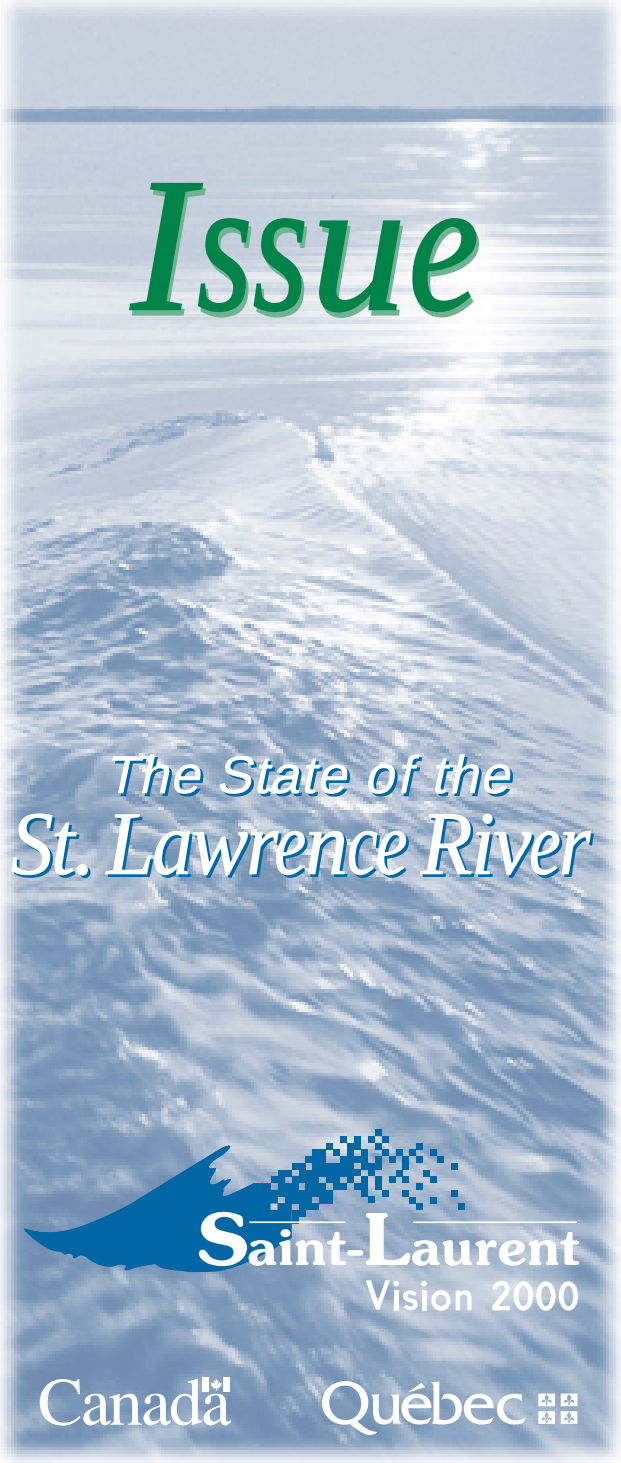



# Fluctuating Water Levels in the St. Lawrence River

The maintenance of certain natural components of the St. Lawrence River, as well as the development of a number of human activities, are dependent on particular water level conditions and may be compromised in the absence of these conditions. Fluctuating water levels have local, regional or global impacts and can affect various environmental components as well as a number of sectors of activity whose needs are often divergent and even contradictory. The management of St. Lawrence water flows and levels is therefore likely to give rise to conflicts in use and to both negative and positive impacts on the natural environment. Furthermore, this problem will probably become more acute during the coming decades, in light of the climate change which has already begun and the threat of diversions of water from the Great Lakes, which could significantly alter St. Lawrence water flows and levels.

This fact sheet presents the main findings of an examination of seasonal and interannual fluctuations in St. Lawrence water levels during the twentieth century and discusses the effects of these fluctuations on uses and components of the natural environment. It also identifies the most important initiatives that have been undertaken with respect to water levels, puts in perspective the role of global climate change and identifies remedial measures for maintaining the uses and components of the St. Lawrence from the standpoint of sustainable development. For further information and a more in-depth analysis of the problem, the reader may refer to the reports listed at the end of the fact sheet.

# Summary Analysis

## The St. Lawrence drainage system

Figure 1 presents the main aspects related to the issue of fluctuations in St. Lawrence water levels. It illustrates the complexity of the St. Lawrence drainage system, particularly in the Montreal region, where numerous regulating structures have been erected since the turn of the century.

Figure 1 also shows that the various uses that may be affected by fluctuations in water levels are not distributed uniformly along the St. Lawrence. For example, the Montreal region is particularly prone to the flooding of riverfront properties, while numerous spawning grounds along the shores of Lake Saint-Pierre require high spring water levels in order to be accessible to fish.

## The state of St. Lawrence water levels and factors influencing these levels

Many natural and anthropogenic factors influence water levels and their effects combine, making it difficult to establish causal links. Table 1 lists the main factors which determine St. Lawrence water levels and indicates the spatial and time scale of each factor's influence.

The relative influence of the various factors depends on the sector concerned. Table 2 provides additional information on this subject. It presents a summary of the findings concerning historical fluctuations in water levels and the factors influencing these levels in the various sectors of the St. Lawrence.

## The effects of fluctuations in St. Lawrence water levels

Seasonal and interannual variations in water levels have been observed, and these two types of fluctuations have an impact on the uses and natural components of the St. Lawrence.

Table 3 provides an overview of the impacts of fluctuations in St. Lawrence water levels on uses and environmental components. It also allows us to quickly assess the magnitude of the impact of high and low water levels on the St. Lawrence as a whole. For example, we can see that high levels cause losses ranging from minor to extreme for riverfront properties, while at the same time these high levels have a beneficial impact on commercial shipping and certain wildlife uses.

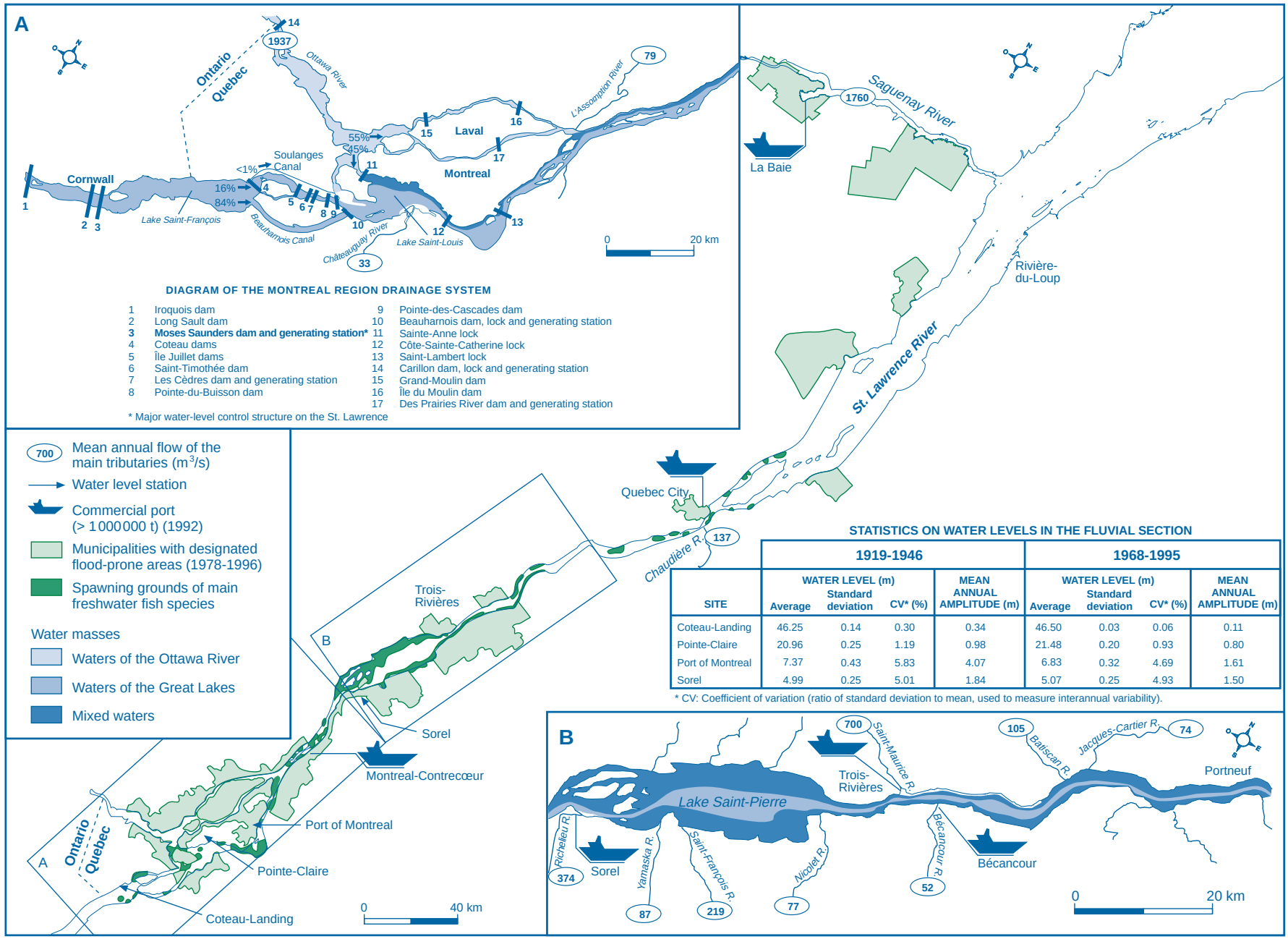
In general, the following two conclusions may be drawn:

- High water levels produce significant benefits for certain uses and environmental components and sometimes extreme losses for others.
- Low water levels have few positive impacts on uses and environmental components and produce negative impacts which can sometimes be significant or extreme.

## Ongoing initiatives

Table 4 lists the major initiatives taken with respect to the water levels of the St. Lawrence. They are programs aimed at water-level regulation or the adaptation of society to such fluctuations.

FIGURE 1 Main Characteristics of the St. Lawrence Drainage System and Identification of Certain Uses Influenced by Water Levels




STATISTICS ON WATER LEVELS IN THE FLUVIAL SECTION

| SITE | 1919-1946 WATER LEVEL (m) Average | Standard deviation | CV* (%) | 1919-1946 MEAN ANNUAL AMPLITUDE (m) | 1968-1995 WATER LEVEL (m) Average | Standard deviation | CV* (%) | 1968-1995 MEAN ANNUAL AMPLITUDE (m) |
|---|---|---|---|---|---|---|---|---|
| Coteau-Landing | 46.25 | 0.14 | 0.30 | 0.34 | 46.50 | 0.03 | 0.06 | 0.11 |
| Pointe-Claire | 20.96 | 0.25 | 1.19 | 0.98 | 21.48 | 0.20 | 0.93 | 0.80 |
| Port of Montreal | 7.37 | 0.43 | 5.83 | 4.07 | 6.83 | 0.32 | 4.69 | 1.61 |
| Sorel | 4.99 | 0.25 | 5.01 | 1.84 | 5.07 | 0.25 | 4.93 | 1.50 |

* CV: Coefficient of variation (ratio of standard deviation to mean, used to measure interannual variability).

Pressure

**Table 1 Description and Influences of Natural and Anthropogenic Factors on St. Lawrence Water Levels**

| Anthropogenic factors | Spatial scale | Time scale | Maximum potential change in the level of the St. Lawrence* | Comments |
|---|---|---|---|---|
| **Control of ice jams** | FS, FE | Hours/weeks | - 5 m (locally) | Canadian Coast Guard (CCG) vessels clear ice jams. |
| **Hydroelectric dams** Moses Saunders and Beauharnois | FS | Hours/months | 0 to + 0.2 m** (average annual amplitude reduced by a factor of 3 at Coteau-Landing) | Control water levels and modify seasonal flows. |
| **Navigable channel and dredging** (Cornwall to Île d'Orléans) | FS, FE | Permanent | Variable | Can decrease water levels near the shore. |
| **Diversions of water** | GLSLB | Permanent | - 0.5 m | The U.S. has multiple water diversion plans starting from the Great Lakes. |
| **Other mechanisms** | A | Variable | Less than ± 0.1 m | Other minor hydroelectric dams and other man-made structures (dikes at Sorel, construction of the Expo 67 site, etc.). |
| State **Natural factors** | | | | |
| **Tides** | FE, UE, LEG | Minutes/hours | + 6 m | The strongest tides are observed in the Quebec City region. |
| **Atmospheric pressure** | FE, UE, LEG | Hours/days | ± 0.5 m | This factor explains the annual maximum water level in the gulf in the fall. |
| **Wind** | A | Hours/days | ± 0.5 m | Significant effect, especially on the fluvial lakes and in the gulf. |
| **Ice jams** | FS, FE | Hours/weeks | + 5 m (locally) | Potentially dangerous phenomenon but controlled by CCG ice-breakers. |
| **Inflows from tributary rivers** | FS, FE, UE | Days/months | ± 0.5 m | The tributary rivers contribute to the increased flow between Cornwall and Quebec City. |
| **Aquatic plant communities** | FS, FE | Weeks/months | ± 0.2 m | Seasonal influences (June-October) |
| **Precipitation** | GLSLB | Weeks/years | ± 1 m | Precipitation is the ultimate source of all water inputs. |
| **Evaporation** | GLSLB | Weeks/years | ± 0.2 m | Negligible factor directly on the St. Lawrence but very important on the GLSLB as a whole. |
| **Rise in sea levels** | FE, UE, LEG | Decades/centuries | + 0.5 m | Caused, in part, by isostatic rebound and global warming. |
| **Isostatic rebound** | A | Centuries | - 0.10 to + 0.50 m | The reference points for measuring water levels change slowly due to this phenomenon. |

*KEY:* GLSLB: Great Lakes-St. Lawrence Basin; FS: Fluvial Section; FE: Fluvial Estuary; UE: Upper Estuary; LEG: Lower Estuary and Gulf; A: all sectors of the St. Lawrence.
* The change is estimated in relation to the historical average of water levels.
**Assessed monthly.

**Table 2 Historical Fluctuations in St. Lawrence Water Levels and Factors Influencing these Levels in the Various Sectors of the St. Lawrence**

State

| Sector | Stations | Fluctuations in water levels | Determining factors |
|---|---|---|---|
| **Fluvial Section** | Coteau-Landing<br>Pointe-Claire<br>Port of Montreal<br>Sorel | Water levels have stabilized above the historical average since the early 1960s. Seasonal and interannual fluctuations have decreased significantly since that time.<br>Seasonal fluctuations are less pronounced for the recent period (1968-1995) than for the first half of the twentieth century. The attenuation of the pattern of water level fluctuations since the 1960s is much less apparent at this station than at Coteau-Landing.<br>A major change in the hydrologic regime has been noted since the 1960s: the amplitude of seasonal fluctuations has decreased significantly.<br>Seasonal fluctuations are less pronounced for the recent period (1968-1995) than for the first half of the twentieth century. Just as at Pointe-Claire, the change in the water regime since the 1960s has been less apparent than at Coteau-Landing. | In the Fluvial Section as a whole, the factors determining water levels are, in order of importance:<br>• natural fluctuations in precipitation (Great Lakes and Ottawa River Basin)<br>• regulating structures<br>• inputs from tributary rivers.<br>At all stations, the average annual amplitude has been reduced by the regulating mechanisms.<br>Regulation has decreased interannual variability in the western portion of the Fluvial Section. In the eastern portion, the effect is less apparent or even absent, possibly masked by fluctuations in natural factors. The influence of regulation decreases rapidly with increasing distance downstream of Beauharnois, becoming insignificant in the Fluvial Estuary. |
| **Fluvial Estuary** | Neuville | Few significant changes in the pattern of water level fluctuations throughout the twentieth century. | In this sector, tides and weather conditions (storms, precipitation in the GLSLB, ice jams, etc.) are the main factors determining water levels. Inputs from the tributary rivers also have a greater impact than regulation. The effect of regulating structures is minor. |
| **Upper Estuary** | | No station has kept records over a long enough period to analyse fluctuations in water levels. | The main factors determining water levels are tides and local and regional weather conditions (winds and low-pressure systems). The effect of regulating structures is negligible. |
| **Lower Estuary and Gulf** | Pointe-au-Père<br>Sept-Îles<br>Harrington Harbour | No apparent change in the hydrologic regime. Long-term upward trend in water levels, especially in the gulf. | The main factors determining water levels are tides and local and regional weather conditions (winds and low-pressure systems). The effect of regulating structures is negligible. |

### *Comments*

- Several of the findings presented above are derived from an analysis of water levels conducted for two separate periods: 1919-1946 and 1968-1995. The first period predates the construction of the St. Lawrence Seaway and dams, regulation plans and major engineering structures on the St. Lawrence. In the second period, the modern era, there were no major modifications of the anthropogenic infrastructures. Comparing the statistics for the two periods shows how the introduction of control and regulation mechanisms have affected St. Lawrence water levels.
- In the St. Lawrence, the Lake Saint-François sector (Coteau-Landing station) is the one with the greatest changes in hydrologic regime over the two periods.
- Episodes of low water levels were observed at all stations in the Fluvial Section in the mid-1930s and the 1960s, while persistent high levels were observed from 1970 to 1986.
- Natural cycles of 20 to 30 years in water levels have been reported in the Great Lakes-St. Lawrence Basin (GLSLB) by a number of authors.
- The seasonal cycle is characterized by a maximum water level in the spring (associated with snow melt) and a minimum level in the summer in the Fluvial Section and the Fluvial Estuary. In the Lower Estuary and the Gulf, the seasonal cycle is quite different, being characterized by a maximum during the winter months and a minimum in the spring.
- A more detailed study would be necessary to establish specific links between the natural factors and St. Lawrence water levels, in the absence and in the presence of anthropogenic regulating structures. A detailed statistical analysis of all the water level data for the entire St. Lawrence would help clarify the effect of management practices and of natural fluctuations in water inflow on interannual fluctuations in water levels.

State

**Table 3 Effects of Extreme or Prolonged High and Low Water Levels on the St. Lawrence and Semi-objective Assessment of their Impacts**

| | High water levels (extreme or prolonged) | Low water levels (extreme or prolonged) | Sensitive sectors |
|---|---|---|---|
| *Uses* | | | |
| **Riverfront properties** | Higher probability of flooding of riverfront infrastructures, particularly in the Montreal region (during the 1970-76 period there were serious floods on the shores of Lake Saint-Louis, Lake des Deux Montagnes, Mille Îles River and des Prairies River);<br>Reduction in the commercial value of riverfront lands and decrease in potential soil use;<br>Increase in compensation costs (insurance);<br>Threat to public safety (e.g. floods of the 1970s in the Montreal region).<br>***Impacts: -4 to -1*** | Few problems for riverfront properties.<br>***Impacts: 0 to +1*** | FS, FE, UE, LEG |
| **Commercial shipping** | Greater than normal cargo-carrying capacity of ships;<br>Increase in the profitability of shipping (positive economic impact for the St. Lawrence);<br>Possibility of dangerous currents.<br>***Impacts: +1 to +2*** | Decrease in cargo-carrying capacity of ships (each 30 cm drop in water level would result in a reduction of approximately 5% in the total cargo of a container ship);<br>Economic losses (during periods of prolonged low levels, shippers will divert cargo to another North American port);<br>Increased navigation difficulties;<br>The most critical sector is the Montreal-Quebec City stretch.<br>***Impacts: -4 to -3*** | FS, FE, UE |
| **Pleasure boating** | Flooding of docks;<br>Loss of revenue for marinas;<br>Possibility of dangerous currents;<br>Increase in navigable area.<br>***Impacts: -1 to +1*** | Drying of launching ramps;<br>Loss of revenue for marinas and pleasure-boat harbours;<br>Navigation difficult and dangerous (Lake Saint-Pierre, Lake Saint-Louis and Lake des Deux Montagnes) or impossible (Mille Îles River and des Prairies River);<br>Increase in the number of groundings (observed at various locations in the Montreal region during prolonged periods of low levels in 1988 and 1995);<br>Reduction in the usable area of waterways because of the proliferation of aquatic plants.<br>***Impacts: -3 to -1*** | FS, FE |
| **Hydroelectric power** | Increase in the production of hydroelectric power.<br>***Impacts: +2*** | Decrease in the production of hydroelectric power.<br>***Impacts: -2*** | FS |
| **Water supply** | No documented effect.<br>***Impacts: 0*** | Drinking water supply more problematic;<br>Additional treatment costs (water quality is often poor since the waste dilution capacity is reduced);<br>Possibility of obstruction of water intakes by frazil ice in winter.<br>***Impacts: -2 to 0*** | TF, EF |

State

| | High water levels (extreme or prolonged) | Low water levels (extreme or prolonged) | Sensitive sectors |
|---|---|---|---|
| *Uses (continued)* | | | |
| **Recreational activities** | Decrease in the area of beaches;<br>Increased beach erosion (the rise in ocean levels is causing significant beach erosion in the Gulf of St. Lawrence).<br>***Impacts: -2 to 0*** | Increase in the area of beaches (but swimming difficult or impossible in certain locations) and increase in immersion distance;<br>Closure of certain beaches because of deteriorating water quality (reduced dilution effect and rise in temperature promote bacterial contamination) or aesthetic degradation (mud and aquatic plants exposed).<br>***Impacts: -2 to +1*** | FS, FE, UE, LEG |
| **Wildlife uses** | Easier upstream migration of fish toward their spawning sites (in the Fluvial Section, a number of species spawn in the flood plains);<br>Limitation of the area of breeding, nesting and nursery habitats of reptiles, muskrats and waterfowl;<br>Flooding of certain habitats (duck nests, muskrat lodges, turtle egg-laying sites, etc.);<br>Losses of riparian habitats caused by increased erosion of the banks.<br>***Impacts: -1 to +3*** | More difficult access to spawning grounds (e.g. the low levels adversely affect the upstream migration of Atlantic tomcod to the mouth of the Sainte-Anne River);<br>Decrease in the area of spawning grounds (for species in the Fluvial Section that spawn in the flood plain);<br>Upstream displacement of the salinity front, upsetting the timing of hatching, larval drift and development in certain species of fish;<br>Reduction in waterfowl and muskrat habitat (as a result of the drainage of swamps caused by low water levels).<br>***Impacts: -3 to -1*** | FS, FE |
| *Environmental components* | | | |
| **Wetlands** | Losses of area (in Lake Saint-Louis, the high levels in 1972-76 had a major negative impact on wetlands there);<br>Decrease in the percentage of emergent aquatic vegetation.<br>***Impacts: -3 to -1*** | Losses of area (drainage of aquatic plant beds);<br>Invasion by aggressive or exotic plant species made easier.<br>***Impacts: -2 to 0*** | FS, FE, UE |
| **Riparian vegetation** | Loss of riparian forests (in the Fluvial Section, the high water levels of the 1970s reportedly caused a severe disturbance in the forest perimeter of Dowker Island, major degradation of the tree and shrub cover on Îles de la Paix, and serious damage to the silver maple around Lake Saint-Louis. Adverse effects on red ash have also been observed in the Fluvial Estuary near Quebec City; recently, losses of riparian forests have been noted in the Gulf of St. Lawrence, due to the rise in sea levels).<br>***Impacts: -3 to -1*** | No documented effect.<br>***Impacts: 0*** | FS, FE, UE, LEG |

State

**Table 3 Effects of Extreme or Prolonged High and Low Water Levels on the St. Lawrence and Semi-objective Assessment of their Impacts *(continued)***

| | High water levels (extreme or prolonged) | Low water levels (extreme or prolonged) | Sensitive sectors |
|---|---|---|---|
| ***Environmental components (continued)*** | | | |
| **Shores and banks** | Losses of shoreline caused by increased erosion (phenomenon observed in all sectors of the St. Lawrence: in the Fluvial Section, it is estimated that 1 to 2 m of shore per year are lost between Boucherville and Lake Saint-Pierre. In the Fluvial Estuary, the high levels of the 1920s and 1970s caused serious erosion at Saint-Antoine-de-Tilly. In the gulf, certain beaches are receding at a rate of 1 to 1.5 m annually because of the rise in sea levels).<br>***Impacts: -4 to -2*** | Decrease in water-induced erosion;<br>Possibility of invasion of the shores by terrestrial vegetation or by human development;<br>Aesthetic degradation (shores exposed).<br>***Impacts: -1 to 0*** | FS, FE, UE, LEG |
| **Water quality** | Increase in the dilution effect and better oxygenation;<br>Risk of degradation of water quality (sewer back-ups, overflow of retaining basins, soil leaching).<br>***Impacts: -2 to 0*** | Decrease in the dilution effect and deterioration of water quality, especially in summer when high temperatures promote bacterial growth (phenomenon more pronounced in sectors such as Lake Saint-Louis where the water flow is now concentrated in the navigation channel, leaving small quantities of water near the shores).<br>***Impacts: -3 to -1*** | FS, FE |
| **Suspended matter and sediments** | Increase in the quantity of suspended matter carried by the St. Lawrence (approximately 50% of the sediment load at Quebec City is transported during the spring thaw and the average diameter of the particles carried is much larger than during low-water periods).<br>***Impacts: -2 to -1*** | Resuspension of fine particles owing to reduced water depth;<br>Risk of resuspension of toxic sediments;<br>Possibility of resuspension of sediments by ships (mainly between Varennes and Lake Saint-Pierre, at Bécancour and at the North Traverse near Île d'Orléans).<br>***Impacts: -1 to 0*** | FS, FE |

***Comments***

- The effects of extreme water levels are presented from a broad perspective rather than in terms of local or sectoral impacts. At any given location, only some of these effects are actually observed.
- It is in the Fluvial Section and in the Fluvial Estuary that fluctuations in water levels are likely to affect the largest number of uses and environmental components.
- Low and high water levels can have negative or positive effects, depending on the use or component concerned.
- For a given use (or component of the environment), low or high water levels can have positive or negative effects, depending on the location concerned, the time of year or other external factors.
- With reference to the use of the St. Lawrence by wildlife, low or high levels alone are not influential. Rather, it is the timing of the different levels with certain parts of the life cycle of the wildlife species concerned that is at issue. The time or seasonal aspect is also important for other uses, particularly for certain recreational activities.
- In the case of wetlands, alternating high and low levels seem to be essential for maintaining the diversity and productivity of these environments.

*KEY:* FS: Fluvial Section; FE: Fluvial Estuary; UE: Upper Estuary; LEG: Lower Estuary and Gulf.
*Assessment of Impacts* – Type of impact: +: Benefit; -: Loss. Intensity of impact: 0: nil; 1: minor; 2: moderate; 3: pronounced; 4: extreme.

Response

## Table 4 Summary of the Main Government Initiatives

| Program name | Type* | Date | Comments |
|---|---|---|---|
| **Water level regulation in the international section of the St. Lawrence River** | R | 1963 | The International St. Lawrence River Board of Control is responsible for regulating water flows. Regulation mechanisms have limited effectiveness since the main factors which modify water inflow into the basin cannot be accurately controlled or predicted. Regulation plan 1958-D is based on considerations aimed mainly at commercial shipping, hydroelectric production and the protection of riverfront properties. The outflow from Lake Ontario into the St. Lawrence is determined on the current and forecast water inputs and water level conditions on Lake Ontario. The Council can modify the flows stipulated by plan 1958-D in order to respond to extreme conditions. Priority is then given to people who live near rivers when flows are high and to navigation and hydroelectric production when flows are too low. A new regulation plan, called Plan 1998, was recently proposed to the International Joint Commission. It is intended to improve management compared to plan 1958-D, but it makes minor changes in the water level and flow regime. |
| **Control of ice jam formation in winter** | R | 1968 | Since 1953, Canadian Coast Guard (CCG) ice-breakers have been used to ensure passage in the navigation channel during winter. However, the channel has been kept open year-round as far as Montreal only since 1968. Moreover, ice control structures have been built across the St. Lawrence near the Champlain Bridge and in the La Prairie Basin. These measures reduce flood risks due to ice jams. Other booms are also installed seasonally between Montreal and Trois-Rivières. |
| **Flood Damage Reduction Program** | A | 1975 | This national program seeks to limit damage rather than provide compensation to victims. The agreement between the Government of Canada and the Government of Quebec therefore endeavours to limit construction in flood-prone areas. For each designated area, the two levels of government agree on the following measures: 1) they will not engage in any construction, or approve or finance any development in the designated areas; 2) they will not pay any compensation for damage caused by floods for any development built after an area has been designated as vulnerable; and 3) the province will encourage local authorities to take flood risks into consideration during the land zoning process. |
| **Ottawa River regulation plan** | R | 1977 | This plan is aimed at limiting flooding while optimizing hydroelectric production on the Ottawa River. It came into being with the establishment of the Ottawa River Regulation Planning Board. There is only partial regulation of the Ottawa River and thus it is possible to effectively limit the flood risk only for the second spring flood crest on the river. Furthermore, this regulation provides no guarantee against high levels, such as those observed from 1972 to 1976. |
| **Canada-Quebec Agreement Respecting Flood Damage Control on the Mille Îles River** | R | 1986 | This Agreement aims to reduce flood damage on the Mille Îles River. Under this agreement, a control structure, the Grand-Moulin dam, was built at the mouth of the river in 1986. This dam limits the discharge of the river to 700 $m^3/s$, the threshold above which virtually all the damage on the Mille Îles River occurs. The Grand-Moulin dam provides improved protection for the Mille Îles River, but does not in any way decrease the flood risk for the des Prairies River and the Lake des Deux Montagnes. |
| **Beauharnois-Les Cèdres complex management program** | R | 1989 | The Beauharnois-Les Cèdres complex, located at the outlet of Lake Saint-François, is managed in conjunction with the Moses Saunders dam in such a way that the outflow is approximately equal to the inflow. The influence of the complex on St. Lawrence water levels is therefore minor compared to that of the Moses Saunders dam. However, the water levels between Coteau and Pointe-des-Cascades are prone to rapid fluctuation. Compensating works have therefore been built by Hydro-Québec in order to regulate flows and maintain constant water levels to, among other reasons, meet local recreational and aesthetic needs. Nonetheless, prior to 1989, there were frequent complaints, about the impacts on uses and fish (fish mortality). Since 1989, new management practices have been in effect following studies conducted for Hydro-Québec. These management practices were adopted following consultations with the various stakeholders involved. They have reportedly eliminated the problem of fish mortality among certain fish species, but still cause concern among people who live near the river. |
| **1992 Memorandum of Understanding** | A | 1992 | Dredging is done to maintain a guaranteed depth for navigation in the ship channel. This guaranteed depth was increased from 10.7 m to 11.0 m with the 1992 Memorandum of Understanding between the CCG and stakeholders in the shipping sector. A network of gauges was also installed for measuring water levels and communicating them to shippers on a constant basis in order to allow ships to be loaded to capacity. This network also makes it possible to issue flood warnings more quickly. Judging from the small number of subscriptions to this network, it seems that shipping companies are not taking full advantage of this information. |

* There are two types of programs: water level regulation programs (R) and programs for adapting to fluctuations in water levels (A).

## Summary

Fluctuations in St. Lawrence water levels are partly attributable to natural factors (such as precipitation), but also to anthropogenic factors such as the presence of hydroelectric dams. A number of engineering structures have been erected on the St. Lawrence during the twentieth century, especially in the Fluvial Section. Management practices are used to regulate water flows upstream and downstream of these structures, substantially modifying annual hydrologic regimes (and water levels), at least in certain sectors of the St. Lawrence. The relative importance of natural and anthropogenic factors is not well understood and varies from one sector to another.

The effects of fluctuations in water levels on uses and natural components are numerous, diversified and often opposed, which means that conflicts of use are inevitable. The expectations of the various groups of users are often difficult to reconcile. It is important to also take into consideration the needs of the ecosystems, which can themselves come into conflict (for example, the reproduction of calm-water fish and the nesting of waterfowl, which are fostered, respectively, by high and low spring water levels). Moreover, water levels can only be partially controlled, since these levels are largely determined by climatic factors which are beyond our control. Global phenomena such as climate change further complicate water management since they operate over larger spatial and time scales (see sidebar).

## Global climate change

Specialists in atmospheric sciences agree that global warming is a reality and it is expected to accelerate if no action is taken to reduce greenhouse gases. One of the major impacts of climate change anticipated for southern Quebec would be a reduction in the flow of the St. Lawrence. This reduction in flow would produce effects of varying magnitude, depending on the sector concerned and the uses and environmental components considered. To study climate change, scientists use atmospheric general circulation models (GCMs). The scenarios produced by these models should not be considered climatic forecasts but rather possible scenarios of climate change. There are no models capable of providing accurate estimates on a regional scale. The results of these models should therefore be interpreted with caution.

### Pressure Components

During the last century, the Great Lakes and St. Lawrence Basin experienced a warming of 0.7°C. In eastern Canada, it appears that we are witnessing primarily an increase in climate variability. A doubling of the carbon dioxide concentration, compared to the preindustrial era, is forecast by the next century if no steps are taken to reduce greenhouse gases. According to GCMs, this would produce an average warming of 3°C along the St. Lawrence within 50 years, an increase in precipitation of 5 to 20% in

winter and approximately 10% in the spring; the first frost would occur 9 to 14 days later and snow melt would begin 13 to 16 days earlier.

### State Components

*Effects on St. Lawrence water flows and levels*

According to the GCM scenarios for an atmosphere whose carbon dioxide concentration has doubled, the water flow from Lake Ontario could be reduced by 21 to 51%. In the case of a scenario involving a 40% reduction, the present flow of the St. Lawrence, estimated at 7300 $m^3$/s near the Port of Montreal, would be no more than 5100 $m^3$/s, which represents a value lower than the minimum record of 5900 $m^3$/s for the last 90 years.

*Effects on uses and components of the natural environment*

The main impact of climate warming on the St. Lawrence would be a drop in water levels in the western portion (Fluvial Section and Fluvial Estuary) and an increase in water levels, compared to normal values, in the estuary and the gulf. The most probable consequences would be the following:

Fluvial Section and Fluvial Estuary

- increase in dredging
- greater risk to navigation and an increase in assistance and rescue operations
- decrease in the cargo-carrying capacity of ships
- deterioration in water quality
- loss of wetland area
- more frequent saline intrusions in the Fluvial Estuary with risk of contamination of groundwater.

Upper Estuary, Lower Estuary and Gulf

- increase in the erosion of beaches and shores
- loss of riparian forests
- possibility of accommodating ships of deeper draught.

### Response Components

After signing the Framework Convention on Climate Change in Rio in 1992, Canada established a program of national action in order to fulfil its commitments. The Great Lakes-St. Lawrence Basin (GLSLB) project aims to improve our understanding of the complex interactions between climate, the environment and society in order to develop regional adaptation strategies in response to climate change in the Great Lakes-St. Lawrence Basin. The project leaders consider it important that we develop adaptation and mitigation mechanisms now, rather than waiting until extreme situations become uncontrollable. Moreover, the *Canada Country Study: Climate Impacts and Adaptation* aims to survey current knowledge of the possible impacts of projected climate change and of measures for adapting to these changes. The portion of the study devoted to Quebec took stock of current knowledge and identified a number of deficiencies and recommendations. In December 1997, Canada signed the *Kyoto Protocol* whereby it undertook to reduce its emissions of greenhouse gases by 6% (compared to 1990 levels) by the 2008-2012 period.

Little is known about the effects of climate change on water level fluctuations. However, this should not be used as a pretext for minimizing the magnitude of the anticipated impacts on the St. Lawrence. Indeed, although they are still uncertain, the impacts anticipated by a number of studies are too important to be ignored. A preventive management approach is therefore desirable. In this context, action could be taken immediately to reduce the vulnerability of uses and natural components to increased climate variability. ■

# Taking Action

From a sustainable development standpoint, it is desirable to set environmental objectives[1] and maintenance-of-use objectives to ensure the sustainability of the resources and uses of the St. Lawrence. With respect to water levels, guidelines that can be considered maintenance-of-use objectives currently exist for commercial shipping (guaranteed depth of 11 m in the navigation channel) and protection of riverfront properties (avoid any construction in areas with a flood recurrence period of 20 years or less). For the other uses, as well as for all the natural components, there are no recognized objectives that can be applied to the entire St. Lawrence. A number of objectives were proposed in the early 1980s for water level management in the Montreal region, notably with respect to wetland vegetation, fish, waterfowl, the Great blue heron, the muskrat, water quality, swimming and pleasure boating. Although they are sometimes based on incomplete data and they may be imperfect and difficult to apply to other regions, these level and flow management objectives could constitute a foundation for present and future efforts.

The establishment of such objectives is difficult since the links between water levels and most uses are still poorly understood. In addition, optimal water levels can vary in certain cases, depending on the season or from one part of the St. Lawrence to another. Lastly, a given water level can be advantageous for one aspect of a use, but disadvantageous for another aspect of the same use. This is the case, notably, for wildlife uses where high water levels can facilitate the upstream migration of fish, but adversely affect the maintenance of the habitats of waterfowl and a number of reptiles. Thus, while identifying the optimal levels for wildlife or maintaining habitats may be desirable, it is difficult to accomplish in practice since the needs of flora and fauna (in terms of water levels and their fluctuations) vary from one species to another.

A first step in setting these objectives could be an effort to forge a consensus among concerned stakeholders with respect to the water levels to favour, from a standpoint of sustainable development. Since a number of uses and natural components have opposing needs, society will have to make choices when setting environmental objectives or maintenance-of-use objectives. It will probably be necessary to adopt a preventive approach in order to ensure the maintenance of uses and natural components, particularly in the context of global climate change.

Some concrete action can be envisioned immediately in light of the conclusions presented in Table 5. This information is separated into five broad categories that, though not exhaustive, correspond to the main fields of activity to be considered for more effectively managing the problem of St. Lawrence water levels and improving the present situation.

1. An environmental objective is a marker, a threshold or a target relating to a human activity, or to a pressure generated by a human activity, or to an ecosystem component affected by this pressure. The aim of such an objective is to maintain a human activity at a level whereby no serious or irreversible effects are observed on ecosystems; to reduce or limit such pressure to an acceptable level for ecosystems and their associated uses; and to protect, reclaim or restore these ecosystems.

## Table 5 Conclusions and Fields of Activity with respect to St. Lawrence Water Levels

### Water level regulation and management

- Between 1986 and 1993, the International Joint Commission (IJC) conducted a vast study designed to examine ways of remedying the adverse effects of fluctuations in water levels. The report's main recommendations emphasize controlling riverfront development rather than introducing new regulating structures. The costs and environmental impacts associated with the large-scale construction required by regulating structures were among the main reasons for these recommendations.
- Water level management must take into consideration the often divergent interests of a growing number of social, economic and environmental stakeholders, which give rise to numerous conflicts of use. In 1995, Environment Canada's St. Lawrence Centre and the Quebec environment ministry (MEF) both submitted briefs to the IJC calling for the maintenance of wildlife uses and natural components to be included in water level regulation strategies in the Great Lakes-St. Lawrence Basin. These demands could entail identifying the optimal levels for wildlife and maintenance of habitats to be considered in the water management of the international section of the river. These demands could also apply to the Ottawa River Regulation Planning Board.
- Many stakeholders are calling for a review of the management practices imposed by the current regulation plan. They are demanding, among other things, that greater emphasis be placed on environmental considerations. In addition, the current plan is based on historical water levels which probably no longer reflect current and future reality, because of the climate change which has already begun.
- There are no government policies specifically concerning water level management. Management is currently governed by a Canada-United States treaty which covers in a very general way the overall needs of a number of U.S. states and Canadian provinces. To improve this situation, a more integrated approach to water management is being demanded by many stakeholders. The policy sought should, among other things, include measures to protect shores, the littoral zone and flood plains, and promote consensus and reconciliation rather than confrontation among the various stakeholders with divergent interests.

### Adaptation to fluctuations in water levels

- Water levels cannot be completely controlled and are largely dependent on climatic factors. The recent floods in Quebec show that natural phenomena sometimes result in extreme hydrologic fluctuations which no existing infrastructure can absorb. In the context of global climate change, an increase in climate variability is entirely possible and could contribute to increasing the frequency of floods. The only way to avoid or attenuate their effects is not to build homes on the flood plain. However, this adaptation should be accompanied by a detailed analysis of the extreme floods that have occurred along the St. Lawrence over the past thirty years.
- The Flood Damage Reduction Program (FDRP), a federal-provincial government program encourages the public not to build homes in the flood plain. In view of the increase in the frequency of floods in Quebec and in Canada in recent years, new, more restrictive measures than those identified in the FDRP could be contemplated in order to limit the damage through future zoning and land use regulations.

### Public education and communication of scientific information

- The establishment of any water level management measure is doomed to failure if it is not understood and accepted by the public and the various stakeholders. The public hearings held by the IJC and, more recently, the numerous briefs presented to the Nicolet Commission on the Saguenay River flooding demonstrate that there are serious deficiencies in the quality of the information circulating among the public and a number of interest groups (people who live near rivers, ecologists, navigators, decision makers), particularly in terms of: 1) the regulation of water levels, the operational constraints and limitations of water management structures; 2) the significance of climatic factors (precipitation, ice jams, wind, etc.) in determining the short-term, seasonal or interannual fluctuations in water levels; and 3) recognition of the real risks of flooding of properties located in flood-prone areas.
- The public has a tendency to trust in technology to solve any technical problem. Recognition by the public of the danger of flooding and of the concept of a flood-prone area remains minimal despite the efforts of the FDRP. Indeed, we observe among the public a number of perceptions that are not consistent with reality with respect to flood risks. Efforts could continue to raise public awareness in this area.
- More effective communication of scientific information would make it possible to eliminate a large number of unrealistic expectations on the part of various interest groups in terms of how dams should be managed, notably with respect to the international portion of the St. Lawrence.

### Monitoring

- A number of human uses are dependent on fluctuations in St. Lawrence water levels. Hence, improving the short-, medium- and long-term forecasts of water levels would be one way to facilitate the planning of a number of uses and also improve public safety. For example, accurate knowledge of water levels and flows through effective monitoring would improve the efficiency and increase the cargo-carrying capacity of shippers while reducing the risks of accidents. Rapid transmission of the data collected by networks of gauging and hydrometeorology stations has improved with the creation of the Coastal and Ocean Water Level Information System, but mechanisms should be established to facilitate more effective use of the information obtained by this system.
- There is no monitoring of the natural components of the St. Lawrence with respect to fluctuations in water levels. Such monitoring would make it possible to improve knowledge of the medium- and long-term effects of fluctuations in water levels. Given the importance of wetlands as a wildlife habitat and their sensitivity to fluctuations in water levels, it would be worthwhile to systematically conduct, in all sectors of the St. Lawrence, a survey of these environments, as has already been undertaken in a number of locations. With respect to wildlife resources, there is also a need to monitor the evolution of certain descriptors. For example, monitoring the size of the cohorts of certain species should be considered as a way of acquiring new relevant data about the status of populations likely to be affected by fluctuations in water levels.
- Wildlife habitats and riverfront properties are very sensitive to the phenomenon of erosion. The erosion of beaches is also an increasingly worrisome phenomenon, notably in the Gulf of St. Lawrence, because of the rise in sea levels. A long-term monitoring network should be introduced to record the erosion of shores and the retreat of cliffs along the St. Lawrence.

## Table 5 Conclusions and Fields of Activity with respect to St. Lawrence Water Levels *(continued)*

**Knowledge acquisition**

- Knowledge of the effects of fluctuations in water levels is still insufficient to establish water level management measures aimed at maintaining the various uses and natural components of the St. Lawrence. Among other things, the relationships between the biotope and variations in St. Lawrence levels or flows have not been quantified — an important step in evaluating the sensitivity of habitats and biological communities. Increased knowledge of the importance of the timing of these phenomena for wildlife, and of the links between water levels, wildlife resources and most human uses is also required. The results of the best models available in each research sector still have to be integrated for this purpose.
- The links between climate and hydrologic cycles are poorly understood. A multivariate statistical analysis of all the hydrologic and climate data available on the Great Lakes-St. Lawrence Basin would enable us to better understand these links.
- Given the major impact of climatic factors on fluctuations in St. Lawrence water levels and the evidence of global climatic change, additional studies are essential. There is a lack of knowledge of what action should be taken to adapt effectively to climate change. There is also an obvious lack of models for evaluating the specific impacts of climate change on the St. Lawrence. The International Joint Commission thus recommends that work should continue to estimate the possible impacts of climate change on the Great Lakes-St. Lawrence Basin so that the areas most vulnerable to climate change can be identified.

St. Lawrence Centre, C. Hudon

## For more information


BERGERON, L. 1995. *Les niveaux extrêmes d'eau dans le Saint-Laurent : ses conséquences économiques et l'influence des facteurs climatiques.* Report submitted to Environment Canada, Atmospheric Environment Branch.

COMMITTEE ON FLOW REGULATION. 1976. Final Report of the Committee on Flow Regulation. Montreal Region. Department of Natural Resources and Environment Canada.

DEPARTMENT OF FISHERIES AND OCEANS CANADA. 1997. MEDS database – Marine Environment Data Service. Canadian Hydrographic Service, Laurentian Region. Mont-Joli.

FARID C., J. JACKSON, and K. CLARK. 1997. *The fate of the Great Lakes: Sustaining or draining the sweetwater seas?* Published by Canadian Environmental Law Association and Great Lakes United. February 1997.

INTERNATIONAL JOINT COMMISSION. 1993. Great Lakes and St. Lawrence Levels Reference Study. Study Board. International Joint Commission, January 1993. Draft final report.

ROBICHAUD, A., and R. DROLET. 1998. *Rapport sur l'état du Saint-Laurent : Les fluctuations des niveaux d'eau du Saint-Laurent.* Technical Report. Federal-provincial SOE team, composed of representatives of Environment Canada, Fisheries and Oceans Canada and the Ministère de l'Environnement et de la Faune du Québec, Sainte-Foy.

SECRÉTARIAT ARCHIPEL. 1986. *Projet Archipel. Étude de faisabilité. Rapport technique nº 4: Évaluation des effets sur l'environnement. Annexe 18: La gestion optimale pour la flore, la faune et les loisirs.* Government of Quebec. Department of Recreation, Fish and Game. Department of Municipal Affairs.

YEE P., R. EDGETT, and A. EBERHARDT. 1995. *Régulation des Grands Lacs et du fleuve Saint-Laurent. Ce que cela signifie et comment cela fonctionne.* Environment Canada, Ontario Region and North Central Division of the U.S. Army Corps of Engineers.



### PRODUCTION

***Design and Structure***

Federal-provincial State-of-the-Environment Team: Hélène Bouchard, Environment Canada and Louis Roy, Ministère de l'Environnement et de la Faune du Québec

***Research and Writing***

Federal-provincial State-of-the-Environment Team: Alain Robichaud; René Drolet, Fisheries and Oceans Canada

### TECHNICAL PRODUCTION

Environment Canada – St. Lawrence Centre
105 McGill Street, 7th floor, Montreal
Quebec H2Y 2E7

***Co-ordination***

Louise Quilliam

***Graphic Design***

Denise Séguin and VirageGraph Inc.

***Cartography***

François Boudreault

***Translation***

Public Works and Government Services Canada

***Linguistic Revision***

Patricia Potvin

### ACKNOWLEDGMENTS

We would like to thank all those who contributed to analysing the issue of fluctuating water levels in the St. Lawrence River, namely:

Ministère de l'Environnement et de la Faune du Québec: Gilles Barabé, André Carpentier, Serge Hébert, Yves Mailhot and Marc Mingelbier

Environment Canada: Alain Armellin, Jean Burton, Jean-François Cantin, Christiane Hudon, Anne Jourdain, Serge Lepage, Gérald Vigeant and Yvan Vigneault

Fisheries and Oceans Canada: Michel Gilbert, Bernard Labrecque, Denis Lefaivre, Michèle Moisan and Pierre Rouleau

Consultant: Michel Slivitzky

# The State of the St. Lawrence River

St. Lawrence Vision 2000 is an action plan governed by a cooperation agreement between the governments of Canada and Quebec. Its aim is to conserve, protect and enhance the St. Lawrence River, with the ultimate goal of returning use of the river to the population. One of the objectives of the action plan is to improve our knowledge of the St. Lawrence River and to disseminate this information to decision makers, riverside communities and the general public.

This approach is reflected in the fact sheets in the series ***The State of the St. Lawrence River***. Its main objective is to collect relevant information about the state of the St. Lawrence in Quebec to provide decision support. The focus is on a series of issues, which are interpreted according to a "pressure-state-response" approach. This approach seeks to identify causal links among the various sources of pressure exerted on the St. Lawrence ecosystem, including natural disasters and human activities, and the state of habitats and resources, and to examine measures taken to counter their effects (existing responses). Each of these environmental issues is the subject of a fact sheet intended for decision makers and those members of the general public for whom the welfare of the St. Lawrence River is a concern. ■

This paper contains at least 20% post-consumer recycled fibres.

Published by Authority of the Minister of the Environment



ISBN: 0-662-26669-2
Cat. No.: En 153-97/1998-2-1E

Legal Deposit – Bibliothèque nationale du Québec, 1998
Legal Deposit – National Library of Canada, 1998

Cover page photograph: Michel Boulianne

Aussi disponible en français sous le titre :
*Les fluctuations des niveaux d'eau du Saint-Laurent*