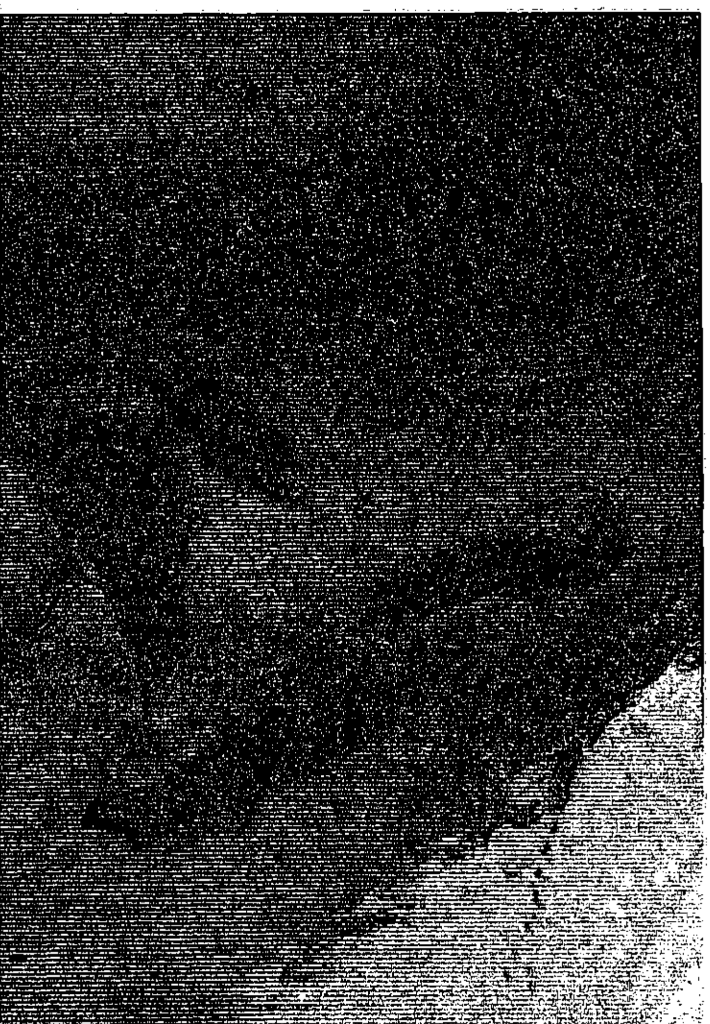
Living With The Lakes: Challenges and Opportunities

Annex E
Potential Actions
to Deal with the
Adverse Consequences of
Fluctuating Water Levels



LIVING WITH THE LAKES:

CHALLENGES

AND

OPPORTUNITIES

ANNEX E

POTENTIAL ACTIONS TO DEAL WITH THE ADVERSE CONSEQUENCES OF FLUCTUATING WATER LEVELS

PREPARED BY THE MEASURES WORK GROUP
FOR THE PROJECT MANAGEMENT TEAM

International Joint Commission
Water Levels Reference Study

MAY, 1989

IJC GREAT LAKES WATER LEVELS REFERENCE STUDY

SUMMARY OF ANNEX E

Annex E was developed to support and supplement the materials contained in the Main Report that deal with the range of measures (actions) available to Governments to attempt to deal with the adverse consequences associated with fluctuating water levels on the Great Lakes, their connecting channels, and the St. Lawrence River. Annex E concentrates on the identification, derivation, and definition of the potential measures available to Governments, while recognizing that there are measures that individuals or groups of individuals can and have taken to begin to deal with fluctuating water levels problem on the Great Lakes, their connecting channels, and the St. Lawrence River.

Annex E is comprised of a main text and four appendices. The main text is entitled, "Annex E - Potential Actions to Deal with the Adverse Consequences of Fluctuating Water Levels". Appendix E-1 is a "Glossary", and Appendix E-2 is a "Bibliography" of Annex E reference material. Appendix E-3 is a collection of "One Page Summaries of the Inventory of Measures", and Appendix E-4 is a more detailed treatment of a small set of the measures listed in Appendix E-3, called "Detailed Descriptions of Representative Measures".

The measures presented in Annex E were developed by a bi-national work group which included members from Functional Groups 1, 2, and 3. The development of measures is one important step in the process of attempting to find a solution(s) to the problem(s). Another step in the process is the testing of measures using an evaluation tool. The testing of this "tool" is presented in Annex F - Evaluation Instrument.

Annex E lists and develops all the measures that have been identified to date in the Study. No attempt was made to prejudge the actions listed in this annex, and no single measure was excluded because it might be perceived as trivial, ineffective, unpopular or costly. Actions have been devised for high and low water level conditions, and some actions will work for the range of water levels, including extremes. The selection of measures having the greatest potential given a set of agreed upon goals and objectives, evaluation criteria, and some trade-off analyses will be the subject of future efforts.

Six types of measures were identified as having potential applications to the problems associated with fluctuating water levels. The six types are as follows:

Type 1 : Regulations and Diversions, defined as "any human engineered mechanism which can alter Great Lakes water supplies, water levels and flows".

Type 2 : Land and Water Adaptations, defined as "actions which involve government investment in changing or modifying local land and water use, in an effort to adapt to water level fluctuations and natural shore processes".

Type 3 : Restrictions on Land and Water Use, defined as "actions whereby governments regulate and restrict how the public uses the land and water of the Great Lakes Basin".

Type 4 : Programs to Influence Use, defined as "public programs and policies to provide information and alter financial incentives to **indirectly** influence the ways in which interests make decisions about the use of land and water".

Type 5 : Emergency Response, defined as "actions by governments to address emergency situations (short term measures to ease immediate problems)".

Type 6 : Combinations, defined as "two or more of the first five types of measures combined to address the issue of fluctuating water levels".

The information base for all measures was developed by researching potential existing and new measures and preparing a one page summary of the information generated for each. The information was organized by giving the measure's description, location(s), time frame for implementation, implementing authority, implementing costs, and existing examples. There are several important areas where additional information will need to be developed on measures. The questions of, "Who Implements the Actions?" and "Who Pays?" and the measures' impacts on both the environment and the various interests will all need detailed study to determine their "net worth" as potential actions Governments may want to take.

There is also additional, more detailed treatment of 23 representative measures selected randomly from the six measures' types. These measures are representative of the categories of measures under each of the six types. These detailed treatments were necessitated by the desire to test the evaluation instrument developed in Annex F. These more detailed descriptions along with some simplifying assumptions made the initial testing of the instrument possible.

Annex E includes a number of conclusions with regard to measures and some recommendations regarding their enhancement in Phase 2 of this Study.

FOREWORD

This annex was developed to support and supplement the material contained in the Main Report that deals with the range of measures (actions) available to Governments to deal with the adverse consequences associated with fluctuating water levels in the Great Lakes and their connecting channels. The development of potential actions is one of the important steps in the process of attempting to find a solution(s) to a problem. This annex concentrates on the identification, derivation, and definition of the potential actions available to Governments. The testing of the evaluation instrument (see Annex F - Evaluation Instrument) included a preliminary assessment of some of these actions and their impacts (both positive and negative).

The Measures Sub-Group was charged with the identification and development of measures by the PMT. This group contained members from Functional Groups 1, 2, and 3 and had both Canadian and U.S. representatives. This approach was used to obtain the broadest possible knowledge base for the development of measures.

As is mentioned in Main Report, the actions (measures) available to Governments are what will be concentrated upon herein, recognizing that in addition to actions by Governments there are any number of measures that have and may continue to be undertaken by individuals or groups of individuals to deal with fluctuating water levels.

PHASE 1 REPORT OUTLINE
IJC FLUCTUATING WATER LEVELS STUDY

MAIN REPORT

ANNEX A - PAST AND FUTURE WATER LEVEL FLUCTUATIONS

ANNEX B - ENVIRONMENTAL FEATURES, PROCESSES AND IMPACTS: AN ECOSYSTEM PERSPECTIVE ON THE GREAT LAKES - ST. LAWRENCE RIVER SYSTEM

ANNEX C - INTERESTS, POLICIES AND DECISION MAKING: PROSPECTS FOR MANAGING THE WATER LEVELS ISSUE IN THE GREAT LAKES - ST. LAWRENCE RIVER BASIN

ANNEX D - THE GREAT LAKES ECOSYSTEM PERSPECTIVE: IMPLICATIONS FOR WATER LEVELS MANAGEMENT

ANNEX E - POTENTIAL ACTIONS TO DEAL WITH THE ADVERSE CONSEQUENCES OF FLUCTUATING WATER LEVELS

ANNEX F - EVALUATION INSTRUMENT

ANNEX G - PUBLIC INFORMATION PROGRAM

ANNEX E

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SECTION 1

INTRODUCTION

This annex is a summary of the possible government actions that could be undertaken to deal with the adverse consequences of fluctuating water levels in the Great Lakes - St. Lawrence River System. Its' purpose is to provide a clear, concise, and unevaluative presentation of all the potential actions available to Governments that have been identified to date for this Study. By being able to understand the full range of actions available, productive dialogue can begin to evaluate of the relative merits of each of these actions in dealing with the adverse consequences of fluctuating water levels.

The terms "actions" or "measures" (used interchangeably) as presented in this Study are defined as any method, plan, strategy, or combination thereof, initiated by a level(s) of Government to attempt to deal with the issue of fluctuating water levels (both highs and lows) in the Great Lakes, their connecting Channels, and the St. Lawrence River. This is not to say that individuals or groups can not, or have not, taken actions themselves. It must be acknowledged that the individual has a number of options available to deal with the consequences of fluctuating water levels. However, this annex and the overall International Great Lakes - St. Lawrence Levels Study concentrates on the options which are available to Governments, be they direct actions, or actions which attempt to influence the individual decisions of the private sector. The conscious decision to do nothing, take "No Action", may also be a viable alternative, and one which acts as the status quo against which all measures are compared.

No attempts were made to evaluate or prejudge the actions listed in this annex. All possible actions that have been identified to date have been included. No single action was excluded just because it might be perceived as trivial, ineffective or costly. Efforts were made to minimize duplications of actions under the six types of actions.

This annex is made up of 11 main sections in addition to this introduction, and four appendices. The first section talks about how actions were classified and the types, presents how they will be described, the environmental considerations of actions, and looks at who will implement and pay for the action(s). The second section looks at the inventory of actions, and explains the approach used in developing the inventory along with the listing of actions by type that have been identified to date. The next six sections will provide detailed information about the six types of actions. The last three sections of the annex will cover: important issues related to actions; Phase 2 study needs; and conclusions about actions at this point in the Study. There are also four appendices to this annex which include: a glossary of terms; a bibliography; a one page summary type inventory of all the actions listed in the annex; and more detailed write-ups on the representative actions.

Lake levels and elevations in this annex are in feet, International Great lakes Datum (1955). Flows are in cubic feet per second (cfs).

SECTION 2

WHAT ARE THE ACTIONS?

CLASSIFICATION AND TYPES OF ACTIONS

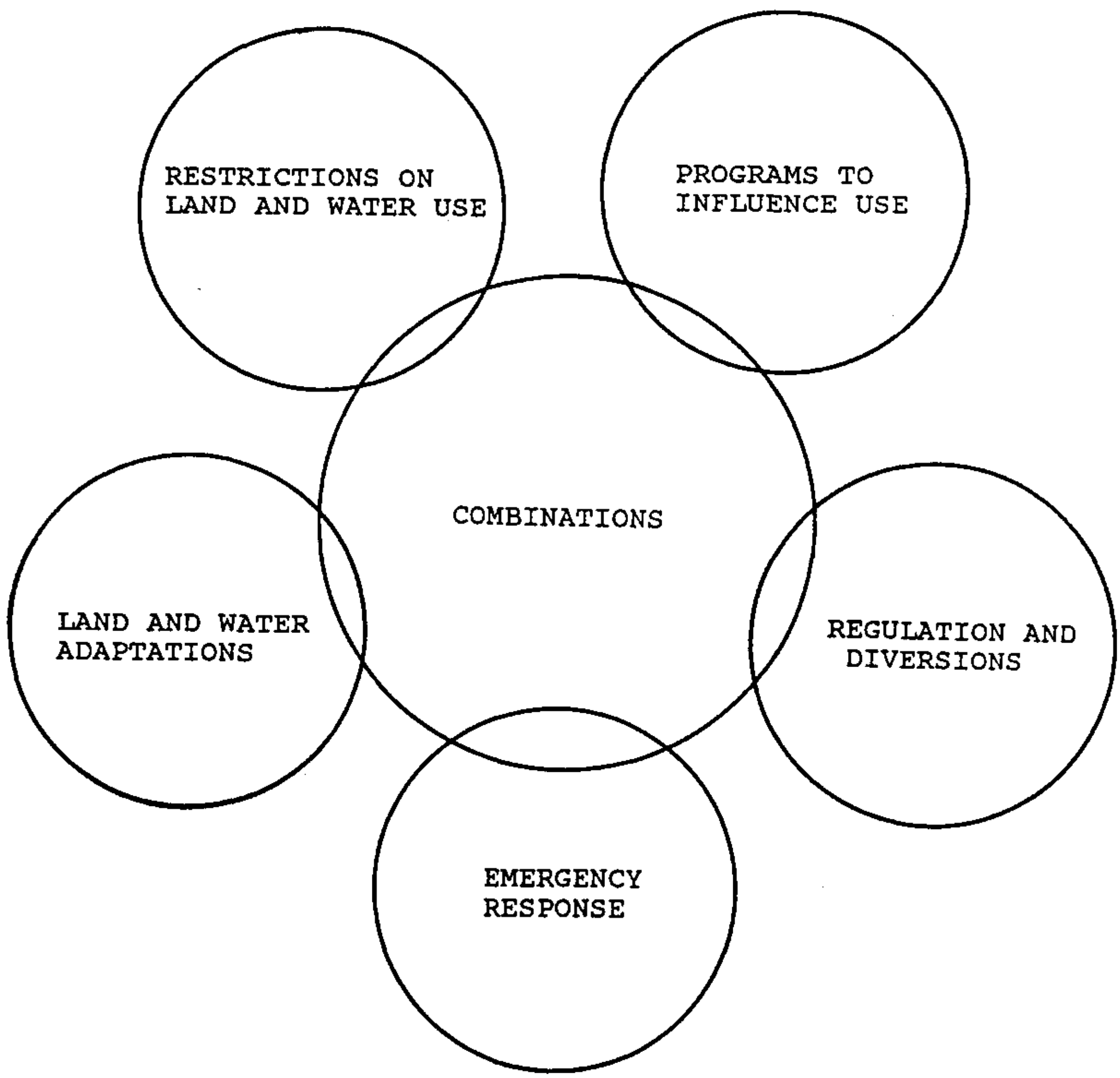
A action (measure) has been defined as any method, plan or strategy initiated by a level(s) of government to address the issue of lake level fluctuations, whether actual or potential, tried or untried, in isolation or in combination, and including the decision to do nothing. Measures may be defined by three elements. The first element is the specific investment of an action intended to affect the land and water resource and/or the human use of the land and water resource (i.e. the cost of the measure). The second element is the manner in which the socio-economic cost burden for an action is distributed (i.e. who pays?). And the third element refers to the implementing authority (i.e. who is responsible for executing and enforcing the action). Governments have available to them literally hundreds of options to deal with fluctuating water levels on the Great Lakes. These options range from building huge control structures to modify the actual lake levels, to information and education programs to influence decisions made by the public. By examining what various actions are intended to do, and who and what they may influence, it becomes apparent that governments have available to them three basic strategies to deal with the issue of water level fluctuations. Firstly, they could attempt to **modify the actual lake level.** This could be done through engineering means to alter Great Lake supplies, water levels and flows. The second strategy available to governments is to attempt to **modify the land to adapt to water level fluctuations.** The third strategy is for governments to attempt to **influence the use of the land and water** in an effort to reduce human susceptibility to water level fluctuations. These three strategies form the basis for the classification of measures.

The first two strategies discussed above are fairly straight forward - change the levels or change the land to adapt to the levels. These strategies may be considered as two "types" of actions. The third strategy, however, which involves governments influencing the ways in which interest use the land and water of the Great Lakes, has a couple of facets. Governments could modify the way interests' use the land and water by restricting or regulating interests use. Governments could also try to influence the use of land and water in a more **indirect** way by influencing how interests **choose** to use the land and water. This distinction between direct influence, through restrictions, and indirect influence, through information and financial incentives, justifies the separation of the third strategy into two types of measures now creating four different types of measures.

Governments also have the option of responding only to the water levels issue during crisis situations. This type of action is not an attempt to solve the long term situation, but rather is short term and temporary and must, therefore, be considered separate from the other types of actions already mentioned.

These five different ways governments could react to the fluctuating water levels issue on the Great Lakes formed the basis for the classification scheme developed. A sixth category was also added which considered combinations of any of these five types. The six main types of measures are defined below and illustrated in Figure E-2-1.

Figure E-2-1: Six Types of Actions



Type 1: Regulation and Diversions

Any human engineered mechanism which can alter Great Lakes water supplies, water levels and flows.

These are actions governments could take to modify water level fluctuations on the Great Lakes. For example, changes could be made in the operation of regulation structures on Lakes Ontario and Superior, or new regulation structures could be built for the unregulated lakes. Existing diversions into and out of the Great Lakes Basin could be operated to improve lake level conditions. In addition, new diversions could be constructed to bring more water into, or out of, the Great Lakes Basin.

Type 2: Land and Water Adaptations

Actions which involve government investment in changing or modifying local land and water use, in an effort to adapt to water level fluctuations and natural shore processes.

This action, or measure, recognizes human occupation and use of the Great Lakes coastal zone, and would see community investment (funding) in methods that would help the community as a whole, better adapt to water level changes, flooding and natural shore processes (e.g., erosion). Examples of these kinds of methods could include: construction of major shore protection works for long stretches of threatened shoreline; acquisition of, or relocation of structures out of, severely threatened hazard land; proper flood proofing of buildings in flood hazard zones; and retrofitting of harbor structures (docks, piers, etc.), so that they too, can adapt to changing water levels.

Type 3: Restrictions on Land and Water Use

Actions whereby governments regulate and restrict how the public uses the land and water of the Great Lakes Basin.

These government actions are designed to prevent adverse consequences of fluctuating water levels on both the human and the natural (or biophysical) resources of the Great Lakes Basin. They include regulations to govern how humans use the water in the lakes and the land surrounding them. Regulations could cover such things as the amount and types of construction that takes place in areas prone to severe flooding and erosion.

Type 4: Programs to Influence Use

Public programs and policies to provide information and alter financial incentives to **indirectly** influence the ways in which interests make decisions about the use of the land and water.

This type of action comprises a number of programs and policies that could be put in place in order to point out to shoreline interests the risk that is inherent in their individual decisions about land or water use. These programs are designed, not to restrict or prohibit a certain land or water use as do Restrictions (Type 3), but instead, to point out to all Great Lake interests, that if they wish to do "something," then there may be a policy, or program in place that can either help them do that "something," or can deter them from doing that "something." As an example, someone who wants to build in a hazard area may discover a policy stating they will be unable to receive flood insurance, or disaster assistance if they build. This may deter that someone from building. Other actions may include information and education programs.

Type 5: Emergency Response

Actions by governments to respond to emergency situations. These are short term measures to ease immediate problems.

These actions would be taken during times of extremely high or extremely low water levels, so that either the consequences of these extremes could be reduced (e.g., sandbagging and diking protection during high levels), or the actual water levels could be altered (e.g., adjustment of existing diversions or control structures).

Type 6: Combinations

Two or more of the above types of actions combined to address the issue of fluctuating water levels.

Any action may not single-handedly deal effectively with the negative consequences of fluctuating water levels. It may have to be combined with a number of other actions in a coordinated fashion. As investigation into possible actions is in its early stages, only a limited treatment of combination actions is possible in this report.

DESCRIPTION OF ACTIONS

In order to describe actions there are a number of questions that need to be answered about them:

What are they?

Where would they be located/applied?

How long would it take to implement them?

Who has (or should have) the authority to implement them?

How much will it cost and how will pay to implement them?

Are there any existing examples of these actions?

This section will outline how these questions will be answered, and provide the outline for the action presentations used in the inventory of actions contained in Appendices E-3 and E-4 to this annex. The information developed for these descriptions was that which was known or the best judgment of the authors at the time this annex was prepared.

Description

Each action needs to be described to tell us what the action consists of in terms of the structures, laws, policies, regulations, methods, and information necessary to make this action a functional way to deal with the adverse consequences of fluctuating water levels. The description also identifies what it is the action is designed to accomplish. For example, some actions may modify the water level regime for some portion or all of the Great Lakes, others may directly or indirectly protect existing facilities along the shoreline, others may help man adapt to the fluctuations, others may influence the potential ways in which individuals may adapt to the fluctuations, and still others may be taken when all previous efforts have been unable to live up to the task.

This description can also discuss some optional ways that the action is used to accomplish its objectives.

Location

The location of the action is important in conceptualizing how it will function and who and what it may potentially impact. In the case of structural and some non-structural actions, some locations may be easy to define. When we think of zoning or applying regulations in areas needing them the location description becomes much broader and necessarily vague. There is a great deal of work that needs to be done in fully developing all actions, and this is one area requiring further detailing. Things like hazard lands mapping and identifying the applicability of certain actions in various geographic areas will help to focus this portion of an action description.

Time Frame for Implementation

The time it takes to put an action into effect can be very important, especially during a crisis or when one is eminent. In general, emergency type actions are the quickest actions that can be implemented because Governments may already have disaster plans for all types of emergencies and are often adept at taking action. At the other extreme there are the major federal civil works type projects that have historically taken between 15 to 25 years (or more) to implement.

The time required will vary but should include: the time it takes to complete the overall Study (currently scheduled for September 1991); time for planning, environmental and institutional investigations; time for design, plans and specifications, cost-sharing agreements, appropriation of funds, obtaining lands, easements, and rights-of-way (if necessary); and construction or implementation (depending on the type of action). In general, if there are no current laws or plans on the books that can be amended or added to its likely that most actions (other than emergency actions) will take at least five years to put in place.

Implementing Authority

The implementing authority in all cases investigated in this Study will be a governmental body or a number of governmental bodies. However, it may be the local/municipal, state/provincial, or the federal levels as well as combinations of these entities within and amongst the two nations. The challenge will be to make these different arrangements work to implement the action(s) that will address the adverse consequences of fluctuating water levels.

Implementing Costs

The total cost of an action may include a number of readily available components and some pieces, such as environmental damage that are difficult to estimate in monetary terms. In addition, for many of the actions being developed in this Study, the scope and cost of the action (like a setback program for existing structures) can only be estimated in terms of the cost per structure because the number of structures that will actually be impacted by implementing the action is unknown. This is just one example of the many possible options in trying to develop costs for all actions. Where costs are known or reasonable estimates are available they are shown, and in other cases they are qualitatively estimated to be within a randomly selected set of broad ranges. These ranges are identified as follows:

COST	RANGE
Very Low	less than $1 million
Low	between $1 - 10 million
Medium	between $10 - 100 million
High	between $100 million & $1 billion
Very High	more than $1 billion

It is assumed that these cost ranges and their descriptors are applicable at higher levels of Government since they become increasingly prohibitive as the governmental body becomes smaller.

Examples of the components that are included in "implementing costs" are:

a. all planning and design costs (including modeling);

b. all costs of environmental and institutional studies;

c. all costs of preparing for and executing contracts;

d. all contractor and monitoring costs;

e. all lands, easements, rights-of-way, and interest during construction costs;

f. all operation and maintenance and replacements costs;

g. all administrative, monitoring and enforcement costs;

h. all other resource (not including natural resources) costs to make the measure fully operational; and

i. all compensatory or mitigation costs to interests or the environment that may be "damaged" by a particular measure.

The cost items listed above cover a wide range of measures including measures which are both structural and non-structural in nature. This is an example list and there may be other costs which were not explicitly mentioned that would also be costs of the measure. In general, only monetary or resource costs are included in this portion of the description.

Existing Examples

This section is designed to talk of past experience with the same or similar types of measures both within and outside the Great Lakes Basin. This enables us to learn from the past applications of these measures to other riverine or coastal situations without having to "reinvent the wheel." All known examples will be included to illustrate the extent of knowledge on a particular measure.

ENVIRONMENTAL CONSIDERATIONS

Another consideration which needs to be addressed is the environmental assessment necessary to implement each action. Each potential action includes an environmental concern. The growing list of possible actions being considered have environmental impacts that range from very low (or even positive) for actions such as setback regulations and/or tax incentives to locate development out of hazard zones, to very high, when system-wide changes are proposed. System changes include major diversions of water and extensive shoreline protection measures. Some of these activities could have a relatively small environmental impact **IF** maintenance of the environment was made an **EQUAL PARTNER** in the design of those specific activities. In general, the time required to assess impacts is from a few months to three years for local specific activities, five years for system-wide activities with five to ten more years of follow-up monitoring to fine tune some of these actions. These times will be incorporated into the actions' "time frame for implementation" as the specifics of each action are developed.

WHO IMPLEMENTS THE ACTIONS?

General

Each level of government has laws, regulations, taxation and fiscal spending powers unique to itself. These powers dictate the amount of authority and resources various governments are capable of applying to actions. In the case of the Great Lakes, the water management issue crosses an international boundary which further complicates the question of who should and can take the actions. The actions considered in this report, and in the overall IJC Reference Study, rely upon initiation and leadership from governments, although some actions could be taken by individuals or groups of individuals. This section will not attempt to address the question of implementation by actual application to individual actions, but will attempt to point out the range of possibilities which must be explored in determining who would take the actions.

Implementing Authorities vs Types Of Actions

There are many levels of government within the U.S. and Canada. They begin at the Federal level, proceed down to the State / Provincial level, and finally end up at the local level, which may include counties, cities, towns, and municipalities. In addition, as evident by the terms of reference given to conduct this overall water levels study, there is at least one other governmental body, the International Joint Commission. Other inter-State, inter-Provincial and other organizations may also exist. The focus in this section is not on all the possible institutional arrangements that do exist, but rather, on the existing government levels and which one, or combination, would likely be involved in implementing the different types of actions.

To undertake actions, governments need two important things: authority and resources. The way a government arrives at its decision making process may be dictated by an action's scope, location, cost, or it's institutional requirements. The following table shows, in general, what levels of governments would initiate the actions based on past experience.

Table E-2-1 - Levels of Government that Implement Actions

Action	Levels of Government				
	U.S.A.	Canada	State/Provincial	Local/Municipal	IJC
Type 1	x	x	-	-	x
Type 2	x	x	x	x	-
Type 3	-	-	x	x	-
Type 4	x	x	x	x	x
Type 5	x	x	x	x	x
Type 6	x	x	x	x	x

Several levels of government may often cooperate to implement actions. One example is the National Flood Insurance Program in the U.S. This program is funded and set up at the federal level, the states may help coordinate the program, and the local governments are responsible for enforcing flood plain regulations. A second example deals with the case of emergency actions, whereby the federal governments might request the International Joint Commission to regulate Lakes Superior and Ontario to provide all possible relief to those interests affected by extreme high or low levels and flows. Although cooperation among various levels of government may make real strides in implementation of some types of actions, there is generally a poor track record with regard to cooperation in implementation and enforcement of certain types of actions. One example is the inconsistency with which many of the non-structural, shoreline management techniques have been implemented and enforced in the past. This track record brings to mind important questions that need to be answered in order to make it possible for all types of actions to have equal opportunity of being implemented.

WHO PAYS FOR THE ACTIONS?

Costs Involved With The Actions

In addition to environmental and social costs that may be associated with actions by governments, there are direct financial costs as well. These may be classified under two types: (1) Fiscal or government costs, which are expenditures governments must assume; and (2) Associated costs, which are cash outlays by affected interests in response to a particular action. The following discusses these in more detail.

a. Fiscal Or Government Costs

There are three costs that governments must assume when implementing any action. The first is the initial or capital cost of implementation. The second is the cost associated with operation and maintenance of an action. The third is a compensatory cost. Often governments provide compensation to mitigate negative impacts caused by an action which altered the pre-project environmental state. Such compensation may be in the form of money paid to those affected by an action, or it may involve creating similar conditions at a different location to mitigate effects of the action.

b. Associated Costs

A government action may have costs that are associated with the action, but are not part of the initial price tag. There are two types of associated costs. The first is a cash cost which is an expenditure required of an interest (e.g. riparian, power, navigation, recreation, etc.) in order to take advantage of an action. For example, if a government offers a subsidized loan program to assist with the construction of shore protection, an interest must first take out a loan in order to receive the subsidy, thus, there is a cost to the interest to make use of the action.

The second type of cost is an opportunity cost. If an action by a government causes some change in the financial standing of an interest, then that interest has assumed an associated cost for that particular action. For example, if governments put load/carrying capacity limitation on shipping interests during low water level periods, shipping companies would sustain some financial losses in relation to the amount they might otherwise have been able to carry.

Payment of Costs

Sources of income for government projects vary in type and amount according to the level of government involved. Cost-sharing agreements between governments can be undertaken so that governments with less potential income per capita can benefit from public funds. Cost-sharing is often done in the form of transfer payments from one level of government to another. It can take place among all levels of government, as well as between similar levels of government (i.e., states) to allow actions which might not have been possible otherwise.

Governments must secure money for actions through financing, either internally, by using money from the existing tax base, or externally through debt. Debt financing will increase the cost of the action, since interest payments will be required. Consequently, costs of implementation, operation, and maintenance will vary, depending on the way in which the action is financed.

Cost Recovery

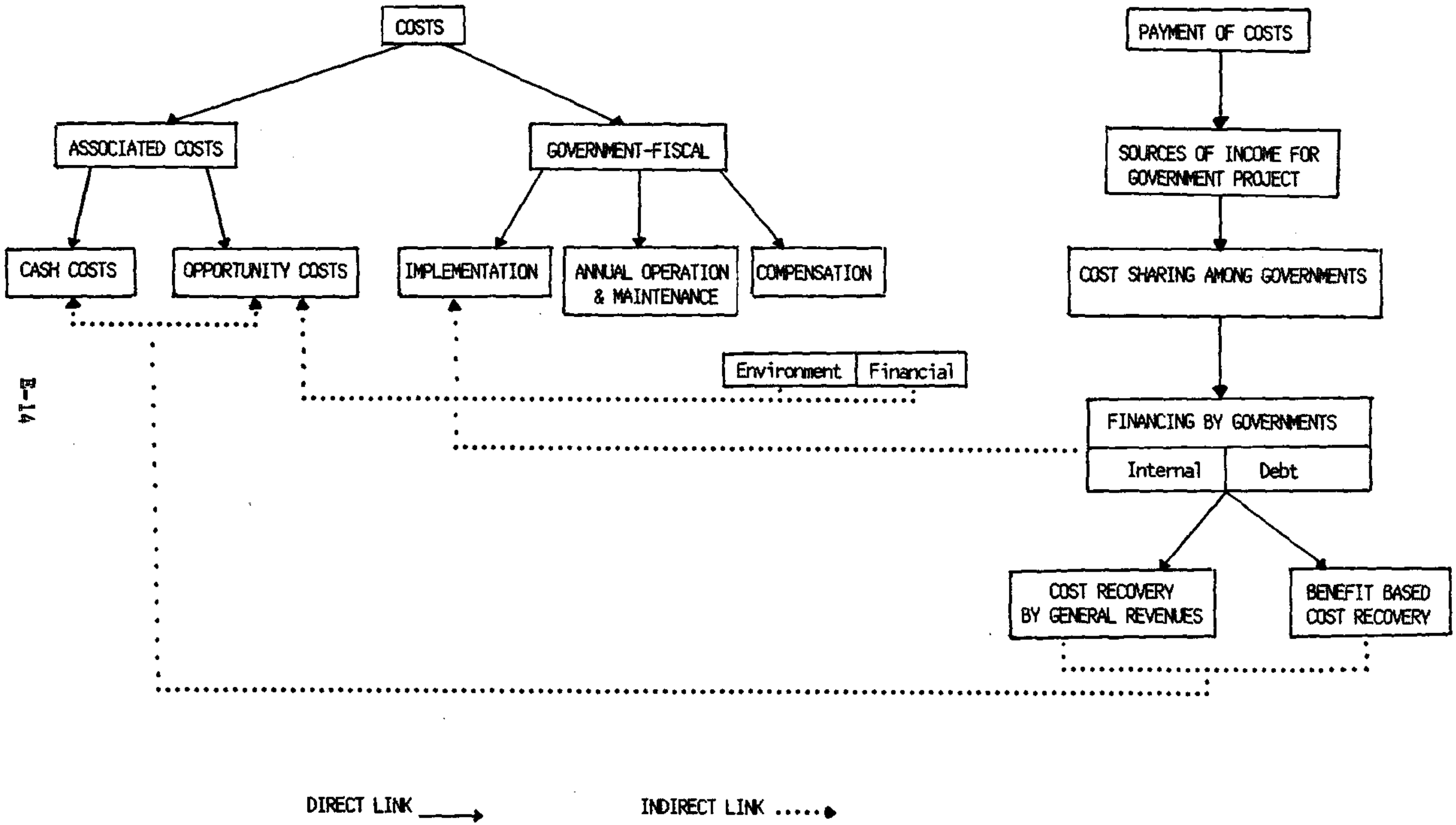
Governments have two ways in which to recover the costs of an action: through general revenues, whereby the tax paying public bears the expense, or, benefit based cost recovery. This type of cost recovery directs the expense to those who benefit most from the action. User-fees and direct taxation are examples of this type of cost recovery.

Figure E-2-2 illustrates the notion of "who pays" when a government decides to implement an action. Some links emerge when this notion is examined. Compensation is often a government reaction to associated costs to interests and is thus, an added cost of the action. How an action is financed will affect the implementation, operation and maintenance costs. How costs are recovered will, in turn, affect both the cash costs and the opportunity costs to the parties. For example, a user-fee method of cost recovery will increase the cash cost to the interest who benefits from a measure. If a beneficiary is taxed directly, net income is reduced. This constitutes an opportunity cost, since the taxed money cannot be spent on something else.

The cost distribution of any action has the potential for changing the impacts and implications of that action. Thus, the question of "who pays" is an important consideration with any measure and one that should be addressed with each and every action that a government might take.

The above section has outlined the cost of projects/actions initiated generally by governments. As mentioned previously, there are actions, where individuals can initiate actions to deal with the problems of fluctuating water levels. However, the financial costs of these actions are the direct burden of the individual and are not the focus of this report.

FIGURE E-2-2 : WHO PAYS?



SECTION 3

INVENTORY OF ACTIONS

APPROACH USED IN DEVELOPING THE INVENTORY OF ACTIONS

According to the Governments' Reference of 1 August 1986, the International Joint Commission was requested to propose and evaluate measures which governments could undertake to alleviate the problems caused by high and low lake levels. In its Directive of 10 April 1987, the IJC recognizes that measures necessary to deal with the lake levels are unlikely to be purely technical. The IJC added that it is improbable that a single solution will emerge, rather a mix of measures over time will be the most likely course. Thus, a first essential element in the study was the identification of all possible measures or actions, both structural and non-structural, to deal with fluctuating lake levels. This section describes how the inventory of measures was prepared.

A comprehensive list of measures would serve as a guide where the major thrust of the study should proceed, identify data gaps, assist in the future screening and evaluation of measures, etc. In order to ensure that such a list would be as comprehensive as possible, study participants from each of the functional groups were assigned to the Measures Sub-Group to prepare the inventory. The following assignments were designated:

FG1 assigned - **Type 1** (Actions to Modify Lake Levels) and
Type 5 (Emergency Response)

FG2 assigned - **Type 2** (Actions to Adapt) and
Type 3 (Actions which Regulate Use of Land and Water).

FG3 assigned - **Type 4** (Actions to Indirectly Influence Public Use of the Land and Water).

Types 1 and 5

The list of Types 1 and 5 measures was based on the review of all existing regulatory facilities on the Great Lakes - St. Lawrence River System, their methods of operation, recent IJC and other study reports on lake levels, suggestions from the citizens and shore resident coalitions, etc. All ideas and inputs collected were used in compiling the list. To make the list as thorough as possible, no single action was ignored or excluded just because it might appear to be trivial, costly or not effective.

Types 2 and 3

In identifying, developing and describing Type 2 and 3 actions, Functional Group (FG) 2 carried out a number of simple steps. To act as a starting point, FG 2 obtained the initial classification of Type 2 and 3 actions as outlined in the Functional Group 3 Status Report (Smit and Shabman, 1988). Following this, a discussion on actions was held at an FG 2 meeting in Windsor on July 25th and 26th, 1988. The purpose of this meeting was:

a. To critique/confirm the classification/inventory of Type 2 and 3 actions as outlined in the FG 3 Status Report;

b. To review and evaluate, by sub-types, existing Type 2 and 3 actions;

c. To develop new Type 2 and 3 actions under each sub-type; and,

d. To identify existing and new actions, from each sub-type, which are most worthy of consideration.

Following this meeting, and utilizing the comments from this meeting, an initial report on Type 2 and 3 actions was prepared. This report included a revised and expanded version of the initial FG 3 classification of Type 2 and 3 actions. This report was then sent to all FG 2 members and co-chairs, by memo dated August 10, 1988, for further comment and revisions.

Through discussions with FG 2 Co-chairs and group members, and through a detailed review of the existing literature, more detailed information was obtained on each of the proposed actions in the inventory. In addition, the inventory of Type 2 and 3 actions was further refined and expanded.

The result of this was the preparation of a final report on Type 2 and 3 actions, dated November 1988 (Stewart, 1988), which includes a detailed one page summary of each of the proposed actions in the Type 2 and 3 inventory. This final report on Type 2 and 3 actions has been used as the primary guideline in formulating the discussion on Type 2 and 3 actions found in this report.

Type 4

Under Functional Group 3 (FG3), a Measures Work Group (MWG) was established to provide an initial overview of the full range of Type 4 measures. The MWG was directed to conduct specific tasks in an effort to gain greater understanding of Type 4 measures (actions to indirectly influence how interests use the land and water). The following tasks were undertaken:

a. Review past studies concerning the history, goals, design, implementation, successes, and failures of public programs to implement Type 4 measures;

b. Interview Great Lakes users, technical experts, and policy makers concerning Type 4 measures, their effectiveness, and innovative options; and,

c. Critically evaluate the policy, implementation, and evaluation issues that must be recognized if Type 4 measures are to be fully considered as viable management options for addressing lake level fluctuation problems.

The following will document and detail the actions undertaken and the methods used in order to develop the initial overview of Type 4 measures. In order to accomplish these tasks a number of methods were used. The following paragraphs present a detailed explanation of the methods.

Task 1 - Literature Search

Task 1 was accomplished by performing a literature search reviewing previous studies dealing with Type 4 measures both within and outside of the Great Lakes Basin. Using DIALOG, the following data bases were searched for references to Type 4 measures: National Technical Information Service, Enviroline, Water Resources Abstracts, Oceanic Abstracts, Georef, U.S. Political Science Documents, and the Electric Power Database. Relevant literature identified by the DIALOG search was obtained from U.S. federal and state governments, universities, and journals. U.S. and Canadian contacts also were made at the Federal, state, provincial, and local government agencies to learn of available reports. In addition, members of other working groups under FG3 were requested to "keep their eyes and ears open" as they canvassed various groups and experts throughout the Basin to complete their tasks. However, no literature was identified by or obtained from the other working groups. All literature obtained was then reviewed for content and applicability to Type 4 measures. The information specifically relevant to each individual Type 4 measure will be presented in the discussion of that particular measure.

Task 2 - Interviews and Data Collection

Task 2 involved telephone interviews with representatives of various federal, state, provincial, and local government agencies, a workshop, and involvement in the Group Depth Interviews (GDIs) conducted by the U.S. Army Corps of Engineers (USACE), St. Paul District. Input from these activities has been incorporated into the discussion of Type 4 measures presented in the next three sections. The Measures Workshop was held on 29 June 1988 in the Detroit, Michigan area. Participants included representatives from agencies concerned with Type 4 measures, U.S. and Canadian experts on Type 4 measures, and representatives of the shoreline property owner interest class (one of the interest groups most affected by Type 4 measures). The objectives of this brainstorming type session were:

a. To critique/confirm the classification/inventory of Type 4 measures;

b. To review and evaluate, by sub-types, existing Type 4 measures;

c. To develop new Type 4 measures under each sub-type; and

d. To identify existing and new measures from each sub-type, which are most worthy of future consideration.

The workshop forum was selected by the MWG over the GDI process because it provided an opportunity to interview in depth a large group of "experts" at one time, and to have them interact in the review of existing and the generation of "new" Type 4 measures. It was more effective due to the use of a facilitator who had no stake in the outcome and who was able to keep the group focused on the workshop objectives. Each of the 14 participants was requested to give an introductory statement relative to his/her experience with or knowledge of Type 4 measures. An inventory of Type 4 measures was reviewed by the group, and confirmation of the classifications was given by the group. The group members were each given an index card and asked to individually write down any additional Type 4 measures they knew of to expand the inventory. These "new" Type 4 measures were then listed on flip charts located in the conference room. These "new" measures were reviewed and expanded upon by the group. The persons at the workshop were then divided up into three groups and asked to individually: 1) review the lists of existing and "new" Type 4 measures; 2) decide which are the most important measures in each category (ranking where appropriate); and 3) write down a rationale for that ranking. Then as a group, they were requested to come up with two or three measures under each of the three sub-types which they, as a group, felt are most worthy of further consideration. These three groups reconvened near the end of the day and presented their findings (rankings) and the rationale for their recommendations. The group prioritization of Type 4 measures most worthy of further consideration was deemed to be more conclusive than individual rankings.

The GDI method met the needs of the Residential, Recreational, Commercial/Industrial, and Governments Working Groups. A total of 11 GDIs were held during the week of 17-23 July 1988, and were attended by the three MWG members specifically to gain information on Type 4 measures to supplement the information obtained at the workshop. A list of discussion topics was developed that was given to the other working groups of FG3 at the 13 May 1988 FG3 status meeting. These discussion topics included hazard insurance, disaster aid, shore protection works funding, land use programs, and information programs. They were incorporated into the interview process used for the GDIs. Attendance at the GDIs allowed firsthand observations to the reactions of the various interest classes to the list of considered measures (all 6 types).

The GDI process did not live up to the expectations of the MWG because neither the depth nor breadth of discussion on Type 4 measures expected surfaced. The facilitators of the GDIs indicated that in this type of process they could not push the group in any one direction or it would undermine the credibility of the process. The GDIs were educational in spite of some lesser degree of focus specifically on Type 4 measures. Additional information from the GDIs was made available after the facilitators provided summaries of the GDIs which were not attended by the MWG members studying Type 4 measures.

Task 3 - Review of Type 4 Measures

Task 3 of the MWG charge was the most difficult and challenging of those given. In Phase 1 of the Reference Study only a small portion of this task was possible with recommendations as to the data needs, studies, and resources that will be required to fully complete this task. This report will identify some of the issues that apply to Type 4 measures, and carry them as far along as the limitations of the Phase 1 exercise permits. The issues themselves were developed from the work done under the previous tasks described above.

Type 6

The Type 6 combination actions are the least studied and least well defined type of measures at this point. They are developed and presented in a preliminary fashion in an attempt to determine how they can be combined and how they might function and benefit from being combined. Some of the combinations that were provided through a survey of the Functional Group Co-Chairs in December 1988 have been included in the inventory, and the remainder are first attempts at consciously combining different types. There remains an almost limitless number of possible combinations and it will be important to develop methods to strategically combine them in Phase 2 of the Study.

INVENTORY OF ACTIONS

This section lists all the potential actions (Table E-3-1) that have been developed using the approaches outlined above. Sections 4 to 9 will provide a more detailed discussion of these actions, while a one page summary of each action can be found in Appendix E-3 of this Annex.

In addition to the one page summaries in Appendix E-3 several measures, labeled "representative measures", were developed in more detail to aid in the testing of the evaluation instrument. These "representative measures" were randomly selected from all types of available measures to illustrate the range of that particular measure type and the categories within types. Appendix E-4 presents these more detailed descriptions while the testing of the evaluation instrument can be found in Appendix F.

Table E-3-1 - Inventory of Actions

Type 1 Actions: Public Investment In Control and Diversion Works

1.1 MODIFIED EXISTING REGULATION

1.1.1 - Modify Existing Regulation Plan for Lake Superior (Plan 1977)
1.1.2 - Modify Existing Regulation Plan for Lake Ontario (Plan 1958-D)
1.1.3 - Return to Pre-Project or Natural Lake Level-Outflow Conditions
1.1.4 - Better Coordination between Lake Ontario and Ottawa River Regulation
1.1.5 - Optimization of Benefits using Mathematical Programming Technique

1.2 FURTHER REGULATION

1.2.1 - Full Regulation of Lake Erie such as Plan 50N
1.2.2 - Limited Regulation of Lake Erie such as Plans 6L, 15S and 25N
1.2.3 - Full Lakes Michigan - Huron Regulation
1.2.4 - Revise Existing Regulation for Lake Superior (Plan 1977) with a Different Objective such as Mod 7
1.2.5 - Control Supplies to the Great Lakes through Tributary Streamflow Regulation
1.2.6 - Construction of a New (6th) Great Lake

1.3 INTERBASIN DIVERSIONS

1.3.1 - Manipulation of Interbasin Diversions such as Long Lac-Ogoki and Chicago Diversions
1.3.2 - Increase Lakes Michigan - Huron Outflows via Increased Chicago Diversion
1.3.3 - Increase or Decrease Lake Erie Outflows via Manipulation of Welland Canal Diversion
1.3.4 - Increase Lake Erie Outflows via new Lake Erie - Lake Ontario Diversion Scheme
1.3.5 - A 50,000 CFS Diversion In and Out of the Great Lakes System
1.3.6 - Increase Lakes Michigan - Huron Outflows through Groundwater Aquifer Recharge
1.3.7 - Increase Lake Erie Outflows via new Lake Erie - Ohio River Canal
1.3.8 - Increase Lake Erie Outflows via New York State Barge Canal
1.3.9 - Increase Lake Erie Outflows via Black Rock Lock Modifications
1.3.10 - Combination of Measures 1.3.2 and 1.3.6

Table E-3-1 (Continued)

1.4 OTHER STRUCTURAL / REMEDIAL WORKS

1.4.1 - Regulate Lake Erie via Hydro Development in Niagara River
1.4.2 - Increase Channel Capacity and Reduce Flood Damage through Channel Enlargement and Remedial Works in the St. Lawrence River
1.4.3 - Installation of Ice Control Measures at Lakes' Outlets and Channels
1.4.4 - Placement of Sills at Lakes' Outlets
1.4.5 - St. Clair - Detroit River Compensatory Works

Type 2 Actions: Public Investment To Direct Land and Water Use To Adapt To Shore Fluctuating Levels.

2.1 CONSTRUCTION OF PROTECTION WORKS FOR EXISTING STRUCTURES

2.1.1 - Seawalls
2.1.2 - Dikes and Levees
2.1.3 - Groins and Jetties to Retard Longshore Transport
2.1.4 - Offshore Breakwaters
2.1.5 - Barrier Island Construction
2.1.6 - Beach Nourishment to Replenish Eroded Areas
2.1.7 - Vegetation Planting to Reduce Erosion Potential
2.1.8 - Bluff Grading to Reduce Sloughing
2.1.9 - Bluff Drainage to Reduce Sloughing
2.1.10 - Revetments
2.1.11 - Artificial Headlands
2.1.12 - Structural Floodproofing

2.2 ACQUISITION AND RELOCATION

2.2.1 - Community Acquisition of Hazard Land (fee simple property rights...)
2.2.2 - Protection and Enhancement of Coastal Habitats
2.2.3 - Relocation of Structures Outside of Hazard Areas

2.3 UTILITIES AND INFRASTRUCTURE ADAPTATION

2.3.1 - Navigation & Access Channel & Harbor Dredging/Deepening
2.3.2 - Increase Lock Capacity Through Management Improvements
2.3.3 - Regionalization and Adaptive Design of Water Supply and Sewage Treatment Systems and Infrastructure
2.3.4 - Power Grid Interconnections
2.3.5 - Adaptive Design of Harbor Structures
2.3.6 - Improved Ship Navigation Procedures (Commercial and Recreational)
2.3.7 - Public Investment in Stormwater Management Activities

Table E-3-1 (Continued)

Type 3 Actions: Direct Public Regulation of Land and Water Use

3.1 REGULATE USE OF PROPERTY IN HAZARD AREAS

3.1.1 - Setbacks For Structures in Zoning Requirements
3.1.2 - Elevations for Structures in Building Code Requirements
3.1.3 - Floodproofing Through Building Code Requirements
3.1.4 - Other Planning and Development Requirements
3.1.5 - Deed Restrictions on Property Use

3.2 REGULATIONS TO REDUCE HUMAN IMPACT ON SHORELINE RESOURCES

3.2.1 & 2 - Regulate Shore Protection Works and Navigation Structure Construction
3.2.3 & 4 - Regulate Extraction of Beach and Nearshore Deposits and Landfills and Alteration of the Shoreline
3.2.5 - Coastal Habitat Protection Regulations

3.3 REGULATIONS TO GOVERN USE

3.3.1 - Regulate Use of Great Lakes Resources in Accordance with Fluctuating Water Levels
3.3.2 - Regulation of Water Withdrawals
3.3.3 - Power Demand / Capacity Management
3.3.4 - Navigation Regulations (Commercial and Recreational)
3.3.5 - Regulation of Land or Water Use to Control Stormwater

Type 4 Actions: Public Programs To Indirectly Influence Land and Water or The Effects of Fluctuating Levels.

4.1 EXPENDITURE POLICY PROGRAMS

4.1.1 - Grants for Capital Investments that Reduce the Potential for Losses in Low Water Conditions
4.1.2 - Grants for Capital Investments in Structural Methods for Dealing with the Potential for Losses due to FWL's
4.1.3 - Grants for Capital Investments in Non-Structural Methods for Dealing with the Potential for Losses due to FWL's
4.1.4 - Grants for Increased Operating Costs during Extreme Water Level Conditions
4.1.5 - Grants for Removal of Existing Structures which Exacerbate the Problems Associated with FWL's
4.1.6 - Guaranteed/Subsidized Loans for Capital Investments that Reduce the Potential for Losses in Low Water Conditions
4.1.7 - Guaranteed/Subsidized Loans for Capital Investments in Structural Methods for Dealing with the Potential for Losses due to FWL's
4.1.8 - Guaranteed/Subsidized Loans for Capital Investments in Non-Structural Methods for Dealing with the Potential for Losses due to FWL's

Table E-3-1 (Continued)

4.1.9 - Guaranteed/Subsidized Loans for Increased Operating Costs during Extreme Water Level Conditions
4.1.10 - Guaranteed/Subsidized Loans for Removal of Existing Structures which Exacerbate the Problems Associated with FWL's
4.1.11 - Eliminate Grants or Loans for Development in Hazard Areas
4.1.12 - Provide Unconditional Disaster Aid to Groups affected by FWL's
4.1.13 - Provide Conditional Disaster Aid to Groups affected by FWL's
4.1.14 - Eliminate/Reduce Disaster Aid in Recognized Hazard Areas
4.1.15 - Locate Public Infrastructure Outside of Hazard Areas
4.1.16 - Incorporate Capacity for Extreme Conditions in Public Infrastructure within Recognized Hazard Areas
4.1.17 - Mandatory Actuarial Rate Insurance for Properties Located in a Recognized Hazard Area
4.1.18 - Require Mandatory Conditional Subsidized Rate Insurance for Recognized Hazard Areas
4.1.19 - Require Mandatory Unconditional Subsidized Rate Insurance for Recognized Hazard Areas
4.1.20 - Optional Actuarial Rate Insurance for Properties Located in a Recognized Hazard Area
4.1.21 - Provide Optional Conditional Subsidized Rate Insurance for Recognized Hazard Areas
4.1.22 - Make Available Unconditional Subsidized Rate Insurance for Recognized Hazard Areas
4.1.23 - Eliminate or Reduce the Availability of Insurance in Recognized Hazard Areas

4.2 TAX POLICY PROGRAMS

4.2.1 - Increased Taxes to Fund Coordinated Complete-Reach Shore Protection Works
4.2.2 - Tax Abatements for Capital Investments That Do Not Increase Loss Potential for Others
4.2.3 - Tax Abatements for Shore Protection Works Designed to Withstand Specific Extreme Events
4.2.4 - Property Tax Abatements for Non-Development of Flood Storage or Wetland Areas
4.2.5 - Tax Abatements for Relocation Behind Designated Setback Limits
4.2.6 - Tax Abatements for Initial Construction Outside Recognized Hazard Limits
4.2.7 - Tax Abatements for Initial Construction Adapted to Extreme Conditions when Hazard Area Location Cannot be Avoided
4.2.8 - Increased Taxes for Development in Hazard Areas
4.2.9 - Increase Taxes to Reflect Increased Government Costs of Coping with FWL's

Table E-3-1 (Continued)

4.3 IMPROVED INFORMATION AND COMMUNICATION

4.3.1 - Public Information and Education (I&E) Programs
4.3.2 - Youth Education Program
4.3.3 - Hazard Mapping
4.3.4 - Information Coordination and Exchange
4.3.5 - Real Estate Disclosure

Type 5 Actions: Emergency Response Capability

5.1 ACTIONS TO MODIFY LAKE LEVELS AND OUTFLOWS

5.1.1 - Weather Modification to Change Local Precipitation
5.1.2 - Increase Niagara River Flows Via the Black Rock Lock
5.1.3 - Storage of Water on Lake Superior
5.1.4 - Storage of Water on Tributary Reservoirs / Streams
5.1.5 - Outlet / Channel Enlargement or Sill Placement
5.1.6 - Manipulation of Existing Diversions
5.1.7 - Regulate Water Withdrawal / Consumptive Uses

5.2 GOVERNMENT SERVICES AND PROGRAMS

5.2.1 - Emergency Sandbagging and Diking Assistance
5.2.2 - Government Programs for Disaster Assistance
5.2.3 - Storm Forecasting
5.2.4 - Diking and Other Protective Works in the St. Lawrence

Type 6 Actions: Combinations

6.1 - Full Regulation of all the Great Lakes by Combining Lake Erie Plan 50N (1.2.1) with the Placement of a Sill in the St. Clair River (1.4.4) which is the Outlet of Lakes Michigan - Huron and Structural Setback Zoning (3.1.1)
6.2 - Full Regulation of Lake Erie (1.2.1) with Structural Setback Zoning (3.1.1)
6.3 - Hazard Mapping (4.3.3) / Structural Setback Zoning (3.1.1) / Public Information and Education (4.3.1) / Real Estate Disclosure (4.3.5)
6.4 - Breakwater Construction (2.1.4) / Public Information and Education (4.3.1)
6.5 - Maximize Use of Existing Regulatory Structures / Procedures (1.1.5), Hazard Land Mapping (4.3.3), and Public Information and Education (4.3.1)
6.6 - Community Acquisition of Hazard Land (2.2.1) / Regulate Use of Property in Hazard Areas (3.1)
6.7 - Full Regulation of Lake Erie - Plan 50N (1.2.1) with Downstream Modifications to Lake Ontario Regulation Plan 1958-D (1.1.2) and Increased Channel Capacity in the St. Lawrence River (1.4.2)

SECTION 4

TYPE 1 ACTIONS

INTRODUCTION

This section discusses a wide range of possible government actions to further control Great Lakes water levels and their outflows. It briefly describes their technical feasibility, quantifies their impacts on water levels and lake outflows, and gives some indications of their costs.

The main objective of all of the Type 1 actions is to reduce the extreme range of water level fluctuations that currently exist. Possible actions range from minor adjustment of the existing regulation facilities on the Great Lakes, to massive interbasin diversions, or full control of the outflows of the unregulated lakes. The impacts on the lakes could range from a few inches to perhaps a one or two-foot increase or decrease on some lakes. Likewise, the cost of these actions could range from a few million, to billions of dollars. It should be noted that none of these actions would reduce the short-term water level variations resulting from storms or other natural processes such as ice jams, which could still have serious temporary and localized effects.

There are numerous Type 1 or structural measures. Even changes to the existing method of regulating the outflows of Lake Superior and Lake Ontario are included as Type 1 Actions although new constructions might not be needed at all. On the other hand, new constructions would be needed if the changes are large enough to significantly affect levels and flows on the other lakes. One such example would be channel enlargements and shore protection/remedial works in the St. Lawrence River if changes to Lake Ontario Plan 1958-D would aggravate the problems downstream.

Within certain single measures, there might be a wide range or scope of actions. For example, limited regulation of Lake Erie would be a small project if Plan 6L is considered, or fairly large project if Plan 25N is used. Increasing the Chicago diversions might be a moderate scheme if a maximum flow of 8,700 cfs is considered, or a large scheme if 25,000 cfs is considered. In order to make the number manageable, Functional Group 1 has assembled and grouped all Type 1 actions into four categories: (1) Modified Existing Regulation, (2) Further Regulation, (3) Interbasin Diversions, and (4) Other Structural/Remedial Works. A total of 25 possible <u>single</u> Type 1 measures were developed and they were listed in Section 3.

A REVIEW OF TYPE 1 ACTIONS

<u>Modified Existing Regulation</u>

At present, the outflows (and hence water levels) of Lakes

Superior and Ontario are regulated. Lake Superior Regulation Plan 1977, formally implemented in 1979, considers both upstream and downstream (Lake Michigan-Huron) conditions in determining Lake Superior's outflows. More precise forecasting of water supplies to the lakes might help to bring about better regulation. This would require increased efforts in hydrologic / computer modeling and some improvements in hydrologic data gathering. Further improvement to Lake Superior regulation would bring about some marginal (less than one foot) improvement on either Lake Superior, or Lakes Michigan-Huron.

Plan 1958-D regulates Lake Ontario and has been in operation since 1963. It was developed to provide benefits to both upstream and downstream users. Departures from plan flows have been made in the past in order to cope with new record high and low supplies. Improvement of Plan 1958-D would not only consider the experience gained in the past 25 years of regulation, but would also consider the changing conditions in the St. Lawrence River (e.g., rapid growth of recreational boating activities). Similar to Lake Superior Plan 1977, an increased effort in hydrologic/computer modeling of the Lake Ontario basin might bring about better knowledge of the conditions and better flow decisions. Also, detailed evaluations of the downstream conditions in the St. Lawrence River would better define flow restraints. Changes resulting from such measures would be further reduction (perhaps less than one foot total) in the total range of water level fluctuation on Lake Ontario.

An extreme option would be to return the Great Lakes water level and outflow conditions to natural, or pre-project, conditions. Preliminary studies show a return to natural conditions (19th century) would lower water levels slightly on Lake Superior (a fraction of a foot), and raise Lakes Michigan-Huron by about one foot.

Further Regulation

It is possible to construct control works on the outlets of the unregulated lakes, Michigan, Huron and Erie. Further regulation could range from small projects that provide limited regulation, to projects that provide full regulation of all the lakes. Limited or partial regulation would be provided by plans such as 6L, 15S, and 25N, which require structural modifications in the Black Rock Navigation Lock, on Squaw Island, and in the Niagara River, respectively. Each option would enable a progressively higher Lake Erie outflow when needed, but would not reduce the outflow when lake levels are low. The impacts of these plans would be to lower the maximum water levels on Lake Erie by approximately 14 inches and on Lakes Michigan-Huron by approximately 4 inches.

Plan 50N would "fully regulate" Lake Erie. The plan would require extensive channel enlargement and construction of a control structure at the head of the Niagara River to provide a flow capacity increase and decrease of up to 50,000 cfs. This would allow for a potential reduction of Lake Erie's maximum level by approximately 1 foot, as well as a potential raising of it's minimum level by the same amount.

Another possibility would be the creation of a sixth Great Lake located outside the basin somewhere north of Lake Superior. Runoff from this lake's watershed would be redirected southward to supplement supplies to the Great Lakes when levels are low. Alternatively, outflows from this lake would be directed to James Bay, when water levels on the Great Lakes are high. This measure would <u>not</u> reduce high Great Lakes water levels, as it would not provide any means of pumping water from the Great Lakes to the sixth lake.

Interbasin Diversions

Several diversion projects are in operation at present, but none of these were initiated for the purpose of Great Lakes water level management. They include: the Long Lac and Ogoki Diversions, which add about 5,600 cfs to Lake Superior; the Chicago Diversion, which withdraws about 3,200 cfs from Lake Michigan; the Welland Canal, which bypasses the Niagara River and diverts approximately 9,000 cfs from Lake Erie to Lake Ontario; and the New York State Barge Canal, which withdraws up to 1,100 cfs from the upper Niagara River for use in western New York State. With the exception of the New York State Barge Canal, all the diversions combined have a maximum impact ranging from a 4 inch lowering of Lake Erie to a 1.5 inch increase in the level of Lake Ontario.

Actions could be taken to manage these diversions so as to bring additional water into the Basin, or to reduce flows out of the Basin, when lake levels are low, and to reverse the process when levels are high.

Other Structural/Remedial Works

In general, these are additional structural options that would have small impacts on water levels. For example, the use of ice booms at the outlet of Lake Huron would reduce the frequency and magnitude of ice runs and ice jams in the St. Clair-Detroit River System which would control the extreme flow fluctuations that can occur due to ice jams.

SECTION 5
TYPE 2 ACTIONS

INTRODUCTION

In the previous section on Type 1 actions, we looked at a series of actions that governments could take to actually change or modify the current water level and water supply regime of the Great Lakes. The actions in this category, Type 2, take a somewhat opposite approach and describe ways in which governments can help communities, themselves and landowners <u>adapt</u> to the natural fluctuations in water levels and shoreline processes that currently exist.

Type 2 actions, or measures, recognize human occupation and use of the Great Lakes coastal zone and would see community investment (funding) in methods that would help the community as a whole, better adapt to the water level changes, flooding and other natural shore processes (e.g. erosion) that may occur. The protection methods involved include those that are commonly used by individuals to deal with fluctuating water levels, but for the purposes of this report and the IJC Reference, these Type 2 actions focus on large scale community-wide programs (as compared to an individual investment in protection for one property) funded and <u>entirely</u> implemented by various levels of government. Methods proposed in this category also recognize that processes such as flooding, erosion, sedimentation and other shore processes often occur independently of lake level fluctuations. Thus, some of the actions proposed suggest ways of adapting to these processes. It should be pointed out that the actions suggested here do not prevent occupation, or eliminate use of the Great Lakes coastal zone, but instead suggest ways in which humans can better adapt to the natural processes that occur in this zone.

Type 2 actions include a number of methods that have been used previously, such as shore protection construction and channel dredging, but they also include a number of methods that have not been utilized with any degree of frequency on the Great Lakes. These include beach nourishment, regionalization of water supply and sewage treatment systems and the community acquisition of hazard land. Type 2 actions have been broken down into three basic groups based on the kind of method involved in the action. These are: 1) Construction Actions; 2) Acquisition and Relocation Actions; and 3) Utility and Infrastructure Adaptation Actions.

<u>Construction</u>

This category recognizes that there may be many options available to governments that involve construction, or renovation, of some type of structure. This may include activities such as; the construction of major shore protection works, such as revetments (Figure E-5-1) or breakwalls (Figure E-5-2), for long stretches of threatened shoreline; retrofitting of structures using proper floodproofing techniques (Figure E-5-3); modifications to lock

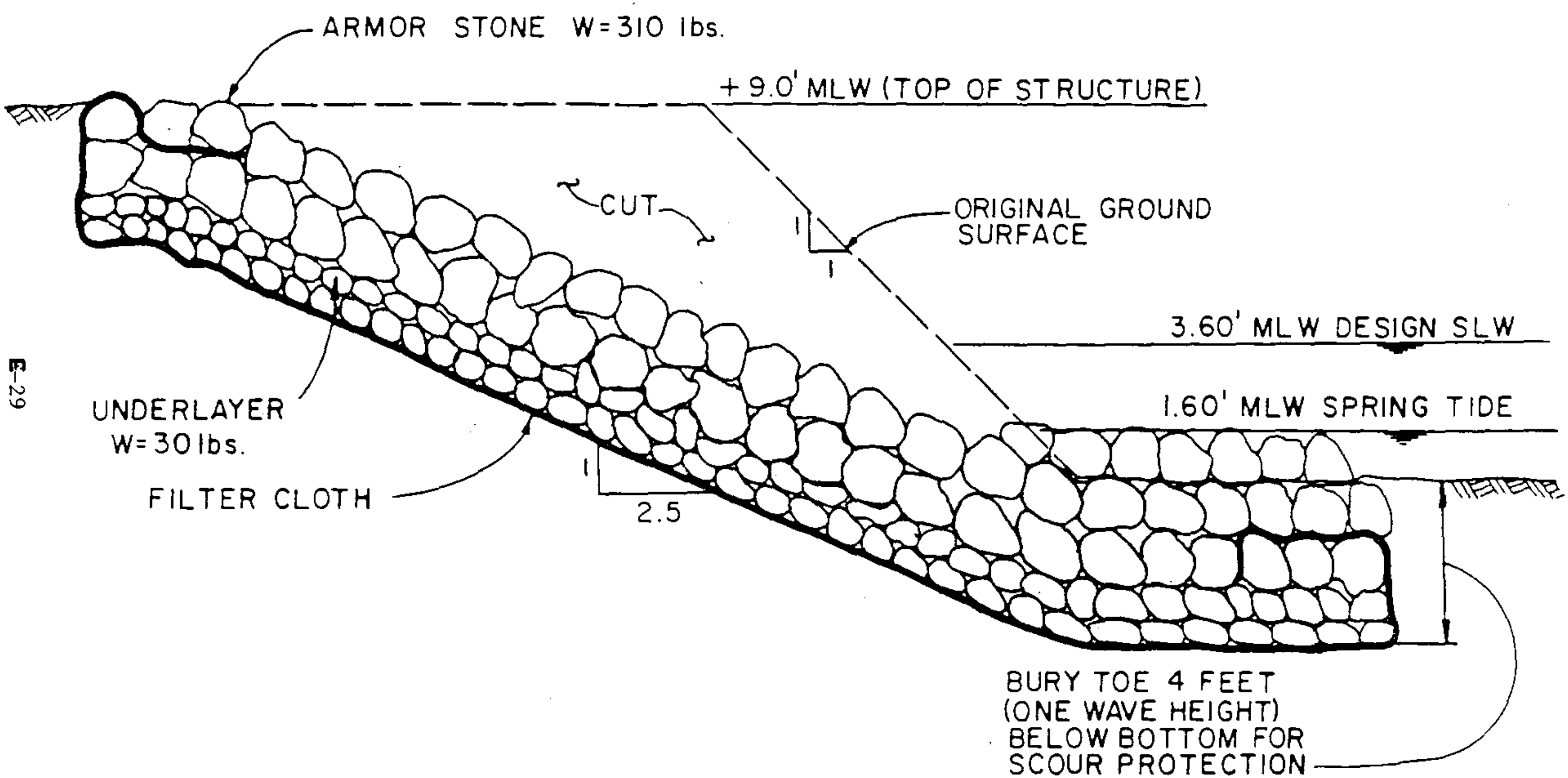


FIGURE E-5-1 : REVETMENT

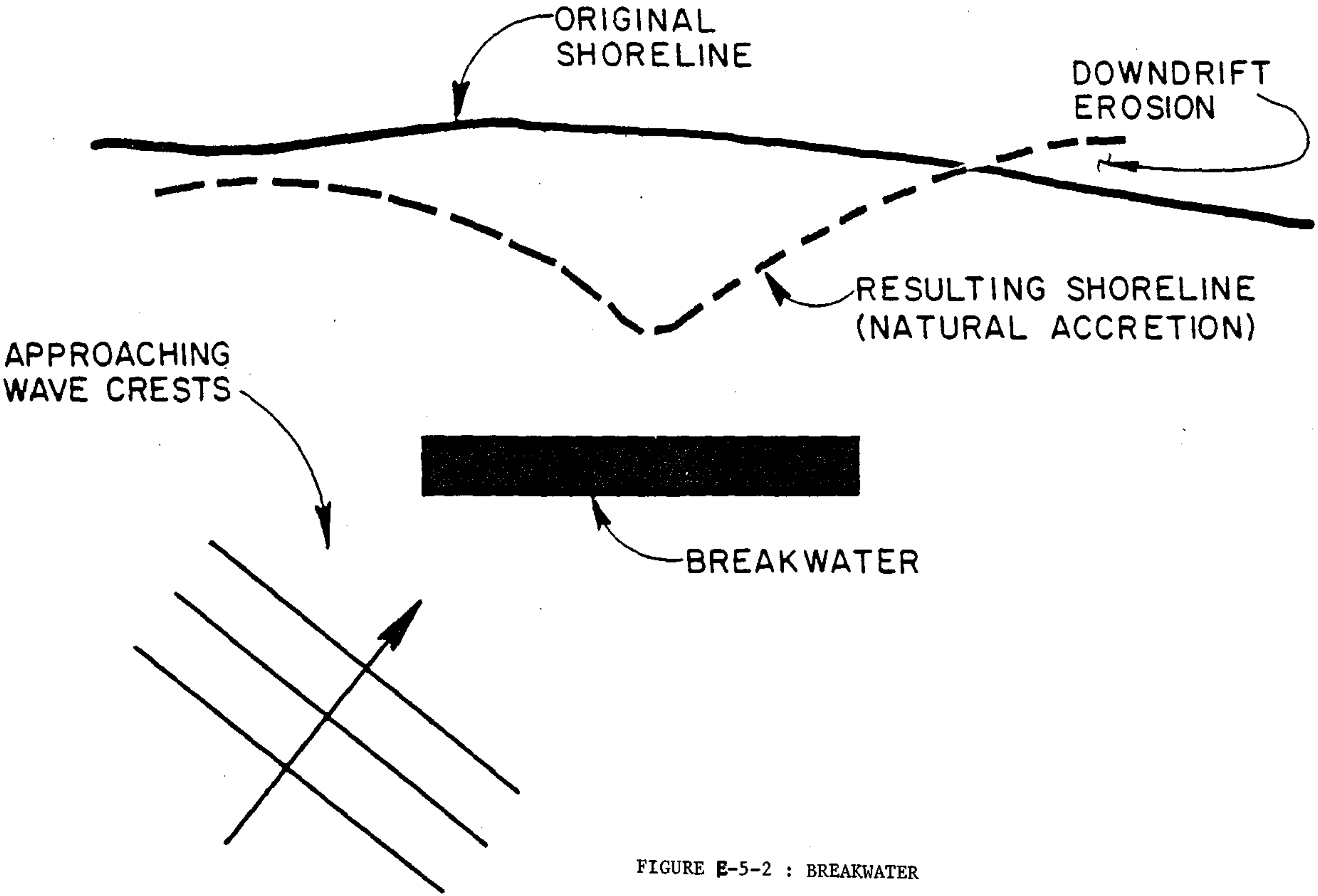


FIGURE E-5-2 : BREAKWATER

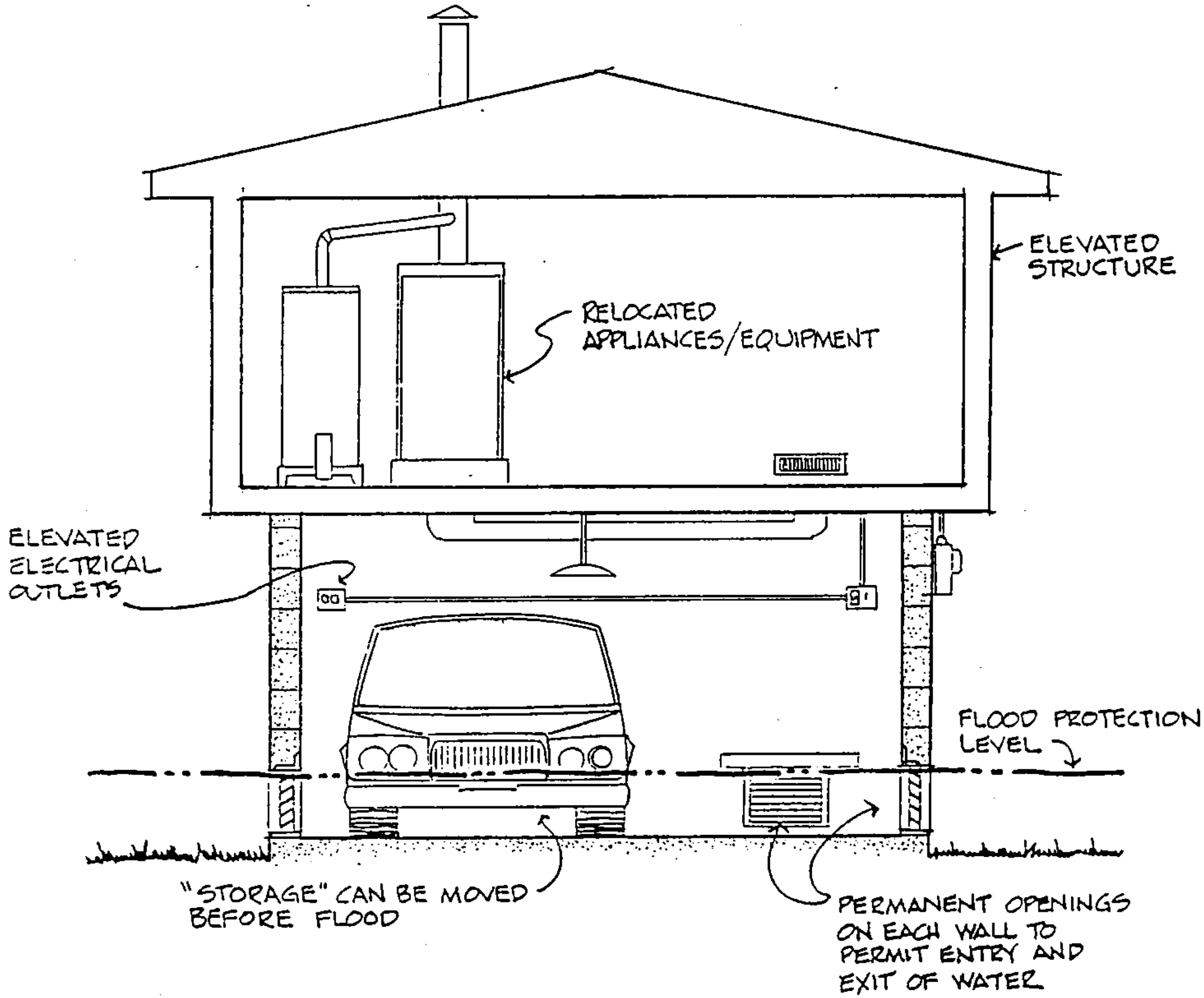


FIGURE E-5-3 : FLOODPROOFING

traffic control facilities to increase capacity; redesigning water supply and sewage treatment system infrastructure; or the reconstruction of harbor structures (docks, piers, etc.), so that they too, can adapt to changing water levels.

Acquisition and Relocation

Other measures fall into an "acquisition and relocation" family, whereby the community can purchase, or acquire coastal hazard land, or sensitive coastal habitats, and then either restrict the type of development that takes place (see Type 3 Actions), or revert the land back to non-hazardous uses. The community could also move structures out of severely threatened hazard land. This group of actions recognizes that in some cases, it may not be feasible, or even possible, to construct shore protection, or properly floodproof a structure, and that the only reasonable alternative is to remove the potential hazard by removing, or relocating any structures that may be present.

Utility and Infrastructure Adaptation

Actions here recognize that public utilities and infrastructure may also experience problems with fluctuating water levels. Actions in this category primarily address problems for water supply and sewage treatment systems that may occur due to these fluctuations. These actions would see an expansion of the community's water supply network, or the development of alternative methods of water supply, such that low lake levels would not cause water shortages. Homes located on hazard land and currently using septic tanks might be converted to regional sewage systems. These sewer systems and associated treatment plants would be upgraded to handle flooding problems during high water and the associated high runoffs from increased precipitation. Similar actions, would see the expansion of a community's power grid connections and infrastructure in order for communities to take full advantage of the hydropower that is available.

Some of the actions proposed in the Type 2 category deal specifically with certain interests, or users of the Great Lakes. For example, some actions have been designed to help recreational boating and commercial shipping interests adapt to fluctuating water levels. These include some of the construction activities mentioned above, but they also include the construction of new lighthouses and channel markers, the dredging of channels and harbors, and improved navigation procedures.

An initial listing of Type 2 actions was presented in Section 3. The table below presents a more detailed breakdown of the Type 2 actions that are available for use by governments. This is followed by a further discussion of the various Type 2 Actions.

Table E-5-1: TYPE 2 ACTIONS : LAND AND WATER ADAPTATIONS

Construction Actions

A. Community Protection Works For Existing Property Along Selected Shoreline Reaches.

1. Seawalls
    a) permanent
        i) steel, timber, concrete
        ii) armourstone
    b) temporary
        i) sandbags
        ii) grout or concrete filled bags / mats
2. Dikes and Levees
3. Groins or Jetties
    a) solid
    b) partially open
4. Gabions
5. Drains and Pumps
6. Breakwaters
    a) detached (offshore)
    b) barrier island construction
    c) attached
        i) solid
        ii) partially open
7. Beach Nourishment
    a) beach berm
    b) beach filling
    c) perched beaches
8. Land Filling
9. Vegetation Planting
10. Bank / Bluff Grading
11. Bluff Drainage For Stability
12. Revetments
    a) precast concrete block
    b) armourstone
13. Artificial Headlands
14. Structural Floodproofing
    a) water tight shutters and doors
    b) elevate on fill / structure raising
    c) wall sealants
    d) relocation of utilities on upper floors
    e) installation of pumps
    f) sewer backflow prevention devices

B. Increases in Navigation Facility (Lock) Capacity

Table E-5-1: TYPE 2 ACTIONS (CONTINUED)

C. Adaptive Design of Water Supply and Sewage Treatment Infrastructure

D. Adaptive Design of Harbor Structures (Docks, Piers, etc.)

Acquisition and Relocation Actions

E. Community Acquisition of Hazard Land

1. Fee Simple Property Rights Purchase With Possible Resale, With Restrictions on Development
2. Purchase of Easements / Development Rights For Set-backs
3. Land Exchanges Or Transfers

F. Protection and Enhancement of Coastal Habitats

1. Public Acquisition of Barrier Beaches, Wetlands and Dunes
2. Restoration and Preservation of Barrier Beaches, Wetlands and Dunes

G.Relocation Of Structures Out of Hazard Area

Utility and Infrastructure Adaptation Actions

H. Regionalization of Water Supply and Sewage Treatment Systems

I. Power Grid Interconnections

Other Actions

J. Channel and Harbor Dredging

K. Improved Ship Navigation Procedures (Commercial and Recreational)

1. Channel Markers and Buoys
2. Lighthouses and Beacons (Construction, Maintenance)

L.Public Investment In Stormwater Management Activities

1. Construction of Stormwater Retention Facilities
2. Modification of Drainageways To Reduce Flow Velocities
3. Purchase of Land To Forestall Development
4. Modification of Land Areas to Reduce Runoff

A REVIEW OF TYPE 2 ACTIONS

Construction Actions

a. Community Protection Works

This action recognizes that existing structure (home) owners would likely want to protect their investment and that in the past, most privately constructed shore protection has been poorly engineered and not very durable. Thus, this measure is designed such that the community (municipality, city, town, etc.), with possible support from higher levels of government, totally funds and constructs well-engineered and durable shore protection for severely threatened stretches of shoreline.

This measure suggests a number of standard methods of "hard" shore protection, such as seawalls, breakwaters and groins, but also includes "soft", or non-structural alternatives like beach nourishment and vegetation planting. A floodproofing measure, whereby the community funds and carries out the retrofitting of threatened homes and buildings with proper floodproofing devices and techniques is also a potential action.

Large scale community protection devices are usually implemented at the federal level. In the United States, the U.S. Army Corps of Engineers has traditionally been responsible for the construction of large scale protection works. Corps programs have included Operation Foresight and the Advance Measures Program, while currently the Corps has a Continuing Authorities program which relates to the construction of shoreline protection. In Canada, a number of different authorities can be involved, depending on the nature and location of the structure. These include Public Works Canada, Environment Canada, Fisheries and Oceans and Agriculture Canada.

Smaller scale protection works could be implemented at the municipal or regional level. In some cases however, municipalities can be responsible for larger scale projects. The city of Luna Pier, Michigan, for example, has been protected by a 3 km long shoreline protection system since 1984 (Becker et al., 1986), which was constructed without any federal involvement. Smaller communities would also be responsible for carrying out many of the "soft" options like vegetation planting, bluff grading and local beach nourishment projects.

Regardless of who implements the projects, policy decisions must be made as to the criteria for constructing community protection devices. These decisions include which communities, or parts of communities warrant this type of protection, and how the costs of the program shall be distributed. Technical and environmental planning must be accomplished to provide effective and permanent structures and to meet legal requirements. Structures should be maintained to continue to provide full levels of protection.

Coordination would be necessary between levels of government and between neighboring areas, to maximize compatibility of programs and actions. Citizens must be educated as to the limitations of community shore protection works. Costs for community protection structures will vary considerably, depending on the complexity and the size of the structure. Small scale projects such as seawalls or groins may be fairly low cost (less than $1 million), whereas the larger projects, such as breakwaters, or offshore barrier islands may cost on the order of 1-10 million dollars. Funding must be arranged ultimately through taxation or a fee system, and would probably require interim financing methods. Construction, which would often be handled through contracts with the private sector, would not necessarily involve real estate acquisition, as the lakebed is in public ownership, but permits and other legal agreements would usually be required at several levels of government.

There are many examples of shore protection methods found in the literature. Many of these have been used on ocean coastlines, but a few have been tried on the Great Lakes with varying degrees of success. Examples of large structural protection projects can be found in Bishop (1983), Ahrens (1984), Becker et al. (1986) and Finkl et al. (1988). Beach nourishment procedures, whereby sand is imported to threatened areas, has been discussed in studies by Bagley and Whitson (1982), Jansen (1985), Pilkey (1988) and Finkl et al.(1988). Examples of the use of vegetation in shoreline stabilization are found in studies by the Great Lakes Basin Commission (1975), Davis (1975), Dai et al.(1977), Salmon et al.(1982) and the Erie County Conservation District (1986).

b. Increases in Lock Capacity

This measure is designed primarily with the commercial shipping companies in mind. The measure would help to reduce the adverse consequences of low water levels on the shipping companies by better traffic management of the locks in the Welland Canal and the St. Lawrence Seaway.

The implementing power for this type of action would likely rest with those who already have jurisdiction over the lock systems on the Great Lakes, namely, the St. Lawrence Seaway Authority, The St. Lawrence Seaway Development Corporation and the U.S. Army Corps of Engineers. Federal departments of Transportation would also be involved. Costs for this type of measure would likely be on the order of $1-10 million. An example of this action includes the new traffic and communication center at the Welland Canal.

c. Adaptive Design of Water Supply and Sewage Treatment Infrastructure

This measure would see improvement of community sewer systems and treatment plants, so that they could handle flooding during high water (and the associated storm runoffs that would come from higher precipitation) and water pumping problems during low water. Community water intake structures and pumping equipment would also be upgraded to deal with extremely low levels.

The local or city government in the area in which this action is taken would be the main implementing authority, possibly using funds provided from a higher government level. This action would have a cost of $1-10 million per municipality, and funding, other than that provided from higher levels of government, would likely come from tax dollars.

d. Adaptive Design of Harbor Structures

This action would ensure that those that presently use the lake can adapt to fluctuating water levels. This would include the installation of floating docks (Figure E-5-4), extension of water intakes / outfalls and the adjustment of ship loading spouts or platforms. The actions would also ensure that any new development would be designed with these adaptive capabilities. This is especially important in the case of small craft harbors and marinas, and any new industrial facilities.

Once again, implementation of this action would take place at a municipal level. Costs are not known, but funds would need to be available to businesses, industries, etc., for these adaptations.

Acquisition and Relocation Actions

a. Community Acquisition of Hazard Land

Purchase of fee simple property rights, or easements, and land exchanges are three actions under this sub-action. These measures are designed to prevent future damages and losses in hazard areas by removing the structure that is threatened and reverting the land back to a "non-hazardous" use. This can be done by either direct community purchase of a property when it goes up for sale, the purchase of an easement that will allow a certain amount of setback from the waterline, or else the exchange of land in non-threatened areas for the hazard land.

The costs of this type of action depend upon a number of factors, including the current market value of the property and inflation rates. In most cases, this cost can be relatively high. Because of this, public acquisitions are usually only considered where the potential of the land for recreational, environmental protection, or other public uses can justify the expenditure. Primary jurisdiction for acquisition should lie with the local municipalities, but they should be governed (supported) by state, federal, or provincial regulations. Some municipalities may be unwilling to convert land to non-hazardous use, or they may not be able to afford the purchase price. In cases like this, regulations, or financial support could come from the higher levels of government. Most governments already have the authority to implement this measure, the taking of private land for the public good. To establish this as an active program would require that some level of government make policy decisions and pass legislation regarding the qualifications of the property, the willingness of the seller, re-use plans and property restrictions. Technical planning would include the defining of hazard areas, and compliance with relevant laws governing the acquisition of private property through federally run, or funded programs. Under this law, the government would also need to assure the existence of safe, sanitary and decent replacement housing, available to the displaced owners. If a senior level of government was responsible for funding the program, its basic source of revenue would probably be the national income tax, and so the costs would be spread very broadly. It might also require cost-sharing by the local government. Local costs probably would be supported by the local property tax base. Administrative requirements would include the legal processes of acquisition, removing existing improvements, modifying infrastructure, entering restrictions on deeds, implementing the reuse plans of the acquired property, and monitoring compliance. Coordination will be needed between governments involved in the program and also with new owners, old owners, or new public operating agencies.

Some examples of community acquisitions of this type have been carried out by the Hamilton Region Conservation Authority on the Hamilton / Burlington Beach Strip in Ontario and by the State of Florida in a beach purchase program known as "Save Our Coast" (Fischer, 1988). The U.S. Federal Emergency Management Agency has a "Section 1362" program which allows purchase of property susceptible to flooding. The Wisconsin town of Soldiers Grove implemented a relocation program for its commercial district, with Federal, State, local and borrowed funds. The Corps of Engineers first relocation project was in Prairie du Chein, Wisconsin. Corps policy requires the removal of human habitation from property it acquires for flowage easement.

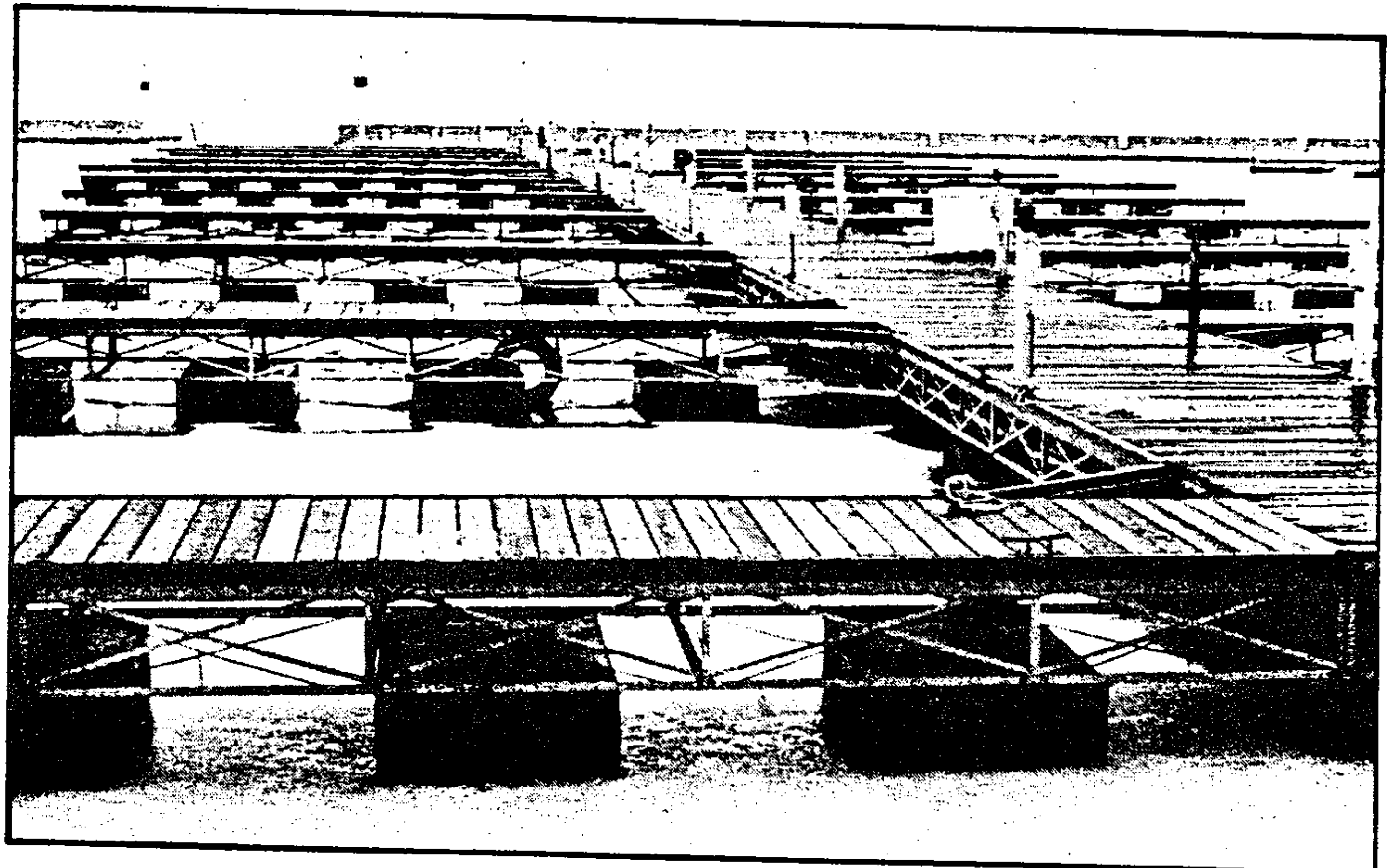


FIGURE E-5-4 : FLOATING DOCKS

b. Protection and Enhancement of Coastal Habitats

This action would see public monies spent on acquiring barrier beaches, dunes and wetlands, and where these habitats were already under community ownership, money would be spent to restore and preserve these coastal habitats in their natural state (e.g. removal of man-made structures, removal of shore protection). A secondary effect of purchase would be to maintain these areas in open space (undeveloped) uses.

This is another form of the community acquisition action, only implementation in this case would be carried out by the federal, state and provincial governments of both countries, as the protection of natural habitats usually falls under their jurisdiction. Costs would again depend on land values and inflation rates.

Examples of this sort include many of the Canadian and American national parks and Ontario's provincial parks, whereby unique habitats have been purchased for protection under the various federal and provincial Parks Acts.

c. Relocation of Structures Out of Hazard Area

Flooding or erosion damage can be reduced or avoided by relocation of existing structures out of hazard areas. In some cases, buildings can be designed or adapted to be relatively easily moved relocation could be implemented only when the need arose, and could perhaps be temporary. In other cases, relocation would have to occur well in advance of a crisis condition and would be a permanent action. The action could be applied to public facilities, or to private property located in hazard areas. In severe cases, entire small communities may have to be relocated, while other cases may only involve individual structures.

Relocation programs could be developed at the state / provincial level, and administered at the municipal level. Such a program would likely involve new legislation for nearly all jurisdictions. Costs for relocation can be highly variable, depending on the value of real estate and structural improvements, as well as the time period over which such efforts could be carried out. It would also vary depending on the extent to which the program is intended to remove existing structures at risk. Costs can include preparing the new site, building a new foundation, installing utilities and ensuring everything conforms to present health / building codes. Additional land may also have to be purchased. One source (Strelchuk, 1981) indicates that the actual relocation cost of the average home varies between $10,000-$20,000, with an additional cost if land must be purchased to relocate the home.

Utility and Infrastructure Adaptation Actions

a. Regionalization of Water Supply and Sewage Treatment Systems

This action would see an expansion of the community's water supply network, such that during low lake levels, water shortages would not be a problem. On the other side of things, the sewer systems for the homes located in hazard areas that are using septic tanks would be converted, so that their sewage system was linked into the community sewer and sewage treatment system. This would eliminate the erosion and flooding damage potential to septic tanks and the associated water quality problems that may result if these septic tanks are damaged.

The local or city government in the area in which this action is taken would be the main implementing authority, possibly using funds provided from a higher government level. Costs for this action would likely range from $1-$10 million per municipality and funding could come from the local tax base.

b. Power Grid Interconnections

This action would see public investment to develop new and more efficient power grid interconnections and infrastructure, so that the communities can take full advantage of any hydropower that is available, or alternatively gain access to power generated by other means. The idea behind this measure is that during lower water periods, when the capacity to generate hydropower is reduced, the communities will still be able to operate normally, without any increase in price or shortage of power.

This action could take place in all those communities around the Great Lakes that rely on hydropower. As such, implementation of this action would be the responsibility of these communities, but would also be dependent upon cooperation of the state power authorities and Ontario Hydro. The expense of this action would likely be in the range of $10-$100 million, as new hydro-corridors, or sub stations may have to be constructed.

Examples of power system interconnections include a number in the U.S. and a few that cross the Canada - U.S. border (e.g. Hydro Quebec supplies power to New England States).

Other Actions

A number of the actions in the Type 2 category have been designed to aid the recreational boating and commercial shipping interests adapt to changing water levels. Measures include: channel and harbor dredging, which would see community funded dredging of small craft harbors, shipping lanes and docksides; improved ship navigation procedures, which would see funding and construction of new lighthouses, channel markers, or other navigational aids; and adaptive design of harbor structures, which might include community installation of floating docks (Wortley, 1987), or installation of adjustable ship docks and loading / unloading platforms and equipment.

These actions would take place at any governmental level. For example, communities could dredge their own small marina basins and enforce navigational procedures. Federal governments may undertake to dredge international shipping channels. Provincial and state governments may also undertake dredging programs. Costs for dredging will vary on the extent and location of any dredging project and would probably vary between $1-$10 million. Problems may be encountered in finding locations for the dredge spoil.

A final action in the Type 2 category is that of public investment in stormwater management activities. Actions here encompass a range of activities that are intended to either reduce the rate at which runoff occurs from precipitation events, or to reduce the amount of runoff from a given land area. These actions include construction of stormwater retention activities (above or below ground), modifying drainageways to reduce flow velocities, purchasing land to forestall development that would increase runoff, and modification of land areas within a watershed to reduce runoff (re-contouring, vegetation planting), or to increase on-land storage (creation of artificial wetlands).

Actions such as these could be carried out anywhere within the Great Lakes - St. Lawrence system, but would have the greatest effect in the headwater areas of stream systems. They would usually be carried out on a municipal, or sub-regional (watershed) basis (eg. Ontario Conservation Authorities) with funding assistance provided from either the State / Provincial, or Federal level. The scale and extent of application of this action necessary to have any significant affect has not been determined to date.

SECTION 6

TYPE 3 ACTIONS

INTRODUCTION

Type 2 Actions looked at those actions whereby governments made decisions about how to adapt to shore processes and fluctuating water levels. Type 3 Actions also involve governments, but in this case governments are developing regulations and enforcing restrictions that can actually modify or prevent specific uses of the land and water. The actions in this type involve individual action to the extent that individuals must conform to the regulations that are being enforced. Type 3 actions differ from Type 4 actions (discussed in the next Section) in that Type 4 actions do not directly control or prevent a certain land or water use, but instead, try to make more tangible an individual's decision about that land or water use.

The actions included in the Type 3 category are designed to prevent future adverse consequences of fluctuating water levels on both the human and physical resources of the Great Lakes Basin, and would see regulations put in place (recognizing that some may already be in place) that would govern how man uses the water in the lakes and the land surrounding the lakes. The actions in this type can actually prevent certain uses of the land or water, or enforce certain uses of the land and water, especially during times of extreme water level fluctuations. Once again, these regulations do not necessarily prevent, or eliminate all development in the shoreline area. Many of the regulations could apply to existing development, as well as new development.

This category includes many actions and regulations that have been attempted previously, or are currently in place in various locations around the Great Lakes shoreline. These include many of the regulations designed to govern the use of property in hazard areas that are discussed below. Other actions in this category are new and innovative and have never been tried on the Great Lakes. These include a number of the actions designed to regulate human impacts on shoreline resources, and a number of those that would govern the use of natural resources.

As mentioned above, Type 3 actions fall into three basic groups. These are: 1) Regulations That Govern Use of Property in Hazard Areas; 2) Regulations To Reduce Human Impact On Shoreline Resources; and 3) Regulations To Govern Use of Natural Resources.

Regulations That Govern The Use Of Property Located In Hazard Areas.

The actions here would see the development of a number of planning and development bylaws designed to eliminate, or reduce damage to structures. Examples here include, placing new, or relocating existing structures behind an erosion, or flood set-back line; placing new, or moving (raising) existing structures above a certain flood elevation; construct new structures, or retrofit existing structures with proper flood proofing devices and techniques; placing restrictions on post disaster construction; and placing deed restrictions on property use.

Regulations To Reduce Human Impact On Shoreline Resources.

This group recognizes that human actions can sometimes have adverse effects on the physical processes that occur in the coastal zone. This is especially true of some shore protection devices that interrupt the natural flow of sediment along the shoreline. One possible action in this category includes the development of a permit program to regulate construction of shoreline protection and navigation structures. Regulations could also govern extraction of beach and near shore deposits, land filling, vegetation removal, and any other alteration of the shoreline. This would also include regulations designed to protect sensitive coastal habitats such as wetlands and barrier beaches.

Regulations To Govern Use Of Natural Resources.

This third category would see regulations developed that would govern how humans use (or extract) the natural resources of the Great Lakes during times of water level extremes. These regulations are designed to control the demand on the resource, instead of looking at maintaining or increasing the supply. Examples of this sort could include speed and carrying capacity regulations for commercial vessels, and restricted areas for other boaters. In addition, regulations might be developed in order to guide consumptive use of water by towns, cities and industries, or to allow those who draw their primary power from Great Lakes hydroelectric projects to maximize, or limit hydro-electric power use during times of low supply, or to enforce community electricity conservation during low water periods.

The initial list of Type 3 actions was presented in Table E-6-1. The table below presents a more detailed breakdown of the Type 3 actions that are available for use by governments. This is followed by a further discussion of Type 3 actions.

Table E-6-1 : TYPE 3 ACTIONS : RESTRICTIONS ON LAND AND WATER USE

Regulate Use Of Property In Hazard Areas

A. Regulate Use of Property In Hazard Areas

1. Setbacks For Structures In Zoning Requirements
    a) flood line setbacks
    b) erosion line setbacks
    c) related environmental zoning
2. Elevations For Structures In Zoning Requirements

Table E-6-1 : TYPE 3 ACTIONS (CONTINUED)

3. Floodproofing through Building Code Requirements
   a) required for new-structures
   b) required retrofitting of existing structures
4. Other Planning and Development Requirements
   a) minimum lot size (subdivision ordinances)
   b) sewer system permits
   c) restrict post-disaster construction
   d) density freezing and transfers
   e) pre-development requirement to obtain professional technical advice
   f) minor variances to allow movement within property
5. Deed Restrictions On Property Use

Regulations To Reduce Human Impact On Shoreline Resources

B. Regulate Human Impact on Shoreline Resources In Hazard Areas

1. Regulate Shore Protection Work
   a) construction permits
   b) requirement for professional technical advice
2. Regulate Navigation Structure Construction
   a) construction permits
   b) requirement for professional technical advice
3. Regulate Extraction of Beach and Nearshore Deposits
4. Regulate Landfilling and Alteration of The Shoreline Including Vegetation Removal
5. Coastal Habitat Protection Regulations
   a) wetlands
   b) barrier beaches
   c) dunes
   d) other sensitive coastal environments

Regulations To Govern Use Of Natural Resources

C. Regulate Use of Great Lakes Resources In Accordance With Fluctuating Water Levels

1. Boat Size / Keel Restrictions
2. Stricter Hunting, Fishing and Trapping Limitations
3. Other Use Limitations

Table E-6-1: TYPE 3 ACTIONS (CONTINUED)

D. Regulation of Water Withdrawals

1. Regulation of Consumptive Use (Management)
2. Permits To Regulate Water Intakes / Outfalls
3. Requirements For Professional Technical Advice in Construction of Intakes / Outfalls

E. Power Demand / Capacity Management

F. Navigation Regulations (Commercial and Recreational)

1. Vessel Speed Regulations and Enforcement
2. Load / Carrying Capacity Limitations

G. Regulation of Land and Water Use To Control Stormwater

1. Restrictions on Timber Cutting and Vegetation Removal
2. Mandatory Installation of Runoff Control Devices
3. Restrictions on Land Surface and Channel Modifications
4. Restrictions on Alteration of Areas Providing Natural Storage

A REVIEW OF TYPE 3 ACTIONS

Regulate Use of Property in Hazard Areas

Under Type 3 actions, regulated use of property in hazard areas recognizes that not all development is eliminated and that some actions (regulations in this case) can apply to existing development, as well as new development. In addition to this, the sub-measures proposed include five sub-classifications: 1) Setbacks For Structures in Zoning Requirements; 2) Elevations For Structures in Zoning Requirements; 3) Floodproofing Through Building Code Requirements; 4) Other Planning and Development Requirements; and 5) Deed Restrictions On Property Use.

These actions are designed to ensure that any existing, or proposed development that takes place in a hazard area is done so in a regulated manner. The regulations are designed so that the problems of fluctuating water levels in the hazard area are minimized, or totally eliminated. These regulations are usually enforced through the means of municipal by-laws or official plans.

The purpose behind setbacks would be to ensure that any new development along the Great Lakes shoreline takes place landward of an erosion or flood control line (typically the 1:100 year flood/erosion line). It would also provide for (but not require) shoreline owners who are currently lakeward of this line to relocate their homes or cottages landward of the line. Any new development lakeward of the line has to get proper authorization from the implementing authority. Construction may be allowed lakeward of the erosion line, so long as the buildings, or other uses, are portable, or temporary and can be moved prior to damage.

The elevation of structures would allow for construction in a hazard area, where zoning procedures do not currently exist or even where they do exist, but would ensure that any new construction, or any existing structures in this hazard area, would be raised above the 1:100 year flood level. This would help to minimize the damages due to flood waters, while still allowing residential use of the shore zone.

Floodproofing also allows for construction within a hazard zone, but is designed to ensure that any new development, or alternatively, any existing development (through retrofitting), lakeward of the 1:100 year flood elevation is constructed using proper and effective floodproofing techniques.

Other planning requirements can also be a powerful tool in regulating land use in hazard areas. Lot size ordinances are important to ensure a lot is deep enough to allow structures to be safely located behind the erosion or flood setback line. Post disaster reconstruction limitations would prevent future damages in the same area and the obtaining of technical advice would add greatly to the quality and durability of structures placed in hazard areas.

Deed restrictions would ensure that certain caveats are placed on property deeds, so that buyers of shoreline property are aware of the hazard potential, or so that buyers of the land use the land for compatible, "non-hazardous" activities. For example, buyers of vacant shoreline property would be notified in their deed that residential development is not permitted. If they proceed with residential development (assuming they bypass any bylaws), their deed can be considered null and void and the buyer could potentially be required to remove any construction.

The majority of the actions discussed above would be implemented at the municipal level through the use of zoning by-laws, official plans and other planning requirements. The United States and Ontario governments have existing policy statements in support of hazard area definition and land use management, as do some of the relevant States. However, mandating the relocation of all structures behind the setback line would require a major policy change. It might also be subject to constitutional challenges in the United States. Technical planning must be continued to fully identify appropriate setback lines. Costs for these actions would be less than $1 million, however this could vary significantly, depending on whether merely administrative costs were involved, or if the governments would provide financial aid to owners of structures which needed to be relocated. Enforcement and education would also require ongoing funding.

The use of land use regulations in coastal hazard planning has been reviewed relatively well in the literature. Jessen et al. (1983) and Kreutzwiser (1988) have looked at examples from various Ontario Great Lakes communities. Detailed regulations and examples have also been discussed for the states of Wisconsin (Yanggen, 1981), California (Crandall, 1974), South Carolina (Fisher and Moore, 1982) and Massachusetts (Brautigam and Robin, 1985).

Regulations To Reduce Human Impact On Shoreline Resources

These actions recognize that human activities can exacerbate the shoreline hazard and proposes sub-actions that are designed to minimize the impacts. These sub-actions include the regulation of shore protection and navigation structure construction, the regulation of beach and nearshore deposit extraction, the regulation of landfills and alteration of the shoreline and coastal habitat protection regulations.

The first two sub-actions deal with the regulation of privately or publicly constructed shore protection and navigation structures (breakwalls, groins, docks, piers, wharfs, jetties, etc.). Regulations would include the obtaining of proper construction permits, which in addition, would not be issued unless the interested party obtains professional technical advice. These types of regulations could also limit the type of protection that goes in, and could charge a fine, or force removal of non-permitted construction. Another possible consequence of this regulation would be to impose a system of "sand rights" (Stone and Kaufman, 1988) whereby a tax (levy, fine, fee) is charged to anyone (individual, organization, etc.) who constructs a structure that interferes with the natural nearshore process of sand transport and deposition (this is covered in greater detail under Type 4 actions).

The second two sub-measures deal with alteration of the nearshore zone itself and would place regulations on the extraction of nearshore deposits. In addition, any landfilling (out into the lake), or other alteration of the shoreline (such as vegetation removal and flattening of dunes for sight purposes) would be strictly regulated. Permission (permits) would have to be obtained before any work of this type could be done. Limitations could also be placed on the amounts of deposit or vegetation that could be removed and the amount of filling that could be carried out.

The final sub-measure in this category is the development of regulations to protect sensitive coastal habitats from the impact of man. In essence, this is a widely used measure in many national, provincial and state parks, which are usually set up to protect areas of natural significance. For example, in Canada, sections of Point Pelee and Long Point, two barrier spits on Lake Erie, are owned largely by the Canadian Parks Service and the

Canadian Wildlife Service respectively, and are maintained in their natural state according to regulations set out by each agency. These regulations include many of the sub-measures above, such as construction bans, deposit extraction bans or limits, and human access regulations.

It is likely that the regulations in this category would be developed and enforced at the state or provincial level. For example, any alteration of the shoreline in Ontario falls directly under the jurisdiction of the provincial Ministry of Natural Resources. This same agency also owns and operates a number of Provincial Parks, and had operated a technical advisory service for shore protection construction. Once again, the only costs involved in these actions would be those incurred in setting up regulatory programs and hiring enforcement personnel.

Regulations To Govern Use Of Natural Resources

a. Regulate Use of Great Lakes Resources in Accordance with Fluctuating Levels

This measure is aimed primarily at recreational users on the Great Lakes and is designed to place limitations on their use of the lakes during sensitive water level periods. It is designed to control the demand on the resource instead of looking at maintaining or increasing the supply. For example, if levels were low enough to be having a major impact on waterfowl population, then perhaps stricter limits could be placed on the number of birds that hunters could take during the hunting season, or limits could be placed on the number of hunters allowed in a sensitive area. Other examples could include a depth limitation on fixed keel sailboats and restricted boating areas for boaters, and stricter catch limits, or fewer fishing permits for fishermen.

While this action might be an important one as far as resources go, it also may be the most difficult to implement. As an example, if wetlands owned by private hunting clubs are placed under regulations that limit hunting, then the private club will likely convert the land into something they can benefit from, (e.g. farmland). In addition, some people may feel that regulations of this type interfere with their constitutional rights, and thus, would be unwilling to accept them.

These regulations would be implemented by the state and provincial governments, and may require new legislation to be drafted, or existing legislation to be amended. This is usually a time consuming process. While there are no known examples of regulations of this type for recreational boaters, many states and the Province of Ontario already have such things as hunting and fishing licensing programs, which specify limits on a catch, or a hunt. For these activities, this action could be an amendment to these licenses.

b. Regulation of Water Withdrawals

This measure would require the development of regulations that would guide the use of water by towns, cities, etc., and in addition to consumptive use regulations, would see the regulation of in-water structures (other than water intakes and navigation structures) through a permit program, and would see regulations put in place that would ensure that water intakes and outfalls are properly designed to withstand extremely high, or low levels. It would also closely monitor and put limitations on the amount of consumptive use by manufacturers in the production of goods which incorporate Great Lakes water, thereby removing water from the basin. Restrictions would also be placed on municipalities, industries, etc., to account for leakages within withdrawal systems.

Policy formulation for this action would probably be handled at different governmental levels for the various components of the action. A key policy element would be determining what water demand needs provide acceptable justification for resource depletion. Planning the actual design criteria and administrative process could be accomplished at the higher government levels, or delegated to local levels. Because this is fundamentally a regulatory program, funding requirements would be minimal, related mainly to administration and monitoring. The program could also provide financial assistance for rebuilding of inadequate water systems.

c. Power Demand / Capacity Management

This measure would see regulations and programs developed that would allow those who draw their primary power from Great Lakes hydro projects, to make better use of this power during times of low supply (extremely low water levels), or would limit the amount of hydro power that could be used, or enforce conservation of electricity by communities during these low water level periods.

This measure would be implemented by the state / provincial and local governments, along with the various hydro entities, who would have to reach agreement on what the regulations should be, and on how they are going to be put in place. Costs are not known, but current examples include the summer electric rates that some utilities have introduced to provide incentives for off-peak power use.

d. Navigation Regulations (Commercial and Recreational)

This measures that would regulate navigation by modifying current operational procedures, such as vessel speed regulations to eliminate wake during high water and carrying capacity limitations to minimize grounding problems during low water. Speed restrictions could also apply during low water, so that ships do not disturb sediment and create water quality problems. These could also include vessel size, or horsepower restrictions.

This action would be implemented by those responsible for the regulation of boating traffic, namely the federal transportation departments, the Coast Guard and the St. Lawrence Seaway agencies.

e. Regulation of Land Or Water Use To Control Stormwater

Stormwater management actions would restrict or prevent the development of areas that provide important natural storage of runoff from precipitation events, or could be used to control the amounts of additional runoff associated with land development and construction. Such regulations would help to avoid damages to public or private property caused by flooding associated with increased runoff from areas that are topographically higher, or located closer to the headwaters of a stream system. Example regulations could include restrictions on timber cutting and other vegetation removal, requiring temporary flow retardation or runoff control devices during construction, and permanent measures to increase infiltration or retard runoff to preconstruction conditions. There could also be restrictions placed on channel modification and other land surface alterations that increase the rate of runoff, and restrictions on altering areas that provide natural storage of runoff.

Such actions would best be implemented for small drainage areas, or toward the headwaters of larger stream systems and would likely be carried out at the municipal level.

SECTION 7

TYPE 4 ACTIONS

INTRODUCTION

Having Now examined three types of actions which governments can take to directly modify the lakes, the land, or the use of land and water, this section will examine possible actions by governments which attempt to indirectly influence the decisions made by interests about how they choose to use the land and water. Distinct consideration of Type 4 actions recognizes limitations of other types of measures. Huge public investments in control and diversion works (Type 1 actions) cannot eliminate all lake level fluctuations. Public investments to adapt to changing levels (Type 2 actions) and emergency response programs (Type 5 actions), even on a large scale, cannot protect all Great Lakes interests. Type 4 actions recognize that individuals can do much to reduce the potential for damages, but often resist attempts to directly regulate their land or water use (Type 3 actions).

Type 4 actions are distinguished from Type 2 actions by their focus on private sector decision making. Type 2 actions focus on programs funded and entirely implemented by various levels of government; they require only governmental involvement. In contrast, while governments may provide the funds for Type 4 actions, decisions by individuals on the extent of their participation in a program determines the degree to which that public program is actually implemented. Type 3 actions focus on regulating land and water use; those regulations can actually prevent specific uses of the land and water. In contrast, Type 4 actions do not explicitly prohibit land or water use. They do, however, attempt to make more tangible the risks associated with an individual's decisions. For example, making the availability of mortgage loans from federally-insured financial institutions contingent upon the purchase of flood insurance for property in a flood hazard area does not prohibit the purchase of that property. Also, Type 4 actions recognize that government policies and programs can influence private sector decisions (e.g., public policies to not develop water supply or transportation infrastructure in hazard areas can influence private sector decisions for development in those areas). This section provides a review of Type 4 actions as they relate to Great Lakes water level fluctuation problems. This section categorizes Type 4 actions into three major sub-types and presents an expanded classification of existing and potential Type 4 measures. This section also provides overviews of the major sub-types of Type 4 measures (expenditure policies, tax policies, and information programs, respectively). For a detailed listing of Type 4 actions, refer to Table E-3-1.

A REVIEW OF TYPE 4 ACTIONS

Expenditure Policy

This section will present all the existing and "new" public expenditure policies that can be used to indirectly influence susceptibility to Great Lakes water level fluctuations. These expenditure policies are comprised of four major groups, subsidies and financial aid, disaster aid, infrastructure investment of governments, and insurance. Under these groups are several subgroupings. The individual policies will be defined and discussed based upon the MWG literature review, citing of existing examples along with their good and bad points, and comments received from persons contacted and the Measures Workshop and GDI participants.

a. Subsidies and Financial Aid

Subsidies and financial aid can be defined as public or private incentives or disincentives to shoreline protection or development that would affect people's ability to cope with fluctuating water levels. They generally take the form of a grant or a loan which is available to the interest class.

1. Public / Private Incentive Grants For Capital Investments

Public or private incentive grants for capital investments would be used to help defray some portion of or all costs of protection works for individual existing structures including: sea walls; dikes; groins; gabions; drains and pumps; breakwaters; beach nourishment; land filling; vegetation planting; flood proofing of existing structures; and elevation or relocation of existing structures including docks. These grants could also be used to provide relief in times of low water by assisting individuals, businesses, and lower levels of government in doing things like extending water lines for intakes or for installing water saving devices. These grants can be used in three ways: (1) to provide funds for capital investments; (2) to provide funds to remove existing structures which are ineffective or harmful to adjacent properties; and (3) to cover increased operating costs due to either high or low water conditions.

There are several public incentive grants currently being used in the Great Lakes Basin. They are the Upton-Jones Amendment to the National Flood Insurance Program, and the state of Michigan Public Act 108. There is also a bill in the U.S. House of Representatives (H.R.2707) entitled, "The Great Lakes Erosion Damage and Prevention Act". These programs provide relief of varying degrees to the shoreline interest affected by fluctuating water levels.

These are all U.S. programs and there are no comparable programs in Canada at this time. These programs are fairly new and do not have long track records. Two problems cited in connection with them were the lack of public awareness of these programs and what they could provide the property owner, and that they were only available during crisis periods which often pass quickly and are soon forgotten about. These programs are being developed in the U.S. but it appears that Canada has taken a "hands off" attitude to this type of program. These programs often have restrictions built into them which require some form of participation on the shoreline owners part. In the case of the Upton-Jones amendment, the owner must be enrolled in the flood insurance program.

Using public / private incentive grants as a way to mitigate the problems associated with fluctuating water levels does appear to have some momentum in the U.S. but has not been used in Canada to date. Concern has been raised that this type of a program rewards poor planning, but it is a proactive program which if well-administered could protect properties and reduce the potential for future losses.

At the Measures Workshop there were statements made that would apply to this type of measure. These included: the need for design guidelines for this type of measure to insure that the measure would indeed be effective and not exacerbate damage to neighboring properties; the fact that this measure bails out (to some extent) people who built in hazard areas; grants to cover the full costs of protective works are not as acceptable as some form of loan requiring a payback which would allow the fund to become self-sufficient. At the governments GDI the attendees had many of the same comments and attitudes as those expressed above. At the residential GDI shoreline residents felt that this type of measure was beneficial to both themselves and the taxpayer in general, rationalizing that if they do not protect the shoreline eventually someone else will (as roads and other public facilities become vulnerable).

2. Guaranteed or Subsidized Loans For Capital Investments

Guaranteed or subsidized loans for capital investments would be used in the same manner as the grants discussed in the section above. These loans could be applied to all the examples given above and provide some measure of relief for the problems associated with fluctuating water levels. Guaranteed loans would only be subsidized in the sense that some level of government would underwrite the loans presumably through banks so that the risk to the lender would be minimized. This guarantee would probably enable the lender to reduce the interest rate as compared to the rate it would have had to charge without the guarantee.

These loans would be used in much the same way as the grants, that is they would provide for capital investments, removal of capital investments (buildings on the brink of falling in or shore protection that exacerbate damages to nearby properties), and to help defray increased operating costs.

Several states and Ontario have subsidized loan programs for individual protection works (as defined earlier). These programs may or may not be available all the time depending on the location. Generally, they take the form of a loan subsidized at a given percentage below the going rate.

Some of the concerns expressed relative to this type of measure are: the protective structure must be properly designed to withstand the conditions in that area and should not exacerbate problems in its vicinity; it rewards poor planning; and the administration of a large program can be difficult and easily misunderstood by the general public. The positive aspects of this type of program are that: it is a self help type of program; is less costly than a grant type program both in terms of administrative and total costs; it involves state/provincial and local governments in addressing the problem; and it can be applied to an individual property or a community. The Ontario Shoreline Management Review Committee has drafted some guidelines for this type of program which include policies stipulating the maximum size of the loan and the maximum cost of the project per meter of shoreline. The loan approvals are only guaranteed following technical approval of proposed works. It has been suggested that a Federal level Great Lakes bond issue be passed to provide this low-cost financing. The funds that are paid back on the loans could return to this fund making it "self-supporting" in the future.

3. Eliminate Grants and Loans For Capital Investments

Another method which could be applied to the subsidies and financial aid category is to eliminate all grant and loan programs for capital investments along the Great Lakes Basin shoreline. This is basically the flip side of the grants and loans programs discussed above. The implementation of this type of measure would be an exceptionally "hard-line" approach by governments which would send out the message load and clear that those that choose to live in hazard areas must accept the full financial responsibility for their actions.

It is unlikely that this type of measure would ever be implemented due to the political overtones associated with it. There has been precedent set in the form of the National Flood Insurance Program in the U.S. and the subsidized loan program in Ontario. Complete elimination of all grants and loans was not mentioned by any of the people interviewed as being a practical measure for dealing with the problems associated with fluctuating water levels. However, there is potential to more strictly enforce existing laws or policies that relate to shoreline development. One example for the U.S. would be to strictly enforce Executive Orders Numbers 11988 and 11990. This softer version of this measure was mentioned as having some potential by participants in the Measures Workshop.

b. Disaster Aid

Disaster aid to victims of natural disasters has a long history in the U.S. especially along the Gulf coast where tropical storms almost yearly create problems for the people living in that region. Disaster aid has also been provided along the Great Lakes shoreline on the U.S. and although there is a Disaster Aid program in Canada, it has never been activated from a water levels or storm event.

Disaster Aid can be a one time disaster declaration (such as the situation with the storm in December 1985) or a long term program set up for dealing with a long term high or low water period. The decision to provide disaster aid can be done in two ways: make the availability of disaster aid conditional on participation in some other program like flood insurance; or make it unconditional relative to other programs. The alternative to providing disaster aid is to eliminate or reduce disaster aid.

1. Provide Disaster Aid For Hazard Areas

The provision of disaster aid could have a condition written into the disaster relief law which requires those in hazard zones to purchase flood or hazard insurance as a prerequisite to receiving any form of disaster aid. One method of adjusting disaster aid procedures would be to provide disaster aid payments only for damages greater than the potential flood / hazard insurance payments. This method would eliminate a potential subsidy to those property owners who elected not to purchase hazard insurance. This would presumably encourage more property owners to share the risk of locating in a hazard zone, and eliminate the situation where those not holding insurance coming out ahead of those that did (the difference being the cost of the hazard insurance in current practice).

Another type of "condition" to be eligible for disaster aid could be that the shoreline owner would be required to show that he/she had used good shoreline management practice in locating the structure or protecting that portion of the shoreline. The theory behind this measure would be to make the most of disaster aid programs by having certain eligibility requirements linked to good shoreline protection practices. Presumably governments would set up some standards which would have to be followed in order to make the works eligible for aid.

Another example of a condition that could be applied to disaster aid would be to allow disaster aid payments for property damage to be used for protection (e.g. hazard proofing) instead of improvements.

Unconditional disaster aid is an alternative to stipulating some conditions, but does not have the foresight that a conditional measure would encompass. The subject of disaster aid was discussed at the workshop and the majority felt that some conditions on the eligibility for the program are warranted. The use of disaster aid has precedent and is likely to continue in the future because it is a politically and socially expedient way of dealing with disasters.

There are several existing U.S. programs for disaster aid through the Small Business Administration and the National Flood Insurance Program. There was a general sense of overlap and perhaps confusion on the publics part relative to these programs in the eyes of the Measures Workshop participants. If these programs were reviewed and revised relative to the Great Lakes situation they may be more effective.

2. Eliminate / Reduce Disaster Aid For Hazard Areas

The fact that disaster aid is available may have some influence on the development within hazard areas. Knowledge that all may not be lost in a disaster situation may have some weight in the decision to locate within a hazard area. Quantification of this effect would be very difficult, but never-the-less it could be one of the decision variables. If, however, every potential shoreline property owner is made aware of the non-existence or reduced level of such aid before he/she makes the investment decision then they must assume a greater portion of the responsibility for his / her actions with reduced potential for recourse. Application of this measure would require a full definition of the "hazard zones" along the Great Lakes and their connecting channels.

c. Infrastructure Investments of Governments

The decision to locate/maintain infrastructure in hazard areas (or connections to hazard areas) may have an indirect influence on land and water use in those areas. Government strategies in this area may require some rethinking or revised guidelines based upon the range of water level fluctuations that have been experienced in the past as compared to those that may be experienced in the future. Two methods of dealing with the infrastructure investments are to locate the infrastructure in such a way as to help prevent future damages in hazard zones, or to provide appropriately constructed infrastructure where there is no alternative to development in the hazard zone. The Center for Great Lakes (1988) reports that one of the most important factors undermining improved shoreline management is poor government investment decisions. These often involve new infrastructure or low interest loans that contribute to development in coastal hazard areas. The report adds that legislative bodies would be more apt to grant new authority required for eliminating poorly thought out public investments if they see it as making government work more efficiently, consistently and intelligently.

1. Locate Infrastructure To Eliminate / Minimize Potential For Economic Losses

This type of measure could be implemented by governments by conscientiously evaluating the potential for hazards prior to locating new infrastructure. By regulating the location of new infrastructure and by allowing phased deterioration of existing infrasrtucture in designated hazard areas governments are serving notice to potential and current shoreline property owners that they must be prepared to fend for themselves. This method was brought up at the Measures Workshop as a way of phasing out the financial responsibility governments have in the hazard zones.

While elimination of existing systems may seem unduly harsh, there may be overriding safety considerations in certain hazard areas where these actions are appropriate. There may be some precedent for this in Canada as there has been abandonment of an access road going out to Long Point on Lake Erie after the December 1985 storm.

The other method for reducing damages in this hazard zone would be to develop hazard land mapping, which would be used by governments in the decision making process as to the location of infrastructure. It could enhance siting so that all associated development would be outside of, or on the fringe of, the hazard zone, with those on the fringe required to build in appropriate flood proofing or protective features.

2. Create Excess Capacity To Minimize Potential For Economic Losses

In some cases it may not be possible/practical to totally restrict development in hazard areas through the location of infrastructure. In such cases it is important that the infrastructure be designed to withstand the conditions anticipated in the hazard zone. Roads should be built to a proper elevation so as to allow for safe exit of residents if an emergency were to arise. Sewers and drainage must be carefully designed and constructed to be usable under the emergency conditions.

d. Hazard Insurance

Insurance can be made available in the hazard zone or eliminated / reduced as a measure of dealing with the problems associated with fluctuating water levels. If insurance is provided it can be provided at the full actuarial cost for that particular hazard or at a rate which has been subsidized to some extent.

1. Provide Hazard Insurance

Providing insurance can be done in several forms. The premiums can be based on the full actuarial rates for the type and location of the hazard zone in question, with / without conditions attached to the policy (e.g. structural flood proofing required).

The provision of flood insurance at the full actuarial cost may be self-defeating in that the premiums in the serious hazard areas will probably be prohibitively expensive. However, if the insurance carrier is given certain "guarantees" by the insured such as the installation of flood proofing devices, use of appropriate setbacks or shore protection the rates may be more reasonable. This type of insurance would put the full burden of cost on the shoreline owner and would not be equitable in the sense that no one else is participating in providing any relief. Of the existing insurance programs none require the shoreline owner to bear the full premium. It is highly unlikely that a program like this would provide any measurable utility to shoreline owners who have a subsidized form of insurance available to them (at least on the U.S. side).

Subsidized flood insurance has been available to U.S. property owners for quite some time and has provided some measure of relief to shoreline owners on the Great Lakes. However, until the passage of the Upton-Jones Amendment, there was no provision for damages caused by erosion. The decision to provide a given subsidized rate for flood insurance is a method by which governments can help to share the burden of shoreline damages with the shoreline owner. It has precedent in the U.S. and was rated as an effective way to deal with the problem by many people attending the Measures Workshop. A suggestion to improve this measure was to put some conditions on the property owner in order to be eligible for it. These conditions would lessen the damage potential of the insured property by floodproofing, construction of appropriate shore protection or something along these lines.

Crop insurance for high and low levels is a method of protecting agricultural lands in hazard zones from flooding or drought conditions.

Making some form of insurance mandatory for any new construction or improvements along the shoreline is one way to inform the property owner of the flood hazard. This method was recommended by those in attendance at the Measures Workshop.

2. Eliminate / Reduce Insurance In The Hazard Zone

Elimination or reduction of flood/hazard and crop insurance in hazard areas is another method to discourage development/ farming of coastal zones or use of lake waters to irrigate adjacent croplands. This again is the flip side of the provision of insurance and is not likely to be well received in areas that traditionally have had flood insurance available to them. It would certainly send a message to those currently relying on some form of insurance to minimize their potential for losses. It would also make the shoreline owner think twice about rebuilding after a disaster or improving his/her property. Since Canada does not currently have a insurance program they already fall within this measure, but for U.S. property owners it would certainly be unpalatable compared to the status quo.

Tax Policy

a. Tax Incentives

The power of tax can be, and is, used to reward or encourage actions which reduce flood and erosion hazards. In Michigan a property tax exemption is given on structural shoreline protection which meets the specifications of the state. (The Center for the Great Lakes, 1988). If a property is putting in a shore protection structure, including a seawall, jetty, groin etc., the property owner may ask the DNR to determine whether the structure qualifies. Portions of the structures which are modified or designed to provide benefits other than protection or prevention from erosion or flooding are not exempt from property taxes. No other state has such a policy.

In Ontario, there is no tax exemption for shore protection, however, there are tax credits or purchases of wetlands to slow development and drainage. This was formulated in 1986 by the Ontario Ministry of Natural Resources, Wildlife Habitat Canada, and Ducks Unlimited (Crowder and Bristow, 1988).

Using the tax base as a form of incentive does not, at this time, seem to be a popular method of dealing with the water level issue. Concern has been raised over providing tax exemptions for shore protection because it is felt that this may encourage shore protection and takes money from the public fund.

At the Measures Workshop some new and innovative tax policy ideas were discussed. These included a littoral tax that recognizes sediment as a public resource and therefore gives tax credits for beach nourishment. This recognizes those who may not put in shore protection to prevent erosion thereby allowing their bluff to continue to erode and add sand supply to the lakes. A property tax abatement program to cover increased operating costs due to low water was discussed. This would primarily be directed to commercial, industrial and transportation interests, but could also apply to hydro and recreational interests as well. For example, a marina may be able to write off the increased expense of dredging during low water periods. Commercial tax credits and waivers that would promote proactive planning for "safe" development were also suggested. An example of this would be a tax credit for building a marina with a guaranteed draft of 6 feet at low water datum.

b. Tax Disincentives

Tax restraints are used to discourage actions which may increase flood and erosion hazards. There are, for example, states which use taxes to mitigate erosion by establishing special assessment districts to finance shoreline protection structures. These districts allow property owners to develop a unified approach to erosion problems that extend beyond their individual property lines (The Center for the Great Lakes, 1988). States involved in this type of program include Illinois, Ohio and Wisconsin. Tax deterrents could be used for the development in hazards lands (i.e., high property taxes). A littoral tax could be used to tax shore protection works to prevent the depleting of sand supply to the lakes. Tax restraints could also include the elimination of tax provision which may subsidize new construction in hazard areas. Tax deterrents could also include putting taxes on shipping loads during low levels to promote light loading. None of the aforementioned are in place in either Canada or the United States but are suggestions which have been raised.

Improved Communication

The classification of Type 4 measures entitled, "improved communication" is sub-classified into five categories. These include: 1. public information and education programs; 2. youth education programs; 3. hazard mapping; 4. information coordination and exchange; and 5. disclosure. Some form of each of these sub-types is in place somewhere in the Basin in some capacity.

a. Public Information and Education Programs

Public information and education programs are initiated or conceptualized with the idea that a better informed public will better understand the issues and options for action and will therefore be better able to cope. Recently many government agencies and academia alike have recommended improved information and communication. The 1983 IJC Study "Further Regulation of Lake Erie" recommended a vigorous information program be followed in order to reduce flood and erosion damages. Christie et al. (1986) included initiatives such as a Great Lakes Basin Information Center in their recommendations. According to a survey by Day et al. (1977) the level of knowledge in Canada of government financial assistance programs was generally low. Seventy-five percent of respondents were not aware of any government assistance and respondents were poorly informed or even misinformed about other aspects of coastal hazard problems. A survey by A. Sudar (1986) of Environment Canada showed that 97% of shoreline property owners were aware of the high water level problem.

In March of 1986, Environment Canada established the Great Lakes Water Level Communication Center whose purpose was not only to operate as a nerve center during storm events, but also to implement programs to educate and inform the public about the Great Lakes and fluctuating water levels. The Province of Ontario through the Ministry of Natural Resources and the Conservation Authorities also provides information through brochures and booklets and technical assistance. In 1986, and as a result of shore damages caused by high water levels in 1985, the Ministers of Natural Resources and Municipal Affairs approved the formation of the Shoreline Management Review Committee. This committee was requested to hold public meetings and seek input form interests on long term approaches to the management of the Great Lakes shoreline in Ontario. These types of meetings help inform the public by fostering their interest and active participation in resolving Great Lakes issues.

In the United States all of the eight states surrounding the Lakes have some form of public information / education programs. Technical assistance to aid in the proper design of private flood and erosion control structures is provided through the Department of Natural Resources and various Sea Grant College programs. The Great Lakes Program at the University of Buffalo has made plans to create a Great Lakes Information Clearinghouse providing directories of those involved in Great Lakes and facilitating international communications. As well in the States, in the past few years many non-profit private organizations have taken a strong interest in the water level issue. The Center for the Great Lakes is a non profit organization created to provide an integrated binational focus for developing effective programs to manage, conserve and develop the region's natural resources. Great Lakes United was established in 1982 and is an international organization dedicated to conserving and protecting the Great Lakes and St. Lawrence River. The Great Lakes Commission has been very active in water level issues and public information, as well, and many of the States have Sea Grant College Programs which work to keep the public informed about water resources and help solve the problems of coastal and water resource users.

Despite the existence of these communication programs within the Basin, it is still felt by many that information and communication needs to be enhanced. At a number of Group Depth Interviews held around the Basin, property owners expressed their desire to have more information available about the types of programs open to them. This along with better information on the natural processes of the lakes to improve understanding would be beneficial. Some expressed concern over the kind of information that was being distributed, questioning its validity and suggesting some form of peer review before documents and publications are distributed to the public. At the measures workshop held in Detroit, it was suggested that a central library be established to house all documents and information on the Great Lakes. Other suggestions included a cooperative extension program directed at current and perspective homeowners, demonstration programs of selected measures to demonstrate the efficacy of shore protection, etc., and stewardship awards to recognize riparians who demonstrate good management of shore resources. Generally, it is felt at the resource level that public information is an effective and necessary method of transferring information. At the public level information not only better informs, but also makes people aware of the efforts that are being taken to deal with the issues at hand. Thus, given that information is accurate and readily available, communication is viewed as a positive method of improving government / public relations and a necessary endeavor by governments.

b. Youth Education Programs

School education includes any program with is established through the school system to better inform the young people about the processes and dynamics of the Great Lakes.

The Great Lakes Water Level Communication Center in Burlington provides tours to student groups. Information is made available upon request, to students who are studying water levels and to teachers who wish to add the study of water levels to their programs. In addition, a list of resources on Great Lakes water levels and shoreline management is available. Although the study of water and the earth's fresh water supplies are included in the high school geography curriculum in Ontario and Quebec, no formal mention the Great Lakes or water levels is given. It has been suggested (Christie et al. 1986) that curriculum revisions take place to strengthen primary and secondary education systems to improve basic understanding of the Great Lakes as a system. In the United States the Sea Grant Colleges have developed teaching units and manuals on Great Lakes topics. There is a Great Lakes Basin Educator's Network associated with the IJC. Most recently the Great Lakes Commission has established a Great Lakes speakers Directory Bureau in both Canada and the U.S. This bureau is made up of professional and academics with some expertise on the Great Lakes who are available to speak with students at all levels. However, there is no formal education program within the school curriculum itself.

At a number of the GDI's school education was expressed as being a crucial element of the future of the Great Lakes Basin. It was felt that unless the young people are made aware of the issues, problems and benefits surrounding the Great Lakes, there will not be appropriate, well thought out, and coordinated policies in the future.

c. Hazard Mapping

In the United States the creation of the U.S. National Flood Insurance Program in 1968 explicitly acknowledged the essential nature of delineating areas subject to flooding (PL 90-448). Under the National Shoreline Study, initiated in 1968, the USACE conducted an inventory of the entire U.S. Great Lakes shoreline (USACE, 1971). They identified, at a scale of 1 inch to 15 miles, the shoreland uses, environmental values, water intakes, waste outfalls, physical characteristics, ownership, and shoreline reaches with flooding and erosion problems. Even though hazard maps are recognized as the basis for many other land and water management strategies, development of the maps is not without controversy. The Federal Emergency Management Agency (FEMA) designates flood hazard areas using statistical analysis of records, information obtained from the community, topographic surveys, and hydrologic analysis (FEMA, 1987). According to the Shoreline Management Guide put out by the Center for the Great Lakes (1988), Illinois and Ohio do not require flood plain management programs although mapping has been undertaken by the States.

In Canada the federal and Ontario governments signed a Flood Damage Reduction Agreement in 1978 with the primary objective of mapping flood risk areas. Since that time erosion maps have also been developed which delineate erosion setback distances with the intent that Conservation Authorities and municipalities regulate within these areas. Flood and erosion mapping have also been undertaken by Quebec.

Hazard maps can be costly to make. Although costs vary depending on the specific hazard and geologic situation, coastal zone hazard mapping required about $15,000 for 155 square kilometers for two study areas in California in 1978 (Williams, 1978); the Tennessee State Planning Office estimated that flood insurance rate maps for 21 riverine locations would cost $300,000 to $400,000 in 1982 (Thackston et. al, 1982).

Another cost-related issue concerns who will pay for the mapping. Park and Miller (1982) propose that if the hazard maps will ultimately be used for zoning that provides broad public benefits with no specific beneficiaries, then the costs of mapping should be borne by the general public. The level of government responsible for the mapping is also a concern. Early flood and erosion hazard mapping was handled by the USACE (Walker, 1971; USACE, 1971). However, in the Great Lakes region, the states seem to have taken on the responsibilities for much of the mapping. California's Coastal Plan attempts to transfer to local governments much of the responsibilities for shoreline land use planning, including hazard mapping (Williams, 1978). However, local governments typically operate under conditions of inadequate finances, shortages of trained personnel, and the lack of existing hazard data. Although the use of consultants was found to be feasible alternative, permanent staff to interpret the hazard maps was still required for the program to be effective (Williams, 1978). Given that there are often local-level conflicts between shoreline management and economic development, transfer of responsibility for hazard mapping to local governments seems questionable.

In the U.S., Michigan, New York, and Pennsylvania require that homes, businesses and other structures be set back from the bluffs' edge, and have developed some mapping along with Illinois and Ohio. Much support was given to the idea of hazard land mapping at the GDIs, with the belief that we must first be aware of the problem areas before we can establish solutions.

Because many programs are based on information derived from hazard maps, errors in the maps can have important effects. Daniel and Williams (1977) provide a detailed description of the sources of error in defining flood hazard areas, and the types of costs associated with those errors. Briefly, errors result from improper reasoning, the lack of information, and the uncertainty about the natural processes contributing to the hazard. By overstating the hazard, property values in Canada and the U.S. may suffer due to poorly marked zones. There are also social costs if the hazard overstatement results in less than optimal development of a flood or erosion zone, which is especially likely in flood fringe areas and can have important effects in areas with significant growth potential. Public costs would be incurred by higher infrastructure costs, especially for sewer facilities.

At the Measures Workshop in Detroit it was suggested that hazard maps include coastal barrier mapping, 30 year erosion zone mapping, and wave run-up mapping. It was also suggested that erosion hazard zones and flood hazard zones be mapped for the Great Lakes. A final suggestion was to make hazard maps a mandatory part of the legal property transfer documents which can be linked with the notion of disclosure to be discussed later.

d. Information Coordination and Exchange

Intergovernmental and interuniversity cooperation on the Great Lakes research has been becoming more frequent in recent years (Christie et al. 1986). The U.S. government has encouraged state shoreline management initiatives through cost sharing arrangements under the Coastal Zone Management Act of 1972. The Council of Great Lake Governors was established in 1982 to provide a forum through which its six member states could work together to achieve common environmental and economic development goals. Its members include the governors of Illinois, Indiana, Michigan, Minnesota Ohio, and Wisconsin. New York, Pennsylvania, Ontario and Quebec actively participate on issues of common concern (The Center for Great Lakes, 1988). International organizations such as the International Association for Great Lakes, the International Joint Commission, and the Great Lakes Fisheries Commission enhance interaction cooperation through symposiums, workshops, and studies such as this one. In addition, organizations such as the Center for the Great Lakes, Great Lakes United, Great Lakes Tomorrow, The Great Lakes Commission, and the Great Lakes Coalition all have members and / or contacts on both sides of the border. The Sea Grant College Program in the U.S. has an informal network of communications established. In Canada the federal government and the Ontario and Quebec governments have cooperated on facets of shoreline management, most notably in hazard mapping. In Ontario, the Ministry of Natural Resources works to coordinate the various Conservation Authorities within the basin.

In addition to the above mentioned initiatives, suggestions brought out at the Measures Workshop included a Great Lakes Basin Information System involving the development of a binational interagency information system to develop collaborative land and water use planning and research initiatives, (i.e., sand transport and lake level trends and processes). It was suggested that any data gathering, (i.e. shoreline surveys), have U.S. -

Canada compatibility. Some future research concerns included the identification of present and future infrastructure capacities that would promote proactive planning for safe development and the identification of public access to the shoreline.

e. Disclosure

Disclosure involves the revealing of real estate located within a hazard land prior to the sale of the property. Presently, only Wisconsin has a disclosure policy. In this state, real estate transactions forms must be filled as part of the land transfer and the seller must tell the prospective buyer of flooding hazards. Erosion and other hazards need not be disclosed. In Ontario, the township of Norfolk, (on the north shore of Lake Erie), is attempting on a trial basis, a policy whereby building permits for new structures to be located within hazard land areas may be permitted, providing the owner has assumed full responsibilities for the risks and the property deed has been changed to disclose the structures' location within a hazard area.

Although disclosure is not presently a widely used policy, it did receive a fair bit of attention at the Measures Workshop. Most felt that people should be entitled to information about property they intend to buy before making their decision. Some opposition to this idea was raised at the GDIs when the topic came up. Some riparians and local politicians felt that this was infringing on the rights of the seller. But, generally the feeling was positive towards disclosure. It was also suggested at the workshop that disclosure should be a mandatory part of the U.S. National Flood Insurance Program.

SECTION 8

TYPE 5 ACTIONS

INTRODUCTION

The Type 5 Measures include potential actions governments can take during an emergency, (or in anticipation of one), to alleviate the problems caused by extreme fluctuations of Great Lakes water levels. Most of these measures require little or no major construction. Any measures requiring a long period of time, (more than one year), would not be considered as effective short-term emergency actions. The Type 5 measures can be grouped into two categories: 1. actions to modify lake levels and outflows, and 2. government services and programs to provide a measure of relief to the Great Lakes users / interests affected by extreme high or low lake levels.

Actions to modify lake levels and outflows range from very localized action, such as weather modifications and the use of the Black Rock Lock, to massive intervention on the Great Lakes system such as storing water temporarily on Lake Superior. The effectiveness of weather modifications to modify lake levels is highly questionable while storing water on Lake Superior could have some limited but measurable success, as demonstrated in the summer of 1985. While the placement of sills at the lakes' outlets would have a significant impact on lake levels and outflows, it is also doubtful that these can be accomplished within a year's time. As mentioned in the early part of this report, no attempts were made to evaluate the effectiveness or practicability of these measures. The list presented in Table E-3-1 includes all possible actions assembled by the Measures Sub-Group.

Besides actions to modify lake levels and outflows, Governments can initiate a number of public service programs to alleviate the problems caused by extreme lake levels. These include financial assistance to construct temporary shore protection such as sandbagging, and information programs such as storm forecasting.

Type 5 actions would be taken during times of extremely high or extremely low water levels, so that either the consequences of these extremes could be reduced, or the actual water levels could be altered.

A REVIEW OF TYPE 5 ACTIONS

<u>Weather Modifications To Change Local Precipitation</u>

This action would involve seeding of silver iodide or dry ice from aircraft to promote the growth of ice crystal and encourage precipitation. It would take place in very small localized areas where atmospheric water is needed. Past experiments have increased local precipitation by up to 10 per cent. The impact on the Great Lakes is negligible due to the relative small amount of water which might be added to the Great Lakes. The experiment might in some situations reduce precipitation. Technologies for this action already exist and have been tried in the past. This would be a low cost scheme, (<$10 million), when tried on small scales. Examples have been tried on small localized scales in various parts of the world. Studies have also been carried out for Lake Michigan by the Illinois Water Survey.

Increase Niagara River Flows via Black Rock Lock

This action would involve the use of the existing facilities at the Black Rock Lock at the outlet of Lake Erie to increase the Lake Erie outflows by about 1,300 cfs. The technical feasibility of this measure was examined in the IJC Great Lakes Water Levels Task Force in 1987. This measure will have localized impact affecting navigation, water quality and other users of the Black Rock Canal. Impacts of levels and flows would be very minor. Assuming IJC recommendation in 1991, it will require 6 months to prepare a plan of operation for this action. No major construction is required, although repairs to the existing facilities would be required due to its present poor conditions. The U.S. Army Corps of Engineers is the operator of the canal, after agreement by Canada and the United States and thus would be the implementing authority. Implementing Costs would be relatively small since no major constructions are needed. Existing examples include the navigation locks at Sault St. Marie, Michigan, which have been used during the recent record high lake level period to increase Lake Superior outflows.

Storage of Water In Lake Superior

This action would involve reducing Lake Superior's outflow when Lakes Michigan-Huron and Erie levels are very high. The stored water on Lake Superior would be discharged downstream when conditions on the lower lakes improve. This would be accomplished by changing the operation of the regulatory facilities at Sault St. Marie, Ontario/Michigan. The geographic area of impact include local (St. Marys River) and Great Lakes St. Lawrence River system-wide. It might be possible, when conditions on Lake Superior are favorable, to store water on Lake Superior by up to 0.5 foot, with a lowering of about 0.3 foot on Lakes Michigan-Huron. A plan of action would be prepared within a matter of one month, and would be implemented within two months if the measure is to be effective. The action would be implemented by the IJC at the request of Canada and the United States. The operation of all control facilities would come under the supervision of the IJC. Operating and administration cost would be very low, (<$1 million). However, extensive flood, erosion, and other damages would occur on Lake Superior unless remedial measures are also taken. The issue of compensating the interests on Lake Superior should be addressed. Examples include the case when water was stored temporarily on Lake Superior during the 1985-1986 record high water conditions on Lakes Michigan-Huron. That emergency storage was suspended in September 1985 when levels on Lake Superior were also approaching extreme highs.

Storage of Water on Tributary Reservoirs / Streams

Tributary flows to the Great Lakes would be reduced using existing facilities in the watershed when Great Lakes water levels are very high if this measure were to be conducted. The stored water would be released when conditions on the Great Lakes improve. This action would take place throughout the Great Lakes watershed where control facilities exist, especially in the Superior, Michigan and Huron watersheds. To be effective, this measure should be implemented within two months, and it should be implemented by the local operators and governments who operate these facilities. This would be considered a medium cost, ($10-100 million), and would consists mainly of compensating the operators involved. Existing examples include the temporary reduction and cutoff of the Ogoki Diversion which has occurred in the past with very minimal impact on Lake Superior.

Outlet / Channel Enlargement or Sill Placement

This action would see the outlet channels of the Great Lakes be enlarged during very high water level conditions and the placement of sills when levels are extremely low. This action would be implemented at the outlet of Lake Huron (St. Clair-Detroit River System), the outlet of Lake Erie (Niagara River), and the outlet of Lake Ontario (various reaches in the St. Lawrence River). While the extensive nature of this scheme would exclude it for consideration as a short-term emergency measure, it could be implemented in the long term by Canada and the United States on recommendation from the IJC. Assuming implementation was possible, this would be a high ($1 million-1 billion) cost scheme. There are no existing examples of anything this size on the Great Lakes.

Manipulation of Existing Diversions

The amount of the diversions at the Long Lac, Ogoki, Chicago and Welland diversions would be adjusted to provide a measure of relief to the Great Lakes interests affected by extreme high or low water level conditions if this action were to be carried out. This is similar to Measure 1.3.1 except that in this case, the diversions will be operated according to emergency plans developed by the IJC or Governments. These adjustments would take place at the Long Lac and Ogoki Diversions, which divert water into the Lake Superior basin; the Chicago Diversion, which diverts water from Lake Michigan and discharges it into the Mississippi River; and the Welland Canal, which diverts water from Lake Erie to Lake Ontario. The area of impact includes specific sites of diversions, the Great Lakes - St. Lawrence River, the Mississippi River and the Albany River watershed. This measure should be implemented within a matter of several months to be effective. It would be implemented by Canada, the United States and the operators of the diversions. This could be a medium cost ($10-100 million annually for the duration of the emergency) measure. Existing examples include the minor changes in the Ogoki diversions that have been made in the past. Also, flows in the Welland Canal were maintained at the maximum possible during the record high water years of 1985 and 1986.

Regulate Water Withdrawal / Consumptive Uses

This action would reduce water withdrawal and consumptive uses in the Great Lakes Basin when lake levels are extremely low. It would likely be an action carried out Great Lakes basin-wide. A very rough estimate is that this measure would have a very tiny impact on lake levels and flows. This measure should be implemented within a matter of several months. The very tiny impacts on lake levels and flows, and the difficulties in regulating water withdrawal and consumptive uses, make this measure very questionable. The federal governments of both countries should be the implementing authorities as major social disruptions are expected and the financial losses would be in the millions of dollars. There are no existing examples on a scale such as the Great Lakes. Local governments have regulations and by-laws concerning non-essential use (such as lawn watering) when draught conditions exist locally.

Emergency Sandbagging and Diking Assistance

In times of high lake levels, this action would provide sandbagging and diking assistance to needy communities. In times of drought, this action would provide emergency water supplies by trucking or pipelines. Other assistance would include government loans to assist in rebuilding, repair, relocation or property acquisition, and engineering advice on shore protection works. This action could take place throughout the affected shoreline on the Great Lakes - St. Lawrence River system. This action is to be implemented by federal and local governments when situation arises. Under emergency conditions, preventive local measures like sandbagging can be implemented in a few days or weeks. Repairs and relocation would require much longer. This would be a medium cost scheme ($10-100 million) for large areas but low cost for only local areas. Existing examples include various programs operated by local governments and by provinces and states. Also, the Corps of Engineers PL-84-99 Emergency Assistance Program was carried out during the 1985-87 record high water levels on the Great Lakes.

Government Programs For Disaster Assistance

This action would provide assistance to shore property owners who suffered major flood and/or storm damages. This action could be carried out throughout the Great Lakes - St. Lawrence River system. The time frame for implementation would vary depending on the programs, which themselves would be implemented by various levels of governments. Implementing costs will depend on factors such as the nature of the storm/flood event, area affected, and government budget. In the United States, existing examples include the Corps of Engineers Great Lakes Emergency Measures Program (PL-84-99, Advance Measures and Emergency Assistance Programs) which were implemented during the 1985-87 record high water levels. Also, under true emergency conditions, an area can be declared a "disaster area" making other government assistance available.

Storm Forecasting

This action would see the development of information centers responsible for collecting, analyzing and disseminating Great Lakes water level, flow, shore erosion, storm forecasts and other related information. This information could be passed along for inclusion in local weather radio broadcasts to inform boaters and shore residents on water level and storm information in their particular locale. This action would take place in any major Great Lakes urban area easily accessed by the general public. About one year would be required to have the centers operational, but the center could be set up within a matter of weeks for emergency operations. Implementing authority would be Environment Canada in co-operation with the Province of Ontario. In the United States, the center could be operated by the Corps of Engineers with assistance from the states and NOAA. This would be a very low cost scheme (<$1 million per year) for each center. Existing examples include Environment Canada's Great Lakes Water Level Communications Center, and the U.S. Army Corps of Engineers' Great Lakes Water Levels and Forecasting Information Center.

Diking and Other Protective Works in The St. Lawrence River

This measure would be very similar to Measure 1.4.2, except that this would be implemented as an emergency measure and hence protection of lands and other shore properties from imminent flooding is paramount. This action would protect low lying and other vulnerable areas in the St. Lawrence River. It would need to be implemented within a matter of weeks if this measure is to be effective, and should be implemented by Canada and the United States for works necessary in the International Reach of the St. Lawrence. Canada, Ontario and Quebec would be responsible for works in the Canadian Reach of the St. Lawrence River. This could be a medium cost scheme ($10-100M). Existing examples include protective dikes that have been placed in certain parts of the St. Lawrence River in the past.

SECTION 9

TYPE 6 ACTIONS

INTRODUCTION

This section discusses the rationale for establishing Type 6 - Combinations of Actions. It also provides a general description of several combinations.

As described earlier in this annex, all measures identified in this study have been grouped as follows:

Type 1 - Regulation and Diversions
Type 2 - Land and Water Adaptations
Type 3 - Restrictions on Land and Water Use
Type 4 - Programs to Influence Use
Type 5 - Emergency Response
Type 6 - Combinations

Since measures under Type 5 are essentially short-term emergency measures, none of them have been considered in the formulation of the Type 6 measures, but could be used independently to deal with short-term emergency situations.

APPROACH IN DEVELOPING TYPE 6 ACTIONS

There are some general logical guidelines that can be applied to the development of combination measures. These guidelines are as follows:

a. A combination measure is made up of two or more measures. They may fall within the same type OR combine any number of types.

b. Each of the measures that are considered for combination should have positive, practical qualities which make it a potential candidate for combination.

c. The combination of measures should be done in such a way that they enhance each measure's effectiveness. Measures that conflict or reduce each others effectiveness should not be combined.

d. Combination measures should be responsive (to the extent possible) to extremes of water levels and the full range of fluctuations.

e. Combination measures should provide the creative opportunity to attempt to mitigate basin-wide, regional and local problems and should be devised with this spacial context in mind.

The above guidelines and considerations will enhance the development of some meaningful combinations of measures. The list presented in this annex is by no means final or complete. Other combinations should be considered as the Study progresses into Phase 2 and more information and better understanding emerge.

A REVIEW OF SOME COMBINATION ACTIONS

Full Regulation of all the Great Lakes by Combining Full Lake Erie Regulation with the Placement of a Sill in the St. Clair River and Structural Setback Zoning

This measure is a combination of Type 1 (Measures 1.2.1 and 1.4.4) and Type 3 (Measure 3.1.1) Measures. More detailed information concerning these measures can be found in earlier sections of this Annex and in Appendices E-3 and E-4 of this Annex. The following is a summary of the discussion. The outflows of Lake Erie via the Niagara River would be fully regulated. The flows in the Niagara River would be increased or reduced, depending on the hydrologic conditions and the regulation objectives. The main objective in the present study is to reduce the range of water level fluctuations on Lake Erie, while maintaining, as much as possible, its long-term average monthly levels and seasonal fluctuation characteristics. Changes to the present regulation plan for Lake Ontario and remedial works in the St. Lawrence River would be required to accommodate Lake Erie regulation.

In addition, sills would be placed at the outlet of Lake Huron, in the St. Clair - Detroit River System, to compensate the lowering impacts on Lakes Michigan - Huron due to past dredging. A sill, or series of sills, placed at the outlet of a lake will change the lake's level and outflow relationship. With the added flow obstruction, the lake's water level would have to rise by certain amounts in order to discharge the same outflow. Another purpose of the sills would be to offset the impacts of climate changes which might cause significant reductions in the water supplies to the Great Lakes. In this study, the sills are intended to compensate the effects of past dredging only. This action would raise the water levels on Lakes Michigan - Huron to a slightly higher regime.

Thirdly, changes would be made to the present regulation plan for Lake Superior (Plan 1977). New monthly mean target levels for Lakes Michigan - Huron would have to be developed to reflect the desired new water level regime on Lakes Michigan - Huron.

Full regulation of Lake Erie would reduce its extreme range of total water level fluctuation. About 20-30 per cent of the water level impacts would be transmitted to Lakes Michigan - Huron due to the backwater effects. Thus, Lakes St. Clair and Michigan - Huron would also benefit to a smaller extent from Lake Erie regulation. Since Lake Superior Plan 1977 considers both the water level conditions on Lake Superior and Lakes Michigan - Huron in determining Lake Superior outflows, this combination is, in effect, total Great Lakes system-wide regulation.

Added to the above would be the implementation of regulations that would govern future development on flood and erosion prone areas along the Great Lakes shoreline.

Lake Erie Regulation would require channel enlargement at the head of the Niagara River, in the vicinity of the Peace Bridge, and the construction of a control structure at this site. These would offer the flow increase and decrease capacities, respectively. A series of Lake Erie trial regulation plans have been developed, with their impacts ranging from slight to large reductions in the range of Lake Erie water level fluctuation.

The geographic area of impact initially would be the extensive channel enlargement in the upper Niagara River, where the material to be removed is mainly rock in the fast moving river. The environmental issue relating to this excavation and dredged disposal should be addressed. Construction of the control structure would require cofferdams, which would alter the natural flow conditions. Upon completion, the area of impact includes local area caused by high or low flows / levels or sudden changes in these flows / levels, and Great Lakes - St. Lawrence River system-wide especially Lakes Ontario and Erie.

In the previous Lake Erie Regulation Study, it was noted that channel enlargements in the international reach and in the Canadian reach (Lachine Rapids) of the St. Lawrence River would be required to implement limited regulation of Lake Erie, using plans such as Plan 6L, 15S or 25N. Also, Lake Ontario Regulation Plan 1958-D would have to be modified to accommodate the inflows from Lake Erie under these plans. Preliminary studies thus far have identified similar remedial actions which would be needed for full Lake Erie regulation. Plans such as 50N are expected to call for more extensive works when compared with Plan 25N.

Placement of Sills would take place at the outlet of Lake Huron, or at the head of the St. Clair River. If existing water surface profile is to be strictly maintained, then a series of sills along the St. Clair River would be required. No sills are considered necessary in the Detroit River, partly because sills, on a smaller scale, have been placed in the past in this River. Another reason is that there have been no identified needs to raise Lake St. Clair's water level to a new regime. With the sills in place, water levels in Lakes Michigan - Huron would be about 0.6 foot higher than the pre-project regime. The seasonal or annual cycle characteristics would remain similar as before.

Structural Setback Regulations would apply to all areas along the entire Great Lakes shoreline that are severely threatened by erosion, especially undeveloped, or moderately developed areas. Erosion set-back lines should be developed for all shoreline reaches. Impacts of this action would be local and would depend on the degree of development already in place and the development pressure on the remainder of the shore.

Lake Erie Regulation would require two years to prepare final detailed engineering design and cost estimates, three years for construction. Implementation could start in 1996. This assumes that by 1996, the potential problems on Lake Ontario and downstream would have been fully addressed through Lake Ontario Regulation Plan 1958-D revisions and compensating works in the St. Lawrence River. Placement of Sills as a long-term measure would require extensive engineering studies and field surveys, and environmental studies that could add up to 5-10 years. Structural Setbacks might be applied to all the shoreline within 3 years. This is a rather optimistic estimate.

Lake Erie Regulation would be implemented by the IJC as a reference from Canada and the United States. Placement of Sills would be implemented by the IJC after agreement by Canada and the United States. Structural Setbacks would be implemented by State, Provincial and local governments.

Lake Erie Regulation would cost about $500 million to $1 billion, placement of Sills about $25 to $50 million, and Structural Setbacks costs in some area might be minimal, as most states and Ontario already have enabling legislation in place. Existing Examples include Lake Superior and Lake Ontario regulation, compensating dikes on a small scale in the Detroit River, and various government acts and legislation regarding land use and zoning.

Full Regulation of Lake Erie with Structural Setback Zoning

This is a combination of Measures 1.2.1 and 3.1.1. The descriptions of these measures appear in earlier sections of this annex as well as in the Appendices and therefore will not be repeated here.

Maximize Use of Existing Regulatory Structures / Procedures and Hazard Land Mapping and Public Education

As the title suggests, this measure does not call for new constructions or control structures to further control Great Lakes water levels and outflows. Rather, it would consider the use of all existing facilities built for regulation purposes, or built for other purposes, but are also being used in lake level/outflow regulation.

Under this measure, changes and update would be made to the present regulation plan for Lake Superior (Plan 1977), which would in turn change the method in operating the control facilities at Sault St. Marie. Improvements to Plan 1977 would include updating the plan's hydrologic parameters by expanding the set of water data to include the last 10 years of record, improving the hydrologic forecast feature in the plan, and incorporating larger flow capacity due to the recent completion of the Canadian power plant. Another improvement would be in the area of basin supply forecast using real-time hydrometeorlogical data, however this technique is still at the research stage.

Any improvements brought about by changing Plan 1977 might be slight. In terms of levels on that lake, it might mean a very slight reduction in the total range of level fluctuation on both Lakes Superior and Michigan - Huron.

Changes would also be made to Lake Ontario Regulation Plan 1958-D, after a thorough examination of the flow constraints in the St. Lawrence River which were factors taken into consideration in the development of the plan. As new information emerges due to changing environmental and other economic conditions along the St. Lawrence, it might be possible to improve the plan and thus not only manage the lake level slightly more within the acceptable range, but also eliminate the necessity of extreme high or low flows in the St. Lawrence River, or sudden and wide changes of these flows.

The following lists the existing regulatory structures. On the St. Marys River at Sault St. Marie, Ontario/Michigan, the existing regulatory structures include the 16-gated control structure called the Lake Superior Compensating Works, the hydroelectric power plant operated by Great Lakes Power Company in Canada, two power plants in the United States operated by Edison Sault Electric Company and the U.S. Government, respectively, four navigation locks in the U.S., and one lock in Canada. All these works are operated in unison to discharge the Lake Superior outflows specified by Regulation Plan 1977.

On the St. Lawrence River at Cornwall, Ontario/Massena, New York, the existing regulatory structures include the Robert Saunders Power Plant operated by Ontario Hydro, the Robert Moses Power Plant operated by New York Power Authority, the Long Sault Dam and the Iroquois Dam, which is located some distance upstream of Cornwall. The power plants are the principle regulatory structures and discharge the Lake Ontario outflows specified by Regulation Plan 1958-D.

Control facilities not included in this measure are all existing major diversions such as the Long Lac, Ogoki, Chicago and Welland diversions. These are studied as separate Type 1 measures. Also, excluded is the use of the Chippewa - Grass Island Pool Control Structure located near Niagara Falls. This structure was built for local water level regulation and efficient diversion of Niagara River water for power purposes. Recent field tests did not identify any measurable effect on Lake Erie outflows due to operation of this control structure.

Some update and improvements have been made to Plan 1977. However, these would have to be evaluated before full implementation. A period of 3 years might be required for evaluation and for obtaining the necessary approval. Lake

Ontario regulation improvement study is on-going and will take a much longer period, due to the need for surveys, basin modeling, plan revisions and evaluation, etc. A period of 5 years or more might be required to implement an improved Lake Ontario regulation plan.

This action would be implemented by the IJC after agreement by Canada and the United States. As no construction is considered, this would be a low cost option (<$10 million). Existing examples include Lakes Superior and Ontario Regulation.

SECTION 10

IMPORTANT ISSUES RELATED TO ACTIONS

INTRODUCTION

The list of actions developed for this Reference is quite extensive and includes many actions that are currently in place, or have been tried previously. It also includes a number of actions that are relatively new to the Great Lakes. One of the most important issues that has arisen in this Reference is the past preference for Type 1 Actions over and above all the other types. This stems in part from the fact that they are preferred by the most vocal interest group, the riparians, and as such, the study seems to be addressing them in more detail. The importance of all other types of actions, especially the non-structural, or shoreline management actions need to be addressed in more detail. Many of these types of actions will be needed to be used, even if water levels are controlled, and as such, the importance of these actions needs to be given more attention. This section discusses some of the previous problems experienced with the implementation of Type 2, 3, and 4 actions, in an effort to try and understand ways in which they can be better implemented. Direct recommendations on how to better use these actions are also provided.

TYPE 2 AND TYPE 3 ACTIONS

The phrase, "many have tried, but few have conquered" applies nicely to Type 2 and 3 actions. Many of these actions have been tried, but few have had success against reducing shoreline erosion, or eliminating shoreline damages. Why has this been the case? Jessen et al. (1983) cite poor administration and enforcement as the reason for failure of non-structural regulations in the region of Haldimond - Norfolk on Lake Erie. Davidson-Arnott and Keizer (1982) point out that the durability of private shore protection structures is reflective of poor design and construction of the structures and lack of communication among property owners. Nowak (1988) and Rooney (1988, personal communication) discuss failure of these types of actions with regard to the criteria of social acceptability and institutional implementability.

Governments, during past high, or low water crises, have always had a high degree of concern about the impacts on the regions under their jurisdiction. In most cases, this concern was "crisis-oriented", that is, "levels are high <u>now</u>, what can we do <u>now</u>?" Very little thought was ever given to the question, "what can be done <u>now</u>, to prevent these impacts from happening <u>again</u>?" This is where Type 2 and 3 actions come in to play. With the exception of community protection works, (although it could be argued that they are preventative actions), all the actions in these categories are designed to help prevent or reduce future shoreline damages, or to help humans adapt to the water level fluctuations and shore processes that do occur.

This issue of why many Type 2 and 3 actions have failed in the past and why agencies and the public are often reluctant to aggressively apply them (when compared to Type 1 actions), is perhaps a key issue for this Reference. This section of the measures report will outline this and a number of other issues, especially as they pertain to Type 2 and 3 actions, and will provide some suggestions on how these actions can be better used and understood.

Type 2 Issues

One of the key issues regarding Type 2 actions is the inability of governments and the public to use them successfully. This applies primarily to the construction of shore protection works. Many of these devices are installed by private landowners who may or may not obtain any professional technical advice prior to implementation. The number and types of assistance programs available for construction of protection devices varies from state to state and from municipality to municipality, while the approval process (where it exists) for installing these structures usually takes longer than shore owners are willing to wait. This sometimes results in the construction of piece-meal, poorly engineered devices, that fail within a few years of construction. In addition, many structures are built without any regard of what their impact is on the shoreline environment. Thus, in some cases, protection structures actually result in greater shoreline erosion, loss of biological habitat, and interference with other natural shoreline processes, not to mention the negative aesthetic impact that they can have. Focus has also always been on "hard" structural protection works. Many "soft" protection actions such as beach nourishment and vegetation planting work equally as well, or in some cases, better than hard structures.

The "Acquisition and Relocation" actions in the Type 2 category suffer many of the same "implementing problems" as Type 3 actions. This includes reluctance, lack of enforcement, and the scale of application. These points are discussed in more detail in the following section on Type 3 issues.

Type 3 Issues

In many previous studies, including past References, a number of Types 3 actions were recommended, but were largely ignored by those who were meant to benefit from them. The reason for the failure of these types of actions is twofold, and has to do with the administrative will of governments and the social acceptability of the actions themselves.

There are a number of "governmental" reasons why these types of actions have failed in the past. First and foremost is the fact that governments seem to lack the political and administrative will to put these actions in place. Governments are sensitive to the needs of their local constituents and tend not to want to disturb these people, lest they lose votes, or decrease the tax base. Thus, regulations and actions, some of which may require shore owners to drastically change their lifestyle, or make major adjustments (which may force them to move), are disfavored by governments simply because of the effect that these regulations might have on shore owners.

A second governmental problem, which can apply equally as well to Type 2 actions, has been a lack of continuity of implementing previous actions. Some municipalities, for example, enforce setbacks, some do not. Some municipalities build community protection, others do not. This type of situation has led to the occurrence of regulatory "oases", and has led to continued development in hazard areas in those municipalities that don't enforce regulations. This in turn "penalizes" the conscientious municipalities, as shoreline related tax base and construction related jobs move elsewhere.

Related to this is the question regarding the scale of application of these types of actions. The multiplicity of local jurisdictions makes effective uniformity in implementation hard to attain, let alone maintain over time. It is obvious that some regional coordination, along with the elevation of the regulatory process, is needed to prevent serious problems from occurring and to ensure uniform implementation of Type 2 and 3 actions.

As mentioned, enforcement of Type 3 (and some Type 2) actions has also been a problem. If the odds of being caught are small, or if the penalty is minor, regulations may be ignored by a proportion of individuals or developers. This has and could lead to a serious inequity between those who abide by the regulations (and are economically "penalized" for doing so) and those who pay no heed, but receive an economic "reward." In some situations, penalties for violations are so small, that they are viewed by developers as part of the cost of doing business.

Training of those that do the enforcing, and in fact, training of those who make the initial decision about whether or not to implement Type 2 or 3 actions is also a problem. Many local decision makers are ill prepared for the responsibilities they face in making these difficult decisions. Another problem is that the rate of turnover among these local decision makers is usually very high. This necessitates the need for constant re-training and reorientation to the problems at hand.

A further reason for resistance of Type 3 actions has to do with the problem of "the path of least resistance." In situations where publicly funded solutions (especially structural ones) to problems are perceived as easy to obtain, resistance to other actions, especially those that restrict land use, will be much greater. In other words, if there is a "quick fix," then more sensible, long term solutions may be ignored. For example, the federal government can fund (via cost-sharing alternatives) shore protection (a Type 2 action), but can't regulate land use (a Type 3 action). In a crisis situation, shore protection is an expedient, visible action that governments can take, and is thus perceived as being better than Type 3 actions.

Social Acceptability of Actions

The issue of "social acceptability" plays a key role in the implementation of Type 2 and 3 actions. Nowak (1988) describes social acceptability as the degree to which a measure is perceived or evaluated as congruent with the norms, values, and behaviors of the individuals or groups who will be influenced by the measures preference. This acceptability can be defined by five attributes: 1)permanence - the extent to which the measure is perceived to be durable or continuing; 2) relative advantage - the degree to which the measure is perceived to be superior to the situation or practice it is designed to replace; 3) compatibility - the degree to which the measure is perceived as being consistent with lifestyle, values, experiences and needs; 4) complexity - the degree to which a measure is perceived to be relatively difficult to understand, install or maintain; and 5) divisibility - the degree a measure is perceived to be capable of being adopted in part or on a trial basis without an irreversible commitment.

If we take the case of riparians and look at water level regulation (Type 1) versus setbacks (Type 3), as an example, we can see how this reluctance comes about. For water level regulation, it is obviously viewed as a permanent measure. Once installed, it stays installed. It thus has permanence. Riparians view regulation as being superior to their current situation. They would rather see controlled water levels, instead of wildly fluctuating water levels. Thus the measure has relative advantage. Installing regulation structures would not cause the shore owner any changes in their lifestyle, values, or experiences. They can continue to use the shore property the way they always have. Thus, the measure has compatibility. Finally, riparians view controlling the levels as a simple process; you build a dam, you build some gates, you control the flow through these gates and thus control water levels. In their mind, it is not a complex measure and is thus favored.

Setbacks are not permanent. A home may have to be moved again in ten years, so why move it now? Setbacks do not have relative advantage. They do nothing to stop water level fluctuations. They do nothing to reduce erosion rates. Setbacks are not compatible. Shore owners may have to move their house. They have to change the way they use their land, thereby interfering with their "shoreline experience." Setbacks can be viewed as complex. How do we move our home? Who decides where it can be moved to? How do they decide where it can be moved to? What is an erosion setback line? How is it calculated? What if we don't have enough property to move back on? etc., etc.

As mentioned previously, this reluctance to support other types of actions is a key issue in this study. Shoreline interests, most notably riparians, need to realize that water level fluctuations, erosion and storm activity on their own are not hazards, and that there are a host of other actions available, other than water level control, that can effectively deal with their problems. How then can this be emphasized? Well, first and foremost, governments need to have a strong political and administrative desire to put these actions in place. They need to send a message to shoreline interests that they are serious about implementing and enforcing Type 2 and 3 actions. This will require strong commitments to training and enforcement programs. It will require regional co-ordination with other levels of governments. Most importantly, it will require flexibility. These actions need to be developed and implemented, keeping in mind the social viewpoints of those who the actions will affect. No action can be designed that will not lead to unforeseen, inequitable, or illogical results. By being flexible and by making a strong commitment to these other types of actions, governments can go a long way towards reducing many of their shoreline "problems" and allow humans to live and work in harmony with the Great Lakes shoreline environment.

TYPE 4 ACTIONS

Historical Reasons For Not Using Type 4 Actions

Several issues relating to Type 4 actions (measures) can be examined by looking at the reasons Type 4 actions, with several important exceptions, have typically not been used to address fluctuating Great Lakes levels and their common attendant hazards (i.e., flooding and erosion). Much of the present non-use of Type 4 measures derives from the history of federal water policy (explicit and implicit) in the U.S. and Canada. In the U.S., structural protection (e.g., dams, levees) has traditionally been the primary approach to deal with flooding. This began when the USACE mission was interpreted in the 1930's as enabling that agency, which was after all a "Corps of Engineers," to use their engineering expertise to control floodwaters. When non-structural measures became accepted strategies for dealing with flooding, structural protection still won out due to biases in accounting schemes and the distribution of costs for the projects. In determining the worthiness of a measure, accounting schemes for structural protection measures included development expected in the "protected" hazard areas. In addition, the structural protection measures typically required little cost-sharing by communities benefiting from the measure. Thus, what community wouldn't opt for the measure (structural protection) that actually costs the residents the least and could even bring outside money (federal money) into the local economy?

Because the U.S. federal government had assumed responsibility for protecting communities from flooding, they also implicitly assumed responsibility for the relief of victims when the protection works proved insufficient or had not been installed. Thus, disaster aid, a Type 4 measure, became an important mechanism for dealing with flooding. After a while, disaster aid became expected; governments could hardly restrict assistance without loud cries to the media and legislative representatives. However, assistance rarely covered all types of costs actually incurred by flooding victims, and dissatisfaction with the amount, timing, and distribution of the aid was common. Feelings of "being used" surfaced when an area received aid repeatedly without changing their behavior to reduce their exposure to the hazard. Thus, the Type 4 measure first implemented, and probably the most widely known, may engender much negative feeling about Type 4 measures in general.

As early as the 1940's, but especially in the 1960's, realizations began to develop that existing strategies for coping with flood hazards just weren't working. Even though tremendous investments had been made to control floodwaters and protect communities, more damage was occurring than ever before, requiring more and more disaster assistance. It was obvious that flood damages were going up because people were putting themselves at risk by locating in floodways. A shift in the government's philosophy was made to begin to try and change people's investment decisions. Three additional strategies were developed to compete/complement structural protection and disaster aid. The primary new strategy was land use regulation. The focus on land use regulation may have really been a product of the times; governmental regulation as a whole was growing rapidly, encompassing many diverse aspects of society. Regardless, land use regulation actually had to be implemented in the U.S. on a local level, due to tradition and constitutional interpretation. The local-level tension between land use regulation and economic development has subsequently caused many to question the effectiveness of this approach. Because the land use regulations were local concerns, many people felt that federal government programs should also be expanded.

Insurance had generally worked for many other types of disasters (e.g. fire, accidents, hail), but was generally unavailable to compensate for flood damages due to reluctance on the part of private insurers; they simply thought the risks were too high and too concentrated to be profitable. However, insurance backed by the federal government was seen as workable. One of the primary assumptions behind the federal insurance program was that the insurance premiums would make the costs of locating in a hazard area more tangible; because insurance premiums would reflect the risks associated with a specific location, people would better understand their level of risk and that extra information would sway their investment decisions. However, like disaster aid, insurance dealt with compensating people after damage occurred and thus generated many of the same negative associations with Type 4 measures. Insurance rarely covered all types of costs actually incurred by flooding victims, and dissatisfaction with the amount, timing, and distribution of the compensation was common. In addition, insurance costs individuals and communities hard cash. Compared to structural measures, financed mostly by the federal government and with the potential to bring economic development to the community, insurance simply wasn't as attractive.

The third new strategy for coping with flooding in the U.S. could be easily implemented by any level of government. The strategy was to provide information to the public, with the assumption that many people built in flood hazard areas simply because they weren't aware of the risks. Brochures, reports, and presentations explaining flood hazards to the general public could be easily prepared and distributed. Information programs have been probably the most accepted Type 4 measure, because they are so innocuous. They don't require that anyone suffer before receiving their benefits, they don't require direct expenditures by those at risk, and they don't require any change in behavior. Who can dispute that providing more information is a laudable goal? Thus, of any of the Type 4 measures, information programs typically receive the most emphasis in actual agency implementation. The real question, however, is whether those programs are effective.

In Canada, governmental water policy has historically been laissez-faire. For some highly visible disasters, the provincial and federal governments have provided assistance, but generally only with reluctance, and at levels sometimes below those achieved by non-government fund-raising efforts. However, even in Canada, damages and disaster aid continued to rise as people more and more exposed themselves to the risks of flooding. Canadian citizens have different property rights than those of U.S. citizens which make land use regulation measures more practical in Canada. Governments also focused on information programs, much for the same reason as in the U.S.

This brief history of water policy in the U.S. and Canada highlights several of the issues that should be examined to ensure that Type 4 measures are properly considered for application to Great Lakes levels problems. Canada simply has little history of any measures for coping with hazards, except two Type 4 programs, disaster aid and information. The U.S. has focused on structural protection for flood control. Type 4 measures aren't as concrete as flood control works, they aren't as direct as regulation, and most Type 4 measures are more demanding of individuals and communities than information programs. Thus, with the exception of flood insurance, Type 4 measures are often considered new, unusual, not known well enough, and too risky to seriously consider when trying to compare measures on the basis of costs and benefits. Studies examining a broad range of measures often therefore dismiss Type 4 measures (with the exception of information programs) with broad statements rather, than detailed analyses. Those analyses are possible. They just require effort on the same scale as is typically given for structural measures. Even early phase analyses of structural measures often include detailed construction plans, site evaluations, hydrometeorological analyses, and funding alternatives.

In addition, except for information programs and disaster aid, Type 4 measures require that individuals take some action in concert with governments. Type 4 measures take more effort than simply letting an agency come in and construct protection works. They also may require individuals to pay more for their use of hazard prone areas, since many of the costs are presently transferred to other interests or to the general taxpayer. This often makes Type 4 measures less attractive to special interests than structural approaches that are funded largely from outside their own group or community. It should be noted, however, that increased cost-sharing requirements for local communities that want protection works may make this less of an issue.

Opportunities For Improving Type 4 Actions

Type 4 measures have often been used to cope with coastal hazards, particularly information programs, disaster aid, and insurance. However, there is general consensus that the use of Type 4 measures must be, and can be made more effective. To improve their effectiveness, several issues should be addressed. Probably the most critical issue is one of coordination and consistency. The many measures available for dealing with lake level extremes and erosion should work together to reinforce the idea that use of the lakes has inherent risks and that only those uses that can accommodate that risk should be made. Thus, measures should work to make the costs of those risks more tangible and applied to those who benefit from the lakes. Making disaster assistance contingent on the purchase of flood insurance or relocation, making recipients of emergency measures bear the costs of providing them through taxes, directing information programs at changing specific behaviors or attitudes about other measures, and removing the incentives for seeking variances from land use regulations, would reinforce this concept and help influence the overall response to fluctuating Great Lakes levels. Alternatively, regulation structures that may give people an unwarranted sense of protection from wind setup, tax abatements that would lower operating costs under extreme conditions, and unconditional and complete rehabilitation after extreme events, would undermine measures aimed at making the costs of decisions more explicit and directly borne by those who benefit.

To be more effective, Type 4 measures should also be available even when there is no crisis. Some people may be interested in taking advantage of a program only under extreme conditions (e.g. relocation). Unless the program is in place before the crisis occurs, conditions may return to normal and the public may become disinterested before the program is created and implemented. Others simply may not be able to take advantage of a program for the short period of time during a crisis. For example, shore protection works may require substantial investment on the part of the property owner, who may not have the resources during the one or two years that a partial grant program may be available. However, several years later, when conditions are not extreme, they may be able to afford the project in conjunction with the grant. Unless that program is still around, an opportunity to reduce their potential for loss has been missed. Also, information programs must constantly remind people about lake level fluctuations and approaches for coping with that variability.

TYPE 6 ACTIONS

Combination measures have not been given a great deal of treatment or development in Phase 1 of this Study. There are several reasons for this: first, only a relatively small number of measures have been developed to any level of detail prior to commencement of this Study; second, the study of combinations of different types of measures have not been attempted in the past for any number of reasons (i.e. different governmental levels responsible for different types of measures, different philosophies regarding dealing with fluctuating water levels, etc.), and thirdly, because there was no method or procedure available to evaluate combinations of different types of measures in some equitable fashion.

This Annex and its appendices describe some Type 6 measures in a preliminary way. The issue for Phase 2 of this Study revolves around the more detailed development of all types of measures, individually and in combination. Some decisions need to be made in terms of the further development of measures. Which individual measures deserve detailed treatment and how should they be selected? How can individual measures be combined in ways to enhance their individual characteristics? These are issues which should be addressed early on in Phase 2 so that work can begin in further detailed development of all types of measures. The evaluation framework (refer to Annex F) is a tool which can help to organize data about measures and their impacts in an organized and consistent fashion. Its further development and the further development of measures are linked and should be considered as an integrated task.

SECTION 11

PHASE 2 STUDY NEEDS

INTRODUCTION

The previous section discussed some issues relative to actions. This section will continue that discussion somewhat, but will focus on specific recommendations regarding actions that need to be addressed in Phase 2 of this Reference. While some of these recommendations apply specifically to Type 2, 3 and 4 actions, many deal with actions in general, and address the path the Study seems to be taking regarding these actions.

TYPE 2 AND 3 ACTIONS

As mentioned, one of the largest issues regarding these actions (most notably Type 3 actions) is reluctance by agencies and the public to enforce, or implement them. It is felt that some of this reluctance is due to a lack of knowledge about how these actions operate and about the benefits that they can provide. To better inform and educate agencies and the public, it is recommended that:

a. As a crucial part of Phase 2 activities, demonstration projects of Type 2 and 3 actions be undertaken, so as to show how the actions work and the benefits that they can provide. These demonstrations should be undertaken for specific shoreline types (urban, sandy beach, eroding bluff, etc.). It is initially proposed that the projects take place for Point Pelee, Ontario (a sandy beach / barrier with a mix of undeveloped, agricultural, recreational and residential areas) and Chicago, Illinois (an intensively developed urban shoreline); and

b. A primary goal for Phase 2, and indeed for the future, should be the development of a better education and information system, so that shoreline interests can become more aware of the details about all actions (including Type 2 and 3) available to them. This could be done through the development of information centers, development of better "Great Lakes education" courses in high school and university, or possibly courses for those thinking of purchasing shoreline property.

To evaluate all the potential actions that are being developed for this Reference, the PMT is developing, for use by governments, an evaluation instrument. In its ideal form, this instrument will judge each action on the basis of certain criteria, and will rank each action accordingly. In developing this instrument, a representative set of actions was put forth in order to test the operation of the instrument and its effectiveness in judging actions. There was, and still is, a good deal of concern that this representative list would be put forth as the list of actions that should be considered for future study, and that all other actions would not be considered further. To address this concern, it is recommended that:

c. While it is fine to use a representative list for testing the instrument, all potential actions should be run through the evaluation instrument (once refined) and judged accordingly, based on the appropriate criteria. Representative actions are just that (representative), and they are not meant to indicate any preference of one action over another. **All** actions must be evaluated fully in Phase 2.

In evaluating all actions, it is recommended that:

d. All the detailed quantitative studies that are now underway by FG2 and FG3 be completed and the data used appropriately in the evaluation instrument. Actions can not be accurately evaluated given the qualitative data that currently exists, and no evaluation should be done until these studies are completed in Phase 2; and

e. That the evaluation instrument is further developed taking into consideration the social acceptability of all the actions. There needs to be a detailed assessment of this acceptability for all actions, and this data needs to be incorporated into the instrument.

It is also recommended that:

f. Environmental concerns be given appropriate weighting in the assessment and evaluation of actions. The environment has often taken a back seat in previous References and it needs to be brought to the forefront in this Reference. Many of the actions proposed can have enormous environmental impacts on the shoreline area. These types of impacts need to be given priority along with economic impacts of other interest groups. To aid in assessing environmental impacts, it is recommended that:

g. The Geographic Information System (GIS) being developed by Functional Group 2, be used in concert with the evaluation instrument to better assess and evaluate the environmental impact of all actions. Recent demonstrations have shown that a GIS can be a useful tool for this type of analysis.

Finally, it is recommended that:

h. The Measures Sub-Work Group as it stands now, continue to be involved in the further development, analysis and evaluation of actions, and the development of the evaluation instrument. In this way, the comments and concerns of all Functional Groups can be heard, thereby helping to develop an evaluation instrument and technique that is easy to use, understandable to all, and fair to all actions.

TYPE 4 ACTIONS

The detailed analysis of Type 4 measures will not be an easy task. It will require a considerable commitment on the part of those given this responsibility. In effect the analysis of Type 4 measures has some catching up to do in terms of the relative past studies of specific measures. As with Type 2 and 3 measures, Type 4 Measures are not well understood by the public. Investigations into them as a viable option have been limited. Very few Type 4 measures are presently in place with the exception of the National Flood Insurance Program in the U.S., and hazard mapping. Unlike Type 2 and 3 Measures which have often been tried and were unsuccessful, Type 4 measures in many cases have not even reached the tried stage. There are many new and innovative ideas associated with Type 4 measures which attempt to put the onus on the public interest to take action themselves. If Type 4 measures have failed, it is generally because they were either not publicized or not understood. For example, loan programs put in place during 1985-86 were not widely publicized and consequently not often taken advantage of. For Type 4 measures to be effective they must be well publicized and utilized by the public. Type 4 measures, being dependent on public action, are useless unless they are adopted by the interests involved. For Type 4 measures to become an accepted option for governments, they must undergo further study into their capabilities.

It is important, therefore, that investigations to an equal level of development as the other types of measures be a goal of this Study. This will require a study team made up of policy experts and analysts, experts in various levels of government and their interactions, and experts who have dealt with natural hazards in other situations.

The MWG of FG3 found the Measures Workshop to be a very useful but limited exercise useful in the first study phase. This may be an appropriate mechanism to bring together officials at the state / provincial level in Phase 2 for review and comment on the more detailed development of the measures. They are not recommended for general use in the data gathering and detailed development portions of the Type 4 measures investigation. Instead, the MSG recommends that extended interviews be given to a survey sample of local government (i.e. towns, cities, counties, municipalities,and conservation authorities) officials to develop a current data base on Type 4 measures and an attitudinal survey of how they feel about them.

The detailed investigation of Type 4 measures would also require that the methods of implementation, costs, and benefits be determined. There are a number of consultants that deal in natural hazards and their mitigation. Experts in this area as well as those having backgrounds in governmental policy are needed to sort through the many questions that surround Type 4 measures.

Another recommendation would be that other agencies / organizations (both public and private) currently dealing in Type 4 measures be involved in the detailed investigation. The Federal Emergency Management Agency deals with flood insurance and natural disasters and is a good example of a U.S. agency involved in Type 4 measures. Other agencies / organizations in both the U.S. and Canada could be involved in the investigations.

SECTION 12

CONCLUSIONS

This annex report has attempted to increase the basic understanding of the range of potential actions that may be taken to deal with the problems caused by fluctuating water levels and shore processes in the Great Lakes - St. Lawrence River System. Types of actions have been discussed and defined in order to give a clear picture of what these actions would, and would not do. The questions of "Who Implements the Actions?" and "Who Pays?" have been discussed. While the specific costs of these actions can not be identified at this time, a discussion of this subject was also presented. Actions have been devised for high and low water level conditions, and some actions will work for the range of water levels, including extremes.

This annex report provides a firm foundation on which to build the inventory of actions. Now defined, some of the more difficult questions can be addressed as work continues on further development of these actions.

CREDITS

Annex E, the input to the main report, and the information contained in the appendices to Annex E were primarily the products of two groups with bi-national and inter-Functional Group representation that worked under the umbrella of the IJC Reference Study on Fluctuating Water Levels. These two groups are the Measures Sub-Work Group which was developed by the Project Management Team, and the Measures Work Group which has members from Functional Groups 1, 2 and 3.

The Measures Sub-Work Group developed the greater portion of the input for the development of all measures types presented in this annex. The primary contributors were:

James Karsten	Chairman (Corps of Engineers)
Peter Yee	FG1 Group Member (Environment Canada)
Christian Stewart	FG2 Group Member (Environment Canada)
Wendy Shoots	FG3 Group Member (Environment Canada)

Others whose contributions are acknowledged include:

Anthony Eberhardt	FG1 (Corps of Engineers)
Dieter Busch	FG2 (US Fish and Wildlife Service)
Ruth Edgett	Environment Canada
Leonard Shabman	U.S. Co-Chair, FG3
Barry Smit	Canadian Co-Chair, FG3
Reid Kreutzwiser	Canadian Co-Chair, FG2
Robert Roden	U.S. Co-Chair, FG2

The Measures Work Group consisted of: Peter Yee representing FG1 and responsible for measures' Types 1 and 5; Christian Stewart representing FG2 and responsible for measures' Types 2 and 3; and Holly Hartmann (National Oceanographic and Atmospheric Administration), Wendy Shoots, and James Karsten representing FG3 were responsible for the development of Type 4 measures. The group responsible for the development of Type 4 measures was assisted by the St. Paul District, a contract facilitator, and a number of experts at a workshop held in June 1988, and their contribution is gratefully acknowledged.

ANNEX E

APPENDIX E - 1

GLOSSARY

GLOSSARY OF TERMS

Accretion: Accretion may be either natural or artificial. Natural accretion is the build-up of land, solely by the action of the forces of nature, on a beach by deposition of water or redistribution of material by wind. Artificial accretion is a similar build-up of land by reasons of an act of man, such as the accretion formed by a groin, breakwater, or beach fill deposited by mechanical means.

Action: see "Measures"

Adverse Consequence (a common usage): Some negative implication of fluctuating water levels for a social, economic, environmental or political investment.

Aggregate Sensitivity Model: The link between the visual situation model(s) and the "what if" modelling capability, this step in the analytical process will describe those factors most sensitive or critical in resolving problems caused by fluctuating water levels in the Great Lakes, taking into account the range of measures and stakeholder interests under consideration.

Aggregate Visual Situation Model: 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.

Agreements: Joint statements among two or more governmental units on (i) criteria (purposes and goals) which should guide basin decision making, (ii) processes of decision making and (iii) authorities of governments to act. Agreements must be formalized in charters, treaties, letters of understanding, etc. Agreements serve to define the boundaries and constraints on choice of measures.

Agricultural Interests: These interests benefit 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.

Alternative Dispute Resolution (ADR): Decision making guided by professional experts and based on scientific management principles, but includes interest groups in developing and assessing alternatives and in making tradeoffs between alternatives.

Associated Costs: Costs incurred as a result of implementing a measure. There are two types of associated costs. (1) Cash costs are expenditures required of an interest in order to take advantage of a measure. (2) Opportunity costs are a change in the welfare of an interest as a result of a measure.

Bathymetry: The topography or relief of the lake bottom, as in the measurement of depths of water in oceans, seas and lakes; also information derived from such measurements.

Beneficial Consequence: Some positive implication of fluctuating water levels for a social, economic, environmental or political investment.

Commercial Fishing: Commercial fishing interests use the Great Lakes habitat and shore access services to earn income and sustain a lifestyle from sale of fish and fish products.

Commercial/Industrial: Commercial and industrial interests are those 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.

Compensation: Any expenditure received by an interest to mitigate costs imposed by a measure. Compensation may be in the form of money paid to those affected by an action, or it may involve creating similar conditions to the pre-project state to mitigate effects of the measure.

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.

Convergent Shores: The phenomena of converging shorelines; such as Saginaw Bay. Water-level fluctuations are exaggerated as shorelines converge.

Criteria: These are evaluative rules on some dimension of concern to one or more interests in the decision making process. Criteria are conceptual but must have operational (measurable in principle) components. Any single criterion can be used to judge the merits of a measure or policy along the dimensions encompassed by the criterion. Criteria are used to judge measures and criteria are used to judge the decision making process (for example, group access to the decision making bodies).

Crustal Movement: The change in level of the earth's surface at a location with respect to another location. Crustal movement is expressed as a differential rate of the change in level over time. This process is still continuing and effects differences in elevations.

Decision by Governments: A choice by government to spend money or to change laws and regulations to implement measures.

Distribution: An assessment of the effectiveness and efficiency of a measure, or combinations of measures, on a basis which considers all of the interests affected by a problem associated with fluctuating water levels. (For consideration within the evaluation framework).

Diurnal Tide: A tide with one high water and one low water in a tidal day.

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.

Drainage Basin: That part of the surface of the earth that is occupied by a drainage system of rivers and lakes.

Economic Sustainability: The objective of maintaining, at a minimum, the existing level of economic activity within the Great Lakes-St. Lawrence River Basin. Economic growth and development can be realized through greater productivity in the application of existing economic and natural resources so that these goals are not achieved at the expense of environmental, social, and cultural resources of significant value of society.

Ecosystem: The interacting complex of living organisms and their non-living environment. In the context of this IJC study, these concerns relate primarily to biophysical impacts within the coastal zone as a consequence of fluctuating water levels.

Educational and Learning Activities: Activities undertaken through the formal education system, in post-secondary settings, for the media, and in informal, public meetings. Example: supplemental curricular lessons and activities for secondary school students.

Effectiveness: The degree to which a problem associated with fluctuating water levels is resolved or made worse by implementation of a measure. (For consideration within the evaluation framework.)

Efficiency: A comparison of the benefits gained and the costs incurred in implementing a measure in response to a problem associated with fluctuating water levels. (For consideration within the evaluation framework.)

Electric Power Interest: 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 head, cooling water and steam power and therefore includes hydro power, nuclear power, and fossil fuel-fired electric power.

Empirical: Relying or based solely on experiment and observation rather than theory.

Environment: The natural conditions and resources fundamental to sustaining life and the well-being of mankind and wildlife. In the context of this IJC study, these concerns relate to the ways in which fluctuating water levels affect such interests as domestic water supply and sanitation, agriculture, recreation and tourism, use of shore property, both public and private, flood control, and wildlife habitats.

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.

Environmental Interests: This class of interest is primarily concerned with the environment in its own right and not with any specific use or exploitation from the Great Lakes Ecosystem. The class is represented primarily by naturalist and conservation groups and government agencies with a mandate of preserving 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 riverbed by the action of waves and currents. Shoreline erosion on the Great Lakes is most often a result of the combined action of waves and currents.

Evaluation: The application of data, analytical procedures and judgment related to criteria to establish a judgment on the merit of a measure, policy or institution. Evaluation is a process which is 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, components of the environment, stakeholders, and stakeholder interests.

Evapotranspiration: The loss of water from the soil by evaporation and transpiration (the passage of water from plants through membranes or pores).

Governance System: The complex of interest, policy and institutions which result in decisions on measures that are adopted over time.

Government Interests: These interest include all levels of government, local, regional, state/provincial and federal.

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 technique used in the field of 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.

Hanging Dam: A form of ice jam.

Hydrodynamics: A branch of science that deals with the motion of fluids and the forces acting on solid bodies immersed in fluids and in motion relative to them.

Hydrometeorology: A branch of science concerned with the study of the atmospheric and land phases of the hydrological cycle, with emphasis on the interrelationships involved.

Ice Boom: A structure installed to aid in the formation and maintenance of an ice arch at the head of a river, and thus reduce the adverse effects of ice on river levels and flows.

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

Ice Retardation: The difference between the amount of water discharged at given lake and river stages under open water conditions and under ice conditions.

Impact Matrix: A display which contains across-the-board assessments of how the various measures analyzed impact on the natural environment and all identified stakeholders and their interests, using the criteria agreed upon in the evaluation framework.

Implementation Cost: There are three costs that governments must assume when implementing any action; the initial or capital cost of implementation, costs associated with operation and maintenance of an action, and any compensatory costs.

Implementability: The ability to put into effect a measure considering factors of engineering, economic, environmental, social and institutional feasibility. (For consideration within the evaluation framework).

Implementability and Political Acceptability: The coalescence of sufficient support to endorse a measure and the identification of a legal or institutional mechanism able to be applied to put the measure into effect. The greater the breadth of support, agreement, and consensus among affected interests, the more likely is the measure to be politically acceptable and implementable. The more demonstrable the feasibility of a measure, in its engineering, economic, environmental, social, and financial aspects, the more likely it is to be politically acceptable and implementable.

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 implementation of measures.

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

Interest Classification System: A categorization of the different types of impacts caused by fluctuating water levels. Envisioned as part of an Impacts Matrix whereby the affects of introducing various measures on each area of impact can be displayed.

Investment: Expenditure made by an interest in one time period to capture benefits in another period. The investment decision presumes knowledge and understanding of future risks and uncertainty.

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

Lake Years: A hydrologic year considered to begin in August.

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.

Low Water Datum: The plane on each lake to which navigation chart depths and Federal navigation improvement depths are referred. Also referred to as Chart Datum.

Marsh: see "Wetlands".

Mass Transfer Relationship for Evaporation: An application of Dalton's Law, where evaporation is considered to be a function of the wind speed and the difference between the vapor pressure of saturated air at the water surface and the vapor pressure of the air above.

Measures: Any action, initiated by a level(s) of government to address the issue of lake level fluctuations, including the decision to do nothing. Measures are defined by three elements. The first element is the specific investment or action intended to affect the land and water resource and/or the human use of the land and water resource. The second element is the manner in which the socio-economic cost burden for an action is distributed (i.e. who pays?). And the third element refers to the implementing authority (i.e. who is responsible for executing and enforcing the action). Actions have been classified into six types:

<u>Type 1 - Regulation and Diversions</u>: Any engineering action which can alter Great Lakes water supplies, water levels and flows.

<u>Type 2 - Land and Water Adaptations</u>: Actions which involve government investment to adapt to or modify local land and water use in an effort to adapt to water level fluctuations and natural shore processes.

Type 3 - Restrictions on Land and Water Use: Actions whereby governments restrict how interests may use the land and water of the Great Lakes Basin.

Type 4 - Programs to Influence Use: Public programs and policies to provide information and alter financial incentives to influence the ways in which interests make decisions about the use of the land and water.

Type 5 - Emergency Response: Actions by governments to emergency situations. These are short-term measures to ease immediate problems.

Type 6 - Combinations: Two or more of the above types of actions combined to address the issue of fluctuating water levels.

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

Negotiation: The process of seeking accommodation and agreement on measures and policies among two or more interests having initially conflicting positions by a "voluntary" or "non-legal" approach.

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, and the inflows to the lake and the outflows from it.

Physiography: A descriptive study of the earth's surface.

Policy: Policy may cause certain positions to be taken by the governments without evaluation, and may result in positions of other interests to be discarded or accepted without evaluation.

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 are based upon an evaluation process. Positions may be directly stated or may be inferred by 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.

Recreational Interests: Non-riparian recreation interests include individuals, some of which 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. These interests seek 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.

Regression Equation: A mathematical expression which statistically relates two or more variables.

Regulation: In accordance with a rule designed to accomplish certain goals. In this study, the term applies both to controls of water levels and controls of land and water use.

Riparian: The interest group is comprised of very many individuals, some of which are represented by various coalitions and associations with a wide range of organization and political strength.

Riparians: Persons residing on the banks of a body of water.

Robustness: The breadth or depth across fluctuation effects or across stakeholders of the effectiveness of a measure in resolving a problem associated with fluctuating water levels under a variety of changing conditions. (For consideration within the evaluation framework).

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

Seiche: A standing wave oscillation of a body of water that continues, pendulum fashion, after the cessation of the originating force.

Sensitivity: The degree to which an interest is effected by, receives benefits from, or suffers consequences of, water level fluctuations. Sensitivity is related to the preparedness of the interest to the effects of levels and the ability of the interest to adapt. (see also "Adverse Consequence - FG3 Operational Definition).

Snowpack Water: The depth of water which would result from the melting snow cover of a given area.

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 needs should be achieved (paid for) along with other competing requirements of society.

Socio-economic Conditions: Pertaining to the demographics of a region.

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.

Steady-state: No change over time.

Systems Approach: An analysis which is structured in such a way as to identify the many interrelated problems and interests affected by fluctuating water levels in the Great Lakes-St. Lawrence River Basin. This means an overriding concern that all aspects of the problems associated with fluctuating water levels be analyzed and evaluated, and their linkages be identified and weighted as to the degree of sensitivity in the system.

Transportation Interests: 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 sub-classes: ocean going and lake carrier shipping companies, often represented by shipping associations, and 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.

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 from rural 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.

Wetlands: "Lands where the water table is at, near or above the land surface long enough each year to support the growth of hydrophytes (plants which prefer wet conditions), as long as other environmental variables are favorable." (Cowardin, et.al., 1977) Along the Great Lakes shoreline they include marshes, swamps and other lands generally considered to be potential havens for fish and wildlife areas.

"What If" Modelling Capability: The ability to simultaneously determine the impacts of many different stakeholders and their interests in response to the implementation of a wide range of measures to deal with problems associated with fluctuating water levels in the Great Lakes-St. Lawrence River Basin.

ANNEX E

APPENDIX E - 2

BIBLIOGRAPHY

APPENDIX E-2

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ANNEX E

APPENDIX E - 3

ONE PAGE SUMMARIES OF THE INVENTORY OF MEASURES

APPENDIX E-3
INVENTORY OF MEASURES

This appendix contains a one page summary of all the measures compiled by the Measures Sub-Group. To ensure compatibility between measures, the following guidelines were used.

1. Description - It describes in simple term the nature and scope of the measure.

2. Location - It identifies the location of the measures or new structures that would be required. It also gives an idea of the area of impacts due to the measure.

3. Time Frame For Implementation - It gives an estimate of the time required to implement the measure. This assumes that the study will be completed in 1991. It also gives the length of the phase in which the measure is in place.

4. Implementing Authority - It identifies the levels of governments that would be involved in authorizing such measures, and the subsequent operations thereafter.

5. Implementing Costs - It gives a very rough estimate of the cost for each measure. For those measures that are under close examination, preliminary cost estimates are available. For other measures, only a very rough guess is given using the following criterion:

very low cost:	$ 1 million or less
low cost:	$ 1 - 10 million
medium cost:	$ 10 - 100 million
high cost:	$ 100 million - 1 billion
very high cost:	$ 1 billion or more

6. Existing Examples - it gives an example on where a similar measure exists.

The above guidelines were used in preparing a one-page summary on all the measures presented in this appendix. More detailed descriptions on representative measures are contained in Appendix E-4.

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MEASURE 1.1.1
MODIFY EXISTING REGULATION PLAN (PLAN 1977) FOR LAKE SUPERIOR

1. Description: Plan 1977 is the plan used in regulating the outflows of Lake Superior. It uses a water level balancing technique for Lake Superior and Lakes Michigan-Huron to determine the outflows that would provide systemic (levels) benefits for upstream and downstream interests. Facilities used in the regulation of Lake Superior's outflows are the 16-gated control structure, hydro-electric power plants and navigation locks, all located at Sault Ste. Marie, Ontario/Michigan. The IJC's International Lake Superior Board of Control supervises the operation of all works at the Soo so as to implement Plan 1977.

2. Location: Changes in the operation of the regulatory facilities at Sault Ste. Marie, Ontario/Michigan. The geographic area of impact include local (St. Marys River) and Great Lakes St. Lawrence River system-wide in terms of levels and flows.
The long-term average levels on Lakes Superior and Michigan-Huron are not expected to undergo any noticeable changes. The total range of fluctuations might perhaps be reduced by a very small amount, with a slight reductions in their peak levels and a slight raising of their lows.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it would take one year or more to implement the above unless major constructions are needed.

4. Implementing Authority: The IJC after authorization from Canada and the United States. Operation of the regulatory facilities will continue to be carried out by their owners and operators under the supervision of the IJC.

5. Implementing Costs: These can be considered low cost options (<$10M) since no construction of works is needed. Initial costs are about $0.5M with an annual operating cost of about $0.5-1.0M, mainly for hydrologic modeling and data collection. These costs would be shared by Canada and the United States through additional resources for the IJC and its Superior Board.

6. Existing Examples: Lake Superior's outflows are currently being regulated according to Plan 1977 as described above. Another example is Lake Ontario Regulation.

MEASURE 1.1.2
MODIFY EXISTING REGULATION PLAN FOR LAKE ONTARIO (PLAN 1958-D)

1. Description: Plan 1958-D is the plan used in regulating the outflows of Lake Ontario. It has the objective of maintaining the levels of Lake Ontario close to their long-term monthly averages, and at the same time provide safeguards to upstream and downstream interests. Facilities used in the regulation are located at Cornwall, Ontario/Massena New York, at the downstream end of the international section of the St. Lawrence River. The IJC's International St. Lawrence River Board of Control supervises the operation of all facilities in the International Section of the River so as to implement Plan 1958-D.

2. Location: Changes in the operation of the facilities at Cornwall, Ontario/Massena, New York. The geographic area of impact includes immediate area as well as water level/flow conditions on Lake Ontario and the St. Lawrence River.

The total range of levels on Lake Ontario might perhaps be further reduced very slightly. But levels and flows in the St. Lawrence River would experience changes that could be considered beneficial and adverse, depending on the changes to the regulation plan.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year to implement unless regulatory and remedial works are required.

4. Implementing Authority: The IJC after authorization from Canada and the United States. Operation of the control facilities will continued to be carried out by their owners (Ontario Hydro and New York Power Authority) under the direction of the IJC.

5. Implementing Costs: These are low cost options (<$10M) since no construction of works is needed. Initial costs for each would be about $1.0M with annual operating cost about $0.5M. Detailed field surveys of the St. Lawrence River might add another $1-2M.
These costs would be shared by Canada and the United States through additional resources for the IJC and its St. Lawrence River Board. Canada, Ontario and Quebec would share the costs of any additional work by the Ottawa River Board.

6. Existing Examples: Lake Ontario's outflows are regulated by the IJC using Regulation Plan 1958-D as described above. Regulatory facilities at Sault Ste. Marie, Ontario/Michigan regulating the outflows of Lake Superior.

MEASURE 1.1.3
RETURN TO PRE-PROJECT CONDITIONS

1. Description: Complete removal of all existing water level/flow and diversion control structures and remedial works, restore the outlets of all the Great Lakes to natural conditions, or operate these structures in a manner such that levels and flows of the Great Lakes would be exactly as Nature would have done "alone".

2. Location: Removal of all power plants, locks and other control structures at Sault Ste. Marie, Ontario/Michigan and return this part of the St. Marys River to natural or pre-development condition. Terminate all existing major diversions such as the Long Lac and Ogoki diversions, the Lake Michigan diversion at Chicago, the Welland Canal diversion, the New York State Barge Canal diversion. Restore St. Clair-Detroit River system to pre-dredging and pre-shoreline modification condition. Removal of all man-made obstructions on the Niagara River and all power plants and control works at Niagara. Stop further use of the ice booms on the Great Lakes. Removal of all power and navigation facilities in the St. Lawrence River.

The combined effect of all man-made actions listed above have some impacts (relative to natural factors) on the levels and flows. A return to natural condition is not expected to see a very different level and flow regime. The geographic area of impact would be at specific sites, with major social-economic and environmental disruptions.

3. Time Frame for Implementation: Engineering works and power plant decommissioning, for example, would take perhaps 20-30 years. Time required for society to adjust to this new era would take perhaps much longer.

4. Implementing Authority: Canada and the United States.

5. Implementing Costs: It is not unreasonable to estimate these in terms of billions of dollars. Massive government funding would be needed to compensate those interests affected by it. Government administrative cost would be very high.

6. Existing Examples: No known project has been tried anywhere in this world on such a grand scale.

MEASURE 1.1.4
BETTER COORDINATION BETWEEN LAKE ONTARIO AND OTTAWA RIVER REGULATION

1. Description: Lake Ontario Regulation Plan 1958-D was developed to provide some safeguard to downstream interests against extreme high flows or levels in the river. Thus the plan specifies maximum allowable outflows for various parts of the year. Prior to and during the Ottawa River annual spring runoff, the outflows from Lake Ontario have be to adjusted so as not to compound the problems downstream. This measure involves better coordinations, once identified, in the regulation of these two river systems.

2. Location: Changes in the operation of the facilities at Cornwall, Ontario/Massena, New York and the facilities on the Ottawa River. The geographic area of impact includes the local areas of these facilities and on the St. Lawrence and Ottawa River systems. Some further slight improvements, in terms of reductions in extreme level and flow fluctuations, for users in the St. Lawrence and riparians on Lake Ontario might be possible.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year to initiate. The measure is assumed to be permanent.

4. Implementing Authority: The IJC and the Ottawa River Engineering Board which is a Canada-Ontario-Quebec organization.

5. Implementing Costs: This can be considered low cost option (<$10M) as it does not require any major constructions. Annual operating cost would be about $0.5M. Additional data collecting/reporting and modeling effort will have some costs ($0.5M annually). The cost would be shared by Canada and the United States through additional resources to the IJC, the St. Lawrence River and the Ottawa River Boards. There might be also some cost due to losses or reductions in power generation on the Ottawa River which might require government compensation.

6. Existing Examples: Regulatory facilities on the Ottawa River are being operated under the direction of the Ottawa River Engineering Board. Currently, informal co-ordination takes place between the Boards via the various operating groups/entities of both regulation systems.

MEASURE 1.1.5
OPTIMIZATION OF BENEFITS USING MATHEMATICAL PROGRAMMING TECHNIQUE

1. Description: Evaluate the application of mathematical programming optimization techniques for overall Great Lakes system regulation. This involves models for evaluating: (a) how existing regulation can be carried out more efficiently; and (b) evaluating and comparing combinations of user-specified sizes, locations and operations policies of alternate regulation measures throughout the Great Lakes-St. Lawrence system.

2. Location: Existing regulatory/remedial and proposed works located in the Great Lakes connecting channels and the St. Lawrence River (see Measures 1.1.1 and 1.1.2). Expected results would be some small reductions in the extreme range of level and flow fluctuations.

3. Time Frame for Implementation: Significant work effort and data collection/surveys are required to develop this measure after which detailed socio-economic and environmental evaluations would have to be carried out. It is unlikely that this measure can be developed by 1991.

4. Implementing Authority: The IJC.

5. Implementing Costs: This can be considered a low cost option (<$10M) but a more precise figure is not possible at this time. The cost would be shared by Canada and the United States through additional resources for the IJC to conduct such studies.

6. Existing Examples: Regulation of the Ottawa River is an example although it is more concentrated on the production of hydro-power. Some efforts in carrying out such an optimization of the Great Lakes system was made by the International Great Lakes Levels Board in the early 1970's.

MEASURE 1.2.1
FULL REGULATION OF LAKE ERIE SUCH AS PLAN 50N

1. Description: Outflows of Lake Erie to be increased or reduced by up to 50,000 cfs depending on the hydrologic conditions and the regulation objectives. The main objective is to reduce the range of water level fluctuations on Lake Erie while maintaining its long-term average level.

2. Location: Channel enlargement and a control structure spanning across the river at the outlet of Lake Erie (Buffalo, New York/Fort Erie, Ontario). The control structure, to be located near the existing Peace Bridge, might include a bridge that could provide additional transportation link between Buffalo, New York and Fort Erie, Ontario.

The geographic area of impact includes local area caused by high or low flows/levels or sudden changes in these flows/levels, and Great Lakes-St. Lawrence River system-wide especially Lakes Ontario and Erie. Modifications to Lake Ontario Plan 1958-D and channel improvements in the St. Lawrence River would be required to cope with full regulation of Lake Erie.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take two years to prepare final detailed engineering design and cost estimates, 4-5 years for construction. Implementation could start in 1996. The measure is assumed to be permanent.

4. Implementing Authority: The IJC after authorization by Canada and the United States. The Province of Ontario and the State of New York need to be involved since the control structure and Niagara River channel enlargement will be located in their area of jurisdiction.

5. Implementing Costs: A very rough cost for the 50N Niagara River structure, including channel enlargement, would be about $400-500M (high cost scheme). The addition of a bridge would add perhaps another $75M. This does not include any cost due to Plan 1958-D modifications or remedial works necessary in the St. Lawrence River. Cost would be shared by Canada and the United States.

6. Existing Examples: Regulatory facilities at Sault Ste. Marie, Ontario/Michigan regulating the outflows of Lake Superior, and at Cornwall, Ontario/Massena, New York regulating the outflows of Lake Ontario.

MEASURE 1.2.2

LIMITED REGULATION OF LAKE ERIE SUCH AS PLANS 6L, 15S AND 25N

1. Description: Update Limited Lake Erie Regulation Plans 6L, 15S and 25N and their corresponding regulatory/remedial works requirements. These plans were developed in the previous IJC study and are intended to provide a limited regulation of Lake Erie. The regulatory works, all located at the outlet of Lake Erie, permit a range of flow increases (up to 25,000 cfs) but do not have flow reduction features. The objective of these plans is to lower the high water levels on Lake Erie and to minimize the impacts on Lake Erie when its levels are low or at average.

2. Location: All required regulatory works would be located at the head of the Niagara River at Buffalo, New York/Fort Erie, Ontario. These include: (a) Plan 6L: modifications to the existing Black Rock Lock, (b) Plan 15S: Squaw Island diversion channel, and (c) Plan 25N: channel enlargement and construction of a control structure in the Niagara River.

The construction and operation of these works will have localized as well as system-wide impacts, particularly on Lake Erie, Lake Ontario and downstream. Problems on Lake Ontario would be compounded unless changes are to be made to Lake Ontario Regulation Plan 1958-D and channel improvement and/or remedial works in the St. Lawrence River.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take 2 years to prepare detailed engineering design and cost estimates, 2 to 3 years for construction. Implementation could start in 1996. The measure is assumed to be permanent.

4. Implementing Authority: The IJC after authorization by Canada and the United States. The Province of Ontario and the State of New York need to be involved since the works will be located in their area of jurisdiction. The same can be said for the Province of Quebec regarding the works necessary in the St. Lawrence River.

5. Implementing Costs: Plan 6L structure would cost about $15M, Plan 15S about $23M and Plan 25N about $176M., all at 1987 price level. Thus, these are medium to high cost schemes. These costs do not include any necessary works on Lake Ontario or the St. Lawrence River. Cost would be shared by Canada and the United States.

6. Existing Examples: Lake Superior and Lake Ontario regulation.

MEASURE 1.2.3
FULL LAKES MICHIGAN-HURON REGULATION

1. Description: Regulation of the outflows of Lakes Michigan-Huron and Lake St. Clair will require channel enlargement and a series of control structures in the St. Clair-Detroit River system. This measure would be carried out in conjunction with the existing Lake Superior regulation, and with the addition of Lake Erie regulation. The primary objective is to reduce the range of levels fluctuation on Lakes Michigan-Huron.

2. Location: St. Clair-Detroit River system. Channel enlargement would be carried out in narrow/shallow areas. A series of low-head control structures would be placed to regulate the flows, maintain existing water surface profiles, and provide navigation passages. The operation of these works will have local and system-wide impacts. Dredging and disposal of dredged material would be one of the major issues that need to be evaluated.

Some reductions in the total range of water level fluctuation on Lakes Michigan-Huron are expected, with a small lowering of the maximum and a raising of the minimum. The average level is not expected to change much.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take 2 years to prepare detailed engineering design and cost estimates, 3-4 years for construction. Implementation could start in 1997. The measure is assumed to be permanent.

4. Implementing Authority: The IJC after authorization by Canada and the United States. The Province of Ontario and the State of Michigan need to be involved since the works will be located in their area of jurisdiction.

5. Implementing Costs: This measure was examined in the Levels Board study which provided some rough cost estimates as well as very preliminary engineering design. These would have to be updated. This measure would be considered high cost ($500M-1B). The cost would be shared by Canada and the United States.

6. Existing Examples: Regulatory facilities at Sault Ste. Marie, Ontario/Michigan regulating the outflows of Lake Superior, and at Cornwall, Ontario/Massena, New York regulating the outflows of Lake Ontario.

MEASURE 1.2.4
REVISE EXISTING REGULATION FOR LAKE SUPERIOR (PLAN 1977) WITH A DIFFERENT OBJECTIVE SUCH AS MOD 77

1. Description: Evaluate the feasibility of modifying existing regulation plan for Lake Superior (Plan 1977) to allow for lower permissible levels, thereby adding additional potential storage capacity on Lake Superior. This measure was examined briefly in the IJC's previous Levels Board study.

2. Location: Changes in the operation of the control facilities at Sault Ste. Marie, Ontario/Michigan (see Measure 1.1.1). The geographic area of impact will be site specific and Great Lakes-St. Lawrence River system-wide, especially on Lake Superior which will experience lower levels as well as higher incidence of low levels when compared with present operation.

3. Time Frame for Implementation: Factors affecting the timing include dredging of harbours and marinas on Lake Superior, and the question of discharge capability of the facilities at the Soo at these new low ranges of levels. A rough estimate would be 5-10 years.

4. Implementing Authority: The IJC after authorization by Canada and the United States.

5. Implementing Costs: Initial costs would include about $0.5M for engineering and regulation studies; and perhaps <$10M to modify facilities at the Soo to handle a lower range of levels on Lake Superior. Channel and harbour improvements on Lake Superior would be a high cost item (>$100M).

6. Existing Examples: This practice is carried out on small watersheds and reservoirs where advantages and benefits are expected. Many Great Lakes harbours have been constructed and deepened throughout the system for many years.

MEASURE 1.2.5
CONTROL SUPPLIES TO THE GREAT LAKES THROUGH TRIBUTARY STREAMFLOW REGULATION

1. Description: A number of tributaries within the Great Lakes watershed are regulated for local needs (irrigation, power, recreation or domestic water supplies, etc.). Since tributary flows constitute a major supply of water to the Great Lakes, consideration should be given to regulating these flows in co-ordination with the Great Lakes water level fluctuations. Plans would be developed for those tributaries already regulated so that levels on the Great Lakes are a factor in determining their releases.

2. Locations: Existing flow control facilities on tributaries to the Great Lakes. Local reservoirs would be used to temporarily store water when Great Lakes levels are high. Improvements on the Great Lakes could be very marginal, whereas local impacts could be significantly adverse. No major constructions are assumed.

3. Time Frame for Implementation: The operation of local dams and reservoirs are often under private or local government jurisdictions. Any changes to their existing operating policies to benefit the Great Lakes could take many years to implement.

4. Implementing Authority: Local governments, owners and operators of dams/reservoirs.

5. Implementing Costs: This could be a high cost measure (>$100M). Compensations by Canada and the United States would be necessary.

6. Existing Examples: No known practice on any large scale.

MEASURE 1.2.6
CONSTRUCTION OF A NEW (6TH) GREAT LAKE

1. Description: Addition of a new artificial Great Lake to the existing system. The new lake would be located north of Lake Superior (outside the Lake Superior watershed). Local runoff that normally flows to the James Bay would be directed southward to either Lake Nipigon or directly to Lake Superior in times of drought on the Great Lakes. When high levels on the Great Lakes occur, outflows from this lake would be directed to the James Bay. The operation of this system would be entirely for the benefit of the Great Lakes.

2. Location: In the Albany River and Ogoki River watersheds. A series of dams, embankment and spillways would be built to form the reservoir. An area about the size of Lake Ontario would be made permanently flooded. Diversion channels would be cut across the drainage divide to connect with the Great Lakes. Local communities, towns, population would be re-located. Highways and railroads would be relocated. All vegetation and trees at the site would be cleared or burned.

3. Time Frame for Implementation: A project of such grand scale would take 20 years or more.

4. Implementing Authority: Canada and the United States and particularly the Province of Ontario and local Canadian native governments. The operation of the new Great Lake would be under the supervision of the IJC.

5. Implementing Costs: Not yet investigated in the current study. The C. Lorne Campbell idea of forming a new Great Lake is contained in a 1925 discussion paper by Wallace J. Laut, and entitled "A Canadian's Plan to Restore the Water Levels of the Great Lakes" The paper gave an estimated expenditure of $150-200M (1925 price level).

6. Existing Examples: The artificial formation of new lakes and reservoirs have been a common practice in the past, but none of them are of such magnitude as discussed here.

MEASURE 1.3.1
MANIPULATION OF INTERBASIN DIVERSIONS SUCH AS
LONG LAC-OGOKI AND CHICAGO DIVERSIONS

1. Description: The amount of the diversions at the Long Lac, Ogoki, Chicago and Welland diversions to be adjusted depending on the hydrologic conditions on the Great Lakes and the regulation objectives. Physical constraints include the hydrologic conditions on these watersheds and the discharge capabilities of the facilities involved. For example drought conditions on the Ogoki watershed would not enable more water to be diverted into the Great Lakes where levels are already low. Existing Welland Canal also restricts the amount that can be diverted.

2. Location: Long Lac and Ogoki Diversions which divert water into the Lake Superior basin; Chicago Diversion which diverts water from Lake Michigan and discharges it into the Mississippi River basin; the Welland Canal which diverts water from Lake Erie to Lake Ontario. These diversions already have some impacts on the Great Lakes, and their operations would be changed to benefit the Great Lakes rather then solely to meet local needs. The area of impact include specific sites of diversions, the Great Lakes-St. Lawrence River, the Mississippi River and the Albany River watershed.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take one to two years to implement unless extensive structural and remedial works are needed, especially those intended to increase the quantities of the diversions. The measure is assumed to be permanent.

4. Implementing Authority: Canada and the United States would have to agree. The operators of the existing diversions would have to be involved.

5. Implementing Costs: This could be considered a medium cost scheme (<$100M). For example, shutting off entirely the Long Lac and Ogoki diversions would incur an annual cost of about 15M.

6. Existing Examples: As described above. The diversions already exist and therefore it is primarily a matter of varying the amount of flow within existing capabilities for purposes of lake level management. Recent studies have been carried out by the IJC as described in its report to Governments, "Great Lakes Diversions and Consumptive Uses", January 1985.

MEASURE 1.3.2
INCREASE LAKES MICHIGAN-HURON OUTFLOWS VIA
INCREASED CHICAGO DIVERSION

1. Description: Increase the Lake Michigan Diversion at Chicago to up to 25,000 cfs with the objective of lowering the levels on the Great Lakes when they are very high. The diverted water would be discharged into the Mississippi River outside the Great Lakes Basin. This would require canal widening and flood-protection measures on the Illinois waterway and other channels.

2. Location: Chicago Sanitary and Ship Canal and diversion intakes on Lake Michigan. The impacts will be Great Lakes-St. Lawrence River system-wide as well as the facilities mentioned above.

3. Time Frame for Implementation: Unknown at this time. It is expected that several years would be required to expand the diversion facilities and protective works. An operational plan would also need to be developed by the IJC in conjunction with the operator of the diversion.

4. Implementing Authority: Canada and the United States would need to agree on recommendation from the IJC. The operator of the Chicago diversion would proceed under the direction of the IJC.

5. Implementing costs: This could be considered a high cost scheme (>$100M). Beside major engineering and construction works, extensive environmental studies would be required of the Chicago Sanitary and Shipping Canal.

6. Existing Examples: Chicago diversion already in place, with the diversion limit specified by the United States Supreme Court at 3,200 cfs.

MEASURE 1.3.3
INCREASE OR DECREASE LAKE ERIE OUTFLOWS VIA
MANIPULATION OF WELLAND CANAL DIVERSION

1. Description: Increase the diversion of Lake Erie water by way of the Welland Canal to lower Lake Erie water levels when they are high, and reduce the diversion when levels are low. Present flows in the canal are near the canal's carrying capacity and any higher flows will increase bank erosion and cause more traffic hazards. This subject was examined in the IJC Water Levels Task Force.

2. Location: The Welland Canal. The geographic area of impact include the canal itself which has a limited capacity, Lake Erie and Lake Ontario levels and to a lesser extent the other Great Lakes.

3. Time Frame for Implementation: Since no major structural works are required, this measure could be initiated at any time after IJC recommendation in 1991. Extensive shore protection and improved navigation operation would be required to facilitate perhaps a very small flow increase.

4. Implementing Authority: Canada and the United States. The canal is operated by the St. Lawrence Seaway Authority.

5. Implementing Costs: This is a low cost scheme (<$10M). It would require remedial protective works due to increased bank erosion, and additional costs to shipping or remedial measures due to hazards in canal traffic.

6. Existing Examples: The present Welland Canal diversion, which has increased the flow amounts over the past several years, especially during high Lake Erie level conditions.

MEASURE 1.3.4
INCREASE LAKE ERIE OUTFLOWS VIA NEW LAKE ERIE - LAKE ONTARIO DIVERSION SCHEME

1. Description: Construction of a diversion channel connecting Lake Erie with Lake Ontario similar to the Welland Canal. The diversion would have the capacity up to 10,000 cfs. It will be designed for one-way (Lake Erie to Lake Ontario) and hydro-power generation during high Lake Erie levels and pump-storage operation during average and low water level conditions. The objective is to increase the outflow capacity of Lake Erie.

2. Location: Southern Ontario or western New York state. The area of impact will be localized as well as Great Lakes-St. Lawrence River system-wide.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take 2 years to develop detailed engineering design and cost estimates, and 4 to 5 years to construct. As this would be a major undertaking, extensive environmental assessment or evaluation would be required by the state or province involved. Implementation could begin as early as 1998.

4. Implementing Authority: The IJC after agreement between Canada and the United States. The Province of Ontario and the State of New York would need to be involved since the facility would be located in their area of jurisdiction.

5. Implementing Costs: This would be a very high cost scheme (>$1B).

6. Existing Examples: The Welland Canal. Studies have been considered in the past for an all-American canal in New York State.

MEASURE 1.3.5
A 50,000 CFS DIVERSION IN AND OUT OF THE GREAT LAKES SYSTEM

1. Description: Diversion of the James Bay/Hudson Bay water or other source into the Great Lakes basin especially when supplies to the Great Lakes are low. Water could be diverted further towards the U.S. midwest, or discharged via the Great Lakes connecting channels and the St. Lawrence River. The objective is to raise the lake levels caused by drought conditions in the basin and to have minimum impacts on the long-term average flow in the St. Lawrence River.

2. Location: Provinces of Ontario and Quebec will be the source of the diversions. The geographic area of impact could be continent-wide.

3. Time Frame for Implementation: Unknown at this time, but a major undertaking of this kind could take at least 15 years or more.

4. Implementation Authority: Canada and the United States.

5. Implementation Costs: Projects of this magnitude would probably be in the billions of dollars.

6. Existing Examples: Only very relatively small diversions are in place and they are the Long Lac and Ogoki projects which divert water into the Lake Superior basin. Major studies of this and similar continental diversions (e.g., North America Water and Power Alliance).

MEASURE 1.3.6
INCREASED LAKES MICHIGAN-HURON OUTFLOWS THROUGH
GROUNDWATER AQUIFER RECHARGE

1. Description: Diversion of Great Lakes water in times of high supplies/levels to recharge groundwater aquifer in Illinois, Wisconsin and other United States area outside of the Great Lakes Basin. The objective is to lower the lake levels when they are high.

2. Location: The Great Lakes will be the source of the water supplies to the groundwater aquifer in the United States midwest. Impacts on water levels and flows will be Great Lakes-St. Lawrence River system-wide, as well as areas in the United States outside the Great Lakes Basin.

3. Time Frame for Implementation: 10-15 years minimum.

4. Implementing Authority: Canada and the United States, and the Great Lakes states and provinces.

5. Implementing Costs: This would be a very high cost scheme (>$1 billion).

6. Existing Examples: None at present using the Great Lakes water. The Illinois Water Survey carried out some studies on this and considered some possible demonstration programs in Illinois.

MEASURE 1.3.7
INCREASE LAKE ERIE OUTFLOWS VIA NEW LAKE ERIE-OHIO
RIVER SHIPPING CANAL

1. Description: Construction of a shipping canal which would divert water from Lake Erie to the Ohio River when lake levels are high.

2. Location: Lake Erie, with diversion intakes on its southshore. The geographic area of impact will be Great Lakes-St. Lawrence River system-wide, especially a lowering effect on Lake Erie and a reduced flow in the St. Lawrence River, and an increased flow in the Ohio River which receive the water.

3. Time Frame for Implementation: 10-15 years.

4. Implementing Authority: Canada and the United States and particularly the State of Ohio.

5. Implementing Costs: This would be a very high cost scheme (>$1 billion).

6. Existing Examples: Lake Michigan Diversion at Chicago. However, this diversion is fixed at 3,200 cfs and currently does not vary with changing Great Lakes level conditions.

MEASURE 1.3.8
INCREASE LAKE ERIE OUTFLOWS VIA NEW YORK STATE BARGE CANAL

1. Description: Increase diversion of water from the Niagara River when Lake Erie levels are high, using the existing or expanded New York State Barge Canal facilities..

2. Location: Upper Niagara River at Tonawanda, New York where water is diverted into the New York State Barge Canal. Water would then be returned to Lake Ontario as is presently the case, or diverted further eastward to the Albany River. The latter case would require some major construction. The geographic area of impact would include Great Lakes-St. Lawrence River system-wide as well as western New York State. Due to the location of the intake on the Niagara River, the effectiveness of increasing Lake Erie's outflows is highly questionable. Also, the present dimension of the canal does not permit any significant increases in flow.

3. Time Frame for Implementation: Facilities already exist.

4. Implementing Authority: Canada and the United States. The canal is operated by the State of New York.

5. Implementing Costs: Cost would be considered minimal if existing facilities were to be used (but with resulting no impacts). Major constructions would be needed to relocate the intake and enlarge the canal to make this measure to have measurable impacts on Lake Erie levels. The cost then, would be high ($100 million - $1 billion).

6. Existing examples: Present diversion of the Niagara River water by the New York State Barge Canal.

MEASURE 1.3.9
INCREASE LAKE ERIE OUTFLOW VIA BLACK ROCK LOCK MODIFICATIONS

1. Description: Structural modifications to the existing Black Rock Lock to increase the Niagara River flows by up to 12,000 cfs. The objective is to lower Lake Erie's water levels when they are high. The idea is very similar to Plan 15S (see Measure 1.2.2).

2. Location: Black Rock Lock near the outlet of Lake Erie. The geographic area of impact will be localized as well as Great Lakes-St. Lawrence River system-wide. Impacts on lake levels would be a slight reduction in the water levels of Lake Erie and corresponding increases on Lake Ontario.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take 1 year to prepare detailed engineering design and cost estimates, 2 years for construction. Implementation could start in 1994. The measure is assumed to be permanent.

4. Implementing Authority: Canada and the United States. The lock is operated by the U.S. Army Corps of Engineers.

5. Implementing Costs: Modifications of the Lock would cost <$10M and therefore is considered a low cost scheme.

6. Existing Examples: The operation of the present lock has no impact on Lake Erie outflows. Investigations and tests have been carried out and reports prepared. Also, similar actual operations were carried out at the Soo Locks during the 1985-86 emergency regulation of Lake Superior.

MEASURE 1.4.1
REGULATE LAKE ERIE VIA HYDRO DEVELOPMENT IN NIAGARA RIVER

1. Description: Construction of control dams and diversion channels in the upper Niagara River for the dual purposes of regulating the outflows of Lake Erie and increasing the production of hydro power.

2. Location: Niagara River and adjacent land. The geographic area of impact would include local area caused by high or low flows/levels or sudden changes in these flows/levels, and Great Lakes-St. Lawrence River system-wide especially Lakes Ontario and Erie.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it would take 2 years to prepare detailed engineering design and cost estimates, 4-5 years for construction. Implementation could start in 1998. The measure is assumed to be permanent.

4. Implementing Authority: The IJC after authorization by Canada and the United States. The Province of Ontario and the State of New York would need to be involved since the construction and power development will be located in their area of jurisdiction. The operation of these facilities would be under the supervision of the IJC.

5. Implementing Costs: A very rough estimate has been prepared by one private citizen (Mr. Tarapcik) which would have to be reviewed in this study. This measure would be considered high cost ($100-1,000M). As hydro-power generation would increase, the cost could be shared by the power entities beside the two federal governments.

6. Existing Examples: Existing hydro-electric installations at Niagara Falls on both sides of the border. However, the operation of these facilities has no impact on Lake Erie levels due to their locations and mode of operations.

MEASURE 1.4.2
INCREASE CHANNEL CAPACITY AND REDUCE FLOOD DAMAGE THROUGH CHANNEL ENLARGEMENT AND REMEDIAL WORKS IN THE ST. LAWRENCE RIVER

1. Description: Channel enlargement and diking in vulnerable areas of the St. Lawrence River to protect shore properties and farm land. Channel improvements in certain areas to reduce adverse effects to navigation from high flows and cross currents is also required. This measure would also allow for higher Lake Ontario outflows when compared to existing limitations imposed by the present regulation plan (see Measure 1.1.2).

2. Location: Various places along the St. Lawrence River. The construction of these dikes and dredging would have localized effect as well as dredged-disposal problem. The impacts on levels and flows will be confined to Lake Ontario and the St. Lawrence River.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it would take 2 years to prepare detailed design and cost estimates, 3 years to complete the construction. Implementation could start in 1996.

4. Implementing Authority: The IJC. The State of New York, the Provinces of Ontario and Quebec would have to be involved since the works will be located in their area of jurisdiction.

5. Implementing Costs: This would be considered a medium cost scheme ($10-100M). Cost would be shared by Canada and the United States in the International Reach of the St. Lawrence River; and by Canada, Ontario and Quebec in the Canadian Reach of the River.

6. Existing Examples: Channel enlargement was carried out in the International reach of the St. Lawrence River during the construction of the Seaway. Dikes have been placed in some parts of the St. Lawrence River to protect farmland, commercial and urban areas.

MEASURE 1.4.3
INSTALLATION OF ICE CONTROL MEASURES AT LAKES' OUTLETS AND CHANNELS

1. Description: The use of ice control measures such as an ice boom for more efficient winter flows and for the purpose of reducing the frequency and severity of ice jams.

2. Location: At the outlet of Lake Huron. Large short-term flow fluctuations caused by ice jams will be reduced. The magnitude of the range of levels on Lake St. Clair would be reduced. Impacts on the other Great Lakes would be relatively small.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about 1 year to prepare detailed engineering design and cost estimates, and 1 year to construct. It could be placed starting in the winter of 1994-1995. The measure is assumed to be permanent. Since it will be used every winter, this may be considered a long-term measure rather than an emergency short-term one.

4. Implementing Authority: Canada and the United States. The operation of these ice control structures would be under the supervision of the IJC.

5. Implementing Costs: This would be a medium cost measure (10-100M).

6. Existing Examples: Ice booms in the St. Marys River, at the outlet of Lake Erie and at several places in the St. Lawrence River. Also, studies relating to a Lake Huron-St. Clair River ice boom have been carried out by the Detroit District of the U.S. Army Corps of Engineers.

MEASURE 1.4.4
PLACEMENT OF SILLS AT LAKES' OUTLETS

1. Description: Placing sills at a lake's outlet would retard its outflow capability. Sills are underwater obstructions placed to reduce the channel's flow capacity. The purpose is to reduce or prevent excessive lowering of the lake levels during drought conditions. This is not necessarily just an emergency measure, but could be considered also as a long-term scheme to raise the lake's level to a more desired and generally accepted range.

2. Location: At the outlet of Lake Huron and strategic locations along the St. Clair-Detroit River system; at the outlet of Lake Erie or the head of the Niagara River.

3. Time Frame for Implementation: This measure would require 5-10 years to implement.

4. Implementing Authority: Canada and the United States on the recommendation of the IJC. Costs would be shared by the two countries.

5. Implementing Costs: This would be a medium cost scheme ($10-100M).

6. Existing Examples: Compensating dykes, on a much smaller scale than presently studied, have been placed in the Detroit River to offset some effects of past dredging. Sills on the St. Clair River were studied in the past but not placed.

MEASURE 1.4.5
ST. CLAIR - DETROIT RIVER COMPENSATING WORKS

1. Description: Replace the existing fixed compensating dikes in the Detroit River with movable gate-type dikes for increasing the flow capacity by up to 10,000 cfs when Lakes Michigan-Huron levels are high. The technical feasibility of this measure was examined in the IJC Great Lakes Water Levels Task Force in 1987.

2. Location: St. Clair-Detroit River system. Removing the existing dikes would require land-based disposal of dredged material. The geographic area of impact would be levels and flows Great Lakes-St. Lawrence River system-wide.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take 2 years to prepare detailed engineering design and cost estimates, 3 years for construction. Implementation could start 1996. The measure is assumed to be permanent.

4. Implementing Authority: Canada and the United States. The Province of Ontario and the State of Michigan would need to be involved since the measure will take place in their area of jurisdiction.

5. Implementing Costs: This would be a high cost scheme ($100-1,000M).

6. Existing Examples: As described above, there currently exists channel dredging and remedial/compensating works in the St. Clair and Detroit Rivers.

MEASURE 2.1.1
SEAWALLS

1. Description: A seawall is a shoreline protection structure used to protect public and or private structures that is placed in a vertical position, separating land and water areas. It is primarily designed to prevent erosion and other damage due to wave action. A secondary purpose may be to hold or prevent sliding of the land behind it. Structures of this type are commonly referred to as bulkheads.

Seawalls can vary in size from small structures, usually installed by a group of private home owners, to massive structures built in areas of high development. They can be constructed of many types of material, but are commonly made of concrete or corrugated sheet steel.

2. Location: Seawalls could be installed in all areas where a severe threat of erosion exists and in areas of intense development. Seawalls should not be built in areas that consist primarily of a sandy beach, as they can lead to increased erosion rates in these types of areas.

3. Time Frame For Implementation: Seawalls could be implemented within one to three years, allowing time for the proper construction expertise to be located and for determination of suitable locations. Bylaws and other regulatory approvals may also be needed.

4. Implementing Authority: Would likely be implemented by the local municipality in conjunction with governmental agencies such as the Ontario Ministry of Natural Resources, USACE or State Departments of Natural Resources.

5. Implementing Costs: Will vary depending on size and complexity of the project. Typical costs for a steel pile seawall are around $500 per linear foot.

6. Existing Examples: There are many examples of seawalls located throughout the Great Lakes Basin and on ocean coastlines.

MEASURE 2.1.2
DIKES AND LEVEES

1. Description: Dikes and levees are commonly linear mounds of natural or man made material, built up higher than the surrounding ground level, and forming a protective barrier in front of, the lower lying land. Their primary purpose is to keep floodwater from inundating the lower lying land. In some cases dikes may also act as a form of erosion protection if they are the first line of defence between the land and the water.

2. Location: Would likely be located in front of valuable, low lying land such as agricultural land or wetlands. Could also be located in front of any land subject to periodic inundation by flood waters (eg. residential commercial and industrial).

3. Time Frame For Implementation: 1-5 years, depending on location decisions and regulatory approvals.

4. Implementing Authority: Municipal authorities, provincial/ state governments and other concerned governmental agencies. Larger structures would have federal involvement.

5. Implementing Costs: Will vary depending on complexity and size, but likely in the millions of dollars.

6. Existing Examples: Point Pelee, Lake Erie. Areas on the Canadian shoreline of Lake St. Clair. East shore of Green Bay, Lake Michigan.

MEASURE 2.1.3
GROINS AND JETTIES

1. Description: Groins and jetties are constructed perpendicular to the shoreline and extend out into the water. Used singly or in groups known as groin fields, they trap sand or retard its alongshore movement along beaches. Sand accumulates in fillets on the updrift side of the groin or jetty and the shoreline rotates to align itself with the crests of the incoming waves. These sand fillets act as protective barriers which waves can attack and erode without damaging the previously unprotected upland areas. Groins can take many forms, being constructed from quarrystone, wood, gabion baskets and corrugated steel.

2. Location: Areas threatened by severe erosion that have high rates of alongshore sediment transport, as this is a requirement for the successful operation of groynes.

3. Time Frame For Implementation: Could be constructed following evaluation studies of net drift direction and amount of alongshore sediment transport, at selected sites. Generally, within 1-2 years.

4. Implementing Authority: Can be implemented by the municipality, under the direction of government agencies such as OMNR, USACE or Environment Canada.

5. Implementing Costs: Can vary depending on size of project, but likely high.

6. Existing Examples: Have been tried with limited degrees of success in various locations around the Great Lakes shoreline.

MEASURE 2.1.4
BREAKWATERS

1. Description: Breakwaters are shoreline protection devices that, in contrast to bulkheads or seawalls, are placed out in the water, rather than directly on shore, to intercept the energy of approaching waves and form a low-energy shadow zone on their landward side. Due to this decrease in wave energy, sand moving alongshore, becomes trapped behind the structure and accumulates. While commonly thought of as harbour protection devices, they can be used to protect the shoreline as well.

2. Location: Breakwaters and/or barrier islands could be constructed for areas of high hazard potential on all Great Lakes shorelines. These could include low lying residential developments, but could also include areas where severe erosion is a problem. In addition, they should only be constructed in areas where substantial sediment movement occurs, as they can cause downdrift erosion. They should also be constructed in shallow water near the shoreline for reasons of economy. Impacts of the structures would vary depending on the geologic and geomorphic nature of the site and also on the local wind and wave climate. The main impacts would be local (new beach formation, reduced wave energy) and downdrift (possible increased erosion). Other local impacts can include reduced water quality behind the structures and navigational hazards for boaters.

3. Time Frame For Implementation: 2-3 years. Background studies would have to be done to select appropriate sites, determine what style of breakwater to use and find a suitable contractor. Shoreline and environmental impact studies would also have to be completed in order to determine the suitability of a particular site. This may add another year or two to the implementation timeframe.

4. Implementing Authority: Major breakwater projects will be implemented by the federal governments of either country. Smaller projects will be implemented at the state or provincial level.

5. Implementing Costs: Basic gabion basket breakwaters generally cost approximately $100-120 U.S. per linear foot, but more extravagant structures, such as barrier islands could run into the millions of dollars.

6. Existing Examples: A number of examples of both fixed and floating breakwaters have been tried in the Great Lakes basin, such as Lake Forest, Illinois. Fixed breakwaters can be found at virtually every harbour in the Great Lakes.

MEASURE 2.1.5
BARRIER ISLAND CONSTRUCTION

1. Description: This measure would see the construction of offshore barrier islands opposite severely threatened areas in order to reduce storm wave activity and create a peaceful lagoon between the shoreline and the island. This would reduce the amount of wave energy reaching the shoreline, thereby reducing erosion and also allowing sediment to fill in behind the islands, potentially creating a wider beach zone and an even more effective form of natural shore protection. Barrier islands differ from standard breakwaters in that they are larger and can support non-hazardous activity such as parkland and other recreational activities.

2. Location: Islands could be constructed for areas of high hazard potential on all Great Lakes shorelines. These could include low lying residential developments, but could also include areas where severe erosion is a problem. Impacts of the structures would vary depending on the geologic and geomorphic nature of the site and also on the local wind and wave climate.

3. Time Frame For Implementation: 5 years. It is recommended that before construction of the islands, the areas eligible be thoroughly studied in terms of geology, geomorphology and wind and wave climate, in order that the effectiveness and feasibility of the islands can be determined. Test sites for islands may also be recommended before full implementation of this type of measure.

4. Implementing Authority: Would likely be at the federal level (USACE, Public Works Canada, Environment Canada). Municipal, state, or provincial governments could operate any recreational areas on the islands.

5. Implementing Costs: Costs would be extremely high and would have to be some sort of cost sharing agreement between federal, state, provincial, or municipal governments.

6. Existing Examples: None known, although some theoretical examples have been proposed for the city of Chicago, Illinois and Milwaukee, Wisconsin. The Toronto Islands can be considered a variation of this type of construction.

MEASURE 2.1.6
BEACH NOURISHMENT

1. Description: Beach nourishment or beach filling involves the placing of sand on a shoreline by mechanical means, such as dredging and pumping from offshore deposits, or overland hauling and dumping by trucks. The imported sand can be placed on the beach in three different ways. First it can be dumped in the form of a beach berm (placing it in a long pile on the beach). Incoming waves then distribute the material across the beach zone. Secondly, the material can be dumped and then graded into a smooth beach by man. Thirdly, if the imported material is placed as fill behind a seawall or a breakwater, it becomes known as a perched beach. It should be noted that the material placed on the beach will be eroded and some will likely be transported away from the threatened area. Beach nourishment has to be done with this in mind and it is likely that periodic re-nourishment of the beach will have to take place.

2. Location: Beach nourishment can be used in areas where beaches have previously existed, but have gradually disappeared, as long as re-nourishment is considered. Steeply sloping nearshore areas are likely not good locations for beach fill, are areas with extremely high rates of alongshore sediment transport, as this will increase the rate of loss of fill.

3. Time Frame For Implementation: 2-3 years, allowing for the proper study of appropriate sites, grain size studies and wind and wave climate studies.

4. Implementing Authority: Would likely be carried out under the jurisdiction of provincial agencies in Canada and Federal agencies in Canada.

5. Implementing Costs: Would vary depending on the size of the project, the costs of importing sand, and the degree of detail required in the background studies.

6. Existing Examples: Presque Isle, Pennsylvania. Numerous ocean examples including Miami Beach, Oceanside California, and Atlantic City, N.J.

MEASURE 2.1.7-9
VEGETATION PLANTING, BLUFF GRADING, BLUFF DRAINAGE

1. Description: These measures are being considered as one because in most cases they would be carried out in tandem. This measure is designed to stabilize areas of high erosion by using three different methods. Vegetation planting would see vegetation planted on bluffs, dunes, shorelines, etc. The resulting root network and the vegetation itself would help to reduce the impact of erosion. In addition, on sandy beaches, vegetation would help to trap windblown sand, thereby building up a beach or a dune. Bluff grading and bluff drainage are measures designed to reduce the susceptibility of bluff shorelines from further erosion, by stabilizing the bluff. Grading will reduce the slope of the bluff to a more stable angle, while better bluff drainage will reduce the possibility of bluff failure due to soil saturation. These measures can be used together. Bluffs can be graded to a stable slope and then planted with vegetation to stabilize them further.

2. Location: Measures of this type could be located in areas of erodible bluff shoreline, or areas with erodible dune shorelines, where the height of the bluff or the nature of the soil does not limit grading, or planting possibilities.

3. Time Frame For Implementation: This measure could be implemented within 2 years of study completion date, as the measure is relatively easy to carry out. Background studies would have to be completed to determine what vegetation types could be used and to select appropriate sites.

4. Implementing Authority: This type of measure could be implemented by the local municipality, under the guidance of state or provincial departments of Natural Resources.

5. Implementing costs: In most cases these approaches are usually a fairly low cost alternative to hard, structural measures of shore protection. Moderate costs would be incurred in conducting the background studies, as geotechnical and vegetation experts would likely have to be consulted.

6. Existing Examples: State of Pennsylvania Lake Erie shoreline. Many other individual examples on the Great Lakes shoreline and on ocean coasts.

MEASURE 2.1.10
REVETMENTS

1. Description: A revetment is a heavy facing (armour) that is placed on a slope to protect it and the adjacent upland against wave erosion and scour. Revetments depend on the soil beneath them for support and are built on an angle to allow wave dissipation over them (unlike vertical seawalls). Revetments are composed of three components: the armour layer, the filter layer and toe protection. The armour layer, which has to be stable against movement by waves, commonly consists of large, rough angular rocks (quarrystone or armourstone), or variously shaped concrete blocks. Various other devices have also been used in revetment construction. These include, grout filled bags, gabion baskets, masonry blocks and patented devices such as Shiplap Blocks, Lok-Gard Blocks, Turfblocks, Nami Rings and Gobi Blocks. Depending on the style of revetment utilized, they can either be flexible, semi-rigid, or rigid. The most common revetments, quarrystone and rip rap are examples of flexible revetments.

2. Location: Revetments should only be installed in areas with low rates of erosion as they rely on the soil beneath them for support and they should not be installed on slopes steeper than 1:1.5 unless the slopes are flattened. In addition, revetments should be well tied-in to adjoining protection, or the shoreline, as flanking is a common problem.

3. Time Frame For Implementation: 1-2 years following study completion date. Studies would have to be done to determine appropriate sites for revetments. Each revetment would have to be designed with site specific data in mind (wave, wind climate, design heights, etc.).

4. Implementing Authority: Design and implementation of revetments should only be carried out by competent coastal engineering firms, under the direction of the provincial or state government.

5. Implementing Costs: Revetments can be quite expensive depending on their size and the degree of protection required. Costs will also be incurred in finding and transporting suitable amounts of armourstone or rip rap to the site.

6. Existing Examples: Numerous examples of many different type of revetments exist throughout the Great Lakes basin.

MEASURE 2.1.11
ARTIFICIAL HEADLANDS

1. Description: Artificial headlands are a form of offshore breakwater that are constructed so that they are aligned to the predominate direction of wave approach. This will allow the beach to erode back into a stable configuration that is commonly found in a headland-bay situation (small bays in between rock outcrops). Studies have found that headland bays tend to adjust to the direction of incoming waves such that littoral drift is reduced to zero, or is balanced by other sediment inputs. Thus, the shape of the bay remains fairly stable and recession occurs primarily by recession of the headlands. It follows that if the headlands can be stabilized, the bays (shoreline) will remain in position. It also follows that if this is the case, ordinary shorelines can be stabilized by the creation of artificial headlands. Headlands can be constructed of any material suitable for a fixed breakwater such as rip rap, or concrete.

2. Location: As artificial headlands are designed to allow the erosion of a beach to a stable configuration, they should be constructed on sections of Great Lakes shoreline that are sufficiently wide enough to permit this erosion. As such, this measure may not be appropriate for highly developed areas, as some structures may be lost. In addition, as headland control methods involve a fairly long section of shoreline, this measure may not be appropriate for small segments of shoreline (e.g. individual lots).

3. Time Frame For Implementation: 3-5 years after completion of study. As artificial headland construction involves large sections of shorelines, detailed studies would have to be completed on wave climate, sediment budgets, construction procedures, and extent of the structures for each proposed site. Design considerations for the structures will also have to be considered. Time must also be allowed for the stabilization process to proceed following construction.

4. Implementing Authority: Projects of this nature should be implemented at the federal level by departments such as USACE, Public Works Canada, or Environment Canada.

5. Implementing Costs: Would likely be very high and may involve cost sharing between federal and local governments.

6. Existing Examples: The use of artificial headlands is a fairly new practice and as a result, field experience is limited. An example of using the technique in the Great Lakes can be found in Bishop (1983).

MEASURE 2.1.12
STRUCTURAL FLOODPROOFING

1. Description: This measure would involve floodproof buildings currently located in hazardous areas. There are two main methods of floodproofing commonly used. First, structures can be dry floodproofed by ensuring that the walls are watertight, that the openings are closed, and that the walls and floors are strong enough to resist hydrostatic pressures from below. This type of floodproofing works best for structures on slab with brick or masonry walls that are subject to shallow flooding (less than 3 feet).

A second method known as wet floodproofing, allows water to enter the structure, so that the hydrostatic pressures are equalized. This is a cheaper method of floodproofing, but it has one drawback; everything below flood level will get wet. Wet floodproofing is generally most appropriate for structures with masonry or concrete basements, or lower areas that are subject to flood depths of 2 to 8 feet.

2. Location: The extent of Great Lakes shoreline where flooding is the major cause of shoreline damage (floodproofing offers limited protection from wave damage). Impacts will vary depending on which states or municipalities adopt the measure. The area impacted would be the immediate site of implementation (ie. the individual structures).

3. Time Frame For Implementation: This program could be implemented following the 1991 study completion date. Some states and provinces may require development of new by-laws or regulations to ensure proper floodproofing techniques are carried out. Actual floodproofing of a structure should be able to be accomplished within a year. This will allow sufficient time for the location of a suitable contractor, determination of the proper floodproofing method, and the actual construction itself.

4. Implementing Authority: The implementing authority should be at the municipal level, with the program being developed at the state /provincial level. The municipality should also be responsible for enforcing any floodproofing laws that are developed.

5. Implementing Costs: Actual costs would vary with the size and the number of structures, but it would likely be at a cost of $10,000-20,000 per structure.

6. Existing Examples: The Illinois Department of Transportation, Division of Water Resources has sponsored examples of floodproofing in riverine situations. No other examples are known of at this time.

MEASURE 2.2.1
COMMUNITY ACQUISITION OF HAZARD LAND
(FEE SIMPLE PROPERTY RIGHTS)

1. Description: This measure is designed to prevent, or reduce future damages and losses in hazard areas and would see communities, or community agencies (e.g. Ontario Conservation Authorities) purchase property located in hazard areas. Once the property is under community ownership, the community has complete control of the land uses and development that occur on the land. For example, the land can be converted into parkland, allowing for recreation and public access space. Alternatively, the community could resell the property, except that the new owners would be restricted (by deed) to the types of activities that could be carried out on the land. Structures located on the property could be removed, condemned, or left in states of disrepair, in order to discourage further development. Direct community purchase of a property when it goes up for sale is an ever increasingly expensive method of shore property acquisition. Shore property values are rapidly increasing and many communities find it difficult to acquire the capital needed to buy the property.

2. Location: This measure could take place in all areas of urban development that are threatened by flooding or erosion. Due to the substantial costs involved however, shore acquisition of this type should only be considered where the potential of the land for recreation, environmental protection, or other public uses can justify the expenditure. The impact of a measure of this type would primarily be restricted to the local municipality.

3. Time Frame For Implementation: Greater than 5 years after study completion. Communities would have to wait until properties became available for sale, and then would have to ensure that they have the capital to purchase the properties. Benefit/cost analyses will have to be done in order to determine what areas will provide the highest economic returns to a community for recreation and other uses.

4. Implementing Authority: This action should be implemented by the municipality, or an agency of the municipality (eg. Ontario Conservation Authority), in conjunction with the provincial/state government.

5. Implementing Costs: Will vary depending on the current market value of property and inflation rates.

6. Existing Examples: Hamilton Region Conservation Authority on the Hamilton/Burlington, Ontario Beach Strip, and by the state of Florida in a beach purchase program known as Save Our Coast, (Fischer, 1988). Also the Federal Emergency Management Agency (U.S) "Section 1362" program allows purchase of property susceptible to flooding.

MEASURE 2.2.2
PROTECTION AND ENHANCEMENT OF COASTAL HABITATS

1. Description: This measure would see public monies spent on acquiring barrier beaches, dunes and wetlands, and where these habitats were already under community ownership, money would be spent to restore and preserve these coastal habitats in their natural state (eg. removal of man-made structures, removal of shore protection). A secondary effect of purchase would be to maintain these areas in open space (undeveloped) uses.

2. Location: Areas of hazard potential to man and of natural significance (eg. entire Long Point peninsula, Lake Erie) in the Great Lakes basin.

3. Time Frame For Implementation: As with the community acquisition measure, this measure would likely take a number of years to be fully implemented. Finances would have to be found to purchase these habitats from private ownership, and communities would have to wait until a property became available.

4. Implementing Authority: Implementation of this type of measure would likely be carried out by the federal, state and provincial governments of both countries, as the protection of natural habitats usually fall under their jurisdiction.

5. Implementing Costs: Not known, but likely high and dependant on land values.

6. Existing Examples: Examples of this sort include many of the Canadian and American national parks, Ontario's Provincial Parks and U.S. State Parks, whereby unique habitats have been protected and preserved under the various and respective park regulations and management guidelines.

MEASURE 2.2.3
RELOCATION OF STRUCTURES OUT OF HAZARD AREA

1. Description: Flooding or erosion damage can be reduced or avoided by relocation of existing structures out of hazard areas. In some cases, buildings can be designed or adapted to be relatively easy to move and relocation could be implemented only when the need arose and could perhaps be temporary. In other cases, relocation would have to occur well in advance of a crisis condition and would be a permanent action. While initially expensive, it can be cost-effective when compared to the financial commitment required for some shore protection devices. Also, if shore protection fails, not only is the investment in the erosion control structure lost, but possible the home or building as well.

2. Location: This measure could be enacted along any flood or erosion hazard area along the Great Lakes and connecting channels. It would most likely occur in areas where substantial structural development is in existence. The impact area would include coastal erosion and flooding hazard areas, as well as the nearby non-hazard areas to which the structures would be moved.

3. Time Frame For Implementation: This measure could occur after a few weeks, or months, or might take years depending on the perceived need to act and the presence or lack of legal authority and funding to implement.

4. Implementing Authority: The program could be developed at the state/provincial level, and administered at the municipal level. Such a program would likely involve new legislation for nearly all jurisdictions.

5. Implementing Costs: Highly variable, depending on the value of real estate and structural improvements, as well as the time period over which such efforts would be carried out. Would also vary depending on the extent to which the program is intended to remove existing structures at risk. Costs can include preparing the new site, building a new foundation, installing utilities and conforming to present health/building codes. Additional land may also have to be purchased. On average, costs for moving a home range from $10,000-$20,000, excluding the cost of land.

6. Existing Examples: There are no known examples of entire community relocation programs. Relocation plans such as Michigan's interest rate "buy-down", Michigan's Emergency Home Moving Program and the new "Jones-Upton" Amendment are examples of "subsidized" measures for individual structures and they do not take in to consideration entire community moves.

MEASURE 2.3.1
CHANNEL AND HARBOUR DREDGING

1. Description: This measure would ensure that those that presently use the lake for shipping and other boating purposes (commercial /recreational) could adapt to fluctuating water levels. This would primarily involve the dredging of connecting channels, commercial and small craft harbours and other areas where shallow water would affect boating.

2. Location: These measures would apply mainly to the connecting channels, major industrial harbours and small craft marinas and harbours along all of the Great Lakes shoreline. Residential properties would not benefit from these measures as they are not designed for them. Impacts will vary depending on the lake or connecting channel and the degree of problem experienced. Areas impacted will be the immediate sites, although dredging of channels and harbours may impact water quality for other parts of the lake (e.g. toxic sediment re-suspension, etc.).

3. Time Frame For Implementation: Dredging could begin after completion of the study as needed and after proper authorization, appropriation, surveys, etc. are carried out. Delays may be experienced in deciding where dredge spoil should be placed and on what the water quality problems of further dredging would be.

4. Implementing Authority: Provincial/state, federal or local governments could implement this measure depending on the size of the harbour.

5. Implementing Costs: Not known.

6. Existing Examples: Many of the connecting channels, particularly the St. Clair, Detroit and St. Lawrence Rivers, have been dredged in the past. The U.S. Army Corps dredges all the authorized commercial recreational harbours in the Great Lakes. Private industries and small marinas and harbours also carry out their own dredging when required.

MEASURE 2.3.2
INCREASES IN LOCK CAPACITY

1. Description: This measure is designed primarily with the commercial shipping companies in mind. The measure would help to reduce the adverse consequences of low water levels on the shipping companies by increasing the effective capacity of the locks in the Welland Canal and the St. Lawrence Seaway by improving operational methods.

2. Location: Sault Ste. Marie, The Welland Canal and The St. Lawrence River are the only locations on the Great Lakes with locks.

3. Time Frame For Implementation: Modifications to the locks operational methods could begin as early as the first non-shipping season after the study on the Welland Canal and the St. Lawrence. Modifications could only start once funding has been acquired and the proper modifications to traffic control systems completed. It is likely that completion of the capacity increases would take about three years.

4. Implementing Authority: Would likely rest with those who already have jurisdiction over the lock systems, namely the St. Lawrence Seaway Authority, The St. Lawrence Seaway Development Corporation and the U.S. Army Corps of Engineers. Federal Departments of Transportation would also be involved.

5. Implementing Costs: Not known but likely to be relatively low.

6. Existing Examples: An example would be the Welland Canal traffic control system that was updated a few years ago.

MEASURE 2.3.3
REGIONALIZATION AND ADAPTIVE DESIGN OF WATER SUPPLY AND SEWAGE TREATMENT SYSTEMS AND INFRASTRUCTURE

1. Description: This measure would first of all see an expansion of a community's water supply network, such that during low lake levels, water shortages would not be a problem. On the other side of things, homes located in hazard areas that are using septic tanks would be converted, so that their sewage system was linked into the community sewer and sewage treatment system. This would eliminate the erosion and flooding damage potential to septic tanks and the associated water quality problems that may result. Secondly, this measure would see the improvement of community sewer systems and treatment plants, so that they could handle flooding during high water (and the associated storm runoff that would come from higher precipitation), and water pumping problems during low water. Community water intake structures and pumping equipment would also be upgraded to deal with extremely low levels.

2. Location: This measure could be implemented for all major urban centres on the Great Lakes shoreline, especially those that have experienced water level problems in the past.

3. Time Frame For Implementation: Greater than 5 years after completion of the study. Time would have to be allowed for detailed engineering studies and then for the conversion and construction of new sewer systems and various other revisions to infrastructure.

4. Implementing Authority: The city concerned would be the main implementing authority, possibly using funds provided at a state /provincial, or federal level.

5. Implementing Costs: Extensive. Funding would likely come from tax dollars and be provided to the cities from federal or state/ provincial governments.

6. Existing Examples: None known of at this time.

MEASURE 2.3.4
POWER GRID INTERCONNECTIONS

1. Description: This measure would see public investment to develop new and more efficient power grid interconnections and infrastructure, so that the communities can take full advantage of any hydropower that is available, or alternatively gain access to power generated by other means. The idea behind this measure is that during lower water periods, when the capacity to generate hydropower is reduced, the communities will still be able to operate normally, without any increase in price, or shortage of power.

2. Location: This measure could take place in all communities around the Great Lakes that depend on hydropower from the lakes. The primary impact would be on these local communities, but if new hydro corridors, or sub-stations are constructed, there would likely be impacts on other areas.

3. Time Frame For Implementation: Greater than 5 years after study completion. Funding for the measure would have to be acquired, engineering studies would have to be conducted. If new construction is required, site selection will be required.

4. Implementing Authority: State Power Authorities, Ontario Hydro, and the Local Municipalities (Cities).

5. Implementing Costs: Not Known.

6. Existing Examples: There are numerous examples of power system interconnections in the U.S. and a few that cross the Canada-U.S. border (eg. Hydro Quebec supplies power to New England States).

MEASURE 2.3.5
ADAPTIVE DESIGN OF HARBOUR STRUCTURES

1. Description: These measures would ensure that those who presently use the lake can adapt to fluctuating water levels. This would include the installation of floating docks, extension of commercial and industrial water intakes/outfalls and the adjustment of ship loading spouts or platforms. The measures would also ensure that any new development would be designed with these adaptive capabilities. This is especially important in the case of small craft harbours and marinas.

2. Location: This measure would apply mainly to major industrial harbours and small craft marinas and harbours along all of the Great Lakes shoreline. Residential properties would also benefit from these measures, especially those that have docking facilities. Impacts will vary depending on the lake and the degree of problem experienced.

3. Time Frame For Implementation: Floating dock construction and other adaptive measures could begin immediately after completion of the study as needed. Delays may be encountered in letting contracts for construction of dock systems, or finding suitable contractors.

4. Implementing Authority: Provincial/state, or local governments could implement these measures.

5. Implementing Costs: Not known.

6. Existing Examples: Floating docks have been used with some success on Lake Superior and in the Port of Buffalo. Other measures in this category are not known.

MEASURE 2.3.6
IMPROVED SHIP NAVIGATION PROCEDURES
(COMMERCIAL AND RECREATIONAL).

1. Description: This measure would see public funding and construction of new lighthouses, channel markers, or other navigational aids, to primarily aid boaters and shippers in times of extremely low water levels. The theory behind this measure is that better marking of channels may help ships and recreational boaters keep from running aground, or striking bottom during these low levels.

2. Location: This measure could be implemented in all areas of navigation hazard in the Great Lakes, especially connecting channels and small harbours.

3. Time Frame For Implementation: This type of measure could be implemented immediately after completion of the study. Other aspects of this measure, such as channel markers, could be implemented on an emergency basis (ie. marking shoals during low water).

4. Implementing Authority: Would likely rest with the St. Lawrence Seaway and federal Departments of Transportation.

5. Implementing Costs: Not known, but the only high costs would be new lighthouse construction or renovation.

6. Existing Examples: Not known.

MEASURE 2.3.7
PUBLIC INVESTMENT IN STORMWATER MANAGEMENT ACTIVITIES

1. Description: Stormwater management encompasses a range of activities or facilities that are intended to either reduce the rate at which runoff occurs from precipitation events, or to reduce the total amount of runoff from a given area of land. Such efforts may coincidentally serve to increase groundwater recharge, improve water quality, or create wildlife habitat, but they are not the primary purpose. Among the specific types of activities that can be undertaken by the private sector are:

   1. Construction of stormwater retention facilities, either above or below ground.

   2. Modifying drainageways to reduce flow velocities (creating meanders or irregularities on the channel, planting of vegetation to retard flow, etc.).

   3. Purchase of land to forestall development that would increase runoff.

   4. Modification of land areas within a watershed to reduce runoff (re-contouring to lengthen flow paths, planting of vegetation, etc.) or to increase on-land storage (creation of artificial wetlands).

2. Location: Could occur anywhere within the Great Lakes-St. Lawrence Basin. As a practical matter, such practices are of greatest effect in the headwaters areas of stream systems.

3. Time Frame For Implementation: Varies from a month or less to several or more years, depending on the specific approach.

4. Implementing Authority: Such projects are typically undertaken on a municipal or sub-regional (watershed) basis. Funding support and technical assistance may come from the state/provincial or federal levels.

5. Implementing Costs: Variable, depending on the specific approach taken.

6. Existing Examples: The cities of Milwaukee and Chicago have developed (or are developing) massive underground reservoirs for storage of urban runoff (at least in part to reduce nonpoint pollution). Many of the Ontario Conservation Authorities operate small dams and other control works that regulate streamflow on a number of major streams in Ontario.

MEASURE 3.1.1
SETBACKS FOR STRUCTURES IN ZONING REQUIREMENTS

1. Description: The purpose would be to ensure that any new development along the Great Lakes shoreline takes place landward of an erosion or flood control line (typically the 1:100 year erosion line). It would also provide for shoreline owners who are currently lakeward of this line to re-locate their homes or cottages landward of the line. Any new development lakeward of the line has to get proper authorization from the implementing authority. Construction may be allowed lakeward of the erosion line, so long as the buildings, or other uses, are portable, or temporary and can be moved prior to damage, and provided the structures are intended for flood or erosion control, or are normally associated with shoreline stabilization (note that these too would have to be approved). Aside from shore protection, uses of this nature can include agriculture, conservation, forestry, wildlife management areas, parkland and other outdoor recreation activities.

2. Location: Areas along the entire Great Lakes shoreline that are severely threatened by erosion, especially undeveloped, or moderately developed areas. Impacts of this measure would be local and would depend on the degree of development already in place and the development pressure on the remainder of the shore.

3. Time Frame For Implementation: Erosion set back lines would have to be completed for the entire basin before the program could be fully implemented. Progress in this is already underway. Existing, enabling legislation would have to be modified (e.g. Ontario Planning Act) in all states and provinces and appropriate municipal by-laws would be necessary for enforcement. Implementation should be possible within 3 years of the initial decision.

4. Implementing Authority: State and provincial governments will have the jurisdiction to develop erosion set-back lines. This has already been done in Ontario (1978) and these lines are currently being updated. Some U.S. States have also determined erosion setback lines. Municipalities should be responsible for enforcing the appropriate laws.

5. Implementing Costs: Costs would be minimal as most states and Ontario already have enabling legislation in place (e.g. Ontario Planning Act). Provinces/states, possibly in association with the federal governments, will fund the delineation of erosion setback lines.

6. Existing Examples: Canada/Ontario Flood Damage Reduction Program. Ontario Ministry of Natural Resources Floodplain zoning regulations (Conservation Authorities).

MEASURE 3.1.2

ELEVATIONS FOR STRUCTURES IN BUILDING CODE REQUIREMENTS

1. Description: This measure would allow for construction in a hazard area, where zoning procedures do not currently exist. This would ensure that any new construction, or any existing structures in this hazard area, would be raised above the 1:100 year flood level. This would help to minimize the damages due to flood waters, while still allowing residential use of the shore zone.

2. Location: This measure could be implemented for all areas of Great Lakes shorelines, especially those that are already developed, or are being considered for development. Impacts would be confined to the shoreline properties, as it would mean different housing designs. Municipalities would still have the tax base from this development.

3. Time Frame For Implementation: 1-2 years from the completion of the study. Regulatory bylaws would have to be developed and some sort of enforcement laws (fines, no building permit issued) would have to be drawn up.

4. Implementing Authority: The local municipality would be responsible for implementing the bylaws, under the guidance of provincial or state governments. Those responsible for issuing building permits could control haphazard development (ie. if plans do not show building above flood elevation, no permit will be issued).

5. Implementing Costs: Whatever costs are involved in passing a new bylaw and setting up a governing body to enforce the bylaw.

6. Existing Examples: Some conservation authorities (Ministry of Natural Resources) in Ontario have implemented a minimum building elevation for hazard areas along the Great Lakes. Contractors (builders) must get CA (MNR) approval before construction can begin. The U.S. National Flood Insurance program also requires elevation restrictions in participating communities.

MEASURE 3.1.3
FLOODPROOFING THROUGH BUILDING CODE REQUIREMENTS

1. Description: This measure also allows for construction within a hazard zone, but is designed to ensure that any new development, or alternatively, any existing development (through retrofitting), lakeward of the 1:100 year flood elevation is constructed using proper and effective floodproofing techniques (See Type II.A.14).

2. Location: This measure could be implemented for all areas of Great Lakes shorelines, especially those that are already developed, or are being considered for development. Impacts would be confined to the shoreline properties, as it would mean different structural designs. Municipalities would still have the tax base from this development.

3. Time Frame For Implementation: 1-2 years from the completion of the study. Regulatory bylaws would have to be developed and some sort of enforcement laws (fines, no building permit issued) would have to be drawn up.

4. Implementing Authority: The local municipality would be responsible for implementing the bylaws, under the guidance of provincial or state governments. Those responsible for issuing building permits could control haphazard development (i.e. if plans do not show building to be properly floodproofed, no permit will be issued).

5. Implementing Costs: Whatever costs are involved in passing a new bylaw and setting up a governing body to enforce the bylaw.

6. Existing Examples: None Known.

MEASURE 3.1.4
OTHER PLANNING AND DEVELOPMENT REQUIREMENTS

1. Description: This measure would see the development of a number of other planning and development regulations that are designed to ensure that any development that takes place in a hazard area is done so in a regulated manner, and in a way that will minimize damages. Included in this measure are lot size ordinances, which would allow a lot to be deep enough so structures could be safely located behind the erosion or flood set-back line; post disaster re-construction limitations, which would prevent future damages in the same area; and the requirement to obtain proper professional technical advice, which would improve the quality and durability of structures placed in hazard areas.

2. Location: This measure could be implemented for all areas of Great Lakes shorelines, especially those that are already developed, or are being considered for development. Impacts would be confined to the shoreline properties, as it would mean different housing designs, or different plans for non-residential property. Municipalities would still have the tax base from this development.

3. Time Frame For Implementation: 1-2 years from the completion of the study. Regulatory bylaws would have to be developed and some sort of enforcement laws (fines, no building permit issued) would have to be drawn up.

4. Implementing Authority: The local municipality would be responsible for implementing the bylaws, under the guidance of provincial or state governments. Those responsible for issuing building permits could control haphazard development (i.e. if plans do not reflect these building code requirements, no permit will be issued).

5. Implementing Costs: Whatever costs are involved in passing new bylaws and setting up a governing body to enforce these bylaws.

6. Existing Examples: The use of land use regulations in coastal hazard planning has been reviewed relatively well in the literature. Jessen et al. (1983) and Kreutzwiser (1988) have looked at examples from various Ontario Great Lakes communities. Detailed regulations and examples have also been discussed for the states of Wisconsin (Yanggen, 1981), California (Crandall, 1974), South Carolina (Fisher and Moore, 1982) and Massachusetts (Brautigam and Robin, 1985).

MEASURE 3.1.5
DEED RESTRICTIONS ON PROPERTY USE

1. Description: This measure would ensure that certain caveats are placed on property deeds, so that buyers of shoreline property are aware of the hazard potential, or so that buyers of the land use the land for compatible, "non-hazardous" activities. For example, buyers of vacant shoreline property would be notified in their deed that residential development is not permitted. If they proceed with residential development (assuming they bypass any bylaws), their deed can be considered null and void and the buyer could potentially lose the property.

2. Location: This measure could be implemented for all properties currently existing on the Great Lakes shoreline. Current development would have to notify potential buyers of the hazard, while vacant property would have deed restrictions on development.

3. Time Frame For Implementation: 1-2 years after study completion date. Restrictions would have to be determined, likely on a site specific basis (some shore property may be acceptable for development). A governing body would have to be set up to enforce these deed restrictions and current property deeds would have to be modified to indicate the shoreline hazard.

4. Implementing Authority: Provincial and state housing departments, in conjunction with the local municipality.

5. Implementing Costs: Not known.

6. Existing Examples: Michigan has proposed legislation on disclosure in high hazard erosion areas and California requires disclosure in coastal hazard areas.

MEASURE 3.2.1-2
REGULATE SHORE PROTECTION WORK AND NAVIGATION
STRUCTURE CONSTRUCTION

1. Description: This measure recognizes that man's activities can exacerbate the shoreline hazard and proposes measures that are designed to minimize the impacts. This measure deals with the regulation of privately or publicly constructed shore protection and navigation structures (breakwalls, groins, docks, piers, wharfs, jetties, etc.). Regulations would include the obtaining of proper construction permits, which in addition, would not be issued unless the interested party obtains professional technical advice. These types of regulations could also limit the type of protection that goes in, and could charge a fine, or force removal of non-permitted construction. Another possible consequence of this regulation would be to impose a system of "sand rights" (see Stone and Kaufman, 1988) whereby a tax (levy, fine, fee) is charged to anyone (individual, organization, etc.) who constructs a structure that interferes with the natural nearshore process of sand transport and deposition.

2. Location: All developed areas of the Great Lakes and connecting channels.

3. Time Frame For Implementation: 1-2 years from the completion of the study. Regulatory bylaws would have to be developed and some sort of enforcement laws (fines), would have to be drawn up.

4. Implementing Authority: The local municipality would be responsible for implementing the bylaws, under the guidance of provincial or state governments. State and provincial departments of natural resources could be responsible for regulating shore protection and for providing technical advice.

5. Implementing Costs: Costs would be incurred in setting up regulatory programs and technical advice personnel.

6. Existing Examples: Ontario's Ministry of Natural Resources had a Technical Advisory Service for shore protection in place, whereby personnel trained in shore protection and shore processes would visit a property and make appropriate recommendations.

MEASURE 3.2.3-4
REGULATE EXTRACTION OF BEACH AND NEARSHORE DEPOSITS AND LANDFILLING AND ALTERATION OF THE SHORELINE

1. Description: This measure deals with alteration of the nearshore zone itself and would place regulations on the extraction of nearshore deposits, be it for commercial purposes, or just to fill the kid's sandbox. In addition, any landfilling (out into the lake), or other alteration of the shoreline (such as vegetation removal and flattening of dunes for sight purposes) would be strictly regulated. Proper permission (permits) would have to be obtained before any work of this type could be done. Limitations could also be placed on the amounts of deposit or vegetation that could be removed and the amount of filling that could be carried out.

2. Location: Entire Great Lakes shoreline.

3. Time Frame For Implementation: 1-2 years from the date of completion of the study. Regulations would have to be drawn up and put in place, and governing bodies would have to be established.

4. Implementing Authority: This would likely be at the Provincial or state level and possibly the municipal level. In Ontario for example, any alteration of the shoreline falls under jurisdiction of the Ministry of Natural Resources.

5. Implementing Costs: Costs associated with developing and enacting regulations of this type.

6. Existing Examples: Beach Protection Act in Ontario. Many States regulate dredging offshore. Wisconsin also regulates grading on the bank and excavation of ponds, lagoons etc., within 500 feet of a lake or stream. Wisconsin's shoreland zoning program requires local zoning permits for grading and excavating and certain vegetation removal is prohibited.

MEASURE 3.2.5
COASTAL HABITAT PROTECTION REGULATIONS

1. Description: This measure would see the development of regulations to protect sensitive coastal habitats, currently located on privately owned land, from the impact of man. In essence, this is a widely used measure in many national, provincial and state parks, which are usually set up to protect areas of natural significance. For example, in Canada, sections of Point Pelee and Long Point, two barrier spits on Lake Erie, are owned largely by the Canadian Parks Service and the Canadian Wildlife Service respectively, and are maintained in their natural state according to regulations set out by each agency. These regulations include many of the measures discussed previously, such as construction bans, deposit extraction bans or limits, and human access regulations.

2. Location: All sections of the Great Lakes shoreline that are areas of natural significance, or are currently included in the system of state, provincial, or national parks.

3. Time Frame For Implementation: Less than 1 year after study completion date. Many of these regulations are already in place in the various parks systems. It should be possible to extend them to areas outside of park boundaries. If new parks, or preserves were to be created, this may cause a delay.

4. Implementing Authority: Will vary, depending on park ownership and who will be willing to take over currently unprotected areas.

5. Implementing Costs: Not known.

6. Existing Examples: State, provincial and national park systems. U.S. Army Corps of Engineers wetlands permits. Environmentally Sensitive Areas policies in some Ontario municipalities.

MEASURE 3.3.1
REGULATE USE OF GREAT LAKES RESOURCES
IN ACCORDANCE WITH FLUCTUATING WATER LEVELS

1. Description: This measure is aimed primarily at recreational users on the Great Lakes and is designed to place limitations on their use of the lakes during sensitive water level periods. It is designed to control the demand on the resource, instead of looking at maintaining or increasing the supply. For example, if levels were low enough to be having a major impact on waterfowl population, then perhaps stricter limits could be placed on the number of birds that hunters could take during the hunting season. Limits could be placed on the number of hunters allowed in a sensitive area. Other examples could include a depth limitation on fixed keel sailboats and restricted boating areas for boaters, stricter catch limits, or fewer fishing permits for fishermen.

While this measure might be an important one as far as resources go, it also may be the most difficult to implement. As an example, if wetlands owned by private hunting clubs are placed under regulations that limit hunting, then the private club will likely convert the land into something they can benefit from (e.g. farmland). In addition, some people may feel that regulations of this type interfere with their constitutional rights, and thus, would be unwilling to accept them.

2. Location: All communities and other areas on the Great Lakes where recreational uses are dominant.

3. Time Frame For Implementation: 1-2 years after study completion. To implement this measure would likely require new legislation to be drafted, especially for boating regulations. This is often a time consuming process. Government agencies, such as Provincial and National Parks that currently allow hunting (eg.) could implement this measure within 1 year of study completion, as their management guidelines may be easier to amend than provincial or federal law.

4. Implementing Authority: Provincial and State governments.

5. Implementing Costs: Not known.

6. Existing Examples: Many states and the Province of Ontario already have such things as hunting and fishing licencing programs, which specify limits on a catch, or hunt. For these activities, the measure could be an amendment to these licenses. There are no known examples of a measure of this type being applied to boaters.

MEASURE 3.3.2
REGULATION OF WATER WITHDRAWALS

1. Description: This measure would see the development of regulations that would guide the use of water by towns, cities, etc., and in addition to consumptive use regulations, would see the regulation of in-water structures (other than water intakes and navigation structures) through a permit program, and would see regulations put in place that would ensure that water intakes and outfalls are properly designed to withstand extremely high, or low levels.

2. Location: All towns, cities and municipalities that draw their water supply directly from the Great Lakes.

3. Time Frame For Implementation: 1-2 years after completion of the study would be required to set up proper regulations and permit programs. A body would also have to be formed to issue the permits and enforce the regulations drafted. Water intakes and outfalls may also have to be redesigned.

4. Implementing Authority: The city, town, or municipality of concern, with possible funding assistance from the state, or province.

5. Implementing Costs: Relatively small, unless major re-design of structures has to take place. Possible cost-sharing arrangements between the city and the state/province could be arranged.

6. Existing Examples: Some states have permit programs for water diversion (withdrawals) and for construction of water intakes/outfalls on the lake bed. Many such structures are regulated by the Corps of Engineers.

MEASURE 3.3.3
POWER DEMAND / CAPACITY MANAGEMENT

1. Description: This measure would see regulations and programs developed that would allow those who draw their primary power from Great Lakes hydro projects, to make better use of this power during times of low supply (extremely low water levels), or would limit the amount of hydro power that could be used, or enforce conservation of electricity by communities, during these low water level periods.

2. Location: Any town, city or municipality that derives the majority of its electricity from hydro-electric power.

3. Time Frame For Implementation: 3-5 years. The regulations that are developed would remain in place during emergency low water level periods, with normal operation resuming at normal water levels.

4. Implementing Authority: State/Provincial, local governments, along with the various hydro entities (Ontario Hydro, etc.) would have to reach agreement on what the regulations should be and on how they are going to be put in place.

5. Implementing Costs: Not known.

6. Existing Examples: Ontario Hydro (At Sault Ste. Marie) is going to a "time of day" pricing structure. Many electric utilities have summer electric rates to provide an incentive for off-peak power use.

MEASURE 3.3.4
NAVIGATION REGULATIONS
(COMMERCIAL AND RECREATIONAL)

1. Description: Similar to measure 2.3.6, this measure includes only those measures that would regulate navigation, such as vessel speed regulations to eliminate wake during high water and carrying capacity limitations to minimize grounding problems during low water. Speed restrictions could also apply during low water, so that ships do not disturb sediment and create water quality problems. These could also include vessel size, or horsepower restrictions.

2. Location: All areas on the Great Lakes where commercial and recreational boating prevail, especially the connecting channels.

3. Time Frame For Implementation: Within 1 year of study completion date. These regulations could be put in place immediately after the study and enforced fairly easily.

4. Implementing Authority: Those responsible for regulation of boating traffic, namely federal transportation departments, coast guard and St. Lawrence Seaway Agencies.

5. Implementing Costs: Not known.

6. Existing Examples: Some speed limitations exist in small craft harbours and other areas, but they are sometimes poorly enforced.

MEASURE 3.3.5
REGULATION OF LAND OR WATER USE TO CONTROL STORMWATER

1. <u>Description</u>: Stormwater management regulations would restrict or prevent the development of areas that provide important natural storage of runoff from precipitation events, or could be used to control the amount of additional runoff associated with land development and construction. Such regulations would help to avoid damages to public or private property caused by flooding associated with increased runoff from areas that are topographically higher or located closer to the headwaters of a stream system. Among the specific types of regulations that might be implemented by governments are:

1. Restrictions on timber cutting and other vegetation removal.

2. Requiring temporary flow retarding, or runoff control devices during construction and permanent measures to increase infiltration or retard runoff to pre-construction conditions after project completion.

3. Restrictions on channel modifications and other land surface alterations that increase the rate of runoff.

4. Restrictions on altering areas providing significant natural storage of runoff.

2. <u>Location</u>: Could occur anywhere within the Great Lakes-St. Lawrence basin. Such measures are most efficiently implemented for small drainage areas or towards the headwaters of larger stream systems.

3. <u>Time Frame For Implementation</u>: 6-12 months to adopt regulations.

4. <u>Implementing Authority</u>: Usually carried out at the municipal level. States/Provinces could adopt laws mandating such regulations.

5. <u>Implementing Costs</u>: From a few hundred to a few thousands of dollars, depending on the type of regulation, the area affected, and whether the implementing authority lacks sufficient staff to administer the regulations.

6. <u>Existing Examples</u>: None known of at this time.

MEASURE 4.1.1
GRANTS FOR CAPITAL INVESTMENTS THAT REDUCE THE POTENTIAL FOR LOSSES IN LOW WATER CONDITIONS

1. Description: This measure uses a grant, which is the transfer of some amount of money from one level of government to, either another level of government, or to the public to provide incentive to shoreline users (municipal, commercial, industrial, residential, and agricultural) for the installation and operation of water saving devices and/or methods. A grant is basically a gift and need not be paid back.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels, especially harbours, inlets and bays. The measure would impact only those who made use of the grant.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. Implementing actions could take up to one year, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.2

GRANTS FOR CAPITAL INVESTMENTS IN STRUCTURAL METHODS FOR DEALING WITH THE POTENTIAL FOR LOSSES DUE TO FLUCTUATING WATER LEVELS

1. Description: This measure uses a government grant (transfer of money from government to public) as an incentive to a shoreline interest to use some structural method to protect the property and/or structure. Examples of these measures include construction of: seawalls; breakwaters; gabion; dikes; landfills; and revetments.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels, but may be most appropriate for erosion and flood hazard areas.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. The actual construction of the measure would depend on the individuals applying for the grants. The time required to obtain the necessary permits and for construction is about one year. Based on these times, 1994 is the estimated timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: The Upton-Jones amendment to the National Flood Insurance Program (U.S.) and the State of Michigan Public Act 108. Illinois has given financial assistance to the city of Chicago to help defray part of the city's costs for construction of Lake Michigan shoreline erosion controls (Center for Great Lakes, 1988). New York provides financial assistance to local governments as well.

MEASURE 4.1.3
GRANTS FOR CAPITAL INVESTMENTS IN NON-STRUCTURAL METHODS FOR DEALING WITH THE POTENTIAL FOR LOSSES DUE TO FLUCTUATING WATER LEVELS

1. Description: This measure uses a government grant (transfer of money to another level of government or to the public) as an incentive to a shoreline interest to use some non-structural method to adapt the property and/or structure to the fluctuating levels. Examples of these measures include: relocation of existing structures; floodproofing; drains and pumps; vegetation planting; floating docks; and beach nourishment.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels, but especially for flood and erosion hazard areas.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. The actual implementation of the measure would depend on the individuals applying for the grants. The time required to obtain the necessary permits and implement the measure is about one year. Based on these times, 1994 is the estimated timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: The Upton-Jones amendment to the National Flood Insurance Program (U.S.) and the State of Michigan Public Act 108. Grants are provided by the Ontario Ministry of Natural Resources to Conservation Authorities to provide technical assistance to shore property owners. Pennsylvania and Indiana provide grants to local governments who administer local bluff set back requirements (Center for Great Lakes, 1988)

MEASURE 4.1.4
GRANTS FOR INCREASED OPERATING COSTS DURING EXTREME WATER LEVEL CONDITIONS

1. Description: This measure uses grants to help reduce the financial hardships on Great Lakes interests caused by extremes in water level fluctuations. Examples of this measure are grants for: extending or deepening water intakes; adapting production processes to reduce water use; shipping lockage costs; irrigation systems; no-till farming; dredging at marinas and harbours;and private road and bridge repair.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. Actual implementation of the measure could take up to another year making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities. Private grants are also possible.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.5
GRANTS FOR REMOVAL OF EXISTING STRUCTURES WHICH EXACERBATE THE PROBLEMS ASSOCIATED WITH FLUCTUATING WATER LEVELS

1. Description: This measure uses grants as an incentive to remove existing structures which: have been destroyed; are in imminent danger of substantial damage or destruction; or are contributing to the potential for losses by others (i.e. some configurations of jetties, seawalls, steep revetments or groins).

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. Implementing actions could take up to one year, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities. Private grants are also possible.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.6

GUARANTEED/SUBSIDIZED LOANS FOR CAPITAL INVESTMENTS THAT REDUCE THE POTENTIAL FOR LOSSES IN LOW WATER CONDITIONS

1. Description: This measure uses a guaranteed/subsidized loan to provide incentive to shoreline users (municipal, commercial, industrial, residential, and agricultural) for the installation and operation of water saving devices and/or methods. A guaranteed loan for capital investment is only subsidized in the sense that some level of government would underwrite the loans presumably through banks so that the risk to the lender would be minimized. The guarantee would probably enable the lender to reduce the interest rate as compared to the rate it would charge without the guarantee.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. Implementing actions could take up to one year, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.7

GUARANTEED/SUBSIDIZED LOANS FOR CAPITAL INVESTMENTS IN STRUCTURAL METHODS FOR DEALING WITH THE POTENTIAL FOR LOSSES DUE TO FLUCTUATING WATER LEVELS

1. Description: This measure uses a guaranteed/subsidized loan as an incentive to a shoreline interest to use some **structural** method to protect the property and/or structure. Examples of these measures include construction of: seawalls; breakwaters; gabion; dikes; landfills; and revetments. A guaranteed loan for capital investment is only subsidized in the sense that some level of government would underwrite the loans presumably through banks so that the risk to the lender would be minimized. The guarantee would probably enable the lender to reduce the interest rate as compared to the rate it would charge without the guarantee.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. The actual construction of the measure would depend on the individuals applying for the guaranteed/subsidized loans. The time required to obtain the necessary permits and for construction is about one year. Based on these times, 1994 is the estimated timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million). However, the loans could be structured in such a way as to repay the fund, thereby perpetuating the fund after it is initially funded.

6. Existing Examples: Several states and the Province of Ontario have subsidized loan programs. (i.e. Ohio, Wisconsin and Ontario).

MEASURE 4.1.8
GUARANTEED/SUBSIDIZED LOANS FOR CAPITAL INVESTMENTS IN NON-STRUCTURAL METHODS FOR DEALING WITH THE POTENTIAL FOR LOSSES DUE TO FLUCTUATING WATER LEVELS

1. Description: This measure is similar to 4.7, but uses a guaranteed/subsidized loan as an incentive to a shoreline interest to use some **non-structural** method to adapt the property and/or building to the fluctuating levels. Examples of these measures include: relocation of existing structures; floodproofing; drains and pumps; vegetation planting; and beach nourishment.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. The actual implementation of the measure would depend on the individuals applying for the guaranteed/subsidized loan. The time required to obtain the necessary permits and implement the measure is about one year. Based on these times, 1994 is the estimated timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million). However, the loans could be structured in such a way as to repay the fund, thereby perpetuating the fund after it is initially funded.

6. Existing Examples: Several states and the Province of Ontario have subsidized loan programs.

MEASURE 4.1.9
GUARANTEED/SUBSIDIZED LOANS FOR INCREASED OPERATING COSTS DURING EXTREME WATER LEVEL CONDITIONS

1. Description: This measure is similar to other loan measures, but this uses guaranteed/subsidized loans to help reduce the financial hardships on Great Lakes interests caused by extremes in water level fluctuations. Examples of this measure are grants for: extending or deepening water intakes; adapting production processes to reduce water use; shipping lockage costs; irrigation systems; no-till farming; dredging at marinas and harbours;and private road and bridge repair.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. Actual implementation of the measure could take up to another year making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million). However, the loans could be structured in such a way as to repay the fund, thereby perpetuating the fund after it is initially funded.

6. Existing Examples: Several states and the Province of Ontario have subsidized loan programs.

MEASURE 4.1.10
GUARANTEED/SUBSIDIZED LOANS FOR REMOVAL OF EXISTING STRUCTURES WHICH EXACERBATE THE PROBLEMS ASSOCIATED WITH FLUCTUATING WATER LEVELS

1. Description: This measure uses guaranteed/subsidized loans as an incentive to remove existing structures which: have been destroyed; are in imminent danger of substantial damage or destruction; or are contributing to the potential for losses by others (i.e. some configurations of jetties, seawalls, steep revetments or groins).

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented. Implementing actions could take up to one year, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the subsidy which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.11
ELIMINATE GRANTS OR LOANS FOR DEVELOPMENT IN HAZARD AREAS

1. Description: This measure would eliminate all grant and loan programs which provide any type or incentive for any type of development in hazard areas.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: The only cost associated with this measure is the cost of putting the implementing legislation in place. This cost is expected to be very low (under $1 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.12
PROVIDE UNCONDITIONAL DISASTER AID TO GROUPS AFFECTED BY FLUCTUATING WATER LEVELS

1. Description: This measure provides unconditional disaster aid to those damaged by extremes of water level fluctuation (i.e. storms or droughts). This means there are no specific requirements or stipulations to receive funding. The amount of aid given would depend on how the laws are written.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about one year beyond that date for the federal governments, states and provinces laws to be implemented/changed.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the disaster aid which is not known, but could be expected to be in the medium cost range ($10-100 million) for any given period of extreme levels.
Costs could be assumed by either the State/Province, the Federal government, or they could be shared between the two.

6. Existing Examples: There are several existing programs for disaster aid in the U.S. through the Small Business Administration and the National Flood Insurance Program. In Canada a Disaster Aid program has been established but no situation, due to water levels, has been declared a disaster.

MEASURE 4.1.13
PROVIDE CONDITIONAL DISASTER AID TO GROUPS AFFECTED BY FLUCTUATING WATER LEVELS

1. Description: This measure provides conditional disaster aid to those damaged by extremes of water level fluctuation (i.e. storms or droughts). A conditional disaster aid refers to eligibility based on specific requirements and stipulations. The amount of aid given would depend on how the laws are written, and would require that the shoreline interest take some actions in order to be eligible for disaster aid. Examples of these actions might be requiring floodproofing of structures or the design of protective structures be able to withstand a given event.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels. Conditional aid would most likely be applied to hazard zoned areas.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about one year beyond that date for the federal governments, states and provinces laws to be implemented/changed. The conditional requirements may take up to one year to put in place, making 1993 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces and with possible administrative support from municipalities. The locals would have to have some type of inspection program to insure that the aid recipients comply with the conditions.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the disaster aid which is not known, but could be expected to be in the medium cost range ($10-100 million) for any given period of extreme levels.

6. Existing Examples: There are several existing programs for disaster aid in the U.S. through the Small Business Administration and the National Flood Insurance Program.

MEASURE 4.1.14
ELIMINATE OR REDUCE DISASTER AID IN RECOGNIZED HAZARD AREAS

1. Description: This measure would eliminate all forms of disaster aid in hazard areas to put the shoreline property owner in a position where they are totally responsible for any damage to their property caused by water level fluctuations. The intent of the measure is to get governments out of the business of bailing out those who unwisely develop in recognized hazard areas.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provincial laws to be implemented/changed.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: The only cost of this measure would be the governmental costs of passing the laws necessary to enact this measure. These costs are estimated to be very low (under $1 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.15
LOCATE PUBLIC INFRASTRUCTURE OUTSIDE OF HAZARD AREAS

1. Description: This measure would reduce the future potential for losses due to fluctuating water levels by locating public infrastructure outside of recognized hazard areas.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about one year beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: The only cost of this measure is the cost to governments to enact a law prohibiting future public infrastructure investments in recognized hazard areas.

6. Existing Examples: None in the Great Lakes at this time, although the road to Long Point on the Lake Erie shoreline has not been repaired to date.

MEASURE 4.1.16
INCORPORATE CAPACITY FOR EXTREME CONDITIONS IN PUBLIC INFRASTRUCTURE WITHIN RECOGNIZED HAZARD AREAS

1. Description: This measure would reduce the future potential for losses due to fluctuating water levels by designing and locating public infrastructure outside of recognized hazard areas. For example: during initial development or rehabilitation after substantial damage, elevate water supply or wastewater lines, elevate roads, floodproof buildings that must be in a hazard area, and incorporate water saving devices and procedures.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about one year beyond that date for the federal governments, states and provinces and municipal by-laws to be changed so the measure could be implemented.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces. The municipal level would take the necessary actions.

5. Implementation Costs: The costs of this measure are the cost to governments to enact a law requiring that all public infrastructure investments in recognized hazard areas must meet certain design conditions to incorporate capacity for extreme conditions.

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.1.17
MANDATORY ACTUARIAL RATE INSURANCE FOR PROPERTIES LOCATED IN A RECOGNIZED HAZARD AREA

1. Description: This measure would require that all owners of shoreline property within the recognized hazard area purchase full actuarial rate (unsubsidized) insurance to cover the property against the hazards inherent at that location.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces laws to be implemented/changed. It may take up to another year for insurance companies to develop the rates and make policies available to the property owners. Therefore, 1994 is an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first are the administrative costs of setting the laws in place and insurance company administration which is expected to be low (i.e. under $10 million). The second cost is the cost of the insurance itself which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: None in the Great Lakes area at this time.

MEASURE 4.1.18
REQUIRE MANDATORY CONDITIONAL SUBSIDIZED RATE INSURANCE FOR RECOGNIZED HAZARD AREAS

1. Description: This measure would require the shoreline property owner to purchase subsidized rate hazard insurance with certain conditions as a requirement for community or individual floodproofing.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provincial laws to be implemented/changed. It may take up to another year to get the rates, policies, and people signed up, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the insurance and any of the conditional requirement costs which are not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: There is the National Flood Insurance Program in the U.S. but it is not mandatory and has no conditions on its purchasers.

MEASURE 4.1.19
REQUIRE MANDATORY UNCONDITIONAL SUBSIDIZED RATE INSURANCE FOR RECOGNIZED HAZARD AREAS

1. Description: This measure would require the shoreline property owner to purchase subsidized rate hazard insurance within recognized hazard areas.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provincial laws to be implemented/changed. It may take up to another year to get the rates, policies, and people signed up, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the insurance which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: There is the National Flood Insurance Program in the U.S. but it is not mandatory.

MEASURE 4.1.20
OPTIONAL ACTUARIAL RATE INSURANCE FOR PROPERTIES LOCATED IN A RECOGNIZED HAZARD AREA

1. Description: This measure would provide the option for all owners of shoreline property within the recognized hazard area to purchase full actuarial rate (unsubsidized) insurance to cover the property against the hazards inherent at that location.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes, and their connecting channels having recognized hazard zoned areas.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provinces laws to be implemented/changed. It may take up to another year for insurance companies to develop the rates and make policies available to the property owners. Therefore, 1994 is an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first are the administrative costs of setting the laws in place and insurance company administration which is expected to be low (i.e. under $10 million). The second cost is the cost of the insurance itself which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: None in the Great Lakes area at this time.

MEASURE 4.1.21
PROVIDE OPTIONAL CONDITIONAL SUBSIDIZED RATE INSURANCE FOR RECOGNIZED HAZARD AREAS

1. Description: This measure would make available optional subsidized rate hazard insurance with certain conditions like a requirement for community or individual floodproofing to shoreline property owners in recognized hazard areas.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provincial laws to be implemented/changed. It may take up to another year to get the rates, policies, and people signed up, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the insurance and any of the conditional requirement costs which are not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: There is the National Flood Insurance Program in the U.S. but it has no conditions on its purchasers.

MEASURE 4.1.22
MAKE AVAILABLE UNCONDITIONAL SUBSIDIZED RATE INSURANCE FOR RECOGNIZED HAZARD AREAS

1. Description: This measure would make available to the shoreline property owner unconditional subsidized rate hazard insurance within recognized hazard areas.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about two years beyond that date for the federal governments, states and provincial laws to be implemented/changed. It may take up to another year to get the rates, policies, and people signed up, making 1994 an appropriate timeframe.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: There are two types of costs that would be incurred by implementation of this measure. The first is the administrative cost which is expected to be low (i.e. under $10 million). The second cost is the cost of the insurance which is not known, but could be expected to be in the medium cost range ($10-100 million).

6. Existing Examples: There is the National Flood Insurance Program in the U.S.

MEASURE 4.1.23
ELIMINATE OR REDUCE THE AVAILABILITY OF INSURANCE IN RECOGNIZED HAZARD AREAS

1. Description: This measure would eliminate or reduce the availability of hazard insurance to shoreline property owners putting them "on their own" rather than subsidizing them through insurance availability.

2. Location: This measure could be applied to all shoreline areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and acceptance by U.S. and Canadian federal governments, it will take about one year to eliminate or reduce the only available program in the U.S.

4. Implementing Authority: The U.S. and Canada would establish this measure by law for actual implementation by states/provinces.

5. Implementation Costs: The only cost for this measure is writing the National Flood Insurance Program (U.S.) out of the books. This is a very low cost measure (under $1 million).

6. Existing Examples: None in the Great Lakes at this time.

MEASURE 4.2.1
INCREASED TAXES TO FUND COORDINATED COMPLETE- REACH SHORE PROTECTION WORKS

1. Description: This measure uses taxes collected from a group of shoreline property owners to provide funds to some overseeing entity whose responsibility it would be to design and construct some form of shoreline protection for a complete-reach which requires flood/erosion protection.

2. Location: This measure could be applied to all defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be established and implemented. Actual completion of construction of the protective works could accomplished by 1993.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The actual cost of implementing this measure would be low (i.e. under $10 million). The cost of the actual constructed shore protection works would depend on the number of feet/meters protected, and would likely be in the medium cost range ($10-100 million).

6. Existing Examples: There are states and provinces which have conservation districts or other duly authorized organizations which are empowered to provide community shore protection using its taxing authority. (e.g. Ohio).

MEASURE 4.2.2
TAX ABATEMENTS FOR CAPITAL INVESTMENTS THAT DO NOT INCREASE LOSS POTENTIAL FOR OTHERS

1. Description: This measure gives a "tax break" for capital investments which meet specific design and construction guidelines so that the constructed works have no or minimal impacts on adjacent properties.

2. Location: This measure could be applied to all defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be implemented. Actual completion of construction could be accomplished by 1993.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The actual administrative costs to implement this program would be low (i.e. under $10 million). The cost of the actual constructed project would depend on the type and scope of the project, and would likely be in the medium cost range ($10-100 million).

6. Existing Examples: The State of Michigan has a program which gives a property tax exemption on the shore protection works if it meets the standards set up by the state.

MEASURE 4.2.3
TAX ABATEMENTS FOR SHORE PROTECTION WORKS DESIGNED TO WITHSTAND SPECIFIC EXTREME EVENTS

1. Description: This measure gives a "tax break" for individuals who install approved shore protection works that are designed to protect against extreme events such as the 100-year event (wave run-up and wave height).

2. Location: This measure could be applied to all defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be established and implemented. Actual completion of construction of the protective works could be accomplished by 1993.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The actual administrative cost to implement this program would be low (i.e. under $10 million). The cost of the actual constructed shore protection works would depend on the number of feet/meters protected, and would likely be in the medium cost range ($10-100 million).

6. Existing Examples: The State of Michigan has a program which gives a property tax exemption on the shore protection works if it meets the standards set up by the state.

MEASURE 4.2.4
PROPERTY TAX ABATEMENTS FOR NON-DEVELOPMENT OF FLOOD STORAGE OR WETLAND AREAS

1. Description: This measure gives property tax relief to owners who purchase and maintain flood storage or wetland areas, hence precluding its development and thereby adding to the potential hazards inherent in shoreline hazard zones. These areas may also retain water which reduces impacts elsewhere, and provide valuable fish and wildlife habitat.

2. Location: This measure could be applied at appropriate flood storage or wetland sites throughout the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be implemented. Property owned by the applicant would immediately be included in the program. Other properties could be covered after they are purchased.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The administrative costs to implement this program would be low (i.e. under $10 million). The property tax exemptions and the property purchases would likely be in the medium cost range ($10-100 million).

6. Existing Examples: In the Province of Ontario there are tax credits for purchases of wetlands to slow development and drainage.

MEASURE 4.2.5
TAX ABATEMENTS FOR RELOCATION BEHIND DESIGNATED SETBACK LIMITS

1. Description: This measure uses tax abatements as an incentive for shoreline property owners to relocate existing structures behind a designated setback limit for the erosion or flood hazard that may pose a threat to that structure.

2. Location: This measure could be applied to all defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be implemented. The relocations themselves could take up to one year which makes this measure implementable by 1993.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The actual administrative cost of implementing this program would be low (i.e. under $10 million). The costs of the tax abatements and physical relocations is likely to be in the medium range ($10-100 million).

6. Existing Examples: The State of Wisconsin recently proposed a measure like this, but it died in committee.

MEASURE 4.2.6
TAX ABATEMENTS FOR INITIAL CONSTRUCTION OUTSIDE RECOGNIZED HAZARD LIMITS

1. Description: This measure uses tax abatements as an incentive for a shoreline property owner to locate any new structures behind the recognized hazard zones for erosion and flooding.

2. Location: This measure could be applied to all defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be implemented. The measure could then be implemented immediately and be in place from that time on or for a specified period.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The actual administrative costs of implementing this measure would be low (i.e. under $10 million). The cost of the tax abatements is not known but could reach the medium range ($10-100 million).

6. Existing Examples: None in place at this time.

MEASURE 4.2.7
TAX ABATEMENTS FOR INITIAL CONSTRUCTION ADAPTED TO EXTREME CONDITIONS WHEN HAZARD AREA LOCATION CANNOT BE AVOIDED

1. Description: This measure uses tax abatements to provide incentives to a property owner/developer for adapting the constructed project to the known hazard when use of the hazardous location cannot be avoided. This measure is intended to minimize the damage potential to structures/facilities constructed in the hazard zone by adaptive design of those structures facilities.

2. Location: This measure could be applied to all the defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be implemented. The measure could then be implemented immediately and be in place from that time on or for a specified period.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The actual administrative costs of this measure would be low (i.e. under $10 million). The tax abatements and the additional adaptive construction costs are not known, but would likely be in the medium cost range ($10-100 million).

6. Existing Examples: This approach has been recommended in other areas, but has not been used along the Great Lakes or their connecting channels.

MEASURE 4.2.8
INCREASE TAXES FOR DEVELOPMENT IN HAZARD AREAS

1. Description: This measure imposes an increased tax penalty on anyone developing in a designated hazard area. The intent of this measure is to penalize development in designated hazard areas to attempt to stop or impede inappropriate development in those areas.

2. Location: This measure could be applied to all defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be enforced. It could be implemented immediately at that point.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level.

5. Implementation Costs: The administrative costs of this measure would be low (i.e. under $10 million). The cost to developers for this measure is not known, but conceivably be in the medium cost range ($10-100 million).

6. Existing Examples: There are none in existence on the Great Lakes or their connecting channels.

MEASURE 4.2.9
INCREASE TAXES TO REFLECT INCREASED GOVERNMENT COSTS OF COPING WITH FLUCTUATING WATER LEVELS

1. Description: This measure would increase the tax burden of shoreline property owners and developers to pay for the increased government costs (i.e. flood and hazard insurance, emergency actions,etc.) incurred in dealing with the impacts of fluctuating water levels.

2. Location: This measure could be applied to all defined hazard areas along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be enforced. It could be implemented immediately after that.

4. Implementing Authority: The implementing authority could be at the state/provincial or municipal level with the municipal level acting as the collection agent.

5. Implementation Costs: The administrative costs of this measure would be low (i.e. under $10 million). The tax increases to the taxpayer are unknown, but could be in the medium range ($10-100 million).

6. Existing Examples: There are none in the Great Lakes area at this time.

MEASURE 4.3.1
PUBLIC INFORMATION AND EDUCATION (I&E) PROGRAMS

1. Description: These are programs aimed at improving the public's understanding of the Great Lakes issues and options for action to better enable them to cope. They can include material management, such and cataloguing I&E material, public repositories for I&E materials, oversight groups and refinement of materials and programs. They could also include outreach programs such as cooperative extension programs technical assistance, demonstration programs and stewardship awards.

Another example would include setting up a series of 10 Great Lakes information centres at various location around the Great Lakes Basin, each having current information on Great Lakes Water Levels would offer information pertaining to water levels on the Great Lakes.

3. Time Frame For Implementation: Information Centres can be implemented in a reasonably short time. The Great Lakes Water Level Communication Centre for example was established from the time of conceptualization to the time of operation in under two weeks. From that point it took about two-three months for the Centre to become fully functional.

4. Implementing Authority: The implementing authority for information centres would be the U.S. Army Corps of Engineers in the United States, and Environment Canada in Canada. These federal agencies are presently responsible for water level data and are therefore the most appropriate for this responsibility.

5. Implementing Cost: Information programs can be established at a fairly low cost relative to other measures (< 10 million). It requires man-hours, costs for information material, computer facilities etc. The cost for implementation and operation will be assumed by the two federal governments, each being responsible for the locations within their respective countries.

6. Existing Examples: Environment Canada's Great Lakes Water Level Communication Centre. Ontario's Shoreline Management Review Committee and Advisory Council. Ontario's Ministry of Natural Resources and the Conservation Authorities also provide information through brochures, booklets and technical assistance. The eight states surrounding the Lakes have some form of public information/education program. Technical assistance to aid in the proper design of private flood and erosion control structures is provided through the Department of Natural Resources and various Sea Grant and College programs. Others include: University of Buffalo's a Great Lakes Information Clearinghouse; the Center for the Great Lakes; Great Lakes United; and the Great Lakes Commission.

MEASURE 4.3.2
YOUTH EDUCATION PROGRAM

1. Description: School education programs focus on teaching young people about the processes and dynamics of the Great Lakes. It is expected that such education will enable them, as adults, to make better informed decisions regarding the use of the lakes. It is also expected that continued exposure to the Great Lakes through their schooling will develop their empathy for the lakes and commitment to wise use of the lakes' resources. Youth programs may include: a) material management initiatives such as a public repository for I&E materials; b) outreach programs such as cooperative extension programs, nature centers or interpretive centers; and c) formal education programs through the school system at primary, secondary or post-secondary levels.

2. Location: Youth programs could be implemented in all areas surrounding the Great Lakes and beyond.

3. Time Frame For Implementation: There would be a certain amount of set-up and training time necessary to establish any youth programs. Teachers, trainers and interpreters would have to be educated themselves. Programs would have to be developed and there would be an implementing period as programs are proposed and approved by school boards, municipalities, university boards etc. A rough estimate might be 2 years from time of proposal to the time of implementation.

4. Implementing Authority: (1) Material Management: Federal or state/provincial governments through any public or private organization which wishes to take on the initiative. (2) Outreach: Any level of government through public or private organizations. (3) Formal: State/Provincial education departments and ministries or regional school boards.

5. Implementing Costs: Costs include training cost, material distribution, program development, administrative costs. Formal education programs could come out of education budgets. Some cost sharing between federal and local levels are possible for other programs. Low cost measure (< $10 million).

6. Existing Examples: Many education materials and their opportunities exist for use by schools. In Ontario, the Great Lakes Water Levels Communications Centre has many materials available for use by school groups and provide tours to student groups. In the U.S., Sea Grant programs in Minnesota, Wisconsin, Ohio, and Michigan have developed teaching units and manuals on many Great Lakes topics. There is also a Great Lakes Basin Educator's Network associated with the IJC, under the Science Advisory Board's Social and Economic Considerations Committee. Extension programs, private organizations, nature centers, and outdoor educations also provide education about the Great Lakes.

MEASURE 4.3.3
HAZARD MAPPING

1. Description: (a) Develop Hazard Mapping - Hazard mapping programs focus on determining the susceptibility of lands to flooding, erosion, or drought damages. Hazard maps are recognized as the basis for many other land and water management strategies such as zoning and setback regulations. (b) Extend definitions of hazards - For those areas which have already been mapped, it may be appropriate to either extend or alter the existing hazard areas, or to include coastal barrier mapping and wave velocity hazard mapping. Incorporation of seiche, setup, and wave run-up effects in flooding and erosion hazard maps is also an option.

2. Location: Areas in the entire basin susceptible to flood or other water-related hazards.

3. Time Frame For Implementation: (a) Given that air photos and other data are available hazard maps can be developed a reach of shoreline (i.e. a Conservation Authority) could be mapped within a year. (b) Given that the information is available, extensions could be added to hazard mapping within a relatively short period of time once the decision has been map to do so (i.e. a few months).

4. Implementing Authority: (a) Cooperative effort between Federal and State/Provincial governments. (b) Same as (a) although local governments could undertake this initiative as well.

5. Implementing Costs: Costs vary depending on the specific hazard and geologic situation, coastal zone hazard mapping required about $15,000 for 155 square kilometres for two cost-study areas in California in 1978 (Williams, 1978); the Tennessee State Planning Office estimated that flood insurance rate map for 21 riverine locations would cost $300,000 to $400,000 in 1982 (Thackston et. al, 1982). Costs would be distributed between the federal and state/provincial levels.

6. Existing Examples: a) All eight states surrounding the Great Lakes have undertaken some degree of hazard mapping. In Canada hazard mapping is undertaken by the Flood Damage Reduction Agreement which includes the delineation of erosion setback distances. Michigan, New York, and Pennsylvania require that homes, businesses and other structures be set back from the bluff's edge and have developed some mapping along with Illinois and Ohio. (b) In Ontario surge calculations and wave run-up estimates are presently being developed under the Flood Reduction Program. In the U.S., Wisconsin has required the local governmental units to update their flood hazard maps to include wave run-up.

MEASURE 4.3.4
INFORMATION COORDINATION AND EXCHANGE

1. Description: Coordination and exchange of information about hazards such as flooding, storms, and erosion are widely recognized as improving the overall status of hazard management programs. Lack of interaction between agencies often results in duplication of effort and confusion when assessments of hazard risks or recommendations for coping with the hazards differ between agencies. The public becomes confused when various agencies are giving out different information. Information coordination and exchange can be through (a) research such as coordinating directions and levels of activity for research programs via visiting scientist programs, IJC study boards, ad hoc inter-agency committees, scientific research organization committees; (b) data collection such as coordinating timing and scale of data collection via visiting scientist programs, IJC study boards, etc; and (c) information reporting such as peer review, coordinating hazard advisories, coordinated data, coordinated I&E materials.

2. Location: Information coordination and exchange to be successful should be international, interstate and inter-agency.

3. Time Frame For Implementation: All coordinating initiatives can be implemented immediately. This measure only needs the idea and will to undertake such initiatives.

4. Implementing Authority: Coordination can take place at any level of government.

5. Implementing Cost: Most coordinating efforts will have inherent costs of travel, distribution, and administrative costs. Overall this measure can be considered a low cost measure (< $10 million). (a) Research - no specific costs; (b) Data Collection - data collection compatibility could be costly ie investment in comparable data bases, techniques and equipment; and (c) Information Reporting - no specific costs.

6. Existing Examples: International: IJC Reference Studies; IJC Science Advisory Board and the establishment of a Council of Great Lakes Research Managers; the Coordinating Committee on Great Lakes Basin Hydraulic and Hydrologic Data; International Association for Great Lakes; and the Great Lakes Fisheries Commission. U.S.: Council of Great Lakes Governors. Canada : Federal Government and Ontario and Quebec have cooperated on facets of shoreline management most notably in hazard mapping. In Ontario MNR works to coordinate the various Conservation Authorities within the basin. Organizations: Center for the Great Lakes, Great Lakes United, Great Lakes Tomorrow, The Great Lakes Commission, and the Great Lakes Coalition all have member and/or contacts on both sides of the border.

MEASURE 4.3.5
REAL ESTATE DISCLOSURE

1. Description: The purpose of this program is to inform prospective buyers of shoreline property of the associated risks. All real estate agents, investors and planning departments would be provided with hazard land maps. Real estate agents would then be required by law to reveal hazard land properties to prospective buyers. Owners of shoreline property must disclose any past damage or repair costs associated with flooding and erosion problems and any other unusual risks associated with shoreline property. If they refuse to disclose problems they can legally be held responsible for any damages incurred by the new buyers.

2. Location: The program could be implemented in all states and provinces within the Great Lakes basin. The geographical area of impact would not exceed the basin unless similar legislation is implemented for river flood plains and other hazard areas.

3. Time Frame For Implementation: Hazard Maps would have to be completed for the entire basin before the program could be properly implemented. Bills must be passed in all states and provinces and the appropriate municipal by-laws would be necessary for enforcement. Implementation should be possible within 1 year of the initial decision.

4. Implementing Authority: The provincial and state governments have the jurisdiction to implement province/state wide laws for disclosure and for the distribution of hazard maps. Enforcement of the laws would be the responsibility of the municipalities.

5. Implementing Costs: Provinces/States must fund the delineation of hazard lands and the distribution of hazard maps. Some funding may also be available from federal governments.

6. Existing Examples: Lake Superior Management Board, having authority over 3 counties and 7 municipalities along the Great Lakes shoreline, has plans underway to amend property deeds to include disclosures of erosion hazard lands. Information is available from the Lake Superior Management Board. Presently only Wisconsin has a disclosure policy. In this state, real estate transactions forms must be filled out as part of the land transfer and the seller must tell the prospective buyer of flooding hazards. Erosion and other hazards need not be disclosed. In Ontario, the township of Norfolk, is attempting, on a trial basis, a policy whereby permits for new structures may be granted for properties located within designated hazard land areas but the fact that the structure is located within a hazard area is added directly to the property deed.

MEASURE 5.1.1
WEATHER MODIFICATIONS TO CHANGE LOCAL PRECIPITATION

1. Description: Seeding of silver iodide or dry ice from aircraft to promote the growth of ice crystal and encourage precipitation.

2. Location: Very small localized area where atmospheric water is needed. Past experiments have increased local precipitation by up to 10 per cent. The impact on the Great Lakes is negligible due to the relative small amount of water which might be added to the Great Lakes. The experiment might in some situations reduce precipitation.

3. Time Frame for Implementation: Technologies already exist and have been tried in the past.

4. Implementing Authority: Due to the negligible impact on Great Lakes over-all hydrology, it is assumed that government authorization is not required.

5. Implementing Costs: This would be a low cost scheme (<10M) when tried on small scales.

6. Existing Examples: Tried on small localized scale in various parts of the world. Studies have also been carried out for Lake Michigan by the Illinois Water Survey.

MEASURE 5.1.2
INCREASE NIAGARA RIVER FLOWS VIA BLACK ROCK LOCK

1. Description: The use of the existing facilities at the Black Rock Lock to increase the Lake Erie outflows by about 1,300 cfs. The technical feasibility of this measure was examined in the IJC Great Lakes Water Levels Task Force in 1987.

2. Location: Black Rock Lock at the outlet of Lake Erie. This measure will have localized impact affecting navigation, water quality and other users of the Black Rock Canal. Impacts of levels and flows would be very minor.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will require 6 months to prepare a plan of operation. No major construction is required, although repairs to the existing facilities would be required due to its present poor conditions.

4. Implementing Authority: The U.S. Army Corps of Engineers is the operator of the canal, after agreement by Canada and the United States.

5. Implementing Costs: Relatively small since no major constructions are needed.

6. Existing Examples: The navigation locks at Sault Ste. Marie, Michigan have been used during the recent record high lake level period to increase Lake Superior outflows.

MEASURE 5.1.3
STORAGE OF WATER IN LAKE SUPERIOR

1. Description: Reducing Lake Superior's outflow when Lakes Michigan-Huron and Erie levels are very high. The stored water on Lake Superior would be discharged downstream when conditions on the lower lakes improve.

2. Location: Changes in the operation of the regulatory facilities at Sault Ste. Marie, Ontario/Michigan. The geographic area of impact include local (St. Marys River) and Great Lakes- St. Lawrence River system-wide. It might be possible, when conditions on Lake Superior are favourable, to store water on Lake Superior by up to 0.5 foot, with a lowering of about 0.3 foot on Lakes Michigan-Huron.

3. Time Frame for Implementation: A plan of action would be prepared within a matter of one month, and would be implemented within two months if the measure is to be effective.

4. Implementing Authority: The IJC at the request of Canada and the United States. The operation of all control facilities would come under the supervision of the IJC.

5. Implementing Costs: Operating and Administration costs would be very low (<$1M). However, extensive flood, erosion and other damages would occur on Lake Superior unless remedial measures are also taken. The issue of compensating the interests on Lake Superior should be addressed.

6. Existing Examples: Water was stored temporarily on Lake Superior during the 1985-1986 record high water conditions on Lakes Michigan-Huron. That emergency storage was suspended in September 1985, when levels on Lake Superior were also approaching extreme highs.

MEASURE 5.1.4
STORAGE OF WATER ON TRIBUTARY RESERVOIRS/STREAMS

1. Description: Tributary flows to the Great Lakes would be reduced using existing facilities in the watershed when Great Lakes water levels are very high. The stored water would be released when conditions on the Great Lakes improve.

2. Location: Throughout the Great Lakes watershed where control facilities exist, especially in the Superior, Michigan and Huron watersheds.

3. Time Frame for Implementation: To be effective, this measure should be implemented within two months.

4. Implementing Authority: Local operators and governments who operate these facilities.

5. Implementing Costs: This would be considered a medium cost ($10-100M) and would consists mainly of compensating the operators involved.

6. Existing Examples: Temporary reduction and cutoff of the Ogoki Diversion have occurred in the past with very minimal impact on Lake Superior.

MEASURE 5.1.5
OUTLET/CHANNEL ENLARGEMENT OR SILL PLACEMENT

1. Description: The outlet channels of the Great Lakes would be enlarged during very high water level conditions; and placement of sills when levels are extremely low.

2. Location: At the outlet of Lake Huron (St. Clair-Detroit River System), the outlet of Lake Erie (Niagara River) and the outlet of Lake Ontario (various reaches in the St. Lawrence River).

3. Time Frame for Implementation: The extensive nature of this scheme would exclude it for consideration as short-term emergency measure.

4. Implementing Authority: Canada and the United States on recommendation from the IJC.

5. Implementing Costs: Assuming possible, this would be a high ($100-1,000M) cost scheme.

6. Existing Examples: Not tried on a grand scale as with the Great Lakes.

MEASURE 5.1.6
MANIPULATION OF EXISTING DIVERSIONS

1. Description: The amount of the diversions at the Long Lac, Ogoki, Chicago and Welland diversions would be adjusted to provide a measure of relief to the Great Lakes interests affected by extreme high or low water level conditions. This is similar to Measure 1.3.1 except that in this case, the diversions will be operated according to emergency plans developed by the IJC or Governments.

2. Location: Long Lac and Ogoki Diversions which divert water into the Lake Superior basin; Chicago Diversion which diverts water from Lake Michigan and discharges it into the Mississippi River; the Welland Canal which diverts water from Lake Erie to Lake Ontario. The area of impact includes specific sites of diversions, the Great Lakes - St. Lawrence River, the Mississippi River and the Albany River watershed.

3. Time Frame for Implementation: This measure should be implemented within a matter of several months to be effective.

4. Implementing Authority: Canada and the United States and the operators of the diversions.

5. Implementing Costs: This could be a medium cost ($10-100 million annually for the duration of the emergency).

6. Existing Examples: Minor changes in the Ogoki diversions have been made in the past. Also, flows in the Welland Canal were maintained at the maximum possible during the record high water years of 1985 and 1986.

MEASURE 5.1.7
REGULATE WATER WITHDRAWAL/CONSUMPTIVE USES

1. Description: Reduce water withdrawal and consumptive uses in the Great Lakes basin when lake levels are extremely low.

2. Location: Great Lakes basin-wide. A very rough estimate is that this measure would have a very tiny impact on lake levels and flows.

3. Time Frame for Implementation: This measure should be implemented within a matter of several months. The very tiny impacts on lake levels and flows, and the difficulties in regulating water withdrawal and consumptive uses make this measure very questionable.

4. Implementing Authority: Canada and the United States.

5. Implementing Costs: Major social disruptions are expected and the financial losses would be in the millions of dollars.

6. Existing Examples: None on a scale such as the Great Lakes. Local governments have regulations and bylaws concerning non-essential use (such as lawn watering) when draught conditions exist locally.

MEASURE 5.2.1
EMERGENCY SANDBAG AND DIKING ASSISTANCE

1. Description: In times of high lake levels, provide sandbagging and diking assistance. In times of draught, provide emergency water supplies by trucking or pipelines. Other assistance includes government loans to assist in rebuilding, repair, relocation or property acquisition, and engineering advice on shore protection works.

2. Location: Throughout the affected shoreline on the Great Lakes-St. Lawrence River system.

3. Time Frame for Implementation: To be implemented by federal and local governments when situation arises. Under emergency conditions, preventive local measures like sandbagging can be implemented in a few days or weeks. Repairs and relocation would require much longer.

4. Implementing Authority: Various levels of governments.

5. Implementing Costs: This would be a medium cost scheme ($10-100M) for large areas but low cost for only local areas.

6. Existing Examples: Various programs operated by local governments and by provinces and states. Also the Corps of Engineers PL-84-99 Emergency Assistance Program was carried out during the 1985-87 record high water levels on the Great Lakes.

MEASURE 5.2.2
GOVERNMENT PROGRAM FOR DISASTER ASSISTANCE

1. Description: Provide assistance to shore property owners who suffered major flood and/or storm damages.

2. Location: Throughout the Great Lakes-St. Lawrence River system.

3. Time Frame for Implementation: Varies depending on the programs.

4. Implementing Authority: Various levels of governments responsible for the programs.

5. Implementing Costs: Depends on factors such as nature of the storm/flood event, area affected, and government budget.

6. Existing Examples: In the United States, the Corps of Engineers Great Lakes Emergency Measures Program (PL-84-99, Advance Measures and Emergency Assistance Programs) during the 1985-87 record high water levels. Also under true emergency conditions, an area can be declared a "disaster area" making other government assistance available.

MEASURE 5.2.3
STORM FORECASTING

1. Description: Information centres responsible for collecting, analyzing and disseminating Great Lakes water level, flow, shore erosion, storm forecasts and other related information. Weather radio broadcasts to inform boaters and shore residents on water level and storm information.

2. Location: Major Great Lakes urban area easily accessed by the general public.

3. Time Frame for Implementation: About 1 year would be required to have the centres operational, but the centre could be set up within a matter of weeks for emergency operations.

4. Implementing Authority: Environment Canada in co-operation with the Province of Ontario. In the United States, the centre could be operated by the Corps of Engineers with assistance from the states and NOAA.

5. Implementing Costs: This would be a very low cost scheme (<$1M per year) for each centre.

6. Existing Examples: Environment Canada's Great Lakes Water Level Communications Centre. The U.S. Army Corps of Engineers' Great Lakes Water Levels and Forecasting Information Center.

MEASURE 5.2.4
DIKING AND OTHER PROTECTIVE WORKS IN THE ST. LAWRENCE RIVER

1. Description: This measure would be very similar to Measure 1.4.2 except that this would be implemented as an emergency measure and hence protection of lands and other shore properties from imminent flooding is paramount.

2. Location: Low lying and other vulnerable areas in the St. Lawrence River.

3. Time Frame for Implementation: Within a matter of weeks if this measure is to be effective.

4. Implementing Authority: Canada and the United States for works necessary in the International Reach of the St. Lawrence. Canada Ontario and Quebec in the Canadian Reach of the St. Lawrence River.

5. Implementing Costs: This could be a medium cost scheme ($10-100M).

6. Existing Examples: Protective dikes have been placed in certain parts of the St. Lawrence River in the past.

MEASURE 6.1
FULL REGULATION OF ALL THE GREAT LAKES BY COMBINING LAKE ERIE PLAN 50N WITH THE PLACEMENT OF A SILL IN THE ST. CLAIR RIVER WHICH IS THE OUTLET OF LAKES MICHIGAN-HURON, AND STRUCTURAL SETBACK ZONING (MEASURES 1.2.1 + 1.4.4 + 3.1.1)

1. Description: This combination incorporates structural and non-structural measures selected from the previous five types. It includes Lake Erie regulation, placement of a sill in the St. Clair River, and setback zoning. More detailed information on each of these measures appear in Appendix E-4.

Lake Erie regulation would reduce the range of water level fluctuation on that lake, and to a lesser degree that on Lakes Michigan-Huron due to the backwater effect extending upstream via the St. Clair and Detroit River system.

A sill at the outlet of Lake Huron would bring Lakes Michigan-Huron up to the pre-Seaway condition. The sill would compensate for the most recent major dredging completed in 1962 that in effect lowered the levels of Lakes Michigan-Huron by about 0.6 foot. Lake Superior Regulation Plan 1977 would need to be revised to reflect this objective. Lake Ontario Regulation Plan 1958-D would need to be revised to cope with Lake Erie regulation. Channel improvements would also be required in the St. Lawrence River.

The last component of this combination measure is structural setback zoning aimed at reducing future hazards on the Great Lakes by requiring all new or upgraded structures to be setback a given distance so that erosion will not destroy the structure before its useful life has been completed. This portion of the combination measure would help to address the problems associated with short term fluctuations (i.e. storms) that cannot be handled by lake level regulation.

2. Location:

(a) Lake Erie Plan 50N - Channel enlargement and a control structure at the outlet of Lake Erie.

(b) Sills in the St. Clair River would be located at the head of the river near the outlet of Lake Huron.

(c) Structural setback regulations would apply to all areas along the entire Great Lakes shoreline that are severely threatened by erosion, especially undeveloped or moderately developed areas. Erosion set-back lines would be developed for all shoreline reaches. Impacts of this action would be local and would depend on the degree of development already in place and the development pressure on the remainder of the shoreline.

3. Time Frame for Implementation: Each piece of the combination

plan is likely to take differing amounts of time to put in place. However, based on the discussions of each piece below, it is expected that the earliest this combination could be fully implemented would likely be 10 to 15 years after the decision is made to move ahead on such a combination plan.

(a) Lake Erie Plan 50N would require two years or more to perform the necessary planning, environmental and design studies. Add to this would be four-five years for construction. In addition, assuming modifications are needed to the St. Lawrence River's channel capacity, a similar time commitment concurrently with the above would be required because of the extent of the undertaking.

(b) Sills are also a long-term type measure requiring times similar to the previous portion of the plan.

(c) Structural setback zoning could likely be applied to all shoreline areas within three to five years. As it is not physically tied to the other portions of the plan, it could be put in place in advance of the actual construction of those works.

4. Implementing Authority:

(a) Lake Erie Plan 50N - The IJC can implement given appropriate authorization from the U.S. and Canada.

(b) Sills - The IJC after agreement by the U.S. and Canada.

(c) Structural Setbacks - State / Provincial and local governments.

5. Implementing Costs:

(a) Lake Erie Plan 50N - About $400-500 million for works at Niagara. Total cost could be $1 billion if channel enlargement in the St. Lawrence river is included.

(b) Sills - Between $10 million and $100 million.

(c) Structural Setbacks - Costs in some areas may be minimal where there are few hazard designated areas or programs are already in existence. In other areas there would be the administrative c osts of establishing, monitoring, and enforcing the program. The total cost of this type of program is unknown at this time.

6. Existing Examples: Lakes Superior and Ontario regulation. Compensating dikes (on a small scale) in the Detroit River. Examples of setback programs include the State of Michigan Emergency Home Relocation Program. Some municipalities and Conservation Authorities also have some setback regulations.

MEASURE 6.2
FULL REGULATION OF LAKE ERIE WITH STRUCTURAL SETBACK ZONING
(MEASURES 1.2.1 + 3.1.1)

1. Description: This measure combines Lake Erie Plan 50N with Structural Setback Zoning (a structural measure with a non-structural one). This combination recognizes that while reductions of high lake levels due to regulation would reduce some of the flood damages, there will always be damages due to short term fluctuations (i.e. storms, seiches, and waves). Setback zoning aims at reducing this damage potential. More detailed information on these measures appear in Appendix E-4.

Lake Erie regulation would reduce the range of water level fluctuation on that lake, and to a lesser degree that on Lakes Michigan-Huron due to the backwater effect extending upstream via the St. Clair and Detroit River system. Lake Ontario Regulation Plan 1958-D would need to be revised to cope with Lake Erie regulation. Channel improvements would also be required in the St. Lawrence River.

The second component of this combination measure is structural setback zoning aimed at reducing future hazards on the Great Lakes by requiring all new or upgraded structures to setback a given distance so that erosion will not destroy the structure before its useful life has been completed. This portion of the combination measure would help to address the problems associated with short term fluctuations (i.e. storms) that cannot be handled by lake level regulation.

2. Location:

(a) Lake Erie Plan 50N - Channel enlargement and a control structure at the outlet of Lake Erie.

(b) Structural setback regulations would apply to all areas along the entire Great Lakes shoreline that are severely threatened by erosion, especially undeveloped or moderately developed areas. Erosion set-back lines would be developed for all shoreline reaches. Impacts of this action would be local and would depend on the degree of development already in place and the development pressure on the remainder of the shoreline.

3. Time Frame for Implementation:

(a) Lake Erie Plan 50N would require two years or more to perform the necessary planning, environmental and design studies. Add to this four-five years for construction. In addition, assuming modifications are needed to the St. Lawrence River's channel capacity, a similar time commitment concurrently with the above would be required because of the extent of the undertaking.

(b) Structural setback zoning could likely be applied to all shoreline areas within three to five years. As it is not physically tied to the other portions of the plan, it could be put in place in advance of the actual construction of those works. The control structure would likely take between 10 to 15 years based upon experience with similar scale water resources projects. Full implementation of setbacks are likely to take about three years after recommendation from the IJC and acceptance of this action by Governments.

4. Implementing Authority:

(a) Lake Erie Plan 50N - The IJC can implement given appropriate authorization from the U.S. and Canada.

(b) Structural Setbacks - State / Provincial and local governments.

5. Implementing Costs:

(a) Lake Erie Plan 50N - About $400-500 million for works at Niagara. Total cost could be $1 billion if channel enlargement in the St. Lawrence river is included.

(b) Structural Setbacks - Costs in some areas may be minimal where there are few hazard designated areas or programs are already be in existence. In other areas there would be the administrative costs of establishing, monitoring, and enforcing the program. The total cost of this type of program is unknown at this time.

6. Existing Examples: Lakes Superior and Ontario regulation. Compensating dikes (on a small scale) in the Detroit River. Examples of setback programs include the State of Michigan Emergency Home Relocation Program. Some municipalities and Conservation Authorities also have some setback regulations in place. and various government acts and legislations regarding land use and zoning.

MEASURE 6.3
HAZARD LAND MAPPING / STRUCTURAL SETBACK ZONING / PUBLIC INFORMATION AND EDUCATION / REAL ESTATE DISCLOSURE
(MEASURES 4.3.3 + 3.1.1 + 4.3.1 + 4.3.5)

1. Description: This combination of non-structural measures is designed to have people adapt to the environment rather than the reverse. Hazard land mapping is necessary in order to effectively implement many different types of actions. Hazard mapping, along with information and education programs, and the real estate disclosure will make current and future shoreline owners/users more aware of the hazards that the Lakes' impose both in terms of flooding and erosion. The setback zoning requires all future construction to be cognizant of the erosion hazard, and places development back a safe distance that depends on the location and the useful life of the structure.

2. Location: This combination measure can be applied to all shorelines of the Great Lakes and their connecting channels.

3. Time Frame for Implementation: Hazard zone mapping is already under way in many locations. Some public information and education programs are already in place. The setbacks and real estate disclosure are estimated to take about three years to implement once the decision to take these specific actions is made.

4. Implementing Authority: Typically the federal level has been involved in the public information business, but has not been directly responsible for the "grass roots"-type education (actual high school) proposed in this piece of the measure. The states / provinces have some setback programs and are the appropriate level at which to execute this program. The hazard mapping itself could be accomplished by states / provinces with federal level support, and the real estate disclosure should be a state / provincial program as well.

5. Implementing Costs: The costs of all these types of programs are unknown at this time. However, they are all relatively low cost programs when one compares then to structural type measures.

6. Existing Examples: Hazard land mapping has been done and is currently underway in several locations. Setback programs have been set up under the Province of Ontario's MNR Floodplains zoning regulations. Agencies of the federal governments have set up public information centers during times of crisis. For disclosure the only current policy in the Great Lakes area is the one the State of Wisconsin has established.

MEASURE 6.4
BREAKWATER CONSTRUCTION / PUBLIC INFORMATION AND EDUCATION
(MEASURES 2.1.4 + 4.3.1)

1. Description: This combination would include breakwaters to protect those areas that are severely threatened by wave action/erosion, and public information and education programs to make people aware of the hazards associated with living in the shore zone.

Breakwaters intercept and dissipate the energy of approaching waves before they can erode the shoreline or damage structures. Public information and education programs could include the development of information centers, demonstrations of shoreline management techniques, outreach programs,and youth education programs (particularly in the school curriculum).

2. Location: Breakwaters can be installed in any area where there is a severe erosion hazard in the Great Lakes. Their impacts would be fairly localized with possible downstream effects. Education programs should take place throughout the entire Great Lakes Basin, and have basinwide effects.

3. Time Frame for Implementation: Breakwaters would take two to three years for implementation. Background studies would have to be done to select appropriate sites, determine what style of breakwater to use, and construct the breakwaters. Information programs could be set up within two to three months of the decision to fund them. Formal education programs would take longer to implement, as the curriculum would need to be developed, approved and instituted by the appropriate school boards. This is estimated to take two to three years to implement.

4. Implementing Authority: Major civil works type breakwater projects would be implemented by the government agencies of the federal governments, the USACE in the U.S., and Environment or Public Works Canada. Education and information programs could be implemented at all levels of government, depending upon where money is available.

5. Implementing Costs: Breakwater costs would depend on the number, style, and size of breakwaters constructed, but it is likely to be very high if all erosion-prone areas are protected. For information and education programs, costs would be low to moderate and would likely be carried primarily at the state/provincial level except in the case of information centers such as those that have been set up by federal governments in the past.

6. Existing Examples: Numerous breakwaters throughout the Great Lakes, Environment Canada's Great Lakes Water Level Communication Center, various state and provincial information programs.

MEASURE 6.5

MAXIMIZE USE OF EXISTING REGULATORY STRUCTURES AND PROCEDURES / HAZARD LAND MAPPING / PUBLIC INFORMATION AND EDUCATION (MEASURES 1.1.5 + 4.3.3 + 4.3.1)

1. Description: This combination includes the use of existing structures to minimize flood and erosion losses, and maximize public awareness of the hazards of building in flood and erosion prone areas. This is viewed as a non-structural measure because no new structures would be required.

2. Location: This measure would require improved/updated regulation plans for the control works in the St. Marys and St. Lawrence Rivers (Plan 1977 and Plan 1958-D, respectively).Hazard land mapping and information and education programs would have basinwide applications.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991 and the availability of Hazard Zone Mapping by that date, a review of current regulation plans could be accomplished in about two to three years which is about the same length of time it would take to get a public education program in place.

4. Implementing Authority: The IJC would be the implementing authority on the modifications to the regulation plans (after U.S. and Canadian governments approval). The IJC could also increase its current efforts in public information activities related to Great Lakes levels. The Great Lakes States and the Provinces of Ontario and Quebec are in the best position to implement the public information program and hazard land mapping.

5. Implementing Costs: The cost of implementing regulation plan changes could be low (i.e. under $10 million). The nature and extent of hazard land mapping, engineering studies, and the public information programs will determine their costs.

6. Existing Examples: The existing regulation plans for the control structures in the St. Marys and St. Lawrence Rivers. The Province of Ontario and several states have done hazard lands mapping, and some public education/awareness programs used in times of emergency. Environment Canada also operates the Great Lakes Water Level Communications Center.

MEASURE 6.6

COMMUNITY ACQUISITION OF HAZARD LAND / REGULATE USE OF PROPERTY IN HAZARD AREAS (MEASURE 2.1.1 + 3.1)

1. Description: This action is a combination of Type 2 and 3 actions and is designed to prevent further damages to structures in hazard areas by acquiring hazard land and by regulating the use of property in hazard areas. If lands are acquired, the community can then resell it, but with certain restrictions, such as the prohibition of residential development. The community can also revert the land to parkland and retain ownership. The community could also retain ownership, not remove or repair any structures, and let nature take its course. Regulations could apply to existing developed land, but would be better suited to undeveloped, or moderately developed land. These regulations would insure that any development that takes place is done so with due consideration to the natural hazards that exist in the shore zone. Regulations of this type might even apply to land that the community has acquired.

2. Location: Areas of past residential damage, all undeveloped or moderately developed shorelines in designated hazard zones along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: This combination action could be implemented within one to two years after the study completion date. Many similar regulations may already exist, and only simple modifications to these may be required. Acquisition may take longer to totally implement, as communities would have to wait for properties to become available.

4. Implementing Authority: The municipality or local government body would likely have the main implementing authority, but would need direction from higher levels of government.

5. Implementing Costs: The costs will vary depending on current and future market values of the property, and on the costs involved in setting up governing bodies for any new by-laws that are introduced. Funding for programs of this type should come from federal and state / provincial governments.

6. Existing Examples: The Hamilton Region Conservation Authority, State of Florida, and U.S. Federal Emergency Management Agency have been involved in community acquisition of hazard lands in the past. Similar regulations have been employed in Canada, Ontario has a Flood Damage Reduction Program (erosion/flood setbacks). Ontario Conservation Authorities have elevation regulations, and there are other related municipal by-laws in Ontario.

MEASURE 6.7

FULL REGULATION OF LAKE ERIE WITH DOWNSTREAM MODIFICATIONS TO LAKE ONTARIO REGULATION PLAN 1958-D AND INCREASED CHANNEL CAPACITY IN THE ST. LAWRENCE RIVER (MEASURES 1.2.1 + 1.1.2 +1.4.2)

1. Description: This measure is basically Type 1.2.1: Full Regulation Of Lake Erie. Whereas Type 1.2.1 identifies the concerns regarding the impacts on downstream interests, this combination measure emphasizes that detailed investigations on the downstream impacts would be carried out, and that Lake Erie Regulation would proceed only after these concerns have been fully addressed.

A description of this measure can be found in Measures 1.2.1, 1.1.2, 1.4.2 and to some extent also in 6.1. More detailed information on Lake Erie regulation can be found in Appendix F-4.

2. Location: The Plan 50N control structure would be located in the Niagara River near the outlet of Lake Erie. The need for channel enlargements to cope with Limited Lake Erie Plan 25N has been studied briefly in the previous Lake Erie Regulation Study in 1981. The areas for channel enlargement would include the International Reach and the Lachine Rapids in the St. Lawrence River. Detailed studies would be required to update this infomation.

3. Time Frame for Implementation: As with other large scale public works such as measure 6.1 its estimated that 10 to 15 years would be required to implement this type of major undertaking.

4. Implementing Authority: The IJC and the U.S. and Canadian governments would all play major roles. In addition, the State of New York and Provinces of Ontario and Quebec would have construction related interest in the locations of the control structure and dredged areas (and disposal of dredgings).

5. Implementing Costs: The rough estimate for Plan 50N with the downstream modifications necessary to mitigate for the additional outflow capacity of Lake Erie is between $500 million to $1 billion.

6. Existing Examples: The control structures on the St. Marys and St. Lawrence Rivers and regulation Plans 1977 and 1958-D. In addition, channel enlargements were carried out in the St. Lawrence River when the Seaway was built in the late 1950's.

ANNEX E

APPENDIX E - 4

DETAILED DESCRIPTIONS OF THE REPRESENTATIVE MEASURES

ANNEX E

APPENDIX E- 4

DETAILED DESCRIPTION OF REPRESENTATIVE MEASURES

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APPENDIX E - 4

SECTION 1

INTRODUCTION

This appendix to Annex E presents the detailed descriptions of the "representative measures." These representative measures were randomly chosen from the entire inventory of measures (refer to Appendix E-3) to illustrate the range and sub-categories within the six measures types that are possible in an effort to deal with the adverse consequences of fluctuating water levels.

In total, there are 23 representative measures shown in the list that follows this introduction. Following that are the detailed descriptions of these representatives. Note that some descriptions are more detailed than others because there is more background data available, or because there has been historical and continued interest in that particular measure or type of measure. The Type 1 measures are a good example of this more detailed treatment because past IJC studies have tended to focus on structural solutions to the fluctuating water levels problem.

This appendix begins with the listing of the representative measures and moves on to their detailed development. Anyone wishing to review the entire range (inventory) of measures is referred to the Annex E text and Appendix E-3 which contains one page summary descriptions of all identified measures (over 100). The data used in these appendices is that which was available in March 1989.

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SECTION 2

LIST OF REPRESENTATIVE MEASURES

TYPE 1 - PUBLIC INVESTMENT IN CONTROL AND DIVERSION WORKS

1.2.1 - Full Regulation of Lake Erie such as Plan 50N

1.3.1 - Manipulation of the Existing Diversions of the Great Lakes

1.3.5 - A 50,000 cfs Diversion In and Out of the Great Lakes System

1.4.4 - Placement of Sills at Lakes' Outlets

TYPE 2 - PUBLIC INVESTMENT TO DIRECT LAND AND WATER USE TO ADAPT TO SHORE FLUCTUATING LEVELS

2.1.5 - Breakwater Construction

2.1.12- Structural Floodproofing

2.2.4 - Fee Simple Property Rights Purchase with Possible Resale, with Restrictions on Development

2.3.1 - Navigation & Access Channel & Harbor Dredging / Deepening

TYPE 3 - DIRECT PUBLIC REGULATION OF LAND AND WATER USE

3.1.1 - Setbacks for Structures in Zoning Requirements

3.1.6 - Subsidized Structure Relocation

3.2.1 - Regulate Shore Protection Works and Navigation Structure Construction

3.3.1 - Regulation of Water Withdrawals / Consumptive Use

TYPE 4 - PUBLIC PROGRAMS TO INDIRECTLY INFLUENCE LAND AND WATER OR THE EFFECTS OF FLUCTUATING LEVELS

4.1.7 - Interest Rate Subsidy Loan

4.2.9 - Tax Abatement to Cover Increased Operating Costs

4.3.1 - Public Information and Education Programs

4.3.5 - Real Estate Disclosure

TYPE 5 - EMERGENCY RESPONSE CAPABILITY

5.2.1 - Emergency Sandbagging and Diking Assistance

5.2.3 - Storm Forecasting

5.1.2 - Increase Niagara River Flows using the Black Rock Lock

TYPE 6 - COMBINATIONS

6.1 - Full Regulation of all the Great Lakes by combining Lake Erie Plan 50N (1.2.1) with Placement of a Sill in the St. Clair River (1.4.4), which is the outlet to Lakes Michigan-Huron, and Setbacks for Structures in Zoning Requirements (3.1.1)

6.4 - Breakwater Construction (2.1.4) / Public Information and Education Programs (4.3.1)

6.5 - Maximize Use of Existing Regulatory Structures / Procedures (1.1.5), Hazard Land Mapping (4.3.3), and Public Information and Education Programs (4.3.1)

6.6 - Community Acquisition of Hazard Land (2.2.1) / Regulate Use of Property in Hazard Areas (3.1)

APPENDIX E - 4

SECTION 3

TYPE 1 REPRESENTATIVE MEASURES

MEASURE 1.2.1 :
FULL REGULATION OF LAKE ERIE SUCH AS PLAN 50N

1. Description: The Lake Erie outflows via the Niagara River would be increased or reduced by up to 50,000 cfs depending on the hydrologic conditions and the regulation objectives. The main objective in the present study is to reduce the range of water level fluctuations on Lake Erie while maintaining its long-term average monthly mean levels.

Under the present hydraulic condition, the outflow from Lake Erie is controlled primarily by a natural limestone ledge in the river bed. This ledge, located in the vicinity of the Peace Bridge, has an effect similar to the common hydraulic device known as a submerged weir; that is, the flow increases when the lake level rises and decreases when the level drops. This natural feature tends to stabilize the lake levels when high or low water supplies occur. The seasonal water level fluctuation on the lake is about 1-1.5 feet; whereas the long-term fluctuation is about 6 feet.

Regulation of Lake Erie would affect the timing and the magnitude of the water supplies to Lake Ontario. In times of extreme high water supply conditions in the Great Lakes - St. Lawrence River System, increasing the outflows of Lake Erie could compound the problems on Lake Ontario and further downstream. In times of drought, withholding water on Lake Erie could also have negative impacts on downstream users. The resulting impacts on Lake Ontario would be an increase in its total range of level fluctuation and possibly, an increase in the frequency of high and low flows in the St. Lawrence River.

All water levels and outflows generated under trial Lake Erie 50N plans are compared to Scenario 1 (the Basis-of-Comparison) to evaluate the impacts of these plans. Scenario 1 assumes the present (1987) outlet conditions for Lake Erie and that the present plan for Lake Ontario regulation (Plan 1958-D) would remain in effect.

The Lake Erie 50N Plans were initially evaluated, under the current methodology of Plan 1958-D, to identify only the impacts due to Lake Erie regulation. Next, modifications are made to Plan 1958-D which would offset some of the adverse impacts due to Lake Erie regulation. It might also be necessary to enlarge the St. Lawrence River to increase its flow capacity. The study completed thusfar in Phase 1 includes some preliminary changes to Plan 1958-D in order to cope with Lake Erie regulation. Further analysis of this scheme, including the resulting flows in the St. Lawrence River and the question of remedial works in the St. Lawrence River will be examined more thoroughly in Phase 2.

The Lake Erie 50N Plans are full (as opposed to limited) regulation plans and should not be interpreted strictly as plans which would increase or decrease the Lake Erie outflows by a full 50,000 cfs. Because each 50N Plan has different objectives, flow criteria and trigger mechanisms, they each have different impacts on Lake Erie levels.

To regulate the outflows of Lake Erie, two basic modifications to the existing Lake Erie outlet would be necessary: first, an increase in the channel capacity of the Niagara River so that when necessary, more water can be released than is currently possible; and secondly, a control structure capable of reducing the flow when necessary. The increase in the channel capacity would lower the lake levels during high supply periods, while the control structure would be used to raise the levels during low supply periods. The flow capacities of these proposed schemes, at a minimum, should handle historical supplies; but additionally, these schemes could possibly be designed to accommodate more extreme supplies in the future, due to either extreme climatic events or the greenhouse effect.

2. <u>Location</u>: One potential location for the control structure for a 50N Plan would be about 3,000 feet downstream of the Peace Bridge. The area of the Niagara River to be excavated, to increase the channel capacity, measures about 1,200 feet wide extending from 4,250 feet upstream of the Peace Bridge to 2,860 feet downstream. Depth of excavation would vary up to 13 feet at the Peace Bridge.

A great deal of concern has been expressed regarding construction aspects in the fast-moving waters near the Peace Bridge. Specific concerns along with assumptions made to deal with them are as follows:

(a) Cofferdaming - Due to difficulties anticipated because of high velocities in the river, consideration has been given to constructing out from each shore. Half of the structure would be built from the United States shore, and operated during construction of the other half on the Canadian side. Although this project would cause higher water levels on Lake Erie throughout its 3-year construction period, and would reduce Niagara River flows, this manner of construction would alleviate some of these impacts.

To insure the integrity of the Peace Bridge, reinforced concrete encasement would be required around the structure's piers.

(b) Disposal of Dredged Material - On the United States side, dredged material would be disposed into the lake, with a portion used to replenish Strawberry Island in the Niagara River. In Canada, material would be disposed at some undesignated land site.

The control works would consist of two gated structures, each roughly 460 feet long, extending from the Canadian and United

States shores. Each structure would be separated by a 340-foot opening and would have six gates. The control works might also include a bridge linking Fort Erie with Buffalo. It would then serve as a second bridge for the area, since the Peace Bridge is still considered structurally sound enough to provide many more years of service.

Regulation of the Lake Erie outflows would allow the lake to be used as a peaking and ponding reservoir for the hydroelectric power entities on the Niagara River. Flows in the Niagara River would be permitted to fluctuate on a daily or weekly basis, within limits to be specified by the IJC to protect Niagara River riparian interests to maximize the power generating capabilities along the river. This subject has not as yet been examined in detail, but operational schemes could be developed to enhance hydroelectric power generation, if a Lake Erie regulation was implemented.
The geographic area of impact would initially be in the vicinity of the channel excavation. The environmental issue relating to this excavation and dredged disposal should be addressed. Construction of the control structure, requiring cofferdams, would also have an impact in that it would alter the natural flow conditions in the river. Upon completion, the geographic area of impact would include the local area effected by high or low flows/levels or sudden changes in these flows/levels, and Great Lakes-St. Lawrence River system-wide, especially Lakes Ontario and Erie.

No specific criteria have been incorporated, to date, into the 50N plans to address local or system-wide socio-economic or environmental concerns. The objective of reducing extreme high or low lake levels is based on input from a segment of the public who have expressed their desire to see a much smaller range of fluctuations on Lake Erie.

A decision-making process, or a trigger mechanism, was put into these plans which would call for either flow increases or decreases, with their magnitudes depending on the hydrologic conditions on the Great Lakes. It must be noted that all 50N plans developed are trial plans only and have not been refined. The modeling efforts undertaken thus far have been confined to trigger mechanism development and basic hydrologic analysis. Based on the objective of reducing the range of water level fluctuations on Lake Erie while maintaining its long-term monthly average levels, trial plans were developed to evaluate the impacts of various trigger mechanisms. These trigger mechanisms could be based on historical water supplies (such as Limited Lake Erie Regulation Plan 25N which employed previous 12-month supplies to the upper lakes), and/or water levels on Lake Erie and/or an upper lake, or a combination of both levels and supplies.

At this point, it is worthwhile to review Plan 25N, which was developed in a previous study, and compare its features with the general 50N approach. Plan 25N is a limited regulation plan developed to address the concerns of extreme high lake levels. The 25N channel enlargement and control structure have the capacity of increasing the river flow by up to 25,000 cfs (above the pre-project condition), as well as the capability to adjust the river flow to pre-project conditions. However, Plan 25N was not designed to reduce Lake Erie's outflows and thus raise its minimum levels. On the other hand, the 50N series plans do have features to increase or decrease the flows by up to 50,000 cfs.

The trigger mechanism employed by Plan 25N was a fixed on-off mechanism which directed either a zero or full 25,000 cfs increase. Plan 50N, depending on the types of trigger employed, would call for high flow increases during extreme high supply or water level conditions. Near average levels or supplies would result in very slight flow changes in Lake Erie's outflows, when compared with the natural level-outflow relationship; while low water conditions would likely result in reductions in the Lake Erie outflow.

The 50N plans could also incorporate some safeguards for Niagara River riparians, by prohibiting extreme high or low flows in the Niagara River, or large variations in flows between consecutive months. These would be the subject of plan refinement together with detailed Lake Ontario study scheduled for Phase 2.

Hydrologic evaluations of a series of trial 50N plans, using past supplies (1900-1986) for comparison purposes, show Plan 50N Option 504B would reduce Lake Erie's maximum level by about one foot as well as raising its minimum almost a foot. This plan uses the Lake Erie level as a factor in determining the flow changes. Thus, a six-foot total range on Lake Erie would be compressed to about four feet. This could be considered as one of the most extreme case of all Plan 50N options. A fraction of these hydrologic impacts would be felt on Lakes Michigan-Huron and still much smaller impacts on Lake Superior. Lake Ontario, on the other hand, would take the brunt of Plan 50N unless actions were also taken to modify Plan 1958-D and to place remedial works in the St. Lawrence River (to be discussed later). One assumption made thus far in this study is that Plan 1977 would remain in effect as the regulation plan for Lake Superior.

If an even greater impact on Lake Erie is desired, one might consider Plan 50N Option TV-1. This option would provide either a 50,000 cfs increase or decrease in the Lake Erie outflow, depending on the monthly mean level of the lake. Under Option TV-1, if the monthly mean level for a specific month is above the long-term average (under Scenario 1) for that month, the outflow for the following month is increased by 50,000 cfs, Conversely, a monthly mean level below the monthly long-term average would trigger a 50,000 cfs decrease in outflow. Option TV-1 would lower Lake Erie's maximum level to 572.28 feet (1.27 foot drop) and raise its minimum level to 569.38 feet (1.46 foot rise), thus compressing the range to 2.90 feet. The impacts on Lake Ontario under Option TV-1 would be even more severe than under Option 504B, with the expansion of the range from almost 6 feet to about 12 feet. Again, these are preliminary results based on the assumption that the current Plan 1958-D for Lake Ontario will remain in effect. Changes in the Lake Ontario regulation plan would be required if this plan was to become a viable solution.

The following is a hydrologic summary of Plan 50N Option 504B.

	Scenario 1 (no Lake Erie Regulation) levels (FEET)	flows (TCFS)	Plan 50N (Option 504B) levels (FEET)	flows (TCFS)	Impacts (FEET)
Superior					
mean	600.44	79	600.45	79	+0.01
maximum	601.94	120	601.94	120	0
minimum	598.62	55	598.66	55	+0.04
range	3.32		3.28		
Mich-Huron					
mean	578.37	187	578.38	187	+0.01
maximum	581.62	241	581.33	244	-0.29
minimum	575.37	114	575.57	113	+0.20
range	6.25		5.76		
Erie					
mean	570.73	211	570.74	211	+0.01
maximum	573.55	276	572.62	279	-0.93
minimum	567.92	156	568.71	146	+0.79
range	5.63		3.91		
Ontario (see note below)					
mean	244.68	247	244.62	247	-0.06
maximum	247.55	350	248.53	350	+0.98
minimum	241.80	176	240.35	176	-1.45
range	5.75		8.18		
Lake St. Louis					
mean	68.24	288	68.24	288	0
maximum	72.89	452	72.89	452	0
minimum	65.38	207	65.27	205	-0.11
range	7.51		7.62		

Note: Lake Ontario assumed to be regulated by Plan 1958-D with the discretionary actions of the past.

The following is a hydrologic summary of Plan 50N Option TV1.

	Scenario 1 (no Lake Erie Regulation) levels (FEET)	Scenario 1 (no Lake Erie Regulation) flows (TCFS)	Plan 50N (Option TV1) levels (FEET)	Plan 50N (Option TV1) flows (TCFS)	Impacts (FEET)
Superior					
mean	600.44	79	600.45	79	+0.01
maximum	601.94	120	601.94	120	0
minimum	598.62	55	598.64	55	+0.02
range	3.32		3.30		
Mich-Huron					
mean	578.37	187	578.39	188	+0.02
maximum	581.62	241	581.14	246	-0.48
minimum	575.37	114	575.75	109	+0.38
range	6.25		5.39		
Erie					
mean	570.73	211	570.75	212	+0.02
maximum	573.55	276	572.28	295	-1.27
minimum	567.92	156	569.38	134	+1.46
range	5.63		2.90		
Ontario (see note below)					
mean	244.68	247	244.51	247	-0.17
maximum	247.55	350	249.74	350	+2.19
minimum	241.80	176	237.97	176	-3.83
range	5.75		11.77		
Lake St. Louis					
mean	68.24	288	68.24	288	0
maximum	72.89	452	73.10	459	+0.21
minimum	65.38	207	65.27	205	-0.11
range	7.51		7.83		

Note: Lake Ontario assumed to be regulated by Plan 1958-D with the discretionary actions of the past.

A comparison of the long-term mean, maximum and minimum values is only a part of the detailed hydrologic evaluation process. Other comparisons would include frequency analyses. Figure 1 shows the frequency of occurrence of Lake Erie water levels under the base case, Plan 50N Options 504B and TV1. The number of occurrences of average and near average levels on Lake Erie would be increased under Option 504B, and even more so under Option TV-1. The number of occurrences of extreme high and low levels would be reduced under Option 504B and more significantly under Option TV-1.

Figure 2 shows the frequency of occurrence of Lake Erie outflows for the three cases. Under Option 504B, there would be a slight increase in the frequency of occurrences of high and low flows, a reduction in the occurrences of average flows. Also the range of flows under Option 504B would be slightly expanded. The frequency curves for Option TV-1 shows a very different story. Because of the technique used in the trigger mechanism for TV-1, there would be a complete elimination of average and near average flows in the Niagara River. Also there would be a significant increase in the occurrences of extreme high and low flows. The range of flows would also be significantly increased.

While Option TV-1 approach might be considered an extreme case, it non the less serves to illustrate the point that management of both lake levels and their outflows go hand-in-hand and one can not be over-emphasized at the expense of the other.

The following discusses some of the potential changes to Lake Ontario Regulation Plan 1958-D and how they might affect Lake Ontario under a Lake Erie regulation scenario using Plan 50N - Options 504B and TV-1 as examples.

Within the 1958-D plan, there are a number of flow limitations incorporated to provide protection (against both high and low levels and flows) for users located both upstream and downstream of the St. Lawrence Seaway and Power Project facilities. The changes involve waiving or adjusting these limitations, as discussed below:

(a) "I" Limitation - The "I" limitation under Plan 1958-D relates to the maximum permissible release of water from Lake St. Louis during the last half of December. This limitation was incorporated into Plan 1958-D to provide for ice formation under a proposed plan for the Lachine Rapids power development. This development has not occurred. As a result, the International St. Lawrence River Board of Control has, on numerous occasions, waived this limitation under actual operation without adverse impact. Under a modified Plan 1958-D to cope with Lake Erie regulation, this restriction on flow during the last half of December has been waived for the entire study period (1900-1986).

(b) "J" Limitation - To restrict the variation in outflow from one quarter-month to the next, Plan 1958-D limited changes between regulation periods to 20,000 cfs, Under a modified Plan 1958-D, the limit has been raised to 45,000 cfs. The need for the greater flexibility is due to the sometimes sudden changes in water supply, caused by the regulation technique being employed on Lake Erie.

(c) "L" Limitation - To provide stipulated depths and velocities for navigation and power, channel excavations have been provided in the St. Lawrence River. To keep the regulated Lake Ontario outflows and resulting levels and velocities in the river consistent with these channel excavations, restrictions have been placed on flow releases during various periods of the year. However, under actual operation (regulation began in 1960), some of these restrictions were relaxed to a point where the stipulated maximum channel velocity of four feet per second was exceeded, but the minimum navigation depth was not. Employing these operational flows as a guide, changes were made to the procedural L-Limitation values to accommodate for the increased inflow caused by regulation of Lake Erie under Plan 50N. The changes do not affect the lower portion of the L-Curve.

The changes are as follows:

	Existing (tcfs)	Modified (tcfs)
January	220	235
1st quarter, February	240	280
2nd and 3rd quarter, February	260	280
4th quarter of February	280	280
March	280	300
April to December	310	340

(d) "M" Limitation - The IJC Criterion (e) for the regulation of Lake Ontario, states: "Consistent with other requirements, the minimum regulated monthly outflows from Lake Ontario shall be such as to secure the maximum dependable flow for power." Criterion (j) states: "The regulated level of Lake Ontario on 1 April shall not be lower than elevation 242.77 feet. The regulated monthly mean level of the lake from 1 April to 30 November shall be maintained at or above elevation 242.77 feet". In an attempt to satisfy these criteria, some changes to the Plan 1958-D minimum flows were made, as shown below:

	Existing (Plan 1958-D) (tcfs)	Modified (tcfs)	
		50N-504B	50N-TV1
January	210	195	190
February	207	195	190
March	204	195	190
April	188	188	188
May	188	188	188
June	190	190	190
July	193	190	190
August	193	195	190
September	193	195	190
October	193	195	190
November	198	195	190
December	210	195	190

(e) "P" Limitation - The "P" Limitation restricts the regulated outflow to an amount that would occur if pre-project (before Seaway development) channel conditions existed. This limitation on flow has been incorporated into Plan 1958-D so as not to aggravate flooding conditions in the Lake St. Louis - Montreal Harbour areas during the ice break-up period and during the annual flood discharge of the Ottawa River. The "P" flow limitation is applicable from February to mid-April, and from mid-April to the end-of-July for those periods when the outflow from Lake St. Louis exceeds 345,000 cfs. Studies of this limitation under actual operation indicate that employment of the 345,000 cfs is conservative. Hence, the limiting control number in Plan 1958-D has been increased by 15,000 cfs when the outflow from Lake St. Louis during the preceding quarter (month) exceeds 345,000 cfs.

Changes to Plan 1958-D as discussed above were incorporated into the Great Lakes - St. Lawrence River system-wide modeling along with Lake Erie Regulation Plan 50N. Supplies of the past (1900-1986) were used to determine the resulting levels and flows, thus permitting the evaluation of these changes. The following two tables show the results for Lake Ontario and downstream. It should be noted that comparison of the long-term average, maximum and minimum levels under the different scenarios is only a part of the hydrologic evaluation process. A detailed evaluation should include the examination of the impacts on the frequencies of high and low lake levels and outflows, the timings of these occurrences, and perhaps testing these scenarios with different sets of supply conditions, etc. The following tables show that changes to Plan 1958-D to accommodate Lake Erie regulation is technically possible to offset the impacts due to Lake Erie regulation, but detailed month by month examination of the impacts on downstream is the only way to look at the whole picture.

The following is a hydrologic summary of Plan 50N Option 504B, along with modified Plan 1958-D. As Lake Ontario regulation has no hydraulic impacts on the upstream lakes, the figures for the upstream lakes are the same as those in the previous tables.

	Scenario 1 (No Lake Erie Regulation)		Plan 50N Option 504B & Modified 1958-D-R2		Impacts
	levels (FEET)	flows (TCFS)	levels (FEET)	flows (TCFS)	(FEET)
Ontario					
mean	244.68	247	244.64	247	-0.04
maximum	247.55	350	247.39	340	-0.16
minimum	241.80	176	242.10	188	+0.30
range	5.75		5.29		
Lake St. Louis					
mean	68.24	288	68.24	288	0
maximum	72.89	452	73.50	474	+0.61
minimum	65.38	207	65.34	204	-0.04
range	7.51		8.16		

The following is a hydrologic summary of Plan 50N Option TV-1, along with modified Plan 1958-D-R2.

	Scenario 1 (No Lake Erie Regulation) levels (FEET)	flows (TCFS)	Plan 50N Option TV-1 & Modified 1958-D-R2 levels (FEET)	flows (TCFS)	Impacts (FEET)
Ontario					
mean	244.68	247	244.53	247	-0.15
maximum	247.55	350	248.15	340	+0.60
minimum	241.80	176	240.66	188	-1.14
range	5.75		7.49		
Lake St. Louis					
mean	68.24	288	68.24	288	0
maximum	72.89	452	73.61	478	+0.72
minimum	65.38	207	65.03	198	-0.35
range	7.51		8.58		

Figure 3 shows the frequency of occurrence of Lake Ontario water levels under the base case, and those under Plan 50N with the changes to Plan 1958-D as described above. Figure 4 shows the frequency of occurrence of Lake Ontario outflows.

As mentioned earlier, further analysis on the changes to Plan 1958-D as well as the subject of channel improvements in the St. Lawrence River will be addressed in Phase 2 of the study.

3. Time Frame for Implementation: Assuming IJC recommendation in 1991, it will take two years to prepare final detailed engineering design and cost estimates for the Niagara River regulatory works, and 4-5 years for construction. Implementation could start in 1996. This measure is assumed to be permanent. The above schedule assumes that by 1997, the potential problems on Lake Ontario and downstream would have been fully addressed through Lake Ontario Regulation Plan 1958-D revisions and compensating works in the St. Lawrence River.

4. Implementing Authority: Canada and the United States by agreement or Treaty on the recommendation of the IJC. The IJC could be given the mandate to oversee the designs and construction of the project. Upon completion, the IJC would supervise the operation of the control structure. The Province of Ontario and the State of New York would need to be involved since the control structure and Niagara River channel enlargement and dredged disposal would be located in their area of jurisdiction.

5. Implementing Costs: A very rough cost for the 50N Niagara River structure, including Niagara River channel enlargement, would be about $400-500M. The addition of a bridge would add perhaps another

$75M. Uncertainty factors which might have a bearing on the final cost include the extent of environmental studies and remedial actions, and the difficulties that might occur during the construction in the fast moving waters. The cost of modifying Lake Ontario Plan 1958-D would be perhaps under $10M which would include field surveys and further hydrologic analysis. Remedial and protective works necessary in the St. Lawrence River to accommodate Lake Erie Regulation would cost perhaps another $100M. In summary, a price tag of all engineering works necessary for Plan 50N is about $1 billion which can be considered a ball park figure.

In the United States, the U.S. Army Corps of Engineers would be given the federal authority to assist the IJC. In Canada, Environment Canada and the Department of Public Works would jointly administer the project.

Upon completion of the construction, an operational board similar to the present Lake Superior or Lake Ontario Boards of Control would be set up by the IJC to supervise the project. Annual operation cost would be about $1-5M.

6. Existing Examples: Regulatory facilities at Sault Ste. Marie, Ontario/Michigan regulating the outflows of Lake Superior, and at Cornwall, Ontario/Massena, New York regulating the outflows of Lake Ontario. At Sault St. Marie, the costs of operating and maintaining the power diversions and navigation locks are shared by their owners. The United States portion of the Lake Superior Compensating Works is owned and operated by the United States Government through the Corps of Engineers. The Canadian portion of the Compensating Works is owned and operated by Great Lakes Power Limited. At Cornwall, Ontario/Massena, New York, the power house is owned and operated by Ontario Hydro and New York Power Authority.

Frequency of Occurrence of Levels

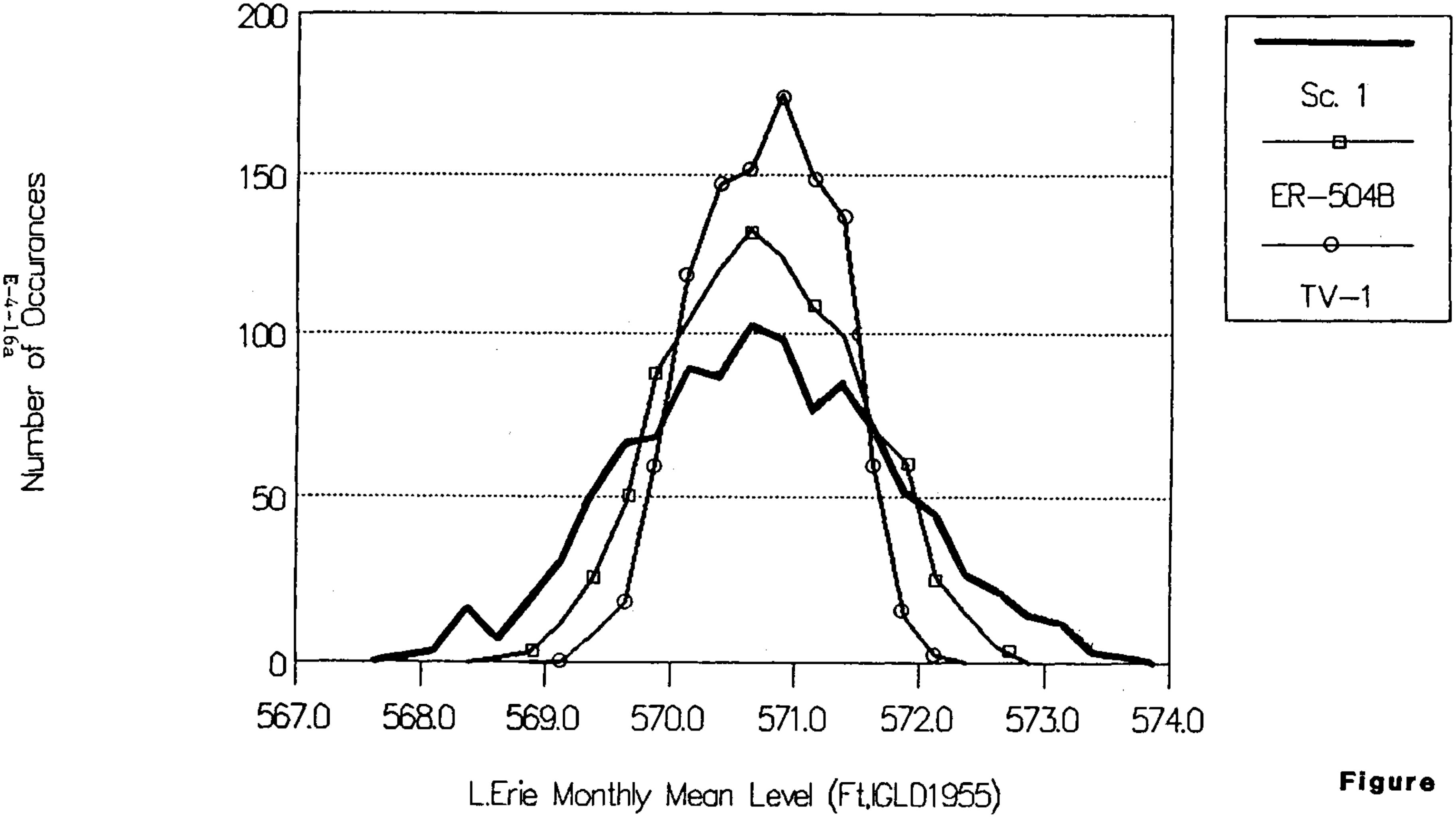

Figure 1

E-4-16a

Frequency of Occurrence of Outflows

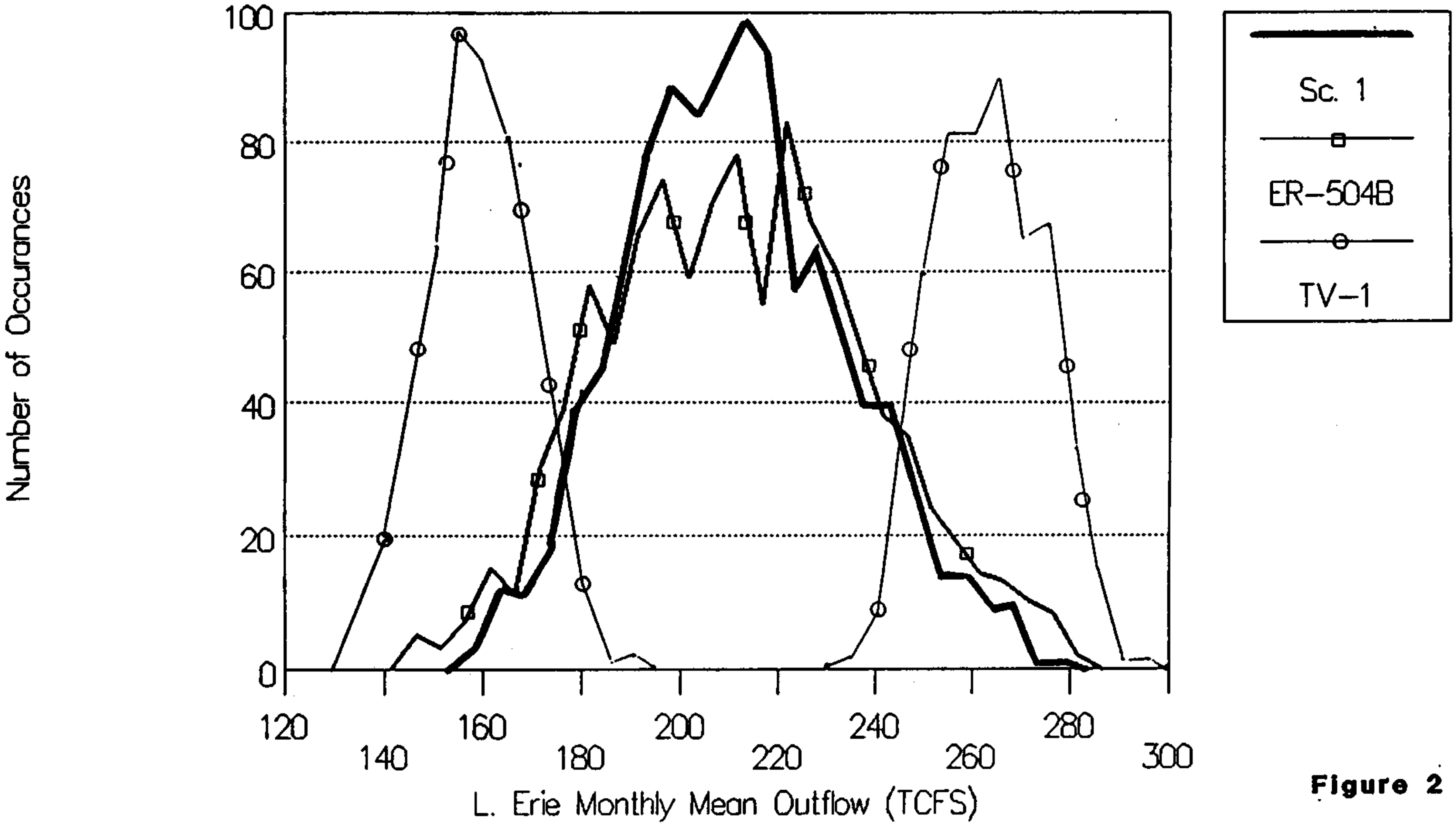

Figure 2

Frequency of Occurrence of Levels

Lake Ontario

E-4-16c

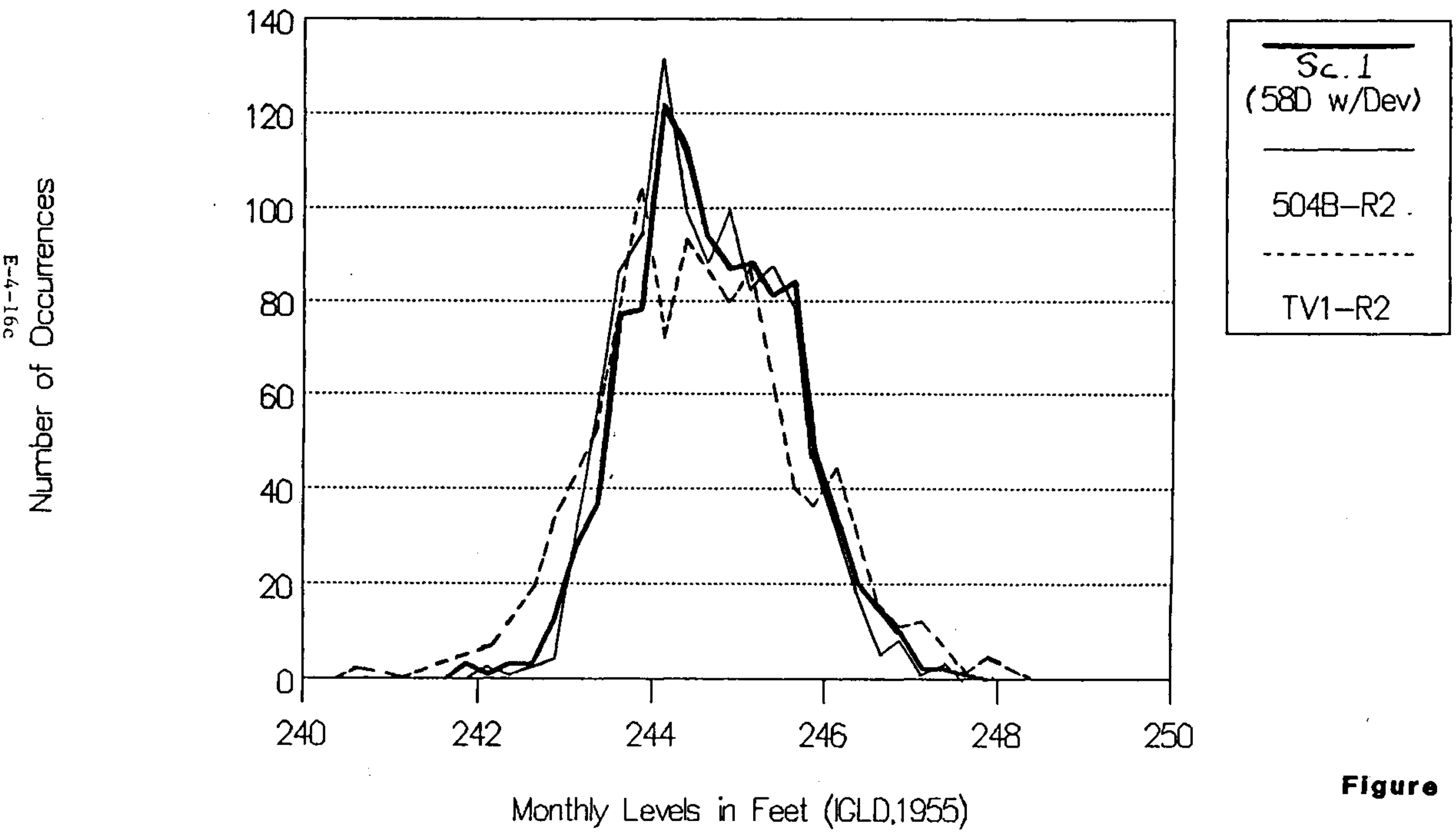

Figure 3

Frequency of Occurrence of Outflows

Lake Ontario

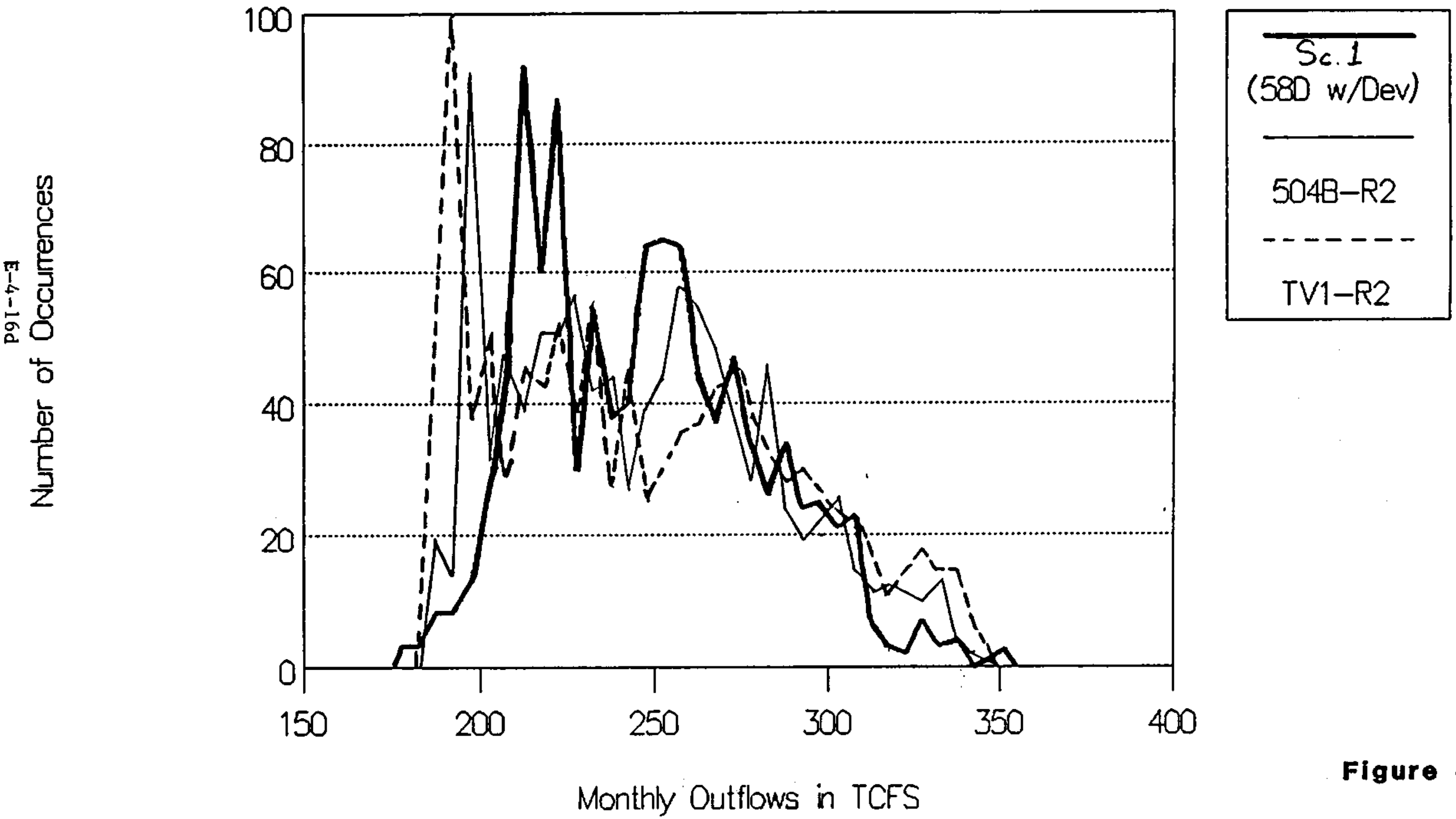

Figure 4

MEASURE 1.3.1 :
MANIPULATION OF THE EXISTING DIVERSIONS OF THE GREAT LAKES

1. Description: There are several existing diversions on the Great Lakes Basin, but none were initiated for the purpose of lake level management. The present study is to identify those diversion management scenarios which would reduce the extreme range of level fluctuations while maintaining as near as possible, the long-term monthly average levels on the lakes.

More detailed information on the existing diversions can be found in the final report "Great Lakes Diversions and Consumptive Uses" 1981 by the International Great Lakes Diversions and Consumptive Uses Study Board. The following contains a summary of the results of the study thus far and is extracted from the status report for Task 141, dated December 21, 1988 and prepared by Functional Group 1 - Hydrology, Hydraulics and Climate.

The development of diversion management scenarios assumes no changes in the present capacities of the existing diversions. Maximum and minimum flow limits of each diversion are consistent with past experience. Within these limits, the effects of changes in diversion rates on levels and outflows over the full range of historic (1900-1986) water supply conditions were determined. The management of these diversions to cope with future (possibly more extreme) supplies due to more extreme climatic conditions or the greenhouse effect is the subject of a separate study by Functional Group 1 and thus will not be discussed here.

It is worthwhile to describe briefly the diversions before going into the development of the diversion management scenarios.

(a) Long Lac and Ogoki Diversions - The Long Lac and Ogoki projects divert about 5,600 cfs of the James Bay drainage system water into Lake Superior. It is physically possible to reduce one or both of these diversions to zero, during periods of high water supply to the Great Lakes. Historical data show that the Ogoki Diversion has been completely closed or operated at reduced rates in the past. The meteorologic conditions of the Albany River Basin indicate that, during periods of low water supply to the Great Lakes, the Albany River Basin experiences similar conditions; hence, it is not practical to increase the flow through the diversion projects during periods of low water supply.

For this study, in addition to the current (Basis-of-Comparison) rate of 5,600 cfs, two alternative reduction rates were selected: a reduction from 5,600 cfs to 2,800 cfs; and an ultimate reduction to zero flow. Since the existing diversions have the effect of slightly raising lake levels and increasing outflows, any reduction in the flow rate of this diversion would offset some of these effects. Closing or reducing the diversions would adversely affect the local pulp and paper industry, hydroelectric power generation, and possibly have adverse environmental effects on fish spawning areas and habitat, and the flow conditions on the Ogoki and Albany watersheds.

(b) Lake Michigan Diversion at Chicago - The Lake Michigan Diversion at Chicago withdraws water from the Lake Michigan Basin and discharges it, through the Illinois Waterway and eventually into the Mississippi River. Before 1967, the annual average flow rate of this diversion had been as high as 10,000 cfs. However, the United States Supreme Court, by a 1967 decree, limited it to an average of 3,200 cfs.

During periods of low water levels along the Illinois Waterway, daily flows of up to 12,000 cfs are possible. However, this high flow cannot be maintained due to the necessity for constraining this release whenever bankfull or near bankfull conditions exist on the Waterway. Because of this constraint, when tested over the period-of-record, the average annual diversion would approximate 8,700 cfs.

Based on the above, diversion management scenarios were developed assuming: in addition to the current (Basis-of-Comparison) rate of 3,200 cfs, increases in flow up to annual averages of 6,600 cfs, 8,700 cfs and 10,000 cfs. As in the case of the Long Lac and Ogoki Diversions, consideration was also given to decreasing the diversion (to less than 3,200 cfs) during periods of low water supply to the Great Lakes. However, since much of this water is used for domestic and sanitary purposes, it is not practical to reduce this diversion from its present rate by any substantial amount. In spite of this, the diversion's zero rate was also selected to be evaluated.

Since the existing diversion results in a lowering of lake levels and reduction in outflows, any flow increases would cause further lowering and reduction effects. Water quality in the Illinois waterway would be enhanced; also, local hydroelectric power generation and possibly navigation in the waterway and the upper Mississippi River would benefit somewhat, from an increase in the diversion rates. Potential adverse effects include increased flood and erosion in the waterway.

(c) Welland Canal - The Welland Canal connects Lake Erie with Lake Ontario, thus bypassing the Niagara River. The diversion rate has increased in the last several decades from about 7,000 cfs to about 9,200 cfs to satisfy an ever increasing demand for water for power generation, water consumptions and navigation. To provide the needed water in the canal, releases of as much as 10,000 cfs, during months of peak demand, could be satisfied; with the knowledge that the penalty of this increased flow would be additional maintenance of canal banks, more dredging and a greater inconvenience to shipping. Recognizing that 10,000 cfs cannot be discharged at all times, due to disruptions to shipping and maintenance work, the rate of 9,200 cfs (Basis-of-Comparison rate) was determined to be the maximum average annual flow through the canal in the future, under its present characteristics.

Consideration was also given to reducing the flow below 9,200 cfs, during periods of low water supply. Recognizing that it is not practical to shut down the diversion (it would completely cut off all navigation, dilution and municipal and industrial water supplies), a minimum rate of 2,600 cfs was adopted for evaluation. To test various flows over the greatest range of possibilities, it was elected to use the following rates: zero, 2,800 cfs, 7,000 cfs, 9,200 cfs and 10,000 cfs. Being very close to the Basis-of-Comparison rate of 9,200 cfs, the 10,000 cfs diversion scenario would have a very minor lowering impact on Lake Erie. Conversely, the scenarios employing reduced rates would raise Lake Erie's levels slightly.

(d) New York State Barge Canal - This diversion takes water from the upper Niagara River at Tonawanda, New York, and releases it into Lake Ontario at several points. Since this diversion is small, and because its entry location is downstream of the natural hydraulic control section located at the head of the Niagara river, no consideration was given to the use of this canal to modify the lake level regimes. Currently, the amount of water diverted through the canal averages about 700 cfs, with a maximum flow during the navigation season of 1,100 cfs.

Considering the above and to cover an entire spectrum of possible management scenarios, various combinations of diversions and diversion rates were selected for hydrologic evaluation, as shown in the matrix below. These scenarios were evaluated over the historic water supply period 1900-1986.

Similar to the 50N Plans, which use a trigger mechanism directing flow increases and decreases, some type of trigger is required to direct the required diversion increases or decreases (from the Basis-of-Comparison rates to the scenario rates and visa versa). For example, under Scenario 32, when required, the Long Lac and Ogoki diversions would be reduced to 2,800 cfs (from 5,600 cfs), the Welland diversion reduced to 7,000 cfs (from 9,200 cfs), and the Chicago diversion increased to 10,000 cfs (from 3,200 cfs).

Two indicators, a targeted lake level and water supply, for signalling when a change in the diversion rates should occur, were studied and evaluated as triggers in the International Great Lakes Diversions and Consumptive Uses Study. In that study, a comparison of Lakes Michigan-Huron water levels and supplies was conducted. That analysis revealed that water supply is the better of the two indicators. It permits an earlier change in diversion rates in a rising lake situation and an earlier return to the Basis-of-Comparison rates in a falling lake level situation. That investigation also indicated that the use of water supply to Lakes Michigan-Huron, which is not only the major water supplier to the lower lakes, but also the basin that receives the greatest local supply, is a more responsive and timely indicator. It was further noted that the use of a 12-month moving mean trigger would result in smoother transitions from on/off situations, especially when supply conditions change radically from month to month.

For this study, an updated long-term (1900-1986) 12-month moving mean Lakes Michigan-Huron net basin supply value of 112,800 cfs-months was determined to be the value to be used as the trigger to signal diversion rate changes.

Matrix Showing Possible Combinations of Diversion Scenarios

Welland cfs	Long Lac and Ogoki			Chicago cfs
	0 cfs	2,800 cfs	5,600 cfs	
0	1	2	3	0
0	4	5	6	3,200
0	7	8	9	6,600
0	10	11	12	8,700
0	13	14	15	10,000
2,600	16	17	18	3,200
7,000	19	20	21	0
7,000	22	23	24	3,200
7,000	25	26	27	6,600
7,000	28	29	30	8,700
7,000	31	32	33	10,000
9,200	34	35	36	0
9,200	37	38	base	3,200
9,200	40	41	42	6,600
9,200	43	44	45	8,700
9,200	46	47	48	10,000
10,000	49	50	51	0
10,000	52	53	54	3,200
10,000	55	56	57	6,600
10,000	58	59	60	8,700
10,000	61	62	63	10,000
2,600	64	65	66	0
2,600	67	68	69	6,600
2,600	70	71	72	8,700
2,600	73	74	75	10,000

As shown in matrix, up to 74 diversion scenarios have been developed and tested using the 1900-1986 historical supplies. The scenario which would have the maximum effect in reducing extreme high lake levels is Scenario 61. Under this scenario, above-average supply conditions would completely shut off the Long Lac and Ogoki Diversions and increase both the Welland and Chicago Diversions to 10,000 cfs. This scenario would lower the maximum levels of Lakes Superior, Michigan-Huron, Erie and Ontario by 0.09, 0.69, 0.44 and 1.58 foot, respectively. This scenario would also lower the average and minimum levels as shown in the following table.

Summary of Hydrologic Effects of Diversion Scenarios 61 and 18

	Scenario 1		Scenario 61		Scenario 18	
	Levels	Flows	Levels	Flows	Levels	Flows
Superior						
mean	600.44	79	600.27	76	600.46	79
max	601.94	120	601.85	119	601.94	120
min	598.62	55	598.30	55	598.64	55
range	3.32	65	3.55	64	3.30	65
Michigan-Huron						
mean	578.37	187	577.97	181	578.42	187
max	581.62	241	580.93	230	581.63	241
min	575.37	114	575.23	112	575.51	114
range	6.25	127	5.70	118	6.12	127
Erie						
mean	570.73	211	570.46	205	570.88	211
max	573.55	276	573.11	265	573.56	276
min	567.92	156	567.80	154	568.25	156
range	5.63	120	5.31	111	5.31	120
Ontario (strict application of Plan 1958-D)						
mean	244.86	246	244.63	241	244.89	246
max	249.78	310	248.20	310	249.99	310
min	241.61	188	240.94	188	241.51	188
range	8.17	122	7.26	122	8.48	122

The table also shows the impacts due to Scenario 18 which would raise the minimum levels of the lakes. Scenario 18 assumes the maintenance of the existing rates for the Long Lac, Ogoki and Chicago diversions, but would reduce the Welland Canal flows to 2,600 cfs. This scenario would raise the minimum levels on Lakes Superior, Michigan-Huron and Erie by 0.02, 0.14 and 0.33 foot, respectively, while lowering the minimum water levels on Lake Ontario by 0.10 foot.

3. Time Frame for Implementation: It is expected that several years would be required to upgrade the existing diversion facilities to ensure that they can be operated year-round and provide the capacities needed. An operational plan for these diversions would have to be developed by the IJC in conjunction with the existing regulation procedures for Lake Superior and Lake Ontario.

4. Implementing Authority: The United States and Canada on the recommendation of the IJC. Diversion adjustments will be made monthly. The operation of all diversion facilities would by placed under joint management between their operators and the IJC.

5. Implementing costs: This could be considered a medium cost scheme ($10M-$100M).

While no refined cost estimates are available at this time, one Corps of Engineers study option gives a cost figure of $160M for works only on the Illinois Waterway and downstream of it in order to initiate a diversion of 25,000 cfs. Thus, the cost for a 10,000 cfs diversion would be lower. Uncertainty factors which could have a bearing on the final cost include the extent of environmental studies and remedial actions, and the protective and remedial works and compensations.

Shutting off the Long Lac and Ogoki Diversions would also cause an annual loss of about $15M in hydro-electric power generation on these projects. Additionally, as mentioned earlier, the local industries, the environment and the flow conditions on the Ogoki and Albany watersheds would be adversely impacted.

Increasing the flows in the Welland Canal would cause increased bank erosion and greater inconvenience, or perhaps increased hazards for navigation. Reducing the flows would adversely affect hydroelectric power generation at the DeCew Power Plant, which uses the Welland Canal water.

6. Existing Examples: The diversions under study are already in place. However, none of these were initiated for the purpose of Great Lakes water level management and regulation.

MEASURE 1.3.5 :
A 50,000 CFS DIVERSION IN AND OUT OF THE GREAT LAKES SYSTEM

1. Description: This study evaluated a hypothetical new diversion rate of up to 50,000 cfs into and out of the Lakes Michigan-Huron Basin. The objective of this scenario is to reduce the total range of water level fluctuations on the Great Lakes, while maintaining, as near as possible, their long-term average water levels.

The purpose is to divert water from the James Bay/Hudson Bay (or from other sources) into the Great Lakes Basin when the lake levels are low, and to divert water out of the Basin when lake levels are high. This idea is very similar to the manipulation of existing diversions except that an entirely new project, with much greater diversion rates, is being examined.

2. Location: No specific sites have been selected as a point source for bringing the water in, nor for diverting the water out of the basin. It has been determined that Lakes Michigan-Huron would be the most logical choice for several reasons. First, their geographic location would most likely make it easier (less costly) to divert the northern water into and out of the Great Lakes System. Secondly, since Lakes Michigan-Huron are located in the middle of the upper Great Lakes, manipulating this diversion supply to these lakes would permit more timely and effective management of Lakes Superior and Michigan-Huron, and indirectly, Lake Erie, when compared with a scheme using Lake Superior as a receiving lake.

A fixed value on/off trigger, as used in the alternative diversion management scenario evaluations, was not used in the investigation. Instead, a linear relationship between Lakes Michigan-Huron's previous month's mean water levels and the hypothetical diversion rates was used. The range of the hypothetical scenario was from a maximum diversion out of (-) the Lakes Michigan-Huron Basin of 50,000 cfs to a maximum diversion of the same value into (+) the Lakes Michigan-Huron Basin. The range of the previous month's mean water level was derived from the Basis-of-Comparison's regime of levels (1900-1986), and was between that month's long term monthly mean minimum value to its long term monthly mean maximum value. By virtue of the linear relationship, established between the two ranges, the relative position of the previous month's mean water level, in comparison to the basis-of-comparison's range of levels, provides guidance either to increase or restrict the diversion flow into the Lakes Michigan-Huron. This linear relationship increases the diversion flow into the basin whenever lake levels fall and curtails the flow whenever lake levels rise.

The scenario presented herein meets the above noted intended objective and would have the effects as shown below.

Effects of the 50,000 CFS Lakes Michigan-Huron Diversion Scenario

	Impacts On Levels in Feet (+ denotes raising)
Superior	
mean	+0.03
maximum	+0.02
minimum	+0.06
Michigan-Huron	
mean	+0.04
maximum	-0.75
minimum	+0.91
Erie	
mean	+0.03
maximum	-0.53
minimum	+0.62
Ontario	
mean	-0.06
maximum	-1.31
minimum	+1.25

3. <u>Timeframe for Implementation</u>: A major project of such magnitude could take at least 20 years or more.

4. <u>Implementing Authority</u>: Canada and the United States.

5. <u>Implementing Costs</u>: Since no specific diversion project has been identified for this hypothetical scenario, only "educated guess" construction cost estimates could be formulated, based upon prior studies of similar diversion schemes. One such study of diverting water into the Great Lakes Basin, is known as the "Grand Canal Concept". In that study, water would be diverted south from the James Bay, in the Province of Quebec, to the Georgian Bay which is a part of Lakes Michigan-Huron. The estimated construction cost of this concept is in the order of $79 billion (source: IJC's Great Lakes Diversions and Consumptive Uses Report, January 1985). A diversion rate was not discussed in the IJC report.

Previous studies have also been conducted concerning the diversion of water out of the Great Lakes to the High Plains area of the western United States (Ogallala Aquifer region). From these studies, it was roughly estimated that construction costs for a diversion of 50,000 cfs of water out of Lakes Michigan-Huron to the High Plains area would be in the order of $95 to $135 billion. These estimates could be off by several orders of magnitude, depending on the specific plans, but they nevertheless, illustrate the high cost of ventures of the size. If large scale interbasin transfers of this nature are contemplated, more detailed investigations would have to be conducted in the future.

6. Existing Examples: Only very relatively small diversion projects are currently in place such as the Long Lac, Ogoki and Chicago Diversions.

MEASURE 1.4.4 :
PLACEMENT OF SILLS AT LAKES' OUTLETS

1. Description: The purpose of placing sills at a lake's outlet is to reduce or prevent excessive lowering of that lake during drought conditions, or to raise the lake to a more desired and generally accepted range; such sills function by retarding the lakes outflow capability.

Sills have no impacts on long-term average flows as they can neither add nor subtract water supplies to the Great Lakes. However, they would have temporary impacts on flows until the lakes reach a new water level regime. Sills could be considered a short-term emergency measure to deal with an extreme low level/supply condition, or a long-term measure to offset the effects of past dredging in the connecting channels; or to offset the adverse impacts due to climate change. Sills placed under an emergency situation would be removed when lake levels improve. Since no specific scenario has been developed, the following general discussion is presented which focuses on permanent placement of sills.

2. Location: The outlet of Lakes Michigan-Huron and strategic locations along the St. Clair-Detroit River System and the outlet of Lake Erie.

Sills placed at the outlet of a lake would change its present level and outflow relationship. The water level of the lake would have to rise by certain increments in order to discharge the same outflows as under current conditions. For example, sills at the outlet of Lake Erie, causing a flow reduction of 20,000 cfs, would ultimately raise Lake Erie's level by about one foot. These sills might be considered a permanent structure which would offset the effect of the Welland Canal Diversion (0.44 foot lowering) or the effect of the Chicago Diversion (0.14 foot lowering). Sills at the Lake Erie outlet would also cause the level of Lakes Michigan-Huron to rise due to the backwater effect.

Sills placed on the St. Clair-Detroit River System would offset the effect of the 25-foot and 27-foot dredging projects in this river system. These sills would be placed in areas which would not affect navigation, but would offer the needed flow retardation. The hydrologic impacts of these structures would be a permanent rise in the level of Lakes Michigan-Huron of 0.5 foot or more depending on the desired regime. Levels on Lake Superior would also rise, but by a smaller amount, due to the balancing characteristics of its regulation plan (Plan 1977). Although Plan 1977 could be modified to offset the impacts of these sills, this is not the subject of detailed study at this time. The placement of sills at Lakes Michigan-Huron's outlet would cause a temporary, but significant reduction in flows to Lake Erie, thereby lowering its levels. The long-term impacts on Lake Erie would be considered negligible.

Based on the above discussion, it can be concluded that sills placed at the outlets of Lake Erie and Lakes Michigan-Huron are engineeringly possible, with the size and scope of the works dependent upon the desired range of levels (yet to be determined). The following tables illustrate the potential impacts of sills, when combined with full regulation of Lake Erie, on Great Lakes levels and flows. Options 504-B and TV-1 under the 50N-series plans were used as examples. Figures for Lake Ontario and downstream were determined after making some modifications to Regulation Plan 1958-D (see Measure 1.2.1 for these changes).

Hydrologic Summary of Combined: (1) Sills at the Outlet of Lake Huron; (2) Lake Erie Plan 50N Option -504B; and (3) Modified Lake Ontario Plan 1958-D-R2

	Scenario 1 (no Lake Erie Regulation)		Sills & 50N-504B & Modified 1958-D-R2		Impacts
	levels (FEET)	flows (TCFS)	levels (FEET)	flows (TCFS)	(FEET)
Superior					
mean	600.44	79	600.61	79	+0.17
maximum	601.94	120	601.96	120	+0.02
minimum	598.62	55	598.88	55	+0.26
range	3.32		3.08		
Mich-Huron					
mean	578.37	187	578.86	187	+0.49
maximum	581.62	241	581.80	243	+0.18
minimum	575.37	114	576.04	112	+0.67
range	6.25		5.76		
Erie					
mean	570.73	211	570.74	211	+0.01
maximum	573.55	276	572.64	280	-0.91
minimum	567.92	156	568.72	142	+0.80
range	5.63		3.92		
Ontario					
mean	244.68	247	244.64	247	-0.04
maximum	247.55	350	247.39	340	-0.16
minimum	241.80	176	242.14	188	-0.34
range	5.75		5.25		
Lake St. Louis					
mean	68.24	288	68.23	288	-0.01
maximum	72.89	452	73.50	474	+0.61
minimum	65.38	207	65.34	204	-0.04
range	7.51		8.16		

Hydrologic Summary of Combined: (1) Sills at the Outlet of Lake Huron; (2) Lake Erie Plan 50N Option -TV-1; and (3) Modified Lake Ontario Plan 1958-D-R2

	Scenario 1 (no Lake Erie Regulation)		Sills & 50N-TV-1 & Modified 1958-D-R2		Impacts
	levels (FEET)	flows (TCFS)	levels (FEET)	flows (TCFS)	(FEET)
Superior					
mean	600.44	79	600.62	79	+0.18
maximum	601.94	120	601.96	120	+0.02
minimum	598.62	55	598.88	55	+0.26
range	3.32		3.08		
Mich-Huron					
mean	578.37	187	578.88	187	+0.51
maximum	581.62	241	581.63	244	+0.01
minimum	575.37	114	576.22	109	+0.85
range	6.25		5.41		
Erie					
mean	570.73	211	570.74	211	+0.01
maximum	573.55	276	572.19	292	-1.36
minimum	567.92	156	569.03	127	+1.11
range	5.63		3.16		
Ontario					
mean	244.68	247	244.56	247	-0.12
maximum	247.55	350	248.10	340	+0.55
minimum	241.80	176	240.77	188	-1.03
range	5.75		7.33		
Lake St. Louis					
mean	68.24	288	68.23	288	-0.01
maximum	72.89	452	73.68	480	+0.79
minimum	65.38	207	65.16	198	-0.22
range	7.51		8.52		

The effect and feasibility of placing sills in the river was model tested at the Waterways Experiment Station (WES) in 1934 and 1964. The requirements specified for these model tests were: 1) that the crests of the sills be located 30 feet below low water datum so as not to interfere with navigation; and 2) that the cross-sectional areas over the sills be 40,000 square feet or greater, so that objectional high velocities would not occur. These model tests indicated that it was technically possible to place these sills to satisfy the given requirement, and that using eight sills would raise the level of Lakes Michigan-Huron about 0.5 foot at average flow. Additional studies and model tests have been made since that date to determine more effective sill placement and shapes. Each of these studies concluded that it was technically possible to offset the effect of this dredging and that as little as three sills could be used.

Other methods to compensate for the dredging of the connecting channels have also been studied. These methods include (1) closure of the North Channel in the St. Clair River delta, (2) closure of channels east of Stag and Fawn Islands, (3) a parallel and longitudinal dike extending into Lake Huron, and (4) construction of a longitudinal dike extending several miles downstream from Bay Point Light. Although each of these alternatives is technically feasible, they would require construction in an area of the river used extensively by deep-draft navigation and for fishing and recreational boats. In addition, the above studies indicated that these alternatives would be more costly than the placing of sills and that they were unacceptable to the navigation and recreational interests and would not be recommended without further study.

The placement of sills would have the effect of causing the total existing range of level fluctuations on a lake to be shifted slightly to a higher regime. More precise impacts could be calculated only after the scenarios have been developed and tested against historical and hypothetical (future) supplies.

3. <u>Time Frame for Implementation</u>: As a long-term measure, extensive engineering studies and field surveys, and environmental studies would be required. It would require 5-10 years to implement. As an emergency measure, construction should begin within six months if the measure is to be effective.

4. <u>Implementing Authority</u>: Canada and the United States on the recommendation of the IJC. Costs would be shared by the two countries. In the United States, the Corps of Engineers would administer the project. In Canada, Transport Canada and Environment Canada would jointly administer the project. Final plan is to be approved by the IJC.

5. <u>Implementing Costs</u>: The field surveys, detailed design and engineering/modelling studies, and construction would cost about $25-50M (a ball park figure). Uncertainty factors that might have a bearing on the final cost include environmental studies and remedial actions, and handling of dredged material and placement of sill material.

6. <u>Existing Examples</u>: Compensating dykes, on a much smaller scale than presently discussed, have been placed in the Detroit River to offset some effects of past dredging. Sills on the St. Clair River were studied in the past but not placed.

APPENDIX E -4

SECTION 4

TYPE 2 REPRESENTATIVE MEASURES

MEASURE 2.1.5 :
BREAKWATER CONSTRUCTION

1. Description: Breakwaters are shoreline protection devices that, in contrast to bulkheads or seawalls, are placed out in the water, rather than directly on shore, to intercept the energy of approaching waves and form a low-energy shadow zone on their landward side. Due to this decrease in wave energy, sand moving along shore becomes trapped behind the structure and accumulates. While commonly thought of as harbor protection devices, they can be used to protect the shoreline as well.

Breakwaters can either be fixed to the shore bottom or floating. Floating breakwaters are constructed of buoyant materials such as logs, hollow concrete boxes, or rubber tires. Floating breakwaters are only effective against small, short-period waves, and they require a good deal of maintenance. Fixed breakwaters can be constructed of concrete, quarrystone, gabion baskets, grout filled bags and devices known as longard tubes. Breakwaters can either be fixed to shoreline or detached. Shore connected breakwaters are used primarily in harbor protection. They provide shelter and calm water in their lee, however they prevent the natural movement of littoral sediment transport, possibly influencing downdrift erosion. Offshore breakwaters are used to reduce wave energy reaching the shore and are commonly used to enlarge or reclaim beach areas directly behind them. Breakwaters can be continuous for long distances, or segmented with passages between them to allow for the exchange of water.

Another type of breakwater suggested here is the construction of offshore barrier islands. Barrier islands are similar in construction to fixed offshore breakwaters but they differ in that they are larger and can support non-hazardous activity such as park land and other recreational activities.
Because of their size, they may be an extremely expensive method of shore protection and only justifiable for important areas (eg. major cities).

2. Location: Breakwaters and /or barrier islands could be constructed for areas of high hazard potential on all Great Lakes shorelines. These could include low lying residential developments, but could also include areas where severe erosion is a problem. In addition, they should only be constructed in areas where substantial sediment movement occurs, as they can cause downdrift erosion. They should also be constructed in shallow water near the shoreline for reasons of economy. Impacts of the structures would vary depending on the geologic and geomorphic nature of the site and also on the local wind and wave climate. The main impacts would be local (new beach formation, reduced wave

energy) and downdrift (possible increased erosion). Other local impacts can include reduced water quality behind the structures and navigational hazards for boaters. As breakwaters and barrier islands can be an expensive form of protection, sites to be protected in this manner should be areas where significant problems have occurred, and where a large capital investment exists, such as major harbors and urban waterfronts. Finally, breakwaters should not be located in areas where the physical nature of the shoreline, exceeds the design capabilities of the breakwater (ie. consider wave climate and shore processes).

3. Time Frame For Implementation: The time frame for implementation is estimated to be two to three years. Background studies would have to be done to select appropriate sites, determine what style of breakwater to use and find a suitable contractor. Shoreline and environmental impact studies would also have to be completed in order to determine the suitability of a particular site. This may add another year or two to the implementation time frame.

4. Implementing Authority: Major breakwater projects, such as barrier islands, or harbor protection breakwaters, will be implemented by the federal governments of either country. Smaller projects, such as single, offshore breakwaters, will be implemented at the state or provincial level.

5. Implementing Costs: This will depend on the style of breakwater used. Basic gabion basket breakwaters generally cost approximately $100-120 U.S. per linear foot, but more extravagant structures, such as barrier islands could run into the millions of dollars. Costs will also be involved in completing the necessary background studies. In the case of large structures, funding would come from the federal government tax base through general revenues. For smaller scale projects, funding will be through the provincial / state tax base, through benefit based cost recovery.

6. Examples: A number of examples of both fixed and floating breakwaters have been tried in the Great Lakes basin, such as Lake Forest, Illinois. Fixed breakwaters can be found at virtually every harbor in the Great Lakes.

Barrier island construction has not taken place in the Great Lakes, but hypothetical examples have been proposed for the cities of Chicago, Illinois and Milwaukee, Wisconsin.

MEASURE 2.1.12 : STRUCTURAL FLOODPROOFING

1. Description: This measure would involve public investment to properly floodproof any public or private buildings currently located in hazardous areas. This would involve the construction or installation of facilities, inside or outside the structure, which reduce the potential for damage to the building and / or its contents from flooding. An alternative is to construct the building in such a way that the damage potential is reduced. There are two main methods of floodproofing commonly used. First, structures can be dry floodproofed by ensuring that the walls are watertight, that the openings are closed, and that the walls and floors are strong enough to resist hydrostatic pressures from below. This type of floodproofing works best for structures on slab with brick or masonry walls that are subject to shallow flooding (less than 3 feet).

A second method known as wet floodproofing, allows water to enter the structure, so that the hydrostatic pressures are equalized. This is a cheaper method of floodproofing, but it has one drawback; everything below flood level will get wet. It is thus, important to ensure that all valuables, appliances, utilities, etc. are located above flood level, and that the material used in construction of the lower levels is not susceptible to water damage (eg. paneling and carpeting). Wet floodproofing is generally most appropriate for structures with masonry or concrete basements, or lower areas that are subject to flood depths of 2 to 8 feet.

2. Location: The extent of Great Lakes shoreline where flooding is the major cause of shoreline damage (floodproofing offers limited protection from wave damage). This program would be designed for implementation on all of the Great Lakes shoreline subject to flooding and would therefore encompass parts of the eight states and two provinces. Impacts will vary depending on which states or municipalities adopt the measure. The area impacted would be the immediate site of implementation (i.e. the individual structures).

3. Time Frame For Implementation: This program could be implemented following the 1991 study completion date. Some states and provinces may require development of new by-laws or regulations to ensure proper floodproofing techniques are carried out. Actual floodproofing of a structure should be able to be accomplished within a year. This will allow sufficient time for the location of a suitable contractor, determination of the proper floodproofing method, and the actual construction itself.

4. Implementing Authority: The implementing authority should be at the municipal level, with the program being developed at the state / provincial level. The municipality should also be responsible for enforcing any floodproofing laws that are developed.

5. Implementing Costs: Funding could be provided initially by the state / province for floodproofing of public structures. Funding for the floodproofing of private structures could be attained through direct taxation (benefit based cost recovery) of those whose structures are floodproofed. Actual costs would vary with the size of the structure, but are estimated to be in the $10-20 thousand range per structure.

6. Existing Examples: The Illinois Department of Transportation, Division of Water Resources has sponsored examples of floodproofing in riverine situations. No other examples are known of at this time.

MEASURE 2.2.4 :
FEE SIMPLE PROPERTY RIGHTS PURCHASE WITH POSSIBLE RESALE WITH RESTRICTIONS ON DEVELOPMENT

1. Description: This measure is designed to prevent, or reduce future damages and losses in hazard areas and would see communities, or community agencies (eg. Ontario Conservation Authorities) purchase property located in hazard areas. Once the property is under community ownership, the community has complete control of the land uses and development that occur on the land. For example, the land can be converted into park land, allowing for recreation and public access space. Alternatively, the community could resell the property, except that the new owners would be restricted (by deed) to the types of activities that could be carried out on the land. Structures located on the property could be removed, condemned, or left in states of disrepair, in order to discourage further development. Direct community purchase of a property when it goes up for sale is an ever increasingly expensive method of shore property acquisition. Shore property values are rapidly increasing and many communities find it difficult to acquire the capital needed to buy the property.

2. Location: This measure could take place in all areas of urban development that are threatened by flooding or erosion. Due to the substantial costs involved however, shore acquisition of this type should only be considered where the potential of the land for recreation, environmental protection, or other public uses can justify the expenditure. The impact of a measure of this type would primarily be restricted to the local municipality. The tax base from the structure would be lost, but valuable park land and public access to the water would be gained.

3. Time Frame For Implementation: Greater than 5 years after study completion. Communities would have to wait until properties became available for sale, and then would have to ensure that they have the capital to purchase the properties. Benefit / cost analyses will have to be done in order to determine what areas will provide the highest economic returns to a community for recreation and other uses. Where necessary, regulatory approvals would have to be passed (by-laws).

4. Implementing Authority: This action should be implemented by the municipality, or an agency of the municipality (eg. Ontario Conservation Authority), in conjunction with the provincial / state government.

5. Implementing Costs: This will vary depending on the current

market value of property and inflation rates. Funding will be provided under a cost sharing basis, with the provincial / state government providing 50 percent of the funding and the associated municipalities of the Conservation Authority (or like U.S. agency) providing the remaining 50 percent. Limitations should be put on the amount of provincial / state contribution in any one year, and where grants are requested, the proposed purchases will be approved by the state / provincial departments of Natural Resources.

6. Existing Examples: Some examples of community acquisitions of this type have been carried out by the Hamilton Region Conservation Authority on the Hamilton / Burlington, Ontario Beach Strip, and by the state of Florida in a beach purchase program known as Save Our Coast (Fischer, 1988). Also the Federal Emergency Management Agency (U.S) "Section 1362" program allows purchase of property susceptible to flooding.

MEASURE 2.3.1 :
NAVIGATION AND ACCESS CHANNEL AND HARBOR DREDGING / DEEPENING

1. Description: This measure is one that helps man adapt to the water level fluctuations while maintaining the level of service that would have been possible with static levels. Commercial and recreational vessels have defined draft and underkeel clearance safety requirements that are necessary to enable then to be operational. In addition, there are necessary load requirements that must be met if their operation is to be profitable. This measure would meet these needs by dredging/deepening the navigation and access channels in the Great Lakes and their connecting channels where shallow water would compromise either safety or profitability.

2. Location: This measure can be applied to all the navigation and access channels in the Great Lakes - St. Lawrence Seaway System. The navigation system is vast and covers all the Great Lakes and their connecting channels from Montreal, Ontario to Duluth Harbor, Minnesota. There are also a large number of ports and harbors that feed this system. Many rivers and streams are deepened at their mouths for some distance upstream to provide access to vessels.

3. Time Frame For Implementation: Assuming IJC recommendation in 1991, this measure could be approved by governments within about two years after careful review of the sites requiring modification and decisions being made as to the scope of the program that will be initiated. Typically in the U.S. dredging or deepening requires studies to optimize the area(s) to be dredged along with environmental assessments of sediments, location of disposal sites (if necessary), benefit/cost analysis, public involvement, and cost-sharing agreements. These studies along with design work, plans and specifications, bidding, award, and construction typically takes as long as 15 years from start to finish. This puts the time frame for this measure beyond the turn of the century. This is not to say a program could not be set up to move the measure along faster, but these are the current policies and procedures that the U.S. water resources projects operates under.

4. Implementing Authority: The scenario above assumes that the federal governments of the U.S. and Canada implement all major harbor and navigation channel work. Alternatively, smaller projects involving access channels may be done under state/provincial authority, and in some cases they could be handled at the local level. The states/provinces may even set up a program to assist local governments or private clubs/marinas with funds

once the formalities of the process are complied with (including permits and the like).

5. Implementation Costs: As with most measures there is an administrative cost which is likely to be rather small in comparison to the actual construction of projects. This program could be in the range of the medium ($10-100 million) to high cost ($100-1,000 million) depending on the number of sites that would require dredging and the depth to which they would have to be dredged. Disposal costs are also becoming very expensive and disposal sites are harder and harder to come by.

6. Existing Examples: The public already has a system of channels and harbors on the Great Lakes, and it would involve adapting that system to anticipated low water conditions. There is no large scale example of this measure, but given the low water conditions on the St. Lawrence River in the Last two years its likely that some marina operators in that area have had to take some action in order to operate.

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SECTION 5

TYPE 3 REPRESENTATIVE MEASURES

MEASURE 3.1.1 :
SETBACKS FOR STRUCTURES IN ZONING REQUIREMENTS

1. Description: The purpose behind this program would be to ensure that any new development along the Great Lakes shoreline takes place landward of an erosion or flood control line (typically the 1:100 year erosion line). It would also provide for shoreline owners who are currently lakeward of this line to relocate their homes or cottages landward of the line. Any new development lakeward of the line has to get proper authorization from the implementing authority. Construction may be allowed lakeward of the erosion line, so long as the buildings, or other uses, are portable, or temporary and can be moved prior to damage, and provided the structures are intended for flood or erosion control, or are normally associated with shoreline stabilization (note that these too would have to be approved). Aside from shore protection, uses of this nature can include agriculture, conservation, forestry, wildlife management areas, park land and other outdoor recreation activities.

2. Location: Areas along the entire Great Lakes shoreline that are severely threatened by erosion, especially undeveloped, or moderately developed areas. Erosion set-back lines should be developed for all 9 states and two provinces. Impacts of this measure would be local and would depend on the degree of development already in place and the development pressure on the remainder of the shore.

3. Time Frame For Implementation: Erosion set back lines would have to be completed for the entire basin before the program could be fully implemented. Progress in this is already underway. Existing, enabling legislation would have to be modified (eg. Ontario Planning Act) in all states and provinces and appropriate municipal by-laws would be necessary for enforcement. Implementation should be possible within 3 years of the initial decision.

4. Implementing Authority: State and provincial governments will have the jurisdiction to develop erosion set-back lines. This has already been done in Ontario (1978) and these lines are currently being updated. Some U.S. States have also determined erosion setback lines. Municipalities should be responsible for enforcing the appropriate laws.

5. Implementing Costs: Costs would be minimal as most states and Ontario already have enabling legislation in place (eg. Ontario

Planning Act). Provinces / states, possibly in association with the federal governments, will fund the delineation of erosion setback lines.

6. <u>Examples</u>: The Canada / Ontario Flood Damage Reduction Program, and the Ontario Ministry of Natural Resources Floodplain zoning regulations (Conservation Authorities).

MEASURE 3.1.6 :
SUBSIDIZED RELOCATION OF STRUCTURES OUT OF HAZARD AREAS

1. Description: Flooding or erosion damage can be reduced or avoided by relocation of existing structures out of hazard areas. In some cases, buildings can be designed or adapted to be relatively easy to move and relocation could be implemented only when the need arose, and could perhaps be temporary. In other cases, relocation would have to occur well in advance of a crisis condition and would be a permanent action. The action could be applied to public facilities, or to private property located in hazard areas. In severe cases, entire small communities may have to be relocated, while other cases may only involve individual structures. For this measure, subsidy payments by governments would cover all or part of the cost of relocating structures.

Relocation of structures can be one of the best options available for reducing shore damages. While initially expensive, it can be cost-effective when compared to the financial commitment required for some shore protection devices. Also, if shore protection fails, not only is the investment in the erosion control structure lost, but possibly the home or building is lost as well. Relocation, however, is not always possible. There must be enough land between the shoreline and the building to move in the necessary heavy equipment. Also, there must be land available to relocate the building on, and it too, must not be immediately threatened by erosion.

2. Location: This measure could be enacted along any flood or erosion hazard area along the Great Lakes and their connecting channels. It would most likely occur in areas where substantial structural development is in existence. The impact area would include coastal erosion and flooding hazard areas, as well as the nearby non-hazard areas to which the structures would be moved.

3. Time Frame For Implementation: This measure could occur after a few weeks, or months, or might take years depending on the perceived need to act and the presence or lack of legal authority and funding to implement it. The measure would continue to take place as long as deemed necessary (until, for example, the estimated average annual structural damage becomes less than the average annual cost of the program).

4. Implementing Authority: The program could be developed at the state / provincial level, and administered at the municipal level. Such a program would likely involve new legislation for nearly all jurisdictions.

5. <u>Implementing Costs</u>: These are highly variable, depending on the value of real estate and structural improvements, as well as the time period over which such efforts would be carried out. It would also vary depending on the extent to which the program is intended to remove existing structures at risk. Costs can include preparing the new site, building a new foundation, installing utilities and conforming to present health / building codes. Additional land may also have to be purchased. One source indicates that the actual relocation cost of the average home varies between $10-20 K, with an additional $10K if land must be purchased to relocate the home. Source of funding for this measure would likely be at the provincial / state, or federal level, depending on where post-disaster financial assistance is handled (this measure can be viewed as a means of reducing or avoiding such payments).

6. <u>Examples</u>: There are no known examples of entire community relocation programs. Relocation plans such as Michigan's interest rate "buy-down", Michigan's Emergency Home Moving Program and the new "Jones-Upton" Amendment are examples of "subsidized" measures for individual structures and they do not take into consideration entire community moves.

MEASURE 3.2.1 :
REGULATE SHORE PROTECTION WORKS AND NAVIGATION STRUCTURE CONSTRUCTION

1. Description: This measure recognizes that man's activities can exacerbate the shoreline hazard and proposes measures that are designed to minimize the impacts. This measure deals with the regulation of privately or publicly constructed shore protection and navigation structures (breakwalls, groins, docks, piers, wharfs, jetties, etc.). Regulations would include the obtaining of proper construction permits, which in addition, would not be issued unless the interested party obtains professional technical advice. These types of regulations could also limit the type of protection that goes in, and could charge a fine, or force removal of non-permitted construction. Another possible consequence of this regulation would be to impose a system of "sand rights" (see Stone and Kaufman, 1988) whereby a tax (levy, fine, fee) is charged to anyone (individual, organization, etc.) who constructs a structure that interferes with the natural nearshore process of sand transport and deposition.

2. Location: All developed areas of the Great Lakes and their connecting channels.

3. Time Frame For Implementation: One to two years from the completion of the study will be required for implementation. Regulatory bylaws would have to be developed and some sort of enforcement laws (fines), would have to be drawn up.

4. Implementing Authority: The local municipality would be responsible for implementing the bylaws, under the guidance of provincial or state governments. State and provincial departments of natural resources could be responsible for regulating shore protection and for providing technical advice.

5. Implementing Costs: Costs would be incurred in setting up regulatory programs and technical advice personnel, and this is estimated to cost less than $1 million annually.

6. Examples: Ontario's Ministry of Natural Resources had a Technical Advisory Service for shore protection in place, whereby personnel trained in shore protection and shore processes would visit a property and make appropriate recommendations.

MEASURE 3.3.1 :
REGULATION OF WATER WITHDRAWALS / CONSUMPTIVE USE

1. Description: This measure would see the development of regulations that would guide the use of water by towns, cities, etc., and in addition to consumptive use regulations, would see the regulation of in-water structures (other than water intakes and navigation structures) through a permit program, and would see regulations put in place that would ensure that water intakes and outfalls are properly designed to withstand extremely high, or low levels. It would also closely monitor and put limitations on the amount of consumptive use by manufacturers in the production of goods which incorporate Great Lakes water and thereby remove water from the basin. Restrictions would also be placed on municipalities, industries, manufacturers,etc. to account for leakage within withdrawal systems.

2. Location: All towns, cities and municipalities that draw their water supply directly from the Great Lakes. This also includes all manufacturers which incorporate Great Lakes water in goods which are removed from the basin.

3. Time Frame For Implementation: One to two years after completion of the study would be required to set up proper regulations and permit programs. A body would also have to be formed to issue the permits and enforce the regulations drafted. An additional 2 to 5 years would be required for the inspection of the withdrawal systems to determine the degree of leakage. Water intakes, outfalls, and water lines may also have to be redesigned or rehabilitated.

4. Implementing Authority: The city, town, or municipality of concern would have authority, with possible funding assistance from the state, or province. Costs would also be borne by private manufacturers.

5. Implementing Costs: Costs would be relatively small, unless major redesign of structures has to take place. Possible cost-sharing arrangements between the city and the state / province and private industries / manufacturers could be arranged.

6. Existing Examples: Some states have permit programs for water diversion (withdrawal) and for construction of water intakes / outfalls on the lake bed. Many such structures are regulated by the Corps of Engineers.

Infiltration / inflow (I/I) studies are being undertaken within the water distribution systems of major Great Lakes cities. he percentage of leakage is determined with rehabilitation recommended (i.e. Buffalo, NY). Restrictions would facilitate rehabilitation, and thus reduce "consumptive use" as defined in this study.

Since consumptive use also includes evaporation and transpiration, weather and land use / cover modification could also be considered. Such actions, however, are costly and results are difficult to quantify.

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SECTION 6

TYPE 4 REPRESENTATIVE MEASURES

MEASURE 4.1.7 :
INTEREST RATE SUBSIDY LOAN

1. Description: The purpose of this program is to provide assistance to private owners through low-interest loans for protective works to help defray some of the costs. The loan applies to protective works and repairs for individual existing structures, including sea walls, dikes, groins, gabions, drains and pumps, breakwaters, beach nourishment, land filling, vegetation planting, flood proofing of existing structures, and relocation of existing structures. This type of expenditure policy will allow a maximum loan of 75% of the total cost or $40,000. Loans for shoreline repair or protection should not exceed $500 per meter of shoreline. (Prices are taken from recommendations made by the Shoreline Management Review Committee). Loan approvals are to be guaranteed following technical approval of proposed works. The loan is repayable through municipal taxes.

2. Location: Local government units which surround the Great Lakes.

The loan program is designed for implementation for all the Great Lakes and would therefore encompass the eight states and two provinces which surround the five Great Lakes. Obviously, the impacts vary depending upon the states and provinces which adopt the measure. For this representative measure, assume that all the Basin states and provinces participate. The geographical area impacted by this program would encompass the immediate sites of implementation. States/provinces outside the basin would not be affected.

3. Time Frame For Implementation: A loan program could be implemented immediately in most states/provinces subsequent to the 1991 study completion date. However, some states and provinces may require specific amendments to current acts before the plan could be put in place. A test phase for the loan program may be desirable, but this is up to the discretion of the province or state. Otherwise the loan program has no termination date, although periodic review may be necessary.

4. Implementing Authority: The implementing authority shall be at the state/provincial level. The loan is made to the property owner by the municipality at an interest rate of two percentage points below prime. Municipalities may participate in the program only after passing a by-law approved by the state or provincial authority (eg.Ontario Municipal Board), authorizing the sale of debentures to the province.

5. <u>Implementing Costs</u>: The province/state, through its relevant agency, finances the loan by purchasing debentures from the municipality at the same repayment terms. Direct costs are expected to be of two forms: a) administrative costs borne by province /state and municipalities, and b) opportunity cost of the low interest rate loan.

6. <u>Existing Examples</u>: Currently interest rate subsidy loans are available in Ontario, Michigan, New York, Pennsylvania and Wisconsin. However, there are considerable variations between the programs. Information on the Ontario Program can be received through the Ministry of Municipal Affairs. Information on the State programs is available from The Center for the Great Lakes.

MEASURE 4.2.9 :
TAX ABATEMENTS TO COVER INCREASED OPERATING COSTS

1. Description: This measure uses tax abatements to help cover the increased operating costs incurred by shoreline property owners/users due to fluctuating water levels. Examples of increased operating costs are:

a. modification of docking marina facilities (eg. installing floating docks and dredging channels to deal with high and low levels);

b. modifying water intakes and outfalls at publicly-owned and commercial/industrial facilities (longer pipes and pumps may be necessary) for low water conditions;

c. additional pumping capability may be necessary to irrigate lands adjacent to the lakes during low water levels; and

d. modification of wharves and docks and channel depths in commercial harbors may be required to adjust to fluctuating water levels.

The abatements can be in the form of credits to offset future taxes or rebates on taxes already paid, and would be payable through some government established and managed program. The structure of the abatements or credits would be established with some compliance requirements to the benefiting interests. These compliance requirements will need to be inspected and documented in order to determine the amount of the abatement or credit.

2. Location: This measure could be applied along the Great Lakes and their connecting channels along with any water areas that are hydraulically connected to or influenced by fluctuating water levels (i.e. harbors and river mouths upstream to the point where lake level is not the controlling mechanism).

3. Time Frame For Implementation: Assuming IJC recommendation in 1991, it will take about one year beyond that date for states and provinces and municipal by-laws to be changed so the measure could be implemented. The actions necessary to make the entities eligible for the tax abatements could then be implemented. Assuming the design, permitting, and construction takes another two years, it is likely that this measure could be in place by 1994.

4. Implementing Authority: The implementing authority would likely

be at the state/provincial or municipal level. The program would likely be at the state/provincial level with implementation by the local governments, who would also be responsible for the enforcement/administration of the program.

5. Implementation Costs: The actual administrative costs of this measure would be low (i.e. under $10 million). The tax abatements and the additional adaptive construction costs are not known, but would likely be in the medium cost range ($10-100 million). The program scope is not known at this time and additional data would be needed to get a better handle on the costs.

6. Existing Examples: This approach has been recommended in other areas, but has not been used along the Great Lakes or their connecting channels.

MEASURE 4.3.1 :
PUBLIC INFORMATION AND EDUCATION (I&E) PROGRAMS

1. Description: Public information and education programs deal with programs specifically directed at the general public; they are aimed at improving the public's understanding of the Great Lakes issues and options for action to better enable them to cope. These programs can vary widely in their content and means of implementation. They can include material management such as cataloging I&E material, public repositories for I&E materials, oversight groups and refinement of materials and programs. They could also include outreach programs such as cooperative extension programs, technical assistance, demonstration programs, and stewardship awards. Regardless of their form they generally all have the common goal of improving the understanding of the risks and options associated with use of the shoreline areas of the Great Lakes, their connecting channels, and the St. Lawrence River.

2. Location: Ten locations around the Great Lakes Basin.

1. Montreal	6. Potsdam
2. Cornwall	7. Cleveland
3. Burlington	8. Detroit
4. Owen Sound	9. Chicago
5. Thunder Bay	10. Sault St. Marie

3. Time Frame For Implementation: Information Centers can be implemented in a reasonably short time. The Great Lakes Water Level Communication Center for example was established from the time of conceptualization to the time of operation in under two weeks. From that point it took about two or three months for the Center to become fully functional. This outlines the speed at which this type of measure could be implemented. To establish all 10 sites and connect them all to a central computer system could be accomplished in under a year.

4. Implementing Authority: The implementing authority for information centers would be the U.S. Army Corps of Engineers in the United States, and Environment Canada in Canada.
These federal agencies are presently responsible for water level data and are therefore the most appropriate for this responsibility.

5. Implementing Cost: Information programs can be established at a fairly low cost relative to other measures. It requires man-hours, costs for information material, computer facilities etc. The cost for implementation and operation will be assumed by the two federal governments, each being responsible for the locations

within their respective countries.

6. Existing Examples: There presently are no coordinated Great Lakes information centers existing within the Great Lakes Basin.

Example Measure: A series of 10 Great Lakes information centers set up at various location around the Great Lakes Basin with a central headquarters at the Canada Center for Inland Waters in Burlington. Five U.S. locations and five Canadian locations, each having current information on Great Lakes Water Levels would offer information pertaining to water levels on the Great Lakes. The centers would be run by one or two people who have a strong background in water levels and coastal processes. Each center could be hooked by a main frame computer an a central library system. People wishing to review technical information not available at the local center could order it through them. Current water levels would be charted at each center for the viewing of the general public. This type of program would make information more readily available to the public. Far out places such as Thunder Bay would have some place to voice their concerns. This effort would help to connect the Basin and would promote information exchange both nationally and internationally.

Similar Examples: In March of 1986, Environment Canada established the Great Lakes Water Level Communication Center whose purpose was not only to operate as a nerve center during storm events, but also to implement programs to educate and inform the public about the Great Lakes and fluctuating water levels. There are no comparable centers in the U.S. The province of Ontario through the Ministry of Natural Resources and the Conservation Authorities also provides information through brochures, booklets and technical assistance. In 1986, and as a result of shore damages caused by high water levels in 1985, the Ministers of Natural Resources and Municipal Affairs approved the formation of the Shoreline Management Review Committee. This committee was requested to hold public meetings and seek input from interests on long term approaches to the management of the Great Lakes shoreline in Ontario.

In the United States all of the eight states surrounding the Lakes have some form of public information/education program. Technical assistance to aid in the proper design of private flood and erosion control structures is provided through the Department of Natural Resources and various Sea Grant and College programs. The Great Lakes Program at the University of Buffalo has created a Great Lakes Information Clearinghouse to provide directories of those involved in Great Lakes and facilitate international communications. The Center for the Great Lakes is a non-profit organization created to provide an integrated binational focus for developing effective programs to manage, conserve and develop the region's natural resources. Great Lakes United was established in

1982 and is an international organization dedicated to conserving and protecting the Great Lakes and St, Lawrence River. The Great Lakes Commission has also been very active in water level issues and public information. As well many of the States have Sea Grant College Programs which work to keep the public informed about water resources and help solve the problems of coastal and water resource users.

MEASURE 4.3.5 :
REAL ESTATE DISCLOSURE

1. Description: The purpose of this program is to inform prospective shoreline property buyers of the associated risks. All real estate agents, investors and planning departments would be provided with hazard land maps. Real estate agents would then be required by law to reveal hazard land properties to prospective buyers. Owners of shoreline property must disclose any past damage or repair costs associated with flooding and erosion problems and any other unusual risks associated with shoreline property. If they refuse to disclose problems, they can legally be held responsible for any damages incurred by the new buyers.

2. Location: Great Lakes Basin. The program could be implemented in all states and provinces within the Great Lakes basin. The geographical area of impact would not exceed the basin unless similar legislation is implemented for river flood plains and other hazard areas.

3. Time Frame for Implementation: Hazard Maps would have to be completed for the entire basin before the program could be properly implemented. Bills must be passed in all states and provinces and the appropriate municipal by-laws would be necessary for enforcement. Implementation should be possible within 1 year of the initial decision.

4. Implementing Authority: The provincial and state governments have the jurisdiction to implement province/state wide laws for disclosure and for the distribution of hazard maps. Enforcement of the laws would be the responsibility of the municipality.

5. Implementing Costs: Provinces/States must fund the delineation of hazard lands and the distribution of hazard maps. Some funding may also be available from federal governments.

6. Existing Examples: Lake Superior Management Board, having authority over three counties and seven municipalities along the Great Lakes shoreline, has plans underway to amend property deeds to include disclosures of erosion hazard lands. Information is available from the Lake Superior Management Board. Presently only Wisconsin has a disclosure policy. In that state real estate transaction forms must be filled out as part of the land transfer and the seller must tell the prospective buyer of flooding hazards. Erosion and other hazards need not be disclosed. In Ontario, the township of Norfolk, on the north shore of Lake Erie is attempting, on a trail basis, a policy whereby permits for new structures may be granted for properties located within hazard land areas, but this is added directly to the property deed.

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SECTION 7

TYPE 5 REPRESENTATIVE MEASURES

TYPE 5.2.1 :
EMERGENCY SANDBAGGING AND DIKING ASSISTANCE

1. Description: During periods of high lake levels, provide sandbagging and diking assistance to reduce flood and erosion damage.

2. Location: Along the affected shorelines of the Great Lakes-St. Lawrence River System.

3. Time Frame for Implementation: To be implemented by federal and local governments when situation arises.

4. Implementing Authority: Various levels of governments.

5. Implementing Costs: This would be a medium cost scheme ($10-100M). Past sandbagging activities carried out by the Corps of Engineers and by Ontario Ministry of Natural Resources and its local conservation authorities would provide some ideas on costs and their effectiveness.

6. Existing Examples: Various programs operated by provinces and states. Also, the Corps of Engineers PL-84-99 Emergency Assistance Program was carried out during the 1985-87 record high water levels on the Great Lakes. The following gives more detailed information.

In response to a request from the Governor of Michigan in April 1985, the Detroit District Commander implemented the Advance Measures Program, under the provisions of P.L. 84-99, for areas of Michigan impacted by high water storm surges on the Great Lakes.

The area under consideration by the District for Advance Measures Projects was eventually expanded to include the Great Lakes shorelines of Wisconsin and Minnesota. In all, the Detroit District investigated the merits of providing Advance measures construction project protection at over 60 communities within these three Great Lakes states. Under this program, all six Advance Measures protection projects located along the western (Michigan) shoreline of Lake Erie, as well as on the Hampton Township Advance Measures Project located in Bay County, Michigan, adjacent to Saginaw Bay. As of November 1, 1988, four of the seven Advance Measures protection projects in Michigan have been turned over to local sponsors for operation and maintenance. The remaining three Advance Measures Projects are scheduled to be turned over to local sponsors by the end of January 1989. The projects ranged in dollar amounts from $215K to $2.6M, with the total to complete all seven projects currently estimated at $9M.

During this time of rising water levels, the Urgent Supplemental Appropriation Act of 1986, (P.L. 99-349) was signed on July 2, 1986. A provision of the Act directed the Secretary of the Army to develop emergency contingency plans to prevent near-term flooding along the Great Lakes. The Detroit District was directed to take the lead in coordinating this effort and formulating a contingency plan of emergency actions. Subsequently, and in response to Great Lakes water levels rising to record and near record elevations, the Advance Measures Self-Help Program under P.L. 84-99 was approved by the Assistant Secretary of the Army for Civil Works, on October 1986. Under this program, 3,750,340 sandbags, 23,802 tons of sand and 1,801 rolls of plastic sheeting were distributed by the Detroit District through County Emergency Governments to shoreline residents along Lakes Erie, Michigan, Huron, St. Clair and Superior. As a result of the recession in lake levels, the Self-Help Program ended June 1, 1988.

TYPE 5.2.3 :
STORM FORECASTING

1. Description: Information centers are responsible for improving and issuing storm forecasting, collecting, analyzing and disseminating Great Lakes water level, outflow and shore erosion data, storm forecasts and other related information. These centers can pass along information for local radio weather broadcasts to inform boaters and shore residents on water level and storms. The discussion that follows focuses on storm forecasting.

2. Location: The information centers would be located in major Great Lakes urban areas easily accessed by the general public. Storm forecasting would be for those Great Lakes shore areas most vulnerable to property damage from storm action. Storm forecasts would be issued to the public by radio, television, toll-free telephone lines and other means as a storm approaches. The forecasts would also be issued to the relevant local agencies such as the conservation authorities in Canada. The frequencies of the forecasts would increase during the storms.

3. Time Frame for Implementation: Storm forecasting is already a routine operation in Canada by Environment Canada and in the United States by the National Weather Service of NOAA. Efforts are on-going to improve and expand the area of forecast.
The establishment of information centers could be carried out within a matter of days using existing personnel from the relevant government agencies.

4. Implementing Authority: Environment Canada would work in co-operation with the Province of Ontario. In the United States, the National Weather Service would co-ordinate its effort with the Corps of Engineers with assistance from the states.

5. Implementing Costs: The preparation and dissemination of storm forecasts would be a very low cost scheme (<$1M per year) for each country. The level of service (effort) and cost would vary somewhat with water levels since there is a reduced need for forecasts during periods of lower levels. The operation of an information centre which also provides other services would cost perhaps $1M annually.

6. Existing Examples: Environment Canada's Great Lakes Water Level Communications Centre. The U.S. Army Corps of Engineers' Great Lakes Water Levels and Forecasting Information Center.

TYPE 5.1.2 :
INCREASE NIAGARA RIVER FLOWS USING THE BLACK ROCK LOCK

1. Description: This measure considers increasing the Niagara River flows by modifying the existing Black Rock navigation lock. The objective is to lower Lake Erie's extremely high water levels.

There have been several alternative measures studied involving modifications to the Black Rock Lock. Although the Lake Erie Water Level Study examined a lock modification scheme, called Plan 6L, it was not designed as an emergency measure. Two potential emergency measures could be considered. The first alternative would require opening the lock's butterfly valves and culverts to direct small flow increases. This measure would not require any structural changes and could be carried out immediately; however, it would at most, increase Lake Erie's outflows by only 1,300 cfs, resulting in a 1/2-inch lowering of Lake Erie. Another alternative (called Plan 12L) is to modify the lock in order to discharge greater flows (12,000 cfs). While there are some disadvantages due to the delay caused by construction, this alternative would have a much greater impact than the first and is discussed herein.

Additional detailed information can be found in the Report on Follow-On Activities Resulting from the IJC Task Force Report on Potential Measures to Alleviate Problems Created by the Current High Lake Levels - FLOWING 12,000 CFS THROUGH THE BLACK ROCK LOCK, August 1988, by the U.S. Army Corps of Engineers, Buffalo District. Much of the following is based on this report.

2. Location: The middle miter gates in the existing lock would be permanently removed. The miter gate recesses would be filled with reinforced concrete to provide smooth chamber faces. The necessary lock bulkhead recesses would be formed in the new concrete. A set of twelve removable lock bulkheads would be supplied to provide the required control structure. Each structural steel lock bulkhead would be 77 feet long and 3 feet high. This proposal would permit the opening of the upstream and downstream miter gates and allow water to discharge through the lock chamber. The control would be achieved by partial or complete removal of lock bulkheads. A reinforced concrete overlay would be anchored to the existing middle miter gate sill to complete the control structure installation.

The operational constraints placed on the Plan 12L structural modifications would depend on the severity of the emergency. If normal operation for lockage is maintained (moderate emergency), then it can be assumed that operation will take place only during the non-navigation season from mid-November through mid-April. There would be uninterrupted operation during this period, with average annual flows of 5,000 cfs. However, assuming that the lock would be shut down for maintenance every five years, the average annual discharge capacity would be about 4,000 cfs. The above operation mode is different from those previously studied (Plan 6L), in that it was assumed that the proposed structures would be operated sporadically whenever lockages were not occurring during the navigation season and full-time during the non-navigation season.

During severe emergencies, Plan 12L could be continuously operated, resulting in an average annual discharge of about 12,000 cfs. This would require termination of the lock for navigational purposes, resulting in negative economic impacts on recreational and commercial navigation and other dependent or related interests.

In the Lake Erie Water Level Study, Black Rock Lock modifications and Squaw Island Diversions structures were considered. The plans most nearly matching the average annual discharges associated with moderate (4,000 cfs) and severe (12,000 cfs) emergency designations discussed herein are Plans 6L (3,680 cfs) and 19S (12,000 cfs). The following table is a summary of the hydrologic impacts, as reported in the Lake Erie Study, associated with Plans 6L and 19S. Although these estimated impacts were calculated using historical (1900-1976) supplies, and given that supplies during an emergency situation could be more severe, the table nonetheless gives a good indication of the magnitude of impacts which would result from Plan 12L.

Summary of Hydrologic Impacts Associated with Plan 12L under Moderate and Severe Emergency Designations

Impacts in Feet (negative value means lowering)

	Moderate (6L)	Severe (19S)
Superior		
mean	-0.01	-0.04
max	0	0
min	-0.01	-0.08
Michigan-Huron		
mean	-0.03	-0.11
max	-0.06	-0.19
min	-0.02	-0.06
Erie		
mean	-0.09	-0.29
max	-0.15	-0.53
min	-0.02	-0.09
Ontario		
mean	+0.03	+0.04
max	+0.02	+0.21
min	-0.07	-0.20

As can be seen in the table, year-round operation of Plan 12L under a severe emergency situation would reduce Lake Erie's maximum level by 0.53 foot, and Lakes Michigan-Huron 0.19 foot. Since no changes were assumed in the regulation of Lake Ontario, the operation would raise Lake Ontario's maximum level by up to 0.21 foot. The impacts on minimum and average levels have much less significant meaning, since during average and below-average lake level conditions, there is no need to consider using Plan 12L to lower the lake levels. Lakes Erie and Ontario would be the first to be affected by implementation of Plan 12L. These impacts would increase progressively and would reach their maximum within 18-24 months. Because of the time-lag in transmitting the effects upstream, it would take several years for Lakes Michigan-Huron (Lake Superior even longer) to feel the maximum impacts under Plan 12L.

3. Time Frame for Implementation: This study assumed that all necessary structural modifications would be completed in one year. Since additional design work is necessary, it should be conducted well in advance to avoid delays.

4. Implementing Authority: The U.S. Army Corps of Engineers which is the operator of the Black Rock Lock. In an emergency (to be declared by the Canadian and United States Governments), the IJC would be given the authority to formulate an operational plan and to oversee its implementation.

5. Implementing Costs: The first cost of the control structure and appurtenant works would be about $3.1 million, based on August 1988 price levels. Subsequent to the completion of any necessary stability modifications to the lock walls, all construction associated with Plan 12L could be accomplished during one 12-month construction season. Various construction phases would be scheduled throughout the year to minimize any adverse impacts on navigation.

6. Existing Examples: Navigation lock facilities at Sault Ste. Marie, Michigan have been used to increase Lake Superior's outflows during the emergency situation of 1985-86.

APPENDIX E - 4

SECTION 8

TYPE 6 REPRESENTATIVE MEASURES

MEASURE 6.1 :
FULL REGULATION OF ALL THE GREAT LAKES BY COMBINING LAKE ERIE PLAN 50N (1.2.1) WITH THE PLACEMENT OF A SILL IN THE ST. CLAIR RIVER (1.4.4) WHICH IS THE OUTLET TO LAKES MICHIGAN-HURON AND STRUCTURAL SETBACK ZONING (3.1.1)

1. Description: This plan incorporates some increased control over water levels in the Great Lakes by adding control of Lake Erie via a control structure in the Niagara River and by placing a sill in the St. Clair River to bring Lakes Michigan-Huron up to the pre-Seaway condition. The sills would compensate for the navigation channel dredging that in effect lowered the levels of Lakes Michigan-Huron by 0.6 feet. The last component of the combination measure is structural setback zoning which would tend to reduce future hazards on the Great Lakes by requiring all new or upgraded structures to setback a given distance so that erosion will not destroy the structure before its useful life has been completed. All three of these measures happen to be representative measures and therefore more detailed information on each is available in previous sections.

The use of Plan 50N on Lake Erie would involve the need for a control structure in the Niagara River to regulate the outflows of Lake Erie and produce a reduced range of fluctuations in the lake. In effect, it would lower the average long term highs (-0.93) and increase the average long term lows (+0.79). Because of backwater conditions this plan would also lower the long term average highs on Lakes Michigan-Huron by 0.29 feet and raise the long term low level by 0.20 feet. Also, because more water is now being dumped into Lake Ontario the range of fluctuations will increase from 5.75 feet to 8.18 feet if only Plan 1958D is used to mitigate the increased flow (channel modifications in the St. Lawrence River could also be added to the plan to reduce the impacts on Lake Ontario and the St. Lawrence River). The objective of this part of the plan would be to reduce the long term highs and increase the long term lows on Lake Erie thereby reducing the total range of fluctuation while maintaining, as much as possible, its long term average monthly levels and seasonal fluctuation characteristics.

The placement of sills in the St. Clair River would compensate for the past lowering effect of the navigation channel dredging in the Detroit, St. Clair River system on Lakes Michigan-Huron. This plan would raise the water levels in Lakes Michigan-Huron by about 0.6 feet. This rise would be permanent and would raise the entire range by about that amount. This portion of the plan would need to be followed up with changes to the present reulation plan for Lake Superior (Plan 1977).

The combined effects of these two portions of the plan would be to reduce the extreme range of water level fluctuations on Lake Erie. The lakes upstream would be effected to a lesser degree than Lake Erie, and since the regulation of Lake Superior reflects both upstream and downstream conditions these plans (along with existing regulatory structuresand regulation plans) tend to provide for some degree of regulation for all the Great Lakes.

Added to the above would be the implementation of regulations that would govern future development of flood and erosion-prone hazard areas along the Great Lakes shoreline. This portion of the combination measure would help to address the problems associated with short term fluctuations (i.e. storms) that cannot be significantly reduced by lake level regulation plans.

2. <u>Location</u>:

(a) Lake Erie Plan 50N - This portion of the measure will require channel enlargement near the head of the Niagara River in the vicinity of the Peace Bridge and a control structure at that site. These would provide for the flow increase and decrease capacities, respectively. The geographic area of impact would initially be the extensive channel enlargement area in the upper Niagara River where large quanities of rock would have to be removed from the fast moving river. The environmental issues relating to the rock removal and disposal would need to be addressed. The construction of the control structure would require cofferdams which would alter the natural flow conditions. Upon completion, the area of impact includes the local area where increased high/low flows or sudden changes in flows/levels take place. After completion the broader changes on the system mentioned under "description" can be expected. In addition to the need for changes in the Lake Ontario regulation plan (1958D), some channel capacity increase will be necessary to reduce the impacts of the Lake Erie regulation on the range of fluctuations on Lake Ontario and the St. Lawrence River.

(b) Sills in the St. Clair River would be located at the head of the river near the outlet of Lake Huron. If the existing water surface profile is to be strictly maintained, then a series of sills along the St. Clair River would be required. No sills are considered necessary in the Detroit River, partly because sills, on a smaller scale, have been placed in a smaller scale in the past in this river. Another reason is that ther have been no identified needs to raise Lake St. Clair's water level to a new regime. With the sills in place by themselves, water levels in Lkaes Michigan-Huron would be about 0.6 feet higher than existing conditions at the present time. The seasonal or annual cycle characteristics would remain similar to those observed in the past.

(c) Structural setback regulations would apply to all areas along

the entire Great Lakes shoreline that are severely threatened by erosion, especially undeveloped or moderately developed areas. Erosion set-back lines would be developed for all shoreline reaches. Impacts of this action would be local and would depend on the degree of development already in place and the development .pa
pressure on the remainder of the shoreline.

3. Time Frame for Implementation: Each piece of the combination plan is likely to take differing amounts of time to put in place. Howerver, based on the discussions of each piece below it is expected that the earliest this combination could be fully implemented would likely be 10 to 15 years after the decision is made to move ahead on such a combination plan.

(a) Lake Erie Plan 50N would require three to five years to perform the necessary planning, environmental and design studies. Add to this cost estimates, plans and specifications, and construction time of about another five years. In addition, assuming modifications are needed to the St. Lawrence River's channel capacity a similar time commitment would be required because of the extent of the undertaking.

(b) Sills are also a long-term type measure requiring times similar to the previous portion of the plan.

(c) Structural setback zoning could likely be applied to all shoreline areas within three to five years, and because it is not physically tied to the other portions of the plan it could be put in place in advance of the actual construction of those works.

4. Implementing Authority:

(a) Lake Erie Plan 50N - The IJC can implement given appropriate authorization from the U.S. and Canada.

(b) Sills - The IJC after agreement by the U.S. and Canada.

(c) Structural Setbacks - State / Provincial and local governments.

5. Implementing Costs:

(a) Lake Erie Plan 50N - About $500 million to $1 billion.

(b) Sills - About $25 to $50 million.

(c) Structural Setbacks - Costs in some areas may be minimal where there are few hazard designated areas, or programs are already in existance. In other areas there would be the administrative costs of establishing, monitoring, and enforcing the program. The total cost of this type of program is difficult to determine, but would likely be in the low ($1 to 10 million) range.

6. Existing Examples: Some examples are: Lakes Superior and Ontario regulation, compensating dikes (on a small scale) in the Detroit River, and various government acts and legislations regarding land use and zoning.

MEASURE 6.4 :
BREAKWATER CONSTRUCTION (2.1.5) / PUBLIC INFORMATION AND EDUCATION PROGRAMS (4.3.1)

1. Description: This measure would include the construction of offshore breakwaters to protect those areas that are severely threatened by wave action/erosion, and the development and application of improved public information and education programs to make people aware of the hazards associated with living in the shore zone. Breakwaters intercept and dissipate the energy of approaching waves before they can erode the shoreline or damage structures. Public information and education programs could include the development of information centers, demonstrations of shoreline management techniques, outreach programs,and youth education programs (particularly in the school curriculum).

2. Location: Breakwaters can be installed in any area where there is a severe erosion hazard in the Great Lakes, and their impacts would be fairly localized with possible downstream effects. Education programs should take place throughout the entire Great Lakes Basin, and have basinwide effects.

3. Time Frame for Implementation: Breakwaters would take two to three years for implementation. Background studies would have to be done to select appropriate sites, determine what style of breakwater to use, and construct the breakwaters. Information programs could be set up within two to three months of the decision to fund them. Formal education programs would take longer to implement as the curriculum would need to be developed, approved and instituted by the appropriate school boards. This is estimated to take two to three years to implement.

4. Implementing Authority: Major civil works type breakwater projects would be implemented by the government agencies of the federal governments, the USACE in the U.S. and Environment or Public Works Canada. Education and information programs could be implemented at all levels of government, depending upon where money is available.

5. Implementing Costs: Breakwater costs would depend on the number, style, and size of breakwaters constructed, but it is likely to be very high if all erosion-prone areas are protected. Funding for them would come at least partially from increased taxes on those who directly benefit from their installation (i.e. from provincial/state, or federal tax base). For information and education programs, costs would be low to moderate and would likely

be carried primarily at the state/provincial level except in the case of information centers such as those that have been set up by federal governments in the past. Some costs sharing for these programs may be possible between the state / provincial .pa and federal governments.

6. <u>Existing Examples</u>: There are numerous examples of breakwaters throughout the Great Lakes. The Great Lakes Water Level Communication Center in Canada is an example of an information center. Many education materials and opportunities exist for their use by schools. The Great Lakes Water Level Communications Center and many of the State Sea Grant Programs have developed teaching Units and manuals on a number of Great Lakes topics. There is also a Great Lakes Basin educators network associated with the IJC, under the Science Advisory Board's Social and Economic Considerations Committee.

MEASURE 6.5 :
MAXIMIZE USE OF EXISTING REGULATORY STRUCTURES / PROCEDURES (1.1.5) AND HAZARD LAND MAPPING (4.3.3) AND PUBLIC INFORMATION AND EDUCATION PROGRAMS (4.3.1)

1. Description: This measure is a combination of Types 1 and 4 designed to maximize (optimize) the use of existing structures and maximize public awareness of the hazards of fluctuating water levels. This is viewed as a non-structural measure because no new structures would be required (only "optimizing" the use of existing ones), and the emphasis is on keeping the public out of the hazard areas by making them aware of the dangers/risks associated with locating there. Hazard land mapping is assumed to be an action that will be implemented during the course of the Reference Study and available by 1991.

2. Location: This measure would require improved/updated regulation plans for the control works in the St. Mary's and St. Lawrence Rivers (Plan 1977 and Plan 1958-D, respectively). It also would involve all the shoreline areas in the Great Lakes and their connecting Channels. Hazard land mapping and information and education programs would have basinwide applications.

3. Timeframe for Implementation: Assuming IJC recommendation in 1991 and the availability of Hazard Zone Mapping by that date, a review of current regulation plans could be accomplished in about two to three years which is about the same length of time it would take to get a public education program in place.

4. Implementing Authority: The IJC would be the implementing authority on the modifications to the regulation plans (after U.S. and Canadian governments approval), and the hazard land mapping. The Great Lakes States and the Provinces of Ontario and Quebec are in the best position to implement the public information program.

5. Implementing Costs: The actual cost of implementing this measure would be low (i.e. under $10 million). The hazard land mapping, engineering studies, and the public information programs are assumed to be the only cost considerations. No costs are factored in for the possibility that modifications to the existing regulation plans would require environmental assessments.

6. Existing Examples: The existing regulation plans for the control structures in the St. Mary's and St. Lawrence Rivers. The Province of Ontario and several states have done hazard lands mapping, and the have been some public education/awareness programs used in times of emergency (i.e. the Great Lakes Water Level Communications Center).

MEASURE 6.6 :
COMMUNITY ACQUISITION OF HAZARD LAND (2.2.1) /
REGULATE USE OF PROPERTY IN HAZARD AREAS (3.1)

1. Description: This action is a combination of Type 2 and 3 actions and is designed to prevent further damages to structures in hazard areas by acquiring hazard land and by regulating the use of property in hazard areas. If lands are acquired, the community can then resell it, but with certain restrictions, such as the prohibition of residential development. The community can also revert the land to parkland and retain ownership. The community could also retain ownership, not remove or repair any structures, and let nature take its course. Regulations could apply to existing developed land, but would be better suited to undeveloped, or moderately developed land. These regulations would insure that any development that takes place is done so with due consideration to the natural hazards that exist in the shore zone. Regulations of this type might even apply to land that the community has acquired.

2. Location: Areas of past residential damage, all undeveloped or moderately developed shorelines in designated hazard zones along the Great Lakes and their connecting channels.

3. Time Frame for Implementation: This combination action could be implemented within one to two years after the study completion date. Many similar regulations may already exist, and only simple modifications to these may be required. Acquisition may take longer to totally implement, as communities would have to wait for properties to become available.

4. Implementing Authority: The municipality or local government body would likely have the main implementing authority, but would need direction from higher levels of government.

5. Implementing Costs: The costs will vary depending on current and future market values of the property, and on the costs involved in setting up governing bodies for any new by-laws that are introduced. Funding for programs of this type should come from federal and state / provincial governments.

6. Existing Examples: The Hamilton Region Conservation Authority, State of Florida, and U.S. Federal Emergency Management Agency have been involved in community acquisition of hazard lands in the past. Similar regulations have been employed in Canada. Ontario has a Flood Damage Reduction Program (erosion/flood setbacks). Ontario Conservation Authorities also have elevation regulations, and other related municipal by-laws.

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