A REPORT ON
1996 WATER LEVELS
OF THE GREAT LAKES
AND THE ST. LAWRENCE RIVER

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SUMMARY

Water levels of the Great Lakes started the year 1996 very close to average. Above average precipitation during the year caused levels to rise significantly.

The biggest change from the previous year occurred on Lake Superior, where the lake rose from 16 cm below average in July 1995 to 22 cm above average in August 1996. The St Lawrence River levels at Montreal returned to average following the extreme low levels in the summer of 1995.

The Lake Superior outflows for a few months were less than those specified by the regulation plan due to repairs at the St. Marys River Compensating Works. By the end of August, 5 cm of water was retained on Lake Superior; and Lakes Michigan-Huron levels were lowered by 3 cm. Subsequent increases in outflows following the repairs removed these effects by late November.

Except for the first five months in 1996, the water levels on the middle lakes (Michigan-Huron, St. Clair and Erie) were above average. However, the lakes remained below the previous recorded maximums that occurred in 1986.

While Lake Ontario received well above average water supplies from Lake Erie and at times from its drainage basin, very high outflows through regulation kept the levels below flood stage. However, the high flows exacerbated the low water level conditions on Lake St. Lawrence.

For the St. Lawrence River downstream of Cornwall, the levels in 1996 were non-problematic. The arrival of the Ottawa River freshet, albeit later than usual, provided sufficiently high levels for fish to reach their spawning areas on Lake St. Louis and downstream. During the year, recreational boaters and commercial ships on Lake St. Louis and at the Port of Montreal enjoyed levels at or above average.

While lake levels were high in 1996, flood and erosion damage was light due to the absence of major storms. At the end of the year, the levels on all the lakes remained above average. The risk of serious flood and erosion damage, particularly on the middle lakes, remains high for the spring of 1997.

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1.0 INTRODUCTION

This report describes the water level fluctuations in the Great Lakes - St. Lawrence River system in 1996. It also provides an assessment of hydrologic data collected by other agencies. Water level elevations are in metres above sea level at Rimouski, Quebec, on the International Great Lakes Datum (IGLD) of 1985. River flows are in cubic metres per second (m^3/s).

2.0 THE GREAT LAKES - ST. LAWRENCE SYSTEM

The Great Lakes - St. Lawrence River basin (including land and lake surface) covers an area of more than one million square kilometres (see Figure 1). As shown in Figure 2, the Great Lakes comprise a series of natural reservoirs positioned in a step-wise manner, with Lake Superior as the highest step and Lake Ontario the lowest. Lakes Michigan and Huron are considered one lake in hydraulic terms, because they are connected by the wide and deep Straits of Mackinac and stand at the same elevation.

Water levels fluctuate according to the climate of the region. Over-lake precipitation, evaporation and runoff are the main factors that affect water levels. Other factors include flow retardation due to ice in winter, or aquatic vegetation in the lakes' outlet rivers in the summer. Weather disturbances cause short-term fluctuations in water levels. Human impacts on water levels include regulation of lake outflows, dredging of outlet channels, water diversions and consumption of water.

Lakes Superior and Ontario are the only two lakes that have their outflows regulated by structures at their outlets. The outflows of the un-regulated lakes (Michigan-Huron, St. Clair and Erie) are dependent on their water levels. For Lakes Michigan-Huron and Lake St. Clair, their outflows through the St. Clair - Detroit River system depend also to a minor extent on the levels of Lake Erie due to backwater effect on these rivers.

Water level fluctuations on Lake Ontario do not affect the levels of Lake Erie due to the cascades and Niagara Falls in the Niagara River.

Lake St. Lawrence is that part of the St. Lawrence River extending from about Iroquois to Cornwall, Ontario. Several factors affect the water level fluctuations in this area. They include: Lake Ontario level, flow at the hydropower dam at Cornwall, ice in the river and winds.

Lake St. Francis extends from just below Cornwall to its outlets at the Beauharnois-Cedars hydro and navigation installations. Large water level fluctuations on Lake St. Francis are rare because the water level on Lake St. Francis is regulated within a narrow range by Hydro Quebec's control works at Coteau. Besides the inflows from upstream, factors that also affect Lake St. Francis levels are local runoff, winds, and ice in the river.

Lake St. Louis is located near Montreal, at the confluence of the St. Lawrence River and a part of the Ottawa River. Due to its small area, the water levels of Lake St. Louis can rise rapidly during the spring freshet following snow melt on the Ottawa River basin. Local runoff during heavy rain storms can also raise the levels significantly.

Like Lake St. Louis, the levels at Montreal are affected by flows from Lake Ontario, the Ottawa River, local runoff and downstream ice conditions.

3. HYDROLOGIC CONDITIONS IN 1996

3.1 Weather Conditions

The winter of 1995-96 arrived early with sub-zero temperatures extending from early November into December 1995. As a result, ice formed early on the Great Lakes and in the St. Lawrence River. An ice jam in the St. Clair River on two occasions in early 1996 caused large water level fluctuations on Lake St. Clair. Otherwise, Great Lakes ice covers were non-problematic in terms of levels and flows.

The ice dissipation in 1996 was considered uneventful. The mid-January thaw and another mild weather condition in February melted much of the ice in the middle lakes and the St. Lawrence River. Ice dissipation on Lake Superior, which was almost totally ice covered in February, occurred in April.

Spring 1996 was relatively cool, while July and August appeared to be milder than normal with occasional hot spells.

The Great Lakes escaped the brunt of the weather system on July 20 that caused disastrous flooding in the Saguenay-Lac Saint-Jean region in Quebec. However, the same weather system dumped plentiful rain on the Ottawa basin, causing a temporary rise in the levels of the St. Lawrence River at Montreal and downstream.

Several cold fronts arrived in early November and December 1996. They brought with them strong northerly and westerly winds, and caused heavy snowfall a short distance inland due to the lake effect. Air temperatures in late November were a bit below normal while those in December were slightly milder than normal.

3.2 Precipitation

On average, 820 millimetres (mm) of precipitation fall on the Great Lakes basin each year. Readings from about 100 precipitation stations scattered throughout the basin (excluding St. Lawrence River) are used to measure precipitation. This averages to about 7700 square kilometres of area covered by each station. The density of stations is greater on the lower Great Lakes basins, and less so on the upper Great Lakes basins.

Table 1 compares the 1996 monthly precipitation with long-term averages since 1900. The total basin-wide figure for 1996 was about 930 mm, and 113 percent of average. The 1996 figure ranks the fifth highest since 1900, following those for 1951, 1977, 1985 and 1990. Eight of the twelve months in 1996 had precipitation amounts above average.

Basin-by-basin, Lake Superior received 930 mm of precipitation which was 121% of average. Coincidentally, this amount also ranks fifth highest and also matches the amount recorded in 1988. The amount in January was twice the average and also a record high for the month. Except for March, May and August, precipitation in 1996 was above average.

Similar to the Lake Superior basin, the Lakes Michigan-Huron precipitation showed a similar pattern, with below average precipitation in March, May, August, and November, and above average amount the rest of the year. The total amount for the year was 107% of average.

The 1996 precipitation on the Lake Erie and Lake Ontario basins were 117% and 118% of average, respectively. September was a particular wet month on both basins, with a record amount for the month on the Lake Erie basin while that for Lake Ontario almost matched the previous maximum. By contrast, August was a record dry month for Lake Erie basin.

3.3 Water Levels and Outflows

Table 2 lists the water levels for the Great Lakes and the above mentioned sites in the St. Lawrence River in 1996. The tables also show how the 1996 figures compare with historical data. The information is also shown graphically in Figures 3 to 10.

For Great Lakes water level comparisons, records since 1918 are used in accordance with the procedure agreed between Canada and the United States. A network of gauges located around each lake is used to determine the mean monthly water level of the lake. Water level records for Lake St. Lawrence, as measured at the Long Sault gauge, started in 1960 following completion of the St. Lawrence seaway and power projects. Data at Pointe Claire, which measure the water levels on Lake St. Louis, extend to 1915. For Montreal Harbour, data since 1967 are used following the most recent physical changes to that part of the river.

Lake Superior (Figure 3) started 1996 at its long-term average level. During the first four months of the year, the level remained very close to average. In mid-April, the level rose sharply due to heavy snowmelt on the Lake Superior basin and higher than average precipitation. The level continued to rise at a rate faster than usual until it peaked in August. The monthly mean level for August was 22 cm above average, but 8 cm below the previous maximum for the month that occurred in 1952. The level then declined slowly between September and December. At the end of the year, the level was 24 cm above average.

While Lake Superior's levels were above average in 1996, conditions were quite different a year earlier. For much of 1995, the levels were below average by as much as 16 cm in June and July. Rain in the August - October period of 1995 brought the level back to average.

The water levels on Lakes Michigan-Huron (Figure 4) exhibited a trend similar to that on Lake Superior, except that the decline during the fall months was much slower than that on Lake Superior. Lakes Michigan-Huron peaked in August about 23 cm higher than average for that time of year. At the end of 1996, the level was 42 cm above average.

The higher than average precipitation on their basins is one of the factors causing high water levels on Lakes Michigan-Huron. Secondly, high precipitation means more overcast days and reduced evaporation from the lakes' surfaces. In addition, the inflows from Lake Superior in 1996 averaged 380 m^3/s more than average. This difference is equivalent to an additional 15 cm of water on Lakes Michigan-Huron.

The Lake St. Clair levels (Figure 5) were affected considerably by ice in the St. Clair River on two occasions. During early January, ice began to form in the St. Clair River reducing the flow out of Lake Huron. The reduction in the inflow caused the Lake St. Clair level to drop almost 30 cm over a period of two weeks. The levels recovered following the mid-January thaw when much of the ice in the river melted away. An ice jam in the St. Clair River that lasted several weeks starting mid-March caused the level of Lake St. Clair to drop by as much as 50 cm compared to conditions prior to the jam. Extensive ice breaking efforts cleared the jam late in April and the lake's level recovered to slightly above average by early May. The ice jam had minimal impacts on the water levels of Lakes Michigan-Huron and Lake Erie, owing to the sizes of these lakes.

Due to its size and proximity to Lakes Michigan-Huron, Lake St. Clair levels fluctuate depending on the levels of Lakes Michigan-Huron. Like the upper lakes, Lake St. Clair rose significantly during the April-June period, and declined by very small amount the rest of the year. At year end, the lake was 60 cm above average.

Lake Erie levels (Figure 6) were slightly above average during the first four months in 1996. The level rose much faster than usual in May and June, and reached its peak at the end of June. The level then declined at a rate slower than usual for the rest of the year. By year end, the level was 47 cm above average.

A mid-January thaw with three days of very mild temperatures and rain melted much of the snow on the Lake Ontario basin. As a result, the Lake Ontario level (Figure 7) rose rapidly in the second half of January. Very little change in the levels occurred from February until mid-April, when the levels rose rapidly through the end of May. Levels then declined gradually the rest of the year, although the decline was halted somewhat in the September-November period due to very high water supplies to the lake. The year end level was 17 cm above average.

The water levels of Lake St. Lawrence (Figure 8) during the first half of 1996 were close to average, although there were several periods of large fluctuations caused by upstream ice, and winds. Beginning in June, the levels fell below average, a condition brought on by the

continued high flows at the hydropower dam and declining Lake Ontario water levels. On several occasions, strong easterly winds further lowered the levels of Lake St. Lawrence. From October until the end of the year, levels were well below seasonal average.

Except for a very brief period in early April when its levels were below average, Lake St. Louis (Figure 9) was above average in 1996. The high flows from Lake Ontario, the Ottawa River and local tributaries were factors causing above average water levels on Lake St. Louis.

During 1996, levels at the Port of Montreal (Figure 10) were at or above the average of the past 30 years. The exception was in late March and early April when levels were below average due to the late arrival of the spring freshet on the Ottawa River basin. But the April rain on Lake Ontario, along with the Ottawa River freshet that came during the second half of April significantly increased the flow in this part of the river. As a result, the levels rose rapidly during the latter part of April. For the rest of the year, the levels remained very close to, or slightly above average. The water levels in Montreal in 1996 were quite different from a year earlier, when levels for several months were the lowest in 30 years.

Table 3 lists the 1996 monthly outflows from each of the Great Lakes. The Lake Superior outflow for the year averaged 2520 m^3/s, about 18% above average. The higher than average outflow reflected the high water level conditions on the lake.

Lakes Michigan-Huron's outflow for the year was slightly above average. The relatively high flows for much of the year were offset by the very low flows in January and April during the ice jams. Lake Erie and Lake Ontario outflows throughout the year were 109% and 114%, respectively, above average.

It is interesting to note that the higher than average Lake Erie outflow, in the amount of 500 m^3/s for the year, was equivalent to 40 cm of water on Lake Ontario. In the case of Lake Ontario, very high outflows, made possible following the seaway and hydro developments in the St. Lawrence River, managed to keep Lake Ontario levels in 1996 below flood stage.

4.0 WATER MANAGEMENT RELATED TO WATER LEVELS

4.1 Lake Superior Regulation

Lake Superior's Regulation Plan 1977-A specifies monthly outflows from the lake based upon this lake's level and the level of Lakes Michigan-Huron downstream. The procedure of taking downstream lake levels into account is termed systemic regulation, and is a requirement of the International Joint Commission (IJC). Assessment of the hydrologic conditions on the upper Great Lakes is the responsibility of the IJC's International Lake Superior Board of Control. In normal operations, the Lake Superior outflow is the amount specified by the regulation plan. Under certain conditions, the IJC approves deviations from the regulation plan on the advice of its Lake Superior Board.

The outflow of Lake Superior is regulated by a number of structures in the St. Marys River at Sault Ste. Marie, Ontario and Sault Ste. Marie, Michigan, as discussed below.

Water leaving Lake Superior flows through three hydropower plants, four navigation locks, and the St. Marys River Compensating Works. The 16-gated compensating works was built near the turn of the century to offset the extra flow capacity added to the St. Marys River by the hydropower developments. This structure is located immediately upstream of Whitefish Rapids.

The IJC requires a minimum flow equivalent to one-half gate open at the compensating works in order to supply water to the main portion of the St. Marys Rapids. In addition, the most northerly gate is kept partially open to ensure a continuous supply of water to the fishery remedial channel. With these gate settings in place, changes to Lake Superior's outflow are usually made by adjusting the water flows at the hydropower plants. If the hydropower plants can not fully use their allotted shares of the water, the excess is released through the compensating works by opening additional gates.

From May to September, the owners of the compensating works carried out major repairs to the structure. The repairs by Great Lakes Power Limited to the Canadian portion of the Compensating Works, and by the U.S. Army Corps of Engineers to the U.S. portion of the structure, required dewatering of the gate areas by means of cofferdams on the upstream and downstream sides of the gates. To ensure safe access by work boats that transported work crews and equipment to the upstream side of the gates, and to prevent overtopping of the downstream temporary dykes, the gate open setting and thus the flow through the compensating works was limited. To limit flows at the structure, the Lake Superior Board made some outflow deviations from the regulation plan, as discussed below:

The Lake Superior outflows were as specified by the regulation plan in the first four months of 1996. On April 26 as soon as ice conditions at the compensating works permitted, the Board directed an increase in the gate open setting from the winter setting of 1/2 gate open to 2 gates open. The increased outflow was designed to partially offset the flow reductions during the repairs, which started in May and were completed in September.

The repair progress and experience gained during the initial stage of the repair enabled a third gate to be opened on June 24. On August 22, the gate open setting was increased to five upon completion of the repairs to the Canadian portion of the dam. Nonetheless, the Lake Superior outflows remained less than those specified by the regulation plan such that, by the end of August, about 5 cm of water was retained on Lake Superior. Also, Lakes Michigan-Huron levels were lowered by 3 cm as a result of the reductions in the inflows from Lake Superior during the same period.

On September 21, the gate open setting was increased to all 16 gates open upon completion of the U.S. repairs. This action brought the Lake Superior outflow for the month of September very close to that specified by the regulation plan. With 16 gates fully open,

along with maximum flows at the hydropower plants, flows were higher than specified by the regulation plan such that, by late November, all the 5-centimetres of water previously retained on Lake Superior were eliminated. During the last week of November, most of the gates were gradually closed in preparation for the coming winter months.

On June 18, the Lake Superior Board held a meeting with the public in Paradise, Michigan. Paradise is located in the Whitefish Bay area of Lake Superior, a short distance west of Sault Ste. Marie, Michigan. Area residents expressed concern that the high Lake Superior level was accelerating the erosion process.

4.2 Lake Ontario Regulation

The outflow of Lake Ontario is regulated using the hydropower dam and spillway in the St. Lawrence River near Cornwall, Ontario and Massena, New York. Lake Ontario Regulation Plan 1958-D specifies weekly outflows based upon the lake's levels and trends in water supplies. The regulation plan helps prevent water level extremes both upstream and downstream of the regulation structures, and it attempts to balance the interests of shoreline property owners, commercial navigation and hydropower interests.

Lake Ontario outflow regulation is overseen by the IJC's International St. Lawrence River Board of Control. In normal operations, the Lake Ontario outflow is the amount specified by the regulation plan. However, the Board has some discretionary authority to direct flow deviations from the regulation plan to meet certain objectives. These objectives include providing certain interest(s) benefits or relief from adverse impacts associated with water level and flow fluctuations, provided that such deviations would not harm other interests. In recent years, the Board has also taken into consideration the needs of the additional interests, namely recreational boating and the environment, in making its regulation decisions.

During 1996, the Board made a number of deviations in response to the changing conditions in the Lake Ontario - St. Lawrence River system. These are discussed below.

The favourable ice in the St. Lawrence River during the winter of 1995-96 posed very little restriction to flows in the river. As a result, outflows higher than those specified by the regulation plan were released in January and February as a part of normal winter operations. The overdischarges, equivalent to 3 cm lowering on Lake Ontario, were subsequently offset by flow reductions in April and May.

During the period April 23 - May 17, the Lake Ontario outflows were reduced to below those specified by the regulation plan to prevent flooding on Lake St. Louis during the Ottawa River freshet. Until the arrival of the Ottawa River freshet, water levels on Lake St. Louis and areas downstream were low, and there was a concern that the continued low levels would have an adverse impact on fish spawning in Lake St. Louis and other areas downstream. Abundant rain in late April in the Lake Ontario and Ottawa River basins eliminated the threat of low water levels on Lake St. Louis.

Flows higher than those specified by Plan 1958-D took place during June and July such that by August, nearly all previous flow deviations were eliminated.

The Lake Ontario outflows for the rest of the year were much above average. However, these high flows were a factor in lowering the water levels on Lake St. Lawrence. As a result, the Board made a number of short-term flow reductions, of limited magnitude, in order to prevent extreme low levels on Lake St. Lawrence.

For example, between August 12 and September 6, flows were slightly below plan in order to maintain adequate levels for recreational boaters on Lake St. Lawrence. Between late September and December 26 when Seaway navigation stopped, there were also a number of short-term flow reductions, primarily during periods of strong easterly winds, to prevent the Lake St. Lawrence levels from falling below chart datum, which is the minimum requirement for Seaway navigation.

Subsequent to the closing of the Seaway navigation season on December 26, the Board further increased the Lake Ontario outflows. By early January 1997, the over-discharge deviations from the regulation plan have resulted in a 27 cm lowering of Lake Ontario levels. The actual Lake Ontario level at that time was estimated to be about 67 cm lower than that which would have occurred if there were no Lake Ontario regulation.

The Lake Ontario outflows will remain above average through the winter of 1996-97. Flows are also expected to be varied due to changing ice conditions in the St. Lawrence River.

In addition to its regulation operations, the Board continued to assess two alternative regulation plans in order to examine potential improvements to Lake Ontario regulation. This 3-year assessment began in early 1994. One plan, called Plan 35-P, is a product of the IJC Levels Reference Study completed in 1993 and is a modified version of the current regulation plan. The other plan, called IS, uses an optimization technique that attempts to achieve best possible compromises among all interests. An evaluation of the two alternative regulation plans will start in early 1997 and be completed during the summer of 1997.

In 1995, the St. Lawrence Board was also requested by the IJC to prepare a scope of work of the studies that would be required to review and possibly update the Lake Ontario regulation criteria. This request was in response to the 1993 Levels Reference Study report which recommended, among other things, that new regulation criteria be added to consider the needs of the recreational boating and environmental interests. In early 1996, the Board submitted a scope of work to the IJC.

On June 3, the Board held a public meeting in Watertown, New York. At the meeting, Lake Ontario shore property owners and area elected officials expressed concern about the relatively high water levels on Lake Ontario and ongoing erosion problems. On the other hand, recreational boaters and marina operators on eastern Lake Ontario and the Thousand Islands area of the St. Lawrence River expressed a preference for higher levels.

4.3 Activities by Environment Canada

Environment Canada continued to provide technical support to the IJC's Boards in the regulation of the outflows of Lake Superior and Lake Ontario, which are discussed in earlier sections.

Environment Canada also continued to issue each month, the six-month water level forecasts for the Great Lakes and Montreal Harbour jointly with the U.S. Army Corps of Engineers. A monthly newsletter was also published to update readers on news related to water levels. The forecasts and the Levels News appear monthly in the water level bulletins distributed by Fisheries and Oceans Canada.

As in previous years, the department also issued monthly water level bulletins during the recreational boating season for Lake Ontario and locations on the St. Lawrence River as far downstream as Lake St. Louis. The bulletins were distributed to local media, shore property owners and marinas to advise citizens of water level and flow conditions in the river.

In support of the International St. Lawrence River Board of Control, a weekly distribution of the Lake Ontario and St. Lawrence River hydrologic data is also made to subscribers on an E-mail list.

Environment Canada continued to provide up-to-date water level and related information to the public through the World Wide Web. The Great Lakes Information Management Resource (GLIMR) is a catalog of available information on the Great Lakes. For those with access to the World Wide Web, GLIMR's URL is http://www.cciw.ca/glimr/intro.html.

In an effort to improve the ease with which lake-related data can be located, a page with links to many sources of data has been created on GLIMR www address. The page has links to sources of recent, historic and forecasted water levels, and it also contains links to sources of data on precipitation, wind, waves, currents, flows, water temperatures and ice cover. Also contained on the page at GLIMR are links to homepages for the International Joint Commission's International Lake Superior Board of Control and the International St. Lawrence River Board of Control. These homepages contain access to the Boards' brochures, and current water level and flow conditions.

The Cornwall and Burlington offices of Environment Canada continue to respond to requests for information related to Great Lakes levels, flows, and Lake Superior and Lake Ontario outflow regulation.

5.0 EFFECTS OF WATER LEVEL FLUCTUATIONS

5.1 Shore Properties

The high water level conditions on the Great Lakes have generated numerous concerns among shore property owners. There were also reports of some flood and erosion damage. Fortunately, the absence of major storms prevented serious damages.

On Lake Superior, concerns were expressed by Thunder Bay area residents and harbour officials during July and August. As mentioned earlier, residents in the Whitefish Bay area of the State of Michigan have also expressed concerns about the impacts of the high water levels on erosion in the area.

Several residents in the lower St. Marys River complained about high water levels and damage to boat docks in late September. This occurred when the flows in the river were increased following completion of the repairs to the Compensating Works. Erosion continued to occur along Lake Huron's shore, including a large slide in the Goderich area.

Concern amongst residents along Lake Erie's shore increased through the summer and fall as the lake's level declined at a slower than average rate. Fortunately, there were relatively few storms with high winds during the fall. The most severe storm occurred on October 30, with strong westerly winds that caused a surge of 1.4 m at the easterly end of the lake. Some flooding, erosion and wave damage to shore properties occurred during the storm. Other smaller events through the fall also caused problems for property owners.

5.2 Commercial Navigation

The above average water level conditions on the Great Lakes resulted in generally favourable conditions for shipping. Lake St. Louis and Montreal Harbour saw major improvements in levels compared to a year earlier. But there were some exceptions, as follows:

Some ships were reported to have difficulties navigating in parts of the lower St. Marys River in late September, following the increase in the Lake Superior outflows.

The ice jam in the St. Clair River in the early part of the year caused some delays in ship transit; however, no serious impacts were reported.

Of particularly concern to shipping in 1996 were conditions on Lake St. Lawrence in the St. Lawrence River. As described earlier, the very high Lake Ontario outflows, at times aided by strong easterly winds, lowered the river levels substantially. While no ship stoppages occurred, it was reported that pilots had difficulties navigating in some of the high currents.

An absence of ice on the Great Lakes and the St. Lawrence River
led to a trouble-free closing of the 1996 navigation season on the Great Lakes.

5.3 Recreational Boating

Similar to commercial navigation, recreational boaters generally enjoyed the higher than average water level conditions on the Great Lakes and the St. Lawrence River in 1996. The area of exception was also Lake St. Lawrence. There were numerous complaints from boaters in this area during July and August. The low levels prompted the International St. Lawrence River Board of Control to direct some limited flow reductions to prevent further lowering of Lake St. Lawrence's levels.

As Lake St. Lawrence levels further declined during late September and October, boat owners and marinas had extreme difficulties removing their boats from the water. During the period October 17-21, boat owners who were removing their boats had to cope with very low levels caused by strong easterly winds at that time.

5.4 Hydropower Generation

Hydro-electric facilities at Sault Ste. Marie in the St. Marys River continued to attempt to use the amounts of water specified by the regulation plan for power generation. However, repairs at times reduced the plants' capabilities to use their full share of water. The unusable amounts, however, were small and were temporarily retained on Lake Superior.

Higher-than-average flows in the Niagara River resulted in above average power production. Due to cool spring temperatures and a late breakup of ice in Lake Erie, removal of the Lake Erie ice boom was delayed. Removal began on April 19 and was completed on May 3. Inclement weather contributed to the length of time required for its removal. The installation of the boom for the 1996-97 winter season took place during December 9-11. At the end of 1996, no ice had yet formed in eastern Lake Erie.

Hydropower generation at the Moses-Saunders Generating Station near Cornwall, Ontario was well above average. There were few instances in 1996 when a very small portion of the flow was released at the Long Sault spillway. This occurred when a temporary energy surplus existed in Ontario Hydro's system and the utility could not use its full share of the water.

6.0 FORECAST OF FUTURE WATER LEVEL CONDITIONS

Water levels of the Great Lakes fluctuate according to weather conditions. Since it is not possible to accurately forecast weather conditions several months in advance, forecasts are made assuming average, wet and dry weather conditions for the next six months.

Assuming the most probable water supplies, the levels of all the Great Lakes are forecast to remain above their seasonal averages for the next six months.

If very wet conditions prevail over the next six months, with the exception of Lake Ontario, the lakes could reach within 10 cm of their record high seasonal levels by the end of June.

Even with very dry conditions for the next six months, the levels of Lakes Superior, Michigan-Huron, St. Clair and Erie would remain above their seasonal averages. Lake Ontario's levels would fall below average this spring with dry supplies. None of the lakes would approach record low levels in the next six months.

7.0 CONCLUSIONS

1. Above average precipitation on the Great Lakes basin caused the lake levels to rise above average in 1996. However, levels remained well below the previous maximums.

2. There were some reports of flood and erosion damage. The absence of major storms in 1996 kept these damage to a minimum.

3. The Lake Superior flow reductions during repairs to the St. Marys River Compensating Works resulted in 5 cm of water being temporarily retained on Lake Superior. Lakes Michigan-Huron levels were lowered by 3 cm as a result. These effects were dissipated by the end of the year.

4. Except for the ice jam in the St. Clair River in early 1996, Great Lakes ice was non-problematic in terms of water levels.

5. The high Lake Ontario outflow kept Lake Ontario levels below flood stage. However, these flows, and at times easterly winds, exacerbated the low water levels on Lake St. Lawrence, affecting recreational boating and Seaway traffic.

6. With water levels on all the lakes above average, the risk of serious flood and erosion damage remains significant for the spring of 1997.

Table 1 Comparison of 1996 Great Lakes Basin Precipitation and Long-Term Average (millimetres)

Superior Basin

	1996	Percentage of average	Average 1900-1995	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	101.8R	207	49.3	91.4 (1935)	22.5 (1961)
Feb	58.4	159	36.7	84.4 (1939)	10.6 (1993)
Mar	32.8	75	43.9	101.6 (1979)	9.6 (1910)
Apr	69.8	140	49.9	105.6 (1960)	17.4 (1949)
May	43.9	64	69.2	129.4 (1970)	21.1 (1948)
Jun	98.8	119	82.8	151.4 (1943)	22.7 (1910)
Jly	125.0	150	83.1	141.7 (1952)	27.7 (1936)
Aug	71.9	88	81.8	185.9 (1988)	26.3 (1930)
Sep	93.2	104	89.6	163.5 (1941)	32.7 (1967)
Oct	99.8	143	69.6	140.1 (1995)	15.6 (1947)
Nov	78.2	123	63.7	119.5 (1985)	11.0 (1939)
Dec	56.6	111	51.2	90.1 (1984)	9.0 (1913)
Sum	930	121	770		

Michigan-Huron Basin

	1996	Percentage of average	Average 1900-1995	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	67.3	127	52.9	91.8 (1950)	20.5 (1956)
Feb	52.3	121	43.3	86.2 (1908)	14.3 (1969)
Mar	32.0	59	54.5	116.2 (1976)	15.1 (1958)
Apr	92.5	141	65.7	125.6 (1929)	25.6 (1946)
May	64.5	85	75.6	141.6 (1983)	31.1 (1925)
Jun	101.1	128	78.8	143.8 (1969)	29.3 (1988)
Jly	90.7	119	76.1	132.2 (1952)	29.9 (1936)
Aug	42.7	54	78.7	136.1 (1972)	23.8 (1927)
Sep	110.7	126	88.0	213.3 (1986)	29.6 (1979)
Oct	77.0	106	72.3	147.4 (1954)	13.9 (1924)
Nov	54.1	77	70.6	127.9 (1985)	18.6 (1904)
Dec	88.4	151	58.4	105.7 (1971)	14.4 (1913)
Sum	870	107	810		

Erie Basin

	1996	Percentage of average	Average 1900-1995	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	64.5	104	61.9	160.5 (1950)	14.3 (1961)
Feb	39.9	76	52.3	117.1 (1990)	10.4 (1987)
Mar	55.9	80	70.1	170.6 (1913)	11.0 (1910)
Apr	125.0	157	79.6	152.1 (1961)	23.5 (1946)
May	90.9	109	83.2	175.8 (1943)	16.8 (1934)
Jun	117.9	135	87.0	167.9 (1937)	19.0 (1988)
Jly	94.0	111	84.3	190.5 (1992)	29.3 (1930)
Aug	27.4R	34	81.0	179.7 (1975)	33.1 (1969)
Sep	198.6R	250	79.4	176.0 (1926)	19.3 (1908)
Oct	77.0	110	69.8	196.2 (1954)	11.2 (1924)
Nov	70.1	97	72.3	191.8 (1985)	9.8 (1904)
Dec	78.7	118	66.2	160.0 (1990)	21.1 (1943)
Sum	1040	117	890		

Table 1 (continued)

Ontario Basin

	1996	Percentage of average	Average 1900-1995	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	85.3	126	68.0	137.2 (1978)	27.6 (1981)
Feb	46.7	78	59.9	112.5 (1971)	22.9 (1969)
Mar	45.2	67	67.3	143.4 (1936)	18.2 (1915)
Apr	112.3	153	73.3	126.6 (1929)	28.6 (1915)
May	84.3	109	77.8	144.7 (1943)	15.9 (1920)
Jun	112.3	145	77.6	159.1 (1972)	30.3 (1912)
Jly	85.3	108	79.2	159.5 (1992)	31.7 (1933)
Aug	63.5	80	79.3	142.3 (1977)	32.1 (1907)
Sep	154.9	192	80.9	159.2 (1945)	24.3 (1964)
Oct	90.4	117	77.4	211.5 (1955)	12.9 (1963)
Nov	77.0	97	79.4	168.0 (1927)	15.4 (1904)
Dec	97.5	132	73.6	139.9 (1990)	27.0 (1943)
Sum	1050	118	890		

Great Lakes Basin

	1996	Percentage of average	Average 1900-1995	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	78.5	143	54.9	100.5 (1950)	21.9 (1961)
Feb	51.6	115	44.7	80.1 (1908)	16.8 (1969)
Mar	37.1	67	55.0	110.7 (1976)	15.4 (1910)
Apr	93.0	145	64.0	106.0 (1929)	28.6 (1915)
May	65.0	87	75.0	116.1 (1983)	32.7 (1934)
Jun	104.1	129	80.7	121.1 (1968)	36.5 (1910)
Jly	99.8	126	79.3	123.7 (1992)	31.7 (1936)
Aug	51.0	64	79.9	128.1 (1977)	28.7 (1930)
Sep	122.9	142	86.4	166.2 (1986)	38.9 (1948)
Oct	85.6	119	71.8	127.0 (1954)	20.7 (1924)
Nov	65.5	94	69.9	136.7 (1985)	18.0 (1904)
Dec	79.5	134	59.3	92.5 (1983)	16.9 (1913)
Sum	930	113	820		

Source: Preliminary data provided by NOAA, Corps of Engineers compiled from stations in the U.S. and Canada
R denotes new record
Figures are in millimetres rounded to one decimal place.

Table 2 Great Lakes Water Levels in 1995 and 1996 and Their Comparison with Previous Records (Metres, IGLD-1985)

Lake Superior

	1996	1995	Average 1918-1995	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	183.34	183.33	183.35	183.70 (1986)	182.83 (1926)
Feb	183.32	183.24	183.29	183.63 (1986)	182.76 (1926)
Mar	183.30	183.19	183.26	183.61 (1986)	182.74 (1926)
Apr	183.31	183.20	183.28	183.68 (1986)	182.72 (1926)
May	183.46	183.26	183.39	183.74 (1986)	182.76 (1926)
Jun	183.59	183.31	183.47	183.76 (1986)	182.85 (1926)
Jul	183.70	183.37	183.53	183.82 (1950)	182.96 (1926)
Aug	183.78	183.40	183.56	183.86 (1952)	183.02 (1926)
Sep	183.78	183.44	183.57	183.86 (1985)	183.12 (1926)
Oct	183.71	183.49	183.54	183.91 (1985)	183.10 (1925)
Nov	183.67	183.48	183.50	183.89 (1985)	183.01 (1925)
Dec	183.63	183.41	183.43	183.81 (1985)	182.92 (1925)

Lakes Michigan-Huron

	1996	1995	Average 1918-1995	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	176.37	176.53	176.3	177.18 (1987)	175.60 (1965)
Feb	176.39	176.49	176.33	177.11 (1986)	175.59 (1964)
Mar	176.39	176.47	176.35	177.12 (1986)	175.58 (1964)
Apr	176.46	176.49	176.44	177.23 (1986)	175.61 (1964)
May	176.63	176.58	176.53	177.28 (1986)	175.74 (1964)
Jun	176.76	176.64	176.59	177.33 (1986)	175.76 (1964)
Jul	176.83	176.63	176.62	177.39 (1986)	175.78 (1964)
Aug	176.84	176.64	176.61	177.39 (1986)	175.77 (1964)
Sep	176.82	176.55	176.56	177.38 (1986)	175.76 (1964)
Oct	176.80	176.46	176.49	177.50 (1986)	175.70 (1964)
Nov	176.79	176.44	176.43	177.38 (1986)	175.65 (1964)
Dec	176.77	176.41	176.39	177.26 (1986)	175.62 (1964)

Lake St. Clair

	1996	1995	Average 1918-1995	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	174.74	175.22	174.83	175.80 (1986)	173.88 (1936)
Feb	175.01	175.09	174.77	175.80 (1986)	173.89 (1926)
Mar	175.00	175.08	174.89	175.80 (1986)	174.05 (1934)
Apr	174.85	175.19	175.05	175.82 (1986)	174.32 (1926)
May	175.31	175.26	175.13	175.83 (1986)	174.42 (1934)
Jun	175.45	175.31	175.17	175.92 (1986)	174.45 (1934)
Jul	175.50	175.34	175.19	175.93 (1986)	174.50 (1934)
Aug	175.48	175.35	175.15	175.90 (1986)	174.41 (1934)
Sep	175.47	175.22	175.09	175.84 (1986)	174.34 (1934)
Oct	175.41	175.08	175.00	175.96 (1986)	174.27 (1934)
Nov	175.36	175.05	174.92	175.82 (1986)	174.18 (1934)
Dec	175.37	175.01	174.92	175.80 (1986)	174.24 (1964)

Table 2 (Continued)

Lake Erie

	1996	1995	Average 1918-1995	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	174.04	174.24	173.98	174.86 (1987)	173.21 (1935)
Feb	174.06	174.26	173.97	174.78 (1987)	173.18 (1936)
Mar	174.15	174.29	174.05	174.88 (1986)	173.20 (1934)
Apr	174.23	174.37	174.21	174.98 (1985)	173.38 (1934)
May	174.44	174.43	174.29	174.97 (1986)	173.44 (1934)
Jun	174.58	174.46	174.32	175.04 (1986)	173.45 (1934)
Jul	174.62	174.43	174.31	175.03 (1986)	173.45 (1934)
Aug	174.57	174.41	174.24	174.94 (1986)	173.43 (1934)
Sep	174.52	174.25	174.16	174.83 (1986)	173.38 (1934)
Oct	174.48	174.16	174.06	174.94 (1986)	173.30 (1934)
Nov	174.42	174.10	173.99	174.85 (1986)	173.20 (1934)
Dec	174.47	174.08	173.98	174.90 (1986)	173.19 (1934)

Lake Ontario

	1996	1995	Average 1918-1995	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	74.62	74.54	74.55	75.16 (1946)	73.81 (1935)
Feb	74.75	74.72	74.58	75.27 (1952)	73.78 (1936)
Mar	74.77	74.72	74.66	75.37 (1952)	73.94 (1935)
Apr	74.82	74.70	74.87	75.65 (1973)	74.03 (1935)
May	75.13	74.80	75.00	75.73 (1973)	74.11 (1935)
Jun	75.23	74.90	75.03	75.76 (1952)	74.19 (1935)
Jul	75.15	74.91	74.98	75.66 (1947)	74.14 (1934)
Aug	74.99	74.88	74.87	75.58 (1947)	74.00 (1934)
Sep	74.83	74.70	74.74	75.41 (1947)	73.91 (1934)
Oct	74.74	74.65	74.61	75.22 (1945)	73.82 (1934)
Nov	74.72	74.70	74.54	75.18 (1945)	73.75 (1934)
Dec	74.73	74.65	74.52	75.20 (1945)	73.74 (1934)

Lake St. Lawrence

	1996	1995	Average 1960-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	72.81	73.28	72.84	73.62 (1967)	71.78 (1977)
Feb	72.47	73.12	72.39	73.32 (1983)	71.38 (1978)
Mar	72.96	72.95	72.75	73.42 (1966)	71.58 (1993)
Apr	73.38	73.35	73.53	73.94 (1962)	73.16 (1972)
May	73.69	73.75	73.65	74.00 (1973)	73.02 (1987)
Jun	73.53	73.72	73.60	73.96 (1966)	72.98 (1987)
Jul	73.35	73.74	73.52	73.92 (1967)	72.84 (1987)
Aug	73.04	73.52	73.37	73.90 (1967)	72.78 (1987)
Sep	72.90	73.33	73.20	73.90 (1967)	72.74 (1985)
Oct	72.75	73.33	73.11	73.78 (1962)	72.62 (1973)
Nov	72.65	73.08	73.03	73.72 (1972)	72.64 (1985)
Dec	72.57	73.18	73.09	73.66 (1966)	72.54 (1981)

Table 2 (Continued)

Lake St. Louis

	1996	1995	Average 1915-1995	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	21.46	21.27	21.19	21.61 (1952)	20.39 (1934)
Feb	21.55	21.26	21.16	21.97 (1978)	20.33 (1936)
Mar	21.41	21.52	21.17	22.12 (1973)	20.35 (1965)
Apr	21.58	21.10	21.59	22.45 (1951)	20.54 (1965)
May	21.99	20.98	21.58	22.55 (1974)	20.51 (1964)
Jun	21.62	21.06	21.32	22.46 (1947)	20.39 (1965)
Jul	21.58	20.82	21.15	22.01 (1973)	20.44 (1965)
Aug	21.49	20.92	21.02	21.81 (1972)	20.19 (1934)
Sep	21.29	20.84	20.94	21.74 (1986)	20.12 (1934)
Oct	21.37	20.97	20.94	21.81 (1986)	20.11 (1934)
Nov	21.61	21.37	20.97	21.86 (1986)	20.07 (1934)
Dec	21.68	21.43	21.06	21.80 (1986)	20.32 (1935)

Montreal Harbour

	1996	1995	Average 1967-1995	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6.70	6.63	6.91	8.96 (1968)	6.18 (1992)
Feb	6.95	6.64	7.11	9.04 (1967)	6.34 (1989)
Mar	6.70	7.10	7.11	8.36 (1973)	6.13 (1989)
Apr	7.07	6.23R	7.60	8.82 (1976)	6.23 (1995)
May	7.76	6.13R	7.37	8.93 (1974)	6.13 (1995)
Jun	6.82	6.14	6.82	8.12 (1974)	5.93 (1988)
Jul	6.89	5.66R	6.56	7.49 (1973)	5.66 (1988)
Aug	6.63	5.84R	6.46	7.27 (1972)	5.84 (1995)
Sep	6.32	5.64R	6.39	7.08 (1986)	5.64 (1995)
Oct	6.40	5.83	6.46	7.16 (1986)	5.82 (1991)
Nov	6.80	6.58	6.61	7.31 (1967)	5.64 (1991)
Dec	7.00	6.56	6.66	7.24 (1972)	5.87 (1978)

Table 3 Outflows from the Great Lakes in 1995 and 1996
(cubic metres per second)

Lake Superior

	1996	1995	Average 1900-1993	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	2050	2160	1950	2630 (1971)	1250 (1922)
Feb	2000	2030	1910	2610 (1969)	1270 (1922)
Mar	2000	1730	1880	2690 (1969)	1290 (1982)
Apr	1970	1810	1950	2940 (1951)	1300 (1922)
May	2280	1950	2120	3450 (1951)	1250 (1931)
Jun	2460	1850	2200	3480 (1951)	1220 (1922)
Jul	2600	1700	2280	3570 (1938)	1270 (1922)
Aug	2680	1990	2370	3600 (1950)	1270 (1926)
Sep	3150	1730	2360	3570 (1950)	1160 (1955)
Oct	3570R	1960	2300	3510 (1968)	1250 (1926)
Nov	3140	2260	2260	3750 (1985)	1250 (1981)
Dec	2380	2050	2070	3170 (1950)	1310 (1981)
Annual	2520	1940	2140		

Lakes Michigan-Huron

	1996	1995	Average 1900-1993	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	3970	5320	4500	6060 (1987)	3060 (1934)
Feb	4770	4780	4370	5720 (1974)	3000 (1942)
Mar	4900	4940	4820	5830 (1986)	3510 (1931)
Apr	4360	5250	5140	6260 (1986)	3600 (1901)
May	5500	5390	5360	6370 (1986)	4390 (1964)
Jun	5510	5460	5460	6430 (1985)	4420 (1964)
Jly	5740	5370	5520	6570 (1974)	4500 (1964)
Aug	5740	5320	5520	6630 (1986)	4530 (1964)
Sep	5680	5410	5480	6600 (1986)	4470 (1933)
Oct	5660	5230	5430	6740 (1986)	4420 (1933)
Nov	5780	5330	5370	6650 (1986)	4390 (1934)
Dec	5730	5060	5190	6230 (1986)	3990 (1935)
Annual	5280	5240	5180		

Table 3 (Continued)

Lake Erie

	1996	1995	Average 1900-1993	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	5720	6490	5600	7420 (1987)	4050 (1936)
Feb	5750	6090	5480	7050 (1987)	3340 (1936)
Mar	5940	6210	5640	7480 (1986)	4110 (1934)
Apr	6000	6390	5920	7700 (1974)	4390 (1935)
May	6520	6540	6210	7760 (1974)	4590 (1934)
Jun	6640	6200	6240	7820 (1986)	4560 (1934)
Jly	6560	6340	6120	7670 (1986)	4450 (1934)
Aug	6500	6130	6020	7420 (1986)	4470 (1934)
Sep	6670	5800	5910	7140 (1986)	4450 (1934)
Oct	6590	5940	5810	7450 (1986)	4420 (1934)
Nov	6810	6160	5810	7280 (1986)	4280 (1934)
Dec	6850	6010	5800	7620 (1985)	4330 (1934)
Annual	6380	6190	5880		

Lake Ontario

	1996	1995	Average 1900-1993	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6510	6520	6290	8470 (1987)	4700 (1935)
Feb	7270	6740	6350	8160 (1986)	4360 (1936)
Mar	7550	7480	6650	8890 (1991)	5010 (1935)
Apr	7390	7160	7080	9200 (1973)	5070 (1964)
May	7740	6460	7330	10100 (1993)	4980 (1965)
Jun	8340	6640	7430	10010 (1993)	5350 (1965)
Jly	8460	6660	7370	9910 (1976)	5520 (1934)
Aug	8340	6920	7210	9340 (1974)	5300 (1934)
Sep	7960	6890	7020	9230 (1986)	5100 (1934)
Oct	8100	6880	6840	9170 (1986)	4960 (1934)
Nov	8350	7560	6720	9570 (1986)	4810 (1934)
Dec	8580	7180	6600	9260 (1986)	4810 (1934)
Annual	7880	6920	6910		

Source: Environment Canada, Ontario Region

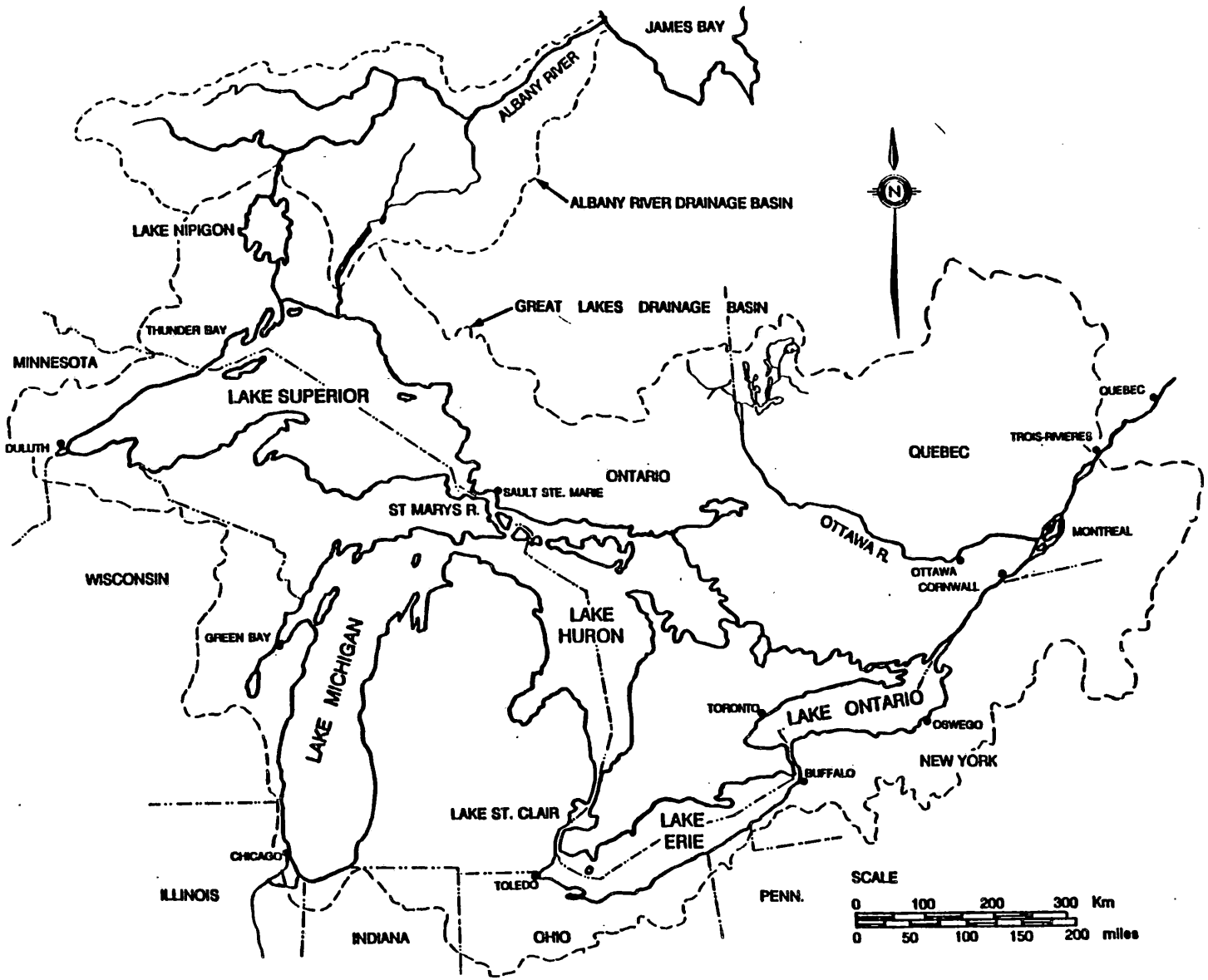

FIGURE 1. **Great Lakes-St. Lawrence River Basin**

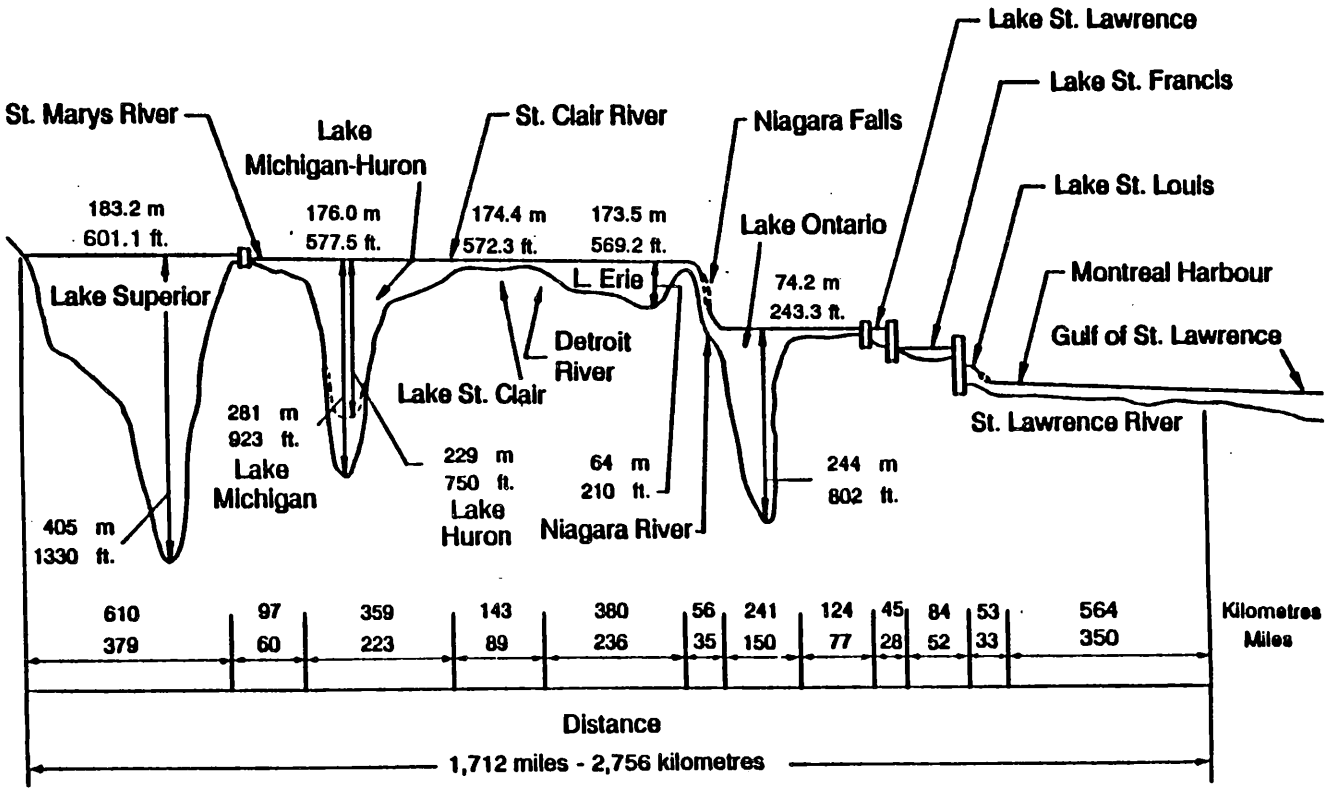

FIGURE 2. **Profile of Great Lakes-St. Lawrence River System**

Figure 3 Lake Superior Levels, IGLD 1985

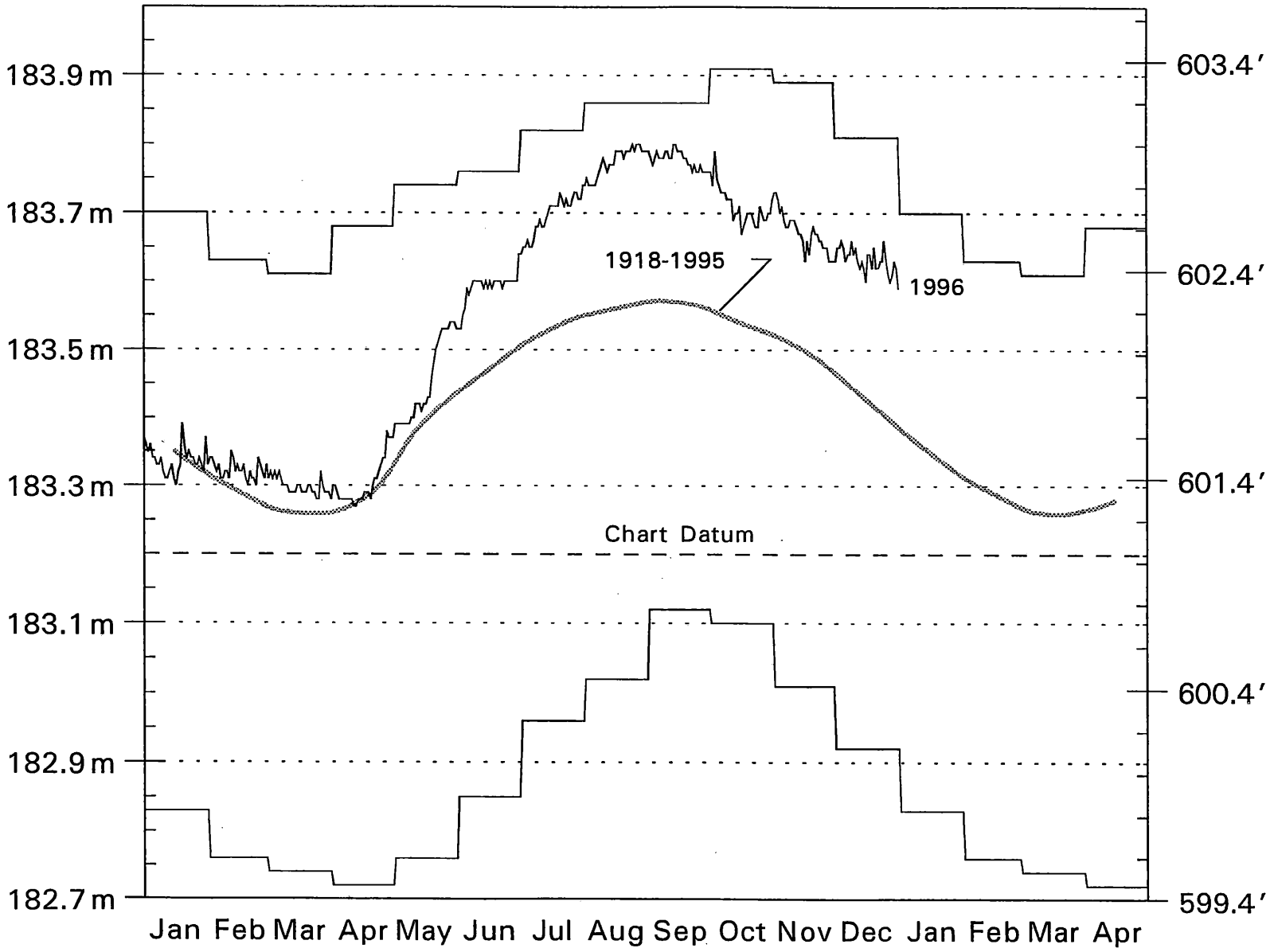

Figure 4 Lakes Michigan-Huron Levels, IGLD 1985

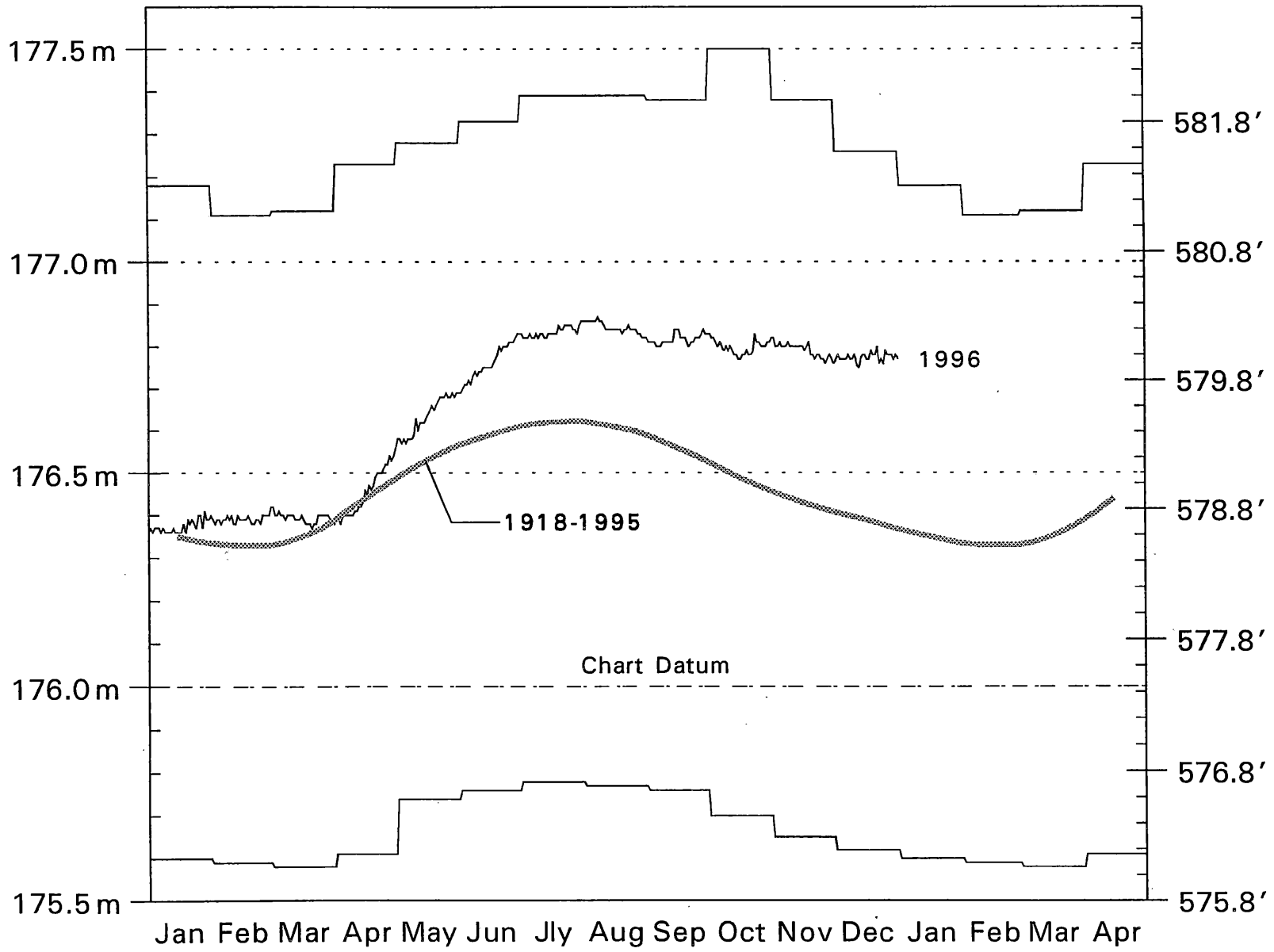

Figure 5 Lake St. Clair Levels, IGLD 1985

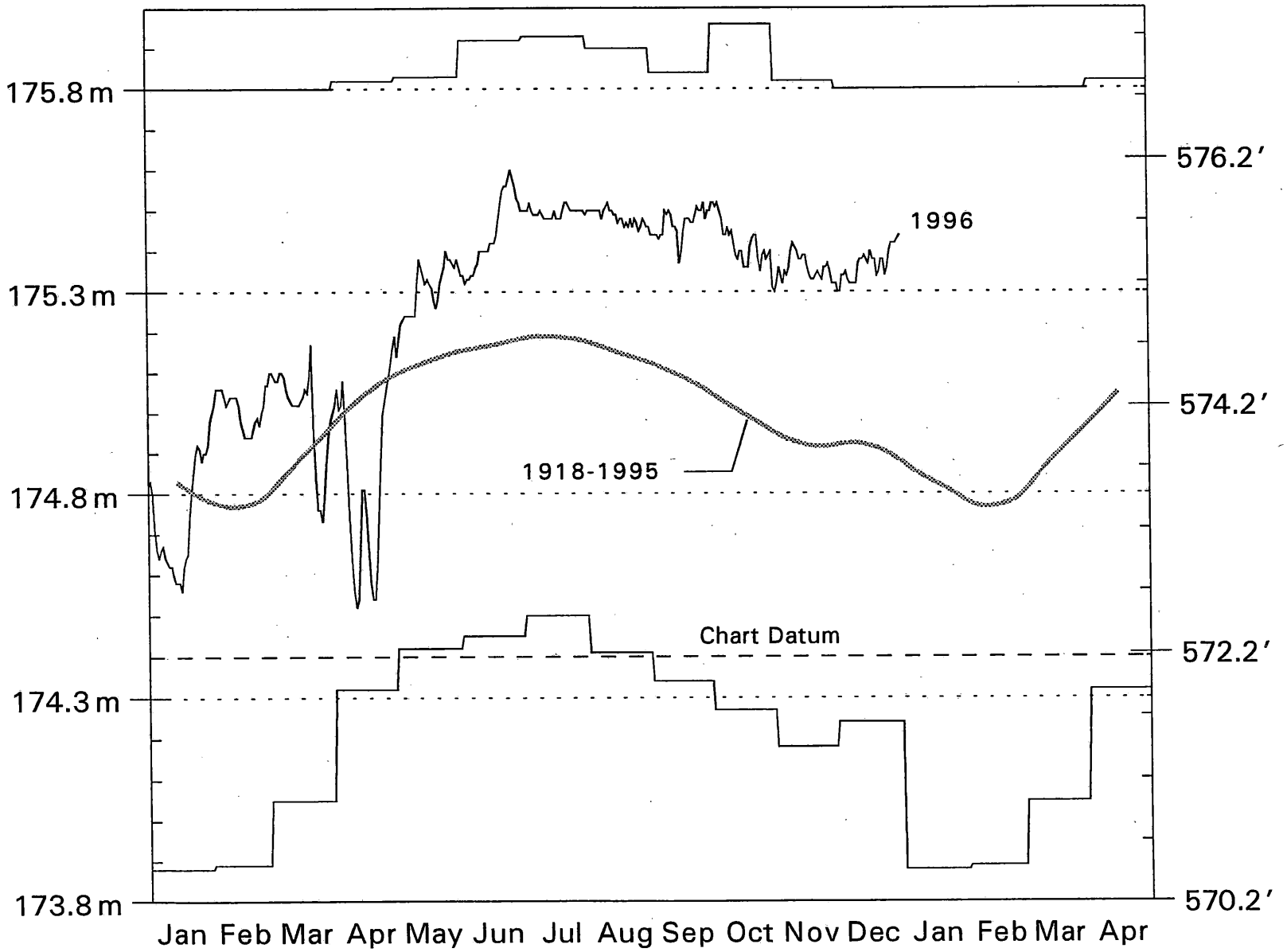

Figure 6 Lake Erie Levels, IGLD 1985

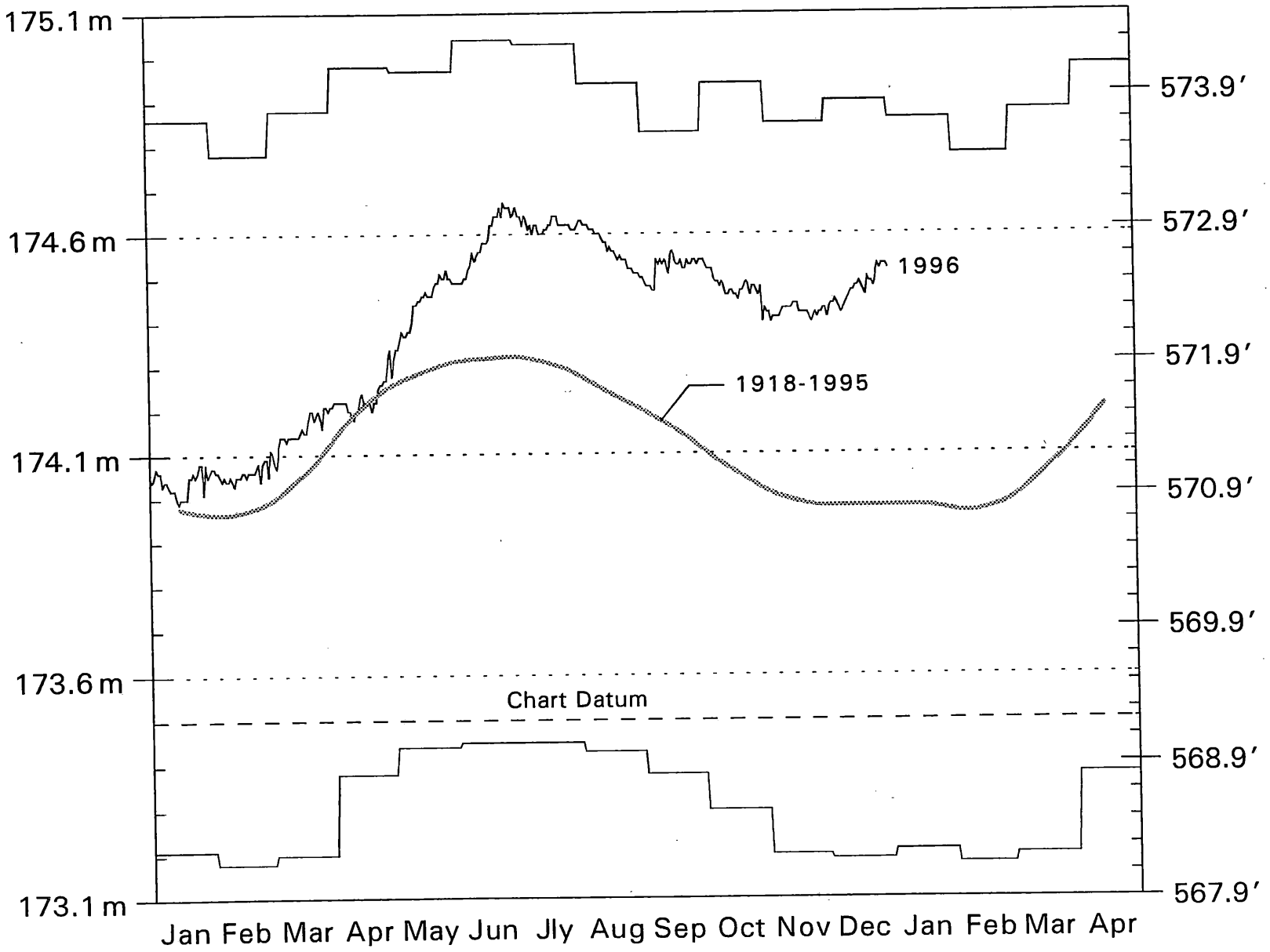

Figure 7 Lake Ontario Levels, IGLD 1985

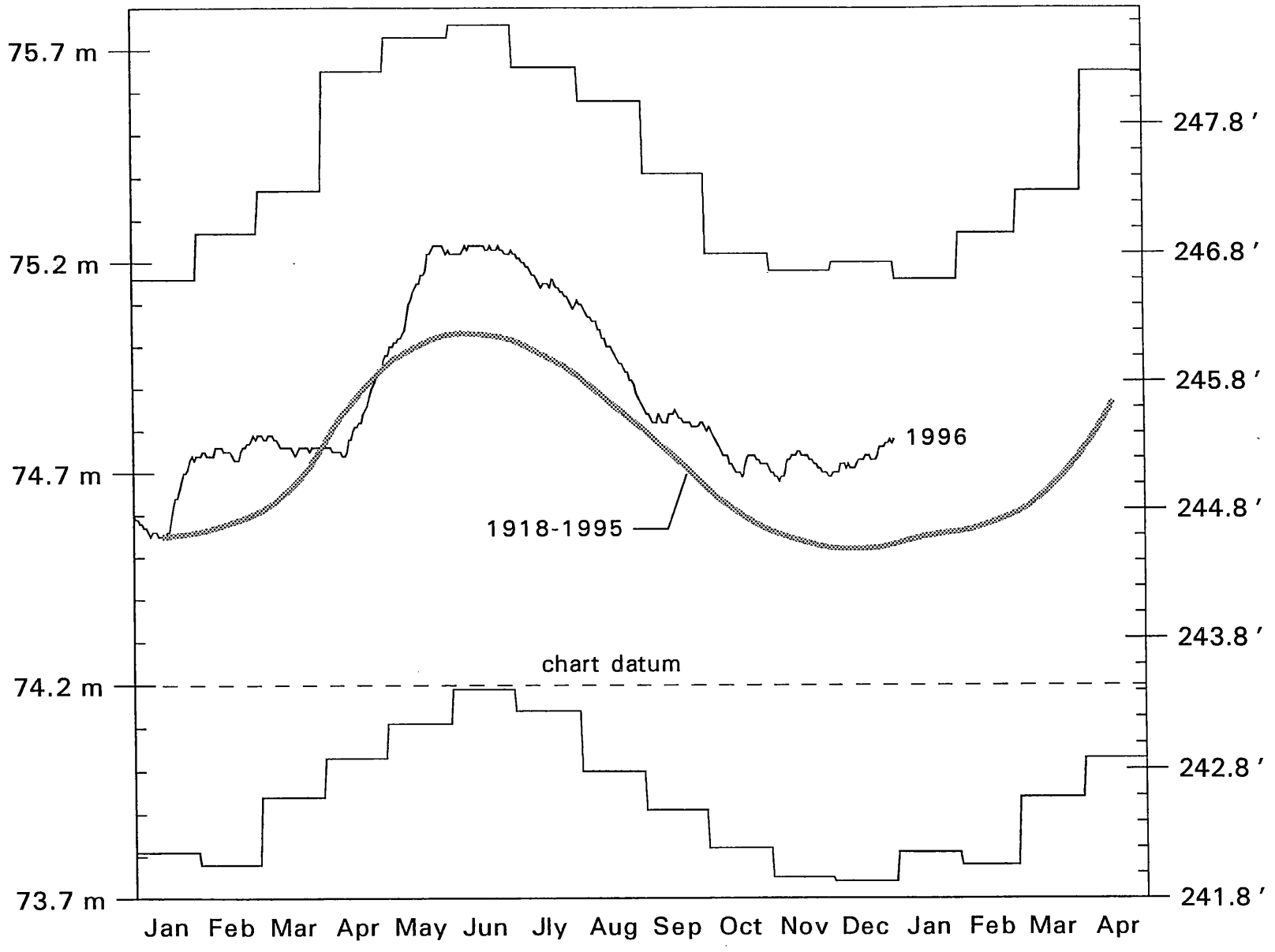

Figure 8 Lake St. Lawrence Levels, IGLD 85

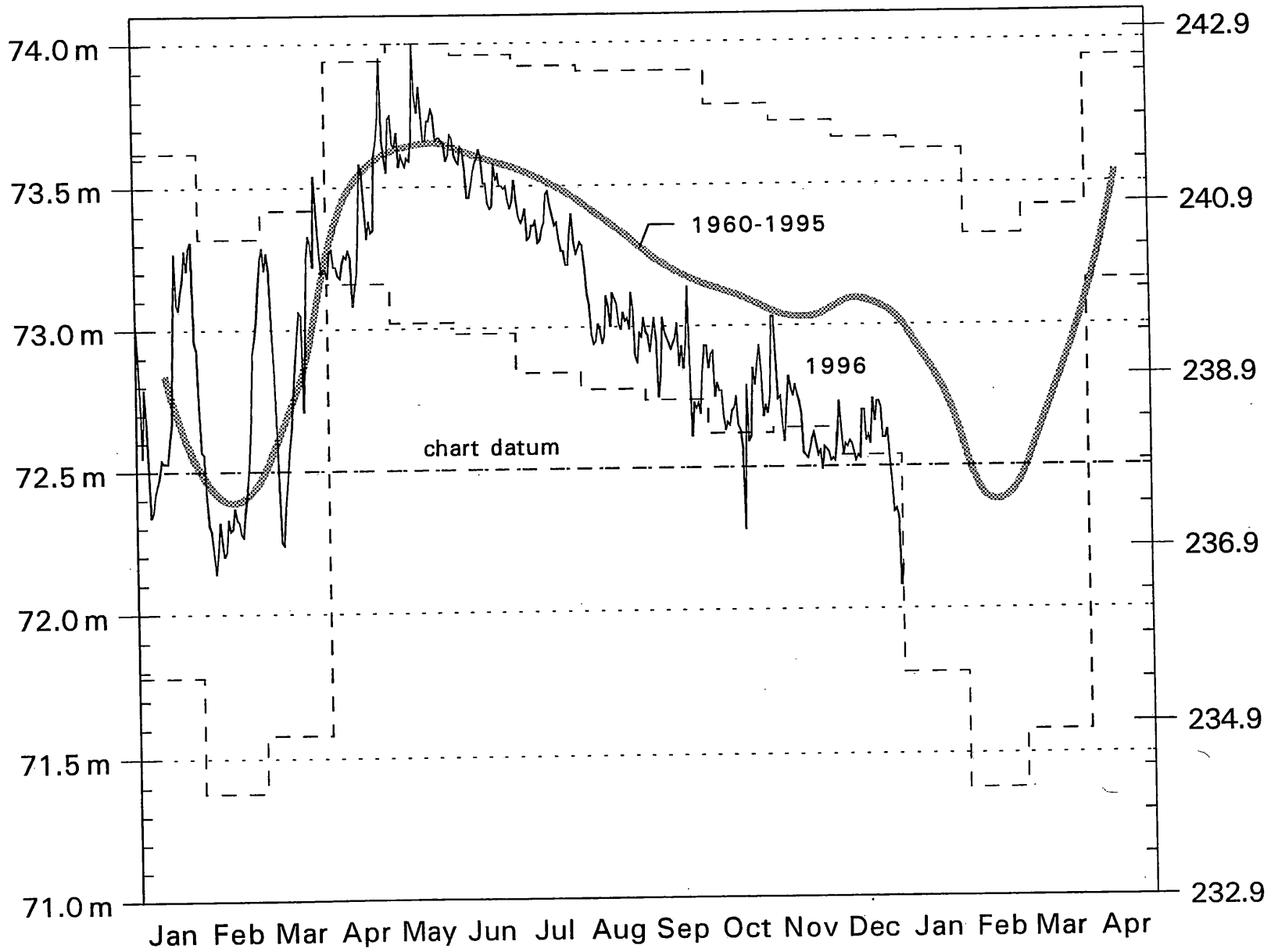

Figure 9 Lake St. Louis Levels, IGLD 1985

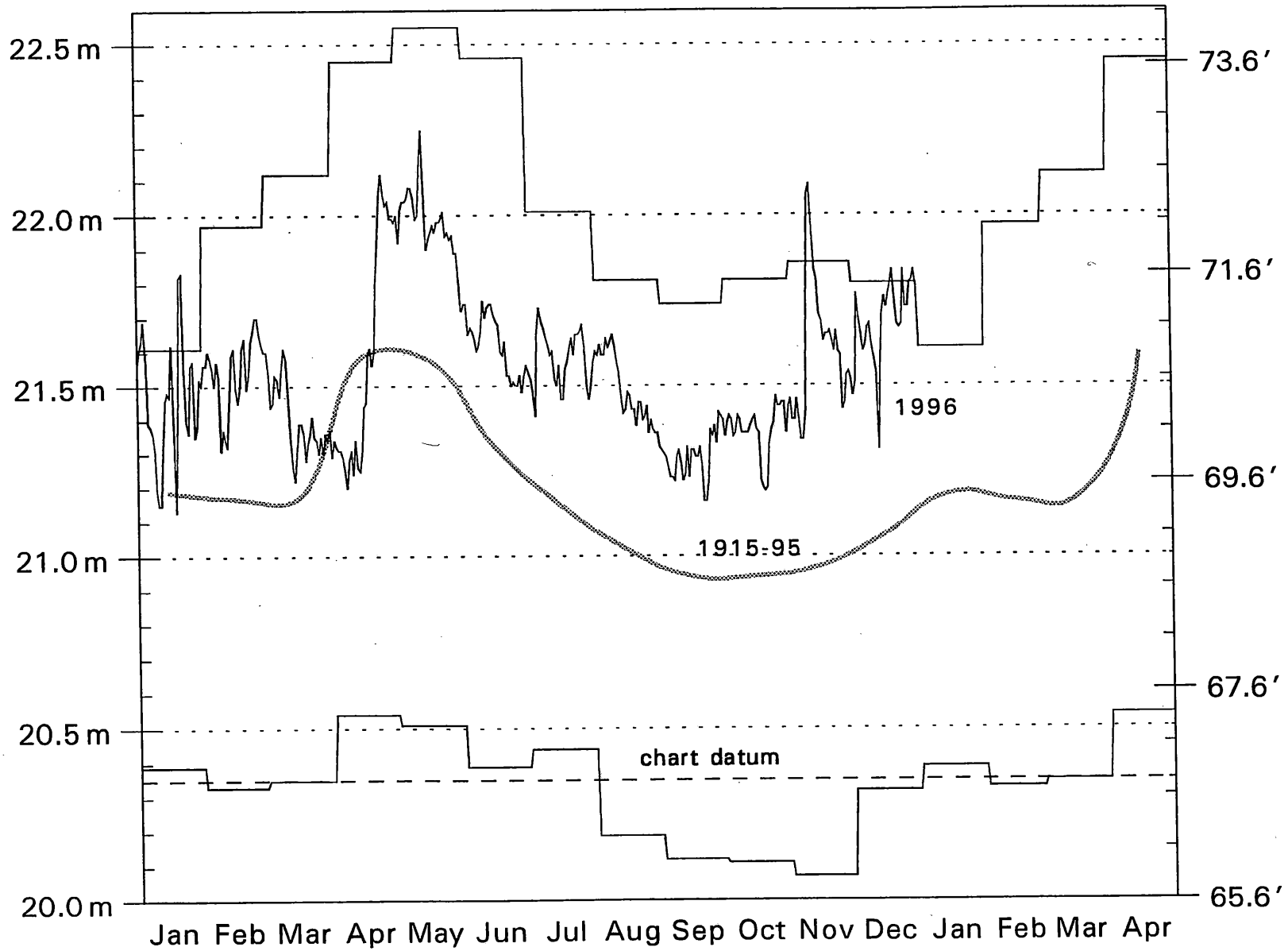
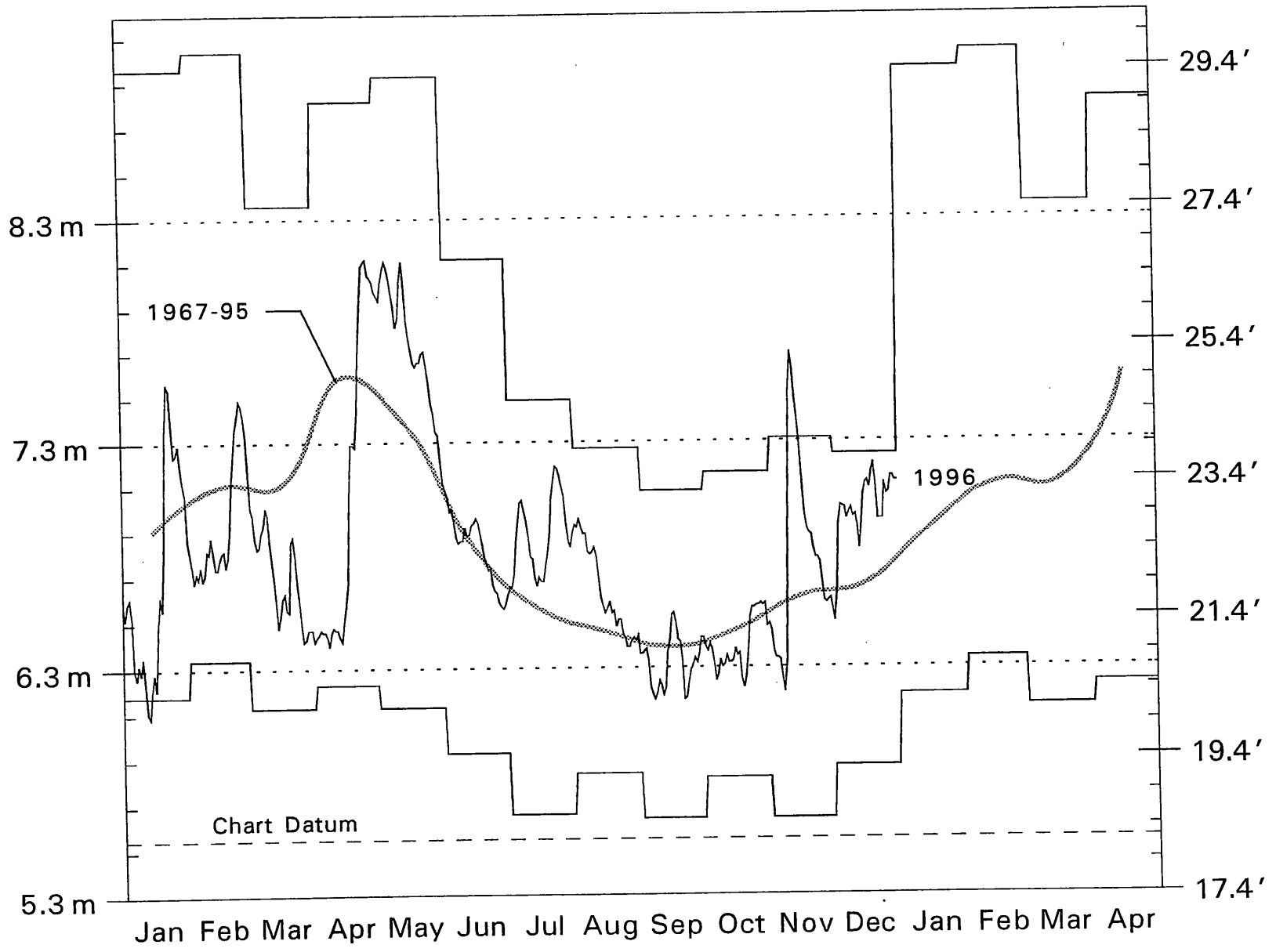
Figure 10 Montreal Harbour Levels, IGLD 1985