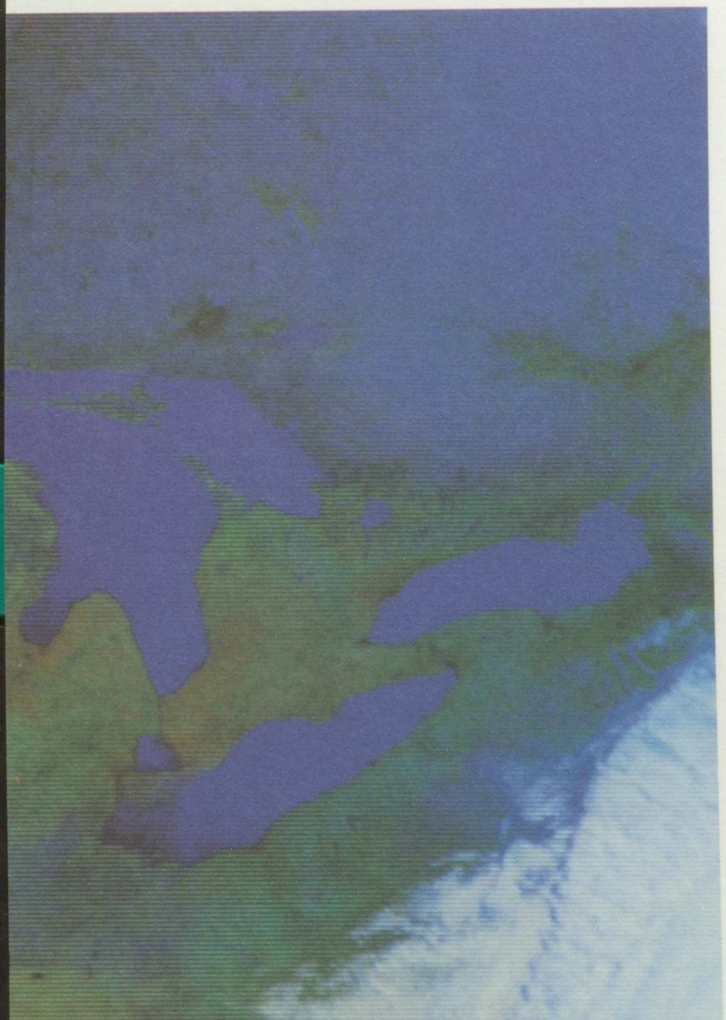
1989-07-01

Living With the Lakes: Challenges and Opportunities: A Progress Report to the International Joint Commission

International Joint Commission. Project Management Team

Living With The Lakes: Challenges and Opportunities

A Progress Report To The International Joint Commission



A satellite view
of the Great Lakes.
Photo courtesy of
the Atmospheric
Environment Service,
Environment Canada.

Living With The Lakes: Challenges and Opportunities

A Progress Report To The
International Joint Commission

July 1989

Submitted By The
Project Management Team

This publication contains recycled fibres.

Table of Contents

List of Illustrations

List Of Tables

sensitive to human activity, potentially confounding even well-intended actions by unexpected and undesired side effects. It signifies the need for greatly expanded analysis of ecological effects in the context of governing activities on the lakes.

• Misunderstanding and misperception of the problem mean that governments need to undertake broad and multifarious programmes to inform the public about water level fluctuations and their consequences. These misunderstandings and misperceptions signify that the expectations and desires of public and private interests, once informed, could change radically from those that prompted this study.

• Impediments due to the nature of current governance means great difficulty in reaching agreement at any level on policy regarding measures to alleviate adverse consequences of fluctuations, much less in taking concerted bi-lateral or multi-lateral action. They signify the need for a common strategy for the Great Lakes — St. Lawrence River Basin and for new and innovative fora to effect policy and programme formulation.

Certain fundamental factors are important to a general understanding of the nature of the problem:

Levels and flows of the Great Lakes — St. Lawrence River System are never constant. There have been record lows in the 1920's, 1930's and 1960's and record highs in the 1950's, 1970's and, most recently, in 1986. The lakes also fluctuate seasonally. Many studies have indicated that human interventions have relatively minor impacts on fluctuations in comparison with natural forces, and that storms induce the most dramatic changes in local levels.

By and large, static levels are determined by the differences between net basin supplies (overlake precipitation plus inflows minus evaporation) and outflows. When net supplies are larger than outflows, a lake will rise and vice versa. Major changes in levels require a trend in supplies over months or years. The recent high levels of 1985 and 1986, for example, were caused by consistent above-average precipitation in the Basin. Local levels generated by storm conditions, of course, occur within hours. Predicting changes in levels is made difficult, if not impossible, by the unreliability of long-term supply forecasts. Short-term forecasts, while more accurate, allow little time to react. Also, short-term forecasts are of little help in either predicting or dealing with long term trends in fluctuations.

Shoreline erosion, of major concern to some interests, is the result of dynamic natural processes, sometimes exacerbated by human activities, such as shoreline structures. They shape the contours of the shore, according to its geomorphology. These processes are affected to varying degrees by fluctuating water levels, especially the local exaggerations from storm surges. For many shore types, however, fluctuating water levels have little effect on long-term recession rates. Better knowledge of shoreline features would enhance the ability to project effects of changing levels and flows on erosion.

Besides the problem of erosion, fluctuations affect different groups of people (hereinafter, interests) in different ways. High levels are feared by shoreline property owners. Low levels hamper recreation, constrain hydroelectric power production and jeopardize commercial shipping. On the other hand, fluctuations are considered beneficial for the environment. Further complicating this picture is the fact that interests are differently affected when levels are extremely high or low, that is, outside a generally accepted band. Moreover, a particular interest may have objectives at one location which may conflict with their objectives at a different location.

Currently, governments lack the tools to measure these effects on interests in a systematic way. Past attempts, which have inadequately considered the systemic complex and ecosystem dynamics in alleviating adverse consequences to a particular interest in a specific locale, are construable as futile in the systemic perspective. Also lacking is comprehensive and coherent agreement on how benefits and costs of government action should be distributed and shared. A systemic approach, by contrast, must encompass the interrelatedness of the parts, dynamic change, and the inevitability of new and unexpected concatenations of all influential factors.

This study poses a watershed in understanding of the problem and in evolving an approach to concerted and logical action.

First, Phase I identified the priority goals of developing a set of principles to guide decision-making, a strategy that could educe coherent and effective government action and a methodology for evaluating measures for specific, local scenarios in a broad and systemic context.

Work towards these goals has begun, producing the following: a preliminary mapping of interrelations among components of the natural and human systems; indications of the positions held by interests; and a coalescing sense of need for an overall strategy of governance. Parallel to this work possible measures have been catalogued and a methodology drafted for evaluating them in an orderly and organized manner. It will be important in Phase II to ensure coherence and consonance among guiding principles, an overall strategy and the criteria used in evaluating measures.

Secondly, Phase I also concludes that measures, particularly combinations of measures, may have high potential for alleviating adverse consequences at specific locales. Discoveries concerning systemic context, ecological dynamism, public misunderstanding and governance impediments do not converge to rule out the potential utility and broad efficacy of solutions tailored to unique, local circumstances. The taxonomy of possible measures and the draft evaluation methodology relate impacts of fluctuations to generic interests and suggest groups of certain measures, thereby expanding our understanding of the overall problem.

Phase II shall aim, then, at four collective objectives:

- a set of binational principles as guides for decision-making;
- an overall strategy and general plan of action;
- improvements in governance;
- refinements in understanding of critical aspects of the system.

Included under these rubrics, specific topical objectives will be accomplished, such as improvements in existing Regulatory Plans and creation or refinement of analytic tools, such as a Geographic Information System. Phase II will also describe prototype remedies, consisting of sets of measures, suitable for generic local settings, such as urban water fronts, areas of dense recreational use, and environmentally sensitive or vulnerable sites. As requested, an information/communication programme for governments will be developed.

The base built in Phase I of this study will assure the success of Phase II. The issues are defined and many of the potential solutions can already be seen in outline. The task of Phase II will be to bring these beginnings to fruition and, thereby, to give governments in future decades clear guidelines for the management of the water levels and flows of the Great Lakes — St. Lawrence River Basin.

Foreword

On August 1, 1986, the Governments of the United States and Canada asked the International Joint Commission to examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes – St. Lawrence River Basin. In the Commission's Directive of April 10, 1987, the complexity and unprecedented scope of the Reference was clearly recognized. In order to attempt to carry out the task assigned, the study was organized under a Project Management Team consisting of two co-chairs, two deputies of the co-chairs, two lead staff from the Commission and co-chairs of five functional work groups. The present report is an interim, progress report of the Project Management Team.

At the time the Reference was received, water levels of the lakes were at or near recorded highs for this century which led to an initial emphasis on high water levels and interim emergency actions which could be taken to bring relief to interests harmed or threatened by the high levels. An interim task force dealt with the emergency situation existing at the time and the study team addressed the long-term systemic issues associated with fluctuating water levels and flows.

From the beginning, it was recognized that most of the issues associated with fluctuating levels and flows in this international system were complex and interconnected and were not amenable to single, one-time solutions. However, as the study progressed, it became apparent that one of the prerequisites for managing water levels issues over the long-term was a better appreciation of how fluctuations in levels and flows influence the relationships between humans, their institutions and the Great Lakes – St. Lawrence River System. It was also recognized that some short-term actions intended to alleviate adverse consequences could in reality increase overall susceptibility to fluctuations in levels and flows.

Study participants were aware of the Commission's previous reports on regulation of Great Lakes levels, which have encouraged appropriate jurisdictions to institute improved shoreline management practices. They also knew that these earlier studies had not had a great deal of influence. There was a clear sense that this study must be more than an updated version of earlier studies.

The specific tasks and questions raised in the Reference continued to serve as reminders that the practical questions needed to be addressed. At the same time, the increased focus on long-term considerations allowed for reflection and re-thinking. As the study developed, the information, ideas, insights and perspectives that emerged in the functional work groups led the Project Management Team to consider other matters which it saw as being relevant and, in the minds of many, essential to the overall purpose of the study. In a very real sense, the study has been a learning process that has focussed as much on clarifying the thinking as it has on data gathering to answer specific questions. Some might argue that the primary contribution of this first phase of the study has been to redefine the basic questions and tasks which need to be addressed if our two nations are to find workable ways of managing the issues associated with fluctuating water levels and flows in the system.

This report reflects these different, but complementary approaches. Some of the issues raised were brought a long way toward completion; others require more time and resources than were available for the first phase of this study. This is, then, a progress report, which, together with its annexes, reflects the work that was completed in response to specific undertakings identified in the Reference, the Directive, and the Plan of Study. At the same time, the report reflects the considerable effort directed at identifying and addressing questions which were not always identified in earlier documents. Many of those involved in the study saw this reformulation of some of the basic concepts, questions and tasks as essential steps in developing an overall understanding of issues associated with fluctuating water levels. These reformulations are a reflection of the evolving nature of the study and will, it is hoped, prove to be a substantial contribution to addressing the issue of alleviating the adverse consequences of fluctuations in water levels and flows in the Great Lakes — St. Lawrence River Basin in its broadest sense and to posing the challenges for governments arising out of these consequences.

Chapter

1

Study Background

The years 1985 and 1986 will long be remembered by the inhabitants of the shores of the Great Lakes as a time of high water, floods, frustration and bewilderment at the behaviour of the water levels on the huge, inland lakes which contain one-fifth of the world's supply of fresh surface water. Some saw their homes swept away; others watched the large wetlands inundated and replenished for fish and wildlife; some worried about municipal roads and problems relating to the operation of sewage treatment plants; others produced additional hydropower and transported goods more efficiently. It was those who suffered damage, however, who were most upset by the extremely high water levels and it was their voices which were heard in the government chambers of both the United States and Canada.

On August 1, 1986, the United States Department of State and Canada's Department of External Affairs issued separate letters to the International Joint Commission requesting that the Commission "examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes—St. Lawrence River Basin." (*Lake Levels Reference*)

The concern about periodic variation of water levels on the Great Lakes was neither new nor simply a response to specific, regional pressure. Use of the waters of the Great Lakes—St. Lawrence River Basin, as shown in Figure 1, has been of historic importance in the economic and social development of the region. The benefits of deep draft commercial navigation, cheap hydroelectric energy, and the concentration of huge industrial production have all been reflected in a high standard of living and have been made possible through the development of the water resources available within the Basin. This focus on development, regulation, and control constituted the historic attitude toward the resource, and is reflected in the 1964 request by the two governments to the International Joint Commission "to determine whether measures within the Great Lakes Basin can be taken in the public interest to regulate further the levels of the Great Lakes, or any of them and their connecting waters so as to reduce the extremes of stage which have been experienced...". (*Great Lakes Levels Reference*, October 7, 1964). Ironically, this reference was in response to conditions after a period of severe drought and corresponding low lake levels.

The results of the 1964 Study did not follow as quickly as anticipated. It took ten years of technical investigation and twenty-two public hearings before a final report was submitted to the Commission. By that time, the looming environmental concerns associated with intensive uses of the region and the increasingly sensitive recreational and residential presence in the system had begun a process of re-assessment and re-consideration of the basic approach to the question of water levels and flows; the Report argued that only limited regulation of actual water levels was advisable and that many other, non-structural methods of dealing with fluctuating water levels, such as planned and regulated development of land use along the shorelines, should be explored. Up to this point the focus of the studies had been on regulation of the water levels. The shift in focus from regulating lake levels to other methods of dealing with the impacts of water levels opened the investigation to a vast range of questions which amounted to a philosophical and methodological change in thinking.

The recognized need for a new approach was evident in the report, *Great Lakes Diversions and Consumptive Uses* (1985). The Report summarized it very succinctly: "The Commission believes a holistic approach to the resource is necessary..." The investigation into diversions and uses had quickly run up against the inadequacy of knowledge, particularly in environmental, social and economic areas, and the confining limitations of the mandate. Future approaches to the issue had to be new, comprehensive and open-ended. There was not just one problem with one solution, which would resolve the issue for future generations. There were many problems, or, perhaps better stated, clusters of problems; they were changing and evolving; they were subject to factors completely outside of the specific parameters of the Basin in climatic, legal, economic and political realms; their nature and implications were largely unknown; and, by no means least, stakeholders and interests had to be reached more effectively and included in the process of decision-making.

It is immediately against the background of the conclusions of the report on *Great Lakes Diversions and Consumptive Uses* that the Reference for the present study must be seen. On the one hand, the adverse effects of the high and low water levels had to be alleviated and ways of bringing down the water looked at; on the other, it was felt the net must be cast more widely to include review of previous work, analysis of land use and shoreline management practices, assessment of impacts on the full range of interests and an improved method of informing the public. (News release, International Joint Commission, September 10, 1986) As the Reference goes on to say, "Wherever appropriate, the Commission is encouraged to use improved analytical techniques which would best represent the changing conditions and socio-economic values in the Great Lakes region."

Although the Reference is deceptively simple in its statement, the implications for the Commission were, and are, much larger. The requirement is really for a new paradigm, a new way of thinking about the future of the Basin, a new way of solving problems and making decisions and a new methodology for assembling and analyzing information. In its news release, the Commission recognized the size and scope of the undertaking in general, even if not in detail: "The Commission appreciates and welcomes the fact that this far-reaching Reference will involve new initiatives and that its nature and terms authorize the Commission to undertake new approaches far beyond those authorized in previous References." (News release, International Joint Commission, September 10, 1986)

How to do it? After a series of meetings and discussions, the Commission decided to invite a number of specialists to come together to discuss the designing of the study. The workshop took place January 13 and 14, 1987 and its proceedings were recorded and distributed as *Design Exploration Discussions Regarding the Great Lakes Levels Reference*. The agenda included speakers on fluctuating lake levels, climate, ecology, land use, modelling, conflict resolution and mediation, and economics.

What had been foreseen by the Commission was confirmed by the presentations and discussions of the workshop: The Great Lakes Basin had to be thought about in a more comprehensive manner. Whatever short-term actions might be taken, the Commission had to develop a long-term strategy which would recognize that "given the unknown fluctuations in the natural system, the multiple jurisdictions, the diverse stakeholders' interests, the process of accommodation is diverse and complex". The process of decision-making and implementation would have to take into account the often conflicting agendas of the various interests concerned about the fluctuations in lake levels. No solution, including do nothing or total control of the levels, would satisfy all interests and, indeed, no solution would satisfy similar interests in different areas of the Basin. While extremely high water may replenish wetlands and run hydroelectric generators at or over capacity, it may also com-

Figure 1: GREAT LAKES - ST. LAWRENCE RIVER BASIN

bine with storms to erode shorelines and damage lakeshore property. The task of the Commission was to map out a strategy which would be both responsive to the concerns of the interests and responsible to future generations, to secure and analyze data and inform and involve the interests and the public so that decisions and actions might be made with a substantial amount of consensus.

This realization was both realistic and difficult. It seemed obvious to all that there was no single, simple solution, but addressing the positions of many interests is basically the balancing of competing values. Each interest presented a value-based argument, that is, an argument for what that interest interpreted as a "good"; how can these "goods" be weighed and evaluated against one another? A common ground had to be found, if possible, which was coherent with an overriding common good. What was the common good? What was the common ground? These were the underlying and informing questions that had to be addressed by the study process as a whole and by each work group implicitly, if not explicitly.

The acceptance and, then, affirmation that disagreement was basic to the process led to the approach taken in the Plan of Study and the organization of the work groups. After further consideration, the Commission issued a *Directive* on April 10, 1987. The *Directive* foresaw four steps necessary to the successful completion of the work: 1) Review and analysis of the physical, economic and environmental situation; 2) Identification of critical issues; 3) Development of a full range of measures and an evaluation of their impacts and implications; and, 4) Formulation of recommendations for future consideration and action.

In order to carry out this work, five Functional Study Groups would be organized. These Groups would bring their findings, questions and concerns to a Project Management Team consisting of an executive and the chairs of all the functional groups. The Project Management Team would be responsible for "the conceptual, technical and administrative integration of the study". Overall policy leadership, ratification of decisions and recommendations would be given by the six Commissioners, advised by a Steering Committee, consisting of the co-chairs of the Project Management Team, two Commissioners, and two lead staff of the International Joint Commission. Project Advisory Groups would be formed, where necessary, to give advice to the Commissioners. As it turned out, several Project Advisory Groups were set up to provide advice to the Functional Groups. The membership of all committees and groups would be strictly bi-national and the Project Management Team would be headed up by bi-national co-chairs. Later, an Executive Director was appointed to facilitate the administration of the project.

It was decided that three of the five functional groups would be organized on a subject base, that is, they were to look at areas affected by lake levels, and two were organized on a functional base, that is, they were to examine how the process of redress and management was to be conceived, explained and organized. The *Directive* envisaged their areas of responsibility as follows:

Group 1 — Hydraulics, Hydrology and Climate (subject oriented)
Group 2 — Coastal Zone Ecology, Resources, Uses and Management (subject oriented)
Group 3 — Socio-Economic and Environmental Assessment (subject oriented)
Group 4 — *Public Participation and Communications (functionally oriented)*
Group 5 — Systems Analysis and Synthesis (functionally oriented)

The groups were to be interlinked by a common task of developing "an analytical framework" with Group 5 and through participation by the functional group co-chairs in the Project Management Team (PMT).

Finally, the *Directive* appointed the Regional Director General (Ontario), Environment Canada, and the North Central Division Commander of the U.S. Army Corps of Engineers, as members of the Steering Committee and co-chairs of the Project Management Team with instructions to proceed with appointing chairs for the Functional Groups and mapping out a Plan of Study for the Reference.

As the groups were assembled and initial discussions began and as the Plan of Study was being thought through in its detail, the size and complexity of the undertaking became more and more evident. In November, 1987, the Project Management Team co-chairs released a background paper for the Plan of Study, which explored some of the larger issues that would characterize the study and the concerns with which the groups would have to deal. It was clear that a new flexibility of approach and a long-term effort was required. In the *Background Paper*, the co-chairs speak of "a continuing analytical capability", "future decision-making", and updating of models.

The *Background Paper* also emphasized, without trying to anticipate the results of the functional groups' deliberations, the possibility of a combination of solutions rather than one solution, be it regulation, management or legislation. The study had to produce some specific recommendations to deal with the effects of the fluctuating lake levels, but it foresaw that they had to be placed in the perspective of a long-term management solution or process of combining solutions. "This study, while identifying point-in-time solutions for current lake level problems, has as its expressed goal and purpose to initiate a continuing management process that will be geared to enhancing understanding of the options for both high and low water conditions available for consideration by Governments over time."

The size of the undertaking and the problem of meeting the 1989 deadline had to be faced and the *Background Paper* projected a phasing of the study. Phase I would be submitted in the form of a report on May 31, 1989, as planned, but a second phase, which would extend and complete elements of Phase I, would continue into 1991. Phase I, therefore, would contain:

- a characterization of fluctuations and consequences
- a comprehensive inventory of measures
- a systemic and comprehensive evaluation framework

Phase II would contain:

- a refinement of data bases
- detailed evaluation of selected measures

In addition, a programme of public participation and communication would be created as an on-going element of the two phases, and, in Phase II explicitly, an Information Programme for use by Governments would be developed. In the final *Plan of Study*, the communication component was explicitly included in the two phases of the study as an Information Program for use by Governments.

The *Plan of Study* further detailed tasks for each of the Functional Groups which would provide the preliminary material needed for a comprehensive report. These tasks, in effect, described what the Project Management Team envisaged as the scope and substance of the Study.

It is always difficult at the beginning of a large and complicated task to envisage the final product (which, of course, is what was demanded of the formulators of the *Plan of Study*). The selection of specialists from so many different disciplines and backgrounds was, in itself, an assertion that the Commission wished the study to be more than a simple analysis of pre-determined topics or the completion of pre-assigned tasks.

The intense discussions which ensued both in the Functional Groups and at the Project Management Team level led to changing priorities, conceptions and even scope of work, and, although the *Plan of Study* held as an overall guide, many of the emphases changed. What had been seen as complex but containable in the four areas mapped out in the *Plan of Study* proved to be anything but containable. Again and again, the functional groups and their subgroups felt the need to start from the beginning and re-assess exactly how the issue should be dealt with, what the priorities were, and where the greatest inroads could be made in developing solutions that would allow Governments to approach the issue of the fluctuating water levels with coherent and effective policies.

Three issues, which were to re-direct inquiry at points in the study and which arose from the discussions of the Functional Groups were agreement on principles and strategy, governance, and public participation and involvement. Although none of these issues is specifically foreseen in the *Plan of Study*, each of them is entwined in the very mechanisms of carrying out the majority of tasks assigned to the Groups.

Succinctly stated, the issue of agreement and strategy posed the question, How can you proceed to select measures or structure evaluations before you have established a preliminary strategy for deciding which measures are relevant and how, or if evaluations should be weighted?

Under the general term governance, the question of authority and jurisdiction was raised. Who is responsible and how is that responsibility structured? What kinds of problems are we dealing with? Do not the answers to these questions determine how you approach the entire Study? Otherwise, the measures will be too general and not formed for real jurisdictional implementation, and the evaluations will not be judged in relation to the positions of the interests.

The discussions of public participation and involvement raised the most basic issue of democratic society: It is easy to espouse public consultation, but how do you do it? And what does it mean? Education? Opinion surveys? Essential roles in decision-making? Open procedures? And, at what stage? Moreover, surely the accurate and continual flow of information is basic to all processes envisaged in the Study and needs to be structured into those processes from the beginning. The Information Program outlined in the *Plan of Study* was just the tip of the iceberg.

At early stages, such questioning discourages work already being done in areas which seem basic and essential to any understanding of the situation in the Great Lakes Basin. In the long run, it stimulates further enquiries and clarifies the reasons for and potential of much of the work already being done. The other consideration that comes to the fore is that there is a range of basic work in any area of enquiry—data accumulation, measures identification, evaluation delineation—which must go on even as the problems and approaches are re-thought. Indeed, in a dynamic decision-making process the basic orientations will continue to be re-thought in response to new data and additional opportunities for evaluation and action, and, in turn, these new questions will influence future tasks outlined in future studies.

The problem for the Project Management Team was to incorporate the new directions into the Study with both a clear appreciation of the knowledge already acquired and a recognition of the formative role of the new insights and perspectives that had arisen in the process of working through the directives of the Reference. In the last days of 1988, the Project Management Team Co-chairs issued the *December Plan of Action*, which outlined the timetable for completion of the work envisaged in the *Plan of Study*, and proposed an outline for the report on Phase I of the Study. A structure of nine chapters was proposed, each group contributing to one or more of them. The basic four parts of the *Plan of Study* were included and the new directions and knowledge incorporated in such a way as to attempt to give a context for the subjects handled in each chapter. These chapters subsequently became the Annexes of the present progress report.

It is hoped that this approach, which addresses several dimensions of the problem simultaneously, not only will give useful guidance to Governments in their policy formulations, but also will itself become a part of the changing, responsive and open-ended process of decision-making which is envisaged for the management of the Great Lakes—St. Lawrence River Basin in the future.

Chapter 2

The Whole is Greater Than The Sum of its Parts

The pressure for solutions in the face of crisis is overwhelming. There is no time for lengthy considerations. However, once the immediate crisis has passed or been dealt with, it is necessary to develop a strategy to deal with future crises. That, briefly, is the task of the present study on Great Lakes – St. Lawrence Basin water levels.

The Problem

Every inquiry begins with a problem. In a profound sense, this inquiry has been an extended attempt to state what that problem is.

The Reference to the International Joint Commission simply asked that the Commission "examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes – St. Lawrence Basin". After thousands of hours of discussions with experts, managers, policy makers, business people, environmentalists, and citizens of Canada and the United States, that "problem" seems anything but simple.

The first item that needs clarification is, What is an adverse consequence? There are over thirty-nine million people living and working in the Great Lakes – St. Lawrence Basin. In one way or another, they all benefit from the waters and are affected by their levels. However, they are affected in different ways.

This inquiry began because of extraordinary high water levels and storms in 1985 and 1986. The people who live, own property, or have facilities on the shorelines of the lakes react most quickly because they experience the immediate threat – flooding. These "riparians" see "adverse" as primarily damage to property, both to structures and to the shoreline through erosion. Amongst the shoreline interests, however, there can be a considerable range of reaction: The cottager picturesquely perched on the shore of a lake, the municipality maintaining sewage treatment facilities or roads near the lakeshore, the farmer drawing water for irrigation, and the recreationalist using one of the Basin's many marinas have varying levels of tolerance and expectations and different resources for dealing with the fluctuations. But even this picture is too simple; it is not possible to delineate the positions of the interests so clearly. The riparian homeowner may dock his boat at the local marina, fish, and enjoy watching migratory waterfowl flying into their nesting grounds. His or her children may swim at the nearby beach. The electricity used to cook dinner comes from a hydroelectric facility in the Basin. The corn they have with the meal was originally developed by the native peoples of the continent and may be grown locally in a field irrigated by Great Lakes water. To pay for the home, the riparian may work in a steel mill whose raw material is shipped in on a 1,000 foot long vessel through the Great Lakes — St. Lawrence Seaway transportation system.

The effect of fluctuation of the water levels also may be of an entirely different scale on one lake from another. In 1985 and 1986, for example, the record high water levels of the upper lakes were not experienced on Lake Ontario.

Whereas the high water levels are "adverse" for many shoreline interests, extreme low water levels are "adverse" for others, such as recreation, hydroelectric generation and commercial shipping, and for those who draw water from the Great Lakes, their connecting channels, or a groundwater source dependent on Great Lakes levels. Historically, the levels have hit record lows in the 1920's, 1930's and 1960's and record highs in the 1950's, 1970's and 1980's. "Adverse", therefore, has to be defined for both lows and highs and for the many different interests. It also has to be put on some sort of scale in order to determine whether we are talking about an inconvenience or a catastrophe.

To complicate an already complicated situation, there are some aspects of the system, notably the natural ecology of the region, which benefit from the fluctuations themselves and even from their extremes. The periodic high levels flood and flush the vast, but shrinking wetlands of the Basin, renewing them for the myriad of fish and wildlife needs, such as spawning, nesting, feeding and cover. The lower levels which follow promote the growth of aquatic plants, grasses, and other associated vegetation. What is an aberration for the shoreline owner is the life-support process for the inhabitants of the wetlands. In fact, the wetlands are damaged by there *not* being periodic fluctuation. This consequence suggests that there is another side of the coin to alleviating adverse consequences and that is enhancing, or, at least, maintaining beneficial consequences of fluctuating water levels. (See Annex B, especially Section 3.3)

A further complication in determining adverse consequences is that the exact extent and degree of the impact of lake levels is not known. The storms on the Great Lakes are notorious for their unexpectedness and their magnitude. The battering of storm-driven waves, superimposed upon storm-induced water level increases up to eight feet due to high winds coming in over the lakes, wreak havoc, complicating attempts to separate the effects of wave and storm action from the effects of lake levels, or to determine exactly the role played by shoreline geomorphology and man-made protective structures located there. Again, it is the problem of separating the action of the parts from the whole and yet determining their interconnectedness.

There are many consequences of fluctuating lake levels but some of the questions posed in this inquiry are, Which ones are adverse? To whom are they adverse? How adverse are they? Whose responsibility are they? The answers to these questions will determine the consideration of ways of alleviating them. It is clear, however, even from a preliminary look at the number of interests and their often conflicting needs, that whatever approach is developed, it will have to be comprehensive enough to deal with the sheer diversity of positions and the inevitability of conflict.

It has been important to focus on the meaning of "adverse consequences" first, not only because it brings to light the range and complexity of possible definitions, but also because it forces the questioner to realize that we must deal with the opinions of human beings who have established themselves in the Great Lakes — St. Lawrence Basin. The problem centres on their perception of consequences and causes, as much as on the actions of the lake levels themselves.

One of the more perplexing aspects of the problem, or cluster of problems, associated with adverse consequences of fluctuating lake levels, is the matter of human intervention in the natural system of the Basin. There is not only the question of control of the lake levels; there is also the question of control of human activities. The temptation on the part of some is to see the control of the lake levels rather than self-control as the only possible way to alleviate adverse consequences. That is, the focussing on the lakes instead of on the human interventions narrows the inquiry down to an approach which sees regulation of lake levels as the sole answer.

If we accept that human interventions are part and parcel of the problem, the road is opened to a range of courses of action. At the simplest level, either the high water level can be kept away from the building or the building can be removed from the high water level. The world is not, however, so simple; some of the facilities, such as the entire shoreline development of the city of Chicago, are not removable. Effective action requires lead time; weather forecasts are able to provide several hours of notice for specific storm warnings, but predictions over a period of several months or years are clearly not accurate enough to provide direction on regulatory actions to avoid low or high water levels. And even if something could be done in time for the shoreline owner, there are other interests with different needs: major production facilities need plentiful supplies of water and high water levels may be preferable to low. The natural habitat must be fed and nurtured by fluctuating water levels in order to survive. With such a range of conflicting demands, any approach has to take into account the real and very diverse world as it exists, the spectrum of needs and desires and, by no means least, the long range "good" of the Basin in all its multiplicity of life.

The very diversity of the implications of impacts of courses of action can lead to endless discussions, all of which may be germane to the issue of the fluctuating water levels, but which actually will never result in practical solutions. No matter what courses of action are recommended, it is imperative that certain realities of the situation be faced. The collapsing bluff face, the flooded facilities and the marina left high and dry cannot be forgotten in the attempt to unravel the complex strands of analysis.

The Approach

If the problem were narrowed down to how to control the fluctuating water levels, it could be solved by focussing on the mechanics of control dams or channels, locks, sills in outlet channels, diversions and other regulatory engineering systems. The solution would be complex in that we are dealing with huge amounts of water, unpredictable weather patterns, massive investments of money and complex monitoring systems. The problem, however, could be considered straightforward; it could be costed out and structured into a project timetable.

This approach has had notable success and will continue to have success where applied to problems which can be solved by this method. Difficulty arises with very complex systems, in which it is not possible to isolate the problems. An example of such a systems problem might be the case of the human body in solving a medical problem. An approach which treats only the isolated problem can create further problems through ignoring the relationship of the parts to each other and to the whole. Such an approach breaks down because it cannot deal either with the interconnectedness of the parts of the system or with the dynamic and change. The adding up of the parts does not adequately recreate the whole; the solutions for the parts are not the solution for the whole.

The natural and human components which make up the Great Lakes – St. Lawrence River Basin are a complex, interrelated and continuously changing system. The issue of water levels is not a single, simple problem, but a cluster of problems, each identifiable but interrelated and interdependent in ways which have to be made clear. Change is of its very essence – water levels vary continuously, shoreline use changes, economic investment follows its own course, land erodes, wildlife and natural habitats flourish and decline, recreational demands change, social habits reflect new value systems.

It is argued in this study that the Great Lakes – St. Lawrence River Basin is an ecosystem, which has to be approached as a functional whole, recognizing its high diversity, its interconnectedness and interdependence, its high rates of change and the need for integration of conflicting forces. Only recognition of these factors will allow for effective public policy. (See Annex D)

The approach taken here, often called a systems approach and depicted in Figure 2, must be able to incorporate these dynamics in its process of analysis and problem-solving. While much of the work which has already been done can be used in this approach, there are four characteristics of the Systems Approach which will inform and put into context specific studies and discussions. These are:

1) Wholeness: There are aspects of the whole which cannot be described or dealt with by analyzing the parts.

2) Interconnectedness: Not only the parts but the relationship and mutual effects of the parts on each other and to the whole must be taken into account.

3) Complexity and Irreducibility: The reduction of a system to units or parts is a misrepresentation of the system. Complexity itself is a property of the system.

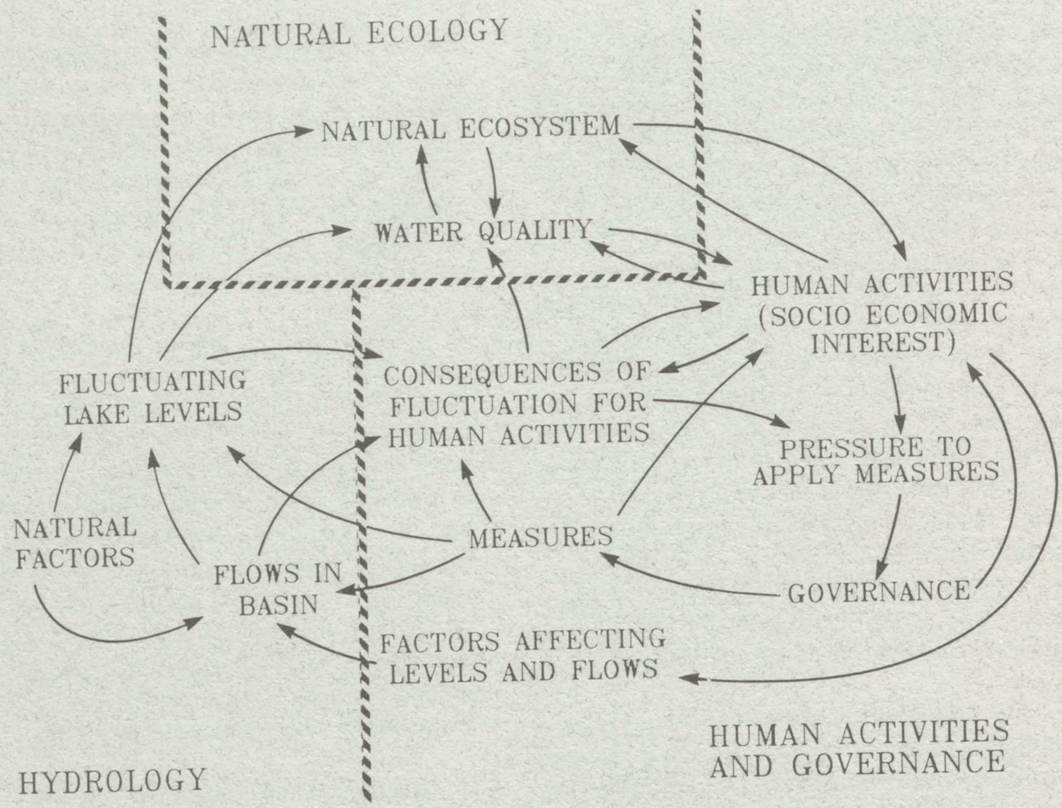


Figure 2: SYSTEM OVERVIEW DIAGRAM

4) Synergy: Interaction of the parts produces new properties which are not inherent in any specific part and the behaviour of the parts does not allow the behaviour of the whole to be predicted.

One of the ways developed in this study for visualizing and understanding the system and its parts in interaction has been through diagrams derived from a methodology known as system dynamics an example of which is shown in Figure 3. The key components and their interactions are diagrammed in progressively complex representations, which attempt to establish the important interactions and the cause and effect relationships of the components. Of particular importance are the positive and negative feedback loops as shown in Figure 4, which identify circular cause and effect relationships.

In adopting a systems approach to this study, the Commission echoes a need expressed in many previous studies for what has been called an "ecosystem approach". Isolated solutions and narrowly defined measurement criteria have led to situations in which results were not anticipated much less taken into consideration, where the interrelatedness of activities was not sufficiently well understood and where the elements of change were ignored.

In whatever way individual, short-term crises may be addressed, the long-term need is for comprehensive and effective management which will deal with what has been described as the "stress" in the system. Although the Great Lakes, as a natural system, are one the most resilient and stable systems on the planet, the natural system seems no longer able to cope with the size and scale of human intervention. Human activities must be self-regulated. The natural and the human can no longer be separated or even seen as separable; they are unavoidably intertwined. Any solutions proposed must be responsive to that intertwining and establish a means for dealing with all the "adverse consequences" of fluctuating water levels in a system encompassing both natural and human phenomena.

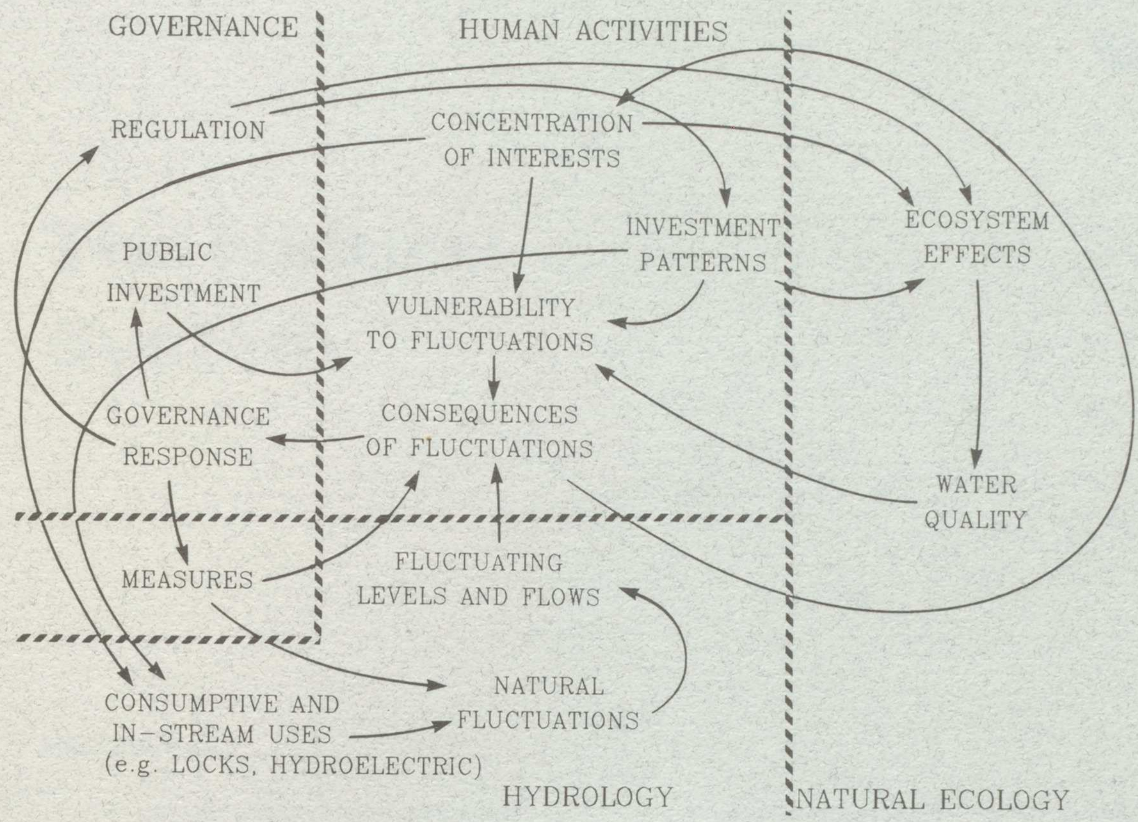


Figure 3: SUMMARY OVERVIEW - CONCEPT OF VULNERABILITY

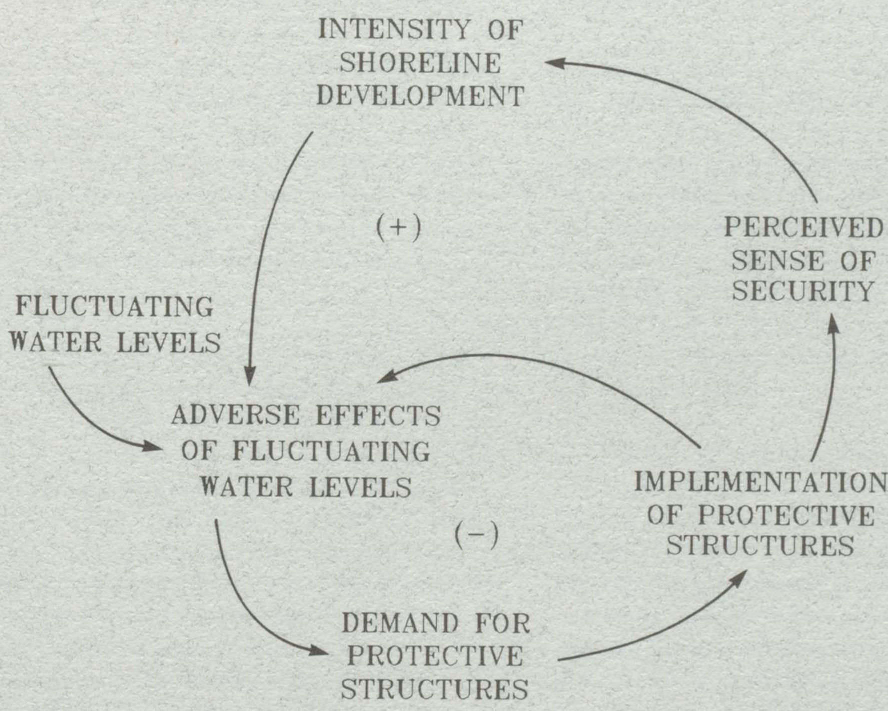


Figure 4: CONCEPT OF FEEDBACK LOOPS

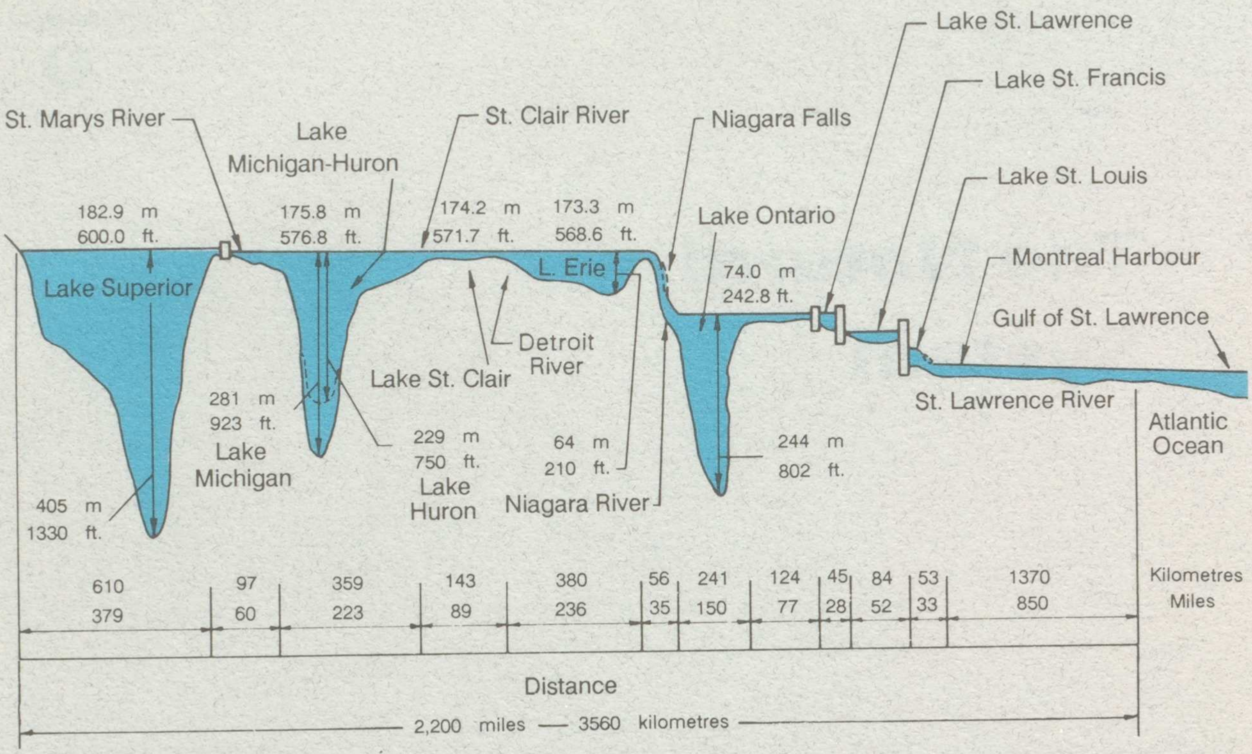


Figure 5: SCHEMATIC PROFILE OF THE GREAT LAKES - ST. LAWRENCE RIVER SYSTEM

future work required in order to produce data and conclusions for future decisions. The process is ongoing; the tools for developing the necessary information, however, are in some cases already designed, in use and being continuously brought up to date.

The Natural System

The Great Lakes Basin with dimensions as shown in Table 1, (see Annex A, Sec. 1) consists of an area of approximately 297,000 square miles (769,000 square kilometres), reaching from about 50 miles (80 kilometres) west of Lake Superior to the outlet of Lake Ontario and from Lake Nipigon in the Province of Ontario almost to the middle of the State of Ohio. Of this area, 174,000 square miles (451,000 square kilometres) are in the United States, including all of the State of Michigan and portions of Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania and New York. In Canada, there are 123,000 square miles (318,000 square kilometres), all in the Province of Ontario. About one-third of the drainage area, or about 95,000 square miles (246,000 square kilometres) is comprised of the water surfaces of the five Great Lakes (Superior, Michigan, Huron, Erie and Ontario), Lake St. Clair and their connecting channels. There are 11,000 miles (18,000 kilometres) of shoreline and an estimated 5,440 cubic miles (22,800 cubic kilometres) of water held in the system. Maximum water depths range from twenty-one feet (six metres) in Lake St. Clair (not taking into account the twenty-seven foot channel maintained for shipping) to over 1,330 feet (405 metres) in Lake Superior.

The St. Lawrence River from Lake Ontario to Quebec City adds an additional 130,000 square miles (337,000 square kilometres) drainage area, most of which is in the Province of Quebec. The Great Lakes — St. Lawrence River System, from the western end of Lake Superior to the Atlantic Ocean, as illustrated in Figure 5, is about 2,200 miles (3,500 kilometres).

The most singular characteristic of the Great Lakes Basin as a natural system is the enormous storage capacity of the Great Lakes. The lakes are reservoirs which store the largest supply of fresh water on the planet. The large surface area of these lakes acts as a natural regulator of their water levels. Compared to other natural water systems, such as the highly variable Mississippi Basin, the Great Lakes regulate themselves to a remarkable degree, discharging proportionately

Table 1 Dimensions of The Great Lakes

	Water Surface		Shoreline Length		Depth	
	Area sq. km. (sq. mi.)	Volume cu. km. (cu. mi.)	Mainland km. (mi.)	Island km. (mi.)	Average m. (ft.)	Maximum m. (ft.)
Lake Superior	82,100	12,100	2,780	1,600	147	405
	(31,700)	(2,900)	(1,729)	(997)	(483)	(1,330)
St. Marys River	230	–	153	244	–	–
	(89)	–	(95)	(152)	–	–
Lake Michigan	57,800	4,920	2,250	383	85	281
	(22,300)	(1,180)	(1,400)	(238)	(279)	(923)
Lake Huron	59,600	3,540	2,970	3,180	59	229
	(23,000)	(850)	(1,850)	(1,977)	(195)	(750)
St. Clair River	55	–	93	8	–	–
	(21)	–	(58)	(5)	–	–
Lake St. Clair	1,110	–	210	204	–	6
	(430)	–	(130)	(127)	–	(21)
Detroit River	100	–	96	116	–	–
	(39)	–	(60)	(72)	–	–
Lake Erie	25,700	484	1,290	116	19	64
	(9,910)	(116)	(799)	(72)	(62)	(210)
Niagara River	60	–	110	60	–	–
	(23)	–	(69)	(37)	–	–
Lake Ontario	18,960	1,640	1,020	125	87	244
	(7,340)	(393)	(634)	(78)	(283)	(802)
St. Lawrence River from Lake Ontario to Cornwall-Massena Powerhouse	610	–	484	567	–	–
	(235)	–	(301)	(352)	–	–

Source: Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, 1977

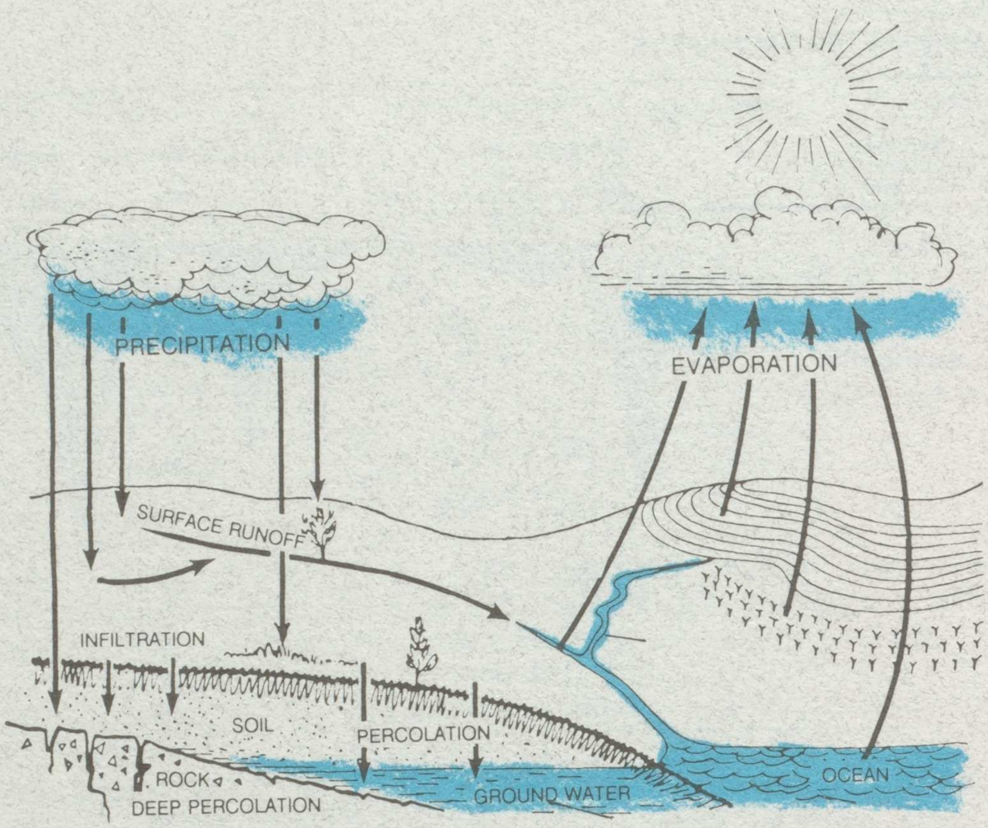


Figure 6: THE HYDROLOGIC CYCLE

less water in prolonged dry periods and more water in times of cumulative water surplus. The present man-made control systems have only a small impact on the natural regulatory processes.

The second point to remember is that the five lakes vary greatly one from the other. Size, depth, outflows, location in the chain, nature and configuration of shoreline and level of human intervention, all determine the levels of the lakes and the impact these have on inhabitants of the Basin. Of the lakes, Lake Erie, shallow and with much highly erodible shoreline, is the most sensitive to storm-induced water level changes. Lake Superior, deep and with a largely stable shoreline, is least affected by water level changes due to storms.

The Water Levels

The Great Lakes water levels have been monitored regularly since 1860 (see Annex A, Sec. 1). The seasonal fluctuations, following natural cycles of precipitation, run-off and evaporation, as depicted in Figure 6, vary on the average in any given year between the highest and lowest monthly means (Figure 7) from about 1.0 foot (0.3 metres) on Lake Superior to about 1.6 feet (0.5 metres) on Lake Ontario. There is a seasonal pattern of fluctuations with higher levels in late spring to mid-summer and lower levels in winter.

Long-term fluctuations as shown in Figure 8, occur over years as a result of precipitation and climatic variability. These are not regular or predictable and follow long-term variations in weather. Between 1900 and 1988 the monthly mean levels, from extreme high to extreme low, have varied on Lake Superior by about 4.0 feet (1.2 metres), on lakes Michigan, Huron and Erie by about 6.0 feet (1.8 metres) and on lakes St. Clair and Ontario by about 6.5 feet (2.0 metres). Archaeological and geological evidence suggests that the levels were much higher for varying periods over the past 2,500 years, but the exact reasons for this are not clearly known. It is, however, clear that, barring major human intervention, significant changes in the lake levels will only occur as a result of significant climatic changes.

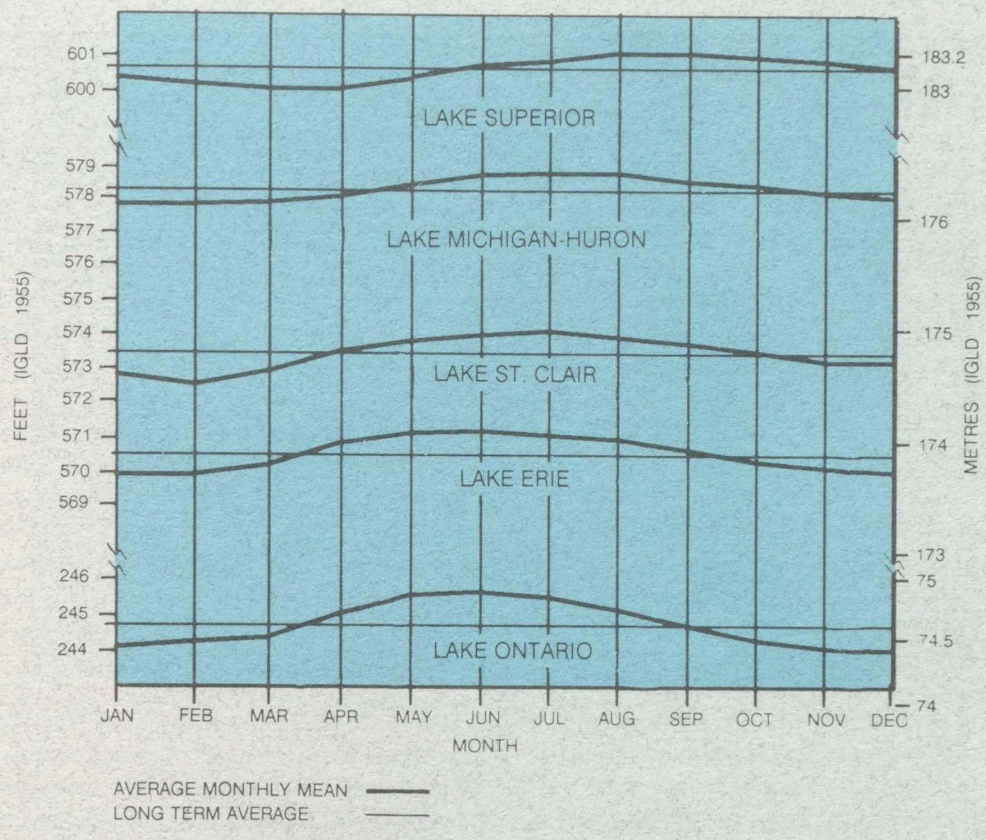


Figure 7: SEASONAL FLUCTUATIONS OF GREAT LAKES WATER LEVELS (1900-1988)

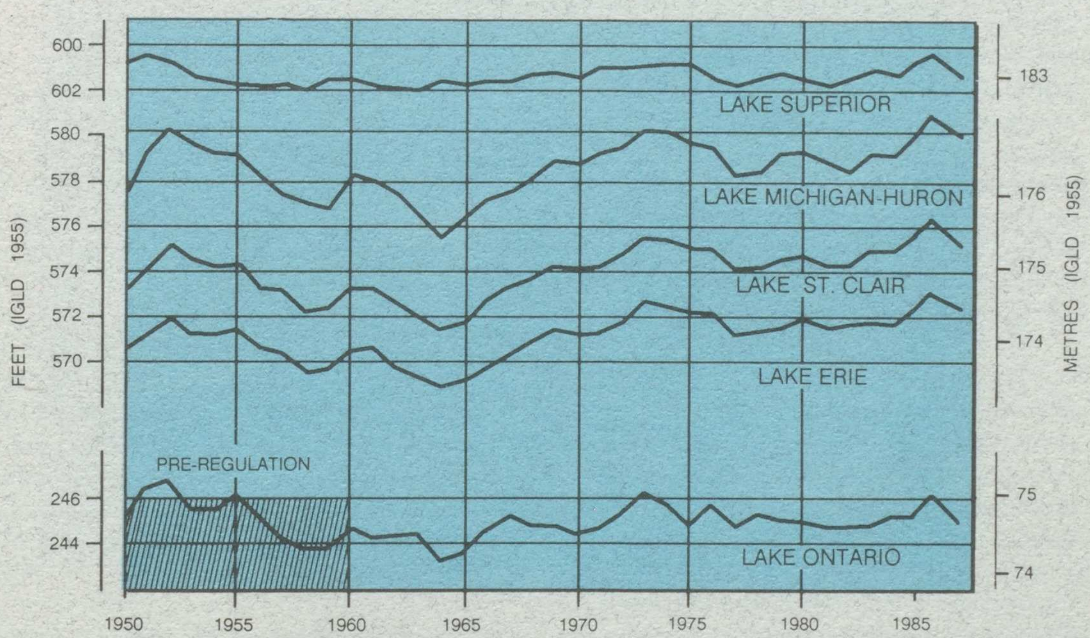


Figure 8: ANNUAL AVERAGE GREAT LAKES WATER LEVELS (1950-1988)

This study was initiated during the record-breaking high levels of 1985 and 1986. The precipitation for 1985 and 1986 was well above average and, combined with the previous eighteen year period of above-average precipitation, caused the record high water levels of the lakes during those two years. These highs parallel in severity the lows experienced in 1934 and 1964. In each case the quantity of water stored in the lakes varied by about 30 cubic miles (125 cubic kilometres). This range of about 60 cubic miles (250 cubic kilometres), however, represents only about 1.0 percent of the average volume of water contained in the lakes.

Factors affecting Water Levels

Although precipitation, evaporation and the rate of flow out of the system are major factors in the fluctuation of lake levels, other factors have to be taken into account in determining the functioning of the natural system (see Annex A, Sec. 2). Such phenomena as run-off patterns, ice build-up, meteorological and climatic occurrences, rebound of the earth's crust and, of course, human modifications to the system affect the water levels on the lakes. In the last case, a lowering of levels would substantially increase flows in the channels, while a storing of water in lakes would decrease flows.

Precipitation

Precipitation is the primary source of water for the Basin. The average annual precipitation over the Basin is 32 inches (81 centimetres), with some variance between the Lake Superior area and the Lake Ontario area. The latter receives an average of 34 inches (86 centimetres) per year; the former, an average of 30 inches (76 centimetres) per year. In 1985, the wettest year on record, the Basin received an average of 40 inches (102 centimetres). For several years prior to the low levels of 1964, precipitation was below average over much of the Basin (Figure 9).

Although lake outflows increase during periods of rising water levels, the amount is not proportionate to the amount of water entering the system. In 1985 and 1986, for example, new record high monthly mean levels were set on all lakes except Lake Ontario, the furthest downstream. The other lakes, therefore, increased their storage, hence their record high levels. This change seems, however, to reflect the normal response of the lakes to climatic variability. Levels declined rapidly in 1987, due largely to abnormally low precipitation from late 1986 to June of 1987 (Figure 10).

Runoff

Precipitation falling on the lake surfaces enters the system immediately; precipitation on land areas comes into the lakes over a period of time. On the land, some of the precipitation enters into storage in lakes, swamps and streams; some moves through the soil; some accumulates in groundwater storage and becomes the source for springs and streams. If it falls as snow, there is a different pattern of entry into these runoff systems. The rate of runoff is affected by a wide range of factors, including soil make-up and structure, the existing moisture levels of the soil, the rate of snow melt, and the type of spring breakup. Land uses, such as forest, agriculture and urban settlement, affect the runoff, sometimes in major ways.

The amounts of water entering the lakes from runoff are relatively well known and records are kept for a number of tributary streams. These amounts are proportionate to the amounts of precipitation, but certain human activities, such as de-forestation and urban build-up, can increase the volume of runoff.

Evaporation

The evaporation of water from the surfaces of the lakes can be estimated with some assurance. Proportionately more evaporates from warm and shallow lakes, such as Erie, than does from cold and deep lakes, such as Superior. It is estimated that evaporation from Lake Erie's surface is of similar magnitude to the precipitation which falls on it, whereas evaporation from Lake Superior is about one-half the precipitation falling on that lake surface. Approximately 55% to 65% of precipitation over land surfaces will be lost through evapotranspiration, absorption by the soil and other factors.

Evaporation varies greatly over the course of each year due to changes in air and water temperatures, wind speed, and "ambient" atmospheric moisture control, but remains relatively constant from year to year. It is possible, therefore, to calculate on an annual basis the amounts of outflow which will result from a given amount of precipitation.

Climate and Weather

Inhabitants of the Basin are most aware of the effects of storms on the lakes. High winds produce short-term, but severe fluctuations in

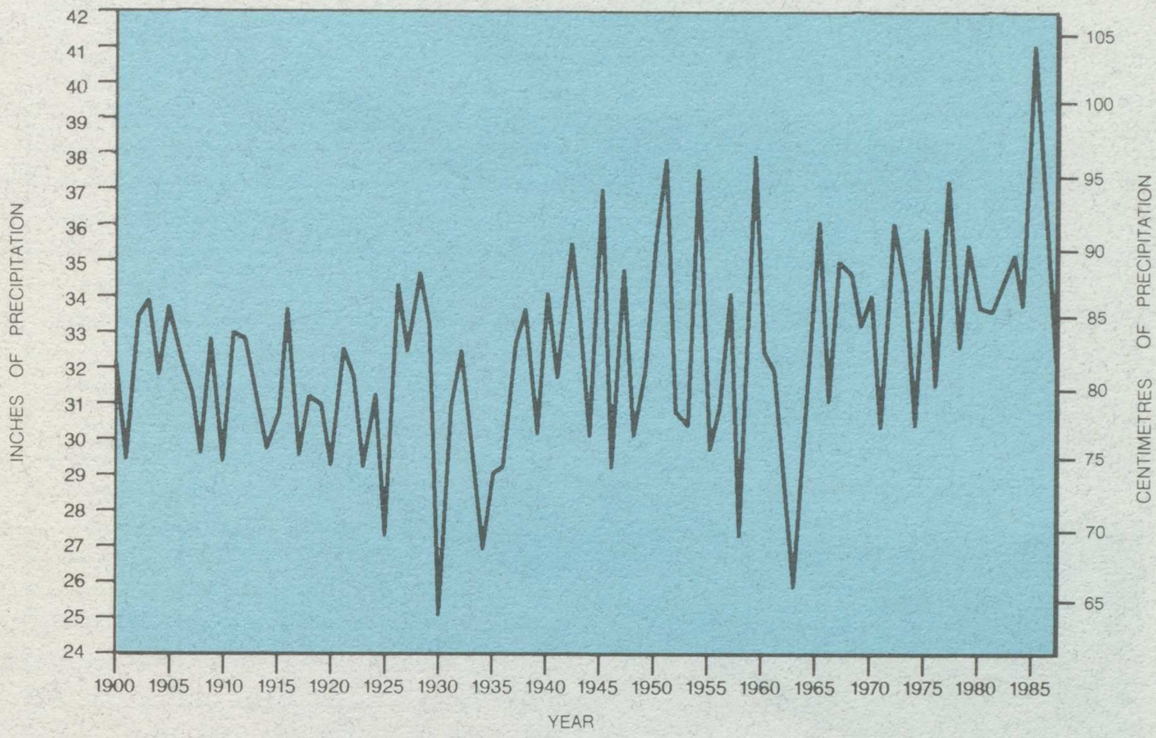


Figure 9: COMBINED PRECIPITATION ON LAKES MICHIGAN-HURON, ST. CLAIR AND ERIE

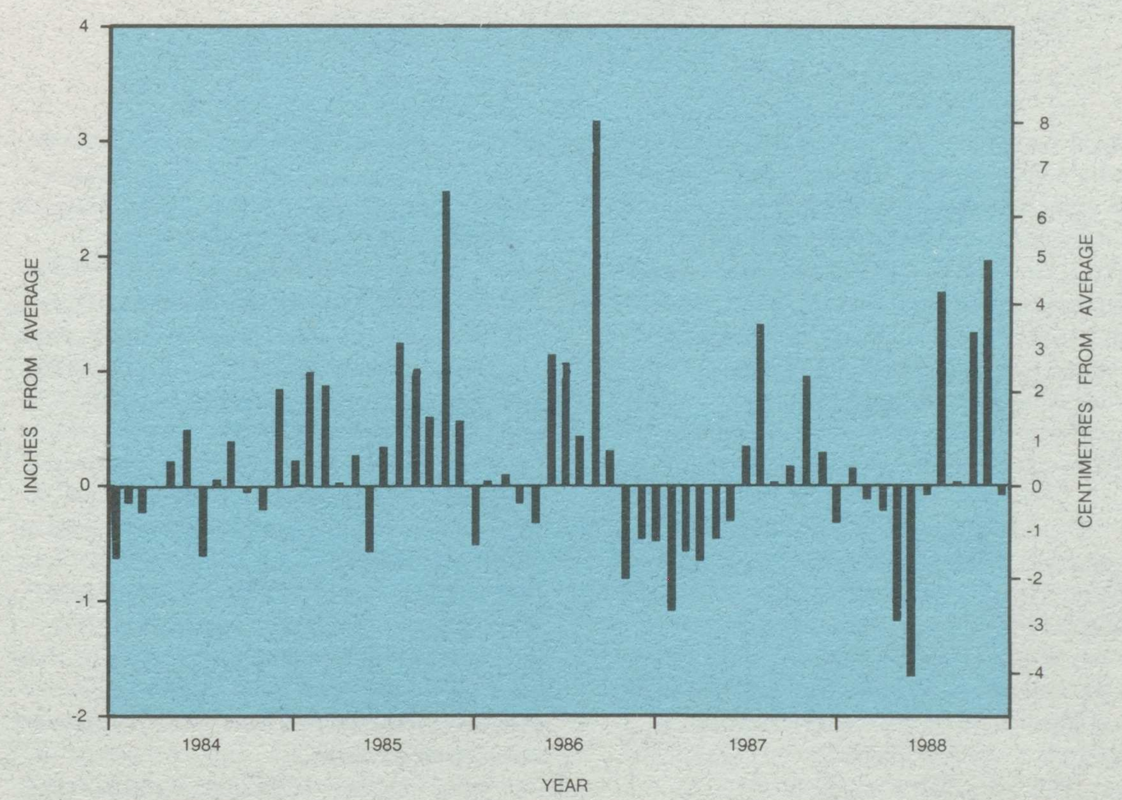


Figure 10: GREAT LAKES BASIN MONTHLY PRECIPITATION (1984-1988)

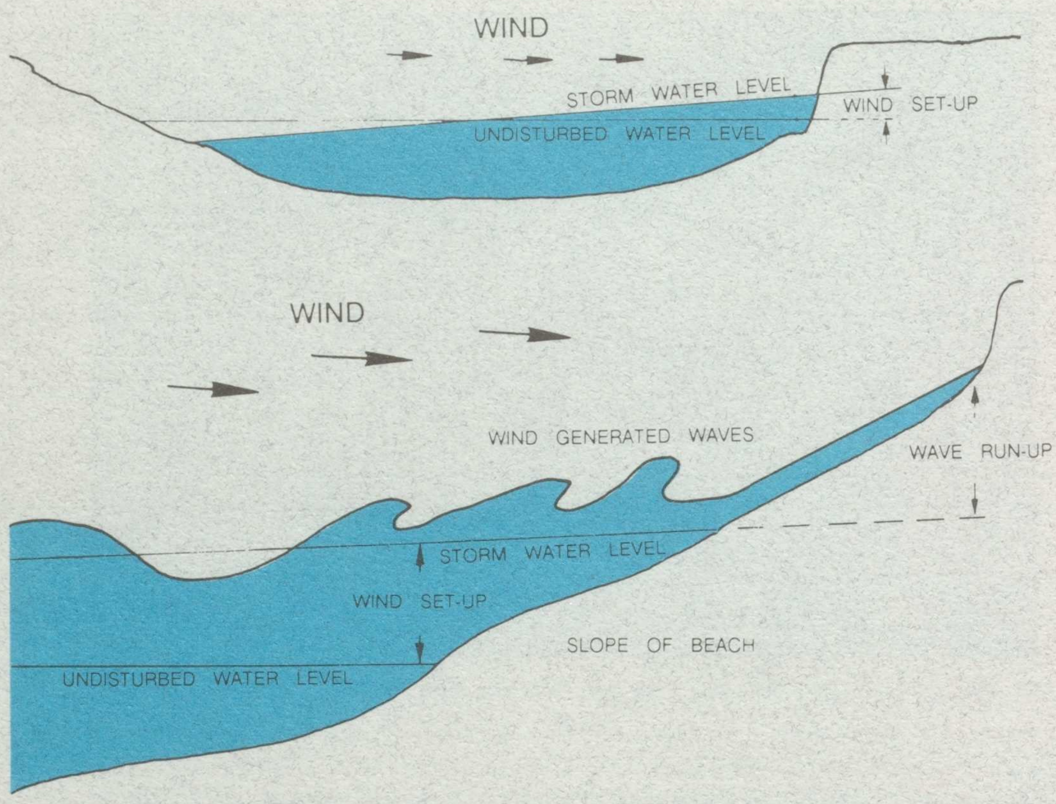


Figure 11: WIND EFFECTS ON LAKE LEVELS

lake levels as illustrated in Figure 11. During the storm of December 2, 1985, the water level of Lake Erie rose seven feet (2.1 metres) at Buffalo at the eastern end of the lake and dropped eight feet (2.4 metres) at Toledo on the western end (Figure 12). While Lake Erie is the extreme example for short-term fluctuation, all the lakes are affected by severe weather. The measure of severity depends on size and depth of the lake, but also on the orientation and shape of the lake and, of course, the magnitude of the storm.

There are also seasonal and long-term changes in the climate which vary over the Basin. The northern location, with its accompanying seasons, the variability of precipitation, the temperature ranges over the 700 latitudinal miles (1,100 kilometres) and the impact of the huge quantity of water in the lakes themselves, all affect the climate of the Basin. The climate, in turn, determines the amounts of water in the lakes and its behaviour. One major influence on lake levels is air temperature. At higher air temperatures, evaporation and plant transpiration both increase, resulting in less runoff; at lower air temperatures, given the same precipitation, the loss through evaporation and transpiration is less and the runoff, therefore, more.

The impact of changes in air temperature can most easily be seen from an example. From 1960 to the present, readings taken at Lake Erie indicate a 0.8 degree Celsius drop in mean annual air temperature. This resulted in a 5% increase in runoff. The combined effect of an increase in precipitation, with a decrease in temperature resulted in a 19% increase in runoff to the lake. The high levels of the early 1970's to the mid-1980's were partly the result of an increased precipitation regime since 1940, coupled with a lower temperature regime since 1960.

Aquatic Plants, Ice and Movements of the Earth's Crust

Temporary flow restrictions in the connecting channels can cause short-term increases in lake levels. Ice jams in winter and excessive plant growth in shallow waters, such as the

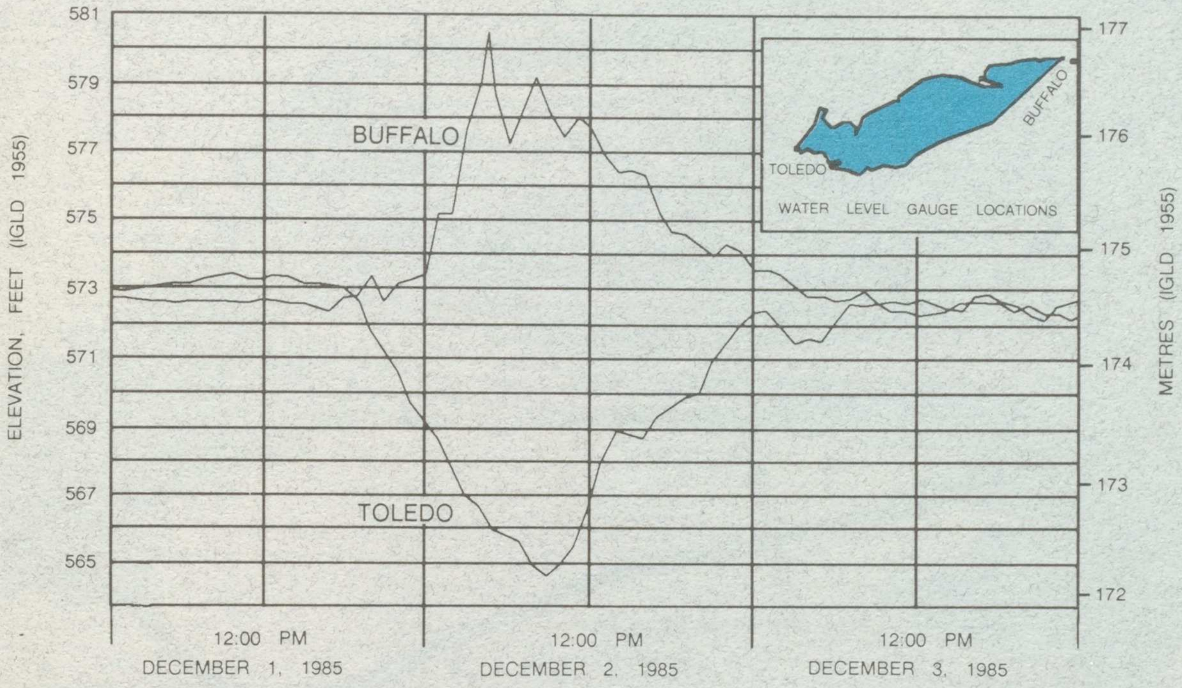


Figure 12: WIND, TIDE AND SEICHE EFFECT ON LAKE ERIE DURING STORM OF DECEMBER 2, 1985

Niagara River, in summer are the most common causes of these restrictions.

A long-term change is taking place as a result of rebounding of the earth's crust since the last glacial period. Basically, the entire Great Lakes Basin is rising and tilting. Over time the water levels on the south and west shores will rise relative to levels on the north and east shores due to different rebound rates. At Duluth, for example, it is estimated that there could be a 0.5 foot (0.15 metre) rise in water level over the next 50 years due to this crustal movement.

Modifications to the Natural System

Various artificial changes have been made in this century that have had an influence on the Great Lakes water levels and their outflows. These changes were the subject of investigations in the past by the IJC's International Great Lakes Levels Board (1973), the Diversions and Consumptive Uses Study Board (1981), and, most recently, by the Great Lakes Water Levels Task Force (1987) (see Annex A, Sec. 3).

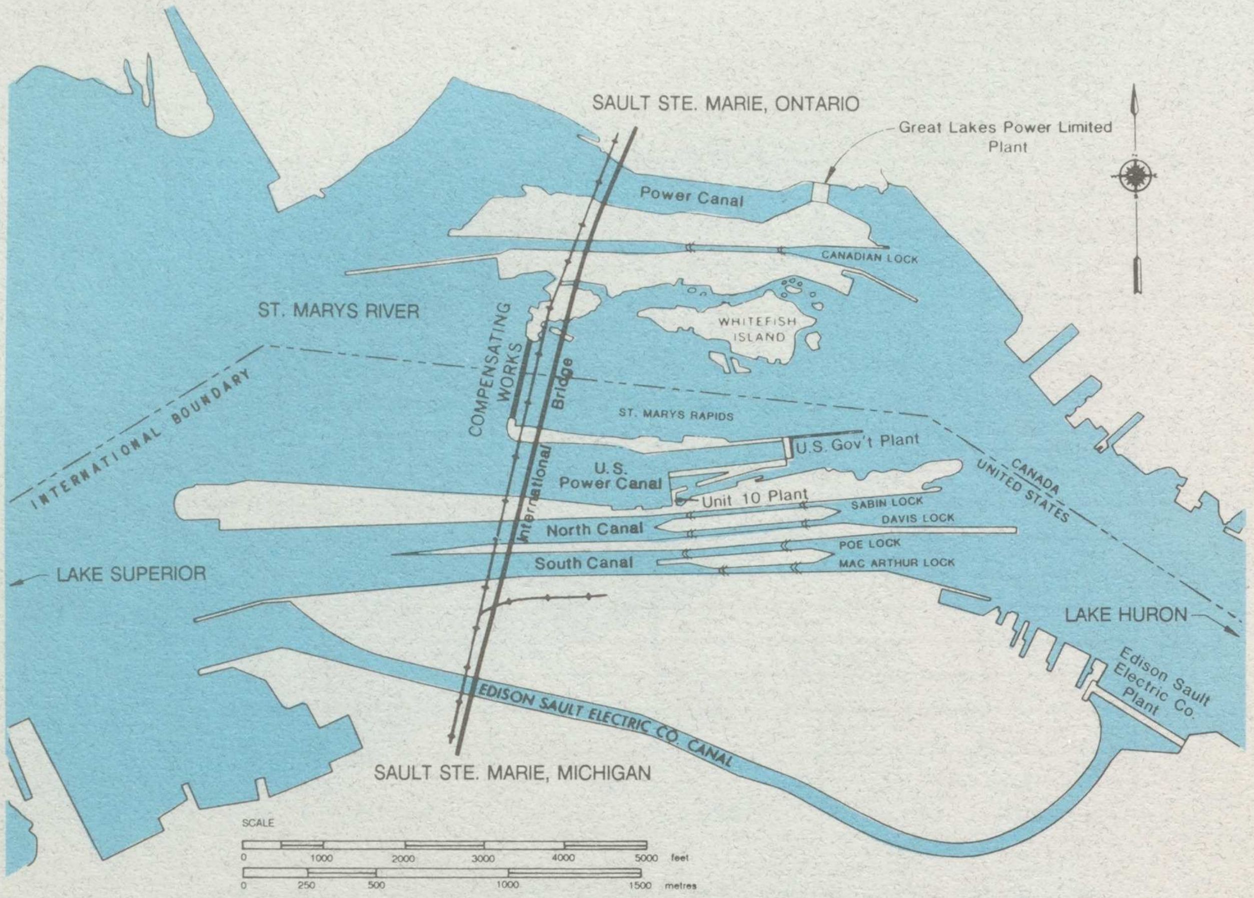


Figure 13: LAKE SUPERIOR CONTROL STRUCTURES

The most significant projects built specifically for the purpose of managing the lake levels for human benefit are the Lake Superior and Lake Ontario control structures (Figures 13 and 14). Lake Superior has been regulated since 1921 as a result of the hydro-power and navigation developments in the St. Marys River. Lake Ontario has been similarly regulated since 1960.

Five diversions have been constructed in the Great Lakes Basin to meet various needs of society on the shores (Figure 15). Two of these, Long Lac and Ogoki Diversions, divert some of the tributary flow of the Hudson Bay southward into the Lake Superior basin. These diversions raise water levels of the Great Lakes by minor amounts.

The diversion of water through the Sanitary and Ship Canal at Chicago from the Great Lakes system to the Mississippi River is for purposes of sanitation, navigation and hydro-electric production. This diversion lowers water levels of the Great Lakes by minor amounts.

The other two diversions, the Welland Canal and the New York State Barge Canal, are inter-basinal. These have no overall effect on the Great Lakes — St. Lawrence River system, but the Welland Canal lowers the water levels of Lakes Erie and Michigan-Huron.

Channel modifications have been undertaken in the St. Clair-Detroit River system. These modifications range from sand and gravel mining to large scale channel dredging for navigation. In some cases, dikes were placed as compensating measures and for disposal of dredged materials. As a result of these modifications, water levels of lakes Michigan-Huron have been lowered by minor amounts.

Channel and shoreline modifications have also been carried out in the Niagara River. Construction of the Peace Bridge, the International Railway Bridge, the Black Rock navigation lock and canal, and other shoreline changes have caused restrictions in the flows in the Niagara River, thereby raising water levels in Lake Erie by very minor amounts.

Both the control and diversion modifications affect the lake levels in terms of inches rather than feet and do not, therefore, constitute major factors in the natural system. The estimated impacts of these modifications to the natural system are shown in Table 2.

Since the 1930's, there has been a noticeable increase in the rate of basin runoff. It is thought that land use changes in the Basin, such as deforestation, drainage of wetlands, and urbanization, have been instrumental in this change. Similarly, various controls on ice build-up and movement and plant growth, flood control storage constructions and other modifications to streams have affected the timing of water movement. A varying amount of water is also withdrawn from the system for consumptive uses of various kinds and not returned. This amount presently runs at about 4,500 cubic feet per second (127 cubic metres per second) and could double by the year 2000.

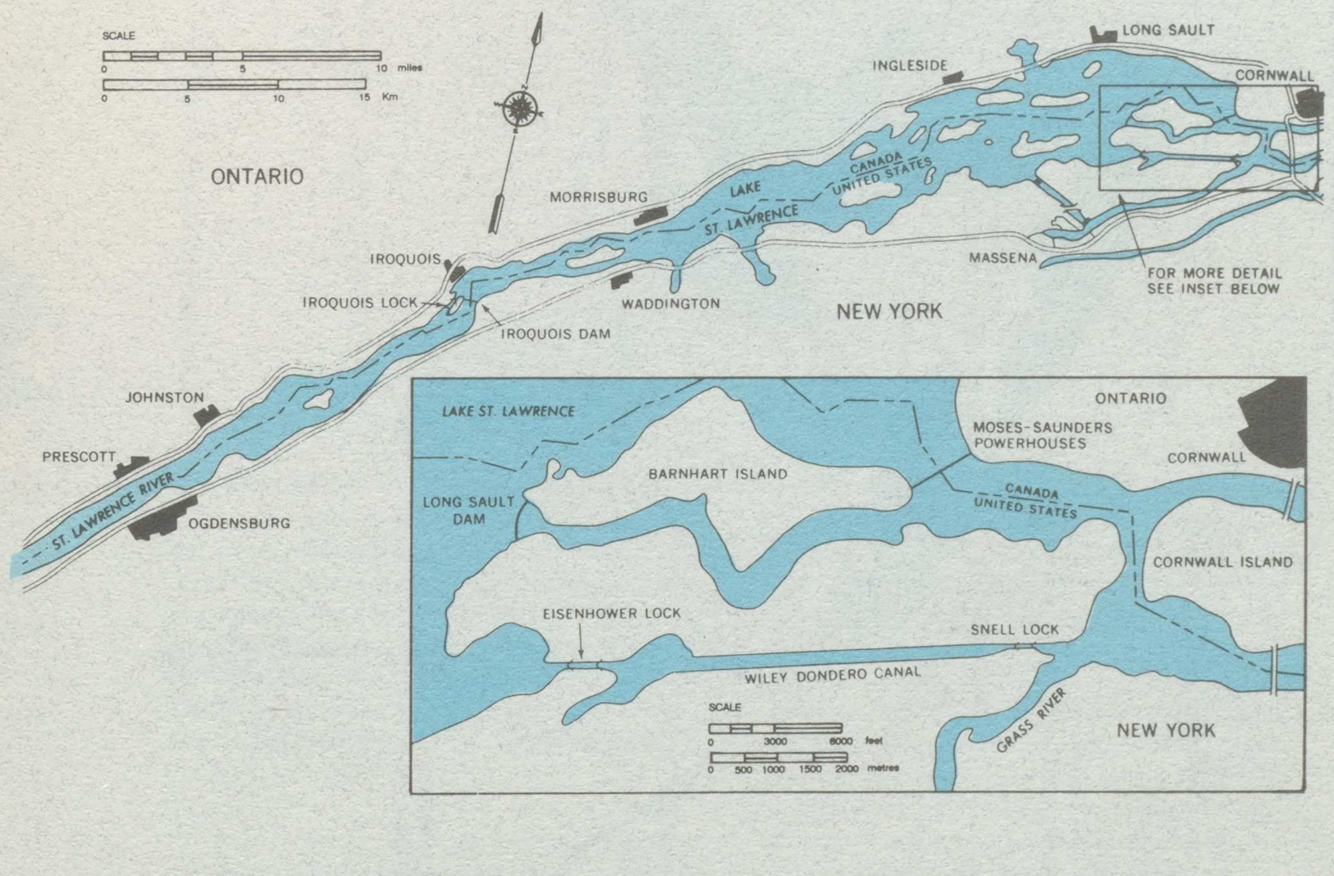


Figure 14: LAKE ONTARIO CONTROL STRUCTURES

Figure 15: GREAT LAKES DIVERSIONS

Table 2 Estimated Impact of Modifications to The Natural System in Metres (Feet)

	Impacts of Channel Dredging/Infilling		Impacts of Current Diversions			Impacts of Current Regulation		Accumulated Impacts
	Michigan/ Huron	**Erie**	**Long Lac/ Ogoki**	**Chicago**	**Welland**	**Superior**	**Ontario**	
Superior	0	0	+0.09	0	0	*	0	+0.09
	(0)	(0)	(+0.3)	(0)	(0)		(0)	(+0.3)
Michigan/Huron	-0.38	+0.04	+0.11	-0.06	-0.04	*	0	-0.33
	(-1.3)	(+0.1)	(+0.4)	(-0.2)	(-0.1)		(0)	(-1.1)
Erie	0	+0.12	+0.07	-0.04	-0.12	*	0	+0.03
	(0)	(+0.4)	(+0.2)	(-0.1)	(-0.4)		(0)	(+0.1)
Ontario	0	0	+0.07	-0.04	0	*	-0.09	-0.06
	(0)	(0)	(+0.2)	(-0.1)	(0)		(-0.3)	(-0.2)

* A comparison of regulated versus natural Lake Superior levels is inconclusive due to uncertainty in the natural Lake Superior outlet conditions and lake level data prior to modification of the outlet.

The Shoreline

For this section of the report, the focus of the present study is on the impact of fluctuating water levels on the shorelines of the Great Lakes — St. Lawrence River Basin. The shoreline, its nature and how it is affected by lake levels, is the second major component of the natural system which has to be considered in any analysis of the impacts of policies and actions (see Annex B, Sec. 3).

At this point in the study, it is still necessary to describe the shoreline characteristics qualitatively. Computer models have been designed which will enable us in the near future to give much more accurate and detailed descriptions of both the nature and response of the shoreline to lake levels and to assess actions taken in regard to them.

The shoreline is described by several major types of physical occurrences: bluffs, beaches, wetlands and rocky shores. Each type responds to the action of the lake waters in different ways. The bluff areas are most susceptible to erosion; the rocky shores least. Beaches are most changeable and shifting, adapting themselves to prevailing wind and water action. Wetlands, which are often separated by low natural barriers from the main bodies of water, are highly dependent on fluctuating lake levels and renewal through periodic flooding. The effects of water levels and wave action differ markedly according to the dominant type of shoreline and, therefore, each lake experiences different effects.

Lake Superior has long stretches of rocky cliffs along its northern and a part of its south central shore. The western end, however, is predominantly low-lying clay and gravel bluffs. There are also extensive wetlands, particularly along parts of the southern shore and some sandy beaches, for example at Pancake Bay, Ontario and Whitefish Bay, Michigan. The shores of St. Marys River, connecting Lake Superior and Lake Huron, are low-lying and generally erodible and contain wetlands and numerous islands.

The shoreline of Lake Michigan is known for its miles of sand beaches and dunes along the eastern side of the lake, which extend almost from the Indiana border at the southern tip to the Straits of Mackinac in the North. The low erodible plain in the vicinity of Chicago is extensively protected. On the western side of the lake, the predominant land characteristic is highly erodible bluffs. At the northern end, there are stretches of rocky shore. There are wetlands along Green Bay, Big and Little Bays de Noc and at the drowned mouths of rivers draining into the lake.

Much of the northern shore of Lake Huron and eastern shore of Georgian Bay are composed of exposed igneous rock. Limestone bedrock dominates the shores of Manitoulin Island and the Bruce Peninsula. Much of the western shore of Lake Huron is erodible low plain. The southern shore of Georgian Bay and the south eastern shore of Lake Huron consist predominantly of beaches and dunes, for example at Wasaga Beach and Ipperwash, and stretches of low bluffs. The flood-susceptible shore of Saginaw Bay, Michigan consists of the extensive wetlands of Inner Bay and sandy beaches of Outer Bay.

The St. Clair River, Lake St. Clair and Detroit River connect lakes Huron and Erie. The shoreline of this region is generally low-lying and susceptible to flooding and erosion; shore protection is common. Extensive wetlands are found in the St. Clair River delta and along the eastern shore of Lake St. Clair.

Perhaps the most erodible shoreline is the north shore of Lake Erie, much of which consists of deposits of glacial till and stretches of exposed bluffs up to 120 feet (37 metres) in height. Extensive wetlands are found here as well, some of which have been diked and drained for agricultural uses. Much of the shoreline along the western end of Lake Erie is flood-susceptible low plain, and extensive areas of the southern shore are erodible. Exposed limestone bedrock or shale deposits characterize parts of the eastern end of the lake. Major sand depositional features, such as Long Point, Ontario and Presque Isle, Pennsylvania, are found on the Erie shoreline. The Niagara River, connecting Lake Erie and Lake Ontario, is composed of low banks in the upper portion and a deep gorge cut through the limestone bedrock in the lower river below the Falls.

Much of the northern and western shores of Lake Ontario are consolidated clay, silt and sand and are characterized by bluffs and some sandy beaches and marshes. The harbour at Hamilton is formed by a substantial sand bar. Sand beaches form Toronto Island, which protects the harbour there. From Prince Edward County to the St. Lawrence River, the shoreline changes to bedrock with a few beaches and marshes in low-lying areas. The shoreline along New York State is predominantly bluffs which are subject to erosion, especially from wave action. The bluffs are interspersed with wetlands and a few gravel and sand beaches, especially near Rochester and Irondequoit.

The international part of the St. Lawrence River flows over bedrock and is basically non-erodible. The Quebec portion, upstream of Montreal, is low-lying and erodible, with wetlands around Lac St. Francois. The St. Lawrence River has an impact on the levels and flows on Lac Des Deux Montagnes and the Back Rivers that surround the Island of Montreal, where extensive diking protects low-lying urban development. Downstream of Montreal, the shoreline is generally low-lying, erodible and marshy in places, for example around Lac St. Pierre.

Interaction of Land and Water

The zone of interaction of land and water has complex characteristics; the shoreline changes constantly through the movement, removal and deposition of materials by the action of the water. The different types of shoreline and their configurations respond to the erosive action of waves and lake currents in different ways and to different degrees. (Annex B, Section 3.2)

Waves generated by wind are the cause of most shoreline erosion, deposition of materials and beach configuration. By calculating height, length and period (time between successive crests), the impact of waves can be estimated, although the shoreline itself through its orientation, configuration and materials determines the effect the waves will have. Bluffs, if formed of glacial or other erodible soils, will collapse or slump as the waves undermine the toe of the bluff. This action results in the typical vertical, bare bluff faces on some parts of the lakes. Beaches, on the other hand, shift and change in response to storms and wave action. Generally, the main movement of sand is along the shore, although there may be significant offshore losses in some cases, and the movement of sand is dictated by wave direction.

Currents in the lakes are caused by the earth's rotation, inflows and outflows and wind. The shoreline processes, however, are driven primarily by currents resulting from wave action. The action of the waves entering shallow shoreline areas causes underwater currents which dislodge sediments. Since waves regularly break at a slight angle to the shoreline, the sediments tend to be transported along the shore. The movement of water in the system and the prevailing winds influence the pattern of this deposition.

The constant interaction of land, waves and currents causes variations in the development of the shoreline. The waves whipped up in a storm strip beaches of sand; the long, swell waves build beaches by depositing sand. Material eroded from the bluff can be deposited along the shore. These activities take place within the littoral zone, which is defined spatially as being between the point where waves break offshore and the limit of wave penetration onshore.

Sand movement along shore in the littoral zone is critical to the development of the shoreline. (Annex B, Section 3.2) Lateral boundaries of littoral cells can be determined by the direction of net sediment transport alongshore, which is controlled by the predominant direction of incoming waves in relation to the shoreline. Shoreline protection and navigation structures can directly influence the natural transport system, impeding sediment, increasing erosion downdrift, and reducing the buildup of natural depositional areas such as Long Point.

Fluctuations in water levels have little influence on long-term recession in many shoreline areas. Wave action and composition of shore materials are the most significant determinants of long-term changes in the shorelines. (Annex B, Section 3.2). The level of the lakes determines the shoreline areas most affected by flooding, but it is apparent that most flood damage is attributable to storm events. Although not yet developed in sufficient local detail for all areas, a flood plain for the Great Lakes has been identified.

Other factors, such as groundwater, surface water, wind and ice action also dictate change in the shoreline. In many bluff areas, groundwater flows out through the face of the bluff causing a collapse of the bluff face and extensive loss of land. In other bluff locations, the flow of surface drainage water down the bluff face creates large gullies. Some gullies are over 500 feet (150 metres) wide at the lakeshore and extend inland for over one mile (1.6 kilometres). Direct wind action and the action of ice also cause important localized shoreline changes.

The Wetlands, Wildlife and the Habitat

Coastal wetlands are the most productive and diverse component of the Great Lakes ecosystem. Not only do they provide the natural habitat for a myriad of flora and fauna, but their vegetation absorbs and slows the quantity of toxic pollutants and nutrients entering the lakes. In the wetlands, water level changes have a significant and complex impact.

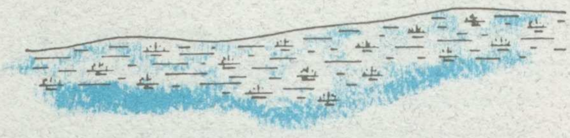
The vegetation of the wetlands depends on the cycles of change for survival and balance. At low water levels, the soil becomes more aerated (oxic), vegetation changes dramatically as species emerge from reserves of buried seeds, and trees and shrubs encroach on the lake. At high water levels, the soil changes to anoxic and the rising water opens up the dense growths of cattails, trees, shrubs and other plants. These periodic perturbations are what allows the wetlands to sustain a range of emergent plant life, which do not flourish, for example, in smaller lakes with more stable water levels. This process involves a multitude of species of vegetation and the greatest diversity is often supported in those areas of the wetlands where the water levels fluctuate the most. Reducing the intensity and frequency of change would cause major changes in the wetlands.

There are many types of wetland configurations on the Great Lakes (Figure 16), but they share an immediate dependency on the actions of the lake levels for their cyclical transformations. Fluctuating water levels increase wildlife diversity. During high water periods, waterfowl, muskrats, terns and herons and many reptiles and amphibians flourish. Fish populations increase through their access to the lake from the spawning grounds provided in the wetlands. Low water levels allow for different populations, such as red-winged blackbirds, marsh wrens, rails, deer, rabbits and smaller mammals, to be nurtured. The important thing to note here is that neither flooded wetlands nor dry wetlands are most suitable to wildlife, but rather the changes themselves are what seem to be most effective in sustaining and balancing populations. (Annex B, Section 3.3)

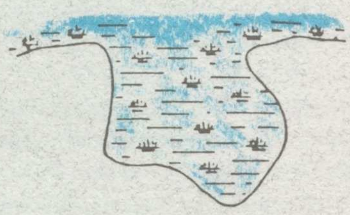
The relationship of water levels, wildlife and vegetation is the basis for the support of life in the Great Lakes Basin. Although not all aspects of this relationship are known and understood, it is clear that changes in any part of it will have very wide implications for the others. For some wildlife, such as migratory waterfowl, the wetlands of the Great Lakes are critical to their survival.

The role of wetlands in water purification is also of critical importance in attempting to gain an overview of the interconnectedness of the elements of the natural ecosystem and the implications for humans in the Basin. Recent studies have indicated that the role of the wetlands in water purification needs to be given serious consideration. Not only do the wetlands slow down the movement of sediments and, thereby, trap pollutants, but the plant life absorbs many of the more persistent pollutants, such as heavy metals. All these functions are, of course, in addition to the uses which humans make of the wetlands for sport, recreation, commercial activities and aesthetic enjoyment.

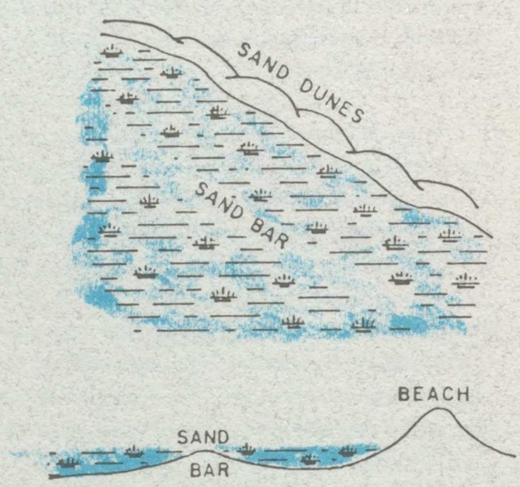
The extent of the wetlands today is different from what it was earlier in the century. Approximately 50% of the original wetlands in the entire Basin have been lost through human interventions and this loss continues at a rate of about 20,000 acres (8,000 hectares) per year. Cumulative wetland impacts, while appearing minor individually, amount to significant losses. Today there are about 500,000 acres (170,000 hectares) left along the shores of the Great Lakes. Much of the wetland area remaining is further reduced in function and value because of shoreline changes, proximity of deleterious human activity and reduced size or access to the lakes. However, in spite of this, the remaining wetlands are of extreme value to the natural system.



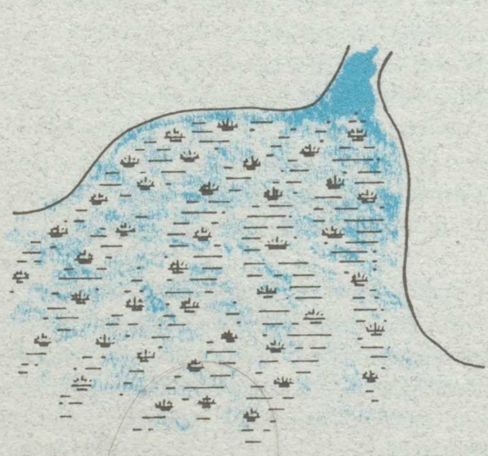
1. OPEN SHORELINE



2. UNRESTRICTED BAY



3. SHALLOW SLOPING BEACH



4. RIVER DELTA

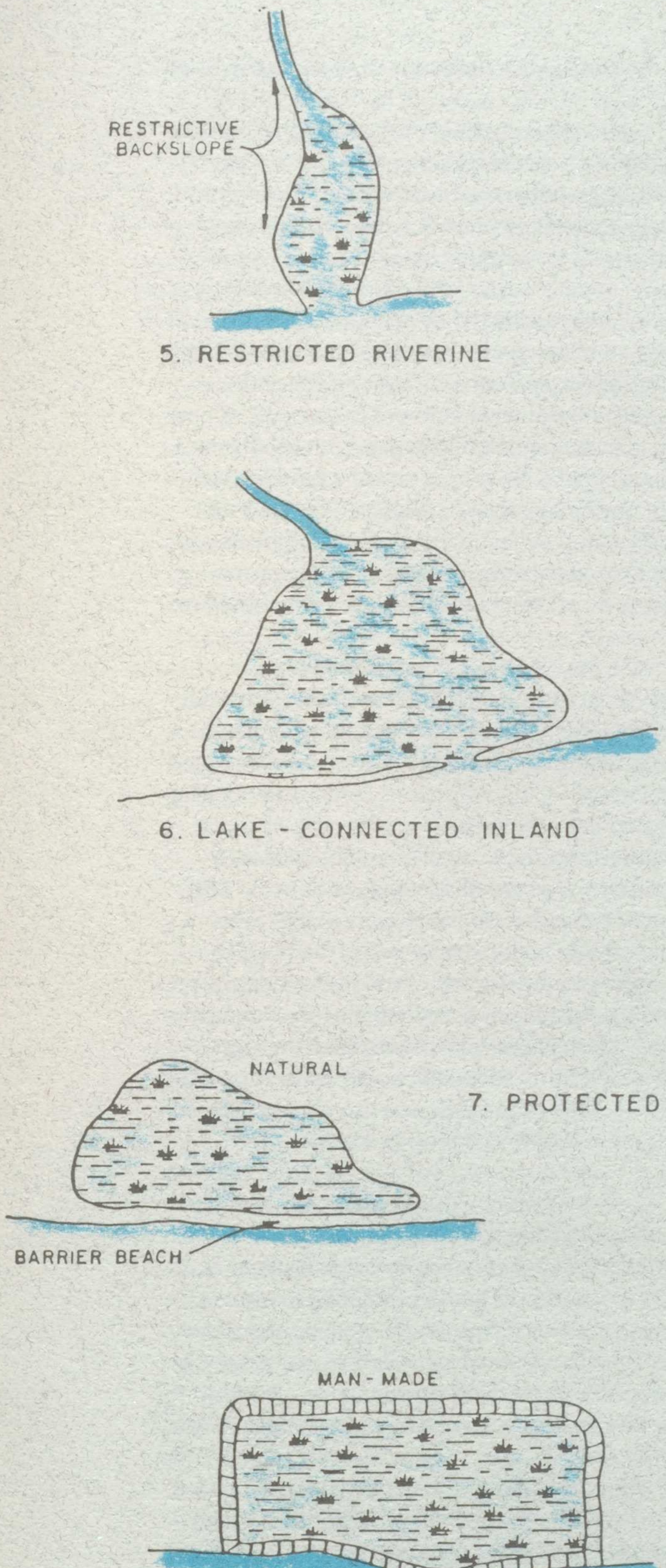


Figure 16: GREAT LAKES WETLAND TYPES

The Aquatic Environment, Habitat and Water Quality

The aquatic environment of the Great Lakes and connecting channels is vast in size, varied in composition, and a home to many life forms (see Annex B, Sec. 3.4). Basically, this environment consists of the water itself, with its differing physical and chemical properties, and of the rock or sediment which underlies it. The lakes themselves are separated into nearshore areas, where the influence of waves and currents is more apparent and the effect of human use of the shoreline is most evident, and the deeper offshore areas where stability is the dominant factor and human intrusion has not left as clear a mark. The connecting channels are very much a reflection of the lakes which contribute water to them. The dominant factor here is the rapid movement of water and short-term changes brought about by variations in the flow. Depths in the channels vary but the amount of water stored even in the deeper areas is insignificant compared to that in the lakes.

A rich variety of life is found in these waters. Fish are the most significant for humans, but they are dependent on "lower" forms of life, such as plankton, in both plant and animal form, which inhabit the open water near the surface. A multitude of animal life exists within the bottom sediments. Water temperature, levels of oxygen, the quantity of nutrients or plant and animal material available for food, the presence or absence of sunlight penetrating the shallower depths, and the presence or absence of contaminants in the water or sediments determine the species present and their relative abundance.

All of the lakes and channels show some sign of chemical contamination from industry, agriculture, waste disposal, and other human activities. (Annex B, Section 2.4). Lake Superior is least affected; parts of lakes Michigan, Erie and Ontario and the Niagara River show the most stress. The International Joint Commission has identified 42 "Areas of Concern" throughout the Great Lakes. Nearly all of these locations require immediate and concentrated remedial attention because of the degree to which their bottom sediments, and, therefore, overlying waters, are polluted. Water quality is less problematic outside of the Areas of Concern, but is still an issue of system-wide significance. The farther downstream one proceeds, the more water quality is influenced by the cumulative inputs from human activity in upstream areas.

Lake Superior consists of two large basins, the westerly one having a smooth mud bottom with some rock outcrops and the easterly characterized by a north-to-south system of ridges and valleys. Both its plankton and fish communities are dominated by species indicative of excellent water quality and low fertility. The fishery consists largely of lake trout, whitefish, and lake herring.

Lake Michigan is divided into three basins, the southern being gently sloping and with a sediment-covered floor, the central, irregular with a limestone bottom, and the northern, with a rock-dominated ridge and valley system. The deeper waters are generally infertile, while those close to shore contain more nutrients. Chemical contamination is a concern in Green Bay and in the southern basin. Aquatic life is more varied than in Lake Superior; salmon, whitefish, perch and cisco comprise most of the fishery.

Lake Huron contains three basins: shallow Georgian Bay and the northern and southern basins of the lake. Nearshore areas have sandy bottoms, while in deeper areas the lakebed is largely clay. Water quality is second only to Lake Superior, with the exception of Saginaw Bay and small portions of Georgian Bay. The fishery is primarily lake trout, whitefish and bloater chub.

Lake Erie is the most eutrophic of the lakes, largely because of its shallowness; chemical contamination is evident in a number of areas. There are three separate basins and the bottom of all three is sediment-covered with either silt or clay. The plankton community is dominated by species tolerant of higher fertility; walleye, yellow perch, and smelt are the most significant fish species.

Lake Ontario is divided into a gently sloping, mud and clay bottom western basin and an eastern basin, also of mud and clay, but characterized by rock outcroppings, including islands. The waters are moderately fertile, with localized evidence of contamination. Lake trout, salmon, smelt and alewife are the dominant fish species.

Connecting channel bottoms are mostly clay where significant currents exist, silty in areas less frequently flushed out. Water quality reflects the input from the upstream lake(s) as well as the often concentrated industry along their shores. The fish and plankton species generally reflect those of the upstream (also downstream in the case of fish) lake.

Generally speaking, the aquatic environment of the lakes is less influenced by water level fluctuations than are wetlands and the shoreline. (Annex B, Section 3.4). Much of this environment is beyond the influence of waves and many aquatic organisms are mobile and seek conditions to which they are suited. Storms have an effect, particularly on nearshore or rocky shoal areas, and can provide and distribute organic matter and sediment to some locations, while scouring and flushing out others. The cleansing of rocky shoals used by fish for spawning may be especially beneficial. On the other hand, the connecting channels, being most susceptible to changes, are the aquatic environments most affected by water level fluctuations.

On the whole, high levels tend to be beneficial to aquatic habitat and water quality, because of the lower concentrations of pollutants and reduced need to dredge contaminated sediments. At the same time, some water quality degradation can result from flooding of septic systems, reduced treatment plant efficiency and submergence of shoreline vegetation and nutrient-rich soil. Sustained low water levels concentrate pollutants, increase the need to dredge, reduce dilution of waste discharges, limit the flushing and cleansing of shallow nearshore areas and embayments, and, through wave-action, re-suspend contaminated fine sediments. Water temperatures rise and dissolved oxygen levels drop during low levels.

Low levels also reduce the amount of "edge" habitat for fish and other aquatic organisms, especially in the connecting channels, and may lead to isolation of some fish habitats. Habitats for fish spawning may be particularly susceptible. High flows move larval fish and other small organisms more rapidly through the system, improving their prospects for growth and survival.

A perspective that must be kept throughout this discussion is that, while sustained high or low levels and flows can have either positive or negative consequences for water quality, aquatic habitat, and aquatic life, fluctuations in water levels and flows are a positive force from which life forms have evolved and adapted over millennia, and upon which continued ecological balance depends.

Geographic Information System

In anticipation of the needs of this study for a simulation model of environmental interactions which can manage large amounts of data, format variables and visually depict the geographic results and responses to proposed plans of action, three components are being integrated (see Annex B, Sec. 5). The first is a Spatial Evaluation Framework. This is the framework for providing spatial detail with respect to resources, measures and impacts. The framework encompasses divisions in the data to accommodate assessments at the scale of all the lakes, an individual lake, a littoral cell within a lake, or a number of reaches within a littoral cell. Each of these levels of resolution is required because of the nature of the measures, some of which have basin wide impacts, whereas others have impacts limited to a single reach. This resolution is also required because of the nature of environmental resources which exist in some reaches, but not in others. The nature of the problem will constrain the range of measures selected to address it.

The second is a Coastal Zone Database, which is the collection of information which exists for each spatial sub-division within the Spatial Evaluation Framework. Information on wetlands, fish habitat, water quality, nearshore sediments, coastal processes, and land use, provides the raw material with which to begin assessments of measures.

The third, the Geographical Information System (GIS), is a set of computer software, which allows the overlay, analysis, and display of spatial information stored in the Coastal Zone Database. Combining information from different data sources provides knowledge not presently available, such as the number of square kilometres of flood prone and erosion prone land along shorelines. Combining information on the location of residential buildings with the location of flood and erosion zones, provides accurate counts of dwellings at risk. Using the shoreline information and the modelling capabilities of the Geographic Information System, the results would provide a visual, geographic picture of the coastal zone as it would respond to various projected actions or conditions.

The Climate

There is much speculation and some serious study being attempted in order to predict and understand future climatic change (see Annex A, Sec. 4). Much of this has been brought about in the last decade by a concern for the effect on the earth's atmosphere of the accumulation of chemicals produced by the industrial world. Although the climate is a matter of global scope, the impacts of climate change will be felt directly in the natural ecosystem of the Great Lakes—St. Lawrence River Basin. It is worthwhile, therefore, to pursue some of the possible consequences of scenarios which have been put forward in regard to future climatic variation. If the historical record is analyzed and the possibility of major climatic change set aside for the moment, there are indications that the first forty years or so of the 20th century was a period of unusually low water levels. Both before and after that period we have experienced higher than average levels on the lakes. It might be concluded from this that recent high levels are a return to "normal" levels rather than an aberration.

In the past few years, however, much of our attention has been directed toward the so-called "greenhouse effect" of rapidly increasing levels of carbon dioxide and other changes in the upper levels of the earth's atmosphere. If, for example, the carbon dioxide levels doubled, the impact on the natural ecosystem could be dramatic due to increased air temperatures. Higher evapotranspiration over the land mass, higher lake surface evaporation, and lower runoff could lower lake levels. The timing of runoff and the present flow patterns of the Basin drainage would also be affected by the decrease in snow and ice coverage and the increase in aquatic plant growth in the tributary systems. Exact estimations are difficult to make, but trial calculations for a period of 35 years (model of Oregon State University) suggest that the change in mean lake levels would range from -0.78 foot (0.24 metre) on Lake Superior to -3.14 foot (0.96 metre) on Lake Michigan and Lake Huron. Other models suggest as much as -8.27 feet (2.5 metres) on the middle lakes. Even in the more conservative of these estimates, the present control regulations would no longer function because the water supplies would be lower than those on which regulation plans for Lake Superior and Lake Ontario are based.

Although the climate change models now being created are speculative and a long-term concern, work is underway to predict more accurately near-term weather and water supplies in the Basin. As these come into more common use, it may be possible to issue more cogent warnings about future conditions than is now possible. In turn, our growing understanding of climate change processes will allow us to estimate more accurately the impacts which will be experienced in the system and to develop decision-making tools for dealing with risk and uncertainty.

While the natural system is complex and difficult to analyze exhaustively, it is possible to determine the key factors which need major consideration in any process of decision-making or management for the Great Lakes — St. Lawrence Basin.

The fluctuating levels of the Great Lakes are the result of the variability of supplies of water in the Basin. In fact, the fluctuating lake levels are the mechanism by which the lakes average out the changing supplies of water. The two key factors for this hydrological performance are precipitation and air temperature. The predictability of the system depends on the analytical knowledge of these factors and an understanding of their underlying physical processes and interconnectedness. A great deal is known about the natural ecosystem. Factors, such as precipitation, evaporation, and runoff, have been the subject of careful recordkeeping and extensive analysis in this century. This work continues; a recent area of study has focussed on increasing knowledge of runoff through a streamflow gauging network.

The effect of the water on the shoreline is primarily a result of the composition and configuration of the material base (geomorphology) of the shoreline and of the impact of waves and currents on it. The lake levels influence the landward extent of the waves and currents and flooding of low-lying areas, but for many shore areas, have little influence over long-term recession rates.

The ability of the wetlands to function is strongly dependent on lake level fluctuations. The key factor for wetlands is diversity. At near-constant water levels, stable plant communities develop at various depths, and each is ultimately dominated by the species that compete best. This results in large, uniform stands of plants, such as cattails, loss of rare plant species, and loss of diverse habitats and food sources for fish and wildlife. When water levels fluctuate, the plant communities respond, the result being an ever-changing wetland with many plant and animal species. Since the wetlands support wildlife and its habitat, and are important in maintaining water quality, their gradual reduction can be seen as one of the changes which magnifies the impacts of lake levels in the natural system.

The basic coastal processes, such as wind, climate, wave hydrodynamics, currents, water level fluctuations, hydrological processes and climatological processes are well known, and we have good general knowledge about the composition of existing shorelines and their response to wave action, storm activity, and water level fluctuations. We need more work in establishing the exact relationship between static water levels and storm activities in regard to erosion and flooding of specific shore areas.

The prime importance of wetlands as habitat for plant and animal species has become very clear, but we still need more information on location and extent of wetlands, especially on Lake Superior and Lake Huron. Because of the great variety of types of wetlands, more specific knowledge is required to understand the effect of duration of water level fluctuations, the relationship of change in vegetation to animal species and the response of rare types of wetlands and wetlands which have been disturbed by human intervention.

One area in which our knowledge is as yet very limited is in fish spawning and fish habitats. A system of classification for fish habitats is needed and spawning areas need to be fully inventoried. This knowledge is basic to understanding the impacts of water level fluctuations on fish populations and habits.

Although human intervention, whether regulation, dredging, diversions, shoreline changes, consumptive uses or land use changes, has had little impact on water levels and flows, the impact of future interventions are not known. A great deal of further study is required in order to understand the economic pressures, changing values and political developments, as well as the growth of population and urban expansion, which will affect future impacts on water levels and flows.

Although long-range climatic change cannot be predicted with any certainty, short-range weather changes can be anticipated. The three most important factors of weather forecasting for the Basin are air temperatures, precipitation and storms. In regard to climate change, we know that the levels of carbon dioxide and other gases in the atmosphere are increasing and that there is a very real danger that these will cause what has been called a greenhouse effect on the planet. More knowledge is needed, however, about factors contributing to climate change and how to improve the prediction of future weather patterns.

In the area of water quality, the impacts of extreme levels on the resuspension of pollutants and on the volume of discharge from sewage treatment plants and septic systems will require future study in order to better establish the relationship between water quantity and water quality.

The salient factors of the natural system, or that part of the ecosystem which is not primarily human activity, are, then, precipitation, air temperature, evaporation, runoff, shoreline composition and configuration, wave and current action, wetland extent, storms, and the plant and animal species and their habitat. Although there are many other factors that will be brought into this study, these are the ones which must be included in any basic analysis of the Great Lakes—St. Lawrence River Basin as a natural ecosystem.

While much is known about the natural system and how it functions, much is left to be done. Each avenue of investigation opens up new areas of knowledge, and these must be studied and the interrelations carefully ascertained. The components of the human system, in turn, are interconnected with the natural and the total complex poses the problems which governments will have to deal with in the future.

Chapter 4

Interests and Their Investments

Introduction

The boundaries of human activity which are germane to an analysis of the ecosystem are much more difficult to determine than those of the natural system. The geographical boundary of the natural ecosystem does not delimit human activities, many of which take place thousands of miles from the Basin. One need only think of the decisions for industrial and commercial investment or the legislative decisions of national governments to be aware of their distance from and yet undeniable importance to the ecosystem. Indeed, almost any of the human activities could be pursued to sources or purposes outside of the geographic basin.

Any identifiable groups, who see themselves as affected by the fluctuations in water levels and flows or by policies and measures to address fluctuations, have been defined for the purposes of this Study as interests. These interests, both inside and outside the Great Lakes – St. Lawrence River Basin system, have been categorized into ten groups based upon their use of the basin. These categories are: agriculture, commercial fishing, commercial and industrial, electric power, environment, native peoples, recreation, residential shoreline property owners (riparians), transportation, and government. The categories cannot be completely separated; native peoples, for example, may be shoreline dwellers, environmentalists and commercial operators. In effect, this categorization focusses on the dominant activities and concerns.

It is important to attempt to describe how the human activities interact with the natural ecosystem and with each other. These interactions need to be seen against the spectrum of implications of actions and decisions. It was not possible to pursue these implications in detail, but the possible results of actions need to be delineated. A number of factors affect these interactions, including such determinants as location, nature of the shoreline, nature of technology used, political jurisdiction, economic environment or context, proximity to other users and attitudes.

Progress in resolving or managing the water levels issue depends in large part on understanding the reasons for which interests petition governments and the relationships between these "positions" and the responsibilities of government. The current decision-making process in resource management is becoming more complex; in addition to evaluation of hydrologic phenomena, engineering possibilities, costs, economic development benefits and public information, there is an involvement of a larger public component which necessitates close consideration of the positions taken by interests, how they respond to changing conditions and how they interact with governments.

Attempting to describe these interests and their interactions with each other and with the natural environment is a difficult task. The element of subjectivity of such an exercise is compounded by the political voice of the interests and their influence on the process of decision-making. In this study, an initial investigation of the positions of the interests has been carried out through a series of in-depth interviews (See Annex C) and public interaction via television hook-up in ten key centres in the Basin (See Annex G). The resulting generalizations made will of necessity become a part of the process of interactions from which a strategy for action will eventually be developed.

Given the diversity of interests in the Great Lakes—St. Lawrence River Basin and their greatly varying perceptions, a description of their positions would be complicated enough, but further complications arise from the accuracy of the information on which that position is based, the variations in positions within each interest and their level of access to the decision-making processes for the Basin. Was the erosion caused by wave action, run-off or water levels, as the interest claimed? What control of lake levels is possible, much less desirable? The impacts of lowering lake levels on the upper lakes to benefit shoreline interests there will elicit a different response from the shoreline interests on Lake Ontario and those on the lower St. Lawrence who experience the increased flows released through the control structures at Massena/Cornwall. There are thousands of riparians on the shores of the lakes, but few electrical generating plants, and, yet, the power plants each represent a very large capital investment and have millions of people, including the riparians, depending on them. These are all important dimensions of the positions of the interests, which determine their participation as parts of the larger ecosystem and its governance.

Behind each interest's position are values, which the interest sees as of prime importance. The rights of private property as opposed to communal rights is an issue which touches every attempt to deal with issues through regulatory channels. There are other values which the interests feel should direct governmental decisions. For example, the transportation interests may see economic advantage as an overriding value, whereas the riparian may give priority to the value of social accommodation or equity. The environmentalist, on the other hand, may see the protection of the ecology as the foremost requirement of any human activity, whether of government or of individuals. These values, while desirable in many contexts, are often conflicting or need to be rated for priority. They colour whether or not the interests trust the findings of the "experts", how compassionately they judge the needs of other interests, and how inflexible their positions may be.

An important factor in the positions taken by interests is the resiliency of the interest to fluctuations in water levels and flows. Their situation, therefore, cannot be simply measured in terms of impact, but must also include consideration of how readily they can adapt to a change in lake levels. Shipping may prefer higher lake levels because they allow them to carry greater loads, but they can adapt by varying the amount they transport. A riparian who has built on the shoreline has fewer options. The environmentalist, watching valuable wetlands disappear every year from pressure for development, knows these habitats as nature provided them are gone forever and that the resiliency of the wildlife and vegetation has been reduced. The ability to adapt is very different in each case and the intensity of the positions taken may vary accordingly.

Geographic location and the period of time under consideration will affect the position taken by interests. Often, decisions made at some distance from the Basin will drastically change the range of activities of the interests; the decline of the world market for steel, the availability of more leisure time and money, a heavy harvest or a multinational takeover can cause far-reaching changes in the Basin. This interaction makes it more difficult to ascertain how hydrological changes will affect particular interests and more imperative to define the positions of the interests.

The human system and the natural system are bound together in a constantly changing process of unconscious adjustments in the natural system and conscious adjustment in the human system. This "conscious adjustment" needs to be better understood in its social, economic and political dimensions.

The Investment Model

The decision to locate in the Basin may be looked at in terms of an "investment model". The investment decision is made, by and large, in order to obtain a maximum of utility or benefit over costs, which in this case may in part relate to water fluctuations. Location, technology, past experience, reliability and availability of information, and level of risk-taking are some of the considerations that may determine the final decision. Once the investment is made, there will exist an asset, which may be said to have a profile resulting from the considerations that went into the decision-making. It is this asset profile which determines the kind of conscious adjustments to fluctuating lake levels which can be made.

Another concept which may be generalized from the activities of interests in the Basin is that of the "design range" of the investment. Thus, the distance from the reach of lake levels, the depth of water required for passage, the flow of water needed for removing wastes are all aspects of the design range. This range can be radically affected by the conflicting pressures and trade-offs of opportunity costs and levels of vulnerability. By purchasing only shallow draft ships, a shipping company could establish a design range which would assure low vulnerability, but the economics of being able to transport larger quantities and the competition from deeper draft ships may lead the company to narrow the design range and risk increased vulnerability. Similarly, the riparian may build closer to the shoreline, thereby narrowing the design range of the investment, in order to enjoy fuller utility of his or her asset. The issue of the design range is made more complex by the life expectancy of the asset. A decision may be made with short-term calculations which nevertheless produce a long-term asset. In this case, it is entirely possible that the vulnerability may change merely because of the long-term change in the natural and human systems.

The positions taken by each of the interests is primarily one of self-interest and, therefore, needs to be continually placed in the perspective of the entire ecosystem and the needs of all the interests both of the natural and human systems. The interest invests in the Basin in order to enjoy a flow of benefits. Lakeshore property returns to the riparian a benefit of recreational and aesthetic nature, and is reflected in the property value. For the industrial or commercial interest, the benefit is profit. The environmentalist interest has a return of enjoyment of nature and a sense of playing a major role for future generations.

Each of these investments has a cost, usually of both money and time. There is, however, also a risk cost, not only of business failure, but of potential damage due to the decision of locating in the Basin. What we have earlier called the "design range" is a result of the calculations made by the interest in order to find a balance which gives a maximum of benefit and a minimum of cost. These calculations are based on information: first, about the behaviour of the natural and human systems; and, second, about the availability of outside incentives which would affect the level of risk. An example of the latter information would be government programmes which would allow the cost of risks to be shifted to general taxpayers.

Most conscious adjustments within the human system and between the human system and the natural system only make sense if seen as long-term. Seen at its most simplistic, the role of governance is to facilitate the process of making informed and responsible decisions. In accomplishing this, the long-range investments and their design range must be seen clearly as an integral part of the overall ecosystem of the Basin. Responsible decisions, however, require better information, and some way of avoiding short-term decisions which may jeopardize the flexibility of the process of decision-making itself.

In this chapter, interests in the Basin, who perceive their welfare to be influenced by water levels and policies pertaining to them, are classified and described in terms of how they use or invest in the resources of the Basin. For each interest is given a description of its sensitivities to fluctuating water levels and flows and an analysis of why the interest seems to take a particular stand.

The Interests and their Interactions

Over 39,000,000 people live in the Great Lakes — St. Lawrence River Basin, of which 29,000,000 live in the United States and 10,000,000 in Canada. The heaviest concentrations are on Lake Michigan with 14,000,000 and Lake Erie with 13,000,000 with large urban populations in Chicago, Detroit, Cleveland, and Buffalo. The heaviest concentrations on the Canadian side of the border are in the Toronto-Hamilton and Montreal areas.

The most important general trend in the Basin has been toward decreased use of the Basin for agricultural purposes, fishing and forestry and increased use for urban growth, industry and recreation. These developments vary according to lake with Lake Superior having not only the most stable population growth, but also the least urban and industrial expansion. Lakes Michigan, Erie and Ontario are the "stress" points of modern development. Table 3 shows the various types of land uses.

A large proportion of the population of the Basin is, in one way or another, directly affected by the fluctuation of the lake levels. In this first phase of the Study, participants attempted in markedly different ways to state the central question raised by the impact of fluctuating levels and flows on the interests located in the Basin. Some sought to define the implications of "adverse consequences". The term used here was "vulnerability", which is a description of the susceptibility of basin users to the effects of fluctuations. (This is the approach taken in Annex D) Although such a term cannot be easily quantified, it does serve as a way to compare relative effects of actions. A residential property owner who decides to build on the shoreline floodplain has opted for high vulnerability for some benefit of access, view, or price, while the cottager who builds well back from the flood area has lower vulnerability. Basically, when we are talking of the consequences of the fluctuating lake levels, we are speaking of the effects on humans measured by their vulnerability. All interests have some level of vulnerability.

Others sought to ask not "How are you vulnerable?", but "Why do you petition governments?". (This is the approach taken in Annex C) The thrust of this line of inquiry was to focus on what the interests see as the problems and solutions. By establishing these positions, it was argued, the key elements of the political challenges can be identified and compared to the mandates and stated policies of government and to the current knowledge about fluctuating levels and ecological processes.

In Annexes C, D, E, and F, these two approaches can be followed in more detail. In this phase of the Study, the usefulness of each has not been assessed.

The following descriptions of the positions taken by interests is designed to give the reader a basic understanding of some of the complexity of the issues. The material for this section can be found mainly in Annex C, Section 7.

Agriculture

Rich as the Basin is in agricultural land, relatively little of it is on the lakeshores and that is steadily declining with the rapid growth of urban areas.

Agricultural lands are more vulnerable to shoreline erosion and flooding at high water levels when exacerbated by storm-driven waves. The lands most vulnerable to flooding are those reclaimed from former floodplains and wetlands. In some of these areas, notably the lower Saginaw River Basin in Michigan and Kent and Essex counties in Ontario, elaborate networks of dikes have been constructed.

Farmers are concerned about erosion and flooding of their properties and associated crop yield losses. However, they are accustomed to dealing with uncertainties of nature, and have an understanding of the consequences of fluctuating water levels, and other natural hazards, and, in most cases, have adjusted accordingly.

Commercial Fishing

Commercial fishing on the Great Lakes has changed significantly during the course of the 20th century. In Canada, output has risen and employment is stable; in the United States, however, much of the stock has been reallocated to the recreational sector. Commercial fishing in Canada remains a major industry with annual landings of over 60 million pounds, mostly from Lake Erie. The composition of harvests has shifted to warmer water species and non-indigenous smelt and alewife.

Water levels are known to influence growth rates of fish and higher levels promote more rapid, abundant growth of fish in size and numbers. The annual fluctuations associated with spring run-offs and rains and melt water also appear to influence stocks and harvests. The greater the increase in levels between January and June, the more beneficial it is for spawning and young of the year. This, in turn, contributes to better harvests two or three years later, depending on species. Water levels and natural fluctuations are critically important for increasing room to grow and bringing new food energy into the lakes each year. Since many important fish species use wetlands during part of the

Table 3 Land Use of The Great Lakes Shoreline For Canada and the United States

	Superior Canada	Superior U.S.	Michigan U.S.	Huron Canada	Huron U.S.	Erie Canada	Erie U.S.	Ontario Canada	Ontario U.S.
Shoreline (km x 1000)	2.9	1.5	2.2	5.0	1.1	0.6	0.8	0.3	0.8
Area (km sq x 1000)	209.8		175.8	193.7		103.7		83	
Inland Water (%)		2.7	0.9		3.7		0.4		3.3
Wetland (%)	0.2	0.8	5.9	0.68	7.5	1.01	6.7	1.65	2.8
Forest (%)	98.8	62.1	35.8	74.99	31.6	14.77	10.6	42.59	24.4
Brushland (%)	0.08	4.5	8	3.09	9.6	7.24	9	9.83	14
Grassland (%)	0.44	1.1	5.6	12.09	4.1	21.63	4.8	25.58	7.8
Barren (%)	0.12	5.6	1.3	0.22	0	0.12	1	0.18	0.1
Plowed (%)	0.02	0.5	5.6	5.96	7.4	51.02	9.7	13.43	5.2
High Density Residential (%)	0.01	1.4	7.1	0.02	9	0.33	23.4	1.17	5.7
Low Density Residential (%)	0.04	1.4	25.3	0.09	27	1.19	21.7	1.57	36.3
Commercial (%)	0.03	0.02	4.5	0.11	0.2	0.93	12.7	1.6	0.4
Total Urban (%)	0.09	15.6	36.9	0.97	36.2	3.67	57.8	5.46	42.4

Sources United States – Monteith, T., J. O. Myll and P.J. Wagner 1978, Summary of the Existing and projected land use for the Great Lakes Coastal Counties. Great Lakes Basin Commission, Ann Arbour, MI.

Canada – Gierman, D. and R.A. Ryerson. 1974. Land Use Mapping in the Canadian Great Lakes Basin: Report on the Canadian Sector of Task B IJC, Pollution From Land Use Activities Reference Group, Windsor.

reproductive cycle, the impact of fluctuating water levels on the wetlands is of concern for the commercial fishing industry.

High or low water affects fishermen's docking facilities and other aspects of their trade, but basically commercial fishing has a relatively high level of resiliency in dealing with fluctuating lake levels.

The fishermen on the Great Lakes have conflicting views about water level fluctuations and the implications of fluctuations for their operations. The perceptions of fishermen who fish in the same area with the same type of gear and vessels sometimes differ. Some of them perceive highs to be more detrimental to their operations; while others perceive lows to be more harmful. In general though, most fishermen contacted had the opinion that fluctuating water levels do not have great impact on their operations, if any at all. Lake level changes are a part of their normal operations and they have, by and large, developed a resiliency to extremes through modifications to their boats, docks and fishing methods. They tend to be more concerned about the restrictive commercial fishing regulations that most of the states have imposed in order to protect and enhance the recreational fishing industry.

Commercial and Industrial

Major industries are located along the shores of the Great Lakes in both the United States and Canada. Iron and steel, grain handling, pulp and paper, petroleum and chemical refining, metal mining and refining, and food and beverage processing industries use the lakes both for water supply and waste disposal. These industries are concentrated in the United States along the southern shores of lakes Michigan, Huron, Erie and Ontario. In Canada they are located on the northern shores of lakes Erie and Ontario, and at Thunder Bay and Sault Ste. Marie on Lake Superior and the St. Marys River.

The growth industry of the Basin is recreation and tourism. Marinas, hotels, motels and resorts have sprung up on both sides of the border, adding greatly to employment in the service sector of the economy within the Basin.

As with all facilities on the shorelines of the Great Lakes, periodic damage is experienced to property through the action of storms and flooding. Higher water up to the level of flooding, however, is on the whole more beneficial in that it satisfies the needs for water supply, greater dilution of waste discharges, access to water for boats, and clearances for commercial navigation deliveries to industrial users.

Most commercial and industrial businesses accept the fluctuating water levels as a part of the cost of doing business. Although they have different views, a majority of them probably favour higher over lower water levels. Some of these businesses have taken steps to protect themselves from damage by extremely high water and storms. Most, however, fear extreme low levels more than extreme high levels. As a consequence, many commercial and industrial businesses favour regulation of levels and flows in order to allow them better capability of predicting the need and amount of adaptation they will require. Geographically, those supporting regulation are located on the middle lakes, while those on the St. Lawrence River and the connecting channels do not. Better information is the prime element of all commercial and industrial interest positions. They see location on the shore a far greater advantage than the disadvantage of changing water levels. Smaller businesses, such as marinas and other commercial operations, may exhibit more concern because they tend to be financially less able to adjust to fluctuations.

Electric Power

Electricity in the Great Lakes – St. Lawrence River Basin is generated by hydropower and thermal power (coal, oil, natural gas and uranium). Major utilities that produce electric power throughout the Basin are interconnected by transmission lines and electricity can be transferred to different areas, depending on demand and capacity limitations of the transmission lines. It is necessary, therefore, to examine both the operations of individual utilities and the power production system as a whole.

Approximately 94,400 megawatts of electric power generated by utility and non-utility owned electric power projects located in the Great Lakes – St. Lawrence River Basin could be affected by fluctuating water levels and flows. Of this amount, approximately 7300 megawatts of hydropower would be directly affected. These projects, for the most part, are located along the Niagara River (4500 megawatts), at Sault Ste. Marie on the St. Marys River (101 megawatts) and on the St. Lawrence River (2720 megawatts). In addition, there are numerous smaller hydropower plants located on tributaries to the Great Lakes.

Fluctuating water levels affect individual electric power facilities in various ways. During high water periods, thermal power facilities can experience greater generating efficiency due to lower temperatures of cooling water. The costs of pumping cooling water and transporting raw materials by water could also be reduced. Hydropower outputs can be increased with increasing levels and flows, although there is a threshold of extreme highs above which extra flow cannot be utilized due to physical limitations of equipment and/or hydraulic limitations. Hydropower output decreases if levels fall below long term averages. Thermal power projects can provide make-up power at a higher cost, as long as the decrease in hydropower capacity is not large and demand does not increase significantly. Lower than average water levels are a concern to thermal power projects because of the higher probability of exceeding temperature regulations for cooling water discharge, increased cooling water pumping costs, warmer cooling water, which adversely affects generating capacity, and increased costs of raw materials obtained by water transportation.

What has to be remembered, however, is that any increase in thermal power generation has negative impacts on the environment. For example, the environment could be negatively affected by increased emissions of gases contributing to the greenhouse effect and other atmospheric pollutants, thermal pollution from cooling water discharge, and the increased need to dispose of solid wastes, such as flyash and spent nuclear fuel. Moreover, the cost of make-up power can be several times greater than the cost of lost hydropower generation.

The general lack of petitioning to governments by the power interest reflects the fact that they are already well-informed about levels and can adapt to fluctuations without suffering major costs. They would, however, react unfavourably to proposals to alter flows currently available and could not readily withstand the impacts of extended periods of prolonged drought.

Within a range of fluctuations around the long term averages of the Great Lakes, the electric power interest can reliably generate electric power primarily through the diversity of generating options available. There are associated environmental, social and economic effects and trade-offs. Extreme high water periods are not considered adverse by the interest and can even be beneficial to a degree. Extreme lows over extended periods of time would result in adverse environmental, social and economic impacts to the interest and customers it serves within and outside of the Basin.

Environmental

The environmental interest is very diverse and consists of many different groups and organizations, including citizens' groups, governmental agencies, and scientific and research groups. Examples include environmental conservation and protection associations, hiking and camping organizations, scientific and environmental research establishments, health and medical agencies, heritage and cultural resources agencies, and groups interested in preserving and enhancing certain aspects of Great Lakes environment, such as wildlife, wetlands and dunes. Their central concern is the impact of human activities on the natural system. To the extent that they contribute one voice for the natural system, they can be seen as a bridge between the natural and human systems.

Although the environmental interest is diverse, it is unified on many positions. Citizens' groups, such as Great Lakes United, governmental agencies and scientific/research groups, who represent thousands of people involved in programmes for the protection and conservation of the natural environment, are united in seeing the fluctuating water levels and flows as a dynamic, changeable resource, a part of the natural process, which must be preserved. They do not have major concerns about the fluctuations, but they do have concerns about any attempt to manage the Great Lakes. They are also not willing to support most governmental actions dealing with structural measures, the consequences of which are not clearly known. The majority of groups see these measures as encouraging encroachment on existing natural habitats. Some groups would give support to such measures if they can be proven to be environmentally sound and will not cause damage elsewhere. On the whole, non-structural measures are seen by the environmental interest as the best way to deal with fluctuations.

Native Peoples

Although the activities of the Native Peoples populations on the shores of the Great Lakes could be categorized with other shoreline users, the reservations are different in that they are really micro-societies within the ecosystem. There are approximately 7,000,000 acres of federally recognized reserve lands in the Great Lakes — St. Lawrence River System Basin. Of the 350,000 native peoples of 110 nations, who live on these lands, about 60% live along the shoreline, mainly at the narrowing points of the connecting channels. Their activities are parallel to and intertwined with those of the rest of society, but those activities are more coordinated into an identifiable way of life. That way of life is informed both by a marginal relationship with the industrial, urban society of the Basin and a traditional relationship with the natural system.

Dependent as they are on fishing and hunting for food, native peoples' concerns centre on the maintenance of the natural environment. They see lake levels as a part of that environment, but are more concerned about water quality and balance in the ecosystem. They feel that there should be a Native Peoples representative on any taskforce dealing with lake levels.

Recreation

Recreation is increasingly becoming an important social and economic activity in the Great Lakes Basin, as more and more people have greater amounts of leisure time. Millions of people, both within and outside the Basin, use the Great Lakes and the shoreline for a variety of recreational purposes. Some of the major activities include boating, sports fishing, hunting, bird watching, camping, swimming, windsurfing, picnicking and scenic drives along the shoreline.

An extensive network of private and public facilities, including marinas, campgrounds, parks, and boat launches, have grown up on the shorelines of the lakes to support the ever-growing recreation demand. The range of these activities is so great, it is impossible to generalize about the impacts of lake level fluctuations on them and their users. Low levels expose more beach for bathers; higher levels improve boating and docking for sailors; fluctuating levels maintain waterfowl habitat for hunters and fish spawning grounds for anglers.

Generalizations are difficult in an industry which embraces so many different activities. Within those activities there are some, such as boaters, who would prefer higher water to lower. But even here, it is sudden changes in levels which are the most detrimental. They emphasize the need for more accurate forecasting of water levels, so that they can plan their operations and activities. Others, especially those whose recreational activities are centred on the wetlands, such as hunters, bird watchers and sports fishermen, are anxious that the fluctuations continue and that the wetlands be preserved. Apart from the extent of the wetlands and the encroachment on their shores, this group has little other concern for the lake levels. Loss of recreational land to the lakes is an area of concern, but basically the recreational interest is the most flexible of all interest groups. Lake levels are of moderate concern, behind water quality and access to the water. Along the St. Lawrence River, however, levels and flows questions are persistently raised by this interest group.

Residential Shoreline Property Owners (Riparians)

"Riparians" refers to shoreline residential property owners, both permanent and seasonal. The greatest concentration of permanent owners tend to be found in and around major urban centres, while the distribution of seasonal owners is more sparse along the shorelines. The exact number of residential shoreline owners situated on or near the Great Lakes and St. Lawrence River is not known at this time, but a detailed list of Great Lakes Riparian properties is now being compiled in Canada and the United States. Preliminary studies have found that there are over 75,000 vacation homes located on the Great Lakes shoreline in Canada.

The degree of risk or impact incurred by riparian land owners depends on their location. The most serious impacts to riparians are those associated with flooding and erosion which are most prevalent during storms. Some of the impacts include loss of land and trees and damages to shore protection structures and buildings and their contents. Economic impacts include the cost of alternate accommodation, costs of maintaining septic systems and costs of repairing or replacing damaged shore protection works, buildings and contents.

The relationship between damage and static water levels is not entirely clear. For example, the majority of damage on Lake Erie, although exacerbated by existing high levels, occurred in

April and December of 1985 during storm periods and not during the record breaking static water levels of 1986, when far fewer and less severe storms occurred. Similarly, the effect of static lake levels on erosion is limited in many areas of the shoreline. At the present time, a large census and survey is underway in order to gain a better understanding of the magnitude of these impacts on shoreline properties. It is clear, however, that it is storm-driven waves and surge actions which are most damaging.

Primarily in response to the high water levels and storms of 1985/86, the riparian interest has begun to organize into groups which are mandated to further the views of shoreline residents. The largest of these organizations with members on both sides of the border is the International Great Lakes Coalition. They have a high concern about fluctuating lake levels and are strong advocates of total control through centralized management and engineering water controls. The Coalition is highly critical of existing government programmes, especially those which look to land use planning and public information rather than water level control as solutions to their problems of erosion and flooding. They also feel that it is unfair for them to bear the costs of apparent governmental inaction or ineffectual action. Because of the wide range of shoreline residences and locations and the individualized nature of this interest, it is difficult to judge how representative the position of the Coalition is. It is important, however, to point out that the element of surprise plays a large part in the reactions of shoreline residents. Surprise is based on the predictability of events affecting water levels and flows and the resiliency of the property owner. The information and its availability and the quality of lake levels prediction are all judged inadequate by the riparian interest.

There are some geographic patterns to riparian positions. Those located on the middle lakes tend to favour total regulation of the water levels. Riparians on both Lake Superior and along the St. Lawrence view with suspicion regulation of levels as being primarily for the benefit of those located on the middle lakes.

Transportation

According to the Lake Carriers Association's annual reports for the year 1988, approximately 181,000,000 tons of bulk cargo, including petroleum, moved into and out of Canadian and United States ports located in the Great Lakes — St. Lawrence River System Basin. This represents a drop of about 59,000,000 tons or almost 25% from the peak year in 1979. Although annual figures vary, there has clearly been a decrease in the amount of goods transported on the Great Lakes in both the United States and Canada.

Most of the goods shipped are bulk commodities. Ships are designed with full knowledge of channel and harbour depths, which are maintained throughout the system and referenced to low water marks. Generally speaking, higher levels benefit shipping; lower levels are detrimental. Adjustments are made in loads and the industry is vulnerable only to extreme highs and lows.

The timing of the fluctuation is of importance in that the interlake shipping season is limited to the ice-free months (typically April through mid-December). Variations in cost can be passed forward to customers, or absorbed by the ship owner. Great Lakes shipping is one part of a larger multi-modal transportation system and there is some flexibility in that some commodities can be shipped alternatively by rail. In some cases, truck haul may be possible to other modes or waterways. For example, the Great Lakes grain hinterland overlaps with the inland waterway in the mid-Western United States. These alternatives often would entail increased costs.

Lake levels may not be the primary concern of the transportation companies and ports, but they argue that they incur higher costs when the lake levels fall because of the reduced load carrying capacities and narrower revenue/profit margin. This net change varies with the size and routes of the ships, but may involve a very narrow clearance when navigating the connecting channels.

The transportation interest may be divided into ocean-going and lake carrier shipping companies and the ports. The latter, through the lock operating agencies, set the draft limits, based upon available channel depths. These limitations prevent the ships from carrying extra tonnage. Shipping companies, port authorities and dock operators have learned to adapt to the vagaries of lake levels. Extreme lows and highs, however, do affect the transportation interest and can change its profit or loss margin substantially.

Of greater importance for the transportation interest are such factors as labour, energy, materials, tolls and pilotage costs. The transportation interest tends to use vessels with a range of carrying capacities to increase their flexibility, and a few firms now negotiate contracts which include variable rate structures, in order to increase their adaptability. In this case, passing on the costs to the customer tends to spread the impact of increased risks between the shipper and customer.

Governments

International agencies and the three levels of government, federal, provincial/state and local, are very much a part of the Great Lakes — St. Lawrence River Basin ecosystem. The location, construction, financing, protection and continuation of commercial, industrial, residential and recreational facilities are all affected by governmental decisions. In addition, governments themselves often own land, recreational facilities, roadways, parks, and buildings along the shoreline. These activities are affected by fluctuating lake levels in the same way as those of private owners. Other governmental facilities are directly designed to affect the lake levels through control systems, dredging operations and construction of dikes, sills, breakwaters and systems for changing the action of the waters. A major activity of governments is the provision of information about the lakes and human activities in the Basin. All of these make Governments important users of the Basin and, as such, a part of the human system.

No other presence in the Basin is as instrumental in directing other human activities as government. That direction, however, is not always well coordinated. The decisions made emanate from a wide range of agencies, departments and other official jurisdictions which not only have differing objectives and degrees of concern about the Great Lakes, but also conflicting programmes and plans of action. Government investment decisions, for example in roads, utilities and other infrastructure, can induce private investment in hazard-susceptible shoreline locations and can, therefore, increase vulnerability. In this study, we refer to the patchwork of decision-making activities by governments and other entities as the "governance" of the Basin. The various governance directives vary enormously in nature and importance, but it is possible to obtain some insight into them by approaching them from three angles:

1) Land use regulation and practice;
2) Specific measures undertaken to address the impacts of lake level fluctuations; and
3) Advisory and advocacy programmes.

Development along the shorelines of the Great Lakes is subject to a number of regulations, designed to control the concentrations and impacts of interests in various locations within the Basin. These range from zoning bylaws to health standards legislation. Through them, some order is maintained in assuring that development is balanced against capacity of the location to support it. At optimum performance, such regulation would work to reduce the vulnerability of shoreline users. However, the very independence of the bodies making decisions allows for varying interpretations of vulnerability and, of course, political pressures can bring about unplanned development even in the face of regulations.

There are a number of ways in which governments address the issue of fluctuating lake levels directly. The control systems on Lake Superior and Lake Ontario are examples of regulation of the actual lake levels and outflows. Protective systems have been constructed which prevent anticipated damage from occurring and offer some degree of protection for shoreline property. Other government programmes lessen the adverse consequences of fluctuating lake levels by payment for damages or by assisting shoreline users in adapting their facilities to the lake fluctuations. Each of these actions on the part of governments seem relatively straight forward until some of the implications are mapped. Not only do controls apply to entire lakes and, therefore, affect a number of shoreline users and systems, all of which may not desire the same level of control or, indeed, any control at all, but also a control may itself encourage shoreline users to take greater risks because they count on the control to protect them. This in turn may decrease the flexibility of the control system, which creates a need for greater controls. Similarly, a land use regulation not only reduces vulnerability, but also reduces the amount of land available for development. This places a higher value on that land which is available, which in turn places greater pressure on governments to relax land use regulations.

Governments are also major sources of information on the Basin and sometimes use that information to attempt to reduce the vulnerability of human activities. Increased ability to predict lake levels, for example, could allow shoreline users to reduce exposure to fluctuations. Self-help guides and recommendations concerning location and construction help to regulate the relationship between the human system and the natural. The key to its success is accurate knowledge and wide dissemination.

It is difficult to think of governments as an interest among others. The reason for their inclusion as an interest is that the divisions and levels of government create certain foci of opinions and perceptions which have an impact in the management of the ecosystem. At the most basic level, governments operate facilities, such as sewage treatment plants, which are directly affected by water levels and flows. Local governments tend to adopt a position in regard to lake levels which is very close to the shoreline residential interest. This may not be surprising in that they not only operate facilities of their own but are most directly involved in zoning and decisions related to location of facilities along the shoreline. Federal departments devoted to resource protection and wildlife rehabilitation adopt a position very close to that of the environmental interest. Sometimes these positions may be seen as an echo of the other interests, but because of their location in the governing system, they have access to decision-making processes usually unavailable to other interests. State and provincial governments and their agencies have their own concerns which range from hazard management to economic development to environmental protection.

It should be noted that governmental agencies also represent interests that are unrepresented or underrepresented, such as the general taxpaying public, future generations, the poor or those outside the Basin.

Interests and Governance

The positions of the interests, as presented here, are preliminary and will need to be more closely defined through further discussion with the key groups and individuals. The process of establishing these positions is a part of the process of identifying the prospects for improved management of water fluctuation issues and the impediments which have to be considered.

The critical question is, however, How does one get from this understanding of how the interests view the problem and why they adopt certain perspectives to a strategy for dealing with the issues? The other major "position" which has to be known is that of the governments, not as interests, but as legislators. In effect, the mandates and policies of government set the rules and boundaries within which decisions are made. Every analysis of an "adverse consequence" or of an interest's position takes place in the context of the very diverse and multi-tiered system of governance of the Basin.

One of the arguments of Phase I of this Study is that the policies of governments and the principles and criteria on which they are based have not been clearly articulated and the interests, therefore, are not able to see their position in the context of public policy. This lack of communication is one of the basic factors leading to surprise in the investment model which has been described in this chapter. Every investment is fraught with risk and much of the information is of its nature incomplete. Decisions on the part of both the interests and the government are made in a context of uncertainty. Although we may work at reducing uncertainty, it is a condition with which we shall always have to deal. In order to develop courses of action which are socially desirable and implementable, a critical step is to understand the structure and jurisdictions of governments in the Basin and the principles on which they act.

Chapter
5

Governments and The Basin

The Great Lakes – St. Lawrence River Basin is a resource shared not simply between two national governments, but in a complex manner among two national governments, eight states, two provinces and hundreds of municipalities and counties, each of which in turn has delegated or allowed certain functions to be carried out by agencies, institutes, citizens' groups and other organizations. Studies have identified as many as 650 governmental units and 1300 organizations. Effective ecosystem management will have to relate to and integrate this present diversity of approach. Indeed, the very concept of an ecosystem approach to the water levels issue of the Great Lakes – St. Lawrence River Basin has to take into account the historic governing traditions of the nation state, for which all governmental activity in North America has been designed.

In this chapter an attempt is made to describe the areas both of agreement and of co-ordination which exist in governmental activity at the present time in regard to the Great Lakes – St. Lawrence River Basin. (See Annex C, Sections 5 and 9 for discussion of policies, organization, and decision-making processes of government)

A Question of Values

The term "ecosystem" itself establishes a context whereby value-driven tradeoffs between human and natural systems are brought into focus. Its use assumes the continued existence of a measure of equilibrium among the parts of the system and a concern for the overall welfare rather than the predominant welfare of any one part. The destruction of one aspect for the sole benefit of another is not acceptable. The term is extended to include the concept of "integrity". "Ecosystem integrity" not only re-emphasizes the wholeness of the system, but also introduces a further dimension of wholesomeness and inviolability.

Terms, such as "ecosystem" and "environmental integrity", have begun to appear in governmental legislation and policy statements in recent years. These terms, along with assertions related to inter-generational equity and joint trusteeship of the ecosystem, create a conceptual base for future governmental action. There are, of course, much older values of governing which do not seem to have declined in importance even though concern for the environment has grown. Two of the most obvious of these are the furtherance of the economic well-being of the people and the preservation of national sovereignty. The question of values is, therefore, a question of potentially conflicting values.

These values underlie the policies governing day-to-day decisions of government. As the values change, the policies will be modified and adjusted to the existing situation. It is this slowly changing relationship of values and policies in existence which makes up the real world of decision-making.

If we look at some of the policies informing governmental decisions in the two countries, something of the potential relevance of existing legislation on the governance of the ecosystem can be seen. In both the United States and Canada, for example, investments in the Basin are considered to be made at the risk of the investor. Even in the case of disaster relief programmes, when this policy is bypassed for one of perceived wider equity, governments attempt to limit incentives which would encourage use of vulnerable areas and which would spread costs to general taxpayers. A policy pursued by both nations is to keep subsidies to a minimum. For example, in the United States, these policies show up in regulations by which the distribution of risk in insurance is limited. In Canada, flood insurance is not available.

Both nations have a policy of national economic efficiency, which may be seen in requirements for extensive evaluation of projects and for justification of these projects as contributory to economic efficiency. Both nations have policies which favour the costing out of the use of water resources, and, in the United States, the policy dictates the recovery of that cost, which embraces the concept of equity of cost burden.

It is important to know some of the policies of the two nations which are directly relevant to the various components of the human system —agriculture, commercial fishing, commercial and industrial interests, electric power, environmental interests, native peoples, recreation, residential shoreline property owners, transportation, and governments. As may be imagined, the full scope of policy making in the two countries defies treatment in a summary document, but it is possible to delineate some of the salient points in fiscal and regulatory policies at a national level.

In the development of shipping channels, both federal governments see it as their role to provide channels and maintain harbour depths of known and unvarying dimensions for transportation needs. They also work jointly in sharing knowledge and developing new facilities. Cost recovery systems, however, vary considerably. In Canada, it is by and large considered a public responsibility to provide small craft harbours and to dredge for waterborne shipping. In the United States, these are cost recovery or user-pay services.

The power systems of the two countries are integrated on a continental scale. Each country, however, has a distinct, national history of governmental relationship to the development of power. In Canada, authority for power production is a provincial matter and power utilities are usually government owned and treated as a public benefit. The pattern of development is formed directly by political decisions and such considerations as environmental impact, investment choices in hydro-electric, fossil fuel or nuclear generation and compensation are a part of governmental policy and planning. In the United States, most power companies are private, profit-oriented concerns, which are, however, highly regulated both by federal and state authorities. Both systems insist on careful consideration of risks taken in investments and calculation of any costs involved in environmental damage.

Land use is in Canada largely a provincial matter and in the United States, a matter of state jurisdiction. In both countries, there is a tendency to delegate much of land use regulation to local governments. As a result of the fragmentation of land use policy-making and management, the systems in the two countries are not only different from each other but varied within each country. In dealing with shoreline facilities, whether in agriculture, industry or residential owners, the Canadian governments have maintained a policy of assigning risk primarily to the shoreline user. Governments have been willing to fund programmes identifying the flood and erosion hazard areas and information services. They have steadfastly refused, however, to compensate interests experiencing damage except at a very minimal level or to become involved in the construction of protective works for new developments along the shore (except for compensation for flood losses in Quebec along the St. Lawrence). In marked contrast, governmental authorities in the United States have traditionally favoured large, federally financed structural projects to protect floodplain occupants and have been willing to pay for emergency disaster aid and rehabilitation. These policies in the United States are now changing. Local authorities have been asked to contribute up to 50% of the cost of new protective works, relief has been increasingly tied to preventative commitments for rehabilitation, and land use and development restrictions are being implemented. In spite of these different traditions, federal governments of both countries affirm the responsibility of the shoreline user in deciding the design range of his or her investment and in shouldering the risk. The role of government is seen as providing information and protecting the shore environments through regulation of the location and design of new buildings and structures. The increasing awareness of these basic policy stances has moved policy-makers on both sides of the border toward a more similar approach to the question of land use.

The central governmental concerns in regard to commercial fishing have been in the area of maintenance and improvement of habitat for fish populations. Although water quality is a significant concern, the action of lake levels on spawning grounds is of prime importance. The Canadian policy of no net loss of fish habitat and general habitat protection requirements in United States legislation will influence future ecosystem legislation.

Considerations of recreational users have been and still are low priorities both in fiscal and planning policies of the federal governments of Canada and the United States. Apart from general water quality and some maintenance of harbours, the current policy of both countries seems to be one of little or no involvement.

Increased concern for the environment has been accompanied by a concomitant change in governmental approaches to decision-making in the management of natural resources. There is a trend toward bringing specific environmental issues before the public and seeking their participation and reactions. This recognition of public involvement in matters related to the management of natural resources will increasingly become the basis for future decision-making.

Much work still needs to be done in establishing and analyzing the policies of governments in the two countries before the problems related to the lack of co-ordination can be better defined. Initial studies have uncovered a large degree of apathy and an unstated policy of "do nothing" at the local level. It would seem, however, that there are areas of common agreement in policies and values which can be utilized in reaching some level of co-ordination.

The Question of Authority

Throughout most of this century, the federal level of the United States government has asserted its leadership in most areas of resource management and, even in co-operative ventures, the federal partner has through its overwhelming fiscal dominance controlled the decision-making process. State and local governments, however, play key roles in the practical management of resources and, in particular, in the management of shoreline development and water use. The Great Lakes states have broad responsibility in such areas as water supply, sewage treatment plant construction, waste disposal, water quality, phosphorus control, fish and wildlife, planning and standard setting. Local governments, on the other hand, control direct programmes in such areas as shoreline zoning, and nonpoint source control. During the 1980's, a new concept of federalism has resulted in the wide transference of programmes and responsibilities from the federal to state jurisdictions. The states, in response, have begun to re-organize the management of the Great Lakes programmes, including the use of several regional institutions, such as the Great Lakes Commission and the Council of Great Lakes Governors.

In Canada, the areas of authority are divided by the British North America Act of 1867 (now the Constitution Act) between federal and provincial governments. Provincial governments have jurisdiction over management and sale of public lands and forests, inter-provincial commerce, property and civil rights, municipal governments and matters of a private and local nature. They explicitly have the right to resources within their boundaries. The federal government, on the other hand, has jurisdiction over federal lands, coastal and inland fisheries, oceans, navigation and shipping and matters of national or extra-provincial nature, such as transportation and international commerce. Agriculture is a shared jurisdiction. As a result of this distribution of authority, policy-making and implementation is only possible through intergovernmental co-operation. In the case of a resource such as the Great Lakes, a number of federal-provincial agreements, such as the Canada-Ontario Agreement Respecting Great Lakes Water Quality and the Canada-Ontario Flood Damage Reduction Agreement, have been signed by both levels of government.

Governmental departments and agencies in both countries have, as a whole, the authority and programmes to deal with most issues arising from the fluctuating lake levels. In order for these organizations to make realistic decisions, it is important to understand the systems of both countries. The central problem, however, is the lack of overview and a method of co-ordinating actions through a common strategy.

The Question of Implementation

The management of the Great Lakes has constituted a major bi-national project of co-ordination for both countries. Institutionally, the International Joint Commission and the Great Lakes Fishery Commission are in different ways a part of that co-ordination. Similarly, the two nations have concluded a number of treaties, agreements, conventions, memoranda and diplomatic exchanges in order to facilitate the management of the Basin. Two regional organizations, the Council of Great Lakes Governors (and Premiers) and the Great Lakes Commission are means by which discussions and agreements are facilitated. In addition to these decision-making arrangements, there are regional institutions and organizations set up as multi-jurisdictional management structures. These are largely confined to co-ordination, research, planning, monitoring, surveillance, advisory and recommendatory functions.

Any decision made will have to be reviewed in order to determine the manner in which it will have to be implemented in each country and the requirements for coordinating implementation. At the present time, there is limited capability to effect such co-ordination. It is also important to note that, while the implementation of a course of action requiring structural regulatory controls affecting water levels would require bi-national agreement, courses of action having to do with localized land use or site-specific construction works are a matter of state and provincial jurisdictions. It has been suggested by the Center for the Great Lakes, however, that in many instances authority and programmes to cope with the effects of local flooding and erosion are already in place.

The two nations have found a number of different ways to meet the pressing needs for joint management of the resources of the Great Lakes — St. Lawrence River Basin. The incorporation of the concept of the ecosystem into the governance will require the formulation of an agreement based on values and policies common to both nations and coordinated institutional mandates and implementational processes. It will also require a means by which the concerns of the interests can be heard and integrated into the governance of the Basin.

Chapter 6

Measures and The Evaluation Framework

The problem of investigating, comparing and evaluating alternate courses of action is a part of the day-to-day process of governing. It is a process of determining the range of possible measures which might be taken and projecting the implications of their implementation for both the natural and human systems.

An initial step was to establish the types of measures available to the governing authorities. (See Annex E). For the question posed by this study of taking action "to alleviate the adverse consequences of fluctuating lake levels", there are three general kinds of action available. These are:

- actions to modify the lake levels;
- actions to modify the impacts of fluctuating lake levels;
- regulatory and non-structural actions to modify human susceptibility to fluctuating levels.

These general types of action are divided into categories of measures and finally into specific actions. Six categories or types of measures are suggested as representing the spectrum of alternatives available to government. These are:

Type 1 structural regulations and diversions, which would affect lake levels by the control of flows through the connecting channels, or by diversions into or out of the system;

Type 2 land and water adaptations, which might include such actions as construction of major shore protection works, relocation of facilities and flood proofing of facilities, and dredging of sediments under low water conditions;

Type 3 restrictions on land and water use, which would be implemented as regulations on such things as the amount and types of construction in hazardous zones and the amount of water withdrawal;

Type 4 programs to influence use but which maintain the individual's right to take an informed risk;

Type 5 emergency responses for short-term relief; and

Type 6 combinations of these measures.

Since measures may be located under the authority of different levels of government, provisions would have to be made for different implementation plans. For example, Types 1 and 2 require bi-national action at the federal level, whereas Types 3, 4, and 5 and part of 6 can be enacted by state, provincial and municipal governments. Each measure also reflects a different type and sharing of costs. An initial investigation indicates that there are over 100 different specific measures that can be grouped under these six categories, and that this inventory can be continually expanded and updated. The focus on measures for the purposes of this Study is on the actions that can be undertaken by Governments to attempt to deal with the adverse consequences of fluctuations. There are, of course, also actions which individuals have taken in the past and can take in the future. The following discussion centres on twenty-three representative measures that were explored in detail by the study groups, (See Annex E) and later used to test the evaluation framework (Annex F).

Type 1: Public Investment in Control and Diversion Works

Under this type, four possible courses of action were identified and described and their time frame, implementation authority, costs and historic precedents explored. The first measure was a scenario for full regulation of Lake Erie. This measure is referred to as Plan 50N, because it projects the development of structural controls at the mouth of the Niagara River which, depending on hydrological conditions and regulation objectives, would be able to increase or reduce water outflows from the lake by up to 50,000 cubic feet per second (cfs) or, 1,400 cubic metres per second (cms). The second measure developed a means by which diversions, such as Long Lac-Ogoki, Chicago and Welland, could be controlled and upgraded to increase capacities. A third measure expanded the basic plan of upgrading existing diversions into a plan for a 50,000 cfs inflow and outflow system for lakes Michigan and Huron, involving major diversion of water into and out of James Bay/Hudson Bay. This measure could also be carried out by directing the diversion of water out of the Great Lakes to the High Plains area of the western United States (Ogallala Aquifer region). A fourth measure involved placing sills at the outlets of Lake Huron, Lake Erie and at strategic locations along the St. Clair-Detroit River system. Basically, these sills would act as outflow obstructions. Some limited model testing of placing sills in the river system has already been carried out by past studies.

Type 2: Public Investment to Direct Land and Water Use to Adapt to Shore Fluctuating Levels

Under this type of measure, four representative plans were examined. The first measure attempted to deal with the problem of shoreline protection through the construction of breakwaters. Breakwaters are devices that are placed out in the water to intercept the energy of approaching waves and form a low-energy shadow zone on their landward side. One form of breakwaters might be barrier islands, which could also be used as parkland or for recreational facilities. A second measure was floodproofing of structures, either by making them watertight and able to withstand water pressures or by building in planned accommodation of flood waters. The third representative measure was developed from several recent moves on the part of provincial and state governments to acquire through purchase lands deemed in hazard areas. The main thrust of this measure is to prevent, or reduce future damages and losses. The land is then converted to community use. A final measure examined under Type 2 was the possibility of dealing with some of the consequences of low water levels by dredging and deepening navigation and access channels and harbours.

Type 3: Direct Public Regulation of Land and Water Use

The four representative measures in Type 3 are designed to modify the impacts of fluctuating water levels and reduce human susceptibility through government regulation. One kind of regulation investigated was setbacks for structures in zoning requirements. This measure would ensure that any new development would take place landward of an erosion or flood control line, but it could also provide relocation assistance for shoreline owners presently located lakeward of the control line. There are existing programs such as this in effect. A second representative measure of this type was the subsidizing of the relocation of structures out of hazard areas. A third measure was developed to control the construction of shoreline protection works and navigation structures. This regulation would reduce activities which increase shoreline hazard. The fourth Type 3 measure was a set of regulations designed to control water withdrawal and consumptive uses in the Basin. A part of this regulation would be guidelines for designing water intakes and outfalls which would be functional over the entire range of water levels and flows.

Type 4: Public Programmes to Influence Indirectly Land and Water Use on the Effects of Fluctuating Levels

The first measure under this type was a plan for guaranteed, subsidized loans for capital investments in structural methods for dealing with the potential for losses due to fluctuating water levels. These low-interest loans would assist private owners in constructing and repairing protective works and for shoreline repair or protection. A second measure was identified for providing guaranteed, subsidized loans for increased operating costs during extreme water level conditions. This measure uses tax abatements to help cover the increased operating costs incurred by shoreline property owners and users due to fluctuating water levels, and would include such projects as modification of docking facilities at marinas, modification of intakes and outfalls, additional pumping capacity for irrigation and modification of wharves and docks and channel depths in commercial harbours. A third Type 4 measure was public information and education programmes. The goal of these programmes would be improved understanding of the Great Lakes — St. Lawrence River Basin and the risks and options involved in locating near the shoreline in the Basin. The fourth representational measure was real estate disclosure. Under disclosure regulations, real estate agents would be required by law to reveal hazard land properties and owners of shoreline properties would have to disclose any past damage or repair costs associated with flooding and erosion problems.

Type 5: Emergency Response Capability

The measures under this type have all been designed for immediate implementation as the need arises. The first of these measures included sandbagging, diking, or, in times of drought, emergency water supplies. This measure was characterized by immediate, physical assistance. A second measure focussed on enhanced storm forecasting and included information centres and improved communications. The third measure was designed specifically for the situation on Lake Erie. Basically, the measure consisted of increasing the Niagara River flows by modifying the existing Black Rock navigation lock. Although modest increases can be achieved through existing controls, further construction would be necessary to effect substantial changes in outflows.

Type 6: Combinations

The possible number of combinations of different types of measures are large and continuously expandable as new plans develop. The following four measures have been developed as examples of combinations which group different types of measures for optimal impact. The first measure explored was one which incorporated increased regulation of water levels in the Great Lakes by combining Lake Erie Plan 50N (Type 1) with a sill placed in the St. Clair River (Type 1) and structural setback zoning (Type 3). This combination provided a reduction in the extreme range of water level fluctuations on Lake Erie, some reduction in lakes Michigan-Huron levels, and some assistance for the impact of short term fluctuations (storms) that cannot be significantly reduced by lake level regulation plans. A second combination of measures investigated was breakwater construction (Type 2) with enhanced public information and education programmes (Type 4). The third combination of measures developed maximized the use of existing regulatory structures and procedures (Type 1) with enhanced programmes of hazard land mapping (Type 4) and public information and education (Type 4). The fourth plan combined community acquisition of hazard land (Type 2) with regulation of the use of property in hazard areas (Type 3).

These types of measures and representative measures have been investigated specifically with the mandate of the Reference in mind, that is, "to develop appropriate methods to alleviate the adverse consequences of fluctuating water levels". They do not directly address issues which have become increasingly important in the course of this study, such as increasing the beneficial consequences of fluctuating water levels and basing the selection of measures on a systemic perspective derived from common goals and strategies or from basin-wide involvement of interests in the governance of the system.

The Evaluation Framework

One of the tasks of the Study was to develop a means by which proposed measures could be compared and assessed in an orderly and comprehensive manner. This evaluation process would take the inquiry well beyond the questions of feasibility and cost to the development of profiles of measures as seen from the perspective of the relevant components of the natural and human systems. The resulting framework of evaluation is an attempt to demonstrate a method of assessing each measure against a set of criteria used to evaluate its impacts. (See Annex F) For this purpose, six core criteria were selected as key standards for determining an ideal measure. This ideal measure would:

- Be economically efficient and sustainable;
- Maintain or enhance environmental integrity;
- Be socially beneficial or acceptable;
- Avoid risk or enhance certainty;

- Be politically implementable; and,
- Be fair and equitable.

These core criteria were then sub-divided into "operational criteria", which were to enable judgments specific enough that a scoring scale could be established to assist in rendering judgments on the assessment of impacts. Under the core criterion, Social Desirability, for example, four specific operational criteria were identified. These were: 1) human health, security, and well-being; 2) private property rights; 3) effects across social strata; and, 4) public access to natural and cultural resources. The evaluation framework was designed to enable weighing among the operational criteria and the core criteria by whomever evaluates the measure(s). As an aid in the evaluation process, an impacts matrix for each measure was developed whereby the various types of impacts and interest group concerns were identified and related to categories of interest groups and the natural environment.

The evaluation framework developed and tested in this phase of the Study is a systematic attempt to organize the assessment of measures, but flexibility was a major consideration. The inventory of measures can be modified or expanded as new ideas and proposals are developed and the criteria can be applied in different ways depending on the underlying objectives, policies, and values. The essential purpose was to establish a means by which evaluation could be carried out through an analytical process in an organized manner. Future development of an evaluation system will have to pay particular attention to the methods of quantification and to the specific contexts in which evaluation is best applicable. Some measures, for example, can be implemented in local situations, while others affect the Basin as a whole. Each analysis will have to look both to the overall goals of Basin management and to local needs, and the evaluation process will have to be modified accordingly. This is the first step in the development of a system of evaluating measures, but an evaluation framework, when fully developed, can be a sophisticated method for advising governments on policy. Future development of the evaluation process will have to be subjected to a rigorous analysis of the relationship of criteria to the system and to what is most significant about each measure.

Chapter 7

Towards A Strategy

Taking a whole system view implies the development of an overall strategy for dealing with issues arising from fluctuating water levels. The multifaceted, multidimensional characteristics of level-related issues, including hydrological, climatic, environmental, socio-economic, and political aspects, mean that piecemeal application of single local measures is not likely to suffice and that an effort must be made to integrate proposed measures in the perspective of the entire natural and human system. (See Annex D)

An overall strategy will require an agreement about goals, a coherent plan of action for deploying measures and the development of appropriate mechanisms for governance.

Agreement on Goals

An important step in attempting to develop a strategy for adapting to fluctuating water levels in the Great Lakes — St. Lawrence River Basin is to find the common ground and areas of agreement between the two nations in regard to the desirable goals and principles for future development of the region. Preliminary analysis of federal government policies shows there is already considerable consistency in the broad policy themes of the two countries. Recent bi-national agreements concerning water quality, for example, may be a potential source for some of these goals and principles. Such accepted positions on the inseparability of environmental quality and sustainability of human use would provide guidance in establishing goals for dealing with water levels issues in the long-term perspective of the future well being of the Basin as a whole. Private ownership, rights of interest groups, protection and restoration of the environment, and the common good of society will have to be accommodated and balanced out. The goals will have to be directed toward the future needs of the Basin, but be specific enough to give guidance on operational planning and implementation of measures.

Plan of Action

The development of a plan of action for deploying measures will have to be consistent with the agreement on goals and must lay out an agreed framework for action, consistent with bi-national regional goals, and directed toward the specific need to alleviate the adverse consequences of fluctuating water levels. Because of the variety and complexity of the tasks involved, the dynamics of change and the interconnectedness of issues, the plan of action will have to be a flexible guiding concept rather than a master plan. It will have to take into account how the measures should be deployed and how they relate not only to the overall goals but also to local circumstances, topographical conditions, population distribution, and type of damage. The deployment of measures must be particularly well planned because of the need to respect local autonomy, private ownership and governmental responsibility. It may be that important elements of this plan will include use of large scale, protective measures where populations are dense and investment high, further modification of existing control capabilities, protection or some redress of damage for properties which are privately owned, regulation of future developments and emergency programmes for specific areas. Funding sources, distribution of costs, priorities, sequence of implementation and allocation of resources will all have to be developed.

The System of Governance

Institutional arrangements and other mechanisms for governance must assure that the development of agreements and plans of action and the implementation of decisions are carried out over the long term and across jurisdictions and facilitate the process of management. At each level of government, there are various authorities, mandates and capabilities and these need to coordinate their actions in a manner which is consistent with the perceived overall good of the Basin. The existing coordinating bodies, such as the Council of Great Lakes Governors (and Premiers), have already begun to develop and implement joint agreements and some interests have organized for coherent action. It is important that these governance processes be organized so as effectively to balance local autonomy with the need to plan, integrate and operate for the common good.

Communication is closely interlinked with the functioning of the system of governance. On the most basic level, there are programmes designed to deliver "public information". This process is a one-way flow of information from the distributing agency, usually governmental, to the public. The information is presented with an eye to different uses. The needs of the transportation industry, the shoreline resident, the naturalist, the boater and the schools may vary greatly in the format for delivery of what may be very similar information. The information required for decision-making, on the other hand, may be of a very different nature.

It has been realized in the process of carrying out this study that the present system of public information is not adequate. Information is being developed and distributed by governmental and non-governmental centres throughout the Basin. This information is more or less accurate, depending on the source, and more or less available, depending on the mandate and financial resources of the agencies. Information presently being distributed includes material related to risks involved in living on the shoreline, assistance programmes available for property owners in coping with lake levels, marine data, explanations of why water levels change and historical perspectives on water levels and water level studies. There is a need for co-ordination, sharing and joint development of the structural functions of governance. It is obvious, however, that it is not possible to think in terms of a single information programme.

The role of communication in governance is key to the successful implementation of measures and will continue to grow in importance as the demand for new knowledge and technical information, information services, planning needs, and educational material increases. Information is basic to the ability of the interests to invest wisely, weighing benefit and cost and choosing the design range with which they feel comfortable. It is basic to the needs for research and technical knowledge without which the implications of courses of action cannot be plotted and the predictive needs cannot be met. It is necessary for the policy and decision-makers in planning actions. The communication of information, opinions, positions, decisions and concerns is the web of interactions of the system, through which human activities are regulated and the natural system is understood.

One of the information systems being developed in the present study, the Geographic Information System (GIS), may play an important role in the future governance of the Basin. There is a strong tendency in recent years to consider very carefully environmental impacts of measures before any action is taken. Various tools are available to assist in assessing the consequences of water level fluctuations and the environmental impacts of measures. Because of the variation over space and time in the natural and human elements of the Basin, and of the processes which influence and interrelate them, this study has devoted substantial effort to the development and initial testing of a computer-supported GIS. The GIS allows significant relationships to be identified and analyzed, and the results to be displayed in a manner which accommodates vast amounts of information and enhances comprehension of the functioning of the ecosystem.

Parallel to the development of the GIS, the study group on communications developed a television hook-up in ten major centres in the Basin. A system for bringing various groups into contact with each other and with specialists in a range of fields connected with the Basin is needed to facilitate the interchange of information, ideas, and positions among the widely varying groups. Innovative use of communications technology will be one of the components of the successful development of a coordinated system of governance.

Conflict seems of the very essence of the functioning of the ecosystem, especially in regard to the uses demanded of the natural system by the industrial, urban society. Good communication relieves some of the edge of conflicting interests, but many of the values and activities are inherently at odds with one another. It has been suggested that many of the methods of decision-making need to be supplemented with an organized negotiating process. Such negotiating procedures, which attempt to organize the conflict of interests through the provision of a forum and method for the statement, discussion and conclusion of issues, are generically referred to as alternative dispute resolution processes.

The alternative dispute resolution processes are an exercise in consensus-building and, as such, offer assistance to traditional decision-making methods. The focussing on issues rather than solutions, the relaxation of confrontation, the sense of real participation in formulating solutions and the enhanced likelihood of decisions being accepted are possible advantages to the negotiation process. The greatest side benefit of the process is the learning opportunities for all interests as they have to deal with technical information and opposing arguments and have to modify their own positions in response to the new information. These benefits accrue even if an agreement is not signed off at the end of the process.

Negotiation in itself will not guarantee solutions acceptable to everyone, but it will improve communications and will facilitate the process of decision-making. Every process of problem resolution, whether based on negotiations or not, takes place within a certain context of authority. Limitations are determined by everything from constitutional directives to legislative and legal precedent to the practical questions of financing. These limitations need to be set out clearly for all involved in the alternative dispute resolution process at the beginning, so that participants know exactly what decisions they are making and within what bounds.

Governance mechanisms must evolve to match the complexity and variety of the tasks required for effective management of the water quantity issues. Effective governance will facilitate continuity, communication, participation and coordination.

The development of an overall strategy will determine where future efforts and resources need to be assigned. One of the salient findings of this Study is that the problems identified in the Basin's natural and human systems are enormously complex. A clear overall strategy is needed simply to determine what parts of the complexity merit attention immediately and what parts will have to wait or require extensive consideration. Not only must the perspective on the issue of water levels be systemic; the appropriate measures taken by government will have to be systemic as well.

Chapter 8

Conclusions and Recommendations

The call to deal with the Great Lakes — St. Lawrence River Basin from the perspective of a total system has been voiced for more than a decade. This study has for the first time explicitly attempted to organize an inquiry into water levels and flows which takes into account the full range of components of both the natural and human phenomena of the Basin. These include hydrological and ecological as well as political and economic aspects. Not only have the changes in water levels been studied and the impacts of the action of water on the shoreline, but also how humans respond to and adapt to changes in the environment and what system of governance is needed in the Basin.

This systems approach is a conceptual reorientation from the problem-specific analyses of the past. Even though it has been recognized in previous studies that the issues associated with fluctuating water levels cannot be adequately addressed as single or discrete problems and even though the term ecosystem and holistic approach have become a part of the vocabulary for discussing Great Lakes — St. Lawrence River Basin issues, it is far from easy to conceive of and carry out a systems analysis of the issue of fluctuating water levels and flows in the Basin. The very attempt to channel into the inquiry the thinking of specialists from widely different disciplines and the positions of government, governmental and non-governmental agencies, and a range of involved groups has emphasized the difficulty of developing a comprehensive approach. Phase I of the Study evidences the various degrees of success in this attempt; the lessons learned will direct the work of Phase II.

Not only do the water levels and flows themselves constantly change, but human positions, values and institutions are also in a continuous process of adaptation, sometimes to the water levels and flows, sometimes to stimuli outside the Basin, sometimes to their own varying needs and circumstances. So, too, in this Study, we have had to take as a starting point the assumptions of the participants and allow the discussions to move as freely as possible toward the comprehensive level of a systems analysis. Change and adaptation were as much part of our process as they are basic to the system we were studying. For, there is no simple, enduring solution for dealing with what has been called "adverse consequences" in the Reference. The systems approach requires that complexity and change be wedded to the need for an organized process of decision-making and implementation over the long-term.

Water levels issues take place in the context of many other natural, political, social, economic and technological factors and possible solutions and courses of action must be sensitive to and consistent with these factors. Political concerns, such as national sovereignty and economic well-being, ecological concerns, such as water quality, natural issues, such as climate change and wildlife habitat protection, and large-scale economic and social changes are interwoven into the fabric of the development of the region. Any measure or set of measures designed to deal with Basin issues has to anticipate a range of considerations (hydrological, geomorphological, ecological, economic, land use, demographic, political and legal) or they may actually increase the problem they are meant to resolve. Awareness of the total geographic area is necessary in discussing any course of action for the Basin. What seems a desirable action in one part of the system may have negative results in another. The systems approach emphasizes that the wholeness of the system has to be foremost in our minds.

Not only space but consciousness of time is essential to systems analysis. Solutions must be designed to answer not only the problems of today but also future contingencies, no matter how uncertain our predictions of the future may be.

At this juncture in the Study, we are convinced that for purposes of managing the water levels issues over a long time frame, it is necessary that a broad planning approach be developed, which will include:

- the development of bi-national agreement on principles designed to provide broad guidelines for future decisions in regard to water levels issues.

- the development of an overall strategy for deploying measures. It is important that both the needs of the entire Basin as well as the circumstances of specific locales be encompassed.

- the development of a framework for an effective governance system, including considerations for the appropriate role of interests and the public.

We intend to carry out these three tasks in Phase II of this Study. One of the tools we shall develop for these purposes will be a set of policy models, relating to issues of hydrology, the effectiveness of measures, and the activities and sensitivities of interests. These models will be designed for use by policy makers or interests themselves in exploring the impacts of various positions and possible actions.

Since state and provincial governments have direct shoreline authority and their participation is vital to the management of the water levels issues, these jurisdictions should be involved in the process of arriving at agreement on goals and objectives and in developing an overall strategy for the region regarding water levels issues.

Whatever decisions are made in the future concerning the water levels and flows in the Great Lakes — St. Lawrence River Basin, they will have to take into account, work around, and build on decisions that have been made in the past and which affect the day-to-day life of the Basin. Moreover, natural changes will continue to be major factors in the future as they have in the past and must be taken into account. Even without significant changes in regional water supply or lake outlet conditions, lake levels are going to continue to vary, and it is possible that they will vary beyond the recordings in the 20th century. The probability or possibility of these occurrences of extreme levels cannot be quantified precisely; they simply have to be taken into account when projecting impacts of various courses of action.

Similarly, climate change, especially if it causes persistent trends in water supply to the lakes over a period of several years, can have a considerable effect on lake levels. It is not possible to tell from existing recorded data, however, whether a long-term change is establishing itself or not; we will only be able to see whether a new pattern is being established by looking back at the records. We will, therefore, have to continue to deal with uncertainty as part and parcel of the process of decision-making. Prediction will always be based on incomplete, perhaps even inaccurate knowledge. Climate change, like prediction of extreme levels, is a factor which has to be noted, but which cannot be assigned an exact importance. Furthermore, in the issues of the Basin as a whole, the climate change phenomena may have much more impact in social, technological, political and economic areas than in the issues associated directly with the fluctuations of water levels and flows.

A great deal of discussion in Phase I of the study centred on the two issues which attract the most attention in controversies regarding water levels: full control and regulation of the lakes and protection and restoration of the environment. At the extreme, advocates of full control and advocates of environmental integrity have often found themselves diametrically opposed on what courses of action should be taken in the Basin in regard to water levels. The two positions may be simply stated as maximum human involvement as opposed to minimum human involvement. They are often seen, however, as an older way of thinking, characterized by faith in technology and engineering and the human ability to solve any problems, and a newer emphasis on the necessity for human activities to accommodate themselves to natural processes.

The mandate of the study was to examine ways of alleviating the adverse consequences of the fluctuating water levels and both of these extreme positions as well as a spectrum of variations had to be examined. The possible positions or courses of actions between the extremes engender less ardent support, but they may well be the ones which yield practical and acceptable ways of dealing with the fluctuating water levels issue. In this phase of the study these various courses of action (measures) were looked at and given a preliminary testing, but in outlining these courses of action certain, what may be called cautionary considerations had to be made. At first reading, these considerations seem to be almost too obvious to mention, but their importance for finding a way of dealing with the issue of water levels and flows cannot be over-emphasized.

The first of these considerations is that any course of action taken to resolve issues in regard to fluctuating water levels and flows leads to disagreements over how the system is to be used and managed and how costs, benefits, and access are to be allocated. These conflicts centre on the different perceptions and needs of interests, on impacts on the natural ecology and on concerns for health and productivity. We are, therefore, not talking about a solution or a course of action, with which everyone will agree, but about a set of measures managed over a long time, which satisfies the most critical concerns. Those concerns will be looked at from the point of view of the entire Basin, but they will encompass the needs of individual communities and localized situations. The message is clear, however, for those holding extreme positions, prepare to compromise.

The second obvious, but often overlooked consideration is that full regulation designed to reduce the range of historic fluctuations on all of the lakes would further exacerbate the extreme flow variation in the connecting rivers and in the St. Lawrence River, unless provisions were made for the diversion of large quantities of water into or out of the Basin at the critical time. In effect, this exigency places a practical limitation on the extent of possible control, even if full regulation were implemented.

The third point that needs to be emphasized is that at this stage in the present study there seems no reason to modify the conclusions presented in previous studies in regard to the likelihood of full regulation being implemented. The current understanding of the technical merit, socio-economic rationale and government policy support for full regulation all make the implementation of such a proposal unlikely in the foreseeable future. The conclusion, that full regulation is not the preferred course of action at this time, does not arise because of lack of knowledge or investigation, but because of the realities of the present economic and political situation. Historically, efforts to deal with the problems of water levels tended to focus on structural measures; in fact, few resources have been directed toward the vast array of potential, alternate measures. Engineering solutions alone are applicable to relatively few of the gamut of problems and a restricted number of local conditions. The adoption of combinations of measures is seen, therefore, as achieving better overall results when focussed on specific, localized areas. Beyond consideration of historic approaches and technological factors, the present economic and political situation has to be taken into account. Cost estimates for full regulation and its associated accommodations for the rest of the system are extremely high, and the net economic benefits of water level regulation are not clear. And, not least, in both countries increased awareness and concern for the environment has meant that no mega-projects can go forward without passing through strict environmental assessment procedures which can take years to complete.

On the environmental side, a great deal of attention has been given over the past years to the function and importance of the wetlands in the Basin. Fluctuating water levels are a natural process which are important for the maintenance and replenishment of wetlands. Although the exact impact of fluctuating water levels on wetlands is not known, it is clear that the alternating seasonal and periodic extreme fluctuations are basic to the productivity of the natural habitats. The wetlands, in turn, provide a rich and varied habitat for fish, plant, and wildlife species and play an important role in modulating flows and cycling matter and energy throughout the Great Lakes — St. Lawrence River Basin. They also play a role as a buffer for fluctuations and storms. With the loss of over one-half of the wetlands in the Basin, mostly in this century, there is concern about any plan which might compromise the remaining wetlands in the Basin.

And, lastly, there are major changes in socio-economic structures, which reflect much larger changes in values, technology, organizational behaviour and world markets and demographics. Here, too, our knowledge is not sufficient to give definitive answers to all questions, but the growing demands for a better understanding of the interrelatedness of these changes will have to be met before the impacts of possible courses of action can be thoroughly evaluated.

We have to deal with uncertainty as an unavoidable condition for decision-making, always recognizing that as full a range of considerations and as much reliable information as possible have to be brought to bear on the issue. For example, it is possible that a measure or set of measures, if all conditions are not taken into account, may actually increase the very problem they were intended to resolve. It is, therefore, critical that any measure or set of measures designed to address the issue of fluctuating water levels in the Basin be examined in the light of a full range of considerations. At the same time, it is important that long-term strategies for dealing with significant deviations in levels, such as those that may be caused by the "greenhouse effect", be developed along with an improved capability for estimating the probabilities of certain levels.

All these cautionary considerations are based on incomplete knowledge, and, perhaps, it is partially because of the incompleteness of our understanding that there is resistance to proceeding with measures which may have unforeseen impacts and which may not be reversible. It is certain that these considerations are, however, not to be disregarded in trying to weigh the merits of the various courses of action available to governments.

Even though there is a perception among certain interests that structural works are necessary and appropriate, the Study to this point does not support such a conclusion. Based on our findings, we feel strongly that full regulation should be recognized as unlikely to be implemented by governments in the near future and that combinations of measures of all types should be vigorously pursued in study and implementation.

Recommendation: It is recommended that the federal governments not undertake commitments toward planning, funding, or constructing major public works to control levels and flows in the Great Lakes — St. Lawrence River Basin watershed until there is more consultation with interests and a more comprehensive evaluation of the impacts of such works on the environment.

In surveying opinion in the Basin, members of the study groups discovered that there were misperceptions, inaccurate information and lack of clarity concerning both the natural processes and the impacts of human activities. These shortcomings make discussion of possible measures difficult if not impossible. As we move into Phase II of this study, there are a number of points which need to be cleared up.

First, land use, consumptive water uses, and other human interventions have a minimal influence on fluctuation of lake and flow levels. For example, current regulation of levels has very little effect on much of the system, except for Lake Ontario and the Upper St. Lawrence River system and to lesser extent for Lake Superior. The greatest impact of regulation is in the trade-offs between levels and flows. Water held back in sustained dry periods to maintain lake levels results in lower river flows and, conversely, excessive discharges made to lower lake levels during sustained wet periods result in higher river flows. Present, limited regulation criteria have historically been designed to provide benefits for commercial navigation and power. However, the socio-economic structure and land use patterns and values have changed significantly in the past 10 — 15 years, and setting new objectives, even for the limited regulation of levels now in effect, is difficult. Knowledge of the present objectives is very limited among interests and this engenders many suspicions and unrealistic expectations toward the International Joint Commission. This situation makes present operation more difficult and does not serve as a useful guide in developing future plans. It is clear, however, that present objectives of regulation are in need of thorough review.

The causes of shoreline erosion are also widely misunderstood. Although water level fluctuation can be important for some shore types, for many other types fluctuations have little influence over the long-term rate of recession (erosion). Much more important to shoreline dynamics are storms. Shoreline erosion and flood damage occur primarily during storm events. These damages can be further exacerbated in local areas by the presence of high water levels and the geological characteristics of the shoreline. This can be seen most clearly on Lake Erie, which, as a result of its shallow depth and orientation to westerly storms, has the most extreme short-term, lake level variation due to storm conditions and the highest shore erosion rates of any of the Great Lakes because of its shoreline characteristics. Although much work has already been done and there is wide consensus on various processes, we need more knowledge about erosion in specific locations, as well as about wetland rejuvenation and the creation and alteration of nearshore depositional features as a function of water levels fluctuations.

A third occasion for misunderstanding identified by some participants in the study involved the very idea of an "adverse consequence". Adverse for whom? If what is adverse for one interest is beneficial for another, is it still adverse? It has been argued that human activity in the Basin represents investments, in which a decision is made to benefit from locating there. Benefits vary, but all can be weighed against the costs and the level of risk that is comfortable. These investment decisions are made on the basis of information available. The issue, then, may not be whether or by how much an interest "suffers adverse consequences", but how does the interest benefit from lake services, how are the costs factored in and why does the interest petition governments for action. All investments are based on expectations of probable future benefits and costs, and, these in turn are based on information the interest has on what he or she may expect from government. Many interests, for example, believe that they have the right to expect certain levels and flows and certain actions by government. These beliefs are often erroneous and it is incumbent upon government to articulate, perhaps even to review, the current status of those rights. However, when an interest petitions governments for assistance, it is usually a result of the interest either not having expected the magnitude of water level changes or not having the resilience to respond to the changes. Apart from the question of the reliability of and responsibility for information, the central issue in this approach is who bears the costs of the consequences of changing water levels — the investor, the customer, the general taxpayer, the environment? Managing levels, therefore, means managing the process of allocating costs, benefits, and risks across groups. Not only were past planning processes of government often more appropriate for designing and evaluating individual projects than for managing the ecosystem, they also were poorly conceived in regard to informing investment decisions, informing the political positions of interests and informing governments about interests' positions. In the light of this problem, we think action can be taken in this area immediately.

One of the areas, in which participants of this study found a need for the articulation of specific information, was in the operational objectives regarding lake level control. The knowledge of most interests regarding the existing operational objectives for Lake Ontario and Lake Superior levels is very limited and therefore engenders suspicion and unrealistic expectations toward the International Joint Commission. Clear enunciation of these objectives would do a great deal to promote more reasonable expectations among concerned interests. Along with articulation of objectives, the existing hydrological and hydraulic models could be accommodated to deal with scenarios ranging from existing controls to total Basin regulation, including a review of existing regulation plans for 1958D and 1977 for Lake Ontario and Lake Superior respectively.

Recommendation: It is recommended that the International Joint Commission communicate its operational objective regarding Lake Ontario and Lake Superior levels so as to promote reasonable expectations among concerned interests.

In addition to misperceptions and misunderstandings on the one side, there are real inadequacies in the performance of government in providing information to interests in the Basin. This situation has been noted many times in previous reports and steps have been taken to improve the situation. Information provided by governments, however, is still inadequate and poorly and unequally distributed. Some interests, such as commercial and industrial enterprises, have access to reliable information; others may not know what information is available or where to obtain it, and, in many cases, when they do get information it is often not in a format useful to their decision-making. Information related to water levels made available by government also seems to follow an "issue-attention cycle". The problem is compounded by the uncoordinated multitude of governmental and non-governmental sources of information throughout the Basin, and by the fact that there are apparent inconsistencies in policies, authority, programmes, and implementation structures of federal and other levels of governmental departments and agencies.

In addition to more accurate and available information, there is a perceived need for different kinds of information presented in different formats. It is clear that the ways by which information is made available must vary according to the user. Informed risk-taking begins with reliable information. Information is in many instances a two-way process, in which public response and involvement are critical to future decision-making.

Certain areas, in which more knowledge is needed, have already been identified in this phase of the Study. For example, the geomorphological susceptibility of different segments of the shoreline to short-term and longer-term water level fluctuations, storm patterns, and wave and wind action need further analysis. This type of information can be used to map vulnerability tiers using a geographic information system covering the shoreline throughout the Basin. We also believe that our knowledge of the basis of the relationship between water levels, interests, and environmental processes needs improvement. By concentrating on the specific vulnerabilities (e.g. damage potential) and the benefits of fluctuations in relation to interests and wetlands and environmental processes, knowledge can be gained that will enhance and refine the capabilities of the Geographic Information System being developed jointly by both countries.

In the realm of human activities, there is a range of areas of analysis which require our attention in Phase II. We do not know in enough depth many basic socio-economic aspects of the Basin. Urbanization, the growth of leisure and recreational activities, changes in the industrial base of contemporary North American society, changing demographics of population concentrations, investment patterns and government policy development are areas of direct concern for a systems approach to the problems of the Basin. Large as these areas of study are, they will have to be de-limited and focussed in order to be of use in the future decisions which will be made by governments in both countries.

During the course of this study, our preliminary investigation on governmental decisions in regard to management of water related issues indicated that Canada and the United States agree on a wide range of principles and goals, but have not yet articulated them clearly. Until these principles and goals are publicly stated by the federal governments, it is difficult for other levels of government to develop plans and programmes for the Basin and for interests to make informed decisions.

Recommendation: It is recommended that the federal governments issue a statement on federal policy goals regarding water issues.

One of the products of Phase II of this Study will be an improved public information programme, which will assure interests of equal access and ability to use information. We also intend in Phase II to carry out further in-depth surveys and analyses of interests to understand better the location and economic investments of interest sub-classes. It is hoped that these surveys and analyses will further help to explain the different sensitivities of the interests to fluctuating water levels, as well as identify better the type and timing of information needs for responsible decision-making.

In some areas, Phase I of the Study has only begun to uncover the problems which have to be dealt with in addressing the water levels issue. One of the areas is the interconnection of water quality and water quantity. It is known, for example, that fluctuations in levels and flows can affect the quality of water in localized areas, as seen in the impact of low levels on the concentration of pollutants or of high levels on urban sewer infrastructures or cottage septic units. It is not clear, however, what the importance of this relationship is or the degree of impact water levels have on water quality basin-wide.

If we are to carry out a successful systems analysis of the Great Lakes – St. Lawrence River Basin, we have to understand better the nature and interrelatedness of human activities. Population changes, new investment decisions, industrial re-configurations and developments and government policy are interrelated with the natural environment. We feel that the first steps have been taken in this phase of the Study, but much remains to be done.

The attempt to adopt a systems perspective on the issue of water level fluctuations has in many ways raised as many questions as it has answered. A wide range of exploration and inquiry has been encouraged in this first phase of the Study; it remains for Phase II to pull these investigations together. Some parts of the inquiry will prove fruitful; some will end in a cul-de-sac.

Appropriate as these new and modified systems investigations were for the formation of a coherent overall approach, it was felt there had to be an ongoing process of distilling basic premises and criteria from the investigations in order to test, in a practical way, their relevance for the process of decision-making. During the latter part of Phase I, an attempt was made to summarize and categorize the possible courses of action (measures) which could be entertained by governments, and to develop a method of evaluating those measures by assessing their impacts throughout the system as a whole. For the first time in studies on the water levels issue, a list of possible measures related to this issue was drawn up and, if we set aside emergency measures and combinations of measures, four basic categories or types of measures were identified – Public Investment in Control and Diversion Works, Public Investment to Direct Land and Water Use to Adapt to Fluctuating Levels, Direct Public Regulation of Land and Water Use, and Public Programmes to Influence Indirectly Land and Water Use or the Effects of Fluctuating Levels. These include over a hundred specific measures. This first attempt to bring together a wide array of measures will have to be tested in the context of government and public acceptability.

Phase I of the Study produced a process in preliminary form for evaluating the relative acceptability of the measures and combinations of measures by subjecting them to an assessment based on certain core criteria. Evaluative criteria were exercised in a structured framework to assess the impacts of measures on interests and on the natural environment, and to establish the range and combinations of measures and the goals and values which will shape and determine future evaluative processes. The evaluation was carried out to test it as an analytical tool for governments, but it has the potential to be used as a mechanism for engaging public participation and involvement.

In Phase II of this Study, the comprehensiveness of the list of measures and the process of evaluation will have to be reviewed and developed. The first run-through is, however, completed and it is now possible to see the strengths and weaknesses of the present approach and some of the implications for the development of future evaluative methods. These investigations will have to be explicitly related to the development of an overall strategy. There will always be a need for specific attention to local situations, but these must be assessed in the context of an overall strategy for the Basin. The challenge will be to give full consideration to basin-wide issues while focussing on local exigencies.

At the completion of Phase I of this study, our understanding of the extent of the problem is now much clearer, but the magnitude of the task has not been reduced. Even at this early stage in our investigations, we can see clearly that there are certain actions which should be taken immediately. These include a moratorium on all major public works related to control of levels and flows, the clear articulation of the operational objectives for Lake Ontario and Lake Superior, and the articulation of federal policy goals regarding water levels issues.

The work carried out in Phase II will have to be more closely directed to yield specific results, and projects which are ongoing will have to be brought to completion. The major challenges have, however, been identified and there seems every reason to believe that the final product will be instrumental in reshaping in a major way future thinking and actions concerning the water level fluctuations in the Great Lakes – St. Lawrence River Basin.

Appendix 1:

Lake Levels Reference, August 1, 1986

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

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

Canada

OTTAWA, ONTARIO
K1A OG2

August 1, 1986

Dear Mr. Chance,

I have the honour to inform you that the Governments of Canada and the United States of America, pursuant to Article IX of the Boundary Waters Treaty of 1909, have agreed to request the Commission to examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes - St. Lawrence River Basin. In doing so, the Governments acknowledge previous Commission reports on regulation of Great Lakes levels, which have encouraged appropriate jurisdictions to institute improved shoreline management practices.

The Governments note that the previous reports were based upon recorded water supplies which have subsequently been exceeded, that economic conditions have changed, and that improved analytical techniques may now be available. The Governments conclude, therefore, that further investigation is now required to revise previous reports and develop appropriate methods to alleviate the adverse consequences of fluctuating water levels.

Accordingly, the Commission, building upon previous studies, should:

1. propose and evaluate measures which governments could take, under crisis conditions, to alleviate problems created by high and low lake levels;

2. review its previous lake regulation studies and revise their engineering, economic and environmental evaluations;

...2

Mr. David Chance
Secretary, Canadian Section
International Joint Commission
Berger Building, 18th floor
100 Metcalfe Street
Ottawa, Ontario
K1A ON2

3. examine past, present and potential future changes in land use and management practices along the shorelines of the Great Lakes, their connecting channels and the St. Lawrence River;

4. determine, to the maximum extent practicable, the socio-economic costs and benefits of alternative land use and shoreline management practices and compare these with the revised costs and benefits of lake regulation schemes;

5. investigate any feasible methods of improving the outflow capacity of connecting channels and the St. Lawrence River;

6. develop an information program which could be carried out by responsible governmental agencies to better inform the public on lake level fluctuations; and

7. consider any other matters that the Commission deems relevant to the purpose of this study.

The Commission is requested to examine the effects both within and outside the basin of the measures it considers on:

(1) domestic water supply and sanitation;

(2) navigation;

(3) water supply for power generation, industrial and commercial purposes;

(4) agriculture;

(5) shore property, both public and private;

(6) flood control;

(7) fish, wildlife and other environmental aspects;

(8) recreation and tourism; and

(9) such other effects and implications which the Commission may deem appropriate and relevant.

Wherever appropriate, the Commission is encouraged to use improved analytical techniques which would best represent the changing conditions and socio-ecnomic values in the Great Lakes region. In order to assess the viability of lake level regulation, the Commission should take into account changes in land use practices induced by actions which previously have affected levels in the Great Lakes basins.

In the event that the Commission's investigations show that new or altered works or other regulatory measures appear to be economically and environmentally practicable, it shall determine the full costs and benefits of such works or measures and indicate how the various interests on either side of the boundary would be affected thereby. In addition, the Commission shall determine the need for and costs of remedial or compensatory works or measures to offset costs to the interests which may be adversely affected by any proposed regulatory measures.

In conducting its investigations and in preparing its report the Commission shall use data which is available now or which is developed during the course of its study. In addition, the Commission shall seek the assistance, as required, of specially qualified personnel in Canada and the United States. The Governments, subject to their applicable laws and regulations, shall make available, or as necessary, seek the authorization and appropriation of funds required to provide promptly to the commission the resources needed to discharge its reference obligations within the specified time period. The Commission shall develop, as soon as practicable, study cost projections for the information of Governments

The Commission, subject to the availability of adequate appropriations, should proceed with the studies as expeditiously as practicable and present its final report to Governments no later than May 1, 1989. The Governments also request that an interim report, focussing on measures to alleviate the present crisis, be submitted no later than one year from the date the Commission's study board actively begins its work.

An idential letter is being forwarded to the United States Section of the Commission by the Department of State.

Yours sincerely,

United ates Department of State

Washington, D.C. 20520

FILE COPY

August 1, 1986

IJC-WASHINGTON
AUG 1986
FILE No.

Mr. David LaRoche
Secretary, U.S. Section
International Joint Commission
2001 S. St., N.W.
Washington, D.C. 20440

Dear Mr. La Roche: David

I have the honor to inform you that the Governments of the United States of America and of Canada, pursuant to Article IX of the Boundary Waters Treaty of 1909, have agreed to request the Commission to examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes-St. Lawrence River Basin. In doing so, the Governments acknowledge previous Commission reports on regulation of Great Lakes levels, which have encouraged appropriate jurisdictions to institute improved shoreline management practices.

The Governments note that the previous reports were based upon recorded water supplies which have subsequently been exceeded, that economic conditions have changed, and that improved analytical techniques may now be available. The Governments conclude, therefore, that further investigation is now required to revise previous reports and develop appropriate methods to alleviate the adverse consequences of fluctuating water levels.

Accordingly, the Commission, building upon previous studies, should:

1. propose and evaluate any measures which Governments could take, under crisis conditions, to alleviate problems created by high and low lake levels;

2. review its previous lake regulation studies and revise their engineering, economic and environmental evaluations;

3. examine past, present and potential future changes in land use and management practices along the shorelines of the Great Lakes, their connecting channels and the St. Lawrence River;

4. determine, to the maximum extent practicable, the socio-economic costs and benefits of alternative land use and shoreline management practices and compare these with the revised costs and benefits of lake regulation schemes;

5. investigate any feasible methods of improving the outflow capacity of connecting channels and the St. Lawrence River;

6. develop an information program which could be carried out by responsible government agencies to better inform the public on lake level fluctuations;and,

7. consider any other matters that the Commission deems relevant to the purpose of this study.

The Commission is requested to examine the effects both within and outside the basin of the measures it considers on:

1) domestic water supply and sanitation;

2) navigation;

3) water supply for power generation, industrial and commercial purposes;

4) agriculture;

5) shore property, both public and private;

6) flood control;

7) fish, wildlife and other environmental aspects;

8) recreation and tourism; and,

9) such other effects and implications which the Commission may deem appropriate and relevant.

Wherever appropriate, the Commission is encouraged to use improved analytical techniques which would best represent the changing conditions and socio-economic values in the Great Lakes region. In order to assess the viability of lake level regulation, the Commission should take into account changes in land use practices induced by actions which previously have affected water levels in the Great Lakes basin.

In the event that the Commission's investigations show that new or altered works or other regulatory measures appear to be economically and environmentally practicable, it shall determine the full costs and benefits of such works or measures and indicate how the various interests on either side of the boundary would be affected thereby. In addition, the Commission shall determine the need for and costs of remedial or compensatory works or measures to offset costs to the interests which may be adversely affected by any proposed regulatory measures.

In conducting its investigations and in preparing its report, the Commission shall use data which is available now or which is developed during the course of its study. In addition, the Commission shall seek the assistance, as required, of specially qualified personnel in the United States and Canada. The Governments, subject to their applicable laws and regulations, shall make available, or, as necessary, seek the authorization and appropriation of funds required to provide promptly to the Commission the resources needed to discharge its reference obligations within the specified time period. The Commission shall develop, as soon as practicable, study cost projections for the information of Governments.

The Commission, subject to the availability of adequate appropriations, should proceed with the studies as expeditiously as practicable and present its final report to Governments no later than May 1, 1989. The Governments also request that an interim report, focussing on measures to alleviate the present crisis, be submitted no later than one year from the date the Commission's study board actively begins its work.

An identical letter is being forwarded to the Canadian Section of the Commission by the Department of External Affairs.

Sincerely,

Jim

James M. Medas
Deputy Assistant Secretary
for Canada

Appendix 2:

International Joint Commission News Release
September 10, 1986

NEWS RELEASE

INTERNATIONAL JOINT COMMISSION

COMMUNIQUE

COMMISSION MIXTE INTERNATIONALE

OTTAWA OFFICE TELEPHONE (613) 995-2984
WASHINGTON OFFICE TELEPHONE (202) 673-6222

FOR IMMEDIATE RELEAS
POUR PUBLICATION IMMÉDIA

September 10, 1986

Commission discusses new Lake Levels Reference

The International Joint Commission, at executive sessions in Washington, D.C., reviewed in detail the recent Reference from the Governments of the United States and Canada requesting in part that "the Commission examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes - St. Lawrence River Basin," etc.

The Commission appreciates and welcomes the fact that this far-reaching Reference will involve new initiatives and that its nature and terms authorize the Commission to undertake new approaches far beyond those authorized in previous References. To carry out this task, it is desirable to have the assistance of individuals whose depth of experience and varied expertise gives them the breadth of perspective necessary to address this task. Accordingly, the Commission is embarking immediately upon a series of discussions with such persons to obtain their assistance in the formulation of work plans and directives and in the selection of those who might be given appropriate responsibilities on various expert working groups to be constituted for the three-year, majcr in depth study requested in the Reference.

The Commission also took notice of the two national Governments' additional request for a one-year limited interim report focusing on re-examining any in place available means that might presently be utilized to help alleviate the immediate high levels crisis. Certain members of the Commission staff were designated to serve as part of a special task force to commence immediate consideration regarding the limited interim report. It is the present intention of the Commission to respond to the limited interim request in advance of the one year suggested in the Governments' Reference.

The Commission notes that Lakes Michigan, Huron, St. Clair and Erie exceeded their all-time record August levels, that Lake Superior was just below its record August level and that only Lake Ontario was within its normal August range of fluctuations.

Appendix 3:

Directive Concerning the Reference on Fluctuating Water Levels in the Great Lakes-St. Lawrence River Basin, April 10, 1987

DIRECTIVE CONCERNING THE REFERENCE ON FLUCTUATING WATER LEVELS IN THE GREAT LAKES-ST. LAWRENCE RIVER BASIN

April 10, 1987

1. INTRODUCTION

On August 1, 1986 the Governments of the United States and Canada forwarded the attached Reference to the International Joint Commission (the Commission) pursuant to Article IX of the Boundary Waters Treaty of 1909.

The Reference requests the Commission to examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes-St. Lawrence River Basin by addressing the immediate high water level crisis, while at the same time developing a solid foundation for identifying and evaluating intermediate and long-term potential measures.

The Reference also requests the Commission to examine the effects and implications, both within and outside the Basin, of the measures it considers on such vital matters as domestic water supply and sanitation, navigation, agriculture, shore property, flood control, wildlife and others as listed in the Reference.

The Reference provides that in the event that the Commission's investigations show that new or altered works or other regulatory measures appear to be economically and environmentally practicable, the Commission shall determine the full costs and benefits of such works or measures and indicate how the various interests on either side of the boundary would be affected thereby. In addition, the Commission shall determine the need for and costs of remedial or compensatory works or measures to offset costs to the interests which may be adversely affected by any proposed regulatory measures.

To date, the Commission has proceeded with its Reference responsibilities on three tracks. First, based on currently available information, the Commission submitted an initial report to Governments, by letters dated November 14, and December 10, 1986 (Copies attached).

Second, the Commission formed a Task Force to undertake a technical evaluation of measures which could be implemented within approximately one year to reduce high water levels.

Third, the Commission has sought broad expert advice for developing the longer-term implications of the Reference.

2. APPROACH

Recognizing the complexity and unprecedented scope of the Reference, the Commission regards the following elements as essential for successful implementation of this study:

- The study will require broad participation and a multidisciplinary approach. Measures necessary to deal with the adverse consequences of fluctuating water levels are unlikely to be purely technical. Further, it is improbable that a single solution will emerge, rather a mix of measures over time will be the most likely course.

- The study will require substantial international and interagency participation, the recruitment of the finest expertise available from governmental and non-governmental sectors in both nations, and a commitment to provide the resources necessary to produce a useful and enduring product. Because the effort needs to be an on-going, evolving process, the Commission believes flexibility, creativity, and innovation are critical.

- Because of the many interdependent aspects of the Reference an integrated systems approach is essential. This will be accomplished by carefully co-ordinating the various aspects of the study, providing for a cross system impact evaluation capability, as well as by having a stronger integrating role for the Commission and its staff.

3. SCOPE

The study will develop, for review by Governments, a range of potential measures with clear evaluation of their impacts and implications. It ought to involve the following steps:

- Review and analyse the physical, economic and environmental situation.

- Based on the above review and analysis identify critical issues related to fluctuating water levels.

- Develop a full range of potential measures and evaluate their impacts and implication.

- Highlight major issues for future consideration including advice on subsequent actions.

4. ORGANIZATION AND MANAGEMENT

The complex nature of the Reference requires that integrating Reference issues and activities be given the highest priority and that the Commission will be actively and consistently involved throughout.

° Effective integration of the study's elements will be enhanced through:

- The conceptual structure of the study as it relates to definition of subject matter, work groups, and their interaction.

- The use of the appropriate technology in support of cross-system simulations and impact evaluations.

- The management of the study as related to:
  - Policy level
  - Project Management Team level
  - Working Functional Group level

° From the viewpoint of management four distinct functions, embodied in four different groups are envisioned:

- Governance level: consisting of the six Commissioners will be responsible for overall policy leadership, ratifying decisions and recommendations, and for reporting to and advising Governments.

- Steering Committee level: consisting of two lead Commissioners and the two co-chairs of the Project Management Team. The Steering Committee will be staffed by two Commission lead staff and will provide overall direction to the study on behalf of the Commission. It will review progress continuously and make recommendations to the Commission on the various study related issues as they arise.

- Project Management Team level: consisting of an executive and the chairmen of all functional study groups. The Project Management Team will be responsible for on-going project management and the conceptual, technical and administrative integration of the study and its various activities, including final assignment and coordination of responsibility for specific study areas.

  The executive, at the core of the Project Management Team, will consist of the two project Co-chairmen, their deputies, and two Commission lead staff as well as the Chairman of the Cross-System Impact Evaluation Group who will be appointed by the Commission on the recommendation of the lead Commissioners.

- Functional Study Group Level: consisting of their Chair(s) and members, including Commission staff, responsible for the execution of all specific study assignments, and for ensuring that interdisciplinary analysis and a transdisciplinary perspective will be maintained.

These levels of organization and management are summarized in Table 1.

In addition, Project Advisory Groups will be formed to provide advice, when necessary, to the Steering Committee, and/or the Commissioners, on specific questions that arise during the course of the study.

The overall organizational structure envisaged for this project, and the relationship of the Project Management Team to the five main areas of the study are depicted in Figures 1 and 2 which follow.

5. STUDY GROUPS

Because of the complexity of the issues to be addressed during the study, the bulk of the work will be assigned to functional study groups each with a responsibility to play a lead role with respect to a group of related tasks. The work activities of each group, in turn, will frequently require integration and close collaboration with work activities of the other groups. Considerable thought to orchestrating and integrating work activities as they unfold will be required. While this will be a prime responsibility of the Project Management Team, it should permeate the conceptual orientation of all the participants in the study.

In addressing potential measures for alleviating the adverse effects of water level fluctuations the functional study groups will identify and provide advice on crisis intervention, intermediate measures and long-term considerations, building on, as appropriate, the work of the existing Commission's Task Force.

Five study groups are envisioned as follows:

- Hydraulic, Hydrology and Climate Group
- Coastal Zone Ecology, Resources, Uses and Management Group
- Socio-Economic and Environmental Impact Assessment Group
- Public Participation and Communications Group
- Cross-System Impact Evaluation Group

FUNCTION	GROUP(S)	MEMBERSHIP
*Policy leadership *Ratify decisions *Report to and advise Governments *Ex-officio status for all Reference-related groups	Commission	6 Commissioners
*Review progress *Recommendations to Commission *Overall project direction *Review of Policy/Issues	Steering Committee	2 Lead Commissioners 2 Co-Chairs of Project Management Team Staffing: 2 Commission lead staff
*Ongoing project management *Conceptual, technical and administrative support *Integration and final assignment of functional study group work	Project Management Team	2 Co-Chairs of Project Management Team 2 Commission lead staff Chairmen of functional groups
*Execution of specific assignments *Planning and Integration of sub-group work	Project functional groups and sub-groups	Multiple teams of best available personnel and Commission staff liaisons

TABLE 1 - Levels of Organization and Management

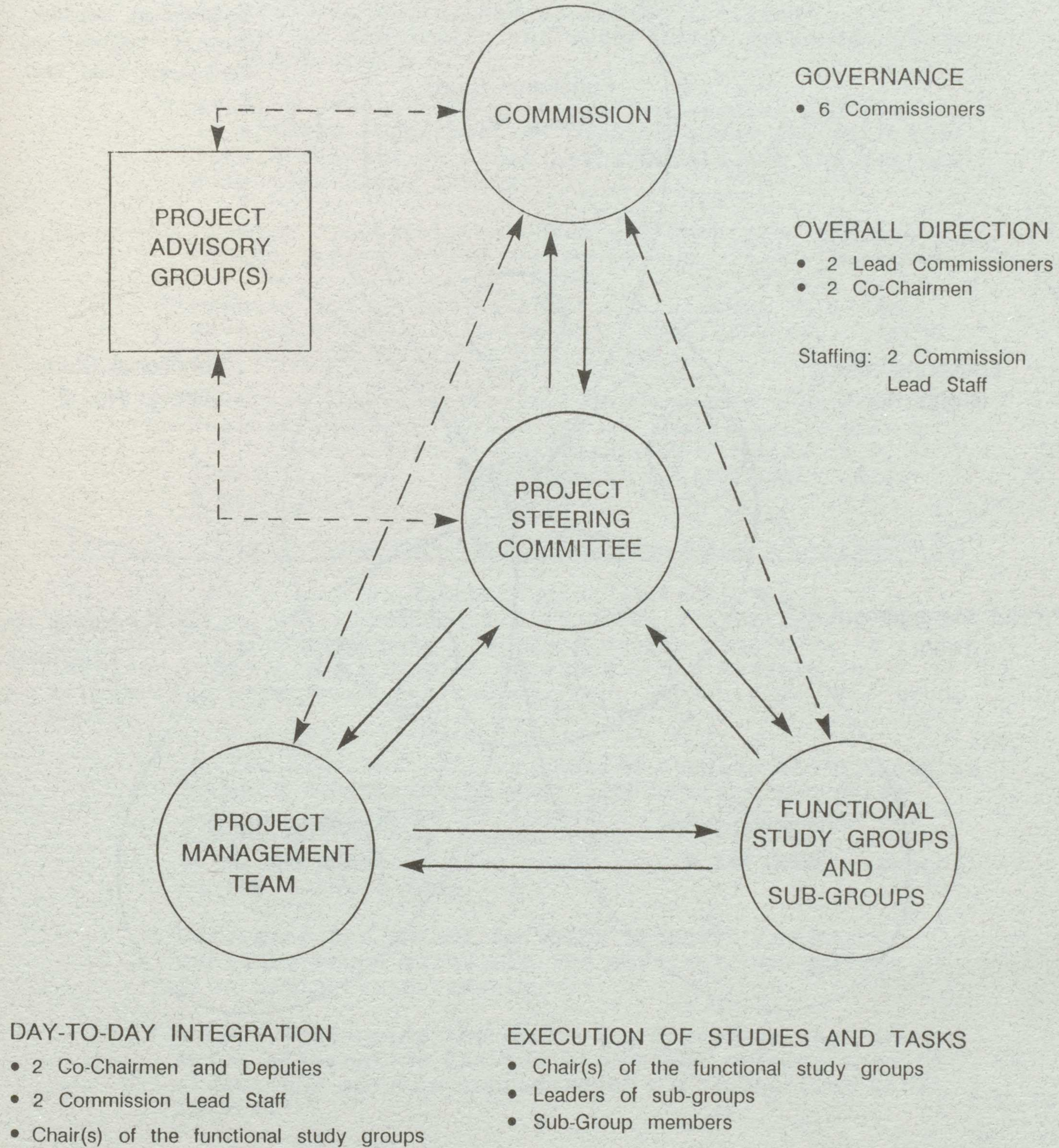


FIGURE 1 - Organization Structure

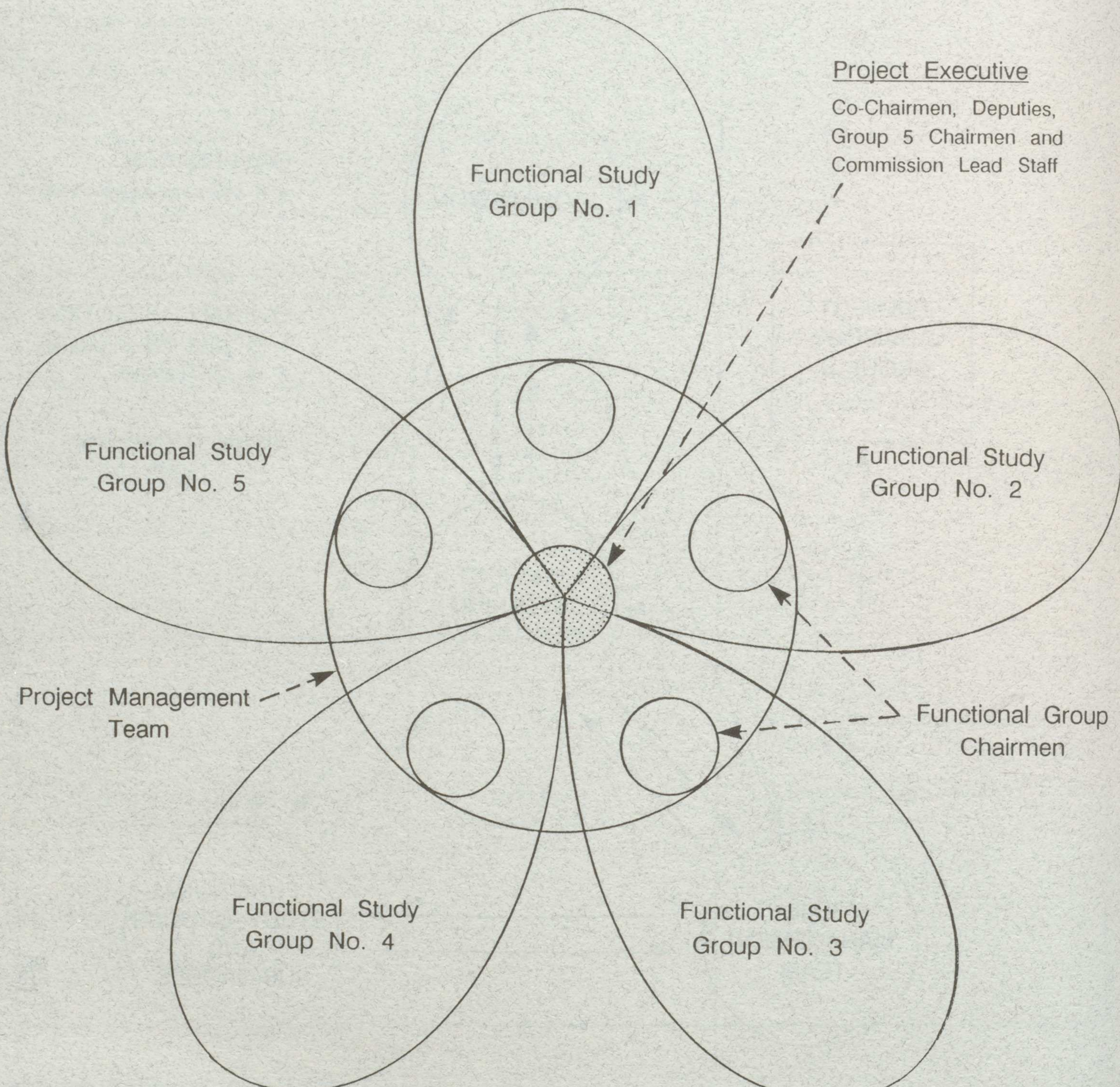


FIGURE 2 - Functional Study Groups and the Project Management Team

The general themes for each of these groups are summarized as follows:

Group 1 - Hydraulics, Hydrology and Climate

This group is envisioned as having the lead responsibility for developing the water level component of the study. The group would:

° Examine previous lake regulation studies and provide an updated assessment of past, present and potential future changes in Great Lakes Levels and the factors affecting these levels.

° Propose regulatory measures and determine the cost of design, construction and operation of such measures.

° Propose and determine the costs of ways to offset adverse effects of potential regulatory measures on the various interests involved.

° Develop, in collaboration with the Cross-System Impact Evaluation Group (Group 5), an analytical framework for assessing and communicating the hydraulic, hydrologic and climate aspects of the Great Lakes System.

Group 2 - Coastal Zone Ecology, Resources, Uses and Management

This group is envisioned as having the lead responsibility for assessing the impacts of fluctuating water levels on the coastal zone. Because of the magnitude of effort involved, this group may wish to address the aquatic and terrestrial aspects of the coastal zone separately. The group would:

° Review previous lake regulation studies and provide an updated assessment of past, present and potential future changes in the ecology, resources, uses and management of the coastal zone and determine the effects of fluctuating water levels on these aspects of the coastal zone.

° Determine the extent to which proposed regulatory measures would alleviate the adverse consequences of fluctuating water levels.

° Assess, determine the cost of and propose ways in which alternative use and management practices would affect the adverse consequences of fluctuating water levels.

- Develop schemes for alleviating potentially adverse effects of such use and management practices-related measures, evaluate their associated cost and comment on requirements for successful implementation.

- Develop, in collaboration with the Cross-System Impact Evaluation Group (Group 5), an analytical framework for assessing and communicating the relationship between fluctuating water levels and the ecology, resources, uses and management of the coastal zone.

Group 3 - Socio-Economic and Environmental Assessment

This work group is envisioned as having lead responsibility for the analysis and assessment of socio-economic and environmental impacts including significant impacts on interests outside the coastal zone and outside the region. This group would:

- Review previous lake regulation studies and provide a comprehensive analysis of socio-economic and environmental impacts of fluctuating water levels in the Great Lakes-St. Lawrence River Basin.

- Assess socio-economic and environmental impacts of proposed regulatory measures, and alternative use and management practices, on affected interests.

- Develop appropriate schemes for alleviating adverse socio-economic and environmental impacts of proposed measures and identify possible compensatory actions and evaluate their potential costs.

- Develop, in collaboration with the Cross-System Evaluation Group (Group 5), an analytical framework for assessing, and communicating information on socio-economic and environmental impacts on affected interests.

Group 4 - Public Participation and Communications

This group is assigned the lead responsibility for developing the public participation and communications program. It will be integrated with the existing Public Information Committee of the Commission. This group would:

- Develop an information program which could be carried out by responsible government agencies.

- Develop strategies for involving the public in the various studies.

Group 5 - Cross-System Impact Evaluation

This group will have the responsibility for identifying and addressing meta cross-system issues and developing an interactive modelling capability for evaluating system wide impacts. Its key tasks will consist of the following:

- In close collaboration with other groups, develop the logical framework for identifying and addressing cross system issues.
- Develop an interactive "what if" modelling capability for evaluating system-wide impacts under various scenarios given different assumptions concerning pertinent underlying conditions and potential remedial measures.
- Utilize the system modelling effort in order to assist in the development of the direction, intensity and level of resolution of the relevant studies conducted in the other functional areas.
- Provide special support to the Project Management Team in the overall conceptual direction of the study, the integration of its various elements, their synthesis and design.

6. DIRECTIONS FOR IMMEDIATE ACTIONS

The Commission hereby appoints Ms. Elizabeth Dowdeswell (Environment Canada) and Brigadier General Joseph Pratt (U.S. Army Corps of Engineers) as members of the Steering Committee and Co-Chairmen of the Project Management Team and instructs the Steering Committee to proceed with the following:

- Appoint deputies for the Co-chairmen and institute the Project Executive.
- Name Chairmen for each of the five functional groups who will oversee each of these areas and be members of the Project Management Team.
- Instruct the Project Management Team to develop a Plan of Study including: membership in functional groups, tasks to be undertaken, schedules and estimates of costs.
- Submit a Plan of Study for review and approval by the Commission so that study activities can begin no later than September 1987.

Appendix 4:

Glossary

Glossary Of Terms

Adverse Consequences: Negative implication of fluctuating water levels for social, economic, environmental or political investments.

Agreements: Joint statements among two or more governmental units on (i) goals and purposes which should guide basin decision-making, (ii) processes of decision-making and (iii) authorities of governments to act. Agreements are an attempt to remedy a shared problem, and they serve to define the boundaries and constraints on choice of measures.

Alternative Dispute Resolution (ADR): A process aimed at reaching a consensus agreement in order to end a dispute or reduce conflict among interest groups that have some stake in and can influence the outcome of decisions or actions related to the water level issue. The distinguishing characteristics of ADR are that 1) interest groups are actively included in developing and assessing alternatives and making tradeoffs between alternatives, and 2) issues are decided on their merits rather than on the interests access to the decision-making process. Policy dialogues and negotiation are types of ADR processes.

Aquifer: Any subsurface material that holds a relatively large quantity of groundwater and is able to transmit that water readily.

Authority: The right to enforce laws and regulations or to create policy.

Average Water Level: see Monthly Mean Level

Basin (Great Lakes – St.Lawrence River): The surface area contributing runoff to all of the Great Lakes and the St. Lawrence River downstream to Trois Rivières, Quebec.

Basin: The rounded depression of a lake bed.

Bathymetry: The measurement of depths of water in oceans, seas and lakes; also information derived from such measurements.

Beach: The zone of unconsolidated material that extends landward from the average annual low water level to either the place where there is marked change in material or physiographic form, the line of permanent vegetation, or the high water mark.

Beneficial Consequence: Positive implication of fluctuating water levels for social, economic, environmental or political investments.

Bluff: A steep bank or cliff of variable heights, composed of glacial tills and lacustrine deposits consisting of clay, silt, gravel and boulders.

Breakwater: An offshore barrier to break the force of waves, which affords shelter to shore structures.

Climate: The sum total of meteorological phenomena over a period of time which combine to characterize the average and extreme condition of the atmosphere at any place on the earth's surface.

Coastal Zone Data Base: Information of the various attributes of the key components of the Great Lakes ecosystem, gathered and stored in the GIS.

Connecting Channels: A natural or artificial waterway of perceptible extent, which either periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. The Detroit River, Lake St. Clair and the St. Clair River comprise the connecting channel between Lake Huron and Lake Erie. Between Lake Superior and Lake Huron, the connecting channel is the St. Marys River.

Consumptive Use: The quantity of water withdrawn or withheld from the Great Lakes and assumed to be lost or otherwise not returned to them, due to evaporation during use, leakage, incorporation into manufactured products or otherwise consumed in various processes.

Control Works: Hydraulic structures (channel improvements, locks, powerhouses, or dams) built to control outflows and levels of a lake or lake system.

Criteria: A principle or standard by which a judgement or decision is made. Criteria are conceptual but must have operational (measurable in principle) components. Any single criterion can be used to compare the merit of measures or policies along the dimensions encompassed by the criterion. Criteria are used to assess measures *and* criteria are used to assess the decision making process (for example, group access to the decision making bodies).

Criteria, Core: The broad principles upon which the overall value of any measure can be assessed relative to other measures. They include economic sustainability, environmental integrity, social desirability, uncertainty and risk, political acceptability and implementability, and equitability.

Criteria, Operational: These criteria are subsets of the core criteria. These sub-criteria are quantified on the basis of the application of specific group rules to data or estimates of impacts of the measure. Impact assessments used to score sub-criteria are ultimately used to compare the profiles of measures.

Current: The flowing of water in the lakes caused by the earth's rotation, inflow and outflows, and wind.

Design Range: The range of factors (including expected water levels) taken into consideration when making an investment decision.

Diversions: A transfer of water either into the Great Lakes watershed from an adjacent watershed, or vice versa, or from the watershed of one of the Great Lakes into that of another.

Dike: A wall or earth mound built around a low lying area to prevent flooding.

Drainage Basin: The area that contributes runoff to a stream, river, or lake.

Ecology: The science which relates living forms to their environment.

Ecosystem: A subdivision of the Biosphere with boundaries arbitrarily defined according to particular purposes. An ecosystem is a dynamic totality comprised of interacting living and non-living components. The Great Lakes-St. Lawrence River Basin Ecosystem is an example which encompasses the interacting components of sunlight, air, water, soil, plants, and animals (including humans), within the Basin.

Ecosystem Integrity: "Ecosystem integrity" refers to a state of health, or wholesomeness" of an ecosystem. It encompasses integrated, balanced and self-organizing interactions among its components, with no single component or group of components breaking the bounds of interdependency to singularly dominate the whole.

Environment: Air, land or water; plant and animal life including humans; and the social, economic, cultural, physical, biological and other conditions that may act on an organism or community to influence its development or existence.

Environmental Integrity: The sustenance of important biophysical processes which support plant and animal life and which must be allowed to continue without significant change. The objective is to assure the continued health of essential life support systems of nature, including air, water, and soil, by protecting the resilience, diversity, and purity of natural communities (ecosystems) within the environment.

Equitability: The assessment of the fairness of a measure in its distribution of favorable or unfavorable impacts across the economic, environmental, social, and political interests that are affected.

Erosion: The wearing away of the shoreline and lake or river bed by the action of waves and currents, and other natural processes.

Eutrophic: Waters high in nutrient content and productivity arising either naturally or from agricultural, municipal, or industrial sources; often accompanied by undesirable changes in aquatic species composition.

Evaluation: The application of data, analytical procedures and assessment related to criteria to establish a judgment on the relative merit of a measure, policy or institution. Evaluation is a process which can be conducted both within formal studies and by separate interests, although different data, procedures and criteria may be employed in the evaluation by different interests.

Evaluation Framework: A systematic accounting of the criteria considered and methodologies applied in determining the impact of measures on lake levels, stakeholders, and stakeholder interests.

Evapotranspiration: Evaporation from water bodies and soil and transpiration from plant surface.

Feed Back Loop: Feed back loops are circular cause and effect relationships dominating some interaction of particular sets of system's key variables. Feed back loops belong generally to one of two types: "negative feed back loops" which act to maintain the value of a particular variable around a given level, and "positive feed back loops" which act to cause the value of a particular variable to increase or decrease in a self-amplifying manner, and, usually at a geometric rate.

Flooding: The inundation of low lying areas by water.

Fluctuation: A period of rise and succeeding period of decline of water level. Fluctuations occur seasonally with higher levels in late spring to mid-summer and lower levels in winter. Fluctuations occur over the years due to precipitation and climatic variability. As well, fluctuations can occur on a short-term basis due to the of effects periodic events such as storms, surges, ice jams, etc.

Geographical Information System (GIS): A computer-based "tool" which captures, displays and manipulates geographically referenced data.

Geomorphology: The field of earth science that studies the origin and distribution of landforms, with special emphasis on the nature of erosional processes.

Governance System: The complex, dynamic mosaic of governmental and non-governmental entities having some authority to manage, or the ability to influence the management of Basin resources.

Greenhouse Effect: The warming of the earth's atmosphere and associated meteorological effects due to increased carbon dioxide and other trace gases in the atmosphere. This is expected to have implications for long-term climate change.

Groundwater: Subsurface water occupying the zone of saturation. In a strict sense, the term is applied only to water below the water table.

Group Depth Interviews (GDI's): A tool borrowed from marketing to gather perceptual data from a small group of representatives of local interests and governments on the following: the problems caused by different lake levels; the opportunities presented by different Measures; the factors involved in decision making about adopting Measures; and the consequences of Measures. It should be noted the GDI's reflect accurately the perceptions of the attendees but do not necessarily reflect the perceptions of all individuals within an interest.

Gullies: Deep, V-shaped trenches carved by newly formed streams, or groundwater action, in rapid headward/forward growth during advanced stages of accelerated soil erosion.

Hazard Land: An area of land that is susceptible to flooding, erosion, or wave impact.

Hydraulics: That branch of engineering science dealing primarily with the flow of water or other liquids.

Hydrology: The applied science concerned with the water of the earth in all its states.

Ice Jam: An accumulation of river ice, in any form which obstructs the normal river flow.

Implementability: The ability to put into effect a measure considering factors of engineering, economic, environmental, social, political and institutional feasibility.

Implementing Authority: Any governmental agency at any level having appropriate authority to authorize and execute the implementation of any particular action and the jurisdiction to enforce an action.

Infiltration: Movement of water through the soil surface and into the soil.

Institution: An organization of governmental units which have the authority and ability to facilitate and/or make decisions affecting the water levels issue.

Interests: Any identifiable group, including specialized mission agencies of governments which (1) perceive that their constituents'/members' welfare is influenced by lake level fluctuation or policies and measures to address lake level fluctuation, and which (2) are willing and able to enter the decision making process to protect the welfare of their constituents/members.

Interest, Agriculture: This interest benefits from the services of shore location (fertility and climate), water supply, and indirectly from the transport of grains. This interest class includes all types of farming and production agriculture.

Interest, Commercial Fishing: This interest uses the Great Lakes habitat and shore access services to earn income and sustain a lifestyle from sale of fish and fish products.

Interest, Commercial/Industrial: A commercial and industrial interest includes firms whose activities are tied into having a fixed point location along the shoreline and whose net income position is potentially affected by fluctuating lake levels. The interest is made up of a number of diverse businesses that are often represented by specialized trade associations and because of diversity of activities and geographic dispersion may not be uniformly affected by lake level fluctuations.

Interest, Electric Power: Power interests are composed of all forms of electrical generation that depend on water as an integral part of power production process. The interest uses the Great Lakes and the St. Lawrence River for shore access service and water supply for hydro power, cooling water and steam power and therefore includes hydro power, nuclear power, and fossil fuel-fired electric power.

Interest, Environment: This class of interest receives a service form the knowledge that particular Great Lake ecosystems exist. The class is represented primarily by naturalist and conservation groups, as well as government agencies with a mandate for preserving the environment.

Interest, Government: This interest includes all levels of government, local, regional, state/provincial and federal with some vested interest in the Great Lakes – St. Lawrence River water levels issue.

Interest, Native Peoples: This interest includes Native populations whose reservations are located on the shores of the Great Lakes – St. Lawrence River. The benefits derived from shoreline location of Natives include subsistence, residential location, aesthetics and cultural heritage.

Interest, Recreational: Non-riparian recreation interests include individuals, some of whom are represented by specialized associations, which are located both inside and outside the Great Lakes Basin. This interest does not include those who own shoreline property. This interest seeks access to the lakeshore and to some extent depends upon the habitat services of the lakes for serving its interests. Recreation interests benefit from angling, hunting, non-consumptive recreation, boating, swimming and camping.

Interest, Residential Shoreline Property Owner: This interest group, also referred to as riparians, is comprised of many individuals who have seasonal or permanent shoreline residences along the Great Lakes – St. Lawrence River. A number of riparians are represented by various coalitions and associations with a wide range of organizational and political strength.

Interest, Transportation: Transportation includes movement of goods in Great Lakes-St. Lawrence shipping channels and into and out of Great Lakes-St. Lawrence ports. Transportation interests are comprised of two major subclasses: (1) ocean going and lake carrier shipping companies, often represented by shipping associations, and (2) ports, often represented by port associations. Associated with the lake transportation interests are other interests within the regional transportation infrastructure, including truck and rail interests.

International Joint Commission (IJC): A binational Commission created under authority of the 1909 Boundary Water Treaty. The IJC has three primary functions: 1) quasi-judicial, with responsibility for approving applications to affect natural flows or levels of boundary waters; 2) investigation of matters at the request of the two governments, with the limitation that resulting recommendations are not binding on the governments, and can be modified or ignored; 3) surveillance/coordination, through monitoring or coordinating the implementation of recommendations, at the request of the governments.

Investment: Expenditure made by an interest to capture benefits. The investment decision reflects available information and understanding about the system, government responsibilities and risks.

Jurisdiction: The extent or territory over which authority may be legally exercised.

Lake Outflow: The amount of water flowing out of a lake.

Littoral: Pertaining to or along the shore, particularly to describe currents, deposits and drift.

Littoral Cell: An area under the continuous influence of specific longshore currents.

Littoral Zone: The area extending from the outermost breaker or where wave characteristics significantly alter due to decreased depth of water to: either the place where there is marked change in material or physiographic form; the line of permanent vegetation (usually the effective limit of storm waves); or the limit of wave uprush at average annual high water level.

Location Benefit: Positive effect on the welfare of an interest derived from shore location and water level situation.

Location Cost: Negative effect on the welfare of an interest derived from shore location and water level situation.

Marsh: An area of soft, wet or periodically inundated land, generally treeless and usually characterized by grasses and other low growth.

Measure: Any action, initiated by a level(s) of government to address the issue of lake level fluctuations, including the decision to do nothing.

Measure, Non-Structural: Any measure that does not require physical construction.

Measure, Structural: Any measure that requires some form of construction. Commonly includes control works and shore protection devices.

Monthly Mean Water Level: The arithmetic average of all past observations (of water levels or flows) for that month. The period of record used in this Study commences January 1900. This term is used interchangeably with average.

Meteorological: Pertaining to the atmosphere or atmospheric phenomena; of weather or climate.

Model: A model may be a mental conceptualization; a physical device; or a structured collection of mathematical, statistical, and/or empirical statements.

Model, Computer: A series of equations and mathematical terms based on physical laws and statistical theories that simulate natural processes.

Model, Hydraulic: A small-scale reproduction of the prototype used in studies of spillways, stilling basins, control structures, river beds, etc.

Model, Visual Situation: A pictorial display linked to an automated information/geographic information system(s) which connects the problems associated with fluctuating water levels with the stakeholders and their interests that are impacted by the problems, with an emphasis on overlapping or interacting relationships.

Negotiation: The process of seeking accommodation and agreement on measures and policies among two or more interests or agencies having initially conflicting positions by a "voluntary" or "non-legal" approach. This is often considered a part of an ADR process.

Net Basin Supply: Represents the supply of water a lake receives from its own basin less the losses by evaporation from the lake surface and loss or gain due to seepage.

No Net Loss: A working principle by which a department or agency strives to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions to Canada's fisheries or U.S. wetland resources due to habitat loss or damage may be prevented.

Operating Plan: A list of procedures to be followed in making changes to the lake levels or their outflows for the specific purpose or to achieve certain objectives. Operation of regulatory facilities on the Great Lakes are carried out by their owners and operators under the supervision of the IJC and in accordance with Plan 1977 (Lake Superior) and Plan 1958D (Lake Ontario).

Oxic: To expose to oxygen.

Physiography: A descriptive study of the earth and its natural phenomena, such as climate, surface, etc.

Planimetric Capabilities: The capability of a system to measure areas.

Policy: The position adopted by a government on an issue which is expected to structure and guide the decision making process.

Position of Interests: The perceptions, beliefs and preferences of interests regarding fluctuating water levels, implications of those levels, and acceptability of a measure or policy to an interest. Positions may be directly stated or may be inferred from supporting or opposing activities taken by the interest in the decision making process.

Public Communications: Activities where the purpose, design, and plan intends for two-way communication for a defined period of time between Study personnel and the public or various publics. Examples: the Toledo Public Information Meeting and the Public Comment Process on the Task Force Report and Background Paper.

Public Information: Activities where the purpose, design, and plan intends to deliver information to the public or various publics. Examples: press releases and articles in the IJC's Focus Newsletter.

Public Involvement: Activities where the purpose, design, and plan is such that members of the public or various publics are engaged in the Study on a continuing basis with other "expert" resources. Example: a member of an interest group serving as a functional group member.

Public Participation: Activities where purpose, design, and plan intends that members of the public have an opportunity to participate for a defined period of time in a Study activity. Example: input into a portion of the work activities of a functional group through a workshop.

Reach: A length of shore with fairly uniform onshore and offshore physiographic features and subject to the same wave dynamics.

Rebound (Crustal Movement): The uplift or recovery of the earth's crust in areas where a past continental glaciation had depressed the earth's crust by the weight of the ice.

Recession: A landward retreat of the shoreline by removal of shore materials in a direction perpendicular or parallel to the shore.

Regulations: Control of land and water use in accordance with rules designed to accomplish certain goals.

Regulation: Artificial changes to the lake levels or their outflows for specific purpose or to achieve certain objectives.

Resiliency: The ability to readily recover from an unexpected event, either because costs were not significantly affected by changing levels, another source of income provided a cushion to levels induced costs, and/or a conscious effort was made on the part of the interest.

Riparians: Persons residing on the banks of a body of water. (see Interests, Residential Property Owner).

Runoff: The portion of precipitation on the land that ultimately reaches streams and lakes.

Shoreline: Intersection of a specified plane of water with the shore.

Sills: Underwater obstructions placed to reduce a channel's flow capacity.

Social Desirability: The continued health and well-being of individuals and their organizations, businesses, and communities to be able to provide for the material, recreational, aesthetic, cultural, and other individual and collective needs that comprise a valued quality of life. The satisfaction of this objective includes a consideration of individual rights, community responsibilities and requirements, the distributional impacts of meeting these needs, and the determination of how these need should be achieved (paid for) along with other competing requirements of society.

Spatial Evaluation Framework: The classification and delineation of terrestrial, wetland and aquatic environments in spatial units meaningful to an assessment of fluctuating levels and measures.

Stakeholder: An individual, group, or institution with an interest or concern, either economic, societal or environmental, that is affected by fluctuating water levels or by measures proposed to respond to fluctuating water levels within the Great Lakes-St. Lawrence River Basin.

Strategy: A general conceptual framework for guiding action based upon a particular purpose and selected means for achieving agreed upon ends.

Steady State: No change over time.

System Dynamics: A simulation modelling methodology developed at Massachusetts Institute of Technology (M.I.T.) for the study of the behaviour of complex systems. System Dynamics is based upon the identification of key system variables, the interactions between them and the study of the effects of these interactions over time.

Systems Approach: A method of inquiry which complements the classical analytical method of science by emphasizing the concept of "whole systems" and the irreducible properties of whole systems that result from the interactions among individual components.

Uncertainty and Risk: The evaluation of a proposed measure in terms of the unpredictability and magnitude of the consequence which may follow, the detectability of anticipated or unanticipated consequences, and the ability to reverse, adapt, or redirect the measure, depending on its effects.

Urbanization: The change of character of land, due to development, from rural or agricultural to urban.

Water Supply: Water reaching the Great Lakes as a direct result of precipitation, less evaporation from land and lake surfaces.

Watershed: The area drained by a river or lake system.

Wave: An oscillatory movement in a body of water which results in an alternate rise and fall of the surface.

Wave Crest: The highest part of a wave.

Wave Direction: The direction from which a wave approaches.

Wave Period: The time for two successive wave crests to pass a fixed point.

Weather: The meteorological condition of the atmosphere defined by the measurement of the six main meteorological elements: air temperature; barometric pressure; wind velocity; humidity; clouds; and precipitation.

Wetlands: Wetlands (marshes, swamps, bogs and fens) are defined as lands where the water table is at, near or above the land surface long enough each year to support the formation of hydric soils and to support the growth of hydrophytes, as long as other environmental variables are favorable.

Vulnerability: Vulnerability is a concept pertaining to a relative susceptibility of interests to the adverse consequences of water level fluctuations. Depending on the choice of level of resolution, the concept of vulnerability could pertain to a spectrum of identifications of interests ranging from an individual, to a group of interests (industry) or to some notion of "society as a whole." Vulnerability would thus be dependent on the concentration of interests in the Basin, the type of activity they are engaged in, the assets they employ, including such factors as location and setting, design range of the building or equipment, the ability of the interest to adapt, and the like.

Appendix 5:

Members of Steering Committee and Project Management Team

Members of Steering Committee

	Canadian	United States
Co-Chairs	Commissioner Robert Welch International Joint Commission (Effective April 1989) Commissioner P-André Bissonnette International Joint Commission (April 1987 – March 1989)	Commissioner Donald Totten International Joint Commission
Project Management Team Co-Chairs	Ms. Elizabeth Dowdeswell Regional Director General Conservation & Protection Environment Canada	Brig. Gen. Theodore Vander Els North Central Division Commander U.S. Army Corps of Engineers (Effective August 1987) Brig. Gen. Joseph Pratt North Central Division Commander U.S. Army Corps of Engineers (April 1987 – August 1987)
IJC Lead Staff	Dr. Murray Clamen International Joint Commission	Donald Parsons International Joint Commission (Effective February 1988) David LaRoche International Joint Commission (April 1987 – February 1988)
Study Executive Director		Kenneth Murdock North Central Division U.S. Army Corps of Engineers (Effective April 1988)

Members of Project Management Team

	Canadian	United States
Co-Chairs	Ms. Elizabeth Dowdeswell Regional Director General Conservation & Protection Environment Canada	Brig. Gen. Theodore Vander Els North Central Division Commander U.S. Army Corps of Engineers (Effective August 1987) Brig. Gen. Joseph Pratt North Central Division Commander U.S. Army Corps of Engineers (April 1987 – August 1987)
Deputies	Tony Wagner Inland Waters Directorate Environment Canada	Bob MacLauchlin North Central Division U.S. Army Corps of Engineer
Functional Group 1	Douglas Cuthbert Inland Waters Directorate Environment Canada	Phillip O'Dell North Central Division U.S. Army Corps of Engineers (Effective February 1989) Zane Goodwin North Central Division U.S. Army Corps of Engineers (April 1987 – January 1989)
Functional Group 2	Dr. Reid Kreutzwiser Department of Geography University of Guelph (Effective July 1988) Jean Thie Lands Directorate Environment Canada (April 1987 – June 1988)	Robert Roden Bureau of Water Regulation and Zoning Wisconsin Department of Natural Resources
Functional Group 3	Dr. Barry Smit Department of Geography University of Guelph	Dr. Leonard Shabman Department of Agricultural Economics Virginia Tech

Members of Project Management Team (Continued)

	Canadian	United States
Functional Group 4	Alan Clarke International Joint Commission (Effective February 1988)	David LaRoche International Joint Commission (Effective February 1988)
	Commissioner Robert Welch International Joint Commission (April 1987 – January 1988)	Commissioner L. Keith Bulen International Joint Commission (April 1987 – January 1988)
Functional Group 5	Dr. Andrew Hamilton International Joint Commission	Dr. Michael Ben-Eli The Cybertec Consulting Group
IJC Lead Staff	Dr. Murray Clamen International Joint Commission	Donald Parsons International Joint Commission (Effective February 1988)
		David LaRoche International Joint Commission (April 1987 – February 1988)
Study Executive Director		Kenneth Murdock North Central Division U.S. Army Corps of Engineers (Effective April 1988)