

International
Lake Ontario -
St. Lawrence River
Study Board

Year 3 Report

To the
International
Joint
Commission



April 1, 2002 to March 31, 2004

International Lake Ontario - St. Lawrence River Study Board

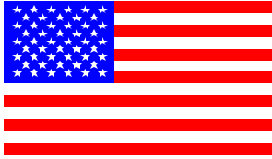
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The International Lake Ontario - St. Lawrence River Study Board was formed in December 2000 by the International Joint Commission to manage a comprehensive five-year study that will assess and evaluate the Order of Approval used to regulate outflows from Lake Ontario through the St. Lawrence River.



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ST. LAWRENCE RIVER
STUDY BOARD**



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August, 2004

Dear Chairman Schornack and Chairman Gray:

The International Lake Ontario - St. Lawrence River Study Board is pleased to transmit herewith the Year 3 Report at the request of the International Joint Commission.

Respectfully submitted,

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Lake Ontario -
St. Lawrence River
Study Board

Year 3 Report

To the
International
Joint
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April 1, 2002 to March 31, 2004

FOREWARD

This report was developed by the International Lake Ontario - St. Lawrence River Study Board at the request of the International Joint Commission to provide an interim report on the Study and its findings following completion of three years of Study effort. This report is a summary of the findings of the first three years of the Study Team effort by the Study Board, the Public Interest Advisory Group and all Technical Work Groups as of the spring of 2004. The many supporting papers, documents and technical reports generated during this time period are referenced in this report. All supporting documentation for the Study is available on written request to the Study secretariats.

Over a hundred individuals continue to devote considerable time, effort and intellectual energy to the Study, many on a volunteer basis. The Study Board would like to thank all Study participants for their valuable contributions.

Disclaimer

The statements, opinions and findings expressed in this report are those of the International Lake Ontario-St. Lawrence River Study Board and are not necessarily those of the International Joint Commission. Any mention of or reference to statements contained in this report should not be construed as endorsement by the International Joint Commission.

Ce rapport est également disponible en français.

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1.0 INTRODUCTION

Throughout the last decades of the 1900s the International Joint Commission's (IJC) Lake Ontario regulation plan known as 1958D and its criteria were considered or perceived to be increasingly deficient in recognizing and considering evolving and changing Lake Ontario-St. Lawrence River water level interests. Hydropower, commercial navigation and to a degree Lake Ontario shoreline property interests were specifically mentioned in the October 29, 1952 Orders of Approval as amended by supplementary order dated July 2, 1956. Domestic, industrial and municipal water use interests were a Commission priority as acknowledged in the 1909 Boundary Waters treaty. But nowhere was there mention of recreational boating nor the environment as interests to be considered when determining water levels and flow conditions for Lake Ontario and St. Lawrence River.

In 1993, the IJC's International Levels Reference Study Board identified the need for a review of the Lake Ontario regulation criteria and plan 1958D and made a recommendation to that effect to the IJC citing the following; "criteria for the regulation of Lake Ontario (should) be revised to better reflect the current needs of the users and interests of the system", and "criteria should be added that consider the environmental interest on Lake Ontario and the St. Lawrence River downstream as far as Trois Rivières", (*Levels Reference Study, March 1993*).

The Commission's International St. Lawrence River Board of Control has been taking regular and increasingly frequent actions to "deviate" from the 1958D plan in an attempt to address and reduce water level concerns. Specifically actions have been taken to address recreational boating and shoreline property problems, and on occasion the evolving needs of commercial navigation, hydropower and occasionally for environmental purposes. Despite these actions, public dissatisfaction over the water levels regime of Lake Ontario and the St. Lawrence River increased during the 1990s, particularly during what were considered extreme high water level conditions in 1993 and low water levels later in the decade. Public and agency statements of these concerns led to a decision by the IJC to initiate investigations required to evaluate options for regulating levels and flows in the Lake Ontario-St. Lawrence River system.

Public expectations are that a thorough, comprehensive and open review of regulation plan alternatives will take place and changes will be made to address current concerns.

1.1 BOARD MANDATE AND APPROACH

On December 11, 2000, the IJC created the International Lake Ontario-St. Lawrence River Study Board to evaluate the procedures and criteria used to regulate the outflows of Lake Ontario and the management of the levels of the Lake and St. Lawrence River to Trois Rivières, Quebec. Prior to the Board's establishment, an international team developed a report entitled "Plan of Study for Criteria Review" for the IJC in September 1999, which outlined the procedures that should be undertaken to perform the required comprehensive evaluations. The

IJC also established a volunteer Public Interest Advisory Group to ensure effective communication between the public and the Study Team.

The Board adopted suggestions made within the Plan of Study report and established Technical Work Groups (TWGs) to perform the required evaluations. In addition, a Plan Formulation and Evaluation Group (PFEG) was created. Members of each of these TWGs were chosen for their expertise in the interest to be evaluated. In order to provide guidance and support to the TWGs, Board members liaise with these groups. Individual members of the Public Interest Advisory Group (PIAG) also liaise with these groups to ensure that necessary assessments consider public concerns and interests.

1.2 VISION, GOAL AND GUIDELINES

The Study Board developed a vision, goal and guidelines to provide the foundation for the development and evaluation of criteria and regulation plans and subsequent advice to the Commission.

Vision

To contribute to economic, environmental and social sustainability of the Lake Ontario and St. Lawrence River System.

Goal

To identify flow regulation criteria that best serve the wide range of affected interests and climatic conditions in the basin and that are widely accepted by all interests.

Guidelines

1. Criteria and Regulation Plans will be environmentally sustainable and respect the integrity of the Lake Ontario-St. Lawrence River ecosystem.
2. Criteria and Regulation Plans will produce a net benefit to the Lake Ontario-St. Lawrence River System and its users and will not result in disproportionate loss to any particular interest or geographic area.
3. Criteria and Regulation Plans will be able to respond to unusual or unexpected conditions affecting the Lake Ontario-St. Lawrence River System.
4. Mitigation alternatives may be identified to limit damages when considered appropriate. Regulation of the Lake Ontario-St. Lawrence River System will be adaptable to reflect the potential for changes in water supply as a result of climate change and variability.
5. Decision-making with respect to the development of the Lake Ontario-St. Lawrence River System Criteria and Plans will be transparent, involving and considering the full range of interests affected by any decisions with broad stakeholder input.
6. Criteria and Regulation Plans will incorporate current knowledge, state-of-the-art technology and the flexibility to adapt to future advances in knowledge, science and technology.

1.3 ACCOMPLISHMENTS

This report summarizes the findings of the Study effort as of the spring of 2004 and builds upon the Year 1 Study report package covering the period December 12, 2000 to March 31, 2002. There is no “end-of-year” 2 report nor is it planned that there will be a year 4 report. Many Study findings are summarized throughout this Year 3 Report.

Some accomplishment highlights during Study Years 2 and 3 are listed below, with more detail contained in the four Study Board semi-annual reports to the IJC covering the period April 2002 through March of 2004 (*Study Board, September 2002, March 2003, September 2003 and April 2004*).

A considerable accomplishment to date has been the involvement and contribution of the PIAG and its members in all aspects of the Study. The PIAG have taken on and very effectively delivered lead responsibility for the Study’s public outreach and communications program. PIAG members have participated and contributed in a very positive manner to all Board and TWG functions.

Other accomplishments include:

- Inventory of all recreational boating marinas in the Study area;
- Inventory of all domestic, industrial and municipal water intakes and wastewater outfalls in the Study area;
- Classification of the entire Lake Ontario and upper and lower St. Lawrence River shoreline and incorporation into a flood erosion and prediction system (FEPS);
- Inventory of all major wetlands in the Study area;
- Development of the triangular evaluation concept, whereby, test criteria, performance indicators (PI) and alternative plans can be developed, refined and evaluated;
- Development of a unique Shared Vision Model (SVM) approach which incorporates PI for all interests to evaluate regulation plan alternatives;
- Development and refinement of regulation criteria and PI by all TWGs defining conditions for specific interests and locales, although some are expected to provide additional indicators.
- Establishment of an Economics Advisory Committee (EAC) consisting of experts providing guidance regarding evaluation parameters;

- Development of a unique Integrated Ecological Response Model (IERM) to integrate the findings and PI of numerous individual environmental researchers;
- Completion of connections between the FEPS and IERM developed by the Coastal and Environmental TWGs, respectively, and SVM;
- Completion of all work by the Hydrology and Hydraulics (H&H) TWG, including climate change scenarios and hydrologic products providing them to various TWGs for individual evaluations and also incorporation into the SVM;
- Distribution of five newsletters by PIAG, bringing the total published to eight reaching more than 4,400 households in Canada and the United States;
- Initiation of an information management strategy which will include three archival sites: Environment Canada at Ste-Foy, Quebec; Land Information Office (LIO) at Peterborough, Ontario; and the Great Lakes Commission (GLC) Office in Ann Arbor, Michigan.

1.4 FUNDING

Since December 2000, \$7.97 million (U.S. dollars) and \$11.84 million (Canadian dollars) have been made available to initiate activities outlined in the Plan of Study dated September 1999 and to accomplish the goals of the Study as noted below.

Shortly after Study initiation, it was determined that the Plan of Study (POS) document did not include and/or underestimated the cost of some activities, particularly, data collection, information management and archival, and plan formulation and evaluation. In January 2003, a request was made to the IJC to retool the annual funding allocations in order to accomplish the goals of the Study while maintaining the original intent of the POS and the Study Reference. Tables 1 and 2 below give a comparison of the proposed POS funding figures and expenditures that have actually been incurred. To date through the end of Study Year 3 (U.S. fiscal year: September 30, 2003 and Canadian fiscal year: March 31, 2004), \$7.65 million (U.S. dollars) and \$10.64 million (Canadian dollars) have been spent for Study activities.

Since the Study's inception, individuals and agencies supporting Study activities have provided significant in-kind services over and above the direct expenditures identified above. In addition, the Public Interest Advisory Group has contributed hundreds of hours of volunteer time participating in Study activities and in preparing for and giving presentations at stakeholder meetings throughout the Study area.

U.S. Funding (in U.S.\$)						
Cost Summary all Activities	Year 1		Year 2		Year 3	
	POS	Spent	POS	Spent	POS	Spent
Common Data Needs –Info. Management	500,000	635,000	-	641,625	-	97,000
Environment	640,000	276,593	540,000	494,799	575,000	707,280
Rec. Boating	160,000	109,201	180,000	187,037	160,000	215,383
Coastal	770,000	300,000	1,030,000	1,206,079	670,000	494,509
Com. Nav.	49,000	48,157	73,000	-	105,000	63,153
Hydro.	0	0	0	0	0	0
Water Uses	79,000	50,000	79,000	130,000	32,000	50,498
H&H	160,000	31,800	215,000	108,123	185,000	85,551
PIAG	270,000	150,560	270,000	138,642	270,000	168,925
PFEG	50,000	80,000	50,000	150,000	50,000	215,000
Board & GM	200,000	226,902	200,000	296,874	200,000	267,129
IJC	-	13,410	-	7,725	-	6,720
Totals	2,878,000	1,921,623	2,637,000	3,360,904	2,247,000	2,371,153
Re-Profiled	-648,000	-	+730,423	-	+126,280	-
Grand Total	2,230,000	1,921,623	3,367,423	3,360,904	2,373,280	2,371,153

Table 1. U.S. Funding for Years 1 through 3 Compared to the POS

Canadian Funding (in Cdn\$)						
Cost Summary all Activities	Year 1		Year 2		Year 3	
	POS	Spent	POS	Spent	POS	Spent
Common Data Needs –Info. Management	700,000	749,980	-	281,000	-	81,921
Environment	865,000	779,500	955,000	963,245	1,055,000	1,159,188
Rec. Boating	200,000	206,357	180,000	195,359	160,000	61,771
Coastal	770,000	346,896	1,130,000	710,884	570,000	956,180
Com. Nav.	197,000	55,000	396,000	37,800	638,000	342,981
Hydro.	0	0	0	0	0	0
Water Uses	116,000	0	124,000	25,956	52,000	71,134
H&H	235,000	302,356	295,000	335,186	385,000	343,955
PIAG	340,000	177,620	340,000	187,597	340,000	280,613
PFEG	50,000	0	50,000	84,733	50,000	232,840
Board & GM	200,000	500,889	200,000	302,541	200,000	329,516
IJC	-	136,706	-	200,000	-	200,000
Totals	3,673,000	3,255,304	3,670,000	3,324,301	3,450,000	4,060,099
Re-Profiled	-300,000	-	+300,000	-	+1,050,000	-
Grand Total	3,373,000	3,255,304	3,970,000	3,324,301	4,500,000	4,060,099

Table 2. Canadian Funding for Years 1 through 3 Compared to the POS

2.0 PUBLIC INTEREST ADVISORY GROUP

To ensure that the public is fully engaged in the Study, the IJC appointed concerned citizens with a knowledge of the Lake Ontario – St. Lawrence River system to participate in a Public Interest Advisory Group (PIAG).

During Study Years 2 and 3, the PIAG met a total of eight times. In addition, PIAG representatives were in attendance at all Study Board meetings and many TWG meetings. During this period, they and other Study personnel participated in 71 public outreach events that were either directly hosted by the PIAG, or to which Study representatives were invited to make presentations on behalf of the Study. Direct contact was made in this way with some 3,520 people. Not surprisingly PIAG members have found that their effective participation in the Study has required more time than was initially understood. The information flow via e-mail and other means has been overwhelming at times.

However, this investment in time has enabled all PIAG members to gain a far better understanding and insight into the workings of the Great Lakes-St. Lawrence system, as well as knowledge of the concerns and issues of affected interests and stakeholders. The PIAG realizes and has been communicating the point that water levels and flows cannot be controlled in such a way as to satisfy “all interests all of the time”.

During Years 2 and 3, the PIAG undertook a number of activities due in part to a PIAG Year 1 finding (*Public Interest Advisory Group, August 2002*) that there is significant public misunderstanding about how the Great Lakes-St. Lawrence system works, and many “information and trust gaps” exist between the public and regulating bodies, (i.e. the IJC and its St. Lawrence River Board of Control).

Investigation of the production of a comprehensive video on the water levels issue was explored with a contractor engaged to draft a video “storyboard” and estimate costs. The need certainly exists to increase public awareness and understanding of the complexities of water levels, flow variations and associated impacts. A video for public station broadcast is one of several vehicles that could be considered to deliver this information. However, the PIAG concluded that a video did not rank as a priority for Study outreach purposes and decided not to follow through with a video production. The PIAG did partner with a local access cable TV station to tape a video of their Year 3 public PowerPoint presentation, which ran during the fall of 2003 in the Rochester area.

The Commission’s International St. Lawrence River Board of Control has been receiving criticism for shortfalls in its communications activities. PIAG met with representatives of this Board, reviewed its communications program and strategy and provided suggestions, including that a network of community people be developed to assist in disseminating Board of Control information throughout the region.

During Study Years 2 and 3, five volumes of the Study newsletter *Ripple Effects* were

produced and sent to the Study mailing list of some 4,400 recipients. Public surveys carried out by PIAG have found that people prefer receiving Study information quarterly, that is, every three months, and by newsletter or e-mail rather than other means, i.e., information fairs and toll-free hot lines. The survey results also indicate, not surprisingly, that the preferred time period for public information meetings and open houses is during summer months when seasonal as well as full-time residents are in the area. Future Study newsletters and public meetings will continue to be tailored to these preferences.

At the request of the Study Board, the PIAG undertook to gather public input on the PI developed by the TWGs. Comment was sought during public meetings held in 2003 and through response items in the Study's newsletters and website. The PIAG received a good response and interest in the performance indicators with some 70 to 80 specific comments being received. Answers to these comments were prepared with the assistance of TWG, Study Board and PIAG members. The PIAG feels that these interactions are developing a significantly improved understanding of the Lake Ontario-St. Lawrence system in the public forum.

Over the course of its efforts, the PIAG has received and responded to a myriad of questions and requests for information. Included in this "correspondence" were some lengthy reports prepared by agencies and interested people, including an analysis of the impacts of fluctuating water levels on the marshlands of Cootes Paradise at the western end of Lake Ontario (*Royal Botanical Gardens, March 2003*), and a paper on the diversion of fresh water from the Hudson Bay drainage basin (*Kierans, undated*).

Despite these communications "successes", there are still many questions and disparate views on how the Lake Ontario-St. Lawrence River water management "system" should be "run". Complete lists of public questions and answers as well as a synopsis of the concerns and issues that were expressed at each PIAG public meeting held during 2002 and 2003 are contained in the *Public Interest Advisory Group Report for Years Two and Three, April 2002-March 2004*.

Examples of these views and concerns are:

- Study results will only accurately reflect the wishes of the people through public participation.
- Shoreline erosion and property damage due to high water levels is a major concern.
- Timing of water levels (variations) and alerting mariners prior to extreme water level conditions is considered critical in dealing with detrimental effects.
- Wouldn't a dam downstream of Montreal solve a lot of our problems?
- Credibility for following through on recommendations and political interaction is considered integral to the Study.

A more complete grasp of the nature of the 2002 and 2003 public meetings can be gained by reviewing the meeting summaries in the PIAG Year 2-3 report.

Examples of earlier PIAG findings are in the Year 1 Report (*PIAG, August 2002*).

3.0 THE EVOLVING DECISION MAKING PROCESS–PLAN FORMULATION AND EVALUATION

In Year 1, the Study Board spent considerable time discussing how to formulate and then evaluate alternative regulation plans and criteria in order to provide strategic direction for data collection, a framework for the Study and an orderly and well-understood decision-making process throughout the Study (Year 1 Report). In Years 2 and 3, and in order to provide a focus and center of energy for this decision-making process and activity, the Board formed a Plan Formulation and Evaluation Group (PFEG).

3.1 SHARED VISION MODEL

The Study Board finds it desirable and necessary to use a unified computer simulation model of the water level and flow conditions and the related concerns of affected interests in the Lake Ontario-St. Lawrence system that their recommendations will affect. It is called the Shared Vision Model (SVM). The SVM integrates plan formulation and evaluation so that new regulation plans can be designed and immediately evaluated. The development of the model also assures that research will be designed to address the issues that people care most about and which have the greatest influence on the decision process.

The primary input into the SVM from TWGs are the mathematical relationships that estimate how changes in water levels will affect the economy and the environment. A Performance Indicator (PI) is some measure of those effects. For example, the Coastal TWG is estimating the relationships between water levels and shoreline erosion damages in terms of dollars. All the TWGs have focused on determining the most scientifically accurate assessment of the relationship between different water levels and flows across the Study area and over time to their chosen PI. These relationships, whether in terms of stage/damage curves or some other mathematical formula, are what is being incorporated into the SVM for evaluation. The name “Shared Vision” reflects the fact that modelers have to work with experts and stakeholders to build measures of assessment of changes to water levels and flow regulation, and all parties must agree that the SVM correctly models the movement of water through the system. The SVM has been built from scratch with the help of all TWGs, so that it is as easy as possible to use and all parties can develop and evaluate their own ideas on managing the regulation of Lake Ontario.

3.2 THE TRIANGULAR APPROACH

As a result of discussions at a March 2003 Study-wide workshop, the Study Board decided on a strategy to simultaneously evaluate regulation plans and the “building-block” criteria in these plans. The strategy is based on a triangular approach. The three vertices of the triangle (shown in Figure 1) include the regulation plans, the criteria and the third component, PI. The criteria are hydrologic conditions or standards for judging how well regulation plans meet a variety of objectives. The PI are numerical measures of the things society cares about that are affected by regulation (for example, economic benefits related to boating or changes in the area or quality of

wetlands). The relationships between water levels and flows and the indicators are embedded in studies conducted by the TWGs.

Regulation Plans are made up of a series of rules and limits that try to meet certain hydrologic objectives (criteria).

The **triangular approach** is an iterative process that has been and will be circled many times throughout the Study:

- Plans have been designed with an initial set of suggested criteria in mind. The first suggested criteria were based on best professional judgment, not analysis.
- The plans were evaluated in the SVM against both the criteria and initial PI to see if they met the criteria and produce good performance scores.
- If plans did well on criteria but not performance, or vice versa, the criteria were adjusted to reflect the performance scores.
- Plans were refined based on how well they performed.
- Plan evaluations were judged against the guidelines of the Study Board.

To prepare the Study Team and improve their decision-making capability, the PFEG found it very beneficial to hold a series of workshops. At each workshop, more information was added and evaluated leading to a fully operational SVM to be used in making some initial decisions.

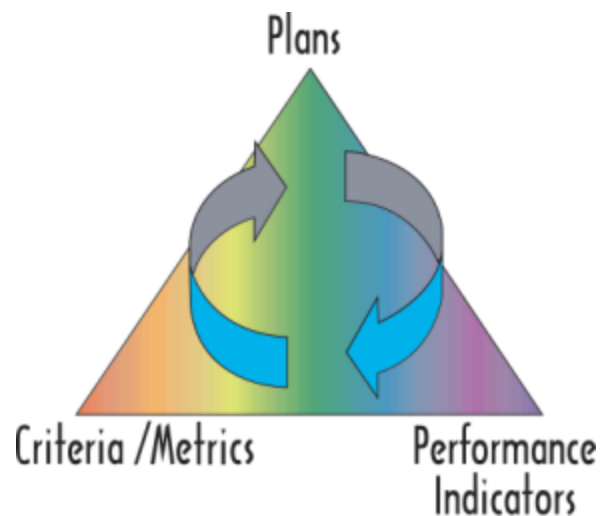


Figure 1. The Triangular Approach

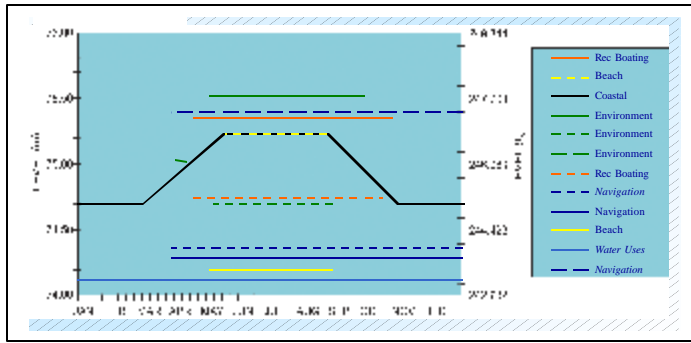
3.3 FORMULATING ALTERNATIVE PLANS

Regulation plans can and are being developed within the SVM. Regulation plans are generally made up of a set of rule curves that specify how much water should be released based on Lake Ontario and St. Lawrence River conditions. These rule curve releases are adjusted based on forecasts of how much water is expected to flow into the system, and then limits are applied to the adjusted release to avoid flooding or extreme low water conditions. In designing plans, the Study's PFEG came up with a three-part strategy. First, look at plans developed under previous studies such as Plan 1998 and work on trying to improve on these plans. Second, try to make modifications to the un-regulated releases to see if a more "natural" condition could be designed that would benefit the environment, but not to the detriment of other interests. Thirdly, try a quasi-optimization approach based on the performance indicator functions for each of the interests. In addition to these three approaches, the Study Team is also accepting individual ideas on how the lake and river should be regulated and working with those to design a regulation plan that captures the ideas expressed.

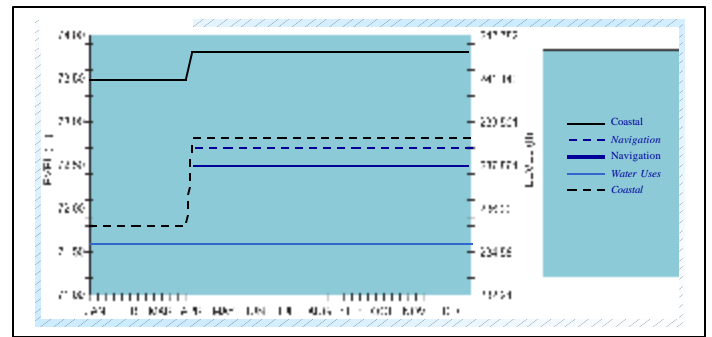
While the plan formulation process has been somewhat restricted as the Study awaits the completion of the PI, early indications point to the fact that 1958D with Deviations is not an easy plan to beat.

3.4 SUGGESTED HYDROLOGIC CRITERIA

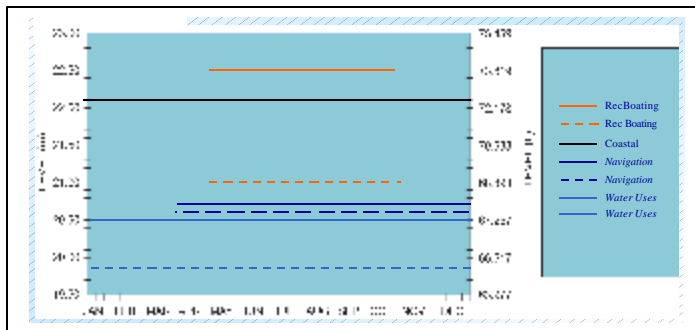
Over the course of Study Years 2 and 3, proposed new "criteria" for regulation evolved, first using the current 1958D "Order of Approval" criteria, then through polling Study Team members for additions, modifications, refinements and prioritization of new potential criteria. At one point up to about 90 different criteria statements were identified, rationale was defined supporting them, and they were prioritized. Subsequent examination of these criteria by the Study Team in workshops enabled them to be refined down to the following list of ten plus four "part b" generalized criteria as of the spring of 2004. Detailed statements of specific targets for water levels and flows, which more fully define the criteria, have been termed "metrics" by the Study Team. Some of these metrics are graphically displayed in draft form in Figure 2 for illustrative purposes only.



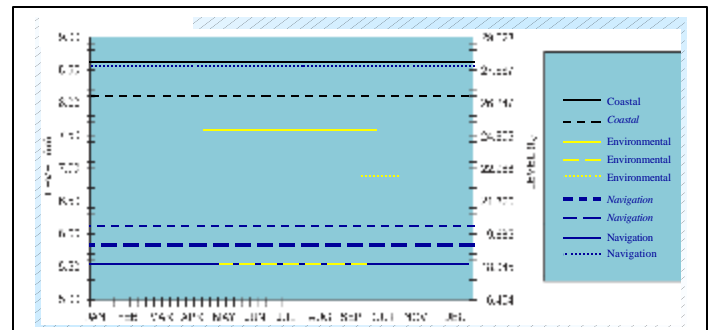
(a) Lake Ontario



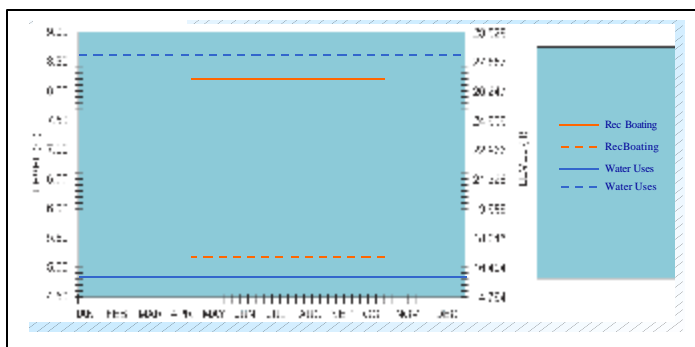
(b) Lake St. Lawrence at Long Sault



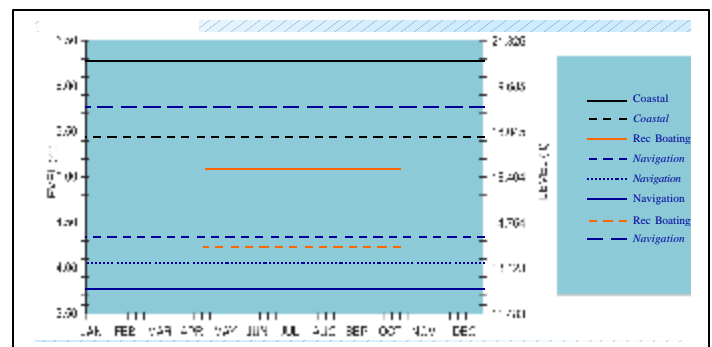
(c) Lac St. Louis at Pointe Claire



(d) Montreal Harbour



(e) St. Lawrence River at Varennes



(f) Sorel

Figure 2. Set of Metrics which relate to Specific Hydrologic “Tests” of Plan Performance

The proposed criteria as of this point in the Study are:

1. a) Minimize the frequency, severity and duration of high levels on Lake Ontario and the upper St. Lawrence River above the dam that can prevent access to beaches, cause flooding and erosion damage to shore properties, water and wastewater treatment plants, marinas and ports, or cause ships to reduce speeds to prevent erosion caused by ship wake.
1. b) Minimize the frequency, severity and duration of high levels on the lower St. Lawrence River below the dam that can cause flooding and erosion damage to shore properties, water and wastewater treatment plants, marinas and ports, or cause ships to reduce speeds to prevent erosion damage due to ship wake.
2. a) Minimize the frequency, severity and duration of low levels on Lake Ontario and the upper St. Lawrence River above the dam to allow water intakes to operate at their design capacity, prevent off-loading and stoppages for seaway vessels, minimize negative economic impacts to recreational boaters, and optimize access to beaches and the associated recreational benefits.
2. b) Minimize the frequency, severity and duration of low levels on the lower St. Lawrence River below the dam to allow water intakes to operate at their design capacity, prevent off-loading and stoppages of vessels and minimize negative economic impacts to recreational boaters.
3. a) Allow Lake Ontario levels to increase during years of high supplies to permit the flooding of wetlands and destroy over-dominant wetland vegetation on a periodic basis similar to pre-regulation lake-level behavior. Likewise, during low supply conditions, and ideally after a peak in levels, allow Lake Ontario levels to drop to a level which will stimulate germination of emergent plants from the seed bank, force a die-back of dominant submersed plant species at those elevations, and favor growth of sedges and grasses at upper elevations.
3. b) Allow St. Lawrence River levels to increase to permit the flooding of wetlands and destroy over-dominant wetland vegetation on a periodic basis similar to pre-regulation lake-level behavior. Likewise, allow St. Lawrence River levels to drop to a level which will stimulate germination of emergent plants from the seed bank, force a die-back of dominant submersed plant species at those elevations, and favor growth of sedges and grasses at upper elevations.
4. a) Allow Lake Ontario and the upper St. Lawrence River levels to rise during the spring to support spawning.
4. b) Allow the lower St. Lawrence River levels to rise during the spring to support fish spawning.
5. During the Seaway Navigation season, minimize the frequency, severity and duration of differences in levels on the St. Lawrence River that result in channel velocities that are not safe for commercial navigation.
6. Minimize the rate of change of levels on Lake Ontario and the St. Lawrence River to benefit recreational boating.

7. Manage the system to mimic, as closely as possible, the natural variability of Lake Ontario and the St. Lawrence River as it would be under pre-project conditions.
8. Minimize the annual range of water levels downstream of Montreal from the spring high water level to the autumn low water level to reduce erosion damages.
9. Manage flows in order to promote a stable, smooth ice cover on the St. Lawrence River and prevent ice jams.
10. Manage levels and flows in the Lake Ontario-St. Lawrence system to get the most value for hydro power from the water flowing through the St. Lawrence system and a dependable amount of energy during peak winter and summer demand periods.

These are not intended to be “operational criteria”, although some may evolve into such criteria. The PI will be used along with these criteria and metrics to evaluate the merits of the different plans.

3.5 EVALUATION AND DECISION PROCESS

The Study Board needs to do more than just evaluate plans and criteria; it needs to compare the evaluation results and see which mix of outcomes it prefers. It is almost certain that no plan will outperform all others for each objective, so the Board will have to trade performance towards one objective for performance towards another. The Board has begun this process using the guidelines and assessing results in terms of a combination of PI scores and compliance with proposed criteria. But the questions remain, which PI are most indicative of the guidelines, what tradeoffs between interests are acceptable, and what tradeoffs between the lake and river interests are acceptable?

The Study Team is working with experts to design a clear and defensible tradeoff process that is customized to the needs of this Study, a process that can take full advantage of the power of the SVM.

The decision process is an iterative one. The Study Board has worked through practice decisions using a set of suggested hydrologic criteria to evaluate a number of test regulation plans. During this exercise the Study Board discovered how difficult it can be to make a decision since none of the plans did well on all of the criteria, and an easy “winner” was difficult to discern. As the Board works through the decision process, they have noted that they would not want to make a decision without a geographic display of the “scores” and prioritized criteria. They also recognized that this is only half the picture and clear data on the PI is vital in making the decision process meaningful.

The Board found the use of the guidelines very beneficial in the decision process. They followed a methodical process and ranked each plan under seven steps. However, reducing seven scores to one preferred plan is difficult. Clear rules for each ranking are needed to get to one score. More details on the PI are needed along with the ability to “drill down” to view and consider more specific information. Time is required for these deliberations and to build trust and reach

consensus on these decisions.

3.6 PEER REVIEW

Over the course of the Study, several TWGs have found it desirable to initiate and engage internal and external review and advice mechanisms. The purpose of these review mechanisms has ranged from assistance in planning science and technical undertakings, review of methodologies and completed work, and advice on direction for evaluations and trade-off analyses.

Board and PIAG members themselves form a primary internal review mechanism, with Board members drawing on their particular field of expertise, i.e., environmental, economics, hydrology and hydraulics, watershed planning, and group decision-making. PIAG members have contributed to TWGs of specific interest to them and for which they have professional and/or life experiences.

Further internal review occurs as TWG members work with the PFEG to review and validate all components within the SVM including hydrology, PI, criteria, etc. to ensure that the model is accurately capturing the relationships established for each. The TWG applies an actual “stamp of approval” to all verified components within the SVM.

External review experts and boards were engaged by the Coastal TWG to plan science approaches to their work; by the Environmental TWG to review and validate the science of completed work; and by the PFEG to advise on economic principals and practices to follow throughout the Study. A consultant was also engaged by the PFEG to advise on trade-off practices when assessing and weighing PI of economic and non-economic nature. Internal reviews by members within specific TWGs also delivered a strong peer review function. Additional “peer review” mechanisms will be explored and used in Years 4 and 5 of the Study to validate and strengthen the Study process and results.

4.0 FINDINGS OF TECHNICAL WORK GROUPS

The sections that follow contain summaries of the findings identified by the TWGs. More detailed activity descriptions are provided as supporting documents and are published separately. Each TWG has developed a list of PI, which help define how their interest is affected by changing water levels or flows. These are being used collectively by the PFEG to define and evaluate regulation criteria and alternative regulation plans.

4.1 COASTAL PROCESSES

The Coastal TWG has accomplished a considerable effort focused on a) collection of vast volumes of spatial (mapping) and temporal (time series) data and b) the development of computer modeling tools to define, evaluate and determine shoreline flooding and erosion characteristics and responses to fluctuating water levels along the shoreline of Lake Ontario and the St. Lawrence River.

4.1.1 Lake Ontario and the Upper St. Lawrence River

Data Collection

A wealth of existing spatial and temporal data exists and is necessary to examine coastal processes for the Study. A dedicated computer, known as the Coastal Data Server (CDS), was acquired and setup to store these vast volumes of data, including: lake bottom depths (bathymetry), land surface elevations (topography), ortho-photographs of the current shoreline conditions, historical aerial photographs that documented the shoreline and river conditions from approximately the 1930's to present, historical recession rates, information on previous flooding events, hourly water level data at gauges on the lake and river, time series wind speed and direction, and historical ice cover data for Lake Ontario. Presently, the CDS consists of 120 gigabytes of digital information that is actively part of the decision making process.

The Flood and Erosion Prediction System (FEPS)

The FEPS computer model was developed by W.F. Baird and Associates, Ltd. in 1997 under contract to the United States Army Corps of Engineers (USACE) for the Lake Michigan Potential Damages Study (USACE, 1999). This model has been adapted for the specific needs of the Study and further upgraded.

Coastal Performance Indicators

The impacts of water level fluctuations on Lake Ontario and upper St. Lawrence River shoreline communities have been categorized by six PI, specifically: shoreline erosion, sediment budgets, existing shoreline protection structures, flooding, beach access and barrier beaches and dunes.

Shoreline erosion and the associated economic impacts have been calculated for individual property parcels around the perimeter of the lake and on the river. Presently, the database includes over 19,000 digital property parcels. A sample of the parcel database for East Bay Park in Wayne County, NY is presented in Figure 3. The long-term recession rate for the bluff at this location is approximately 0.3 m/yr (1 ft/yr). Detailed modeling tools in the FEPS can be used to predict future bluff recession rates for alternative regulation plans under consideration.

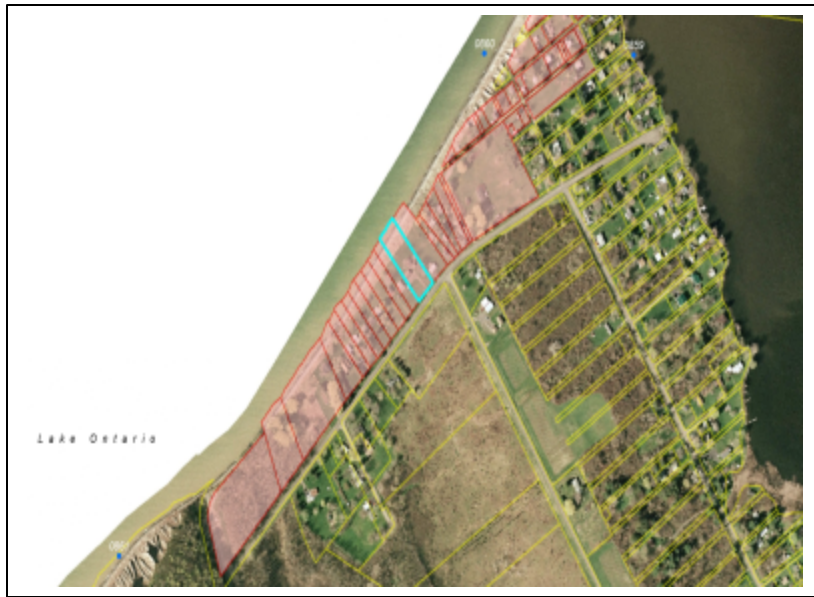


Figure 3. Sample of Digital Property Parcels for East Bay Park, Wayne County, New York

The sediment budget PI was developed to categorize the relationship between shoreline recession and barrier beaches and dune environments. The bluff shorelines of Lake Ontario have been eroding for thousands of years. This process provides new sand and gravel for the nearshore zone and thus is the source of new material for beach and dune environments around the lake. Without a “background” erosion rate, there would be no new sand and gravel to nourish the beaches and dunes along the shore.

Shoreline protection structures are already present for a large percentage of riparian properties exposed to flooding and erosion hazards around the perimeter of Lake Ontario. Based on the parcel database, approximately half of the shoreline length has been armored with good quality seawalls and revetments. For the evaluation of new regulation plans, it is assumed these structures are stable, will be maintained and will continue to provide effective erosion protection. However, if a regulation plan results in more extreme high water levels, there will be negative impacts on the existing structures that were designed for the range of lake levels since 1960. The existing shoreline protection PI will quantify the impacts of the alternative regulation plans on the structures currently providing effective erosion control around the perimeter of Lake Ontario and the St. Lawrence River.

Over 3,000 shoreline property parcels are located below elevation 77.2 m (253.22 ft) and could be at risk of flooding on Lake Ontario. For these properties, flood damages generally occur during periods of high lake levels and severe storms. The flooding PI quantifies the

impacts of flooding due to inundation of structures and the force of waves striking the buildings. Similar to the other PI, the economic damage calculations are made for individual property parcels at risk to flooding during a 101-year simulation.

The beach access PI was developed to quantify water level impacts on beaches, such as those located in provincial and state parks. During high lake levels, beach width naturally decreases as more sand is submerged, thus reducing the width of the beach for recreation. A field survey was completed at two large provincial and state parks (Sandbanks and Hamlin respectively) to collect data from the beach users. This information, along with existing published data on beach visitation and economic behavior is being used to quantify the impact of water levels on beach visitation. An economic function has then been developed to determine the impacts of high and low lake levels.

The beach and dune PI was developed to quantify water level impacts on natural beach and dune systems, such as barrier beach complexes protecting wetlands. The sandy barrier systems, such as the beaches at Eastern Lake Ontario, are sensitive to high lake levels and storms.

Automated Functions for Coastal PIs

The automated functions for the PI outlined above calculate the coastal impacts of lake level fluctuations and associated economic impacts for shoreline land owners. These functions are complex and rely on sophisticated computer programming to link the engineering models in the FEPS to a relational database. Then economic damages are calculated for the alternative regulation plans under consideration. These PI functions were developed in the FEPS, which will be directly linked to the SVM.

New Criteria

Specific attention was devoted to new proposed criteria that recognize the specific interests of shoreline communities around Lake Ontario and the St. Lawrence River. For example, one proposal is for a floating monthly maximum level (rather than one fixed elevation all year), specifically for Lake Ontario, elevation 74.7 m (245.02 ft) in the winter months and 75.2 m (246.66 ft) during the calm summer months. Similar criteria have been developed for the St. Lawrence River.

4.1.2 The Lower St. Lawrence River

Erosion

Application of regional-scale computer modeling to the shorelines of the lower St. Lawrence River from Cornwall, Ontario to Trois-Rivières, Quebec has created a new and clear understanding of the relative importance of river currents, wind waves and ship-generated waves and how they interact with water levels (*Pacific International Engineering, March*

2004). This has enabled the development of simplified erosion predictive tools and an assessment of economic impacts for application within the SVM.

For illustrative purposes, simulations run for four 101-year water level regulation scenarios (Plan 1958D with Deviations, Plan 1958D, Plan 1998, Pre-Project) show consistent spatial and temporal patterns in erosion response between plans. As illustrated in Figure 4, the comparison of impacts between plans is complicated, varying spatially as well as temporally. It was found that shoreline erosion performance during critical periods (e.g., high water levels in the 1970s) does not necessarily follow these same patterns.

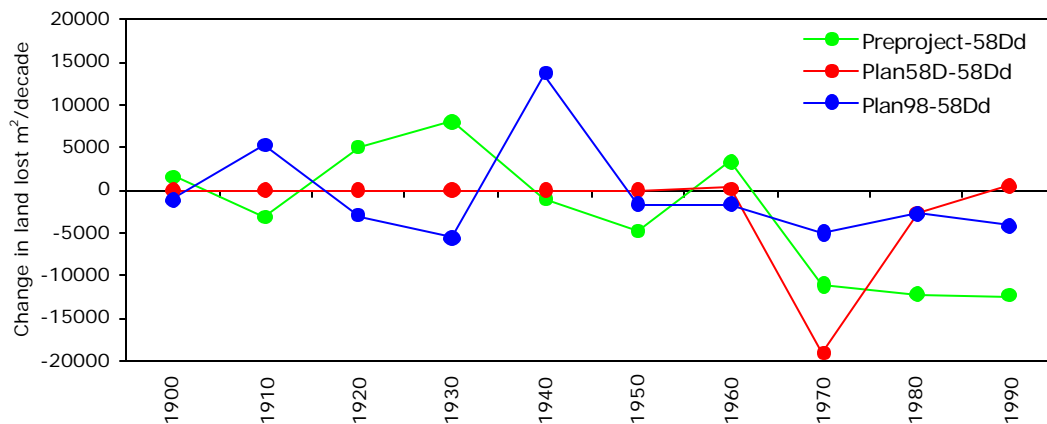


Figure 4: Simulated Changes in Land Lost per Decade in the Lower St. Lawrence River relative to Plan 1958D with Deviations

Economic analysis shows that the cost of shore protection far outweighs the cost of land lost due to erosion Figure 5. This emphasizes the fact that a PI for land lost due to erosion needs to be a separate PI, since the combination of land loss costs with structural impacts does not create a suitable measure of the effects of water level regulation on the shoreline.

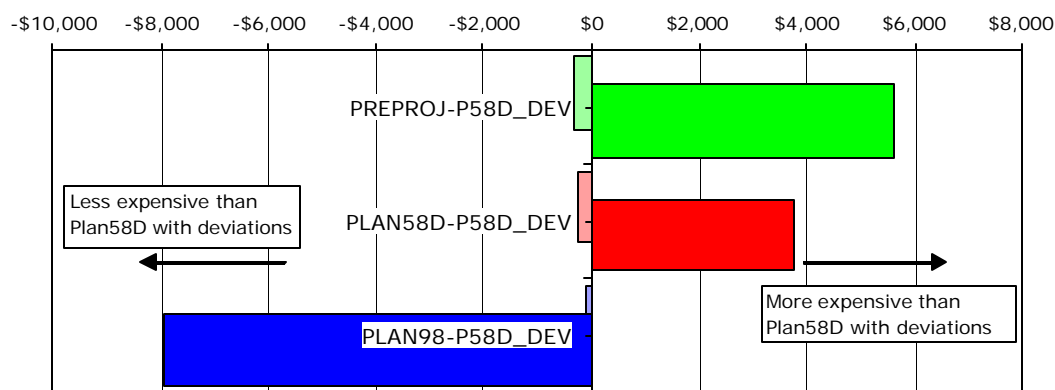


Figure 5: Simulated Cost of Erosion throughout the Lower River (striped) and Change in Annualized Equivalent Cost of Shore Protection (solid). (Both relative to Plan 1958D with Deviations and expressed in \$/yr over 101-year simulations)

It should be stressed that the differences between the various plans are generally slight (approximately 2½% in total range) and may well be within the order of accuracy of the solution methodology, i.e., the results are essentially the same.

A significant finding based on field observations and modeling studies is that, in many areas along the lower river, erosion is primarily ship-wake driven. While water levels play a significant role in erosion processes along the river, regulation of Lake Ontario outflow is seen to have a secondary influence on erosion rates relative to the large seasonal fluctuations in river levels.

Flooding

Local flood depth-damage curves are available for buildings in the floodplain of the St. Lawrence River, as shown in Figure 6.

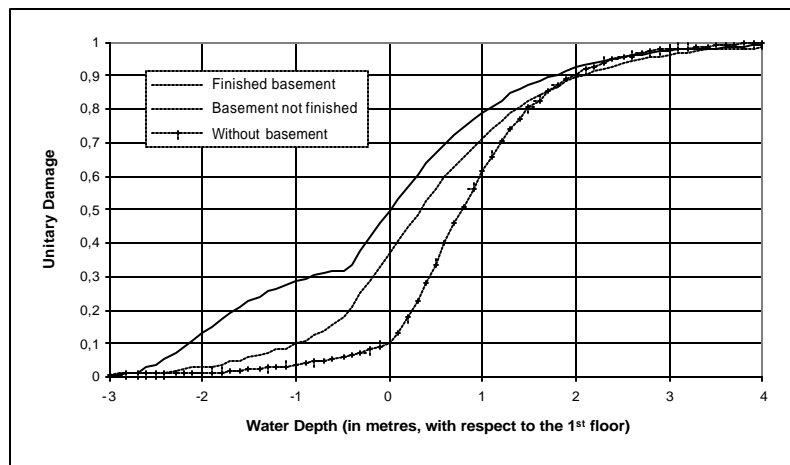


Figure 6: Depth-Damage Curves Applicable to One-Story Buildings within the St. Lawrence Floodplain

Regional numerical models and functions relating this damage data have been integrated into the SVM. Simulations run for 101-year (1900-2000) water level regulation scenarios provide results as illustrated in Figure 7 that show that the Sorel Islands as well as the municipalities around the Lac St. Pierre are by far the most flood damage prone. In the Lac St. Louis area, the municipalities at most risk are Beauharnois, Léry and Notre-Dame-de-l'Île-Perrot. This test analysis also established that Plan 1958D with Deviations is, from the four plans tested, the one that would have caused the least residential flood damage.

It is postulated that economic PI are not sufficient to fully describe the impacts of a flood on communities and therefore societal PI have been established to form the basis of the socio-economic assessment tool for flooding. As a result, some PI measure the damage in terms of dollars while others account for societal aspects of the damage. However, they all reflect direct damage.

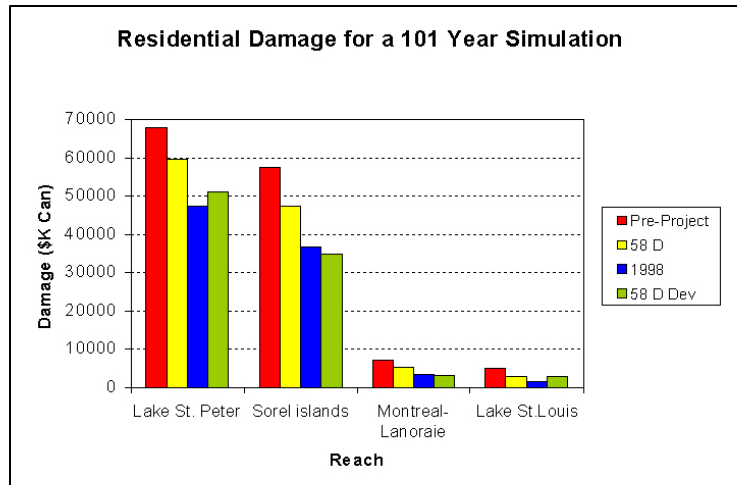


Figure 7: Distribution of the Residential Damage Expressed in \$K (Cdn) for each Regulation Plan over a 101-Year Simulation

The selected PI include:

- Cost (\$) of the damage for residential buildings (structural damage alone, i.e., excluding the content of the residence),
- Number of flooded residential buildings,
- Number of expropriated properties,
- Total area (in hectares) of flooded lands quantified by land-use type, and
- Total length (in km) of flooded roads quantified by road type.

4.2 ENVIRONMENTAL

Human induced changes to natural water level fluctuations can alter abundance and diversity of plants and animals in a variety of ways. Biological communities in the short term adapt to the range of fluctuations in water levels - changes that occur daily, seasonally, and yearly. Patterns of water levels can determine the diversity and condition of wetland plant communities, and the habitats they provide for a variety of invertebrates, amphibians, reptiles, fish, birds, and mammals. Water level regulation has altered these natural processes on Lake Ontario and in the St. Lawrence River.

4.2.1 Integrated Ecological Response Model (IERM)

An IERM has been developed to bring together environmental studies and demonstrate how different regulation plans may impact the Lake Ontario and St. Lawrence River ecosystems. The IERM is being used to develop environmental input for the Study's SVM and will serve as

a template for design of the environmental portion of the SVM.

The IERM provides a means of interconnecting the environmental components of the Study and allows for a more complete assessment of the environmental response to water level and flow changes. It provides a platform for comparing environmental response to different regulation plans. For example, the models of the fish sub-group will be able to predict both how the supply of suitable habitat is affected by regulation, and how dynamic populations respond to changes in suitable habitat. This type of habitat supply analysis requires many parameters describing hydrology, water temperature, aquatic vegetation and habitat quantity.

4.2.2 Wetland Habitat

Key findings of investigations (*Wilcox & Ingram*) into the effects of water level regulation on wetland plant communities around Lake Ontario and the upper St. Lawrence River are as follows:

- Cattails are a natural inhabitant of wetland communities in the Study area. There is some evidence to suggest that cattail production and coverage of some wetlands began shortly after the turn of the last century. However, there is also good information that indicates cattail production has accelerated since the regulation of Lake Ontario water levels, and the abundance of cattails represents a major change in habitat in all Lake Ontario wetlands studied.
- Increased cattail coverage has in many locations been at the expense of the meadow marsh (sedge/grass) community at the upper wetland elevations. This invasion likely occurred because extremely low lake levels were not present following the mid-1960s, and upper elevations remained wet enough to support cattails, thus reducing the competitive advantage of sedges and grasses that can tolerate drier soils.
- Additional cattail encroachment occurred toward the lake at the expense of short emergent and floating/submersed communities. This invasion likely occurred because of an absence of extreme high water levels needed for flooding of marsh areas. This flooding would limit cattail production and permit a greater diversity of plant communities to germinate. In addition, relatively stable water levels may have promoted creation and survival of floating cattail mats.
- Upland plant species have also colonized upper wetland elevations. Considerable diversity of wetland plant species still exists, although the area in which the diversity occurs is not great. It is suggested that short-term, extreme water levels (highs and lows) should be allowed to occur approximately every 17 years in order to maintain this diversity.
- In the lower St. Lawrence River, specific wetland habitat investigations have focused on Lac St. Pierre, the single most significant wetland complex in the Lake Ontario-St. Lawrence River system. Plant assemblages modeled in this area (*Hudon et al 2004*)

allowed the historical (1961-2002) variations in the surface area, distribution and biomass in marshes resulting from high or low water levels to be defined.

- *Hudon et al 2004* suggest that hydrology largely determines the structure, distribution and biomass of herbaceous plant assemblages in the 0.1m (0-3 foot) deep zone of Lac St. Pierre wetlands. This zone also reacts to hydrological conditions of the previous season and defines the availability of different habitats and food supply for aquatic organisms.
- PI quantifying the linkages between hydrological variables and wetland characteristics were identified for the Lac St. Pierre area and can be translated into two regulation criteria for environmentally sustainable water management:
 1. maximize the water level range between spring (high) and late summer-fall (low) levels; and
 2. maintain patterns of current and flow closest to natural, unmanaged conditions.
- *Hudon et al 2004* conclude that returning to pre-regulation conditions is most beneficial for wetland habitats.
- Studying wetlands in Lac St. Pierre and the St. Lawrence River below Beauharnois indicated that water temperature, transparency, turbidity, and light extinction coefficients vary markedly with water level. In conjunction with changes of water depth, these variables determine submerged aquatic plant biomass, species composition and distribution, thus altering fish habitat quality and overall primary productivity in the river (De la Fontaine, undated). They also found that water temperature, color, turbidity, suspended solids concentration, and light extinction coefficients are different for water originating from Lake Ontario, from the Ottawa River and from other tributaries. These differences are considered environmentally important.
- Long-term (1960-2002) variations in physical and biological conditions in Lac St. Pierre show that the lake has in the past alternated between a lake environment and a marsh environment over this relatively short time period, making it highly sensitive to discharge regulation and to chronic low levels.
- It is proposed that the wetland ecosystem will benefit if spring flood, seasonal, and long-term (10- to 15-year) water level variations are maintained and extreme low levels and sharp inter-annual (1- to 2-year) variations are reduced when possible.

4.2.3 Fish Habitat, Supply and Abundance

Fish and fish habitat investigations on Lake Ontario (*Minns et al., March 2004*) have encompassed classification of shoreline reaches of Lake Ontario, fish habitat supply assessment, wetland fish community and thermal regime studies, and fish population modeling.

Although changing water levels will impact the amount of suitable habitat available for fishes,

larval fish sampling in wetlands (*Minns et al., March 2004*) indicates that there was no consistent pattern identified in fish composition, abundance and richness by wetland type between the two sampling years. This information can be incorporated into uncertainty estimates for suitable habitat supply.

Minns suggests that water temperature variability in the near shore is greatest in the fall, followed by spring, summer and winter, and is largely responsible for fish egg and larval survival during these times, in addition to water level fluctuations.

Process-based models being completed in the summer of 2004 will focus on whether changes in water level regime will affect fish populations, and the degree of sensitivity of those populations to water level fluctuations.

Fish studies on the U. S. shoreline of Lake Ontario and the upper St. Lawrence River (*Farrell, Mead, Murray and Toner, undated*) found that springtime water levels that enhance northern pike spawning success were historically important, but today do not appear to be connected to age-0 production and subsequent year-class formation. This may be due to habitat changes, including the increase of cattail, and the loss of sedge meadow habitats that are preferred for northern pike spawning. Current regression models indicate greater importance for late summer/fall water levels, where low water levels promote stronger year-classes. Rate of spring warming (days until 8°C (46°F) is reached); and summer temperatures (number of days >20°C (68°F)) are also important.

In the lower St. Lawrence River between Cornwall and Trois-Rivières, research indicates that access to managed marshes for early spawning fish is often prevented by low water levels (*Mingelbier and Morin, May 2004*). Mitigation actions, such as installing fish ladders at the mouth of the largest managed marshes will be required if the regulation plan favors low water levels during spawning. Specific controlling elevations for these marshes are available. *Mingelbier and Morin* suggest a moving calendar based on temperature should be used in determining spring flows for spawning conditions in the regulation plan. This would allow greater flexibility in operation and increased sensitivity to fish spawning migrations.

Based on research findings, the following water level management criteria have been suggested:

- For the Lake St-Pierre area during the spring freshet period (*Mingelbier, undated*) and just after the ice melt in early April when water temperature is >3°C (37°F), water levels at Sorel should be >5.6 m (18.4 ft) to enable fish access to both natural and managed marshes. This minimum water level should be maintained at least 30 days to enhance fish diversity in the marshes and reduce young-of-year fish mortality.
- During the spring hatching and spawning period (April, May and June), the regulation plan should avoid high frequency water level variations to avoid drying eggs and incursions of cooling water in the spawning site. This fact is particularly applicable for the lower St.

Lawrence River where increased flows of 800-1,000 cubic metres per second (28,300 – 35,300 cubic feet per second (cfs)) represents water level variations of about 25-30 cm (10-12 inches) at Lake St-Pierre over a few hours. Such variations may also flood waterfowl nests during the same time period.

- A maximum water level drawdown rate of less than 18 mm (0.7 inch) per day in early May following the spring freshet is recommended to avoid drying fish eggs or trapping “young of year” fish in pools located in the floodplain. This rate corresponds to the observed mean rate at Sorel for the period 1960-2002 and is consistent with the scientific literature.
- Water levels at Sorel should be <5.0 m (16.4 ft) by the end of June to enable drawdown in managed marshes in order to transfer this fish production to the open river system and reduce summer and winter mortality in the managed marshes.

Impact studies of hydrological variation on the seasonal occurrence and migratory timing of freshwater fish species in the lower St. Lawrence River (*de Lafontaine and Marchand, undated*) indicate that proposed scenarios for water level management in the St. Lawrence River will effect the temporal distribution and migratory patterns of fish in the river. Moreover, the annual timing and/or the duration of occurrence of 20 fish species components were significantly related to water levels in the river. They conclude that an increase in the spring river level would delay the annual timing of occurrence of spring fish in the river. In contrast, high river levels in the fall are associated with earlier occurrence for fall fish components. Summer fish components appeared to be relatively unaffected by inter-annual variations in level.

De Lafontaine and Marchand also found that fish populations and communities are changing. The authors concluded that these variations in fish groupings are the result of the shift in the hydrological regime from high to low water level conditions that have occurred in the St. Lawrence River over the past 30 years. In a majority of cases, the spring high water level and the spring baseline water temperature were the two abiotic attributes that explained, to variable degrees, the between-year variation in the abundance of fish species and groupings.

Significant changes in fish assemblage have occurred since 1975, without showing signs of persistence or resilience. The results of this study suggest that high water levels and flows may favor higher productivity of fish from various trophic levels or from different habitat groups. They conclude that future water level management in the St. Lawrence River must aim to maintain a high level of interannual variability in the hydrological regime, driven by climate as much as possible, in order to maintain high fish productivity and fish diversity.

4.2.4 Wetland Bird Abundance and Diversity

Since water regulation can contribute to the loss of wetland habitats through homogenization of water regimes, it can also impact on bird assemblage composition and diversity (*Ingram and DesGranges, undated*). As well, small changes in the rate of water level fluctuations during the

breeding season can have significant negative effects on reproductive success due to nest flooding or increased rates of nest predation, potentially compromising the ability of regional wetland bird communities to maintain viable populations.

Some wetland bird species and their nesting habitats are protected (considered special concern, vulnerable, threatened or endangered) under Federal, State and Provincial laws. Wetland birds are seen as indicators of wetland quality, and are used as parameters of restoration success and regional biodiversity. A profitable eco-tourist industry continues to rapidly develop around wetlands and their diversified wildlife.

Multiple years of bird survey data have enabled surveying of wetland habitats under varying degrees of water inundation, depth and fluctuation. Analysis of this multi-year data has revealed strong correlations between estimated breeding pair densities and water depth, as well as degree of water level fluctuation during the breeding season for a suite of wetland bird species using emergent, meadow, shrub and treed swamp habitats. These additional hydrologic associations allow for much more sensitive predictive models related to habitat quality and overall potential carrying capacity on an annual and long-term basis. Predicted habitat quality (as measured by estimated breeding pair density) can change significantly within a specific wetland plant community based solely on changes in water depth during the breeding season. In addition, overall bird species richness is also responsive to the same wetland and hydrologic parameters. The field-based data also support water level change thresholds and potential nest loss PI that were developed based on nest record databases and published literature.

Findings of this work were that during the bird-nesting season, from May 10 to June 20, the water level in marshes and wet prairies should be maintained between:

- 1 to 5 cm (0.5 to 2 inches) for Common Yellowthroat, a species that nests on or close to the ground in scrubby vegetation away from the water edge;
- 20 to 30 cm (8 to 12 inches) for the Common Snipe, a species that nests on the ground close to the water edge;
- 20 to 30 cm (8 to 12 inches) for the American Bittern, a species with a sturdily built ground nest;
- 20 to 30 cm (8 to 12 inches) for the Black Tern, a species with a “floating” nest; and
- 20 to 40 cm (8 to 16 inches) for the Least Bittern, a species that nests in rigid vegetation above water.

During nesting, an abrupt increase in water level, in the order of:

- >10 cm (4 inches) would be detrimental to Common Snipe;
- >15 cm (6 inches) would be detrimental to Common Yellowthroat; and
- >20 cm (8 inches) would be detrimental to American Bittern, Black Tern, and Least Bittern.

During nesting, an abrupt decrease in water level, in the order of:

- >20 cm (8 inches) would be detrimental to Common Yellowthroat, Common Snipe, and American Bittern; and
- >30 cm (12 inches) would be detrimental to Black Tern and Least Bittern.

During the bird-nesting season (late May to the end of July):

- The frequency and magnitude of water level increases over 5 quarter-month periods that exceed 20 cm (8 inches) should not exceed current regulation plan frequencies, and reductions to pre-project frequencies and magnitudes are preferred. The frequency of water level increases that exceed 40 cm (16 inches) (over a 5 quarter-month period) should be minimized or reduced to pre-project frequencies.
- The frequency and magnitude of water level decreases over 5 quarter-month periods that exceed 20 cm (8 inches) should not exceed current regulation plan frequencies, and reductions to pre-project frequencies and magnitudes are preferred. The frequency of water level decreases that exceed 50 cm (20 inches) (over a 5 quarter-month period) should be minimized or reduced to pre-project frequencies.

The different archipelagos found within the fluvial section of the St. Lawrence River between Lake St. Louis and Trois-Rivières including the adjacent lands, harbour some 6,000 nests of dabbling ducks that provide close to 700 flying broods in the fall (*Lehoux and Dauphin, undated*). This area can be considered as one of the major breeding sites for waterfowl within the entire St. Lawrence River.

For many waterfowl, nesting takes place between the end of April and the end of July, with a peak at mid-June. The brood rearing period lasts between the end of June and the beginning of September, with a peak at the end of July. The archipelagos of Berthier-Sorel and Contrecoeur support close to 70% of all nests produced.

Review of the PI information reveals that water levels will rarely be a limiting factor for nesting habitats. Water rises could, on the other hand, represent a serious threat to nesting females through nest flooding, especially if those increases take place during the most intensive nesting periods such as in June. Average water levels registered between April and October could be detrimental to broods if they are too high (reduction of emergent marsh acreage) or too low (leading to development of botulism).

Successive nest losses that have occurred since 1968 could be one of the major factors explaining the drastic decrease of close to 50% of the productivity of the breeding population of the dabbling ducks in the fluvial section of the St. Lawrence River during the past several decades. A threshold of 200 nest losses is considered critical.

4.2.5 Herpetile Habitat Supply

Although some change in reptile and amphibian populations in Lake Ontario and the St. Lawrence River occurs directly in response to hydrological change (i.e., through creation of

temporary breeding pools for amphibians associated with high water events, or overwintering mortality in turtles associated with low water events), most population change is likely associated with change in habitat availability. Change in habitat availability is determined largely by the effects of lake and river hydrology on the composition and spatial organization of wetland plant communities. Thus amphibian and reptile population change is expected to be driven primarily through indirect associations with lake and river hydrology as mediated by hydrological effects on wetland plant communities.

PI have been defined for several species of reptiles and amphibians, including at least two endangered species (Blanding's Turtle and Eastern Spiny Softshell Turtle), in terms of population estimates. Regression models have been developed to link these populations to wetland habitat changes that may result from water level fluctuations and these regressions will be included in the IERM.

4.2.6 Species at Risk Habitat Supply

Lantry and Schiavone are using predictions from the IERM and Coastal Processes' dune erosion model to evaluate the impact of water level regulation plans on habitat availability for Lake Ontario and upper St. Lawrence River species at risk (Table 3). Results will be reported once models are complete, incorporated in the IERM and predictions are generated.

TYPE	Common Name	Province of Ontario	Canada COSEWIC	Canada (SARA)	New York State
Bird	Black Tern	VUL			END
Bird	King Rail	END-R	END	END	THR
Bird	Least Bittern	VUL	THR	THR	THR
Bird	Pied-billed Grebe				THR
Bird	Yellow Rail	VUL	SC	SC	
Fish	Pugnose Shiner	THR	SC		END
Fish	Bridle Shiner	VUL	SC	SC	
Reptile	Spiny-Softshell Turtle	THR	THR		SC
Reptile	Blanding's Turtle		THR		THR
Plant	Awned sedge				END
Plant	Champlain beechgrass				END
Plant	Low sand-cherry				END
Plant	Sand dune willow				END

Table 3. Species-at-Risk Sensitive to Water Level Changes in Lake Ontario and the Upper St. Lawrence River and their Provincial, State and Federal Status. (COSEWIC-Committee on the Status of Endangered Wildlife in Canada; SARA-Species at Risk Act; END-Endangered; VUL-Vulnerable; THR-Threatened; SC-Special Concern; Sch-Schedule).

In the lower St. Lawrence River between Cornwall and Trois-Rivières, the impacts of water level fluctuations on 13 species are being examined with preliminary findings (*Giguère et Laporte, undated*) indicating that species at risk seem to be very sensitive to regulation plan changes. The potential habitat PI developed for Channel Darter, Least Bittern and Yellow Rail show that the pre-project management plan brings better reproduction habitat availability for the Channel Darter, while the 1958D management plan brings more reproduction habitat availability to the Least Bittern and Yellow Rail. Also, information from the available data and literature indicates that mortality/disappearance risks coming from water level fluctuations bring adverse effects to these species.

4.2.7 Muskrat Abundance

Evaluation of the effects of hydrologic management on muskrat populations in Lake Ontario and the upper St. Lawrence River (*Farrell, Toner and Mead, undated*) indicate that muskrat house densities for drowned river mouth wetlands based on winter house counts are very low relative to many cattail marshes and several recently constructed water level managed sites. Managed marshes and beaver dams have significantly higher house densities than adjacent wetlands under the influence of St. Lawrence River water levels management.

Winter severity influences muskrat populations when water depths are low. During the mild winter of 2002, an increase in the number of active houses was observed for most of the wetlands.

Active houses were generally found located along the deepest parts of the marshes (along channels). These habitats are limited in area and are considered marginal for muskrat overwintering. Increasing water levels for September through February can significantly increase the area of suitable muskrat habitat.

Late fall and winter water levels within most of the wetland area were too low to support healthy muskrat populations. Only one elevation (74.27m (243.7 ft) IGLD) had sufficient water depth to support muskrats during the winter. However, this elevation contains cattails only along the edge and comprises a small percentage of the surface area for each wetland. All other elevations within these wetlands have zero winter water depths.

Muskrat herbivory can have a major influence on cattail density. Comparisons of cattail production vs. consumption in managed marshes of the upper St. Lawrence River indicate muskrats can consume 28% of the annual cattail production.

It is possible that water level changes alone may not reduce dense cattail stands, given their tolerance to a wide range of water depths. However, water level changes resulting in favorable muskrat habitat are likely to influence these stands. Most of the proposed water level scenarios likely will not produce enough muskrats to develop problems associated with “eat-outs”. Periodic low water levels, similar to those proposed in some of the scenarios, will likely prevent these conditions from occurring and will allow wetlands to respond favorably to muskrat

disturbance.

4.2.8 Summary

From the position of minimizing the adverse environmental impacts resulting from application of the water management criteria over the past fifty plus years, an ecological argument is made that the water management plan that best meets the needs of the environment is the plan or set of criteria that restores the natural system as far as possible.

No PI show massive environmental impacts between plans 1958D and “pre-project”, with the possible exception of some rare species. We are most likely going to observe modulations in “ecosystem” abundance rather than population crashes. The challenge will be the significance of long-term impacts (Morin, Champoux, Mingelbier, et al., undated)

4.3 RECREATIONAL BOATING AND TOURISM

The Recreational Boating and Tourism TWG developed a three-pronged approach to study the impacts of water level changes on recreational boating and related tourism:

(1) surveying recreational boaters who used Lake Ontario and the St. Lawrence River; (2) contacting Lake Ontario and the St. Lawrence River marina and yacht club owners; and (3) surveying charter boat operators.

The methodology for the Canadian recreational boating survey differed from the American in that where a survey of charter boaters was carried out in the U.S., a tour boat and excursion craft operator survey was undertaken in Canada. Figure 8 shows the locations of marinas and yacht clubs on Lake Ontario and the upper St. Lawrence River. Figure 9 shows the boating facilities on the lower St. Lawrence River. Data from all three survey groups were used to create water level – impact relationships. Each relationship shows the impacts in terms of PI as losses to the local economy and losses in days of use to the recreational community as the water level decreases or increases.

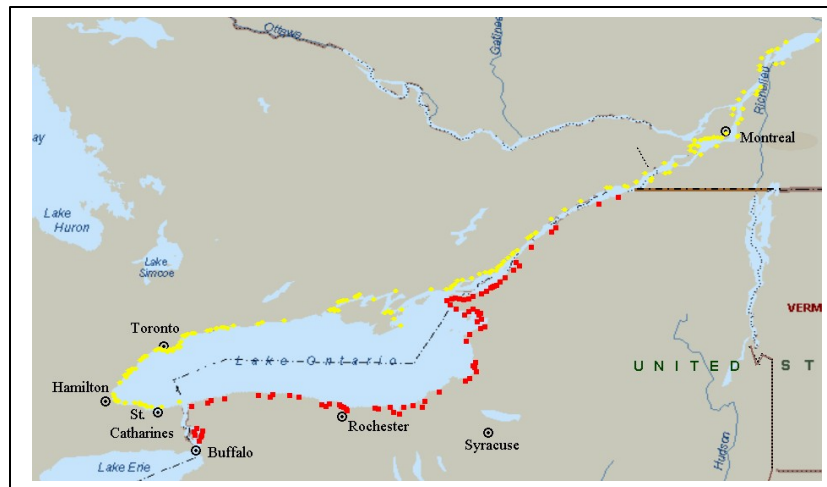


Figure 8. Marinas and Yacht Clubs on Lake Ontario and the Upper St. Lawrence River

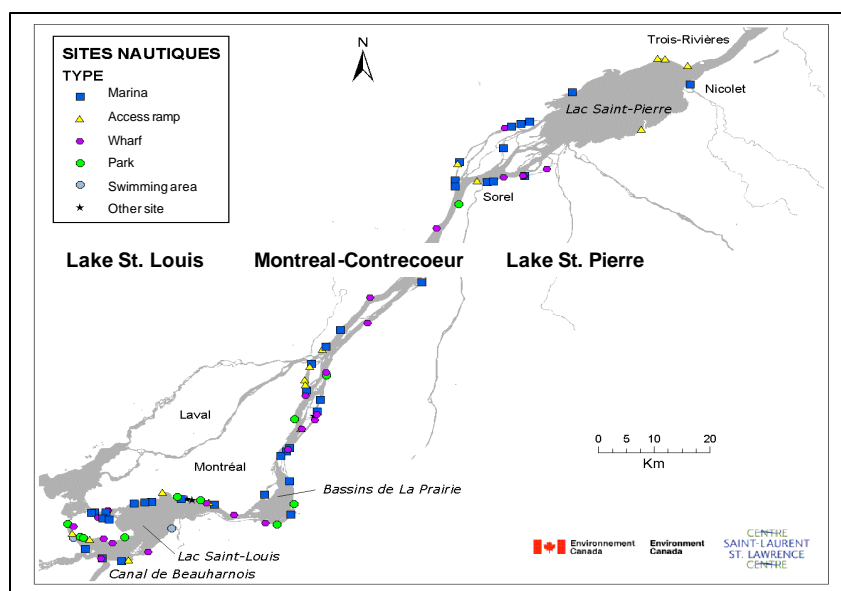


Figure 9. Boating Facilities on the Lower St. Lawrence River

4.3.1 Boater Surveys

A U.S. survey sample was drawn from a database of boats registered in New York State in 2002. Boaters using Lake Ontario and the St. Lawrence River boated an estimated 1.3 million days or an average of 28.4 days per boat on these waters in 2002. Boaters spent (in U.S.dollars) an average of \$137 per day in New York State counties bordering Lake Ontario and the St. Lawrence River for a total of \$178 million. They spent an additional \$18.50 per day in areas outside the New York State bordering counties for a total of \$24 million. Boaters' consumer surplus or what boaters would have been willing to pay over and above what they actually paid for their boating experience averaged \$69.36 per day totaling \$90 million for all boater days in the 2002 season. Almost half of boaters (43%) indicated there were days in 2002 when they wanted to go boating on Lake Ontario or the St. Lawrence River but could not because of low water level conditions. Low water was more likely to affect boaters who accessed the water from private docks.

On the lower St. Lawrence River, boating days were estimated to 47 days per boat for a typical season, based on 2002 information, totaling about 2.83 million boater days per year. Between 55 and 60% of boat owners do short one or two day trips. Others do 10-20 day or 20-30 day trips. July and August are the typical peak boating months, followed by June and September, and then by May and October. Typical expenditures (in Canadian dollars) averaged about \$206 per day, ranging \$163 to \$280 per day depending on the area. When the extreme low and high values are excluded, the range of average daily expenses is \$101 per day on Lake Ontario and \$125 per day on the lower St. Lawrence River. Boat owners' total (gross) willingness to pay (WTP) above these daily expenditures is between \$153 and \$188 per day on a typical boating trip depending on area considered. In addition to daily expenses and WTP, boat owners spend an additional \$3,330 annually for insurance, boat improvement and

repairs. Approximately 2,900 boating days were lost because of low water in 2001, 60% of which occurred in August and September.

4.3.2 Marina, Yacht Club, Launch Ramp and Charter Boat Surveys

An inventory of all marinas, yacht clubs, and state or privately run boat launch ramps was conducted in the U.S. during the summer of 2002. One hundred and sixty-eight marinas and yacht clubs were identified in operation along Lake Ontario and St. Lawrence River shoreline during the 2002 boating season. Operators were asked about impacts to their business from both high and low water conditions and mitigation measures used. Most of the marinas (78%) impacted by low water in 2001 indicated they had lost revenue due to the low water conditions. Lake Ontario marinas (80%) and smaller marinas (83%) were slightly more likely to indicate they lost revenue in 2001. The average revenue lost per marina impacted was \$15,000. The total estimated loss of revenue in 2001 was approximately \$1,396,000 (in constant 2002 U.S. dollars). Over half (54%) of the businesses that were impacted took some form of action to mitigate the problems caused by low water levels. Marina operators spent a total of \$538,500 (in 2002 constant U.S. dollars) on mitigation actions.

One hundred interviews were completed in person or by telephone of the 133 marinas operating on the Ontario shoreline of Lake Ontario and the upper St. Lawrence River. The number of slips available was counted and occupancy per month was estimated. Operators were asked about ideal and acceptable maximum and minimum water levels. These responses were averaged by reach and stage damage curves were created showing losses as water levels fluctuated from ideal by month based on occupancy and days boated. The data collected from the marina/yacht clubs public boat launch sites indicated approximately two-thirds (67.5%) of all facilities visited were equipped primarily or exclusively with floating docks. Three-quarters (75%) of St. Lawrence River facilities and nearly two-thirds (64.7%) of Lake Ontario facilities had floating docks. Only one-third of all the facilities surveyed relied primarily on permanent docks (25% of St. Lawrence River and 35% of Lake Ontario facilities). Three-quarters (75.8%) of facilities in the Study area have some of the docking infrastructure necessary to deal with fluctuating water levels (i.e. floating dock infrastructure). These observations provide an indication of the relative sensitivity of these facilities to water level fluctuations based on infrastructure-type characteristics.

New York charter boat captains were surveyed by mail in the winter of 2003. There were an estimated 210 charter boat operators calling Lake Ontario their home port in 2002, 34 on the St. Lawrence River, and 13 on the lower Niagara River (accessing Lake Ontario). One-third of charter boat captains indicated there were times in the past five years when they wanted to take out a charter but could not because of high or low water conditions. The problems occurred primarily in the fall, September and October, during low water level conditions.

4.3.3 Regional Economic Impact Analysis

A regional economic impact model was used to measure the impact of money brought into the local economy by boaters coming from outside the region and how much additional spending

results from this money. The impact varies by region ranging from \$12 per day along western Lake Ontario to \$37 per day in the Alexandria Bay region.

4.3.4 Performance Indicators

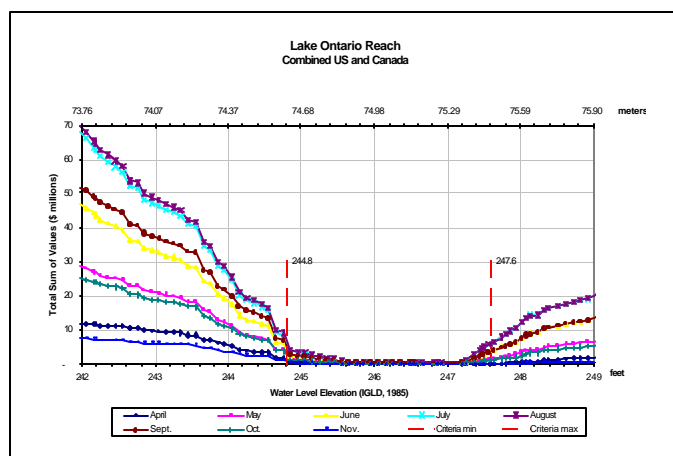
PI were calculated based on the data collected and associated with different water levels to construct water level – impact relationships. Twelve PI were conceptualized for U.S. boaters to measure losses in days lost and in economic terms. The four sources of data (marinas, launch ramps, private docks, and charter boats) were aggregated by reach and month to form composite water level – impact relationships.

In Canada, data to be used to create PI on days boated, expenditures, and WTP were collected in the survey of power squadron members. These boaters were considered to be representative of marina and yacht club users, but not private dock or launch ramp users. To estimate PI for these users, ratios developed from U.S. data (e.g., days boated by marina users/ days boated by launch ramp users) were applied to the Canadian power squadron data. Ten PI were calculated for Canadian boaters. The PI were based on average days boated, economic indicators (e.g. expenditures per day and net economic value), and the number of additional days under ideal water level conditions. Data revealed significant boater days lost due to low water levels in the fall. Regional economic impact analysis was not done for Canadian boaters due to the lack of residential identification of the Canadian power squadron boaters.

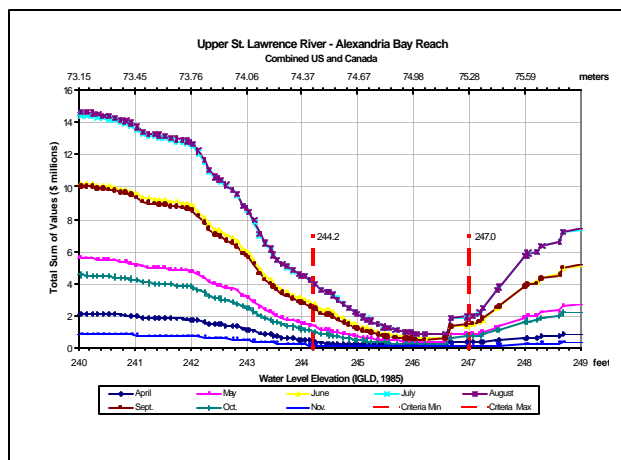
For purposes of rationalization of the recreational boating information, Lake Ontario and the upper St. Lawrence River were divided into three reaches. The Lake Ontario reach includes the lake itself and the portion of the St. Lawrence River down to and including Cape Vincent. The remainder of the upper St. Lawrence River was divided into two reaches associated with the water level gauge measurements at Alexandria Bay and Ogdensburg. Canadian and U.S. data for these reaches were aggregated. The three reaches on the lower St. Lawrence River were delineated and data were referenced to the water level gauges at Pointe Claire for Lake St. Louis, Varennes for Montreal-Contrecoeur and Sorel for Lake St. Pierre.

4.3.5 Aggregated Stage Damage Curves

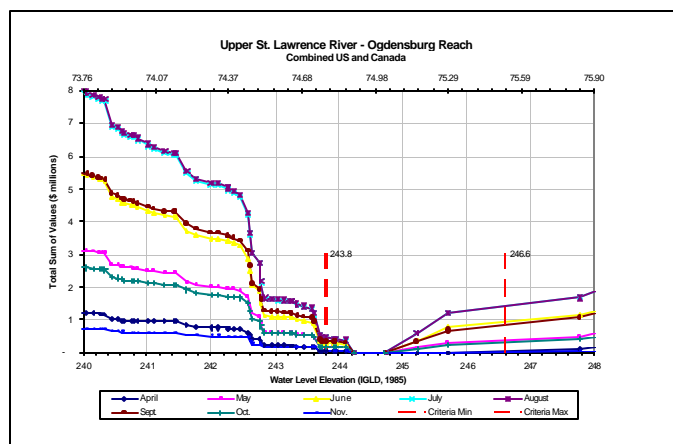
The data associated with the three methods boaters use to access the water (marinas, private docks, and launch ramps and charter boats in the U.S.) were added by reach to create one very large database that measured accumulated losses as water levels varied up or down from ideal. U.S. and Canadian PI were aggregated by reach for Lake Ontario and the upper St. Lawrence River. Economic indicators measured in dollars were all converted to 2002 U.S. dollar equivalents. Figure 10 presents the final aggregated water level – impact relationships for the six study reaches.



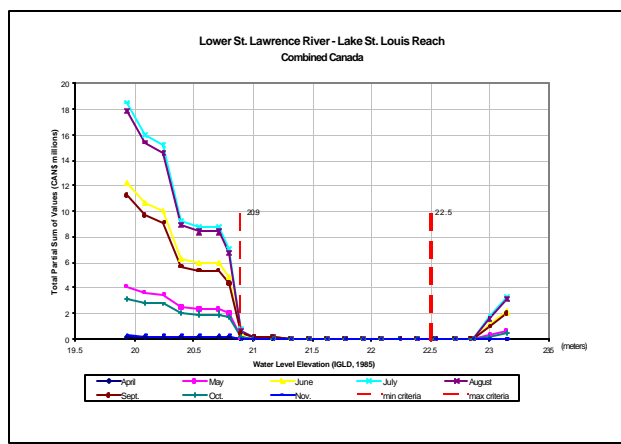
(a) Lake Ontario Reach



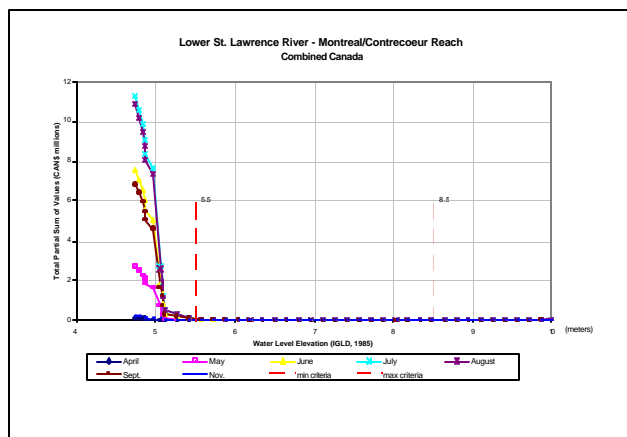
(b) Alexandria Bay Reach



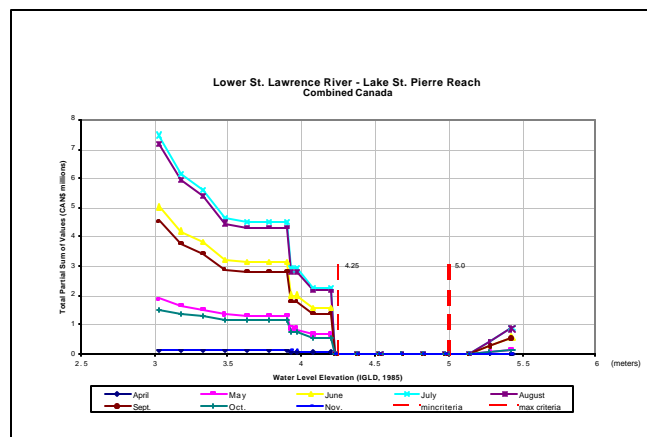
(c) Ogdensburg Reach



(d) Lake St. Louis Reach



(e) Montreal/ Contrecoeur Reach



(f) Lake St. Pierre Reach

Figure 10. Water Level-Impact Relationships for Six Recreational Boating Survey Reaches

4.3.6 Water Level Criteria

One of the primary objectives of the TWG was to determine ideal criteria for water levels for each of the reaches that would best meet the needs of recreational boaters and associated businesses. The TWG reviewed the final PI (water level impact relationships), and established the range of water levels which was deemed overall acceptable for the boating constituency. For each reach, the water level that minimizes adverse impacts was selected. The TWG reached a consensus that a ± 0.43 m (1.4-foot) variance around the ideal level for Lake Ontario was a reasonable water level range for boaters which when considering the hydraulic affect of that range selection on upper St. Lawrence River reaches (Alexandria Bay and Ogdensburg) was also acceptable. For the lower St. Lawrence River, the range is higher.

It is important to note that the critical period during the boating season subject to unacceptable water levels has historically occurred from late August through mid October. Therefore the TWG strongly emphasizes that the range specified is to be applied for the full extent of the boating season 15 April through 15 October.

Table 4 presents the preliminary ideal target level by reach along with the acceptable lower and upper bounds.

Study Reach	Ideal Level m (ft)	Minimum Level m (ft)	Maximum Level m (ft)
Lake Ontario	75.04 (246.20)	74.62 (244.82)	75.47 (247.61)
Alexandria Bay	74.86 (245.61)	74.43 (244.20)	75.29 (247.02)
Ogdensburg	74.74 (245.21)	74.31 (243.80)	75.17 (246.62)
Lake St. Louis	21.50 (70.54)	20.90 (68.57)	22.50 (73.82)
Montreal - Contrecoeur	6.50 (21.33)	5.50 (18.04)	8.50 (27.89)
Lake St. Pierre	4.50 (14.76)	4.25 (13.94)	5.00 (16.40)

Table 4. Ideal Criteria for Water Levels by Reach for Recreational Boating Interests for the Boating Season 15 April through 15 October. (The specified levels are considered draft criteria subject to change by the Recreational Boating and Tourism TWG once a detailed review can be made).

4.4 COMMERCIAL NAVIGATION

The Commercial Navigation TWG concentrated on developing a Commercial Navigation Economic Impact Model. The geographical area for the model is Lake Ontario and the St. Lawrence River to Bécancour, Quebec. The model uses the goals, objectives and metrics identified by the TWG in the document: *“Planning Objectives and Performance Metrics for Evaluating Impacts of Lake Ontario Outflow Regulation Plans on Commercial Navigation”*. Metrics have been developed defining relationships between water levels and commercial navigation impacts in terms of changes in vessel operating costs.

4.4.1 Goals and Objectives

Changes in Lake Ontario and St. Lawrence River water levels can affect commercial navigation from Lake Ontario to Bécancour, Quebec. Commercial navigation is impacted at defined low and high water levels, and by high currents. The timing of the related discharges (seasonal and weekly) and the resulting currents also affect vessel movements as well as ice formation.

Given the above, four planning objectives were identified:

- Optimize water levels and currents to minimize damages, maximize benefits and maintain navigational safety, without exceeding flood thresholds.
- Minimize extremes in water levels and currents in terms of amplitude and frequencies of variations to provide stability and predictability of water levels, in order to optimize long-term cargo load planning and navigation.
- Maintain currents in a safe range for commercial navigation.
- Maximize ice-cover stability and integrity from Montreal to Bécancour to prevent ice jams and resulting flooding, and maintain safe navigation.

4.4.2 Geographical Reaches

Five distinct geographical reaches were identified for which impacts on commercial navigation from regulation of Lake Ontario outflows are addressed: 1) Port Weller to Kingston (Lake Ontario); 2) Kingston to Cornwall; 3) Cornwall to Beauharnois; 4) Beauharnois to Montreal and 5) Montreal to Bécancour. The navigation season for the first four areas is approximately nine months, from late March to the end of December. The navigation season for the Port of Montréal and downstream is year around. Each of these five reaches has specific concerns about water levels as affected by regulation of Lake Ontario. Impacts from high and low Lake Ontario outflows and from timing of discharges have been developed for each of the five reaches.

4.4.3 Performance Metrics and Performance Indicators

Hydraulic attributes that lead to commercial navigation impacts in each geographical reach have been identified and performance metrics defined to identify water levels that trigger impacts. A total of 42 metrics were required to identify when impacts to navigation are encountered (e.g., speed reductions, loading reductions, cessation of vessel movement due to unsafe current conditions). Performance metrics are required for high and low water level conditions, timing of discharges and target gradients by reach. Metrics were also defined for the development of a stable ice cover on the River.

Maximum and minimum hydraulic limits considered by the Commercial Navigation economic impact model are defined in Table 5. Sample metrics for Lake Ontario, and their impacts on commercial navigation, are identified in Table 6.

Hydraulic Attribute	Max		Min	
	m	(ft)	m	(ft)
Lake Ontario level	76.2	(250.00)	73.5	(241.14)
St Lawrence River level at Ogdensburg	75.9	(249.02)	73.2	(240.16)
St Lawrence River level at Cardinal	75.6	(248.03)	72.8	(238.85)
St Lawrence River level above Iroquois Dam	75.4	(247.38)	72.5	(237.86)
St Lawrence River level at Morrisburg	74.3	(243.77)	72.0	(236.22)
St Lawrence River level at Long Sault Dam	74.0	(242.78)	71.0	(232.94)
St Lawrence River level at Summerstown	47.2	(154.86)	45.7	(149.94)
Lac Saint-Louis at Pointe Claire	23.5	(77.10)	20.0	(65.62)
St Lawrence River level at Montreal Harbour	11.0	(36.09)	4.0	(13.12)
St Lawrence River level at Varennes	10.0	(32.81)	3.5	(11.48)
St Lawrence River level at Sorel	8.5	(27.89)	3.0	(9.84)
Lac St Pierre level	8.5	(27.89)	2.7	(8.86)
St Lawrence River level at Trois-Rivières	8.0	(26.25)	2.1	(6.89)
St Lawrence River level at Batiscan	7.0	(22.97)	1.7	(5.58)
	m ³ /s	(cfs)	m ³ /s	(cfs)
Lake Ontario Outflow or St. Lawrence R flow upstream of dam	11000	(388,472)	4000	(141,263)
Lac Saint-Louis outflow	17000	(600,366)	5000	(176,578)

Table 5. Limits of Hydraulic Attributes Evaluated by Economic Impact Model

Type of limit	Elevation Above Sea Level (IGLD 1985)	
	m	(ft)
High threshold level (1)	75.37	(247.28)
Alert level for navigation (2)	74.35	(243.93)
Minimum level for navigation (3)	74.27	(243.67)

Table 6. Lake Ontario Metrics (Port Weller to Kingston)

- (1) Triggers speed reduction to prevent shore damages on eastern end of Lake Ontario.
(2) Speed reduction in certain areas necessary to maintain safe underkeel clearances.
(3) Triggers loading reduction below 8 m (26.2 ft) draft.

Changing water levels affect both vessel and port/dock operations in terms of maximum allowable drafts and loading conditions. In general, as water levels fall, vessel speeds can be reduced to maintain safe under keel clearances. Eventually, a water elevation is reached (i.e., 74.27 meters on Lake Ontario) where it becomes necessary to light load vessels in order to maintain safe under keel clearance.

Key water level elevations have been identified for each of the five geographical reaches. When ships encounter these water levels during their voyage, either vessel travel time or ship carrying capacity is affected.

4.4.4 Economic Impact Model

The function of the economic impact model is to convert the 42 metrics into algorithms that calculate economic impacts. The algorithms quantify the economic impacts of water levels, flows and velocities on commercial navigation for traffic moving through the reaches. The model then derives transportation and ship-operating costs associated with various Lake Ontario regulation schemes, based on commodity and vessel origin-destination data for the 1995 through 1999 navigation seasons.

Low water levels either lead to vessel slowdowns or light loadings. In general, high water levels do not cause a problem for commercial navigation. There are, however, two negative impacts to commercial navigation from high water levels. High lake levels can cause inundation of commercial docks and high river current velocities, which make navigation unsafe. Consequently, vessels must stop and wait until the velocities and or flows have receded to safe navigation levels.

The timing and frequency of the water level fluctuations and the time of year they occur also play a role in the impact on commercial navigation.

4.4.5 Economic Cost Curves

Data on vessel voyage costs are being used to develop water level/navigation cost curves. These water level cost curves are being imported into the SVM.

4.4.6 Short-Term Future Outlook

The St. Lawrence Seaway tonnage volumes are recovering from the global economic aftermath of September 11th events and are beginning to return to 2002 levels. Approximately 29 million tons of cargo were shipped via the Montreal – Lake Ontario section of the Seaway in 2003, with grain, iron ore and coal being the dominant cargoes. Approximately 32 million tons were shipped via the Welland Canal. The removal of steel tariffs will help the Seaway to return to its classic trading pattern of steel-in-grain-out in 2004 and a thriving economy will promote a thriving Seaway.

Traffic at the Port of Montreal is expected to grow to 23.4 million tons by 2008 from the 18.7 million tons recorded in 2002. Growth is expected to be derived mainly in the container sector and an increase in liquid bulk traffic.

Factors that have and will continue to affect Seaway traffic include global freight rates, the relative values of the Euro, U.S. and Canadian dollars, the Canadian Wheat Board push for western grain movement, and the growth of U.S. imports to China. China's boom has raised global freight rates and pushed up commodity prices, including North American imports.

4.5 HYDROPOWER

The International St. Lawrence Power Project spanning the international portion of the St. Lawrence River at Cornwall-Massena consists of four structures, the Robert Moses-Saunders Power Dam and Generating Station, the Long Sault Dam, the Massena Intake and the Iroquois Dam. New York Power Authority (NYPA) operates the Robert Moses Generating Station, and Ontario Power Generation (OPG) operates the Robert Saunders Station, each of which represents half of the single control structure spanning the international boundary. The Long Sault Dam is operated and maintained by NYPA and the Iroquois dam by OPG as part of their Joint Works program whereby all costs for operation and maintenance of joint works are shared equally between the two entities (*Hydropower TWG, February 2003*).

The individual and combined electrical power output, best efficiency discharges and maximum discharges for the Moses-Saunders plants are listed in Table 7.

Station	At best efficiency point		Maximum output	
	Output Mw	Discharge m ³ /s (cfs)	Output Mw	Discharge m ³ /s (cfs)
Moses	860	3,940 (138,900)	1,010	5,060 (178,820)
Saunders	1,007	4,610 (162 750)	1,057	5,010 (176,930)
Total	1,867	8,550 (301,650)	2,067	10,070 (355,750)

Table 7. Moses-Saunders Power Output and Discharge Capacities

Any river flows above the maximum discharge capacity of 10,070 cms (355,750 cfs) is spilled downstream through the Long Sault Dam, which has a capacity of 20,950 cms (740,000 cfs).

Owned and operated by Hydro Quebec, the Beauharnois-Les Cedres Hydropower Complex is located approximately 80 km (50 miles) downstream of the Moses-Saunders plants from which it receives about 96% of its inflow. The installed capacity, best efficiency points and maximum discharge capacities of this complex are summarized in Table 8.

Station	At best efficiency point		Maximum output	
	Output Mw	Discharge m ³ /s (cfs)	Output Mw	Discharge m ³ /s (cfs)
Beauharnois	1574	7,500 (264,860)	1,670	8,340 (294,520)
Les Cèdres	-----	-----	160	1,500 (53,000)
Total	1574	7,500 (264,860)	1830	9,840 (347,520)

Table 8. Beauharnois-Les Cedres Power Output and Discharge Capacities

The total average annual hydropower production from these three plants is approximately 25,000,000 MWh, representing 13,000,000 MWh at Moses-Saunders divided equally by NYPA and OPG, and 12,000,000 MWh at Beauharnois-Les Cedres. NYPA, OPG and

Hydro-Quebec are public utilities owned by New York state and the Provinces of Ontario and Quebec, respectively.

4.5.1 Ice Formation and Management

Formation of a stable ice cover on the St. Lawrence River from Beauharnois upstream to the vicinity of Ogdensburg-Prescott, approximately 64 km (40 miles) upstream of the Moses-Saunders Power Dam, is critical to controlling outflows from Lake Ontario. Ice jams and hanging ice dams can restrict winter flows in the river and thwart regulation of the outflows from Lake Ontario.

To form a stable ice cover on the river, maximum outflows of 6,230 cms (220,000 cfs) should not be exceeded during ice formation, which usually occurs during a four-day to one-month period between mid-December and early February.

4.5.2 Peaking and Ponding

The NYPA and OPG power companies conduct peaking and ponding operations to match demands for electricity and maximize the value of the resource. No effective peaking occurs at Beauharnois.

Peaking is the variation of hourly flow about the daily mean, is conducted when outflows are 7,930 cms (280,000 cfs) or less and varies to a maximum of 850 cms (30,000 cfs) around the daily mean flow. Ponding is the variation of the daily mean flow about the weekly average with lower flows typically on weekends and higher flows during weekdays. The maximum range of ponding is -570cms (-20,000 cfs) for Saturday and Sunday and +230 cms (+8,000 cfs) for the five weekdays. Ponding is only carried out during the non-navigation season, is limited or suspended under ice conditions, and thus is not a frequent occurrence.

Peaking and ponding operations are conducted with the agreement of the three power entities, commercial navigation interests, and under the approval and review of the IJC through its International St. Lawrence River Board of Control.

4.5.3 Operations Under Emergency Conditions

Emergency situations can occur when unscheduled flow changes must be made very quickly to alleviate critical situations. Recent examples are the August 14, 2003 blackout and the Ice Storm of January 1998.

When these situations occur, the International St. Lawrence River Board of Control's Regulation Representatives are empowered by the Control Board to coordinate immediate flow changes. The Regulation Representatives then notify the Board of Control and the IJC.

Deviations from the flows presently specified by Plan 1958D that result from these emergencies are generally offset by compensating flow changes over successive quarter-month periods when conditions allow. The Board of Control may also use discretionary authority to retain some of these deviations or elect to restore them in a more judicious manner to prevent additional and/or undue harm to any interest.

4.5.4 Electricity Markets

NYPA, OPG and Hydro Quebec operate in different and independent market environments. Their transmission systems are inter-connected to provide stability within the systems and to permit import/export of energy between systems. However, market rules, availability of generation, transmission constraints, demand for energy and peak and off-peak demand times all contribute to making each of these systems unique.

New York and Ontario are considered to be summer peak markets, whereas Quebec is a winter peak market.

Peaking is considered critical to the operations of NYPA and OPG, whereas efficiency of operations is more beneficial to Hydro Quebec than peaking. Relatively even flows throughout the year with no spillage is desirable by all the utilities for hydropower production. Predictability of flow is also important for market operations and maintenance scheduling.

4.6 DOMESTIC, INDUSTRIAL AND MUNICIPAL WATER USES

4.6.1 Lake Ontario and the Upper St. Lawrence River

Data and analyses from contracted out work on water supply intakes, wastewater discharges via storm and sewer water mains, and self-supplied residential water systems have revealed that on Lake Ontario and upper St. Lawrence River shorelines, water level impacts on municipal and industrial (M&I) water intakes and outfalls are minimal (*PMCL, May 2003*). However, low lake elevations can have negative impacts on water supplies for thermal power generating plants, and self-supplied, domestic water systems (i.e., shore wells and lake intakes lines).

Many municipal water supply systems in rely on Lake Ontario and the St. Lawrence River as their primary sources of potable water – approximately 1.2 million people in the New York and 5.1 million in Ontario. In New York and Ontario, variations within the long-term water level range on Lake Ontario do not have significant direct or widespread adverse impacts on the ability of municipal water supply intakes to effectively provide water for the public. Most public intakes, including the largest facilities that serve the big population centers, i.e., Rochester and Toronto, are at depths and distances from the shore that eliminates or greatly mitigates problems with respect to water levels. Facilities that did report problems are relatively small and account for less than 0.5 percent of the total population served by intakes in Ontario and New York. The Villages of Albion and Wolcott currently experience problems withdrawing water from the

lake. Albion's 5 m (16 ft) deep intake and Wolcott's 4 m (12 ft) deep intake are impacted by wave action. The primary impact is clogging of the intakes with seaweed, algae and ice brought on by high wave action. On six occasions in the recent past it has been necessary for Wolcott to cease operations due to clogged intake screens. Lower lake levels would likely exacerbate problems at these smaller facilities.

Low water impacts on water utilities and industry can be measured in economic terms, either in additional costs to provide the same level of service or in the loss of benefits if full service cannot be provided. The impact of low water levels on two thermal power facilities in New York that have reported significant concerns or impacts associated with source water elevation are being assessed. The objective is to determine relationships between source water elevation and economic costs associated with the loss of head for cooling water intakes for the power plants and to approximate economic costs of structural measures to address low and high water impacts. Due to security concerns and staffing issues at the two facilities, initial data collection activities were limited.

The effects on people who rely on shorewells and lake lines are not best measured in economic terms. The dollar value of consequences to individual homeowners is very small in comparison to uses such as thermal power plants. Residents with lake lines can minimize difficulties by extending their lines, and many did that during the low water levels of 1998. People who rely on shorewells may not have other full service options. Sometimes they may not be able to install traditional wells because of poor water quality and/or lack of suitable aquifers. In addition, costs of connecting systems to water utilities are generally prohibitive. People who cannot get water from shorewells can buy bottled drinking water and water hauled by trucks for showers and flushing. Self-supplied residential systems are generally concentrated in two areas: 1) shoreline communities in the Thousand Islands area of Ontario and the U.S. and 2) portions of the Upper St. Lawrence in the Lake St. Lawrence area. In August 2003, advertisements were placed in local newspapers in Jefferson and St. Lawrence counties in New York and the Kingston and Brockville regions in Ontario. The intent of the Study was briefly summarized and questions were provided designed to focus responses from the target audience. In total, only 17 residents (3 in Ontario and 14 in New York) replied. Most respondents were from the U.S. side of the lake in bayside communities surrounding Watertown, New York. Canadian respondents were all from communities near Bath, Ontario.

The majority of respondents occupied their lakefront homes on a year-round basis. Four of the 17 were seasonal occupants. Over 90 percent of respondents use water from their shorewells for non-potable purposes only. Bottled water from retail outlets or natural springs is typically used for drinking. For all respondents, bottled water was their only alternative source of water. Problems were centered on capacity issues in the form of intermittent flows or insufficient flows. Several respondents reported concern regarding the quality of well water. Six of the seven respondents with problems considered severe have deepened their existing wells or have constructed new wells. The remaining respondent was planning construction of a new well at the time of the survey. None of the respondents with mild or significant problems have made major

changes to their shorewells.

4.6.2 The Lower St. Lawrence River

In Quebec, 2.4 million people receive their potable water from the St. Lawrence River. A data inventory of the 30 drinking water treatment plants located in the lower St. Lawrence River provided information to calculate critical water levels for each installation (*École Polytechnique de Montréal, December 2003*). Critical water levels for each plant were then compared to each other in order to identify the most vulnerable utilities. The survey also inventoried problems experienced by the plants. Potential water quality degradations related to water levels and their anticipated impacts on water treatment plant operations were also evaluated.

The survey reported that 42% of the utilities suffer from taste and odor problems in drinking water, while 50% experience problems due to frazil ice at their intakes. Taste, odor and frazil problems are not necessarily directly related to low water levels but tend to increase in such conditions according to utilities. Capacity limitations under low water conditions were reported by 3 installations out of 30. The depth of water intakes is one of the most important information items collected. Under low water level conditions (*chart datum*), the depths of water above the intakes range from 0.6 m to 6.5 m (2 to 21 ft), with an average depth of only 2.6 m (8.5 ft). This information highlights the potential vulnerability of several plants in the Quebec portion of the St. Lawrence River. In comparison, the minimum water intake depths along Lake Ontario were on average 13.4 m (44 ft) in Ontario and 9.6 m (31 ft) in New York.

The calculated critical water levels indicate that water treatment plants in the lower St. Lawrence are vulnerable to low water levels. Any variation of flow that lowers water levels close to the historical minimum of 20.04 m (65.7 ft) or even the chart datum in Pointe-Claire 20.35 m (66.8 ft) would be critical for at least 3 plants. The fact that the principal Montreal water intake is one of the most vulnerable ones emphasizes the critical impacts of low water levels on drinking water treatment plants. In recent years, similar water levels were reached, forcing Montreal to open its emergency intake. Two issues should be kept in mind when analyzing the results: 1) the conditions considered when determining the critical level and 2) the consequences of reaching this level. The critical level was calculated for the nominal capacity (maximum production) of the plant to allow a common basis of comparison. Since the critical water level is water demand-dependent, water treatment plants currently producing significantly lower flows than what they are designed for, have a significant safety factor. The consequences of reaching the critical level are also different for each plant. Large facilities with more than one pumping station could probably fulfill an average day water demand with one well out of operation. For small plants on the other hand, once the threshold water level in the well is reached, alternative measures should be considered to maintain distribution. The advantage of small plants is that temporary solutions are possible and the response time is shorter (e.g., rental pumps, temporary lines).

The impact assessment of lower water levels on water quality was made by evaluating the

influence of the Ottawa River on the water quality at the Montreal water intake. Eight years of water quality data were retrieved from the Montreal Atwater plant and correlated with flow data in order to establish causal relationships. The results show higher dissolved organic carbon, color and turbidity when the contribution of the Ottawa River is greater during its freshet. The opening of the emergency intake of Montreal's plants was also shown to influence water quality through the demonstration of increased chemical costs. The water withdrawn from the emergency intake contains a greater fraction of Ottawa River water as this water mass travels closer to the shore where this intake is located. An annual increase in costs of \$73,000 Cdn was attributed to the 6% increase in chlorine doses observed during the opening of the emergency intake.

As utilities mentioned that this problem seems to increase in low water conditions, cost estimates were determined for the upgrade of water treatment plants to be able to treat taste and odor events. The costs of upgrading the 14 treatment plants not presently equipped to treat these events depends on the technology chosen. Total annual costs to resolve this problem are estimated to be in the range of \$3.7 to \$4.1 million Cdn.

The impacts of water levels on water treatment plants in the lower St. Lawrence River have been included in the SVM through the definition of three PI. The first describes the cost of treating for taste and odor events. The second represents infrastructure costs related to solutions if critical levels are reached. The third identifies the population affected when an alarm level is reached corresponding to the opening of the emergency intake.

High water levels are also suspected to have an impact on wastewater treatment plants. However, the data suggests that this is not a widespread problem, as only two utilities were able to provide a critical high water elevation. It was determined that wastewater treatment plants are less affected by water levels than drinking water plants.

4.7 HYDROLOGY AND HYDRAULICS

4.7.1 Great Lakes Net Basin Supply and Ottawa River Inflows

For regulation plans to be thoroughly evaluated, it is paramount that they be tested for robustness, flexibility and system representation in a hydrologic sense. That is, not just for the recorded sequence of historical water supplies and flows, but also for different water supply sequences and conditions that could be expected to occur in the future, as the future will surely be different from the past, at least in hydrologic terms. For this purpose, simulated series of stochastically generated water supplies were produced to test regulation plans against different sequences of water supply conditions. The stochastic nature of the simulation process implies that the statistical properties of the simulated and historical supplies are generally similar.

For the purposes of simulation, the project is carried out in three distinct spatial zones; these are for the Great Lakes, the Ottawa River System and the local tributaries downstream of Moses-

Saunders dam to Trois-Rivières. The product from this project consists of two time-series of different lengths. The first of 20,000 years in length has been analysed for statistical properties and comparison with the historical time series. The second set is 50,000 years long to be provided to other TWGs as a raw product with no analysis.

4.7.2 Climate Change Scenarios

General Circulation Model (GCM) results for climate change conditions were used to define possible water supply conditions for the Great Lakes, for the Ottawa River drainage basin and for the other local tributaries to the St. Lawrence River.

In order to capture the range of potential climate change impacts on water supplies, lake levels and flows, four probable scenarios were selected. Two of these scenarios are based on the second-generation Canadian general circulation model: warm/dry and not so warm/dry. The other two scenarios are derived from the United Kingdom based third generation Hadley model: warm/wet and not so warm/wet. These four scenarios were considered to be representative of the range and current state-of-the-art in climate change science applications to the Great Lakes–St. Lawrence River region. Four work efforts were then required to address different spatial components of the climate change evaluation. Hydro-climate information was then employed to generate net basin water supplies into the Great Lakes and into the Ottawa River basin. Flows were then generated and routed through the system.

The resulting net basin supplies, water levels and flows are generally less than the base case-historical condition for all changed-climate scenarios and for all lakes except for the not so warm/wet scenario on Lakes St. Clair, Erie, and Ontario. The greatest reductions in net basin supplies occur on all lakes under the warm/dry scenario, followed by either the not so warm/dry or warm/wet scenarios depending on the lake. The smallest water supply/lake level/flow reductions occurred on all lakes under the not so warm/wet scenario.

4.7.3 Water Supply Forecasting

Great Lakes above Cornwall: The existing operational net basin supply (NBS) and lake level forecast methods on the Great Lakes above Cornwall, were reviewed to evaluate the techniques used by various agencies in the management of the system. The extended weather forecasting, pertinent to use in Great Lakes water level forecasting was also studied. The relative worth of near real-time data availability and weather forecasts on hydrological forecasts were evaluated by building forecasts with and without their use and assessing agreement with observations over recent data periods. The existing operational NBS and lake level forecast methods on the Great Lakes above Cornwall were examined by comparing them and for their “goodness of forecast.”

St. Lawrence River below Cornwall: In order to improve hydrological forecasts for the St. Lawrence River below Cornwall, an analysis of the spring melt in April 2002 was undertaken in three steps. The first was to hindcast the conditions of April 2002 with the atmospheric,

hydrologic and water level models. The next two steps were to issue a ten-day forecast on two dates: one starting on April 10, and the second one starting on April 15, 2002. The two forecasts were then compared with the hindcasted conditions for performance evaluation. They were also compared to the actual forecasts issued at the time when applicable. In this regard, this Study is using state-of-the-art forecasting tools not readily available operationally. It is the object of this Study to show what gains in forecasting could be made available in the future.

Findings from this work suggest that the 1-week Ottawa River forecasts be applied to Lake Ontario/St. Lawrence River regulation rules during the spring freshet period. For late summer and early fall, the extended 1- to 14-week forecasts could be used to build in some protection for low level and flow situations at Montreal. The 1- to 2-week forecasts appear to be best for all other time periods of the year.

4.7.4 Hydrodynamic Modelling of St. Lawrence River Conditions

Kingston/Cape Vincent to Cornwall Reach: The initial simulation runs of the upper St. Lawrence River model were completed in May of 2003. The simulations were prepared and processed to allow easy access to the hydrodynamic data for the St. Lawrence River by the TWGs. A total of 19 simulations were performed to cover the expected range of hydrological conditions. The Commercial Navigation, Recreational Boating and Environmental TWGs have accessed the hydrodynamic simulation data to this point.

Lake Saint-Louis Reach: The model developed for Lake Saint-Louis was refined and calibrated/validated with current measurements in the field acquired in spring and summer of 2002. Hydrodynamic simulations were presented for the spring and summer of 2002 and for 13 scenarios covering the majority of open-water conditions.

A refined mesh containing 37,720 elements and 78,367 nodes was built and used to model the water levels, flows and currents of Lake Saint-Louis. An analysis of the hydrological complexities in terms of both water levels and discharges was produced. The comparisons of velocity vectors show that the model properly reproduces velocity patterns in Lake Saint-Louis. The simulations of the scenarios show that the hydrodynamic field of Lake Saint-Louis is quite varied. This variety is characterized by the presence of the commercial ship channel, large shallow areas, Beauharnois power dam, the Saint-Anne and Vaudreuil channel upstream and Lachine rapids downstream. These simulations were used in integration of the physical component of biological studies as well as to better understanding physical process in the Lake Saint-Louis area. They were also used by the Commercial Navigation, Coastal and Water Uses TWGs.

4.7.5 Water Temperature Modelling

The objective of this work is to develop and make operational a tool or suite of tools capable of computing the water temperature regime of Lake Ontario, the Bay of Quinte and the upper St. Lawrence River. The water temperature model(s) were to be applied to develop several time series of water temperature data that in combination with water level data will be used by the Environmental TWG to assess the impact of regulation on the fish species in the region.

4.8 INFORMATION MANAGEMENT

Information and databases produced by the Study to date can be categorized into the following:

- Geospatial data in the form of aerial imagery in digital form, elevation data including bathymetry and topography, cultural features like transportation, property parcels, etc., and environmental datasets like wetlands extent, composition and diversity;
- Time-series datasets in the form of weekly and monthly water levels on Lake Ontario and along different reaches of St. Lawrence River, flows in the river, water supplies, and wave information;
- Technical Reports, newsletters, questionnaires, Study reports and other documents;
- SVM and plan formulation results, inputs and outputs for other models, i.e., for hydrologic, coastal processes and environmental; and
- Multimedia presentations and graphics.

Over the three years of the Study to date, data and information about the Study is growing at an enormous rate. The result is that specific data and information can be difficult to find, and risks of duplicating and misinterpreting information increases. Significant time has been engaged by Study participants in creating “metadata” which catalogues the characteristics, history, appropriateness of use and other salient properties of the Study’s information resources.

The target users for Study information can be categorized as:

- Study personnel, including TWGs, Study Board and PIAG members;
- Commissioners and staff of the IJC;
- The public and specific interest groups;
- Federal, state, provincial and municipal agencies;
- Academic, research and environmental interest groups;
- Elected representatives; and
- Media.

A distributed Internet-based information system has been implemented by the Study based on three primary computer nodes, one in Ontario, one in Quebec and one in the U.S. This system provides access to all Study information resources in an integrated fashion including searching for all documents compiled by Study participants. Databases are stored on the three primary computer nodes, which also provide for web-based geographic information system (GIS) mapping capabilities. Information used to develop the Study’s SVM is linked through this

distributed network of computers. Figure 11 is a schematic. which showcases this distributed information management strategy.

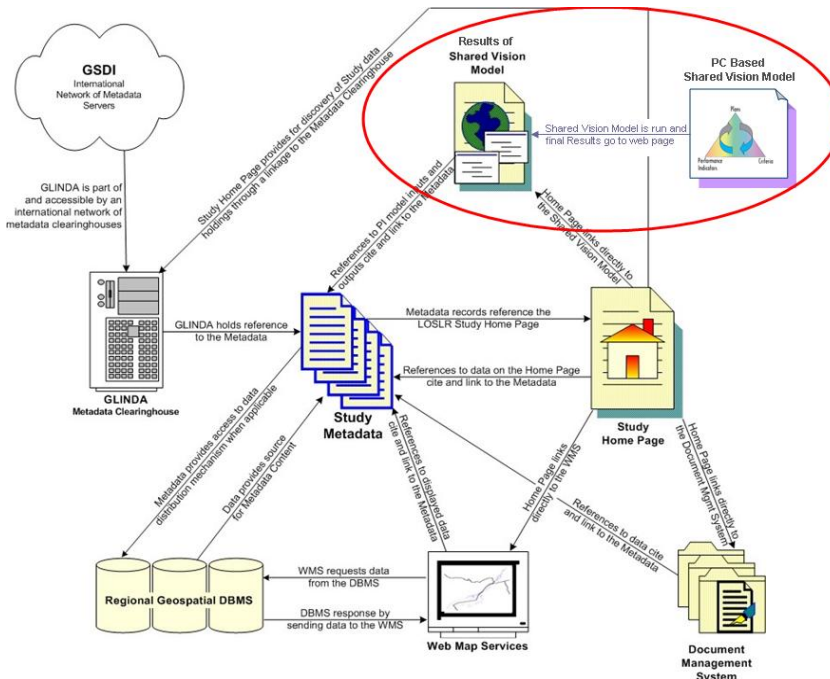


Figure 11. Information Management Strategy Schematic

Through the remainder of the Study, the distributed information management strategy will provide for the storage, retrieval and sharing requirements for all user groups. Continuation of the data sharing relationships after the Study should provide substantial benefits to operational outflow management and ecological protection and restoration across the system.

The distributed information management model permits “drilling-down” through various levels of information to provide links between regulation criteria and SVM results, PI, technical analyses and scientific reports. Figure 12 showcases a series of integrated information queries that can be facilitated by the Study’s information management strategy.

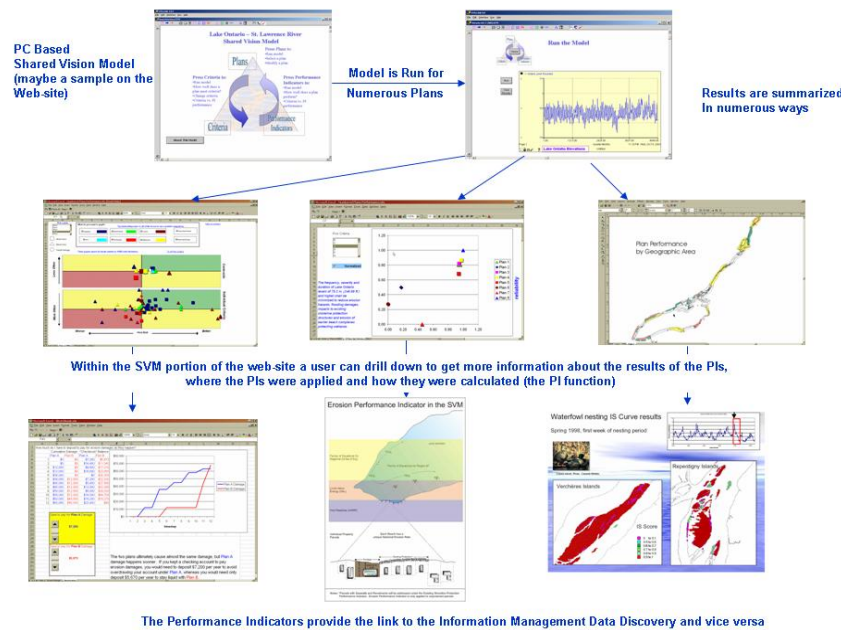


Figure 12. Series of Integrated Information Queries

The information management strategy employed by the Study provides for a high degree of transparency and accountability. All decisions made by Study participants can be tracked back to the basic information from which it is derived. The strategy also provides a strong basis for longer-term sustainability of the information once the Study is completed.

Challenges remaining to fully implement the Study's information management strategy have been identified as:

- Populating the document management system with all new published products created by the Study;
- Compiling all needed metadata for Study datasets, documents and output products
- Compiling a comprehensive information catalogue of Study products and identifying long-term information stewards after the Study;
- Promoting the implementation of formal information sharing agreements between U.S. federal agencies, New York State departments and Ontario and Quebec provincial ministries to continue the functionality of the system after the Study is completed; and
- Engaging and educating end users about how to search for information, evaluate its utility and access desired information.

4.9 ECONOMICS ADVISORY GROUP

In Year 2, the Study Board established an Economics Advisory Committee (EAC) to provide expert advice on the role of economic analysis in the Study. The Committee reports to the Study Board through the PFEG, and is comprised of four professors of economics, two from the United States and two from Canada.

The EAC was asked to determine the degree to which economic models and metrics can be used to rank plans and advise on suitable methods, metrics and procedures to support them. In addition, the economists review the various economic evaluation strategies and provide guidance and expertise to ensure that an unbiased and consistent approach is used.

4.9.1 Standards and Guidelines for Conducting Economic Analyses

To ensure defensibility, internal consistency and objectivity in the economic analyses being conducted by the TWGs several members of PFEG drafted a set of “Standards and Guidelines for Conducting Economic Analyses.” Over Year 3, the EAC provided advice on these Standards with significant progress made by the fall of 2003 in resolving outstanding questions. Drafts of the Standards were presented to the Study Board in May and December 2003 (*PFEG, December 2003*).

Among the more than ten standards and guidelines, it was decided that the overall analytical focus of studies should be on assessing the net marginal changes in economic well-being at a bi-national scale that would result from adoption of an alternative plan to Plan 1958-D with Deviations. TWG studies have used a partial equilibrium approach to analyze how these alternatives can be expected to affect benefits and costs. This means the TWGs are assessing those markets, which are directly affected by a change in water levels (e.g., damage to a house due to flooding), but they are not assessing secondary markets such as the increased demand of carpet cleaners following a flooding event. Willingness-to-pay was adopted as the primary method of measuring economic value such as the value of being able to boat more days of the year. The Standards also permit secondary methods, such as the replacement-cost method, to be used. (e.g., the value of eroded sediment to a beach may be assessed by the cost of trucking in sand).

Since the Recreational Boating TWG has responsibility for both recreational boating and tourism, it was decided that the group should proceed with a formal analysis of both direct effects, as well as indirect effects, i.e., economic impacts in primary markets such as marinas and secondary markets such as employment in a tourist area. To ensure that all TWGs address the issue of economic impacts, during Year 4, the TWGs will prepare “contextual narratives.” Each contextual narrative will set out past trends and existing conditions in the respective sectors and include an analysis of future trends.

Among the more challenging points in the Standards has been how best to deal with time. The question of the value of delaying costs to some future time is central to economic theory. There have been numerous discussions of how expected future dollar benefits and costs should be discounted to express them as present-day values. The advisors and TWG chairs recognize that simulations using historic 20th century hydrology are not meant to predict when recession will occur in the future, only how much recession would occur given the particular sequence of simulated lake levels. The notion that some plans are likely to delay recession is important to shoreline property owners. The question is, how do we calculate expected average annual damages? This issue remains outstanding and will be addressed by the EAC in Year 4.

Another key discussion was whether all dollars were equal and could be added. It was concluded that TWG estimates are potentially equal if estimates are expressed as average annual expected values, and key assumptions are transparent. A further question that will be dealt with is whether the findings from the Recreational Boating TWG economic impact analysis can be equally compared with benefits and costs estimated by other TWGs. PFEG will continue to work with the EAC and the TWGs on this issue in Year 4.

4.9.2 Environmental Valuation and Tradeoff Analysis

Not all PI being assessed within the Study are easily expressed in dollar terms. Unpriced or non-market values such as recreational experiences, beach going, and the services provided by wetlands are not easily quantified in terms of dollars. One question that the Study Board, PFEG, the EAC and Environmental TWG has wrestled with is the merits of conducting studies to estimate people's willingness to pay, in dollar terms, for changes in environmental quality that could be expected to occur if an alternative set of criteria or regulation plan are adopted. The Environmental TWG has clearly and forcefully stated to the Study Team and Board that they are categorically opposed to converting or viewing environmental benefits, dis-benefits or concerns and issues in dollar value terms. The Study Board has accepted this position.

A contractor was retained to examine the feasibility of carrying out an environmental valuation study. Two studies were recommended: a stated-preference study of environmental processes involving criteria with high opportunity costs (e.g., permitting lake levels to follow long-term cycles a little more closely), and a stated-preference study of people's willingness to make tradeoffs across all the sectors. The contractor's recommendations were presented to the Study Board in September 2003.

The Study Board chose not to proceed with these studies agreeing to continue to value both commensurate and non-commensurate impacts. The Board opted to develop a tradeoff procedure for assistance in revealing acceptable tradeoffs, where expected outcomes are expressed in incommensurable units, e.g., dollars benefits and costs, and environmental effects. Across a range of criteria and plans, revealing tradeoffs that are acceptable will be challenging, and work on this procedure will continue through Year 4.

5.0 NATIVE PEOPLES/TRIBAL ISSUES

Several Native Peoples and Tribal communities are located on the shorelines of Lake Ontario and St. Lawrence River Study area. The Mohawk people of St. Regis and Akwesasne live on and adjacent to a considerable length of River shoreline in the vicinity of the Moses-Saunders dam. The Mohawks of Kahnawake live on the southeast shore of Lac St. Louis. The Tyendenaiga community has Lake Ontario shoreline in the Bay of Quinte area.

Over the years, the Mohawk people of Akwesasne have been very concerned with the quality and quantity of the water, which flows through their Territory. In December 2003, the Akwesasne Task Force on the Environment (ATFE) was asked to address the issue of establishing criterion for the maximum preferred hydrology levels for the Territory of Akwesasne. The approved work included a participatory process of interviewing community members regarding the control of water levels, and also a review of literature focusing on three areas: (1) environment, (2) recreational boating, and (3) shoreline erosion.

This work involved a grassroots participatory process that offered an opportunity for the Study Board to gain insight into the relationship that the residents of Akwesasne have with the river. Various studies were reviewed to ascertain the types and variety of habitats extant in and around Akwesasne. In addition, the experiences and observations of over sixty individuals were documented to obtain more precise empirical data on varying water levels and the impact on shorelines, the environment and recreational boating.

The report generated by the ATFE study (*Akwesasne Task Force on the Environment, March 2004*), describes the types of soil, aquatic and terrestrial habitats, including types of shorelines, species of fish, mammals, birds and trees that are both in existence and that are of cultural importance to the people of Akwesasne. Interspersed throughout the report are citations reflecting the kinds of cultural practices and uses the environment provided prior to the construction of the St. Lawrence Seaway and Power Project. The report describes the fundamental cultural changes that have resulted from the construction of the Seaway and the operation of the Moses-Saunders Powerhouse.

PI are an integral part of the SVM in the evaluation of alternative regulation criteria and plans. With this in mind, the ATFE developed an extensive list of performance and cultural indicators that are pertinent to the Akwesasne Community. In terms of erosion and flooding, PI included:

- Total area of farm and pastureland lost;
- Total area of islands lost;
- Decrease in habitats for aquatic and terrestrial wildlife;
- Decrease in habitats for threatened and endangered species;
- Total area of land lost in the Tsi Snaihne area – farm, pastureland and roadways;

- Total amount of loss of woodlots containing black ash, white ash, poplar, elms, oak, willow, basswood, soft maple and white birch;
- Total number of homes with resultant structural damage;
- Total loss of infrastructure, such as community roads;
- Loss of opportunities for recreation and socialization at beaches;
- Cost associated with repair of existing/ providing new shore protection; and
- Turbidity in terms of decreased water quality.

In terms of the environment, PI include:

- Surface areas of large wetland plant classes – deep and shallow marshes;
- Production of submerged and emergent vegetation;
- Emergent vegetation in marsh areas in summer months and cattail brushes in marshes in winter months;
- Progression of Purple Loosestrife and *Phragmites australis*;
- Surface area of emergent wetlands;
- Declining marsh area as a function of low water levels, especially in winter;
- Decrease in the number of harvestable medicinal plants;
- Population trends of indicator endangered species, nest survival due to flooding and due to fluctuating water levels – black terns and American bitterns;
- Diversity of wetland bird assemblages;
- Wetland bird brooding, migration, nesting success and total nesting habitat and productivity;
- Suitable habitat areas for reptile and amphibian indicator species, e.g., Blanding's turtle;
- Muskrat and muskrat lodge losses due to flooding/stranding events;
- Turbidity impacting minnow habitats;
- Suitable habitat areas for various fish species including lake sturgeon, walleye, yellow perch, bass, muskie, long nose gar, sunfish, crappie and bass;
- Suitable habitat areas for American eel;
- Success of spawning as a function of shoreline protection and silting;
- Fish and invertebrate species diversity and of organisms of particular value to the Mohawks of Akwesasne;
- Impact of fluctuating water levels on growth of hazelnut trees;
- Preferred habitat areas for plant species at risk; and
- Potential egg mortality of fish species at risk.

In terms of recreational boating, PI include:

- Economic damages to marinas and docks; and
- Economic damages to small boats as a result of shoals and sand bars occurring with low water levels.

In terms of municipal water, PI include:

- Increased costs to water treatment plants during low water levels;
- Increased pumping costs of municipal water supply systems during low water levels; and
- Increased costs to people with shorewells and water lines during low water levels.

Cultural indicators:

- Increase in the use of and access to aboriginal territory within project lands, as seen in boat launches above the Dam;
- Decline in the number of trappers, e.g., muskrat trapping;
- Loss of habitat of bullheads and related socio-cultural impacts to the Mohawks;
- Loss of cultural knowledge; and
- Access to public areas for swimming.

All of the above indicators are considered a direct function of high and low water levels, and in many cases related to the peaking and ponding operations of the Moses-Saunders powerhouse. Water level fluctuations are important to Native People and construction of the Seaway and Power Project has had a serious impact on the lands and people of the Akwesasne Mohawk Territory. The ATFE report suggests that water levels be maintained which enhance and sustain bio-diversity. Ideally the community prefers levels similar or as close to natural cycles as possible prior to Seaway construction. However, levels that are the same as occur presently or decreased levels can be tolerated. Dependable ice formation to guarantee strong ice bridges for individual travel between islands and mainland was noted.

Since peaking and ponding has a profound impact on community members living in proximity of the powerhouse (a decrease in level of 0.5 m (1-1/2 ft) over a twelve-hour period), operational aspects of any alternative regulation plan will be considered prior to Study completion.

A separate study was conducted by Pacific International Engineering (PIE) investigating the impacts of ship vibrations on erosion of community lands (*Pacific International, February 2004*). The ATFE report also cited increased seismic annoyance of homeowners on islands due to ship vibrations during high water levels. The PIE study found that there might be a linkage between ship-induced vibrations and bank slumping at the southwest corner of Cornwall Island. A vibration monitoring program along with an assessment of soil conditions in the affected area would be required to properly quantify the magnitude and extent of this problem. However, the range of water level scenarios presently being considered and resulting from any alternative regulation plan, in terms of changes in water levels and velocities are not expected to have a significant effect on these processes.

The Kahnawake Territory on the south shore of Lac St. Louis have been considerably affected by the St. Lawrence River Seaway Project with most of their community being separated from the River by construction of the Seaway ship canal along the south shore of Lac St-Louis leading to the St. Lambert lock. The community still has some limited access to the river, with docks used by the Onake Canoe Club. Low rather than high water levels are the prime water level concern of the people of Kahnawake. Ideal water levels for canoe club facilities were determined to be in the range of elevation 21.6 m (70.87 ft). Lac St. Louis water levels in the vicinity of or below elevation 20.7 m (67.91 ft) cause problems for the community. The water intake for the community water supply is also compromised during very low river water levels. No direct contact with or concerns about Lake Ontario water levels have been registered by the Tyendenaiga Community.

6.0 NEXT STEPS – TO STUDY COMPLETION

With data collection and most of the “science” work now complete, the path to Study completion can be categorized into five steps: consultation, completion of the SVM, formulation, assessment and selection of alternative regulation criteria and plans, reporting out on Study results, and archiving of all Study information.

6.1 Consultation

Extensive consultation will be undertaken throughout the Study Years 4 and 5 with agencies, organizations and institutions that have mandates related or linked to water levels and flows, with stakeholder groups in the Lake Ontario-St. Lawrence region, with interested and affected individuals and groups, with elected representatives, and with any other group or individual with an interest and viewpoint on the subject.

Good linkages and briefings by the Study team members have now been made with the many agencies, stakeholders and interest groups, for example the New York State Department of Environmental Conservation, U.S. Army Corps of Engineers, Environment Canada, Environment Quebec, Nature Conservancy, Lake Ontario Lakewide Management Plan, International St. Lawrence River Board of Control, Great Lakes/St. Lawrence Seaway Study, IJC Commissioners, and others too numerous to list without the risk of omitting some.

Briefings of groups will be held, for example, with the International Water Levels Coalition, to assure that the development and evaluation of plans is inspired by the knowledge and views of these organizations; with representatives of the Montreal Metropolitan Council to keep them informed on the issues for drinking water in Montreal during extreme droughts; and with electrical power authorities on the low water issues for the Ginna and Russell power plants in New York State.

The Study Board, the PIAG and TWG representatives will support intensive consultation and outreach through to the delivery of the final report to the IJC in October 2005 and after that time as required by the Commission.

6.2 Completing the Shared Vision Model

It is expected that all PI will be incorporated into the SVM by the October 2004 Study Board workshop. The historic and possible future hydrologic data sets should be installed in the SVM by late summer 2004 and verified by the October workshop. There may be some PI that are not completely finished by October. At this point the only concern is about the Lake Ontario fisheries indicators, and steps have been taken to assure that some reasonable representation of the effects of water levels on Ontario fisheries will be included in the SVM by October.

Portions of the SVM used in ranking and tradeoffs will also be revised for October 2004 based on results from the new PI and the responses to the tradeoff and ranking presentations at the March 2004 workshop in Toronto. This portion of the model is likely to change between October 2004 and the end of the Study as the Board and the public view on tradeoff philosophy evolves.

6.3 Formulation, Assessment and Selection of Criteria and Plans

As the modeling of PI comes to a close, the modeling of regulation plans will gather momentum. Four approaches are being pursued: optimizing (selecting releases that maximize all or some PI), modifications to the current plan 1958D, modifying “unregulated” releases, and using plans suggested by others.

The optimization of Lake Ontario outflow releases for recreational boating, hydropower, coastal and commercial navigation interests is underway. Domestic, municipal and industrial water use concerns will probably be used as limiting factors, since most conditions are good for most PI. It is not yet clear how environmental PI can be used in plan optimization, but as those indicators are modeled that will be clarified. The optimization work will show where changes to releases are most likely to increase performance, so that attention can be focused on appropriate modifications to the existing plan and the unregulated condition. The Study Team will continue to work with stakeholders and others who have ideas for regulation plans with the intent to translate those ideas into computer code that allows the evaluation and improvement of those kinds of plans.

Using the triangulation approach, plan formulation and evaluation will be used to sharpen and simplify the list of criteria that have been developed to date. Modified criteria sets will be defined and refined, with justification for each based on plan evaluations using PI.

New regulation plans will be formulated after the October 2004 workshop for consideration in January 2005. By March 2005 most of the plan formulation work will be done, and the capacity to modify plans in response to public comment will be kept in place.

6.4 Reporting Out on Study Results

Following a series of public meetings and consultations in June and July 2005, the Study Board will complete and deliver the final Study report to the Commission by October 31, 2005. All Study reports are and will be publicly available through the Study Website at www.losl.org.

6.5 Archiving Study Information

It is not yet clear how the huge volume of Study information, data and reports will be archived for future access and use.

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