A REPORT ON 1991 WATER LEVELS OF THE GREAT LAKES

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1.0 PURPOSE AND SCOPE

This report summarizes the events that took place in 1991 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 1991 and how they affected the users of the system. The report 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 1985-1990. All data are in metric units. Water level elevations are in metres on the International Great Lakes Datum (IGLD) 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.

As in previous reports, the assessment of the hydrologic conditions of the Great Lakes - St. Lawrence River basin is based on the information available at the time this report was prepared. The recent reductions in the data collection effort by Environment Canada have reduced the amount of information available for this purpose.

For example, when record high water levels occurred on the Great Lakes in 1985-86, Water Survey of Canada expedited the collection and analyses of data from a number of tributaries in the Canadian portion of the Great Lakes. Subsequently, when the water levels of the Great Lakes improved, low priority was placed on this activity. Although these data were not available for assessment, they will be published in Environment Canada's surface water publications in 1992.

The program to determine monthly average evaporation from the Great Lakes has been suspended by the Atmospheric Environment Service in 1991. This was due to fiscal restraint and re-organization at AES. Hence, evaporation data were not available for assessment.

In the previous reports, the assessment of the water level conditions was based on water level data collected at a single site on each lake. Beginning with this report, the monthly average water levels presented are the averages of the data collected from a network of stations on each of the Great Lakes. For example, water level data from five stations on Lakes Michigan-Huron are used to determine the monthly average water levels, and for Lake Ontario, six stations are used. This is the same procedure used by the International Lake Superior Board of Control and the International St. Lawrence River Board of Control.

Hydrologic assessment of the Great Lakes requires a determination of the changes in the volume of water in the lake. Using water level data from several sites on the lake is considered more accurate since it tends to reduce the error caused by localized sudden water level changes.

2.0 VERTICAL DATUM AND CONVERSION FACTORS

Beginning in January 1992, Canada and the United States will use a new vertical reference (IGLD 1985) to determine water level elevations in the Great Lakes - St. Lawrence River system. This change in the datum is necessary because of the on-going vertical rebound of the land mass in the Great Lakes region since the retreat of the last glaciers about 10,000 years ago. The new datum will provide a more accurate and up to date elevations of water levels relative to sea level. Table 7 contains a list of preliminary conversion factors between the two datum for the water level stations listed in the Canadian and United States water level bulletins.

3.0 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.

The 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.

4.0 FACTORS AFFECTING THE GREAT LAKES LEVELS IN 1991

4.1 Hydrologic Conditions Leading to 1991

Before examining in detail the water level fluctuations in 1991, it is worthwhile to review briefly what has occurred just prior to 1991.

Table 5 shows the net basin supplies the upper Great Lakes received in 1990 and 1991. The supplies to Lake Superior in 1990 were 21,630 cubic metres per second-months, or about 88 percent of average. This difference is equivalent to about 0.1 metre lowering in the level of the lake. The levels of Lake Superior remained below average throughout 1990 with no noticeable change by the end of the year.

Although Lakes Michigan-Huron received less than average inflow from Lake Superior during 1990, the net basin supplies for the year were about 130 percent of average. As a result, the levels on the lake rose, from below average at the beginning of 1990 to near average by the end of the year.

Although accurate figures for supplies for Lake Erie were not available, it was estimated that the lake received very high supplies in 1990 and particularly in December 1990. The 1990 precipitation on the Lake Erie basin was a record high for a year and it raised the lake level from average conditions at the beginning of the year to about 0.3 metre above average by the end of 1990.

Water supplies to Lake Ontario for 1990 were above average. The high Lake Ontario outflows during this year kept the lake level at near average conditions for much of the year. The high supplies in December due to record high precipitation on the basin raised the lake level sharply in December, a condition extending well into early 1991.

4.2 Precipitation

Records since 1900 show that, on average, about 812 mm of precipitation falls on the Great Lakes Basin each year. Average annual precipitation varies from lake basin to lake basin and 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 basin in 1990-91 with the long-term averages.

The Great Lakes basin-wide precipitation in 1991 was above average (by about 10 percent). Well above average precipitation occurred on the upper Great Lakes basin in the second half of 1991, which raised the Lake Superior level to average conditions by early December.

The lower Great Lakes basins received generally below average precipitation in 1991. Six consecutive months (June to November) of below average precipitation on the Lake Ontario basin caused a rapid decline in the lake levels, from very high in early June to below average by mid-November. The relatively high precipitation in December helped to halt any further decline in the levels.

4.3 Water Supplies to the Great Lakes

Net basin supplies is a term used to describe the amount of water a lake receives and is the net effect of over-lake precipitation, runoff and evaporation from the lake. The units are in cubic metres per second-months. Net total supplies to the lake is the sum of the net basin supplies to that lake and the inflow to the lake from the lake upstream.

The net basin supplies to Lake Superior for much of 1991 were near average. Relatively high supplies occurred beginning in October. The supplies to Lakes Michigan-Huron in 1991 were slightly below average whereas the figures for Lake Erie were estimated also below average.

The water supplies to Lake Ontario were above average in the first four months of 1991. Subsequently, the supplies were persistently below average. Preliminary information shows that the December 1991 supply figure is near average. The supply figures are listed in Table 6.

4.4 Outflows

Table 3 lists the monthly outflows from the Great Lakes for 1991. The outflow of Lake Superior in 1991 was 1980 cms, or 8% below average. This was due to the lower than average water level conditions on Lake Superior for 1991.

The outflow from Lakes Michigan-Huron in 1991 was near average which corresponded to the near average lake levels during the year. The outflow from Lake Erie in the first half of 1991 was well above average due the high lake level conditions. When water levels declined rapidly during the summer months, the outflows also declined and, by the end of the year, both the lake level and outflow were near average.

For Lake Ontario, the rapid change from very high levels during the early part of 1991 to low conditions by the fall has been an unusual event. Very high water outflows occurred from February to early June as a result of regulation aimed to prevent the lake from exceeding the upper limit of regulation. After the lake levels had reached their seasonal peak in early June, the outflows began to decline and by October they were below average.

4.5 Lake Water Levels

Figures 3-7 show the seasonal fluctuations of the Great Lakes in 1991. Table 4 lists the monthly average levels for the Great Lakes in 1991 and how they compare with the historical data.

In 1991, 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. However, in response to the rapid changing water supply conditions, the levels of the lakes, in particular Lake Superior and Lake Ontario, have fluctuated somewhat differently when compared with the average values.

For example, the high supplies to Lake Superior in the last three months of 1991 have raised the levels of the lake at the time when levels normally decline. The seasonal decline in the levels of Lake Ontario began about one month earlier than normal and the subsequent sharp decline in the levels was a reflection of the sharp reductions in the water supplies to the lake.

The water levels of Montreal Harbour (see Figure 8) were at record low for four consecutive months in August. These levels were caused by a combination of low flows in the St. Lawrence River and the Ottawa River (part of which flows into Lake St. Louis and hence the harbour as well). For eight days in November, the harbour levels were below the navigation chart datum. The increased precipitation and high local runoff in early December helped to raise the levels and thus alleviated the low water level problems for navigation.

5.0 EFFECTS OF GREAT LAKES WATER LEVELS

As a result of near and below average water level conditions on the upper Great Lakes, there were no reports of serious flood or erosion damages. The below average water level conditions on Lake Superior have made some of the boat docks unusable. Some local residents on Lake Superior and on the St. Marys River upstream of Sault Ste. Marie, Ontario, have expressed concerns about the low water level conditions.

In early 1991, the levels of Lake Ontario and Lake Erie were well above average. Due to the absence of severe storms, there has been no reports of serious flood or erosion damages on the lakes. The Lake Ontario water level conditions in the first half of the boating season were considered ideal by boaters in eastern Lake Ontario and the Thousand Island area. The water levels at that time were generally about 30 centimetres above average. When the lake levels began to decline sharply beginning in June, they became progressively less than ideal for the recreational boaters. By mid-October when the boating season ended, levels were as much as 15 centimetres below average.

The below average levels for Lake Ontario in October and November have had an adverse impacts on some riparians in eastern Lake Ontario extending from Bay of Quinte near Trenton to just downstream of Kingston. The November 1991 monthly level was the lowest since that of November 1964. During this period, many residents had difficulties with dry shore wells because of the low lake levels. The water levels reached their seasonal low in late November. Subsequently, the levels have risen slightly and this has alleviated the problems considerably.

The high flows in the St. Lawrence River in early 1991 were the subject of concern to shore residents in the St. Lawrence River. For example, a number of shore properties in the Morrisburg area experienced extremely high water level conditions. It was reported that high flows, when combined with waves generated by ships, have caused some shoreline erosion and property damages in the area.

The Lake St. Louis and Montreal Harbour experienced both very high and low water level conditions. In early 1991, high flows occurred both in the St. Lawrence River and the Ottawa River. As a result, water levels in Lake St. Louis exceeded the flood stage. There were also reports of structural damages caused by the combined actions of high flows, wind, and ice.

6.0 WATER MANAGEMENT ACTIONS RELATED TO GREAT LAKES WATER LEVELS

6.1 Lake Superior Regulation

In 1991, the International Lake Superior Board of Control regulated the outflows of Lake Superior according to Regulation Plan 1977-A. Since there were no unusual water supply or water level conditions, the Board did not make any departures from the regulation plan.

The Board conducted a open house in Sault Ste. Marie, Ontario, on September 17, 1991. The purpose of the open house was to inform the public of the Board's activities and to hear public comments and suggestions regarding the Board's work. About 45 visitors attended the open house.

6.2 Lake Ontario Regulation

In 1991, Lake Ontario received water supplies ranging from very high in the early part of the year to persistently low in the second part. As a result, a number of steps were taken by the International St. Lawrence River Board of Control. In summary, when the supplies were high and levels were rising sharply, the Board increased the Lake Ontario outflows above those specified by Regulation Plan 1958-D. After the levels had peaked in early June and the risk of a further rise in the levels had diminished, the Board initiated a program of under-discharge to offset the high flows that occurred earlier.

The information in the following paragraphs on regulation has been extracted from the semi-annual report by the International St. Lawrence River Board of Control.

To deal with the high water level conditions on Lake Ontario, the Board initiated, in February, a program of over-discharge. Outflows as much as 9200 cubic metres per second were discharged for a number of days in March. By April 5, the level was as much as 27 centimetres lower than it would have been under the strict application of Plan 1958-D. At that time, the Lake Ontario level was at elevation 74.94 metres, about 28 centimetres below the upper limit of regulation (75.22 metres). The assessment of the conditions showed that the lake levels would continue to rise and thus a continuation of the over-discharge program was necessary.

During the Ottawa River freshet in April, the program of over-discharge was temporarily suspended and Lake Ontario outflows were substantially reduced below those specified by Plan 1958-D to reduce flooding downstream. Even so, Lake St. Louis levels in the Montreal area exceeded the alert and flood stages during the Ottawa River freshet.

The level of Lake Ontario reached its seasonal peak on May 2 at elevation 75.18 metres. Without the Board's actions, this level would have been 18 centimetres higher, or at elevation 75.36 metres. With the seasonal peak level passed, the Board ended its program of over-discharge on May 16 and established the Lake Ontario outflow to that specified by Plan 1958-D for a week. Beginning on May 23, the Board initiated a program of under-discharge in order to offset the high flows that occurred earlier.

On August 30, the Board suspended its program of under-discharge and returned to plan outflows. Beginning August 31, the Lake Ontario outflows were similar to those specified by Plan 1958-D. Beginning on November 19, the Board authorized a very slight increase in the Lake Ontario outflows (about 57 cubic metres per second) to help the critically low water level situations in Montreal Harbour.

The last commercial vessel cleared the international section of the St. Lawrence River on December 24. The mild air temperatures and absence of severe ice conditions in the river made the closing of the 1991 navigation season a smooth event.

During the last two weeks in December, the outflows of Lake Ontario were slightly reduced in order to assist ice management in the Beauharnois canal. These reductions were very small and had no measureable impacts on the levels of Lake Ontario.

The Board conducted a public forum in Kingston, Ontario, on June 27, 1991. The purpose of the forum was to inform the public of the Board's activities and to hear public comments and suggestions regarding the Board's work.

6.3 Great Lakes Water Level Communications Centre (GLWLCC)

The Great Lakes Water Level Communications Centre in Burlington, Ontario, continued its activities in 1991 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 the high water levels of Lake Ontario in the early part of the year and the subsequent below average conditions. The centre also responded to a number of residents on Lake Ontario who have problems with the shore wells.

The staff at the centre provided the support to the International Joint Commission's Phase II Reference Study in public information and involvement activities. Working Committee 1 assisted the Study Board in conducting several public meetings at cities in the Great Lakes Basin. The centre also provided notices of public meetings for the study in the department's monthly news releases on Great Lakes water levels. Centre staff also supported the study's Working Committee 2 (Land Use and Management).

6.4 International Joint Commission Water Levels Reference Study

Phase II of the Water Levels Reference Study which is to examine and report on methods of alleviating the adverse impacts of fluctuating water levels on the Great Lakes, connecting channels, and the St. Lawrence River was initiated in 1990. The Study Board continued to conduct its study in 1991. The following highlights are some of the past year's achievements.

The year began with the development of a work plan for the four working committees and the Citizens Advisory Committee. This was approved by the Study Board in April 1991. In May 1991, the Study Board adopted a set of study evaluation principles which serve as a bench mark against which measures or actions can be examined. In June 1991, the Study Board approved a strategy for measures evaluation which outlined the study approach and included benefit cost analysis, multi-criteria evaluation, and detailed site studies.

In September, the Study Board adopted a set of study planning objectives for each affected water use/interest group category, including methods of measuring impacts. In October 1991, the Study Board accepted a list of 18 measures for detailed examination and evaluation during the study. The measures, both structural and non-structural, range from further regulation of the Great Lakes to land use management and regulation, and protective or remedial structures.

In December 1991, the Study Board approved the Plan Formulation Guidance which defines the baseline conditions and assumptions which are to be used in analysis. Work on impact analysis began during 1991 and will continue into 1992.

Public participation has been a very important element of the Levels Reference Study. Six public meetings were held at various locations around the Great Lakes - St. Lawrence River Basin in 1991. Further opportunities for input will be provided in the spring and fall of 1992. Over the initial months of 1992, the Study Board will be releasing some initial results from the impacts analysis.

7.0 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 3-8. 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.

8.0 FINDINGS AND CONCLUSIONS

1. Both very high and low water supplies to Lake Ontario occurred in 1991 causing high and low water level conditions. The lake levels fluctuated about one metre, almost twice the normal seasonal range.

2. The high Lake Ontario levels and high flows in the St. Lawrence River have caused some flood and erosion damages to some areas in the river. The subsequent low levels and flows have hampered recreational activities in the system and was a serious concern to commercial navigation using Montreal Harbour.

3. The Lake Ontario water level in November 1991 was the lowest since November 1964. Many residents in eastern Lake Ontario have problems with their shore wells.

4. With the exception of Lake Ontario, there were no extreme hydrological events in 1991 relative to lake levels and outflows.

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 1990, 1991* and Their Comparison with Long-Term Average (millimetres)

Superior Basin

	Average	1990	% of Average	1991	% of Average
Jan	47.24	47.50	101	50.29	106
Feb	35.81	31.75	89	20.57	57
Mar	43.94	46.23	105	63.50	145
Apr	49.78	58.93	118	61.98	124
May	68.58	58.17	85	84.33	123
Jun	84.58	125.98	149	67.56	80
Jul	81.28	84.58	104	107.70	132
Aug	81.79	75.18	92	55.63	68
Sep	88.90	85.60	96	123.95	139
Oct	68.07	106.43	156	90.93	134
Nov	62.48	48.77	78	112.52R	180
Dec.	49.53	44.45	90	44.45	90
Total	761.98	813.57	107	883.41	116

Michigan-Huron Basin

	Average	1990	% of Average	1991	% of Average
Jan	52.32	57.15	109	36.58	70
Feb	43.69	44.70	102	27.18	62
Mar	54.61	53.34	98	90.68	166
Apr	64.26	54.36	85	91.69	143
May	75.44	106.17	141	91.69	122
Jun	78.99	126.24	160	34.29	43
Jul	74.42	70.36	95	106.43	143
Aug	77.72	67.06	86	52.83	68
Sep	87.12	91.44	105	85.60	98
Oct	70.87	102.11	144	145.80	206
Nov	68.83	115.06	167	79.25	115
Dec	58.67	74.42	127	60.45	103
Total	806.94	962.41	119	902.47	112

Erie Basin

	Average	1990	% of Average	1991	% of Average
Jan	60.96	57.91	95	49.28	81
Feb	52.83	136.40R	258	42.67	81
Mar	69.34	53.09	77	78.23	113
Apr	77.72	80.01	103	98.04	126
May	82.30	118.36	144	101.60	123
Jun	86.36	89.66	104	45.00	52
Jul	82.55	92.20	112	59.44	72
Aug	80.26	111.25	139	70.36	88
Sep	78.99	123.70	157	49.28	62
Oct	68.58	105.66	154	106.17	155
Nov	70.61	73.91	105	76.20	108
Dec	66.55	165.86R	249	60.96	93
Total	877.05	1208.01R	138	837.23	95

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Table 2 (Continued)

Ontario Basin

	Average	1990	% of Average	1991	% of Average
Jan	67.06	60.20	90	58.42	87
Feb	60.45	96.27	159	36.58	61
Mar	66.80	59.44	89	115.06	172
Apr	71.12	100.58	141	113.03	159
May	76.96	119.38	155	81.53	106
Jun	77.72	78.49	101	31.50	41
Jul	78.49	76.20	97	67.56	86
Aug	78.49	90.68	116	70.87	90
Sep	80.26	66.80	83	79.50	99
Oct	76.45	127.00	166	70.61	92
Nov	76.96	64.52	84	62.23	81
Dec	73.41	145.03R	198	77.47	107
Total	884.17	1084.59	123	864.36	98

Great Lakes Basin

	Average	1990	% of Average	1991	% of Average
Jan	53.85	54.86	102	44.70	83
Feb	44.70	59.69	134	28.45	63
Mar	55.12	52.07	94	84.58	153
Apr	62.99	64.52	102	87.12	138
May	74.68	96.27	129	89.66	120
Jun	81.28	115.57	142	44.45	55
Jul	77.72	77.72	100	95.76	123
Aug	79.25	78.23	99	58.17	73
Sep	85.60	91.44	107	90.42	106
Oct	70.61	106.68	151	116.84	165
Nov	68.33	85.60	125	85.85	126
Dec	58.93	86.87	147	58.17	99
Total	813.06	969.52	119	884.17	109

Source: NOAA, Corps of Engineers
* Preliminary Data.
Average are for the Period 1900-1990
R denotes new record

Table 3 Outflows from the Great Lakes in 1990 and 1991
(cubic metres per second)

Lake Superior	1990	1991	Average 1900-1990	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	1900	1590	1950	2630 (1971)	1250 (1922)
Feb	1900	1560	1900	2610 (1969)	1270 (1982)
Mar	1900	1560	1870	2690 (1969)	1270 (1982)
Apr	1900	1930	1950	2940 (1951)	1300 (1982)
May	2040	2150	2120	3450 (1951)	1250 (1931)
Jun	1610	2150	2180	3480 (1951)	1220 (1922)
Jul	1870	2180	2290	3570 (1938)	1270 (1922)
Aug	1810	2460	2380	3600 (1950)	1270 (1926)
Sep	1840	1950	2380	3570 (1950)	1160 (1955)
Oct	1670	1930	2290	3510 (1968)	1250 (1926)
Nov	1870	1980	2270	3740 (1985)	1250 (1981)
Dec	1730	2350*	2070	3200 (1950)	1300 (1981)
Annual	1840	1980*	2140		

Lakes Michigan-Huron	1990	1991	Average 1900-1990	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	4730	4590	4450	6060 (1987)	3060 (1934)
Feb	4700	4730	4360	5720 (1974)	3000 (1942)
Mar	4700	4930	4810	5830 (1986)	3510 (1931)
Apr	4900	5210	5150	6260 (1986)	3600 (1901)
May	5010	5380	5350	6370 (1986)	4390 (1964)
Jun	5130	5490	5470	6430 (1985)	4420 (1964)
Jly	5300	5440	5520	6570 (1974)	4500 (1964)
Aug	5240	5470	5520	6630 (1986)	4530 (1964)
Sep	5180	5270	5490	6600 (1986)	4470 (1933)
Oct	5130	5270	5440	6740 (1986)	4420 (1933)
Nov	5150	5320	5380	6650 (1986)	4390 (1934)
Dec	5100	5300	5180	6230 (1986)	3990 (1935)
Annual	5020	5200	5180		

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Table 3 (Continued)

Lake Erie	1990	1991	Average 1900-1990	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	5690	6570	5580	7420 (1987)	4050 (1936)
Feb	5950	6510	5470	7050 (1987)	3340 (1936)
Mar	6120	6540	5610	7480 (1986)	4110 (1934)
Apr	6430	6600	5890	7700 (1974)	4390 (1935)
May	6510	6480	6200	7760 (1974)	4590 (1934)
Jun	6430	6290	6230	7820 (1986)	4560 (1934)
Jly	6140	6200	6120	7670 (1986)	4450 (1934)
Aug	6200	6030	6000	7420 (1986)	4470 (1934)
Sep	6310	5890	5890	7140 (1986)	4450 (1934)
Oct	6260	5720	5800	7450 (1986)	4420 (1934)
Nov	6170	5750	5800	7280 (1986)	4280 (1934)
Dec	6340	5860	5780	7620 (1985)	4330 (1934)
Annual	6210	6200	5830		

Lake Ontario	1990	1991	Average 1900-1990	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6880	6710	6260	8470 (1987)	4700 (1935)
Feb	7190	8010	6290	8160 (1986)	4360 (1936)
Mar	7480	8890	6600	8890 (1987)	5010 (1935)
Apr	7840	7900	7050	9200 (1973)	5070 (1964)
May	8160	8670	7310	9540 (1973)	4980 (1965)
Jun	8330	7930	7390	9910 (1973)	5350 (1965)
Jly	7870	7590	7330	9910 (1976)	5520 (1934)
Aug	7560	7360	7160	9340 (1974)	5300 (1934)
Sep	7390	7170	6990	9230 (1986)	5100 (1934)
Oct	7310	6770	6800	9170 (1986)	4960 (1934)
Nov	7310	6340	6680	9570 (1986)	4810 (1934)
Dec	7110	6200	6570	9260 (1986)	4810 (1934)
Annual	7540	7460	6870		

Source: Water Planning and Management Branch, Environment Canada
* Preliminary Data

Table 4 Great Lakes Water Levels in 1990 and 1991 and Their Comparison with Previous Records (Metres, IGLD-1955)

Lake Superior Water Levels				Previous 1900-90 Maxima & Minima at Marquette (Year of Occurrence)	
	1990	1991	Average 1900-1990	Maximum	Minimum
Jan	182.81	182.86	183.00	183.38 (1986)	182.45 (1926)
Feb	182.75	182.79	182.93	183.30 (1986)	182.38 (1926)
Mar	182.72	182.77	182.89	183.28 (1986)	182.37 (1926)
Apr	182.71	182.84	182.91	183.33 (1986)	182.34 (1926)
May	182.79	182.94	183.01	183.40 (1986)	182.36 (1926)
Jun	182.88	183.00	183.10	183.42 (1986)	182.46 (1926)
Jul	182.97	183.08	183.16	183.46 (1986)	182.57 (1926)
Aug	182.98	183.08	183.19	183.50 (1986)	182.62 (1926)
Sep	182.99	183.07	183.20	183.51 (1985)	182.72 (1926)
Oct	183.00	183.05	183.18	183.56 (1985)	182.72 (1925)
Nov	182.99	183.08	183.14	183.56 (1985)	182.63 (1925)
Dec	182.92	183.07	183.07	183.49 (1985)	182.56 (1925)

Lakes Michigan-Huron Levels				Previous 1900-90 Maxima & Minima at Harbor Beach (Year of Occurrence)	
	1990	1991	Average 1900-1990	Maximum	Minimum
Jan	175.94	176.14	176.15	176.98 (1987)	175.38 (1965)
Feb	175.94	176.10	176.14	176.89 (1986)	175.39 (1964)
Mar	175.98	176.12	176.15	176.91 (1986)	175.37 (1964)
Apr	176.05	176.28	176.23	177.01 (1986)	175.37 (1964)
May	176.13	176.39	176.32	177.06 (1986)	175.50 (1964)
Jun	176.23	176.45	176.39	177.11 (1986)	175.53 (1964)
Jul	176.29	176.43	176.43	177.17 (1986)	175.55 (1964)
Aug	176.28	176.38	176.42	177.19 (1986)	175.56 (1964)
Sep	176.24	176.27	176.37	177.17 (1986)	175.55 (1964)
Oct	176.20	176.19	176.30	177.28 (1986)	175.49 (1964)
Nov	176.17	176.17	176.24	177.18 (1986)	175.43 (1964)
Dec	176.19	176.19	176.19	177.05 (1986)	175.38 (1964)

Lake St. Clair Water Levels				Previous 1900-90 Maxima & Minima at St.Clair Shore (Year of Occurrence)	
	1990	1991	Average 1900-1990	Maximum	Minimum
Jan	174.70	175.04	174.60	175.60 (1986)	173.69 (1936)
Feb	174.82	174.93	174.53	175.62 (1986)	173.70 (1926)
Mar	174.89	175.00	174.65	175.62 (1986)	173.86 (1934)
Apr	174.92	175.08	174.81	175.63 (1986)	174.07 (1901)
May	174.97	175.14	174.90	175.64 (1986)	174.24 (1934)
Jun	175.02	175.20	174.95	175.72 (1986)	174.27 (1934)
Jul	175.06	175.15	174.97	175.74 (1986)	174.31 (1934)
Aug	175.06	175.11	174.94	175.70 (1986)	174.22 (1934)
Sep	175.04	174.99	174.87	175.66 (1986)	174.15 (1934)
Oct	174.96	174.84	174.79	175.78 (1986)	174.08 (1934)
Nov	174.90	174.77	174.70	175.63 (1986)	173.99 (1934)
Dec	174.91	174.80	174.71	175.61 (1986)	174.06 (1925)

(Continued on next page)

Table 4 (Continued)

Lake Erie Water Levels	1990	1991	Average 1900-1990	Previous 1900-90 Maxima & Minima at Cleveland (Year of Occurrence): Maximum		Minimum	
Jan	173.79	174.24	173.73	174.67	(1987)	173.01	(1935)
Feb	173.98	174.18	173.73	174.60	(1987)	172.97	(1936)
Mar	174.11	174.24	173.81	174.68	(1986)	173.02	(1934)
Apr	174.17	174.29	173.98	174.79	(1985)	173.19	(1934)
May	174.23	174.35	174.06	174.78	(1986)	173.26	(1934)
Jun	174.26	174.36	174.10	174.86	(1986)	173.27	(1934)
Jul	174.22	174.27	174.09	174.85	(1986)	173.27	(1934)
Aug	174.20	174.17	174.03	174.76	(1986)	173.24	(1934)
Sep	174.19	174.06	173.94	174.67	(1986)	173.20	(1934)
Oct	174.11	173.91	173.84	174.74	(1986)	173.11	(1934)
Nov	174.03	173.85	173.76	174.65	(1986)	173.00	(1934)
Dec	174.06	173.86	173.74	174.68	(1986)	172.98	(1934)

Lake Ontario Water Levels	1990	1991	Average 1900-1990	Previous 1900-90 Maxima & Minima at Oswego (Year of Occurrence): Maximum		Minimum	
Jan	74.38	74.78	74.39	75.01	(1946)	73.66	(1935)
Feb	74.46	74.84	74.42	75.12	(1952)	73.64	(1936)
Mar	74.61	74.90	74.50	75.22	(1952)	73.79	(1935)
Apr	74.83	75.04	74.71	75.50	(1973)	73.88	(1935)
May	74.95	75.13	74.83	75.58	(1952)	73.97	(1935)
Jun	74.98	75.03	74.87	75.61	(1952)	74.04	(1935)
Jul	74.85	74.88	74.83	75.51	(1947)	73.99	(1934)
Aug	74.71	74.70	74.73	75.42	(1947)	73.84	(1934)
Sep	74.54	74.49	74.60	75.26	(1947)	73.74	(1934)
Oct	74.48	74.33	74.48	75.08	(1945)	73.68	(1934)
Nov	74.46	74.20	74.40	75.04	(1945)	73.59	(1934)
Dec	74.49	74.23	74.38	75.04	(1945)	73.60	(1934)

Montreal Harbour (Jetty No.1)	1990	1991	Average 1967-1989	Previous Recorded Maxima & Minima (Year of Occurrence): Maximum		Minimum	
Jan	6.65	6.79	7.02	8.91	(1968)	6.38	(1972)
Feb	6.73	7.01	7.15	8.99	(1967)	6.33	(1977)
Mar	6.89	7.35	7.19	8.31	(1973)	6.49	(1970)
Apr	7.28	8.00	7.70	8.77	(1976)	7.16	(1970)
May	7.02	7.16	7.51	8.89	(1974)	6.38	(1968)
Jun	6.61	6.26	6.91	8.08	(1974)	5.88	(1988)
Jul	6.38	5.96	6.64	7.45	(1973)	5.67	(1988)
Aug	6.16	5.87R	6.53	7.23	(1972)	5.89	(1988)
Sep	5.95	5.79R	6.48	7.03	(1986)	5.88	(1988)
Oct	6.43	5.76R	6.52	7.11	(1986)	6.08	(1971)
Nov	6.51	5.58R	6.60	7.27	(1967)	5.91	(1971)
Dec	6.73	5.85	6.69	7.20	(1972)	5.82	(1978)

R denotes new record. * Preliminary Data.

Table 5 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)	1991 N.B.S. (cms)	1991 Difference in Storage (m)
Jan	-400 cms	30 cms	0.01 m	-790 cms	-0.01 m
Feb	310	-650	-0.03	-250	-0.02
Mar	1270	1560	0.01	2830	0.05
Apr	4220	3540	-0.02	4530	0.01
May	5240	3400	-0.06	4930	-0.01
Jun	4450	5490	0.03	3510	-0.03
Jul	3680	3060	-0.02	3740	0
Aug	2860	1020	-0.06	1360	-0.05
Sep	2100	2380	0.01	1220	-0.03
Oct	1080	2630	0.05	2350	0.04
Nov	540	420	0	3090	0.08
Dec	-650	-1250	-0.02	-340	0.01
Sum	24700	21630	-0.10	26180	0.05

Lakes Michigan-Huron Net Basin Supplies (CMS)

	1900-1988 Average	1990 N.B.S. (cms)	1990 Difference in Storage (m)	1991 N.B.S. (cms)	1991 Difference in Storage (m)
Jan	1500 cms	3570 cms	0.05 m	760 cms	-0.02 m
Feb	2520	2070	-0.01	1610	-0.02
Mar	5210	6990	0.04	7820	0.06
Apr	8130	5270	-0.06	11300	0.07
May	7110	8440	0.03	2700	0.01
Jun	5780	8130	0.05	2780	-0.07
Jul	3620	3280	-0.01	2930	-0.02
Aug	1560	2460	0.02	-710	-0.05
Sep	910	740	0	-2860	-0.08
Oct	30	1930	0.04	4020	0.09
Nov	1020	4760	0.09	2070	0.02
Dec	820	2100	0.03	3030	0.05
Sum	38210	49740	0.25	35450	-0.06

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 6 Lake Ontario Supply Summary

	1900-1988 Average	1990 N.B.S. (cms)	1990 Difference in Storage (metres)	1991 N.B.S. (CMS)	1991 Difference in Storage (metres)
Jan	910 cms	1440 cms	0.07 m	1390 cms	0.06 m
Feb	1050	2210	0.16	1440	0.05
Mar	2120	2520	0.05	3340	0.16
Apr	2630	2920	0.04	3060	0.06
May	1700	2550	0.11	1640	-0.01
Jun	1160	1270	0.01	420	-0.10
Jul	680	620	-0.01	250	-0.06
Aug	230	280	0.01	0	-0.03
Sep	140	-170	-0.04	-60	-0.03
Oct	200	1080	0.12	80	-0.02
Nov	570	850	0.04	140	-0.06
Dec	760	2490	0.23	790	0
Sum	12150	18060	0.80	12490	0.05

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

Table 7 Preliminary Conversion Factors between IGLD 1955 and IGLD 1985

The water level elevations used in this report are on the International Great Lakes Datum (IGLD) 1955. Beginning in January 1992, a new datum - IGLD 1985, will be used to determine water level elevations. The following lists the preliminary conversion factors for the water level stations listed in the Canadian and United States water level bulletins. Final conversion factors will be published by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data.

To convert from IGLD 1955 to IGLD 1985, use the following formula:

IGLD (1955) elevation + Factor = IGLD (1985) elevation

To convert from IGLD 1985 to IGLD 1955, use the following formula:

IGLD (1985) elevation - Factor = IGLD (1955) elevation

	Preliminary Conversion Factors	
	Metres	Feet
Lake Superior at Thunder Bay	0.383	1.257
Marquette	0.345	1.132
Lakes Michigan-Huron at Goderich	0.195	0.640
Harbor Beach	0.214	0.702
Lake St. Clair at Belle River	0.215	0.705
St. Clair Shore	0.191	0.627
Lake Erie at Port Colborne	0.191	0.627
Cleveland	0.182	0.597
Fairport	0.175	0.574
Lake Ontario at Kingston	0.176	0.577
Oswego	0.158	0.518
Montreal Harbour at Jetty 1	0.094	0.308

Add conversion factor to elevations on IGLD 1955 to convert to IGLD 1985.

If your are interested in the conversion factors for other sites in the Great Lakes - St. Lawrence River system not listed here, please contact:

Mr. Rick Sandilands,
Canadian Hydrographic Service,
Department of Fisheries and Oceans,
867 Lakeshore Road,
Burlington, Ontario, L7R 4A6, Telephone: (416) 336 4844

Mr. Fred Young,
Geodetic Survey of Canada,
Energy, Mines and Resources Canada
615 Booth Street,
Ottawa, Ontario, K1A 0E9, Telephone: (613) 992 1728

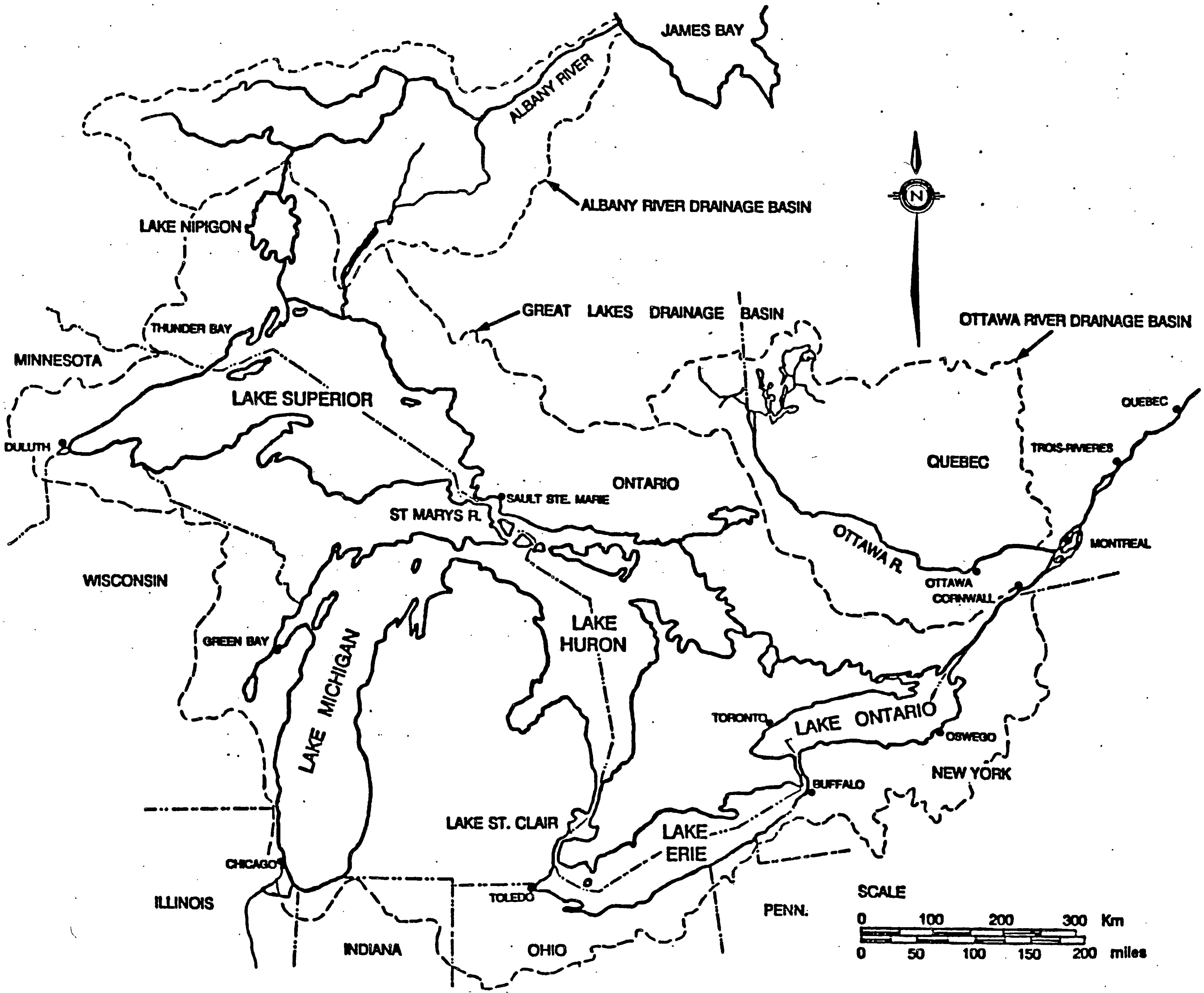

Figure 1 GREAT LAKES - ST. LAWRENCE RIVER LASIN

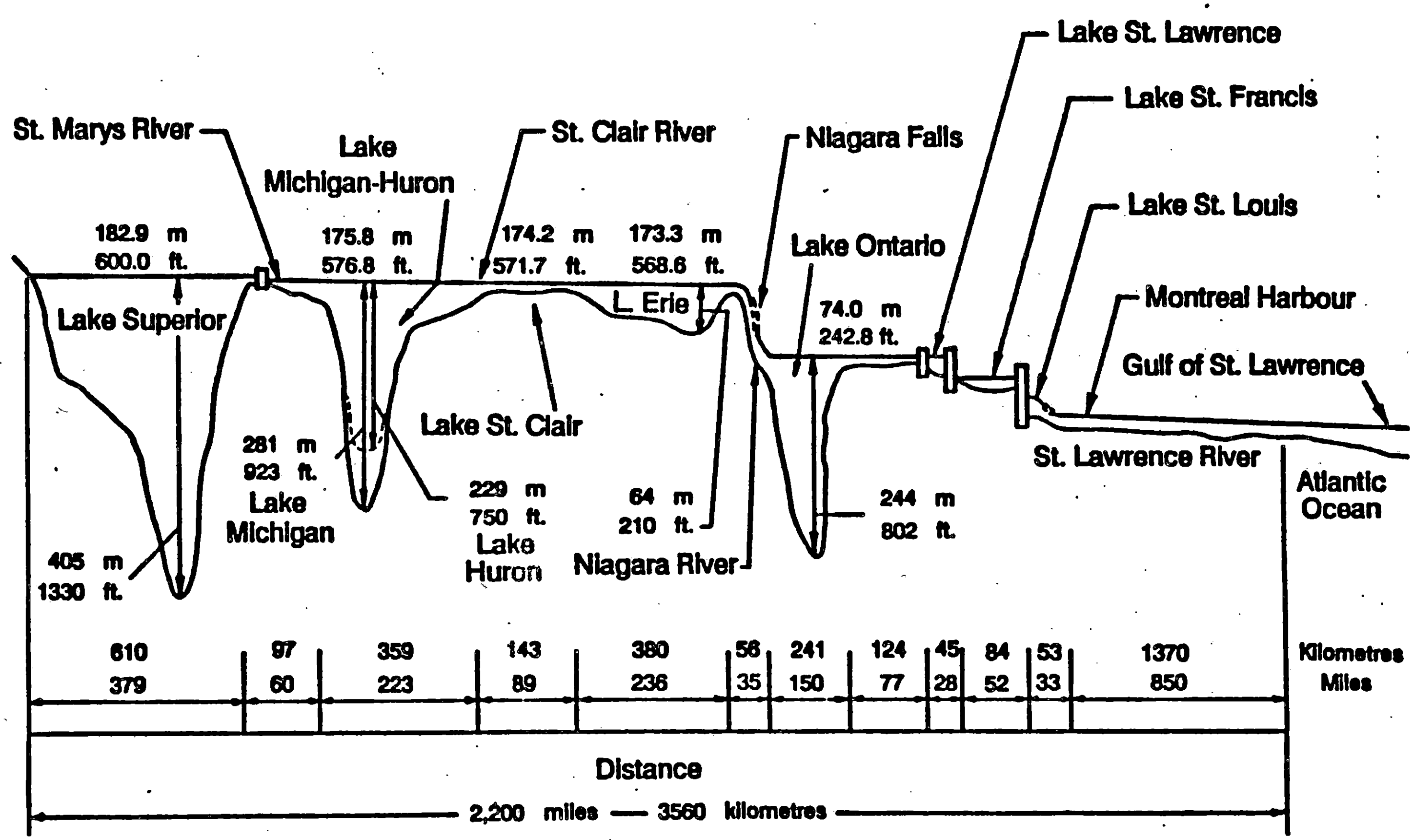

Figure 2 SCHEMATIC PROFILE OF THE GREAT LAKES - ST. LAWRENCE RIVER SYSTEM

LAKE SUPERIOR AT THUNDER BAY

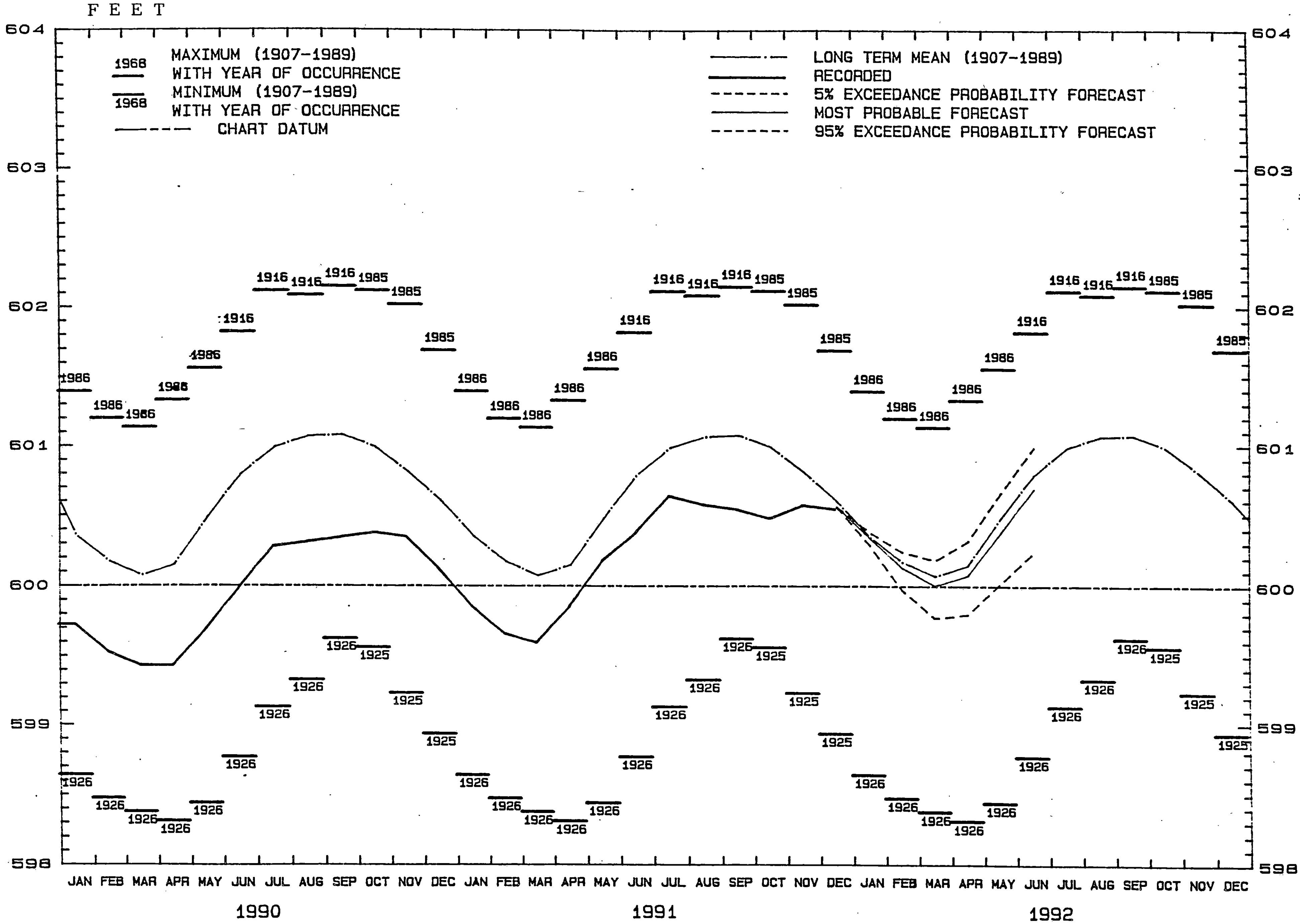

Figure 3

LAKE HURON AT GODERICH

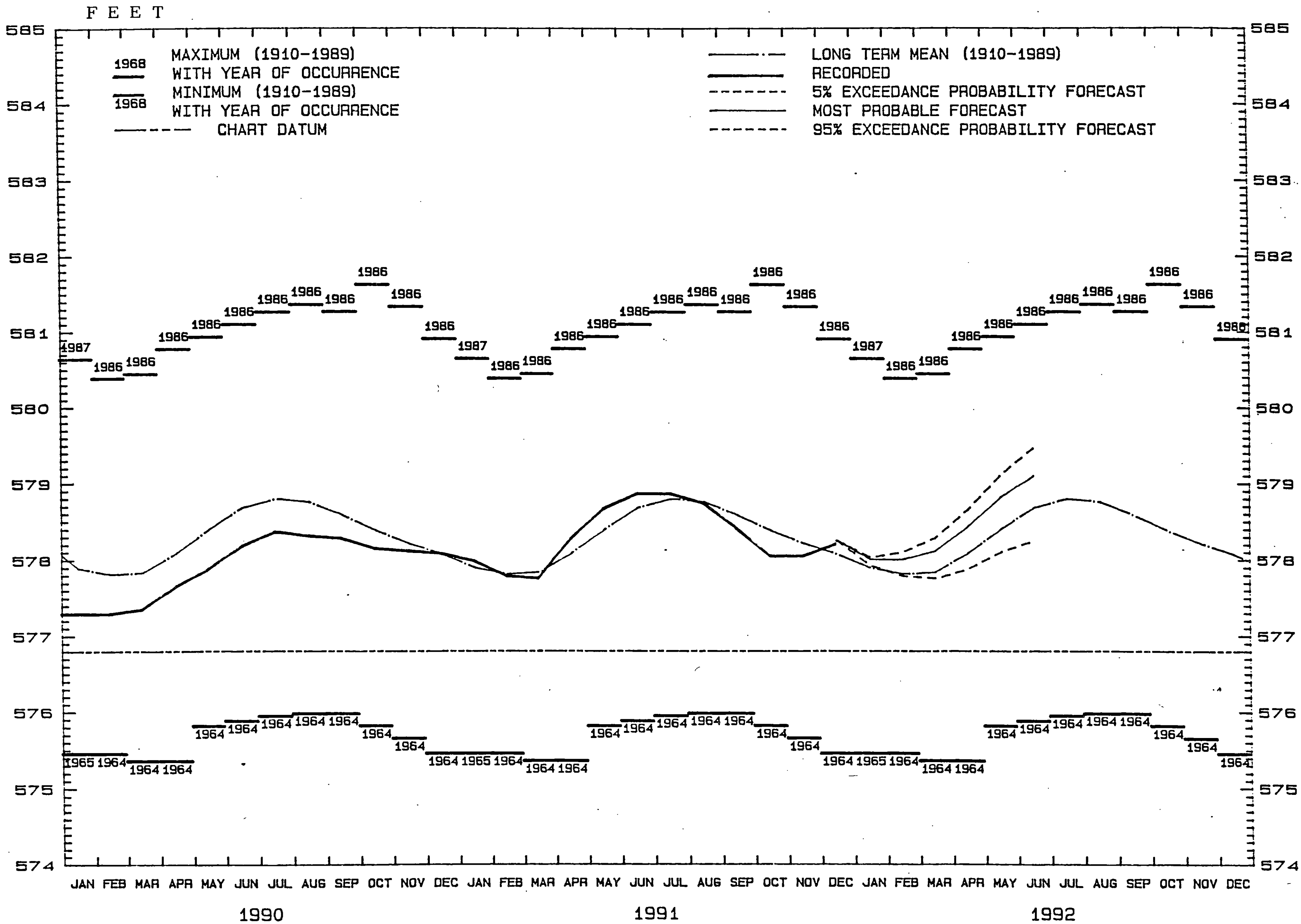

Figure 4

LAKE ST. CLAIR AT BELLE RIVER

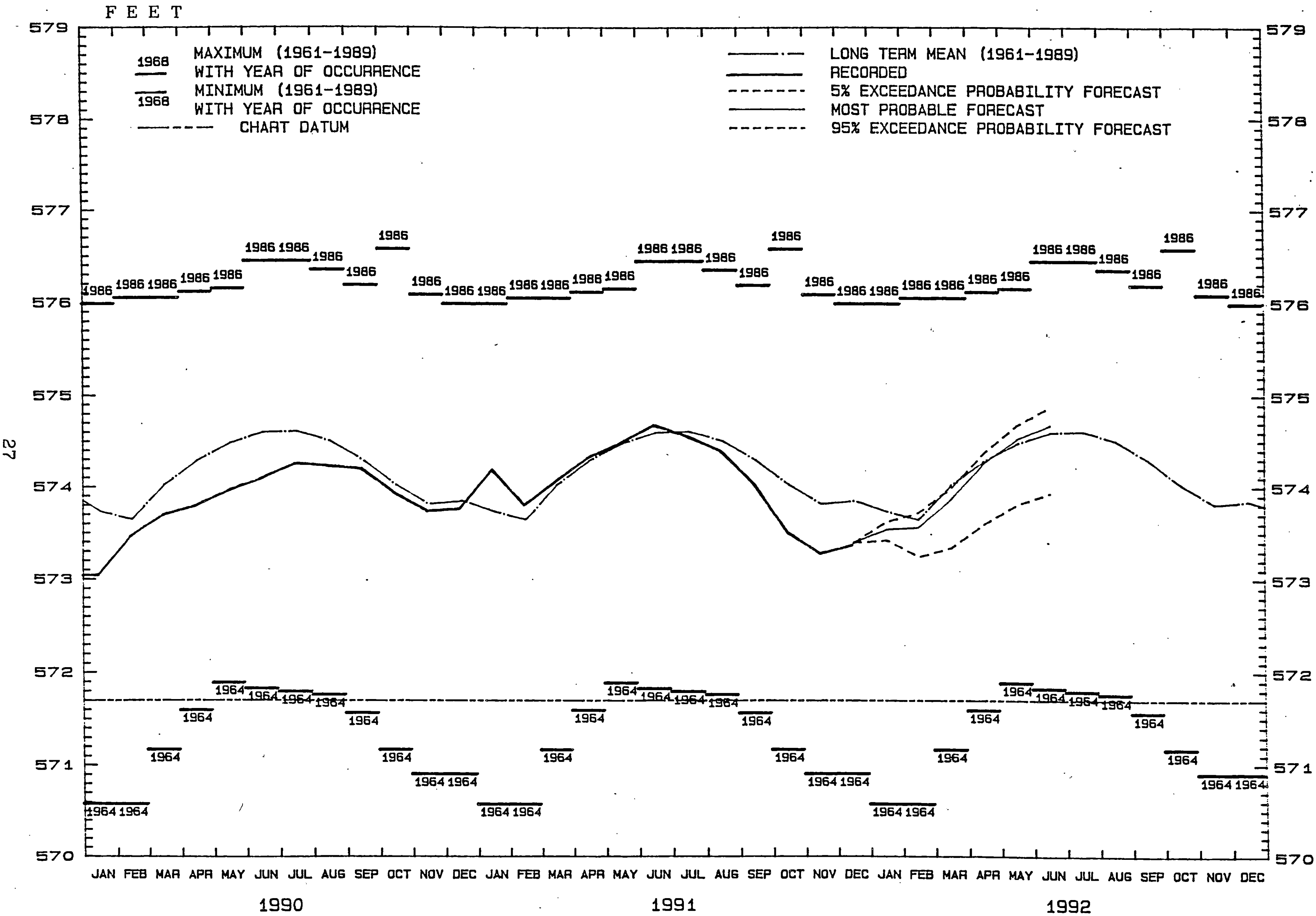

Figure 5

LAKE ERIE AT PORT STANLEY

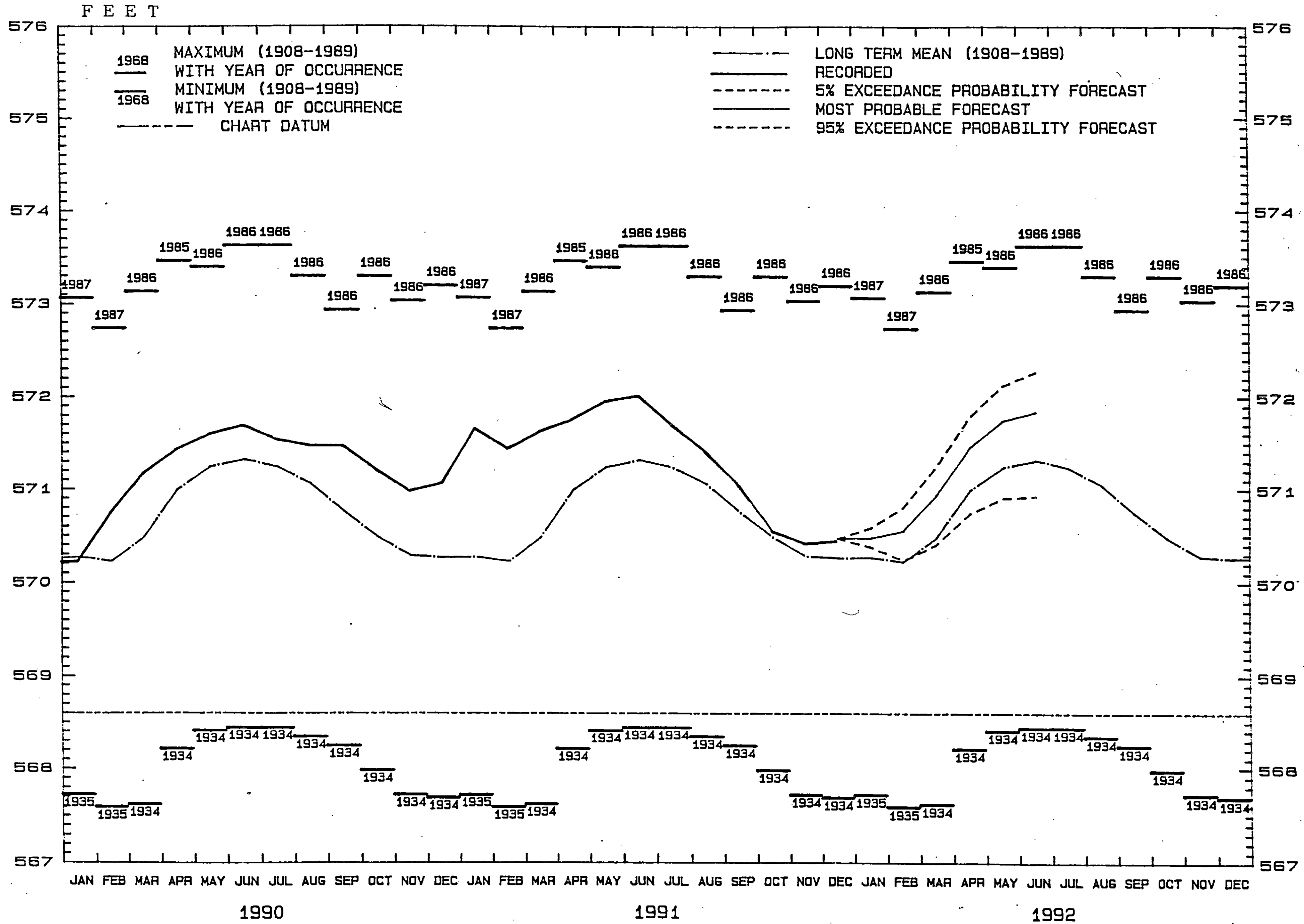

Figure 6

LAKE ONTARIO AT KINGSTON

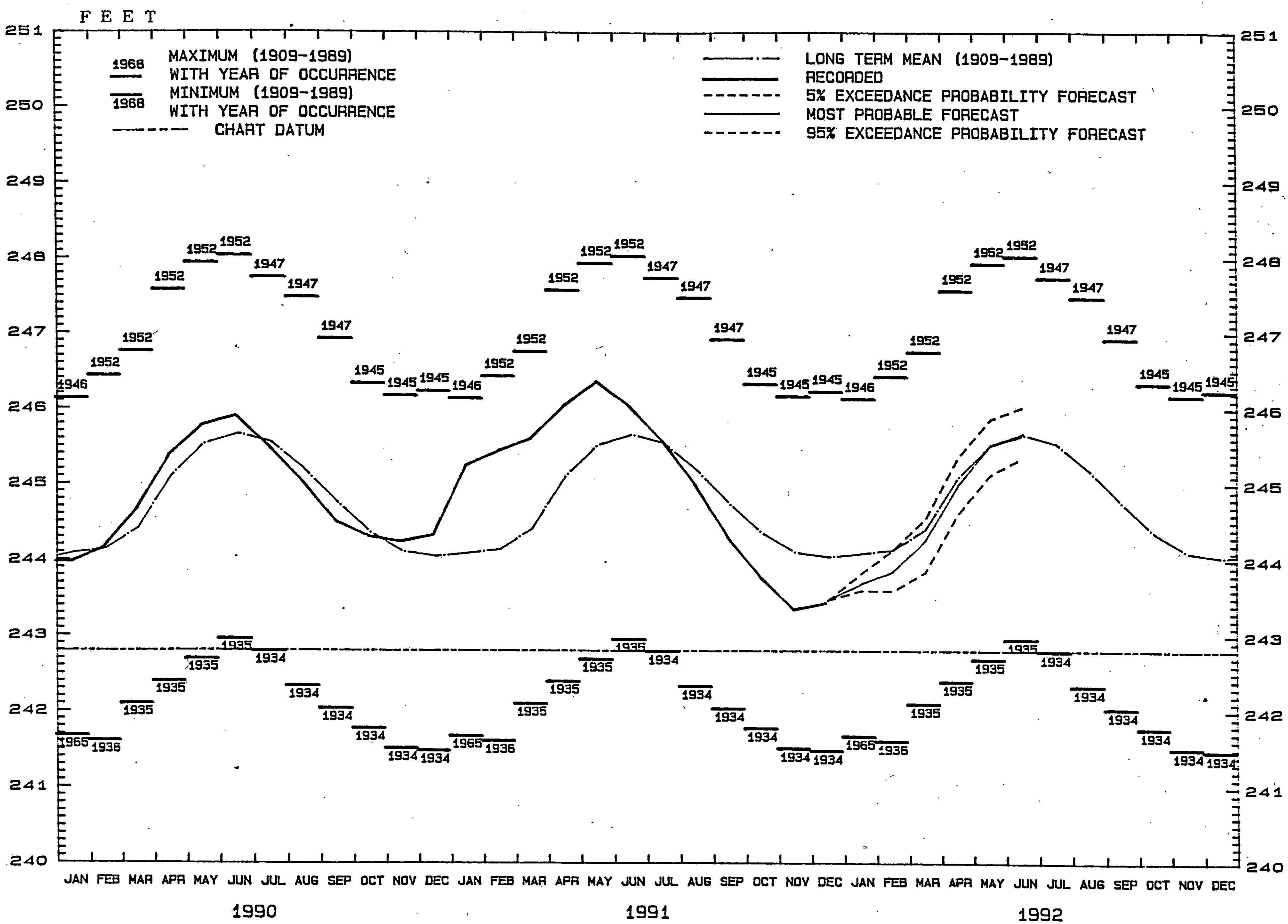

Figure 7

MONTREAL HARBOUR (JETTY NO.1)

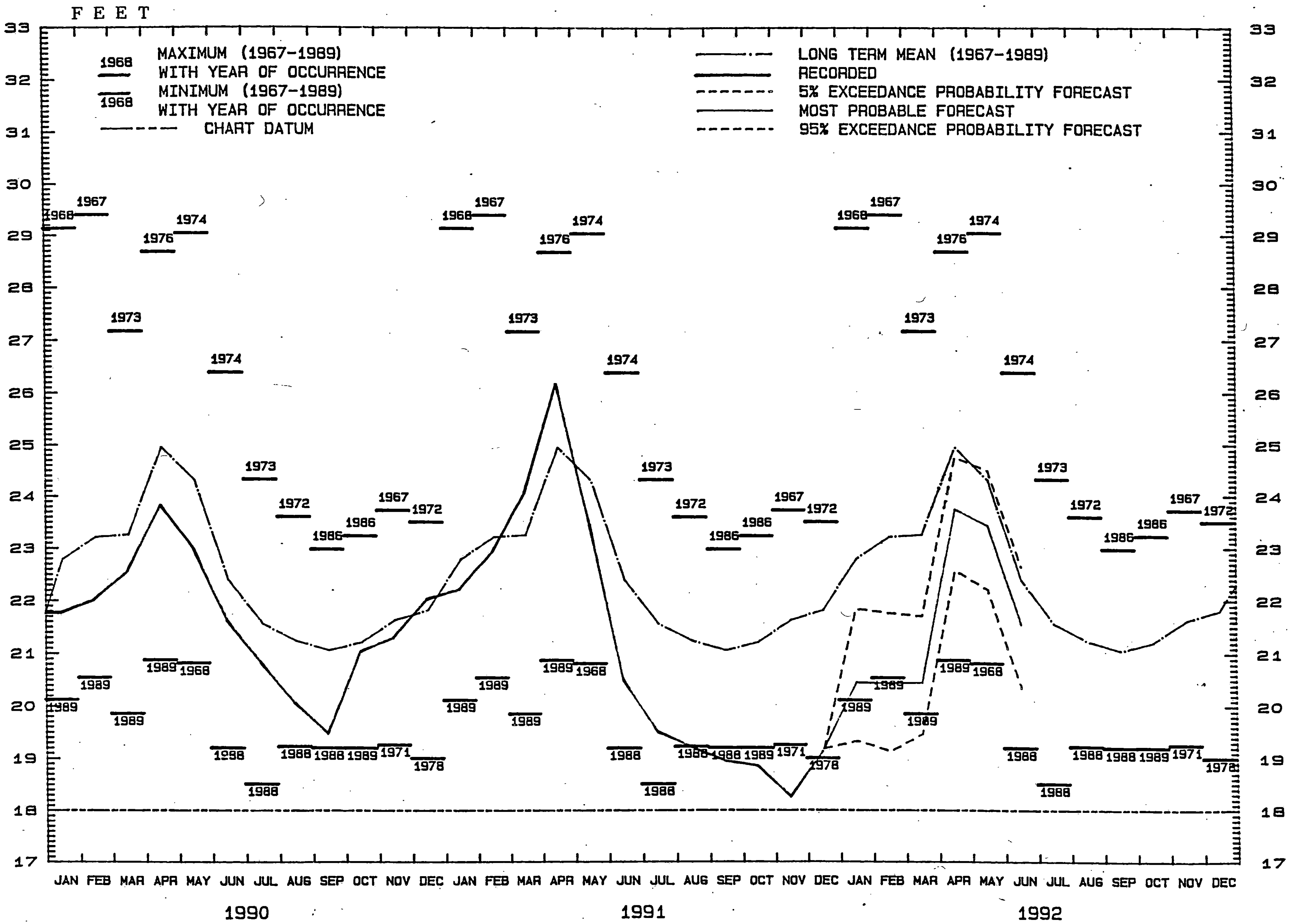

Figure 8