REPORT ON

THE 1973 SAINT JOHN RIVER FLOOD,

NEW BRUNSWICK, CANADA

INLAND WATERS DIRECTORATE

DEPARTMENT OF THE ENVIRONMENT

OTTAWA, CANADA

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REPORT ON CAUSES OF FLOOD DAMAGES AND PROTECTIVE MEASURES ON THE SAINT JOHN RIVER

1. Basin

The Saint John River lies in a broad arc across southeastern Quebec, northern Maine and western New Brunswick. It extends from a point on the international boundary, about 70 miles southeast of Quebec City, to the Bay of Fundy, which is some 200 miles to the east. The total drainage area is 21,300 square miles, of which 51% or 10,950 square miles lie in New Brunswick, 13% or 2,750 square miles in Quebec and the remaining 36% or 7,600 square miles in northern Maine.

From its point of origin in Little Saint John Lake, the Saint John River flows northeastward, for about 100 miles, through the Chaleur Uplands and then swings in a broad arc to the southeast to reach Grand Falls, New Brunswick. Here it turns south and flows through the Uplands for another 60 miles until it enters the New Brunswick Highlands near Woodstock. Below Woodstock, the river flows southeastward and enters the New Brunswick Lowland about 10 miles upstream of Fredericton. It continues southeastward through the Lowland until it enters the Caledonia Highlands where it turns southward to the famous Reversing Falls at Saint John.

Measured along its streambed the Saint John River is approximately 435 miles long, and the total fall between Little Saint John Lake and tide water is about 1,580 feet. River slopes gradually decrease from about eight feet per mile near the headwaters to three feet per mile in the vicinity of Grand Falls and two feet per mile in the reach above Fredericton.

In its upper 200 miles, the Saint John River is fed from the west and north by numerous short tributaries such as the Daaquam, Big and Little Black, St. Francis and Madawaska Rivers, all of which rise in the southeastern slopes of the Notre Dame Mountains. Two important rivers, the Allagash and the Fish enter from the south from the upland areas of Maine. Below Grand Falls, the

Saint John River turns south and is joined from the west by the Aroostook River, whose drainage basin combined with those of the Allagash and Fish Rivers comprises most of the Saint John basin in Maine. Also, below Grand Falls, tributaries from the New Brunswick Highlands begin to come in from the north and east. The Tobique, which enters just below the Aroostook, and the Nashwaak which joins the Saint John at Fredericton, are the two most important of these.

In the section between Edmundston and Fredericton, the river has been extensively developed for hydro-electric power. The New Brunswick Electric Power Commission has three developments on this part of the river. These are: Grand Falls, with a head of 125 feet; Beechwood, located between Woodstock and Grand Falls, which develops a head of 57 feet; and Matacquac, which is located ten miles upstream of Fredericton and presently utilizes a head of about 110 feet.

From Fredericton downstream, the river is influenced by tides, but because of the effect of the Reversing Falls, tidal fluctuations reach only a small fraction of those in the Bay of Fundy. The physical characteristics of this tidal section of the river present a unique condition from the point of view of flooding. The outflow of the river is restricted by the narrow gorge, at its mouth (Reversing Falls) and affected by the tidal regime in Saint John Harbour. The duration of flooding along the river below Fredericton is influenced by large bodies of water along and adjacent to the channel. As flood waters are backed up by the Reversing Falls, large volumes go into storage and consequently the river remains relatively high for a few weeks following the peak runoff period.

2. Past Flood History

Historically, the Saint John River basin has been subject to periodic flood damage as a result of high river flows due to rainfall and snowmelt and high stages due to ice jams. Prior to 1973, the monetary value of flood losses had not been large compared with that of some other parts of the country, but

successive floods in recent years have caused increasing damages primarily as a result of increasing development on the flood plain.

Developed areas subject to flood damage are heavily concentrated in the lower part of the basin. They extend from the City of Fredericton along the main stem of the river to Jemseg. Considerable damages to bridges, highways, railways, utilities and private property have also occured along the Nashwaak and Oromocto Rivers. In the Maugerville-Sheffield area, downstream of Fredericton, extensive flooding of agricultural lands occurs on the average about every second year when the river overtops low sections of the Trans-Canada Highway. Some damage occurs to farmlands while fences and buildings are often seriously damaged by floating ice and debris. Most farm dwelling and service buildings are constructed on filled areas and are damaged only during extreme floods. The inundation of roads and highways in the area is a source of considerable inconvenience and occasionally a late flood delays spring planting long enough to reduce crop production.

On the main stem of the river upstream of Fredericton, flood damages occur occasionally in the communities of Edmundston, Perth-Andover, Bristol and Woodstock. Fort Kent, Maine frequently suffers flooding of residential and commercial areas.

At Fredericton, records of stage are available since 1919. During this period the 1973 peak stage was exceeded only once. That was in 1936 when an ice jam caused the stage to rise for a few hours to a level about one foot above the 1973 peak. The next highest stage recorded occured in 1923 and was 1.6 feet below the maximum 1973 stage.

Discharge records in the Saint John River basin date back to 1918 on the Saint John River at the Pokiok gauging station which was located a few miles

above the present location of the Mactaquac Dam. The maximum discharge recorded prior to 1973 occured in 1923 and was 288,000 cfs. This was significantly less than the daily mean discharge of 393,000 cfs recorded during 1973 below the Mactaquac Dam. The drainage area at Pokiok is only 3 per cent less than that below the Mactaquac Dam. Other significant mean daily discharges at Pokiok were reported in 1958 (277,000 cfs), 1947 (277,000 cfs), 1941 (257,000 cfs), 1934 (253,000 cfs), 1939 (250,000 cfs) and 1961 (249,000 cfs).

Other streamflow records of shorter duration indicate that the largest floods in most parts of the Saint John River basin between 1940 and 1973 occured in 1958, 1961 or 1969. The 1973 flood discharges exceeded these former records at some stations and approached them at others. On the Allagash and Fish Rivers and on the Saint John River at Fort Kent, the 1973 flood discharges were about equal to the previous maxima set in 1961. Records on these rivers date back to about 1930. The flood peaks recorded in 1969 were the maxima prior to 1973 on tributaries draining that portion of the Saint John River in Quebec and on the Saint John River at Grand Falls. The 1969 discharge was higher than the 1973 discharge on the Quebec tributaries but less than the 1973 flow at Grand Falls. On the Saint John River at East Florenceville, the maximum daily mean discharge of 324,000 cubic feet per second was significantly higher than the corresponding maxima of 1958 (240,000 cfs), 1961 (220,000 cfs) or 1969 (216,000 cfs).

The 1973 flood could also be compared to previous floods on the basis of damages. This is a rather difficult task due to a lack of basic information on costs of previous floods. However, an attempt was recently made to estimate the costs of previous floods in a study carried out for the Saint John River Basin Board. The estimates were developed mainly from newspaper reports with a

limited amount of concrete data on physical damages. The study indicated that damages exceeded one million dollars, based on 1972 price levels, in five previous years of this century. The estimated damages are listed below:

Year	Estimated Damage
1922	$ 2,710,000
1923	13,290,000
1936	7,010,000
1961	4,340,000
1970	3,500,000

Comparison with the estimated 1973 cost in the Saint John River basin of $10,800,000 indicates that the 1923 flood damages were probably of the same order of magnitude as those of 1973. The 1936 damages were also large but were composed mainly of the replacement cost of a Canadian National Railway Bridge across the Saint John River at Fredericton which was destroyed by an ice jam. Other floods in 1922, 1961 and 1970 probably cost from one-quarter to one-half as much as the 1973 flood.

3. The Spring Flood of 1973

Flood stages in the Saint John River occur as a result of intense rainfall, snowmelt, ice jams or a combination of these factors. Most of the major floods in the basin have been associated with extra-tropical storms occuring during March, April or May combined with or immediately following the snowmelt period. Ice jams usually add to flood problems when the peak runoff period occurs prior to about April 20.

The spring flood of 1973 was caused by an extra-tropical storm combined with heavy snowmelt. The winter of 1972-73 was one of heavy snowfall in northern and central New Brunswick. By mid-april the water equivalent of accumulated snowfall was as high as 12 inches in some areas and averaged 7.2 inches in the Saint John River basin above the Mactaquac Dam. Snowmelt and some

rainfall from April 21 to April 24 caused river discharges of a magnitude greater than those associated with a normal spring freshet. Most rivers crested about the 24th or 25th of April and then began to recede as snowmelt rates were reduced by cooler temperatures.

On April 27 an extra-tropical (frontal) storm moved into northern and central New Brunswick producing upwards of four inches of rainfall in many areas and causing most of the remaining snow to melt. Rivers rose rapidly, in many cases to levels higher than previously recorded, and peaked on April 29 and 30. The Saint John River below Mactaquac Dam reached a maximum discharge of 435,000 cfs on April 29. At this location the recurrence interval of the flood is estimated to be 84 years. As a comparison, the mean annual flood discharge is 190,000 cfs.

Following the peaks of April 29 and 30, most rivers gradually receded but the lower reach of the Saint John River, between Fredericton and Saint John, continued to rise over the period April 30 to May 2. The constriction of the Reversing Falls at the mouth of the river caused water in this reach to continue to accumulate even though the rate of inflow was declining. Flood characteristics along the lower Saint John River are extremely complex due to the large volumes of water which are backed up by the Reversing Falls.

Warnings provided through weather and flow forecasting permitted some advance planning to react to the emergency. The Emergency Measures Organization co-ordinated all flood disaster activities including public warnings and arrangements for evacuation of people and property. These measures prevented considerable personal hardship and economic losses. Nevertheless the federal and provincial governments paid out a total of $6.6 million in compensation to victims of the flood. Surveys of damages not eligible for compensation including indirect damage indicate that the total economic losses as a result of the flood were $10.8 million.

In terms of economic sectors damages were as follows: public sector (4.3 million), personal sector ($4.0 million), business sector ($1.4 million), agricultural sector ($0.7 million) and organizational ($0.3 million). Most of this damage occured along the Saint John River in the Fredericton area and in the agricultural lands on the flood plain downstream of Fredericton.

4. Protective Measures

The review of the conditions associated with the 1973 flood in New Brunswick has led to some conclusions which will be of use to government agencies and others in developing programs to reduce the magnitude of future damages.

The experience of flood forecasting and emergency action during the flood illustrates the value of even a very short period warning in reducing damage and personal hardship. While an estimate of the savings brought about by these measures is not available, their continuation is clearly justified. Analysis of the damage indicates that in spite of these measures, the value of moveable property lost in the basin was about $2.4 million. This suggests that improvements in flood forecasting and emergency measures procedures can produce additional reductions in flood losses.

The total economic cost of the flood is estimated to be $10.8 million. The magnitude of these losses and the associated personal hardships are sufficient to warrant full consideration of all possible ways to minimize damages in future. Most of the losses took place on a short section of the flood plain, in the vicinity of Fredericton, which has been extensively developed for commercial, residential and agricultural purposes. To date there has been almost no effort to direct this development in such a way as to minimize susceptibility to flooding.

The most obvious approach to minimizing future damage is effective planning and regulation of the use of flood plain land. If such planning and

regulation is not undertaken, the potential for damage from a flood such as that of 1973 will continue to increase . There is also a need to consider ways of reducing future damage to the existing development on the flood plains. Considerable damage could have been avoided if some of the larger government and privately owned buildings in Fredericton had been flood proofed in 1973. In many cases the cost of flood proofing would have been much less than the 1973 losses. Seepage of water into basements during the flood caused severe damage to stock, machinery, equipment and supplies. It may be possible to restrict or discourage extensive use of basements below certain elevations.

REFERENCE

1. Report on the New Brunswick Flood April-May 1973, prepared by the Atlantic Region, Inland Waters Directorate, Department of the Environment, Halifax, Nova Scotia.

Region: New Brunswick
Canada
Catastrophic Floods for the Year 1973

No.	Name of River, Province	Station or Site Location	Co-ordinates	Drainage area in sq. miles of the river up to the station
1	2	3	4	5
	Saint John River, New Brunswick	Saint John River below Mactaquac Dam $8\frac{1}{2}$ miles upstream of Fredericton	45° 57' 44" 66° 49' 51"	Drainage above gauge 15,400 sq. miles Total drainage area to mouth of river - 21,300 sq. miles.

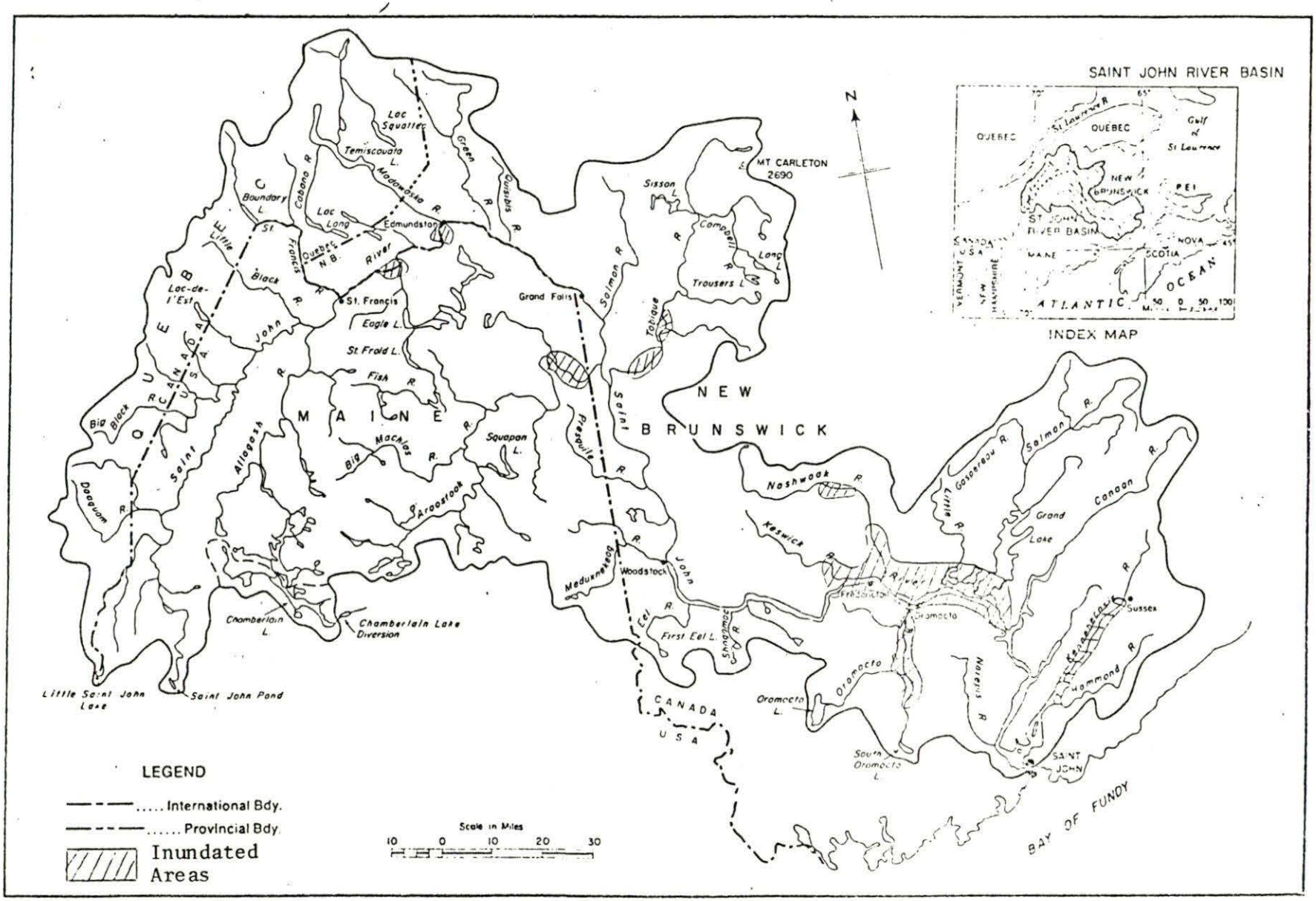
Flood Elevation above M.S.L.		Max. flood levels ever recorded during flood	Period of flood Period of Inundation	Characteristics of Flood	
Damage (danger) level	max. recorded during flood			Base flow	Q_{max}
6	7	8	9	10	11
About 20' above M.S.L. at Fredericton	28.3' at Fredericton	Max. flood levels occured in 1936 when an ice jam caused levels to reach 29.2' (1922-1973)	about 16 days at Fredericton Apr. 23 to May 8 *	40,700 cfs	435,000 cfs

* Period of inundation at Fredericton - 1 week
at Maugerville (downstream of Fredericton) - 3 weeks

Characteristics of Flood					Flood Damages
qmax	h	TB (hrs) t_p (hrs)	P% Type of Probability Used	Type	No. of lives lost Total population affected (in millions)
12	13	14	15	16	17 1 life indirectly attributed to flood
28.25 cfs./sq. mi.	7.7 in*	TB = 18 days (432 hrs.) tp = time of rise not applicable as multiple peak flood	1.2% Max. discharge 435,000cfs computed by Method of Max. likelihood based on extreme value dist postulated by Gumbel	M Mixed	Damages in Fredericton were limited to mainly basement flooding. Total of 0.3 million affected by flood. (1,458 evacuees downstream of Fredericton)

Flood Damages	
Total damages to crops, houses and public utilities	Total area of inundation in acres
18	19
$10,800,000 damage for the entire basin	230,400 acres were flooded along the Saint John River below Fredericton

* Determined for Saint John River at East Florenceville gauge
Drainage area 13,200 sq. mi.
Located 76 miles upstream of Saint John River below Mactaquac Dam gauge.



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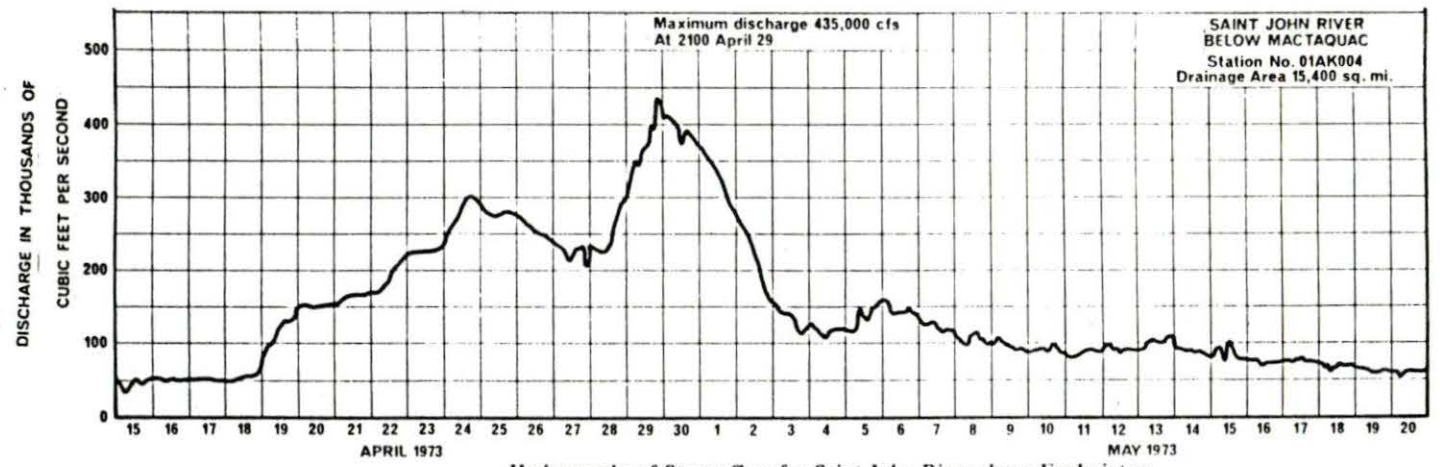
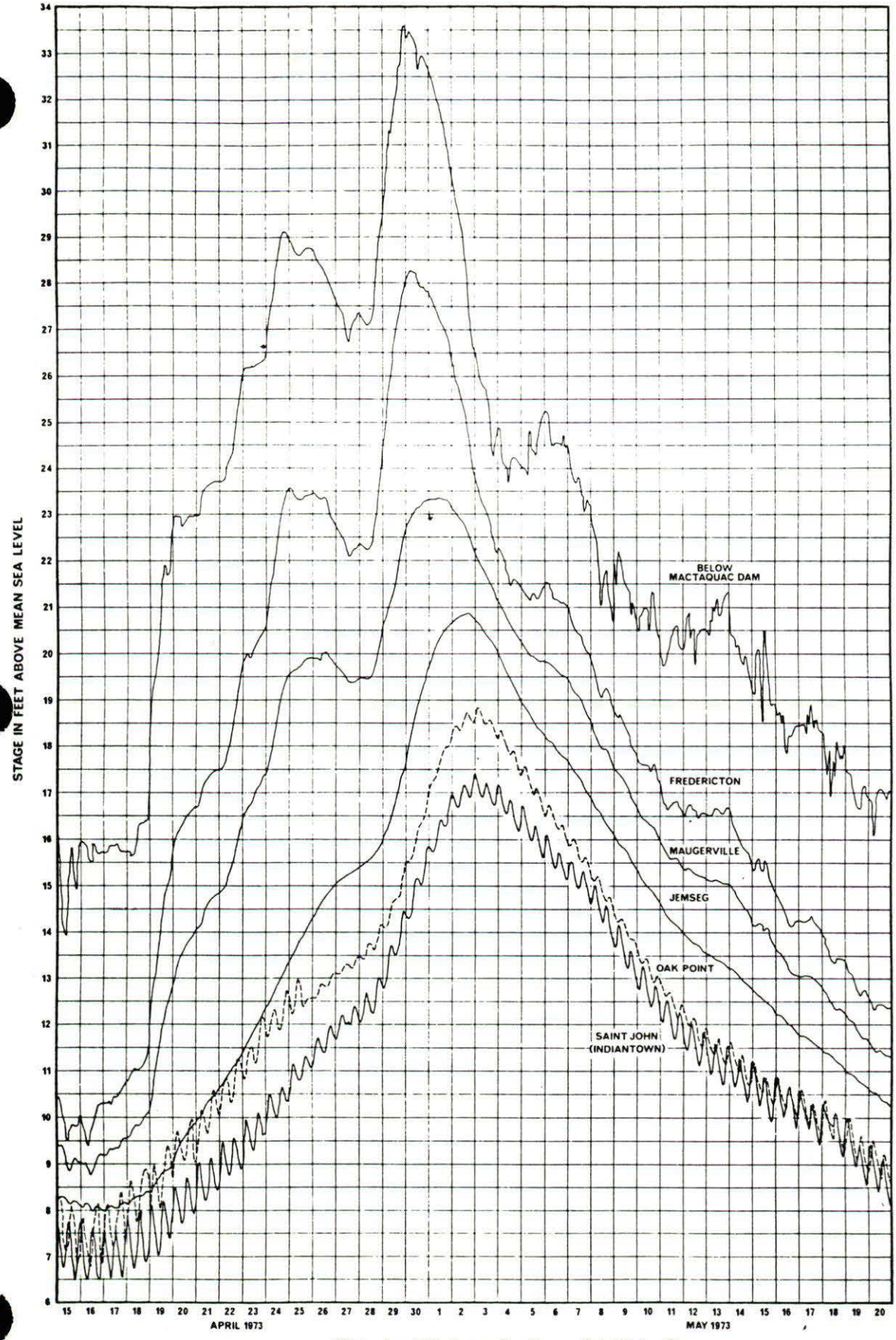


Hydrographs of Streamflow for Saint John River above Fredericton



Water Level Hydrographs - Lower Saint John River