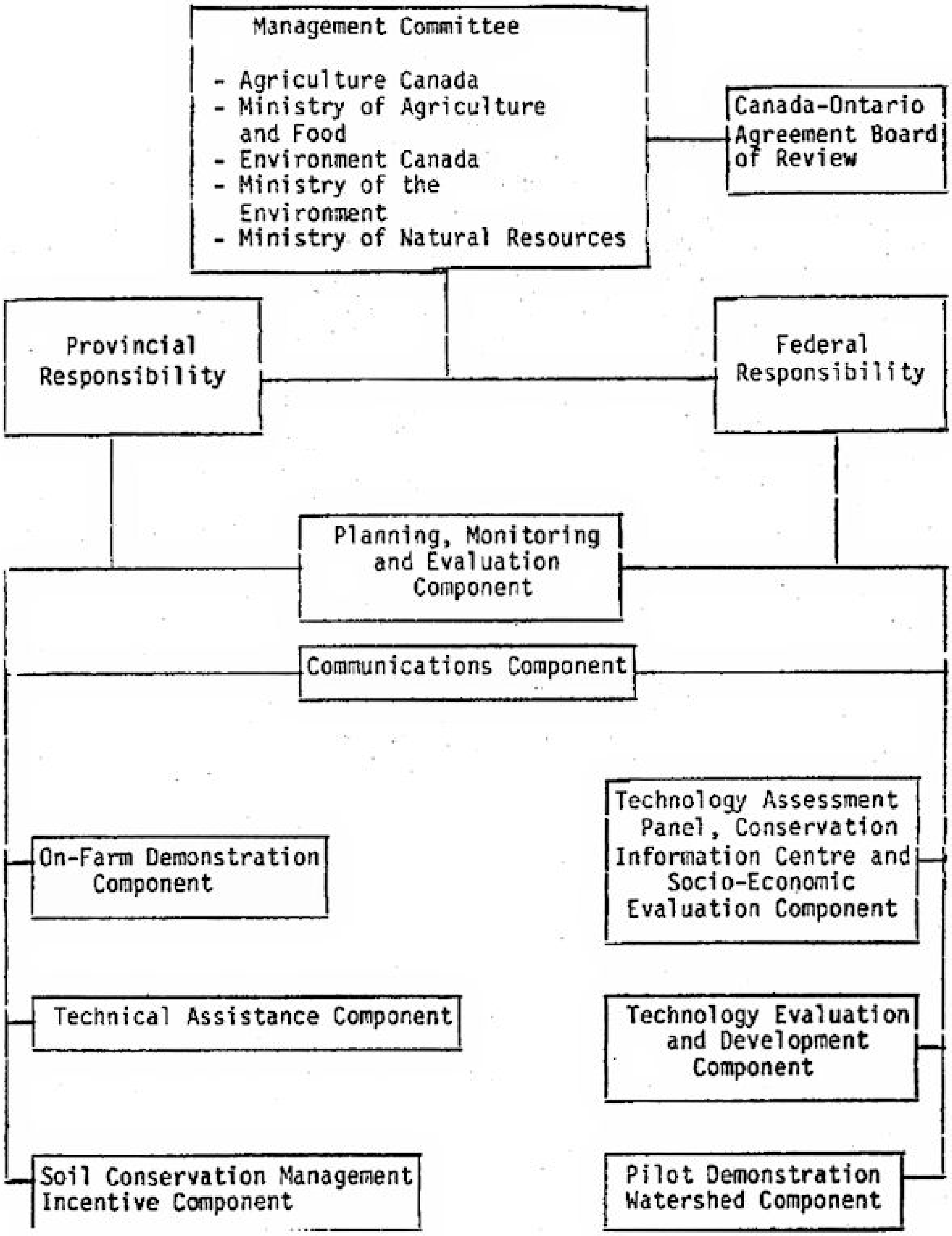
Environment Canada and the Ontario Ministries of the Environment and Natural Resources would establish a set of parallel water quality monitoring activities that would be developed and co-ordinated with the planning and implementation of the agricultural program. These agencies would assume responsibility for measuring the effectiveness of the agricultural program in meeting the phosphorus reduction targets (Section 5.4).

5.3.3 Management Approach

The southwestern Ontario soil and water enhancement plan would be planned, co-ordinated, monitored and evaluated by a federal-provincial management committee. This committee would be co-chaired by a representative each from the Regional Development Branch, Agriculture Canada, and the Plant Industry Branch, Ontario Ministry of Agriculture and Food, who would have decision-making authority. To ensure proper program co-ordination the co-chairmen of the southwestern Ontario soil and water enhancement plan would be members of the Canada-Ontario Agreement Board of Review.

The management committee would be responsible for developing the overall plan, for co-ordinating its implementation, for monitoring and evaluating the implementation of the plan on an ongoing basis and for establishing any necessary sub-committees. This committee would review and appraise the five-year operational plan for each component as well as review and approve annual work plans. The management committee would review the progress of each component with the appropriate administrators from time to time and suggest changes where required to enhance its contribution to attaining overall program objectives.

Environment Canada, the Ontario Ministries of the Environment, and Natural Resources would assume full responsibility for monitoring and reporting on the water quality impact of the agricultural practices. The appropriate environmental agencies would participate in the design of individual projects so as to ensure that the projects' water quality impact can be properly evaluated.


Management Committee
- Agriculture Canada
- Ministry of Agriculture and Food
- Environment Canada
- Ministry of the Environment
- Ministry of Natural Resources
Canada-Ontario Agreement Board of Review
Provincial Responsibility
Federal Responsibility
Planning, Monitoring and Evaluation Component
Communications Component
On-Farm Demonstration Component
Technical Assistance Component
Soil Conservation Management Incentive Component
Technology Assessment Panel, Conservation Information Centre and Socio-Economic Evaluation Component
Technology Evaluation and Development Component
Pilot Demonstration Watershed Component

5.3.4 Program Components

There are eight separate components in the proposed southwestern Ontario soil and water enhancement plan. These components are designed to provide for an immediate phosphorus reduction response through changing farmers' attitudes and actions relative to soil management and conservation practices, while concurrently-developing and evaluating new technologies that these farmers, and others, can adopt, therefore improving long-term soil productivity and further reducing phosphorus loading toward the end of the program and beyond.

The first three components are intended to extend existing and new soil and water conservation technologies to the farm community. Early acceptance and endorsement by leading farmers and farm organizations in each community is key to the success of this program as is provision of technical advice and financial incentives.

i) On-Farm Demonstration Component

This component is directed toward promoting the wider adoption of proven soil and water conservation technology through on-farm demonstrations of integrated production systems, and on-farm demonstrations of single pieces of technology which have the potential to enhance soil productivity by reducing soil erosion and degradation and phosphorus loading of water systems. On-farm demonstrations would be conducted by farm or other organizations or organized groups of farmers consistent with multi-year plans developed for each project or set of projects which in turn are consistent with the plans for the component and the program.

While approximately fifty multi-year projects in the priority areas are anticipated, an attempt will be made to plan the location and size of projects in consultation with a farm organization(s) that can speak on behalf of local or county farm groups. These locations will be consistent with the targeted areas and the magnitude of the phosphorus loading in each project identified by the Management Committee in their program plan.

ii) Technical Assistance Component

The Technical Assistance Component would provide field level professional conservation advice utilizing a team approach. The teams will have expertise in soils and crops, soil and water engineering as well as in farm management. The team approach would be used to provide the component management, and each farm co-operator, with an assessment of the soil degradation and erosion problem on the subject farm, to prepare a crop production and land-use plan, advise on the most appropriate type of conservation tillage and planting equipment, as well to advise on the most appropriate production practices.

The team would be available to consult with other farmers in the priority areas on a non-priority basis. This would increasingly occur in years three, four and five of the program.

iii) Soil Conservation Management Incentives Component

This component is directed toward reducing phosphorus loading to water systems by controlling the movement of water and sediment from lands that are intensively cropped. This will be accomplished by construction or installation of devices and structures on farms in the priority areas.

Funding of this component would provide a 50% grant to eligible farmers for approved projects to install or construct such devices or structures. Field staff of the Technical Assistance Component would promote farmer participation in this component in the priority problem areas.

The next three components are designed to coordinate the efforts of all researchers, to provide leadership to professional and technical specialists and farmers, and to develop, test and evaluate new technologies that might be used to address the subject soil and water problems.

iv) Technology Assessment Panel, Conservation Information Centre and Socio-Economic Evaluation Component

A Technology Assessment Panel and Conservation Information Centre would be established to provide leadership and coordinate and centralize the stock of technical data on soil and water conservation technology applicable to Ontario. A socio-economic evaluation aspect would also be established.

The Technology Assessment Panel would be made up of leading federal, provincial, university and private sector soil and water specialists in Ontario. The Panel would identify and provide a preliminary assessment of soil conservation technologies in terms of their validity and utility for Ontario agriculture. The results of research done by federal, provincial, university and private sector establishments would be considered. Assessments of regional and national and international results would be made. As a result of this assessment, technologies may be recommended for immediate adoption, further evaluation, or for rejection for use in Ontario.

The Conservation Information Centre would assume a leadership role in communicating information on soil conservation and management.TheCentre would work with the Technology

Assessment Panel and would establish a network that will collect, catalogue and distribute soil management and conservation information to researchers, resource staff, soil conservation agencies and private sector organizations. It would have a small staff to perform its function and would also serve as a secretariat to the Technology Assessment Panel. In addition, it may second staff from government, universities or the private sector for periods of time to assist in carrying out its mandate.

The socio-economic evaluation aspect would provide the resources required to conduct economic assessments of technology, to analyze the social and psychological factors involved in adoption of soil management and soil conservation practices, and to study the potential for use of institutional mechanisms to reduce soil erosion and degradation.

v) Technology Evaluation and Development Component

This component is intended to develop, adapt, evaluate and validate new or untested technology related to soil productivity and to phosphorus movement from cropland to water systems. This includes development and evaluation of technologies related to soil and conservation cropping, conservation planting and tillage equipment, soil drainage and integrated pest management as it is related to chemical movement to water systems. Testing of these technologies would occur under commercial farm conditions in priority areas in co-operation with commercial farmers.

The intent of this component is to test systems that have a high probability of being successful on commercial farms. Therefore, the suitability, adaptability and economic viability of the practice or system for demonstration and adoption by commercial farmers would be the key evaluation criterion. Only if rigorous evaluation indicates that a system would perform on a year-to-year basis should it be considered for demonstration or adoption by commercial farmers.

While the administrators of this component would be responsible for planning the applied research program, it is expected that they would work closely in this regard with the Technology Assessment Panel.

The component would be planned, managed and analyses conducted by a small professional staff. Day-to-day field operations will be managed by a technical staff. This component may be broken into several sub-components for administrative purposes,

vi) Pilot Demonstration Watershed Component

The pilot demonstation watershed component would evaluate the effectiveness of implementing comprehensive soil and water conservation practices on all farms on a few selected small pilot watersheds. This thrust would be co-ordinated with Environment Canada and the Ontario Ministries of the Environment and Natural Resources which would simultaneously monitor the change in water quality and fish habitat on the watershed. The intent of this thrust is to evaluate and demonstrate the effectiveness and efficiency of changing soil conservation cropping practices on a total watershed as a means of improving water quality and fish production while economically enhancing soil productivity.

The component would be planned, managed and analyses conducted by a small professional staff. Day-to-day field operations would be managed by technical staff.

The final two components are intended to ensure that all components are planned, co-ordinated and meeting the program objectives. The latter would be ensure that the farm community atlarge is aware of the program and the benefits to themselves and society arising from farming of Ontario's soils in a manner consistent with good soil and water conservation.

vii) Planning, Monitoring and Evaluation Component

The Management Committee has the responsiblity to plan, monitor and evaluate the overall agricultural program and to ensure that each component is contributing to the overall soil productivity and phosphorus reduction goal. This component would support the Management Committee in carrying out its planning, monitoring, evaluation and administrative responsibilities.

viii) Communications Component

The Management Committee has the responsibiity to ensure that information flowing from the program is communicated to the public. This component would provide for this function.

Specific functions would include (i) developement of the guidelines for the communications plan including the guidelines for the communications plan for each component, (ii) development of any logos and insignia to uniquely identify the program including guidelines for the signage required to identify specific projects, (iii) preparation and distributing of project signs, (iv) printing and distributing program reports, newsletters and promotional material on behalf of the Management Committee, and, (v) coordinating communications between federal and provincial communications branches on behalf of the Management Committee.

A brief summary of the phasing of the implementation of the phosphorus management plan for the Great Lakes is included in Appendix 2.

5.3.5 Allocation of Components Between Governments

Federally administered components: Intended to provide leadership and development and evaluate new technology.

- Technology Assessment Panel, Conservation Information Center and Society-Economic Evaluation Component
- Technology Evaluation and Development Component
- Pilot Watershed Demonstration Component

Provincial Administered Components: Intended to extend technology and change farmers attitudes and actions toward conservation cropping.

- On-Farm Demonstration Component- Technical Assistance Component
- Soil Conservation Management Incentive Component

Jointly Administered Components: Intended to ensure that all components are co-ordinated and meeting program objective.

- Planning, Monitoring and Evaluation Component
- Communication Component

5.4 Environmental Monitoring and Modeling Program

A key requirement of the Phosphorus Load Reduction Plan is for a mechanism to ascertain the effectiveness of the point and non-point reduction measures. The results of the various components of the program, outlined below, will provide the necessary basis for review of the overall plan as it progresses.

The proposed individual program components and objectives for the environmental monitoring and modeling program are as follows:

	COMPONENT	OBJECTIVES
A.	Monitoring of tributary phosphorus loads to Lake Erie.	To analyse phosphorus loading trends.
B.	Monitoring of phosphorus loads and biological indicators in six (6) pilot watersheds identified under agricultural programs.	To establish effectiveness of implementation of soiland water conservation practices on phosphorus loading of agricultural watersheds.
C.	Calibration of existing watershed models with data from component B above.	To aid in assessment of basin-wide program effectiveness and planning.
D.	Point-source monitoring: ▸ Municipal ▸ Industrial	To monitor compliance with effluent phosphorus objectives.

5.4.1 Allocation of Components Between Governments

As shown in the accompanying organization chart, the Environmental Monitoring and Modeling Program would be administered by a Management Committee co-chaired by the Ontario Ministry of the Environment and Environment Canada.

Environment Canada and the Ontario Ministry of the Environment would continue to co-operate in obtaining tributary phosphorus loadings for major rivers tributary to Lake Erie. Environment Canada would assume responsibility for the collection of stream flow data while the Ontario Ministry of the Environment would assume responsibility for collection of water quality data - phosphorus parameters.

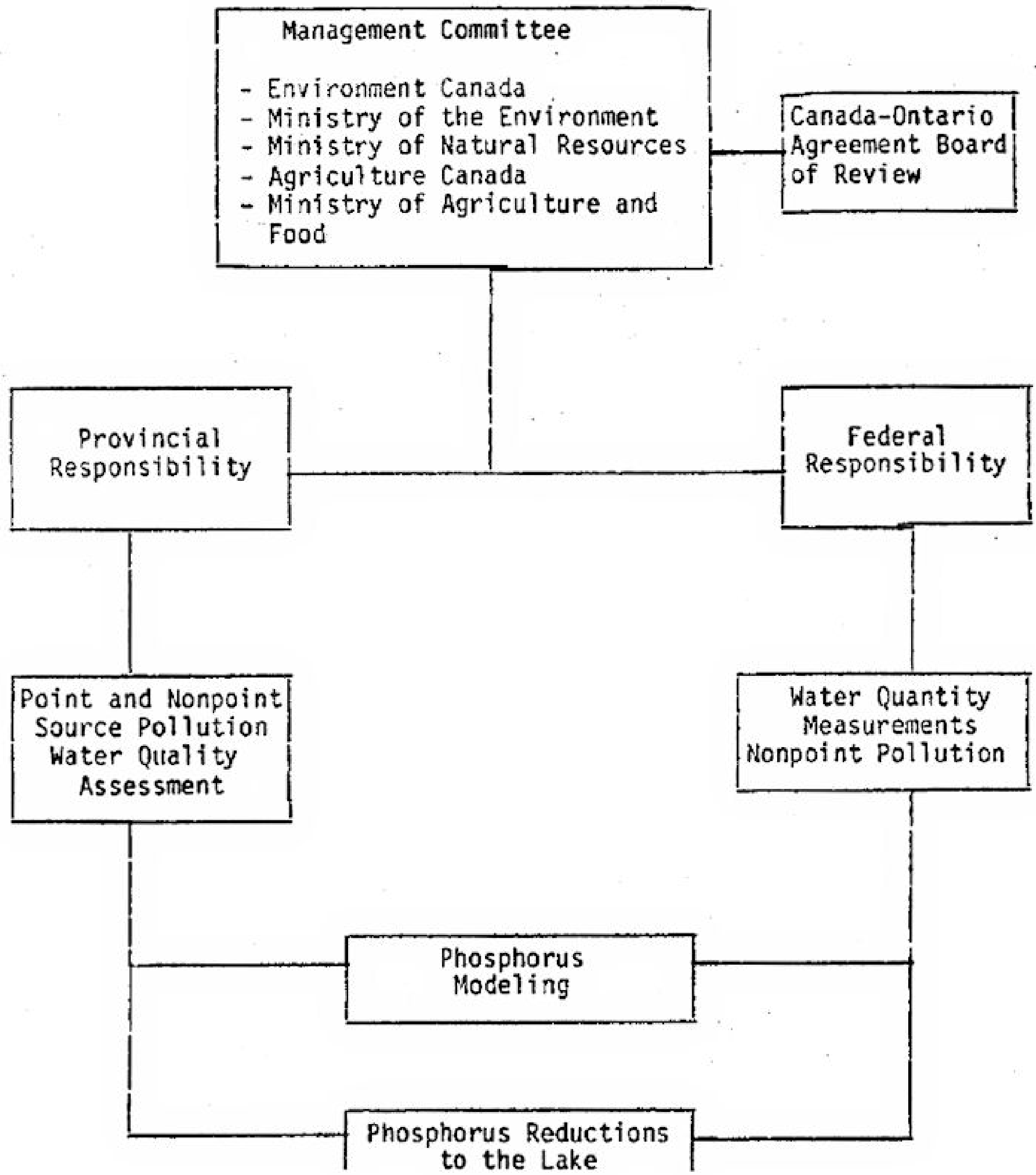
In consultation with Agriculture Canada, the environment agencies would carry out load monitoring activities on the six (6) pilot agricultural watersheds selected for intensive implementation of conservation programs. Environment Canada would assume responsibility forcollecting stream flow data at these locations, and the Ontario Ministry of the Environment would collect water quality data, particularly phosphorus and required meteorological data (precipitation, temperatures, etc.).The Ontario Ministry of NaturalResources would become involved as necessary to address questions of stream rehabilitation, fisheries and other biological aspects of the study.

Environment Canada and the Ontario Ministry of the Environment would co-operate on the integration of information from the above activities in order to derive an overall interpretation of the programs' environmental impact. The Ontario Ministry of the Environment would be addressing questions of statistical theory relating to long-term and short-term interpretation of results from both tributary stations and the small watershed studies. Watershed models such as CREAMS, GAMES and HSP-F would be important for extrapolating site-specific data to larger watersheds.

The Ontario Ministry of the Environment would be responsible for collection of data required for compliance monitoring related to point sources, both municipal pollution control plants and industrial locations.

It is proposed that the results of the Environmental Monitoring and Modeling Program be interpreted in conjunction with information collected by Ontario Ministry of Agriculture and Food and Agriculture Canada on the progress of implementation of the agricultural program. Taken together, these data will provide the major input to the Planning, Monitoring and evaluation aspect of the Phosphorus Load Reduction Plan, which would guide management in assessing its effectiveness.

The following figure illustrates the proposed management committee for the environmental monitoring and modeling aspects of the program.



6.0 Phosphorus Management Plan for Lake Ontario

With the joint signing of the Supplementary Agreement, including the confirmation of phosphorus target loads, on October 16, 1983 a phosphorus load reduction allocation between parties for Lake Ontario is required within twelve months. During the negotiations of the target loads, the Lake Ontario phosphorus inputs and their possible control were insufficiently understood to develop a management plan. During the period between the signing of the 1978 Agreement and the confirmation of Annex 3, additional studies and measurements have been made which make possible the calculation at this time.

The phosphorus concentration in Lake Ontario has decreased from a high of 22.7 µg/L in 1976 to 13.8 µg/L in 1982. This decrease has primarily been the result of phosphorus removal facilities at municipal sewage treatment facilities on Lake Ontario and the reduced input from Lake Erie due to the phosphorus reductions to that lake. Based on the observed relationship between the phosphorus loading to Lake. Ontario and the in-lake concentration, the original target load of 7000 tonnes/year to achieve an in lake concentration of 10 µg/L is still valid.

The concentration of phosphorus in the eastern basin of Lake Erie is still decreasing and is expected to reach its objective of 10 µg/L when the 11,000 tonnes/year target load for Lake Erie is achieved. Using a total phosphorus concentration in the eastern Basin of Lake Erie of 10 µg/L phosphorus and an annual average flow in the Niagara River of 220,000 cfs, the Lake Erie Load to Lake Ontario becomes 1,965 tonnes/year of total phosphorus. This Lake Erie load originates in Canada and the United States on a $^{1}/_{3}$ - $^{2}/_{3}$ split based on their respective contributions to the eastern basin.

Based on the expected phosphorus loads to Lake Ontario when Lake Erie is at its target load and all municipal waste treatment plants in excess of 1 mgd are at an effluent concentration of 1 mg/L phosphorus, the load to Lake Ontario is projected to be in excess of its target of 7,000 tonnes/year by 430 tonnes/year. This is about one-third of the original estimate made in 1981 which was the basis for the reduction called for in the Supplementary Agreement.

This 430 tonnes/year total phosphorus reduction comes from a conservative estimate of the "base year" total load to Lake Ontario of 7430 tonnes/year. Less conservative, but equally defensible assumptions regarding the Lake Erie load to Lake Ontario would result in a near zero total phosphorus reduction. The uncertainties in the various technical calculations are at least equal to the 430 tonnes/year target reduction so that it would be prudent to delay any major additional remedial programs until Lake Ontario has had enough time to respond to the massive reductions in total phosphorus loading already accomplished. In any case, the small remaining reductions can be realized with good operating practices at municipal sewage treatment plants where effluent total phosphorus concentrations of 0.9 or 0.8 mg/L are realistically attainable.

A brief summary of the phasing of the implementation of the phosphorus management plan for the Great Lakes is included in Appendix 2.

7.0 Program Review

The Canada-Ontario Agreement (COA) Board of Review will, in conjunction with participating agencies, conduct an annual program review. The annual program review of the implementation of the phosphorus load reduction plan will serve to monitor progress, identify shortcomings and recommend changes in program direction.

8.0 Plan Budget

The proposed plan for further phosphorus load reduction to the Great Lakes would require funding for: point sources of phosphorus control; nonpoint agricultural sources of phosphorus control; and environmental monitoring and modeling of this progress of the implemented phosphorus control programs. It has been estimated that the implementation of the agricultural cropland phosphorus control program would cost $6 million/year for five year. The federal and provincial agricultural agencies are proceeding with efforts to secure thus funding.

Funds to support the point source phosphorus control program and monitoring and modeling efforts of the proposed plan have been estimated to be approximately $600K per year for five years.

GW/mg/2921

APPENDIX 1

Benefits of Phosphorus Control

BENEFITS FROM PHOSPHORUS-CONTROL POLICIES & PROGRAMS

The purpose of this section of the report is to place accomplished and proposed programs in the meaningful context of benefits to the wide variety of users of water and land resources of the Great Lakes System. What follows herb is not an intensive and traditional cost-benefit analysis of phosphorus control, for various reasons, including the obvious premise that water quality is a qualitative and long-term attribute whose value may be measured in many ways. The equation of value with price is only one useful but narrow quantitative representation of essential quality (Muir 1981). Remedial measures are usually assessed in dollars but there are other considerations such as job-creation, ethical responsibility and, not the least, compliance with laws of the land. Therefore, the approach herein consists of a general overview of the extensive benefits of phosphorus control complemented with examples which adequately evaluate the premise that phosphorus removal policy has and will continue to optimize benefits from the Great Lakes system.

Considerable loss in values and amenities of Great Lakes waters occurred as a result of increasing enrichment by nutrients and consequent reduction in water quality for municipal water supplies and recreation and degradation of fish habitat. The extent of losses to society have never been estimated. Nevertheless impairment was sufficient to bring about phosphorus limitations in detergents and phosphorus removal of sewage-treatment plants.The targets for phosphorus loading and timetable for point-source controls were specified in the 1972 Canada-USA Water Quality Agreement. In general the targets and accomplishments have been calibrated in limnological and engineering terms, hardly ever in socio-economic terms.

However, with the commitment in the 1978 Water Quality Agreement for a more extensive phosphorus removal strategy, with added emphasis on non-point measures and programs in the private sector, there are greater concern with benefits in relation to expenditures. The first phase of phosphorus control was confined largely to public works, using relatively cost-effective and phosphorus-specific measures, and beneficiaries were Great Lakes water users. The expanded program will include a wider variety of measures, with less specificity in many cases and usually great unit costs. Superficially, the return for these expenditures may seem remote and relatively small in comparison to excellent returns on phosphorus control costs at municipal sewage treatment plants.

Actually the benefits are considerably more extensive geographically and in terms of user groups, when the full significance of these programs is placed in a justifiably broad environmental and resources management context. The eutrophication issue should not be viewed in isolation of other resource management issues, nor should Great Lakes resources be managed independently of those in the watershed. The phosphorus removal program should address not only compliance with Great Lakes target phosphorus loading but also the principles of optimizing benefits across the largest possible population and fulfilling existing goals of resources management policy in Ontario and Canada. Furthermore, aside from meeting target loadings, aiming programs at the solution of nearshore, local problems can enhance benefits.

From a wide variety of potentially useful phosphorus control measures, some more than others will be effective in addressing other problems, like erosion of farmland and consequent damages by sedimentation. Removal of phosphorus from one medium (water) to another (land or air) must ensure that new problems are not created.

Disbenefits, beyond the costs of providing and maintaining phosphorus-removal measures should be considered, as, for example, marketing problems if alternative crops are grown, or removing land from crop production. The current phosphorus-control strategy has ramifications through a wide variety of public policy fields. For example, the loss of prime farmland may increase nutrient and sediment losses if proportionately more row cops are grown on land less suited and of higher environmental risk. In the field of employment, programs which create jobs via special public works projects or stimulation of private sector employment, would enhance benefits.

This section on benefits is divided into subsections based on main beneficiaries, from users of water directly for municipal supplies and recreation, to users of the fish communities, and users of the land for housing, industry, recreation and agriculture. Where appropriate the benefits obtained to date and probable benefits from further and full implementation of phosphorus-control policy are both addressed.

WATER SUPPLIES

A small number of water supply plants on the Great Lakes were examined in the Michalski and Associates (1984) study. The western basin of Lake Erie and the Bay of Quinte are two sources of potable water where substantial improvements occurred as a result of the phosphorus removal programs. For example, Nicholls *et al.* (1977, 1980) related declines in phytoplankton abundance at the Union water treatment plant at Kingsville to decreased phosphorus loadings from the Detroit River. Nicholls (1985) also reported on the dramatic reductions in phytoplankton in the Bay of Quinte due to phosphorus control. In the six years since 1977 when significant phosphorus reductions occurred, phytoplankton biomass averaged 45% lower than during the period 1972-77.

While operators at the Union water treatment plant can clearly perceive better water quality conditions than in past years, these improved conditions are not reflected in the day to day operations of the plant. Apparently there have been no reductions in microstrainer use and maintenance requirements over the past 10-15 years. At other treatment plants in the central basin of Lake Erie (e.g. Blenheim), similar water quality improvements have been noted but no in-plant changes have been made to reflect these improvements.

At Belleville, where raw water is drawn from the inner Bay of Quinte, microstrainers are now in use for about eight weeks of the year, whereas, prior to 1978, microstrainers were necessary for about 17 weeks from about the middle of May through to the middle of September. As well, the frequency and intensity of taste and odour problems have diminished substantially, along with improvements in water quality. There has been a modest reduction in chlorine demand, likely owing to the improved water quality conditions. For example, years ago, operators were feeding about 6mg/L chlorine which produced a residual of about 0.8mg/L.

This past summer, the feed has been about 5mg/L with a 1.0mg/L residual chlorine. However, these modest savings are minor compared with the possible cost of a water supply pipeline from Lake Ontario to the north shore of the Bay of Quinte. This major project was deferred pending a review of water quality changes which might result from the phosphorus-removal program in the Bay of Quinte, which included reduction to 0.5 ppm residual phosphorus during May-September. The pipeline project has remained dormant in view of improvements in water quality in the bay.

Dunnville used stationary screens to protect pumps from *Cladophora*; cleaning was a seasonal job for one or two men. A travelling screen was installed finally, but at present it is set in motion once each day to ensure continued maintenance. Taste and odour problems continue, especially in mid-summer but they are not as severe or frequent.

On Lake Ontario at the Metropolitan Toronto, Hamilton and Oakville water treatment plants, no in-plant changes in operation have occurred attributable to improved water quality, and, in the opinion of operators, improvements have been imperceptible. Ontario Hydro spent considerable money to minimize the impacts of *Cladophora* (groynes, water intakes, chlorination) before any benefits from phosphorus management were realized.

The main conclusion of the study by Michalski and Associates (1984) was that benefits which nave been realized to date to water treatment plant operations have been modest. At a number of the plants contacted, no major changes have occurred in inplant operations over the past 10-15 years, although water quality has improved. A few plant operators confided that they were reluctant to alter traditional in-plant operations. If such changes were implanted, it is possible that benefits to water treatment plant operations might be much greater than reported. Additional benefits from further reductions in phosphorus supply in relation to water treatment are likely to be small at existing plants. However, as shown by the City of Belleville, major capital works might have been necessary if deterioration of water quality had proceeded to an unprecendented and unmanageable degree.

RECREATION

Recreational benefits are closely related to aesthetic qualities of beach and water areas. In the Great Lakes the alga *Cladophora*, in nuisance quantities in enriched areas of suitable substrate, has adversely affected water-contact recreation. In some areas phytoplankton pulses have interfered with recreational uses of the water. During the 1960s and early 1970s some waterfront recreational areas were abandoned at times, because rotting *Cladophora* was too abundant. In many recreational areas, *Cladophora* has been reduced to tolerable quantities that are manageable in beach maintenance programs. The Michalski & Associates survey found examples of improvement and an equal number of instances of no substantial change in conditions. Recent work has compared *Cladophora* growths in Lake Ontario in 1972 and in 1982/83 and have demonstrated that, while growths are still plentiful in most traditional areas, total biomass is now less than in past years. There has been a lakewide reduction in algal biomass of 59%. Further analysis of the data indicates that with a small further reduction in lakewide phosphorus concentrations, large returns in terms of biomass reduction could be realized, which would have a major effect On recreational user benefits.

On Lake Erie, two areas where significant improvements have been noted are Long Beach Conservation Area (east of Dunnville) and Port Stanley. At Long Beach, *Cladophora* depositions, which were extreme in the late 1960s and early 1970s, have improved to a manageable level where they pose little impediment to water contact recreation given a constant beach maintenance program. The result has been a considerable recovery in use of this major recreation area, as well as considerable maintenance savings to the Niagara Peninsula Conservation Authority. The Authority reports a continuing improvement in *Cladophora* conditions since the mid 1970s. At Port Stanley, shoreline conditions appear to have improved considerably in terms of factors both related (algae and phytoplankton) and perhaps not related to phosphorus, to the point where there are now no significant limitations to beach use. There has been a dramatic increase in use of the Port Stanley beach, with water quality improvements given most of the credit. Increased maintenance and promotion of the beach are also factors, but these in turn have been encouraged in part by improved water quality.

At Crystal Beach, in eastern Lake Erie, *Cladophora* depositions are frequent but manageable. Constant beach cleaning has maintained conditions at an acceptable level for swimmers. At Turkey PointProvincial Park, *Cladophora* is reported as a serious problem in occasional years (including 1984 when decomposing *Cladophora* had a drastic impact on recreation). On the outer beaches of Rondeau Provincial Park, no phosphorus-related impacts on recreation are reported. No significant improvements have been noted over the last 10-15 years at these sites (Michaelski & Associates 1984). On Lake Ontario, with the exception of sheltered areas such as the Bay of Quinte and Prince Edward County, swimming potentials are naturally limited by low water temperatures and, in many areas, lack of suitable natural beaches. In the inner bay of the Bay of Quinte, where the most dramatic results have been reported for the phosphorus reduction programs, water contact recreation benefits have not been documented. The City of Belleville does not report any improvement in seasonal algal blooms at its beach.This contrasts with results of the waterquality monitoring program, which indicates a reduction of 50% in phytoplankton density in the upper Bay of Quinte from pre-control to post-control (phosphorus) periods. The City of Trenton has onlyrecently established a beach on the bay. At the western end of Lake Ontario the City of Burlington reports no apparent change in the incidence of *Cladophora* deposition on Burlington Beach.

The main water-contact recreation impacts of, phosphorus removal to date appear to be limited to some beaches of Lakes Ontario and Erie. As well, some beaches and intensively used areas of certain inland lakes have responded to phosphorus removal programs; Gravenhurst Bay is an outstanding example of rejuvenation of a heavily used recreational area. In some Great Lakes cases, reductions in *Cladophora* problems have been only from extreme levels to levels manageable through maintenance, but this has made the difference between viability and non-viability of a recreation area. It appears that one of the mostsignificant impacts has been a reduction in the occurrence of nuisance episodes. The benefits which have been derived accrue to users andoperators of public and commercial recreation facilities, and also to owners of private beach property rendered more attractive for water recreation. However, the actual benefits derived from these reductions have in many cases been limited by other contraints on recreational use, such as location relative to major population centres, water temperatures, beach capacity and fecal-coliform pollution.

Further reductions in algae will translate into added recretional benefits in some cases but not in others (Michalski & Associates 1984). At Long Beach Conservation Area, it was felt that the elimination of *Cladophora* would result in a significant increase in use, although much of this would be related to an improvement in long run perceptions about the health of Lake Erie. Obviously, the elimination of extreme *Cladophora* episodes would be of considerable benefit at areas which have experienced these in the past, such as Turkey Point and Long Beach. However, at Belleville, Trenton, Burlington, Crystal Beach and TurkeyPoint Park it was felt that the disappearnce of *Cladophora* (algal-blooms in the case of Belleville) would not necessarily result in any significant increases in beach or enjoyment, because of the nature of overall recreational demand patterns, physical limitations such as beach capacity or water temperatures, and/or the belief that existing beach management is already keeping the nuisance aspects in check.

Changes in long run perceptions which could arise from significant long term improvements at areas with past and present problems could lead to a great willingness by public agencies to invest in new facility development in areas where there is an obvious unsatisfied demand for natural swimming opportunities. However, regardless of how well water quality is improved, some of the major beaches on Lakes Ontario and Erie may not, in the foreseeable future, experience the use' levels sustained between the 1920s and 1950s. Recreational behaviour has changed a great deal, and today there are many more opportunities competing for our free time. Significant reductions in or elimination of *Cladophora* would also yield maintenance cost savings to recreational management agencies which, while not large in the aggregate, could be significant to many individual agencies.

The evidence considered by Michalski and Associates (1984) suggests that in Lakes Erie and Ontario, where phosphorus and *Cladophora* are whole-lake problems, further significant reductions in *Cladophora* levels are necessary to yield additional significant recreational benefits, not only at specific problem sites, but also in terms of long term user perceptions of the lower lakes as desirable and healthy places for water contact recreation.

Aesthetic qualities are significant beyond the bounds of recreation areas, especially in urban/suburban areas where property values may be affected by poor water quality. As in the case of water contact recreation, the aesthetic impacts of phosphorus removal efforts to date would appear to be limited to certain stretches of shoreline. The greatly reduced frequency of the extreme episodes characteristic of the late 1960s and early 1970s, such as reported for Long Beach Conservation Area, and for Pelee Island by Osmond (1971), are clearly identified benefits from phosphorus removal programs. The actual benefits derived from these reductions are more widespread than in the case of water contact recreation. Wherever there are people, clean water, clean beaches, and odour-free air are much appreciated.Thebenefits which have been derived accrue to all shoreline users and to those charged with maintaining shorelines in high use areas.

Over the past 25 years, in answer to an accelerating demand for facilities for outdoor recreation, conservation areas have provided public access to many rivers and reservoirs in southern Ontario. Although most reservoirs were built as part of flood control and water regulation schemes, their secondary use for recreation filled a growing need. Today there are 21 major reservoirs, with a value of $171 million (1983 dollars including land costs). At least 1.4 million visitors used these reservoirs in 1983 (a minimal figure because attendance was unrecorded at some areas).

Because of their location in fertile basins of southern Ontario, water quality in these reservoirs sometimes has been marginal for satisfactory recreational use. Problems include proliferation ofaquatic vegetation, algal blooms, turbidity and bacteriological impairment. Turbidity and plant growths are the result of nutrientenrichment and sediment, to a large extent from farmland. Bacteriological problems may be caused by livestock wastes, by domestic wastes from improperly operated private systems or even from the population using the swimming facilities.

Because the reservoirs and lakes are so vulnerable, being precariously positioned on the gradient of eutrophication, reduction in nutrients and sediment inputs from their watersheds is expected to have province-wide benefits. Where reservoirs and lakes occur, the most beneficial result of comprehensive and intensive livestock waste management will be improvements in bacteriological water quality.

Recent studies have indicated the gross water quality impairment is attributable to livestock wastes entering drainage systems inadvertently and, as well, probably by illegal connections of sewage sources to field tiles. Recreational use of water conservation reservoirs may depend on livestock waste remedial programs in many situations in Ontario.

BENEFITS TO COMMERCIAL AND RECREATIONAL FISHERIES

Fishermen have been affected most by eutrophication and are foremost among beneficiaries of phosphorus control programs in the Great Lakes basin. Degradation of fish stocks accelerated at an alarming rate especially after 1950. Valuable species such as lake trout, lake whitefish, sauger and walleye which comprised 70-80% of early fisheries declined to less than 30%, and, in Lake Ontario, only 5% of the catch in the mid. 1970's (Great Lakes Fishery Commission 1975). The blue pickerel of Lake Erie is extinct. Peak commercial fish production occurred about 1910, averaging 60 million kg valued at over $40 million at current prices. By the mid-1970's the commercial catch averaged only about 45 million at current prices. By the mid-1970's the commercial catch averaged only about 45 million kg valued at less than. $30 million. With full and part-time employment for 7000 people, including those engaged in processing, the commercial fishery is still a significant, albeit struggling, industry in the Great Lakes. In fact, some port towns are primarily dependent on fishing.

In spite of some setbacks, due to depreciation of fish stocks and frequent contamination of surviving populations, recreational fishing continues to expand in the Great Lakes basin. In 1979, recreational fishing activity in Canadian and U.S. waters of the Great Lakes totalled 25 million angler-days and approximately $600 million was put into the economy through sport fisheries expenditures (Talhelm *et al.* 1979).

In three Ontario Ministry of Natural Resource regions in southern Ontario (Southwestern, Central and Eastern) anglers spent close to 8 million days fishing Great Lakes waters and about 11 million days on inland waters in 1980. Close to 2 million of the 19 million days were by non-residents. For those who might perceive that most angling takes place in northern lakes, it is of interest that 51% of the provincial total angler-days took place in these three regions. Some southern Ontario rivers attracted large numbers of anglers, for example, close to 1 million angler-days were spent on the Thames, Grand, Saugeen and Credit rivers. (Ontario Ministry of Natural Resources, 1980).

There are a number of difficulties in assessing benefits from fisheries specifically due to phosphorus-control programs. First, the exact way in which stresses from over-fishing, sea lamprey predation, introduction of exotic fish species, loss of habitat and pollution contributed to depreciation of fish communities is still controversial. Secondly, lag times in the response of fish communities are several years at least. Third, other measures, like sea lamprey control and introduction of Pacific salmon species, make the interpretation of currently favourable responses by fish communities very difficult. And, finally while water quality may have improved for most favoured species, competitive relations with dominant species, inadequacy of restocking programs and, in some cases, over-exploitation of fledgling stocks also may delay potential benefits to some fisheries.

However, there are examples of early benefits to fisheries attributable at least in part to phosphorus-control programs. In most cases degraded fish stocks have begun to recover without stocking (for example; Bay of Quinte walleye and Smallmouth bass, Lake Erie walleye, whitefish in southern Lake Huron, chubs in Lake Michigan and Lake Huron). In other cases, improvements in water quality have acted as a stimulus for fishery managers to begin rehabilitation of formerly valuable stocks that had become virtually extinct. Although there are an unprecedented number of documented recent improvements in fish stocks, only a few cases can be given where decelerated eutrophication can be isolated as the causative factor.These cases are generally found in the larger warmer embayments where water quality degradation was most severe, for example, Green Bay, Saginaw Bay, western basin of Lake Erie and the Bay of Quinte.

The fish community of the Bay of Quinte deteriorated over the post-war period, first with the loss of whitefish, the decline in northern pike and smallmouth bass and, finally in the 1970's, the collapse of a strong walleye population after the 1959 year class passed through the fishery (Hurley and Christie 1977). Fouling of spawning areas by dead and decaying algae, loss of macropytes, reduction in water clarity and changes in macroinvertebrate associations favoured fish species such as the introduced white perch, gizzard shad and alewife. The recreational fishery had relatively little value after 1965. In 1978 several significant shifts in fishspecies abundance were detected. White perch declined while walleye and yellow perch increased. Smallmouth bass have increased slowly over the past dozen years. A more balanced fish community is present and a very significant increase in angling has occurred, based mainly on the walleye. Angling catches of walleye were approximately 83,000 fish in the summer of 1984 and 20,000 during the previous winter (Hurley, 1984). Almost 300,000 angler trips were made during that period. The average daily inputs of phosphorus to Quinte from all sewage treatment plants was 214 kg/day in the 1965-72 period, declined to 156 kg/day by 1983. Algal abundance declined by about 50% since 1977.

Walleye was commercially extinct in Saginaw Bay by 1950, but abundance increased rapidly in the early 1980's. A restocking program obscured the contribution by native fish to the recovery. The angler catch in 1983 was estimated at 21,000 fish, which is remarkable considering that the harvest was virtually zero from the 1940's through 1979. Eutrophication was a major factor in the decline of walleye in Saginaw Bay and phosphorus removal is believed to be responsible for its recovery (Eshenroder 1984).

In Green Bay, Lake Michigan, walleye declined beginning in the 1920's, until only the Menominee River supported a small run by the 1970s (Schneider and Leach 1979). Dams and pollution caused thecollapse of walleye. Dissolved oxygen depletion occurred up to 43 km from the mouth of the Fox River. In the 1970s the fish population of southern Green Bay was dominated by carp, smelt and alewife. With improvement of water quality, Wisconsin Department of Natural Resource's initiated a Walleye fry stocking program in 1979 and continued until 1983. Strong 1980 and 1982 year classes resulted. In 1983 anglers caught approximately 29,000 walleye in the Fox River Area. A smaller fishery returned to Sturgeon

Bay (Lychwick 1984).

The walleye population in the western basin of Lake Erie has been a mixture of stocks from several areas since before the turn of the century. Tagging studies indicate that juveniles and mature walleyes migrate between the western basin, Lake St. Clair and lower Lake Huron (Nepszy 1977). Commercial production peaked in 1956 and declined rapidly to low levels in the 1960s. In 1970 the discovery of mercury contamination closed the fisheries in Ohio, Michigan and Ontario. In 1974 the Ontario fishery was partially opened on a permit basis as mercury levels decined. In 1976 an interagency (Ontario, Ohio and Michigan) quota management system was implemented. Year-class strength, as indicated by Ontario index fishing, was relatively poor in the 1960s but improved in the 1970s and up to 1982. The success rate may be a reflection of improved environmental conditions in the spawning areas of the western basin and reduced exploitation of spawning adults but is also influenced considerably by rates of water temperature rise during the spawning period (Busch *et al.* 1975).

In response to reproductive success and controlled exploitation, walleye abundance in the western basin of Lake Erie has increased steadily since 1970.The increase in stimulated fishable stock has ledto several upward adjustments in quota allocation. The current view of the Walleye Task Group (Great Lakes Fishery Commission) is that the target level of walleye rehabilitation has been attained. Angling has improved markedly, first in the western basin and recently in the central basin. Commercial catches have improved also, from less than 100 tons in the early 1970s to 850-1450 tons per year in the 1980s. However, the apparent shift in age-class structure, with fewer and younger age groups in recent years, could make the population more susceptible to fluctuations in abundance. For example, the almost complete failure of the 1983 year-class will reduce recruitment (Leach 1984).

BENEFITS TO THE AGRICULTURAL COMMUNITY

In most cases rural non-point phosphorus control programs should be considered as soil conservation programs in determining benefits to farmers. With the partial exception of livestock waste management, phosphorus-control programs on farms are erosion-control programs. Soil erosion is a major problem facing farmers, especially in southwestern Ontario where continuous row cropping with large machinery has led to deterioration of soil structure and vulnerability to water and wind erosion. High rates of fertilization and intensive pest management have been necessary to maintain yields. Increased costs of these inputs, fuel, equipment and interest rates, without compensating crop prices, inhibit expenditures on erosion control and livestock waste management.

Southwestern Ontario is the region which contributes highest non-point source phosphorus contributions to the Great Lakes because of both greater unit area loads and downstream transmission. Also, the Lake Erie phosphorus control program, to be successful, requires strong non-point programs in Canada and the U.S. It is fortunate thereforethat the highest priority waters of the Great Lakes are affected in part by agricultural regions of Ontario where farmers will benefit most from phosphorus-control programs.

Remedial programs on agricultural land may be considered in three categories, agricultural practices (fertilization, tillage, crop rotations and variety selection, etc.), structural measures like grassed waterways, and buffer strips and livestock waste management. Benefits vary considerably, from tillage and fertilization methods that are immediately profitable to some structural and waste management measures which may not be feasible without financial assistance.

<u>Agricultural practices</u>

Approximately 80% of the excess output of phosphorus from agricultural areas is attributable to erosion from cropland. Much of this soil and nutrient loss occurs from land under continuous rowcrop production, especially heavier textured soils where tilth has deteriorated due to organic matter depletion, compaction and retarded drainage. Recent studies indicated that the annual cost of erosion, including yield reduction, nutrient and pesticide losses, are approximately $68 million (OMAF 1982). More than 80% of the incurred economic losses occurred in the southern and western regions of the province.

Combinations of various measures in a program of integrated crop management will maximize economic yield and reduce outputs of phosphorus and sediment to surface waters. These measures include the following:

- better crop variety selection in relation to soils and climate
- crop rotation
- more effective use of fertilizer

- modified tillage practices and machinery selection and use
- drainage to enhance soil tilth and productivity

Measures which will reduce phosphorus and soil losses that are readily adaptable and profitable in the short term to many farm operations involve more efficient use of costly inputs - fertilizers, fuel, machinery and labour. Fertilizer efficiency can be improved by use of soil tests and associated recommendations, by timely application, split applications, and optimum placement. Animal manures and legumes in crop rotation will contribute significant nutrients and improve tilth of the soil.

Conservation tillage, in its many forms, is aimed at maintaining significant crop residue at the soil surface and reducing the number of times the soil is worked. Fuel and labour savings are possible fromoptimum selection of machinery and conservation tillage in many farm operations. Conservation tillage and fertilization practices offer the greatest potential for reducing phosphorus outputs from cropland over the next several years with practices which will return short and longterm benefits to farmers. In the short term, with a reduction in soil losses of about one-third (ESCC 1983), savings would be about $30 million annually through improved yields and less fertilizer and pesticide losses. Long-term benefits to farmers have not beenestimated, but certainly would relate to a widening gap in land values between well managed and degraded cropland.

Reduction of phosphorus and soil losses by replacement of continuous rowcrops with crop rotations would be effective, but progress certainly will be slow.While it may be beneficial tointerrupt corn production with red clover and close-sown grains, cash-crop farmers are unlikely to be attacted to longer rotations with spring grain and hay crops because of difficulties in adding equipment and developing markets. However, if the profit margin on cash crops narrows, because of higher input costs, pest-control difficulties or less stable markets, a more diversified agriculture may return to southwestern Ontario farms. At the present time, however, short-term dislocation would appear to detract from longer-term benefits.

Results of experimental studies on the economics of soil erosion control have been mixed. One viewpoint is that farmers are mostprofitably using their resources (in the short-term) producing intensive rowcrops with conventional tillage systems (Stonehouse 1983), although soil conservation may be practised for other reasons in spite or reduction of profits. In the longer term, declining soil fertility and productivity, remedial costs, reduced equity probably outweigh short-term costs, if farmers had the money. Other studies challenged the maximum profitability of both continuous rowcrops (corn, soybeans) and conventional tillage practices.Deloitte Haskins & Sells Associates (1983) concluded that there was a distinct economic advantage in net dollars returned per hectare by altering crop rotations and/or introducing conservation practices. For example, an increased net return of $21.14 per hectare per year can be realized from a corn/red clover rotation.

In studies in Ontario on course-textured soils (Bos and Richards 1983) grain moisture content and yield were similar for conventional and conservation tillage. The no-tillage system produced lower yield than the moldboard plough in two out of three comparisons. In another Ontario study on sandy loam soils (Vyn *et al.* 1982) conservation tillage systems for corn based on fall chisel-ploughing, spring offset discing or spring plough-plant all yield within 3% of fall moldboard plough systems. Zero-tillage systems in continuous corn had yields 10-15% lower than conventional systems on all soil textures except on course sands and gravelly loams in Ontario. The no-tillage system may produce better results if it is incorporated into a crop rotation following sod or a winter cover crop, average yields were within 4% of conventional tillage systems in these situation (Vyn *et al.* 1979).

On medium textured soils Bos and Richards (1983) found tew differences between tillage treatments for plant population, number of leaves per plant, plant height and silking rate. In two cases a fall mulch till treatment out-rated a fall moldboard plough and a spring mulch till treatment in height, silking, grain moisture content and grain yield. In Ontario, research has shown that loam and silt loam soils should be considered separately. On loams many conservation tillage systemsprovide comparable yields to conventional tillage. On silt loams the conventional systems consistently yield 4 to 8% more than such practices as fall chisel ploughing and spring moldboard ploughing in a continuous corn system (Vyn *et al.* 1982). In studies on fine soils by Bos and Richards (1983) there was a trend to highest yields with conventional tillage.

Four out of Seven treatments indicated higheryields from the moldboard plough treatments. Fall moldboard ploughing yielded the highest corn production on clay loam soils, with fall chisel ploughing within 6% (Vyn *et al.* 1982) and, on heavy clay such as Brookston, yields for fall chisel ploughing have averaged 13% lower. Obviously different soil types are more or less amenable to conservation tillage and profitability varies considerably. However results of short-term experiments may be less promising than results to be expected following improvement of tilth and organic matter of soils. Also, changes in the economy such as market prices, cost of fuels, etc., may change competitive advantages among crop production techniques.

The U.S. Environmental Protection Agency, in cooperation with the National Association of Conservation Districts, assessed costs and yields of corn and soyabeans on more than 1800 plots in 31 Lake Erie counties of Indiana, Ohio and Michigan. Yields with no-till and ridge-till were competitive with yields produced under conventional tillage systems. Costs of production for conservation tillage systems were less than or equal to costs of conventional systems and conservation tillage systems reduced phosphorus loadings without increasing herbicide usage (EPA 1984).In the Lake Erie Wastewater ManagementStudy (Yaksich and Pumer 1980) economic analysis showed an increase in net farming income (up to $4.00 per acre) for users of conservation tillage and no-till planting of rowcrops. In the Honey Creek Study (Crumrin and Wurm 1980) in Ohio the net returns from three tillage methods were as follows: conventional fall plowed - $212 per hectare, reduced tillage - $268 per hectare, no-till - $182 per hectare.

A total of 73% of the watershed was amenable to reduced tillage and no-till; the balance required conventional tillage.

Structural measures

Buffer strips, grassed waterways and windbreaks can be highly useful in reducing phosphorus and soil losses. Benefits to the farmer may include savings in tile drain, machinery repairs and sometimes repairs to the land itself. Some individuals may profit from haycrops; others may lack the time and equipment to maintain these facilities. The main disadvantage is removal of land from production of the most profitable crops. In general there may be few short-term benefits, consequently only the most severe erosion problems will be dealt with by taking land out of production. One likely exception is buffer strips along drains where the costs of maintenance warrant improved design to include lower sideslope angles and buffer strips. OMAF (1982) estimated an annual saving of $2 million in municipal drain maintenance costs following implementation of a 10-year soil conservation program, much of which would accrue to farmers.

Livestock waste management

Approximately 20% of annual phosphorus output from farmland is attributable to loss of phosphorus from animal manure. Locally, this proportion may be significantly greater, as recent studies have shown (e.g., Pittock Reservoir watershed) because of losses through field drainage systems and concentrations of livestock. Unlimited access to streams by livestock contributes nutrients and sediment.

Animal health may be affected by water quality and succcess of containment and treatment of livestock wastes, but this is not substantiated, and the overall significance to the livestock industry is unknown. Only a relatively small fraction of nutrients in livestock wastes are lost to surface waters, compared with the large amounts produced by over two million animal units in Ontario. Consequently the dollar value of lost nutrients is not large, although poor waste management may be uneconomical in terms of lost potential to enhance soil tilth and nutrient levels.

In summary, it is worthwhile emphasizing that benefits from agricultural remedial programs are not limited to phosphorus and soil loss reduction and, in fact extend to local municipalities and their population. On the farm there may be reduction in safety hazards (gullies, ditchbanks), less loss of pesticides and nutrients other than phosphorus, improved drainage and workability of the land. In rural municipalities benefits include reduced drain maintenance costs with efficiency of drains, improved water quality for livestock, and enhanced fisheries, wildlife and aesthetic qualities.

COINCIDENT REMOVAL OF OTHER POLLUTANTS

While the phosphorus control program is aimed at curtailing eutrophication of the Great Lakes, most remedial measures remove other pollutants. It seems appropriate to consider removal of other pollutants and abatement of other problems as ancillary benefits of a phosphorus-control program.

Non-point sediment and phosphorus control are closely related in terms of remedial measures but control of sediment losses will provide some distinct, additional benefits, particularly in reducing maintenance costs of harbours and drains and protecting the spawning habitat of fish in streams and lakes.

Reduction in microbiological contamination will occur with better containment and use of livestock wastes and elimination of illegal connections to field drains. This will be essential to improve water quality for recreational use in Ontario lakes and reservoirs and locally in Great Lakes nearshore waters.

Information is lacking in Ontario on reduction of metals with phosphorus removal in tertiary treatment at sewage treatment plants. However, one intensive study in Massachusetts showed significant copper removal with alum and sodium aluminate treatment; the latter enhanced chromium removal and lead probably was reduced also (Aulenback *et al.* 1984).

SUMMARY

The first phase of the phosphorus control program with reductions in detergents and at sewage treatment plants, has produced a variety of benefits through the period 1970-1984. Foremost among these arerejuventation of recreational fisheries in many parts of the Great Lakes and recreational benefits to shoreline users as a result of reductions in *Cladophora* outbreaks to manageable proportions; Improvements in water supplies have net given large savings in terms of water treatment costs, but in a few cases, very expensive public works likely have been avoided because water quality was maintained at manageable levels. In general benefits have been confined mainly todirect users of Great Lakes water, recreational and fisheries resources.

Although changes usually are compared with the pre-phosphorus contol period, a more realistic comparison is to consider the implications of potential water quality in the absence of phosphorus control. This comparison has been made in limnological terms only. For example, model studies by Schertzer and Stevens (1984) proposed that epilimnion phosphorus concentrations in Lake Ontario now would have been 10 ppm greater in 1983 (than is, about 60% greater than observed) without phosphorus control. In Lake Erie hypolimnion oxygen depletion would be substantially more prevalent than observed. In many cases fisheries rehabilitation would not have been attempted at all and Lakeshore recreation would have declined further. Major expenses onmodern sewage treatment systems, (which comprised the main costs of the Great Lakes cleanup, and not the low marginal costs for phosphorus removal) would not have returned benefits largely attributed to the removal of phosphorus. In fact, some major water supply works may have been inevitable.

There is a growing awareness now that water quality issues in the Great Lakes must be dealt with in multi-dimensional programs. For example, abatement of the *Cladophora* problem may be a hollow victory if bacteriological impairment seriously interferes with beach use. Rehabilitiation of fisheries in terms of fish stocks is an irrelevant accomplishment if contaminants jeopardize the usefulness of the harvest. Also, some local problems on the Great Lakes and many problems in inland water may receive little or no relief from the first stage of the phosphorus reduction program, particularly where non-point phosphorus sources are implicated. In fact, target loads for Lake Erie and Lake Ontario cannot be met until non-point sources are managed also.

The most compelling argument for completion of the full phosphorus control program, including non-point sources, is the extension of benefits to the basin and the opportunity to address simultaneously and efficiently other issues such as the very serious problem of deterioration of the best agricultural land in Canada. The second phase of the phosphorus-control program, in addition to extending current benefits in the Great Lakes, will provide benefits unattainable in the first phase. Among these, benefits to the agricultural community will be considerable in the short term and vital in the long term. There will be savings to governments which must allocate much of their current budgets to maintenance of public works, municipal drain maintenance, cleaning culverts and dredging harbours. Also, considering the importance of inland rivers, lakes and reservoirs in southern Ontario for outdoor recreation, their vulnerability to water quality impairment can be decreased significantly.

The second phase of the phosphorus control policy has emerged as a special challenge to policy makers in public and private sectors - to deal effectively with environmental quality issues in terms of resources management accross all resource sectors. Environmental quality management is in the process of maturation, from a progression through a series of pollutants and remedies considered often in isolation to a strategy which emphasizes the interrelations among resources and their uses and misuses and the optimization of benefits across sectors.

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APPENDIX 2

Proposed Phasing of Implementation

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Proposed Phasing of Implementation of the Phosphorus Management Plan for the Great Lakes

	1984	1985	1986	1987	1988	1989	1990
Lake Ontario							
Target Load Confirmation	____						
Allocation to Canada/U.S.A.	____	____					
Implementation							
Upper Lakes							
Municipal Improvement and compliance	____	____	____	____			
Lake Erie							
Industrial Compliance	____						
Municipal Compliance	____	____	____	____			
Agricultural Programs		____	____	____	____	____	____
Environmental Monitoring and Modeling		____	____	____	____	____	____

<u>Review of Program Effectiveness</u>
Dec.1988