Environment Canada   Environnement Canada

New Brunswick Flood April - May 1973

TECHNICAL BULLETIN NO. 81

(Résumé en français)

INLAND WATERS DIRECTORATE,
ATLANTIC REGION,
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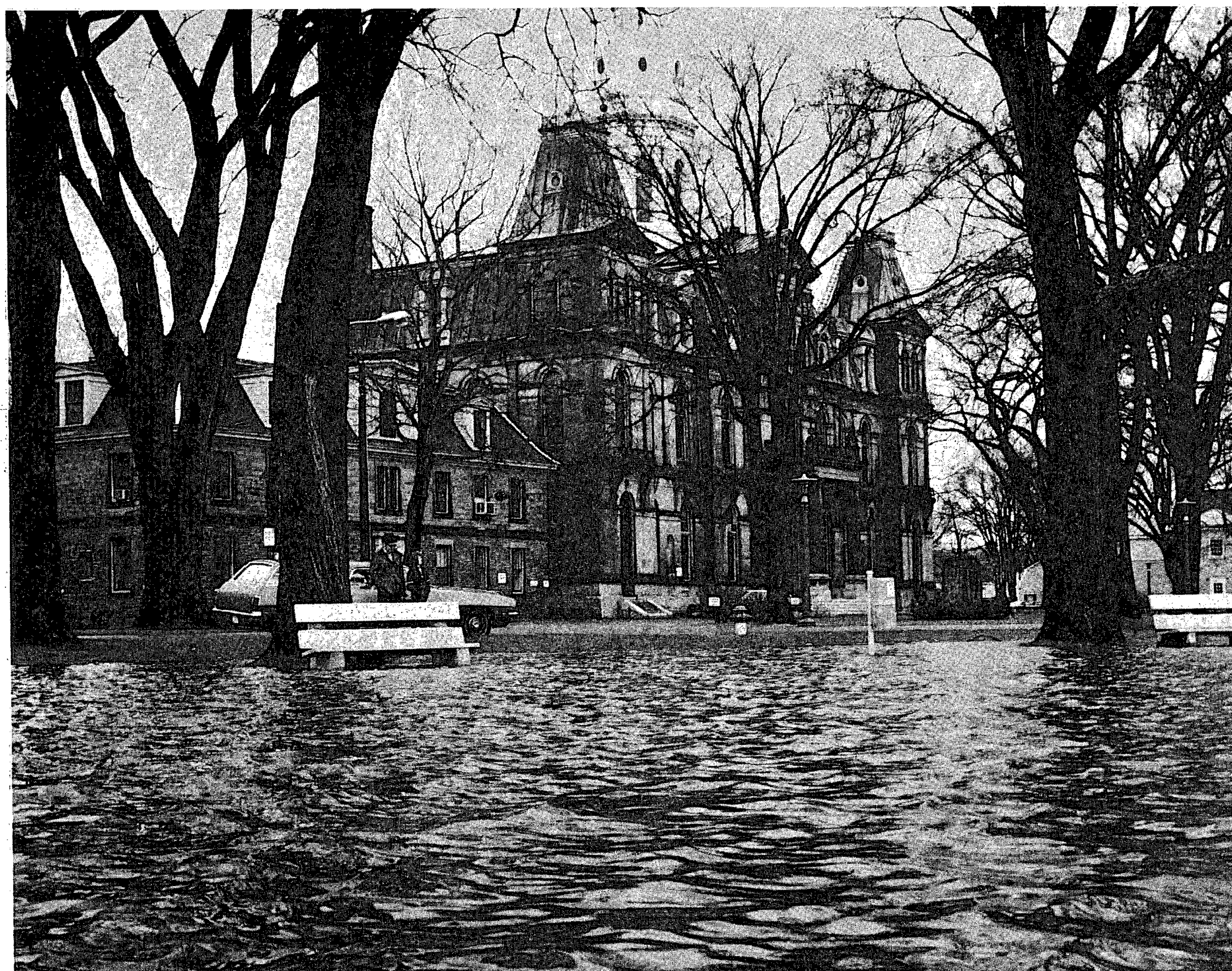


Photograph 1 – Legislative Building, Fredericton, prior to peak stage, 29 April 1973

Abstract

During the latter part of April and early part of May 1973, extreme flood conditions occurred in most parts of New Brunswick. These conditions were caused by rainfall combined with heavy snowmelt.

The winter of 1972-73 was one of above average snowfall in northern and central New Brunswick. By mid-April the water equivalent of accumulated snow 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 bringing higher temperatures and rainfall averaging about three inches. 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 daily mean discharge of 393,000 cubic feet per second on April 30. Based on recorded stage data, the peak stage at Fredericton was estimated to have a recurrence interval of 70 years. Most rivers gradually receded after April 30 but the lower reach of the Saint John River between Fredericton and Saint John continued to rise until May 2. The constriction of the Reversing Falls at the mouth of the river caused a continued accumulation of water in this reach 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.

The total economic cost of the flood was estimated to be $11.9 million. Of this, $10.8 million was attributed to the Saint John River basin, about $1.0 million to the river basins in northeastern New Brunswick and less than $0.1 million to the southwestern basins. In terms of economic sectors; the Public Sector sustained the highest cost of $4.9 million, followed by the Personal Sector with $4.2 million, the Business Sector with $1.7 million, the Agricultural Sector with $0.7 million and the Organizational Sector with $0.3 million. Compensation was provided by the federal and provincial governments to the extent of 63 per cent of the estimated total economic cost in the province. The federal share of this compensation was about $5.3 million.

The most seriously affected part of the province was the flood plain of the lower Saint John River in the Fredericton area and in the agricultural lands a few miles downstream of Fredericton. Damages in these two areas accounted for about 60 per cent of the total economic cost of the flood.

Other areas seriously affected by the flood were the middle and upper parts of the Saint John River basin, the Restigouche River basin, the Miramichi River basin and the Grand Lake area in the lower part of the Saint John River basin. In each of these areas economic costs were in excess of one-half million dollars. The magnitude of the flood varied from river to river, but at most stream gauging stations in these areas, the recorded discharges have estimated recurrence intervals within the range of 10 to 50 years.

Although the 1973 flood was of a high magnitude, it cannot be considered as an isolated occurrence which will not happen again. The Province of New Brunswick, and particularly the Saint John River, has a history of flooding dating back to the arrival of the first settlers. Rough estimates for the Saint John River basin indicate that within the present century, six floods have each caused damages in excess of one million dollars.

The magnitude of the flood problem in New Brunswick is sufficient to warrant full consideration of all possible ways to minimize the effects of future floods. There is a critical need for more effective planning and regulation of the use of floodplain lands. Continued development of these low-lying lands, in the pattern of recent years, will significantly increase the potential for damage from a future flood such as the one of 1973. For protection of existing developments susceptible to flooding, a full range of other alternative flood control measures should be investigated.

During the 1973 flood, forecasting and emergency measures activities were successful in avoiding more serious personal hardship and greater economic losses. Warning provided, through weather and streamflow forecasting, permitted some advance planning to react to the emergency while the Emergency Measures Organization proved its worth in directing the disaster activities. In spite of this, the flood caused an estimated $2.5 million in damage to moveable property. Continuation and improvement of flood forecasting and emergency measures programs are clearly desirable.

Résumé

À la fin avril et au début mai 1973, de fortes inondations se sont produites sur presque tout le territoire du Nouveau-Brunswick. Elles avaient été causées par des pluies accompagnées d'une abondante fonte des neiges.

Pendant l'hiver 1972-73, il est tombé plus de neige que d'habitude dans le centre et le nord du Nouveau-Brunswick. Vers le milieu avril, l'equivalent en eau de la neige accumulée atteignait 12 pouces dans certaines régions et une moyenne de 7.2 pouces dans la partie du bassin du Saint-Jean située en amont du barrage Mactaquac. Du 21 au 24 avril, la fonte des neiges et quelques chutes de pluie ont provoqué des crues plus élevées que les crues printanières habituelles. Dans la plupart des cours d'eau, les eaux ont atteint leur plus haut niveau vers le 24 ou le 25 avril pour ensuite commencer à baisser sous l'effet d'une diminution de température qui a ralenti la fonte des neiges.

Le 27 avril, une tempête extratropicale (frontale) a frappé le nord et le centre du Nouveau-Brunswick, entrainant une hausse de température et des précipitations moyennes de trois pouces environ. Les eaux sont montées rapidement pour atteindre dans plusieurs cas un niveau sans précédent. La crue a atteint sont point culminant le 29 et le 30 avril. Le 30 avril, le Saint-Jean avait, en aval de Mactaquac, un débit quotidien moyen de 393,000 pieds cubes à le seconde. D'après les statistiques sur le niveau de l'eau, le niveau d'inondation maximal, à Fredericton, reviendrait tous les 70 ans. Dans la plupart des cours d'eau, les eaux ont baissé graduellement à partir du 30 avril, mais celles du tronçon inférieur du Saint-Jean, situé entre Fredericton et Saint-Jean, ont continué de monter jusq'au 2 mai. Malgré la réduction des apports, les eaux ont continué de s'accumuler dans le bas du fleuve à cause des "Reversing Falls" de l'embouchure. Les importants volumes d'eau refoulés par la marée à "Reversing Falls" rendent les caractéristiques de crue du bas Saint-Jean extrêmement complexes.

Le coût total de l'inondation s'est chiffré a 11.9 millions de dollars répartis ainsi: 10.8 millions dans le bassin du Saint-Jean; environ 1 million dans les bassins du nord-ouest du Nouveau-Brunswick et moins de 0.1 million dans les bassins du sud-ouest. Le secteur économique le plus durement touché a été le secteur public avec des pertes de 4.9 millions, suivi du secteur des particuliers où elles ont été de 4.2 millions; le commerce, l'agriculture et les organisations ont respectivement subi des pertes de 1.7, 0.7 et 0.3 million de dollars. Les gouvernements fédéral et provincial ont versé des indemnités correspondant à 63 pour cent du total des dégâts matériels subis par la province. La contribution du fédéral à ce programme d'indemnisation s'est élevée à 5.3 millions de dollars.

La plaine d'inondation du bas Saint-Jean, dans la région de Fredericton et dans les terres agricoles situées à quelques milles en aval de Fredericton, a été la région la plus durement touchée. Ces deux régions ont subi, à elles seules, environ 60 pour cent des pertes économiques causées par l'inondation.

Les parties centrale et supérieure du bassin du Saint-Jean, les bassins de la Restigouche et de la Miramichi et la région du Grand Lac, dans la partie inférieure du bassin du Saint-Jean sont d'autres régions où les crues ont causé des dégâts considérables. Chacune d'elles a subi des pertes de plus d'un demi million de dollars. L'importance des crues a varié selon les rivières, mais la fréquance des débits enregistrés à la plupart des stations de jaugeage de ces régions s'établit entre une fois par dix ans et une fois par cinquante ans.

Bien que l'inondation de 1973 ait été particulièrement forte, rien n'indique qu'il s'agisse d'un phénomène exceptionnel qui ne se reproduira plus. Tout le passé du Nouveau-Brunswick, notamment celui du Saint-Jean, témoigne de cette menace constante. Des chiffres approximatifs révèlent qu'il y a eu au cours du présent siècle six inondations dans le bassin du Saint-Jean, causant chacune plus d'un million de dollars de dommages.

La gravité des inondations au Nouveau-Brunswick justifie un examen complet de tous les moyens susceptibles de réduire au minimum les effets des prochaines crues. Les terres situées dans les plaines d'inondation ont un urgent besoin d'une planification et d'une réglementation plus efficaces. Si ces terres basses continuent à être aménagées au même rythme que dans les dernières années, une inondation comme celle de 1973 y causera des dégats beaucoup plus considérables. Il faudrait étudier l'éventail complet de tous les autres moyens de lutte contra les crues afin d'assurer la protection des aménagements actuals déjà exposés aux inondations.

Lors de l'inondation de 1973, les dommages corporels ainsi que les pertes économiques ont pu être limitée grâce à la prévision des crues et aux mesures d'urgence. Les avertissements fournis par les prévisions météorologiques et les prévisions des débits d'eau ont permis d'anticiper les crues et s'y préparer dans une certaine mesure. L'Organisation des mesures d'urgence s'est montrée à la hauteur de la situation par la façon dont elle a dirigé les opérations lors du désastre. Malgré tout, les dommages causés aux biens meubles par l'inondation ont été évalués à environ 2.5 millions de dollars, d'où la nécessité de poursuivre et d'améliorer les programmes de prévisions de crues et de mesures d'urgence.

Acknowledgements

The preparation of this report would not have been possible without the assistance and co-operation of a large number of agencies and individuals. Studies of snowmelt, precipitation and storm meteorology were undertaken by the Atmospheric Environment Service, Department of the Environment. The New Brunswick Electric Power Commission analysed the flow forecasts made during the flood, supplied information and advice on hydrologic aspects of the flood and provided temporary office accommodation in Fredericton for staff collecting data for the report. The New Brunswick Department of Fisheries and Environment assisted by providing information and advice on all aspects of the study.

Many other federal and provincial agencies supplied information and assistance in one form or another. Some of the more significant contributions were made by the Canada Department of Public Works, the Saint John River Basin Board Study Office, the Federal and Provincial Emergency Measures Organizations, the New Brunswick Department of Agriculture, the New Brunswick Department of Municipal Affairs, the New Brunswick Department of Highways, the New Brunswick Treasury Board Office, and the Maritime Resource Management Service.

Acknowledgement must also be given to the many private individuals, business establishments, municipalities, institutions and organizations which co-operated in providing information on direct and indirect flood damages when contacted for this purpose.

Introduction

The primary objective of this report is to provide a basic understanding of the causes, economic effects and conditions associated with the flood of April-May 1973 in New Brunswick. It is hoped that such an understanding will lead to more effective flood plain management and flood damage reduction practices.

This report contains an analysis of the information collected during and following the flood, including meteorological, hydrologic and damage data. It also contains a summary of the climatic and physiographic features of New Brunswick and descriptions of the river basins subject to flooding during 1973.

The causes of the flood are described by reference to snowfall and snow accumulation during the winter of 1972-73, snowmelt rates during the spring of 1973 and rainfall from a frontal storm of late April 1973. The report contains analyses of each of these factors and a summary of the progress of the flood as it occurred in various parts of the province. Particular emphasis is placed on the lower portion of the Saint John River which, during flood periods, acts somewhat like a large storage reservoir in accumulating runoff volumes.

The report examines the maximum discharges recorded at all hydrometric stations in New Brunswick and in adjacent areas of Quebec and Maine. Flood frequency and stage frequency analyses are presented for those stations with ten or more years of record. The effect of storage on peak discharges and runoff volumes is discussed and a comparison is made between recorded runoff volumes and water inputs from rainfall and snowmelt.

A flood forecasting system for the Saint John River basin was developed early in 1973 and operated prior to the flood. This system and the emergency measures undertaken during the flood are described and evaluated in the report.

The report also contains an extensive analysis of the economic costs of the flood. In the process of compiling information on costs, surveys were conducted of direct and indirect damages to the public, personal, business, agricultural and organizational sectors. The methods used and results of these surveys are described along with damage compensation by federal and provincial governments. Economic costs are listed by sector for selected areas of the province. An estimate is also made of the damage to moveable property.

The 1973 flood is compared with former floods, from the point of view of both streamflows and damages, to give an indication of its magnitude. Major lessons to be learned from the flood are also discussed as an aid to government agencies, municipalities and individuals in reducing the effects of future floods.

Physiography and Climatology of New Brunswick

The Province of New Brunswick is the westernmost of the three Maritime Provinces and, with a total of about 28,000 square miles, the largest. It borders on Quebec to the north and Nova Scotia to the east, while to the west and south the province shares the international boundary with the State of Maine.

PHYSIOGRAPHY

New Brunswick is an extension of the system of uplands and highlands of the Appalachian region of eastern North America. About sixty per cent of the province is highland, most of this being forested.

The physiographic divisions of New Brunswick and adjacent areas of Quebec and Maine, as delineated in the 1957 Atlas of Canada(1), are shown on Figure 1. The principal divisions are the Notre Dame Mountains, the Chaleur Uplands, the New Brunswick Highlands and the Gulf of St. Lawrence Plain.

The extreme northwestern part of New Brunswick and most of the Gaspé Peninsula lie in the Notre Dame Mountain Region. In the portion of this region within New Brunswick, elevations vary from about 500 feet in the valleys of the major rivers to more than 2,000 feet. Numerous lakes are found in this region. Most of the area is forested but some land in the river valleys is used for agricultural purposes.

The Chaleur Uplands, comprising most of the basin of the Saint John River upstream of Woodstock and the Restigouche River basin, form a peneplain ranging in elevation from 800 to 1,000 feet above sea level. Swampy plains and numerous lakes characterize the Uplands. The regularity of the plain is broken by valleys, such as that of the Saint John River, and by ridges and peaks. Some of these peaks attain elevations in excess of 2,000 feet. Except for a few small areas where Upper Palaeozoic rocks are found, the Chaleur Uplands are underlain by Lower Palaeozoic sedimentary rocks, consisting chiefly of shale, sandstone and limestone. In many instances, the development of cleavage has obliterated bedding planes. While ~~most~~ of the land in the Chaleur Uplands is forested, a significant portion has been cleared for agricultural purposes and is the center of the important potato growing industry in both Maine and New Brunswick.

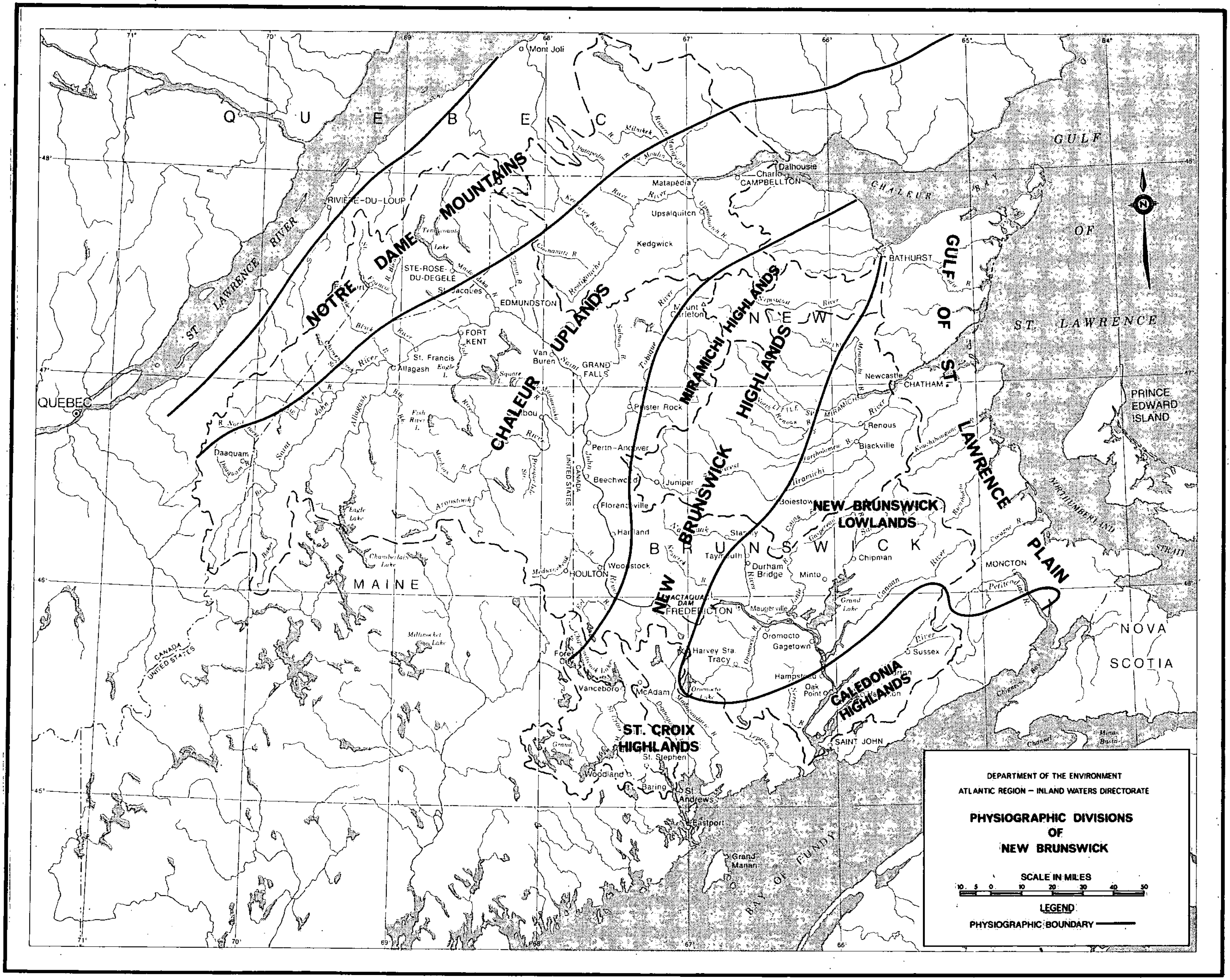
The Miramichi, St. Croix and Caledonia Highlands form a U-shaped region known as the New Brunswick Highlands which cover a large part of central and southern New Brunswick. Mount Carleton (elevation 2,690 feet) in the Miramichi Highlands is the highest point in New Brunswick. The Lower Palaeozoic metamorphosed sedimentary and volcanic rocks underlying the region have been intruded by granite, gabbro and allied igneous rocks. Near Hartland, on the Saint John River, a small area of Upper Palaeozoic rocks has been preserved. The metamorphic rocks are chiefly argillite, quartzite, schist, and gneiss. Since these rock types exhibit a greater resistance to erosion than those of the Uplands and Lowland, the Highlands have a much more rugged topography. Many rock outcrops exist in this region.

The New Brunswick Lowland, which is that portion of the Gulf of St. Lawrence Plain in the province, lies between the two arms of the Highland region. The Lowland is formed by an area of flat or gently dipping Upper Palaeozoic sedimentary rocks. The rocks have formed from continental or brackish water sediments and are chiefly sandstones, shales and conglomerates, accompanied by lesser amounts of coal, gypsum, anhydrite and limestone. They have not been folded to the same extent as the older rocks of the Lower Palaeozoic Age and are, therefore, less compact and more easily eroded. Relief in the area is gentle and rarely exceeds 600 feet above sea level. Gentle river slopes and broad floodplains make this region the major area of flood damage in New Brunswick.

The overburden throughout the province is of Pleistocene origin and is mainly glacial till composed of variable silty, gravelly sand with cobbles and boulders deposited in a blanket of varying thickness over bedrock. The cover is generally thin over the hills and deeper in the valleys. It is absent on the tops and steep slopes of some hills. The composition of the till generally reflects the characteristics of the underlying bedrock. For example, silty tills predominate over shales, whereas sandy tills predominate over sandstone and conglomerate.

Characteristic features in many of the larger valleys are terraces, deltas and glacial outwash plains. Glacial damming of main valleys at the time of the ice retreat temporarily created large lakes in which deposits of silt were formed. The southeastern part of the province was inundated by a post-glacial invasion of the sea and deposits of marine clay were laid down over the outwash material or till.

The preglacial valley of the Saint John River, which was much wider and deeper than its present valley, was filled in with overburden in the Pleistocene Age. Although the Saint John River still flows in the same valley, it has only partially eroded the glacial deposits. It has not cut down to its preglacial level. In most stretches of the


DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION – INLAND WATERS DIRECTORATE
PHYSIOGRAPHIC DIVISIONS OF NEW BRUNSWICK
SCALE IN MILES
LEGEND
PHYSIOGRAPHIC BOUNDARY
NOTRE DAME MOUNTAINS
CHALEUR UPLANDS
MIRAMICHI HIGHLANDS
NEW BRUNSWICK HIGHLANDS
NEW BRUNSWICK LOWLANDS
GULF OF ST. LAWRENCE PLAIN
CALEDONIA HIGHLANDS
ST. CROIX HIGHLANDS
QUEBEC
NEW BRUNSWICK
MAINE
NOVA SCOTIA
PRINCE EDWARD ISLAND
GULF OF ST. LAWRENCE
CHALEUR BAY
BAY OF FUNDY
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Blackville
Boiestown
Chipman
MONCTON
FREDERICTON
MACTAQUAC DAM
Oromocto
Gagetown
Sussex
SAINT JOHN
St. Stephen
St. Andrews
Eastport
Grand Manan
Woodstock
HOULTON
McAdam
Vanceboro
Harvey Sta.
Tracy
Minto
Durham Bridge
Maugerville
Hampstead
Oak Point
Plaster Rock
Perth-Andover
Florenceville
Hartland
Beechwood
Juniper
Stanley
Taymouth
Van Buren
St. Francis
Allagash
Daaquam
Woodland
Baring

Figure 1

river, the side slopes and the bottom of the old valley are completely obscured by overburden deposits. In a few places, however, the river flows very close to the old valley walls, and has exposed rock on the banks and sometimes on the bottom of the river.

CLIMATIC FACTORS

According to the Koppen classification(2), the climate of New Brunswick is categorized as a snow forest climate with no distinct dry season and warm summers.

The mean annual temperature decreases northward from the low 40's at Saint John to the high 30's north of Edmundston and along the Northumberland Strait. Mean monthly and annual temperatures at a number of locations in the province are shown in Table 1. The figures in the table demonstrate the moderating effect of the Bay of Fundy and the Atlantic Ocean on temperatures. Thus, winters are milder and summers cooler along the Bay of Fundy than further inland. In the upper part of the Saint John River basin, minimum temperatures of -30°F are not uncommon and temperatures below -40°F have been reported. Maximum temperatures often exceed 80°F and have occasionally reached 100°F. The average length of the frost-free season varies from approximately 160 days along the Fundy shore to less than 100 days in the northern part of the province.

Annual precipitation varies from about 35 inches in the northwest to about 55 inches along the Bay of Fundy. The mean annual precipitation for the province as a whole is about 42 inches. Table 2 lists average monthly and annual precipitation at specific locations in New Brunswick. The variability of annual precipitation is not too great, the standard deviation being less than 15 per cent of the mean. Precipitation is quite uniformly distributed over the four seasons.

In the northern part of the province, average annual snowfall ranges from 100 to 140 inches. In the southeastern part along the Bay of Fundy the total snowfall is in the order of 70 to 90 inches per year. About 30 per cent of the mean annual precipitation which falls on the northern and central parts of the province is in the form of snow.

Winter snow cover usually runs off in April or in the first half of May. In March of the average year, prior to spring runoff, snow lies about two or three feet deep in that portion of the Saint John River basin above Fredericton and an average of about one foot deep along the Bay of Fundy. Water equivalent in this snow cover averages about five to seven inches in the area north of Fredericton and two to three inches along the Fundy shore(3).

New Brunswick lies in the path of many frontal storms. Hurricanes or tropical storms originating in the

Table 1 – Average Monthly and Annual Temperatures in New Brunswick

(Mean Temperature in Degrees Fahrenheit)

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Bathurst	13.5	14.4	24.4	36.7	48.4	59.0	66.0	63.7	55.1	44.9	33.7	19.3	39.9
Edmundston	9.4	12.7	23.0	36.9	50.2	59.7	65.4	62.8	54.3	44.0	31.5	15.9	38.8
Fredericton	15.4	16.7	27.3	39.2	50.9	60.3	66.3	64.4	56.4	46.3	35.2	20.6	41.6
Moncton	17.5	18.1	27.0	38.4	49.6	58.9	65.5	63.5	55.7	46.0	36.2	22.4	41.6
Saint John	20.3	21.7	39.8	39.7	49.1	56.5	62.0	62.3	56.9	48.3	38.6	26.1	42.6

Table 2 – Average Monthly and Annual Precipitation in New Brunswick

(Mean Precipitation in Inches)

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Bathurst	3.24	2.97	2.91	2.41	3.07	2.98	3.23	3.13	2.93	3.32	3.73	3.06	36.98
Edmundston	2.93	2.98	2.56	2.83	3.23	4.20	3.85	3.51	3.24	3.23	3.55	2.77	38.88
Fredericton	3.57	3.40	2.89	3.18	3.45	3.39	3.55	3.38	3.42	3.58	4.72	4.15	42.68
Moncton	3.70	3.40	3.13	3.01	3.02	3.37	3.09	2.93	2.90	3.41	4.03	3.73	39.72
Saint John	4.95	4.49	3.87	3.93	4.05	3.69	3.53	3.93	3.93	4.12	5.72	5.19	51.40

Caribbean area also occasionally influence parts of the province during the period from July to October. Rainfalls of up to 72 hours in duration with a total precipitation of 12 inches have been recorded. The main storm track affecting the province has a southwest to northeast orientation and the isohyetal patterns tend to be elongated in that direction. Thus, although rainfall may be general over much of the province the extreme precipitation is usually concentrated in a relatively narrow belt. The total storm precipitation usually falls off rapidly in the southeast and northwest direction from the axis of the storm path.

Description of New Brunswick Drainage Basins

The drainage basins of New Brunswick are divided into four regions in this report. The regions, defined principally by geographic location and, to some extent, by climatic and runoff characteristics, are as follows:

- Saint John River Basin
- Southwestern Basins, or those lying to the south and west of the Saint John River basin and draining into the Bay of Fundy west of Saint John
- Northeastern Basins including the Miramichi and those located to the north of the Miramichi which lie east of the Saint John River basin and drain to the Gulf of St. Lawrence
- Southeastern Basins, or those lying east of the Saint John basin and south of the Miramichi basin. They drain either to the Bay of Fundy east of Saint John or to Northumberland Strait south of Chatham.

The principal drainage systems within these regions are delineated on Figure 2.

SAINT JOHN RIVER 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 per cent or 10,950 square miles lie in New Brunswick, 13 per cent or 2,750 square miles in Quebec and the remaining 36 per cent or 7,600 square miles in Maine.

Historically, the Saint John River basin has been subject to periodic flood damage 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. The two most notable examples were the floods of May 1961 and February 1970 which caused direct damages in the basin of about 2.3 million dollars and 3.0 million dollars respectively[4].

The River and Its Tributaries

From its point of origin above 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 Grand Falls, New Brunswick. Here it turns south and continues 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 area of Maine. Below Grand Falls, the Saint John River 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. Some of the larger tributaries, listed in downstream order, and their respective drainage areas at their confluence with the Saint John River are as follows:

Big Black River	625 square miles
Allagash River	1260 square miles
St. Francis River	550 square miles
Fish River	892 square miles
Madawaska River	1177 square miles
Green River	455 square miles
Aroostook River	2423 square miles
Tobique River	1670 square miles
Meduxnekeag River	515 square miles
Nashwaak River	680 square miles
Oromocto River	778 square miles

Salmon River	1500 square miles
Canaan River	589 square miles
Kennebecasis River	531 square miles

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 Mactaquac, which is located eight miles upstream of Fredericton and presently utilizes a head of about 110 feet. The combined capacity of these developments is 572.5 megawatts. A bed profile of the river showing the headponds of these three dams is given on Figure 3.

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 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.

Economic Features

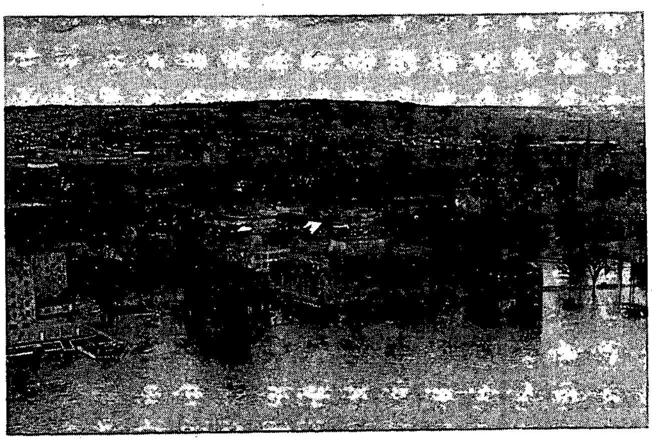
The controlling geographical and topographical factors in the Saint John River basin have led to the concentration of development in the river valleys. Consequently, the Saint John River system has been developed as a multi-use resource, where lumber, pulp and hydro-electric power are the most important though not the only industries. Recreation, fishing, transportation, agriculture and food processing interests also utilize the water resources of the basin. The river has been and is still used to some extent for disposal of municipal and industrial waste. An extreme flood, with the accompanying inundation of industrial, residential, commercial and farm buildings and agricultural lands, damage to intake and control structures, bridges, highways and railroad beds and disruption of transportation and communication facilities, can be a serious blow to the entire economy of the basin.

In the Canadian portion of the northern part of the basin, forestry is the most important industry, while agriculture, mainly potato and dairy farming, is of secondary importance. The most important population centers are Edmundston and Grand Falls. Edmundston is the location of the Fraser Companies Limited pulp mill and other secondary forestry based industries. It is also a regional transportation center served by the main freight line of the Canadian National Railway and by the Trans-Canada Highway. In the Grand Falls area, potato farming and potato processing are of greater importance. Tourism is mainly directed at local residents.

The area between Grand Falls and Woodstock is the heart of the potato industry of New Brunswick. Farming provides the main output of the local economy and food processing at Florenceville is the largest single employer. This part of the basin is also traversed by the Trans-Canada Highway and supports a limited tourist trade. On the tributaries, forestry and power production are the main economic activities.

The lower part of the basin, downstream of Woodstock, is one of the major economic areas in the province. It supports most forms of economic activity. The forest industry is significant but its relationship with the rest of the regional economy is not as one-sided as in the northern portions of the basin. Pulp and paper are produced at Nackawic and Saint John while logging is carried out on the Nashwaak and Oromocto Rivers and, to a lesser extent, in the Grand Lake and Kennebecasis areas.

Agriculture is a major industry in the Maugerville-Sheffield area below Fredericton, where vegetables, dairy products and poultry are produced and in the Sussex and Hampton districts, where dairy farming and beef production are the main activities. Tourists are attracted to this part of the basin by provincial parks at Mactaquac and Grand Lake, the Reversing Falls at Saint John and secluded properties on most tributaries and the main stem of the river. The military installation at Canadian Forces Base Gagetown provides the economic base of the Oromocto district. Mining is an industry of limited importance, but in the Minto-Chipman area on Grand Lake, the local economy relies heavily on coal mining. The lower part of the basin also contains two of the province's three largest urban areas: Fredericton and Saint John.



Photograph 2 – Aerial view of downtown Fredericton, 30 April 1973.

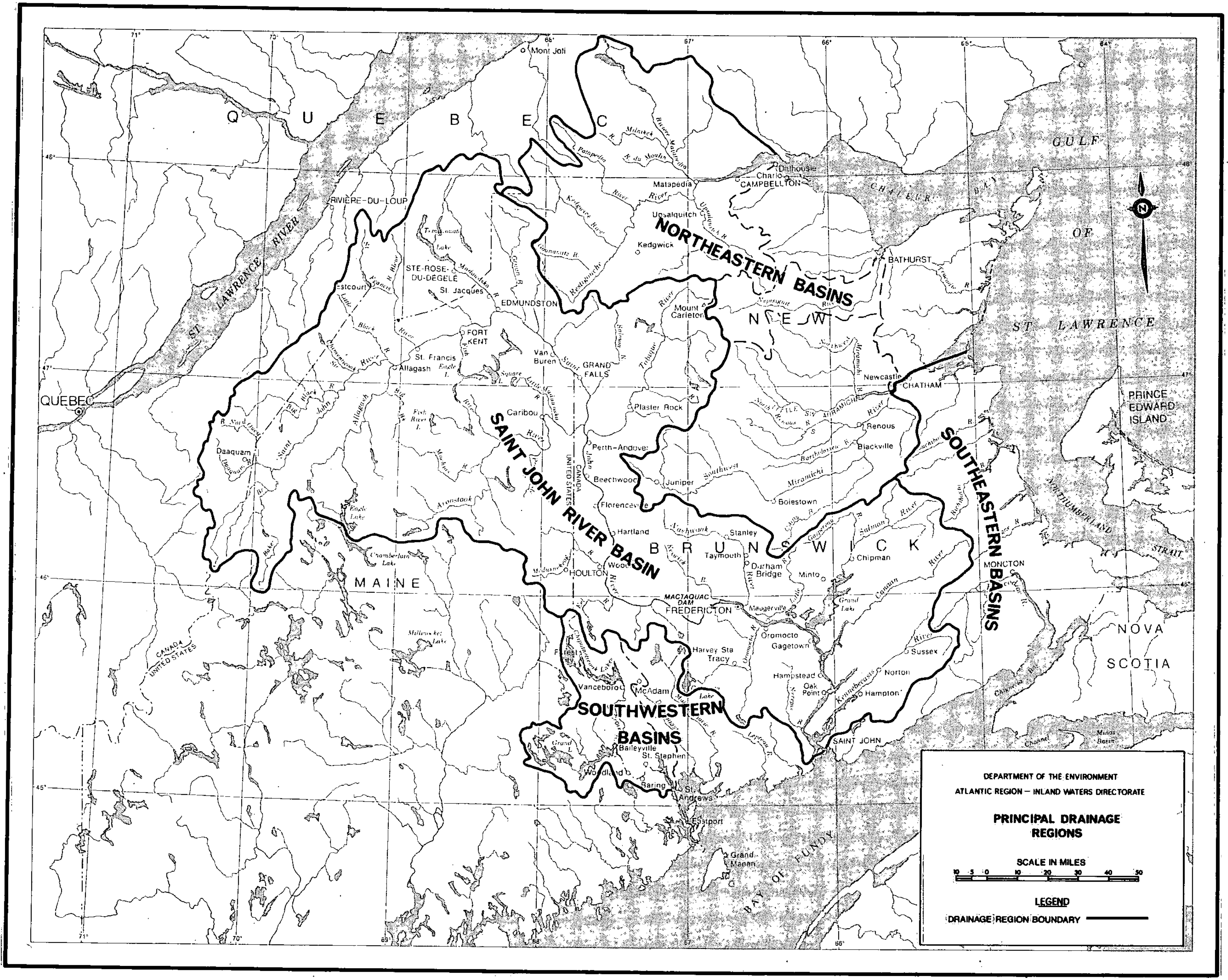

DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION – INLAND WATERS DIRECTORATE
PRINCIPAL DRAINAGE REGIONS
SCALE IN MILES
LEGEND
DRAINAGE REGION BOUNDARY
NORTHEASTERN BASINS
SAINT JOHN RIVER BASIN
SOUTHEASTERN BASINS
SOUTHWESTERN BASINS
QUEBEC
MAINE
NEW BRUNSWICK
NOVA SCOTIA
PRINCE EDWARD ISLAND
GULF OF ST LAWRENCE
BAY OF FUNDY
NORTHUMBERLAND STRAIT
ST. LAWRENCE RIVER
CANADA
UNITED STATES
Mont Joli
RIVIÈRE-DU-LOUP
QUEBEC
STE-ROSE-DU-DEGELE
St. Jacques
EDMUNDSTON
Estcourt
FORT KENT
St. Francis
Allagash
Van Buren
GRAND FALLS
Caribou
Daaquam
Dalhousie
Charlo
CAMPBELLTON
Matapedia
Upsalquitch
Kedgwick
BATHURST
Mount Carleton
Newcastle
CHATHAM
Plaster Rock
Perth-Andover
Renous
Blackville
Juniper
Beechwood
Florenceville
Boiestown
Hartland
Stanley
Taymouth
Durham Bridge
Chipman
Minto
Woodstock
HOULTON
MONCTON
MACTAQUAC DAM
FREDERICTON
Maugerville
Oromocto
Gagetown
Harvey Sta
Tracy
Sussex
Hampstead
Norton
Oak Point
Hampton
Vanceboro
McAdam
Baileyville
St. Stephen
Woodland
Baring
St. Andrews
Eastport
Grand Manan
SAINT JOHN

Figure 2

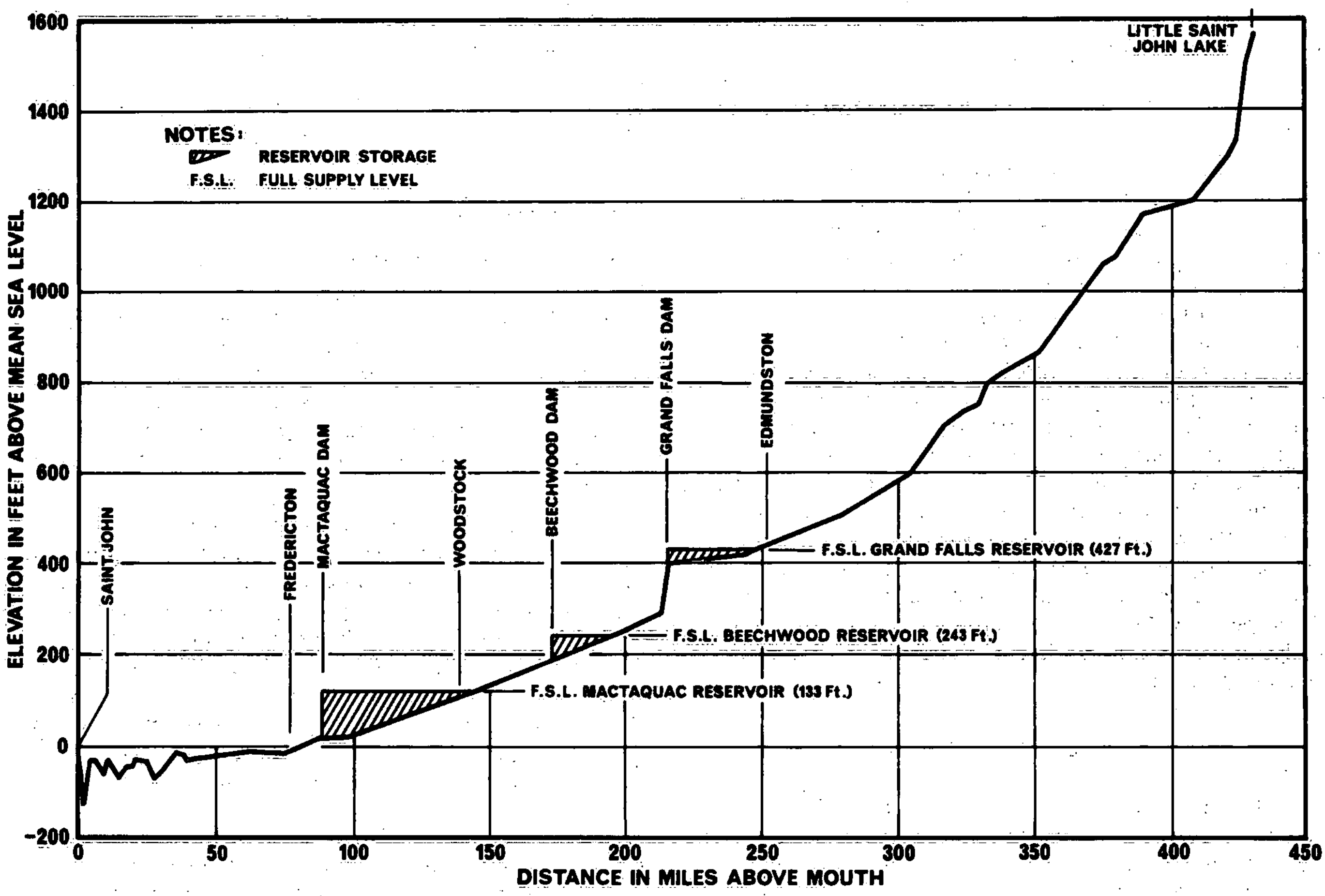


Figure 3 – Bed Profile - Saint John River

The economy of Fredericton is heavily dependent on government and educational institutions. The city is the capital of New Brunswick and houses two universities and a forest ranger school. Secondary manufacturing is an important employer in Fredericton but mostly in light, rather than heavy, industry. The City of Saint John, apart from its forest based activities, counts oil refining, ship building, commercial shipping and fishing among its principal economic activities. It is the largest city in the province and its economy is New Brunswick's most significant. The recently completed oil terminal at Mispec Point and the proposed supertanker port at Lorneville lend credence to the view that Saint John's future as a port is promising.

SOUTHWESTERN BASINS

The river basins to the south and west of the Saint John River basin drain the St. Croix Highlands physiographic region. The principal streams, in their order from east to west, and their approximate drainage areas are as follows:

Lepreau River	92 square miles
Magaguadavic River	650 square miles
Digdeguash River	180 square miles
St. Croix River	1640 square miles

Space does not permit a detailed description of each of these drainage systems but the St. Croix, being the largest and most important, warrants some further comments. It is formed by the confluence of the east and west branches at a point approximately 20 miles upstream from its mouth near St. Stephen, New Brunswick. The east branch rises above the Chiputneticook Lakes along the Maine-New Brunswick boundary about 60 miles west of Fredericton. The west branch flows eastward from its headwaters above West Grand Lake in Maine to converge with the east branch in Big Lake, now a reservoir created by Grand Falls dam located below the confluence of the two branches. About one-eighth of the entire drainage area above Grand Falls is covered by lakes, many of which are controlled for power generation purposes. Three small hydro-electric developments, located along the main stem contain hydro-turbines serving generators with a combined capacity of about 20.5 megawatts.

The St. Croix drainage system has special significance because it defines the International Boundary. The Boundary follows Monument Brook, the highest tributary on the east branch, through Chiputneticook Lakes, along the east branch to Grand Falls, and then down the main stem to the mouth. About 62 per cent of the drainage area lies in the State of Maine and the remainder in New Brunswick.

Essentially there are three basic industries within the southwestern basins. The first, and most important to the overall economy, is the forest industry. The area supports two important pulp and paper mills, one at Woodland on the St. Croix and the other near St. George on the Magaguadavic River. Logging and sawmill operations are the main employers in the inland areas. The lake region in York County and the Fundy coast have both been developed for tourism, the region's second major industry. This industry is enhanced by the existence of major border crossing points between Canada and the United States and ferry connections from Nova Scotia. The third major industry in the region is commercial fishing. Several canneries and processing plants are located on the coast and on offshore islands. Farming, especially the dairy variety, is of minor importance. St. Stephen, the largest town in the region, owes its existence essentially to the forestry and tourism industries but there is some secondary manufacturing.

NORTHEASTERN BASINS

The northeastern basins, which enter the Gulf of St. Lawrence, embrace four physiographic regions: The Notre Dame Mountains, the Chaleur Uplands, the New Brunswick Highlands and the Gulf of St. Lawrence Plain. The largest of the northeastern basins are the Restigouche, the Nepisiguit and the Miramichi. The lower portions and estuaries of these three rivers form the main centers of economic activity in the northeastern part of New Brunswick.

The Restigouche River

The Restigouche River is an interprovincial river draining parts of Quebec and New Brunswick. The boundary between these two provinces extends up the Restigouche from Chaleur Bay to the mouth of the Patapedia and then northward along the Patapedia River to the 48th parallel of latitude. The headwaters and main stem of the Restigouche lie in the Chaleur Uplands. The largest tributaries are the Matapedia, the Patapedia and the Kedgwick Rivers which rise in the Notre Dame Mountains in Quebec and the Upsalquitch which rises in the New Brunswick Highlands and flows northward to the Restigouche. The Restigouche is tidal for about 25 miles of its length and navigable for ocean-going vessels for about 18 miles.

In the Restigouche basin, the major industry is the production of pulp and paper. Roughly one half of the region's population is located in two urban centers, Campbellton and Dalhousie. Both of these centers rely heavily on pulp and paper and associated service industries for employment. Campbellton, on the main passenger line of the Canadian National Railway, roughly halfway between Halifax and Montreal, and at one end of the tourist-rich Gaspé Highway, also serves as a transportation center of limited significance. The economy of the rural parts of the basin is based on forest activities, tourism and sport and commercial fishing.

The Nepisiguit River

The Nepisiguit River basin lies within the New Brunswick Highlands physiographic division. The western divide of the basin reaches an altitude 2,690 feet above mean sea level at Mount Carleton. Throughout its length, the river is fed by small tributaries usually not more than 10 to 15 miles in length. The river has many falls and rapids. Hydro-electric power has been developed at Nepisiguit Falls on the main stem about 20 miles above Bathurst.

The Nepisiguit River basin has two major industries; mining and pulp and paper. Although several mining operations exist in the Bathurst hinterland, this industry is overshadowed by the regionally more important pulp and paper industry. With its operations centered in Bathurst, Consolidated Bathurst Paper Company is the largest single employer in the region. As is the case in Campbellton, Bathurst is a city dominated by one industry with some service industry centered around the heart of the community. It is a minor transportation center as well since it is on the main line of the Canadian National Railway and at the end of the highway which encircles the Lower Gloucester County area. Commercial fishing is more important to the Nepisiguit basin than to the Restigouche area, but sport fishing is less important.

The Miramichi River

The Miramichi River basin is the second largest river basin in New Brunswick. It has a drainage area of 4,510 square miles. The eastern half of the basin is of relatively low relief and lies in the Gulf of St. Lawrence Plain. The western half is part of the New Brunswick Highland region. The Miramichi River basin may be conveniently divided into five major tributary watersheds. These are from north to south; the Northwest Miramichi, the Little Southwest Miramichi, the Renous, the Southwest Miramichi and the Cains River. The Miramichi River comprises the Northwest and Southwest branches which join some 16 miles above the mouth, which is defined as the confluence of the Bartibog River.

In the Miramichi basin the forest industry is of primary importance both in the Newcastle area and at inland locations where sawmill operations exist. The tourist industry, linked especially to the sport fishing of Atlantic salmon, has been highly developed. Mining is important in the basin as well, but to a lesser degree than in the Nepisiguit basin. Commercial fishing is reasonably active in the estuary below Newcastle. The Canadian Forces Base at Chatham and several depots operated by the Department of National Defence are also major employers.

SOUTHEASTERN BASINS

The southeastern part of New Brunswick is drained by numerous small streams rising to the south of the Miramichi River and to the east of the Saint John and flowing eastward to Northumberland Strait or south to the Bay of Fundy. The largest of these streams are the Petitcodiac with a drainage area of 700 square miles and the Richibucto which has a drainage area of 407 square miles. The Petitcodiac River flows eastward and then south into Chignecto Bay at the head of the Bay of Fundy while the Richibucto flows eastward into Northumberland Strait. The southeastern basins were not significantly affected during the flood of late April-early May and are mentioned only in passing in this report.

Causes of the Flood

During the winter of 1972-73, above average snowfall was reported in most of New Brunswick and in adjacent areas of Quebec and Maine. By the end of March, snow accumulation in these areas was higher than normal. Some of the snow melted in the southern parts of New Brunswick during the first part of April, but in the northern regions and in the upper Saint John River basin, cool temperatures and exceptionally heavy snowfall further increased the water equivalent of the snowpack. During the latter part of April, most of this snow melted as a result of higher temperatures. A storm system moved into the New Brunswick area on April 27, dropped precipitation in excess of four inches at many locations, and caused record-breaking discharges on rivers already swollen by snowmelt runoff.

The flood of April 1973 was caused by a combination of the two factors: storm precipitation and snowmelt. This chapter of the report examines the snow accumulation, the estimated snowmelt rates and the meteorological conditions associated with the storm.

SNOW ACCUMULATION

In the province of New Brunswick and adjacent areas of Quebec and Maine, the volume of runoff in the spring is mainly dependent on the amount of water accumulated in the snowpack prior to the runoff period.

Snowfall During the Winter of 1972-73

Snowfall recorded during the winter of 1972-73 at selected meteorological stations in New Brunswick, Quebec and Maine is presented and compared with long term monthly averages in Table 3. Seasonal snowfall was above normal over most of the area. Only Saint John experienced less than the long term average. December snowfalls were much above average at all locations. Other months displayed less consistency, but as a general rule, northern and western parts of the region experienced above average snowfalls while southern and eastern parts had near or below average totals. The monthly weather patterns during the winter of 1972-73 can be described briefly as follows:

November: Generally cool and stormy with temperatures three to five degrees below normal. Snowfall totals were about normal for the month.

December: Temperatures continued three to seven degrees below normal throughout the Province of New Brunswick. Snowfall averaged about 50 inches, more than double the normal amount at many locations.

January: Sunny with normal or below normal snowfall. Temperatures were generally near normal.

February: Temperatures and precipitation were near seasonal levels throughout most of New Brunswick. Snowfall amounts in adjacent areas of Quebec and Maine were considerably above normal.

March: The weather in March was sunny and warm resulting in a temperature anomaly of plus six degrees throughout the region. Snowfall for the month was well below normal. Seasonal totals in the northern regions remained above normal, mainly because of heavy snowfalls in February.

April: April was generally cloudy and mild with above average precipitation. Heavy snowfall during the first part of April resulted in monthly totals well above normal throughout the northern regions. Some stations recorded as much as three times the normal snowfall.

Snow Survey Data

In recent years many snow survey stations have been established throughout New Brunswick, Quebec and Maine. In each area, groups of stations, usually referred to as networks, are systematically surveyed for the purpose of estimating the water equivalent of the snowpack. In New Brunswick snow surveys are undertaken by three organizations: the Water Survey of Canada, Environmental Management Service and the Atmospheric Environment Service of the Department of Environment, and the New Brunswick Electric Power Commission. In the Province of Quebec, they are undertaken by the Provincial Department of Natural Resources and in the State of Maine, by the United States Geological Survey and private organizations.

Snow surveys are made during the winter period approximately once per month at each station. Snow survey data obtained in March and April at eighty-six locations are presented in Table 4. These data have been used to produce Figures 4 and 5 which show estimated isopleths for water equivalent of the pack on March 31 and April 18, respectively. Figure 4 is based on snow survey data obtained in New Brunswick and Maine during the period March 26-31 and on the averages of data obtained in mid-March and mid-April in the Province of

Table 3 – Snowfall for Winter 1972-73

Station		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Annual Total
Fredericton,	(a)	0.8	7.5	26.6	24.8	26.7	17.3	6.3	0.4	110.4
New Brunswick	(b)	1.3	4.6	59.6	27.1	27.9	6.1	10.0	0	136.6
	(c)	162	61.3	224	109	104	32.3	159	0	124
Saint John,	(a)	0.4	5.2	24.2	31.0	28.7	19.9	6.6	0.8	85.4
New Brunswick	(b)	4.5	7.6	36.1	16.5	23.6	4.0	6.3	TR	75.6
	(c)	1125	146	149	53.2	82.2	20.1	95.4	1.2	88.5
Chatham,	(a)	1.1	9.6	22.6	26.8	27.8	21.6	11.2	1.1	121.8
New Brunswick	(b)	1.3	10.8	52.5	20.2	27.0	10.1	20.5	0	142.4
	(c)	118	112	232	75.4	97.1	46.1	183	0	117
Charlo,	(a)	1.6	13.3	32.7	32.6	28.2	28.0	8.4	1.2	146.0
New Brunswick	(b)	3.7	17.6	60.1	24.3	29.9	18.2	29.5	0	183.3
	(c)	231	132	184	74.5	106	65.0	351	0	125
Moncton,	(a)	0.5	7.2	24.6	29.0	27.7	22.7	11.2	0.6	103.1
New Brunswick	(b)	5.3	8.1	40.7	20.2	41.1	9.4	9.3	TR	134.1
	(c)	1060	112	165	69.6	148	41.4	83.0	1.7	130
Mont Joli,	(a)	2.7	12.4	32.0	34.7	31.1	21.4	9.1	1.0	144.4
Quebec	(b)	3.8	12.1	55.4	18.0	37.1	13.9	37.7	TR	178.0
	(c)	141	97.6	173	51.9	119	64.9	414	1.0	123
Rivière-du-	(a)	3.2	6.4	15.7	17.2	21.8	18.7	8.2	1.7	93.1
Loup, Quebec	(b)	6.5	21.1	49.2	21.2	40.2	9.8	13.8	0	161.8
	(c)	203	330	313	123	184	52.4	168	0	173.8
Caribou,	(a)	2.5	12.0	18.8	21.4	24.0	19.0	6.4	1.0	105.1
Maine	(b)	1.7	13.3	59.9	20.3	27.8	7.8	22.2	0	153.0
	(c)	68.0	111	319	94.8	116	41.0	347	0	146
Houlton,	(a)	-	-	-	-	-	-	-	-	-
Maine	(b)	TR	4.6	62.0	24.5	27.5	5.0	13.9	0	137.5
	(c)	-	-	-	-	-	-	-	-	-

Note: (a) - Long Term Average Snowfall in Inches
(b) - Winter 1972-73 Snowfall in Inches
(c) - Winter 1972-73 Snowfall as Per Cent of Long Term Average
TR - Trace

Quebec. Figure 5 was prepared from all available snow data for the period April 11 to 18. Complete coverage was not available at many stations because the responsible agency did not undertake surveys in April. In these areas, isopleths are estimated.

The average water equivalent of the snowpack on April 18 for selected drainage areas is shown below:

Saint John River at Edmundston	7.1 inches
Saint John River at Mactaquac Dam	7.2 inches
Saint John River at Mouth	6.0 inches
Restigouche River at Mouth	10.7 inches
Miramichi River at Mouth	7.7 inches

Comparison with Normal Snow Accumulation

Table 5 presents a comparison of the March survey data with historical data for selected snow courses in New Brunswick, Quebec and Maine. In this table, the March 1973 water content is compared with the averages and extremes reported during the period of record.

The above average snowpack existing at the end of March was largely the result of excessive accumulation from December 1972. Examination of the data on Table 5 shows that the water content of the snow at the end of March 1973, was generally above average, but varied from

Table 4 – Snow Survey Data Obtained at Selected Courses in New Brunswick, Quebec and Maine

(March and April 1973)

Map* No.	Snow Course	Reporting Agency**	Elevation (Ft.)	March Survey			April Survey		
				Day	Depth of Snow (Ins.)	Water Content (Ins.)	Day	Depth of Snow (Ins.)	Water Content (Ins.)
	New Brunswick								
S 1	Clair	NB	600	28	23.6	8.3	11	25.2	6.8
S 2	Connors	NB	700	28	25.8	9.6	11	30.1	9.3
S 3	Connors	WSC	500	28	25.4	11.4	11	28.5	9.4
S 4	Green River	NB	1100	29	31.1	11.6	13	39.0	12.1
S 5	St. Jacques	NB	500	29	27.7	10.8	13	31.7	10.7
S 6	Quisibis	NB	500	29	29.3	10.3	13	34.3	9.9
S 7	Grand River	NB	450	29	20.7	7.3	13	22.0	7.2
S 8	Grand Falls	NB	400	29	16.7	5.7	13	17.3	5.0
S 9	St. Quentin	NB	1200	29	26.1	9.1	13	32.3	10.6
S10	Little Tobique	NB	800	30	29.7	9.8	13	30.2	10.0
S11	Nictau Forks	NB	550	30	31.2	11.0	12	35.8	11.2
S12	Sisson Lake	NB	850	30	26.7	10.4	12	35.4	11.0
S13	Serpentine Lake	NB	1250	28	34.6	9.0	17	37.4	13.2
S14	Tobique	WSC	500	30	16.6	5.9	13	19.2	6.5
S15	Harrison Ridge	NB	1500	28	31.2	8.0	17	27.2	10.3
S16	Trouser Lake	NB	1250	28	36.8	9.8	17	37.0	13.1
S17	Long Lake	NB	1250	28	34.1	9.6	17	35.2	11.2
S18	Mapleview	NB	550	30	28.0	9.0	18	24.8	8.5
S19	Sisson Ridge	NB	1000	30	18.0	5.8	12	21.2	6.3
S20	Tobique Narrows	NB	500	30	15.2	4.9	12	16.2	5.0
S21	Beechwood	NB	500	30	18.0	6.2	12	15.7	5.3
S22	Pokiok (Hawkshaw)	WSC	250	29	20.3	6.4	25	-	-
S23	Sussex	WSC	100	26	0.0	0.0	-	-	-
S24	North Nashwaaksis	WSC	200	30	22.9	7.7	12	27.5	8.4
S25	North Nashwaaksis No. 1	WSC	400	30	17.1	6.1	12	19.5	6.2
S26	North Nashwaaksis No. 2	WSC	500	30	16.3	5.6	12	17.3	5.9
S27	North Nashwaaksis No. 3	WSC	700	30	10.8	4.3	12	8.7	2.1
S28	Elmcroft	WSC	300	27	4.3	1.2	-	-	-
S29	Lepreau	WSC	100	27	Trace	-	-	-	-
S30	Restigouche	WSC	900	26	29.6	15.6	-	-	-
S31	Upsalquitch	WSC	125	27	30.5	13.3	-	-	-
S32	Bathurst	WSC	50	28	25.7	8.6	-	-	-
S33	Lyttleton	WSC	75	28	19.2	10.3	-	-	-
S34	Trout Brook	WSC	75	28	14.1	7.5	-	-	-
S35	Renous	WSC	225	28	13.3	8.3	-	-	-
S36	Chatham Airport	AES	112	-	-	-	1	3.2	1.3
S37	Charlo Airport	AES	125	31	29.2	7.2	-	-	-
S38	McElwain	WSC	600	28	23.8	7.5	11	25.3	7.7
S39	Moncton	WSC	150	27	12.3	7.6	-	-	-
S40	Turtle Creek	WSC	500	27	4.5	2.9	-	-	-
S41	Jacquet (Durham)	WSC	200	27	32.5	11.6	-	-	-
S42	Tracy	WSC	200	28	11.6	3.9	-	-	-
S43	Coal Branch	WSC	200	27	13.1	6.3	-	-	-
S44	Point Wolf Upper	WSC	1200	27	14.2	6.3	-	-	-
S45	Point Wolf Lower	WSC	300	27	6.9	0.5	-	-	-
S46	Pabineau Falls	WSC	100	28	23.5	9.6	-	-	-
S47	Springfield Woods	NB	175	29	23.5	6.8	-	-	-
S48	Becaguimec Woods	NB	450	29	27.0	7.0	12	27.3	5.8
S49	Belleville	NB	375	29	21.9	4.6	12	22.8	3.9
S50	Holmesville	NB	650	30	17.0	5.8	12	15.8	6.5
S51	Gibson Millstream	NB	200	29	21.1	5.5	12	17.3	4.2
S52	Middle Brook	WSC	750	29	26.3	7.5	13	28.7	9.0
S53	Hayden Brook	WSC	800	29	24.1	7.7	13	34.7	11.0
	Quebec								
S54	Ste-Rose-du-Dégelis	QNR	500	11	36.5	11.6	15	31.3	10.0
S55	Daaquam	QNR	1250	14	32.8	10.5	18	15.8	6.1
S56	Escourt	QNR	725	11	23.7	7.0	15	7.7	2.6
S57	Ste-Perpétue	QNR	1500	14	37.8	11.3	18	27.5	10.3
S58	Thetford Mines	QNR	1000	12	13.8	4.9	15	0.0	0.0
S59	Lac Mégantic	QNR	1500	13	15.0	4.1	16	2.8	1.2
S60	Pont de Québec	QNR	250	15	34.8	11.2	18	9.1	3.7

Table 4 – Continued

Map* No.	Snow Course	Reporting Agency**	Elevation (Ft.)	March Survey Day	March Survey Depth of Snow (Ins.)	March Survey Water Content (Ins.)	April Survey Day	April Survey Depth of Snow (Ins.)	April Survey Water Content (Ins.)
S61	St-Etienne-de-Lauzon	QNR	325	14	29.8	9.4	18	9.6	3.8
S62	St-Ludger	QNR	900	13	13.1	4.3	17	0.6	0.3
S63	St-Théophile-de-Bauce	QNR	1675	13	15.1	5.3	17	1.4	0.6
S64	Ste-Rose-de-Watford	QNR	1300	13	30.8	9.8	17	16.5	6.1
S65	Vallée-Jonction	QNR	700	12	27.6	8.8	16	12.4	4.2
S66	Pelletier	QNR	525	10	35.9	10.5	15	42.6	12.4
S67	St-Alexandre	QNR	1000	11	29.6	7.8	15	25.8	9.1
S68	St-Léon-de-Standon	QNR	900	14	25.8	8.9	17	12.7	5.0
S69	Mitis (Price)	QNR	75	12	22.7	6.7	16	25.9	10.9
S70	St. Moïse	QNR	800	12	31.7	9.8	16	35.2	11.7
S71	Ste-Blandine	QNR	500	12	34.4	10.6	15	41.7	13.4
S72	Whitworth	QNR	1000	11	31.2	9.9	15	32.7	10.1
	Maine								
S73	Beech Ridge	US	1300	29	28.6	10.2	-	-	-
S74	Chase Camps "F"	US	667	31	25.1	9.0	-	-	-
S75	Churchill Ridge	US	980	29	25.4	8.8	12	22.1	6.2
S76	Medway	US	840	29	17.0	5.6	12	14.6	4.5
S77	Sebec	US	650	29	4.6	1.4	12	7.8	2.3
S78	Hedgehog Mtn. "A"	US	800	31	21.8	6.1	12	7.8	2.3
S79	Hedgehog Mtn. "B"	US	800	31	24.3	8.5	-	-	-
S80	Millinocket Lake "G"	US	850	31	23.0	7.6	-	-	-
S81	Millinocket Lake "H"	US	780	31	24.2	7.2	-	-	-
S82	Ninemile 'A' & 'B'	US	950	28	28.8	11.0	-	-	-
S83	Salmon Pool "E"	US	730	31	25.6	7.4	-	-	-
S84	Squapan Lake "C"	US	632	31	22.9	4.7	-	-	-
S85	Squapan Lake "D"	US	672	31	17.4	4.1	-	-	-
S86	Telos	US	1000	29	24.9	6.5	12	29.3	5.7

* Refers to locations shown on Figure 4

** NB - New Brunswick Electric Power Commission

WSC - Water Survey of Canada

QNR - Quebec Department of Natural Resources

US - United States Geological Survey

34 to 193 per cent of the average. Relative to the averages at individual stations during the period of record, the areas of heaviest snow accumulation were the Restigouche, Miramichi and upper Saint John River basins. In the Restigouche River basin, the water equivalent of the snow cover was the highest on record, with two stations indicating more than 13 inches of water. In other river basins, the snow cover existing at the end of March was heavier than average but not of record proportions.

The snow cover in New Brunswick generally reaches its maximum depth and water equivalent about March 31. In a normal year the amount of snow added to the cover in April would not contribute significantly to the potential runoff. This was not the case in 1973 as many of the mid-April snow surveys indicated higher water equivalent than those of the previous month.

April was characterized by heavy precipitation in the form of snow, particularly in the northern regions. Comparison of Figures 4 and 5 shows the general recession of the snowline in the southern parts of New Brunswick and Maine, consistent with the seasonal warming trend. However, in central and northern regions, the lessening of the snow cover, normal for this time of year, was offset by the unusually heavy snowfall of early April. Examination of Figure 5 reveals the persistence of heavy snow in the upper Saint John River tributaries and northeastern basins, the cover varying from 8 to 12 inches of water. If it were possible to compare April snow survey data with a long term average, it is almost certain that April 1973 would be outstanding.

SNOWMELT

The Energy Budget approach has been widely used to estimate runoff from snowmelt. The following is a brief description of this method and its application in estimating snowmelt in the New Brunswick region during the period April 15 to May 10, 1973.

Practical application of the energy balance concept to the snowmelt problem has been developed during co-operative snow hydrology studies, in the western United

Table 5 – Comparison of March 1973 Snow Survey Data with Historical Data

Map No.*	Snow Course	Years of Record	Period of Record-March Water Content in Inches			March 1973 Water Content	
			Average	Maximum	Minimum	Inches	Per Cent of Average
S 3	Connors	21	7.6	12.5	1.7	11.4	150
S 7	Grand River	17	7.0	12.8	1.8	7.3	104
S 11	Nictau Forks	19	6.9	11.8	2.4	11.0	160
S 20	Tobique Narrows	19	5.2	12.5	0.0	4.9	94
S 22	Pokiok (Hawkshaw)	29	5.9	12.1	1.0	6.4	108
S 23	Sussex	11	3.6	8.1	0.0	0.0	0
S 28	Elmcroft	26	3.5	11.0	0.0	1.2	34
S 29	Lepreau	27	3.4	9.7	0.0	0.0	0
S 30	Restigouche	16	8.1	15.6	1.0	15.6	193
S 31	Upsalquitch	21	7.6	13.3	1.0	13.3	175
S 33	Lyttleton	20	7.8	12.0	0.0	10.3	132
S 38	McElwain	11	6.2	10.9	0.9	7.5	121
S 39	Moncton	19	6.8	12.1	3.0	7.6	110
S 46	Pabineau Falls	14	9.0	14.9	0.0	9.6	107
S 54	Ste-Rose-du-Dégelis	15	7.5	14.1	1.9	11.6	155
S 55	Daaquam	17	9.5	14.0	4.6	10.5	111
S 56	Escourt	17	6.6	10.7	1.9	7.0	106
S 71	Ste-Blandine	17	10.3	16.0	2.2	10.6	103
S 74	Chase Camps	10	6.3	10.9	1.3	9.0	143
S 82	Ninemile 'A' and 'B'	17	8.9	13.0	3.9	11.0	124
S 86	Telos	24	7.2	13.2	4.1	6.5	90

* Refers to locations shown on Figure 4

States, carried out jointly by the United States Weather Bureau and the United States Army Corps of Engineers[5]. The approach resulting from these studies can be illustrated with reference to the generalized equation for snowmelt.

$$M = M_{rs} + M_{rl} + M_{cc} + M_r + M_g$$

where: M = total snowmelt, M_{rs} = short wave radiation melt, M_{rl} = long wave radiation melt, M_{cc} = convection – condensation melt, M_r = melt due to heat of raindrops, and M_g = melt by heat conduction from the ground. Each of these variables can be computed from physical data such as direction of slope, forest cover, solar radiation, exposure to wind, wind velocity, air temperature and albedo of the snow surface.

The U.S. Army Corps of Engineers has also developed simplified forms of the energy budget which may be used for situations where snowmelt occurs in conjunction with rain.

The major difficulties in the application of the energy budget approach to snowmelt calculations lie in the stringent data requirements and in the uncertainties surrounding the values of some of the coefficients in the equations. The approach is, nevertheless, the preferred one since rational physical limits are imposed on the calculated snowmelt by the budget concept.

Estimates of the average snowmelt rates are shown on Figure 6. During the latter half of April, snowmelt was about 11 inches. By comparison with the water equivalent of accumulated snow on the ground at about mid-April (Figure 5), it is evident that most areas were depleted of snow by May 1. This indicates that most of the relatively heavy accumulation of snow in the spring of 1973 was melted and ran off in a relatively short period of time immediately prior to and during the rainstorm near the end of April.

For comparative purposes, the daily maximum and minimum temperatures at selected meteorological stations are shown on Figure 7. At most stations the highest temperatures during the last half of April occurred during the period April 16-18. At this time a high pressure area produced sunny skies and high temperatures. Snowmelt rates were higher later in the month because of the influence of physical factors other than temperature which are incorporated into the energy budget equations.

THE STORM OF APRIL 27-29

A complex low pressure area, centered south of Lake Erie on April 27, moved slowly northward to position itself as an elongated low along a line from

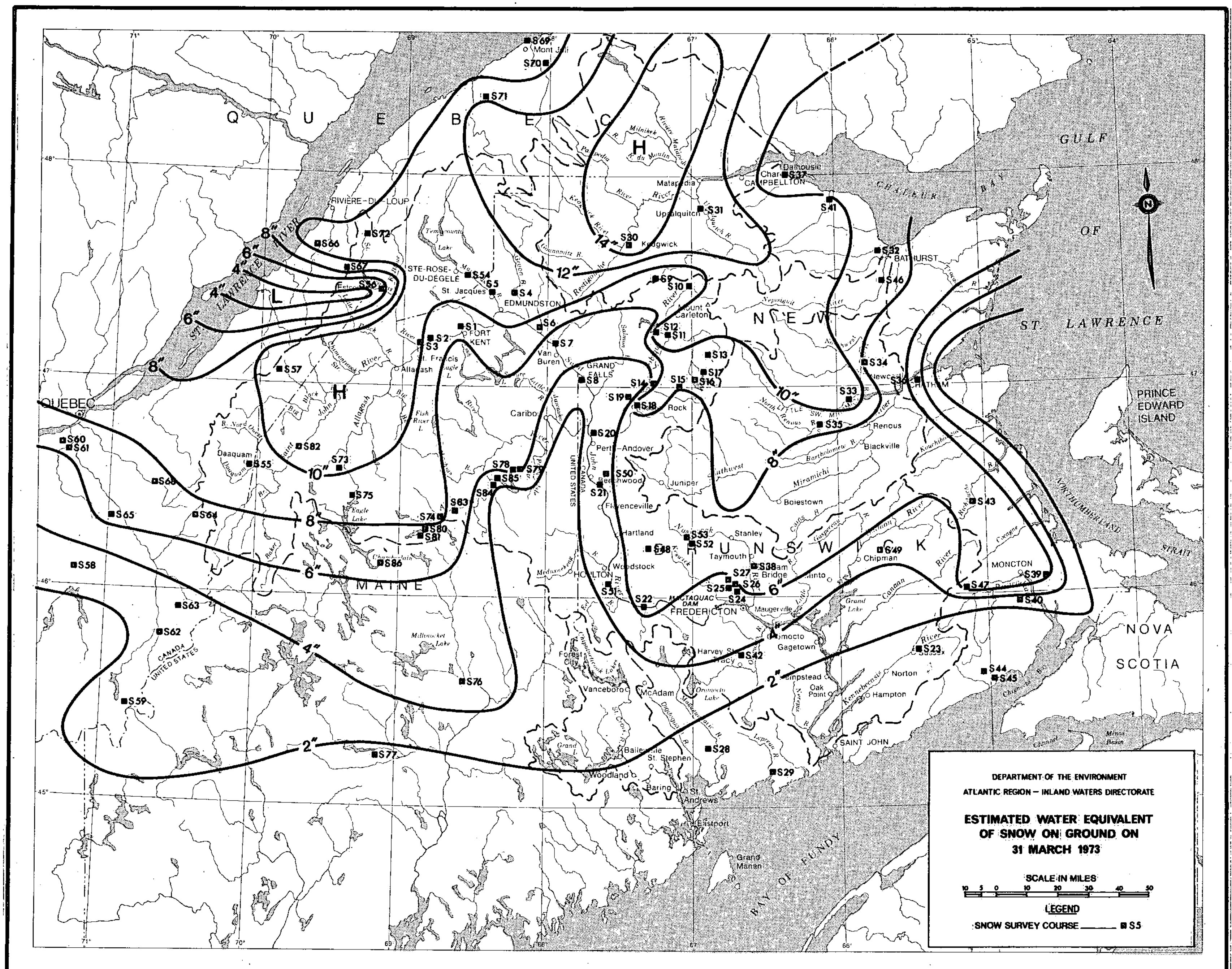
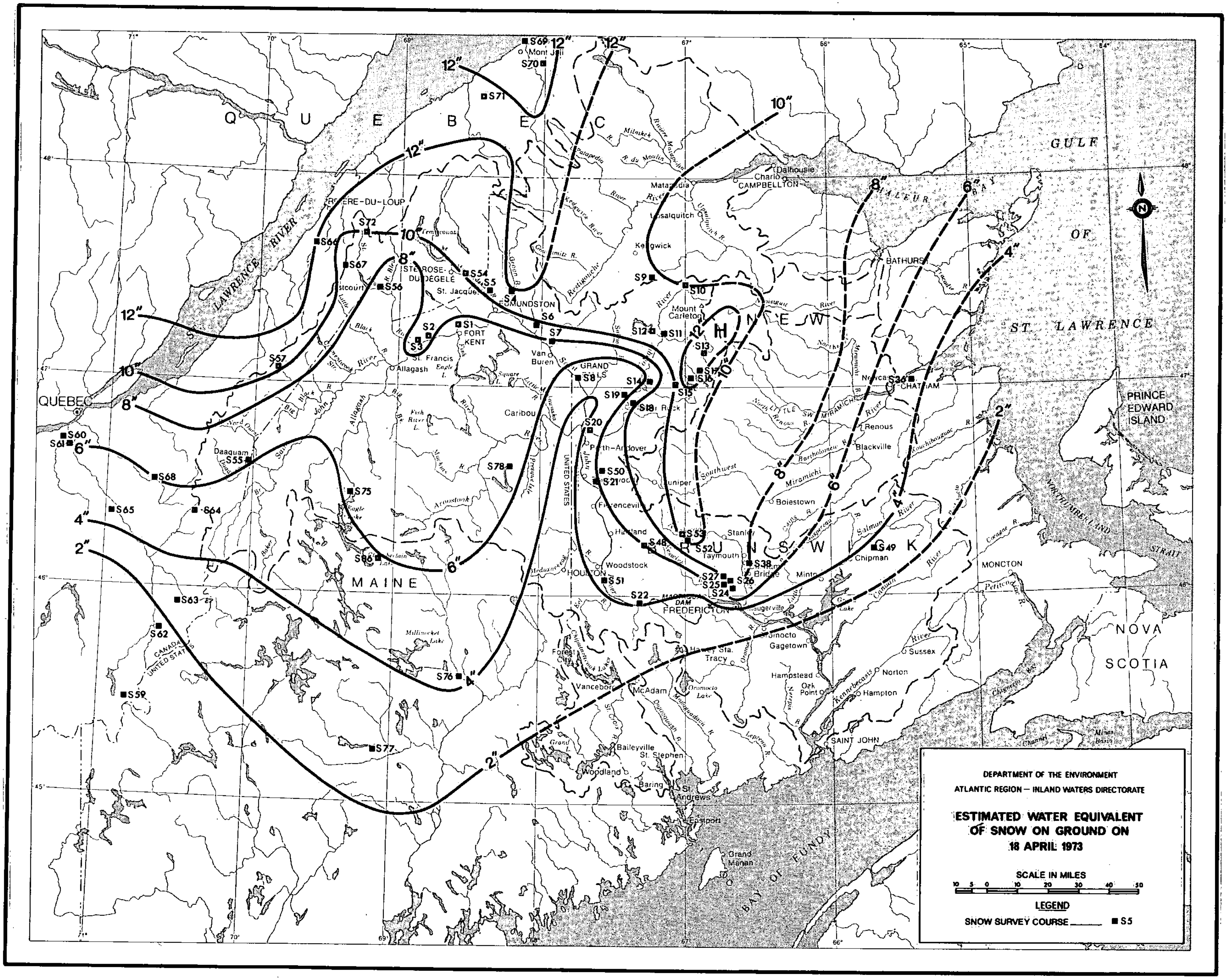

DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION – INLAND WATERS DIRECTORATE
ESTIMATED WATER EQUIVALENT OF SNOW ON GROUND ON 31 MARCH 1973
SCALE IN MILES
10 5 0 10 20 30 40 50
LEGEND
SNOW SURVEY COURSE ■ S5
QUEBEC
NEW BRUNSWICK
MAINE
NOVA SCOTIA
PRINCE EDWARD ISLAND
GULF OF ST. LAWRENCE
BAY OF FUNDY
NORTHUMBERLAND STRAIT
CHALEUR BAY
ST. LAWRENCE RIVER
FREDERICTON
SAINT JOHN
MONCTON
EDMUNDSTON
CAMPBELLTON
BATHURST
RIVIERE-DU-LOUP
2"
4"
6"
8"
10"
12"
14"

Figure 4



DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION – INLAND WATERS DIRECTORATE
ESTIMATED WATER EQUIVALENT OF SNOW ON GROUND ON 18 APRIL 1973
SCALE IN MILES
LEGEND
SNOW SURVEY COURSE ■ S5
QUEBEC
NEW BRUNSWICK
MAINE
UNITED STATES
NOVA SCOTIA
PRINCE EDWARD ISLAND
GULF OF ST LAWRENCE
BAY OF FUNDY
FREDERICTON
MONCTON
SAINT JOHN

Figure 5

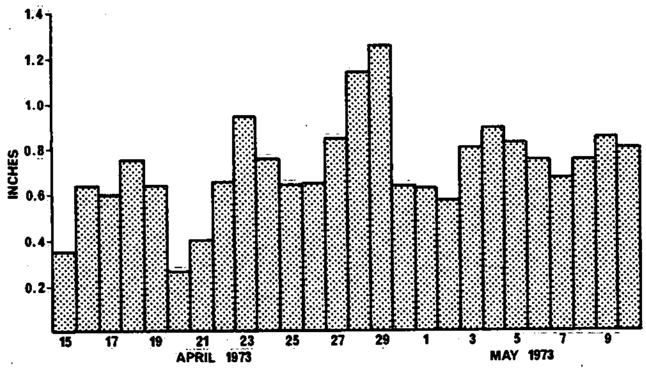


Figure 6 – Estimated Snowmelt for Saint John River Basin April – May 1973

northern Quebec to the Gulf of Maine on the evening of April 29. An occluding frontal system associated with the low produced an extensive area of rain and thunderstorms which spread slowly across the Saint John River basin on the 27th and 28th. As the frontal system moved out of the basin on the morning of April 29, the precipitation ended over the watershed. Precipitation totals in excess of 4.0 inches were recorded over most of the southeastern basins and in the upper Miramichi and central Saint John River basins as indicated on Figure 8. Throughout the period of the storm, a mild southeasterly airflow prevailed over the region and temperatures remained fairly steady in the mid-forties to low fifties. Figure 9 illustrates the synoptic situation at 2 p.m. Atlantic Standard Time on April 28.

The areal distribution of total rainfall for the storm of April 27 to 29 is shown on Figure 8. The temporal distribution of rainfall at locations equipped with recording rain gauges is displayed as mass curves on Figure 10 and as accumulated six-hourly amounts in Table 6.

On April 27 the heaviest rainfall was concentrated in three major areas – the northern part of the Saint John basin in Quebec, the southern part of the basin in New Brunswick, and the southwestern portion of Maine. The greatest quantity of rain reported in the area on April 27 was 1.69 inches at Portland Airport, Maine. In New Brunswick, precipitation ranged from 0.01 inches at Charlo to one inch at McAdam and 0.92 inches at Harvey Station in the southwestern basins. Most stations in eastern and central Maine did not report rain on the 27th.

With the advance of the frontal system, rainfall over New Brunswick increased on the 28th reaching maxima of 3.86 and 4.03 inches in the Milltown-St. Andrews and Campbellton areas, respectively. All stations within the Saint John River basin reported rain on that day with the heaviest precipitation centered over the southern portion of the basin.

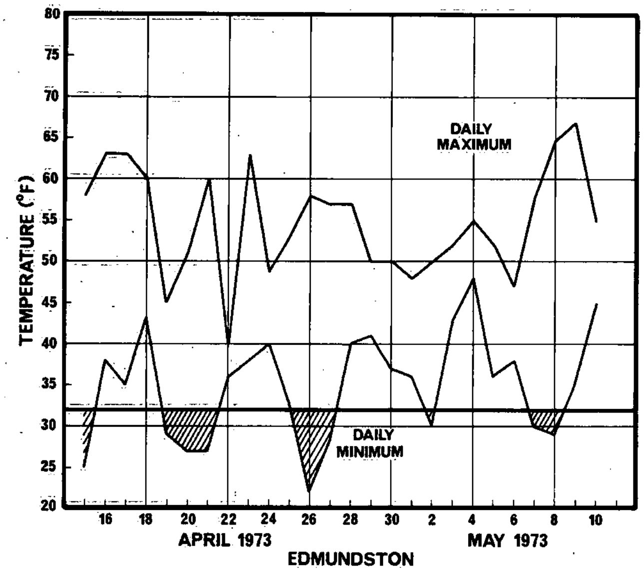
As the storm moved northeastward, precipitation gradually ended over the Saint John River basin on April 29 and simultaneously increased in the eastern parts of the province. A total of 1.35 inches recorded at Miscou Island was the maximum in New Brunswick for that day. Meteorological stations in the southwestern

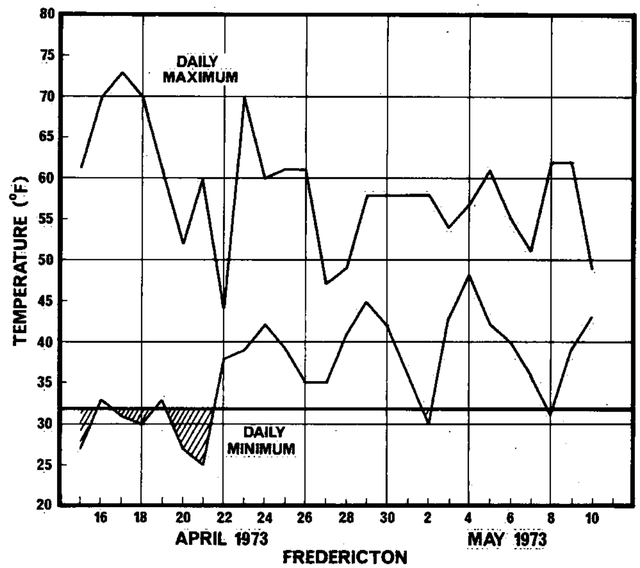
Table 6 – Accumulated 6-hourly Rainfall in Inches

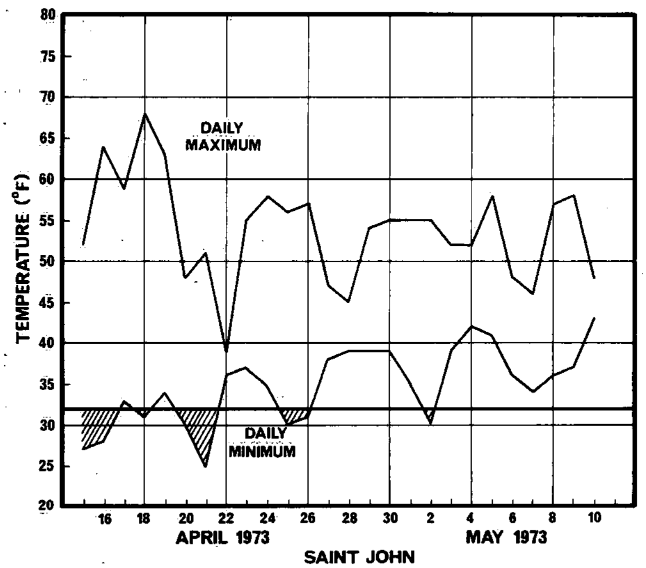
At Meteorological Stations in New Brunswick, Quebec and Maine

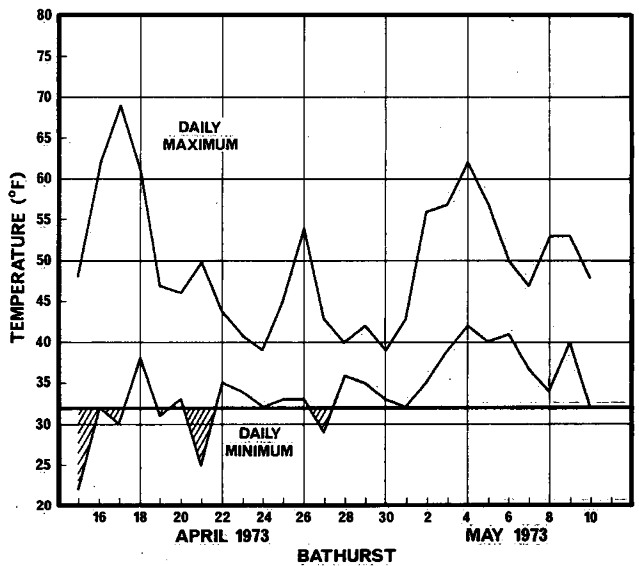
DATE AND TIME / STATION	April 26	April 27				April 28				April 29				April 30	
	14-20	20-02	02-08	08-14	14-20	20-02	02-08	08-14	14-20	20-02	02-08	08-14	14-20	20-02	02-08
Fredericton	0	0	0	0	TR	.44	.74	.78	1.62	2.37	2.51	2.51	2.51	2.51	2.51
Saint John	0	0	TR	TR	TR	.23	.49	.57	1.92	3.32	3.70	3.70	3.70	3.70	3.70
Charlo	0	0	0	0	.01	.01	.02	.18	1.10	1.42	1.96	2.03	2.04	2.07	2.08
Miscou Island	0	0	0	0	0	0	TR	.45	.84	.85	1.25	1.80	2.12	2.20	2.21
Chatham	0	0	TR	TR	TR	TR	.31	.47	.51	.51	.91	1.02	1.03	1.03	1.03
Moncton	0	0	TR	TR	TR	TR	.09	.09	.09	.09	.41	.52	.52	.52	.52
Sherbrooke	0	0	0	0	.23	.29	.29	.29	.43	.43	.50	.58	.66	.71	.77
Quebec	0	0	0	0	.08	.22	.86	.88	1.01	1.02	1.02	1.06	1.09	1.09	1.12
Mont-Joli	0	0	0	0	0	.02	.05	.17	.36	.54	.70	.70	.70	.70	.71
Rivière-du-Loup	0	0	0	0	.03	.13	.47	.81	1.12	1.76	1.79	1.79	1.79	1.79	1.79
Caribou	0	0	0	0	.02	.33	.52	1.01	1.44	2.15	2.19	2.19	2.19	2.19	2.19
Loring	-	-	-	0	0	.57	.93	1.17	1.57	2.20	2.32	2.32	2.32	2.32	2.32
Houlton	0	0	0	0	.02	.45	1.03	1.58	1.97	2.63	2.65	2.65	2.65	2.65	2.65
East Port	0	0	0	0	.08	.55	.76	1.80	2.29	3.90	3.92	3.92	3.92	3.92	3.92
Portland	.08	.27	.42	.62	.90	2.19	2.24	2.30	2.41	2.41	2.42	2.42	2.50	2.51	2.51

Note: All times are Atlantic Standard Time









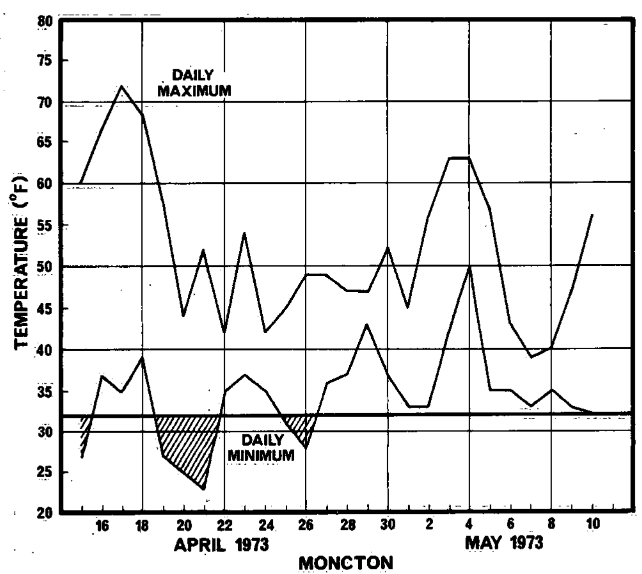


Figure 7 – Daily Extremes of Temperature at Selected Meteorological Stations

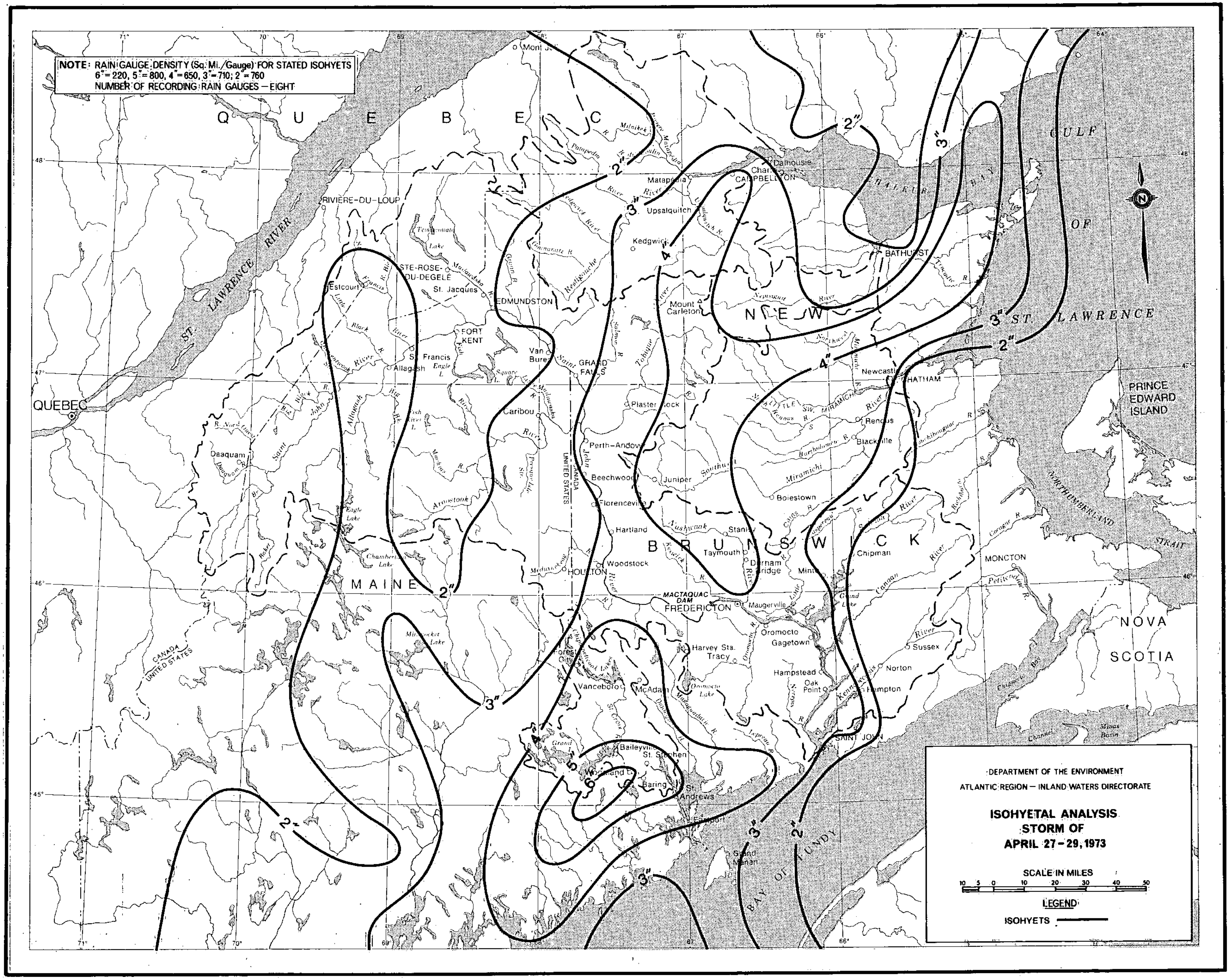

NOTE: RAIN GAUGE DENSITY (Sq. Mi./Gauge) FOR STATED ISOHYETS
6"= 220, 5"= 800, 4"= 650, 3"= 710; 2"= 760
NUMBER OF RECORDING RAIN GAUGES — EIGHT
DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION — INLAND WATERS DIRECTORATE
ISOHYETAL ANALYSIS
STORM OF
APRIL 27-29, 1973
SCALE IN MILES
10 5 0 10 20 30 40 50
LEGEND
ISOHYETS
QUEBEC
NEW BRUNSWICK
MAINE
NOVA SCOTIA
PRINCE EDWARD ISLAND
GULF OF ST. LAWRENCE
BAY OF FUNDY
NORTHUMBERLAND STRAIT
CHALEUR BAY
ST. LAWRENCE RIVER
CANADA
UNITED STATES
RIVIERE-DU-LOUP
EDMUNDSTON
FORT KENT
GRAND FALLS
CAMPBELLTON
Dalhousie
BATHURST
Newcastle
CHATHAM
MONCTON
FREDERICTON
MACTAQUAC DAM
HOULTON
Woodstock
SAINT JOHN
St. Stephen
St. Andrews
Sussex
Norton
Hampton
Oromocto
Gagetown
Plaster Rock
Perth-Andover
Beechwood
Florenceville
Hartland
Juniper
Boiestown
Blackville
Renous
Chipman
Minto
Durham Bridge
Taymouth
Stanley
Harvey Sta.
Tracy
McAdam
Vanceboro
Forest City
Baileyville
Woodland
Baring
Grand Manan
Hampstead
Oak Point
Maugerville
Kedgwick
Upsalquitch
Matapedia
Mount Carleton
Van Buren
Caribou
St. Francis
Allagash
Estcourt
STE-ROSE-DU-DEGELE
St. Jacques
Daaquam
Mont Joli
2"
3"
4"
5"
6"

Figure 8

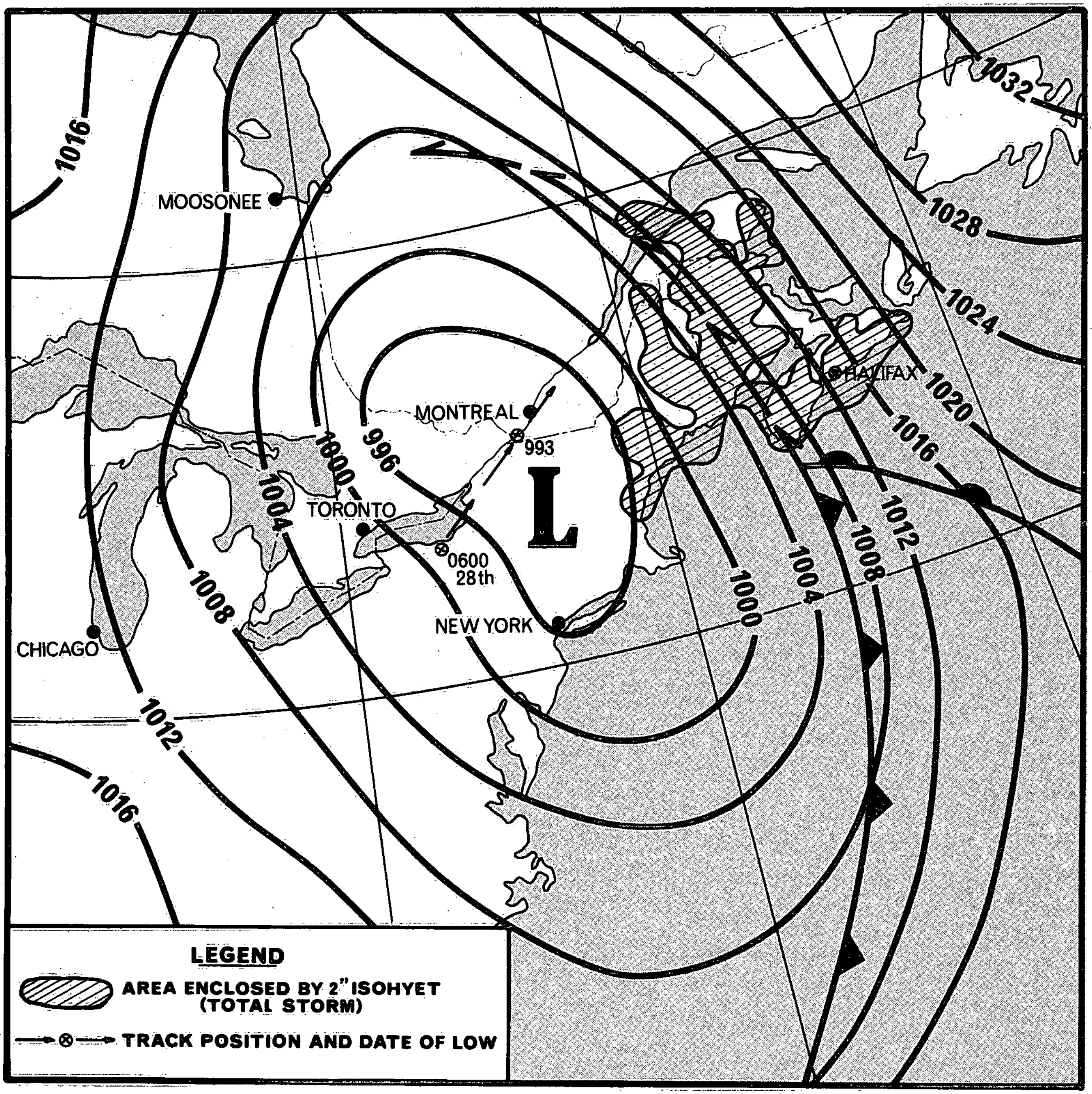


Figure 9 – Synoptic Situation at 2:00 p.m. April 28, 1973

basins had more precipitation on April 29 than on the previous day. In particular, Grand Lake Stream and Woodland recorded 3.11 and 5.25 inches respectively on April 29.

On April 30, rain was experienced in some parts of New Brunswick and southern Quebec but the daily totals did not exceed 0.26 inches, recorded at Rosevale, in New Brunswick and 0.45 inches, recorded at Trinite des Monts, in Quebec.

Because of the magnitude of this flood, it is of interest to investigate the storm rainfall return period at representative stations. Short period rainfall intensity-duration-frequency curves, produced by the Atmospheric Environment Service, are available for Charlo, Fredericton, Moncton and Saint John. Comparison of 6, 12 and 24 hourly rainfall intensities during the April storm with these curves indicates that return periods were generally less than 2 years and never more than 5 years for the four locations. Similarly, when total storm rainfall in New Brunswick and Maine was compared with the Atlas of Rainfall Intensity-Duration-Frequency Data for Canada(6), the return periods were found to be generally around 5 years. The major exception was at Woodland, Maine, where the recorded rainfall of 6.11 inches has an estimated return period of close to 25 years.

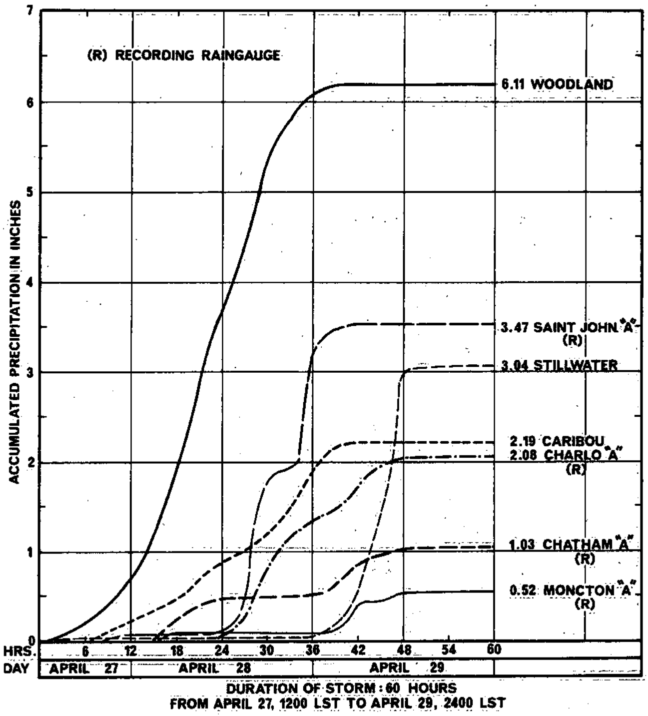


Figure 10 – Mass Curves of Rainfall

Progress of the Flood

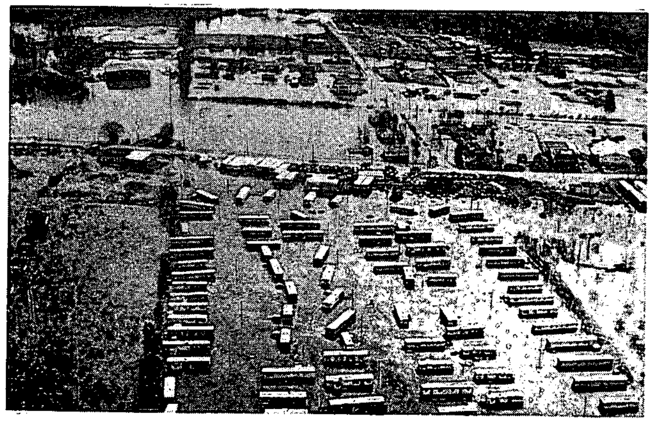
It was pointed out in the preceding chapter that heavy snowmelt occurred during the second half of April in most New Brunswick drainage basins. As indicated on Figure 6, snowmelt rates during this period varied considerably with three distinct periods of rapid snowmelt separated in time by periods of more gradual melt.

From April 16 to 18, a high pressure area centered off the mid-Atlantic coast of the United States produced warm sunny weather over New Brunswick. Maximum temperatures reached the high 70's while minimum temperatures were in the mid 30's. Most of the rivers began to rise about April 17 or 18 as a result of snowmelt. A dry cold front followed on April 19 and the rate of snowmelt declined. Some of the smaller rivers peaked about April 20 and then began to recede. However, hydrometric stations on larger drainage areas showed only a decline in the rate of increase in discharge starting about April 19.

The area was then invaded by a warm frontal system which produced about one inch of rain in New Brunswick on April 22-23. This caused snowmelt rates of close to one inch per day for a three day period from April 22 to 24. Most rivers began to rise more rapidly again on April 22 and peaked about April 24. After the warm frontal system passed the area, cooler weather conditions prevailed and snowmelt rates declined. As a result, the river discharges began falling until April 27 when the major storm moved into the area producing in excess of four inches of precipitation in some areas of New Brunswick. Higher temperatures associated with the storm resulted in increased snowmelt.

Most of the rivers reached their maximum discharge following the April 27-29 period of heavy rainfall. Earlier snowmelt and rainfall which caused separate flood crests also contributed to the magnitude of the April 29 and April 30 peaks because the rivers were still in recession when the rainstorm occurred. Thus, the timing of the April 27-29 storm immediately following a two week period of heavy snowmelt was of utmost importance in producing the record breaking flood discharges.

In this chapter of the report, the conditions on New Brunswick rivers are described for the period April 15 to May 20. The lower portion of the Saint John River below the Mactaquac Dam is treated separately from that portion upstream of the dam because of basic differences in the conditions affecting flooding. For reference purposes, a list of hydrometric stations operating at the time of the flood is given in Table 7 and the locations of these stations are shown on Figure 11.



Photograph 3 – Aerial view of flooding in Lincoln area, near Fredericton.

SAINT JOHN RIVER ABOVE MACTAQUAC DAM

Hydrographs of discharges recorded at several hydrometric stations on the main stem of the Saint John River and on the larger tributaries are shown on Figures 12 and 13. As indicated on these hydrographs, all tributaries and the Saint John River itself showed gradual increases in discharge beginning about April 17 with the initial period of relatively high snowmelt. The increase continued until April 20 when snowmelt rates decreased somewhat.

When the first warm frontal system moved into the basin on April 22, discharge at all hydrometric stations began to increase more sharply. The heaviest rainfall during this storm occurred in the upper part of the basin. Precipitation in excess of one inch was general over that portion of the basin above Grand Falls. At Edmundston 1.61 inches of rain fell between the afternoon of April 21 and the morning of April 23. The Saint John River at Ninemile Bridge reached its highest spring discharge on April 24 as a result of the rainfall and snowmelt associated with this weather system.

In the middle part of the Saint John River basin, precipitation during the April 21-23 storm varied from about one inch at Grand Falls to about one-half an inch at Fredericton but significant flood flows occurred on most of the tributaries and on the main stem. Although the flood crests of April 24 and April 25 were exceeded by the peaks five days later, it is interesting to note that these crests were about equal to the maximum discharges reached during the flood of May 1961. The peaks of 1961 have been regarded as major floods in the basin. The estimated recurrence intervals of the maximum daily discharges reached during April 24 and 25 at several hydrometric stations in the basin are indicated in Table 8.

Table 7 – Hydrometric Stations in New Brunswick and Contributing Areas of Quebec and Maine

Station Number	Station Name	Drainage Area (sq. mi.)	Period of Record
013001	Daaquam River at Bridge 1 mi. downstream of Shidgel	227	1967-73
01010000	Saint John River at Ninemile Bridge	1290	1950-73
01010500	Saint John River at Dickey	2700	1946-73
01011000	Allagash River near Allagash	1250	1931-73
013104	Saint-François 1.3 mi. downstream from Lac Saint-François	20.9	1969-73
01AD003	St. Francis River at outlet of Glasier Lake	520	1951-73
01013500	Fish River near Fort Kent	871	1929-73
01AD002	Saint John River at Fort Kent	5690	1926-73
011702	Madawaska River 1.9 mi. downstream from Lake Temiscouata Dam	1050	1919-73
01AD004	Saint John River at Edmundston	5990	1967-73
01AF003	Green River near Rivière Verte	443	1962-73
01AF006	Black Brook near St.-André-de-Madawaska	5.5	1971-73
01AF002	Saint John River at Grand Falls	8450	1930-73
01015800	Aroostook River near Masardis	888	1957-73
01016500	Machias River near Ashland	330	1951-73
01017000	Aroostook River at Washburn	1652	1930-73
01AG002	Limestone River at Four Falls	77	1967-73
01AH005	Mamozekel River near Campbell River	88.9	1972-73
01AH002	Tobique River at Riley Brook	860	1954-73
01AH003	Tobique River at Plaster Rock	1210	1954-73
01AH004	Tobique River at Narrows	1670	1954-73
01AJ006	Holmes Brook at Moose Mountain	3	1971-73
01AJ007	Holmes Brook near Holmesville	12.1	1971-73
01AJ001	Saint John River at East Florenceville	13200	1951-73
01AJ004	Big Presque Isle Stream at Tracey Mills	187	1967-73
01AJ005	Saint John River at Hartland	-	1969-73*
01017900	Marley Brook near Ludlow	1.47	1964-73
01018000	Meduxnekeag River near Houlton	175	1940-73
01AJ003	Meduxnekeag River near Belleville	466	1967-73
01AK001	Shogomoc Stream near Trans-Canada Highway	90.5	1918-73
01AK007	Nackawic River at Temperance Vale	92.7	1967-73
01AK004	Saint John River below Mactaquac	15400	1961-66*
			1967-73
01AK006	North Nashwaaksis Stream at Sandwith's Farm	2.2	1966-73
01AK005	North Nashwaaksis Stream near Royal Road	10.4	1965-73
01AK003	Saint John River at Fredericton	-	1960-73*
01AL003	Hayden Brook near Narrows Mountain	2.6	1970-73
01AL004	Middle Brook near Narrows Mountain	1.5	1971-73
01AL002	Nashwaak River at Durham Bridge	561	1961*
			1962-73
01AM001	Northwest Oromocto River at Tracy	215	1962-73
01AO002	Saint John River at Maugerville	-	1965-73*
01AN001	Castaway Brook near Castaway	13.3	1971-73
01AO003	Grand Lake at Newcastle Creek	-	1965-73*
01AO004	Jemseg River at Jemseg	-	1966-73*
01AP002	Canaan River at East Canaan	258	1925-41
			1962-73
01AP003	Saint John River at Oak Point	-	1923-73*
01AP004	Kennebecasis River at Apohaqui	425	1961-73
01AP005	Saint John River at Indiantown	-	1966-73*
011507	Matapedia River 0.6 mi. upstream of L'Assemetquagan	1070	1968-73
01BA001	Restigouche River above Kedgwick River	607	1972-73
01BC001	Restigouche River below Kedgwick River	1220	1962-73
01BE001	Upsalquitch River at Upsalquitch	877	1918-33
			1943-73
01BJ007	Restigouche River above Rafting Ground Brook	2990	1968-73
01BJ004	Eel River near Eel River Crossing	34.2	1967-73
01BJ003	Jacquet River near Durham Centre	197	1964-73
01BJ001	Tetagouche River near West Bathurst	140	1922-33
			1951-73
01BJ006	Little River at Carroll's Farm	43.9	1967-73

* Stage Records Only

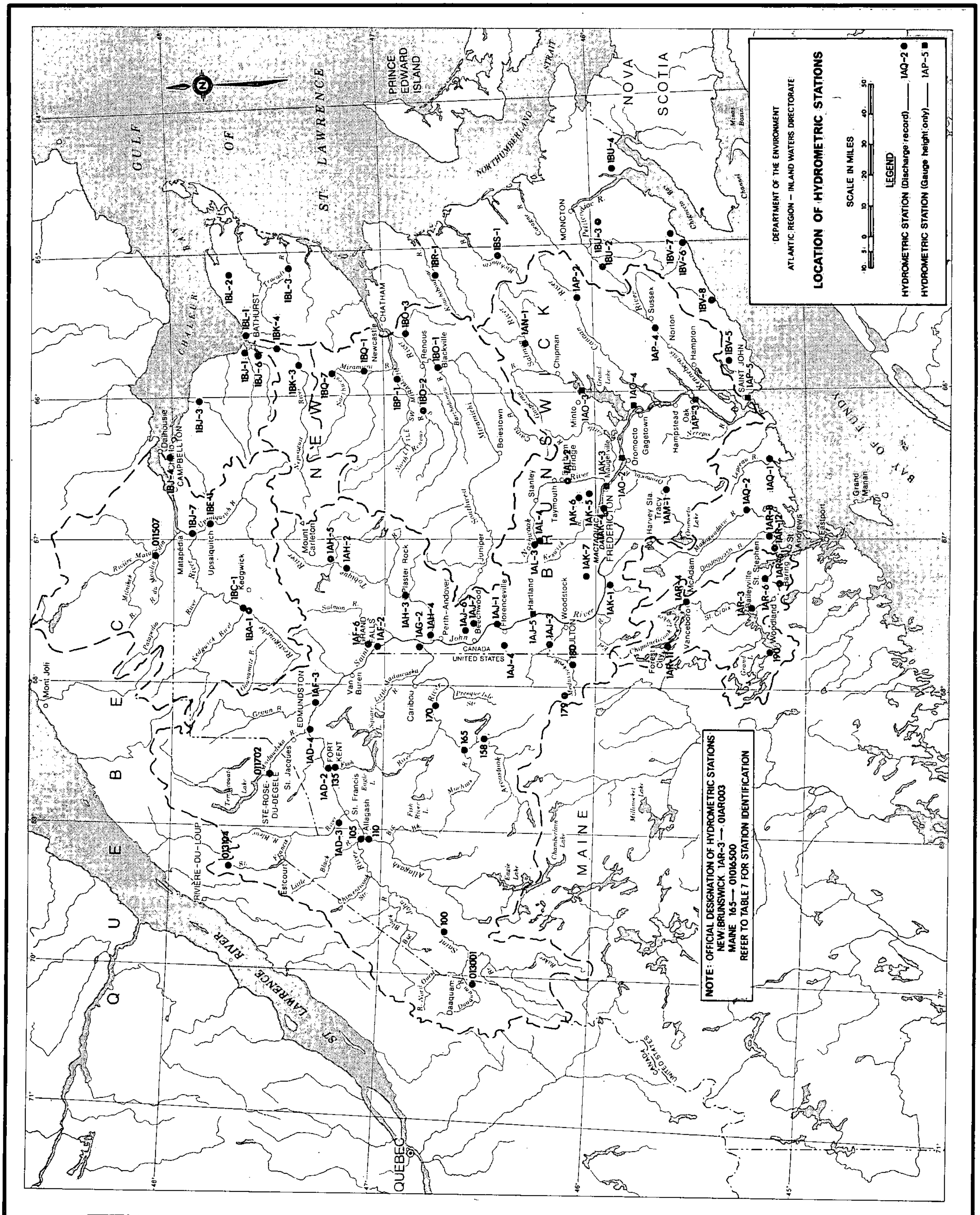

DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION – INLAND WATERS DIRECTORATE
LOCATION OF HYDROMETRIC STATIONS
SCALE IN MILES
LEGEND
HYDROMETRIC STATION (Discharge record) 1AQ-2
HYDROMETRIC STATION (Gauge height only) 1AP-5
NOTE: OFFICIAL DESIGNATION OF HYDROMETRIC STATIONS
NEW BRUNSWICK 1AR-3 — 01AR003
MAINE 165 — 01016500
REFER TO TABLE 7 FOR STATION IDENTIFICATION
GULF OF ST. LAWRENCE
NEW BRUNSWICK
QUEBEC
MAINE
NOVA SCOTIA
PRINCE EDWARD ISLAND
BAY OF FUNDY
NORTHUMBERLAND STRAIT
ST. LAWRENCE RIVER

Figure 11

Table 7 – Continued

Station Number	Station Name	Drainage Area (sq. mi.)	Period of Record
01BK003	Nepisiguit River at Nepisiguit Falls	712	1921-73
01BK004	Nepisiguit River near Pabineau Falls	807	1957-73
01BL001	Bass River at Bass River	67.6	1965-73
01BL002	Southwest Caraquet River at Burnsville	66.8	1969-73
01BL003	Tracadie River at Murchy Bridge Crossing	148	1970-73
01BQ007	Tomogonops River at the Mouth	60.9	1971-73
01BQ001	Northwest Miramichi River at Trout Brook	366	1961-73
01BP001	Little Southwest Miramichi River at Lyttleton	518	1951-73
01BO002	Renous River at McGraw Brook	236	1965-73
01BO001	Southwest Miramichi River at Blackville	1950	1918-33
			1938-39
			1961-73
01BO003	Barnaby River below Semiwagan River	187	1972-73
01BR001	Kouchibouguac River at Acadieville	68.3	1930-33
			1969-73
01BS001	Coal Branch River at Beersville	64.2	1964-73
01BU002	Petitcodiac River near Petitcodiac	151	1961-73
01BU003	Turtle Creek at Turtle Creek	49.9	1962-73
01BU004	Palmers Creek near Dorchester	13.2	1966-73
01BV007	Upper Salmon River near Alma	67.0	1967-73
01BV006	Point Wolf River at Fundy National Park	50.3	1964-73
01BV008	Big Salmon River near St. Martins	111	1970-73
01AQ001	Lepreau River at Lepreau	92.1	1916-73
01AQ002	Magaguadavic River at Elmcroft	547	1917-33
			1943-73
01AR008	Bocabec River Above Tide	16.6	1966-73
01AR012	Chamcook Stream at Little Chamcook Lake Outlet	4.4	1968-73
01AR011	Forest City Stream below Forest City	138	1968-73
01AR004	St. Croix River at Vanceboro	417	1928-73
01019000	Grand Lake Stream at Grand Lake Stream	224	1928-73
01AR003	St. Croix River near Baileyville	1320	1919-73
01AR006	Dennis Stream near St. Stephen	44.2	1966-73

*Stage Records Only

Because these crests were of significant magnitude, it was generally hoped that the Saint John River had reached its annual spring peak when discharges gradually declined from April 25 to April 27. However, the total snowmelt of about seven inches during the period April 15 to April 26 left considerable snow still on the ground in the northern part of the basin.

As the storm of April 27-29 moved into the basin, the rivers began rising again very rapidly. The heaviest rainfall occurred in the eastern and southern portions of the basin. Precipitation of about two inches fell in the area upstream of Fort Kent, Maine on April 28 and 29. This area represents approximately 27 per cent of the total drainage area of the Saint John River. At Fort Kent the river peaked on April 30. Overbank flooding in this town caused the evacuation of about 60 families.

Table 8 – Recurrence Interval of April 24-25 Crest at Selected Hydrometric Stations

Hydrometric Station	Estimated Recurrence Interval of April 24-25 Crest
Saint John River at Ninemile Bridge	8.5 years
Saint John River at Dickey	10.0 years
Saint John River at Fort Kent	7.0 years
Saint John River at Grand Falls	7.3 years
Saint John River at East Florenceville	7.7 years
Saint John River below Mactaquac	11.0 years
Allagash River near Allagash	7.5 years
Fish River near Fort Kent	4.1 years
St. Francis River at Outlet of Glasier Lake	5.5 years
Aroostook River at Washburn	4.4 years

Tributaries in the central part of the basin including the Tobique, Meduxnekeag, Shogomoc and Big Presquile peaked somewhat earlier on April 29. Progressing downstream from Fort Kent along the Saint John River, the time of the peak changed very little as the earlier local inflow more than compensated for the time of travel of the flood peak down the main river channel. It did, however, occur progressively earlier downstream of Grand Falls.

Maximum daily mean discharges reached on April 29 and 30 were about equal to the previous recorded maxima in over forty years of records on the Allagash River, the Fish River and the Saint John River at Fort Kent. Further downstream on the Saint John River, mean daily discharge exceeded the previous maximum recorded during 44 years at Grand Falls. At East Florenceville, the

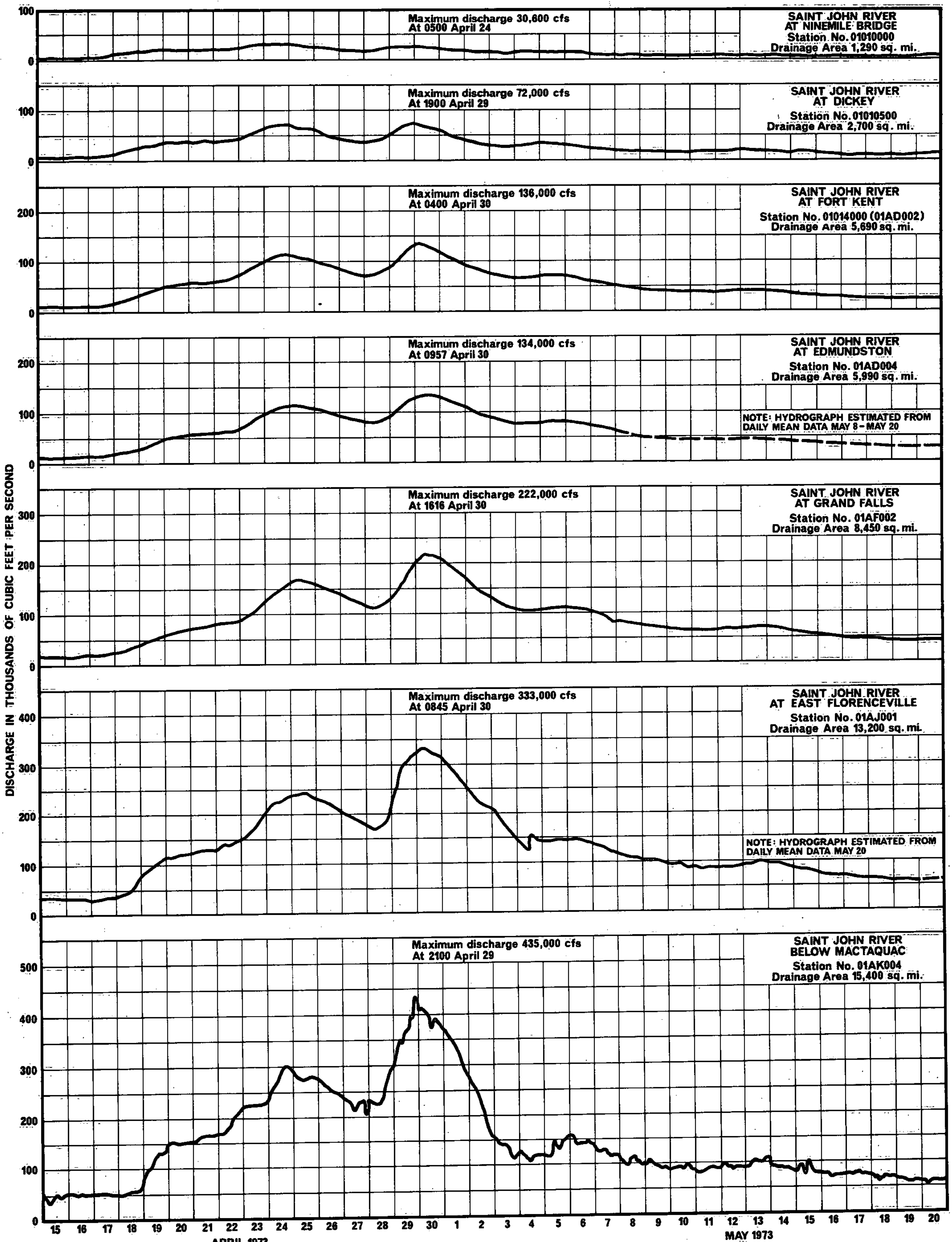


Figure 12 – Hydrographs of Streamflow for Saint John River above Fredericton

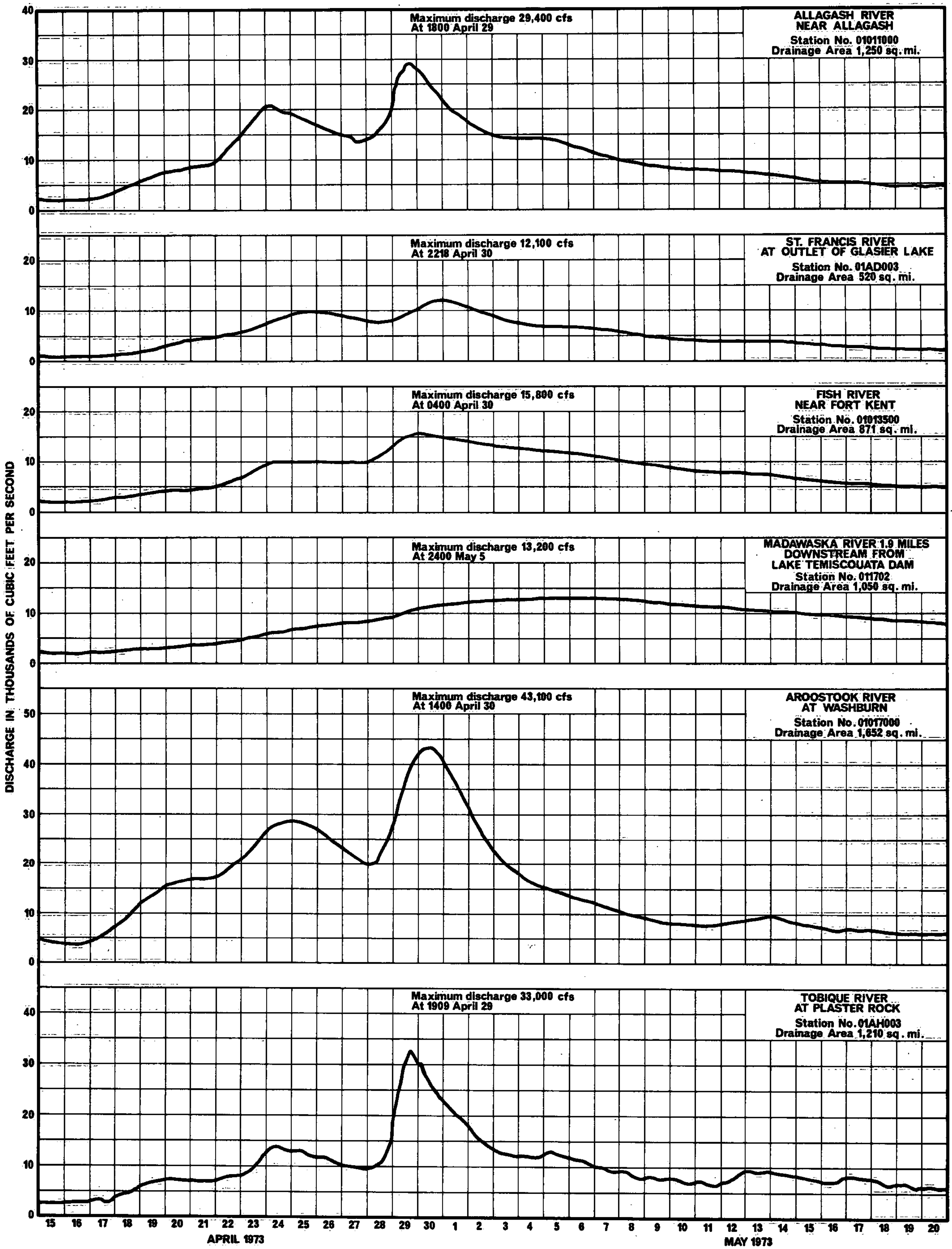


Figure 13 – Hydrographs of Streamflow for Tributaries of Saint John River above Fredericton

maximum daily mean discharge was 84,000 cubic feet per second more than the previous maximum recorded in 1958. Below Mactaquac, the discharge far exceeded any previously recorded maximum in the last seven years and surpassed any recorded discharge in the previous fifty years at the old Pokiok Gauging Station, which was located about 25 miles upstream of the Mactaquac Dam. The magnitude of the April 29 and 30 flood peaks is discussed in greater detail later in this report.

Overbank flooding occurred all along the main stem of the river and on tributaries. Considerable disruption of transportation networks resulted and some flood damage occurred in communities such as Edmundston, Perth-Andover, Hartland and Woodstock.

THE LOWER SAINT JOHN RIVER

The main effects of the flood were felt along the lower portion of the Saint John River from Mactaquac Dam to the Reversing Falls at Saint John.

The physical characteristics of this part of the river are unique. A narrow gorge at the mouth of the river restricts outflow and causes a build up of water upstream. Under normal summer flow conditions and low water in Saint John Harbour, the direction of flow through the gorge is outwards. However, at high water there is an inward flow through the gorge. Thus, the gorge is named "Reversing Falls". During extended periods of low flow, water elevations are frequently as low as one foot above mean sea level just upstream of the Falls and three feet above mean sea level at Fredericton. In contrast, the maximum levels reached during the 1973 flood were 17.4 feet above the Falls and 28.3 feet at Fredericton.

Flooding characteristics of the lower Saint John River are complicated by the large bodies of water along and adjacent to the river (see Figure 14). As flood waters are backed up by the Reversing Falls, they are stored not only in the main channel but also in Kennebecasis Bay, Belleisle Bay, Washademoak Lake, the Grand Lake system and the Oromocto River valley. Thus, a relationship between river flow and stage is difficult to define. Water levels reached during a particular flood are a function of runoff volume as well as antecedent water levels of the main channel and of the large bodies of water adjacent to the river. A given volume of runoff from the river basin may, therefore, produce varying water levels.

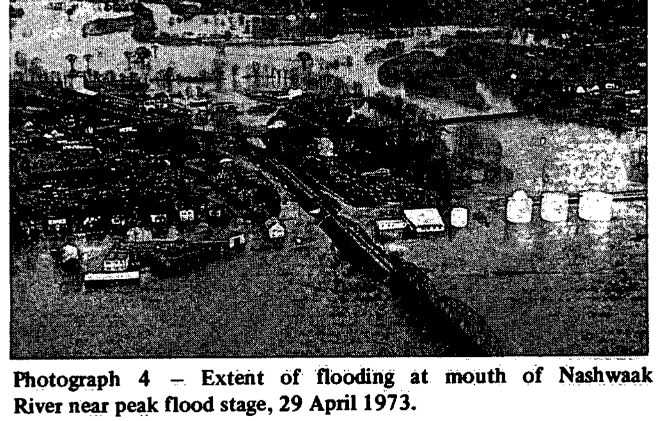
The relationship which exists between Grand Lake and the Saint John River further complicates the flood problem for the lower portion of the river. Under normal conditions, the flow between Grand Lake and the Saint John River fluctuates back and forth through the Jemseg River, depending on the difference in elevation between the two systems. As the Saint John River rises during flood periods, water continually flows in a reverse direction through the Jemseg River into Grand Lake. On a year round basis, however, there is a net outflow from Grand Lake.

The flood plain to the north of the Saint John River in the Portobello Creek and French Lake areas is at a low elevation (about 10 feet above mean sea level). The Trans-Canada Highway, built on a natural levee on the north bank of the Saint John River serves as a dyke for this area at medium stages by preventing the natural overflow of the Saint John onto its flood plain. As the Saint John River rises and increases the stage in Grand Lake, this area begins to flood by backflow from Grand Lake into French Lake and up Portobello Creek. However, when the Saint John River rises above the elevation of the Trans-Canada Highway, as happens about one in every two years, flood waters enter the flood plain area directly from the river and flow downstream into Grand Lake. At the peak of the 1973 flood, several feet of water covered the Trans-Canada Highway. Flow was taking place across the highway onto the flood plain in the Maugerville area and, further downstream, back into the Saint John through the Jemseg River as well as directly across the highway.

Tributary Streamflows

In general, local runoff from the drainage area downstream of the Mactaquac Dam was not particularly high during April and May 1973. On April 1, the water equivalent of the snow cover in this area was less than four inches, except in the Nashwaak basin and the upper portion of the Keswick basin where the water equivalent exceeded eight inches. During the early part of April most of this snow melted except in the Nashwaak and Keswick basins. Runoff from snowmelt increased water levels by about two feet in the river reach between Fredericton and Saint John. By mid-April the river had again dropped to its April 1 elevation.

Recorded streamflow at four hydrometric stations on tributaries below the Mactaquac Dam are shown on Figure 15, for the period April 15 to May 20. Tributaries such as the Canaan and the Kennebecasis in the south-eastern portion of the Saint John River basin did not reach significant flood discharges during this period. Most



Photograph 4 — Extent of flooding at mouth of Nashwaak River near peak flood stage, 29 April 1973.

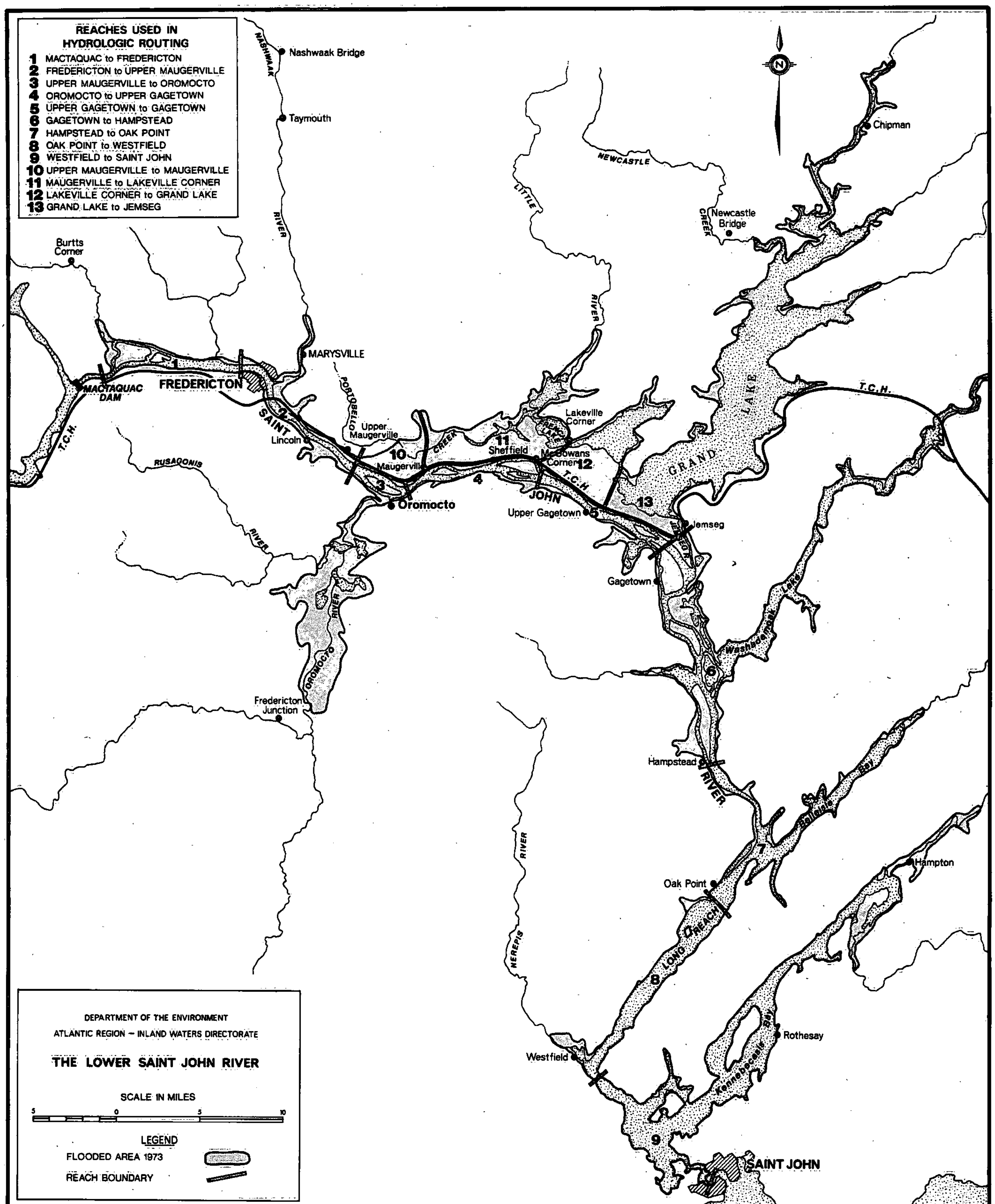

REACHES USED IN HYDROLOGIC ROUTING
1 MACTAQUAC to FREDERICTON
2 FREDERICTON to UPPER MAUGERVILLE
3 UPPER MAUGERVILLE to OROMOCTO
4 OROMOCTO to UPPER GAGETOWN
5 UPPER GAGETOWN to GAGETOWN
6 GAGETOWN to HAMPSTEAD
7 HAMPSTEAD to OAK POINT
8 OAK POINT to WESTFIELD
9 WESTFIELD to SAINT JOHN
10 UPPER MAUGERVILLE to MAUGERVILLE
11 MAUGERVILLE to LAKEVILLE CORNER
12 LAKEVILLE CORNER to GRAND LAKE
13 GRAND LAKE to JEMSEG
Nashwaak Bridge
Taymouth
NASHWAAK
RIVER
Chipman
NEWCASTLE
LITTLE
Newcastle Bridge
CREEK
RIVER
Burtts Corner
MARYSVILLE
MACTAQUAC DAM
FREDERICTON
T.C.H.
SAINT
Lincoln
PORTOBELLO
Upper Maugerville
Maugerville
CREEK
Sheffield
Lakeville Corner
McGowans Corner
JOHN
T.C.H.
GRAND
LAKE
T.C.H.
RUSAGONIS
RIVER
Oromocto
Upper Gagetown
Jemseg
Gagetown
OROMOCTO
RIVER
Washademoak
Lake
Fredericton Junction
Hampstead
RIVER
Belleisle
Bay
Hampton
Oak Point
LONG REACH
RIVER
NEREPIS
Rothesay
Westfield
Kennebecasis Bay
SAINT JOHN
DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION – INLAND WATERS DIRECTORATE
THE LOWER SAINT JOHN RIVER
SCALE IN MILES
5 0 5 10
LEGEND
FLOODED AREA 1973
REACH BOUNDARY

Figure 14

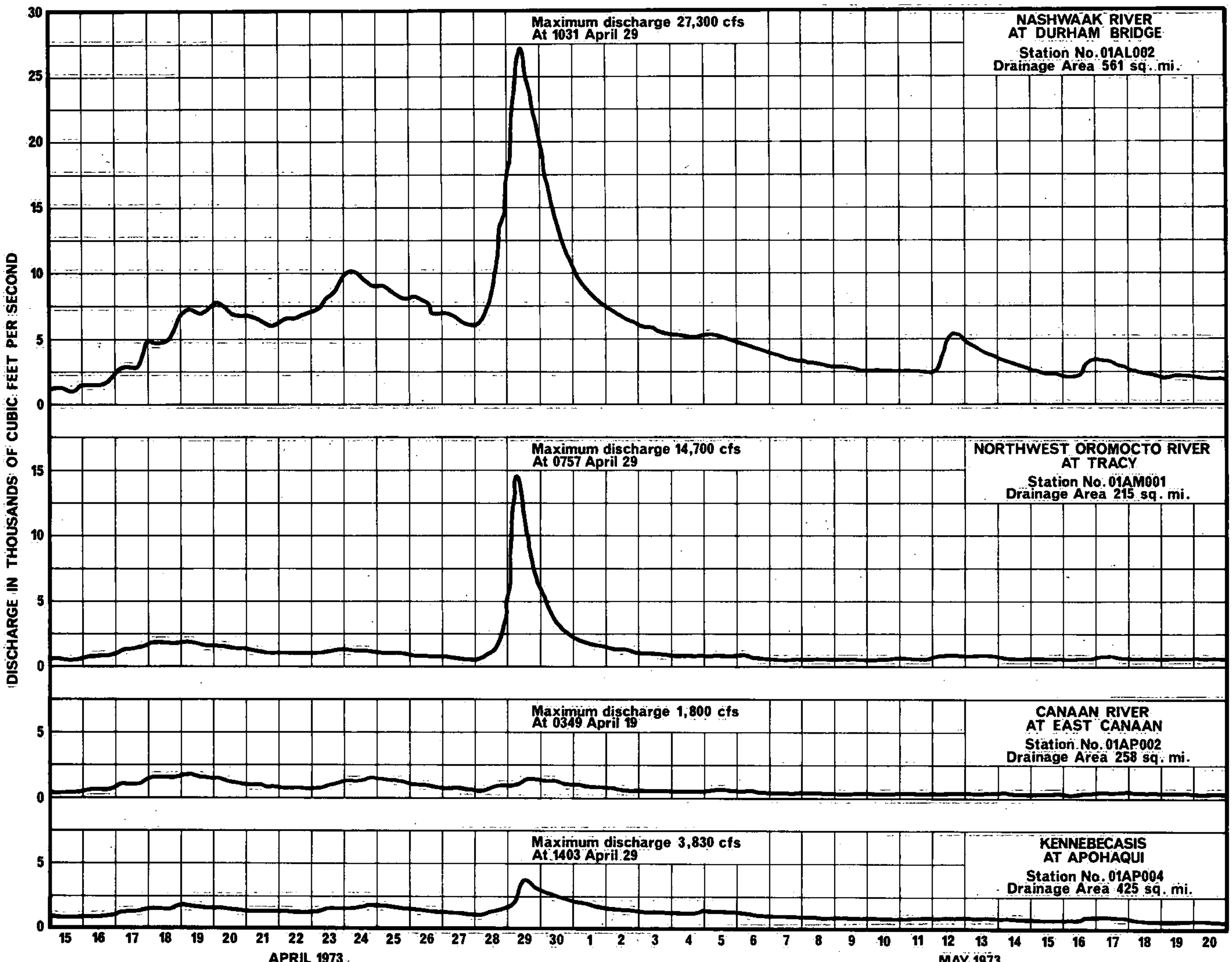


Figure 15 – Hydrographs of Streamflow for Tributaries of Saint John River below Fredericton

of the snow had disappeared by mid-April and the area was on the fringe of the April 27-29 rain storm receiving less than two inches of precipitation. The Oromocto River showed a small flood crest about April 19, probably as a result of melt water from what snow remained on the ground at mid-April. A much larger flood peak followed on April 29, as a result of the April 27-29 storm which dropped between three and four inches of rain on the Oromocto basin. The Nashwaak River crested three times during the last half of April. The first two crests on April 19 and April 24 were caused primarily by runoff from the first two periods of heavy snowmelt. The third, and by far the largest peak on the Nashwaak, occurred on April 29 and was the result of about four inches of rain, during the late April storm, and associated snowmelt.

In examining the flooding conditions of the lower portion of the Saint John River, it is useful to compare the runoff from that portion of the drainage basin below the Mactaquac Dam with the runoff recorded at the hydrometric station near the dam. Recorded runoff, in inches, for the period April 17 to May 6 is shown below for several hydrometric stations.

Saint John River below Mactaquac	10.0 inches
Nashwaak River at Durham Bridge	10.7 inches
Northwest Oromocto River at Tracy	6.2 inches
Canaan River at East Canaan	3.0 inches
Kennebecasis River at Apohaqui	2.9 inches

It is evident that with the exception of the Nashwaak and possibly the Keswick, tributaries below the Mactaquac Dam did not contribute significantly to the high flood levels on the lower portion of the Saint John River during 1973. As will be shown later in this report, the magnitude of the 1973 flood stages, relative to previous years, showed a definite decrease in a downstream direction between the Mactaquac Dam and Saint John.

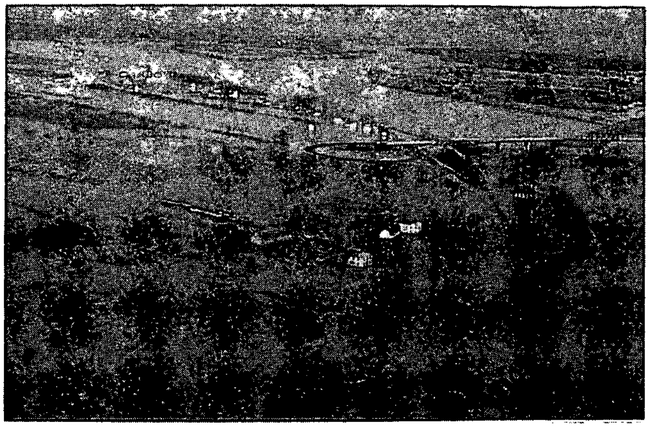
For comparative purposes, the total local runoff downstream of Mactaquac Dam has been estimated from hydrometric records in the lower portion of the Saint John

River basin. A hydrograph of the estimated local runoff is compared with the hydrograph of discharges recorded at the hydrometric station below the Mactaquac Dam on Figure 16. Although the drainage area below Mactaquac is more than one-third of that upstream, the estimated volume of runoff during the period April 15 to May 20 was only 21 per cent.

Water Levels on the Lower Saint John

The progress of the flood from April 17 to May 6 in the lower reach of the Saint John River is indicated on the water level hydrographs on Figure 17. These data were obtained from continuously recording water level gauges operated by the Water Survey of Canada. The location of the gauges are shown on Figure 11.

The influence of tides in the Bay of Fundy is immediately apparent on the hydrographs for the gauges at Indiantown and Oak Point. When the stage immediately upstream of the Reversing Falls is below about 11 feet above mean sea level, flow takes place in both directions across the Falls, depending on the fluctuation in the tide in Saint John Harbour. Above this elevation the flow is continuously outward through the Falls. However, there is considerably more discharge at low water than at high water causing a cyclical pattern of increase and lowering of water levels several miles upstream. At the peak of the 1973 flood, water level fluctuations of about 0.5 feet were recorded at Indiantown. The fluctuations were gradually damped out progressing upstream and were not evident at Jemseg.



Photograph 5 – Looking downstream along Saint John River at flooded agricultural land in Maugerville area, 29 April 1973.

The pattern of buildup in stages on the lower Saint John River is evident from Figure 17. The stage at Fredericton generally followed that of the Mactaquac gauge, cresting initially on April 25, dropping off slightly until April 27 and then rising very sharply to a peak of 28.3 feet above mean sea level at 8:00 a.m. April 30.

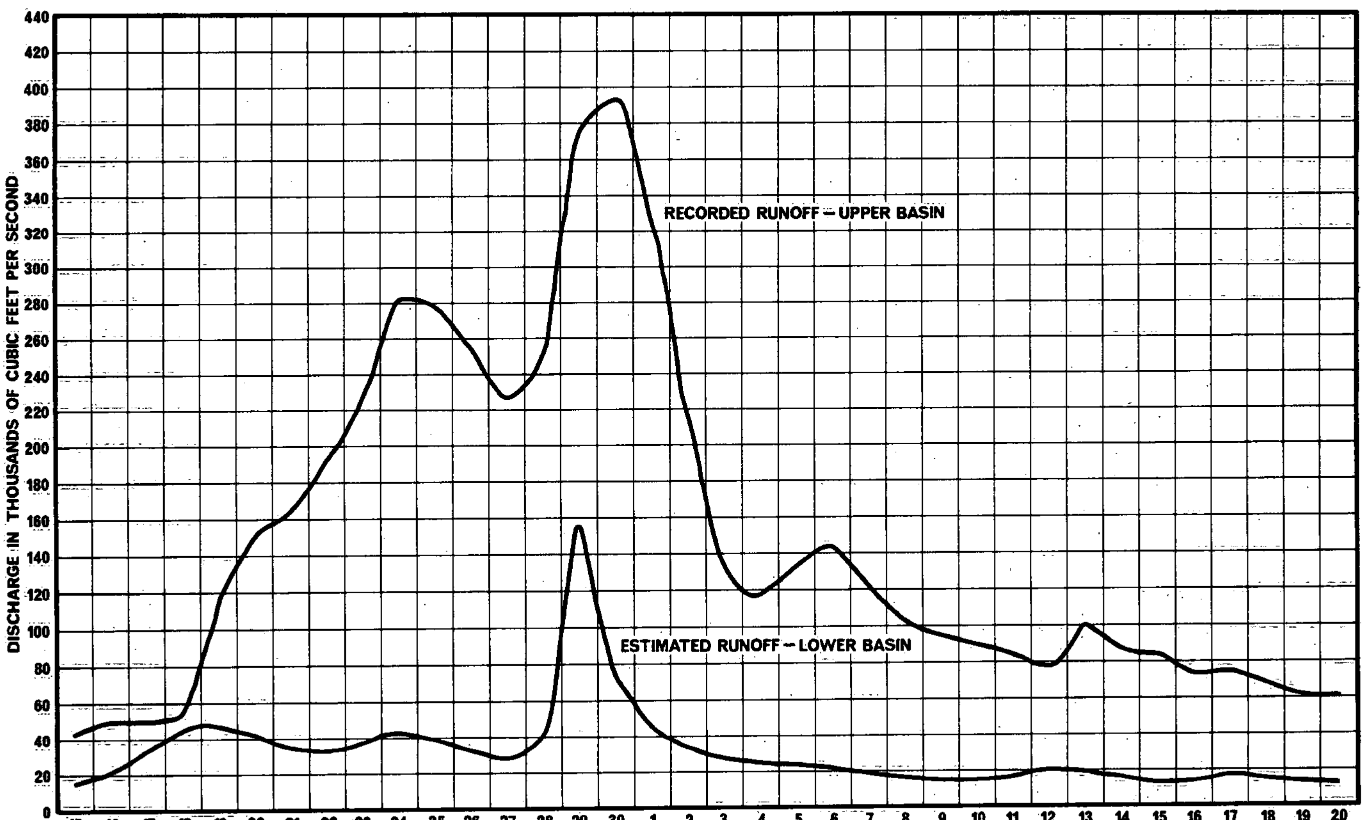


Figure 16 – Daily Mean Runoff - Upper and Lower Saint John River Basin

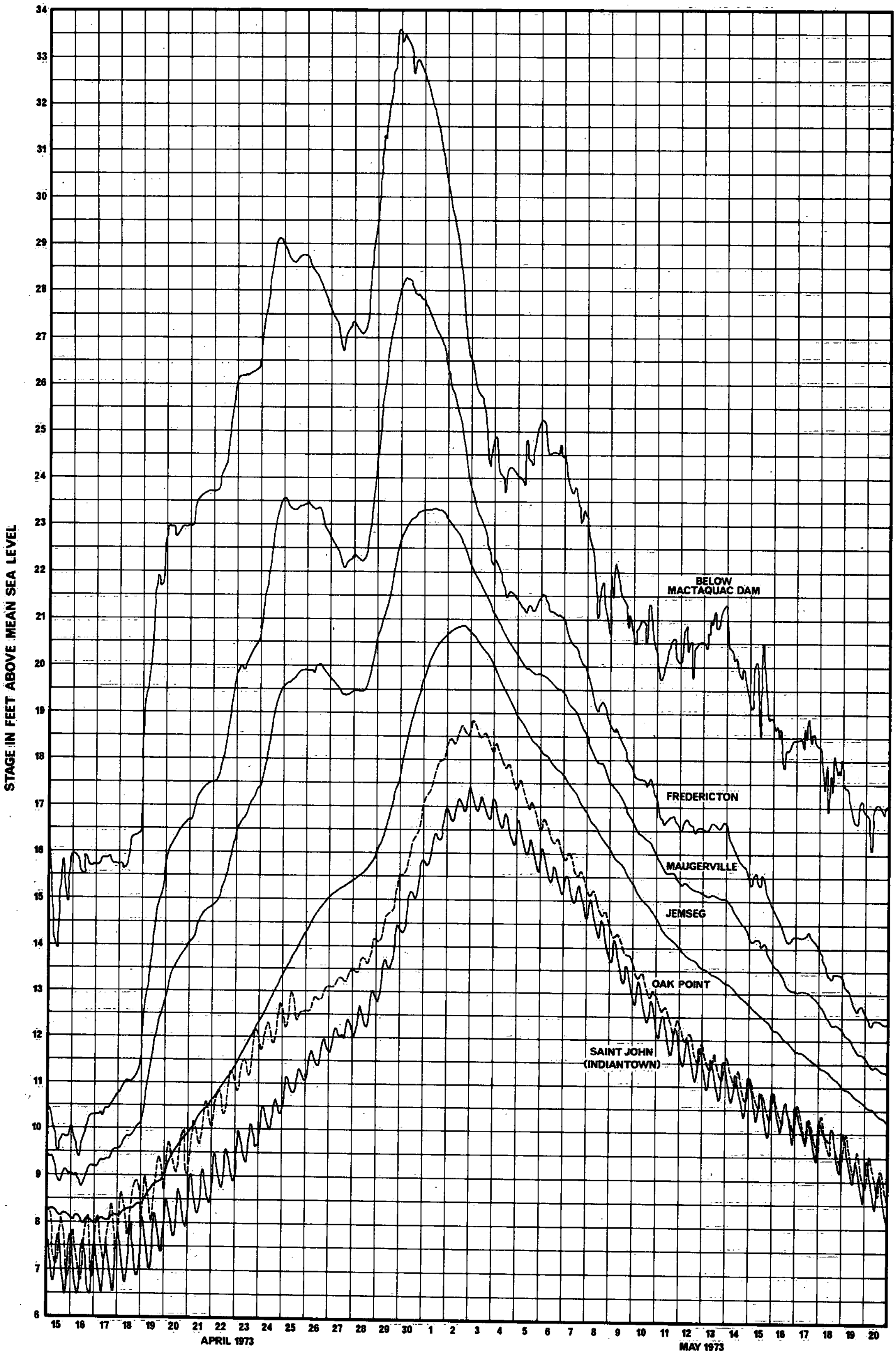


Figure 17 – Water Level Hydrographs - Lower Saint John River

At Maugerville water levels began rising on April 17 as snowmelt caused the discharges to increase in the upper Saint John River. The river rose steadily and started overflowing the Trans-Canada Highway and inundating farmlands on about April 24. The river then crested on April 26, dropped about one-half foot on April 27 and then rose an additional four feet to peak at an elevation of 23.3 feet above mean sea level on May 1. On Grand Lake and at other stage recorders downstream of Maugerville, the effects of the large storage capacities are more apparent. At these locations levels did not drop off during the period of recession on April 26-27 but showed a continuous increase from April 16 to May 2.

In addition to the recorded water level data, a number of spot measurements of river stage were made daily by field crews of the New Brunswick Electric Power Commission during the peak of the flood period, from April 29 to May 4. These measurements were taken at 16 locations between Mactaquac Dam and Saint John. Profiles of water levels developed from analysis of data collected by both Water Survey of Canada and the New Brunswick Electric Power Commission are shown on Figure 18. The profiles indicate how the general water surface slopes changed as the volume of water stored in the channel increased during the flood period.

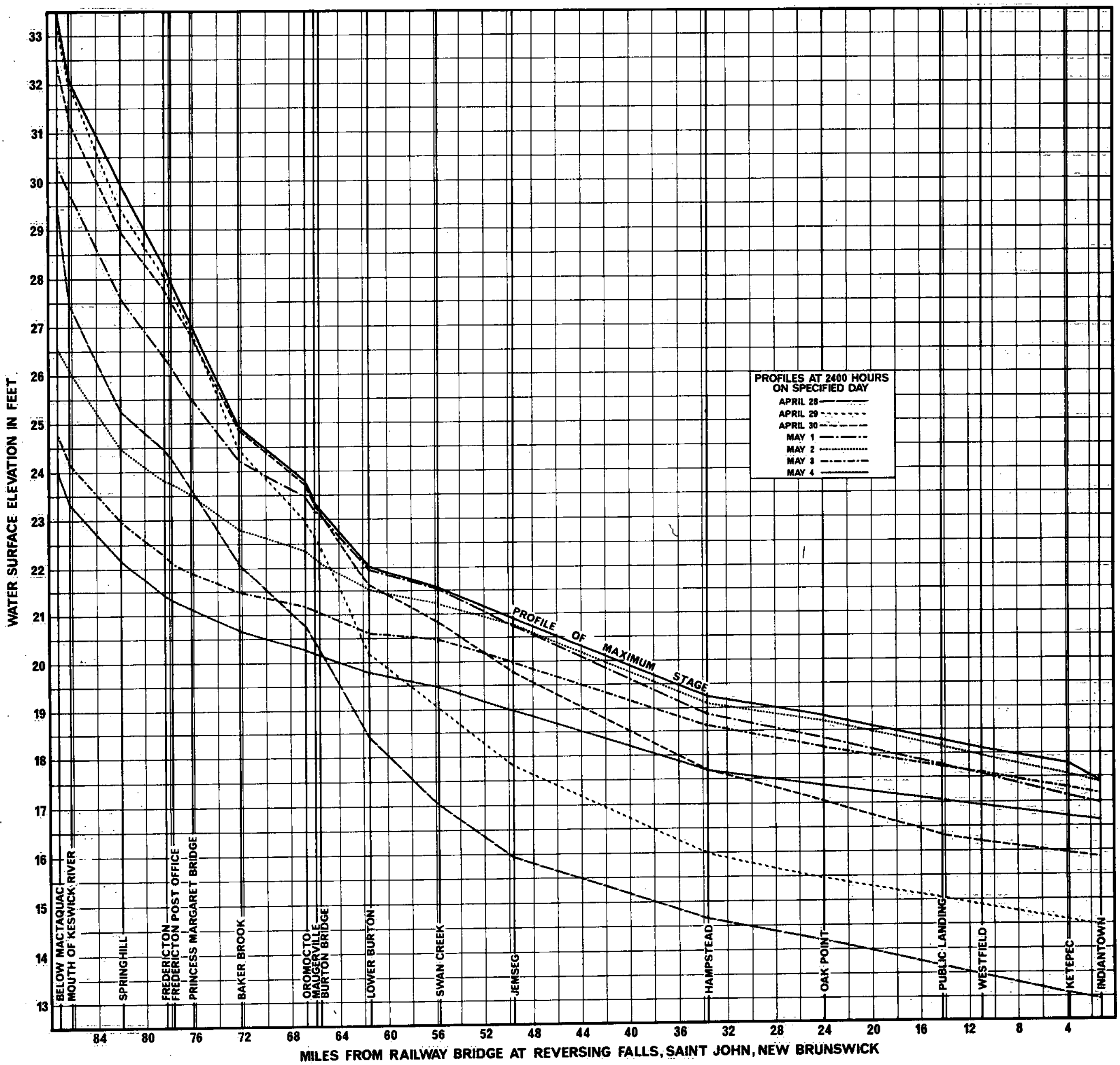


Figure 18 – Water Surface Profiles - Lower Saint John River

The Influence of Channel Storage

In order to examine the influence of storage on flood levels in more detail, an analysis was made of the relationships between stage and storage volumes. The river was divided into 13 reaches for this purpose. The locations of the reaches are shown on Figure 14. Because detailed topographic information was not available for most of the area, stage-storage relationships were developed indirectly by means of aerial photography. A search was made of available aerial photographs and four complete coverages were found. Two of these coverages were obtained from photography during 1973; the first on April 18 and 19 and the second on May 2, near the peak of the flood. The other two coverages were pieced together from a number of flights during 1970, 1971 and 1972.

The areas of water surface at the time of the photographs were traced on 1:50,000 scale topographic maps and planimetered. For each reach, flooded area was plotted against mean stage as estimated from recorded water levels. Since the aerial photographs covered a wide range of water levels from low summer condition to near the peak of the 1973 flood, it was possible to estimate fairly accurately the relationship between surface area and stage throughout a wide range of water level conditions. The stage-area relationships were used to develop the stage-storage curves shown on Figures 19, 20 and 21.

These stage-storage relationships, together with profiles of stage were used to estimate the volume of storage as a function of time. On Figure 22, estimates of storage are shown for three areas along the main channel (Mactaquac Dam to Fredericton, Fredericton to Jemseg and Jemseg to the Reversing Falls) and for the Grand Lake area which includes the low lying flood plain to the north of the Trans-Canada Highway between Fredericton and Grand Lake as well as Grand Lake itself. It should be pointed out that the storage data for the area between Jemseg and the Reversing Falls do not reflect short term cyclical fluctuations due to tidal effects, since the computations were carried out at one-day intervals.

A mass balance approach was used to estimate discharge at various points along the lower Saint John River. The discharge at the downstream end of each reach, shown on Figure 14, was estimated by adjusting the inflow from the upstream reach by the balance between local supply and change in storage. A routing period of one day was used throughout, thus, eliminating from the computations shorter period fluctuations in flow due to the influence of tides. The change in storage in each reach was computed by applying the estimated end of period water levels to the stage-storage relationships shown on Figures 19, 20 and 21. The local inflow was estimated

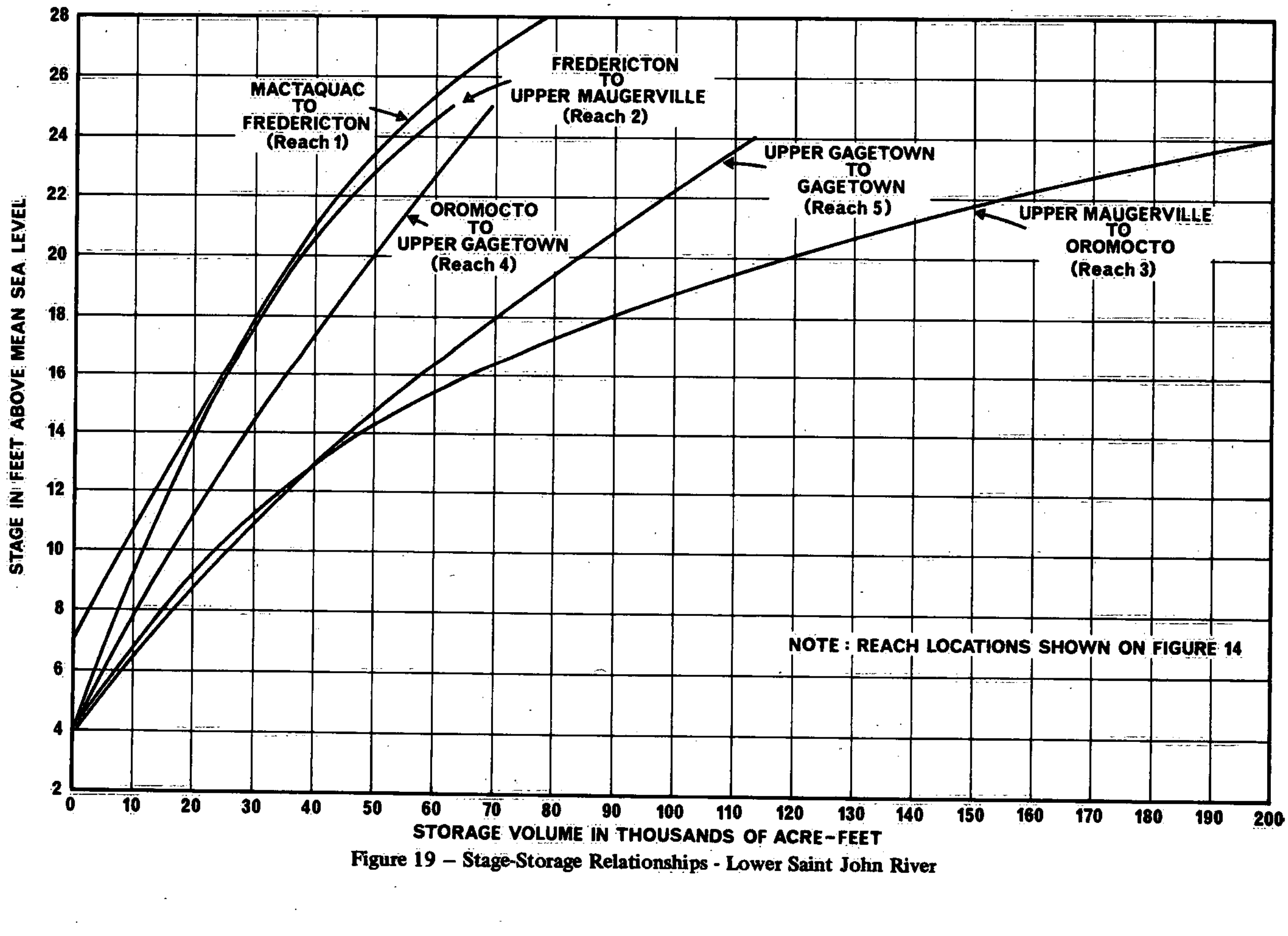


Figure 19 – Stage-Storage Relationships - Lower Saint John River

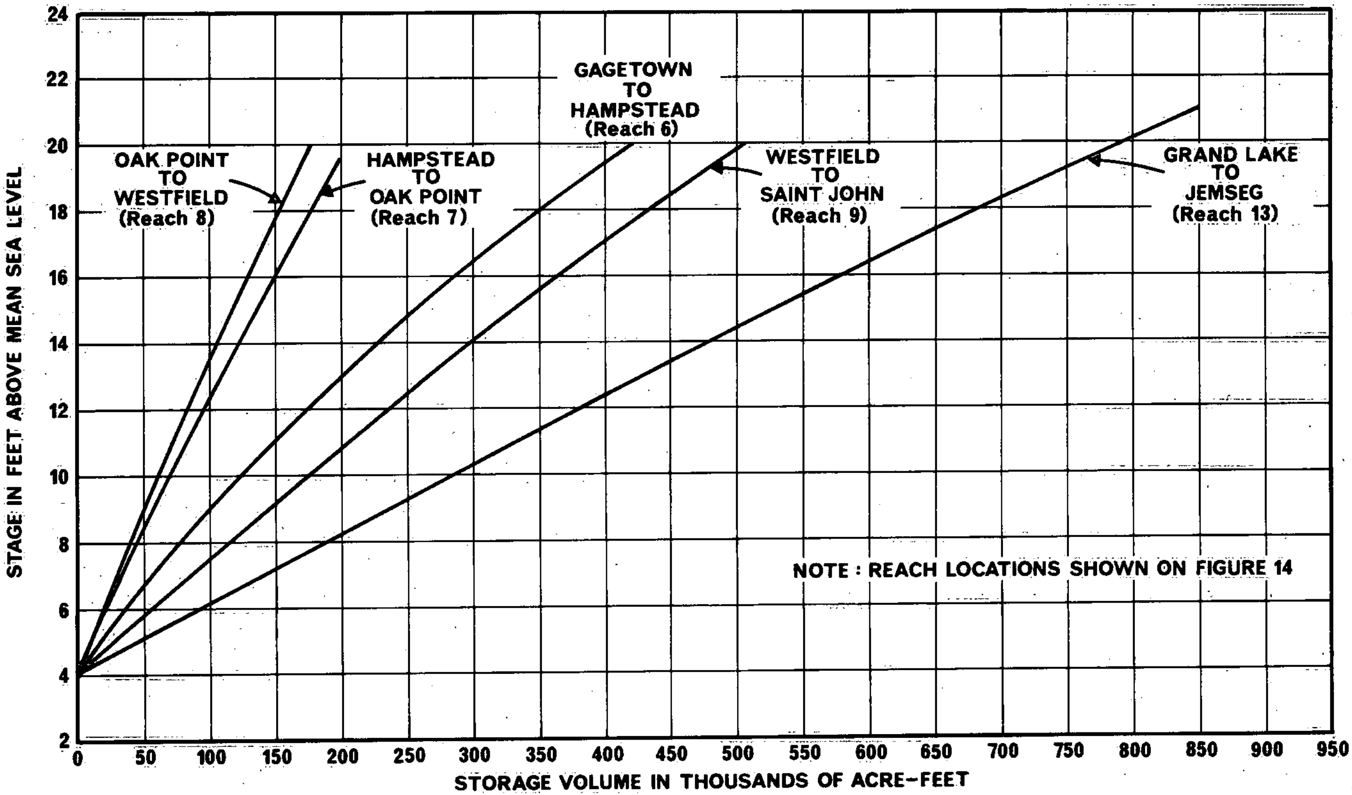


Figure 20 – Stage-Storage Relationships - Lower Saint John River

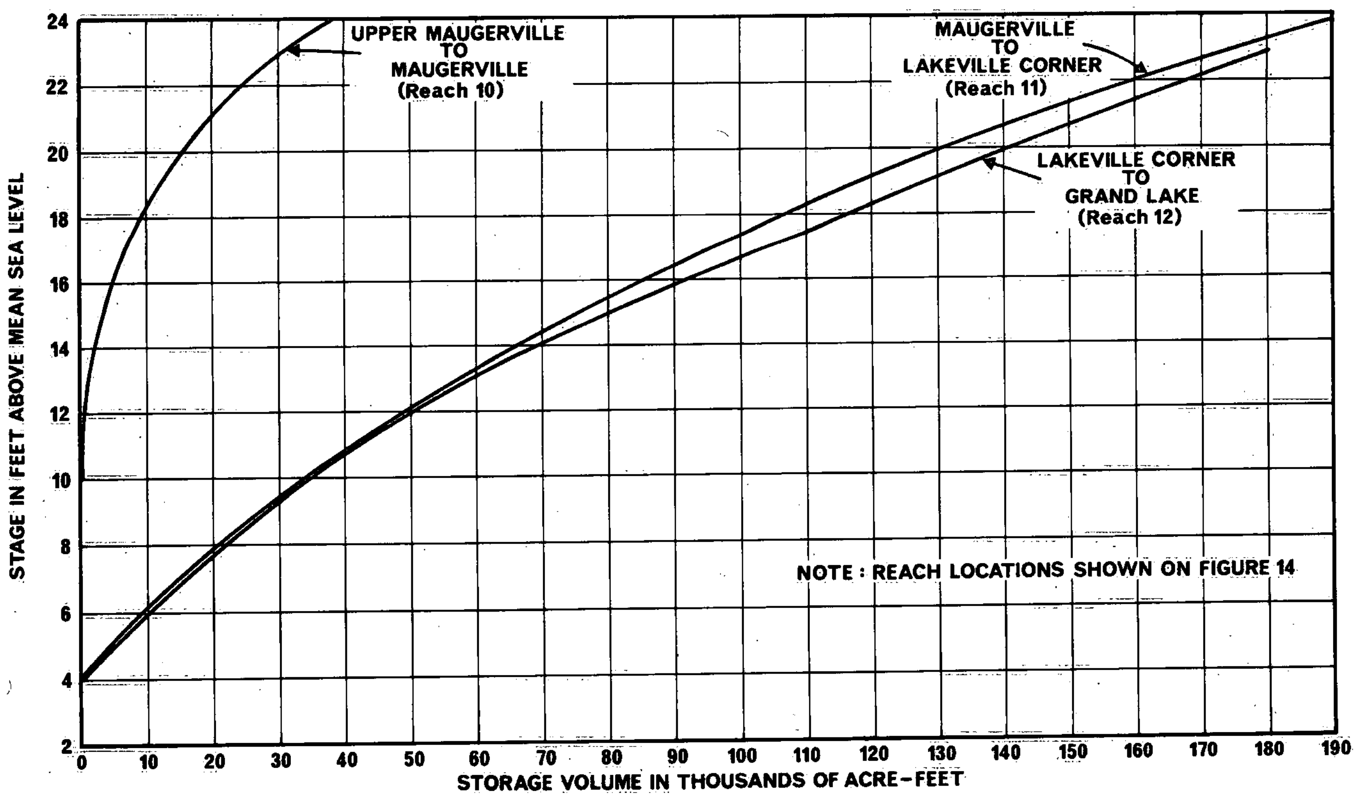


Figure 21 – Stage-Storage Relationships - Lower Saint John River

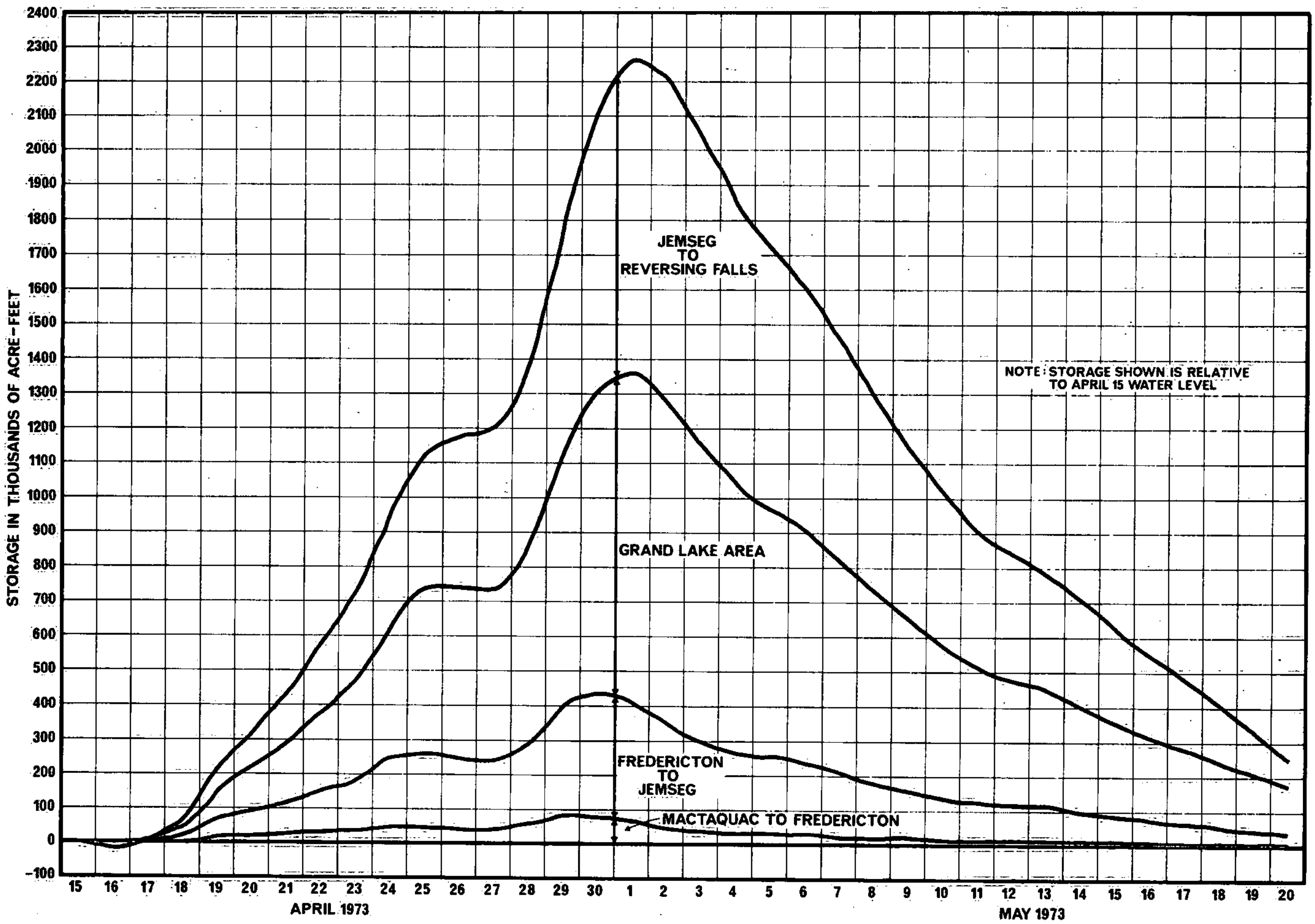


Figure 22 – Changes in Uncontrolled Storage - Lower Saint John River

from hydrometric records of tributaries which were judged representative of the drainage area. Discharge estimated in this manner for the Saint John River at Fredericton, Jemseg and Saint John, along with the recorded discharge at the hydrometric station below Mactaquac Dam, are shown on Figure 23.

The maximum daily mean discharge at Saint John was estimated at approximately 318,000 cubic feet per second on April 29. This is rather surprising when compared to recorded water levels along the lower river, especially those at the Indiantown gauge. The maximum stage at Indiantown did not occur until May 2 and stages remained relatively high for several days. One possible explanation for this is the extreme high tides which occurred in the Bay of Fundy in early May.

The fact that stages at Indiantown were higher than those in the Harbour indicates that the discharge was continuously outward through the Reversing Falls to the Bay of Fundy. However, the magnitude of the outflow is governed to some extent by the drop in water level across the Falls. When this drop reaches a certain value, critical flow takes place. At this point the discharge through the Falls is at its maximum and a lower tidal level in the Harbour does not cause a further increase in outflow. When the difference in level between Indiantown and the Harbour is less than that which produces a critical flow condition, discharge becomes a function of drop in surface water elevation. At low water, the flow condition through the Falls is critical and thus the tidal range does not influence outflow; but at high water, outflow decreases with greater tidal ranges. Thus, for a given river stage at Indiantown, the mean outflow decreases as the tidal range increases.

The computed net flow exchange between the Saint John River and Grand Lake together with the adjacent flood plain in the Maugerville area is plotted on Figure 24. It is interesting to note that although a net inflow of 49,000 cubic feet per second is computed for April 30, the stage recorder at Newcastle Creek on Grand Lake showed a higher elevation than the recorder at Jemseg from April 27 on. This indicates that the flow was continuously outward through the Jemseg River to the Saint John River and that after April 27, Grand Lake was filled by flow across the Trans-Canada Highway and downstream through the flood plain north of the highway. The magnitude of the overflow across the highway cannot be estimated but it was definitely more than 49,000

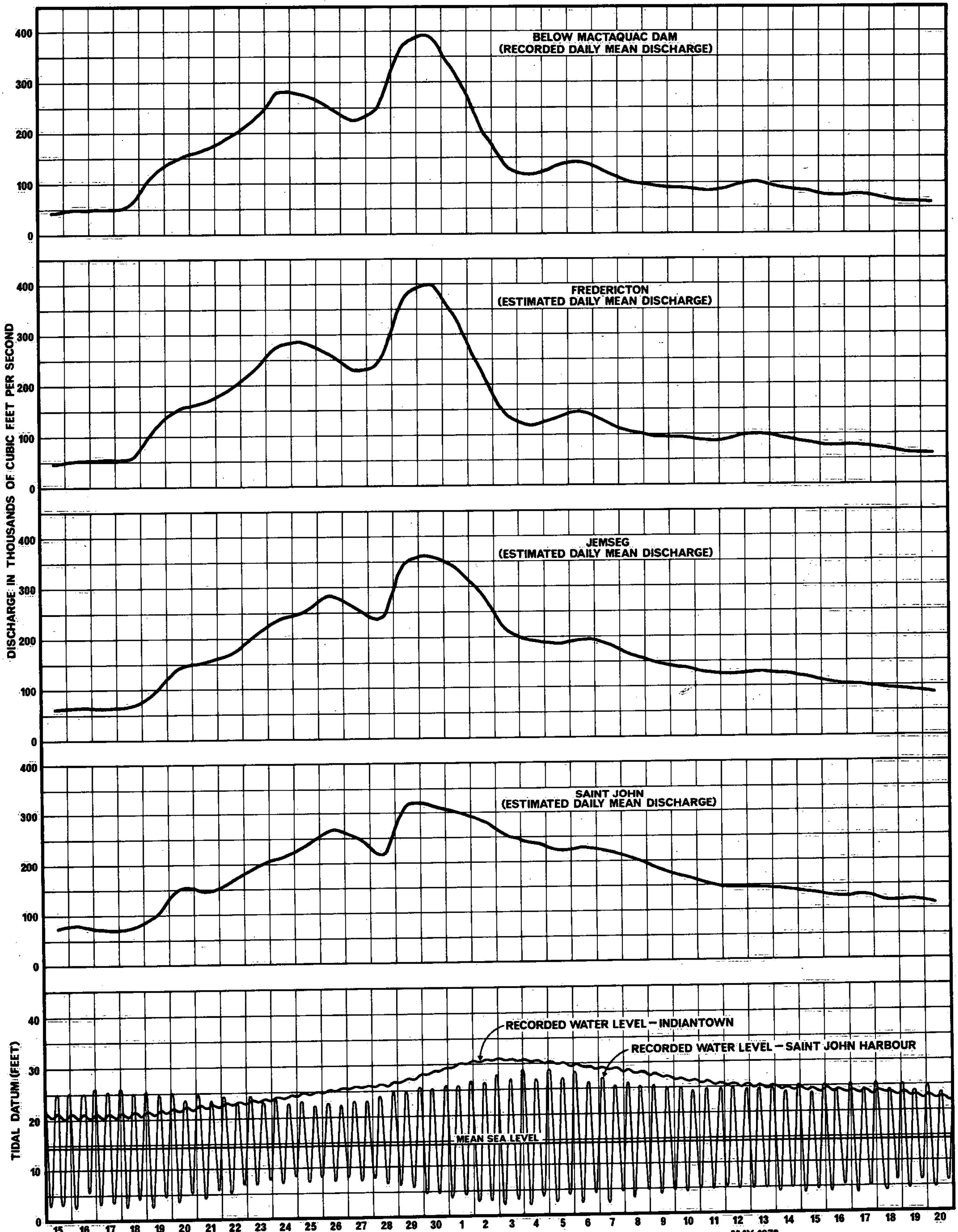


Figure 23 – Discharge Estimates - Lower Saint John River

cubic feet per second.

The discharges along the lower Saint John River have been estimated using the best available techniques. However, there are several possibilities for error in the computations. The following factors should be kept in mind in examining the results.

1) The computed flows at the Mactaquac gauge were developed using a stage fall-discharge relationship which utilized continuous water level data recorded below the dam and at Fredericton. There were no meter measurements on the rising limb of the hydrograph, and the first measurement on the recession was at a flow of about 200,000 cubic feet per second by moving boat technique.

2) The estimate of runoff from ungauged areas could be in error. While the total amount of runoff over the storm period is probably accurate, the distribution of runoff from April 28 to 30 may be more uniform than estimated. This could cause the time of the peak flow at Saint John to occur a maximum of one day ahead of the actual time.

3) The determination of storage volumes, particularly in the floodplain to the north of the Trans-Canada Highway, could introduce errors due to a lack of water level data. The maximum error is estimated to be in the order of ± 20,000 acre-feet. This could have the effect of altering the peak flow at Saint John by one day.

4) A relatively small error may be inherent in the use of a one day routing period as a result of tidal influences.

SOUTHWESTERN BASINS

Hydrographs of discharges at selected hydrometric stations in the southwestern part of New Brunswick are shown on Figure 25. By mid-April most of the snow had melted and water equivalent of the remaining snow was less than two inches throughout most of this area. Consequently none of the hydrometric stations showed significant increases in discharge during the period from April 15 to April 27. The storm of April 22 to 24 produced about one-half an inch of rain in the area and this was reflected in a very moderate increase in discharge.

During the storm of April 27 to 30, rainfall averaged about four inches over the southwestern basins. The St. Croix basin received greater than four inches while less than four inches fell on the Lepreau. The Lepreau and Magaguadavic Rivers peaked on April 29 as a result of this rainfall. The flows in these rivers were relatively low compared to flood discharges recorded in previous years.

The St. Croix River, on the other hand, reached relatively high discharges when compared to previous maximums. The mean daily discharge at Baileyville on April 30 was 18,700 cubic feet per second. This was less than the previous record of 22,900 cubic feet per second but was still a substantial flood discharge. The hydrometric station at Vanceboro is downstream of two large storage reservoirs and at this station discharges remained high for several days. The peak on May 4 was the highest recorded during a period of record commencing in 1928, reflecting the greater spillway capacity of the new Vanceboro Dam.

Flood damage in the southwestern basins was not substantial. In St. Stephen, on the St. Croix River, stock was moved from basements of low lying businesses and several residents made preparations for evacuation but little real damage was reported.

NORTHEASTERN BASINS

Snow accumulation in the northeastern basins was considerably higher than elsewhere in the province. In mid-April the water equivalent of the snow was in excess of eight inches over most of the Restigouche basin and the headwaters of the Miramichi. As indicated by the hydrographs for selected stations on Figure 26, snowmelt did not produce substantial flood flows prior to April 27. This was probably because water from melted snow was retained in the snowpack. Rainfall on April 21 to 24, which was about one-half to three-quarters of an inch in this part of New Brunswick, did not cause snowmelt water to run off in significant amounts.

During the storm of April 27-30, rainfall varied from two inches to more than four inches in the northeast. The rainfall on the basins of major rivers such as the Restigouche, Miramichi and Nepisiguit averaged about three inches. Discharges rose sharply and peaked on April 29 at most hydrometric stations in the northeastern basins. Maximum discharges approached or exceeded previous records at almost all hydrometric stations, but the lack of long term records at most stations make comparisons with previous floods difficult. On the Southwest Miramichi at Blackville the maximum daily mean discharge of 77,200 cubic feet per second on April 30 was the highest in an intermittent period of record from 1918 to 1933, 1938 to 1939 and 1961 to date.

Overbank flooding caused considerable problems in the northeastern basins. Many roads and railways were blocked by flooding and washouts, some agricultural lands were damaged and at Campbellton a few homes had to be evacuated.

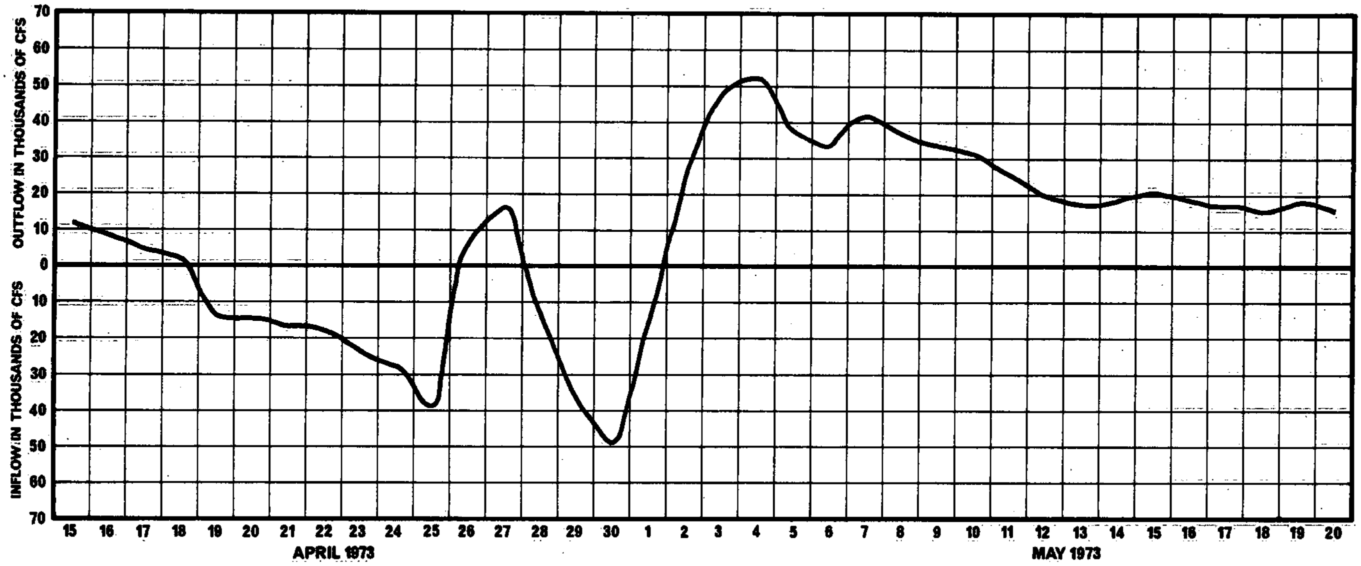


Figure 24 – Flow Exchange of Grand Lake Area

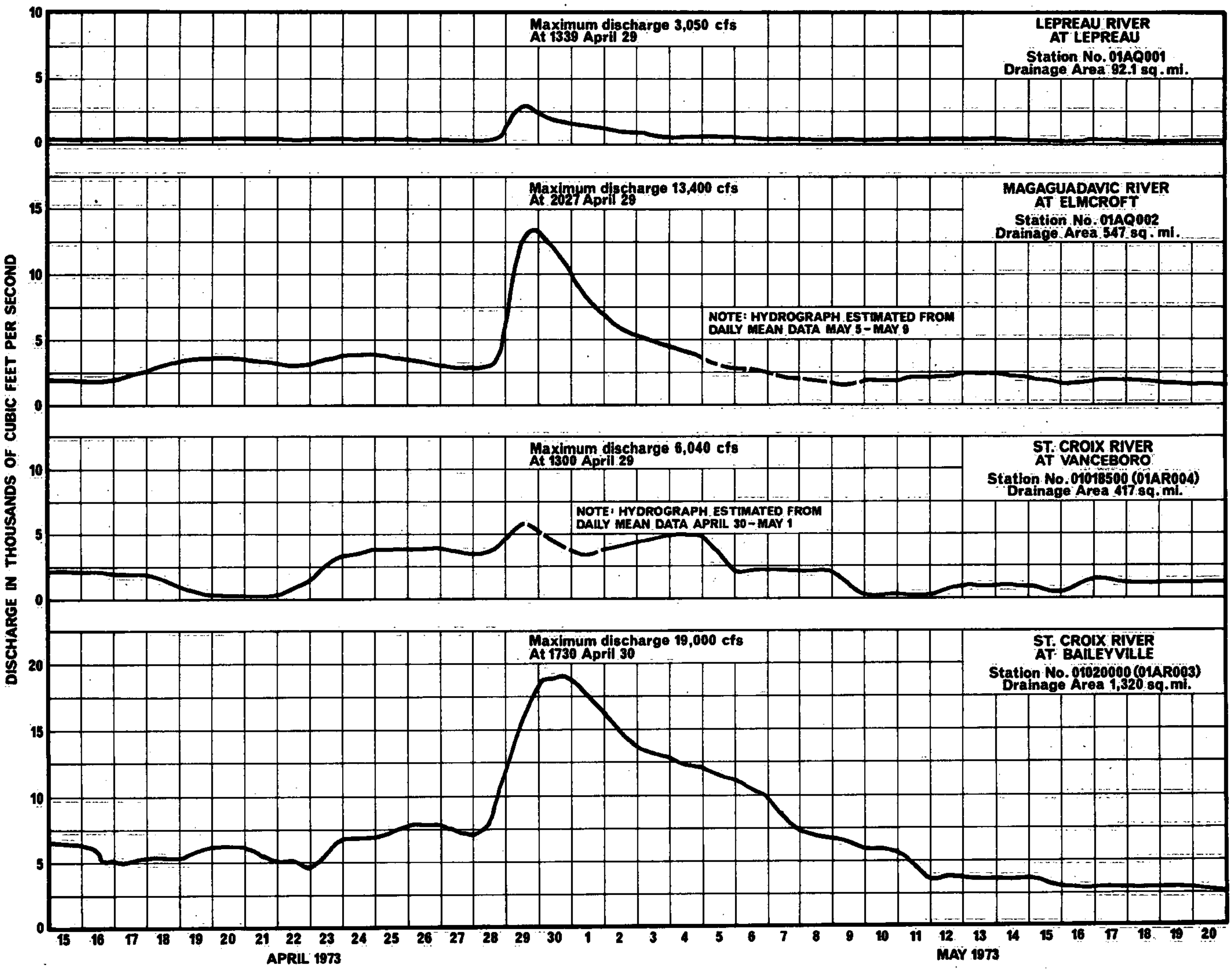


Figure 25 – Hydrographs of Streamflow for Rivers in Southwestern Basins

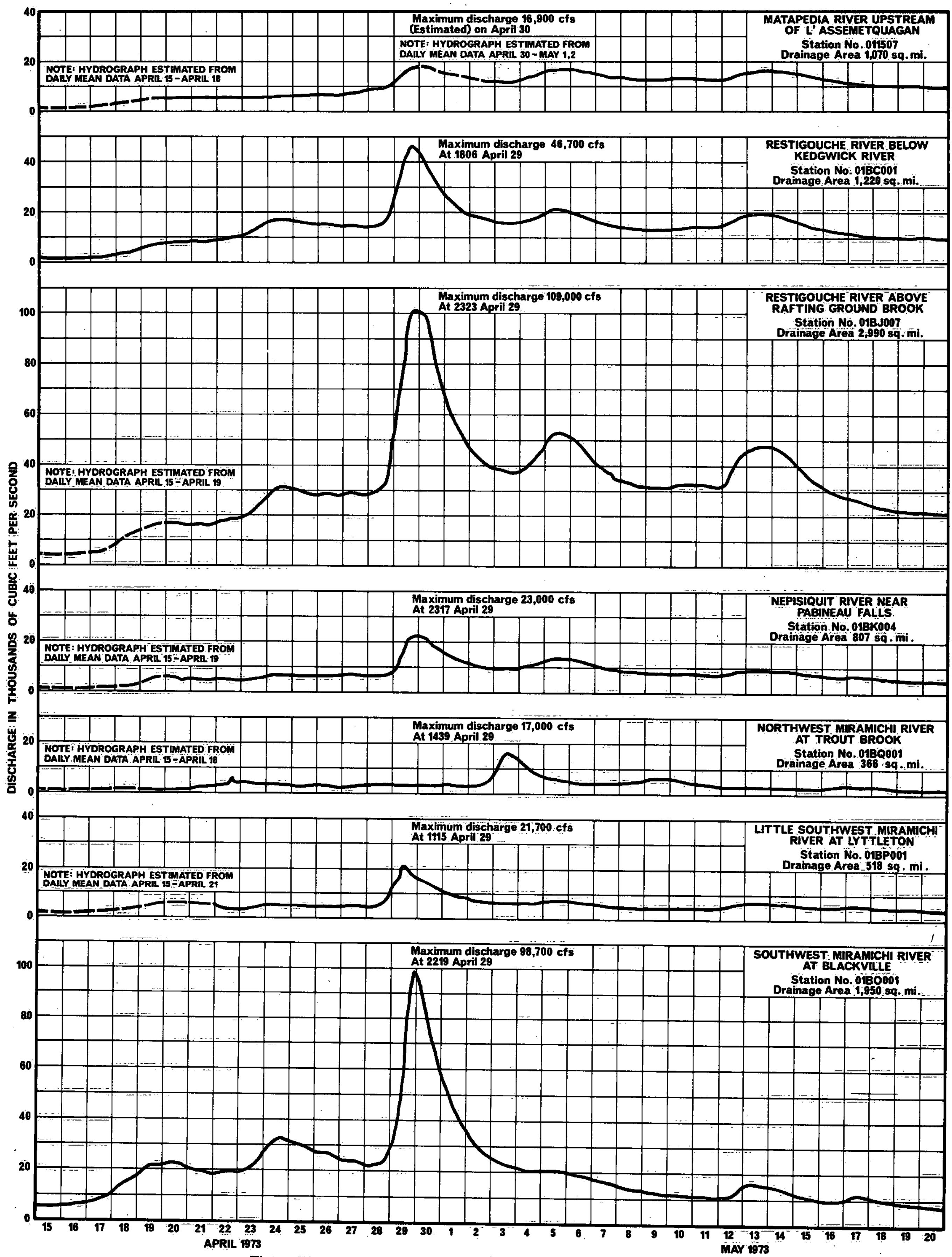


Figure 26 – Hydrographs of Streamflow for Rivers in Northeastern Basins

Flood Magnitudes

This chapter of the report presents an analysis of the peak discharges and flood stages observed during 1973, their estimated frequency of occurrence, the runoff volumes involved, and a comparison of the magnitude of the 1973 flood with past flood magnitudes.

PEAK DISCHARGES

Maximum discharges during the period April 15 to May 20, 1973 are given in Table 9 for all gauging stations in New Brunswick and in contributing areas of Quebec and Maine. The maximum daily mean discharge for the period of record prior to 1973 is included in the table for comparative purposes along with drainage areas to the gauge.

It will be noted that the maxima of record were approached or exceeded at hydrometric stations on the main stem of the Saint John River in Maine and on almost all tributaries of the Saint John upstream of the Mactaquac Dam. On the main stem of the Saint John in Canada, the 1973 peak discharges exceeded the previous flood of record at all stations from Edmundston to Fredericton. The extreme flood conditions on the Saint John were the result of the accumulation of high flood discharges from all tributaries. Although many of the tributaries have had higher flood discharges in the past, they have never all been at such high flood stages during any earlier flood.

The maximum discharges during 1973 also approached or exceeded previously recorded maximum discharges at most hydrometric stations in the northeast and in the St. Croix River basin in the southwest. Elsewhere in the southwestern basins and on tributaries in the lower part of the Saint John River basin, flood discharges in April and May 1973 were much less than previously recorded maximum discharges.

The maximum discharge per unit of drainage area is shown for the April-May 1973 peak in the far right hand column of Table 9. These maximum unit discharge figures are useful for comparison with former floods in the same basin or in other areas and also give an indication of the relative contribution to the flood by the various tributaries.

FLOOD FREQUENCIES

The most widely accepted measure of the magnitude of a flood is its frequency expressed by a recurrence interval (or return period) in years. In order to estimate the recurrence intervals of the April-May 1973 flood, frequency analyses were carried out for all hydrometric stations in New Brunswick and contributing areas of Quebec and Maine with periods of record of at least ten years. It was not the objective of this study to present a regional flood frequency analysis since such analyses have already been carried out, in recent years, for the area under consideration.[7,8]

The flood frequency analysis carried out for the purpose of this study utilized the Method of Maximum Likelihood[9] based on the extreme value distribution postulated by Gumbel. The method was selected because it was readily available in a computerized form.

The results of the frequency analyses are shown in Table 10. Since the method of analysis utilizes the Gumbel distribution, the frequency curves are completely defined by two points. The two values selected in Table 10 are the mean annual flood ($Q_{2.33}$) and the 50-year recurrence interval flood (Q_{50}). Flood frequency curves for selected stations are shown on Figures 27 to 31. The confidence limits shown on these figures give a measure of the possible error in the estimated discharge corresponding to a particular recurrence interval.

Table 10 also shows the estimated recurrence interval of the maximum daily mean discharge which occurred between April 15 and May 20, 1973. The estimated recurrence intervals are more than ten years for most hydrometric stations shown in the Table. On the main stem of the Saint John River, the estimated recurrence interval of the flood shows a continuous increase in a downstream direction from 8.5 years at Ninemile Bridge to 84 years at the hydrometric station below Mactaquac Dam. Recurrence intervals for the tributaries of the Saint John River are generally estimated to be between 10 and 50 years. Notable exceptions are the Kennebecasis and Canaan Rivers in the extreme southern part of the basin. Some of the higher recurrence intervals are those estimated for the Allagash and Fish Rivers in Maine, and the Shogomoc Stream which are all about 40 years.

In the northeastern basins, the estimated recurrence interval of the flood ranges from 2.7 years to 100 years, the higher values occurring in the Miramichi River basin. Recurrence intervals in the Restigouche basin were about 12 years.

In the southeastern and southwestern basins, the flood had a recurrence interval of less than five years at all hydrometric stations except those in the St. Croix River basin where the recurrence intervals were from 9 to 30 years.

Table 9 – Summary of Peak Discharges at Stream Gauging Stations in New Brunswick, Quebec and Maine

Station Number	Station Name	Drainage Area (sq. mi.)	Period of Record	Maximum Daily Mean Discharge prior to 1973		Maximum Daily Mean Discharge 1973		Maximum Instantaneous Discharge 1973			
				Date	Discharge (cfs)	Date	Discharge (cfs)	Date	Time*	Discharge (cfs)	Unit Discharge (cfs/sq.mi.)
Saint John River Basin											
013001	Daaquam R. @ Bridge 1 mi. downstream of Shidgel	227	1967-73	Apr. 26, 1970	9,900	Apr. 24	6,200(E)	Apr. 18	-	8,120	35.77
100	Saint John River @ Nine-mile Bridge	1,290	1950-73	Apr. 25, 1958	33,700	Apr. 24	29,800	Apr. 24	0500	30,600	23.72
105	Saint John R. @ Dickey	2,700	1946-73	May 10, 1969	71,400	Apr. 24	66,800	Apr. 29	2000	72,000	26.67
110	Allagash River near Allagash	1,250	1931-73	May 17, 1961	28,000	Apr. 29	27,200	Apr. 29	1800	29,400	23.52
013104	Saint-François 1.3 mi. down-stream from Lac Saint-François	20.9	1969-73	May 3, 1970	590(E)	Apr. 28	5,765	-	-	-	
01AD003	St. Francis River @ Out-let of Glasier Lake	520	1951-73	May 12, 1969	12,800	May 1	11,600	Apr. 30	2218	12,100	23.27
135	Fish River near Fort Kent	871	1929-73	May 16, 1961	13,300	Apr. 30	15,600	Apr. 30	0400	15,800	18.14
01AD002	Saint John River @ Fort Kent	5,690	1926-73	May 16, 1961	130,000	Apr. 30	130,000	Apr. 30	0400	136,000	23.90
011702	Madawaska River 1.9 mi. downstream from Lake Temiscouata Dam	1,050	1919-73	May 15, 1969	14,700	May 5	13,100	May 5	2400	13,200	12.57
01AD004	Saint John River @ Edmundston	5,990	1967-73	May 11, 1969	131,000	Apr. 30	132,000	Apr.30	0957	134,000	22.37
01AF003	Green River near Rivière Verte	443	1962-73	May 11, 1969	15,600	Apr. 30	11,800	Apr. 29	2327	13,800	31.15
01AF006	Black Brook near St.-André-de-Madawaska	5.5	1971-73	Apr. 20, 1971	249	Apr. 29	223	Apr. 29	0453	326	59.27
01AF002	Saint John River @ Grand Falls	8,450	1930-73	May 11, 1969	201,000	Apr. 30	213,000	Apr. 30	1616	222,000	26.27
158	Aroostook River near Masardis	888	1957-73	Apr. 25, 1958	21,400	-	-	-	-	-	-
165	Machias River near Ashland	330	1951-73	June 29, 1954	13,200	Apr. 29	10,700	Apr. 29	1300	11,400	34.56
170	Aroostook River @ Washburn	1,652	1930-73	Mar. 22, 1936	37,000	Apr. 30	42,400	Apr. 30	1400	43,100	26.09
01AG002	Limestone River @ Four Falls	77	1967-73	Oct. 4, 1970	1,650	Apr. 29	2,470	Apr. 29	0643	3,080	40.00
01AH005	Mamozekel River near Campbell River	88.9	1972-73	Oct. 30,1972	409	Apr. 29	3,250	Apr. 29	1006	3,830	43.08
01AH002	Tobique River @ Riley Brook	860	1954-73	May 28, 1961	21,400	Apr. 29	16,500	Apr. 29	1730	18,000	20.93
01AH003	Tobique River @ Plaster Rock	1,210	1954-73	May 28, 1961	34,400	Apr. 29	27,100	Apr. 29	1909	33,000	27.27

Table 9 – Continued

Station Number	Station Name	Drainage Area (sq. mi.)	Period of Record	Maximum Daily Mean Discharge prior to 1973 Date	Maximum Daily Mean Discharge prior to 1973 Discharge (cfs)	Maximum Daily Mean Discharge 1973 Date	Maximum Daily Mean Discharge 1973 Discharge (cfs)	Maximum Instantaneous Discharge 1973 Date	Time*	Discharge (cfs)	Unit Discharge (cfs/sq.mi.)
01AH004	Tobique River @ Narrows	1,670	1954-73	May 29, 1961	40,500	Apr. 29	43,200	-	-	-	-
01AJ006	Holmes Brook @ Moose Mountain	3	1971-73	May 4, 1972	63.7	Apr. 29	253	-	-	-	-
01AJ007	Holmes Brook near Holmesville	12.1	1971-73	Mar. 19, 1972	306	Apr. 29	534	Apr. 29	0256	826	68.26
01AJ001	Saint John River @ East Florenceville	13,200	1951-73	Apr. 25, 1958	240,000	Apr. 30	324,000	Apr. 30	0845	333,000	25.23
01AJ004	Big Presque Isle Stream @ Tracey Mills	187	1967-73	Apr. 18, 1969	4,380	Apr. 29	7,780	Apr. 29	0958	9,920	53.05
179	Marley Brook near Ludlow	1.47	1964-73	Apr. 15, 1964	58	Apr. 28	47	Apr. 29	0245	98	65.33
180	Meduxnekeag River near Houlton	175	1940-73	Apr. 24, 1958	5,600	Apr. 29	5,650	Apr. 29	1800	6,460	36.91
01AJ003	Meduxnekeag River near Belleville	466	1967-73	Apr. 18, 1969	11,500	Apr. 29	18,000	Apr. 29	1325	21,200	45.49
01AK001	Shogomoc Stream near T.C.H.	90.5	1918-73	Apr. 30, 1923	4,130	Apr. 29	2,770	Apr. 29	0837	3,010	33.26
01AK007	Nackawic River @ Temperance Vale	92.7	1967-73	Feb. 4, 1970	2,690	Apr. 29	3,980	Apr. 29	0601	5,190	55.99
01AK004	Saint John River below Mactaquac	15,400	1967-73	May 11, 1969	225,000	Apr. 30	393,000	Apr. 29	2100	435,000	28.25
01AK006	North Nashwaaksis Stream @ Sandwith's Farm	2.2	1966-73	Feb. 4, 1970	41.1	Apr. 29	75.7	Apr. 29	0411	151	68.64
01AK005	North Nashwaaksis Stream near Royal Road	10.4	1965-73	Feb. 4, 1970	385	Apr. 29	501	Apr. 29	0355	1,150	110.58
01AL003	Hayden Brook near Narrows Mountain	2.6	1970-73	May 15, 1972	91.3	Apr. 29	274	-	-	-	-
01AL004	Middle Brook near Narrows Mountain	1.5	1971-73	May 15, 1972	38.6	Apr. 29	125	-	-	-	-
01AL002	Nashwaak River @ Durham Bridge	561	1962-73	Feb. 4, 1970	29,000	Apr. 29	23,500	Apr. 29	1031	27,300	48.66
01AM001	Northwest Oromocto River @ Tracy	215	1962-73	Feb. 4, 1970	14,000	Apr. 29	10,200	Apr. 29	0757	14,700	68.37
01AN001	Castaway Brook near Castaway	13.3	1971-73	May 5, 1972	343	Apr. 29	301	Apr. 29	0835	466	35.04
01AP002	Canaan River @ East Canaan	258	1925-41 1962-73	May 5, 1972	8,320	Apr. 19	1,690	Apr. 19	0349	1,800	6.97
01AP004	Kennebecasis River @ Apohaqui	425	1961-73	Apr. 2, 1962	18,200	Apr. 29	3,030	Apr. 29	1403	3,830	9.01
Northeastern Basins											
011507	Matapedia River 0.6 mi. upstream of L'Assemetquagan	1,070	1968-73	May 12, 1969	17,500	Apr. 30	16,300(E)	Apr. 30	-	16,900(E)	15.79
01BA001	Restigouche River above Kedgwick River	607	1972-73	-	-	Apr. 29	24,400	Apr. 29	-	29,700	48.93

Table 9 – Continued

Station Number	Station Name	Drainage Area (sq. mi.)	Period of Record	Maximum Daily Mean Discharge prior to 1973: Date	Maximum Daily Mean Discharge prior to 1973: Discharge (cfs)	Maximum Daily Mean Discharge 1973: Date	Maximum Daily Mean Discharge 1973: Discharge (cfs)	Maximum Instantaneous Discharge 1973: Date	Time*	Discharge (cfs)	Unit Discharge (cfs/sq.mi.)
01BC001	Restigouche River below Kedgwick River	1,220	1962-73	May 11, 1969	38,900	Apr. 29	39,400	Apr. 29	1806	46,700	38.28
01BE001	Upsalquitch River @ Upsalquitch	877	1918-33 1943-73	May 28, 1961	30,900	Apr. 29	22,600	Apr. 29	1845	24,800	28.28
01BJ007	Restigouche River above Rafting Ground Brook	2,990	1968-73	May 11, 1969	91,900	Apr. 30	88,300	Apr. 29	2323	109,000	36.45
01BJ004	Eel River near Eel River Crossing	34.2	1967-73	May 7, 1970	1,670	Apr. 29	1,440	Apr. 29	1230	1,580	46.20
01BJ003	Jacquet River near Durham Centre	197	1964-73	May 21, 1969	5,310	Apr. 29	4,810(E)	Apr. 29	-	5,930	30.10
01BJ001	Tetagouche River near West Bathurst	140	1922-33 1951-73	Apr. 25, 1958	5,330	Apr. 30	3,590(E)	-	-	-	-
01BJ006	Little River @ Carroll's Farm	43.9	1967-73	May 21, 1969	1,470	Apr. 30	1,410	Apr. 29	1848	1,580	35.99
01BK003	Nepisiguit River @ Nepisiguit Falls	712	1921-73	May 28, 1961	18,500	Apr. 29	18,700	-	-	-	-
01BK004	Nepisiguit River near Pabineau Falls	807	1957-73	May 28, 1961	24,500	Apr. 30	19,700	Apr. 29	2317	23,000	28.50
01BL001	Bass River @ Bass River	67.6	1965-73	Feb. 5, 1970	2,050	Apr. 30	972	Apr. 30	0330	1,130	16.72
01BL002	Southwest Caraquet River @ Burnsville	66.8	1969-73	Apr. 22, 1971	1,660	Apr. 29	1,010	Apr. 29	2035	1,200	17.96
01BL003	Tracadie River @ Murchy Bridge Crossing	148	1970-73	Apr. 22, 1971	2,960	Apr. 30	2,020	Apr. 30	0346	2,120	14.32
01BQ007	Tomogonops River @ the Mouth	60.9	1971-73	May 19, 1972	1,450	Apr. 29	3,130	Apr. 29	0921	4,320	70.94
01BQ001	Northwest Miramichi River @ Trout Brook	366	1961-73	Feb. 4, 1970	17,200	Apr. 29	13,700	Apr. 29	1439	17,000	46.45
01BP001	Little Southwest Miramichi River @ Lyttleton	518	1951-73	May 28, 1961	25,600	Apr. 29	18,000	Apr. 29	1115	21,700	41.89
01BO002	Renous River @ McGraw Brook	236	1965-73	Feb. 4, 1970	11,300	Apr. 29	10,800	Apr. 29	1122	12,800	54.24
01BO001	Southwest Miramichi River @ Blackville	1,950	1918-33 1938-39 1961-73	May 1, 1923	70,000	Apr. 30	77,200	Apr. 29	2219	98,700	50.62
01BO003	Barnaby River below Semiwagan River	187	1972-73	-	-	Apr. 19	3,010	Apr. 30	0029	3,310	17.70
Southeastern Basins											
01BR001	Kouchibouguac River @ Acadieville	68.3	1930-33 1969-73	Feb. 4, 1970	1,860	Apr. 19	972	Apr. 19	0231	1,080	15.81
01BS001	Coal Branch River @ Beersville	64.2	1964-73	May 13, 1967	2,120	Apr. 18	867	Apr. 18	2119	1,030	16.04
01BU002	Petitcodiac River near Petitcodiac	151	1961-73	Apr. 2, 1962	7,400	Apr. 19	962	Apr. 24	1905	1,050	6.95

Table 9 – Continued

Station Number	Station Name	Drainage Area (sq. mi.)	Period of Record	Maximum Daily Mean Discharge prior to 1973		Maximum Daily Mean Discharge 1973		Maximum Instantaneous Discharge 1973			
				Date	Discharge (cfs)	Date	Discharge (cfs)	Date	Time*	Discharge (cfs)	Unit Discharge (cfs/sq.mi.)
01BU003	Turtle Creek @ Turtle Creek	49.9	1962-73	Nov. 9, 1963	2,710	Apr. 19	535	Apr. 24	1524	607	12.16
01BU004	Palmers Creek near Dorchester	13.2	1966-73	Nov. 10, 1972	797	Apr. 24	152	Apr. 24	1510	233	17.65
01BV007	Upper Salmon River near Alma	67.0	1967-73	May 16, 1972	5,410	Apr. 29	1,520	Apr. 29	0823	2,430	36.27
01BV006	Point Wolf River @ Fundy National Park	50.3	1964-73	May 16, 1972	4,150	Apr. 29	1,700	Apr. 29	0626	3,370	67.00
01BV008	Big Salmon River near St. Martins	111	1970-73	May 16, 1972	4,960	Apr. 29	3,310	Apr. 29	0513	5,760	51.89
Southwestern Basins											
01AQ001	Lepreau River @ Lepreau	92.1	1916-73	Apr. 30, 1923	12,000	Apr. 29	2,640	Apr. 29	1339	3,050	33.12
01AQ002	Magaguadavic River @ Elmcroft	547	1971-73	Feb. 4, 1970	25,500	Apr. 30	11,900	Apr. 29	2027	13,400	24.50
01AR008	Bocabec River above tide	16.6	1966-73	Feb. 4, 1970	612	Apr. 29	642	Apr. 29	0345	968	58.31
01AR012	Chamcook River @ Little Chamcook Lake Outlet	4.4	1968-73	Feb. 5, 1970	60.9	Apr. 30	50.8	Apr. 30	0226	53.3	12.11
01AR011	Forest City Stream below Forest City	138	1968-73	May 19, 1970	1,160	May 4	821	May 3	1630	826	5.99
01AR004	St. Croix River @ Vanceboro	417	1928-73	May 31, 1961	4,930	Apr. 29	5,800	Apr. 29	1300	6,040	14.48
190	Grand Lake Stream @ Grand Lake Stream	224	1928-73	June 13, 1952	2,780	May 4	1,960	May 3	1700	8.75	8.84
01AR003	St. Croix River near Baileyville	1,320	1919-73	May 1, 1923	22,900	Apr. 30	18,700	Apr. 30	1730	19,000	14.39
01AR006	Dennis Stream near St. Stephen	44.2	1956-73	Feb. 4, 1970	2,300	Apr. 29	1,260	Apr. 29	403	1,480	33.48

* Time given is Atlantic Standard Time

(E) Estimated

FREQUENCY OF FLOOD STAGES ON THE LOWER SAINT JOHN

Estimation of the recurrence interval of the flood on the Saint John River below the Mactaquac Dam requires a different approach since records of discharge are not available for 1973 or previous years. For this purpose it was necessary to rely on records of river stage.

Stages of the lower Saint John River have been recorded for 30 years or more at three locations; Fredericton, Oromocto and Oak Point, and for much shorter periods at a number of other locations. Records dating back to the early 1920's are available for the Saint John River at the Fredericton Pumping Station. Prior to 1961, river stage was read once a day by the City of Fredericton. From 1961 to date, the Water Survey of Canada, has maintained a continuously recording gauge at this location.

At Oromocto, river stages were read and recorded once daily from 1919 to 1933 by Canada Department of Public Works. From 1933 to 1949, the gauge was maintained by Water Survey of Canada. Stages of Oak Point were recorded from 1923 to 1933 by Canada Department of Public Works and from 1933 to 1966 by Water Survey of Canada. The gauge was operated jointly by the Tides and Water Levels Section, Marine Sciences Branch and the New Brunswick Electric Power Commission for the period 1966 to 1969. In 1969 responsibility for this gauge was assumed by Water Survey of Canada and water levels have been recorded continuously since that date.

Recorded data at Fredericton for the period 1924

Table 10 – Flood Frequency Analysis for Selected Stations in New Brunswick, Quebec and Maine

Station No.	Description	Period of Record Analysed	Discharge (cfs)		Maximum Daily Mean Discharge April 15-May 20, 1973	
			$Q_{2.33}$	Q_{50}	Discharge (cfs)	Recurrence Interval (yrs.)
0100	Saint John River at Ninemile Bridge	1951-1973	21,632	39,683	29,800	8.5
0105	Saint John River at Dickey	1947-1973	44,381	88,270	66,800	10
0110	Allagash River near Allagash	1932-1973	14,462	28,513	27,200	37
01AD003	St. Francis River at Outlet of Glasier Lake	1952-1973	7,130	14,972	11,600	12.5
0135	Fish River near Fort Kent	1930-1973	8,424	16,097	15,600	40
01AD002	Saint John River at Fort Kent	1927-1973	80,933	156,196	130,000	16
011702	Madawaska River 1.9 mi. downstream from Lake Temiscouata Dam	1923-1973	8,795	15,938	13,100	14.0
01AF003	Green River near Rivière Verte	1963-1973	7,825	17,968	11,800	7.4
01AF002	Saint John River at Grand Falls	1931-1973	115,172	234,856	213,000	28
0165	Machias River near Ashland	1952-1973	6,221	14,025	10,700	13
0170	Aroostook River at Washburn	1931-1973	22,779	45,852	42,400	32
01AH002	Tobique River at Riley Brook	1955-1973	9,114	19,793	16,500	18
01AH003	Tobique River at Plaster Rock	1955-1973	14,495	31,466	27,100	22
01AJ001	Saint John River at East Florenceville	1952-1973	152,299	351,596	324,000	32
0179	Marley Brook near Ludlow	1964-1973	46	81	47	2.5
0180	Meduxnekeag River near Houlton	1941-1973	3,301	6,652	5,650	19
01AK001	Shogomoc Stream near Trans-Canada Hwy.	1944-1973	1,464	2,848	2,770	42
01AK004	Saint John River below Mactaquac*	1919-1973	192,191	366,964	393,000	84
01AL002	Nashwaak River at Durham Bridge	1962-1973	12,206	28,516	23,500	18.4
01AM001	Northwest Oromocto River at Tracy	1963-1973	5,388	11,550	10,200	25
01AP002	Canaan River at East Canaan	1963-1973	5,110	11,300	1,690	1.01
01AP004	Kennebecasis River at Apohaqui	1962-1973	8,737	20,748	3,030	1.05
01BC001	Restigouche River below Kedgwick River	1963-1973	22,814	51,315	39,400	12.5
01BE001	Upsalquitch River at Upsalquitch	1944-1973	13,489	29,578	22,600	12.2
01BJ001	Tetagouche River near West Bathurst	1952-1973	3,320	8,096	3,590	2.7
01BK003	Nepisiquit River at Nepisiquit Falls	1921-1973	9,478	17,950	18,700	60
01BK004	Nepisiquit River near Pabineau Falls	1958-1973	13,677	29,845	19,700	6.7
01BQ001	Northwest Miramichi River at Trout Brook	1962-1973	7,242	16,819	13,700	17
01BP001	Little Southwest Miramichi River at Lyttleton	1952-1973	10,664	25,086	18,000	10
01BO001	Southwest Miramichi River at Blackville	1962-1973	32,128	69,746	77,200	100
01BU002	Petitcodiac River near Petitcodiac	1962-1973	4,026	9,464	962	1.01
01BU003	Turtle Creek at Turtle Creek	1963-1973	1,534	3,710	535	1.14
01AQ001	Lepreau River at Lepreau	1917-1973	2,791	6,119	2,640	2.15
01AQ002	Magaguadavic River at Elmcroft	1944-1973	9,591	18,166	11,900	4.9

* Includes adjusted values from Pokiok for period 1919 to 1966

to 1928 could not be located so estimates of the maximum stage reached during these years were made from a relationship between maximum daily discharge at the Pokiok Gauging Station and Fredericton stage. A relationship between these two parameters is inexact because of the characteristics of the lower Saint John River. However, the relationship was used only to estimate the order of magnitude of stages during years of missing data to determine plotting positions for other years. Since flood levels were not particularly high during any of these years, the frequency curve has not been significantly affected by the approximation. In the years 1932 and 1936, ice jams contributed to abnormally high stages at Fredericton. Since jams of this magnitude can no longer occur because of the Mactaquac Dam, the water level data used for these two years were also estimated in the manner described above.

Frequency analyses of maximum daily mean stage were carried out for the period of record at Fredericton, Oromocto and Oak Point. The resulting relationships are shown on Figure 32. The recurrence intervals for the maximum daily mean stage reached in April-May 1973 as determined from these curves are given in Table 11.

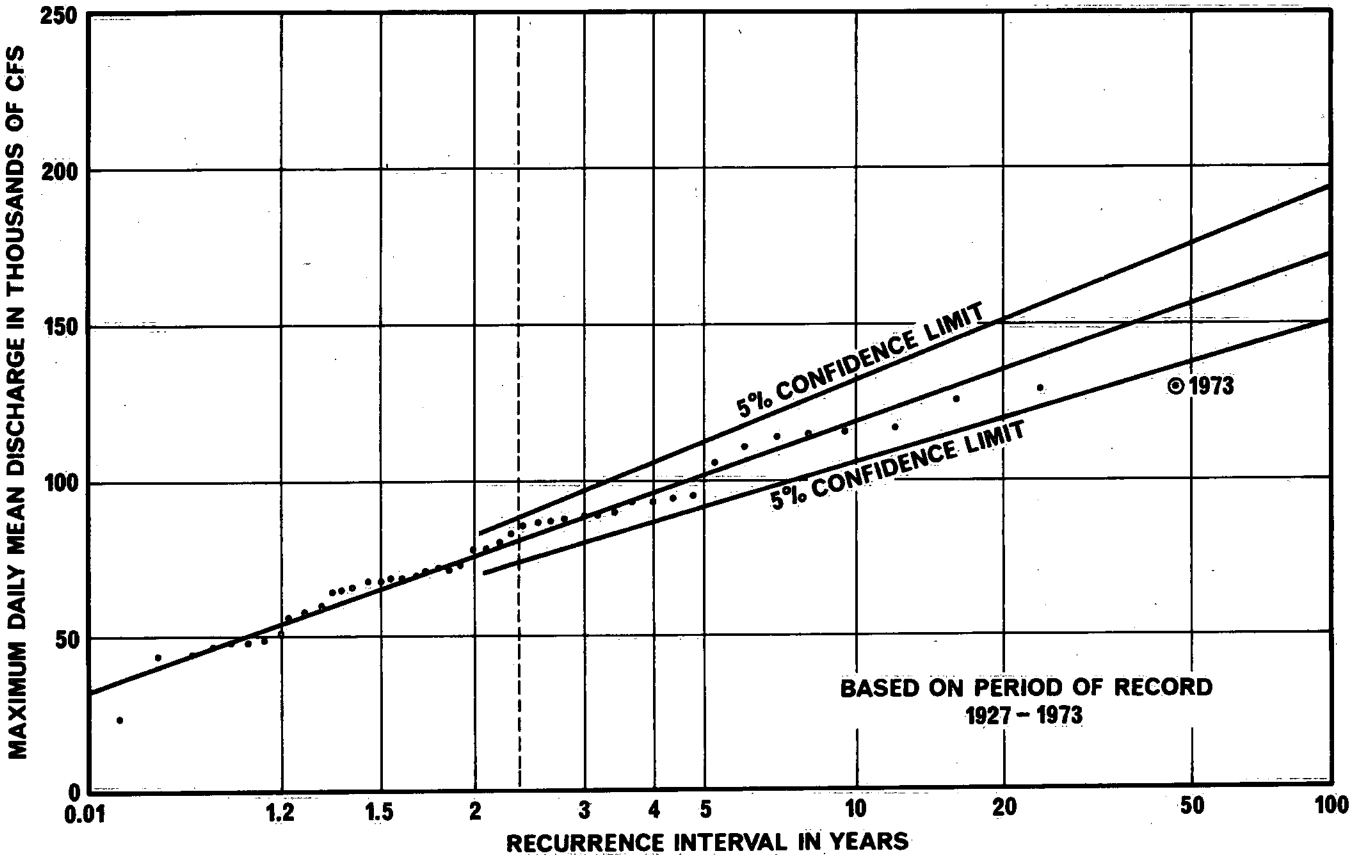


Figure 27 – Distribution of Annual Maximum Daily Mean Discharges - Saint John River at Fort Kent

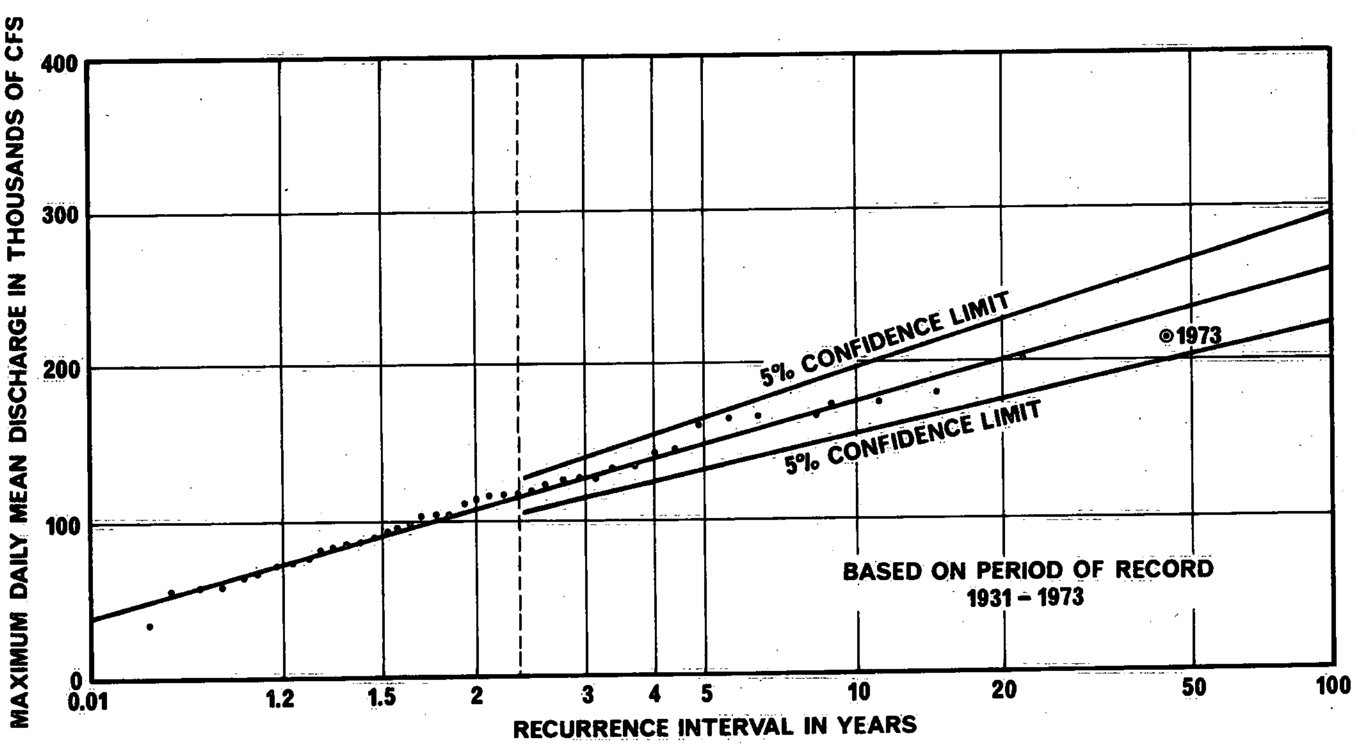


Figure 28 – Distribution of Annual Maximum Daily Mean Discharges - Saint John River at Grand Falls

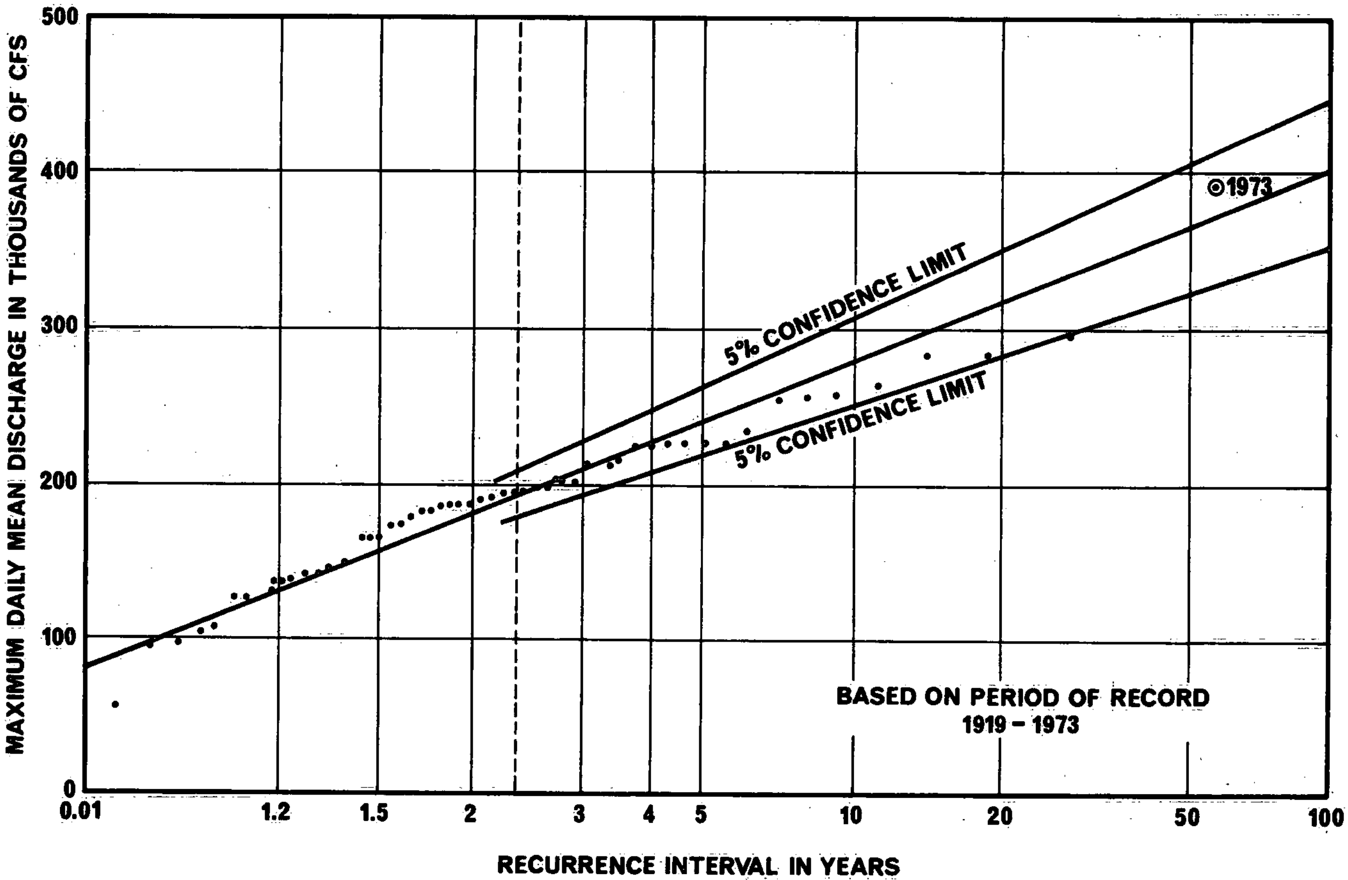


Figure 29 – Distribution of Annual Maximum Daily Mean Discharges - Saint John River below Mactaquac Dam

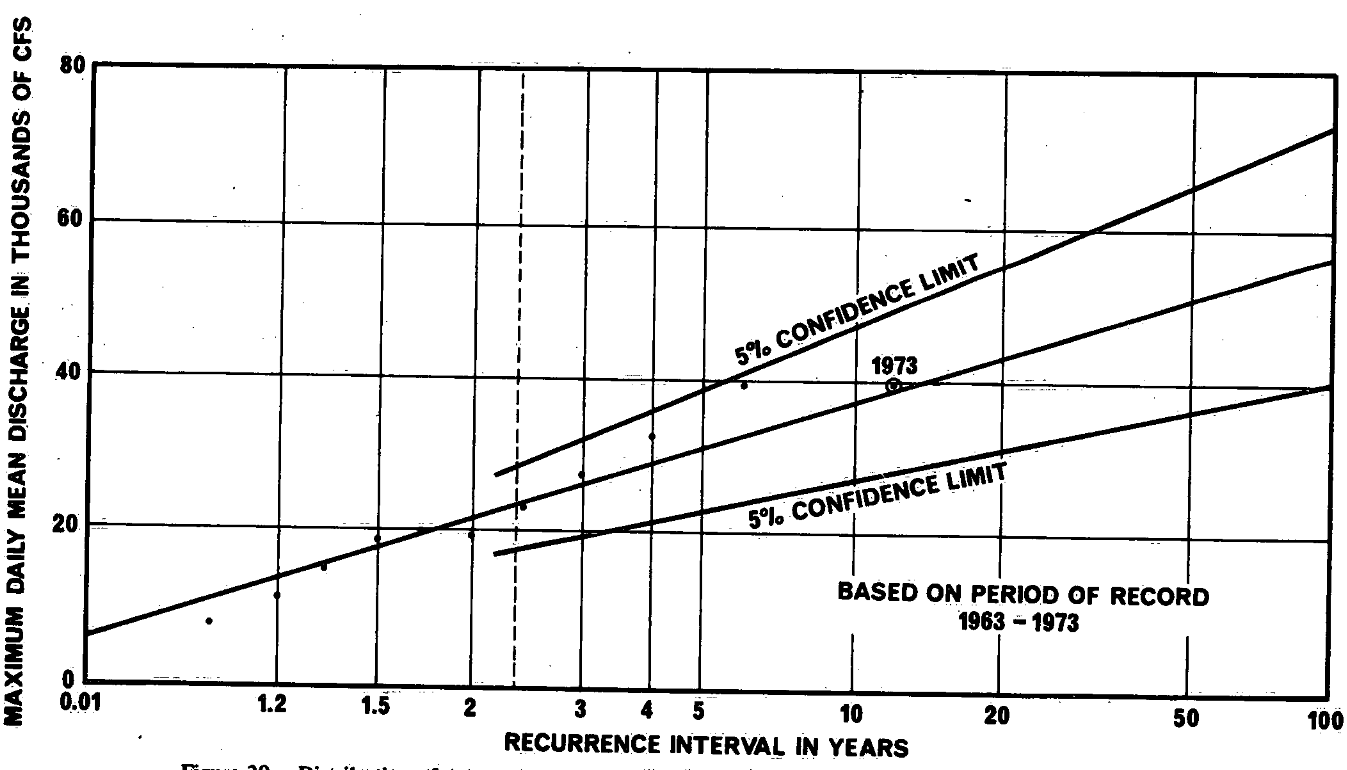


Figure 30 – Distribution of Annual Maximum Daily Mean Discharges - Restigouche River below Kedgwick River

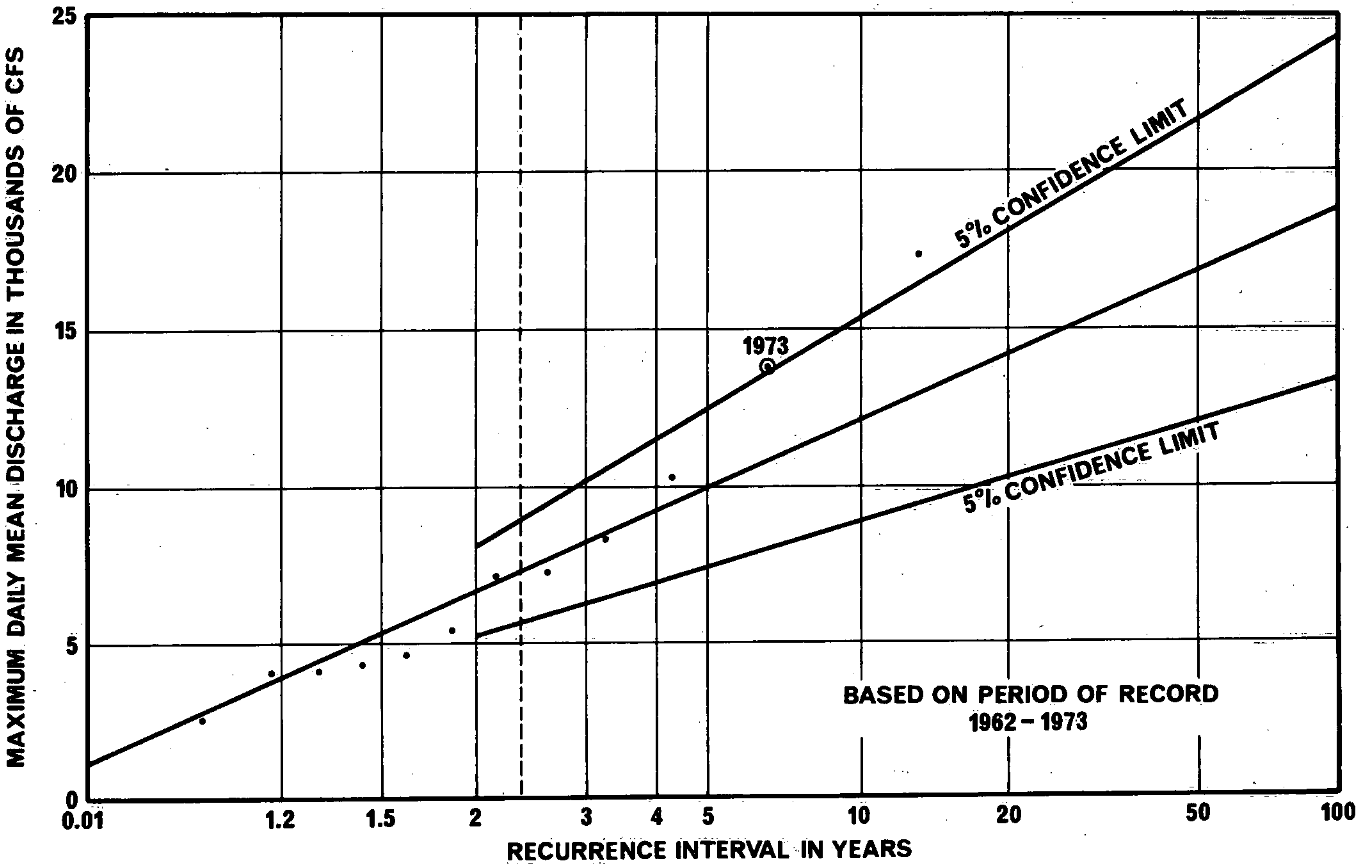


Figure 31 – Distribution of Annual Maximum Daily Mean Discharges - Northwest Miramichi at Trout Brook

Table 11 – Recurrence Intervals for 1973
Maximum Daily Mean Stage

Location	Maximum Daily Stage	Estimated Recurrence Interval
Fredericton	28.0	70 yrs.
Oromocto	23.7	50 yrs.
Oak Point	18.5	40 yrs.

The estimated recurrence interval of the stage at Fredericton is of the same order of magnitude as that determined for the maximum discharge recorded below the Mactaquac Dam. This tends to verify the reliability of both estimates. Downstream of Fredericton the estimated recurrence interval of the 1973 stage decreases somewhat, probably reflecting the much lower runoff from the tributaries in the lower portion of the basin.

EFFECTS OF STORAGE

It is important to consider the effects of storage in discussing the magnitude of the flood. A list of the major storage reservoirs in the Saint John River basin and the southwestern basins is shown in Table 12. There are no storage reservoirs in the northeastern basins.

The general location of each reservoir, its nominal live storage capacity and the quantity in storage at intervals throughout the spring runoff period are given in the table. These data were prepared from information supplied by the various operating agencies.

About half of the 375,000 acre-feet of storage in the Upper Saint John River is located in the Tobique River basin. The other half is divided between the Aroostook and the Madawaska River basins.

The Temiscouata and Millinocket Lakes storages, which have a combined capacity of 128,100 acre-feet are controlled by the installation of stoplogs after the flood peak has passed. Thus, these reservoirs do not retain water in addition to that which would go into natural lake storage. They influence only the rate of release of water from the lakes.

It will be noted in Table 12 that the reservoirs outside of the Tobique River basin were about one-third full at the end of March. The Tobique reservoirs were about one-quarter full at that time. Very little change in storage took place during the first half of April. As snowmelt began during the latter half of April, the reservoirs were gradually raised. By April 27, just prior to the main rainstorm, the Tobique reservoirs were about half full and the others were near their nominal live storage capacities. The Tobique reservoirs were raised

Table 12 – Summary of Storage Data for Reservoirs in Saint John, St. Croix and other New Brunswick Drainage Basins
March 30 to May 4, 1973

Reservoir	Stream	Basin	Nominal Live Storage 1000	Maximum Live Storage in 1973		Live Storage in 1973 (1000 ac-ft)							
			ac-ft	1000 ac-ft	Date	Mar.30	Apr.6	Apr.13	Apr.20	Apr.27	Apr.29	May 1	May 4
Saint John Basin													
Temiscouata Lake*	Madawaska River	Saint John	105.0	154.2	May 7	33.6	33.6	33.6	59.8	135.4	138.6	139.6	139.6
Millinocket Lake*	Aroostook River	Saint John	23.1	25.5	May 16	8.1	9.2	9.9	12.2	21.5	24.0	24.7	24.0
Squapan Lake	Aroostook River	Saint John	58.6	66.1	May 15	24.6	28.1	30.5	35.2	48.6	55.1	57.4	59.8
Trousers Lake	Tobique River	Saint John	36.6	36.6	May 15	8.8	8.8	8.8	9.9	17.2	20.5	23.8	28.5
Long Lake	Tobique River	Saint John	28.3	29.0	May 17	8.8	9.3	11.0	11.9	15.8	17.8	19.5	22.1
Sisson Reservoir	Tobique River	Saint John	97.0	93.9	May 25	25.2	24.2	20.4	17.5	38.8	50.4	61.1	71.8
Serpentine Lake	Tobique River	Saint John	25.6	75.6	May 21	5.9	6.6	7.2	7.9	11.5	13.0	14.8	17.2
Total for Saint John River Basin			374.2			115.0	119.8	121.4	154.4	288.8	319.4	340.9	363.0
Southwestern Basins													
East Grand Lake	St. Croix (East)	St. Croix	105.3	103.0	May 7	71.6	71.6	69.5	72.6	90.6	96.9	100.0	101.1
Spednic Lake	St. Croix (East)	St. Croix	187.1	195.0	Apr. 30	167.8	168.4	168.4	177.7	192.7	194.6	194.6	189
Sysladobsis Lake	Grand Lake Stream	St. Croix	24.9	-	-	-	-	-	-	-	-	-	-
West Grand Lake	Grand Lake Stream	St. Croix	160.7	165.0	May 1	-	-	-	136.0	138.5	151.0	165.0	162.0
Grand Falls at Baileyville	St. Croix	St. Croix	88.0	98.6	Apr. 30	73.0	79.2	71.3	77.4	73.9	88.0	95.0	78.3
Loch Alva	East Musquash River	East Musquash	30.0	30.0	May 25	6.6	9.9	13.2	16.5	22.5	21.3	21.3	22.8
Seven Mile Lake	West Musquash River	West Musquash	10.0	8.6	May 24	3.4	3.9	4.4	5.0	5.0	5.8	6.2	6.5
Log Falls Reservoir	West Musquash River	West Musquash	22.0	22.0	Apr. 16	21.6	20.5	22.0	22.0	15.6	19.8	22.0	22.0

* Reservoir consists of natural lake with stoplog controlled outlet

more rapidly during the period between April 27 and May 4 by storage of flood runoff.

Considering the entire Saint John River basin, the rate of increase in storage varied between 10,000 and 20,000 acre-feet per day during the period April 20 to May 1. This represents a reduction in flow of from 5,000 to 10,000 cubic feet per second on the main stem of the river. Compared with the peak flows on the main stem of 435,000 cubic feet per second below Mactaquac and 333,000 cubic feet per second at East Florenceville this is not too significant. In terms of the volume of runoff, the effect of storage is approximately the same. For example, excluding Temiscouata and Millinocket Lakes, the increase in storage in the basin of 94,200 acre-feet from April 20 to May 1 represents about two per cent of the volume of runoff recorded on the Saint John River at East Florenceville.

On the tributaries of the Saint John River which have storage reservoirs, streamflows were reduced by a much greater extent than on the main stem. The combined effect of the four reservoirs in the Tobique River basin reduced streamflows by about 20 per cent at Plaster Rock during the peak runoff period from April 27 to May 1. This percentage is about the same as the percentage of the area controlled by reservoirs indicating that all runoff beyond the required minimum flow releases was stored.

The St. Croix River has about 566,000 acre-feet of live storage capacity. While storage data are incomplete for this basin, it can be noted from Table 12 that the reservoirs were between 70 per cent and 80 per cent full at mid-April. From April 20 to May 1, the four largest reservoirs on the St. Croix system stored a total of approximately 90,000 acre-feet. This is over 40 per cent of the volume of runoff recorded on the main stem of the St. Croix at Baileyville.

The East and West Musquash Rivers are ungauged and therefore no observations can be made regarding the effects of the storage changes shown in Table 12 on the flows of these rivers.

Not included in Table 12, are the headponds of hydro-electric plants in the Saint John River basin. There are six power developments in the basin but two of these (Tinker Falls and City of Edmundston) have very little storage. The live storage capacities of the remaining four developments are listed below:

Mactaquac	370,000 acre-feet
Beechwood	34,000 acre-feet
Grand Falls	21,000 acre-feet
Tobique Narrows	9,800 acre-feet

Because these headponds are extremely long and narrow, it is not possible to estimate with any reliability their effect on flood discharges and flood volumes. During extreme flood conditions, there are considerable slopes in the water surface elevations of the headponds. Thus, although the water level at a power dam is drawn down considerably from its maximum, the water level in the upper part of the headpond can be as high or higher than the maximum static headpond level due to the natural slope of the river. Estimates of storage volumes based on elevations at the dams are not representative of the true storage.

Notwithstanding the fact that storage volumes cannot be determined, a few generalities can be drawn from the magnitude of the live storage in the headponds and the way in which they were operated during the 1973 flood.

Considering the three smaller headponds at the Beechwood, Grand Falls and Tobique Narrows plants, the combined live storage capacity at low flows is about 65,000 acre-feet. This corresponds to 0.09 inches of runoff on the drainage area above the Beechwood Dam, an insignificant amount when compared with flood runoff. Thus, even if the headponds were drawn down to their minimum levels in advance of the flood, they could not have influenced the volume of water passing downstream to a measurable extent. Also, at the peak of the flood, all gates were fully open so that the three headponds had no effect on peak discharges.

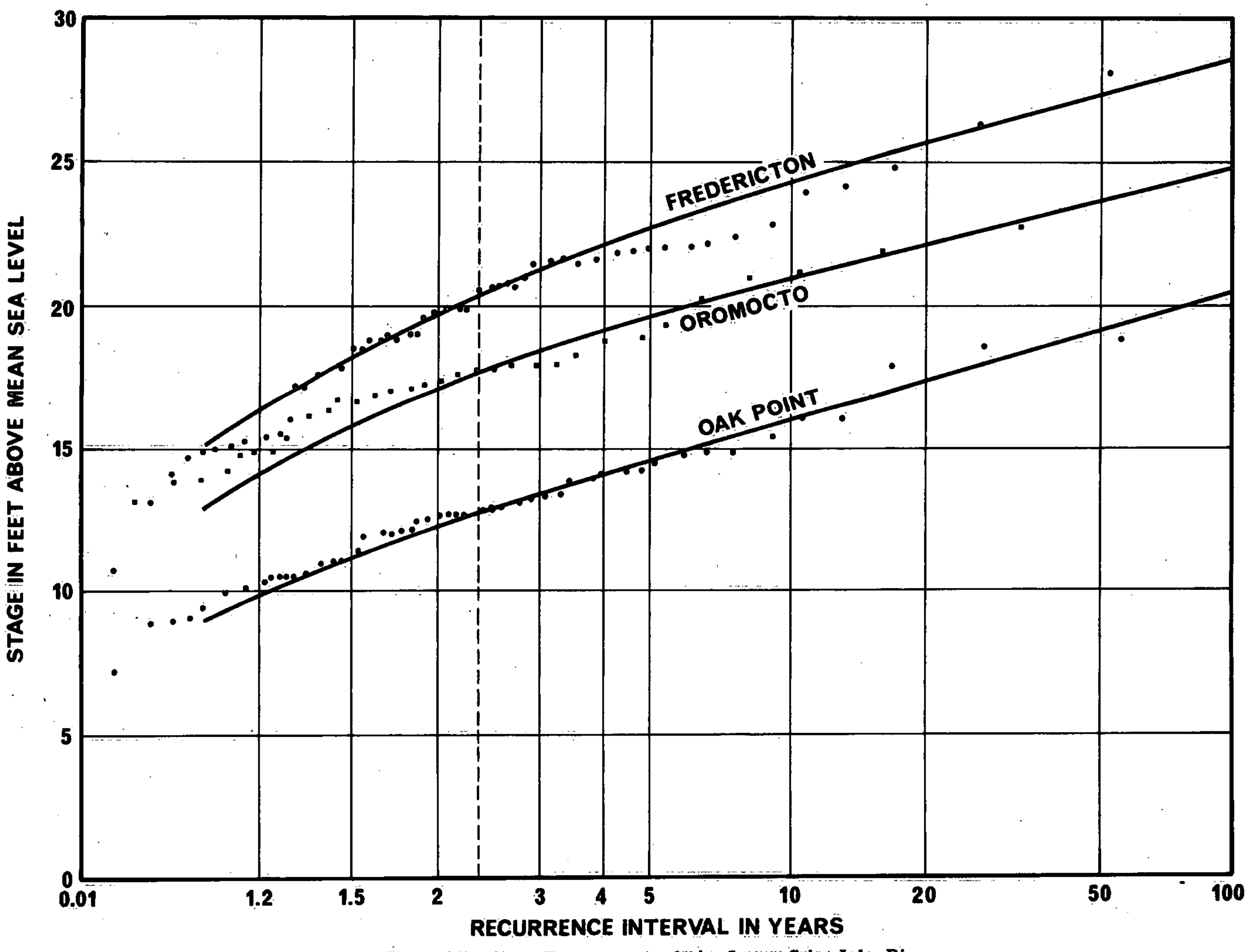
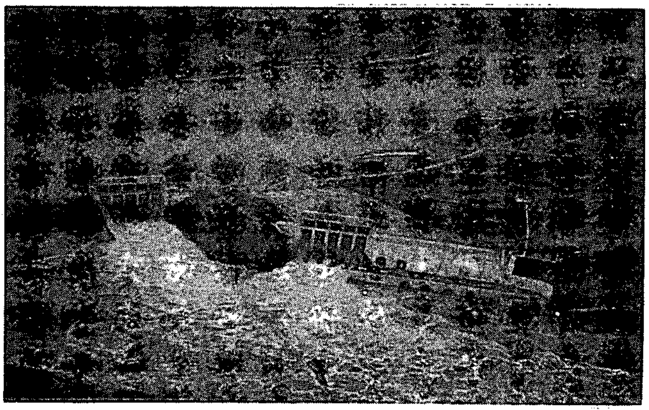


Figure 32 – Stage-Frequency Analysis - Lower Saint John River

The Mactaquac headpond is considerably larger, with a live storage capacity at low flows of 370,000 acre-feet. This is about equal to the amount of water passing through the dam in a 12 hour period around the peak of the flood. At high flows, this can be reduced to about 200,000 acre-feet due to the large slope on the headpond. During spring runoff, the New Brunswick Electric Power Commission operates the Mactaquac Dam in such a manner that the headpond is drawn to a low elevation in advance of the spring flood and then gradually raises it after the peak has occurred. In accordance with this practice, the headpond was drawn down to about elevation 112 feet above mean sea level, 18 feet below the normal operating level, on April 24 just prior to the initial crest at Mactaquac. As the flows began to decline the level of the headpond was gradually raised as it was presumed that the maximum discharge of 1973 had already occurred. By the time the April 29 and 30 peak was initially forecast, the Mactaquac headpond had been raised about three feet from its April 24 level. The Power Commission then began to open the gates in the dam as fast as possible without creating an abrupt increase in flow downstream, and by the afternoon of April 29 the dam was fully opened. This was about six hours before the flood peak occurred below the dam. After the peak had passed, the level of the headpond was again raised and by May 6 it was within a few feet of its normal operating level.



Photograph 6 – Aerial view of Mactaquac Dam, 30 April 1973.

Thus, regulation of the Mactaquac Dam probably caused an increase in the volume of flow downstream prior to the April 24 crest, a slight reduction in flow from April 25 to April 27, a slight increase on April 28 and April 29 and a much larger decrease in flow from May 1 to May 6. Because the dam was completely open at the time of the peak, storage in the headpond had little influence on peak discharges below the dam.

PRECIPITATION AND RUNOFF VOLUMES

In order to examine the relationships between rainfall, snowmelt and the associated runoff, estimates were made of the magnitude of each of these three parameters for selected drainage areas in the Saint John and northeastern basins. Four hydrometric stations were selected for this purpose:

a) Restigouche River above Rafting Ground Brook
b) Southwest Miramichi at Blackville
c) Saint John River at Grand Falls
d) Saint John River at East Florenceville

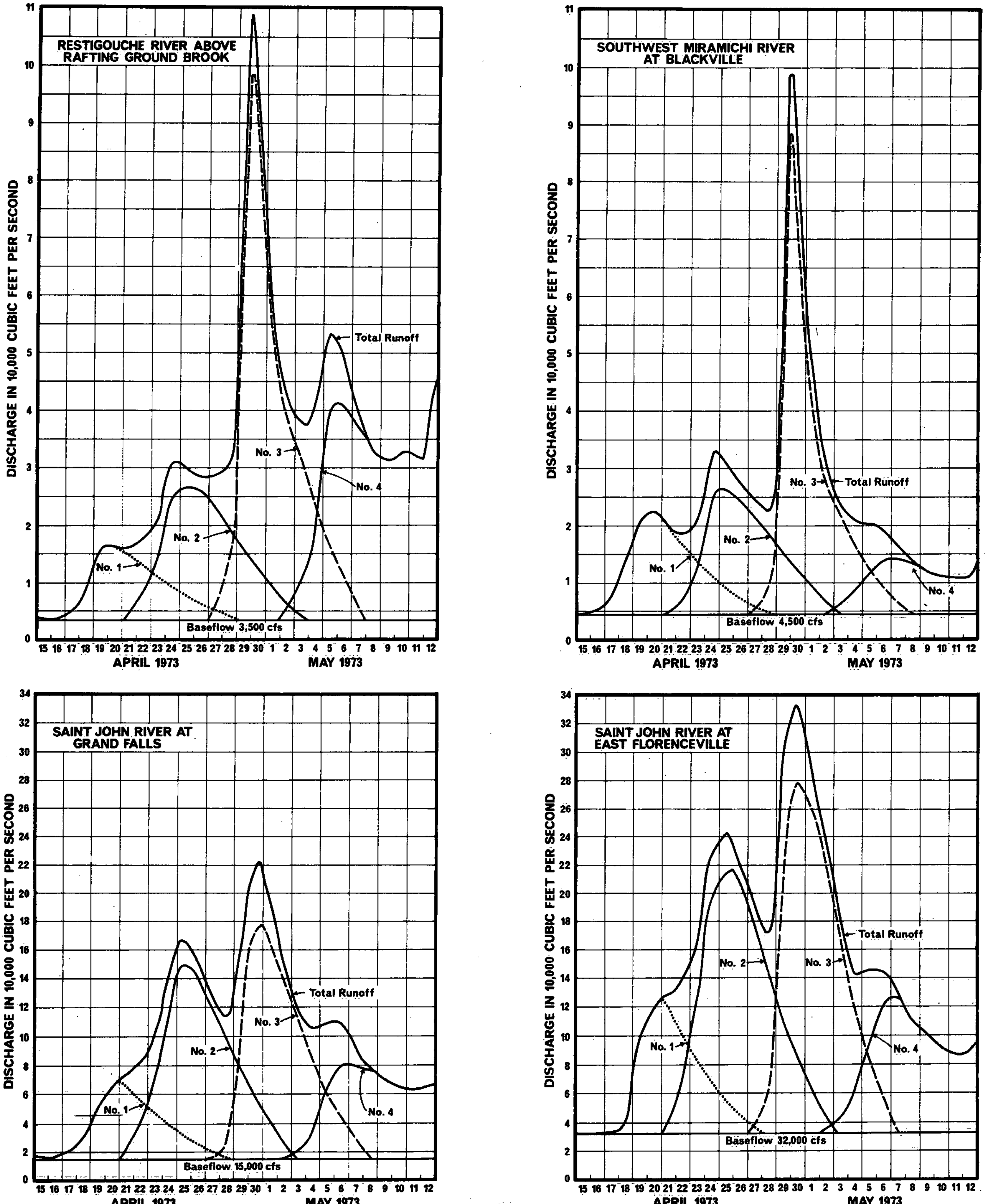
In computing snowmelt and rainfall on the drainage areas upstream of these hydrometric stations three periods were considered; April 15 to April 20, April 21 to April 26 and April 27 to May 1. These three periods were selected so that each contained one of the three periods of high snowmelt in the last half of April and no more than one period of rainfall.

The amount of rainfall was computed from isohyetal maps. The map shown on Figure 8 (page 25) was used to compute the rainfall for the period April 27 to May 1 and a similar map was developed and used to estimate rainfall from April 21 to April 26. No rainfall occurred between April 15 and April 20.

Snowmelt volumes were estimated from information on snow accumulation and snowmelt rates presented earlier in this report. The snowmelt rates given by the the Energy Budget Method were assumed to give the rate of depletion of water equivalent in the snow. As the accumulated snowmelt increased, it was necessary to consider the reduction in snow covered area to compute the average snowmelt for the entire drainage area. As the basin is generally depleted of snow, the average snowmelt in the drainage area becomes a smaller proportion of the potential snowmelt rate as given by the Energy Budget Equations.

Discharge hydrographs of the four selected hydrometric stations have been separated into components representing the runoff for each of the three selected periods. They are shown on Figure 33. On the Restigouche and Miramichi Rivers, the runoff from snowmelt and rainfall from April 27 to May 1 was significantly higher than runoff during the two earlier periods. The runoff from the earlier periods did not significantly add to the April 29 flood peaks on either of these rivers. In the Saint John River basin the volumes of runoff from the second and third periods were of equal magnitude. The April 30 flood peaks on the Saint John were significantly increased by the recession limb of the component runoff hydrograph from the second period.

Comparisons of the runoff volumes, determined from the component hydrographs, with volumes of rainfall and snowmelt are shown in Table 13. The ratios of runoff to rainfall and snowmelt are also shown. In all cases the runoff ratios increased with time. The lowest value corresponds to the first period and the highest value corresponds to the third period. At two of the four stations the computed runoff ratios for the third period are greater than unity. This may be a result of the retention in the snowpack of melt water from earlier periods and subsequent release of this water during the heavy rainfall of April 27 to April 29.



LEGEND

No. 1-RUNOFF FROM SNOWMELT APRIL 15-20 No. 2-RUNOFF FROM SNOWMELT AND RAINFALL APRIL 21-26
No. 3-RUNOFF FROM SNOWMELT AND RAINFALL APRIL 27-MAY 1 No. 4-SNOWMELT FROM MAY 2 ON

Figure 33 – Components of Hydrographs for Selected Hydrometric Stations

Table 13 – Runoff-Precipitation Ratios

Station	Period	Input			Runoff (in.)	Ratio of runoff to rainfall and snowmelt
		Rainfall (in.)	Snowmelt (in.)	Total (in.)		
Restigouche River above Rafting Ground Brook	Apr. 15 - 20	-	3.30	3.30	0.94	0.28
	Apr. 21 - 26	0.86	4.10	4.96	1.91	0.39
	Apr. 27 - May 1	3.06	3.40	6.46	3.93	0.61
Southwest Miramichi at Blackville	Apr. 15 - 20	-	3.30	3.30	1.93	0.58
	Apr. 21 - 26	0.77	3.50	4.27	2.51	0.59
	Apr. 27 - May 1	3.10	1.40	4.50	4.33	0.96
Saint John River at Grand Falls	Apr. 15 - 20	-	3.30	3.30	1.28	0.39
	Apr. 21 - 26	1.17	3.60	4.77	3.47	0.73
	Apr. 27 - May 1	2.02	1.10	3.12	3.48	1.12
Saint John River at East Florenceville	Apr. 15 - 20	-	3.30	3.30	1.27	0.38
	Apr. 21 - 26	1.07	3.40	4.47	3.10	0.69
	Apr. 27 - May 1	2.43	0.90	3.33	3.34	1.00

Forecasting and Emergency Measures

The ability to predict accurately the magnitude of floods and to act quickly in evacuating potential victims and property is of utmost importance in reducing the effects of floods. Fortunately, flood forecasting and emergency measures systems were operational in the Saint John River basin which was the most severely affected basin. This chapter of the report describes and discusses the operation of these systems.

DEVELOPMENT OF THE FORECAST SYSTEM

Flood forecasting has been undertaken in the Saint John River basin for several years with varying degrees of sophistication. In the early 1960's the New Brunswick Electric Power Commission attempted to utilize a computerized forecasting system. The results were unsatisfactory and the system proved cumbersome because computer processing was undertaken on a computer in Niagara Falls, Ontario. For several years following this unsuccessful attempt, intuition and manual methods were used to forecast floods by staff of the New Brunswick Electric Power Commission. In later years assistance was received from the New Brunswick Department of Fisheries and Environment.

Towards the end of 1972 renewed interest arose in the development of a system of flood forecasting using modern computerized techniques. The New Brunswick Department of Fisheries and Environment joined the New Brunswick Electric Power Commission in a search for operational forecasting programs. A computerized flood forecasting program developed by the North Pacific Division of the United States Army Corps of Engineers was selected.

The forecasting program, known as the Streamflow Synthesis and Reservoir Regulation Model (SSARR)(10), is a mathematical-hydrologic model of a river basin system which synthesizes streamflow by evaluating snowmelt and rainfall runoff. The river basin is divided into a number of sub-basins for which the basic snowmelt and rainfall runoff relations are established. River flows are computed by routing runoff from upstream to downstream points through channel and reservoir storage. When used as a predictive tool, the model relies on meteorological forecasts of temperature and precipitation as input data. Flood forecasts can be continuously updated as recorded streamflow and precipitation data are reported. The model also has provision for handling backwater conditions such as those which exist on the Saint John River below the Mactaquac Dam but the model was not calibrated for operation under this provision prior to the 1973 flood.

Model Calibration

The Corps of Engineers SSARR Model was obtained in early February 1973 and the task of applying this model to the Saint John River began immediately. Because of a desire to have the system operational before the 1973 spring flood, an interagency task force was brought together from existing staff of the New Brunswick Electric Power Commission, the New Brunswick Department of Fisheries and Environment and the Inland Waters Directorate.

The first task in model calibration consisted of making numerous computer runs for each of the 34 sub-basins of the Saint John watershed using a fall rain storm which occurred in September-October 1969. These runs provided the initial model parameters for simulation of runoff from the sub-basins and river routing in the main channel. The second task consisted of model calibration for snowmelt conditions. For this, the spring runoff of 1961 was used to obtain the parameters required for snowmelt computations. Due to the short time available, calibration was carried out using only these two historic events, one of which included snowmelt. The model was operational for flood forecasting in the Saint John River on March 26, 1973 and after a two week backup period for final adjustment of parameters and initial conditions the model was successfully put into operation.

Meteorological Forecasts

The ability of the flood forecasting model to predict floods in advance is to a great extent dependent upon the accuracy of meteorological forecasts which are used as model input. The following is a brief description of the forecasts provided by the Atmospheric Environment Service, Environment Canada, to the Saint John River Flood Forecasting Unit.

Twice daily, the Canadian Meteorological Centre in Montreal prepares forecasts of maximum and minimum temperatures and precipitation amounts based on 0000 GMT and 1200 GMT surface and upper air data. These forecasts are sent by teletype and facsimile network to weather offices throughout Canada. After appraisal and tailoring by local meteorologists, the information is disseminated to the public.

The Canadian Meteorological Centre's temperature forecasts are based upon regression equations, applicable to individual cities. They are completely computer produced and have a valid period of either two or three days depending on the time of issue. The quantitative precipitation forecasts are also computer produced and list expected precipitation values at a number of points in a grid system encompassing most of North America. The forecast precipitation for each grid point represents the average amount expected to fall in a square with sides of 381 kilometers in length surrounding the point. The forecasting model produces large scale precipitation whenever ascending air has a dew-point depression less than a pre-determined threshold value. Smaller scale influences (frontal precipitation, air mass showers and induced instability showers) are also incorporated into the model, but very local effects, such as snow showers to the lee of lakes in winter, are not predicted. The valid period for the quantitative precipitation forecasts extends 42 hours from the collection time of the basic data.

For the purpose of flood forecasting, special arrangements were made with the Atmospheric Environment Service to obtain subjective forecasts of temperature and precipitation beyond the period of the computer forecasts produced at the Canadian Meteorological Centre. These subjective forecasts were prepared by meteorologists at the Maritimes Weather Office in Halifax and transmitted along with the computer produced forecasts to the Fredericton Weather Office. Temperature forecasts used in flood forecasting were the computer predictions for Saint John and Fredericton augmented by subjective estimates up to day five. The precipitation forecasts provided by the Maritimes Weather Office were those produced by computer for day one and day two at the three grid points nearest the Saint John River basin together with subjective extensions to days three, four and five for the same points. The subjective predictions indicated only expected occurrence or non-occurrence of precipitation for each day and no attempt was made to forecast precipitation amounts. The Fredericton Weather Office used the computer predictions of temperature and grid point precipitation to prepare forecasts for individual meteorological stations in a form suitable for input to the flood forecast model.

Hydrologic Data Network

The accuracy of the model in forecasting streamflows is also dependent on accurate up-to-date information on actual temperatures, recorded precipitation, snow accumulation and streamflow. The network of stations used in compiling information for the model is shown on Table 14. The network consists of 55 temperature and precipitation stations, 22 stream gauging stations and 71 snow course stations. Data for precipitation, temperature and streamflow was compiled each morning and, during the critical flood period, each afternoon as well. Snow course data was received at two week intervals from co-operating agencies with periodic checks being made more frequently at some locations during the critical flood period.

Table 14 – Hydrologic Data Network Used in Flow Forecasting

Type of Station	Location	Number of Stations
Temperature and Precipitation	New Brunswick	20
	Quebec	16
	Maine	19
Stream Gauging	New Brunswick	14
	Quebec	1
	Maine	7
Snow Courses	New Brunswick	41
	Quebec	7
	Maine	23

Co-operating Agencies

New Brunswick Electric Power Commission
New Brunswick Department of Fisheries and Environment
New Brunswick Department of Natural Resources
Quebec Natural Resources
Atmospheric Environment Service
Water Survey of Canada
Maine Public Service
Maine Parks and Recreation Commission
Maine Forest Service
National Weather Service
United States Geological Service
International Paper Company

FORECASTS DURING THE 1973 FLOOD

As already mentioned, the objectives of the flood forecasting program included the provision of information consistent with the needs of citizens of low-lying areas along the Saint John River, as well as the New Brunswick Electric Power Commission requirements for regulation of hydro-electric developments on the river. To meet these objectives a Saint John River Flood Forecast Unit was established in March 1973 at the New Brunswick Electric Power Commission's Head Office in Fredericton. The staff of the Unit consisted of an Acting Director, a Water Resource Engineer, a Civil Technologist, an Engineering Assistant and a Technical Assistant all from the Power Commission and a Hydrologic Engineer from the New Brunswick Department of Fisheries and Environment. A sub-unit was set up at the Grand Falls Hydro Plant for collection of data for the upper portion of the basin from individual observers in Maine, Quebec and New Brunswick.

The flood forecasting program was run each morning to predict streamflows for a four day period at various points along the river. During the critical flood period additional runs were carried out each afternoon based on an updated weather forecast received at 1:00 p.m. each day from the Fredericton Weather Office. As each new run was made, the previous forecast was updated to correct for changes in input forecast data and antecedent conditions in the basin.

Comparisons of recorded streamflow, precipitation and temperature with forecasts of streamflow, precipitation and temperature made one, two, three and four days in advance are shown on Figures 34 to 36 for selected

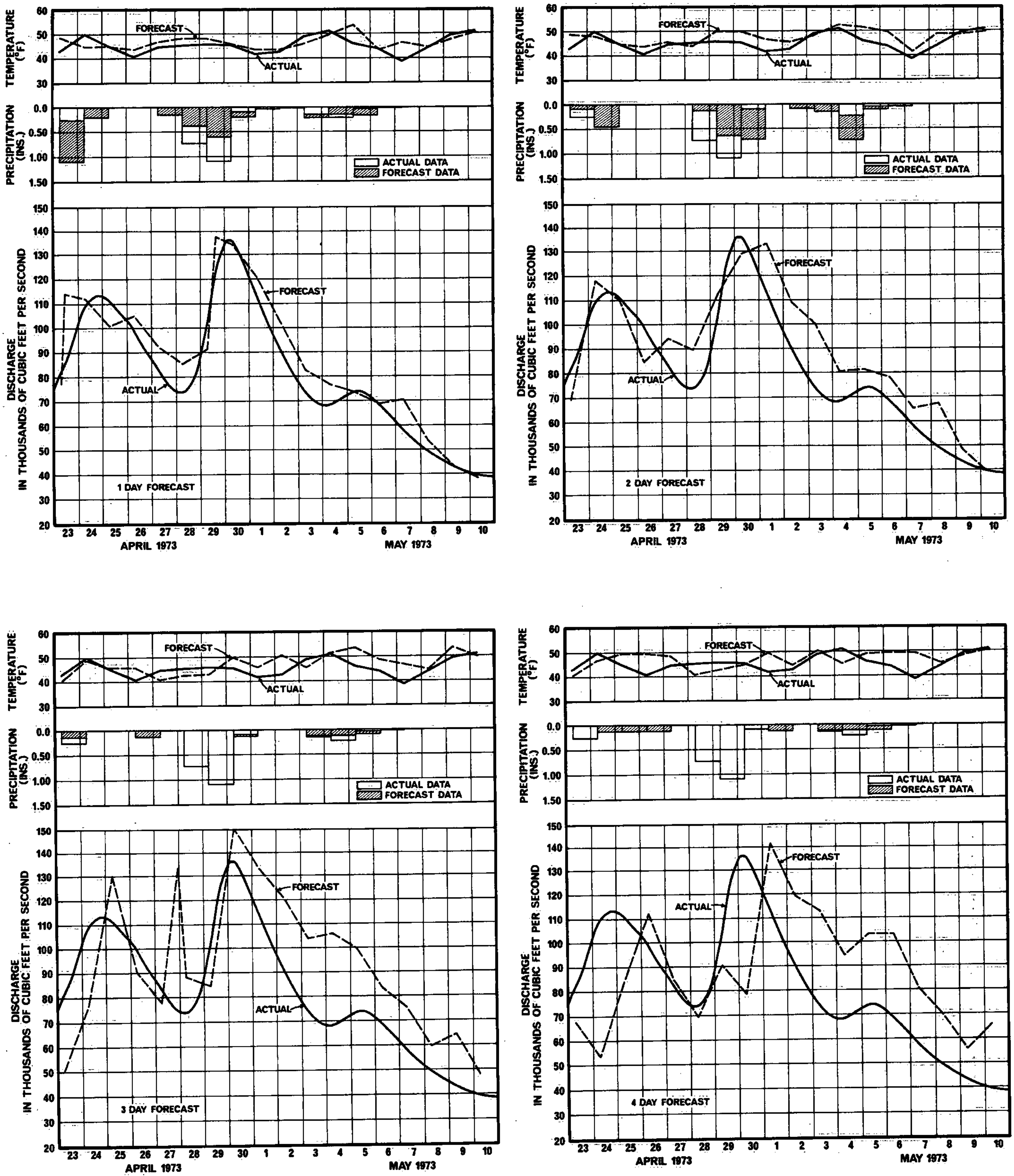


Figure 34 – Comparison of Actual and Forecast Streamflow, Precipitation and Temperature - Saint John River at Fort Kent

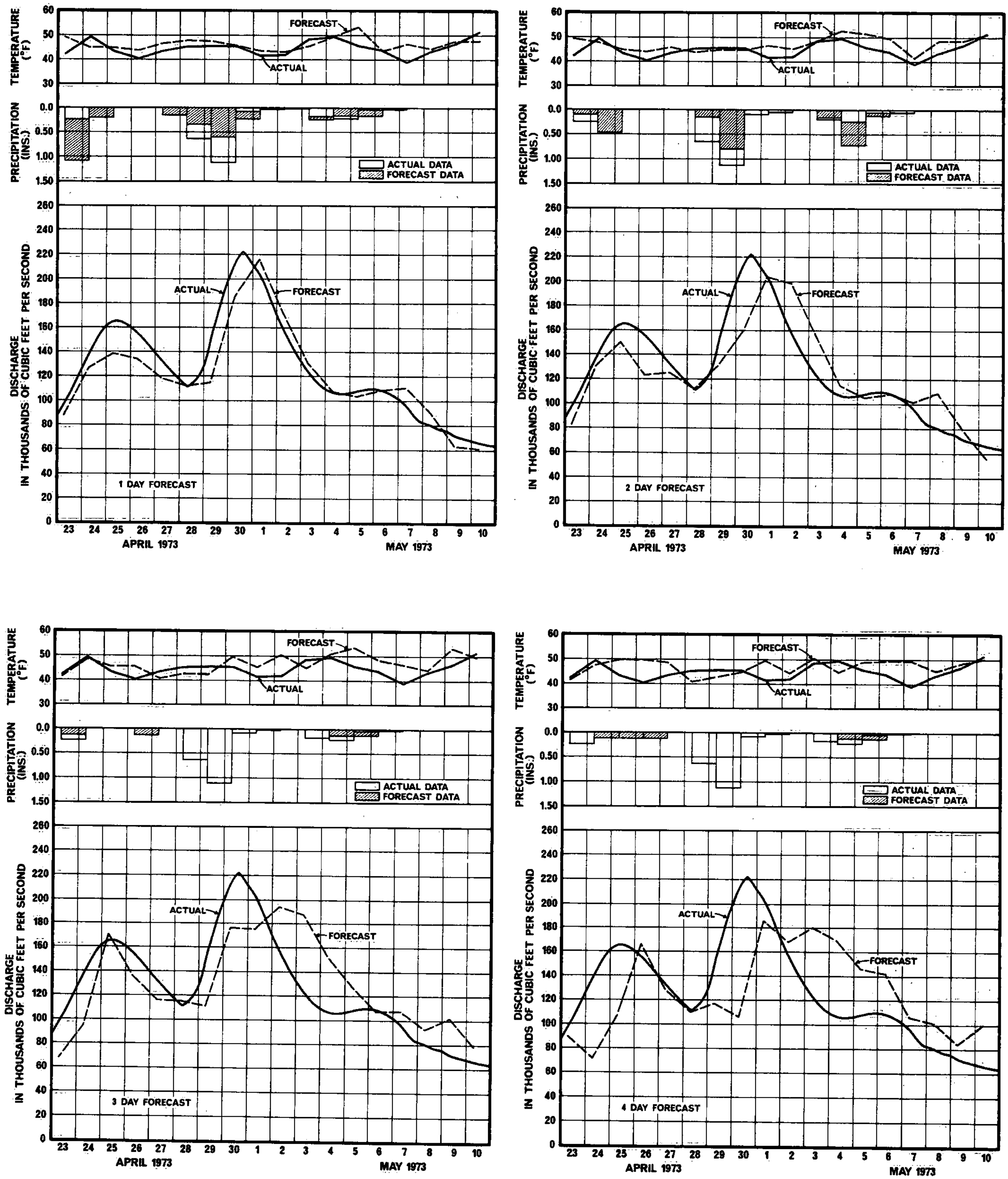


Figure 35 – Comparison of Actual and Forecast Streamflow, Precipitation and Temperature - Saint John River at Grand Falls

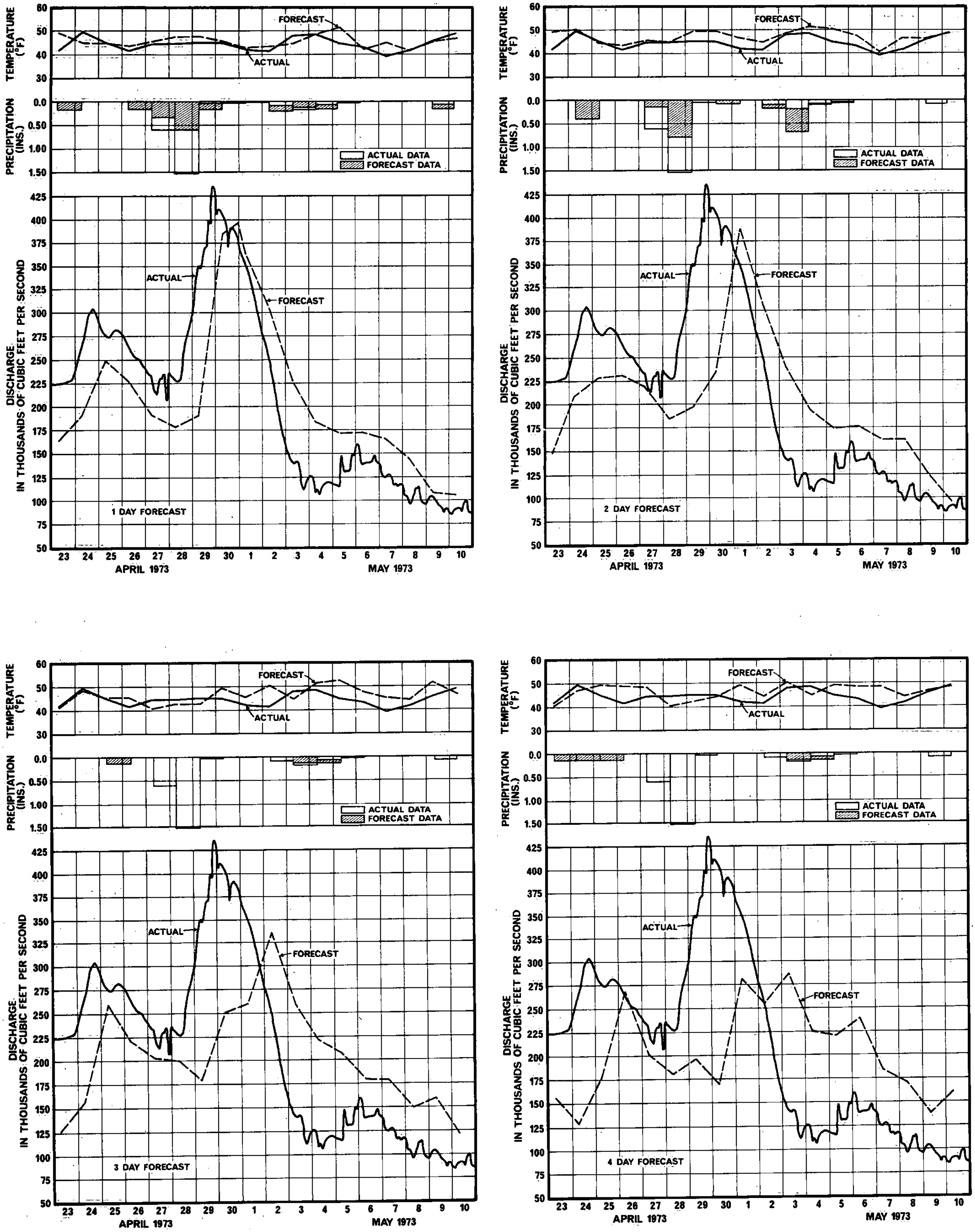


Figure 36 – Comparison of Actual and Forecast Streamflow, Precipitation and Temperature - Saint John River below Mactaquac Dam

hydrometric stations. Examination of these figures reveals that streamflow forecasts were heavily dependent on the precipitation forecasts.

Referring to the hydrograph of the Saint John River below Mactaquac, the first crest was reached on April 25, 1973. The river receded until the afternoon of April 29 and then began to rise again. Meteorological forecasts during the period April 23 to 26 did not predict significant precipitation for the Saint John River basin and the flood forecast predicted that the Saint John River would continue its recession from the April 25 crest. Precipitation forecasts made on the morning of April 27 predicted about one inch of rainfall over the basin by 7:00 a.m. April 29 and no rain during the next two days. Based on this predicted precipitation, the flood forecast model indicated the Saint John River below the Mactaquac Dam would rise to 281,000 cubic feet per second on May 1 at 7:00 a.m. This was the first indication that the Saint John River would peak once again following the April 24 crest. The predicted magnitude was less than the magnitude of the earlier crest and no rainfall was predicted for the two day period beginning April 29 at 8:00 a.m.

In the afternoon of April 27 an amended meteorological forecast was issued by the Atmospheric Environment Service indicating an average of about 1.3 inches of precipitation over the basin by 8:00 a.m. April 29 and predicting rain occurrence for each of the following three days. Based on this amended forecast, the river forecasting model predicted the Saint John River at the gauge below Mactaquac would reach 290,000 cubic feet per second by 7:00 a.m. May 1 and continue to rise. Since rain was forecast for April 29-30, this was the first indication that the Saint John River at the gauge below Mactaquac might excede its April 24 crest. During the evening of Friday, April 27 the following statement was released to the news media by the Flood Forecast Unit:

> "Precipitation is forecast for the Saint John River basin on Saturday and Sunday. Amounts are expected to range from 1" to 1½". Should this materialize it will cause flows in the Saint John River to increase substantially during the next few days. The computerized flood forecast will be run every day and information will be given out over the media as it becomes available.
>
> Residents of low-lying areas are advised to keep posted to the forecast."

The precipitation forecast on the morning of April 28 was downgraded to some extent indicating an average of about 0.6 inches over the basin from 8:00 a.m. April 28 to 8:00 a.m. April 29 and no rain within the next three days. The computer run that morning predicted that the Saint John River would peak at 265,000 cubic feet per second at 7:00 a.m. May 1, a discharge somewhat less than that predicted the previous afternoon. However, by the afternoon of April 28 heavy rain was falling over the Saint John River basin and an amended meteorological forecast predicted about 2.2 inches of rainfall between 8:00 a.m. April 28 and 8:00 a.m. April 30. A rerun of the forecasting model at 3:00 p.m. predicted a flood peak of 342,000 cubic feet per second at 7:00p.m. May 1 below the Mactaquac Dam. It became apparent at this point in time that extensive flooding was likely along the Saint John River. The Director of the Flood Forecast Unit contacted the provincial Emergency Measures Organization and a meeting was arranged for 8:00 p.m. that evening. This set off a chain of emergency actions which greatly reduced personal hardship and damages resulting from the flood as will be discussed later in this chapter of the report. The Flood Forecast Unit also released the following statement to the media:

> "Heavy rains over the Saint John River basin are expected to continue for the next 24 to 36 hours. The flows in the Saint John River, presently at flood levels, are expected to increase during the next 3 days to the point exceeding the previously recorded maximum value of 288,000 cubic feet per second at Pokiok, established on May 2nd, 1923. The latest flood forecast run at 3:00 p.m. on April 28 indicates that the flow could well reach 340,000 cubic feet per second at Fredericton on May 1st. People should appreciate that this value is very much dependent on the weather forecast. Water levels at Fredericton and Maugerville are difficult to predict due to uncertain reaction of the estuary system, including Grand Lake, to extreme high flows."
>
> "However, the Saint John River Flood Forecast Centre at N.B. Power indicates that the elevation at Fredericton and Maugerville could go as high as 26.5 feet. This is about 5 feet higher at Maugerville than it was during the peak period last week."
>
> "Residents of Woodstock-Hartland area should be aware that Saint John River levels could cause flooding problems. At Woodstock in the vicinity of the old highway bridge the river level could go to about 135 feet i.e. about 5 feet above normal level. At Hartland the river could go to about 154 feet which is the same as the level reached during the ice jam in the spring of 1968."
>
> "The flood forecast program will be run each morning during the runoff with additional runs being made as required. This information will be made available to the media by noon each day and residents of low-lying areas are advised to take necessary action."

On the afternoon of April 29, 1973 a computer run indicated that the flow below Mactaquac would reach 396,000 cubic feet per second at 11:00 p.m. on April 30, 1973. This proved to be the highest predicted flow. By this time the Emergency Measures Organization was fully operational and press releases were made by them utilizing data supplied by the Forecast Unit.

EMERGENCY MEASURES

Emergency measures to alleviate the effects of the flood were initiated on Saturday, April 28 when the New Brunswick Emergency Measures Organization was informed by the Flood Forecast Unit that severe flooding would occur. A meeting at 8:00 p.m. that evening, attended by representatives of the federal and provincial Emergency Measures Organizations, was the starting point for emergency actions which took place over the next few days. The following description of these actions is based on a report by the New Brunswick Emergency Measures Organization on the 1973 Flood.(11)

Direction and Control of Operations

Because of the facilities available, an offer of space was accepted in the New Brunswick Electric Power Commission Building in Fredericton for an Emergency Measures Organization Flood Control Headquarters. This location served as the center for control of emergency activities and communications throughout the flood period. The immediate need was to warn inhabitants of low-lying areas. For this purpose, local radio stations were asked by the Emergency Measures Organization to send representatives to Flood Control Headquarters for briefing on the broadcast of warning bulletins.

While the initial flood warning bulletins were being broadcast, a number of government department representatives were called into Flood Control Headquarters, briefed and assigned responsibilities. Because all government departments did not have up to date emergency plans, it was decided that operations would be centrally controlled by the New Brunswick Emergency Measures Organization from the Flood Control Headquarters. During the flood period at least twenty government departments and numerous other agencies and organizations were involved in the emergency operations. The tasks assigned to them were all controlled from the Headquarters and co-ordinated through federal and provincial Emergency Measures Organizations.

An Emergency Operations Center was established at the Burton Court House to serve as the center of activity for evacuation of people and livestock from the Maugerville-Sheffield area. Continuous lines of communication were maintained between this center and the Flood Control Headquarters. Provincial Emergency Measures Organization District Co-ordinators in other parts of the province were also alerted and instructed to set up their headquarters and to report periodically to Flood Control Headquarters in Fredericton.

The Premier was informed of the situation and of the action which had been taken. He immediately visited the Headquarters, where he was briefed by the Director and other officials and then addressed the people of the province on radio and television. Accompanied by Emergency Measures Organization officers, the Premier toured the affected areas several times during the critical period by plane, helicopter and boat.

Communication and Information Services

Extensive communication facilities were established both for the purpose of warning the public and controlling the emergency activities. During the initial stages the public was warned by radio and television bulletins broadcast every few minutes. People were asked to make sure that their neighbors were aware of the situation and to keep radios tuned to local stations for further advice and direction. When it was felt that the general populace had been adequately alerted, this original bulletin was withdrawn. From that point on, additional bulletins were broadcast as required to advise the public of such factors as highway conditions, road closures, school closures, health precautions with respect to water supplies, and arrangements for evacuation of threatened areas. Appeals were also broadcast for volunteers with boats to assist in the evacuation efforts and for information on the temporary location of people who had evacuated their homes.

As soon as local radio stations were advised of the situation a news service facility was established. During the flood period news broadcasts were made on both radio and television to local, national and international audiences. Since all news emanated from one source, accurate up-to-the-minute information was available to the public at large. A 24-hour service was maintained at Flood Control Headquarters by relays of media personnel. The flood was considered to be one of the best covered events involving disaster in the history of New Brunswick.

For the purpose of answering public enquiries, an emergency telephone number was allocated and six telephones were installed at Headquarters on short notice by the New Brunswick Telephone Company. These telephones were manned by R.C.M.P. Auxiliaries and civilian volunteers. The emergency number was broadcast to the public and during the 14 days it was in operation several thousand calls were received.

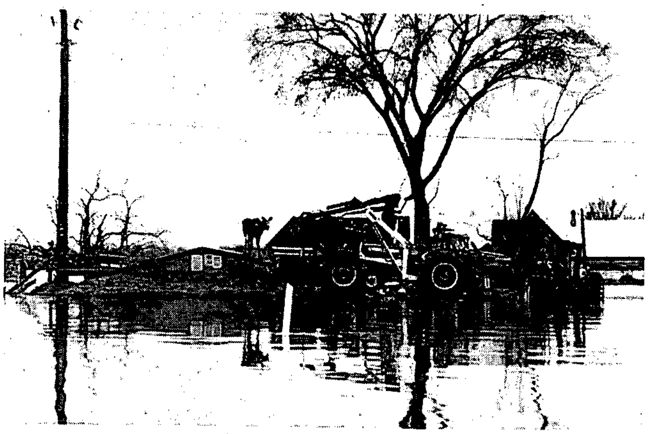
For the purpose of controlling evacuation and other emergency action, radio communication was established at Flood Control Headquarters by several agencies including the Department of Highways, the Department of Natural Resources, the Department of National Defence and the Fredericton City Police. When it became obvious that other parts of the province were involved, volunteers with amateur and citizen band radios were asked to set up base stations at Headquarters to maintain contact with District Headquarters and with volunteers with radio sets in automobiles and boats. Later when flood water caused interruption of telephone service citizen band radio was used more extensively for passing messages around the

Photograph 7 – Emergency Measures Organization Flood Control Headquarters, Fredericton, 29 April 1973

city. Contact between Flood Control Headquarters and the Emergency Operations Center was maintained by the Department of National Defence radio and by amateur and citizen band radio.

Rescue Operations

The main responsibility for rescue operations was split between two provincial departments: Natural Resources and Agriculture. The Department of Natural Resources assumed responsibility for the rescue of people since rescue was a responsibility of the department under the New Brunswick Survival Plan. They also had the capability in boats and manpower for immediate response. The responsibility for controlling the evacuation of livestock from the Maugerville-Sheffield area was assigned to the Department of Agriculture with the assistance of Canadian Forces Personnel from Canadian Forces Base Gagetown.



Photograph 8 – Flooding of agricultural buildings and equipment in Sheffield area, downstream of Fredericton. Moose is stranded on top of shed, 3 May 1973.

In organizing for the evacuation of people, an appeal was broadcast for volunteers with boats. These volunteers together with personnel from federal and provincial departments were assigned specific tasks as required by the Department of Natural Resources. Evacuees were rescued from their homes by boats and brought to various points along the river, from where they were transported to reception areas. Local fire departments and R.C.M.P. officers on duty also assisted in the rescue operations.

The reception of evacuated people was the responsibility of the New Brunswick Department of Social Services. This department reviewed various reception areas and decided to use as an Emergency Welfare Center, a University of New Brunswick residence which had recently been vacated by students. This proved to be an ideal location as it provided separate rooms for families, eating facilities and an infirmary. Arrangements were made for an expected intake of 500 persons in this building. The Welfare Center was placed under the charge of a member of the New Brunswick Department of Social Services. A number of evacuees were also accommodated at Canadian Forces Base Gagetown.

A register of evacuees was compiled and an appeal made for people staying with relatives and friends to inform the Welfare Center at the university so that enquiries from other friends and relatives could be answered. A total of 1,458 evacuees were registered, of which 407 were accommodated at the university, 104 at Canadian Forces Base Gagetown and 947 with friends and relatives.

The activities of the Department of Agriculture included warning of farmers in the Maugerville-Sheffield area by personal contact, controlling the evacuation of livestock and arranging reception centers for livestock on the north side of the Saint John River or on higher ground in the Jemseg area. They were assisted in this effort by men, vehicles and river crossing craft from the Department of National Defence, two tugs and scows from Saint John and additional scows from local construction companies. Requests for cattle trucks were broadcast and a number of local trucking companies and private owners responded.

Photograph 9 – Evacuation of livestock in the Maugerville-Sheffield area, 30 April 1973.

The evacuation could have been completed in a comparatively short time if local residents whose livestock were in danger had believed the forecast height of the flood. It was not until most of the cattle were standing in flooded barns that the farmers became convinced that their cattle should be removed. The operation was, in consequence, made more difficult and dangerous. Of the more than 1200 cattle, 400 hogs and 20 horses evacuated, the losses were only four cattle, one pig and one horse. Area farmers from as far away as Sussex took part in the rescue, and livestock was housed in temporary quarters from Kingsclear to Jemseg including farms on high ground, the Agriculture Research Station and the Fredericton Exhibition grounds.

The provision of feed stuff and milking machinery presented difficult problems which had to be overcome but deliveries to dairies were maintained. Great credit is especially due to farmers who took in livestock and worked day and night without any reward or compensation to assist their less fortunate neighbors.

The rescue of livestock directly involved more than 25 personnel from the New Brunswick Department of Agriculture, 15 from the federal Department of Agriculture and 20 officers and 200 men from Canadian Forces Base Gagetown. The move was completed by the afternoon of Tuesday, May 1. The caretaking went on for several weeks thereafter until farms had dried out and arrangements could be made for the return of livestock.

Emergency Social and Health Services

In order to assist those in need, a number of emergency offices of the Department of Social Services were opened in areas affected by flooding to provide immediate assistance. The locations and hours of operation of these offices were publicized by radio. Clothing banks were established by the Salvation Army, in Fredericton, and by the Canadian Red Cross, in Oromocto, to provide for the needs of evacuees.

One of the main public health concerns was the quality of drinking water supplies from both municipal systems and private wells. The New Brunswick Department of Health in co-operation with other departments issued special bulletins regarding water supplies and precautions to be taken to protect health when returning to flooded areas. Other public health measures included testing and decontamination of wells and other supplies, and the inspection of restaurants and food stores to ensure that no health hazard existed before they were allowed to reopen. No epidemics or undue health hazards occurred as a result of the flood.

Special arrangements were made for doctors and nurses to provide medical service to evacuated persons at the Emergency Welfare Center. Patients from a nursing home were evacuated and temporarily accommodated at the Center.

Traffic Control

The control of traffic in and around flooded areas was another critical problem. To some extent the problem was one of restricting sight-seers from interfering with rescue operations but the question of safety was also of utmost importance. The control of river traffic was entrusted to the provincial Department of Natural Resources. R.C.M.P. boats were used to patrol flooded areas to prevent looting of evacuated homes.

The Department of Highways was asked to set up an office at Flood Control Headquarters and to maintain up-to-the-minute reports on highway and bridge conditions. Highway reports were broadcast from time to time throughout the flood period. As highway conditions became dangerous or impassible, road blocks were set up and manned by R.C.M.P. officers where necessary. In the Campbellton area, heavy equipment was dispatched to make emergency road repairs so that people cut off by high water could evacuate their homes.

Because of the danger to rescue and flood patrol aircraft caused by sight-seeing aircraft, a flight restricted zone was established by the Department of Transport. All aircraft other than those on regular commercial flights were required to obtain prior clearance from the Department of Transport and Flood Control Headquarters before flying over the flood area.

As the flood developed, an up-to-date picture of the traffic situation in Fredericton was maintained by a City Police radio link at Headquarters. This assisted in preventing unnecessary congestion on roads and, from that point of view, tended to ease the already difficult situation in Fredericton. Provincial civil servants were directed by radio not to report to work on April 30 and to remain away until advised to return.

Other Emergency Activities

There were many other combined efforts by public agencies and private individuals which resulted in considerable reduction in flood damages. These efforts included salvage of books, documents and equipment from the basements of schools and government buildings, supplying and operating pumps to prevent inundation and restoration of heat, power and telephone service.

During the emergency many groups of citizens offered their services. Outstanding among these were university and high school students and Cadet Corps who worked long hours on various activities from sand bagging important facilities to removing important records and books from buildings endangered by the flood.

EVALUATION OF FLOOD FORECASTS AND EMERGENCY ACTION

In examining the results of this first serious attempt at flood forecasting and the emergency measures effort, which was the greatest in the history of New Brunswick, it is obvious that considerable reduction in flood damage and personal hardship was achieved.

Although limited time was available for calibrating the SSARR flood forecasting model prior to the flood, it gave good results. The possibility of extensive flooding was predicted approximately three days in advance of its occurrence in the Fredericton area while the likelihood of a major flood was predicted two days in advance. Undoubtedly, more refinements can be made in the model with additional work on calibration which is underway at the time of writing of this report.

It has been noted that there was a very close link between the meteorological forecasts and river flow forecasts. The accuracy of flood predictions and the period of advance warning possible will continue to depend on the accuracy of meteorological forecasts. Although long range temperature forecasts were generally poorer than short range ones, their accuracy was still within plus or minus five degrees Fahrenheit. The ability to forecast precipitation is somewhat more limited.

A comparison of the predicted and observed precipitation amounts at representative meteorological stations in the Saint John River basin is shown on Table 15. This comparison shows that subjective forecasts of "rain" or "no rain" for four and five days ahead were unreliable. The subjective forecasts for three days ahead were considerably more accurate and indicated the likelihood of precipitation during the storm period on the morning of April 25. The usefulness of these subjective forecasts was limited by the fact that no precipitation amounts were specified. In practice, a subjective forecast of "rain" was interpreted, for the purpose of input to the flow forecasting model, as a prediction of a rainfall amount of 0.1 inches. This value is a rough estimate of the average precipitation for rain events in April. It is naturally not representative of major rain storms such as that of April 27-29 and could not be expected to allow an accurate prediction of a major flood. Undoubtedly, however, these subjective forecasts were of some value in drawing attention to the likely development of a rain on snow situation a few days in advance of the event.

Forecasts of precipitation amount for one and two days ahead were prepared by subjective modification of computer estimates supplied by the Canadian Meteorological Centre, Montreal. Examination of Table 15 illustrates that, in general, the one and two day quantitative precipitation forecasts were too low, the only exception being on April 30. It should also be noted that forecast accuracy improved as the lead time shortened, i.e. first day forecasts issued in the afternoon were better than corresponding morning issues.

Based on experience during the flood of 1973, precipitation forecasts for the Saint John River basin can provide an indication of a probable rainfall situation three days in advance of its occurrence, a reliable forecast of a major storm developing two days in advance and a fairly good estimate of precipitation amounts one day in advance. Within the limits of present knowledge, it is probably unreasonable to expect major improvements in the accuracy of precipitation and temperature forecasts in the near future. Introduction of a larger and faster computer at the Canadian Meteorological Centre during late 1973 will permit the development of more complex numerical models and, as a consequence, some limited

Table 15 – Forecast and Observed Precipitation - Saint John River Basin
(based on mean of precipitation amounts at St. Aurlie, Portage, Squa Pan, St. Eleuthere, Aroostook and Arthurette)

	Precipitation in inches or expected occurrence during 24 hour period ending 8:00 a.m.									
	Apr. 24	Apr. 25	Apr. 26	Apr. 27	Apr. 28	Apr. 29	Apr. 30	May 1	May 2	May 3
Precipitation Observed	0.00	0.00	0.00	0.00	0.66	1.44	0.04	0.003	0.00	0.06
Precipitation Forecast issued on										
April 23, Morning	0.20	0.00	0.0	0.1	0.0					
April 24, Morning		0.02	0.00	0.0	0.0	0.0				
April 25, Morning			0.00	0.00	0.1	0.1	0.0			
April 26, Morning				0.00	0.15	0.1	0.0	0.0		
April 27, Morning					0.34	0.77	0.0	0.0	0.0	
April 27, Afternoon					0.39	0.91	0.1	0.1	0.1	
April 28, Morning						0.93	0.21	0.0	0.0	0.0
April 28, Afternoon						1.20	0.90	0.0	0.0	0.0
April 29, Morning							0.18	0.01	0.0	0.0
April 29, Afternoon							0.08	0.00	0.0	0.1

Note: Three, four and five day forecast values of 0.1 and 0.0 are used to indicate expected occurrence or non-occurrence of precipitation. Underlined values represent actual rainfall prediction.

improvements may be expected in forecast accuracy. It appears rather unlikely, however, that reliable forecasts of precipitation amounts for periods of 5 days ahead will be available within the next few years. It seems, therefore, that extended precipitation forecasts will continue to be largely subjective for some time in the future.

From the point of view of river forecasting, these limitations will continue to restrict the possible period of advance warning. However, the lag time between rainfall in the basin and flood peaks in the Fredericton area are from one to two days. Current technology in meteorological forecasting does permit accurate advance flood warning of two or three days. The effectiveness of the emergency measures during 1973 clearly proves the value of such a warning in reducing damage and personal hardship.

The emergency measures operation could be termed "an immediate emergency" in that there was no lead time for any pre-disaster planning or preparation. Many departments and agencies of government had no prepared Disaster Plans or Standing Operating Procedures for such an emergency. Nevertheless, the success of the operation illustrated a well expounded tenet of Emergency Measures teaching; "Given a small nucleus of key personnel with an understanding of disaster control, co-ordination and resource procurement, then using various agencies' expertise in their normal role, the emergency can be handled successfully".

It should be mentioned, however, that had the various departments and agencies of government had Emergency Plans and Standing Operating Procedures, the operation would have functioned more smoothly and the reaction by all groups would have been more positive.

Operating from an Ad Hoc Headquarters each department or agency was called in by the Emergency Measures Organization as required and given tasks suited to their known expertise. This enabled the Director of Operations to maintain overall control of the operation and, at the same time, allowed each group freedom of operation in their own field with co-ordination and support in all phases being supplied by the Emergency Measures Organization.

The flood forecasting model as used to predict this flood did not have the capability to forecast flood stages in the Fredericton area and downstream where the volume of water accumulated in the channel is important. This shortcoming led to some uncertainties immediately prior to the flood event. The backwater routing portion of the model has since been calibrated using data collected during the flood and the results of studies undertaken for the purpose of this report. In future flood forecasts for the Saint John River, it is anticipated that it will be possible to predict water levels for the entire reach between Fredericton and Saint John. This information will provide a more positive basis for emergency measures and with time should lead to greater acceptance by the public of the reliability of flood forecasts.

Flood Damages

Damaging floods in the province of New Brunswick are not an uncommon phenomenon. Although the true economic costs of previous floods have not been estimated, the available information suggests that there have been several floods causing damages in excess of one million dollars each, since the turn of the century.(4) The 1973 flood was probably the most destructive and most widespread of all. Nearly all parts of the province suffered some damage.

The total economic cost of the flood in New Brunswick is estimated to be $11.9 million. About 63 per cent of this or $7.4 million was paid by the federal and provincial governments in the form of compensation to flood victims. A breakdown of these damages for the Saint John River basin, the southwestern basins and the northeastern basins is shown in Table 16. The major portion of the damages, 91 per cent, occurred in the Saint John River basin, while only eight per cent occurred in the northeastern basins and less than one per cent in the southwestern basins.

Table 16 – Estimated Economic Cost and Compensation by Region

Region	Total Economic Cost	Total Compensation
Saint John River	$ 10,777,117	$ 6,632,142
Southwest	56,865	52,386
Northeast	1,043,025	743,077
Total	$ 11,877,077	$ 7,427,605

The studies undertaken for the purpose of estimating these costs are the first of their kind in the Atlantic Provinces and among the first in Canada. Thus, the methodology used in these studies is described in considerable detail in this report. If effective decisions are to be made on flood control or flood plain management, detailed analysis of flood costs as presented in this report must become more widely accepted.

This chapter of the report is divided into four parts. The first deals with the approach to estimation of economic costs; the second concerns the costs of the flood to the various sectors of the economy; the third describes damages by area; and the fourth discusses the damage to moveable property.

APPROACH TO ESTIMATING ECONOMIC COSTS

When floods occur they disrupt many economic linkages in society and cause damage which is devastating as well as heart-breaking. There is, however, an air of inadequacy surrounding estimates of damage caused by flooding. The disruption of linkages in the economy, which is as much a part of the real cost of the flood as the physical damages, is rarely dealt with adequately. Without the inclusion of such costs in the overall analysis, fundamental decisions concerning flood control and flood plain management become speculative at best. The objective of damage studies undertaken for the purpose of this report, therefore, was to identify and measure the direct, indirect and intangible effects of the flood on the various sectors of the New Brunswick economy. The flood caused considerable damage in that part of the Saint John River basin in Maine, but these damages have not been included in the analysis because they are not related to the effects on the economy of New Brunswick.

Compensation Guidelines

For every important natural disaster in Canada, these is provision for financial relief to those directly affected. The 1973 New Brunswick flood was a major disaster in the national sense. In order to fully understand the methodology used to estimate the economic costs of the 1973 flood, it is necessary to review the basis for flood compensation. Information collected for the purpose of compensation was used extensively in compiling the economic cost information in this report.

The federal government provides flood compensation to provinces when the magnitude of the damages is sufficiently large to place an undue financial burden on the province. The damages in New Brunswick during 1973 were deemed to be of such a magnitude. The provincial legislative authority for flood compensation was provided under the Flood Damage Act, 1973 which was enacted by the New Brunswick Legislature immediately following the flood. Compensation to flood victims was made directly by the province and the federal government in turn reimbursed the province for part of the cost of this compensation.

Federal guidelines on flood compensation state that the province is responsible for all damage up to one dollar per capita, on a provincial basis, after which the federal government contributes 50 per cent of the next two dollars per capita, 75 per cent of the following two dollars and 90 per cent of all costs over five dollars per capita. The compensated per capita damage caused by this flood was over eleven dollars per capita. Ottawa thus was responsible for about 72 per cent of the total costs while the province supplied approximately 28 per cent.

Not all flood victims were eligible for compensation. The specific federal E.M.O. guidelines concerning eligibility for compensation as a result of the flood listed the following categories of eligible costs.

1. The Immediate Disaster Period. Eligible costs would be those related to:

- the rescue, transportation, emergency health arrangements and emergency feeding, shelter, clothing and transportation of persons, shelter and feeding for livestock, including the provision and restoration of facilities used for those purposes.
- measures taken on order of the proper authorities to reduce the extent of damage by the removal of valuable chattels and assets and hazardous materials from the area of immediate risk, including the provision of storage space and transportation costs.
- the determination of the area and containment of the extent of the disaster, including emergency provision of essential community services, equipment, material and labour for protective works for individual protection and that of publicly owned institutions and utilities.
- the provision of emergency medical care to casualities of the disaster, or a resulting epidemic, and the transportation of such casualties from an apprehended disaster area, or of regular patients to make way for casualties, and of their return following the disaster.
- special security measures.
- special communications facilities.
- emergency control headquarters.
- special registration and inquiry services.

2. Post Disaster Assistance for Individuals. Eligible costs may include:

- restoration or replacement of or repairs to immovable real property, for any normally occupied dwelling place, appurtenant buildings and farm buildings and items essential to a farm business, where such dwelling place is used entirely for living accommodation, or partly for living accommodation and the earning of livelihood by a member or members of the family unit.
- restoration or replacement or repairs to chattels, furnishings and clothing of an essential nature as these may be determined for each disaster (e.g. stoves, refrigerators, beds, heavy winter clothing).
- assistance in the restoration of small businesses where the owner's livelihood has been destroyed. This includes payments made to restore farm lands to workable condition where a farm operation has been seriously affected by flood erosion or land gouging.
- costs of damage inspection and appraisal and administrative assistance excluding those incurred by permanent staff of government departments.

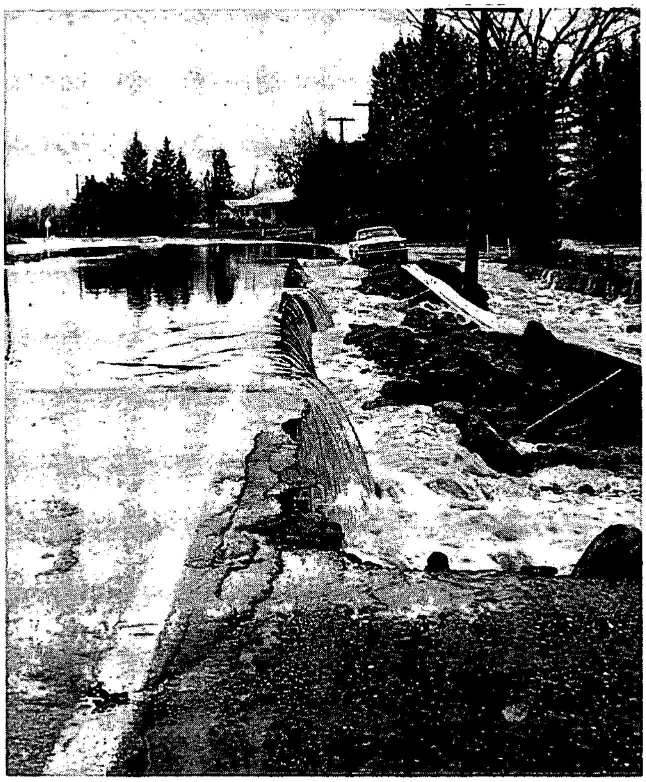
3. Post Disaster Assistance in the Public Sector. Eligible costs may include:

- Clearance of debris and wreckage. Examples are:
  - channels and streams as necessary
  - intake and outfall of sewer and storm drains to permit adequate functioning of the systems
  - water supply reservoirs as necessary
  - removal of buildings which constitute a definite threat to public safety
  - removal of trees and limbs if public safety is endangered
- Protective health and sanitation facilities.
- Repairs to pre-disaster condition of streets, roads, bridges, wharves and docks.
- Repairs to dykes, levees and drainage facilities including flood control and irrigation systems including removal of emergency works and restoration of their sites to pre-disaster condition.
- Repairs to government and public buildings and their related equipment. These include such facilities as schools, hospitals, public libraries, penal and welfare institutions, police and fire stations, public office buildings and public recreational facilities such as bathing beaches, zoos and parks.
- Repairs to publicly-owned sewer and water utilities. Repair costs for damage done to Crown Corporations except those supplying sewer and water services, would be ineligible.
- Costs of inspection and appraisal, and where required planning and design, to determine costs of restoration or replacement excluding those incurred in respect of permanent staff of government agencies.

While the terms and guidelines set for compensation are broad, there are serious limitations in using the compensation amounts to compute the total economic cost of a flood. Compensation covers only direct damage, leaving the very important indirect and intangible costs unaccounted. Even in the direct cost figures for the 1973 flood, compensation covered only 68 per cent of the total costs. Large corporations and public utilities were not compensated. Since second homes were considered luxuries, most cottages and camps were also not compensated.

General Methodology

Many economic costs of the flood were not compensated, and on the other hand, some people received direct and indirect private benefits from the flood for which no "social invoice" was presented. In assessing the flood and its ramifications, it is desirable to consider all costs and benefits, both private and social. In practice



Photograph 10 – Flood damage to Woodstock Road in Garden Creek area west of Fredericton, 29 April 1973.

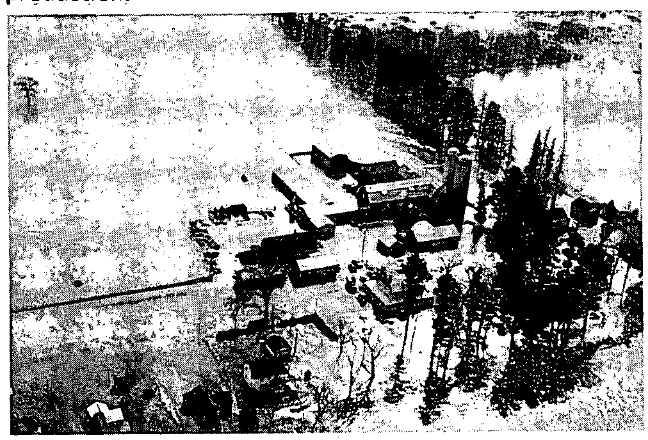
most of the benefits and some of the costs, although real, could not be quantified. Such costs and benefits are treated qualitatively in this report.

Some of the basic information on the costs of the flood was taken directly from damage assessments for the purpose of compensation. A few of the compensation settlements had not been finalized when the information was collected. Thus, minor deviations from the cost data contained in this report may be expected when the final compensation totals are computed. The other source of information on economic costs was surveys conducted by interviewers in the field. It must be emphasized, that because of sampling techniques adopted and the nature of the interviews, the accuracy of this information is much less than that of the compensation assessments. Compensation data represents exact amounts paid and thus many of the cost tables presented in this report give the false impression of a high degree of accuracy even though the figures contained in them are partly based on estimates from surveys.

Brief mention was made earlier of disruption of economic linkages by the flood. It is imperative to fully understand the extent to which the break-up of these linkages is important. Economic linkages exist between sectors of the economy and between the producer and the consumer. Where disruption occurs each party is affected. To better understand the full extent of the break-up of linkages and because of the extent of the damage caused by the flood, the cost was considered by economic sectors, each affected in its own way by the flood, and each having a different role in society. Five sectors were identified: Agricultural, Business, Organizational, Personal and Public.

The Agricultural Sector

The Agricultural Sector is part of the Business Sector but stands out as being different from the rest of the business community because it is involved in primary activity. The spring flood resulted in significant damage to the agricultural community. To summarize the whole impact, mention could be made of the following effects: growing season reduced and loss of early crops due to delay in planting, physical damage to building and machinery, and reduced yield from farming and livestock operations (loss of productivity). One cannot expect immediate recovery from a flood of this magnitude. The loss of fertile soil in a lot of cases will hamper future farm production.



Photograph 11 – Flooding of farm buildings and rural homes in the Lincoln area near Fredericton.

The Business Sector

The economic cost incurred by businesses during the flood probably had a large impact on the community-at-large since most other sectors revolve about business activities.

The definition of businesses as used for compensation purposes is inadequate for the purpose of this study. Only small businesses or family-owned businesses were eligible for compensation since it was assumed that they could not easily cover losses because of their limited operational capabilities. This definition excludes large businesses, many of which suffered extensive damage during the flood and which had a large impact on the general economy. For the purpose of this report, all profit-seeking activities that were affected in any way are considered in the Business Sector.

The Organizational Sector

Organizations are defined as non-personal, non-profit entities which provide recreational and other services to the communtiy. Economic costs in the Organizational Sector were of two types – the cost of relief efforts during the flood and physical damage to property owned by organizations. Although a significant portion of the organizations were compensated, there were some that were not eligible because of the nature of their activities. Yachting and curling clubs are two examples.

The Personal Sector

For the purpose of this report, the Personal Sector includes all privately-owned residences – homes, camps and cottages. Farmers' residences are included in the Personal Sector while other farm property is included in the Agricultural Sector. Damage to furnishings of apartments are included in this sector but structural damage to apartment buildings, which was claimed by the building owner, are included in the Business Sector. The Personal Sector is divided into two sections to facilitate analysis: principal residences and summer residences. Compensation was provided for damages sustained by principal residences but not for damage to summer homes.

The Public Sector

In this report the term Public Sector is taken to mean municipal, provincial and federal government agencies operating in New Brunswick. In the case of agencies of government or crown corporations, certain ambiguities arose during the course of the study and arbitrary classification decisions had to be made. As examples of this, the New Brunswick Electric Power Commission was classified as part of the Public Sector while the Lord Beaverbrook Hotel, owned by the provincial government at the time of this flood, was not.

Nature of Costs and Benefits

Before any effort was made to quantify costs and benefits an attempt was made to identify all types of costs and benefits for each sector. Lists of those identified are shown on Tables 17 and 18. It should be mentioned that these apply individually to sectors; it is quite possible for a benefit in one sector to appear as a cost to another sector. The costs and benefits are of three types: direct, indirect and intangible. Direct costs, also known as primary costs, are those incurred by entities physically affected by the flood. Similarly, primary or direct benefits are those benefits which accrue to the direct users of property affected by the flood. Secondary or indirect costs and benefits are those indirectly induced, while intangible costs and benefits are those which have a qualitative value only.

It must be pointed out that an attempt to define and assess all costs and benefits in such an event as a

Table 17 – Identification of Costs Per Sector

Category	Agricultural	Business	Organizational	Personal	Public
Direct	– Structural/ Building – Crop Losses – Land & Soil Damage – Machinery/ Equipment – Cleanup – Other	– Inventory – Structural/ Building – Frunishings – Machinery/ Equipment – Avoidance – Cleanup – Other	– Inventory – Structural/ Building – Furnishings – Machinery/ Equipment – Cleanup – Relief Effort – Other	– Structural/ Building – Contents – Avoidance – Cleanup – Other	– Structural/ Building – Inventory – Furnishings – Machinery/ Equipment – Avoidance – Cleanup – Other
Indirect	– Lost Productivity – Lost man days – Land value	– Lost man days – Lost Business profit – Transportation problems – Property values	– Lost man days	– Transportation problems – Man day of effort to combat flood – Loss of wages – Property values	– Lost man days – Redirection of effort to the flood – To estimate damage – Transportation problems – Opportunity Cost/Benefit of funds used to compensate victims – Cost of disruption of government activity
Intangible		– Elasticity of new investment	– Loss of recreation enjoyment	– Exhaustion – Family separation – Loss of life – Inconvenience	

Table 18 – Identification of Benefits Per Sector

Category	Agricultural	Business	Organizational	Personal	Public
Direct	– Silt Deposits	– Sale of damaged goods			
Indirect	– Difference in price	– Flood Recovery Businesses Prosper		– Relative decrease in property taxes	– Multiplier effects of block infusions of federal cash into the Provincial Economy – Multiplier effects of transferring public funds into private hands
Intangible	– Flood Experience	– Flood Experience	– Emergency Training	– Flood Experience – Unaffected got curiosity fulfilled – Unexpected public holiday – Other intangible benefits	– Emergency training – Sense of pride and accomplishment

major flood could only lead to mental frustration. For the purpose of this report, an attempt was made to cover all the major elements rather than all the elements of costs and benefits. This latter point should be sufficient to convince the reader that estimates obtained from this study should be treated as estimates rather than all-inclusive costs. Thus, undue reliance should not be placed on them. Estimates made regarding damage over and above compensation levels will hopefully bring us closer to the real cost of the flood. For each sector, a qualitative appreciation of all costs not quantified will be given.

Assumptions

During the course of the study it was necessary to make a number of assumptions. Some are general and apply to all sectors while others are more specific and deal with only one or two of them. The general assumptions are described below while the specific assumptions are described in discussing costs to individual sectors.

1. It was assumed that the number and value of compensation claims that were not filed was insignificant. Those who were entitled to make a claim did in fact do so.
2. The assessed value of damage was assumed to be the true value of damage to any particular item. It is relevant to note that pre-flood values were assessed, not restoration costs. It was assumed that the assessors correctly identified these pre-flood values.
3. Full employment of economic resources: land, labor and capital was assumed. Defining unemployed labor as those people actively seeking work, the army, students, housewives, et cetera can be classified as being gainfully employed members of society. Since most of the volunteer effort came from sectors of the economy that were alternatively employed, it can realistically be assumed that the flood did not use previously unemployed labor. This means that the allocation of costs to the flood-related efforts of these people is justified. The same reasoning applies to capital and land to the extent that these two resources were used. This assumption is critical in that if unemployed or idle resources were used to combat the flood, the efforts expended by these resources should not be included in total economic cost. If an unemployed resource is utilized and paid for its effort, there is no net economic cost to society because the wage cost is totally offset by the added benefit of using a resource that would have been idle.
4. During the flood, several people were unable to work because of inability to get to their places of employment or because of reduced traffic which generally made it unprofitable to open up business establishments to the public. To the extent that these people provided volunteer service, their efforts would not normally be included in economic cost according to the previous assumption made regarding full employment. However, since it would be very difficult to discern between displaced labor and hired labor, it is assumed that those put out of work in effect stayed home for the duration of the flood.
5. It must be assumed that costs are expressed in May 1, 1973 dollars. Damage repairs in all sectors will continue for several years to come, and price

levels at that time will very likely be different from what they were during the flood.

6. A general assumption of uniform quantification rates applied throughout the study. These rates apply to various costs, namely, avoidance, cleanup and lost man-days categories. It is assumed that $3.00 per man-hour and $10.00 per machinery-hour or $24.00 per man-day and $80.00 per machinery-day are generally representative of economic cost incurred under these categories. It is easily realized that in a number of cases, resources of higher value were used in these activities. But also, the rate applied could over-rate certain other resources.

SECTORAL ANALYSIS OF DAMAGE

A breakdown of the estimated cost of the flood by sector is given in Table 19. The most significant portion of cost lies in the Public Sector which accounted for 41 per cent or about $4.9 million damage. Most of this is attributable to the structural/building category which consists of non-moveable fixed assets.

Second in importance, is the Personal Sector accounting for 35 per cent and over $4 million damage. The larger portion is attributable to principal residences making up over $3 million while summer residences are responsible for about $1 million. The most important cost in this case is also structural/building damage. There were an estimated total of 2426 units affected, of which 805 were summer residences.

The Business Sector suffered losses of about $1.7 million, representing 15 per cent of the total. The non-compensated amount is higher than the compensated amount. Large businesses make up the greatest non-compensated portion. In the Business Sector, machinery/equipment losses were the most significant. Many of the damaged items were movable and could have been saved if sufficient warning and manpower had been available.

Losses in the Agricultural Sector amounted to only six per cent of total economic cost but this figure does not reveal the significance to the province of the sector's damage. Crop loss is the most important category, making up over one third of the total amount. This represents, in some areas, complete loss of early crops, resulting in considerable loss of revenue from farm products at the end of the season.

The least significant sector is the Organizational Sector to which about $0.3 million is attributed. Flood relief efforts were the main cost item in this sector.

The purpose of sectoral analysis is to emphasize the relative importance of each sector during the flood. In the following pages each of the five sectors are dealt with separately. The methodologies used in estimating costs are presented and the relative importance of the various types of costs are described.

The Agricultural Sector

The Agricultural Sector was heavily affected. Early crops that had already been planted were swept away, resulting not only in loss of plants but also in loss of sales of these crops later in the year. The sector also incurred steep costs to buildings, machinery and equipment.

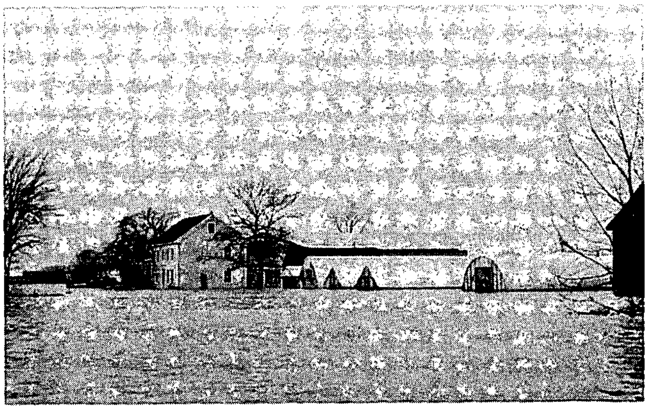
The Maugerville-Sheffield area, which is considered one of the most productive agricultural areas in the province, was entirely flooded by the waters. This represented costs to the economy of the province because of reliance on food supply from this region. To the farmers, it delayed the regular planting season and made early harvesting of crops impossible.

Costs and Benefits Included in the Analysis

All direct cost items and one indirect cost item shown in Table 17 were included in the analysis. A

Table 19 – Economic Cost By Sectors

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 670,785	$ 67,205	$ 737,990	$ 737,990	208
Business	1,588,062	151,151	1,739,213	503,980	406
Organizational	296,705	1,712	298,417	134,129	56
Personal	4,186,987	–	4,186,987	1,991,467	2426
Public	4,150,858	763,542	4,914,400	4,060,039	–
Total	$10,893,397	$ 983,610	$11,877,007	$ 7,427,605	3096



Photograph 12 – Flooding of buildings and greenhouses in the Sheffield area, 3 May 1973

brief description of the types of damage under each category is given below.

(1) Structural/Building: Structural/building costs in the Agricultural Sector refer to damaged barns, equipment sheds, fences, greenhouses and retaining walls.

(2) Crop Losses: This cost refers to damage done to early crops which had been planted a few weeks before the flood. It includes bedding plants and seedlings in greenhouses which were being prepared for planting.

(3) Land and Soil Damage: This cost covers the loss of fertile land as a result of the flood. In some areas rich topsoil was swept away by the waters and replaced by silts and other deposits, resulting in added production costs to the farmers.

(4) Machinery and Equipment: This category covers the cost of repairs to machinery and equipment damaged by the flood.

(5) Cleanup: Cleanup covers man-hours involved in cleaning debris from buildings and fields after the flood.

(6) Other Costs: This category includes a number of items such as costs of evacuating livestock and maintaining them in temporary quarters, oil and gas losses and damage to water supplies. It also includes the value of a relatively small number of livestock which were lost during the flood.

(7) Lost Productivity: Damage to fields and the effects of flooding on livestock results in an indirect cost due to lower production. Lost productivity was estimated by assessors on the basis of the previous years' production and 1973 price levels.

Costs and Benefits Not Included in the Analysis

Several of the categories of costs and benefits are not included in this report, either because they were not quantifiable or because they were insignificant.

(1) Lost Man-days: Hired manpower that was employed during the flood in agricultural activity and did not work but still received wages represents a true economic cost to the Agricultural Sector. No attempt was made to quantify this item, since it is considered of minimum importance to the sector. Consideration has been given to this cost in other sectors where it was felt to be more substantial.

(2) Relative Decline of Property Values: Agricultural lands which were heavily damaged by the flood will probably suffer a relative decline in the value of their properties. There is no means of quantifying this cost.

(3) Benefit of Silt Deposits: Periodic flooding of agricultural land maintains the fertility of that land through soil enrichment. During the 1973 flood, costs far outweigh the possible benefits of such effects. In the course of this study, no attempt has been made to quantify these benefits.

(4) Increased Price Levels: A benefit of an indirect nature worth mentioning is the difference in price as a result of the flood. Because of overall lower production, the supply of farm products was reduced and, with demand unchanged, the probable result was higher prices for agricultural products. This could result in higher farm receipts, especially to farms which incurred minimal damage and were able to maintain production at normal levels.

(5) Flood Experience: Mention could be made also of flood experience as an intangible benefit to the Agricultural Sector. As a result of this flood, farmers may learn how they can minimize their total damage in the event of another flood.

Data Acquisition

In the Agricultural Sector, compensation was provided for all important direct and indirect costs considered to be quantifiable. Compensation guidelines applied to this sector were very broad. Thus, as opposed to methodology undertaken in the other sectors, it was felt that other means of collecting information were unnecessary and that the compensation paid could be assumed to represent the true economic cost incurred by the Agricultural Sector.

Economic Cost Analysis

Table 20 offers the breakdown of cost in the Agricultural Sector resulting from the 1973 flood. In total, 208 units were affected with a total cost of about $738,000. The average economic cost incurred per unit is approximately $3,550. No economic cost was incurred in the southwestern basins.

The following aspects are worth noting from the Table.

(1) Crop losses are the most important cost to the sector accounting for 35 per cent of the total. Structural/Building cost is next in importance representing over 20 per cent of the total economic cost.

Table 20 – Economic Cost in Agricultural Sector by Region

Item	Saint John River	Northeast	Total
Number of properties affected	176	32	208
Structural/Building	$138,056	$10,805	$148,861
Crop Losses	256,898	2,009	258,907
Land and Soil Damage	95,969	11,319	107,288
Machinery/Equipment	54,684	403	55,087
Cleanup	35,125	3,654	38,779
Other	53,336	8,527	61,863
Total Direct	$634,068	$36,717	$670,785
Total Indirect	$ 67,205	-	$ 67,205
TOTAL ECONOMIC COST	$701,273	$36,717	$737,990

(2) Most of the agricultural cost was incurred in the Saint John River basin, $701,000 out of $738,000. This is natural because most agricultural activity in New Brunswick takes place in this basin.

(3) In the northeastern basins land and soil damage accounts for 30.8 per cent of the total cost, while in the Saint John River basin it accounts for only 13.7 per cent.

(4) Indirect costs occurred only in the Saint John River basin and constitute $67,000 or 9.1 per cent of the total.

The figures presented in this table must not be considered as de facto. They are estimates of cost to the sector based on projected 1973 yield of the sector. Damages incurred may handicap productivity of the agricultural land for years to come. This factor was not taken into account as it lies beyond the scope of this study.

The Business Sector

Economic cost attributed to the Business Sector resulted in the greatest disruptive effects on society as a whole. Because the Business Sector has the most linkages to other segments of the economy, the disruption of these linkages affects the whole economic life of the community. This is self-evident when a major or indispensable part of the business community is stranded by flooding waters. During the 1973 flood, it was particularly true since all sectors of the business community were affected, bringing the flow of goods to the consumer to a complete standstill.

Costs and Benefits Included in the Analysis

The following is a description of those categories of costs and benefits which were quantified:

(1) Loss of Inventory: This cost represents the loss of stock inventory at cost price.

(2) Structural/Building: This item covers the cost of labour and materials involved in repairing damage to buildings.

(3) Furnishings: This cost refers mainly to office furniture damaged during the flood.

(4) Machinery/Equipment: Damage to machinery and equipment indispensable to the business operations, either in storage or in yard use, have been estimated at repair cost or replacement cost from which a depreciation percentage was deducted. Damage to railway facilities was included in this category.

(5) Cleanup: This refers mainly to man-hours involved in cleaning operations after the flood had receded.

(6) Avoiding Damage: This cost is mainly representative of man-hours involved and materials purchased to avoid possible water damage.

(7) Lost Man-days: This category covers the dollar value of lost working time, whether or not the employee was actually paid for this time by his employer. In all cases, an arbitrary rate was applied to lost man-days.

(8) Sales of Damaged Goods: This benefit is of minimum importance relative to the cost of lost inventory. Benefits identified under this category were used to offset the cost of inventory losses. When damaged goods were sold, usually the sale price was about equal to the cost price. Therefore, there was no profit margin and no distortion in price levels.

Costs and Benefits Not Included in Analysis

Quantification is narrowed to a number of costs, unfortunately not representative of the total impact of the flood on the sector. Only a qualitative appreciation of most indirect and intangible costs is possible.

(1) Lost Business Profits: A considerable amount of doubt exists as to whether or not lost business profits should be considered a true economic cost of the flood. Some losses of business profit during the period of the flood result in transfer of business sales from one stranded outlet to another safe one. Other losses will be made up by a business after it regains full operations. In the former case, no loss is suffered to the sector because of a transfer of funds from one outlet to another. In the

latter case, the business retains its sales level in the long term, and no loss of profits is apparent. Thus, a true economic cost occurs only when the temporary closure of a business results in non-satisfaction of the demand for a particular service. Attempts to quantify such costs are highly dependent on the nature of the business and require the full co-operation of businessmen. An attempt was made during the course of this study to quantify lost business profits. It was realized, though, that the information gathered fell short of fully capturing these effects. Business profits are very difficult to estimate by the businessmen themselves. In more cases than one, an arbitrary percentage was applied from Business Financial Operations carried by Statistics Canada. This led to two different sources of information. A number of businesses, also, were reluctant to reveal their sales and consequently their profit figures. Both these factors resulted in inconsistency in the gathering of data and for this reason Lost Business Profits were not considered in the total analysis. The information collected on this category of cost is presented for information purposes only.

(2) Transportation Problems: Disruption of transportation caused considerable hardship to businesses. It halted and slowed the flow of goods from the supplier to the retailer and from the retailer to the consumer. The resulting cost was significant and highly underestimated in its importance to the sector. Air, ground and water transportation systems were all affected to some degree in most parts of the province. The task of quantifying the economic cost to businesses because of transportation problems during the flood would have been extremely difficult. It would have required investigation of the normal transportation routes of commodities plus the re-routing patterns of such commodities because of isolation and flooded highways. The added problem of applying a rate structure to the re-routing distance (particularly difficult in the case of ground transportation) made this indirect cost impossible to estimate with any confidence.

(3) Business Property Values: The value of business property which was affected by the flood may be reduced relative to other properties. Such costs are not quantifiable.

(4) Elasticity of New Investment: New investment in affected areas may be jeopardized by the knowledge that physical damage could result from a future flood but there is no means of quantifying trends of this nature.

(5) Flood Recovery Business: Following the 1973 flood, a number of businesses flourished because of the destructive effects of the flood. Furniture stores, construction companies, appliance stores and repair shops are among the businesses which benefited. Because of the difficulty in distinguishing flood recovery business from normal business, this indirect benefit was not estimated.

(6) Flood Experience: Businessmen and workers alike benefited from the flood in terms of increased knowledge of ways to minimize damage and/or increase their sales during or after a flood. This intangible item cannot be quantified but is considered a legitimate benefit of the flood.

Photograph 13 – Looking north along Highway No. 7 at Baker Brook crossing, southeast of Fredericton, 1 May 1973.

Data Acquisition

One basic source of information on Business Sector damage was the compensation claim files from the provincial government. Information gathered from these files concerned direct cost for small businesses. Data on other costs to small businesses and all costs to large businesses were obtained by surveys. The analysis revealed that large business sustained most of the economic cost to the sector.

A total of 406 businesses were contacted. Most of these were interviewed by telephone but a limited number were sent letters asking for information. Difficulties in assessing information obtained by mail were resolved by follow-up telephone interviews. For the compensated businesses, which numbered 208, the information requested concerned costs in categories for which compensation was not paid. These included cleanup and avoidance cost as well as indirect costs. For the remaining businesses, interviews covered all facets of costs incurred by the businesses, direct and indirect.

In a number of cases, the interviewer's judgement was used to assess real damage figures and to make corrections whenever needed. Some businessmen affected by the flood tended to inflate their cost figures for emotional reasons. There is danger of putting undue reliance on these estimates even though the interviews and compilation of data were believed to have been carried out in a most scientific manner. It is assumed that businessmen's estimates, tempered by the interviewer's judgement in a number of cases, represent the true economic cost of the flood. It is also assumed that all businesses that suffered economic cost as a result of the flood are included in the analysis.

Economic Cost Analysis

A summary of cost to the Business Sector is given in Table 21. The information in the table reveals the following interesting facts:

(1) Total economic cost to the Business Sector amounts to about $1.74 million of which over 91 per cent ($1.59 million) is direct costs.

(2) Over 80 per cent of the total economic cost, or $1.42 million, was attributable to the Saint John River basin.

(3) Compensation was provided for only 29 per cent of the total economic costs although over half of the affected businesses received compensation. This reflects the important economic cost suffered by large businesses.

(4) The most important category was machinery/equipment cost, which was responsible for 52 per cent of the direct costs. Next in importance are structural/building costs (17 per cent) and loss of inventory costs.

(5) Avoidance cost constituted only 1.8 per cent of the total direct costs. This is revealing when one considers that a large portion of the items damaged are considered moveable. Given accurate flood warning and sufficient manpower, a significantly greater avoidance effort would likely result in a net reduction in total direct cost.

(6) Over 95 per cent of indirect costs (lost man-days costs) occurred in the Saint John River basin which incurred 80 per cent of the total damage. This reveals the impact of breakup of linkages on the Business Sector in the more seriously affected areas.

(7) Most costs attributable to the southwestern basins were in avoidance cost, reflecting the reaction of the Business Sector to the threat of a flood in that region.

(8) In the northeastern basins, machinery/equipment costs accounted for 72 per cent of the total economic cost while compensation was provided for only 21 per cent of total economic cost. These figures contrast sharply with the breakdown for the entire province.

(9) Total damage to railway facilities in the province, which are included under machinery/equipment cost, amounted to $740,000 or 43 per cent of the total economic costs in the Business Sector. Most of this cost, $530,000, was incurred in the Saint John River basin.

As added information, it was felt worthwhile to present the figures compiled under the category Lost Business Profits. At the outset, warning must be made not to derive any firm conclusions from this added information. As earlier discussed, the information is incomplete and the scientific consistency doubtful. Total economic cost amounts to $62,000 and includes data gathered from 88 firms, which represent 21 per cent of those businesses affected. The greatest concentration is in the City of Fredericton where $44,000 was declared as lost profits. The Saint John River basin accounts for over 95 per cent of the total cost in this category.

The Organizational Sector

The Organizational Sector consists of two distinct groups: organizations that participated in relief efforts dur-

Table 21 – Economic Cost in Business Sector by Regions

Item	Saint John River	Southwest	Northeast	Total
Number of businesses affected	368	4	34	406
Number of businesses compensated	175	4	29	208
Loss of inventory	$ 187,257	$ 1,403	$ 20,266	$ 208,926
Structural/Building	240,972	155	46,934	288,061
Furnishings	55,754	193	6,231	62,178
Machinery/Equipment	688,774	–	224,434	913,208
Cleanup	72,011	805	1,461	74,277
Avoiding Damage	24,834	4,350	–	29,184
Other	1,502	–	10,726	12,228
Total Direct	$1,271,104	$ 6,906	$ 310,052	$1,588,062
Total Indirect	$ 148,757	$ 1,594	$ 800	$ 151,151
TOTAL ECONOMIC COST	$1,419,861	$ 8,500	$ 310,852	$1,739,213
Total Compensation	$ 435,206	$ 4,021	$ 64,753	$ 503,980

ing the flood, and organizations which were physically damaged as a result of the flood. The total cost to this sector is small relative to that of other sectors but the role of the sector during the emergency extends beyond appreciation in monetary terms.

As already described, relief efforts during the flood were for the most part co-ordinated by the Emergency Measures Organization (EMO). The principal organizations involved in the emergency activity include the University of New Brunswick, the Salvation Army, citizens band radio operators and the Chamber of Commerce.

Some organizations also suffered costs similar to those sustained by the Personal Sector. In this category are churches, community centres and service clubs.

Photograph 14 – Looking south along Highway No. 7 in Fredericton just downstream of Princess Margaret Bridge, 30 April 1973.

Costs Included in the Analysis

Costs were quantified for eight categories of direct cost and for one indirect cost. The direct cost categories are listed below:

(1) Loss of Inventory: Inventory stock losses from the flood have been assessed at cost price.

(2) Structural/Building: These losses refer mainly to damage done to club houses, churches and halls.

(3) Furnishings: This cost refers to damage done to furnishings of organizational property as a result of the flood.

(4) Machinery/Equipment: This category includes furnaces, water heaters, and sporting gear.

(5) Avoiding Damage: This item includes the cost of activities such as moving furniture and equipment to higher levels, renting sump pumps to keep water out of basements, and sandbagging to prevent water from coming into the property.

(6) Cleanup: The cleanup of damages and debris occasioned by the flood demanded a considerable amount of effort by organizations. The costs have been estimated from information supplied on the number of man-days expended.

(7) Flood Relief Efforts: Only the organizations that participated in relief efforts during the flood have incurred cost in this category. Costs were incurred in evacuating flood victims from their homes, arranging and providing accommodation for flood victims, evacuating hundreds of farm livestock from low-lying farms and providing information and assistance in the cleanup operations.

(8) Other: This cost included miscellaneous damage, such as that to roads, retaining walls, water lines, and losses of furnace oil.

The only indirect cost quantified in this segment of the study was lost man-days. This represents the dollar value of lost time for any organization employee who could not report to his duties because of the flood. The approach to quantification was the same as that applied in the Business Sector.

Costs and Benefits Not Included in the Analysis

(1) Loss of Recreational Enjoyment: A number of organizations which provide recreational activities had to be closed for repair of damage. This deprived members and the public-at-large of the recreational facilities and created a gap in the full social life of the community. Where no alternative service was available to satisfy the recreational needs, the loss of these facilities is an intangible cost of the flood.

(2) Emergency Training: Many organizations which participated in the emergency activity gained experience which could be useful in dealing with future disasters.

Data Gathering

Information was gathered by two methods. First, costs to some organizations were computed from information on compensation claim files. Secondly, for all organizations that participated in flood relief efforts, either compensated or not, personal interviews were carried out. A total of 15 organizations were interviewed. Data from these two sources form the basis for the total economic cost attributable to the Organizational Sector.

Economic Cost Analysis

The cost figures are contained in Table 22. In terms of the total cost incurred, the Organizational Sector is least significant of the five sectors considered. As mentioned previously, such cost figures do not indicate the sector's relative significance during the disaster period. A review of Table 22 indicates the following interesting facts:

(1) Total cost in the province amounts to $298,000 of which $293,000 was incurred in the Saint John River basin, and the remainder, only $5,000, was incurred in the northeastern basins.

(2) Compensation provided covered less than 50 per cent of the total economic cost. It is worth mentioning that most of the compensation was received by the physically damaged organizations. Most of the organizations which participated in flood relief efforts did not apply for compensation.

(3) Flood Relief Efforts account for 53 per cent of the total economic cost.

(4) Indirect Costs are relatively insignificant compared to the total cost to the sector.

(5) Cleanup costs totalled $38,000 almost 13 per cent of the total cost. This clearly indicates the organizations' share in assisting in the removal of debris left by the flood.

Table 22 – Economic Cost in Organizational Sector by Regions

Item	Saint John River	Northeast	Total
Number of organizations affected	52	4	56
Number of organizations compensated	41	3	44
Loss of Inventory	$ 132	-	$ 132
Structural/Building	79,022	$4,926	83,948
Furnishings	7,606	-	7,606
Machinery/Equipment	1,612	-	1,612
Avoiding Damage	2,231	-	2,231
Cleanup	37,642	-	37,642
Flood Relief Efforts	158,389	-	158,389
Other	4,620	525	5,145
Total Direct	$291,254	$5,451	$296,705
Total Indirect	$ 1,712	-	$ 1,712
TOTAL ECONOMIC COST	$292,966	$5,451	$298,417
Total Compensation	$131,546	$2,583	$134,129

Photograph 15 – Residential area of Fredericton near the peak flood stage, 30 April 1973.

The Personal Sector

The 1973 spring flood of the Saint John River will probably be longest and most vividly remembered by those area residents who suffered damage to their personal property. At the peak of the flood basements and ground floors of homes were flooded, trailers were water-logged, and cottages were ravaged by turbulent waters and floating debris.

Costs Included in the Analysis

Only the five direct cost items shown on Table 17 were considered in the analysis of the Personal Sector, but as indicated below some indirect costs are included in these items.

(1) Structural Damage: Structural damage included cracked foundations; water-soaked walls, floors and wall-to-wall carpeting; broken windows; and battered exteriors.

(2) Content Damage: This item covers damage to contents of homes and cottages such as damaged furnace motors, water-logged furniture, mattresses and clothing, food spoilage, and insulation and electrical problems with freezers, refrigerators, stoves and other appliances.

(3) Cost of Avoiding Damage: Included in this cost are sump pump rental and operating costs, as well as other avoidance elements such as moving furniture, etc.

(4) Cleanup: Cleanup costs include purchase or rental of equipment, payment of cleaning crews and cost of man-hours of work.

(5) Other: This item includes damages not included elsewhere such as erosion, lawn upheaval, damage to fences, driveways, garages or sheds, loss of oil, foregone wages, and non-compensated living expenses for those forced to leave their homes. Some of the indirect costs of the flood have been included under this item.

Costs and Benefits Not Included in the Analysis

Indirect and intangible costs and benefits were not generally included in the analysis of the Personal Sector. However, as described below, some of these costs have been included in other direct cost categories.

(1) Cost of transportation disruptions to individuals: There is no doubt that disruption in transportation linkages causes considerable cost and inconvenience to individuals. Water-covered roads made transportation impossible or necessitated long detours for many people to reach homes, cottages, work and other destinations. Unfortunately, there are no reliable data available for such costs.

(2) Cost of man-days of effort expended in combatting the flood: Under the Personal Sector no separate category was formulated for this cost. In sampling,

the man-hours calculated in avoiding flood damage included the time spent helping neighbours. It is therefore assumed that the majority of man-day effort has been accounted for under Cost of Avoiding Damage.

(3) Loss of wages: For some workers, especially those paid on an hourly basis, time lost as a result of the flood meant also a loss of wages. In the sample data such a cost was listed under "Other". The sample, however, doesn't cover all categories of employees that could suffer lost wages. Workers employed in a flooded area but residing outside it, might have incurred lost wages which would not be reflected in the data collected. However, only a minimal discrepancy is expected to result from not investigating this cost more thoroughly.

(4) Relative decrease in property values in the flood plain: It is possible that some of the properties damaged during 1973 and other properties in the surrounding flood plain will be subject to a relative depreciation in value as a result of the flood. Any estimate of the amount of such depreciation would be highly speculative.

(5) Intangible Costs: Most residents suffered exhaustion, either physical, mental, or both as they laboured and/or worried while the flood waters rose and fell. In many cases, families evacuated from their homes had to split up in order to find accommodation with friends and relatives, thus suffering the pangs of family separation. Most people in and around the flooded areas, as well as those passing through, experienced numerous and varied inconveniences because of the high waters. One highway fatality has been attributed to the flood. These are illustrative of the very real but intangible costs which cannot be reliably quantified.

(6) Relative decrease in property taxes as a result of diminished property values in the flood area: This is an indirect benefit of the flood but was excluded from the analysis for the same reason as the cost of declining property values. The legislation governing property taxation in New Brunswick provides for tax concessions on account of property damage, however, the extent of the tax reduction is relatively small.

(7) Other Intangible Benefits: As with intangible costs, the intangible benefits are real but qualitative rather than quantifiable and are not included in total cost estimates. For many, the flood resulted in a day or two off work, usually with pay. The acquisition of flood experience is an added benefit. In the event of another flood, people might be better prepared and more capable of handling any situation. This benefit will, however, deteriorate over time as memories fade. The rising waters also provided excitement for curious onlookers, as well as for newspaper readers and television viewers. A sense of community was also fostered. Crews of neighbours went from house to house to move contents; many citizens volunteered their time and services to assist in the various EMO-organized relief operations. Basements in the flood plain area are now substantially cleaner and more uncluttered as much water-soaked "junk" had to be discarded; the possibility of fire is thus reduced.

Data Gathering

In accordance with the compensation guidelines, principal residences were compensated but cottages or second homes were not. For the purpose of data gathering, cottages were considered separately from principal residences.

Most of the data on damages sustained by principal residences was developed from compensation files. However, surveys were required to estimate the non-compensated costs. A survey sample of size 50 was randomly chosen with consideration to area representation to ensure that the results were not biased by the fact that individual damages in some areas were higher than in others. Based on the near-final claim tally of 1621, the sample size was about three per cent.

Interviews with these 50 selected home owners provided information on non-compensated costs which was used to compute a ratio of total economic cost to total compensation for each area. The total economic cost for principal residences was then estimated from the ratios. For the entire province it is estimated that the total economic cost was about 1.5 times the amount of compensation paid. A summary of estimated economic cost to principal residences is shown on Table 23.

For estimating the damages to cottages, a random 20 per cent sample was selected from among 312 claims for cottage damage which had been submitted to the compensation board. It was also a reasonably representative sample as the claims were arranged by areas, and then alphabetically by the claimant's last name; every fifth one was picked to form the sample of size 62. In the end, the addition of new cottage claims altered the sample to one of 18.5 per cent. Since no compensation was awarded cottage and camp owners, there is no complete list of damaged second homes available. The assumption was therefore made that those who, mistakenly, did apply for compensation form a representative distribution of all who owned damaged cottages.

Aerial photographs taken near the flood peak were used to estimate the number of cottages suffering water damage. In some cases it was hard to tell whether a roof surrounded by water was a cottage, camp, shed or garage; in other cases it was questionable whether water damage occurred. Therefore, only cottages which could be positively identified as having been flooded were counted. In this manner aerial photographs were used to estimate the number of cottages flooded in four areas: Grand Lake, including Indian and French lakes; Washademoak

Table 23 – Economic Cost to Principal Residences by Regions

Item	Saint John River	Southwest	Northeast	Total
Number of Claims	1,474	5	142	1,621
Compensated Building Cost	$1,242,384	$ 455	$ 52,097	$1,294,936
Compensated Content Cost	560,937	220	27,994	589,151
Other Compensated Cost	89,173	1,455	16,753	107,381
Total Compensation	$1,892,494	$2,130	$ 96,844	$1,991,468
Non-compensated Cost	$1,110,658	-	$ 44,121	$1,154,779
TOTAL ECONOMIC COST	$3,003,152	$2,130	$140,965	$3,146,247

Lake; Maquapit Lake; and Kennebecasis Bay. It was found that the claims for cottages numbered 42 per cent of the of the total number of cottages affected in these four areas. It was assumed that this percentage was applicable to all areas. Thus, the total number of cottages damaged during 1973 was estimated to be 805. The sample of 62 represents a sample size of 7.7 per cent.

Estimates of the total damage to cottages are shown on Table 24. This information was collected entirely by telephone interviews with the 62 cottage owners. The reliability of the information is certainly less than that of other damage figures which are based on assessment for compensation purposes.

Economic Cost Analysis

A summary of the estimated economic cost to the Personal Sector is shown on Table 25. As indicated, the total number of properties affected by the flood amounts to 2,426, with economic costs reaching nearly $4.2 million. This figure is approximately one third of the cost figure for all sectors – indeed a sizeable amount.

Analysis of the principal residences indicates that structural damage amounted to 57 per cent of the total cost. The two other major direct costs, damage to contents and cleanup cost, amounted to 27 per cent and 10 per cent respectively. Obviously, other costs

Table 24 – Economic Cost to Summer Residences by Area

Area	Structural Damage	Content Damage	Avoidance	Cleanup	Other	Total Economic Cost
Restigouche River Basin	$ -	$ -	$ -	$ 1,550	$ -	$ 1,550
Miramichi River Basin	-	3,480	-	1,550	-	5,030
Edmundston Area	25,810	12,900	-	620	-	39,330
Grand Falls Area	138,310	39,360	3,230	14,880	103,900	299,680
Woodstock Area	6,450	260	-	4,780	12,900	24,390
Nashwaak Basin	-	2,580	-	4,960	-	7,540
Fredericton Area	3,810	2,050	100	1,640	1,460	9,060
Maquapit Lake	7,830	23,160	-	12,890	650	44,530
Grand Lake	169,150	94,520	3,320	84,480	10,650	362,120
Washademoak Lake	9,230	10,970	2,480	4,160	-	26,840
Belleisle Bay	44,800	13,610	1,820	4,520	3,080	67,830
Kennebecasis Bay	18,710	12,850	390	13,060	3,360	48,370
Saint John Area	13,550	20,000	410	39,040	31,490	104,490
Total	$437,650	$235,740	$ 11,750	$ 188,130	$ 167,490	$ 1,040,760

were minimal.

Structural damage accounted for approximately 42 per cent of the total cost to cottages, while content damage comprised another 23 per cent. Many of the cottages were severely beaten by wave action while logs and debris were forced through windows, walls and floors. Furniture, electrical appliances, mattresses and bedding were generally so water-soaked that they could not be salvaged; usually they had to be carted away to the dump. Understandably, the cost of avoiding flood damage was minimal. In most cases, cottage and camp owners were unaware that their summer homes were endangered by the rising waters. Even those who were aware of the pending danger were not able to avoid damage, as roads and bridges were generally impassable. Cleanup amounted to approximately 16 per cent of total damage to cottages, a significant figure. Costs under the 'Other' category account for 17.7 per cent of the total and include damage to boats, sheds, septic tanks and barbecues, and land erosion.

The Public Sector

The 1973 flood had its most pronounced effect on the Public Sector of the economy. In terms of dollar damage inflicted, this sector easily suffered the greatest loss. Also, most of the administrative and organizational initiatives designed to deal with the flood peril originated in the public domain. The tendency for damages in the Public Sector to exceed those in others is further explained by the fact that the City of Fredericton was heavily inundated. Fredericton is the provincial capital and with most government offices being located directly adjacent to the Saint John River, it is not difficult to discover why the Public Sector was so vulnerable.

Costs Included in the Analysis

Most of the direct costs and some of the indirect costs shown in Table 17 were included in the analysis of the Public Sector.

(1) Structural/Building: This item refers to damages caused to permanent buildings, roads, bridges, etc., owned by various government departments. This category corresponds to similar categories in all other sectors.

(2) Inventory: This cost refers to supplies or other similar nonpermanent assets held by the Public Sector. Paper forms, books, etc. fit under this heading.

(3) Furnishings: Furnishings refers generally to damages caused to office furniture.

(4) Machinery and equipment: This cost refers to damages inflicted on machines and other operative capital assets.

(5) Avoidance: This category refers to labour and capital resources expended on avoiding damage.

(6) Cleanup: Cleanup refers to the cost, either financial or implicit, necessary to remove debris, water marks, etc. from flooded buildings and public areas.

(7) Other: This category refers to such things as emergency evacuation costs and miscellaneous direct costs not elsewhere classifiable.

(8) Lost Man-days: This indirect cost refers to salaries of government employees which were paid by the government but for which no work was received in return. In effect, this represents the economic cost to the Public Sector of the lost production of these employees during the flood.

Table 25 – Economic Cost in Personal Sector by Regions

Item	Saint John River	Southwest	Northeast	Total
Principal Residences				
Number of claims	1,474	5	142	1,621
Total Compensation	$1,892,494	$2,130	$ 96,844	$1,991,467
Non-compensated Cost	$1,110,658	-	$ 44,121	$1,154,779
TOTAL ECONOMIC COST	$3,003,152	$2,130	$140,965	$3,146,247
Cottages				
Number affected	777	-	28	805
TOTAL ECONOMIC COST	$1,034,180	-	$ 6,580	$1,040,760
Total Number affected	2,251	5	170	2,426
TOTAL ECONOMIC COST	$4,037,332	$2,130	$147,545	$4,187,007

(9) Departmental Redirection of Effort to the Flood: This cost refers to the salaries of employees whose effort, while at their regular jobs, was directed toward some facet of the flood relief effort.

(10) To Estimate Damages: To estimate damages refers to the study costs and to the necessity of evaluating flood costs for compensation purposes.

It is possible that overlap has occurred among some of the above categories. For example, Machinery and Equipment and Furnishings were sometimes difficult to separate. A more tangible example of this point occurred between Redirection of Effort and Other. Since Other contains evacuation costs and since many government employees assisted in the evacuation, their efforts should be reported in the Other column. However, several of these employees, especially in the provincial and federal agriculture departments, were involved in the flood effort long after the evacuation. It was difficult to break down these costs entirely accurately, and thus it cannot be overemphasized that all costs are merely estimates or approximations of reality.

Photograph 16 – Flood damage at Nashwaak Bridge on Nashwaak River, 2 May 1973.

Costs and Benefits Not Included in the Analysis

(1) The cost of transportation disruptions to government departments during the flood: It is assumed that this was a minimal cost in the Public Sector. Most trips by government employees cancelled as a result of the flood would be made up at a later date and there would have been only a small number of employees already en route who had to stay overnight or re-route themselves because of high waters. Thus, in most cases this is not a significant economic cost in the Public Sector since, where it is relevant, the overall effect is small.

(2) Opportunity cost/benefit of funds used to compensate victims: Provincial monies used to compensate victims represent dollars that could have been expended in other areas. The social yield on compensation dollars may or may not turn out to be greater than the social yield on various other types of outlays. If greater, the expenditure of these dollars on compensation involves a benefit to the society. If less, such expenditure involves a cost. In either case, data are not available to accurately measure this opportunity cost/benefit.

(3) Costs of disruptions in day-to-day government activity: Under full employment assumptions, the diversion of government attention from regular problems to those dealing with the flood implies an economic cost imposed by the flood. Except in the case of individuals in various departments whose salaries can be directly attributable to the flood, all disruption costs have been ignored. The justification for this is twofold. First the costs are assumed not to be significant and, secondly, they are difficult to accurately measure. Wherever possible an attempt was made to report an implicit cost for flood effort that was not part of the day-to-day activity of a particular department. The majority of these costs appear under Redirection of Effort to Flood.

(4) Multiplier effects of block infusions of federal money into the provincial economy; and Multiplier effects of transferring provincial public funds into private hands: It is likely that the whole provincial economy (not merely the Public Sector) will experience ripple or multiplier effects from having a block of federal cash pass through its institutions in many stages. The flood compensation will have the effect of increasing the velocity of money in the economy during the relevant time period. This will ultimately have repercussions in all sectors. Time and funding have acted as constraints on a concerted attempt at locating and describing these repercussions although they will likely be substantial. The transferring of funds from public to private hands could cause a similar phenomenon to occur. Under the quite plausible assumption of non-equal marginal efficiencies of the use of funds among sectors, it is entirely possible that shifting control over such a large amount of funds from one sector to another would have either positive or negative results. Again, no assumption is implied as to the sign of these tendencies, only to their existence. No attempt has been made to quantify them for reasons already stated.

(5) Emergency training in crisis situation: Various governmental departments and agencies benefited from the flood in terms of ability to deal with future floods. Organizational resources were marshalled from many areas and experience gained might be extremely valuable in the future. Specifically, the Department of Municipal Affairs (provincial Emergency Measures Organization), the New Brunswick Electric Power Commission, the provincial Treasury Board and Department of Finance, the federal Departments of Defence and Public Works

are all components of the Public Sector that gained experience from the flood. This experience, although real, would be extremely difficult to quantify. It should be noted that the value of the experience gained will decline over time as memories fade and as those directly involved in the public effort leave public life.

(6) Sense of pride and accomplishment among government workers in having coped successfully with the flood and the resulting increase in employee productivity: It has not been demonstrated that this phenomenon actually occurred. If it did occur its effect would likely have been minimal and it is mentioned here only as a possibility and for the sake of completeness.

Data Gathering

In the Public Sector, assessment of damages for compensation purposes was done by the federal Department of Public Works and their estimates have been accepted for the purposes of this report.

It has also been assumed that restoration prices accurately depict social values. For example, when considering the economic cost of lost employee output, it has been assumed that the salaries of displaced labor are representative of its social worth. While this may not be true in the pure sense, it is the best estimate we have and, therefore, the problem of prices not representing true social cost has been eliminated.

The Department of Public Works estimates do not include emergency evacuation or other emergency expenditures. Emergency costs were obtained from invoices filed by the provincial Department of Finance. In some instances it was difficult to discern whether a particular cost applied to Department of Public Works estimated costs or whether it was an emergency-related expense. This confusion arose because all invoices for most departments passed through a single file. Arbitrary decisions were therefore necessary in some cases, but it is not expected that such decisions will materially affect the reliability of the damage breakdown.

Indirect damages and those direct costs not covered by compensation were estimated from two basic sources. The office of the provincial comptroller assisted by obtaining from most departments estimates of man-day losses resulting from the flood. These estimates form the bulk of the figure for man-days lost.

Other indirect and direct cost data were obtained by personal interviews with departmental accountants, engineers and other officials. It was necessary to rely on the information provided by these officials, but in all cases it is felt that the interviews were done in sufficient depth to obtain the most reliable information available. All the interviews were conducted by the same researcher, thus, providing an added degree of consistency to the data obtained.

During many of these interviews it became apparent that a non-financial economic cost had been incurred by the department involved. When this occurred, it was necessary to impute either a rental fee or other dollar value to the particular cost involved. An example of this is the use of pumps to avoid damage. Where possible, such costs were estimated.

Regions used in these damage estimates did not usually correspond with the regions used in this report. For this reason, it was necessary to break down the aggregated estimates of the Department of Public Works. This reclassification of costs into appropriate areas has been crude but, nevertheless, unavoidable. Wherever a cost, incurred generally by a provincial department, could not be classified in a specific region, that cost was assigned to the Fredericton area. This practice has likely resulted in a bias in favor of damages appearing for the greater Fredericton area but it is only the breakdowns, not the total estimates, that must be qualified in this manner.

Economic Cost Analysis

The total economic cost of the 1973 flood to the Public Sector is summarized in Table 26. Structural damage accounted for over 50 per cent of total direct damages. This is an indication of the heavy losses inflicted on public property, particularly roads, bridges and many government buildings located in Fredericton.

The damages have also been broken down on an agency basis for the greater Fredericton area in Table 27 and for the remainder of the province in Table 28. Outside the Fredericton area, most of the damages in the Public Sector were sustained by highways. Municipalities and the Departments of Natural Resources, Tourism, and National Defense accounted for almost all of the rest.

In the greater Fredericton area, economic costs were much more widely dispersed among agencies. This is partly due to the number of provincial and federal departments with office buildings in the Fredericton area and partly a result of the assignment of all general costs which could not be allocated regionally to this area. Some of the major cost items in Table 27 are discussed below by agency:

Social Services: The amount of $15,618 under Other applies to emergency evacuation assistance provided by the department.

Queen's Printer: The amount for inventory damage ($225,000) refers mainly to the cost of reprinting and rebinding only the volumes necessary for day-to-day requisitions. It does not apply to the historical cost of all volumes that were damaged. If it did, it is estimated that the cost could approach two or three million dollars.

Finance: The amount listed under To Estimate Damages applies mainly to the cost of hiring members of the Maritime Independent Adjusters Association to assess damages in the Personal Sector for compensation purposes.

Table 26 – Economic Cost in Public Sector by Regions

Item	Saint John River	Southwest	Northeast	Total
Inventory	$ 599,820	-	-	$ 599,820
Structural/Building	2,106,875	$46,235	$ 531,280	2,684,390
Furnishings	34,623	-	150	34,773
Machinery/Equipment	250,419	-	200	250,619
Avoidance	82,845	-	-	82,845
Cleanup	354,332	-	10,700	365,032
Other	133,379	-	-	133,379
Total Direct	$ 3,562,293	$46,235	$ 542,330	$4,150,858
Lost Man-days	156,126	-	-	156,126
Redirection of Effort to Flood	49,000	-	130	49,130
To Estimate Damage	222,670	-	-	226,670
Other	335,616	-	-	335,616
Total Indirect	$ 763,412	-	$ 130	$ 763,542
TOTAL ECONOMIC COST	$ 4,325,705	$46,235	$ 542,460	$4,914,400
Total Compensation	$ 3,471,624	$46,235	$ 542,180	$4,060,039

Highways: Highway and bridge damages were somewhat arbitrarily divided among the regions but all figures appearing in the structural column approximate road or bridge costs in any given area. Because of the large amount of labor necessary to estimate flood damages to highways and bridges, about $17,000 of departmental effort was expended to help the federal Department of Public Works in their task of assessment.

Municipal Affairs: $21,236 under Other applies to emergency expenditures. The remainder of the direct costs (approximately $30,000) refer to expenses incurred by greater Fredericton municipalities.

Historical Resources: The total $307,800 in Cleanup and Inventory refers to damages inflicted on documents stored both in the basement of the legislative library and in the basement of the old Education building. The latter were essentially Supreme Court documents. Several valuable books and other documents became wet and extensive labor expenditures were made to restore them to their preflood conditions.

Supply and Service: Approximately twenty buildings maintained by this department in Fredericton were flooded. The largest damages occurred in the Centennial building where heating and electrical systems were adversely affected.

Education: By far the most serious direct damage ($171,750) in this department occurred in the School Book Branch. Supplies of books stored in the basement near the corner of York and Queen Streets were damaged or lost. On the indirect side, the amount of $334,616 in the Other column is an estimate of flood-induced student unemployment costs. The earlier assumptions regarding full employment is justification for the inclusion of these costs in total damage.

New Brunswick Electric Power Commission: Most of the direct damages reported here refer to the emergency effort. The indirect cost To Estimate Damages refers essentially to labor costs which would otherwise not have been incurred on flood-related activities. These have been included in flood costs on the assumption that these efforts were prompted by the flood or the possibility of it. Of the direct costs in the greater Fredericton area, the most significant are the damages to inventory and supplies. This is indicative of the fact that government storage areas for these items tend to be in basements of public buildings. On the indirect side, lost employee or student time is the largest component. Compensation for damages is approximately three quarters of a million dollars less than total damages.

REGIONAL ANALYSIS OF FLOOD DAMAGE

In this part of the report, the cost of the flood is examined from a regional point of view. For this purpose, the portion of the province which incurred flood damage has been broken down into the 12 areas shown on Figure 37. The southwestern basins, which received only minor flood damage during 1973, have been considered in their entirety while the northeastern basins have been divided into two areas: Northern New Brunswick which includes the Restigouche and Nepisiguit river basins; and the Miramichi River basin. The Saint John River basin is divided into nine areas for the purpose of analysis: The Upper Saint John River, the Middle Saint John River, the Greater Fredericton area, the Maugerville-Sheffield area, the Oromocto River basin, the western bank between Gagetown and Westfield, the Grand Lake

Table 27 – Economic Cost to the Public Sector in Greater Fredericton Area

Department	Structural/ Building	Inventory	Furnishings	Machinery/ Equipment	Avoidance	Cleanup	Other	Total Direct	Lost Man Days	Redirection of Effort to Flood	To Estimate Damages	Other	Total Indirect	Total Damages	Received Compensation
Provincial															
Tourism	–	–	–	–	$ 10,000	–	–	$ 10,000	$ 5,778	–	–	–	$ 5,778	$ 15,778	$ 3,200
Youth	–	–	–	–	–	–	–	–	1,650	–	–	–	1,650	1,650	–
Civil Service Com.	–	–	–	–	–	–	–	–	1,009	–	–	–	1,009	1,009	–
Prov. Secretary	–	$ 9,198	–	–	–	–	–	9,198	11,042	–	–	–	11,042	20,240	9,198
Premier's Office	–	–	–	–	–	–	$ 364	364	3,236	–	–	–	3,236	3,600	164
Justice	–	–	–	–	–	–	141	141	12,500	–	–	–	12,500	12,641	141
NB Information Ser.	–	–	–	–	–	–	–	–	864	–	$ 1,440	–	2,304	2,304	–
Health	–	–	–	–	–	–	6,333	6,333	16,516	–	–	–	16,516	22,849	6,333
Social Services	–	–	–	–	–	–	15,618	15,618	7,704	–	–	–	7,704	23,322	15,618
NB Dev. Corp	–	–	$ 398	–	120	$ 48	–	566	2,520	–	–	–	2,520	3,086	398
Queen's Printer	–	225,500	–	–	420	–	–	225,920	–	–	–	–	–	225,920	225,000
Fisheries & Envir.	–	–	–	–	–	–	715	715	2,457	$ 258	–	–	2,715	3,430	715
Treasury Board	–	–	–	–	–	–	–	–	–	–	10,680	–	10,680	10,680	–
Finance	–	1,764	–	$ 13,907	–	–	–	15,671	6,487	–	133,699	–	140,186	155,857	134,264
Agriculture	–	–	–	–	–	–	3,646	3,646	6,387	–	–	–	6,387	10,033	13
Labor	–	5,250	–	3,425	–	–	–	8,675	5,514	–	317	–	5,831	14,506	8,675
Highways	$ 45,500	–	–	–	–	–	104	45,604	13,053	–	17,384	–	30,437	76,041	45,604
Municipal Affairs	15,600	–	–	12,037	969	2,094	21,236	51,936	5,182	–	–	–	5,182	57,118	51,936
Historical Resources	800	111,100	700	16,200	–	196,700	–	325,500	1,796	–	–	–	1,796	327,296	325,500
Supply & Services	70,000	30,000	33,265	90,500	–	119,500	–	343,365	12,518	–	–	–	12,518	355,883	330,165
Education	6,900	169,600	–	6,000	–	4,200	–	186,700	15,146	–	–	$334,616	349,762	536,462	180,700
Legislature/ Auditor General	–	–	–	–	–	–	–	–	12,816	–	–	–	12,816	12,816	–
NB Elec. Power Comm.	–	46,997	–	–	28,420	700	–	76,117	3,743	40,974	–	–	44,717	120,834	–
Economic Growth	–	–	–	–	–	–	–	–	2,472	62	–	–	2,534	2,534	–
Total Provincial	$138,800	$599,509	$ 34,363	$142,069	$ 39,929	$323,242	$ 48,157	$ 1,326,069	$150,390	$ 41,294	$163,520	$334,616	$689,820	$ 2,015,889	$ 1,337,624
Federal															
Public Works, Post Office, Sundry	100	–	260	–	1,741	–	–	2,101	5,136	–	9,000	–	14,136	16,237	–
Environment	175	311	–	2,250	775	7,604	306	11,421	–	2,281	50,150	–	52,431	63,852	–
Transport	–	–	–	–	–	–	–	–	600	–	–	1,000	1,600	1,600	–
Total Federal	$ 275	$ 311	$ 260	$ 2,250	$ 2,516	$ 7,604	$ 306	$ 13,522	$ 5,736	$ 2,281	$ 59,150	$ 1,000	$ 68,167	$ 81,689	–
TOTAL ECONOMIC COST	$139,075	$599,820	$ 34,623	$144,319	$ 42,445	$330,846	$ 48,463	$ 1,339,591	$156,126	$ 43,575	$222,670	$335,616	$757,987	$ 2,097,578	$ 1,337,624

Table 28 – Economic Cost to Public Sector Outside the Greater Fredericton Area, by Region

Region	Department	Structural/ Building	Furnishings	Machinery/ Equipment	Avoidance	Cleanup	Other	Total Direct	Redirection of Effort to Flood	Total Indirect	Total Damage	Total Compensation
Northeast	Nat. Res.	$ 61,000	–	–	–	–	–	$ 61,000	–	–	$ 61,000	$ 61,000
	Soc. Serv.	–	$ 150	–	–	–	–	150	–	–	150	–
	Tourism	15,000	–	–	–	$ 10,700	–	25,700	–	–	25,700	25,700
	Mun. Aff.	42,000	–	$ 200	–	–	–	42,200	–	–	42,200	42,200
	Highways	409,880	–	–	–	–	–	409.880	–	–	409,880	409,880
	Education	3,400	–	–	–	–	–	3,400	–	–	3,400	3,400
	NBEPC	–	–	–	–	–	–	–	$ 130	$ 130	130	–
	Total	$ 531,280	$ 150	$ 200	–	$ 10,700	–	$ 542,330	$ 130	$ 130	$ 542,460	$ 542,180
Saint John River	Nat. Res.	11,000	–	–	–	–	–	11,000	5,425	5,425	16,425	11,000
	Tourism	26,800	–	–	–	10,000	–	36,800	–	–	36,800	36,800
	Mun. Aff.	9,600	–	105,800	$ 40,400	8,400	–	164,200	–	–	164,200	164,200
	Highways	1,909,150	–	–	–	–	–	1,909,150	–	–	1,909,150	1,909,150
	Education	11,250	–	–	–	–	$ 1,600	12,850	–	–	12,850	12,850
	NBEPC	–	–	–	–	5,086	2,884	7,970	–	–	7,970	–
	Fed. Defence	–	–	–	–	–	66,000	66,000	–	–	66,000	–
	Fed. Agriculture	–	–	–	–	–	14,432	14,432	–	–	14,432	–
	Fed. DOT	–	–	300	–	–	–	300	–	–	300	–
	Total	$ 1,967,800	–	$106,100	$ 40,400	$ 23,486	$ 84,916	$ 2,222,702	$ 5,425	$ 5,425	$ 2,228,127	$ 2,134,000
Southwest	Mun. Aff.	1,000	–	–	–	–	–	1,000	–	–	1,000	1,000
	Highways	45,235	–	–	–	–	–	45,235	–	–	45,235	45,235
	Totals	46,235	–	–	–	–	–	46,235	–	–	46,235	46,235
TOTAL ECONOMIC COST		$ 2,545,315	$ 150	$106,300	$ 40,400	$ 34,186	$ 84,916	$ 2,811,267	$ 5,555	$ 5,555	$ 2,816,822	$ 2,722,415

area, the Canaan and Kennebecasis area and the City of Saint John.

A summary of the total estimated economic cost in each of the 12 areas is shown on Table 29. The areal concentration of the damages is immediately apparent from this table in that well over one-half of the total occurred in the Fredericton area and the Maugerville-Sheffield area.

In the following pages each of the 12 areas are dealt with separately to point out the main types of damages which occurred. In some areas of lesser damage, a relatively small number of entities were involved. To protect the confidentiality of properties, businesses or organizations damaged by the flood, whenever two or fewer entities were affected, they were included in an adjacent area. This, however, does not significantly alter the validity of the areal breakdown of damage.

Table 29 – Economic Cost and Compensation by Area

Area	Total Economic Cost	Total Compensation
(1) Northern New Brunswick	$ 590,257	$ 513,226
(2) Miramichi River Basin	452,768	229,851
(3) Upper Saint John River	1,426,602	769,205
(4) Middle Saint John River	941,192	561,521
(5) Greater Fredericton Area	5,167,607	3,192,482
(6) Maugerville-Sheffield	1,942,633	1,631,508
(7) Oromocto River Basin	204,654	166,005
(8) Gagetown to Westfield	48,634	39,472
(9) Grand Lake	534,637	88,224
(10) Canaan and Kennebecasis	278,215	93,203
(11) Saint John City	232,943	89,822
(12) Southwestern Region	56,865	52,386
Total	$ 11,877,007	$ 7,427,605

Northern New Brunswick

Economic costs in the Northern New Brunswick area are shown on Table 30. Flood damage was concentrated in Campbellton, in the Restigouche River basin, and to a lesser extent in the Nepisiguit River basin.

The estimated total economic cost represented 5.0 per cent of the provincial total while compensation paid out accounted for 6.9 per cent of the total compensation. Most of the cost constitutes direct damage to physical assets.

The Public Sector was the most severely affected and made up $408,000 or nearly 70 per cent of the area's total damage. Most of this was due to washed out bridges and roads and to sewer system damage in the City of Campbellton and elsewhere in the Restigouche River basin.

Costs incurred by the Personal and Business sectors accounted for most of the remaining 30 per cent of the total cost in the area. In the Personal Sector, most of the households affected incurred basement damage from sewer back up. The difference between compensation

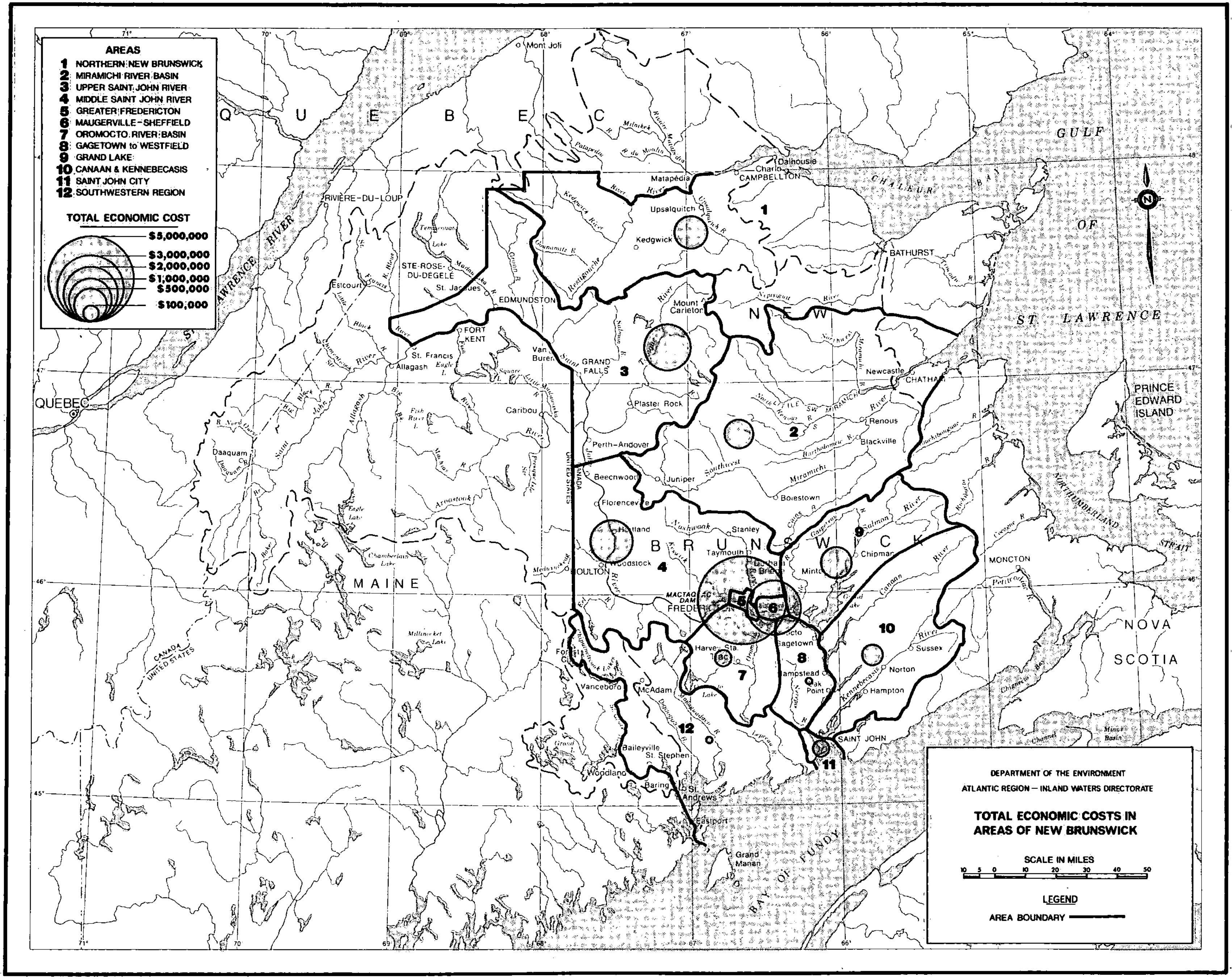

AREAS
1 NORTHERN NEW BRUNSWICK
2 MIRAMICHI RIVER BASIN
3 UPPER SAINT JOHN RIVER
4 MIDDLE SAINT JOHN RIVER
5 GREATER FREDERICTON
6 MAUGERVILLE-SHEFFIELD
7 OROMOCTO RIVER BASIN
8 GAGETOWN to WESTFIELD
9 GRAND LAKE
10 CANAAN & KENNEBECASIS
11 SAINT JOHN CITY
12 SOUTHWESTERN REGION
TOTAL ECONOMIC COST
$5,000,000
$3,000,000
$2,000,000
$1,000,000
$500,000
$100,000
QUEBEC
MAINE
NEW BRUNSWICK
NOVA SCOTIA
PRINCE EDWARD ISLAND
GULF OF ST LAWRENCE
BAY OF FUNDY
NORTHUMBERLAND STRAIT
DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION — INLAND WATERS DIRECTORATE
TOTAL ECONOMIC COSTS IN AREAS OF NEW BRUNSWICK
SCALE IN MILES
LEGEND
AREA BOUNDARY

Figure 37

Table 30 – Economic Cost by Sector in Northern New Brunswick

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 1,913	–	$ 1,913	$ 1,913	3
Business	89,676	$ 320	89,996	34,575	16
Organizational	5,451	–	5,451	2,583	4
Personal	84,527	–	84,527	66,065	123
Public	408,240	130	408,370	408,090	–
Total	$ 589,807	$450	$ 590,257	$ 513,226	146
Percentage of Provincial Total	5.3	0.0	5.0	6.9	4.7

paid and economic cost to the Business Sector reflects the damage done to large businesses, mainly machinery and equipment losses.

Miramichi River Basin Area

Losses were distributed throughout the Miramichi River basin. The most seriously affected communtiy was Juniper which lies in the headwaters of the Southwest Miramichi River. As indicated in Table 31, Business Sector damage is the most significant (49 per cent) with machinery and equipment damage to large businesses making up most of the cost to this sector. Public Sector damage to roads, bridges and buildings accounted for 29 per cent of the total cost in the Miramichi basin. The Personal Sector absorbed cost to a lesser degree in the amount of $63,000, 14 per cent of the total. Principal residences in Juniper, Doaktown and Blackville were heavily affected. A total of 29 low-lying farms were adversely affected by the flood. These sustained 8 per cent of the area damage. No losses were incurred by the Organizational Sector in this area.

The Upper Saint John River Area

The total economic cost of about $1.4 million in this area is 12 per cent of the provincial total. As shown on Table 32, compensation was provided for about half of this cost. The damages were centered in the Edmundston, Grand Falls and Perth-Andover areas.

The Public Sector losses were nearly 50 per cent of the total. Almost all of this ($662,550) was highway damage. The Business Sector sustained 23 per cent of the total damage in the area. Direct damage to large businesses accounts for the difference between compensation amounts and economic cost figures for this sector.

Cost to the Personal Sector is mainly attributable to damage of summer residences. This accounts for the large difference between compensation and total cost for the area. Estimates of Personnel Sector damages in the vicinities of Edmundston, Grand Falls and Perth-Andover are given in Table 33.

Table 31 – Economic Cost by Sector in Miramichi River Basin Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 34,804	-	$ 34,804	$ 34,804	29
Business	220,376	$ 480	220,856	30,178	18
Personal	63,018	-	63,018	30,779	47
Public	134,090	-	134,090	134,090	-
Total	$ 452,288	$ 480	$ 452,768	$ 229,851	94
Percentage of Provincial Total	4.2	0.0	3.8	3.1	3.1

Table 32 – Economic Cost by Sector in Upper Saint John River Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 44,859	$ 500	$ 45,359	$ 45,359	22
Business	334,063	96	334,159	25,734	9
Organizational	924	-	924	924	3
Personal	368,090	-	368,090	27,088	199
Public	678,070	-	678,070	670,100	-
Total	$1,426,006	$ 596	$1,426,602	$ 769,205	233
Percentage of Provincial Total	13.0	0.1	12.0	10.4	7.6

Table 33 – Economic Cost to Personal Sector in Upper Saint John River Area

Sub-Area	Summer Residences		Principal Residences		Total	
	No.	Economic Cost	No.	Economic Cost	No.	Economic Cost
Edmundston	19	$ 39,330	17	$ 11,119	36	$ 40,449
Grand Falls	129	299,670	14	10,478	143	307,163
Perth-Andover	-	-	20	7,493	20	7,493

There was an estimated $300,000 damage to 129 summer residences in the Grand Falls area. The majority of these were located along the Little and Salmon rivers. The Grand Falls vicinity accounts for nearly one-third of the total estimated damage to summer residences in the province. This is indicative of the incidence of non-compensated losses which this area had to absorb.

The Middle Saint John River Area

The damages in the Middle Saint John River area are shown in Table 34. Comprised of mainly Business, Personal and Public sector losses, damages in this area amounted to about $940,000 or 7.9 per cent of the provincial total. The area received approximately eight per cent of the total compensation. Damage was concentrated around the towns of Hartland and Woodstock, and in the Keswick and the Nashwaak river valleys.

The Public Sector cost was mainly Municipal Public Utilities damage amounting to $140,000 and highway damage totalling $170,000.

A significant portion of damage in the Business Sector was sustained by large businesses. Other losses occurred to small businesses in the commercial districts of Hartland and Woodstock.

In the Personal Sector, principal residences received most of the losses as illustrated by the area breakdown in Table 35.

The Nashwaak River basin suffered total personal losses of about $140,000, more than half the total Personal Sector cost in this area. The Woodstock area was inflicted with significantly higher summer residence damage than household damage.

Most of the Agricultural Sector damage occurred in the Nashwaak and the Keswick river basins. These two basins accounted for over 80 per cent of farm damage in the area.

The Greater Fredericton Area

The greater Fredericton area was the most heavily affected part of New Brunswick. All sectors, with the exception of the Agricultural Sector, suffered more damage in Fredericton than in any other area. As indicated in Table 36, the total cost of nearly $5.2 million was 43.5 per cent of the provincial total and the amount of compensation in the area, about $3.2 million, was 43.0 per cent of the total for the province. Nearly 40 per cent of the provincial direct cost and 90 per cent of the provincial indirect cost occurred in this area. The Public and the Business sectors suffered most of the indirect losses.

As indicated in analysis of the Public Sector (Table 27) all provincial departments were affected to some degree. Public buildings situated near the banks of the Saint John River were flooded because service tunnels did not have watertight doors. This disrupted electrical and heating systems and, thus, brought most normal government activities to a halt. The closing of government offices involved a considerable loss of man-days and other

Photograph 17 – Flooding of homes in Nashwaaksis area of Fredericton, 1 May 1973.

indirect damage. Public Sector damage accounted for 50 per cent of the Fredericton area damage.

All the emergency measures and activities during the period of the flood originated and were directed from the capital. Consequently, a significant portion of the Organizational Sector cost was in the Fredericton area.

Economic cost to the Personal Sector in the Fredericton area amounted to nearly $1.8 million or 35 per cent of the total in the area. Because of the magnitude of damages in this sector, a more detailed analysis of the effect of flood levels on damages was undertaken. During the flood period flood levels were recorded for a number of homes in the area by means of photographs. This information was later used to determine maximum flood

Table 34 – Economic Cost by Sector in Middle Saint John River Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 95,158	-	$ 95,158	$ 95,158	57
Business	276,083	$2,776	278,859	32,823	34
Organizational	12,987	-	12,987	12,937	13
Personal	240,928	-	240,928	107,343	147
Public	313,260	-	313,260	313,260	-
Total	$ 938,416	$2,776	$ 941,192	$ 561,521	251
Percentage of Provincial Total	8.9	0.3	7.9	7.6	8.1

Table 35 – Economic Cost to Personal Sector in Middle Saint John River Area

	Summer Residences		Principal Residences		Total	
Sub-Area	No.	Economic Cost	No.	Economic Cost	No.	Economic Cost
Hartland	-	-	35	$ 34,863	35	$ 34,863
Woodstock	10	$ 24,390	6	4,564	16	28,954
Keswick Basin	-	-	35	35,685	35	35,685
Nashwaak Basin	17	7,540	42	132,562	59	140,102

Table 36 – Economic Cost by Sector in Greater Fredericton Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 35,067	-	$ 35,067	$ 35,067	8
Business	478,460	$ 115,274	593,734	216,688	269
Organizational	186,860	1,712	188,572	93,821	20
Personal	1,793,156	-	1,793,156	1,049,782	844
Public	1,799,091	757,987	2,557,078	1,797,124	-
Total	$4,292,634	$ 874,973	$5,167,607	$3,192,482	1141
Percentage of Provincial Total	39.4	88.9	43.5	43.1	36.8

levels in all houses in the greater Fredericton area which sustained damage on the first floor.

The depth of flooding in the 155 homes which were flooded up to the first floor level were correlated with the average compensated damage to produce the relationships shown on Figure 38. Information on damage to the structure and damage to contents was obtained

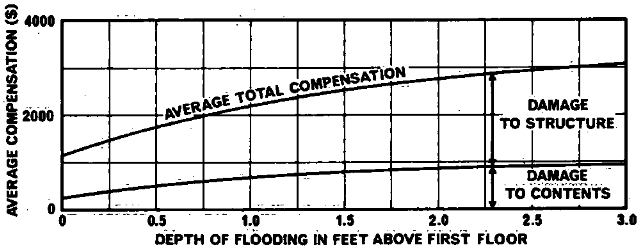


Figure 38 – Average Compensation to Permanent Residences - Fredericton Area

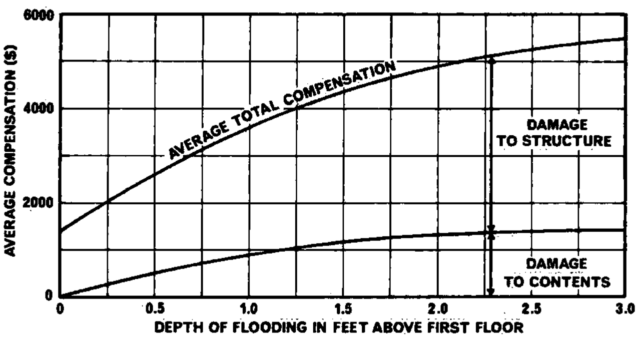


Figure 39 – Average Compensation to Mobile Homes - Fredericton Area

from compensation files. No attempt was made to estimate the magnitude of non-compensated costs as a function of depth of flooding but it is probably reasonable to assume that these costs would be in the order of one-half of the compensated costs. This would be in line with the averages of data obtained by interviews with selected home owners.

A similar analysis of mobile homes is shown on Figure 39. In this case a total of 85 units which had water on the floor were included in the analysis. Most of these were located in the Willow Park Trailer Court in the Lincoln area. The high damage, which is sustained by mobile homes when they are flooded, is immediately apparent from the relationships. The average compensated damage was nearly $5,000 per unit and of many cases the homes were complete write-offs. The main reason for this was a collapse of the insulation which is extremely costly to replace.

Because of the high damage in the Fredericton area, a more detailed breakdown of costs to the Business and Personal sectors has been made to indicate more closely the exact location of property which was damaged. For this purpose damage information has been broken down into nine sub-areas (shown on Figure 40). The Personal and Business Sector costs in each of these areas are listed on Table 37.

A brief description of the damages to the Personal and Business sectors in each of the sub-areas follows.

Fredericton City

This area corresponds to the old City of Fredericton as it existed prior to amalgamation with surrounding municipalities which took place during 1973. Damage occurred to 260 homes in the area and, with the possible exception of one or two of the homes, no flooding of the first floor level occurred. A total of 193 business establishments were also damaged. The most notable business damage was sustained by the Lord Beaverbrook Hotel, which was closed for a few weeks as a result of flooding, but almost all business establishments on King, Queen, York, Campbell and Carleton Streets reported some damage, principally because of basement flooding.

Nashwaaksis (Excluding Burpee Street)

In Nashwaaksis, damage in the Personal Sector was

Table 37 – Personal and Business Sector Costs - Greater Fredericton Area

Sub-Area	Personal Sector Damage			Business Sector Damage		
	Number of Dwellings Affected	Total Economic Cost	Average Cost	Number of Businesses Affected	Total Economic Cost	Average Cost
Fredericton City	260	$ 400,489	$ 1,540	193	$ 451,403	$ 2,228
Nashwaaksis (excluding Burpee St.)	48	113,104	2,356	23	19,097	830
Burpee Street	35	146,126	4,175	-	-	-
Barkers Point	100	193,603	1,936	12	56,566	4,713
Marysville	12	15,660	1,305	-	-	-
Princess Court and Christie Subdivision	48	121,803	2,537	-	-	-
Lower St. Marys	30	61,289	2,042	14	16,684	1,191
Willow Park	84	456,579	5,435	-	-	-
Lincoln	135	275,443	2,040	27	49,984	1,851

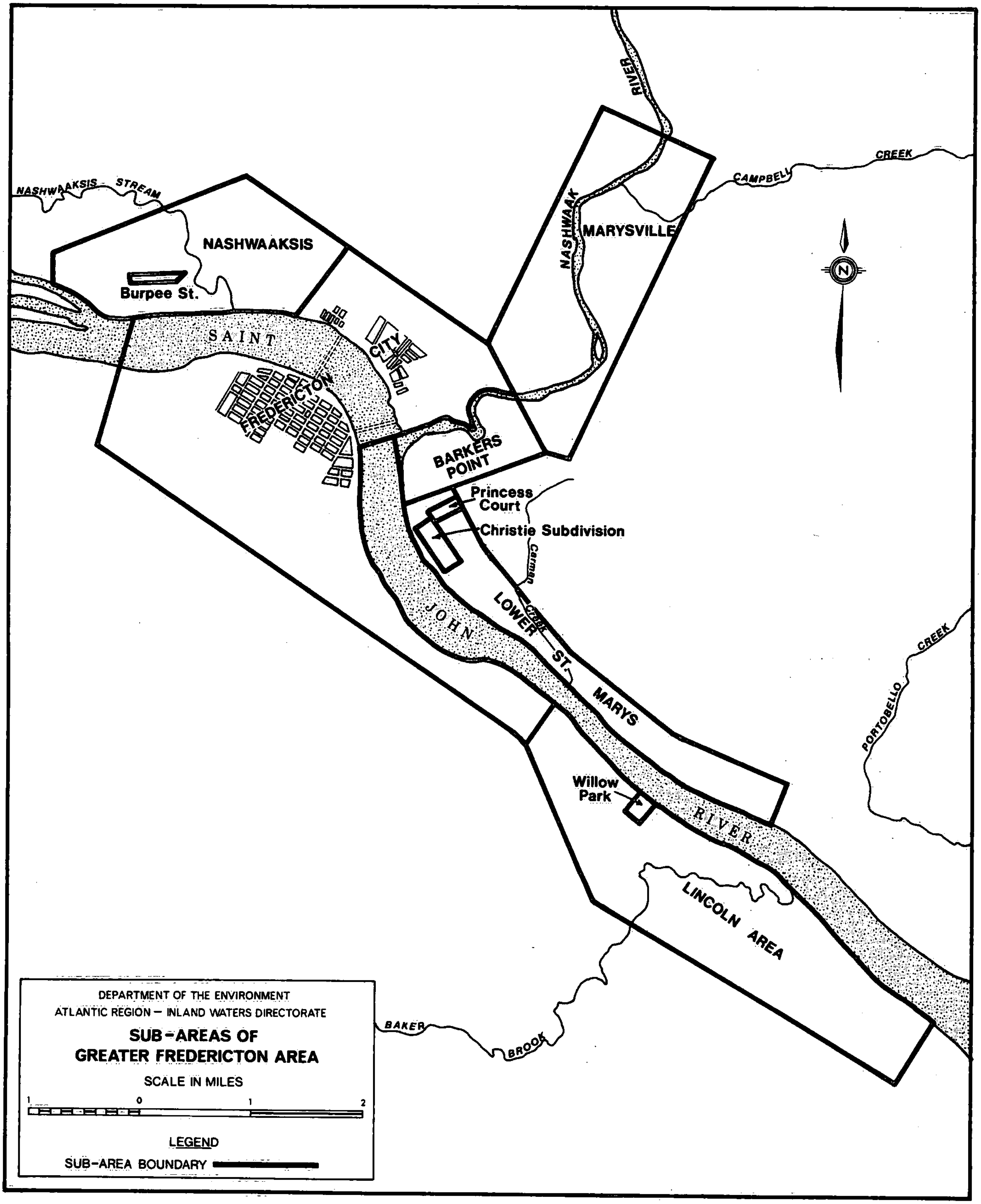

NASHWAAKSIS - STREAM
NASHWAAKSIS
Burpee St.
SAINT
FREDERICTON
CITY
BARKERS POINT
Princess Court
Christie Subdivision
Carman Creek
LOWER ST. MARYS
JOHN
RIVER
NASHWAAK RIVER
MARYSVILLE
CAMPBELL CREEK
PORTOBELLO CREEK
Willow Park
LINCOLN AREA
BAKER BROOK
DEPARTMENT OF THE ENVIRONMENT
ATLANTIC REGION – INLAND WATERS DIRECTORATE
SUB-AREAS OF
GREATER FREDERICTON AREA
SCALE IN MILES
1 0 1 2
LEGEND
SUB-AREA BOUNDARY

Figure 40

caused by flooding of basements only. A total of 48 dwellings were affected. Most of them are located between the Saint John River and Highway No. 105. A few homes on Longwood Drive and Park Street were also damaged. About one-quarter of the affected dwellings are older two-storey homes and the remainder are one and a half storey and bungalow type residences. Approximately 55 per cent of the total were affected by seepage and the remaining 45 per cent by direct flooding with water at least up on the foundations. Business losses in Nashwaaksis were $19,000. A total of 23 establishments scattered along Highway 105 were affected.

Burpee Street

Burpee Street, in Nashwaaksis, is located near the mouth of Nashwaaksis Stream. This particular street was singled out for the purpose of this report because of the extensive damage to homes located on it. Of the 35 homes which sustained damage, at least 23 were constructed since 1969. Most of the homes on the south side of Burpee Street are bungalows with raised foundations. Flood waters reached five to six feet in the basements of these homes and caused damage at the first floor level in two of them. Homes on the north side of the street are generally of the regular bungalow variety but are three to five feet higher due to the natural terrain. Several of the basements in the newer homes on Burpee Street are finished or in the process of being finished. Some residents plan on renting basements. Should this occur, damages resulting from a flood of similar magnitude would be significantly higher.

Barkers Point

Personal Sector damage in Barkers Point was sustained by 100 dwellings. Of these, 35 are one and a half or two-storey homes, 60 are one-storey homes or bungalows and the remainder are mobile homes or apartment buildings. Thirty-four of the dwellings suffered first floor flooding. In five of these, the water level was three feet or more above the first floor; in eight, from two to three feet above the first floor; and in ten, from one to two feet above the first floor. Business damage to 12 establishments amounted to about $57,000.

Marysville

Personal Sector damage in Marysville was limited to 12 homes with flooded basements. Most flooding was due to seepage but in a few cases flood waters reached the foundation level.

Princess Court and Christie Subdivision

Forty-eight dwellings in Princess Court and Christie Subdivision suffered damage. A total of 12 homes and one trailer were flooded at the first floor level. Eleven of these homes were located on Princess Court and adjacent streets. Of the homes flooded on the first floor, the water level was one foot or less above the floor in all but four.

Lower Saint Marys

Thirty dwellings sustained Personal Sector damage in Lower Saint Marys. Three of these, located on Bridgeview Street adjacent to the Princess Margaret Bridge, had first floor flooding. The remainder suffered basement flooding and seepage. Fourteen business establishments suffered damages totalling about $17,000. They are located along the banks of the Saint John River near the Trans-Canada Highway.

Willow Park

The Willow Park Trailer Court, located in Lincoln, is identified as a separate sub-area because of the heavy damage which its residents suffered. It will be noted that the damages per dwelling are considerably higher than those in other sub-areas. Out of a total of 87 mobile homes in the park, only three were not damaged.

Lincoln

Personal Sector damage was reported by 135 home owners in the Lincoln area. Fifteen of these had flooding on the first floor. Most of the dwellings which had first floor flooding are located on McFadzen Lane and along Highway No. 7 immediately adjacent to Baker Brook. Several dwellings on Bourque's Lane were isolated by flood waters but, having raised foundations, they suffered no first floor flooding. Business losses totalled $50,000 from damage done to 27 establishments in this sub-area.

Maugerville-Sheffield Area

The Maugerville-Sheffield area, located on the flood plain of the Saint John River downstream of Fredericton, had the second largest total economic cost of the 12 areas examined in this part of the report. The total losses of nearly $2 million were distributed among all economic sectors as shown in Table 38. Considering that the total population of the area is in the neighborhood of 1000 people, the Maugerville-Sheffield area can be considered the most heavily damaged part of New Brunswick. Life in the two communities was completely disrupted by the flood. Water infiltrated all homes, farms, businesses and organizational establishments.

The Public Sector suffered the largest cost amounting to $634,000. Most of this was damage to highway facilities. The Trans-Canada Highway extending through both communities sustained extensive erosion and complete sections of it had to be repaved. Other significant costs

Table 38 – Economic Cost by Sector in Maugerville-Sheffield Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 432,323	$66,705	$ 499,028	$ 499,028	54
Business	96,952	13,449	110,401	88,202	19
Organizational	87,684	-	87,684	21,418	12
Personal	611,888	-	611,888	469,960	225
Public	633,632	-	633,632	552,900	-
Total	$ 1,862,479	$80,154	$1,942,633	$1,631,508	310
Percentage of Provincial Total	17.1	8.1	16.4	22.1	9.9

were attributable to efforts by the Department of National Defence and other federal and provincial agencies in the evacuation of people and livestock from the area.

In the Personal Sector, 225 dwellings were affected for a total economic cost exceeding $600,000. Of these dwellings, 11 per cent were mobile homes, 14 per cent were bungalows and the remaining 75 per cent were older one-storey, one and a half storey and two-storey houses. Damage at the main floor level occurred in 60 per cent of the affected dwellings. A breakdown of the approximate depth of flooding on individual dwellings is given in Table 39.

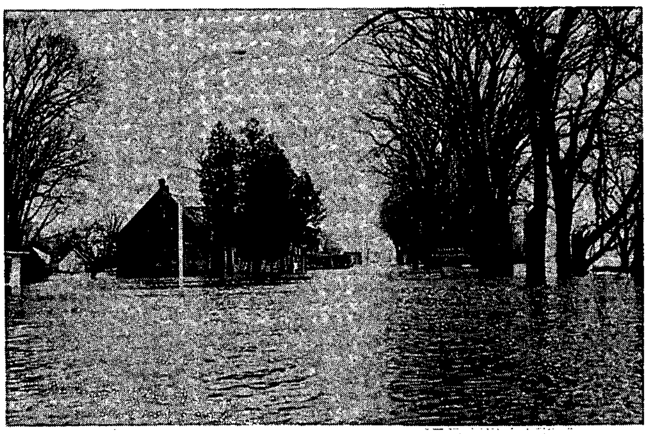
Photograph 18 – Flooding in Maugerville area, 30 April 1973.

Table 39 – Depth of Flooding in Dwellings

Depth of Flooding in feet above first floor elevation	Number of Dwellings
0.0 - 0.3	11
0.4 - 0.8	16
0.9 - 1.3	25
1.4 - 1.8	19
1.9 - 2.3	19
2.4 - 2.8	16
2.9 or more	29

A significant portion of the Organizational Sector economic cost was for Flood Relief Effort, thus, emphasizing the devastating effects of the flood on these two communities.

The cost suffered to businesses accounts for approximately 5.7 per cent of the total cost to the area. Most businesses damaged were located near the Trans-Canada Highway close to the bank of the Saint John River.



Photograph 19 – Looking east along Trans-Canada Highway in Maugerville area, 3 May 1973.

Nearly 70 per cent of the provincial damage in the Agricultural Sector took place in this area which is one of the most productive agricultural regions in the province. A total of 54 farming units were affected to various degrees for a cost of about $499,000. The area suffered $67,000 indirect costs identified under Lost Productivity, which represents over 95 per cent of the provincial cost in this category.

Oromocto River Basin Area

The total economic cost breakdown for the Oromocto River basin is shown in Table 40. The Personal Sector made up nearly half of the total losses in this area. Damage to the Public Sector was $73,000 and that to the Business Sector $28,000. A total of 63 homes were affected throughout the basin with significant concentrations in the Blissville and Nevers Road areas. No damage to summer homes or to organizations was identified in the Oromocto River basin.

Gagetown to Westfield Area

This area which lies along the western shore of the Lower Saint John River incurred very limited damage during the 1973 flood. As shown in Table 41, the Personal Sector accounted for $35,000 of the total cost of less than $49,000. Damages to organizations were not reported in this area.

Grand Lake Area

Damage in the Grand Lake area was focused on the Personal Sector, which sustained 86 per cent of the cost as shown in Table 42. As Grand Lake is one of the province's prime recreational areas, there are a considerable number of summer dwellings along the shore of the lake, most of them located on low-lying ground. The rise of the level of the lake caused severe damage by infiltration and direct flooding of cottages.

It is estimated that 325 summer homes in the area received damages of about $400,000. Most of these homes are located on the shores of Grand Lake but others on Maquapit and French lakes were also affected.

Besides damage to summer dwellings, Personal Sector costs included damage to households mainly in Minto and Chipman totalling $54,000. Some costs were also incurred by the Public Sector (six per cent), mainly to the Tourism Department's facilities, by the Business Sector

Table 40 – Economic Cost by Sector in Oromocto River Basin Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 3,094	–	$ 3,094	$ 3,094	4
Business	16,808	$10,864	27,672	15,420	6
Personal	101,388	–	101,388	74,991	63
Public	72,500	–	72,500	72,500	–
Total	$ 193,790	$10,864	$ 204,654	$ 166,005	73
Percentage of Provincial Total	1.7	1.1	1.7	2.3	2.4

Table 41 – Economic Cost by Sector in Gagetown to Westfield Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 3,567	–	$ 3,567	$ 3,567	5
Business	8,181	–	8,181	8,066	8
Personal	34,896	–	34,896	25,849	41
Public	1,990	–	1,990	1,990	–
Total	$48,634	–	$48,634	$39,472	54
Percentage of Provincial Total	0.5	–	0.4	0.5	1.8

Table 42 – Economic Cost by Sector in Grand Lake Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 14,211	–	$ 14,211	$ 14,211	14
Business	26,902	$ 1,860	28,762	25,841	10
Personal	460,489	–	460,489	19,772	344
Public	28,400	2,775	31,175	28,400	–
Total	$ 530,002	$ 4,635	$ 534,637	$ 88,224	368
Percentage of Provincial Total	4.8	0.5	4.5	1.3	11.9

(five per cent) and by the Agricultural Sector (three per cent). The Organizational Sector suffered no damages in this area.

Canaan and Kennebecasis Area

As shown in Table 43, damage in the Canaan and Kennebecasis area was also concentrated in the Personal Sector which accounted for 85 per cent of the total. A general breakdown of the location of damaged permanent and summer homes in the area is given in Table 44.

The most extensive damage to principal residences occurred in Hampton and Rothesay. Damage to summer dwellings was predominant at other locations on Kennebecasis Bay and on the shores of Washademoak Lake and Belleisle Bay.

Aside from Personal Sector cost, the only other significant damage in this area was that sustained by the Public Sector which accounted for 11 per cent of the area total, mainly in highway damage. It is worth mentioning that although total cost in this area equals about 2.3 per cent of the provincial total, the area accounted for 8.7 per cent of the number of units affected.

Photograph 20 – Cottage flooding at Sand Point on the Saint John River near Saint John, 4 May 1973.

Saint John City Area

In this area also, Personal Sector damage was predominant. As indicated in Table 45, it comprises 82 per cent of the total area cost. The bulk of the damage was along the shores of South Bay, the western side of Grand Bay, and in Milledgeville. Damage to summer dwellings in the area amounted to about $100,000 while the cost incurred by the Business Sector totalled $34,077, the major portion of it in direct costs.

Table 43 – Economic Cost by Sector in Canaan and Kennebecasis Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Agricultural	$ 5,789	-	$ 5,789	$ 5,789	12
Business	3,536	$ 480	4,016	1,835	3
Organizational	2,799	-	2,799	2,446	4
Personal	235,911	-	235,911	56,783	251
Public	27,050	2,650	29,700	27,050	-
Total	$ 275,085	$3,130	$ 278,215	$ 93,903	270
Percentage of Provincial Total	2.5	0.3	2.3	1.3	8.7

Table 44 – Economic Cost to Personal Sector in Canaan and Kennebecasis Area

	Summer Residences		Principal Residences		Total	
Sub-Area	No.	Economic Cost	No.	Economic Cost	No.	Economic Cost
Rothesay	-	-	28	$ 42,328	28	$ 42,328
Hampton	-	-	16	27,377	16	27,377
Kennebecasis Bay	60	$ 48,370	9	7,248	69	55,618
Belleisle Bay	93	67,830	6	9,429	99	77,259
Washademoak Lake	36	26,840	3	8,489	39	35,329

Table 45 – Economic Cost by Sector in Saint John City Area

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Business	$ 30,119	$ 3,958	$ 34,077	$ 20,597	10
Personal	190,566	-	190,566	60,925	137
Public	8,300	-	8,300	8,300	-
Total	$ 228,985	$ 3,958	$ 232,943	$ 89,822	147
Percentage of Provincial Total	2.1	0.4	2.0	1.3	4.8

Southwestern Basins

Compared with other areas, the southwestern basins suffered minimum cost as a result of the flood. The total was about $57,000, mainly in the Public Sector as indicated in Table 46. Highway damage made up most of that amount.

Damage to the Business Sector was mostly in avoidance cost due to evacuation of stock in downtown St. Stephen. This cost, $8,500, is not substantial.

DAMAGE TO MOVEABLE PROPERTY

As already mentioned in this report the flood forecasting and emergency measures in the Saint John River basin prevented significant damage during the 1973 flood. However, moveable items still sustained considerable damages. An analysis of cost data presented in this section of the report indicates that the total damage to moveable items was about $2.5 million in the province.

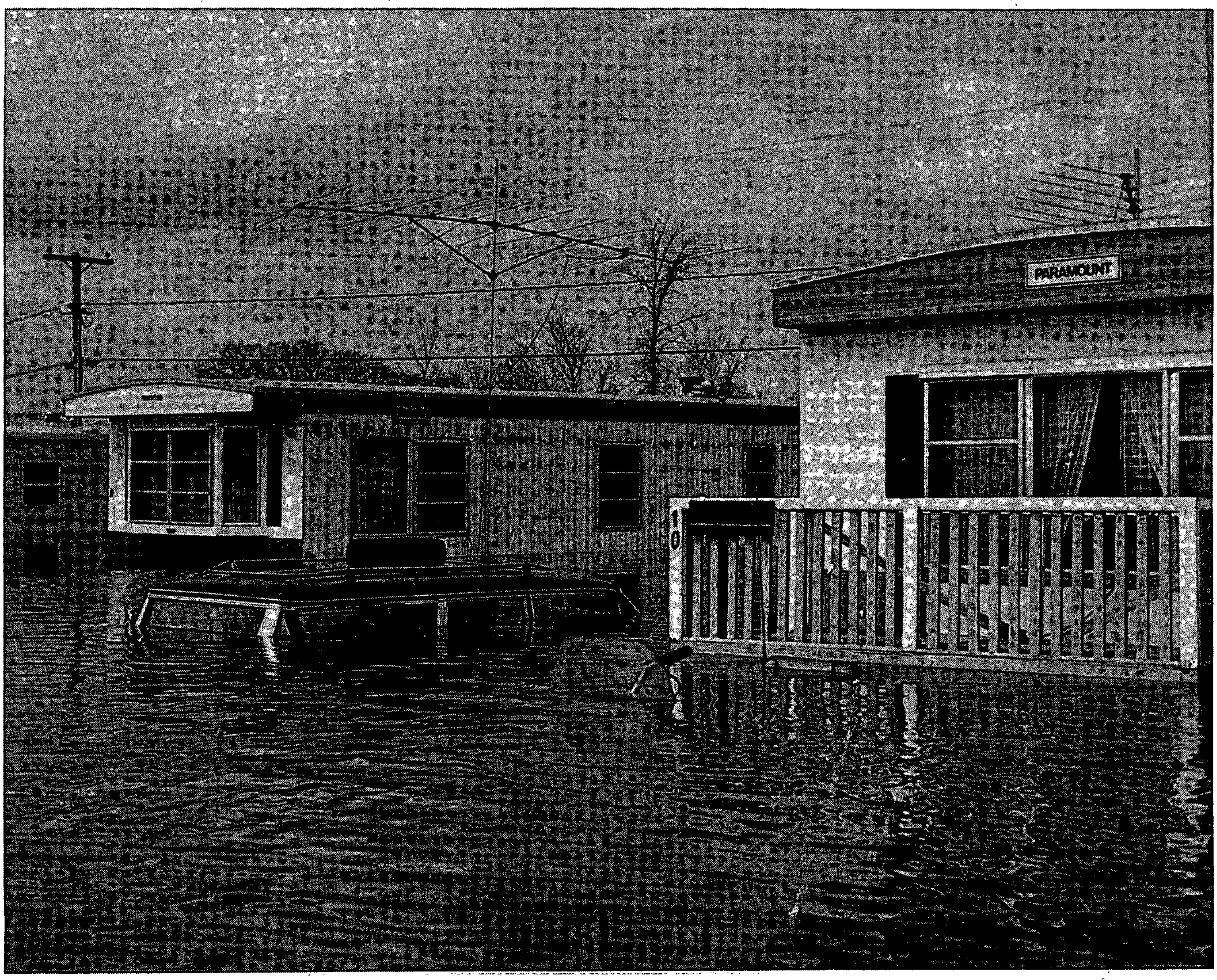
The Saint John River basin was responsible for $2.3 million of the total. A breakdown of damage to moveable items by sectors and regions is given in Table 47.

Table 46 – Economic Cost by Sector in Southwestern Region

Sector	Total Direct	Total Indirect	Total Economic Cost	Total Compensation	Number Affected
Business	$ 6,906	$ 1,594	$ 8,500	$ 4,021	4
Personal	2,130	-	2,130	2,130	5
Public	46,235	-	46,235	46,235	-
Total	$55,271	$ 1,594	$56,865	$52,386	9
Percentage of Provincial Total	0.5	0.2	0.5	0.7	0.3

These estimates are rather arbitrary because of the scarcity of relevant data. A few explanatory notes are warranted on the methodology applied in estimating the figures.

In the Personal Sector, 100 per cent of content damage in the cottage section and 95 per cent of damaged contents in principal dwellings was considered moveable. In the Business, Public and Organizational sectors, all damaged inventory and furnishings were considered moveable. Fixed plant and equipment comprises much of the machinery/equipment category of the Business Sector; it is estimated that only 40 per cent was moveable.



Photograph 21 – Flooding of mobile homes in trailer court southeast of Fredericton, 30 April 1973

Table 47 – Damage to Moveable Property by Sector

Sector	Saint John River	Southwest	Northeast	Total
Agricultural	$ 67,525	-	$ 500	$ 68,025
Business	518,519	$1,590	116,263	636,372
Organizational	10,536	-	-	10,536
Personal	1,111,951	220	44,140	1,156,311
Public	667,605	-	150	667,755
TOTAL DAMAGE	$2,376,136	$1,810	$ 161,053	$2,538,999

Machinery and equipment belonging to organizations generally became damaged through use in rescue operations; in other words, it is all totally moveable. In the Public Sector only five departments suffered damage to machinery and equipment. Machinery and equipment damage in the Supply and Services and the Municipal Affairs departments occurred mainly to electrical wiring and to sewer systems. Thus, only five per cent of the total machinery/equipment cost of these departments is assumed moveable. In the Departments of Historical Resources, Education and Finance most was moveable, 90 per cent, 90 per cent and 80 per cent respectively. Most machinery and equipment in the Agricultural Sector was moveable. Bedding plants in green houses were destroyed by the flood waters. It was assumed that the loss of these bedding plants made up five per cent of the total crop loss.

The arbitrary percentages were estimated from information in compensation files and from investigators' knowledge of the types of facilities damaged. The $2.5 million estimate is probably a minimum since the percentages assumed tended to be conservative. Also, it is likely that savings in damage by the swift removal of building contents would lead to further savings in indirect costs which are not included in this $2.5 million.

It is not reasonable to assume that all of the losses to moveable items can be avoided by flood forecasting and emergency measures but the magnitude of damage in this category indicates that substantial resources should be devoted to these programs.

Comparison with Historic Floods

In comparing the flood of 1973 with past floods, it must be noted that records of stage and discharge exist for only a very short period of time relative to the history of the province.

On the main stem of the Saint John River, records of stage are available since about 1920 at Fredericton, Oromocto and Oak Point. The 1973 peak stage at Fredericton was exceeded only once since 1922. 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 peak stage of 1973. The next highest stage in the period of record occurred in 1923 and was 1.6 feet below the maximum daily mean stage of 1973. The 1923 flood stage was the highest recorded prior to 1973 at Oak Point. The daily mean stage at that time reached a level equal to that of the 1973 level. Other major floods in the lower portion of the Saint John River occurred in 1934, 1958 and 1961. The stages reached in those years are given in Table 48.

Photograph 22 – Departmental Building, Fredericton. Plaque denoting high water mark of 1936 flood is located to the right of the stairs, 1 May 1973.

Table 48 – Maximum Daily Mean Stage - Lower Saint John River

Year	Stage in feet above mean sea level		
	Fredericton	Oromocto	Oak Point
1923	26.4	21.8	18.5
1934	24.2	21.1	17.9
1936	29.2 (ice jam)	22.6	16.0
1958	24.9	not available	16.0
1961	24.3	not available	15.4
1973	28.0	23.7	18.5

Prior to the beginning of stage records there is very little information on flood levels, but newspaper reports give some indication that major floods occurred on the Saint John River in 1831, 1854 and 1887. A high water mark chiseled into the corner stone of a fence post at the rear of the old Normal School in Fredericton shows a mark corresponding to the 1887 flood level at an elevation of 26.8 feet above mean sea level. Comparative descriptions in newspaper reports suggest the peak stage in 1887 was a few inches higher than that reached in 1854 but lower than the 1831 level. It is likely that the maximum stage in 1831 was about equal to that reached in 1973 at Fredericton.

Discharge records in the Saint John River basin date back to 1918 on the Saint John River at the former Pokiok Gauging Station, about 25 miles above the Mactaquac Dam, and on Shogomoc Stream. At both these stations, the maximum discharge prior to 1973 occurred in 1923. On the Shogomoc, the maximum daily discharge in 1923 was 4,130 cubic feet per second, considerably higher than the maximum daily mean of 2,770 cubic feet per second recorded in 1973. At the Pokiok Gauging Station the maximum was 288,000 cubic feet per second in 1923, compared with the daily mean discharge of 393,000 cubic feet per second recorded during 1973 below Mactaquac. The drainage area at Pokiok is only three per cent less than that below the Mactaquac Dam. The years of other significant floods at Pokiok with the maximum daily mean discharge in cubic feet per second are: 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 either the 1958, 1961 or 1969 floods were the largest floods in most parts of the Saint John River basin between 1940 and 1973. 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).

In the northeastern basins, there are very few long term records and comparisons with flood discharges prior to the 1960's is difficult. An incomplete record dating back to 1918 on the Upsalquitch, a tributary of the Restigouche indicated high discharges occurred in 1958 and 1961. The 1973 peak discharge on this tributary approached the 1958 flow but was about 25 per cent less than the 1961 value. Similarly, on the Nepisiguit River the 1973 discharges were less than the former maxima recorded in 1958 and 1961. In the Miramichi basin, the records available suggest that the 1973 flood was greater than the 1923 flood but less than the 1961 flood.

The southwestern basins have a few long term hydrometric stations, on the Lepreau, Magaguadavic and St. Croix Rivers. The 1923 flood is the highest on record at most of the longer term stations. In the St. Croix basin, the 1973 discharges were within 20 per cent of the maxima of 1923, but on other rivers to the east of the St. Croix the 1973 discharges were only a small fraction of those recorded in 1923.

The flood could also be compared with previous floods on the basis of damages. This is rather difficult because very little basic information is available on the economic costs of previous floods. For the Saint John River basin, an attempt was made to estimate the costs of previous floods during studies for the Saint John River Basin Board(4). The estimates were developed mainly from newspaper reports with a limited amount of concrete data on physical damages. These estimates 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:

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

Comparison of these values 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 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 caused damages totaling one-quarter to one-half as much as the 1973 flood.

Lessons for the Future

This 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 flood was caused by a combination of two factors; snowmelt and rainfall. The snow accumulation during the winter of 1972-73 was above average but less than the maximum values reported during the last 10 to 20 years at most locations. Similarly, the rainfall intensities during the period April 27 to April 29 could generally be expected to occur at a frequency of once every two years. The fact that streamflows and river stages were higher than any recorded in periods of over fifty years at some locations can only be attributed to the combination of significant rainfall occurring towards the end of a period of heavy snowmelt.

Available information on earlier floods indicates that this same combination of heavy rainfall at a time of appreciable snowmelt runoff was the cause of the floods of 1887 and 1923 which are probably the two most significant floods in the 100-year period prior to 1973. In future years, this same combination of factors will periodically cause floods as great and even greater than the flood of 1973.

Since extreme floods in New Brunswick are partially caused by rainfall, the ability to predict them in advance is limited by technology in the field of precipitation forecasting. Current technology in the field permits accurate flood warnings of only two or three days on a river such as the Saint John and it is unlikely that improvement will take place within the forseeable future.

The experience of flood forecasting and emergency action during the 1973 flood in the Saint John River basin 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 Saint John River basin was about $2.4 million. This suggests that improvements in flood forecasting and emergency measures procedures can produce additional reductions in flood losses.

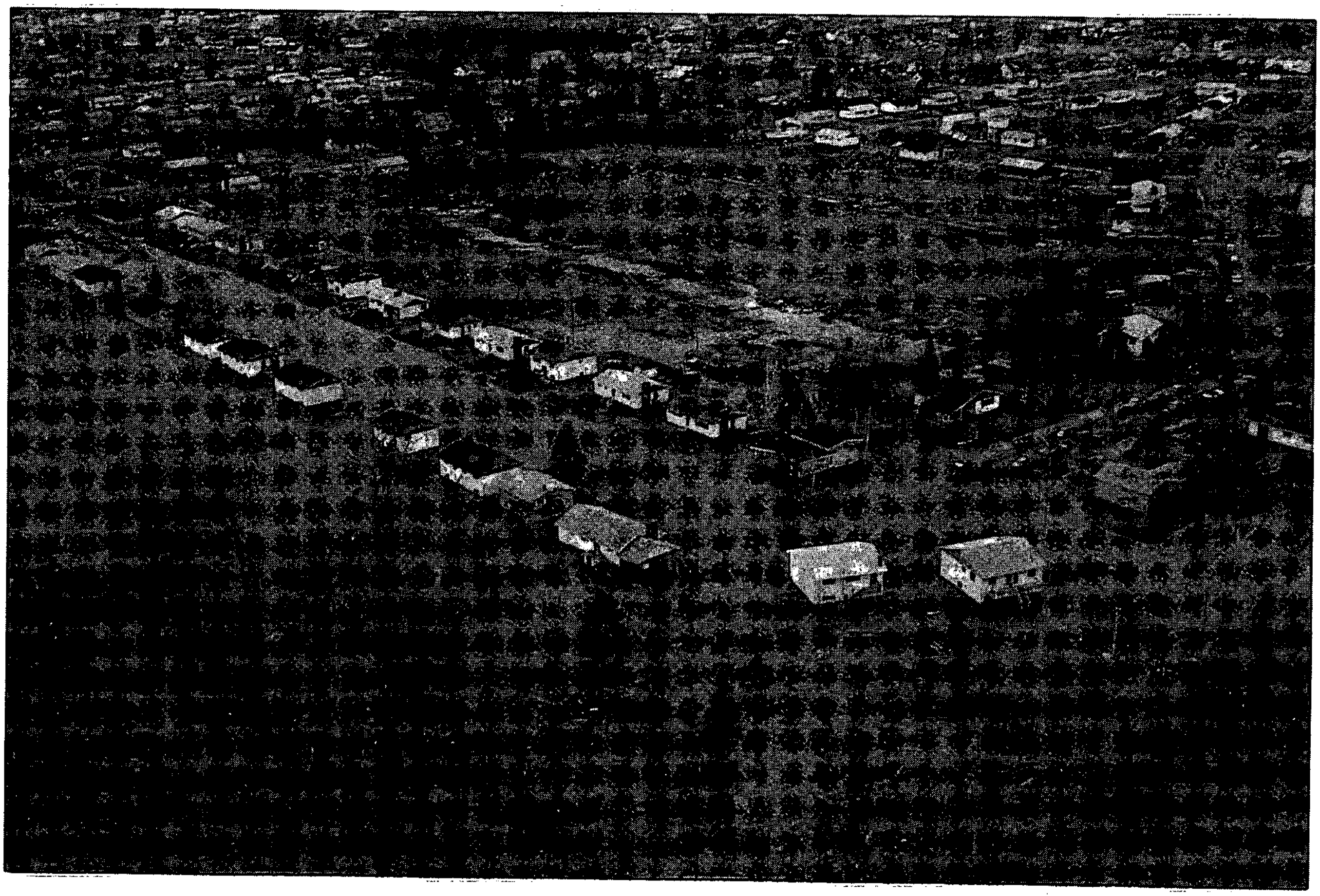
Although limited time was available for calibration of the flow forecasting model prior to the 1973 flood, it gave good results. The accuracy of the model will be improved as a result of additional calibration work which is underway at the time of writing of this report. The model did not have the capability of predicting flood stages in the most flood prone part of the basin, Fredericton and downstream. Additional model development work, also underway, will permit flood stage predictions in this lower section of the river in future years. This will provide a more positive basis for emergency activities. Similarly, some improvements can be made in advance planning for emergency actions to make these actions operate more smoothly in future years.

Flood forecasting was not undertaken on rivers other than the Saint John during 1973. The estimated damage to moveable property of $161,000 in the northeastern basins suggests that the feasibility of extending flood forecasting to other rivers in the province should be examined.

The total economic cost of the flood is estimated to be $11.9 million. Of this, $10.8 million was attributed to the Saint John River basin, about one million dollars to the northeastern basins and less than $100,000 to the southwestern basins. In terms of economic sectors; the Public Sector sustained the highest cost of $4.9 million, followed by the Personal Sector with $4.2 million, the Business Sector with $1.7 million, the Agricultural Sector with $0.7 million and the Organizational Sector with $0.3 million. Compensation was provided by the federal and provincial governments to the extent of 63 per cent of the total economic cost in the province.

The magnitude of these losses and the associated personal hardships are sufficient to warrant full consideration of all possible ways to minimize damages in the future. Most of the losses took place on the flood plain of the Saint John River 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.

About 60 per cent of the total loss took place along a short section of the Saint John River from Fredericton downstream through the Maugerville-Sheffield area. In the vicinity of Fredericton, extensive areas of low-lying flood plain land have been developed without concern to the flood problem. Moreover, much of the most susceptible development has taken place within the last few years. As an example, 35 homes located on one street in Nashwaaksis suffered losses of $146,000. No less than 23 of these homes have been constructed since 1969. At another location, 84 mobile homes in a trailer park suffered damages of nearly one-half a



Photograph 23 – Aerial view of Burpee Street in the Nashwaaksis area of Fredericton, 30 April 1973.

million dollars. Effective land use planning and regulation must be instituted to prevent these types of development.

In the Maugerville-Sheffield area, much of the susceptible development has taken place because of the area's high agricultural productivity. It is obvious that agricultural activity should continue in this area with consideration given to means of limiting damage to farm homes and other buildings. Of greater concern, however, are the additional developments, not related to agriculture, which are taking place in the Maugerville area. These should be strictly controlled because of the susceptibility of the area to flooding.

The most obvious approach to minimizing future damage in the vicintiy of Fredericton, and in other parts of New Brunswick, 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 developments on the flood plains. Flood forecasting and emergency measures can be effective in reducing some of the damage as already mentioned. Considerable damage could have been avoided if some of the larger government and privately owned buildings in Fredericton had been flood proofed. In many cases, the cost of the 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.

A discussion of other methods of reducing flood damages such as flood control through reservoirs, dykes or improved drainage is beyond the scope of this report but these methods may in certain circumstances be economically feasible.

The studies undertaken for the purpose of this report have shown that New Brunswick has a significant flood problem. The 1973 flood was extreme but it was not an event so rare that its recurrence is impossible. Floods of equal magnitude have occurred in the past and will occur in the future. Concerted effort is required to minimize the effects of future floods in the province.

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