SCOPING OF AN ENVIRONMENTAL ICE EFFECTS STUDY: A CASE STUDY ON THE ST. LAWRENCE RIVER

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ABSTRACT

The many factors involved in ice cover formation processes on a river system and their influence on fish habitat in the littoral zone is a complex subject. Using a case example at the R.H. Saunders / St. Lawrence Franklin D. Roosevelt Generating Stations on the St. Lawrence River, located near Cornwall, Ontario and Massena, New York, the Power Utilities (Ontario Hydro and The New York Power Authority) have gained experience in scoping an ice study to determine: the ice cover characteristics in the upstream reach of the station (the reservoir); and, the potential effects of shoreline lateral ice movement on the aquatic environment resulting from river water level fluctuations. The St. Lawrence River is an International river between Canada and the U.S.A. and is regulated by the International Joint Commission's (IJC) St. Lawrence River Board of Control.

This paper reviews the operations of the R.H. Saunders / St. Lawrence F.D.R. Generating Stations and the regulation of Lake Ontario to give an overview of how water levels in the reservoir are managed. Since there are a number of natural and person-made factors which may influence winter water level fluctuations, an environmental ice effects study was designed. The objective of this study was to assess whether winter water level fluctuations affect winter shoreline ice action, and

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to determine the subsequent impacts of shoreline ice movement on fish habitat in the littoral zone.

Although the environmental ice effects study was not conducted, this scoping exercise did provide insights to the safety concerns involved with working during winter conditions and the logistics in implementing an environmental ice programme on a large river system.

INTRODUCTION

The paper presented this afternoon is entitled "Scoping of an Environmental Ice Effects Study: A Case Study on the St. Lawrence River".

We would like to take this opportunity to thank the staff from the New York Power Authority at the St. Lawrence - F.D.R. Power Project, especially Ms. Denise Bisnett and Mr. John Bartholomew. We would also like to thank the following staff from Ontario Hydro: Mr. Tom Wigle, Mr. Bob Metcalfe, Mr. Rob Carson for scoping the ice study tasks.

The main reason for the decision to present this scoping paper today is to elicit comments from the experts in this room today. I would like to start by providing to you a brief history of events that lead to the formulation of this Pilot Scope of Work pertaining to ice effects on the natural environment within our study area. In May, 1991, the IJC approved the International St. Lawrence River Board of Control's recommendation that peaking and ponding operations at the R.H. Saunders / St. Lawrence - F.D.R. Power Dam be permitted to continue (Figure 1).

In addition to a number of other recommendations, the IJC also requested Ontario Hydro and the New York Power Authority to prepare a scope of work to establish whether the reported adverse effects on fish and wildlife habitat resulting from water level fluctuations were significant.

The first step in the scoping process was to identify the specific environmental issues raised by both the United States and Canadian government regulatory agencies with respect to Lake St. Lawrence, upstream of the Power Dam (Figure 2). Through a number of discussions with the Ontario Ministry of Natural Resources, Environment Canada, Department of Fisheries and Oceans, and the New York Department of Environmental Conservation, four main issues emerged, these being:

1.0 <u>Fisheries:</u> Overall biological productivity in the study area littoral zone is purported to be low relative to other areas of the St. Lawrence River, and populations of aquatic macrophytes attached to the substratum (i.e., emergent, floating-leaved and submersed macrophytes) ranged from low to non-existent. This observation can be translated into the absence or reduction of suitable fisheries habitat required for spawning and/or nursery areas. The following species were identified as important to the area:

Northern Pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Smallmouth Bass	*Micropterus dolomieui*
Bullhead	*Ictalurus nebulosus*
Yellow Perch	*Perca flavescens;*

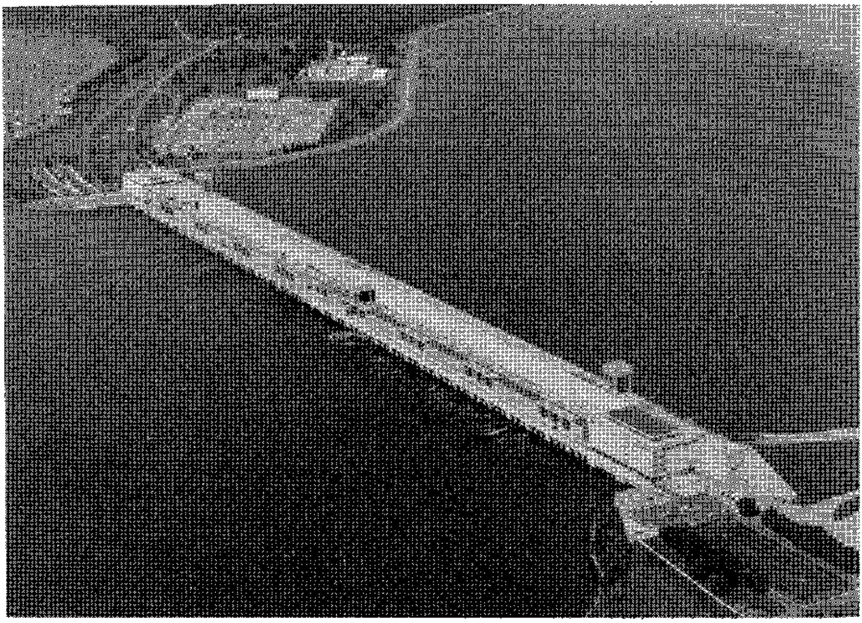
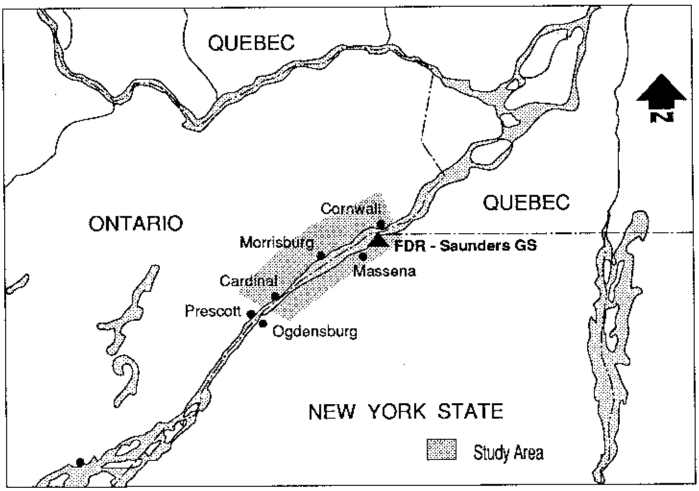


Figure 1. Aerial photograph of the St. Lawrence - Franklin D. Roosevelt / R. H. Saunders Power Dam. Lake St. Lawrence is seen in the top right. The St. Lawrence - FDR Power Project (N.Y.P.A.) is located at the top left and the R. H. Saunders Generating Station (Ontario Hydro) in the lower right.

2.0 Wetlands: Wetlands in the area are being affected by rapid, acute variations in water levels;

3.0 Resource Use: Water level fluctuations are a source of concern with respect to recreational boating. Shore bases can become isolated and often inaccessible resulting in shore dredging or dock construction. This, in turn, leads to the further destruction of aquatic habitats; and of importance to these proceedings,

4.0 Ice Effects: Winter water level fluctuations may cause an upward movement of the ice foot which results in the up-rooting of aquatic macrophytes in the littoral zone of the river and along the shores of wetlands. The "ice foot" is defined as the zone of grounded ice which incorporates frozen sediments and extends into the shoreline edge. It has been suggested further that the concomitant reduction in attached littoral zone macrophytes may result in increased rates of shoreline erosion along the river due to river bank destabilization.



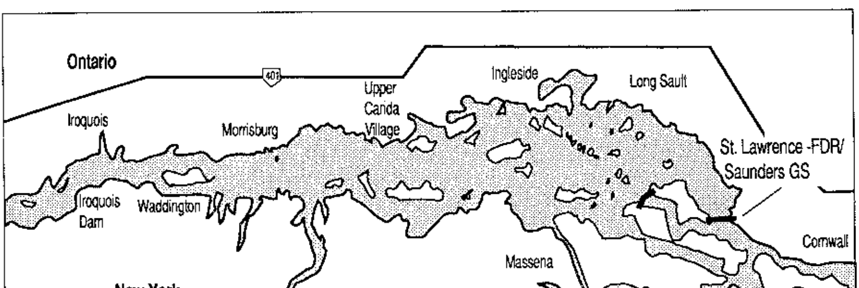


FIGURE 2
Study Area for the Effects of Peaking and Ponding
On the Natural Environment

A complete, multi-phased scope of work was presented jointly by the New York Power Authority and Ontario Hydro to both the International St. Lawrence River Board of Control and the IJC in 1992. At present, we are completing the first phase of this Scope of Work which is a historical hydraulic analysis of Lake St. Lawrence, including analyses on the incremental effects of each factor (man-made or natural) that contributes to water level fluctuations in the lake. We will be presenting these findings to the Board and the IJC in the near future and their recommendations could dictate our future study designs.

However, it is to this last issue on ice effects that is the focus of today's paper. I would like to emphasize that we have not as of yet started this study and our efforts so far have been focussed on scoping. However, the experience gained through the scoping process did provide insight to the safety concerns and difficulties of working in winter conditions.

OBJECTIVES

The objectives of this proposed ice study are:

- To develop a methodology to monitor the effects of Lake St. Lawrence and the St. Lawrence River ice characteristics on the aquatic environment within the littoral zone;

- To relate ice action on shorelines to hydraulic conditions (specifically peaking and ponding operations), meteorologic conditions and shoreline characteristics (geometry and material, vegetation);

- To determine the effects of peaking and/or ponding operations on ice formation, movement, morphology and break-up relative to ice not affected by peaking and ponding;

- To determine the degree of effect "peaking and ponding" ice has on fisheries habitat relative to ice not affected by peaking and ponding; and,

- To identify the needs and additional requirements (parameters, locations, measurements, equipment, analyses, etc.) for a future intensive program.

Before getting into the "core" of this study proposal, it is appropriate at this point to define peaking and ponding and to discuss the basic hydrology of the Lake St. Lawrence study area.

Peaking and Ponding (Figure 3) are defined as:

PEAKING: Is the variation of the flow about the daily mean flow so that the total daily flow is equal to that which would have occurred had the peaking not taken place.

PONDING: Is the variation of the daily mean flow about the weekly mean flow so that the total weekly flow is equal to that which would have occurred had the ponding not taken place.

The effect of peaking and ponding would be fluctuations in water level about the daily and weekly mean levels. Suffice it to say that the value of peaking and ponding operations can be described in qualitative terms as it relates to the ability of a Power System to meet the daily peak pattern of electricity demand while optimizing economics and maintaining security of supply.

The Power Dam's headpond, aptly named Lake St. Lawrence, is unique in the Great Lakes - St. Lawrence River system due to it's large annual water level fluctuations varying by up to 2.75 m on an annual basis, the management of the ice formation process, and its relative newness, having been created when construction of the St. Lawrence Power project was completed in July, 1958. The variation in water levels in Lake St. Lawrence is greater than for other areas of the system since the Power Dam is used to regulate the level of Lake Ontario which is located approximately 210 km upstream.

Lake St. Lawrence is not operated as a typical hydroelectric reservoir. The Power Dam operates primarily as a "run-of-the-river" facility and as such, the outflow of Lake Ontario is passed without storage in Lake St. Lawrence. Peaking and ponding operations deviate from a strict interpretation of this principle, but the amount of water and duration of storage is minimal. To put it in perspective, smaller systems rely on the spring freshet to fill the reservoir, and draw from this storage capacity to augment summer, fall and winter outflows when supplies are typically less. In the case of the St. Lawrence system, the seasonal drop in elevation of the St. Lawrence River is the result of "energy losses" due to the seasonal lowering of Lake Ontario, roughness of the river bottom, and the formation of an ice cover which increases channel roughness.

There are a number of factors, both natural and person-made, which contribute to the water level fluctuations observed in Lake St. Lawrence.

Natural Factors: Natural factors include seiches due to sustained high winds, rapid barometric pressure changes, and ice formation. Seiches may cause water level variations on Lake Ontario as well as raising or lowering the water level at the Power Dam above 73.76 m or below 72.39 m, the normal daily operating limits. This

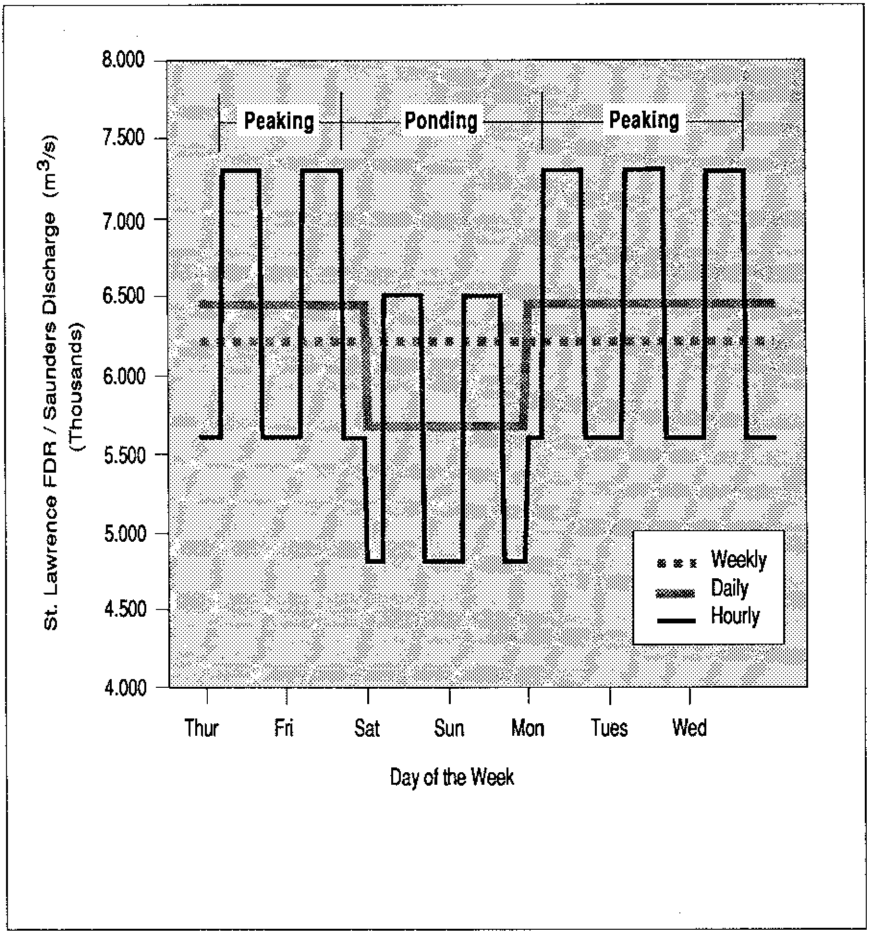


FIGURE 3
St. Lawrence Peaking and Ponding Operation

occurs several times a year, usually during the spring and fall. It can last from several hours to several days. Once an ice cover has developed on the river, this rarely occurs. Remedial action for low levels requires a flow reduction to stabilize water levels. Two actions can be taken to lower high Lake St. Lawrence levels: either by a flow increase through the Power Dam or by lowering the vertical gates at the Iroquois Dam. Lowering the gates is done when the high elevations are forecast to last several days.

In winter, an ice cover forms on the St. Lawrence River from Kingston to the Power Dam, except at the high velocity reaches below the Ogdensburg-Prescott ice boom, and below Iroquois Dam. Since ice increases frictional loss, the slope of the water surface between the downstream end and the upstream end becomes steeper. To discharge the regulated outflows, the fall between Kingston and the Power Dam could be as much as 2.5 m with an average flow of 6,650 cms in January and February.

Ontario Hydro's and the New York Power Authority's successful management of the ice cover formation minimizes the frictional losses and thus the head loss. Nevertheless, during a severely cold winter, excessive formation of ice increases the frictional losses and has caused the level of Lake St. Lawrence to fall to its absolute minimum level of 71 m. In such a case, the outflow must be reduced to match the capacity of the river and prevent the level from falling further.

In the spring, the level of Lake Ontario is generally in the upper part of its range, usually reaching its peak elevation during June. Throughout the summer and into the fall, the level gradually declines due to reductions in rainfall. The level of Lake Ontario declines to its minimum during early-winter. Subsequent to this, the level begins to increase because of reduced outflows caused by ice effects in the St. Lawrence River. In spring, freshet causes the Lake to rise further, where annual variations can be as much as 2.75 m.

Person-made Person made factors affecting water level fluctuations include IJC Regulation and the Power Utilities peaking and ponding operations. Since 1960, Lake Ontario levels and outflow have been regulated. In April 1963, the IJC and the federal governments of the United States and Canada approved the use of Plan 1958-D for the regulation of water levels and flows, aimed primarily toward managing Lake Ontario levels and navigation through the St. Lawrence Seaway. Lake Ontario levels vary from year to year in reaction to the trend of high or low supply conditions. They also vary from season to season in reaction to the seasonal supply conditions. However, the seasonal variation is normally about 0.6 m within the specified overall range. The regulated outflow from Lake Ontario is adjusted weekly according to Plan 1958-D, although deviations from the Plan are occasionally made.

Water level changes can also occur when water is taken out of Lake St. Lawrence during the day and replenished at night to follow the daily demand for electrical power. The range of peaking varies inversely with the regulated outflow: the higher the outflow, the lower the range of peaking. The greatest variation in water levels created by peaking and ponding is in the immediate vicinity of the Power Dam. The magnitude of the water level variation diminishes with distance from the dam and is directly proportional to the magnitude and duration of the peaking and/or ponding operation. Peaking and ponding can occur individually or simultaneously and can be of varying magnitude. During storms, the effect of peaking and ponding could also intensify or offset the seiche effects. As mentioned previously, we are looking at the incremental effects of both peaking and/or ponding on water level fluctuation relative to fluctuations from all other sources.

STUDY AREA:

Based on preliminary field reconnaissance conducted in December, 1991, four experimental sites and two control sites for conducting ice field studies were identified within the study area (Figure 2). The two experimental sites located in New York are Brandy Brook Bay and Cole's Creek. The two experimental sites located in Ontario are Hoople's Bay, which abuts a Provincially significant wetland, and Upper Canada Village. These four sites are known to be fisheries spawning and nursery areas. The two controls, identified as areas where there are no peaking and ponding influences on ice conditions, are located in the Wilson Hill State Fish and Game Management Area in New York and Aultsville Creek in Ontario. Ice effect studies on the aquatic environment will be restricted to the upstream reach of the Power Dam.

METHODS:

Reference marks will be established at field sites for horizontal and vertical survey control. Temporary bench marks can be tied to nearby permanent bench marks if necessary, although assumed datum should be adequate to determine elevation changes. Transect alignment will be established from reference marks located onshore.

Since the ice surface is repeatedly flooded by fluctuating water levels, the snow cover can be wet or frozen. Wet and dry snow depth to the top of the ice cover will be measured directly at locations where ice thickness is measured along the transects. A measuring staff will be frozen into the ice cover to measure the increase in ice cover thickness from freezing of the snow cover. The top and bottom of the ice cover and the water level will be referenced to the measuring staff elevation. If sufficient depth of unsaturated snow covers the ice, a standard snow core sample will be taken to determine snow and water equivalent depths.

Ice: The study parameters and procedures included in this pilot programme for the ice study are as follows:

- One transect will be randomly located at each sample site from elevation 75 m to 68 m or until the river bed levels off. The lower elevation goes beyond the littoral zone depth of 2 m below low water level (absolute minimum 71.02 m);

- Water levels at initial and subsequent formation of ice shoreline contacts;

- Water levels throughout peaking and ponding cycles (weekly) and throughout the winter season;

- Solid ice cover thickness, formation processes and ice characteristics including type, thermal and slush (frazil, snow and/or broken pans) ice composition, ice coring;

- Slush thickness under solid ice cover;

- Snow cover and flooding/freezing;

- Hinge characteristics, including number, length and thickness of links, location of hinge cracks related to formation water levels and peaking/ponding water level cycles, vertical and horizontal movement and evolution of links (flooding/freezing and thickening) and the floating ice cover offshore;

- Nature of shoreline contact and bed freezing, bank material type, sediment grain sizes and slope, freezing of ground above water level;

- Vegetation under cover and freezing into cover;

- Flow velocity under ice cover throughout the peaking/ponding cycle; and,

- Grounded ice mapping.

Environmental: Study parameters and procedures included in this programme for the environmental study are as follows:

- Physical water quality parameters;
    - pH
    - temperature and temperature profile
    - conductivity
    - alkalinity/hardness

secchi depth
turbidity
dissolved oxygen

- Aquatic habitat mapping;

- Macrophyte collection, identification and location;

- Macrophyte relative abundance;

- Benthic and detritus analyses;

- Sediment and macrophytes by species / m^2 grounded ice; and,

- Winter fish creel census at each site, if applicable.

Test Schedule and Frequency

Ice conditions will be monitored at each site through a full weekly schedule of peaking and ponding operation. At each site, on a daily basis, changes in water and ice levels will be monitored through the daily peaking cycle or in other words, the low and high water levels of the cycle. New York and Ontario will be monitored on alternate days. The field surveys will start on Wednesday and run through to the following Wednesday to complete the weekly cycle. A repeated daily peaking pattern at the St. Lawrence F.D.R. and Saunders Power Dam will be requested. In the event there are no ponding operations on Saturday and Sunday, field data collection will be initiated on a Monday and will continue until Thursday, i.e., two full peaking cycles in New York and Ontario.

Three sampling periods during the ice cycle be investigated:

1) post freeze-up/early winter
2) mid-winter (maximum ice thickness)
3) break-up

A fourth sampling period will be required to obtain environmental information, such as macrophyte abundance, during open water conditions immediately following break-up.

Within each period, the following schedule will be used:

DAY	ACTIVITY
Tuesday	Travel Day
Wednesday	Equipment Set-up and Testing
Thursday	Data Collection - Ontario (Peaking)
Friday	Data Collection - All New York (Peaking)
Saturday	Data Collection - All Sites (Ponding)
Sunday	Data Collection - All Sites (Ponding)
Monday	Data Collection - All Sites (Peaking)
Tuesday	Travel Day

AUTHORIZATIONS, PERMITS, PERMISSION

All necessary authorizations, permits and permission notes will be obtained prior to the commencement of any work. This includes Coast Guard Regulations, and permission to cross or use private property at each site.

SAFETY

Safety while working on or in the vicinity of the ice will be of extreme importance. All personnel involved in the ice studies will follow applicable federal, state, and provincial health and safety regulations, as well as the Power Utilities internal safety policies.

ANALYSES AND REPORT

Following the field surveys, the data will be analyzed and a report prepared with conclusions and recommendations. The surveyed ice cover characteristics will be documented. The effect of peaking and ponding on ice cover formation processes and shoreline ice action, including hinge development and evolution, will be determined. Finally, the effect of peaking and ponding on winter fish habitat in the littoral zone will be related to the shoreline ice regime. The need and scope for additional work will be outlined.