A REPORT ON 1990 WATER LEVELS OF THE GREAT LAKES

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1.0 PURPOSE AND SCOPE

This report summarizes the events that took place in 1990 relative to water levels on the Great Lakes - St. Lawrence River. The report examines the hydrologic factors that have shaped the water levels on the Great Lakes in 1990. It also contains a summary of the operations related to Lake Superior and Lake Ontario regulation.

The format of this report is similar to that of previous annual reports prepared for 1985-1989. All data are in metric units. Lake water level elevations are in metres on the International Great Lakes Datum (1955), which has reference zero elevation at mean sea level at Pointe-au-Pere in the Gulf of St. Lawrence. The data used in this report may be subject to revisions by the agencies issuing these data.

2.0 PHYSICAL FEATURES OF THE GREAT LAKES - ST. LAWRENCE RIVER BASIN

A detailed description of the hydrology of the Great Lakes - St. Lawrence River Basin can be found in several recent reports, including one entitled "Living With the Lakes: Challenges and Opportunities" prepared by the International Joint Commission's Project Management Team dated May 1989. The following is a summary based on these reports.

The Great Lakes Basin is about 770,000 square kilometres in area (see Figure 1). The basin extends from about 80 kilometres west of the western tip of Lake Superior to the outlet of Lake Ontario, and from Lake Nipigon in the Province of Ontario south to the central portion of Ohio. About 319,000 square kilometres are in Canada and the remaining 451,000 square kilometres are in the United States and include the entire State of Michigan and portions of Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, and New York. The Great Lakes with their connecting channels and Lake St. Clair have a total water surface area of about 246,000 square kilometres. The St. Lawrence River, from Lake Ontario to Quebec City, adds an additional 337,000 square kilometres of drainage area, most of which is located in the Province of Quebec and the State of New York. The dimensions of the Great Lakes and other physical dimensions are shown in Table 1.

As shown in Figure 2, the Great Lakes comprise a series of natural storage reservoirs which discharge into the St. Lawrence River. They are positioned in a step-wise manner, with Lake Superior being the highest and Lake Ontario the lowest, and are interconnected by a series of rivers and straits. Lake Superior discharges through the St. Marys River into Lake Huron. Lake Michigan also flows into Lake Huron through the Straits of Mackinac. The hydraulically unified Lakes Michigan and Huron (often called Lakes Michigan-Huron) discharge into Lake Erie through the St. Clair - Lake St. Clair - Detroit River system. Lake Erie's outflow is discharged through the Niagara River into Lake Ontario and Lake Ontario, in turn, flows into the Atlantic Ocean via the St. Lawrence River.

Water levels of the Great Lakes fluctuate according to the climate of the region. Over-lake precipitation, evaporation, and runoff in the basin are the main factors affecting water level fluctuations. Other natural factors also having an effect on lake levels are flow retardations due to ice in the river in the winter, or due to aquatic growth in the summer, and meteorological disturbances. Artificial factors include dredging, diversions, consumptive uses, and regulation. A detailed description of these factors can be found in the report by the International Great Lakes Levels Board dated 1973.

3.0 FACTORS AFFECTING THE GREAT LAKES LEVELS IN 1990

3.1 Hydrologic Conditions Leading to 1990

The total water supplies to Lake Superior and Lakes Michigan-Huron in 1989 were below average (see Table 6). As a result, water levels on the lakes, which were close to average in early 1989, dropped below average in May 1989. Thereafter, continued dry climatic conditions on the upper Great Lakes basins kept the levels on these lakes below average for the rest of 1989 and into 1990.

At the beginning of 1990, Lake Erie levels were slightly above average and Lake Ontario levels were near average. Levels at the Montreal Harbour, although still below average, have recovered somewhat from those of 1988 when several record low readings were observed.

Throughout 1990, the water levels of the Great Lakes followed the usual seasonal cycle in which water level rises in the spring and summer months due to increased runoff from snowmelt. Lake levels then dropped in the late summer and fall months due to reduced runoff and increased evaporation. The Great Lakes basin-wide precipitation for 1990 was about 119 percent of average. Much higher than average precipitation occurred on the lower Great Lakes basins.

The next several sections discuss briefly each of the factors in the Great Lakes hydrological cycle.

3.2 Precipitation

Records since 1900 show that about 812 mm of precipitation falls on the Great Lakes Basin each year. Average annual precipitation varies from lake basin to lake basin, and it ranges from less than 700 mm northwest of Lake Superior to as much as 1320 mm in the Adirondacks east of Lake Ontario in New York State. Table 2 compares the monthly precipitation for each lake basin in 1989 and 1990 with the long-term averages.

The Great Lakes basin-wide precipitation in 1990 was above average with that for the lower Great Lakes basins well above average toward the latter part of 1990. The increased water supplies to the lakes have

brought the levels on Lakes Michigan-Huron close to average conditions by the end of 1990.

The Lake Superior basin received precipitation which is about 106 percent of average. However, due to the dry conditions which extended from the fall of 1989 into the new year, the lake levels remained below average.

The Lake Erie basin received about 1201 mm of precipitation, which is about 137 percent of average. For nine consecutive months (April-December), precipitation was above average. The figures also indicate that new records were set for February and December 1990. The 1070 mm of precipitation that fell on the Lake Ontario basin in 1990 was the fourth highest since 1900. The 1208 mm of precipitation on the Lake Erie basin in 1990 was a new high record.

3.3 Runoff

A generalized pattern of streamflow conditions is published monthly by the United States Geological Survey and Environment Canada's Water Resources Branch. The results appear in the agencies' monthly joint publications entitled "The National Water Conditions". Two monthly diagrams, one for the month of April and the other for October, are shown in Figure 3.

A review of the monthly reports shows that runoff in 1990 has been near to slightly above average. In general, runoff was below average in the first half of the year but increased toward the end of the year.

3.4 Evaporation

In general, evaporation is least in the spring when the lakes are cold relative to the air above them and is greatest in the fall and early winter when the lakes are warm relative to the air above them. On the upper Great Lakes, condensation sometimes occurs and the values can be negative as shown in Table 3.

In 1989, evaporation was higher than average for all of the Great Lakes. Evaporation from Lake Huron and Lake Ontario was both about 15 percent higher than average.

In 1990, based on data published through November, it appears that evaporation on the Great Lakes were below average by 10-15%, whereas, the evaporation from Lake Erie has been about 117% of average.

3.5 Outflows

Table 4 lists the monthly outflows from the Great Lakes for 1989 and 1990. The outflow from Lake Superior in 1989 was 2310 cms, or 7% higher than average. In 1990, the figure has dropped to 1840 cms, some 14%

below average. This was due to much lower than average water level conditions on Lake Superior for 1990.

The outflow from Lakes Michigan-Huron in 1989 was 5270 cms, or 102% of average. In 1990 when lake levels were, for most of the time, below average, the outflow for the year was also slightly below average.

The outflow from Lake Erie in 1990 was about 6210 cms, or 107% of average. This was due to higher than average water level conditions on the lake in 1990. The outflow of Lake Ontario for 1990 was 7540 cms, about 10% higher than average.

3.6 Other Factors

The Long Lac and Ogoki diversion projects divert a part of the James Bay water into the Lake Superior basin. These diversions began in 1939 and 1943, respectively. The average rate of diversion is 159 cms. In 1989, the combined Long Lac and Ogoki rate of diversion was below average at about 143 cms. Preliminary figures show that the rate of diversion for 1990 will be near average.

The Chicago diversion takes water from Lake Michigan for the purpose of navigation, domestic and sanitary uses, and hydro-electric power generation in the Illinois Waterway. The water diverted is discharged into the upper Mississippi River. A 1967 decree by the U.S. Supreme Court specifies a maximum allowable diversion at 91 cms. A 1980 court amendment permits the use of a 40-year period in calculating the running average diversion. In 1989, the diversion was about 89 cms. Preliminary figures for 1990 show that the rate of diversion will be near the 91 cms figure.

The Welland Canal connects Lake Erie with Lake Ontario. The diversion in 1989 was 222 cms. In 1990, the diversion was about 215 cms.

The New York State Barge Canal diverts water for navigation from the Niagara River at Tonawanda, New York. All of the water diverted is eventually returned to Lake Ontario. In 1990, the diversion was about 16 cms.

3.7 Lake Water Levels

Table 5 shows a comparison of 1989 and 1990 water levels with previous records (average, maximum, and minimum) for the Great Lakes and for Montreal Harbour. These are also shown graphically in Figures 4-9.

During 1990, the levels of Lake Superior remained about 20-30 cm below average. In the first six months of the year, levels were below the lake chart datum of 182.9 metres. By the end of the year, levels remained 10-20 cm below average.

Levels on Lakes Michigan-Huron were about 20 cm below average at the beginning of 1990. Due to increased water supplies, levels gradually rose during the year and by the end of the year they were very close to the long-term average for that time of the year.

Lake St. Clair water levels, as measured at Belle River, were slightly below the 1961-1989 average for the entire 1990. It should be noted that the records for the Belle River station start in 1961. Between 1961 and the present, water levels on Lake St. Clair have been generally high. For this reason, the average curve published in the water level bulletin is higher than other average curves based on longer period of record, for example, since 1900.

Water levels on Lake Erie were slightly above average at the beginning of 1990. Due to persistently high precipitation, levels increased gradually throughout the year. During the record high precipitation in December, levels rose sharply in the last two weeks of December. At the end of the year, Lake Erie levels stood at some 45 cm above average for that time of the year, the largest departure from average of all the Great Lakes.

Lake Ontario levels were at or slightly above average in the first half of 1990. Then, they dropped off sharply after reaching their seasonal peak in June. From early June to early October, the lake dropped about 50 cm and was below average. In November and December, high precipitation raised the lake's levels sharply. At the end of 1990, levels were about 25 cm higher than average for that time of the year.

Water levels at Montreal Harbour were below average (1967-1989) for much of 1990. Due to increased water supplies from the local basin and the high flows from Lake Ontario, levels rose in September and October and by year end, they were close to the 1967-1989 average.

4.0 EFFECTS OF GREAT LAKES WATER LEVELS

4.1 General

With the water levels of 1990 being fairly close to long-term average on all of the lakes (except Lake Superior), there has been considerably less concern over the danger of flooding and erosion damage. No significant shoreline damage was reported during the year along the Canadian Great Lakes - St. Lawrence shoreline.

4.2 Nature and Extent of Impacts

Some boaters and marina operators in the International Reach of the St. Lawrence River have raised concerns over the sudden and drastic drop in lake levels in the latter part of the boating season. After a rise in levels and flows in the area in October, complaints about low water level problems have declined.

4.3 Storm Events

A number of small storms passed over the Great Lakes - St. Lawrence River Basin during the year. As is the norm, the worst of these occurred in the late fall. Only one storm considered significant is listed below.

On October 19, a strong southwesterly wind with average speeds of up to 45 knots resulted in a high water level warning for eastern Lake Erie for a short period of time. Only minor flooding, small amounts of damage to shore protection, and minor beach erosion were reported.

5.0 WATER MANAGEMENT ACTIONS RELATED TO GREAT LAKES WATER LEVELS

5.1 Lake Superior Regulation

Table 6 lists the Lake Superior and Lakes Michigan-Huron net basin supplies for 1989 and 1990 and their comparison with the long-term averages. Net basin supplies is a measure, expressed in cms-months, of the net water input to the Great Lakes resulting from precipitation, evaporation, and runoff. For Lake Superior, water supplies for 1989 were about 20% below average and in 1990 they were about 5% below average.

The water supplies to Lakes Michigan-Huron in 1989 were well below average in 1989 (64% of average). In 1990, supplies were about 130% of average.

Effective June 1990, a new regulation plan called Plan 1977-A was put into effect in the regulation of the outflows of Lake Superior. Plan 1977-A is very similar to Plan 1977. Both incorporated the objective of systemic regulation and both have been designed to meet the requirements of the Orders of the International Joint Commission. The new plan has included an updated data base and an improved forecasting technique. Because of the very minor differences between the two plans, the flows specified by Plan 1977-A have been similar to those by Plan 1977.

Since water levels on both Lake Superior and Lakes Michigan-Huron were below average in 1990, their outflows were also below average. The Lake Superior outflow for 1990 was about 1840 cms, 20% below average. The outflow of Lakes Michigan-Huron for 1990 was about 4980 cms, about 4% below average.

5.2 Lake Ontario Regulation

In 1990, the Lake Ontario outflows were very close to those specified by Plan 1958-D. The flow figure of 7540 cms was about 10% higher than average. There were some temporary flow changes from those specified by the regulation plan. These flow changes took place at the Robert-Moses power plants, the main control structure used to regulate the outflows

of Lake Ontario. These flow changes were necessary to facilitate proper ice management, improve hydro generation, and to reduce the potential of flood damages upstream and downstream of the project area.

5.3 Great Lakes Water Level Communications Centre (GLWLCC)

The Great Lakes Water Level Communications Centre in Burlington, Ontario, continued its activities in 1990 by issuing the monthly news releases, preparing a newsletter, completing and distributing a brochure on lake level regulation, providing information and responses to inquiries from the public and media, and by giving presentations at meetings.

The GLWLCC responded to about 300 telephone and mail requests for information. These requests included queries about below average levels on Lake Huron, requests for water level data, requests for documentation, and inquiries regarding the International Joint Commission water level study.

5.4 International Joint Commission Water Levels Reference Study

Phase II of the water levels reference study was initiated in 1990. The Study Board was formed in February and a Plan of Study was prepared in July. The Study Board established a Citizens Advisory Committee, which consists of representatives of the many interests affected by lake levels. The intent of the committee is to provide feedback to the Board on the direction of the study.

Four working committees have also been established to undertake components of the study. These committees prepared draft work plans in December 1990.

6.0 FORECAST OF FUTURE WATER LEVEL CONDITIONS

A six-month forecast of the water levels of the Great Lakes and Montreal Harbour is shown in Figures 4-9. It should be noted that the water levels of the Great Lakes fluctuate according to the climatic conditions in the basin. Since it is not possible to accurately forecast long-term climate conditions, the forecasts are made assuming average, wet and dry climatic conditions for the next six months.

Under average climatic conditions, the levels of Lake Superior will remain well below average. Levels will drop below the chart datum in January 1991 and will stay below chart datum for about three to four months. Only extreme high supply conditions will have any significant and rapid improvements to the lake level conditions.

Water levels on the other Great Lakes are expected to remain above average, with those on Lake Erie and Lake Ontario well above average. However, new records are not expected.

7.0 FINDINGS AND CONCLUSIONS

1. The exceptionally high precipitation on the lower Great Lakes basin in the last two months of 1990 increased the water levels of Lakes Erie and Ontario substantially. The above average precipitation in 1990 also caused the levels on Lakes Michigan-Huron to increase slightly during the year.

2. Near average precipitation over the Lake Superior basin in 1990 was not sufficient to cause a significant rise in the lake's level and it remained well below average throughout the year.

3. There were no extreme hydrological events in 1990 related to flooding and erosion and no necessity for major departures from regulation plans for the outflows of Lake Superior and Lake Ontario.

Table 1 Dimensions of the Great Lakes

	Area Sq Km	Volume Cu Km	Shoreline Length Mainland Km	Shoreline Length Island Km	Water Depth Average Metres	Water Depth Maximum Metres
Lake Superior	82100	12100	2780	1600	147	405
St. Mary's River	230		153	244		
Lake Michigan	57800	4920	2250	383	85	281
Lake Huron	59600	3540	2970	3180	59	229
St. Clair River	55		93	8		
Lake St. Clair	1110		210	204		6
Detroit River	100		96	116		
Lake Erie	25700	484	1290	116	19	64
Niagara River	60		111	60		
Lake Ontario	18960	1640	1020	125	87	244
St. Lawrence River*	610		484	567		
**	1540		1130	750		

Source: Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

* Measured from Lake Ontario to Cornwall/Massena.

** Measured from Cornwall/Massena to Ile d'Orleans near Quebec City

Table 2 Precipitation on the Great Lakes Basin in 1989, 1990* and Their Comparison with Long-Term Average (millimetres)

Superior Basin

	Average	1990	% of Average	1989	% of Average
Jan	47.24	47.50	101	57.40	122
Feb	35.81	31.75	89	29.72	83
Mar	44.20	46.23	105	43.18	98
Apr	49.78	58.93	118	34.80	70
May	68.58	58.17	85	70.87	103
Jun	84.33	125.98	149	98.30	117
Jul	81.28	84.58	104	36.32	45
Aug	82.04	75.18	92	86.87	106
Sep	88.90	85.60	96	62.23	70
Oct	67.56	106.43	158	55.37	82
Nov	62.48	48.77	78	61.21	98
Dec.	49.53	36.83	75	48.51	98
Total	761.73	805.95	106	685.18	90

Michigan-Huron Basin

	Average	1990	% of Average	1989	% of Average
Jan	52.32	57.15	109	45.72	87
Feb	43.69	44.70	102	31.24	72
Mar	54.61	53.34	98	63.50	116
Apr	64.26	54.36	85	38.10	59
May	75.18	106.17	141	91.95	122
Jun	78.49	126.24	161	87.88	112
Jul	74.42	70.36	95	40.13	54
Aug	77.72	67.06	86	77.22	99
Sep	86.87	91.44	105	49.53	57
Oct	70.36	102.11	145	63.50	90
Nov	68.58	115.06	168	84.07	123
Dec	58.67	75.44	129	45.72	78
Total	805.17	963.43	120	718.56	89

Erie Basin

	Average	1990	% of Average	1989	% of Average
Jan	61.21	57.91	95	46.23	76
Feb	52.07	136.40R	262	30.99	60
Mar	69.85	53.09	76	59.69	85
Apr	77.72	80.01	103	69.09	89
May	81.79	118.36	145	137.41	168
Jun	86.36	89.66	104	118.87	138
Jul	82.55	92.20	112	75.69	92
Aug	80.01	111.25	139	57.40	72
Sep	78.49	123.70	158	88.39	113
Oct	68.33	105.66	155	65.53	96
Nov	70.61	73.91	105	81.28	115
Dec	65.53	165.86R	253	48.01	73
Total	874.52	1208.01R	138	878.58	100

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Table 2 (Continued)

Ontario Basin

	Average	1990	% of Average	1989	% of Average
Jan	67.06	60.20	90	45.47	68
Feb	60.20	96.27	160	41.91	70
Mar	67.06	59.44	89	67.06	100
Apr	70.87	100.58	142	46.99	66
May	76.45	119.38	156	119.89	157
Jun	77.72	78.49	101	117.86	152
Jul	78.49	76.20	97	37.34	48
Aug	78.49	90.68	116	73.66	94
Sep	80.26	66.80	83	95.00	118
Oct	75.95	127.00	167	90.93	120
Nov	77.22	64.52	84	120.65	156
Dec	72.64	130.30R	179	47.50	65
Total	882.41	1069.86	121	904.26	102

Great Lakes Basin

	Average	1990	% of Average	1989	% of Average
Jan	53.85	54.86	102	49.02	91
Feb	44.70	59.69	134	32.00	72
Mar	55.12	52.07	94	57.91	105
Apr	62.99	64.52	102	42.42	67
May	74.42	96.27	129	95.76	129
Jun	81.03	115.57	143	98.55	122
Jul	77.98	77.72	100	43.69	56
Aug	79.25	78.23	99	76.71	97
Sep	85.60	91.44	107	63.50	74
Oct	70.10	106.68	152	64.77	92
Nov	68.33	85.60	125	81.79	120
Dec	58.67	82.80	142	46.99	80
Total	812.04	965.45	119	753.11	93

Source: NOAA, Corps of Engineers
* Preliminary Data.
Average are for the Period 1900-1989
R denotes new record

Table 3 Evaporation (mm) from the Great Lakes in 1989 & 1990

	Lake Superior			Lake Huron		
	Average	1990	1989	Average	1990	1989
Jan	114.5	57.2	88.6	89.1	46.1	82.7
Feb	42.2	69.8	88.2	38.3	51.0	66.9
Mar	34.2	29.7	25.5	27.1	22.6	30.4
Apr	14.7	5.6	20.4	7.2	0.5	12.0
May	1.6	3.4	1.3	-0.7	1.1	-0.6
Jun	-5.8	-8.2	-6.0	-3.5	-5.9	-3.8
Jul	-7.0	-5.2	-4.4	13.3	9.7	13.9
Aug	4.2	3.0	-4.3	44.1	34.9	52.7
Sep	38.3	29.0	28.7	62.2	87.5	79.4
Oct	60.0	65.4	50.0	76.1	82.1	43.9
Nov	101.5	81.2	134.8	86.2	71.2	132.6
Dec	133.8		126.0	106.5		116.6
Total	532.2		548.8	545.8		626.7

	Georgian Bay			Lake Michigan		
	Average	1990	1989	Average	1990	1989
Jan	65.1	31.9	74.8	n/a	51.0	69.1
Feb	20.3	32.5	39.8	n/a	59.6	89.9
Mar	22.3	21.3	18.8	n/a	25.7	31.4
Apr	8.0	-0.4	10.0	n/a	5.1	6.3
May	-0.4	0.6	-2.5	n/a	1.3	2.2
Jun	-3.3	-3.0	-2.3	n/a	-3.9	-0.5
Jul	17.8	15.4	18.2	n/a	22.4	32.7
Aug	48.8	50.0	45.3	n/a	63.9	69.2
Sep	68.8	88.9	76.6	n/a	93.8	122.6
Oct	80.5	63.3	40.7	n/a	67.5	76.7
Nov	93.4	79.2	148.6	n/a	74.8	154.1
Dec	106.9		80.1	n/a		125.3
Total	528.3		548.1	n/a		779.0

	Lake Erie			Lake Ontario		
	Average	1990	1989	Average	1990	1989
Jan	40.8	15.6	37.9	96.3	33.5	85.3
Feb	19.1	25.2	26.2	55.4	47.5	71.9
Mar	18.6	8.7	15.2	31.3	20.0	34.7
Apr	8.5	6.7	11.7	7.2	1.2	10.6
May	8.8	16.5	8.5	-1.4	-1.0	-6.1
Jun	29.6	9.6	13.9	-0.2	-4.7	-5.4
Jul	72.8	62.2	59.9	27.6	27.2	25.8
Aug	112.3	111.6	142.1	59.5	58.1	77.7
Sep	128.3	140.8	127.0	71.6	65.1	77.3
Oct	121.6	136.1	93.3	72.3	103.2	48.7
Nov	95.6	105.8	157.3	67.7	62.6	113.6
Dec	88.2		94.3	95.0		127.0
Total	744.2		787.3	582.2		661.1

Source: Atmospheric Environment Service, Environment Canada.
Average for the period 1965-1988. Negative denotes condensation.

Table 4 Outflows from the Great Lakes in 1989 and 1990
(cubic metres per second)

Lake Superior	1990	1989	Average 1900-1988	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	1900	2250	1930	2630 (1971)	1250 (1922)
Feb	1900	2260	1900	2610 (1969)	1270 (1982)
Mar	1900	2190	1870	2690 (1969)	1270 (1982)
Apr	1900	2220	1950	2940 (1951)	1300 (1982)
May	2040	2620	2120	3450 (1951)	1250 (1931)
Jun	1610	2660	2210	3480 (1951)	1220 (1922)
Jul	1870	2660	2290	3570 (1938)	1270 (1922)
Aug	1840	2600	2380	3600 (1950)	1270 (1926)
Sep	1840	2400	2380	3570 (1950)	1160 (1955)
Oct	1670	2030	2320	3510 (1968)	1250 (1926)
Nov	1870	1910	2270	3740 (1985)	1250 (1981)
Dec	1730	1900	2070	3200 (1950)	1300 (1981)
Annual	1840	2310	2150		

Lakes Michigan-Huron	1990	1989	Average 1900-1988	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	4810	5150	4450	5920 (1953)	3060 (1934)
Feb	4670	4930	4360	5720 (1974)	3000 (1942)
Mar	4470	4980	4810	5830 (1986)	3510 (1931)
Apr	4810	5240	5150	6260 (1986)	3600 (1901)
May	4960	5380	5350	6370 (1986)	4390 (1964)
Jun	5100	5380	5470	6430 (1985)	4420 (1964)
Jly	5210	5440	5520	6570 (1974)	4500 (1964)
Aug	5180	5440	5520	6630 (1986)	4530 (1964)
Sep	5100	5380	5490	6600 (1986)	4470 (1933)
Oct	5130	5240	5440	6740 (1986)	4420 (1933)
Nov	5240	5210	5380	6650 (1986)	4390 (1934)
Dec	5120	5470	5180	6230 (1986)	3990 (1935)
Annual	4980	5270	5180		

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Table 4 (Continued)

Lake Erie	1990	1989	Average 1900-1988	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	5690	5880	5550	7420 (1987)	4050 (1936)
Feb	5950	5660	5410	7050 (1987)	3340 (1936)
Mar	6120	5510	5580	7480 (1986)	4110 (1934)
Apr	6430	6120	5860	7700 (1974)	4390 (1935)
May	6510	6320	6170	7760 (1974)	4590 (1934)
Jun	6430	6600	6200	7820 (1986)	4560 (1934)
Jly	6140	6390	6090	7670 (1986)	4450 (1934)
Aug	6200	6310	6000	7420 (1986)	4470 (1934)
Sep	6310	6100	5890	7140 (1986)	4450 (1934)
Oct	6260	5900	5780	7450 (1986)	4420 (1934)
Nov	6170	6100	5780	7280 (1986)	4280 (1934)
Dec	6340	5590	5780	7620 (1985)	4330 (1934)
Annual	6210	6040	5830		

Lake Ontario	1990	1989	Average 1961-1987	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6860	6060	6260	7360 (1955)	4700 (1935)
Feb	7190	6390	6290	8160 (1986)	4360 (1936)
Mar	7470	6200	6600	8550 (1974)	5010 (1935)
Apr	7850	5810	7050	9200 (1973)	5070 (1964)
May	8170	6460	7310	9540 (1973)	4980 (1965)
Jun	8330	7380	7390	9910 (1973)	5350 (1965)
Jly	7880	7960	7330	9910 (1976)	5520 (1934)
Aug	7560	7650	7160	9340 (1974)	5300 (1934)
Sep	7380	7430	6990	9230 (1986)	5100 (1934)
Oct	7300	7210	6800	9170 (1986)	4960 (1934)
Nov	7320	7420	6680	9570 (1986)	4810 (1934)
Dec	7140	6700	6570	9260 (1986)	4810 (1934)
Annual	7540	6890	6870		

Source: Water Planning and Management Branch, Environment Canada

Table 5 Great Lakes Water Levels in 1989 and 1990 and Their Comparison with Previous Records (Metres, IGLD-1955)

Lake Superior at Thunder Bay	1990	1989	Average 1916-1989	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	182.81	183.03	183.01	183.33 (1986)	182.49 (1926)
Feb	182.75	182.93	182.95	183.27 (1986)	182.44 (1926)
Mar	182.72	182.89	182.92	183.25 (1986)	182.41 (1926)
Apr	182.71	182.92	182.95	183.31 (1986)	182.39 (1926)
May	182.79	183.00	183.06	183.38 (1986)	182.43 (1926)
Jun	182.88	183.12	183.15	183.46 (1916)	182.53 (1926)
Jul	182.97	183.15	183.21	183.55 (1916)	182.64 (1926)
Aug	182.98	183.13	183.23	183.54 (1916)	182.70 (1926)
Sep	182.99	183.11	183.24	183.56 (1916)	182.78 (1926)
Oct	183.00	183.01	183.20	183.55 (1985)	182.77 (1925)
Nov	182.99	182.97	183.15	183.52 (1985)	182.67 (1925)
Dec	182.92	182.88	183.08	183.42 (1985)	182.58 (1925)

Lake Huron at Goderich	1990	1989	Average 1916-1989	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	175.97	176.17	176.13	176.98 (1987)	175.40 (1965)
Feb	175.97	176.15	176.11	176.90 (1986)	175.40 (1964)
Mar	175.99	176.11	176.12	176.92 (1986)	175.37 (1964)
Apr	176.01	176.20	176.19	177.02 (1986)	175.37 (1964)
May	176.15	176.24	176.29	177.07 (1986)	175.51 (1964)
Jun	176.24	176.35	176.37	177.12 (1986)	175.53 (1964)
Jul	176.30	176.36	176.41	177.17 (1986)	175.55 (1964)
Aug	176.28	176.34	176.40	177.20 (1986)	175.56 (1964)
Sep	176.27	176.28	176.34	177.17 (1986)	175.56 (1964)
Oct	176.23	176.15	176.28	177.28 (1986)	175.51 (1964)
Nov	176.22	176.12	176.23	177.19 (1986)	175.46 (1964)
Dec	176.20	176.01	176.18	177.07 (1986)	175.40 (1964)

Lake St. Clair at Belle River	1990	1989	Average 1961-1989	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	174.67	174.81	174.92	175.62 (1986)	173.97 (1964)
Feb	174.80	174.83	174.89	175.63 (1986)	173.97 (1964)
Mar	174.87	174.75	175.01	175.64 (1986)	174.15 (1964)
Apr	174.90	174.89	175.09	175.65 (1986)	174.27 (1964)
May	174.95	174.94	175.15	175.67 (1986)	174.37 (1964)
Jun	174.99	175.11	175.18	175.75 (1986)	174.35 (1964)
Jul	175.04	175.13	175.19	175.76 (1986)	174.34 (1964)
Aug	175.03	175.04	175.15	175.73 (1986)	174.33 (1964)
Sep	175.02	174.99	175.09	175.67 (1986)	174.26 (1964)
Oct	174.94	174.83	175.01	175.79 (1986)	174.15 (1964)
Nov	174.88	174.72	174.94	175.65 (1986)	174.07 (1964)
Dec	174.89	174.75	174.95	175.62 (1986)	174.07 (1964)

(Continued on next page)

Table 5 (Continued)

Lake Erie at Port Colborne

	1990	1989	Average 1916-1989	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	173.85	173.94	173.82	174.71 (1987)	173.08 (1935)
Feb	173.96	173.94	173.76	174.55 (1987)	173.00 (1935)
Mar	174.09	173.84	173.83	174.70 (1986)	173.00 (1934)
Apr	174.18	174.06	173.98	174.81 (1985)	173.18 (1935)
May	174.22	174.12	174.06	174.76 (1986)	173.24 (1934)
Jun	174.27	174.32	174.10	174.84 (1986)	173.24 (1934)
Jul	174.19	174.29	174.10	174.83 (1986)	173.23 (1934)
Aug	174.17	174.20	174.03	174.75 (1986)	173.21 (1934)
Sep	174.20	174.08	173.94	174.63 (1986)	173.18 (1934)
Oct	174.13	173.98	173.87	174.75 (1986)	173.15 (1934)
Nov	174.08	174.02	173.85	174.68 (1986)	173.06 (1934)
Dec	174.13	173.86	173.84	174.75 (1986)	173.09 (1934)

Lake Ontario at Kingston

	1990	1989	Average 1916-1989	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	74.37	74.26	74.39	75.02 (1946)	73.66 (1965)
Feb	74.43	74.25	74.41	75.11 (1952)	73.64 (1936)
Mar	74.58	74.20	74.49	75.22 (1952)	73.80 (1935)
Apr	74.80	74.52	74.70	75.47 (1952)	73.89 (1935)
May	74.92	74.81	74.83	75.57 (1952)	73.98 (1935)
Jun	74.96	75.03	74.88	75.61 (1952)	73.95 (1935)
Jul	74.83	75.01	74.84	75.51 (1947)	74.00 (1934)
Aug	74.69	74.84	74.73	75.44 (1947)	73.86 (1934)
Sep	74.53	74.66	74.59	75.27 (1947)	73.77 (1934)
Oct	74.47	74.51	74.47	75.09 (1945)	73.69 (1934)
Nov	74.45	74.49	74.39	75.04 (1945)	73.61 (1934)
Dec	74.47	74.39	74.38	75.06 (1945)	73.60 (1934)

Montreal Harbour (Jetty No.1)

	1990	1989	Average 1967-1989	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6.65	6.16R	7.02	8.91 (1968)	6.38 (1972)
Feb	6.73	6.29R	7.15	8.99 (1967)	6.33 (1977)
Mar	6.89	6.09R	7.19	8.31 (1973)	6.49 (1970)
Apr	7.28	6.39R	7.70	8.77 (1976)	7.16 (1970)
May	7.02	6.54	7.51	8.89 (1974)	6.38 (1968)
Jun	6.61	6.63	6.91	8.08 (1974)	5.88 (1988)
Jul	6.38	6.26	6.64	7.45 (1973)	5.67 (1988)
Aug	6.16	6.05	6.53	7.23 (1972)	5.89 (1988)
Sep	5.95	5.89	6.48	7.03 (1986)	5.88 (1988)
Oct	6.43	5.88R	6.52	7.11 (1986)	6.08 (1971)
Nov	6.51	6.37	6.60	7.27 (1967)	5.91 (1971)
Dec	6.73	6.48	6.69	7.20 (1972)	5.82 (1978)

Source: Fisheries and Oceans Canada
R denotes new record. * Preliminary Data.

Table 6 Lakes Superior and Michigan-Huron Supply Summary
(cubic metres per second)

Lake Superior Net Basin Supplies (CMS)

	1900-1988 Average	1990 N.B.S. (cms)	1990 Difference in Storage (m)	1989 N.B.S. (cms)	1989 Difference in Storage (m)
Jan	-400 cms	30 cms	0.01 m	540 cms	0.03 m
Feb	310	-650	0.01	-470	-0.02
Mar	1270	1560	0.01	1600	0.01
Apr	4220	3450	-0.02	3840	-0.01
May	5240	3680	-0.05	5860	0.02
Jun	4450	5720	0.04	5240	0.03
Jul	3680	3280	-0.01	1900	-0.06
Aug	2860	1270	-0.05	2460	-0.01
Sep	2100	2380	0.01	-100	-0.07
Oct	1080	2630	0.05	890	-0.01
Nov	540	420	0	-1030	-0.05
Dec	-650	-1270	-0.02	-1140	-0.02
Sum	24700	22500	-0.07	19590	-0.16

Lakes Michigan-Huron Net Basin Supplies (CMS)

	1900-1988 Average	1990 N.B.S. (cms)	1990 Difference in Storage (m)	1989 N.B.S. (cms)	1989 Difference in Storage (m)
Jan	1500 cms	3570 cms	0.05 m	1330 cms	0 m
Feb	2520	2070	-0.01	-280	-0.06
Mar	5210	6990	0.04	5990	0.02
Apr	8130	5270	-0.06	6070	-0.05
May	7110	8440	0.03	6090	-0.02
Jun	5780	8130	0.05	6740	0.02
Jul	3620	3280	-0.01	1390	-0.05
Aug	1560	2410	0.02	660	-0.02
Sep	910	740	0	-2200	-0.07
Oct	30	1930	0.04	-400	-0.01
Nov	1020	4900	0.09	640	-0.01
Dec	820	1980	0.03	-1590	-0.05
Sum	38210	49710	0.26	24440	-0.31

Source: International Lake Superior Board of Control
31360 cms-month is equivalent to 1 metre storage on Lake Superior
44690 cms-month is equivalent to 1 metre storage on Lakes Mich-Huron

Table 7 Lake Ontario Supply Summary

	1990			1989		1900-1988
	N.B.S. Average	Difference in (cms)	N.B.S. Storage (metres)	Difference in (CMS)	Storage (metres)	
Jan	910 cms	1440 cms	0.07 m	370 cms	-0.07 m	
Feb	1050	2210	0.16	310	-0.10	
Mar	2120	2520	0.05	1440	-0.09	
Apr	2630	2920	0.04	2070	-0.08	
May	1700	2550	0.11	2440	0.10	
Jun	1160	1270	0.01	2010	0.11	
Jul	680	620	-0.01	110	-0.08	
Aug	230	310	0.01	60	-0.02	
Sep	140	-250	-0.05	200	0.01	
Oct	200	1050	0.11	450	0.03	
Nov	570	910	0.05	1250	0.09	
Dec	760	2100	0.18	300	-0.06	
Sum	12150	17650	0.74	8570	-0.15	

Source: International St. Lawrence River Board of Control
7430 cms-months is equivalent to 1 metre storage on Lake Ontario

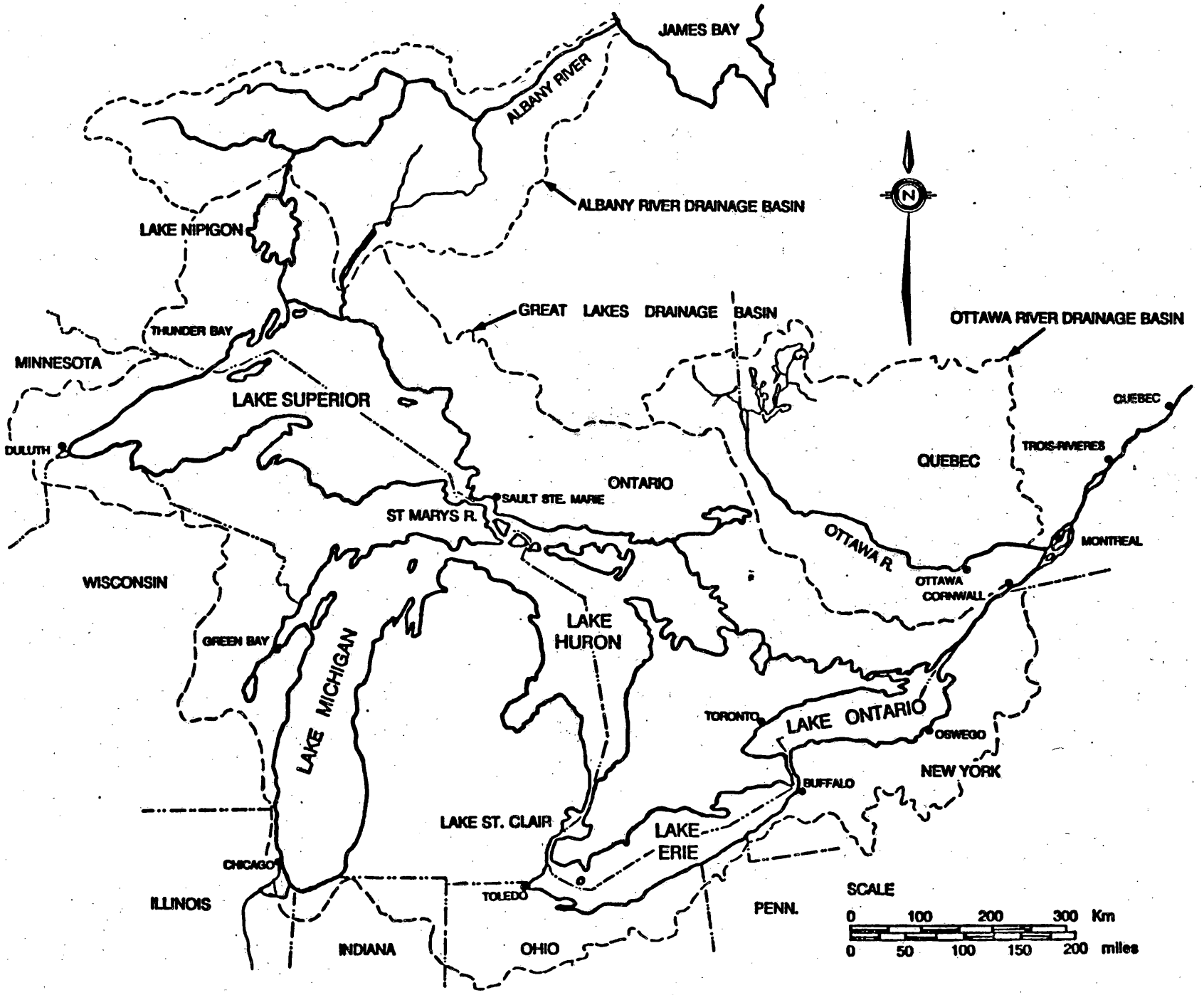


Figure 1 GREAT LAKES - ST. LAWRENCE RIVER BASIN

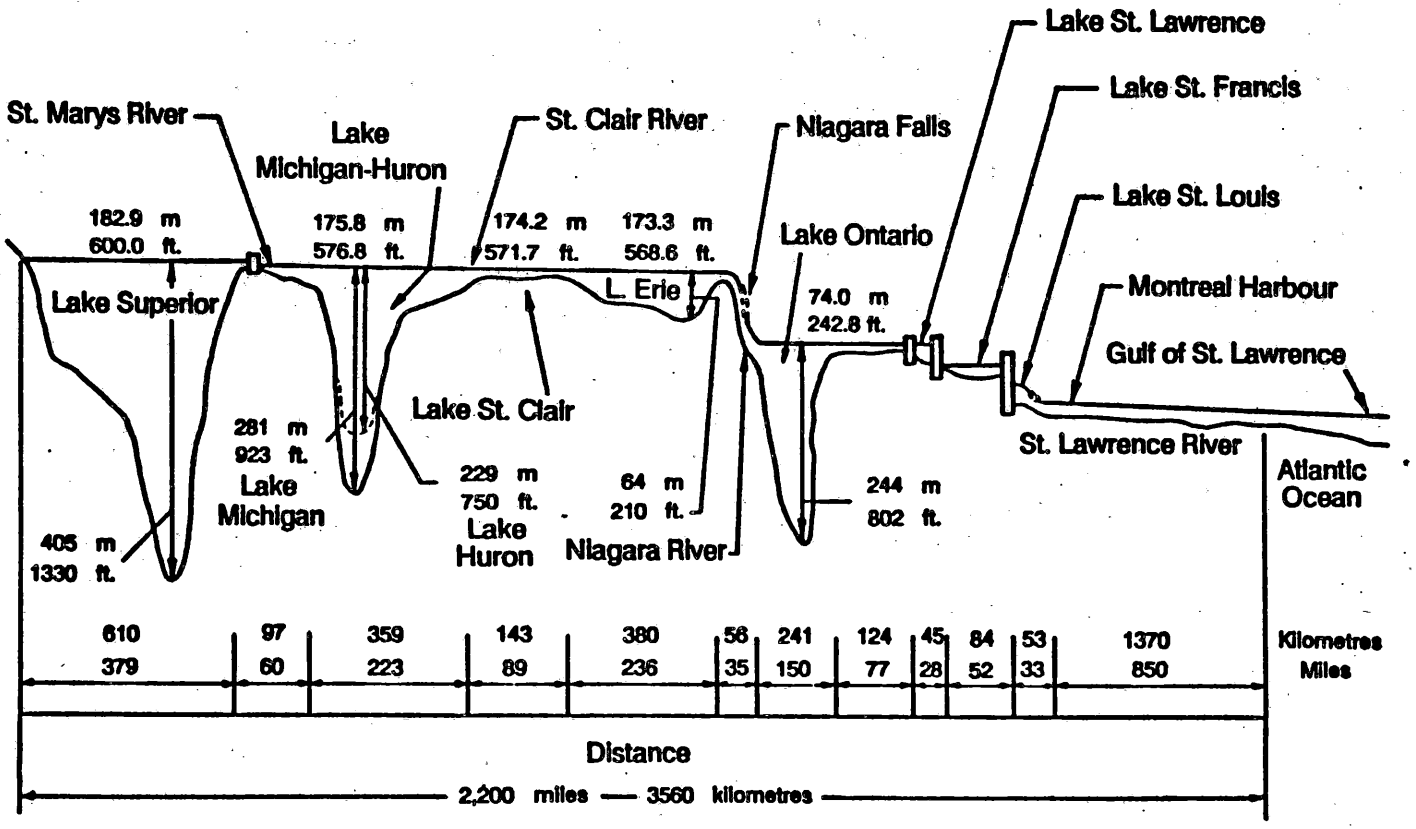
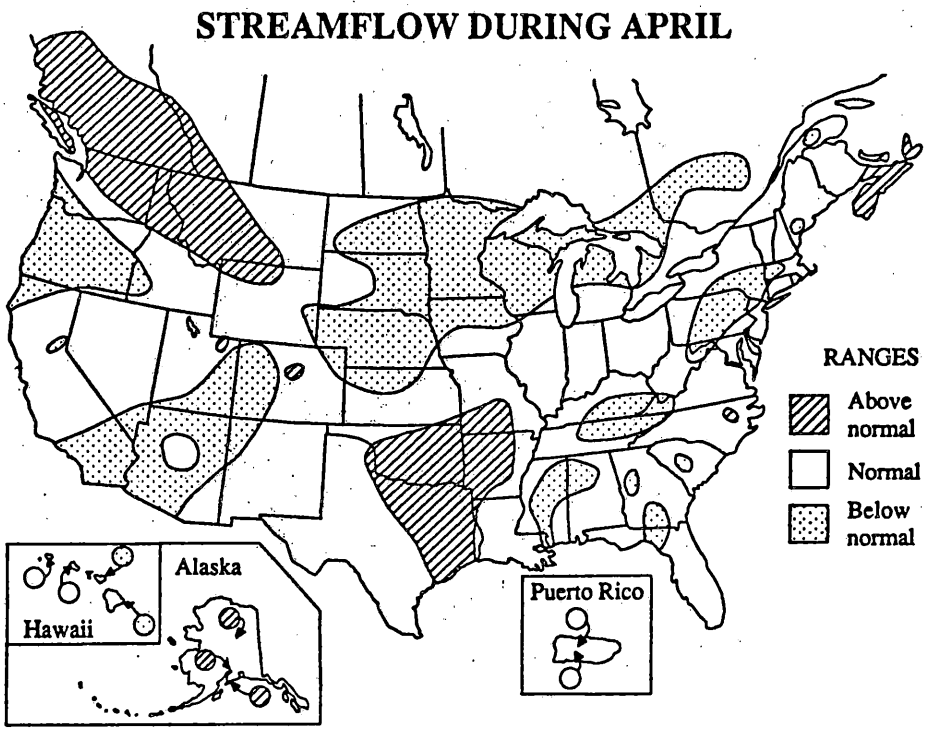


Figure 2 SCHEMATIC PROFILE OF THE GREAT LAKES - ST. LAWRENCE RIVER SYSTEM



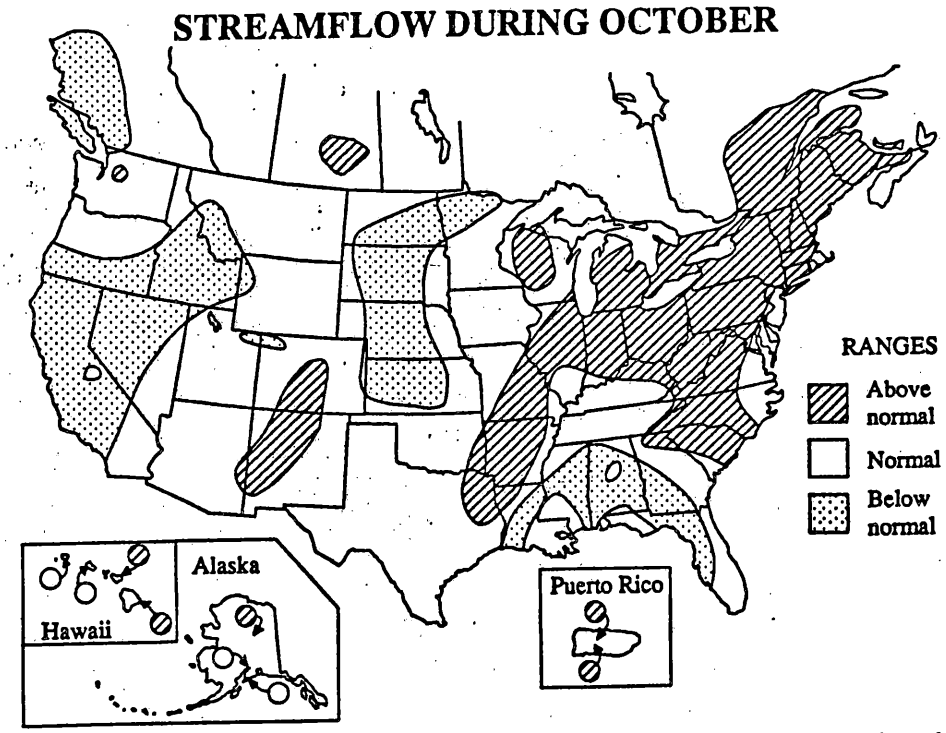


Figure 3 GENERALIZED PATTERN OF STREAMFLOW
(Source: USGS and DOE)

LAKE SUPERIOR (Thunder Bay) LAC SUPÉRIEUR

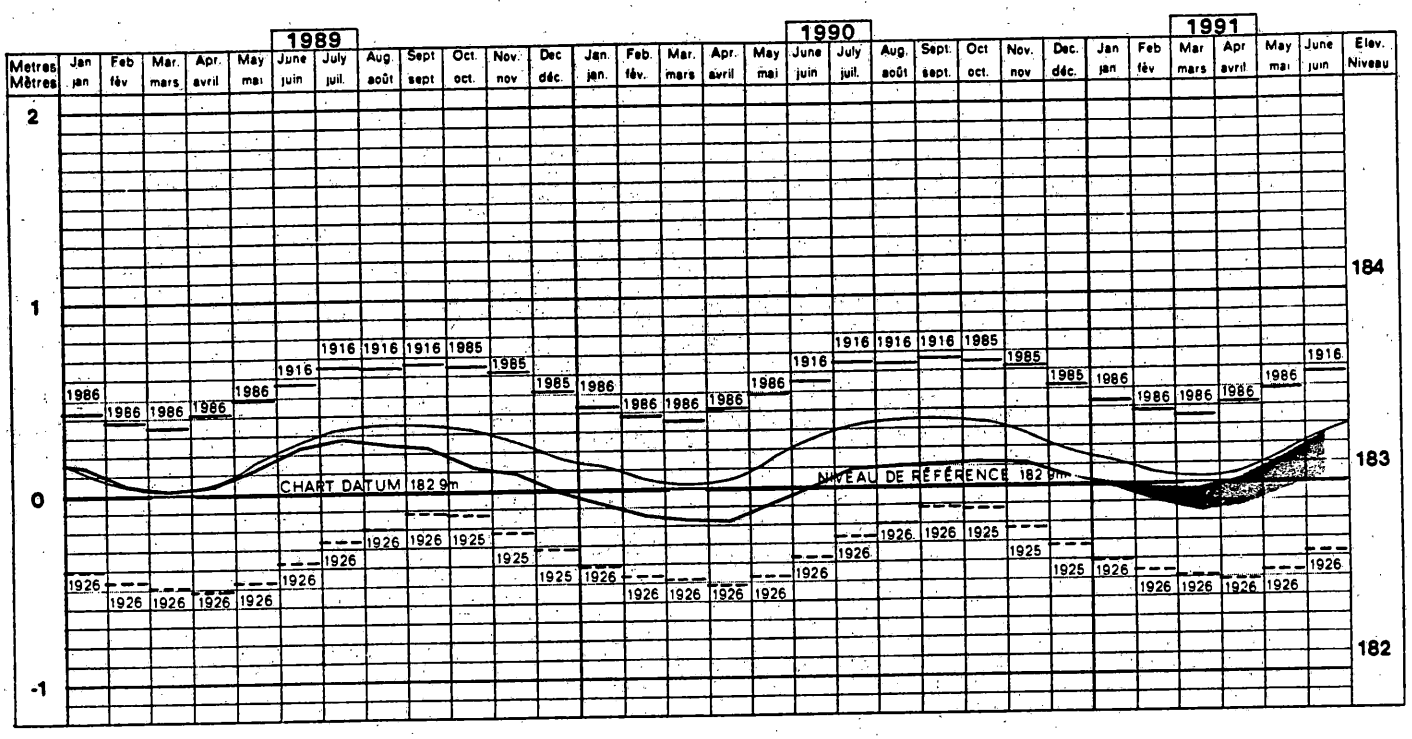


Figure 4 WATER LEVEL HYDROGRAPH OF LAKE SUPERIOR

LAKE HURON (Goderich) LAC HURON

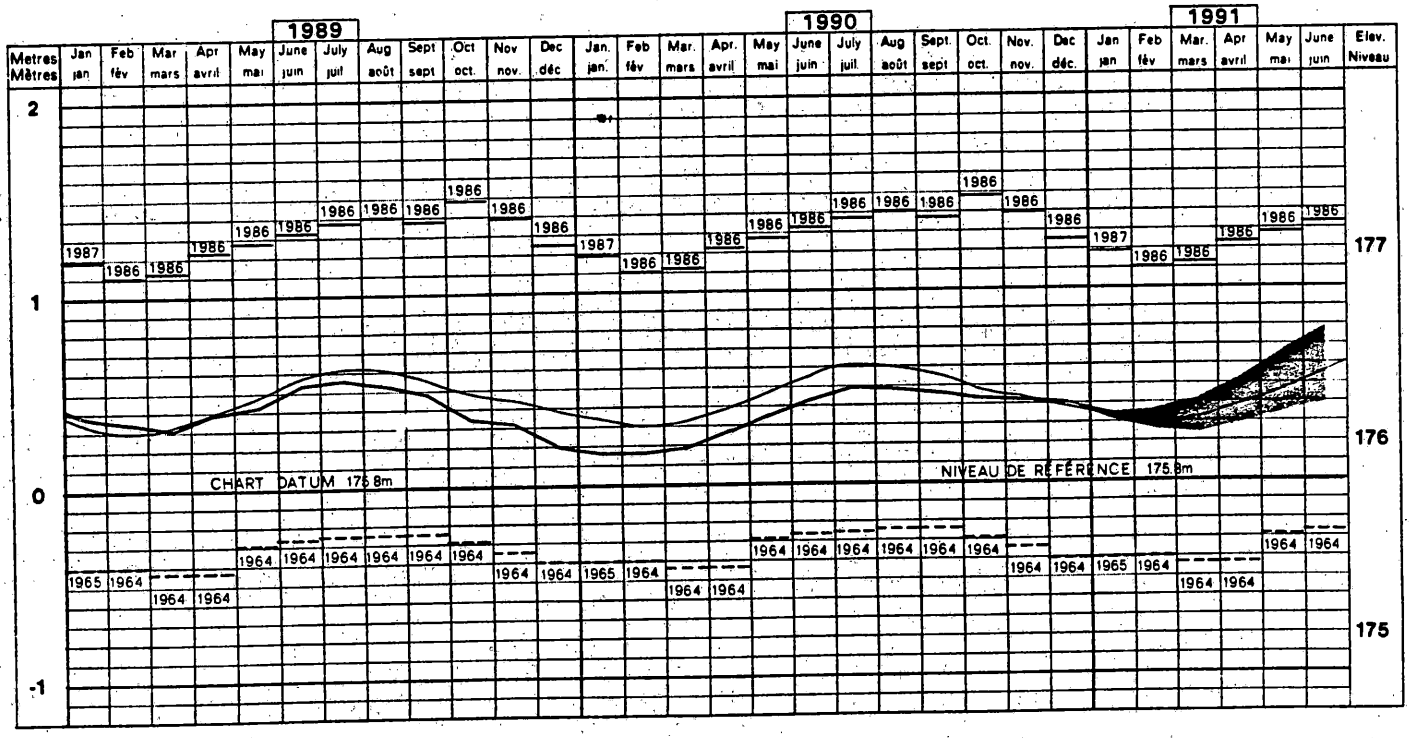


Figure 5 WATER LEVEL HYDROGRAPH OF LAKE HURON

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

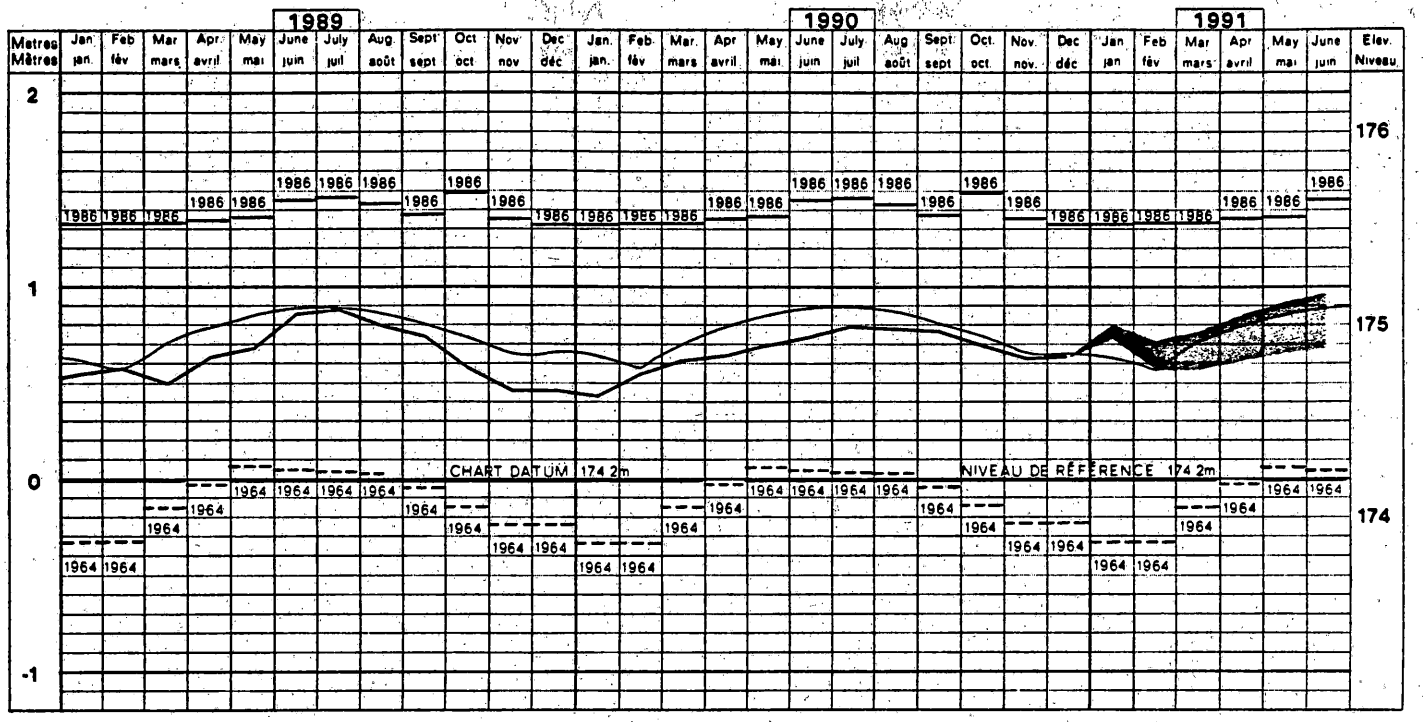


Figure 6 WATER LEVEL HYDROGRAPH OF LAKE ST. CLAIR

LAKE ERIE (Port Colborne) LAC ÉRIÉ

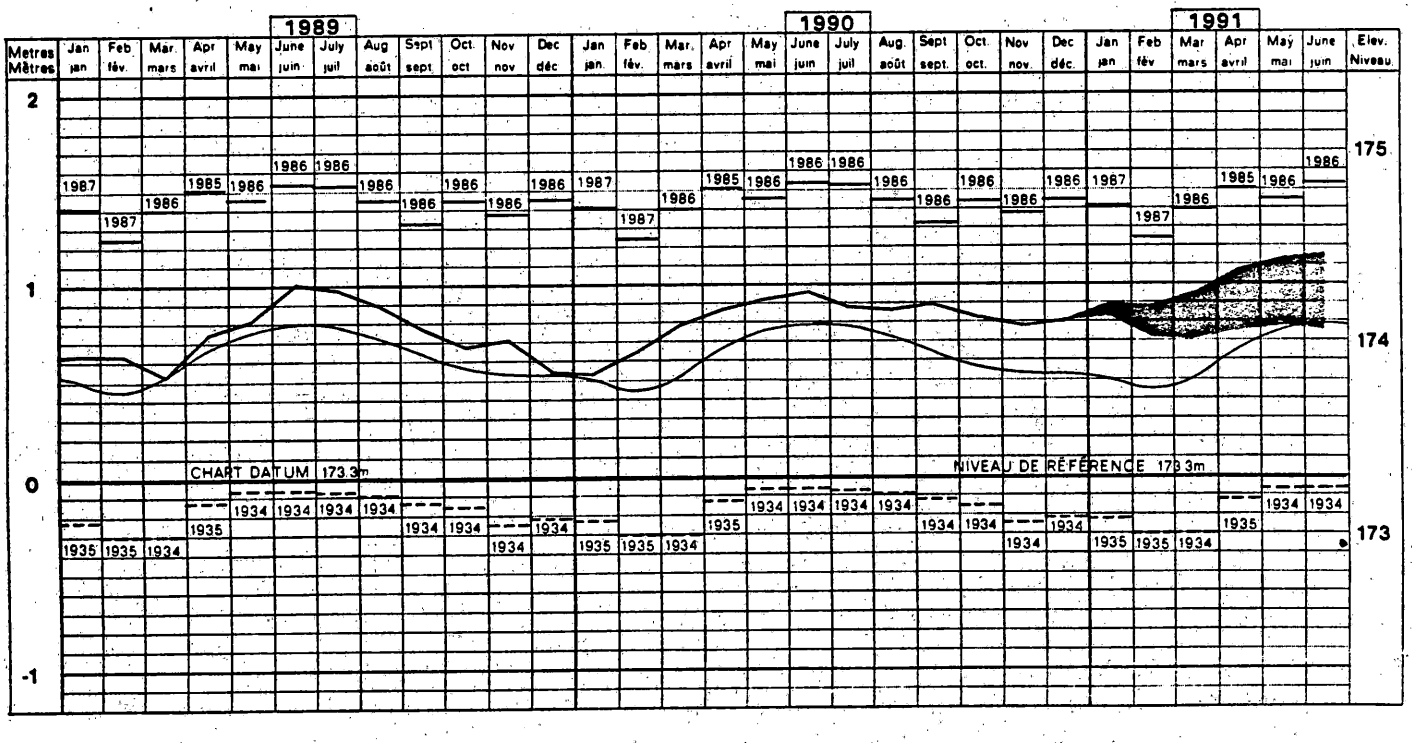


Figure 7 WATER LEVEL HYDROGRAPH OF LAKE ERIE

LAKE ONTARIO (Kingston) LAC ONTARIO

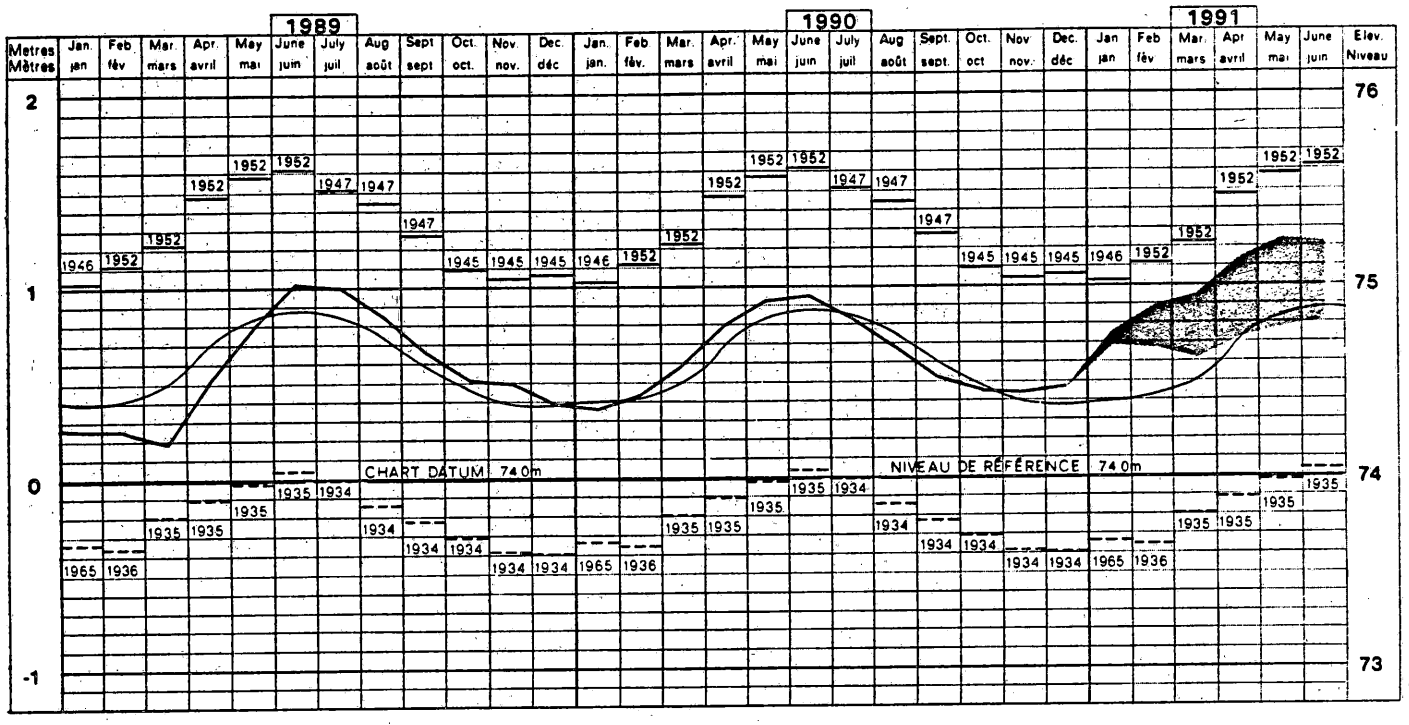


Figure 8 WATER LEVEL HYDROGRAPH OF LAKE ONTARIO

MONTREAL HARBOUR (Jetty No.1) PORT de MONTRÉAL (Jetée No 1)

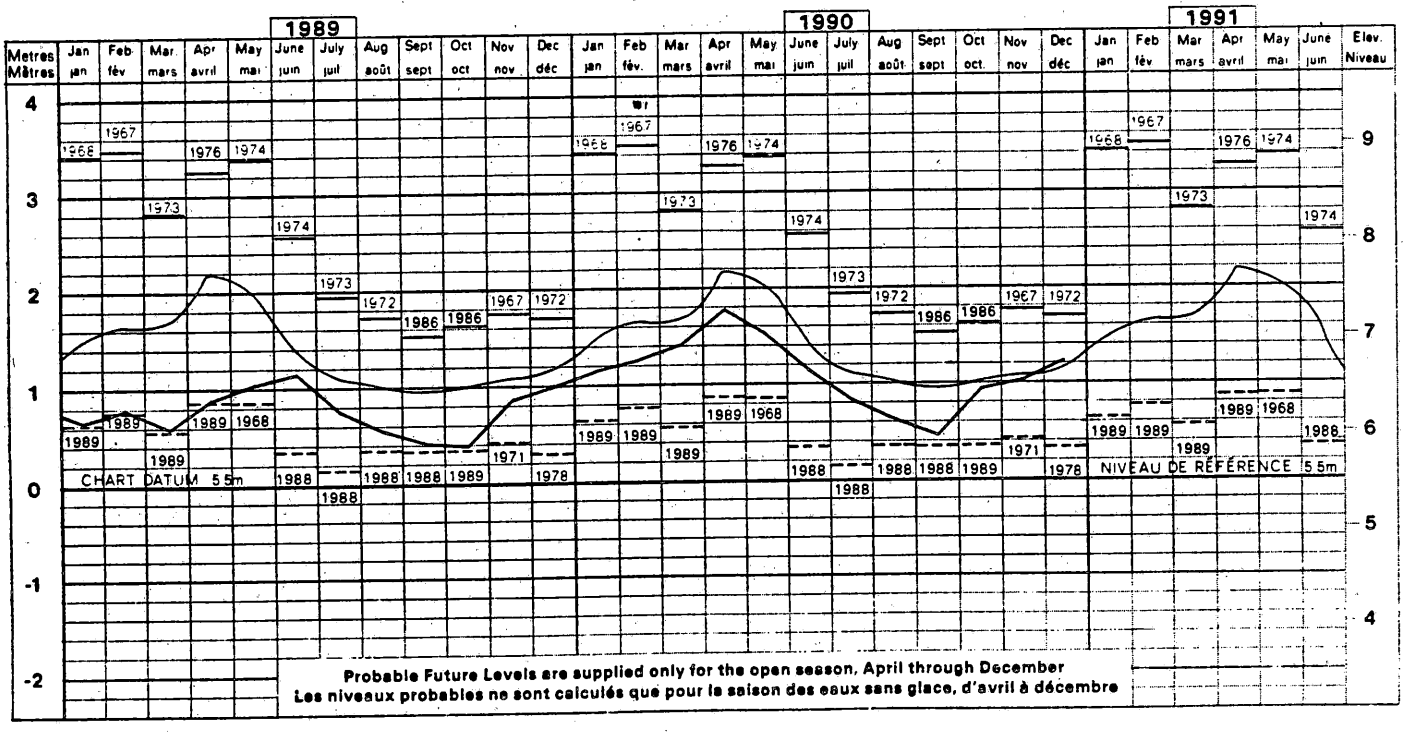


Figure 9 WATER LEVEL HYDROGRAPH OF MONTREAL HARBOUR