A REPORT ON 1997 WATER LEVELS OF THE GREAT LAKES AND THE ST. LAWRENCE RIVER

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SUMMARY

The water levels of the Great Lakes were well above average in 1997. While there were reports of localized shoreline flooding, erosion and structural damage, the absence of severe storms kept the damages low.

Water levels declined fairly rapidly on Lakes Superior and Ontario during the second half of the year and by the end of the year, they were close to seasonal average. Lakes Michigan-Huron, St. Clair and Erie remained high throughout the year and pose a continuing although potentially reduced risk of flood and erosion damage for 1998.

On Lake Superior, a relative dry summer and fall on the watershed was the factor for the accelerated decline in the water level. Very high Lake Ontario outflow, on the other hand, was the main factor in reducing that lake's peak level, and bringing the lake close to average by year end.

Very high Lake Ontario outflows in 1997 caused extremely low water levels on Lake St. Lawrence, that part of the St. Lawrence River above the hydropower dam at Cornwall. The lowering impacts were severe in the summer and fall months, and adversely affected recreational boaters and seaway navigation.

Further downstream, the water levels on Lake St. Louis were above average throughout 1997, due to high flows from Lake Ontario. Lake St. Louis levels were very high in April and May during the time of the Ottawa River freshet, which is typical for that time of the year. However, no serious flooding was reported.

Montreal Harbour levels were also higher than average during the Ottawa River freshet but remained below flood stage, and remained close to the post-1967 average for much of the rest of the year.

Postscript: Subsequent to the preparation of this report, the Lake Ontario water level rose significantly during the ice storm which occurred on January 5-9, 1998. By mid January, the level of Lake Ontario was about 27 cm higher than average and thus poses a risk of flood and erosion damage on Lake Ontario in the spring.

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1.0 INTRODUCTION

This report describes the water level fluctuations in the Great Lakes - St. Lawrence River system in 1997. 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 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. Ice jams in the St. Clair - Detroit River system, though infrequent, can cause large variations in the water level of Lake St. Clair.

Water level fluctuations on Lake Ontario do not affect the levels of Lake Erie, as the two lakes are separated by 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. The hydropower dam at Cornwall, located about 160 kilometres downstream of Lake Ontario, is used to regulation Lake Ontario's outflow. Several factors affect the water level fluctuations on Lake St. Lawrence. 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 on Lake St. Francis.

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. Winds and tides also affect levels in the harbour.

3. HYDROLOGIC CONDITIONS IN 1997

3.1 Weather Conditions

The winter of 1996-97 can be considered near normal, in terms of temperatures and precipitation. While no serious ice jams occurred in the St. Clair - Detroit River system this past winter, a severe ice build-up in the Maid-of-the-Mist Pool in the Niagara River caused some damage to shore structures. In the St. Marys River, ice remained until about mid-May, which is considered normal. In the St. Lawrence River between Lake Ontario and Montreal, ice remained until the end of March but posed no serious difficulties to either the opening of seaway navigation or Lake Ontario regulation.

Spring seemed to come to the Great Lakes basin a bit later than usual. Occasionally, very warm and humid weather occurred in the summer, mainly in July. August and September air temperatures tended to be on the milder side. The weather in the fall months was dry, but with no large departures from the normal temperatures. November temperatures across the basin were a bit lower than normal. December was unseasonably mild with some short cold spells. The effect of the El Nino, more apparent on the prairie provinces and west of Lake Superior, is thought to have also brought some short-term unseasonably mild temperatures to the Great Lakes basin in December. Precipitation in December was below average.

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 the 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 1997 monthly precipitation with long-term averages since 1900. The total basin-wide figure for 1997 was about 800 mm, or slightly below average. It should be noted that the high precipitation in 1996 (which ranks fifth highest since 1900) brought about the high water levels which extended into the year 1997. The Great Lakes basin monthly precipitation for 1996 and 1997 are shown in Figure 3.

Basin-by-basin, Lake Superior received 670 mm of precipitation which was 87% of average. February, April and December had well below average precipitation while March, June and October had above average precipitation.

The Lakes Michigan-Huron basin precipitation was 98% of average for 1997. January, February and August had higher than average precipitation while the other months were dry.

Precipitation on the Lake Erie and Lake Ontario basins were 108% and 97% of average, respectively. Due to the close proximity of each other, the Lake Erie and Lake Ontario basin precipitation exhibit a very similar pattern, except in May when the Lake Erie basin had well above average precipitation compared to the below average value for the Lake Ontario basin.

3.3 Water Levels and Outflows

Table 2 lists the water levels for the Great Lakes and the St. Lawrence River in 1997. The tables also show how they compare with historical data. The information is also shown graphically in Figures 4 to 11.

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.

All the lakes started the year higher than average, a condition that originated a year earlier due to well above average precipitation in 1996.

Lake Superior (Figure 4) started the year 20 cm higher than average. The level declined as usual during the January to March period, after which it began to rise. The level peaked at 183.75 m in early July, about a month or more earlier than usual at a level about 25 cm higher than average. Due to drier conditions on the basin, the level then declined at a faster rate than usual through the balance of the year. At the end of December, Lake Superior was 5 cm above average.

The water levels on Lakes Michigan-Huron (Figure 5) remained generally one-half metre above average throughout 1997. The level rose slowly from January until it peaked at 177.20 m in mid July, about 57 cm higher than average. The subsequent decline in the levels was initially slow in August and September, but more quickly during the fall months in response to the dry conditions and reduced Lake Superior outflows. At the end of December, Lakes Michigan-Huron levels were about 40 cm higher than average.

The Lake St. Clair levels (Figure 6) in 1997 followed a similar pattern as those of Lakes Michigan-Huron. Movements of ice in the St. Clair River caused some rapid fluctuations in the levels of Lake St. Clair in January. However, these fluctuations were small when compared with those one year earlier.

Lake Erie receives a very large portion of its water supplies from Lakes Michigan-Huron. With the upper lakes in 1997 being much higher than normal, Lake Erie was, as expected, also very high (Figure 7). Lake Erie peaked at 175.06 m in early June, 74 cm higher than average. The June monthly mean level of 175.02 m was 2 cm below the maximum that occurred in June 1986. A steady decline in the levels starting in July brought the lake to 50 cm above average by the end of the year.

The Lake Ontario level (Figure 8) was above average during much of 1997. However, in spite of the near record high water supplies, mainly from the upper lakes, Lake Ontario's levels were not extremely high. As discussed later in the report, very high Lake Ontario outflows acted to lower this year's peak level, as well as to accelerate the decline in lake levels during the second half of the year. The lake was generally 30 cm above average during the first half of the year, but a faster than usual decline starting in July brought the lake to 5 cm above average by the end of the year.

Lake St. Lawrence is that part of the St. Lawrence River extending from about the Iroquois Dam at Iroquois, Ontario, to the Moses-Saunders hydropower dam at Cornwall. The hydropower dam is used to regulate the Lake Ontario outflows, and Lake St. Lawrence, being immediate upstream of this control point, is directly affected by flow variations at the dam. High flows at the dam lower Lake St. Lawrence levels, and low flows have the opposite effect. As flows in 1997 were consistently well above average, Lake St. Lawrence levels were consistently well below average (see Figure 9), by as much as one-half metre. Between August and November, levels were near record lows (records started in 1960 when Lake Ontario regulation began). The very low water levels in February and March were caused by a combination of high Lake Ontario outflows, and the retarding effects of the river ice between the power dam and Lake Ontario.

Except for a very brief period in January when its levels were near average, Lake St. Louis (Figure 10) was above average in 1997. The high flows from Lake Ontario were the main factor causing these above average water levels on Lake St. Louis. During the Ottawa River freshet in April and May, the International St. Lawrence River Board of Control reduced the Lake Ontario outflows to prevent levels exceeding flood stage on Lake St. Louis.

During 1997, levels at the Port of Montreal (Figure 11) were close to the post-1967 seasonal average. The exception was in the March to May period, when higher levels occurred due to the high inflows from the Ottawa River.

Table 3 lists the 1997 monthly outflows from each of the Great Lakes. The Lake Superior outflows for the year averaged 2420 m^3/s, 13% above average. The higher than average outflows earlier in the year reflected the high water level conditions on the lake.

Lakes Michigan-Huron and Lake Erie outflows for the year were well above average. The Lake Ontario outflows in February and March were record maximums for the months.

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 and overseeing outflow regulation are the responsibilities 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 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 early in 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 northern half of the structure with eight gates is owned and operated by Great Lakes Power Limited in Canada. The other half with the remaining eight gates is owned by the U.S. Army Corps of Engineers.

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 the minimum one-half gate open setting in place, changes to Lake Superior's outflow are usually accomplished by adjusting the water diversions through the hydropower plants. If the hydropower plants can not fully use the available water, the excess is released through the compensating works by opening additional gates.

From May to October 1997, the U.S. Army Corps of Engineers carried out major repairs to two gates at the compensating works. The repair 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 crews and to prevent overtopping of the downstream temporary dykes, the gate open setting and the flow through the compensating works was limited. To minimize the impact of this work on lake levels, the Lake Superior Board made some outflow deviations from the regulation plan, as discussed below:

The Lake Superior outflows in the first three months of 1997 were as specified by the regulation plan. Towards the end of April, 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 3 gates open. The increased outflow was designed to partially offset the flow reductions during the repairs. In May, June and July, the outflows were slightly less than the amounts specified by the regulation plan. Beginning in August, sufficient gates were available to pass the flow specified by Regulation Plan 1977-A. The flow deviations from the regulation plan due to the repairs have been minimal. The maximum cumulative impact of the flow deviations due to the repair work was a 2 cm rise on Lake Superior, and a 1 cm lowering on Lakes Michigan-Huron. These impacts were dissipated by the end of September.

On June 17, the Lake Superior Board held a meeting with the public in Thunder Bay, Ontario, and toured the Thunder Bay areas that were affected by high water levels.

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 on Lake Ontario, and downstream in the Montreal area, 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 some benefit or relief from adverse impacts associated with water level and flow fluctuations. In recent years, the Board has also taken into consideration the developing recreational boating and the environmental interests, in making its regulation decisions.

In 1997, Lake Ontario received extremely high water supplies. To deal with these supplies and to lower the water levels of Lake Ontario, the IJC invoked Criterion k of its Orders of Approval from January 17 to August 15. This emergency measure required that the Lake Ontario outflows be regulated in order to provide relief to riparians both upstream on Lake Ontario and downstream in the St. Lawrence River. As well, flows were reduced when necessary, such as during the Ottawa River freshet, to avoid flooding downstream on Lake St. Louis and at Montreal Harbour. Therefore, during the period Criterion k was in place, the Lake Ontario outflows were maintained at the maximum possible taking into consideration the water level and ice conditions in the St. Lawrence River. During the summer and fall months, water levels and velocities on Lake St. Lawrence were also taken into consideration in determining maximum possible outflows without halting seaway navigation. A brief description of Lake Ontario outflow regulation in 1997 is described below:

Very high Lake Ontario outflows more than specified by the regulation plan and equalling the capacities of hydro facilities were maintained in early January. Between January 8 and 31, the flow was reduced to help formation of stable ice covers, first in the Beauharnois Canal (near Montreal) and later in the river upstream of Cornwall. The very good ice covers then enabled record maximum Lake Ontario outflows to be released in February and March. In April and May during the Ottawa River freshet, the outflow was reduced to prevent flooding on Lake St. Louis. Subsequent to the Ottawa River freshet, the Board resumed the strategy of maximizing outflows.

The Lake Ontario's daily levels peaked at 75.37 m in May, 53 cm lower than the peak level that would have occurred assuming strict adherence to the regulating plan. The actual peak level was 61 cm lower than the pre-project level, that is, the level that would have occurred had there been no regulation.

While very high outflows were beneficial to Lake Ontario, in terms of shoreline flood reduction, they caused extremely low water level conditions on Lake St. Lawrence. Between June and December, levels on Lake St. Lawrence were generally 40~50 cm below average. The lows levels affected recreational boating on Lake St. Lawrence, and made many docks, commercial and private, unusable. To provide a measure of relief from the low levels, the Board reduced slightly the Lake Ontario outflows for about five weeks beginning on August 16. For two weekends in October, the Board also reduced slightly the outflows to raise the levels on Lake St. Lawrence to assist in boat haul-outs at marinas. However, the extent of the relief was very limited, based on feedback from marina operators.

For the rest of the year, maximum allowable outflows specified by the regulation plan were released. The maximum allowable outflow defines the maximum flow possible without causing excessive water flow velocities or extremely low water levels which would cause seaway stoppage. On occasions, short-term flow reductions were necessary to prevent levels on Lake St. Lawrence at Long Sault from falling below the chart datum elevation of 72.5 m, considered by the seaway as the minimum for navigation.

On December 26, the last vessel cleared the St. Lambert Lock, marking the end of the 1997 seaway season. Subsequently, the Board increased the Lake Ontario outflow until ice formation began in the river.

The Board continued to assess alternative regulation plans. At the request of the IJC, the Board held a series of six public meetings in the Lake Ontario - St. Lawrence basin to solicit input from the public on a new regulation plan. Reactions to the proposed new regulation plan were mixed. It is expected that the IJC will make a decision regarding the new regulation plan in early 1998.

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, as discussed previously.

Environment Canada also continues to issue each month, a six-month water level forecast for the Great Lakes and Montreal Harbour as a joint undertaking with the U.S. Army Corps of Engineers. A monthly newsletter is also published to update readers on water levels. The forecasts and the newsletters appear monthly in the water level bulletins distributed by Fisheries and Oceans Canada on the Internet.

The department also issues monthly water level bulletins during the recreational boating season for locations on the St. Lawrence River as far downstream as Lake St. Louis. The bulletin is 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 Lake Ontario and St. Lawrence River hydrologic data is made to subscribers on an E-mail list.

Environment Canada continues 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 catalogue of available information on the Great Lakes. GLIMR's URL is http://www.cciw.ca/glimr/intro.html. 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 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 provide access to the Boards' brochures, and current water level and flow data.

In anticipation of very high water levels and the potential for severe flood and storm damage, Environment Canada undertook a number of initiatives early in 1997. A meeting of federal and provincial agencies was called in February to ensure that agencies were aware of the situation and to plan joint actions. Environment Canada worked with Emergency Measures Ontario and the Ministry of Natural Resources to communicate with media and municipalities regarding the water level situation and risks, through a news release and two workshops. Media advisories on water levels were issued on a regular basis. Environment Canada also worked with the St. Lawrence Seaway Authority and Ontario Hydro to maximize flows from Lake Erie through the Welland Canal and DeCew Falls generating station. The Welland Canal connects Lake Erie with Lake Ontario, and supplies water to the DeCew power plant.

Enhancements to the SURGE model, which is used to forecast wind-induced fluctuations in lake levels, are underway and should be completed by spring 1998. This will permit access to the model through the Internet.

5.0 EFFECTS OF WATER LEVEL FLUCTUATIONS

5.1 Shore Properties

There were no reports of widespread flood and erosion damage on the shores of the Great Lakes in 1997. But some shoreline flood and erosion damage did occur at a number of locations on the lakes and in the St. Lawrence River, with varying severity. Appendix A contains information on damage information provided by the conservation authorities in Ontario. The severity of damage is related closely to the types of shoreline and their exposure to wind and wave effects, degree of development, setbacks and floodproofing. Communities on Lakes Huron, St. Clair and Erie suffered more damage than those on either Lake Superior or Lake Ontario, owing to water levels being well above average on these middle lakes.

5.2 Commercial Navigation

The opening of the 1997 seaway navigation season took place as scheduled on April 2. An absence of ice in the interconnecting channels and the Welland Canal helped make the opening problem free. However, a small amount of ice was still present in the Beauharnois Canal and caused some inconvenience for a few days for ships that transited the canal.

The above average water level conditions on the Great Lakes resulted in generally favourable conditions for shipping. The same can be said for Lake St. Louis and Montreal Harbour. One big exception was on Lake St. Lawrence where levels were generally one-half metre below average beginning in June and lasted until seaway traffic closed on December 26.

The cause of the very low levels on Lake St. Lawrence was high flows at the hydropower dam at Cornwall. In the early summer months, seaway officials expressed concern with the high river flow velocities. The high flow velocities make it difficult for ships to navigate in areas such as Copeland Cut (above Eisenhower Lock) and the upstream approach to the Iroquois Lock. Beginning in mid October, shippers had to cope with extreme low levels on Lake St. Lawrence and above Iroquois Lock. These conditions were, at times, exacerbated by easterly winds. On several occasions, water levels on Lake St. Lawrence fell below the minimum requirement, forcing a temporary suspension of transit for some deep draft vessels.

5.3 Recreational Boating

Recreational boaters generally benefitted by higher than average water level conditions on the Great Lakes and the St. Lawrence River in 1997. The area of exception was also Lake St. Lawrence, and 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 reported extreme difficulties in removing their boats from the water.

5.4 Hydropower Generation

Hydropower facilities in the St. Marys River continued to attempt to use the amounts of water specified by the regulation plan for power generation. However, their repairs reduced slightly the plants' capabilities to use their full share of water. High flows in the Niagara River and the St. Lawrence River resulted in above average power production. There was some limited spillage at the Beauharnois-Cedars facilities in early 1997.

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 the middle lakes are forecast to remain above seasonal average for the next six months. Lakes Superior and Ontario are expected to stay close to seasonal average in early 1998.

7.0 CONCLUSIONS

1. High water level conditions were experienced throughout the Great Lakes in 1997, a condition that started in 1996 due to high precipitation over the basin. Lakes Superior and Ontario levels returned to near normal by the end of the year. Lakes Michigan-Huron, St. Clair and Erie remain high and represent a risk for flood and erosion damage in 1998.

2. There were some reports of shoreline flood and erosion damage during the year, but an absence of major storms in 1997 kept these damages to a minimum.

3. Repairs to the gates at the Lake Superior Compensating Works in the St. Marys River necessitated temporary reductions in the Lake Superior outflows. The impacts on Lakes Superior and Michigan-Huron water levels were very small.

4. The high outflows of Lake Ontario reduced the peak level on that lake this year by more than one-half metre, thus helped reduce shoreline damage around the lake. However, the high Lake Ontario outflows also caused extremely low water levels on Lake St. Lawrence, affecting the area's riparian and recreational boating interests, and, in the fall, commercial navigation.

5. Except for minor water level fluctuations on Lake St. Clair in early 1997, and the April ice jam in the Maid-of-the-Mist Pool portion of the Niagara River, ice conditions across the Great Lakes were not problematic in terms of water levels.

6. Given the high Great Lakes water level conditions, Environment Canada increased its level of public information activities, in terms of water level forecasts and storm warnings, to promote better understanding of water level fluctuation, and help the public prepare for and cope with the effects of high levels.

Appendix A Flood and Erosion Damage

In November, Environment Canada asked Conservation Authorities on the shores of the Great Lakes to describe damages to shoreline properties as a result of the high lake water levels. The following is a summary of their replies.

(1) Ausable Bayfield Conservation Authority

Erosion along the shoreline of Lake Huron has been medium to high during the year. A subjective estimate would be that in certain areas, one to two metres of the toe of the shoreline bluff has been eroded this year. There are areas with very little above water erosion due to the location of sand bars and temporary beach deposits. However, there are other areas where the toe of the bluff is now a 2~3 metre vertical face.

The Authority was not aware of any buildings or municipal properties that have been directly affected by the high waters. The danger, according to the authority, exists for some damage in the next year or two from slumping of the lakeshore bank in an effort to get back to a more stable slope.

The biggest impact at present is the renewed interest in lot by lot erosion protection with minimum regard for long-term shoreline management principles. This is partly due to the fact that in its watershed, the majority of the shoreline is not controlled or regulated by any agency.

(2) Cataraqui Region Conservation Authority

The Authority's impression was that it got off quite lightly. It has no reports of significant damage. Its office monitored water levels and wind forecasts and conducted periodic reconnaissance along the shoreline. The situation experienced was described as minor.

The western portion of jurisdiction (Kingston and west) is generally the most susceptible to damage. The authority had a few inquiries from citizens and municipalities in that area on the types of shoreline protection and assistance program. It has no reports of significant damage.

(3) Catfish Creek Conservation Authority

With the exception of the Hamlet of Port Bruce located in Malahide Township, the majority of the Lake Erie shoreline within the Authority's watershed is in the form of high bluffs. It is expected that the high levels of the Great Lakes have resulted in an accelerated rate of bluff erosion, mostly at the toe of the bluffs due to wave action, however, no documentation has been completed to demonstrate this.

The high lake levels are a concern in the Hamlet of Port Bruce, however storm surge damages to this community only occur with a very persistent (more than 36 hours) south, or southwest wind. This did occur, and the result was minor nuisance flooding between buildings, and the deposition of sand and debris on some municipal and provincial roads. Damages and cleanup expenses were minimal.

Over the past year, a number of residents of Port Bruce have inquired about shoreline assistance program for relocating and raising residential structures. The Authority has provided these landowners with information about the Shoreline Property Assistance Program.

The Authority, in co-operation with the Township of Malahide and the federal government (Small Craft Harbours) have just completed a flood control project within the Port Bruce Harbour. A concrete/armour stone revetment was constructed at the base of the East Bluff. The necessity for this project was identified a number of years ago, however, the recent high water levels prompted a more serious examination of funding possibilities. The total budget for this project was $150,000, with costs split equally among the three partners..

(4) Central Lake Ontario Conservation Authority

The authority undertakes an annual spring inventory of shoreline damage centres and shoreline recession rates. This year's inventory did not report unusual damage, although the authority anticipates next year's inventory will be more reflective of damages incurred from the continued high water levels.

There were reports of minor shoreline repairs, and a problem with a gravel beach forming and blocking the outlet from a Region of Durham water pollution control plant in Whitby. While the authority could not report financial implications of the high water levels, it has not been viewed as a significant problem within the watershed

(5) Credit Valley Conservation Authority

No significant shoreline flooding or erosion damages were reported. Incidental observations of recreational beaches, in the City of Mississauga, showed reduced accessibility to the shore. In some locations, beaches usually used for passive recreational may have been under water. Similar access problems were likely experienced on private properties. Nuisance minor flooding and debris deposition were also likely results of the high water levels.

(6) Essex Region Conservation Authority

The area within the authority appeared to have suffered the most damages of all the conservation authorities in Ontario. It is estimated that about 25% of shoreline properties are inadequately protected.

To assist with preparedness for flooding and shoreline damage, the authority issued press releases, and provided a wide range of service to property owners including sandbags and pumps, issuing of flood watch and warning, and technical advice. Its staff also provided on-site advice to numerous property owners and municipalities. The information compiled by the authority shows that, during the period January to June 1997, total shoreline damages in the Essex region amounted to $7.8 million, while the total estimated cost of repairs and improvements needed to private break walls was about $4.8 million.

(7) Ganaraska Region Conservation Authority

The authority reported the shoreline suffered very little damage due to the high water levels.

(8) Grand River Conservation Authority

The authority was not aware of any property damage that has resulted from the high lake levels within the Grand River watershed. One firm in Port Maitland spent $32,000 on erosion protection along the lower Grand River. This protection may not have been required if the lake levels had been lower.

(9) Grey Sauble Conservation Authority

There were no reports of damage to buildings or structures. But there has been some damage to roads, park and existing shore protection works. In the town of Thornbury, Bayview Park experienced some beach erosion. The Township of Sarawal spent $8,500 to repair the armour stone protection adjacent to a roadway. The city of Owen Sound estimated that the erosion damage on its parkland and walkway was about $20,000~$30,000, and the gabion wall at a boat club suffered an estimated $150,000~$200,000 damage. Damages to private erosion protection works were estimated at $35,000 in the township of Keppel.

(10) Halton Region Conservation Authority

No significant damage was reported in the area, although the Town of Oakville had some erosion of the bluff.

(11) Hamilton Region Conservation Authority

The Authority's area of jurisdiction includes the shoreline within the City of Hamilton and the City of Stoney Creek.

The 8 kilometre long shoreline, within the City of Hamilton is an accretion zone and therefore is not significantly impacted by erosion. A 3.5 km portion of the shoreline is managed by the authority and is known as Confederation Park - there were no significant impacts noted due to the high water levels. This may have been due to the lack of storms out of the northeast which produce the maximum wave heights and damages.

The remainder of the private shoreline properties within Hamilton are protected by a wide beach and an abandoned railway embankment. High lake levels can cause flooding due to groundwater impacts on the area sandy soils however no property owners reported damages to the authority.

The 10 km long shoreline within the City of Stoney Creek is within an active erosion zone. The vast majority of the shoreline is in private ownership and has some form of shoreline protection. There have been no complaints to the authority about erosion or flooding problems. This can also probably be attributed to the lack of storms out of the northeast.

The authority sent an advisory letter to all lakeshore residents and municipalities in the spring of this year warning about the potential for flooding and erosion damages due to the high lake levels.

(12) Kettle Creek Conservation Authority

The authority has about 27 kilometres of Lake Erie shoreline within its jurisdiction, with the village of Port Stanley. The shoreline outside of Port Stanley consists of high cohesive bluffs that vary in height from 21 metres to over 27 metres. Land uses along the bluff area are predominantly agricultural, with most of the land being used for cash crop production. There is very limited structural development, and the authority is not aware of any reports of damages directly to structures as a result of bluff erosion. There have been losses of tillable land, however, it would be very difficult to quantify the amount or its value.

Within the village of Port Stanley, the shoreline is divided into two distinct types. The area west of Kettle Creek features a large fillet beach which has built up as a result of the harbour breakwall. There is significant cottage development and some commercial development that has occurred historically in this area. Much of the newer development has been floodproofed to meet or exceed the 100 year uprush flood standard. Some minor flooding was experienced in the beach area this year as a result of significant windstorms across the lake, however, no damages were reported. The initial storms resulted in flooding of one of the municipal street ends, and the village did incur some minor clean up costs to sweep up sand and clean out catch basins, but no significant damage to the roads or other infrastructure occurred. After consultation with the authority, the village built up a small sand berm around the subject street end, and this assisted in preventing any further "nuisance" flooding.

The authority assisted landowners in the beach area by securing a stockpile of sand bags for those owners who wanted to build up extra protection around their properties as a preventative measure. About a half a dozen landowners took advantage of the sand bags, which the Authority received from a local Ministry of Transportation depot. The Authority also provided monthly updates on lake levels, in the form of press releases and memorandums to municipal councils, which were based in part on the monthly bulletins provided by Environment Canada. The Authority also provided flood forecasting advisories to residents and local municipalities and agencies during times of flood events. Three flood advisories were issued this year as a result of forecasted lakeshore flooding. The cost of the Authority's involvement in these efforts is estimated to be $8,000.

The easterly side of Port Stanley is predominantly low bluff (less than 5 metres in height) that is almost wholly protected with some form of rubble/stone revetment. This area experienced some minor damages to existing protection that resulted in necessary repairs by landowners. The total cost of these repairs is estimated to be in the order of $35,000. One landowner did replace his existing rubble revetment with an engineered armour stone revetment that cost in excess of $100,000. However, planning for that project began over two years ago and was not initiated in response to the current high water so this cost may not be appropriate. The Authority was involved in providing technical assistance and administering the appropriate permits to authorize the repair works. Authority costs for its involvement are estimated to be $7,000.

The authority has estimated that the total additional costs incurred within the Authority's area of jurisdiction as a result of high lake levels this year was about $50,000. These costs did not include an estimate of the value of tillable land lost due to increased bluff erosion in 1997.

(13) Lakehead Region Conservation Authority

There were no reports of damages to municipal infrastructure or to privately owned structures. Although the authority received general inquiries during the high water level period, there was not the level of concern voiced that occurred during the 1985 high lake levels.

(14) Long Point Region Conservation Authority

In the Township of Norfolk, ongoing repairs and regrading have been done to Hastings Drive in Long Point Village. Some armouring of the shoreline in this area has also been attempted. The estimated cost so far is about $30,000.

In the City of Nanticoke, a portion of the Lakeshore Road was threatened due to continuous erosion over the years. Armouring of the shoreline at this location was undertaken this year. Total expenses are about $127,000.

In the Township of Bayham, County of Elgin, a section of the Front Road (County Road 42) was threatened by rapid gullying. The relationship between gullying and shoreline recession at this location is not clear. Temporary measures, in the form of regrading and use of large straw bales and filter cloth, were put in place. Total cost is between $25,000 and $50,000.

The shoreline between Port Burwell and the eastern boundary of the Bayham Township experienced several large failures due to a combination of toe erosion and groundwater seepage. Some were in the range of 70 m long by 20 m deep with bluff height around 25-30 metres.

Flood damage was generally minor, that is, debris on roads, temporary road closures, a few docks damaged at marinas. The Authority did not receive any reports of significant flood damages.

The Authority provided some assistance to landowners in the form of sand bags and advice. It continued its flood forecasting and monitoring program. No capital remedial measures were undertaken by the Authority.

(15) Lower Thames Conservation Authority

The Erie Shores Drive area of Harwich Township suffered flood and erosion damages during two significant events when strong south-westerly wind blew. Erie Shores Drive is a developed rural area of about 130 residences between Erieau and Erie Beach on the Lake Erie shoreline. The first event occurred on April 6 and 7 while the second one occurred on May 1st. Both events resulted in about half of the residences being flooded or made inaccessible due to flooding. The events caused the municipality to initiate its Emergency Plan and undertake pumping activities to limit the flooding and to reduce the possibility that the road would wash out.

During the late spring, the municipality undertook a $120,000 project to reduce the impacts of flooding during this and other high water periods. The project included the installation of water diversion barriers on the travelled section of the road to direct water to rock lined spillways as well as the installation of catch basins to reduce flooding to the homes.

(16) Lower Trent Region Conservation Authority

It appears that there was not any reported damage to public property in this area. The authority received no calls with regards to problems

(17) Maitland Valley Conservation Authority

The high lake levels of 1997 impacted this shoreline primarily by way of bluff undercutting, excessive landside drainage and subsequent bluff slumps. Over the course of the year, a number of these events impacted the shoreline and adjacent development. Slumps occurred at Meneset Trailer Park resulting in residence relocation (9 mobile home units - approximate costs at $5,000 to $10,000 per unit). Horizon View (near Point Clark), and Bluewater Beach south of Goderich.

Landside drainage, related to the high lake levels, had a significant effect on bank stability. Two access roads into cottage subdivision, adjacent to lakeshore gullies, were affected by slope failures requiring immediate remediation. Goderich Township has had to install drainage works to mitigate the effects of gullying and slope failure resulting from both excessive landside drainage and lakeside undercutting.

Another concern that high lake levels have had in the area is the impact to existing shore protection works. A number of landowners (about 25) and some local municipalities have received technical advice regarding improvements to shore protection works that were being undermined or overtopped.

The Twon of Goderich has experienced some erosion of its water front which has required some remediation. The town is in the progress of implementing a waterfront protection scheme that is expected to cost approximately $1 million. The protection efforts include the construction of a series of artificial headlands. Three have been constructed to date. However, while the current high water levels have accelerated erosion of the beaches, the town was planning to implement this scheme irregardless.

The Authority is not aware of any other public properties which have been impacted directly by the current high lake level scenario to the degree that remedial measures were required.

(18) Metropolitan Toronto and Region Conservation Authority

The Authority's jurisdiction extends from the Whitby/Ajax boundary to the Etobicoke/Mississauga boundary.

At the Ajax Waterfront, erosion caused by wave uprush threatened a 15-metre section of the Waterfront Trail. The Town of Ajax spent about $1,000 to place field stone as interim protection to the trail. Storms caused continued erosion along unprotected and exposed shorelines but no measurements were taken or cost of damages assessed since much of the waterfront is parkland.

At the Pickering Waterfront, no significant damage was reported other than usual shoreline/bluff erosion of unprotected shorelines.

At the Scarborough Waterfront, there has been some erosion of beaches. The last time serious erosion occurred was in 1993. The high levels this year seemed to have compounded the problem there. The authority spent $25,000 in late Fall 1997 placing rip rap stone and armour stone to protect embankment along the back of these beaches. At the Scarborough Bluffs, the authority received the usual number of calls from homeowners concerned about ongoing erosion. Some of the calls were from residents along unprotected shorelines such as the Meadowcliffe Drive sector (immediately east of Bluffers Park) and Guildwood Parkway (at foot of Morningside Avenue).

At the Toronto Waterfront, Toronto Islands continued to experience erosion along Gibraltar Point. This shoreline has a long history of continuous erosion and high lake levels only magnify the problem and along north shoreline near Centre Island ferry dock. The authority has budgeted $50,000 in 1998 to address erosion.

The Toronto Harbour Square bioengineering project, completed in 1996, suffered some damage due to high lake level and wave actions generated by boats. About $20,000 were spent on the repairs in 1997.

Along the eastern beaches of the Toronto Waterfront, storm actions caused extensive erosion damage along about 140 metres of shoreline and threatened a section of a boardwalk. The damage, one estimated close to $100,000, was the result of prolonged easterly wave action on March 13 and 14, 1997.

The Len Ford Park in the Etobicoke Waterfront continued to undergo erosion process. Wave action this past Spring has eroded into the filled areas.

(19) Quinte Conservation Authority

The Authority's area of jurisdiction is considered to cover the areas of what are known as the Moira River, Napanee Region and Prince Edward Region Conservation Authorities. The Authority reported that not much damage occurred in 1997.

(20) Niagara Peninsula Conservation Authority

During 1997, the north shore of Lake Erie was exposed to a number of lake effect storm events, however, none precipitated serious coastal damage. From discussions with lakeshore residents, there have been isolated problems with respect to damaged shore walls.

In the community at Elco Beach in the City of Port Colborne, two separate storm events inundated 25 homes. These flooding incidents occurred as waters from the lake were driven inland by way of a municipal drain. The majority of damages reported occurred to first floor elevations of the noted cottages. A remedy for this situation is being pursued through the Drainage Act.

Within the municipality of Fort Erie, erosion and debris problems occurred several times along the east shoreline of Point Abino. Given the proximity of the access road to the lake, this location is prone to having rocks and pebbles strewn onto the roadway. Also near the Peace Bridge, the break wall near the War Memorial at Mather Park was overtopped and damaged.

The authority also reported some minor erosion problems on its lands at Long Beach, in the Township of Wainfleet. Given the vulnerability of the infrastructure, it allocated $5,000 to fortify an existing armour stone revetment, which was originally installed in 1986, during the last high lake level event.

(21) Nottawasaga Valley Conservation Authority

The Authority's jurisdiction covers the southern portion of Georgian Bay from Collingwood to Wasaga Beach. While significant damages occurred in these areas during the high water level period in 1986, the authority has only one reported flooding problem at a motel in Wasaga Beach. The lack of serious damage can be attributed to the absence of severe storms in the region. Due to the high water levels, the available beachfront in Wasaga Beach Provincial Park was significantly reduced.

The Authority provided advice and comments to shoreline property owners for potential shore works through the Conservation Authority Act Fill, Construction and Alteration to Waterways permit process.

(22) Raisin Region Conservation Authority

The Authority's area is located on Lake St. Francis on the St. Lawrence River. Accelerated erosion has occurred along about 120 metres of the shoreline in the Township of Charlottenburge, with three locations becoming a very serious safety issue. The top of the bank of the shoreline is now the shoulder of the road. The authority is attempting to arrange partnership funding in order to undertake protective works.

The second location of concern is at Point Mouillee/Bainsville Bay, where high water levels have accelerated the erosion at Point Mouillee.

(23) Saugeen Valley Conservation Authority

The Authority's properties and capital works in the vicinity of the shoreline have not been damaged as a result of high lake levels. Its office has received no reports from landowners or municipalities of significant damage to any property or structures along the shoreline resulting from high lake levels.

One reason for the lack of damage to buildings and municipal infrastructure could be that extensive work was undertaken in the mid 80's to address the high levels at that time. These works appear to be providing protection from the present levels.

One problem that has arisen as a result of high lake levels is the blockage of the mouths of some smaller creeks with materials deposited by wave action. A concern that these blockages could cause flooding upstream has prompted a municipal government to remove the blockage at one creek. Upstream flooding has not yet been reported along these watercourses.

(24) Sault Ste. Marie Region Conservation Authority

About $50,000 damage to seawalls and groins was reported by the Authority.

(25) St. Clair Region Conservation Authority

The erosion along the Lake Huron shoreline can be described as extreme. Several cottages and homes were affected, and some are being moved.

Estimates of damages to municipal roads and parks are as follows:

Lakeshore Road in Sarnia: $130,000; shore protection in Point Edward: $5,000; shore dyke in Dover township: $50,000.

In the Highland Glen Conservation area, three to five feet of shoreline property has been eroded. Damage to existing boat ramp is about $50,000.

The Authority provided sandbags to affected landowners at a cost of about $5,000.

Table 1 Comparison of 1997 Great Lakes Basin Precipitation and Long-Term Average (millimetres)

Superior Basin

	1997	Percentage of average	Average 1900-1996	Previous Maximum (Year of Occurrence)	Previous Minimum (Year of Occurrence)
Jan	65.3	132	49.7	91.4 (1935)	22.5 (1961)
Feb	18.8	51	36.9	84.4 (1939)	10.6 (1993)
Mar	53.6	122	43.7	101.6 (1979)	9.6 (1910)
Apr	30.0	59	50.0	105.6 (1960)	17.4 (1949)
May	58.0	84	69.0	129.4 (1970)	21.1 (1948)
Jun	91.0	109	82.9	151.4 (1943)	22.7 (1910)
Jly	87.0	105	83.5	141.7 (1952)	27.7 (1936)
Aug	51.0	62	81.8	185.9 (1988)	26.3 (1930)
Sep	59.0	66	89.6	163.5 (1941)	32.7 (1967)
Oct	76.0	109	70.0	140.1 (1995)	15.6 (1947)
Nov	55.0	86	63.7	119.5 (1985)	11.0 (1939)
Dec	25.6	50	51.5	90.1 (1984)	9.0 (1913)
Sum	670	87	770		

Michigan-Huron Basin

	1997	Percentage of average	Average 1900-1996	Previous Maximum (Year of Occurrence)	Previous Minimum (Year of Occurrence)
Jan	95.0	180	53.0	91.8 (1950)	20.5 (1956)
Feb	79.8	184	43.3	86.2 (1908)	14.3 (1969)
Mar	50.8	93	54.3	116.2 (1976)	15.1 (1958)
Apr	43.0	66	66.0	125.6 (1929)	25.6 (1946)
May	74.0	98	75.5	141.6 (1983)	31.1 (1925)
Jun	69.0	87	79.2	143.8 (1969)	29.3 (1988)
Jly	75.0	99	76.4	132.2 (1952)	29.9 (1936)
Aug	106.4	136	78.5	136.1 (1972)	23.8 (1927)
Sep	80.8	92	88.2	213.3 (1986)	29.6 (1979)
Oct	52.8	74	72.4	147.4 (1954)	13.9 (1924)
Nov	44.0	63	70.4	127.9 (1985)	18.6 (1904)
Dec	32.0	55	58.6	105.7 (1971)	14.4 (1913)
Sum	803	98	820		

Erie Basin

	1997	Percentage of average	Average 1900-1996	Previous Maximum (Year of Occurrence)	Previous Minimum (Year of Occurrence)
Jan	62.0	100	62.0	160.5 (1950)	14.3 (1961)
Feb	94.0	178	52.2	117.1 (1990)	10.4 (1987)
Mar	94.0	134	69.9	170.6 (1913)	11.0 (1910)
Apr	44.0	55	80.0	152.1 (1961)	23.5 (1946)
May	133.0	160	83.3	175.8 (1943)	16.8 (1934)
Jun	90.0	104	87.4	167.9 (1937)	19.0 (1988)
Jly	67.0	80	84.5	190.5 (1992)	29.3 (1930)
Aug	102.0	126	80.5	179.7 (1975)	33.1 (1969)
Sep	104.0	130	80.3	176.0 (1926)	19.3 (1908)
Oct	49.0	70	69.9	196.2 (1954)	11.2 (1924)
Nov	60.0	83	72.4	191.8 (1985)	9.8 (1904)
Dec	64.8	98	66.4	160.0 (1990)	21.1 (1943)
Sum	964	108	890		

Table 1 (continued)

Ontario Basin

	1997	Percentage of average	Average 1900-1996	Previous Maxima (Year of Occurrence) Maximum	Previous Minima (Year of Occurrence) Minimum
Jan	95.0	140	68.2	137.2 (1978)	27.6 (1981)
Feb	68.0	113	59.8	112.5 (1971)	22.9 (1969)
Mar	93.0	138	67.0	143.4 (1936)	18.2 (1915)
Apr	38.0	52	73.7	126.6 (1929)	28.6 (1915)
May	66.0	84	78.0	144.7 (1943)	15.9 (1920)
Jun	74.0	94	77.9	159.1 (1972)	30.3 (1912)
Jly	54.0	69	79.4	159.5 (1992)	31.7 (1933)
Aug	95.0	120	79.2	142.3 (1977)	32.1 (1907)
Sep	101.0	125	81.6	159.2 (1945)	24.3 (1964)
Oct	40.9	53	77.5	211.5 (1955)	12.9 (1963)
Nov	86.0	109	79.6	168.0 (1927)	15.4 (1904)
Dec	56.8	77	73.9	139.9 (1990)	27.0 (1943)
Sum	870	97	900		

Great Lakes Basin

	1997	Percentage of average	Average 1900-1996	Previous Maxima (Year of Occurrence) Maximum	Previous Minima (Year of Occurrence) Minimum
Jan	82.0	150	55.1	100.5 (1950)	21.9 (1961)
Feb	64.0	142	44.7	80.1 (1908)	16.8 (1969)
Mar	65.0	118	54.8	110.7 (1976)	15.4 (1910)
Apr	39.0	61	64.3	106.0 (1929)	28.6 (1915)
May	76.7	102	74.9	116.1 (1983)	32.7 (1934)
Jun	78.0	97	81.0	121.1 (1968)	36.5 (1910)
Jly	75.0	94	79.6	123.7 (1992)	31.7 (1936)
Aug	90.0	112	79.7	128.1 (1977)	28.7 (1930)
Sep	80.0	92	86.7	166.2 (1986)	38.9 (1948)
Oct	57.2	79	72.0	127.0 (1954)	20.7 (1924)
Nov	54.0	78	69.8	136.7 (1985)	18.0 (1904)
Dec	37.7	63	59.5	92.5 (1983)	16.9 (1913)
Sum	800	98	820		

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

Table 2 Great Lakes Water Levels in 1996 and 1997 and Their Comparison with Previous Records (Metres, IGLD-1985)

Lake Superior

	1996	1997	Average 1918-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	183.34	183.59	183.35	183.70 (1986)	182.83 (1926)
Feb	183.32	183.54	183.29	183.63 (1986)	182.76 (1926)
Mar	183.30	183.51	183.26	183.61 (1986)	182.74 (1926)
Apr	183.31	183.55	183.28	183.68 (1986)	182.72 (1926)
May	183.46	183.64	183.39	183.74 (1986)	182.76 (1926)
Jun	183.59	183.65	183.47	183.76 (1986)	182.85 (1926)
Jul	183.70	183.72	183.54	183.82 (1950)	182.96 (1926)
Aug	183.78	183.68	183.57	183.86 (1952)	183.02 (1926)
Sep	183.78	183.64	183.57	183.86 (1985)	183.12 (1926)
Oct	183.71	183.61	183.54	183.91 (1985)	183.10 (1925)
Nov	183.67	183.56	183.50	183.89 (1985)	183.01 (1925)
Dec	183.63	183.48	183.44	183.81 (1985)	182.92 (1925)

Lakes Michigan-Huron

	1996	1997	Average 1918-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum (Year of Occurrence)	Minimum
Jan	176.37	176.79	176.35	177.18 (1987)	175.60 (1965)
Feb	176.39	176.82	176.33	177.11 (1986)	175.59 (1964)
Mar	176.39	176.89	176.35	177.12 (1986)	175.58 (1964)
Apr	176.46	176.95	176.44	177.23 (1986)	175.61 (1964)
May	176.63	177.07	176.53	177.28 (1986)	175.74 (1964)
Jun	176.76	177.13	176.60	177.33 (1986)	175.76 (1964)
Jul	176.83	177.19	176.63	177.39 (1986)	175.78 (1964)
Aug	176.84	177.16	176.61	177.39 (1986)	175.77 (1964)
Sep	176.82	177.12	176.56	177.38 (1986)	175.76 (1964)
Oct	176.80	177.02	176.50	177.50 (1986)	175.70 (1964)
Nov	176.79	176.89	176.44	177.38 (1986)	175.65 (1964)
Dec	176.77	176.78	176.39	177.26 (1986)	175.62 (1964)

Lake St. Clair

	1996	1997	Average 1918-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	174.74	175.52	174.83	175.80 (1986)	173.88 (1936)
Feb	175.01	175.51	174.77	175.80 (1986)	173.89 (1926)
Mar	175.00	175.62	174.90	175.80 (1986)	174.05 (1934)
Apr	174.85	175.62	175.04	175.82 (1986)	174.32 (1926)
May	175.31	175.68	175.13	175.83 (1986)	174.42 (1934)
Jun	175.45	175.81	175.17	175.92 (1986)	174.45 (1934)
Jul	175.50	175.83	175.19	175.93 (1986)	174.50 (1934)
Aug	175.48	175.76	175.16	175.90 (1986)	174.41 (1934)
Sep	175.47	175.68	175.09	175.84 (1986)	174.34 (1934)
Oct	175.41	175.55	175.01	175.96 (1986)	174.27 (1934)
Nov	175.36	175.41	174.92	175.82 (1986)	174.18 (1934)
Dec	175.37	175.36	174.92	175.80 (1986)	174.24 (1964)

Table 2 (Continued)

Lake Erie

	1996	1997	Average 1918-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum		Minimum	
Jan	174.04	174.49	173.98	174.86	(1987)	173.21	(1935)
Feb	174.06	174.54	173.97	174.78	(1987)	173.18	(1936)
Mar	174.15	174.79	174.05	174.88	(1986)	173.20	(1934)
Apr	174.23	174.83	174.21	174.98	(1985)	173.38	(1934)
May	174.44	174.84	174.29	174.97	(1986)	173.44	(1934)
Jun	174.58	175.02	174.32	175.04	(1986)	173.45	(1934)
Jul	174.62	174.97	174.31	175.03	(1986)	173.45	(1934)
Aug	174.57	174.84	174.25	174.94	(1986)	173.43	(1934)
Sep	174.52	174.75	174.16	174.83	(1986)	173.38	(1934)
Oct	174.48	174.62	174.06	174.94	(1986)	173.30	(1934)
Nov	174.42	174.50	173.99	174.85	(1986)	173.20	(1934)
Dec	174.47	174.49	173.99	174.90	(1986)	173.19	(1934)

Lake Ontario

	1996	1997	Average 1918-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum		Minimum	
Jan	74.62	74.81	74.55	75.16	(1946)	73.81	(1935)
Feb	74.75	74.90	74.58	75.27	(1952)	73.78	(1936)
Mar	74.77	75.01	74.66	75.37	(1952)	73.94	(1935)
Apr	74.82	75.17	74.87	75.65	(1973)	74.03	(1935)
May	75.13	75.33	75.00	75.73	(1973)	74.11	(1935)
Jun	75.23	75.30	75.04	75.76	(1952)	74.19	(1935)
Jul	75.15	75.19	74.98	75.66	(1947)	74.14	(1934)
Aug	74.99	75.01	74.87	75.58	(1947)	74.00	(1934)
Sep	74.83	74.87	74.74	75.41	(1947)	73.91	(1934)
Oct	74.74	74.74	74.62	75.22	(1945)	73.82	(1934)
Nov	74.72	74.63	74.54	75.18	(1945)	73.75	(1934)
Dec	74.73	74.59	74.53	75.20	(1945)	73.74	(1934)

Lake St. Lawrence

	1996	1997	Average 1960-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum		Minimum	
Jan	72.81	73.05	72.84	73.62	(1967)	71.78	(1977)
Feb	72.47	71.85	72.39	73.32	(1983)	71.38	(1978)
Mar	72.96	72.29	72.75	73.42	(1966)	71.58	(1993)
Apr	73.38	73.35	73.53	73.94	(1962)	73.16	(1972)
May	73.69	73.66	73.65	74.00	(1973)	73.02	(1987)
Jun	73.53	73.12	73.60	73.96	(1966)	72.98	(1987)
Jul	73.35	73.04	73.52	73.92	(1967)	72.84	(1987)
Aug	73.04	72.90	73.36	73.90	(1967)	72.78	(1987)
Sep	72.90	72.77	73.20	73.90	(1967)	72.74	(1985)
Oct	72.75	72.62	73.10	73.78	(1962)	72.62	(1973)
Nov	72.65	72.64	73.02	73.72	(1972)	72.64	(1985)
Dec	72.57	72.62	73.07	73.66	(1966)	72.54	(1981)

Table 2 (Continued)

Lake St. Louis

	1996	1997	Average 1915-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	21.46	21.52	21.19	21.61 (1952)	20.39 (1934)
Feb	21.55	21.72	21.17	21.97 (1978)	20.33 (1936)
Mar	21.41	21.94	21.17	22.12 (1973)	20.35 (1965)
Apr	21.58	22.20	21.59	22.45 (1951)	20.54 (1965)
May	21.99	22.24	21.58	22.55 (1974)	20.51 (1964)
Jun	21.62	21.86	21.32	22.46 (1947)	20.39 (1965)
Jul	21.58	21.69	21.16	22.01 (1973)	20.44 (1965)
Aug	21.49	21.48	21.02	21.81 (1972)	20.19 (1934)
Sep	21.29	21.41	20.95	21.74 (1986)	20.12 (1934)
Oct	21.37	21.39	20.94	21.81 (1986)	20.11 (1934)
Nov	21.61	21.40	20.98	21.86 (1986)	20.07 (1934)
Dec	21.68	21.34	21.07	21.80 (1986)	20.32 (1935)

Montreal Harbour

	1996	1997	Average 1967-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6.70	6.86	6.92	8.96 (1968)	6.18 (1992)
Feb	6.95	7.42	7.11	9.04 (1967)	6.34 (1989)
Mar	6.70	7.57	7.10	8.36 (1973)	6.13 (1989)
Apr	7.07	8.01	7.58	8.82 (1976)	6.23 (1995)
May	7.76	8.19	7.38	8.93 (1974)	6.13 (1995)
Jun	6.82	7.13	6.82	8.12 (1974)	5.93 (1988)
Jul	6.89	6.87	6.57	7.49 (1973)	5.66 (1988)
Aug	6.63	6.55	6.47	7.27 (1972)	5.84 (1995)
Sep	6.32	6.45	6.39	7.08 (1986)	5.64 (1995)
Oct	6.40	6.40	6.46	7.16 (1986)	5.82 (1991)
Nov	6.80	6.49	6.61	7.31 (1967)	5.64 (1991)
Dec	7.00	6.37	6.67	7.24 (1972)	5.87 (1978)

Table 3 Outflows from the Great Lakes in 1996 and 1997 (cubic metres per second)

Lake Superior

	1996	1997	Average 1900-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	2050	2260	1950	2630 (1971)	1250 (1922)
Feb	2000	2290	1910	2610 (1969)	1270 (1922)
Mar	2000	2300	1880	2690 (1969)	1290 (1982)
Apr	1970	2410	1950	2940 (1951)	1300 (1922)
May	2240	2960	2120	3450 (1951)	1250 (1931)
Jun	2460	3180	2200	3480 (1951)	1220 (1922)
Jul	2600	3260	2280	3570 (1938)	1270 (1922)
Aug	2680	2780	2370	3600 (1950)	1270 (1926)
Sep	3150	2050	2360	3570 (1950)	1160 (1955)
Oct	3570R	1910	2310	3510 (1968)	1250 (1926)
Nov	3170	1800	2270	3740 (1985)	1250 (1981)
Dec	2340	1800	2070	3170 (1950)	1310 (1981)
Annual	2520	2420	2140		

Lakes Michigan-Huron

	1996	1997	Average 1900-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	3970	5180	4500	6060 (1987)	3060 (1934)
Feb	4770	5430	4390	5720 (1974)	3000 (1942)
Mar	4900	5640	4830	5830 (1986)	3510 (1931)
Apr	4360	5840	5140	6260 (1986)	3600 (1901)
May	5500	6020	5370	6370 (1986)	4390 (1964)
Jun	5510	6010	5460	6430 (1985)	4420 (1964)
Jly	5740	6150	5530	6570 (1974)	4500 (1964)
Aug	5740	6240	5530	6630 (1986)	4530 (1964)
Sep	5680	6210	5480	6600 (1986)	4470 (1933)
Oct	5660	6100	5430	6740 (1986)	4420 (1933)
Nov	5750	5910	5380	6650 (1986)	4390 (1934)
Dec	5730	5780	5190	6230 (1986)	3990 (1935)
Annual	5280	5880	5180		

Table 3 (Continued)

Lake Erie

	1996	1997	Average 1900-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	5720	6890	5610	7420 (1987)	4050 (1936)
Feb	5750	6730	5500	7050 (1987)	3340 (1936)
Mar	5940	7310	5650	7480 (1986)	4110 (1934)
Apr	6000	7490	5930	7700 (1974)	4390 (1935)
May	6520	7650	6220	7760 (1974)	4590 (1934)
Jun	6640	7580	6240	7820 (1986)	4560 (1934)
Jly	6560	7570	6140	7670 (1986)	4450 (1934)
Aug	6500	7290	6030	7420 (1986)	4470 (1934)
Sep	6670	7140	5920	7140 (1986)	4450 (1934)
Oct	6590	6930	5820	7450 (1986)	4420 (1934)
Nov	6810	6850	5820	7280 (1986)	4280 (1934)
Dec	6850	6930	5810	7620 (1985)	4330 (1934)
Annual	6380	7200	5890		

Lake Ontario

	1996	1997	Average 1900-1996	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6510	7250	6290	8470 (1987)	4700 (1935)
Feb	7270	8310R	6370	8160 (1986)	4360 (1936)
Mar	7550	9130R	6670	8890 (1991)	5010 (1935)
Apr	7390	8650	7090	9200 (1973)	5070 (1964)
May	7740	8530	7340	10100 (1993)	4980 (1965)
Jun	8340	9400	7440	10010 (1993)	5350 (1965)
Jly	8460	9020	7380	9910 (1976)	5520 (1934)
Aug	8340	8580	7220	9340 (1974)	5300 (1934)
Sep	7960	8400	7040	9230 (1986)	5100 (1934)
Oct	8100	8330	6860	9170 (1986)	4960 (1934)
Nov	8350	8010	6750	9570 (1986)	4810 (1934)
Dec	8580	8070	6630	9260 (1986)	4810 (1934)
Annual	7880	8470	6920		

Source: Environment Canada, Ontario Region

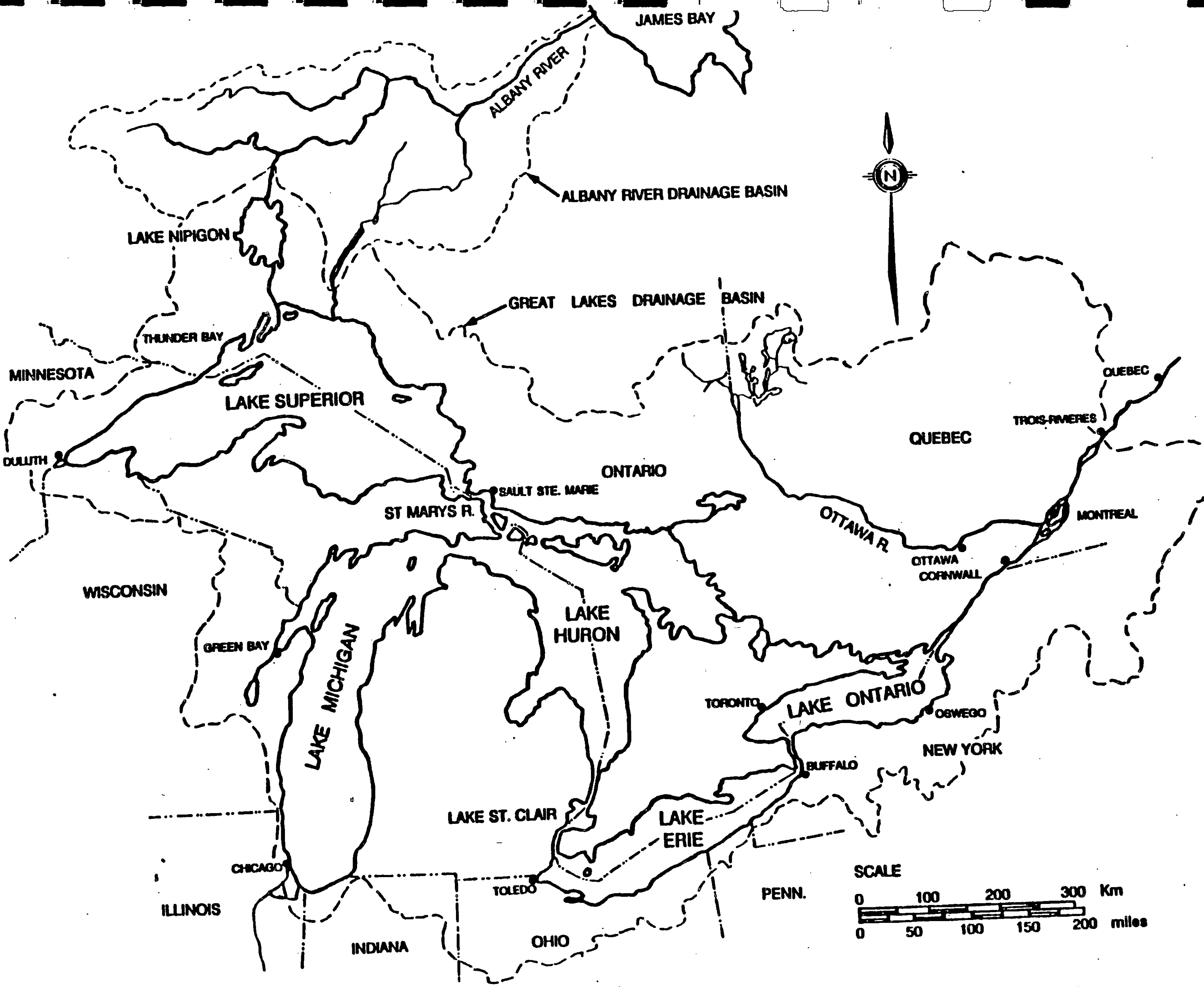

FIGURE 1. **Great Lakes-St. Lawrence River Basin**

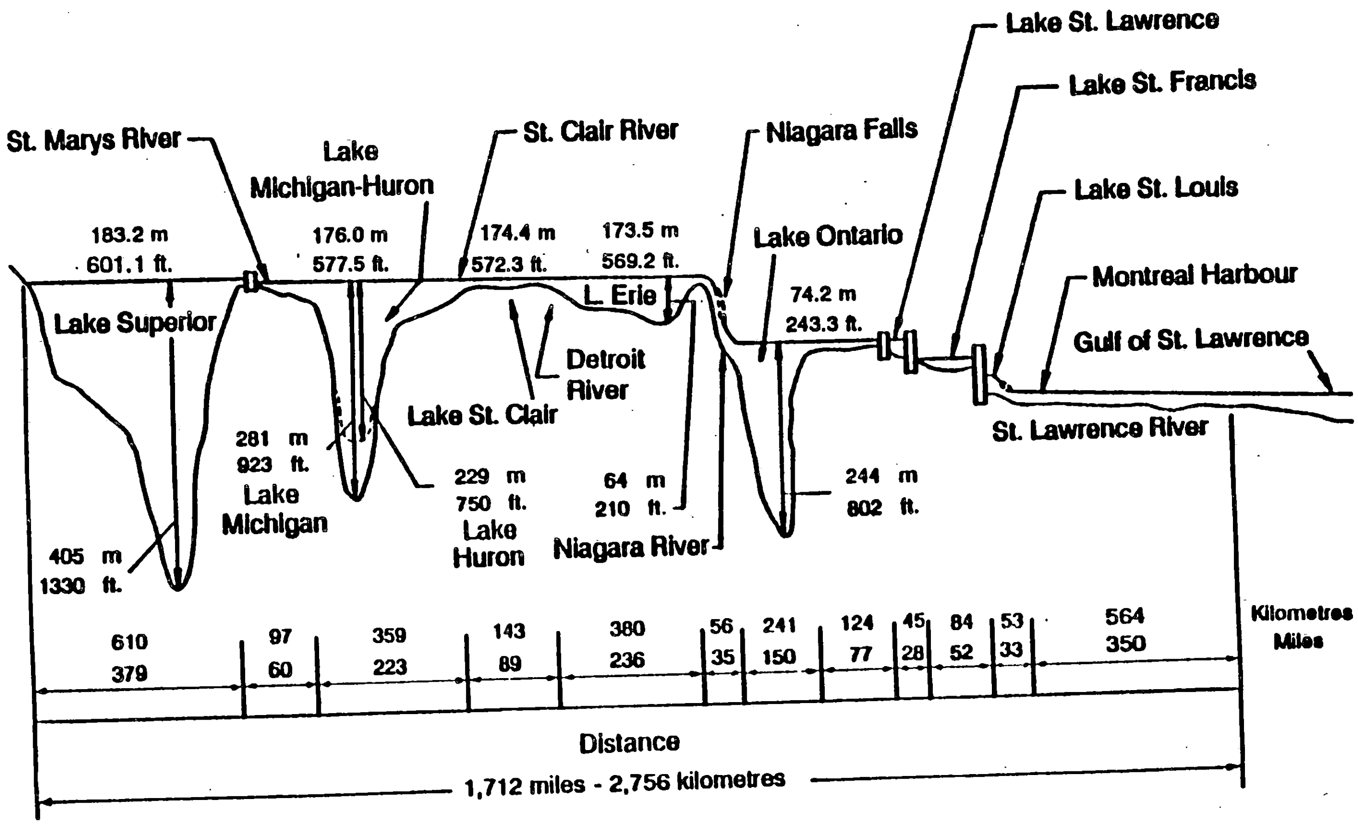

FIGURE 2. Profile of Great Lakes-St. Lawrence River System

Figure 3 Great Lakes Basin Precipitation, mm
1996-1997

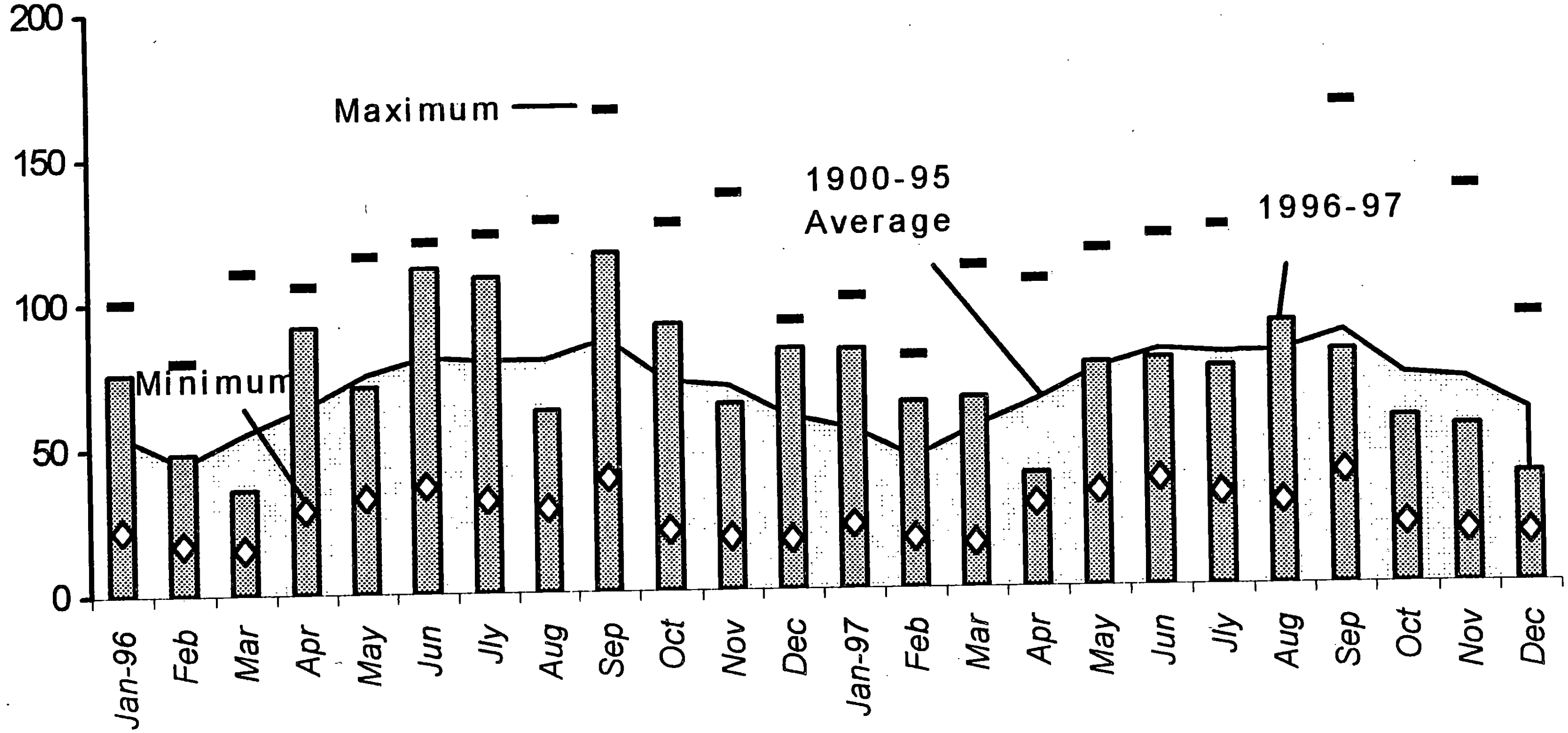

Figure 4 1997 Lake Superior Levels, metres IGLD 1985

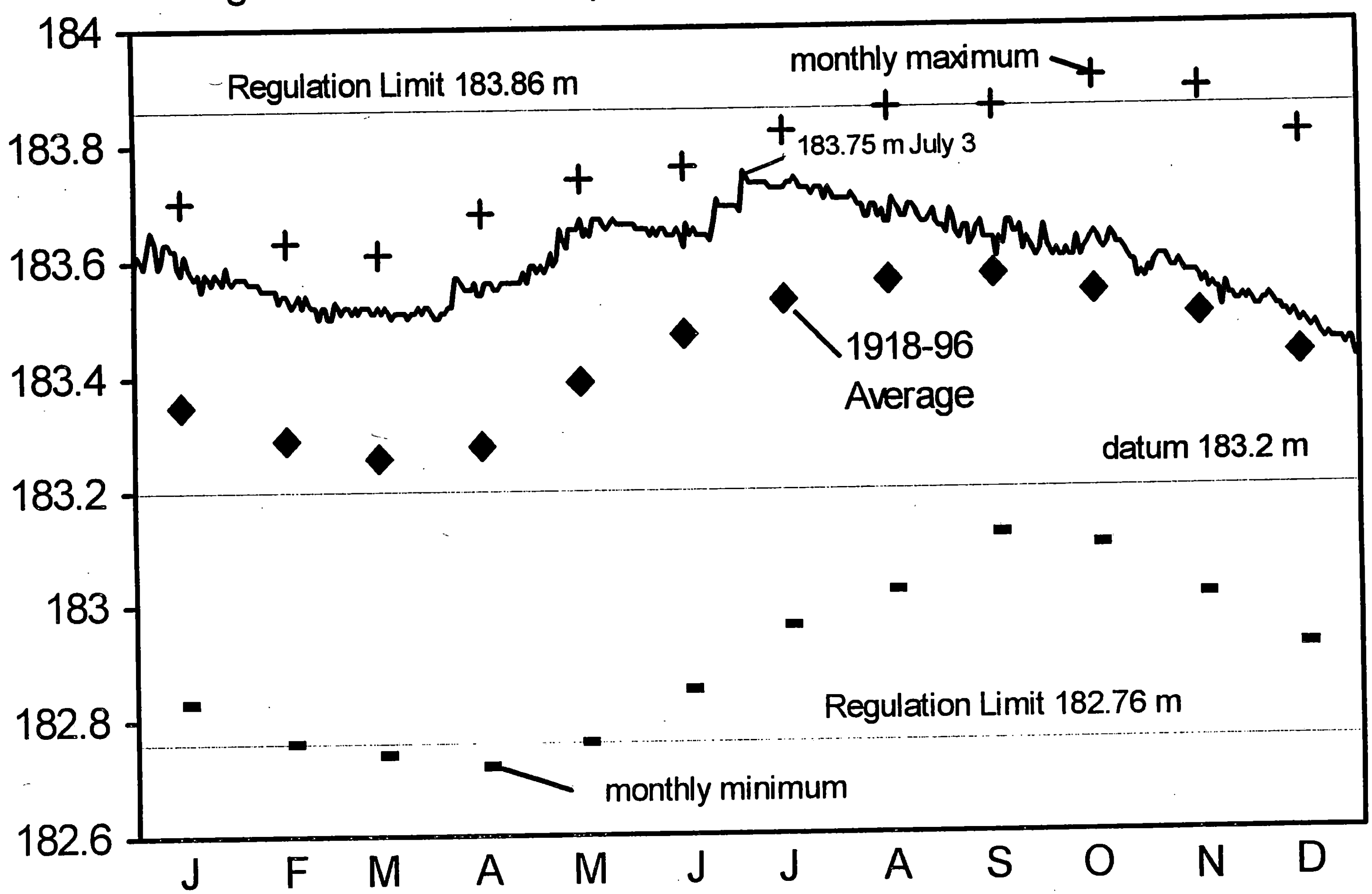

Figure 5 1997 Lakes Mich-Huron Levels, metres IGLD 1985

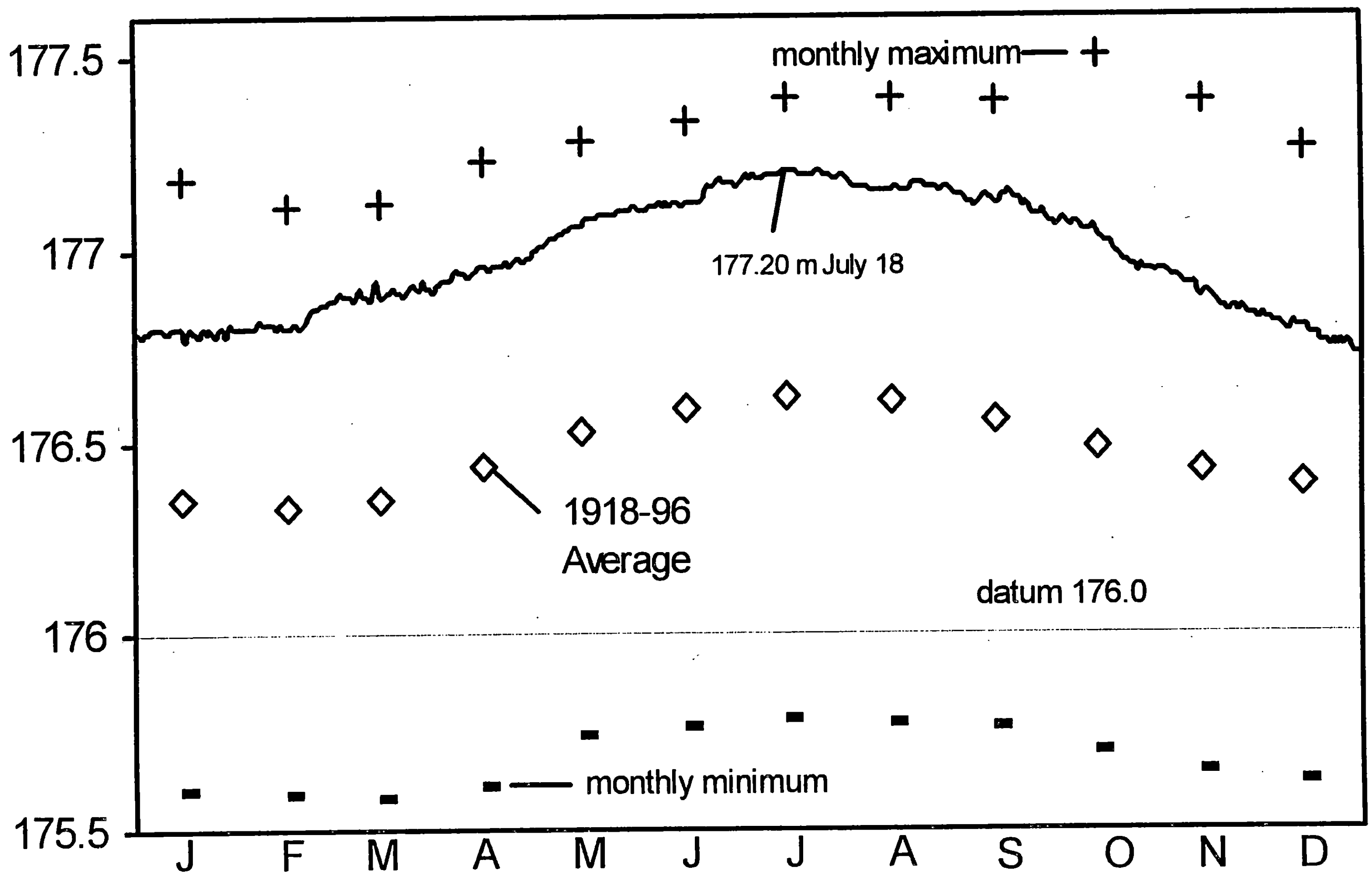

Figure 6 1997 Lake St. Clair Levels, metres, IGLD 1985

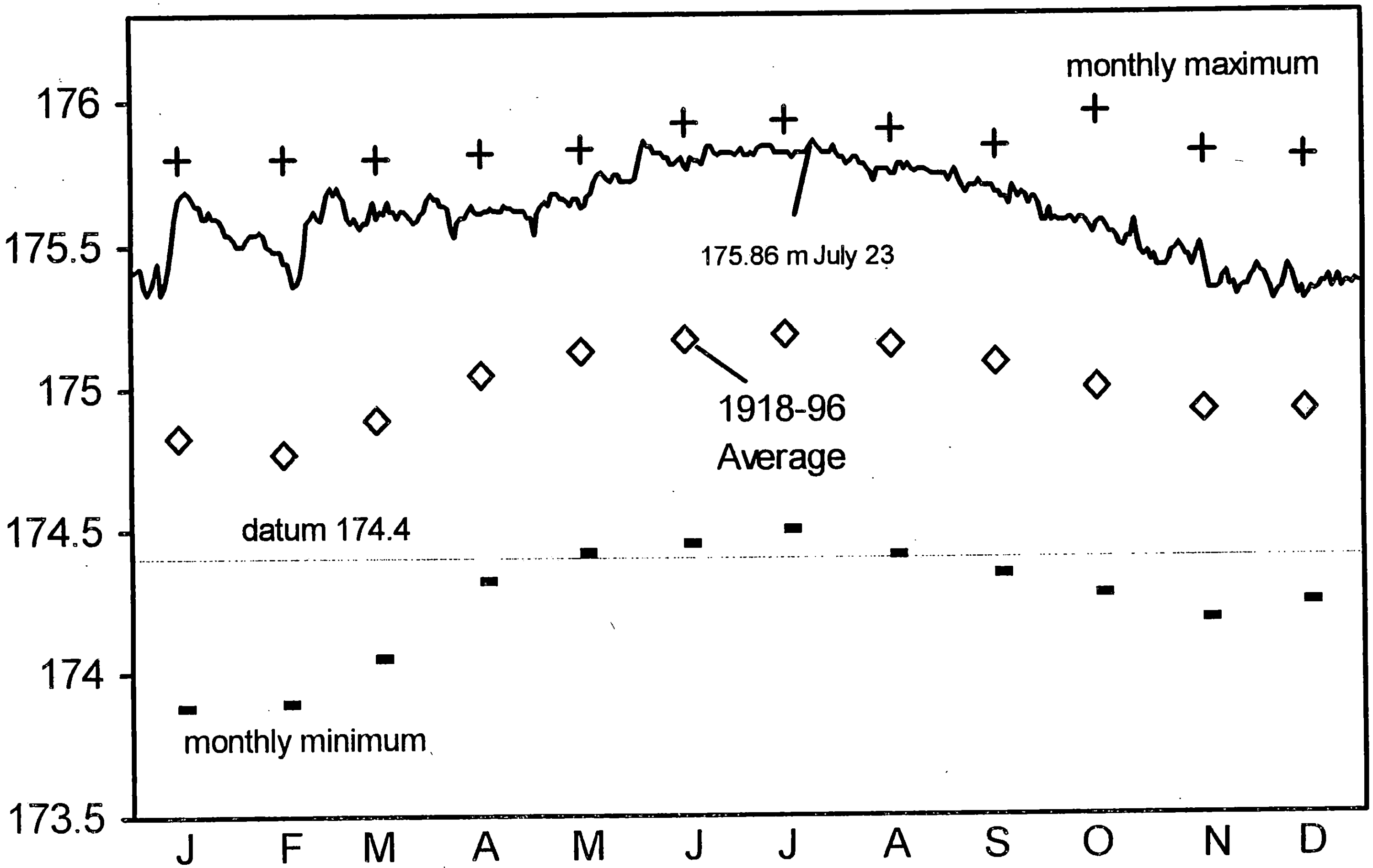

Figure 7 1997 Lake Erie Levels, metres IGLD 1985

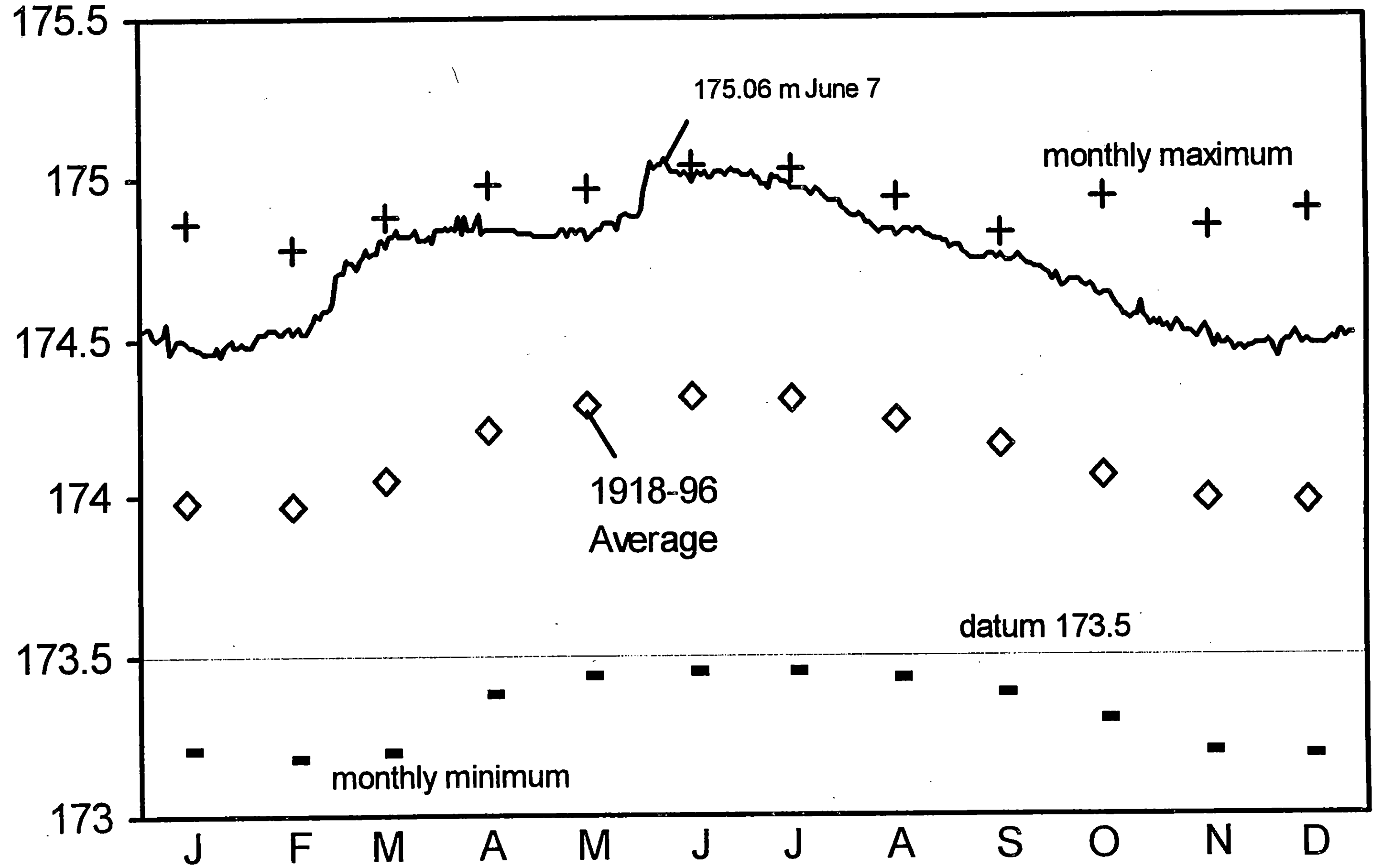

Figure 8 1997 Lake Ontario Levels, metres IGLD 1985

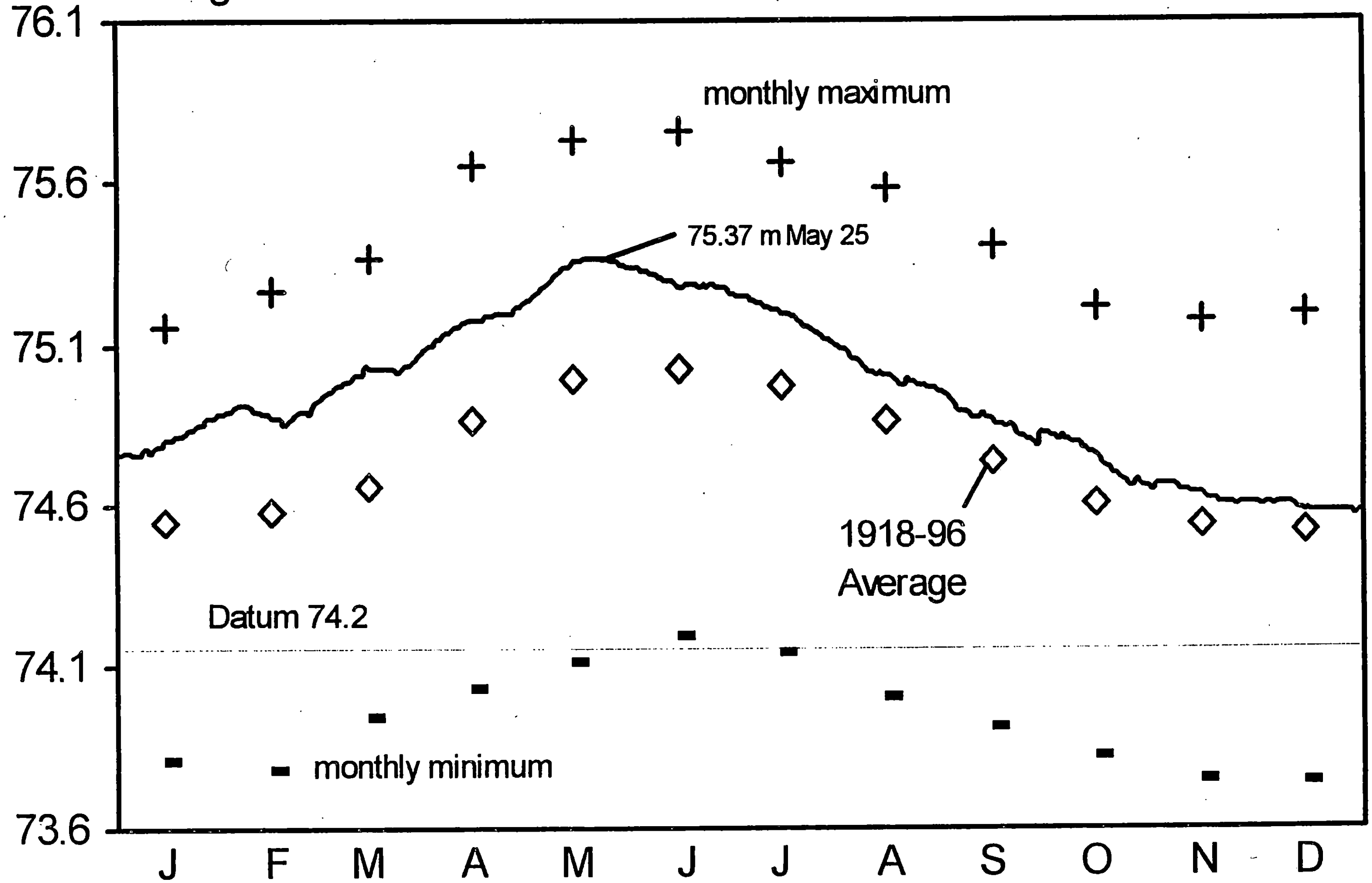

Figure 9 1997 Lake St. Lawrence Levels, metres IGLD 1985

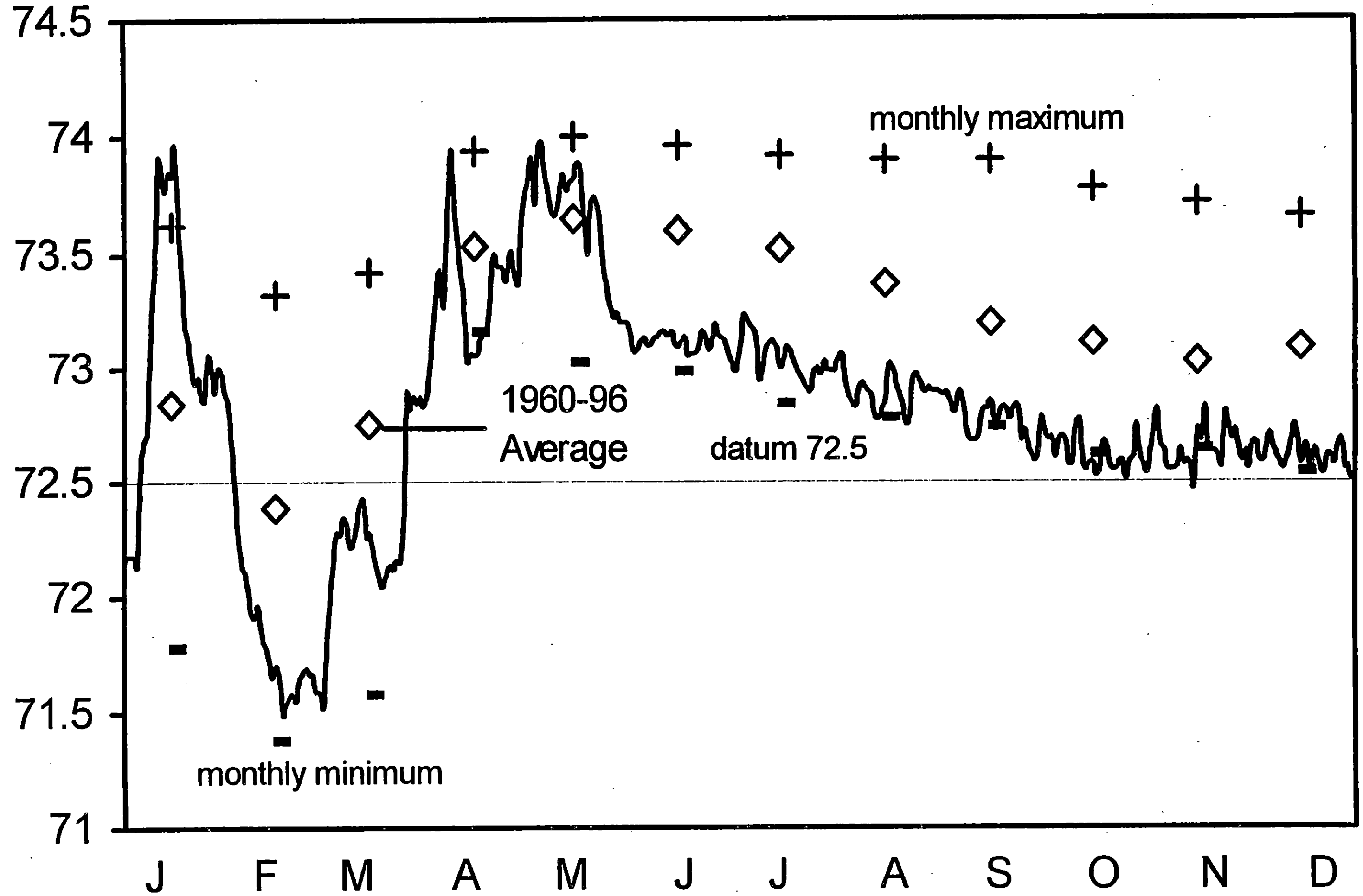

Figure 10 1997 Lake St. Louis Levels, metres IGLD 1985

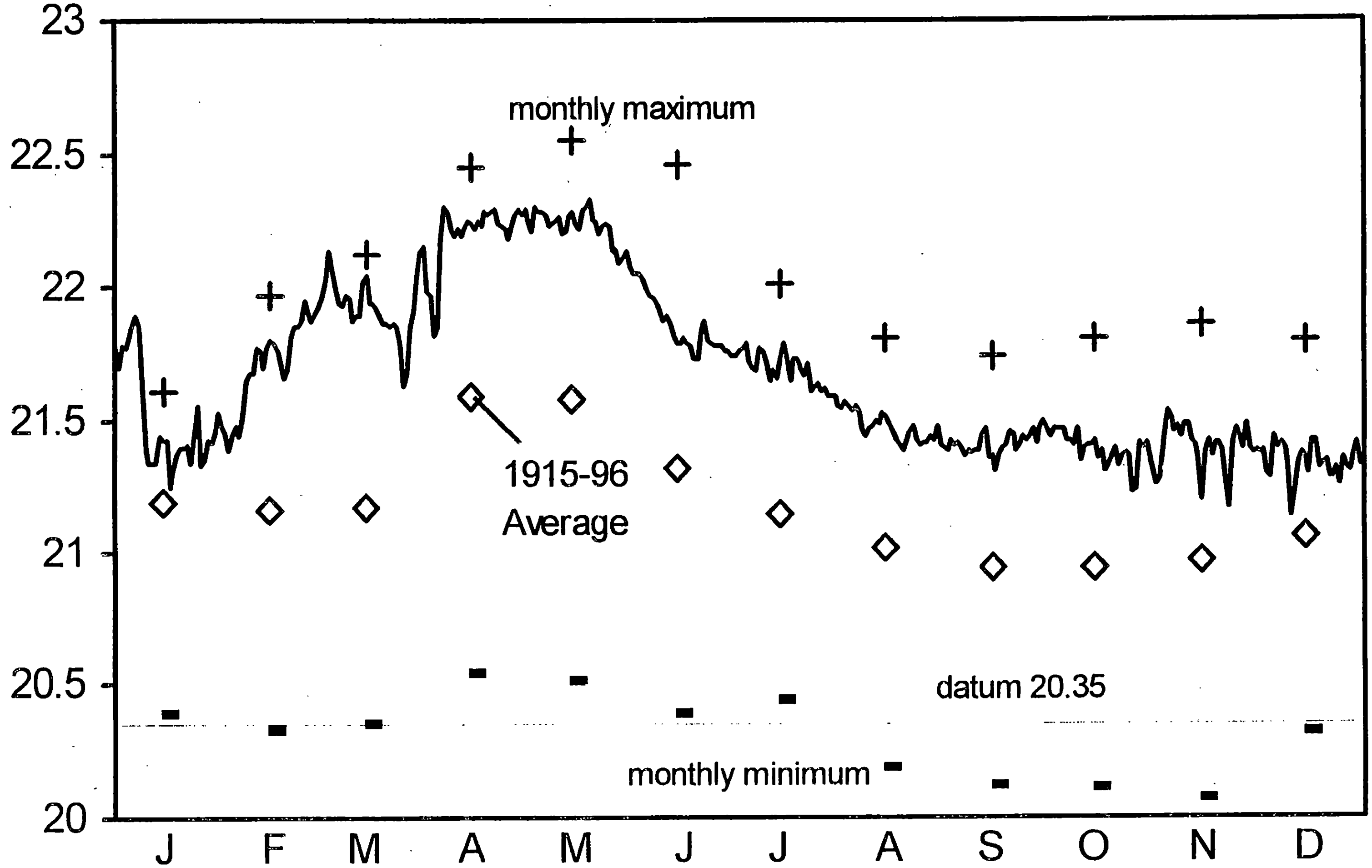

Figure 11 1997 Montreal Harbour Levels, metres IGLD 1985