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A REPORT ON THE 1986 RECORD HIGH WATER LEVELS OF THE GREAT LAKES

Ontario Region

Région de l'Ontario

Canada

A REPORT ON THE 1986 RECORD HIGH WATER LEVELS OF THE GREAT LAKES

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Note: The contents of this report do not necessarily reflect the views and policies of Environment Canada.

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1.0 PURPOSE AND SCOPE

This report summarizes the events that took place in 1986 in connection with the record high water levels on the Great Lakes. Water management actions related to Lake Superior and Lake Ontario regulation, and the Ogoki diversion, as well as their impacts on lake water levels, are discussed. A summary of the reported flood and erosion damages caused by the record high water levels during this time period is also presented.

In December 1985, Water Planning and Management Branch, Ontario Region of Environment Canada prepared a "Report on the 1985 Record High Water Levels of the Great Lakes". That report presents information on the causes and effects of the record high water levels in 1985, and summarizes government and International Joint Commission (IJC) action taken in response to the issue. As the record high Great Lakes water level condition continued, an interim report was prepared in August 1986. This report was also prepared summarizing hydrologic conditions and other events in 1986 related to the Great Lakes water levels issue.

With the exception of some minor modifications, the format of this report is similar to that of the 1985 report. All data in this report are in metric units unless stated otherwise. Lake water levels are expressed in metres on the International Great Lakes Datum (1955).

2.0 CONDITIONS LEADING TO HIGH GREAT LAKES WATER LEVELS IN 1986

2.1 GENERAL

Since the late 1960's, water levels from Lake Superior to Lake Erie have been higher than average. This condition is a result of the persistent above-average precipitation that has occurred over the Great Lakes Basin since 1967.

Table 1 lists the monthly and annual total precipitation for the Great Lakes Basin for the period 1900-1985. The long-term (1900-1985) average annual precipitation over the Great Lakes Basin is about 815 millimetres. A new high precipitation record of 1017 millimetres was set in 1985, exceeding the long-term average by about 25 percent. This event, following 18 years of generally above-average precipitation, led to the occurrence of record high water levels throughout the Great Lakes (except Lake Ontario) in 1985, a condition which has continued into 1986. During 1986, precipitation was near average. However, the excessive moisture in the basin, coupled with the slow response of the lakes to the hydrometeorological process resulted in continued record high water levels on some of the lakes.

2.2. Precipitation

The recorded monthly mean precipitation rates over the Great Lakes in 1986 are summarized by lake in Table 2. Precipitation on the Lake Superior Basin was above average in March, June through September and again in November. Precipitation was below average for much of the rest of the year. Overall, precipitation on the Lake Superior Basin was average for 1986.

On the Lakes Michigan-Huron Basin, the overall precipitation was also near average for 1986. On the Lake Erie Basin, precipitation was below average in early 1986 but was well above average in the latter part of the year. Precipitation on the Lake Ontario Basin was below average for much of the year. Estimated annual watershed precipitation in 1986 are 109 percent and 92 percent of average for the Lake Erie and Lake Ontario Basins, respectively. Over the entire Great Lakes Basin, precipitation in 1986 was about the same as the long-term average.

The average precipitation on the Lake Superior Basin, combined with high outflows from Lake Superior (20% above average) have helped to lower Lake Superior's water level to below those experienced in 1985. A more detailed discussion of the water level condition in 1986 is contained in Section 2.5.

2.3 Runoff

Preliminary streamflow data from a number of selected Canadian tributaries draining into the Great Lakes are summarized in Table 3. These tributaries were selected as being representative of the total runoff to the Great Lakes from Canada. Real-time instrumentation installed at streamflow measuring stations on these tributaries enable fast data retrieval and analysis.

Runoff conditions in the Canadian portion of the Great Lakes Basin in 1986 were about ten percent above average, and followed very closely the precipitation patterns. For example, the below average runoff conditions in May and June reflect the well-below average precipitation in the first part of the year particularly April and May. Similarly, the high runoff conditions in September and October were preceeded by well above-average precipitation in the summer months with September being a very wet month.

2.4 Other Factors

a) Evaporation

Lake evaporation data for 1986 from the Atmospheric Environment Service (AES) of Environment Canada were examined to assess the extent this process affected lake water levels. The results are summarized in Table 4. For comparison purposes, the data for 1985 and the long-term averages for the period 1965-1985 are included.

In 1985, evaporation ranged from near average on the upper Great Lakes to above average on the lower Great Lakes, particularly Lake Erie. In the first nine months of 1986, evaporation was generally below average. Although of much lesser significance than precipitation and runoff, the low evaporation in 1986 is a factor affecting water levels on the Great Lakes.

b) Welland Canal

On October 4, 1985, a small part of the wall at Lock No. 7 of the Welland Canal caved in rendering the lock unusable for about 24 days. The lock was put back into service on November 7, 1985 after emergency repairs were completed. During the period of repair, navigation activities along the Welland Canal ceased and thus reduced, very slightly, the amount of the diversion. As Lock 7 is downstream of the location in the canal where diversion water is taken off for the DeCew Falls Power plants, these power diversions were unaffected by this incident. The estimated temporary impact on lake Erie's water level of this incident was less than 0.01 metre.

The Welland Canal diversion in 1986 was about 230 cubic metres per second (cms). This was a slight increase from the 1985 diversion of 223 cms, but less than the diversions of 245 to 250 cms in 1982, 1983 and 1984. Mechanical breakdowns and necessary repairs to the DeCew Falls power plants in 1985 and 1986 reduced the power diversion and thus the Welland Canal diversion from Lake Erie. As of the end of 1986, the power diversions have returned to normal full operation.

Table 5 contains the diversion data for 1985 and 1986, and draws comparisons with previous records. Diversions in 1985 and 1986 have been near average for the period 1950-1985.

On November 28, 1986, Transport Canada announced a seven year project to rehabilitate the Welland Canal. The work, which includes repairing and reinforcing the locks and lock walls, stabilizing the canal's approach walls and banks and renovating subordinate structures, will be carried out while the canal is closed to shipping during the winter months beginning in January 1987. During the repairs, normal flows to the DeCew Falls power plants and other municipal and industrial users along the canal will continue to the degree possible without compromising the rehabilitation program.

c) Grounded Barge at the Peace Bridge

On August 7, 1986, a tugboat pushing a 53 metre barge ran into difficulty on the upper Niagara River after missing the entrance to the Black Rock Canal. When the tug and barge entered the high velocity area upstream of the Peace Bridge, the barge swung sideways, colliding with and lodging against abutment No. 4 of the Peace Bridge where it remained for almost five months. After a series of setbacks due to a combination of equipment failure, inclement weather, and the fast and ever changing current and water level conditions at the salvage site, the wreckage was finally removed on December 19.

The presence of the wrecked barge at the Peace Bridge was estimated to have reduced the Niagara River flow by up to 200 cms. The reduction in flow represents about 5.7 centimetres (2 1/4 inches) of temporary raising of the water level on Lake Erie. The estimated raising effect on Lakes Michigan-Huron is extremely small.

Immediately after the removal of the obstruction at the Peace Bridge, there was an increase in the flow of the Niagara River, diminishing over time. In about one year, practically all of the waters stored on Lake Erie due to the obstruction will be discharged into Lake Ontario. Table 6 contains the Niagara River flow data for 1985 and 1986, and draws comparisons with previous records. Flows in 1985 and 1986 were well above average, with the 1986 figure setting a new record high.

2.5 Lake Water Levels

Figures 1 to 5 are hydrographs of monthly water levels on the Great Lakes. Table 7 presents a comparison of 1986 levels with previous recorded maximums. On Lake Superior, new record high levels continued to be set through to May 1986, with the levels being marginally higher than those previously experienced in 1951 and 1975. The near average precipitation on the Lake Superior Basin and high outflows in 1986 caused the lake to fall below record levels for the rest of the year.

While the Lakes Michigan-Huron Basin also received near average precipitation in 1986, lake levels increased to a point where new record high levels were set each month throughout the year. It should be noted that virtually no decline in Michigan-Huron water levels took place during the fall of 1985 as is normally the case. Water levels actually rose sharply in December 1985 in response to the record water supplies received in November 1985, a situation which was repeated to a lesser degree following receipt of September 1986 water supplies. The sharp rise in water levels of late 1985 was a primary factor leading to the continuing record high Michigan-Huron water levels of 1986. Other factors were the well above average inflows from Lake Superior in 1985 and 1986 and the generally saturated conditions and above average runoff from the watershed.

Lakes St. Clair and Erie receive over 80 percent of their water supplies from the upper Great Lakes. Thus, the continuing extreme high inflows from Lakes Michigan-Huron caused new record high water levels to occur on Lake St. Clair for every month in 1986. On Lake Erie, new records were also set every month except in the months of January to April.

All the lakes except Lake Superior experienced a rapid rise in water level in the latter part of September and early October 1986 in response to the very high precipitation occurring in September.

Due to high inflows from Lake Erie, Lake Ontario water levels began to rise in late 1985, with levels climbing rapidly in early 1986. Although not breaking previous records, Lake Ontario's level peaked for the year in June at about 75.16 metres or 0.3 metre above average for that time of year despite efforts to release maximum outflows through the St. Lawrence River Control dams. Although Lake Ontario levels experienced their normal seasonal decline after June, the differential between 1986 and long term average levels had increased to almost one-half metre by year end. A brief description of Lake Ontario regulation activities is contained in Section 4.3.

3.0 EFFECTS OF HIGH LAKE WATER LEVELS

3.1 General

Record high water levels on the Great Lakes in 1985 and 1986 in combination with several storms have to date caused millions of dollars in shore property damage. The previous 1985 report provided a summary of the damage to the Canadian shoreline due to storms in 1985. Water levels on the Great Lakes remained at record high in 1986. A number of storms passed over the Great Lakes Basin, which prompted the Atmospheric Environment Service to issue storm watches and storm warnings. Through good fortune no storm event occurred in 1986 that could be considered major in terms of severe wind speeds, duration or catastrophic damages.

3.2 Flood and Erosion Damages

While the storms of 1986 did not match the intensity or duration of the severe storm of December 2, 1985, they still caused generalized flooding and shoreline damage on Georgian Bay, Lake Huron and Lake Erie shores in Canada. Listed below are five of the most severe storm events of 1986:

a) On January 5-6, a storm with winds up to 80 kilometres per hour from the west caused a moderate set up at the eastern end of Lake Erie. The ice that had formed by that date protected much of the shoreline from wave action. As a result, flood and erosion damages were minor;

b) On June 1, strong northerly winds over Lake St. Clair caused generalized flooding on Lake St. Clair;

c) On August 22, a south-westerly wind up to 65 kilometres per hour over Lake Huron-Georgian Bay caused flood and erosion problems in the Wasaga Beach area;

d) On October 5-6, winds from the northwest caused extensive property damage along the south shore of Lake Huron and Georgian Bay. The hardest hit regions were Southampton, Sarnia and Wasaga Beach with localized problems occurring in many other areas. Flooding also occurred along the north shore of Lake St. Clair; and

e) On November 9-10, a storm caused extensive property damage along the Lake Huron shoreline from Port Elgin to Oliphant and along Georgian Bay from Wasaga Beach to Midland. Other portions of Lake Huron and eastern Lake Erie were also effected to a lesser degree.

Some local municipalities, for example the Township of Wainfleet, and the Conservation Authorities in Ontario have compiled flood and erosion damage information in their areas of jurisdiction. In mid 1986, Environment Canada's Great Lakes Water Level Communications Centre distributed a questionnaire to the conservation authorities in Ontario requesting information on damages along the Great Lakes shoreline. This questionnaire was followed by telephone calls in December asking for any updated information. All information received have been summarized in Table 12. The reported damages ranged from light along portions of Lake Superior shoreline where the topography is rugged and development sparse, to extremely heavy in densely developed areas of the other lakes. Areas that sustained moderate to heavy flood and/or erosion damages include sections of shoreline from Parry Sound to Owen Sound on Georgian Bay, Oliphant to Southampton and Kettle Point to Sarnia on Lake Huron, Mitchell Bay and the entire southern shore of Lake St. Clair, and on Lake Erie areas from Amherstburg to Erieau and Long Point to Fort Erie. No significant damages were reported on Lake Ontario.

4.0 WATER MANAGEMENT ACTIONS TAKEN RELATED TO HIGH LAKE WATER LEVELS

4.1 Lake Superior Regulation

At the end of December 1985, the effect of the emergency actions taken during the year by the International Joint Commission to store water on Lake Superior had the effect of an 0.033 metre increase of Lake Superior's level, and respective 0.018, 0.021 and 0.024 metre reductions of Lakes Michigan-Huron, St.Clair and Erie levels in comparison to the levels that would have occurred under the strict application of Plan 1977. The effect of the 1985 emergency action on the Great Lakes for each month for the period May 1985 through December 1986 is shown in Table 8. These emergency actions had no impacts on Lake Ontario levels due to the operation of Lake Ontario's Regulation Plan 1958-D.

Average Lake Superior outflow in the winter months from December 1985 through March 1986 was 2550 cubic metres per second (cms), which was slightly more than the specified Plan flow of about 2340 cms. After reviewing hydrologic conditions, the Superior Board on March 13, 1986 recommended to the IJC that a return to Regulation Plan 1977 flows be made. On March 20, 1986, the Board, on instruction from the IJC, adjusted the Lake Superior outflow to a Plan flow of 2320 cms. Outflows in subsequent months were maintained close to those called for by Plan 1977.

Table 8 lists the actual and Plan outflows for the period May 1985 to December 1986. During 1986, the outflow of Lake Superior was about 2560 cms, or about 20 percent higher than the long term average. Overall, the flows in 1986 were close to those called for by Plan 1977. By the end of 1986, there still remains some 0.024 metre of water stored on Lake Superior due to the emergency regulation actions taken in 1985.

4.2 Ogoki Diversion

The actions taken by Ontario Hydro in 1985 to store Ogoki diversion water on Lake Nipigon and subsequently redirect this diversion water north are summarized in the 1985 report and on Table 9. During the winter of 1985-86, approximately 40 percent of the Ogoki waters were re-directed northward to the Albany River and James Bay.

Following spring breakup in 1986, the Province of Ontario decided to return the Ogoki Diversion to normal operation, that is with Ogoki waters flowing into Lake Nipigon and ultimately Lake Superior. The reasoning behind this decision was that the beneficial effect of closing the Ogoki Diversion on Great Lakes levels and shore damages is very small compared to the losses incurred to hydro power generation on the Ogoki/Nipigon system. Furthermore, flooding and environmental problems were being experienced on the Albany River. Ontario Hydro subsequently adjusted the control dam settings and resumed normal Ogoki diversion operations on May 22, 1986.

The estimated maximum lowering effect on Lake Superior due to storing both the Ogoki diversion water and Lake Nipigon local inflow on Lake Nipigon during 1985 was about 0.015 metre and this occurred in September 1985 (Table 10). Roughly 60 percent of this relief to Lake Superior could be attributed to the storing of the Ogoki waters alone. No attempt has been made to detail how the stored Ogoki waters were later released to Lake Superior, but it is safe to say that all the Ogoki waters stored on Lake Nipigon in 1985 were released to Lake Superior in early 1986.

With the Ogoki diversion returned to normal operation in May 1986, no further action took place regarding storage of the Ogoki waters on Lake Nipigon and the diverted waters continue to constitute a portion of the water supply to Lake Superior. The Ogoki diversion in 1986 was about 98 cms over the year (Table 9) or about 86 percent of the average for the period 1944-1984.

4.3 Lake Ontario Regulation

Throughout 1985, outflows from Lake Ontario were in accordance with the Regulation Plan 1958-D. Total water supplies to Lake Ontario in 1985 were about 20 percent higher than average with actual outflows being about 18 percent above average (Table 11). The high Lake Ontario outflows in 1985 together with the near average water level condition at the beginning of the year are the reason why Lake Ontario did not experience any significant high water level problems through to the end of 1985. It should be noted that Lake Ontario's Regulation Plan called for maximum allowable outflows for much of 1985 consistent with safe water levels and velocities in the St. Lawrence River.

On December 17, 1985, the International Joint Commission directed its International St. Lawrence River Board of Control to implement Criterion (k) of the regulation plan at the closing of the 1985 navigation season. Criterion (k) specifies that:

> "In the event of (receiving) supplies in excess of the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to the riparian owners upstream and downstream. In the event of (receiving) supplies less than the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to navigation and power interests."

Since the inception of Lake Ontario regulation in 1960, there have been two previous periods when Criterion (k) supply conditions have occurred. There were the record low supplies in 1963-1965 and the record high supplies in 1972-1978.

On December 31, 1985, the navigation season was closed and St. Lawrence River flows were reduced to accelerate the formation of a stable ice cover on the river. Flows were subsequently increased in January 1986 to maximum possible rates consistent with the continued formation and retention of a stable ice cover.

Water supplies to Lake Ontario in 1986 were about 30 percent higher than average with record high supplies occurring in the months of July through October. Lake Ontario's outflows in most of 1986 were at maximum allowable with actual flows averaging about 8970 cms, or 7 percent higher than the flows called for by Plan 1958-D and about 31 percent higher than the long-term average. New record high monthly average outflows occurred in February and again from September to December.

There were several occasions during the year when the Lake Ontario's outflows had to be reduced slightly below the called for maximums. For example, in May, September and October, flows were reduced slightly to provide a measure of relief to agricultural lands around Lake St. Pierre on the St. Lawrence River which was severely affected by critically high water levels. In November, flows had to be reduced again due to flooding in the Lake St. Pierre area and due to below-alert-level depths in the Seaway navigation channel upstream of Cornwall. For the most part, Lake Ontario's outflows in 1986 have been maintained at the maximum possible. Despite these extreme actions, Lake Ontario's water level continued to rise and by June reached its seasonal peak at a level marginally below the upper limit of elevation 75.22 metres as called for in the regulation plan. During the second half of the year, record high supplies to Lake Ontario occurred for much of the time. The record high outflows during this period managed to prevent any further rise in lake levels. By the end of December 1986, the action to deviate from the Regulation Plan outflows resulted in a lowering of the level of Lake Ontario by almost one metre in comparison to the levels that would have occurred under strict application of the Plan.

4.4 Great Lakes Water Level Communications Centre (GLWLCC)

On March 27, a Great Lakes Water Level Communications Centre in Burlington, Ontario, was opened by the Honourable Tom McMillan, Minister of the Canadian Department of the Environment. This Centre, in conjunction with the Water Level Forecast Centre operated by Atmospheric Environment Service in Toronto, was organized to act as a focal point for Canadian activities and information related to high Great Lakes water levels and shoreline damages.

From April to December 1986, about 35 high water level watches and warnings were issued by the Water Level Forecast Centre. During these periods, staff at the Burlington office monitored weather and lake level conditions and responded on a 24 hour a day basis to all public and media inquiries regarding storms and related shoreline damages. Several field surveys were conducted following the more severe storms to assess shoreline damages.

Since its opening, the GLWLCC has responded to telephone, letter and media inquiries concerning high lake levels. Many shoreline residents visit the Centre to discuss the subject of lake level fluctuation, regulation and shore protection. Communication Centre staff members have also held or attended meetings with politicians, citizens coalition groups and the public to discuss lake level problems and have distributed information and publications on the subject throughout the watershed.

During the year, the Water Level Forecast Centre in Toronto has stepped up its monitoring of lake and weather conditions. Additional wave buoys have been installed in the Great Lakes to provide real-time data to support marine forecasts. Information on weather forecasts and storm surges are updated three times a day and more frequently during storm watches and warnings and is provided to the public and media by a toll free phone message and news wire service.

In addition to its primary role of providing information to the public a number of related activities have been completed or are currently underway at the Centre. These included: a) a survey of nearshore erosion at selected locations along the Great Lakes shoreline for the purpose of updating the erosion data at these sites; b) a review of new development that has taken place along the shoreline since 1973; c) an assessment of the costs of government acquisition of selected high hazard areas; d) aerial photographic coverage of damage prone sections of the Canadian shoreline of all the Great Lakes; e) initiation of a survey of the damage potential of the Lake Superior shoreline; and f) a public opinion survey on perception and attitudes towards the high water level issue.

4.5 Ontario Shoreline Management Review Committee

In April 1986, a committee to examine long-term options for shoreline management along the Great Lakes was formed by an order-in-council of the Ontario Provincial Cabinet. The seven members of this Committee include representatives from provincial and municipal governments as well as the general public.

The Committee was given the task to examine and make recommendations on options for long term shoreline management, as well as look at the roles and responsibilities of the various levels of government and of private landowners. The main purpose of this committee is to find ways to prevent or reduce the extensive damage caused by high Great Lakes water levels. The Committee submitted its report to the provincial Minister of Natural Resources in November 1986 with public release of the report made on December 16, 1986. The report recommends that the Provincial Government take a lead role in shoreline management around the Great Lakes and create a Shoreline Management Advisory Council. The report also recommends that the province increase its effort to map hazard areas as part of the Canada-Ontario Flood Damage Reduction agreement. The Minister of Natural Resources has also written to the Federal Environment Minister asking that a joint federal-provincial strategy be developed to address the undertaking and funding of major engineering works should they be necessary to mitigate shoreline damages due to continuing high Great Lakes water levels.

4.6 International Joint Commission Reference

In response to the serious high water level and shoreline damage problem on the Great Lakes, the Canadian and United States governments held discussions on the matter during the spring of 1986. An agreement was reached to request the International Joint

Commission to undertake a further investigation of the issue and to develop recommendations on means of alleviating the adverse consequences of fluctuating water levels.

This IJC Reference is to address recent record water supplies and levels as well as changing economic conditions and shoreline development.

The Terms of Reference as provided to the Commission by Governments on August 1, 1986 are reproduced in part as follows:

"The Commission, building upon previous studies should:

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

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

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

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

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

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

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

The Commission has been requested to provide an interim report in 1987 and a final report in 1989.

On November 14, 1986, the IJC submitted an initial report to the governments recommending improvement in storm and storm surge modelling and dissemination of information on Great Lakes water levels to the public. It also informed the Governments of its intention to explore the feasibility of using existing facilities in the Great Lakes Basin to lower the water levels of the Great Lakes. These facilities include the LongLac and Ogoki diversions, the Lake Michigan diversion at Chicago, the Welland Canal and the Black Rock Canal. A report on this segment of the study is expected to be completed by the IJC in 1987.

5.0 FINDINGS AND CONCLUSIONS

Precipitation in the first half of 1986 was below average and in the subsequent six months above average which balanced out to average precipitation over the year. Runoff conditions in the Canadian portion of the Great Lakes Basin were slightly above average, whereas evaporation was slightly below average.

High outflows combined with the other near normal hydrological factors (precipitation and runoff) have improved the water level conditions on Lake Superior in 1986. The absence of the normal fall 1985 decline in Lakes Michigan-Huron water levels together with the rise in levels towards the end of 1986 are the principle factors in causing water levels on these lakes to remain at record highs in 1986. The other factor is the high inflow from Lake Superior. The high Lakes Michigan-Huron outflows in 1986 also caused Lakes St. Clair and Erie water levels to remain at record highs. In spite of high outflows, Lake Ontario levels rose during 1986 due to the very high inflows from Lake Erie.

It appears, that the vast amount of the excess water in the Great Lakes is beginning to very slowly work its way out of the Great Lakes System. Continued average or below average precipitation conditions in the coming months and year(s) will expedite the return of more normal water level conditions.

A review of the actions to redirect or to store the Ogoki diversion waters on Lake Nipigon show that the impacts of these actions on Lake Superior and downstream water levels has been negligible. All of the Ogoki diversion water that was stored on Lake Nipigon during the short period in 1985 passed into Lake Superior in early 1986. With the Ogoki diversion returned to its normal operation in May 1986, the effect on the water level of Lake Superior due to manipulation of this diversion ceased to exist by the end of 1986.

The emergency actions to reduce Lake Superior's outflows raised the water level on Lake Superior by a maximum of 0.1 metre in August and September 1985. Early termination of these actions in late 1985, together with a return to Plan 1977 outflows for Lake Superior in 1986 limited continuing relief to downstream lakes in 1986 due to this action to at most a centimetre or so on Lakes Michigan/Huron.

The IJC decision to implement Criterion (k) has increased Lake Ontario's outflow significantly throughout 1986 and thereby avoided even higher levels on Lake Ontario that could otherwise have exceeded the Regulation Plan's upper limit of elevation 75.22 metres. These extreme high flows in the St. Lawrence River have also served to identify downstream flood and erosion prone areas on the St. Lawrence River especially in the area of Lake St. Pierre. In view of the continuing extreme high water supplies to Lake Ontario as a result of record high water levels on the upper lakes, the potential for high St. Lawrence River flows and thus more downstream shoreline damages remains high.

The Great Lakes Water Level Communications Centre has, through its numerous contacts with the public and media, acted to improve public understanding of the factors and reasons for the record high Great Lakes water levels and has provided a focal point in Canada for water level information that is requested by many and various agencies.

6.0 FORECAST OF FUTURE WATER LEVEL CONDITIONS

The latest six month forecast (Figures 1-5) indicates that Lake Superior water levels should continue to decline until March 1987 at which time it will begin its seasonal rise. Levels on Lake Superior are expected to remain below the record high levels established in 1985 and 1986.

Lakes Michigan-Huron levels are expected to fall to their winter minimum in February and March 1987, but as a result of the surcharge of water received in September 1986, will remain at or above 1986 record levels through to mid-spring 1987.

Due to continuing record high Lake Huron outflows, Lakes St. Clair and Erie levels will experience a lower than normal seasonal decline through the winter. Levels during the winter and early spring of 1987 on the lakes will remain very close to the new record high levels established in 1986.

Despite continued maximum St. Lawrence River flows, Lake Ontario water levels are expected to climb rapidly in the early months of 1987. New record high monthly water levels could be established as early as February 1987. Lake levels in the order of up to half a metre higher than those experienced in 1986 could be expected in 1987. Depending upon winter ice cover and river flow conditions in the St. Lawrence River, Lake Ontario levels in 1987 could challenge record levels previously established in the 1940s and 50s.

Table 1

Monthly and Total Annual Precipitation Data for the Great Lakes for the Period 1900-1985

(Millimetres)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean	SUM
1900	43.2	72.5	43.1	39.0	48.7	62.9	114.1	92.5	103.8	72.5	78.9	31.7	66.8	802.9
1901	45.3	31.0	66.1	43.3	65.2	78.2	106.2	67.0	66.7	71.4	49.6	64.0	63.1	754.0
1902	35.7	34.5	53.3	46.9	80.7	108.3	115.1	52.7	85.3	66.8	63.9	59.9	67.1	803.1
1903	46.4	55.3	57.5	63.9	70.8	68.5	106.0	104.6	85.8	72.1	48.3	58.6	70.0	837.8
1904	52.6	49.9	73.0	55.1	97.8	64.3	81.6	76.1	97.7	73.3	18.0	53.3	66.2	792.7
1905	48.5	39.4	51.2	46.1	93.4	102.9	106.0	73.1	84.5	77.7	63.6	42.8	69.3	829.2
1906	58.0	33.3	55.4	39.8	65.7	103.7	63.5	73.4	63.6	92.9	83.1	57.9	66.1	790.3
1907	74.0	24.8	58.6	58.5	63.8	62.4	75.1	67.1	103.8	52.2	56.1	61.9	63.4	758.3
1908	45.0	80.0	57.6	66.4	110.5	62.9	80.1	62.2	42.9	27.2	53.1	56.6	62.0	744.5
1909	50.1	67.1	46.2	92.4	66.3	54.9	91.3	65.2	62.9	49.0	79.1	73.6	66.4	798.1
1910	53.6	54.0	15.2	73.5	70.7	36.4	67.3	80.4	77.6	74.2	59.6	49.8	59.4	712.3
1911	45.1	51.7	42.5	45.2	80.2	77.0	77.5	79.0	83.0	99.4	87.9	58.3	69.0	826.8
1912	51.6	34.4	32.3	61.0	111.0	39.7	87.2	102.3	97.7	62.1	58.2	56.0	66.3	793.5
1913	67.4	43.6	96.0	58.4	76.0	57.4	87.8	69.0	63.1	91.3	58.7	16.6	65.7	785.3
1914	56.6	34.9	44.3	70.5	67.6	81.7	56.4	90.6	59.0	51.5	56.7	49.5	60.1	719.3
1915	51.8	49.4	21.1	28.6	66.3	94.7	88.1	93.2	106.5	55.0	73.2	50.9	64.9	778.8
1916	84.3	33.4	63.0	67.7	100.4	114.1	37.1	65.0	93.8	85.3	51.2	57.6	71.2	852.9
1917	45.9	30.6	62.0	59.0	61.9	108.3	68.4	70.2	48.5	101.9	23.0	46.0	60.7	725.7
1918	56.9	52.0	36.6	47.1	104.4	61.0	50.5	65.8	84.0	81.6	70.1	65.9	64.8	775.9
1919	33.2	42.5	62.2	75.4	82.8	56.0	57.7	69.6	78.3	98.9	75.2	35.2	64.0	767.0
1920	43.2	25.6	63.3	71.5	36.2	89.5	84.5	59.7	62.3	54.1	59.9	81.3	61.0	731.1
1921	28.4	34.3	87.1	81.7	55.0	49.9	82.4	76.4	92.7	65.8	64.8	66.5	65.6	785.0
1922	42.8	68.0	60.3	84.2	64.2	86.7	97.5	54.9	68.9	49.1	57.7	49.6	65.2	783.9
1923	51.9	34.9	67.5	48.7	61.7	70.2	70.3	68.1	73.8	62.9	40.3	63.3	59.7	713.6
1924	71.4	44.6	36.4	60.4	79.0	74.3	85.1	97.8	88.1	19.7	50.5	64.7	64.4	772.0
1925	36.5	47.6	49.8	40.8	35.7	81.8	81.6	51.7	98.5	72.8	57.3	45.9	58.3	700.0
1926	44.2	47.7	58.9	51.7	49.0	96.3	76.1	90.8	123.2	89.6	104.0	50.7	73.5	882.2
1927	36.6	41.1	48.4	50.6	107.9	61.3	95.2	35.6	86.8	66.7	106.4	77.0	67.9	813.6
1928	47.3	43.9	53.2	71.4	47.7	114.6	91.6	97.1	86.1	103.3	64.1	39.3	71.6	859.6
1929	87.5	29.2	60.1	105.8	85.4	69.6	71.1	42.1	70.7	81.1	57.3	63.0	68.8	822.9

Table 1 Continued

Monthly and Total Annual Precipitation Data for the Great Lakes for the Period 1900-1985

(Millimetres)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean	SUM
1930	63.4	44.4	49.8	41.7	70.0	103.4	53.4	28.5	71.6	51.2	43.4	34.0	54.5	654.8
1931	40.7	25.8	46.8	45.2	76.4	74.5	70.0	57.4	120.3	82.6	90.8	47.2	64.9	777.7
1932	83.8	53.8	53.4	44.3	76.3	53.7	94.6	93.3	64.9	102.7	64.6	67.1	71.3	852.5
1933	39.1	52.4	55.0	74.2	86.1	58.2	57.0	54.1	85.6	88.4	69.4	59.4	64.9	778.9
1934	45.3	23.0	53.0	56.6	32.7	67.7	48.9	63.3	120.5	55.9	92.1	51.2	59.2	710.2
1935	70.6	35.6	48.2	40.2	53.7	100.0	83.7	77.2	73.7	60.1	74.0	45.6	63.7	762.6
1936	50.9	51.0	62.9	53.1	58.8	52.3	31.8	82.9	98.5	78.2	51.9	61.8	61.2	734.1
1937	85.6	59.2	26.1	87.3	67.6	73.9	90.5	75.5	87.0	81.7	63.8	55.5	71.2	853.7
1938	65.3	70.8	70.1	66.0	75.0	85.7	74.9	94.0	89.0	33.6	66.7	60.6	70.9	851.7
1939	63.7	78.4	52.3	63.1	57.4	108.0	55.7	87.4	66.6	68.9	19.7	38.2	63.1	759.4
1940	52.1	37.0	45.1	59.7	99.8	108.1	58.1	101.1	57.7	56.7	88.5	60.3	68.7	824.2
1941	50.3	37.4	29.8	56.3	66.2	62.0	73.5	92.4	112.1	121.4	63.3	51.9	68.2	816.6
1942	48.1	37.7	78.2	44.3	110.8	67.7	85.7	68.8	118.3	76.9	75.0	77.6	74.4	889.1
1943	54.6	45.8	66.0	59.8	115.5	118.9	75.2	83.5	58.0	59.0	68.2	28.7	69.6	833.2
1944	29.0	44.3	72.1	55.9	75.8	113.3	80.0	72.9	89.4	33.1	68.5	57.2	65.7	789.5
1945	42.3	54.2	55.5	85.9	107.0	90.5	75.5	80.3	124.0	75.3	81.5	49.9	76.8	921.9
1946	61.5	51.7	40.3	32.1	84.9	87.1	46.2	62.9	74.6	76.2	67.1	71.0	63.0	755.6
1947	65.3	38.8	49.0	103.1	108.4	97.1	82.3	59.6	97.8	25.4	69.3	48.5	70.4	844.6
1948	48.8	44.5	78.4	74.9	62.9	74.9	71.6	54.2	39.2	52.0	99.4	58.6	63.3	759.4
1949	74.8	56.5	55.6	40.4	66.8	90.3	93.8	59.7	76.5	66.0	62.3	71.6	68.0	814.3
1950	101.0	61.8	64.5	82.5	56.3	88.8	94.1	76.4	66.3	60.4	97.2	60.7	75.9	910.0
1951	53.3	63.1	83.9	84.6	52.5	94.6	89.4	88.3	97.6	97.3	75.6	75.0	79.6	955.2
1952	64.6	32.2	60.8	58.5	75.0	71.8	120.4	87.4	54.5	25.4	73.9	51.4	64.8	775.9
1953	58.7	52.5	66.6	68.4	93.0	85.1	83.7	74.4	79.6	27.4	47.5	63.5	66.8	800.4
1954	54.1	58.5	71.0	104.3	67.9	104.9	53.8	69.9	100.5	128.3	49.1	47.6	75.8	909.9
1955	48.0	45.6	70.1	58.7	66.6	52.7	71.7	90.7	55.3	118.2	73.8	47.5	66.8	798.9
1956	30.9	40.9	52.8	71.4	99.7	71.2	92.6	101.9	61.7	25.2	65.2	57.0	64.3	770.5
1957	49.3	38.4	35.2	81.1	79.2	109.7	74.5	49.7	99.8	59.3	86.0	66.2	69.0	828.4
1958	41.6	29.9	17.9	47.0	46.0	87.1	90.3	87.9	91.4	55.9	84.7	45.5	60.5	725.2
1959	59.1	51.1	51.4	71.4	88.4	51.5	77.9	119.8	101.6	113.8	74.2	62.7	77.1	922.9
1960	62.3	53.6	33.7	88.9	109.6	90.5	74.9	72.2	64.6	59.3	67.5	34.2	67.6	811.3

Table 1 Continued

Monthly and Total Annual Precipitation Data for the Great Lakes for the Period 1900-1985

(Millimetres)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean	SUM
1961	21.8	46.5	63.3	75.2	59.9	81.1	82.7	72.7	120.6	56.1	64.7	56.2	66.7	800.8
1962	65.7	56.4	24.5	50.6	74.4	65.3	66.7	83.1	86.5	62.8	33.9	59.2	60.8	729.1
1963	37.2	28.2	57.7	59.8	72.2	64.9	69.2	79.4	57.2	22.7	71.8	52.7	56.2	673.0
1964	52.2	25.3	61.3	84.9	83.1	65.9	74.6	109.2	87.1	38.6	60.7	64.4	67.4	807.3
1965	70.0	67.4	48.3	60.0	71.6	58.3	68.2	102.6	136.2	70.6	87.4	70.0	75.8	910.6
1966	48.9	40.4	70.6	57.6	47.1	60.7	58.3	98.1	59.8	66.0	105.2	76.5	65.9	789.2
1967	67.1	45.4	36.9	87.1	53.1	119.1	61.5	87.9	59.4	99.9	72.9	68.6	71.6	858.9
1968	45.9	43.5	44.5	72.2	82.8	122.0	86.8	83.4	101.5	75.5	68.4	92.1	76.6	918.6
1969	79.9	16.5	31.5	79.3	83.7	116.3	83.7	45.6	59.6	98.5	69.7	51.3	68.2	815.6
1970	47.6	30.5	44.5	66.3	102.6	67.9	114.1	46.3	129.3	93.7	74.8	67.2	74.0	884.8
1971	60.9	78.5	53.5	34.2	71.4	71.3	81.8	67.6	76.6	67.1	68.1	92.0	68.6	823.0
1972	58.7	50.4	71.0	56.9	64.4	83.7	96.7	118.8	101.3	63.5	64.7	92.5	77.0	922.6
1973	44.0	36.0	75.0	68.2	109.0	95.3	79.4	78.8	67.2	75.0	71.7	73.0	73.0	872.6
1974	68.9	45.3	58.1	78.9	93.5	91.5	70.0	89.3	77.9	57.2	77.1	50.2	71.6	857.9
1975	83.4	55.8	60.8	57.6	66.0	101.7	68.5	114.4	85.5	43.6	87.2	67.3	74.4	891.8
1976	72.4	62.4	111.8	58.6	72.2	84.2	73.5	46.9	63.2	56.8	40.8	49.2	66.1	792.0
1977	51.4	45.5	93.3	67.8	40.0	79.6	90.9	128.7	135.4	63.9	91.6	87.6	81.5	975.7
1978	71.1	19.5	36.5	54.2	80.8	73.4	83.3	97.1	114.0	60.9	61.8	71.6	69.0	824.2
1979	71.2	39.8	86.6	80.2	79.5	89.7	66.9	99.6	55.9	101.0	81.0	58.6	76.1	910.0
1980	58.8	27.1	55.8	77.0	49.8	94.2	92.8	99.7	113.2	69.6	41.6	64.2	70.4	843.8
1981	24.0	69.8	29.9	92.2	62.6	118.2	59.3	87.0	100.9	94.5	41.6	51.0	69.0	831.0
1982	73.4	26.9	60.1	54.5	64.1	78.8	95.8	73.8	96.9	73.7	101.0	85.8	74.0	884.8
1983	38.5	29.0	57.8	74.7	111.4	55.2	65.6	80.4	101.0	95.7	88.4	83.0	73.7	880.8
1984	38.4	42.2	50.1	64.7	83.4	94.9	64.4	84.3	97.6	70.3	63.4	81.5	69.6	835.1
1985	59.4	69.1	77.4	64.1	81.1	66.2	87.6	110.8	112.8	85.5	130.2	72.5	84.8	1016.7
MEAN	54.7	45.3	55.6	63.7	75.0	81.2	78.1	78.4	85.3	69.8	68.2	59.2	68.0	814.6

Table 2

Precipitation Data for the Great Lakes: 1986 and Previous Recorded Means

(Millimetres)

	Jan	Feb	Mar	Apr	May	Jun
Superior						
Mean	49.0	37.4	44.5	50.4	68.6	83.9
1986	49.5	26.9	53.6	38.1	35.3	90.9
% of Mean	101	72	120	76	52	108
Huron/Michigan						
Mean	52.8	43.9	54.5	65.1	75.9	79.3
1986	35.8	35.8	64.0	46.7	55.9	80.8
% of Mean	68	82	117	72	74	102
Erie						
Mean	62.4	52.6	71.1	79.8	83.2	86.9
1986	37.9	67.3	55.4	66.3	86.4	94.0
% of Mean	61	128	78	83	104	108
Ontario						
Mean	68.0	60.3	67.6	72.1	77.1	77.3
1986	43.2	39.9	54.6	53.9	63.3	83.1
% of Mean	64	66	81	75	82	108
Great Lakes						
Mean	54.7	45.3	55.6	63.7	75.0	81.2
1986	40.6	37.9	59.0	47.7	55.1	85.6
% of Mean	74	84	106	75	74	105

Source: National Oceanic and Atmospheric Administration, and U.S. Army Corps of Engineers.

Mean data are calculated for the period 1900-1984 inclusive, except fot the Great Lakes Basin in which the data for 1985 are also used.

1986 data are preliminary

Table 2
(continued)

Precipitation Data for the Great Lakes:

1986 and Previous Recorded Means

(Millimetres)

	Jul	Aug	Sep	Oct	Nov	Dec	Tot
Superior							
Mean	81.3	80.3	88.6	67.8	62.6	50.5	764.9
1986	91.9	89.9	106.2	54.6	66.0	28.4	731.3
% of Mean	113	112	120	81	105	56	96
Huron/Michigan							
Mean	74.7	76.5	86.1	69.8	67.7	58.7	805.0
1986	101.7	89.5	147.6	66.9	35.3	44.1	804.1
% of Mean	136	117	171	96	52	75	100
Erie							
Mean	82.9	79.2	78.6	67.7	69.3	65.9	879.6
1986	101.7	81.5	146.6	91.1	56.6	70.6	955.4
% of Mean	125	103	186	134	82	107	109
Ontario							
Mean	78.8	77.7	78.7	75.4	76.2	73.5	882.7
1986	74.9	79.1	120.9	74.0	60.8	68.1	815.8
% of Mean	95	102	154	98	80	93	92
Great Lakes							
Mean	78.1	78.4	85.3	69.8	68.2	59.2	814.5
1986	96.1	87.4	133.1	67.6	49.3	46.0	805.4
% of Mean	123	112	156	97	72	78	99

Source: National Oceanic and Atmospheric Administration, and U.S. Army Corps of Engineers.

Mean data are calculated for the period 1900-1984 inclusive, except for the Great Lakes Basin in which the data for 1985 are also used.

1986 figures are preliminary.

Table 3

1986 Runoff Conditions in the Canadian Portion of the Great Lakes Basin

(Expressed as a Percentage of the Mean for Period 1960-1984)

	Lake Superior	Lake Huron	Lake St Clair	Lake Erie	Lake Ontario	Total Basin
Jan	121	100	163	118	97	111
Feb	116	81	72	63	87	94
Mar	117	100	150	145	106	115
Apr	109	90	55	52	73	87
May	93	61	75	101	62	75
Jun	82	78	154	117	191	91
Jul	91	102	137	142	83	96
Aug	90	160	112	168	35	109
Sep	91	176	346	632	373	161
Oct	84	170	586	427	405	166
Nov	91	99	108	125	124	100
Dec	Unavailable at time of publication					
Total*	98	100	133	147	115	104

Source: Water Resources Branch - Ontario Region
Inland Waters Directorate, Environment Canada.

* Note: Totals based on data for January - November.

Table 4

Evaporation from the Great Lakes in 1985 and 1986 and Long-Term Mean Data

	January to December			January to September*		
	Mean 1965-1985	1985	% of Mean	Mean 1965-1985	1986	% of Mean
Superior	534	604	113	237	179	76
Huron	539	495	92	269	256	95
Georgian Bay	522	493	94	240	239	100
Erie	738	962	130	436	336	77
Ontario	580	646	111	348	320	92

Note: All figures are in millimetres.

* Data for October-December 1986 unavailable at time of publication.

Table 5

Welland Canal Diversions in 1985 and 1986

and Comparison with Previous Record

Welland Canal Diversion (cms)*

	1985	1986	Mean 1950-1985	Previous Recorded Maxima and year of Occurance
Jan	200	241R	198	241 (1983)
Feb	185	225	198	238 (1976,1980)
Mar	175	227	204	249 (1977,1979)
Apr	248	241	227	278 (1977)
May	265	181	235	275 (1979)
Jun	249	202	232	272 (1973,1979,1981)
Jul	231	173	227	286 (1979)
Aug	216	225	232	280 (1979)
Sep	229	237	235	272 (1973,1978)
Oct	218	249	235	275 (1976)
Nov	231	246	232	278 (1976,1981)
Dec	224	240E	223	269 (1976)
Annual	223	224E	223	263 (1979)

* Figures include the 20 cms of water that is discharged from the Canal to the Welland River.

R Denotes new record

E Denotes estimate

Table 6

Niagara River Flows in 1985 and 1986

and Comparison with Previous Records

Niagara River Flows at Buffalo (cms)

	1985	1986	Mean 1860-1985	Previous Recorded Maxima and year of Occurance	
Jan	6200	6340	5550	6940	(1973)
Feb	5660	6650	5380	6770	(1863)
Mar	6740	7250R	5550	7110	(1973)
Apr	7330	7190	5800	7450	(1974)
May	7330	7480	6120	7500	(1974)
Jun	7280	7590R	6170	7420	(1973)
Jul	6910	7500R	6060	7330	(1973)
Aug	6770	7190R	5980	7050	(1973)
Sep	6680	6910R	5860	6910	(1861)
Oct	6480	7160RE	5750	6940	(1861)
Nov	6820	7020RE	5750	6910	(1861)
Dec	7390R	7310RE	5750	6990	(1972)
Annual	6800	7130RE	5810	6990	(1973)

R Denotes new record

E Denotes estimate

Table 7

Great Lakes Water Levels: 1986 and Previous Recorded Maxima

	Jan	Feb	Mar	Apr	May	Jun
Superior (at Thunder Bay)						
Monthly Mean	183.31*	183.25*	183.23*	183.29*	183.36*	183.39
Previous Record	183.25	183.18	183.16	183.22	183.35	183.44
(year)	1952	1975	1951	1951	1951	1916
Michigan-Huron (at Goderich)						
Monthly Mean	176.96*	176.91*	176.93*	177.03*	177.08*	177.13*
Previous Record	176.77	176.77	176.76	176.92	177.02	177.05
(year)	1973	1952	1973	1985	1985	1985
St. Clair (at Belle River)						
Monthly Mean	175.57*	175.59*	175.59*	175.61*	175.62*	175.70*
Previous Record	175.34	175.35	175.51	175.59	175.58	175.60
(year)	1974	1985	1985	1985	1985	1973
Erie (at Port Colborne)						
Monthly Mean	174.55	174.54*	174.71*	174.75	174.77*	174.85*
Previous Record	174.56	174.45	174.61	174.82	174.73	174.79
(year)	1973	1973	1974	1985	1974	1973
Ontario (at Kingston)						
Monthly Mean	74.73	74.78	74.88	75.10	75.10	75.16
Previous Record	75.03	75.12	75.22	75.47	75.58	75.61
(year)	1946	1952	1952	1952	1952	1952

All elevations are in metres above sea level on the International Great Lakes Datum (1955) as recorded at one Canadian location on each lake. These data are slightly different from those used in lake regulation purposes, where data are used from a number of Canadian and United States stations on each lake.

* Denotes a new record maximum set in 1986

Table 7
(continued)

Great Lakes Water Levels: 1986 and Previous Recorded Maxima

	Jul	Aug	Sep	Oct	Nov	Dec
Superior (at Thunder Bay)						
Monthly Mean	183.43	183.45	183.42	183.40	183.36	183.29
Previous Record	183.53	183.52	183.54	183.53	183.50	183.40
(year)	1916	1916	1916	1985	1985	1985
Michigan-Huron (at Goderich)						
Monthly Mean	177.18*	177.21*	177.18*	177.29*	177.20*	177.07*
Previous Record	177.07	177.07	177.03	176.95	176.97	177.06
(year)	1973	1973	1952	1985	1985	1985
St. Clair (at Belle River)						
Monthly Mean	175.71*	175.69*	175.63*	175.74*	175.60*	175.57*
Previous Record	175.60	175.54	175.47	175.38	175.51	175.54
(year)	1973	1973	1985	1985	1985	1985
Erie (at Port Colborne)						
Monthly Mean	174.84*	174.76*	174.64*	174.76*	174.69*	174.76*
Previous Record	174.76	174.66	174.50	174.38	174.48	174.73
(year)	1973	1973	1973	1973	1985	1985
Ontario (at Kingston)						
Monthly Mean	75.14	75.08	74.93	74.98	74.86	74.84
Previous Record	75.52	75.44	75.27	75.09	75.04	75.06
(year)	1947	1947	1947	1945	1945	1945

All elevations are in metres above sea level on the International Great Lakes Datum (1955) as recorded at one Canadian location on each lake. These data are slightly different from those used in lake regulation purposes, where data are used from a number of Canadian and United States stations on each lake.

* Denotes a new record maximum set in 1986

Table 8

Computed Effects of Emergency Actions Regarding Lake Superior Regulation on Great Lakes Water Levels

	L. Superior Outflow (cms)		End of Month Cumulative Storage on L. Superior (m)	End of Month Lowering Effects (m)		
	Computed Plan 1977	Actual Outflow		Huron/ Michigan	St. Clair	Erie
1985						
May	2 780	1 980	0.024	0.018	0.009	0
June	2 890	1 930	0.055	0.040	0.018	0.003
July	2 750	1 900	0.082	0.055	0.030	0.012
August	3 060	2 320	<u>0.107</u>	<u>0.073</u>	0.040	0.021
September	2 860	2 890	<u>0.107</u>	0.070	<u>0.046</u>	0.027
October	2 350	3 450	0.070	0.043	0.037	<u>0.030</u>
November	3 170	3 740	0.052	0.030	0.030	0.027
December	2 380	2 920	0.033	0.018	0.021	0.024
1986						
January	2 350	2 410	0.030	0.018	0.018	0.018
February	2 320	2 440	0.027	0.018	0.015	0.015
March	2 320	2 410	0.024	0.012	0.015	0.012
April	2 230	2 290	0.024	0.012	0.012	0.012
May	3 000	3 000	0.024	0.012	0.012	0.009
June	3 230	3 230	0.024	0.012	0.009	0.009
July	3 140	3 140	0.024	0.012	0.009	0.009
August	3 230	3 230	0.024	0.009	0.012	0.009
September	3 040	3 000	0.024	0.009	0.009	0.006
October	2 410	2 410	0.024	0.009	0.009	0.006
November	1 640	1 640	0.024	0.009	0.006	0.006
December	1 560*	1 560*	0.024*	0.009*	0.006*	0.006*

Note: No impact on Lake Ontario due to the operation of Lake Ontario's regulation plan.
All flows are in cubic metres per second. Water levels are in metres to three decimal places.
Underlined values indicate maximum effects.

* Denotes Estimate

Table 9

Effects of Storing Water on Lake Nipigon

	Ogoki Water Discharged Northward (cms)	Ogoki Diversion into L. Nipigon (cms)	Ogoki Average Diversion 1944-1984 (cms)	End of Month Accumulated Storage on Lake Nipigon Ogoki (m)	Local Inflow (m)	Total (m)
1985						
June	20	325	201	0.017	0.028	0.045
July	0	210	157	0.135	0.102	0.237
August	18	96	127	0.160	0.091	0.251
September	137	20*	116	0.164	0.113	0.277
October	244	20*	109	0.168	0.082	0.250
November	221	20*	115	0.171	0.018	0.188
December	126	44	108	0.171	-0.138	0.028
1986						
January	50	65	92	0	-0.120	-0.120
February	25	57	73		-0.219	see note
March	13	51	64		-0.389	
April	13	53	65			
May	50	162	140			
June	0	258	201			
July	4	64	157			
August	0	162	127			
September	0	81	116			
October	0	74	109			
November	0	79	115			
December	0	75E	108			

* Leakages at Summit Control Dam

E Estimated

Note: It is assumed that all Ogoki waters stored on Lake Nipigon in 1985 were discharged out of that lake into Lake Superior in early 1986.

Table 10

End of Month Accumulated Lowering Effect on Lake Superior

Due to Storing Water On Lake Nipigon**

	Due to Storage of Ogoki and Local Inflow on Lake Nipigon (m)	Due to Direction of Ogoki Water to James Bay (m)
1985		
June	0.002	nil
July	0.013	nil
August	0.014	nil
September	0.015 (max)	0.004
October	0.014	0.012
November	0.010	0.019
December	0.002	0.023
1986		
January	0	0.025
February	0	0.026
March	0	0.026
April		0.026
May		normal diversion operation resumes in May
June		

**Based on storage constant 1 730 cms-months = 1 metre on Lake Nipigon and 31 400 cms-months = 1 metre on Lake Superior
All effects are in metres rounded to three decimal places

Note: It is assumed that all Ogoki waters stored on Lake Nipigon in 1985 were discharged out of that lake into Lake Superior in early 1986.

Table 11

Lake Ontario Regulation Summary

	Supplies (cms)		Outflows (cms)			Levels (m)	
	1985-86	1900-80 Mean	Plan 1958-D Computed	1985-86	1900-85 Mean	Preproject levels	1985-86
1985							
Jan	7 480	6 570	6 230	6 510	6 230	75.03	74.51
Feb	7 420	6 510	7 190	7 280	6 260	74.94	74.48
Mar	9 940	7 790	7 870	7 840	6 540	75.20	74.71
Apr	9 490	8 580	8 440	8 350	7 020	75.43	74.94
May	8 810	7 930	8 580	8 440	7 250	75.49	75.02
Jun	8 380	7 450	8 640	8 660	7 360	75.50	75.02
Jul	7 670	6 880	8 580	8 580	7 310	75.45	74.95
Aug	7 110	6 290	8 380	8 380	7 140	75.29	74.77
Sep	7 250	6 030	8 410	8 380	6 940	75.20	74.64
Oct	7 140	6 030	8 240	8 160	6 770	75.11	74.48
Nov	9 510	6 340	8 320	8 100	6 650	75.18	74.52
Dec	8 500	6 540	7 450	7 760	6 510	75.33	74.63
1986							
Jan	7 960	6 570	6 290	7 020	6 230	75.30	74.74
Feb	8 100	6 510	7 360	8 160R	6 260	75.35	74.82
Mar	10 190	7 790	7 980	8 520	6 540	75.47	74.90
Apr	9 940	8 580	8 720	8 980	7 020	75.70	75.13
May	9 170	7 930	8 780	9 370	7 250	75.74	75.13
Jun	9 600	7 450	8 780	9 200	7 360	75.80	75.18
Jul	8 980R	6 880	8 780	9 490	7 310	75.81	75.17
Aug	8 550R	6 290	8 780	9 230	7 140	75.77	75.09
Sep	9 060R	6 030	8 780	9 260R	6 940	75.66	74.95
Oct	9 030R	6 030	8 780	9 200R	6 770	75.73	75.00
Nov	8 240	6 340	8 780	9 630R	6 650	75.67	74.89
Dec	9 599R	6 540	8 780E	9 630ER	6 510	75.71	74.86

Note: Preproject levels are those computed had there been no Lake Ontario regulation taking place.
Supplies and outflows are in cubic metres per second.
Water levels are in metres, IGLD (1955)

E Denotes estimates

R Denotes new record high

Table 12

Summary of Flood and Erosion Damages for 1985 and 1986

1985 Damage Estimates

Conservation Authority	Damage Estimate ($1000's)	Comments
Ausable-Bayfield	XXX.X	- Difficult to determine. - Close to nil because only problem was nuissance flooding in Port Franks.
Catfish Creek	161.0	- Estimate itemized in report by the CCCA.
Essex	XXX.X	- Estimate unavailable at time of publication.
Grand River	547.0	- Only an estimate of the Dec 2 storm. - Applies to damages to dwellings and public works. - $17 000 applies to loss of land.
Grey-Sauble	XXX.X	- No damage reports have been received. - No monitoring program in place to document damage.
Kettle Creek	117.0	- Est. Flood Damage = $27 000.00 Est. Erosion Damage = $90 000.00 - Based upon repairs to damaged erosion control structures and clean-up/repairs to flooded structures.
Lakehead	XXX.X	- Estimate unavailable at time of publication.
Long Point	1 533.0+	- A report by the LPRCA summarizes damages incurred during the 2 Dec, to 18 Dec, 1985 storm. We note that damage also occurred as a result of a storm early in April, 1985.
Lower Thames	886.00	- Studies stemming from high water and storms suggested over $10 million of capital works. - The dollar estimate was itemized in the questionnaire return.

Maitland	XXX.X	- No buildings being affected at present. - Main damage is to shore protection structures such as gabions, groynes, revetments, concrete walls and sheet steel walls. - Some accessory structures damaged (boathouses), not extensive nos.
Niagara	8 000.0	- Estimation prepared on behalf of the NPCA by F.J. Reinders & Assoc's Ltd. (after Dec. 2, 1985 storm event). - Twp. of Wainfleet estimated damages to be $4 700 000.00.
Nottawasaga	XXX.X	- Estimate unavailable as Public as well as Authority were not familiar with assistance program and damages or problems were not realized by or reported to Authority.
Saugeen	XXX.X	- Damage values have not been reported to the Authority. - The SVCA undertook erosion control project during 1985/86 approx. $140 000 to protect a water and sewage pumping station in the Town of Port Elgin.
Sault Ste. Marie	487.5*	- Erosion (1985 - '86) - 65 properties estimate to repair damage: $5 000 to $10 000. Therefore, damages = 65 x $7 500 = $487 500 . - Based on OMNR survey and verbal communications.
St. Clair	XXX.X	- Did not complete questionnaire as they have not done any detailed damage survey.

* - Indicates that a combined value for two years was specified. Assigning data to one of both years would be misleading.

XXX.X - Indicates that the damage estimate is either unknown or unavailable at time of publication.

1986 Damage Estimates

Conservation Authority	Damage Estimate ($1000's)	Comments
Ausable-Bayfield	XXX.X	- Same as 1985. - Erosion has increased. - 75% of the shoreline is developed. - Still have more time before any significant damage results. - Real problems could start in 1987 or 1988.
Catfish Creek	000.0	- None this year since spring thaw was controlled by the use of an ice-breaker.
Essex	???.?	- Estimate unavailable at time of publication
Grand River	XXX.X	- Erosion is continuing at an increased rate. - So far this year, no problems have been reported.
Grey-Sauble	XXX.X	- No damage reports have been received. - No monitoring program in place to document damage that may have occurred.
Kettle Creek	89.2	- Costs associated with the repair and construction of erosion control works. - $46 584 spent by municipalities. - $42 600 spent by private residents.
Lakehead	???.?	- Estimate unavailable at time of publication.
Long Point	000.0	- The LPRCA is not aware of any damages incurred during 1986. - Region of Haldimand-Norfolk is presently undertaking an assessment of lakeshore damages.
Lower Thames	448.6	- Damages are probably 25% of 1985 damages due to precautionary action and weaker storms. - City of Port Dover spent $198 550 on dyking and pumping. - 150 acres of land was lost and will not be reclaimed; this is not included in the damage estimate.

Maitland	XXX.X	- Main problem is that high water levels have reduced the beach at the toe of the bluff. - If the toe is left unprotected by land-owners the bluff cottages will begin to suffer direct damage.
Niagara	XXX.X	- No storms of damaging impact or consequences have resulted to date. Therefore no calculation or assessment has occurred.
Nottawasaga	3 000.0+	- Estimate is made by number of inquiries for assistance received by Authority x average cost of remedial works.
Saugeen	XXX.X	- Damage values have not been reported to the Authority. - Both the Town of Kincardine and the Township of Saugeen have undertaken erosion control works in 1985 and 1986.
Sault Ste. Marie	487.5*	- Erosion (1985 - '86) - 65 properties estimate to repair damage: $5 000 to $10 000. Therefore, damages = 65 x $7 500 = $487 500 . Based on OMNR survey and verbal communications.
St. Clair	XXX.X	- Did not complete questionnaire as they have not done any detailed investigating regarding damages.

* - Indicates that a combined value for two years was specified. Assigning data to one of both years would be misleading.

XXX.X - Indicates that the damage estimate is either unknown or unavailable at time of publication.

LAKE SUPERIOR (Thunder Bay) LAC SUPÉRIEUR

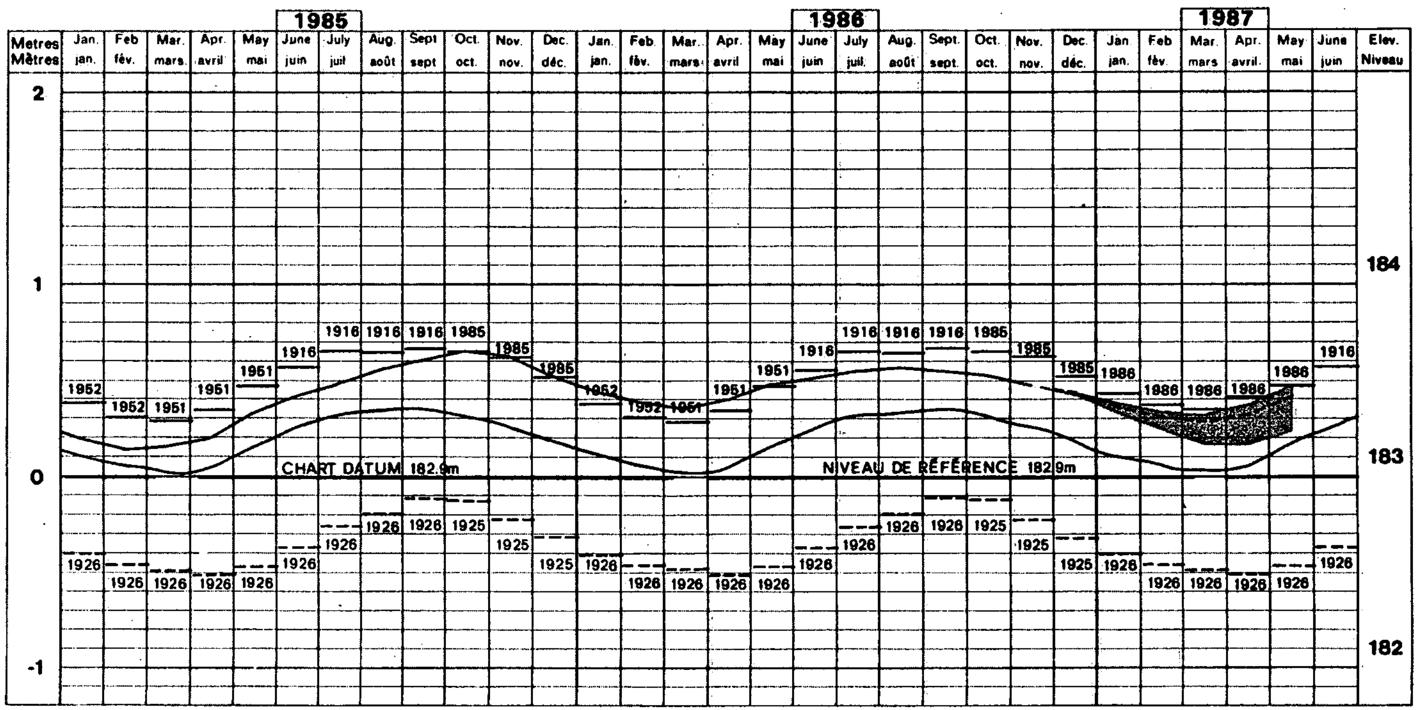

FIGURE 1 WATER LEVEL HYDROGRAPH OF LAKE SUPERIOR

LAKE HURON (Goderich) LAC HURON

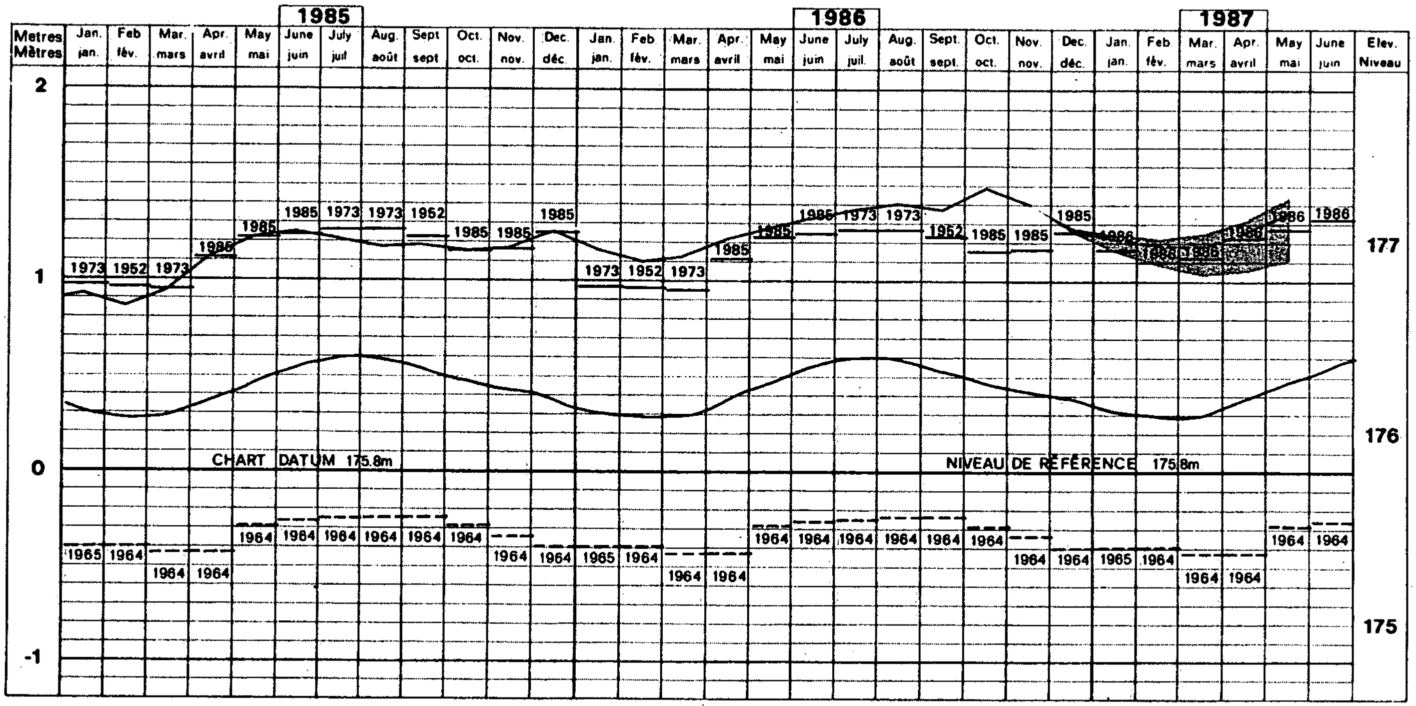

FIGURE 2 WATER LEVEL HYDROGRAPH OF LAKES MICHIGAN-HURON

LAKE ST. CLAIR (Belle River) LAC ST. CLAIR

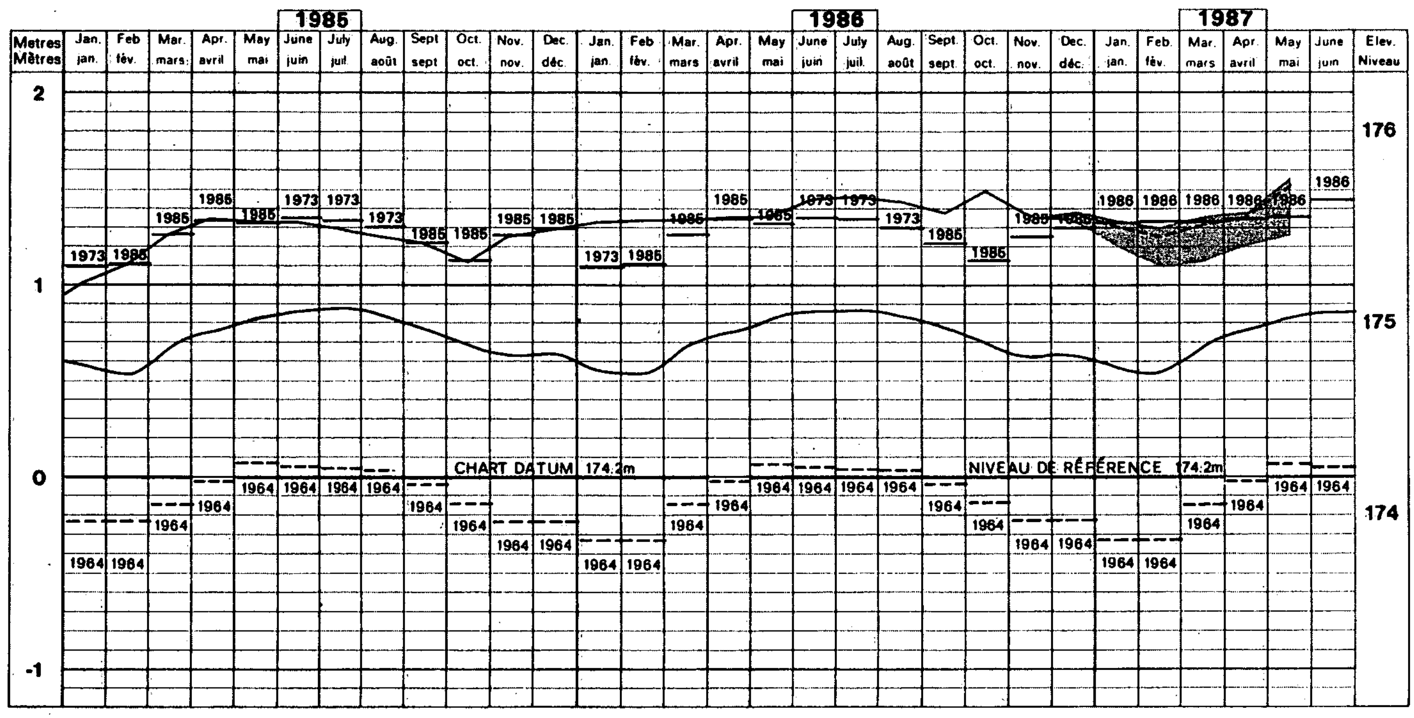

FIGURE 3 WATER LEVEL HYDROGRAPH OF LAKE ST. CLAIR

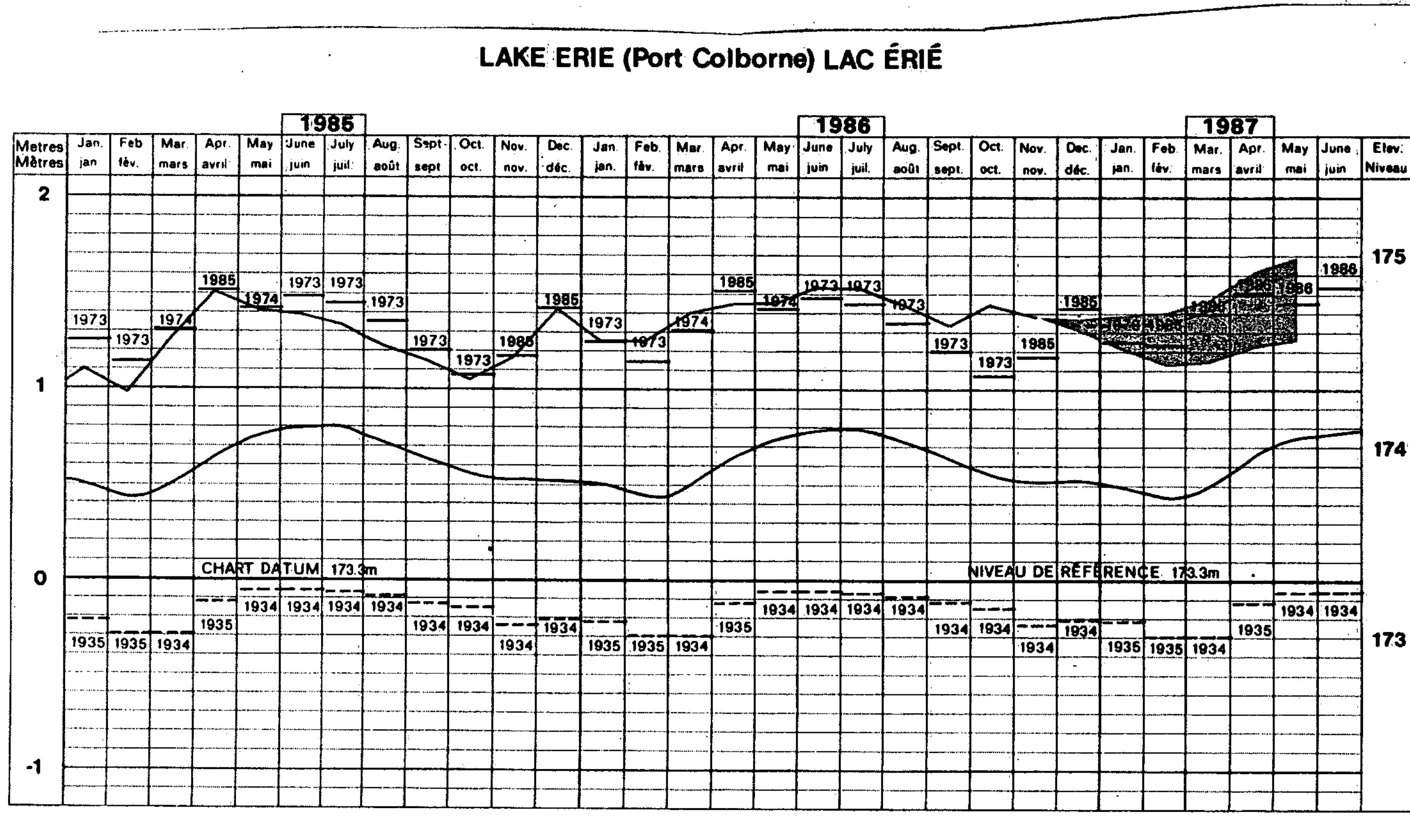

FIGURE 4 WATER LEVEL HYDROGRAPH OF LAKE ERIE

LAKE ONTARIO (Kingston) LAC ONTARIO

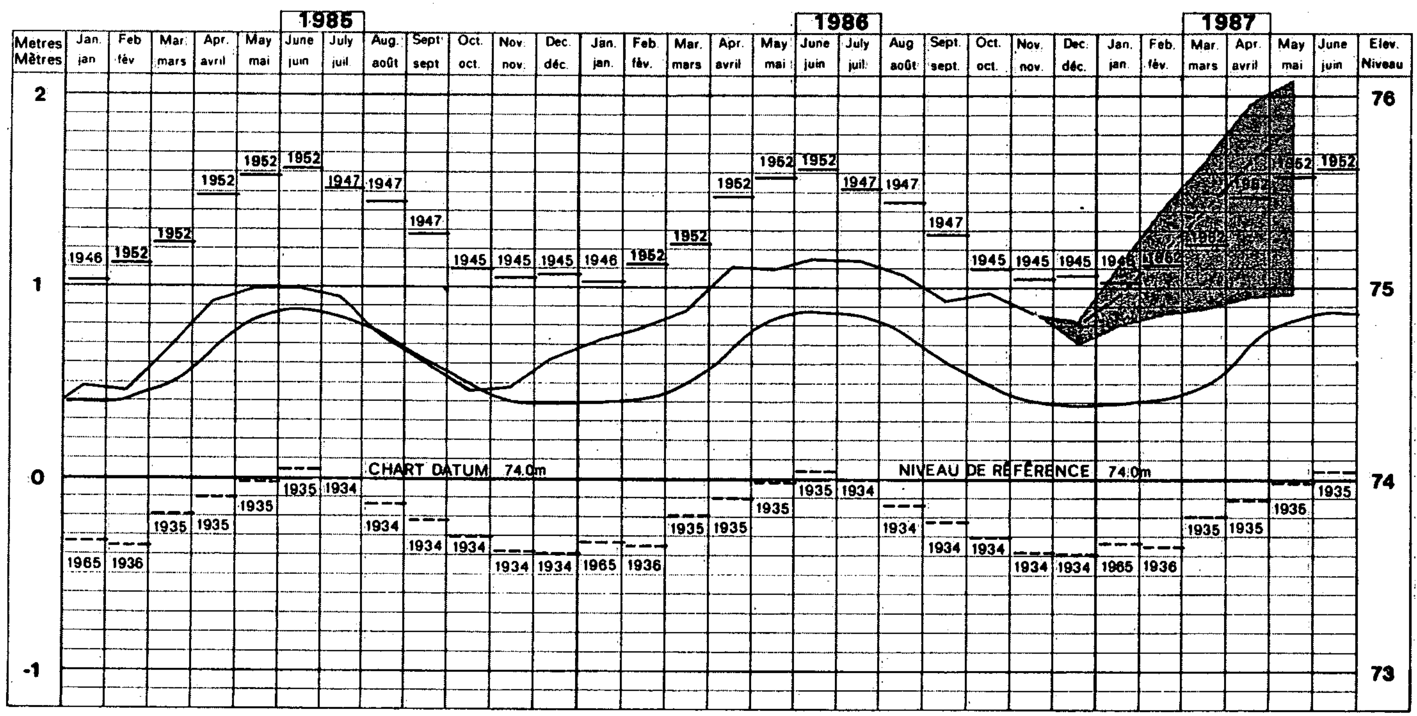

FIGURE 5 WATER LEVEL HYDROGRAPH OF LAKE ONTARIO