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A REPORT ON 1987 WATER LEVELS OF THE GREAT LAKES

Direction générale des eaux intérieures et des terre

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Canada

A REPORT ON
1987 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 interim report summarizes the events that took place in 1987 in connection with water levels on the Great Lakes. Water management actions related to Lake Superior and Lake Ontario regulation, as well as their impacts on lake water levels, are also summarized. Reported flood and erosion damages caused by storms during this time period are 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. A similar report was prepared in December 1986. This report has been prepared summarizing hydrologic conditions and other events of 1987 related to Great Lakes water levels.

The format of this report is similar to that of the 1985 and 1986 reports. All data are in metric units unless stated otherwise. Lake water levels are expressed in metres on the International Great Lakes Datum (1955). The preliminary data used in this report (eg. precipitation) may be subject to future revisions by the agencies issuing these data.

CONDITIONS LEADING TO THE GREAT LAKES WATER LEVELS OF 1987

2.1 GENERAL

Since the late 1960's, water levels on the Great Lakes 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 1900-1987. The long-term (1900-1987) average annual precipitation over the Great Lakes Basin is about 812 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 on all of the Great Lakes with the exception of Lake Ontario, a condition which continued through 1986 and into early 1987. During 1987, precipitation over the basin has been approximately 4% below normal for the year with precipitation over the period November 1986 to June 1987 being unusually low at 27% below the average for that period. As a result of this reduced water supply, lake levels have fallen considerably below the record levels set in 1986. Section 2.2 discusses the precipitation in each of the lake basins in greater detail, while water levels are discussed in Section 2.5.

2.2. Precipitation

The recorded monthly mean precipitation rates over the Great Lakes in 1986 and 1987 are summarized by lake in Table 2. Precipitation on the Lake Superior Basin in 1987 was above average in May, July, August, October and November. Precipitation was below average for the remaining months. Overall, precipitation on the Lake Superior basin was 8% below average for 1987. From January to June, precipitation was 38% below average. In April alone, precipitation was 62% below the mean for that month. During the last six months of the year, precipitation was 11% above the mean.

For the first seven months of 1987, precipitation on the Lake Michigan-Huron basin was approximately 23% below average, the lowest month being February, when precipitation was 59% below the monthly mean. In August of 1987, precipitation over the Lake Michigan-Huron basin was 63% above average. This above average trend continued from August to December, with precipitation being approximately 21% above the mean for that period. Overall, 1987 precipitation over the Lake Michigan-Huron basin was 3% below average for the year.

On the Lake Erie Basin, precipitation for the first five months of 1987 was 31% below average for that period. From June to December,

precipitation has been 24% above average, with precipitation in August being 71% above the mean for that month. Overall, Lake Erie's total 1987 precipitation was 3% above average for the year.

In 1987, precipitation on the Lake Ontario basin in the months of April and June was above normal, however, very low values in February and May (62% and 48% below average respectively) caused precipitation in the Ontario basin to be approximately 11% below average for the first six months of the year. Since July, precipitation has been approximately 6% above average, with September being the only particularly wet month. Overall, precipitation in 1987 was 3% below the long term average.

For the first six months of 1987, precipitation over the entire Great Lakes basin was approximately 25% below average. From July to December, precipitation over the entire basin was 15% above average, causing the total Great Lakes basin precipitation for 1987 to be only 4% below the long term average.

The widespread low rate of precipitation over the basin from November of 1986 and throughout the first half of 1987 has caused the levels of all the Great Lakes to decline to well below the record high levels that were experienced in 1986. A more detailed discussion of the water level conditions in 1987 is contained in Section 2.5.

2.3 Runoff

Preliminary streamflow data from a number of 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 enables fast data retrieval and analysis.

Runoff conditions in the Canadian portion of the Great Lakes basin, from January to December of 1987, have been approximately 36% below average. Two months of note were May and June, when total basin runoff was 65% and 61%

respectively below average. This reflects the below average precipitation experienced over the basin throughout early 1987, as well as the lack of any significant snowmelt or spring freshet in the spring of 1987.

2.4 Other Factors

a) Evaporation

Lake evaporation data for 1987 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 1986 and the long-term averages for the period 1965-1986 are included.

In 1987, evaporation was slightly below average on Lake Ontario and Lake Superior, 3% higher than average on Lake Erie and 13% and 9% higher on Georgian Bay and Lake Huron respectively. On an overall basis, evaporation in 1987 has been 4% higher than average and 18% higher than that for the same period in 1986. Although of lesser significance than precipitation and runoff, the higher evaporation during 1987, is another contributing factor to the lower levels of the lakes this year.

b) Welland Canal

During 1987, this diversion has averaged 237 cubic metres per second. This is marginally higher than the 1986 average diversion flow of 224 cubic metres per second. There were significant reductions in the diversion during February and March of 1987 to allow for major canal renovation work. Subsequently, flows in the Canal have been maintained at the maximum possible, recognizing navigation and other safe operation constraints, and have averaged approximately 244 cubic metres per second.

Table 5 contains the diversion data for 1986 and 1987, and draws comparisons with previous records.

c) Niagara River Flows

Table 6 contains the Niagara River flow data for 1986 and 1987 and draws comparisons with previous records. Flows throughout 1987 were above average and set new records in January and February. Overall, flows averaged approximately 6700 cubic metres per second, which is about 15% above the long term average.

d) Ice Jams in The St. Clair River

Two ice jams in the St. Clair River in February and March of 1987, significantly reduced inflows into Lake St. Clair for short periods of time. Both ice jams, caused by the flow of ice from Lake Huron into the river, lasted approximately one week in length. The first jam, on February 13th, resulted in a temporary lowering of Lake St. Clair by approximately 35 cm. The second, beginning on March 9th, was more severe and resulted in a temporary lowering of Lake St. Clair by approximately 50 cm before it was cleared a week later. The net result of both of these ice-jams was that the mean monthly level of Lake St. Clair, for both February and March of 1987, was significantly reduced from the level that would have occurred. Due to its very small surface area, Lake St. Clair's water level is sensitive to the fluctuations of inflows from Lakes Michigan-Huron. No noticeable impacts on Lakes Michigan-Huron levels were observed as a result of these ice jams.

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 1987 levels with previous recorded maximums. The general trend for the levels of all the lakes in 1987 has been downward. The below average amounts of winter and spring precipitation kept all lakes from experiencing their normal seasonal rise in level, while continued below average precipitation, resultant significant decreases in runoff and higher evaporation rates

helped to accelerate the normal seasonal decline in water levels. The net result is that levels on all the lakes have fallen well below the record levels that were set in 1986, with Lake Michigan-Huron experiencing the most dramatic reduction. Levels on Lake Superior were above average from January to April of 1987, but dropped below average in May. By December of 1987, Lake Superior was 32 cm below the level of a year earlier, 43 cm below the December record level set in 1985 and 9 cm below the long term average.

The record high levels which were set each month throughout 1986 for Lake Michigan-Huron continued into January of 1987, however, the below average precipitation late in 1986 and throughout 1987, has led to a significant reduction in Lake Huron levels. By December of 1987, levels were 58 cm below the record levels of a year earlier, approximately 80 cm below the highest ever recorded level set in October of 1986 and only 30 cm above the long term average.

On Lake St. Clair, 1987 water levels have been well below the 1986 records in all months except January. In February and March, levels dropped markedly below 1986 levels due to ice jams in the St. Clair River, which reduced the lake inflow, and due to the below average precipitation received by the basin. The level of the lake continued to decline throughout the year as inflows from Lake Huron fell. By December of 1987, the average levels of Lake St. Clair were 47 cm lower than the levels recorded in December of 1986, 64 cm below the highest ever recorded levels of October 1986 and only 19 cm above the long term average.

On Lake Erie record high levels persisted into 1987 and new records were set in both January and February. Since then, Erie levels did not exhibit the normal seasonal rise. By December, levels were 49 cm below the levels recorded in December of 1986 and 58 cm below the highest ever recorded levels of June 1986. As of December 1987, Lake Erie was 43 cm above it's long term average for the month.

On Lake Ontario, the record high inflow of water from the upper lakes in 1986 caused 1986 year-end levels to be approximately one half metre above normal. At that time, expectations were that the normal seasonal water rise during the winter and spring of 1987 might result in seriously high levels on Lake Ontario. Some forecasts suggested that Lake Ontario might break the record levels set in 1952. This would have put the lake level approximately one metre above average. Fortunately, the mild, dry weather and the favourable ice cover conditions in the St. Lawrence River, made it possible to discharge record maximum outflows out of Lake Ontario during the winter months of 1987. In view of high inflows from Lake Erie, maximum Lake Ontario outflows were continued until July, as Lake Ontario normally reaches its annual maximum level at that time of year. This year however, the unusually dry spring caused water supplies to the lake to drop off very quickly after April. When combined with high Lake Ontario outflows, this caused a reduction in Lake Ontario water levels to approximately 10 cm below average levels by the end of July. Despite subsequent reductions in lake outflows, Lake Ontario levels of up to 16 cm below average were experienced throughout the late summer and fall months. Increased precipitation and reduced outflows during this period caused the lake level in December to be 1 cm below its long term monthly average. This was 47 cm lower than the corresponding level for 1986.

3.0 EFFECTS OF GREAT LAKES WATER LEVELS

3.1 General

Record high water levels on the Great Lakes from 1985 to 1987 in combination with storm activity have resulted in considerable shore property damage. The previous 1985 and 1986 reports provided a brief summary of damages to Canadian shorelines due to storms in those years. A number of small storms have passed over the Great Lakes Basin in 1987, prompting the Atmospheric Environment Service to issue storm watches and storm warnings. As was the

case in 1986 and through good fortune, no storm event occurred in Canada in 1987 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 1987 did not match the intensity or duration of the severe storm of December 2, 1985 on Lake Erie, they still resulted in some generalized flooding and shoreline damage on Georgian Bay, Lake Huron, Lake St. Clair and Lake Erie shores in Canada. Listed below are the most severe storm events that occurred during 1987:

a) On February 7-8, 1987 gale force northwest winds up to 80 kilometres per hour caused minor damage along the shoreline of Lake Huron from Sarnia to Grand Bend. Climatologically, this was the most severe storm of the winter, but the presence of shorefast ice on both Lake Huron and Lake St. Clair greatly reduced the extent of damages that could have occurred;

b) On April 4-5, 1987, winds out of the north at 55-70 kilometres per hour caused water levels on the south shore of Lake St. Clair to rise almost 45 cm above the still water level. This, combined with waves of 2-3 metres, caused extensive flooding and property damage along the entire south shore, with the most severely affected areas being Belle River, Deerbrook, Stoney Point, Emeryville and Tecumseh.

c) From September to December of 1987, 10 high water level watches or warnings were issued by the Atmospheric Environment Service. Only one of these was a cause for concern. On December 15th, southwest winds of up to 105 kilometres per hour caused water levels on the eastern end of Lake Erie to rise almost 2 metres above the calm lake level. This was almost 90 cm above the critical level and led to minor spot flooding along some sections of the north shore including Port Stanley, Long

Point, Port Dover and Lowbanks. While water levels during this storm were only 35 cm below those of the storm on December 2, 1985, the shorter duration of the storm, significantly lower wave action and the reduced Lake Erie water levels led to minimal shoreline damages.

Some local municipalities, for example the Township of Wainfleet, and conservation authorities in Ontario have compiled flood and erosion damage information in their areas of jurisdiction. In mid 1986 and early 1987, Environment Canada's Great Lakes Water Level Communications Centre distributed a questionnaire to conservation authorities in Ontario requesting information on damages along the Great Lakes shoreline. All information received to date is summarized in Table 10. The reported damages range from light along portions of Lake Superior shoreline, to extremely heavy in densely developed areas of the other lakes. Areas that sustained moderate to heavy flood and/or erosion damages during 1985-1986 included sections of shoreline from Parry Sound to Owen Sound on Georgian Bay, Oliphant to Southampton and Kettle Point to Sarnia on Lake Huron, Mitchell's 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 to the Lake Ontario shoreline were reported during this time and no significant damages were reported anywhere on the Canadian shoreline of the Great Lakes in 1987.

Environment Canada has not acted to review or substantiate these reported shoreline damages and has no information as to their uniformity or nature, other than as noted in Table 10. They are summarized here in order to provide an indication of the scope and time frame of damages experienced on the lakes during the high water level period.

4.0 WATER MANAGEMENT ACTIONS TAKEN RELATED TO HIGH LAKE WATER LEVELS

4.1 Lake Superior Regulation

At the end of December 1987, the effect of the emergency actions taken in

1985 by the International Joint Commission to store water on Lake Superior had stabilized at a net effect of a 0.024 metre increase of Lake Superior's level, and respective 0.009, 0.006 and 0.006 metre reductions of Lakes Michigan-Huron, St.Clair and Erie levels (See Table 8). These emergency actions had no impacts on Lake Ontario levels due to the operation of Lake Ontario's Regulation Plan 1958-D.

Table 8 also lists the Lake Superior outflows for the period July 1986 to December 1987. During 1986, the outflow of Lake Superior was about 2600 cms, or some 20 percent higher than the long term average. For 1987, outflows have averaged approximately 1850 cms, which is approximately 15% below average.

It should be noted that beginning in January of 1988 the International Joint Commission has directed the International Lake Superior Board of Control to release the remaining water that was stored on Lake Superior during the emergency actions that were taken between May of 1985 and March of 1986. This will be accomplished by increasing Lake Superior outflows from the Plan flow of 1560 cms to approximately 1770 cms for each month during the January through April 1988 winter. Thereafter, flows will be in accordance with Plan 1977.

4.2 Lake Ontario Regulation

Total water supplies to Lake Ontario in 1986 were about 30 percent higher than average with actual outflows also being about 30 percent above average (Table 9). In comparison with 1986 conditions, water supplies to Lake Ontario in 1987, were some 15% higher than average. Lake Ontario's outflows during 1987 and particularly in the first half of the year have been high, with actual flows averaging approximately 8300 cms, or 5% higher than the flows called for by Plan 1958-D and approximately 21% higher than the long term average outflows. New record high monthly outflows from Lake Ontario occurred in January and again in March of 1987.

As discussed in Section 2.5, the mild, dry weather this past winter, along with favourable ice conditions on the St. Lawrence River, allowed for very high outflows from Lake Ontario and by winter's end lake levels were approximately 50-70 cm below those that would have occurred given normal winter temperature and precipitation patterns. By the end of 1987, Lake Ontario was 68 cm lower than it would have been without the benefit of regulation.

Despite occasional decreases in flow to prevent downstream flooding in the St. Lawrence River, Lake Ontario outflows were maintained at the maximum possible during the first seven months of 1987. By July, reduced Lake Ontario levels necessitated significant flow reductions. From August to December 1987, outflows were reduced in accordance with flows called for by the regulation Plan 1958-D, from 8,087 cms in August to a low of 7,034 cms in November (Table 9).

As a result of the below average Lake Ontario level and the continuing high outflows from the lake, water levels on the St. Lawrence River between Kingston and Cornwall were much below normal for the months of August and September of 1987, with record low levels being established at several locations along the river. This situation prompted numerous complaints from shore property owners and recreational boaters, particularly in the Thousand Islands to Morrisburg section of the river.

4.3 Great Lakes Water Level Communications Centre (GLWLCC)

The Great Lakes Water Level Communications Centre in Burlington, Ontario, continued it's operation along with the Toronto based High Water Level Forecast Centre during 1987.

During the year, approximately 25-30 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.

During 1987, the Water Level Forecast Centre in Toronto stepped up its monitoring of lake and weather conditions. This included the temporary addition of Lake Ontario to the watch / warning program during January to April of 1987. Additional wave buoys, including a multi-purpose weather buoy, 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.

The Burlington Centre continued its communications activities by issuing the monthly news release, providing information and responses to inquiries from the public and media, and by participating in meetings and municipal briefings for communities around the Great Lakes.

4.4 Ontario Shoreline Management Program

The Provincial Shoreline Management Review Committee, which was formed in April of 1986 to examine long term options for shoreline management on the Great Lakes, released it's report in November of 1986. Many of the recommendations in that report were implemented in 1987. These include:

1) Additional funding was added to the provincial Shoreline Property Assistance Program;

2) A Provincial Shoreline Management Advisory Council was appointed, which will regularly solicit public opinion about shoreline management issues and will have a major involvement in the development of provincial shoreline management planning. This Council has completed it's initial set

of public meetings and is scheduled to report to the Minister of Natural Resources in March of 1988;

3) The Ministry of Natural Resources and The Conservation Authorities were identified as the lead agencies for shoreline management. Conservation Authorities have already initiated the definition of shore management "cells", have held meetings to discuss their role in shore management and are now formulating shore management plans in accordance to guidelines that were issued by the Ministry of Natural Resources;

4) The provincial Technical Advisory Service has been improved so that more assistance can be provided to individual property owners in evaluating shoreline protection; and

5) The mapping of shoreline areas has been given high priority under the Canada-Ontario Flood Damage Reduction Program in order to clearly identify hazard areas and discourage further damage prone development.

4.5 International Joint Commission Reference

In response to the serious high water level and shoreline damage problem on the Great Lakes, the Governments of Canada and the United States requested the International Joint Commission to undertake a further investigation of the subject and to develop recommendations on means of alleviating the adverse consequences of fluctuating water levels. An IJC Water Levels Task Force was set up to determine measures that the Governments can take during crises to alleviate the problems caused by high lake levels. This Task Force completed its study in the fall of 1987 and presented summaries from eight individual task groups. An IJC report to governments on this work is scheduled for submission in the spring of 1988. In addition, the IJC has established a Study Board to look at long-term solutions to the problems associated with extreme high lake levels. The work of this

study board is underway.

5.0 FINDINGS AND CONCLUSIONS

Precipitation in the last two months of 1986 and the first half of 1987 was well below average for the entire Great Lakes basin. During the second half of 1987, total basin precipitation was above average. For all of 1987, total basin precipitation was only slightly below the long term average. The resultant spring and summer runoff conditions in the basin were well below average and evaporation was above average, especially on Lake Huron and Georgian Bay.

The combination of very low precipitation in the first half of the year, high lake outflows and increased evaporation led to a marked decrease in the lake levels for all lakes in 1987. March of 1987 was the first month in over a year and a half, that no new record high water levels were set on any of the lakes. As of December 1987, Lake Superior was slightly below average and 32 cm below the level recorded a year previously. On Lakes Huron, St. Clair and Erie, levels were 58, 47 and 49 cm respectively below those recorded in December of 1986. Lake Ontario was 47 cm below its level of a year earlier only 1 cm below average.

It is apparent that the vast amount of the excess water that was received by and stored in the Great Lakes system in 1985 and 1986 is slowly working its way through and out of the watershed. Continued receipt of average or below average precipitation in the coming months and year(s) will continue this trend to more average water level conditions on the middle lakes, while Lakes Superior and Ontario can be expected to experience about average levels. Should the above average precipitation that has occurred in the last half of 1987 continue, then the middle lakes will remain above average and Lakes Superior and Ontario could rise slightly above their long term averages.

The effects of emergency actions in 1985 to reduce Lake Superior's outflows still have a small and virtually constant effect on the lakes. By December of 1987, there was approximately 2.5 cm of storage remaining on Lake Superior, while the reduction in levels on Lakes Huron, St. Clair and Erie was at most, a centimetre. Beginning in January of 1988, this emergency storage is to be eliminated from Lake Superior.

The ability to maintain maximum possible outflows from Lake Ontario throughout late 1986 and early 1987, combined with low precipitation over a number of months acted to avoid high levels on Lake Ontario.

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 be slightly below their long term average. By June of 1988 levels on Lake Superior are expected to be at or slightly below the long term average, which is well below the record high levels that were established in 1985 and 1986.

Lakes Michigan-Huron levels are expected to drop to their winter minimum by February of 1988, but will remain above the long term average. Given average precipitation over the winter and spring months, June levels on Lake Michigan-Huron could be approximately 50 cm below its 1986 record level, 20 cm below the June of 1987 level and 30 cm above the long term average.

Future levels on Lakes St. Clair and Erie will remain above average by 15-25 and 30-40 cm respectively, but should remain well below record levels that were set in 1986 and 1987. By June of 1988, given average amounts of precipitation, these two lakes are expected to be 10-15 cm and 30-35 cm respectively above their long term averages. Lake Ontario should remain at or slightly above average levels during the winter and spring and be near its average level in June of 1988.

Table 1

Monthly and Total Annual Precipitation Data for the Great Lakes for the Period 1900-1986

(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 Con ued

Monthly and Total Annual Precipitation Data for the Great Lakes for the Period 1900- 1986

(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	59.9	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	82.9	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
1986	40.4	45.5	57.7	59.4	65.8	110.2	105.9	90.4	167.1	77.9	47.5	46.7	76.2	914.7
1987	41.7	17.3	40.4	46.2	62.2	72.8	87.4	115.3	85.9	75.4	70.1	67.6	65.2	782.3
MEAN	54.0	44.9	55.2	63.5	74.6	81.4	78.0	78.8	85.6	69.9	67.8	58.5	68.0	812.0

Table 2

Precipitation Data for the Great Lakes: 1986, 1987 and Previous Recorded Means

(Millimetres)

	Jan	Feb	Mar	Apr	May	Jun
Superior						
Mean	47.0	36.1	44.2	50.0	68.8	84.3
1986	39.8	33.8	46.9	59.7	45.2	117.8
% of Mean	85.0	93.0	105.0	119.0	66.0	139.0
1987	34.0	17.3	24.1	22.4	75.4	47.0
% of Mean	72.3	47.9	54.5	44.8	109.6	55.8
Huron/Michigan						
Mean	52.0	43.6	54.5	64.3	75.3	79.0
1986	37.9	42.8	61.5	53.3	68.0	95.4
% of Mean	72.0	97.0	113.0	83.0	90.0	121.0
1987	37.8	17.8	38.9	50.2	61.0	69.9
% of Mean	72.9	40.9	71.5	78.1	81.1	88.5
Erie						
Mean	61.5	52.3	69.9	78.0	82.0	86.4
1986	35.3	69.6	56.9	75.2	85.3	135.9
% of Mean	57.0	132.0	81.0	96.0	104.0	158.0
1987	51.3	10.7	60.5	54.4	59.9	114.8
% of Mean	83.4	20.5	86.5	69.7	73.1	132.9
Ontario						
Mean	68.1	60.2	67.3	71.1	75.9	77.9
1986	57.9	55.4	68.6	65.8	82.3	122.7
% of Mean	85.0	91.0	102.0	93.0	108.0	158.0
1987	64.8	23.1	59.9	75.7	39.1	97.0
% of Mean	95.2	38.4	89.1	106.5	51.5	124.6
Great Lakes						
Mean	53.8	44.9	55.1	63.7	74.4	81.5
1986	40.4	45.5	57.7	59.4	65.8	110.2
% of Mean	75.0	101.0	104.0	93.0	88.0	135.0
1987	41.7	17.3	40.4	46.2	62.2	72.8
% of Mean	77.4	38.5	73.3	72.6	83.6	89.3

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

Mean data are calculated for the period 1900-1987 inclusive.

September to December 1987 data are preliminary.

Table 2
(continued)

Precipitation Data for the Great Lakes:

1986, 1987 and Previous Recorded Means

(Millimetres)

	Jul	Aug	Sep	Oct	Nov	Dec	Tot
Superior							
Mean	81.8	81.0	89.4	67.6	62.2	49.0	761.4
1986	105.6	104.4	103.4	69.1	60.8	31.5	818.1
% of Mean	129.0	129.0	116.0	102.0	98.0	64.0	107.0
1987	120.4	99.6	78.0	77.2	62.5	42.2	700.1
% of Mean	147.2	122.9	87.2	114.2	101.0	86.0	91.9
Huron/Michigan							
Mean	74.8	77.6	87.0	69.7	67.8	58.4	804.0
1986	106.6	76.3	210.9	74.9	32.9	37.8	898.5
% of Mean	142.0	99.0	242.0	107.0	49.0	65.0	112.0
1987	67.5	126.3	86.5	76.3	70.9	77.0	780.1
% of Mean	90.3	162.8	99.5	109.4	105.0	131.8	97.0
Erie							
Mean	81.8	79.8	78.5	67.8	69.9	65.8	873.7
1986	106.4	89.9	151.1	100.1	57.7	72.6	1036.0
% of Mean	130.0	114.0	192.0	148.0	83.0	110.0	119.0
1987	88.9	136.4	75.2	76.9	73.9	93.5	896.4
% of Mean	108.7	170.9	95.8	113.5	106.0	142.1	102.6
Ontario							
Mean	79.0	78.0	79.5	75.2	76.2	73.2	881.6
1986	102.9	115.8	155.2	85.1	63.8	87.9	1063.2
% of Mean	131.0	149.0	195.0	113.0	83.0	120.0	121.0
1987	89.4	82.3	113.8	65.8	81.3	58.4	850.6
% of Mean	113.2	105.5	143.1	87.5	107.0	79.8	96.5
Great Lakes							
Mean	78.0	78.7	85.6	69.9	67.5	58.4	811.8
1986	105.9	90.4	167.1	77.9	47.5	46.7	914.7
% of Mean	136.0	116.0	195.0	112.0	70.0	80.0	113.0
1987	87.4	115.3	85.9	75.4	70.1	67.6	782.3
% of Mean	112.0	146.5	100.3	107.9	103.9	115.7	96.4

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

Mean data are calculated for the period 1900-1987 inclusive.

September to December 1987 figures are preliminary.

Table 3

1986 and 1987 Runoff Conditions in the Canadian Portion of the Great Lakes Basin

(Expressed as a Percentage of the Mean for Period 1969-1984)

	Lake Superior		Lake Huron		Lake St Clair		Lake Erie		Lake Ontario		Total Basin	
	'86	'87	'86	'87	'86	'87	'86	'87	'86	'87	'86	'87
Jan	121	92	100	86	163	100	118	113	97	103	111	93
Feb	116	88	81	82	72	30	63	57	87	70	94	78
Mar	117	88	100	92	150	80	145	110	106	88	115	91
Apr	109	77	90	56	55	84	52	93	73	119	87	77
May	93	40	61	28	75	36	101	58	62	35	75	35
Jun	82	34	78	35	154	66	117	74	191	66	91	39
Jul	91	47	102	45	137	73	142	141	83	56	96	50
Aug	90	52	160	50	112	69	168	120	35	41	109	54
Sep	91	54	176	36	346	63	632	89	373	69	161	51
Oct	84	54	170	31	586	61	427	108	405	58	166	48
Nov	91	48	99	44	108	105	125	106	124	82	100	54
Dec	99	54	82	81	129	161	115	159	112	128	96	86
Total	98	60	98	56	133	82	144	101	118	86	104	64

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

Table 4

Evaporation from the Great Lakes in 1986 and 1987

and Long-Term Mean Data

	January to December			January to December		
	Mean 1965-1986	1986	% of Mean	Mean 1965-1986	1987	% of Mean
Superior	530	437	82	530	525	99
Huron	536	485	90	536	582	109
Georgian Bay	521	504	97	521	589	113
Erie	733	613	84	733	755	103
Ontario	578	519	90	578	564	98
				TOTALS: 2898	3015	104

Note: All figures are in millimetres.

Table 5

Welland Canal Diversions in 1986 and 1987 and Comparison with Previous Record

Welland Canal Diversion (cms)*

	1986	1987	Mean 1950-1987	Previous Recorded Maxima and year of Occurance
Jan	241	233	200	241 (1983, 1986)
Feb	225	199	198	238 (1976,1980)
Mar	227	215	204	249 (1977,1979)
Apr	241	246	228	278 (1977)
May	181	247	233	275 (1979)
Jun	202	234	231	272 (1973,1979,1981)
Jul	173	241	225	286 (1979)
Aug	225	228	232	280 (1979)
Sep	237	250	235	272 (1973,1978)
Oct	249	247	235	275 (1976)
Nov	246	252	233	278 (1976,1981)
Dec	238	250E	224E	269 (1976)
Annual	224	237E	223E	263 (1979)

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

E Denotes estimate
December 1987 data not available at time of publication.

Table 6

Niagara River Flows in 1986 and 1987 and Comparison with Previous Records

Niagara River Flows at Buffalo (cms)

	1986	1987	Mean 1860-1987	Previous Recorded Maxima and year of Occurance
Jan	6340	7192R	5572	6940 (1973)
Feb	6650	6852R	5401	6770 (1863)
Mar	7250R	6796	5570	7110 (1973)
Apr	7190	7051	5820	7450 (1974)
May	7480	6965	6137	7500 (1974)
Jun	7590R	6824	6185	7420 (1973)
Jul	7500R	6881	6076	7330 (1973)
Aug	7190R	6655	5995	7050 (1973)
Sep	6910R	6541	5875	6910 (1861)
Oct	7192R	6371	5765	6940 (1861)
Nov	7022R	6145	5763	6910 (1861)
Dec	7305	6100	5763E	7390 (1985)
Annual	7134R	6698E	5827E	6990 (1973)

R Denotes new record

E Denotes estimate
December 1987 data not available at time of publication.

Table 7

Great Lakes Water Levels: 1987 and Previous Recorded Maxima

(METRES)

	Jan	Feb	Mar	Apr	May	Jun
Superior (at Thunder Bay)						
Monthly Mean	183.19	183.11	183.05	183.03	183.04	183.09
Previous Record	183.31	183.25	183.23	183.29	183.36	183.44
(year)	1986	1986	1986	1986	1986	1916
Michigan-Huron (at Goderich)						
Monthly Mean	176.99*	176.89	176.84	176.87	176.85	176.87
Previous Record	176.96	176.91	176.93	177.03	177.08	177.13
(year)	1986	1986	1986	1986	1986	1986
St. Clair (at Belle River)						
Monthly Mean	175.56	175.40	175.35	175.50	175.44	175.44
Previous Record	175.57	175.59	175.59	175.61	175.62	175.70
(year)	1986	1986	1986	1986	1986	1986
Erie (at Port Colborne)						
Monthly Mean	174.72*	174.56*	174.51	174.61	174.59	174.59
Previous Record	174.56	174.54	174.71	174.82	174.77	174.85
(year)	1973	1986	1986	1985	1986	1986
Ontario (at Kingston)						
Monthly Mean	74.82	74.85	74.80	75.00	74.95	74.84
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 1987.

(continued)

Great Lakes Water Levels: 1987 and Previous Recorded Maxima

(METRES)

	Jul	Aug	Sep	Oct	Nov	Dec
Superior (at Thunder Bay)						
Monthly Mean	183.12	183.16	183.13	183.06	183.00	182.97
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	176.85	176.79	176.71	176.62	176.52	176.49
Previous Record	177.18	177.21	177.18	177.29	177.20	177.07
(year)	1986	1986	1986	1986	1986	1986
St. Clair (at Belle River)						
Monthly Mean	175.44	175.38	175.30	175.15	175.08	175.10
Previous Record	175.71	175.69	175.63	175.74	175.60	175.57
(year)	1986	1986	1986	1986	1986	1986
Erie (at Port Colborne)						
Monthly Mean	174.59	174.47	174.41	174.31	174.20	174.27
Previous Record	174.84	174.76	174.64	174.76	174.69	174.76
(year)	1986	1986	1986	1986	1986	1986
Ontario (at Kingston)						
Monthly Mean	74.75	74.57	74.44	74.35	74.26	74.37
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 1987.

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)		
	Actual Outflow		Huron/ Michigan	St. Clair	Erie
1986					
July	3 140	0.024	0.012	0.009	0.009
August	3 230	0.024	0.009	0.012	0.009
September	3 000	0.024	0.009	0.009	0.006
October	2 410	0.024	0.009	0.009	0.006
November	1 640	0.024	0.009	0.006	0.006
December	1 980	0.024	0.009	0.006	0.006
1987					
January	2 010	0.024	0.006	0.009	0.009
February	1 980	0.024	0.009	0.009	0.009
March	2 010	0.024	0.009	0.009	0.009
April	2 010	0.024	0.009	0.009	0.009
May	2 410	0.024	0.009	0.009	0.009
June	2 180	0.024	0.009	0.009	0.006
July	1 590	0.024	0.009	0.006	0.006
August	1 560	0.024	0.009	0.006	0.006
September	1 560	0.024	0.009	0.006	0.006
October	1 670	0.024	0.009	0.006	0.006
November	1 560	0.024	0.009	0.006	0.006
December	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.

Table 9

Lake Ontario Regulation Summary

	Supplies (cms)		Outflows (cms)			Levels (m)	
	1986-87	1900-80 Mean	Plan 1958-D Computed	1986-87	1900-85 Mean	Preproject levels	1986-87
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	7 520	9 327R	6 510	75.71	74.86
1987							
Jan	8 580	6 570	6 307	8 485R	6 230	75.73	74.83
Feb	7 560	6 510	7 403	8 095	6 260	75.64	74.88
Mar	9 175	7 790	7 930	8 903R	6 540	75.61	74.80
Apr	10 250	8 580	8 693	8 860	7 020	75.76	75.00
May	8 155	7 930	8 495	9 020	7 250	75.73	74.95
Jun	8 155	7 450	8 778	8 882	7 360	75.63	74.84
Jul	7 730	6 880	8 778	8 657	7 310	75.55	74.75
Aug	6 569	6 290	8 087	8 087	7 140	75.37	74.57
Sep	7 504	6 030	7 830	7 804	6 940	75.19	74.44
Oct	6 626	6 030	7 709	7 721	6 770	75.11	74.35
Nov	6 881	6 340	7 034	7 034	6 650	75.00	74.26
Dec	8 127	6 540	7 051	7 555	6 510	75.05	74.37

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

Revised June 8, 1987

Table 10

Summary of Flood and Erosion Damages for 1985 to 1987

1985 Damage Estimates

Conservation Authority	Damage Estimate ($1000's)	Comments
Ausable-Bayfield	XXX.X	- Difficult to determine. - Close to nil because only problem was nuisance flooding in Port Franks.
Catfish Creek	161.0	- Estimate itemized in report by the Conservation Authority
Essex	XXX.X	- Estimate unavailable.
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.
Long Point	1 533.0+	- A report by the C.A. 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 (eg. boathouses).
Niagara	8 000.0	- Estimation prepared on behalf of the C.A. 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 C.A. 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	XXX.X	- Estimate unavailable.
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	XXX.X	- Estimate unavailable.
Long Point	000.0	- The C.A. 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. - Dover Township 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 landowners 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 times 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 ONNR survey and verbal communications.
St. Clair	XXX.X	- Did not complete questionnaire as they have not done any detailed investigating regarding damages.

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* - 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.

1987 Damage Estimates

Conservation Authority	Damage Estimates ($1000's)	Comments
Ausable-Bayfield	XXX	-Very little damage. -Some nuisance flooding. -No significant erosion damage except for some shoreline protection.
Catfish Creek	XXX	-No significant damage since 1985.
Essex	500	-Includes flooding and erosion damage. -Majority of damage is structural damage to homes and shoreline protection. -Does not include loss of land.
Grand River	XXX	
Grey-Sauble	XXX	-Some damage in Fall of 1986. -Minor damage on fishing islands and to shoreline roads. -Minor damage to some cottages.
Kettle Creek	XXX	-No major damage in last 9 months to a year.
Lakehead	XXX	-Some erosion of beaches and headwalls. -No real flooding or structural damage.
Long Point	XXX	-Minor flood and erosion damage.
Lower Thames	XXX	-No major damage since '85-'86.
Maitland Valley	XXX	-Some damage to seawalls and other shore protection.
Niagara	XXX	-Minor damage. -Technical Advisory Service has been busy, most notably on Lake Ontario.

Nottawasaga	XXX	-Shore protection and structural damage in Sept. '86 storm. -Insignificant damage in 1987.
Saugeen	XXX	-Damage to roads and protection. -Port Elgin Erosion Damage Project is correcting damages to sewage pumping plant and water intake: $150,000.
Sault Ste. Marie	XXX	-No significant damage.
St. Clair	XXX	-Sarnia Township reported $500,000 damage to roadway. -Very little structural damage reported.

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

LAKE SUPERIOR (Thunder Bay) LAC SUPÉRIEUR

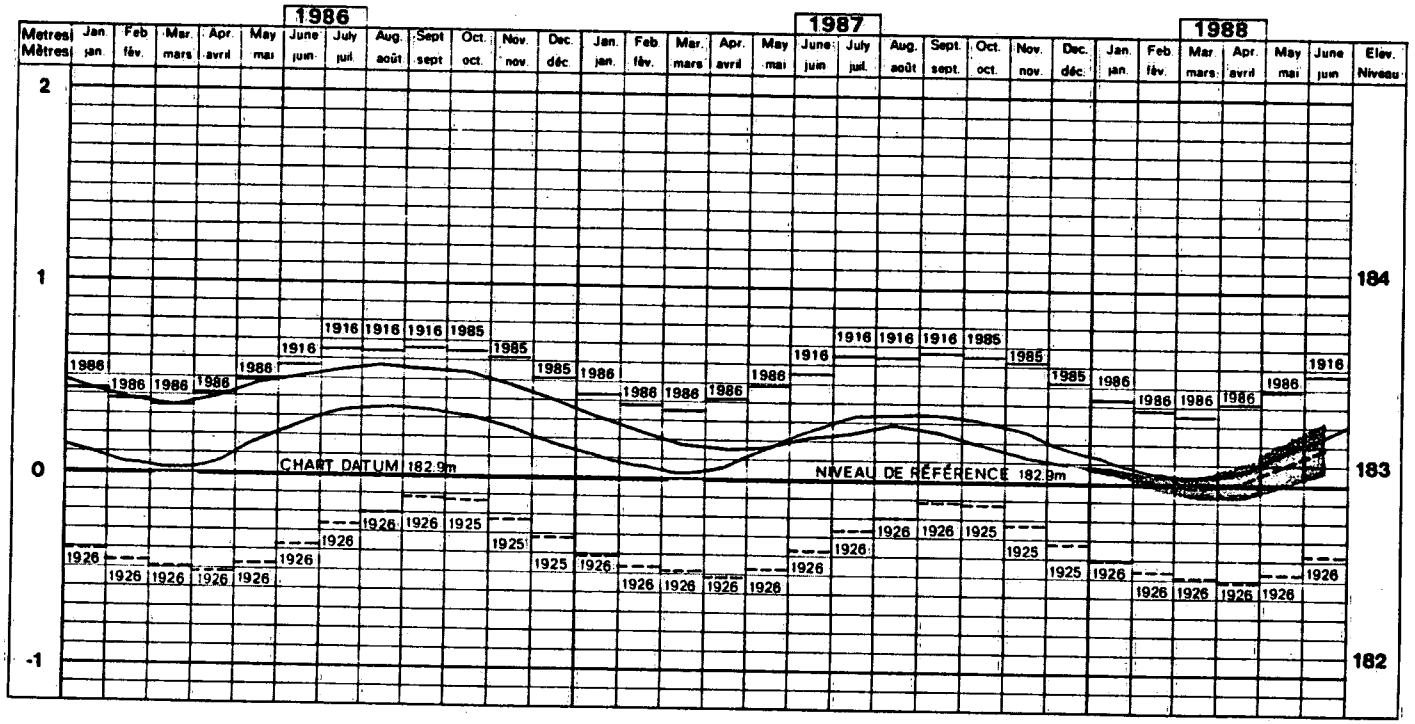

FIGURE 1: WATER LEVEL HYDROGRAPH OF LAKE SUPERIOR, DECEMBER 1987

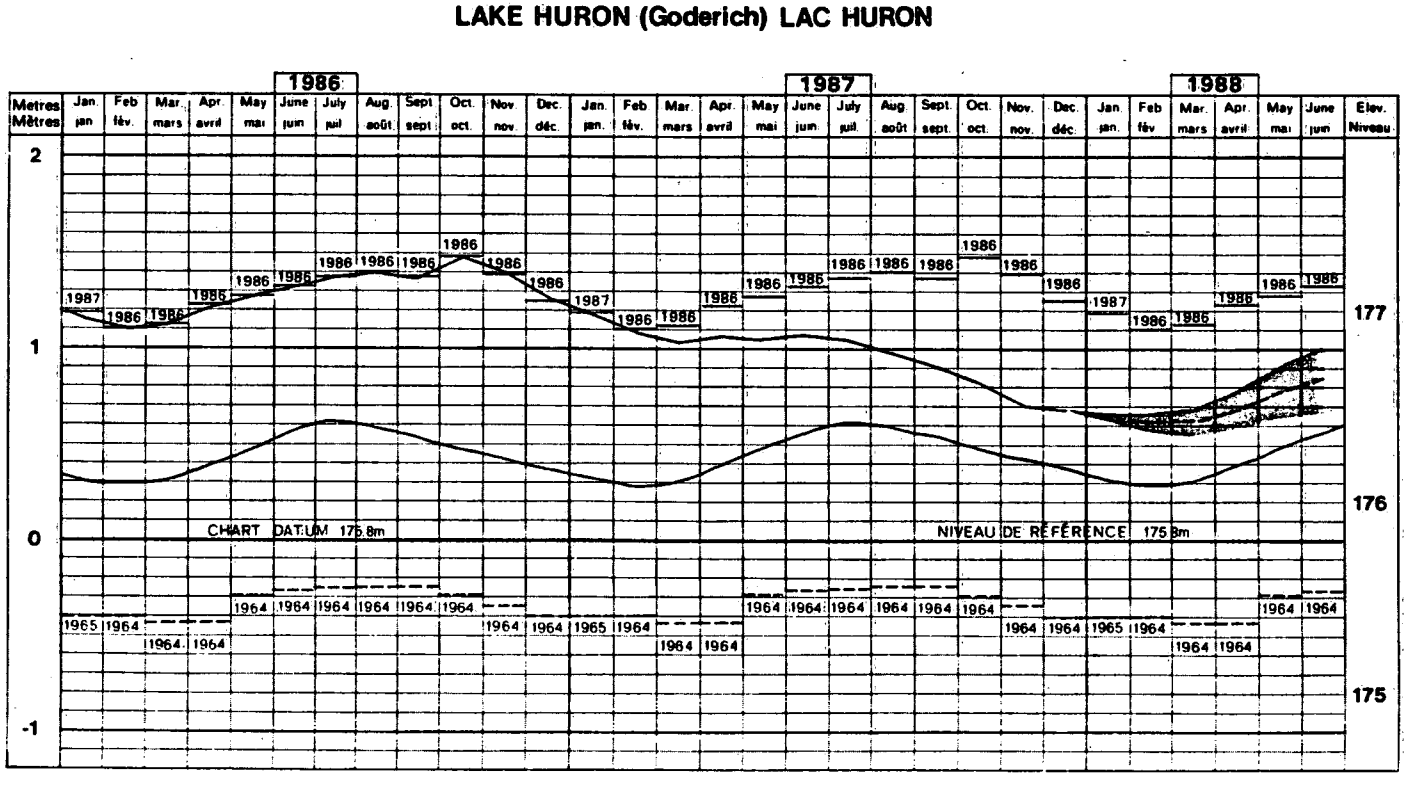

FIGURE 2: WATER LEVEL HYDROGRAPH OF LAKE HURON, DECEMBER 1987

DECEMBER 1987 **DECEMBRE 1987**

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

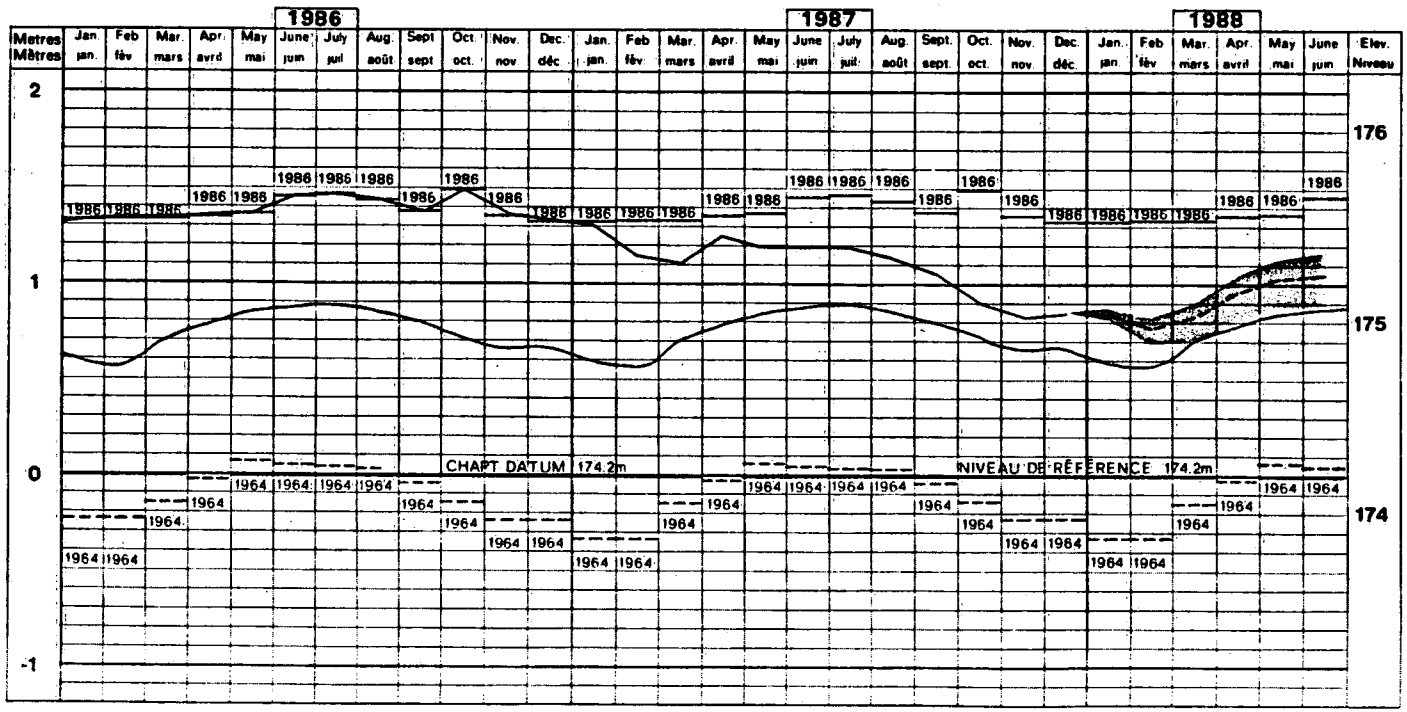

FIGURE 3: WATER LEVEL HYDROGRAPH OF LAKE ST. CLAIR, DECEMBER 1987

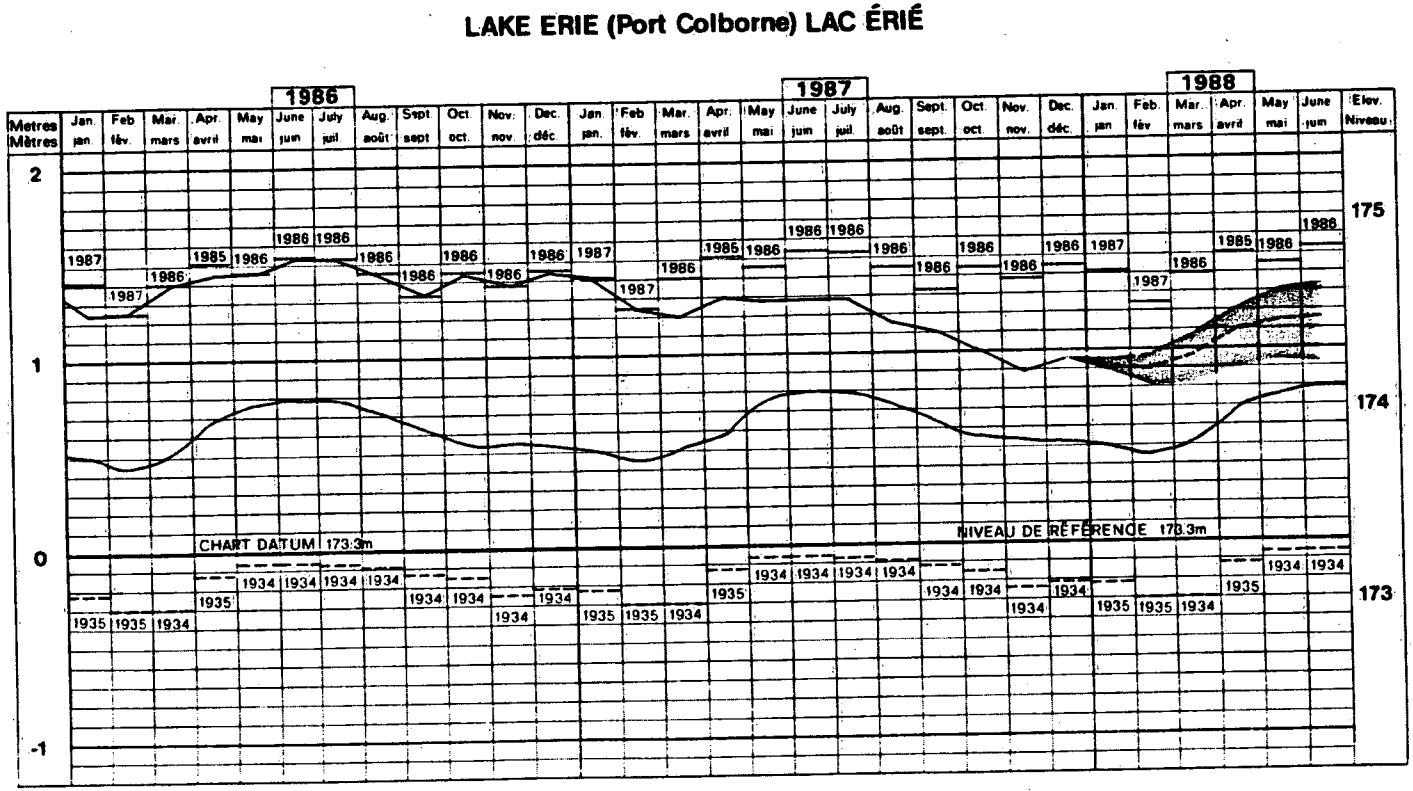

FIGURE 4: WATER LEVEL HYDROGRAPH OF LAKE ERIE, DECEMBER 1987

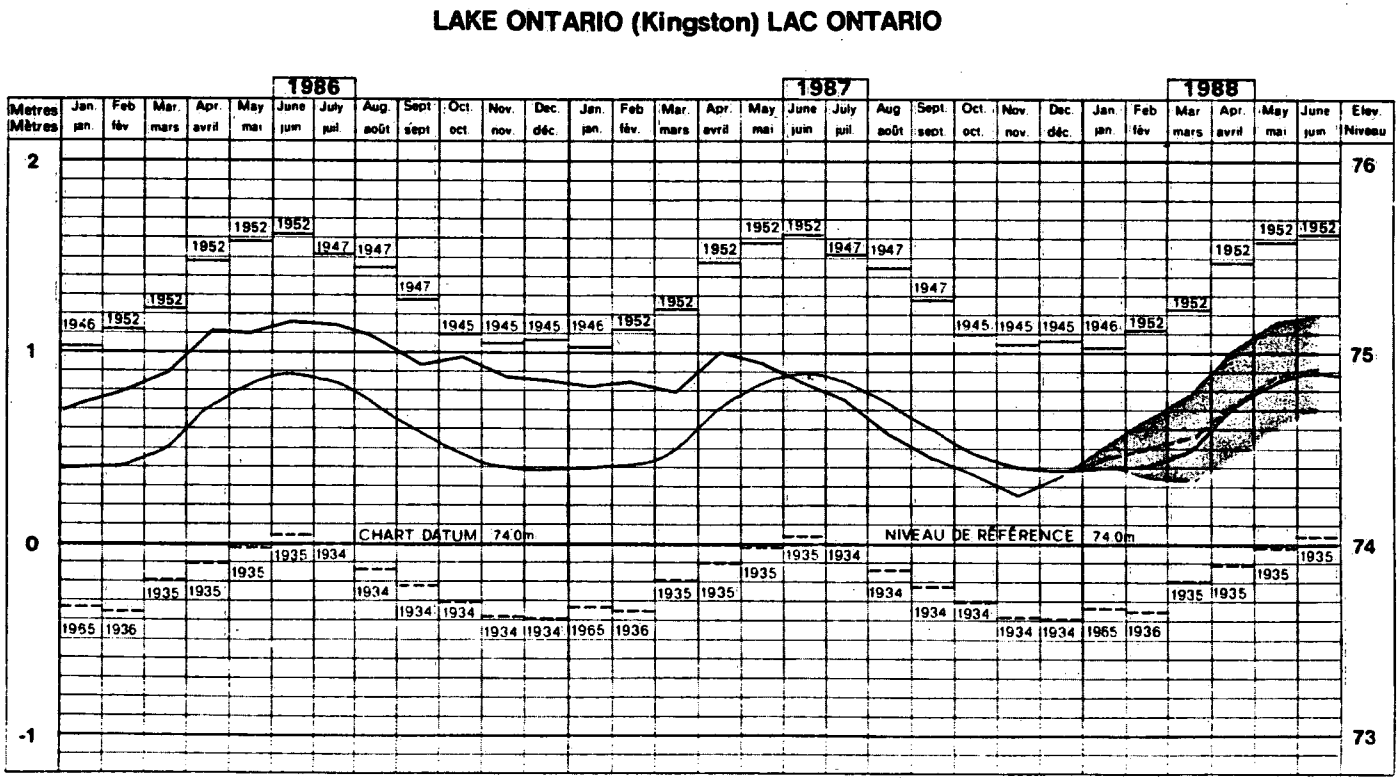

FIGURE 5: WATER LEVEL HYDROGRAPH OF LAKE ONTARIO, DECEMBER 1987

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