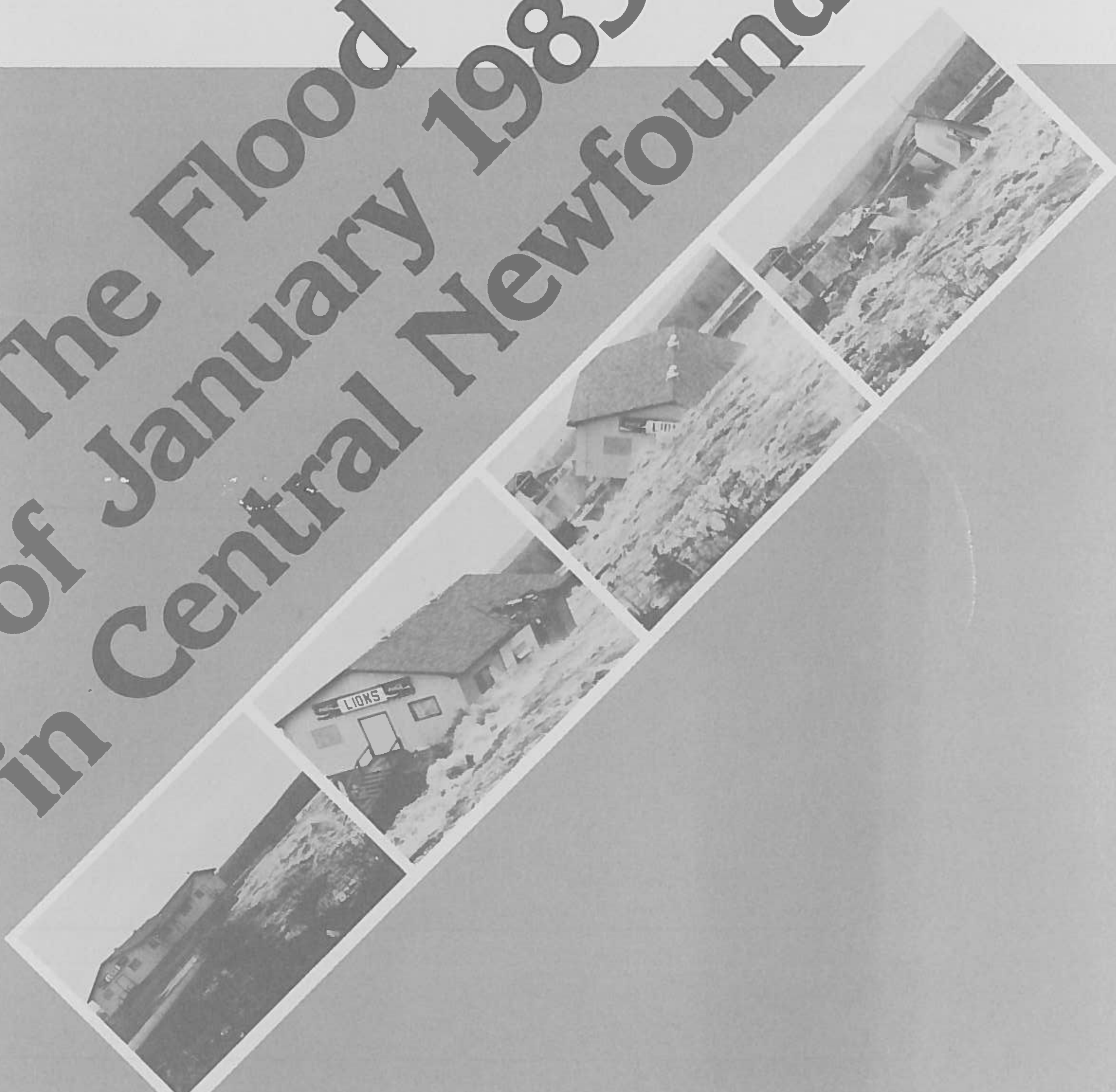
Environment Canada

Newfoundland Environment

# The Flood of January 1983 in Central Newfoundland



Environment Canada / Environnement Canada

Environmental Conservation / Conservation de l'environnement

Inland Waters Directorate
Atlantic Region
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February 15, 1985

Your file / Votre référence

Our file / Notre référence

5120-12d

Members
Flood Report Steering Committee

Gentlemen:

Re: **The Flood of January 1983 in Central Newfoundland**

I am pleased to submit herewith the report on the flood event stated above. In the role of lead agency, I would like to express my appreciation to members of the other agencies contributing to this report.

Yours sincerely,

D.C. Ambler

D.C. Ambler, P. Eng.
Regional Hydrologist
Water Resources Branch

DCA/0425D

# THE FLOOD OF JANUARY 1983

# IN CENTRAL NEWFOUNDLAND

Prepared Jointly By


ENVIRONMENT CANADA

INLAND WATERS DIRECTORATE

ATLANTIC REGION

ATMOSPHERIC ENVIRONMENT SERVICE

ATLANTIC REGION

and

GOVERNMENT OF NEWFOUNDLAND

AND LABRADOR

DEPARTMENT OF ENVIRONMENT

WATER RESOURCES DIVISION



IWD-AR-WRB-85-73

FEBRUARY 1985

# PREFACE

Flooding and related property damages, unprecedented in the recorded history of Newfoundland, were experienced in Central and South Coast areas during a major storm in January 1983. It was considered important by the water management agencies in the region to document this historic flooding event.

The flood was caused by a combination of storm rainfall and rapid snowmelt. The return period for a 48 hour duration rainfall was 35 years in the Burgeo area, while the return period was in excess of 100 years in the St. Albans area. Streamflows resulting from the storm were the highest on record at four hydrometric station locations. The Gander River experienced flows estimated to be up to a one in five hundred year event. The large flood flows recorded in the Exploits River were produced from only the lower half of the Basin. The gates in the dam located at the outlet of Red Indian Lake were closed at midday on January 13, thus containing all flows in the upper half of the Basin. The flow from the lower Exploits River Basin was estimated to have a return period of more than 500 years.

The storm resulted in extensive damages to public and private property and disrupted the normal activities of thousands of people. The total documented direct damages is estimated to be in the order of 34 million dollars. Additional costs, not directly calculated, will increase this value.

FLOOD REPORT STEERING COMMITTEE


Mr. R.D. McBride, Chief,
Water Resources Branch
Inland Waters Directorate

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Water Resources Division
Department of Environment
Government of Newfoundland
and Labrador

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Inland Waters Directorate

Mr. J.O. Bursey, Meteorolgist,
Scientific Services Division
Atmospheric Environment Service

ACKNOWLEDGEMENTS

The preparation of this report would not have been possible without the assistance and cooperation of a large number of agencies and individuals. Many federal and provincial agencies supplied information and assistance in documenting the extent of damages caused by this flood which formed the basis of the economic analysis. The more significant contributions were made by the Provincial Departments of Municipal Affairs, Social Services and Transportation, Newfoundland and Labrador Hydro, Newfoundland Light and Power Company, Abitibi Price Inc., and federal departments and agencies such as Fisheries and Oceans and C.N. Railway.

All other individuals, government departments and agencies, institutions and organizations which directly or indirectly contributed in the preparation of this report are gratefully acknowledged.

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Photographs on the Cover courtesy of Sweeney's Photo Studios, Grand Falls, Newfoundland.

# 1. INTRODUCTION

Flooding and related property damages were experienced by communities in Central Newfoundland and on the South Coast in January 1983. The floods were unprecedented in the history of the Province. The Town of Bishop's Falls was the hardest hit community where the magnitude and extent of damage was very large. It was a frightening experience for the residents of Bishop's Falls who watched the sudden disappearance of a section of their Town. The section became part of a new channel developed by the Exploits River's record setting flow. It is considered worthwhile to document this dramatic historical event - the worst flooding disaster ever recorded on the Island.

The Water Resources Division, Department of the Environment, St. John's, Newfoundland, the Water Resources Branch and the Water Planning and Management Branch, Inland Waters Directorate, Environment Canada, Dartmouth, Nova Scotia and the Scientific Services Division, Atmospheric Environment Service, Environment Canada, St. John's, Newfoundland, agreed to prepare this technical report on the January 1983 flood event.

The primary objective of this report is to provide a basic understanding of the causes, magnitude and economic effects of the flood. It is hoped that such an understanding will lead to more effective flood damage reduction practices including: flood plain management, dam inspection procedures, hydrologic and hydraulic design specifications and river channel management.

Most of the communities, transportation facilities and other properties damaged during this flood are located in three river basins: the Exploits and Gander Rivers in Central Newfoundland, and the Conne River on the South Coast. This report pertains only to these areas. Figure 1.1 illustrates the location of these basins.

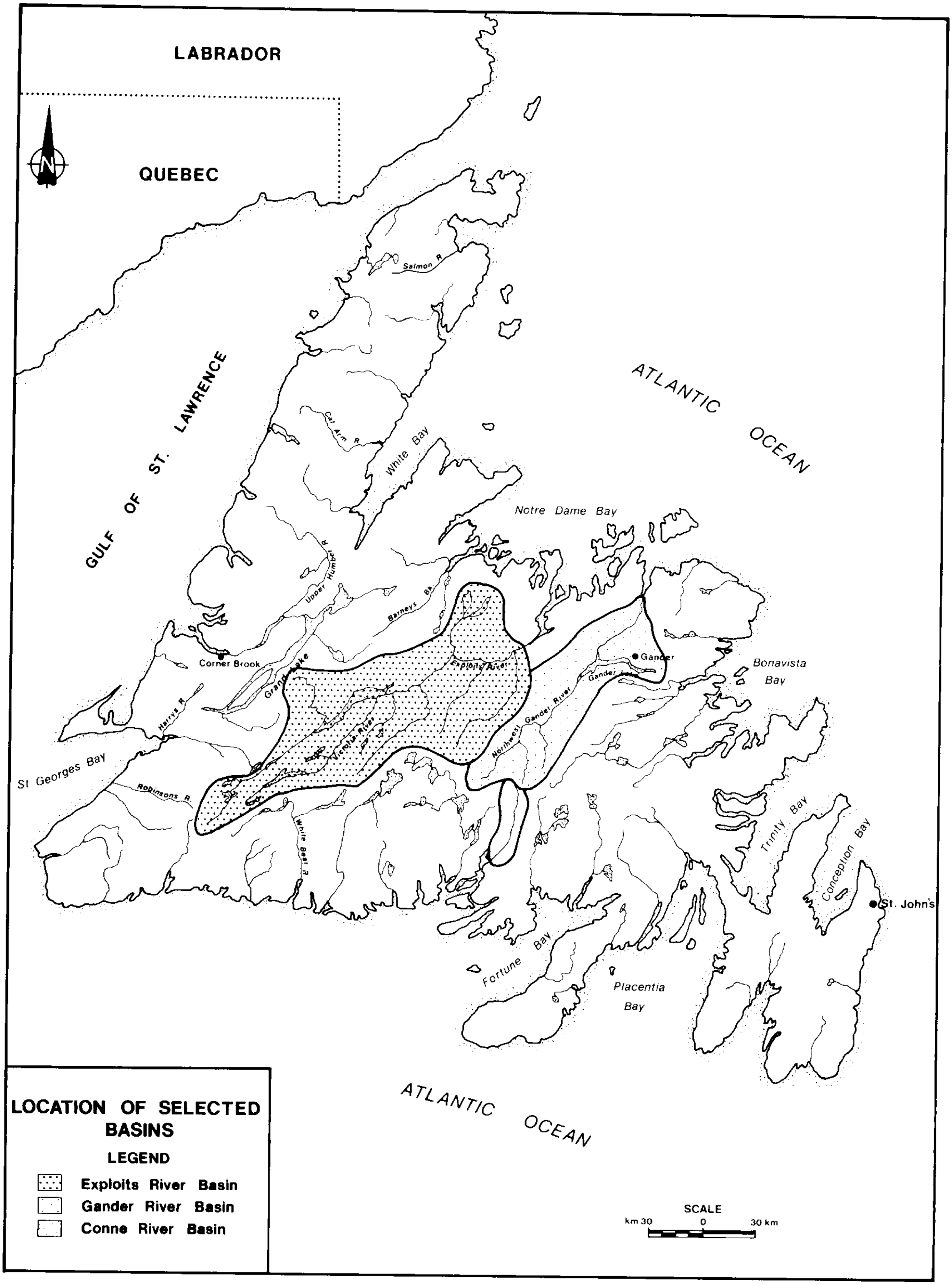



**Figure 1.1 Location of Selected Basins**

The storm of January 11 to 14 was associated with a low pressure system which moved over the south and central part of the Island bringing strong winds, unseasonally high temperatures and heavy rainfall. The effects of this storm are examined using available streamflow data, observed river stage levels and flood water levels. The role of Red Indian Lake in holding back flood runoff from the upper part of the Exploits River Basin is analysed. The effect of the orientation of these basins in relation to the storm path is discussed. An estimate of the rainfall return period recorded and the streamflow return period are provided and discussed, and the sequence of events that led to the flooding of Bishop's Falls is documented.

The report also contains an analysis of the economic costs of the flood. Information on costs of direct and indirect damages to public, personal and business sectors affected by this flood were obtained from various agencies . Some details of the damage compensation provided by the Federal and Provincial governments under the Disaster Assistance Program are outlined.

Finally, the report contains conclusions and recommendations to assist government agencies, municipalities and individuals in reducing the effects of future floods.

# 2. PHYSIOGRAPHY AND CLIMATOLOGY OF SELECTED BASINS IN CENTRAL AND SOUTHERN NEWFOUNDLAND

## 2.1 Physiography

The physiography of the Island of Newfoundland consists primarily of a tilted plateau which is higher in the west than in the east. The highland areas in the west range from 210 to 610 m above sea level, with some peaks rising to over 760 m. The central part of the Island has an elevation which ranges from 180 to 300 m. The rolling topography has been less modified by erosion than in the highland areas. The eastern part of the Island, including the Avalon Peninsula, is at a generally lower elevation, and has an undulating topography where only isolated peaks reach an elevation of 300 m.

The pattern of the topography is largely controlled by geological factors. Some areas of more resistant rocks form highlands, while others of less resistant rocks form lowlands. The drainage pattern of the Island was originally influenced by the geological structure, which trends southwest to northeast. The original drainage pattern was extensively modified by glaciation which over-deepened some of the valleys and interrupted the drainage network on the plateaus by deposition of drift. As a result of the modification of the drainage pattern, the plateaus are now largely covered with lakes and swamps.

The depression of the Island relative to sea level by the load of ice on the land and the fluctuations in sea level due to the amount of water held as ice, has resulted in the formation of fjords and other features of a drowned topography.

### 2.1.1 Exploits River Basin

The Exploits River flows in an east northeast direction to the Atlantic Ocean at the Bay of Exploits.

The total drainage area of the Exploits River is 12,000 $km^2$, the largest basin on the Island.

The basin is considered to consist of two drainage areas: the upper basin, upstream of the Exploits Dam at the Red Indian Lake outlet, and the lower basin, consisting of the area downstream of the Exploits Dam (see Figure 2.1).

The largest tributary in the upper basin is the Victoria River which flows into Red Indian Lake from the southern part of the upper basin. The next largest tributary in the upper basin is the Lloyds River. Shanadithit Brook and Buchans Brook comprise the remainder of the main tributaries of Red Indian Lake. Red Indian Lake, which is the largest in the Exploits system, has a surface elevation about 150 m above sea level. The Annieopsquotch Mountains within the watershed and the Long Range Mountains, bounding the upper basin area, have peaks which exceed 670 m.

The Exploits River proper commences at the outlet of Red Indian Lake from where it flows a distance of about 110 km to the Bay of Exploits. On route to the sea, several tributaries join the main river stem, the largest of which are Noel Pauls Brook, Stony Brook and Great Rattling Brook.

The basin terrain is rocky and hilly, rising into mountainous territory in the west and north, with extensive areas of lakes and ponds. The mean relief is 280 m with absolute relief lying between 690 m in the Annieopsquotch Mountains and 30 m at the stream gauge located below Stony Brook. In taking the overall distance from the source to

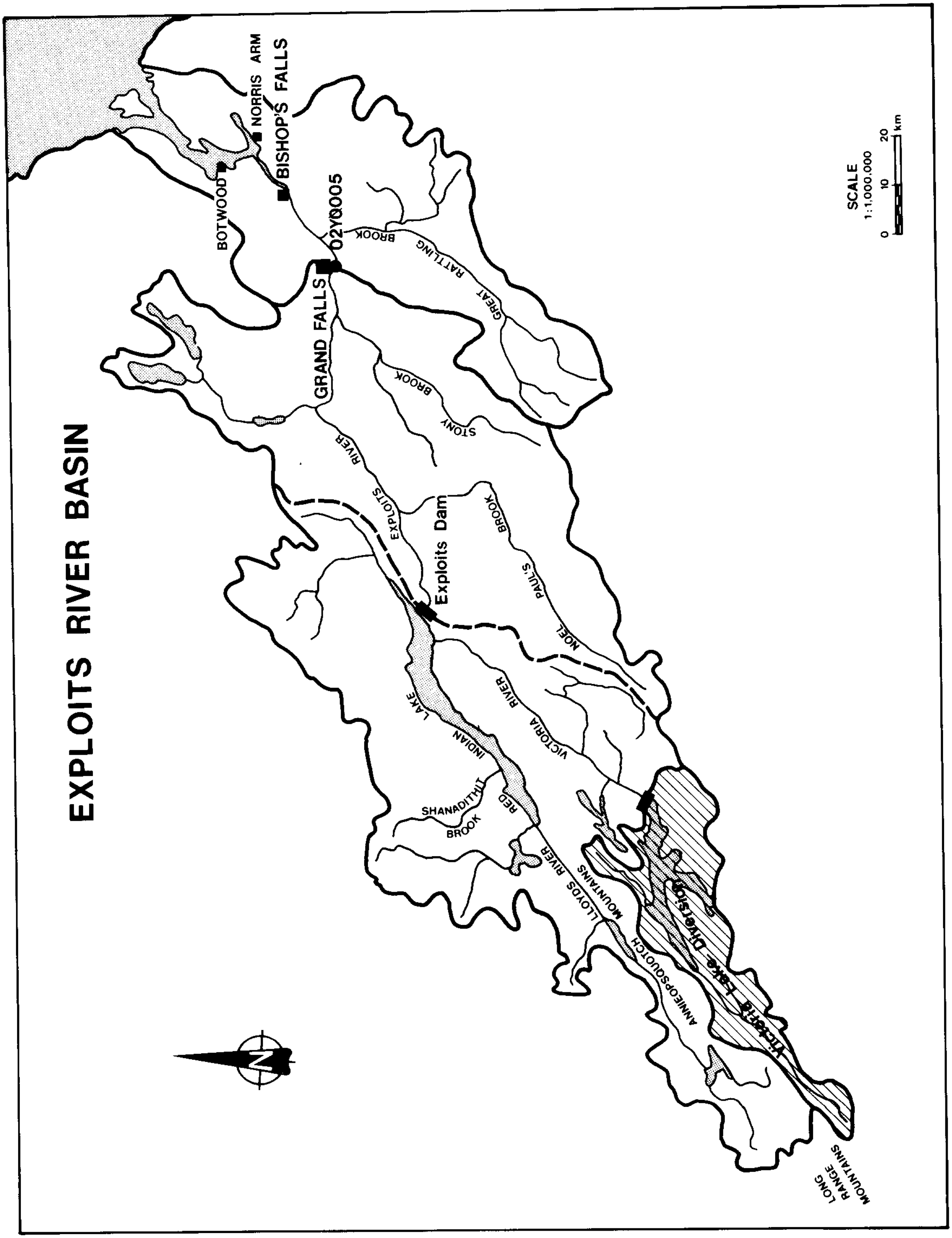



**Figure 2.1 Exploits River Basin**

the mouth, inclusive of lakes, the gradient is 0.18% . Excluding lakes, the mean gradient is 0.26%.

The main Exploits River channel is rough, with boulders in most reaches. No transition between bedrock and alluvial reaches occurs within the basin.

The catchment's land cover is classified as partly forested and partly barren. Slightly more than half of the eastern basin area is in a zone of balsam fir and black spruce, with white spruce and tamarack occurring throughout. The remainder of the catchment, about 46%, is classified as barren uplands with shrubs and peat deposits.

There are many large lakes in the basin, including Red Indian, Victoria, Long, North Twin, South Twin, Mary Ann, Sandy, Buchans, Star, King George IV and Lloyds. The Victoria Lake flows are now diverted towards the Bay d'Espoir basin. This diversion is 1050 $km^2$ in drainage area. The area of lakes in the whole basin is approximately 1100 $km^2$. Red Indian Lake has a calculated area of 205 $km^2$. The Exploits Basin has something in the order of 96,000 lakes and ponds.

The Exploits River Basin cuts across the centre of the Island. This region is underlain by rocks of sedimentary and volcanic origin of Ordovician and Silurian age. Granitic and ultra basic rocks lie to the northwest, and ultra basic rocks to the east of Grand Falls. Devonian volcanic rocks also occupy an area to the south of Grand Falls. In the vicinity of Red Indian Lake, sedimentary Carboniferous rocks with Silurian volcanics are predominant, while more granitic and ultra basic rocks lie to the north and west of the lake. The basin above Red Indian Lake is situated mainly on highly metamorphosed rocks of Ordovician, Silurian and Devonian age, with numerous igneous intrusions of varying composition.

The surficial deposits of the Exploits River Basin consist largely of ground and ablation moraine, with some area of ribbed moraine at the southern edge of the basin. The moraine deposits are known to be thick in some parts of the basin, with a maximum thickness of 48 m recorded at Buchans. Over most of the area, however, the thickness is probably 10 m or less with areas of exposed rock on high ground and extensive swamps on low ground and on parts of the high plateau (Shawinigan and MacLaren, 1968).

Soils are mainly podzolic. There are also extensive peat areas and extensive terrace deposits in the valley bottom from the foot of Red Indian Lake to the estuary. These are mainly gravelly sand with a surface of about 10 m above sea level in the lower reaches and 2.5 m above river level in the reach from Red Indian Lake to Grand Falls.

The amount of area covered by lakes, marshes, barrens and forest in the basin to the streamflow gauge below Stony Brook is shown in Table 2.1. This table also includes other physiographic data obtained from Reference 7.

### 2.1.2 Gander River Basin

The Gander River, shown in Fig. 1.1, flows in an east northeast direction, to the Atlantic Ocean at Gander Bay.

The total drainage area of the Gander River into Gander Bay is 5,400 $km^2$ (Shawinigan and MacLaren 1968) which makes it the third largest basin on the Island. The drainage area to the gauging station, Gander River at Big Chute (02YQ001), near Glenwood is 4,400 $km,^2$. The gauged area excludes approximately the last 40 km of the river's length and its associated drainage area.

## PHYSIOGRAPHIC PARAMETERS OF SELECTED RIVER SYSTEMS

| River | Hydrometric Station Number | Location | Drainage Area $km^2$ | Lake Area $km^2$ | Swamp Area $km^2$ | Forest Area $km^2$ | Barren Area $km^2$ | Length of Main Channel km | *Elevation Difference m | +Slope % | Shape Factor *** | Area** Controlled by Lake and Swamp % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exploits River | 02Y0005 | Below Stony Brook | 8640 | 893 | 1382 | 5245 | 1120 | 235 | 300 | 0.170 | 2.53 | 95 |
| Gander River | 02YQ001 | At Big Chute | 4400 | 375 | 367 | 3355 | 303 | 134 | 297 | 0.222 | 2.08 | 91 |
| Conne River | No Gauge | Near New Hwy. Bridge | 573 | 46 | 32 | 319 | 176 | 49.5 | 126 | 0.254 | 1.56 | 41.4 |

\+ Slope = $\frac{\text{Elevation Difference}}{\text{Length of Main Channel}}$

* Elevation Difference: The difference between a point on the basin divide in the vicinity of the origin of the main channel and the hydrometric station (or outlet of the area under consideration).

** See ref. 6 or ref. 7.

*** SHAPE FACTOR: 0.28 x basin perimeter/ $\sqrt{D.A.}$

TABLE 2.1

In terms of stream length, it is the second longest on the Island, being next only to the Exploits River.

There are several lakes and ponds in the basin, and all of these are comparatively small except for Gander Lake which is the largest natural lake on the eastern half of the Island.

Most of the basin has a cover of ground ablation and end moraine which varies in thickness, but has a mean depth of about 6 m. Twenty seven percent of the basin is covered with ribbed moraine which is generally thicker than the other moraines, with an average depth of about 9 m. Five percent of the basin has a cover of sands and gravels in the form of alluvial and outwash deposits along the Gander River and at the end of Gander Lake, and there are eskers south of Gander Lake. Eighteen percent of the basin has a cover of marsh and bog.

In this basin, there are a number of basic and ultrabasic intrusions as well as granitic ones. They occur in a strip to the east of the Gander River and in the southern part of the basin. The remainder of the basin is occupied by metamorphosed Lower Paleozoic rocks.

The amount of area covered by lakes, marshes, barrens and forest in the gauged basin is given in Table 2.1.

### 2.1.3 Conne River Basin

The Conne River flows in a southwest direction to the Atlantic Ocean at Bay d'Espoir. The total drainage area of the Conne River into Bay d'Espoir is 710 $km^2$.

The bedrock of the area consists of Ordovician, Silurian and Devonian sedimentary and metamorphic rocks, and some minor areas of volcanic rocks. There are also a number of major igneous intrusions, mainly granitic in composition. Only about a tenth of the area of igneous rocks is occupied by basic and ultrabasic intrusions.

In the coastal areas, much of the bedrock is exposed with no significant cover of surficial material. The inland parts of the basin have a cover of ribbed moraine, and there is a zone of ground moraine between the ribbed moraine and the exposed rock at the seacoast. There are some areas of alluvium and eskers. Also, some of the moraines in the basin have been described as end moraine.

There are no large lakes or ponds in the Conne River Basin. The lake and pond area covers 8 percent, bog and marsh area 6 percent, forest area 56 percent and barren area 30 percent of the total area. The amount of area covered by lakes, marshes, barrens and forest area in the basin is shown in Table 2.1.

## 2.2 Climatology

The climate of Newfoundland, according to the Koppen classification (2), is categorized as a cool snow forest climate with no distinct dry season and cool-to-warm summers.

The mean annual temperature decreases northward from $5^{o}C$ in southern Newfoundland to near $1^{o}C$ in the St. Anthony area. Mean monthly and annual temperatures at a number of locations on the Island are shown in Table 2.2. The moderating effect on temperatures of the Gulf of St. Lawrence and the surrounding ocean is apparent from Table 2.2. Thus, winters are milder near the ice free waters of the south compared to other coastal and inland locations. Also, summers are cooler near the sea than further inland. In central and northern portions of the Island, extreme temperature minima vary between $-35^{o}$ and $-41^{o}C$. Summertime maxima often reach the mid twenties where winds are not

**AVERAGE MONTHLY AND ANNUAL TEMPERATURES IN NEWFOUNDLAND**

(Temperatures in Degrees Celsius)

Based on the period 1951 to 1980

| Location | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Port aux Basques | -4.1 | -5.7 | -2.7 | 0.8 | 4.7 | 9.0 | 13.2 | 14.7 | 11.3 | 7.0 | 3.2 | -1.7 | 4.1 |
| Deer Lake | -6.8 | -7.8 | -3.9 | 1.2 | 6.5 | 12.2 | 16.6 | 15.8 | 11.4 | 6.3 | 1.8 | -4.1 | 4.1 |
| St. Anthony | -8.8 | -8.8 | -5.3 | -0.9 | 3.0 | 8.0 | 12.8 | 13.0 | 9.6 | 4.3 | -0.3 | -5.8 | 1.7 |
| Gander (A) | -6.2 | -6.8 | -3.5 | 0.9 | 6.2 | 11.8 | 16.5 | 15.6 | 11.4 | 6.0 | 1.8 | -3.8 | 4.2 |
| St. John's (A) | -3.9 | -4.5 | -2.3 | 1.2 | 5.4 | 10.9 | 15.5 | 15.3 | 11.6 | 6.9 | 3.4 | -1.5 | 4.8 |
| St. Albans | -5.3 | -5.8 | -2.5 | 2.4 | 7.0 | 11.5 | 15.5 | 16.1 | 12.2 | 7.2 | 3.1 | -2.7 | 4.9 |
| Exploits Dam | -7.7 | -9.2 | -4.8 | 0.3 | 5.7 | 11.2 | 15.4 | 14.7 | 10.3 | 5.5 | 1.3 | -4.6 | 3.2 |

**TABLE 2.2**

onshore and extreme values of 35°C or more have been recorded in central Newfoundland. The average length of frost-free season varies from approximately 135 days or more along the coast to 90 days or less in inland valleys.

Annual precipitation varies from 900 to 1100 mm in the north and west to about 1500 to 1700 mm in southern and eastern Newfoundland. Mean annual precipitation for the Island is, however, near 1200 mm. Table 2.3 lists average monthly and annual precipitation at specific locations on the Island. The variability of annual precipitation from year to year is less than 15% of the mean. From this table, it is noted that spring and/or summer monthly precipitation is approximately 20% to 50% less than that received in the fall.

Along the south coast, annual snowfall is in the order of 100 to 200 cm which is 10% to 15% of yearly precipitation. The snowfall increases to a range of about 300 to 500 cm in the north and west, which is about 25% to 35% of annual precipitation.

In Central Newfoundland, winter snow cover usually melts between April and early June, but the starting time is quite variable. In March of an average year, prior to spring runoff, the depth of snow is 60 to 120 cm deep in coniferous forests and shaded areas. Along the South Coast and the Avalon Peninsula, however, the depth is of the order of 10 to 20 cm in most places. The ratio of snow depth to water equivalent ranged from 5 to 1 down to 8 to 1 during the winter of 1983.

Newfoundland lies in the path of many frontal storms. In addition, hurricanes and tropical storms, originating in the Caribbean area, occasionally influence parts of the Island during the period July to October. Rain persisting for more than 80 hours, with amounts in excess

**AVERAGE MONTHLY AND ANNUAL PRECIPITATION IN NEWFOUNDLAND**

(Precipitation in millimetres)

Based on the Period 1951 to 1980

| Location | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Port aux Basques | 133.9 | 116.9 | 104.7 | 93.0 | 118.1 | 102.9 | 108.1 | 115.0 | 115.4 | 132.4 | 155.3 | 155.6 | 1451.7 |
| Deer Lake | 91.6 | 70.7 | 73.7 | 61.2 | 66.1 | 76.3 | 78.2 | 105.2 | 89.8 | 112.8 | 107.8 | 99.7 | 1033.1 |
| St. Anthony | 122.0 | 101.3 | 119.9 | 50.9 | 59.5 | 78.5 | 81.2 | 98.8 | 87.4 | 94.9 | 102.1 | 88.9 | 1080.5 |
| Gander (A) | 109.1 | 99.7 | 110.1 | 93.2 | 70.0 | 80.3 | 69.0 | 97.3 | 81.2 | 104.7 | 107.3 | 108.2 | 1130.1 |
| St. John's (A) | 155.8 | 140.1 | 131.9 | 115.6 | 101.8 | 85.6 | 75.3 | 121.6 | 116.7 | 145.5 | 167.5 | 161.2 | 1513.6 |
| St. Albans | 143.9 | 145.8 | 120.8 | 133.8 | 104.3 | 109.5 | 120.2 | 145.5 | 135.5 | 156.1 | 166.8 | 160.7 | 1643.9 |
| Exploits Dam | 97.7 | 77.7 | 95.8 | 70.2 | 64.2 | 83.4 | 94.5 | 90.0 | 88.5 | 109.1 | 112.5 | 115.4 | 1099.0 |

**TABLE 2.3**

of 275 mm have been recorded. Twenty-four hour totals exceeding 170 mm have also been observed.

The main storm track affecting the Island has a southwest to northeast orientation and the isohyetal patterns tend to be elongated somewhat in that direction. Thus, although rainfall may be general over much of the Island, the extreme precipitation is usually concentrated in a relatively narrow belt. Therefore, the total storm precipitation usually falls off rapidly toward the southeast and northwest directions from the axis of the storm track.

# 3. CAUSES OF THE FLOOD

## 3.1 Climatic Conditions

The flood of January, 1983, was caused by a combination of two factors - storm precipitation and snowmelt. This chapter examines the snow accumulation, the estimated snowmelt rate and the meteorological conditions associated with the storm.

During the fall and early winter of 1982-83, total precipitation was about normal on the Island, with the snowfall portion of the total precipitation being quite variable. Although detailed information is lacking in Central Newfoundland, evidence suggests that at least 30 cm of snow had accumulated in the central and east-central areas prior to the onset of the storm on January 11.

### 3.1.1 Snowfall During the Fall and Early Winter of 1982-83

Snowfall recorded from October 1982 to January 1983 at selected meteorological stations on the Island is presented and compared with long term monthly averages in Table 3.1. Snowfall was mostly below normal, but a rectangular area through Central Newfoundland reported amounts some

**SNOWFALL FOR OCTOBER TO JANUARY, 1982-83**

| Station | | October | November | December | January | Oct. to Dec. Total | Oct. to Jan. Total |
|---|---|---|---|---|---|---|---|
| Daniel's Harbour | (A) | 4.6 | 26.2 | 69.8 | 88.8 | 100.6 | 189.4 |
| | (B) | 5.0 | 32.8 | 90.8 | 98.4 | 128.6 | 227.0 |
| | (C) | 108.7 | 125.2 | 130.1 | 110.8 | 127.8 | 119.9 |
| Gander | (A) | 12.2 | 31.8 | 70.9 | 78.7 | 114.9 | 193.6 |
| | (B) | 11.8 | 30.8 | 111.1 | 94.8 | 153.7 | 248.5 |
| | (C) | 96.7 | 96.9 | 156.7 | 120.5 | 133.8 | 128.4 |
| St. John's (A) | (A) | 4.4 | 21.2 | 65.1 | 81.4 | 90.7 | 172.1 |
| | (B) | 0.8 | 11.0 | 20.4 | 62.7 | 32.2 | 94.9 |
| | (C) | 18.2 | 51.9 | 31.3 | 77.0 | 35.5 | 55.1 |
| St. Albans | (A) | 3.6 | 10.7 | 49.3 | 55.2 | 63.6 | 118.8 |
| | (B) | TR | 30.0 | 66.6 | 55.6 | 96.6 | 152.2 |
| | (C) | 2.8 | 280.4 | 135.1 | 100.7 | 151.9 | 128.1 |
| Port aux Basques | (A) | 3.2 | 11.4 | 54.2 | 73.6 | 68.8 | 142.4 |
| | (B) | 0.4 | 24.4 | 32.4 | 46.2 | 57.2 | 87.0 |
| | (C) | 12.5 | 214.0 | 59.8 | 62.8 | 83.1 | 61.1 |
| Burnt Pond | (A) | 4.1 | 20.6 | 84.6 | 76.7 | 109.3 | 186.0 |
| | (B) | 0.0 | 27.7 | 55.7 | 70.6 | 83.4 | 154.0 |
| | (C) | 0.0 | 134.5 | 65.8 | 92.0 | 76.3 | 82.8 |
| Buchans (A) | (A) | 6.1 | 30.2 | 63.1 | 79.6 | 99.4 | 179.0 |
| | (B) | TR | 20.0 | 54.0 | 56.1 | 74.0 | 130.1 |
| | (C) | 1.6 | 66.2 | 85.6 | 70.5 | 74.4 | 72.7 |
| Exploits Dam | (A) | 7.4 | 22.8 | 64.2 | 68.2 | 94.4 | 162.6 |
| | (B) | 2.4 | 11.4 | 57.1 | 64.6 | 70.9 | 135.5 |
| | (C) | 32.4 | 50.0 | 88.9 | 94.7 | 75.0 | 83.3 |
| Grand Falls | (A) | 6.5 | 18.7 | 48.1 | 57.2 | 73.3 | 130.5 |
| | (B) | TR | 15.0 | 70.4 | 59.6 | 85.4 | 145.0 |
| | (C) | 1.5 | 80.2 | 146.4 | 104.2 | 116.5 | 111.1 |

NOTE: (A) Long Term Average Snowfall in Centimetres
(B) Fall and Winter Snowfall in Centimetres (1982-83)
(C) Fall and Winter Snowfall as Percent of Long Term Average

**TABLE 3.1**

10% to 30% above average. The monthly weather patterns during this period can be briefly described as follows:

<u>October</u>: Mean temperatures $1^{o}$ to $2^{o}C$ below normal. Precipitation about normal, snowfall mostly below normal.

<u>November</u>: Mean temperatures normal in the south to $1^{o}C$ colder in the north. Total precipitation near normal but the snowfall component was above normal along the southwest and west coasts and below normal elsewhere.

<u>December</u>: Mean temperatures about $1^{o}C$ below normal along the south coast, to over $3^{o}C$ below normal in the St. Anthony area. Precipitation near normal, but the snowfall component in northern and a portion of central Newfoundland was above normal.

<u>January</u>: Mean temperatures varied from near normal in the south to about $2^{o}C$ colder than normal in the north. Precipitation was generally above normal with snowfall above normal in the north, and below normal in the south and east.

Figures 3.1 and 3.2 illustrate the depth of snow measured at four sites in October, November, December and January of 1982/83, and compare it to the long term average snowfall for each of the same months.

### 3.1.2 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 Newfoundland during the storm of January 11 to 14, 1983

Practical application of the energy budget approach to the snowmelt problem was developed in the western United States by the United States Weather Bureau and the United States Army Corps of Engineers (3).

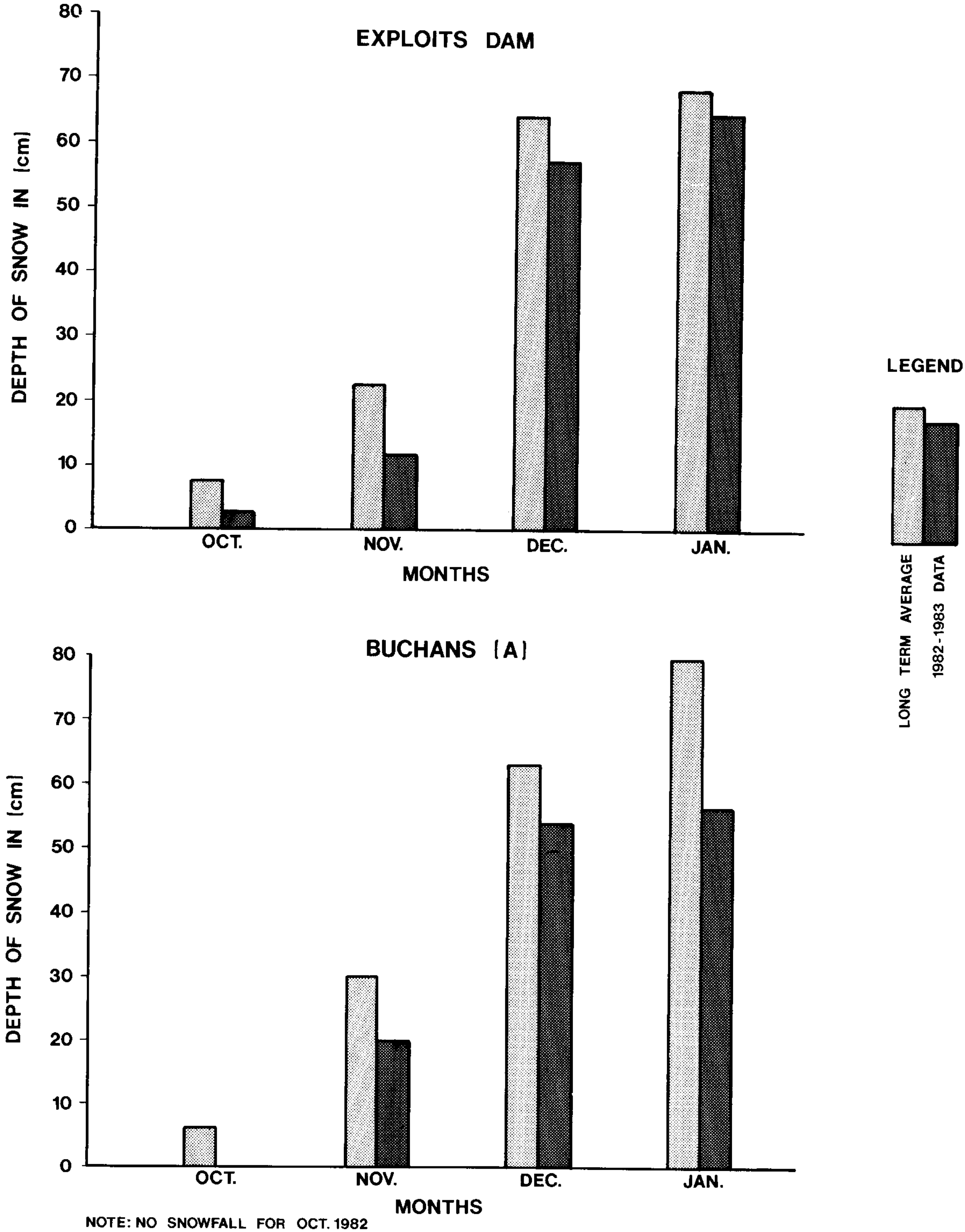



Figure 3.1 Comparison of 1982/83 Snowfall with Long Term Average Snowfall

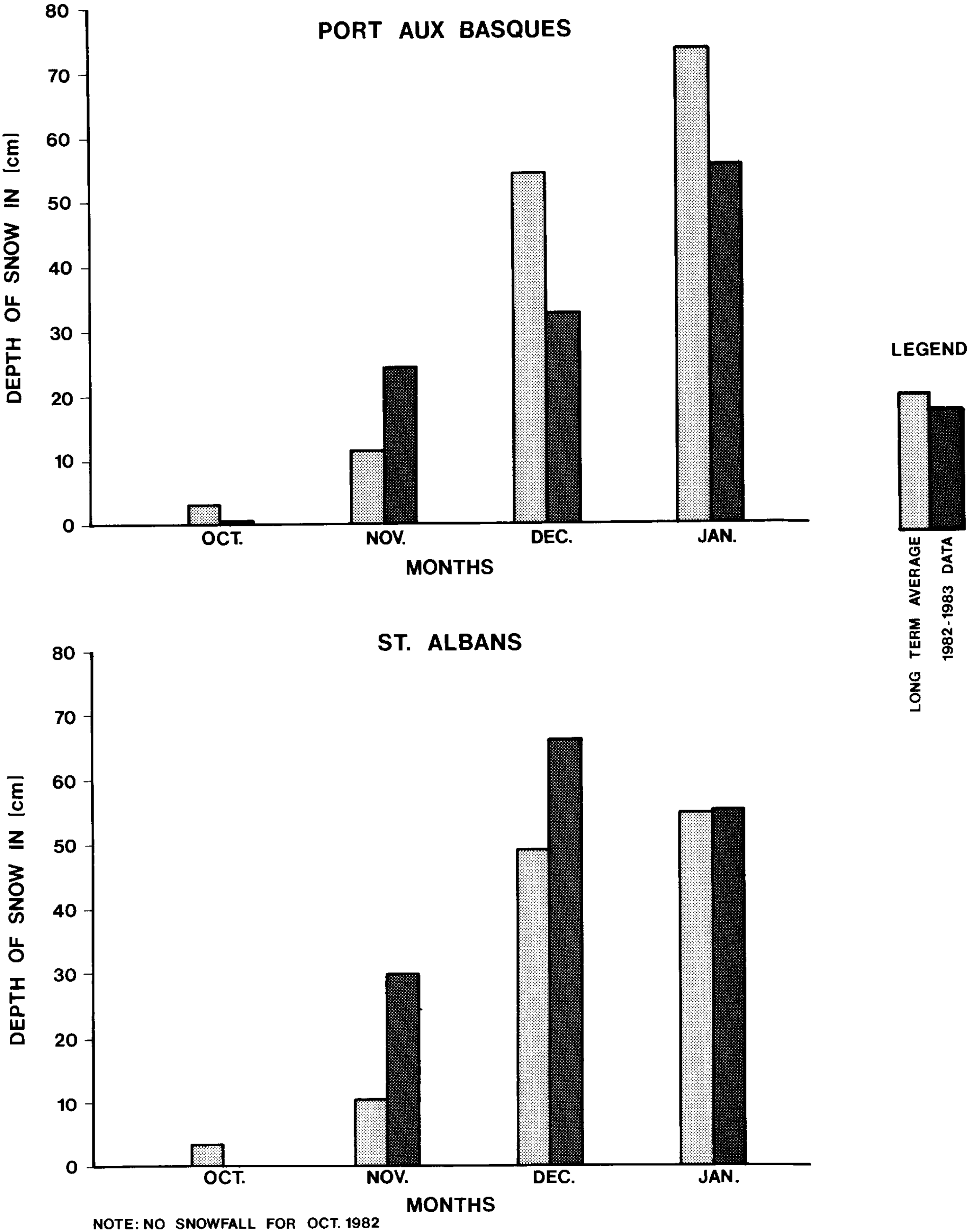



Figure 3.2 Comparison of 1982/83 Snowfall with Long Term Average Snowfall

The approach resulting from these studies is stated in the form of 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

$M_{g}$ = 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 empirical 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 estimated snowmelt by the energy budget approach. The simplified form of the generalized basin snowmelt equation was applied to calculate potential snowmelt.

Estimates of the average potential snowmelt rates are shown on Figure 3.3. By comparison with the water equivalent of accumulated snow (Figure 3.4), it can be deduced that most areas were depleted of snow by day's end, January 12. This indicates that most of the snow that accmulated prior to the storm melted and ran off in little more that 24 hours beginning late on January 11.

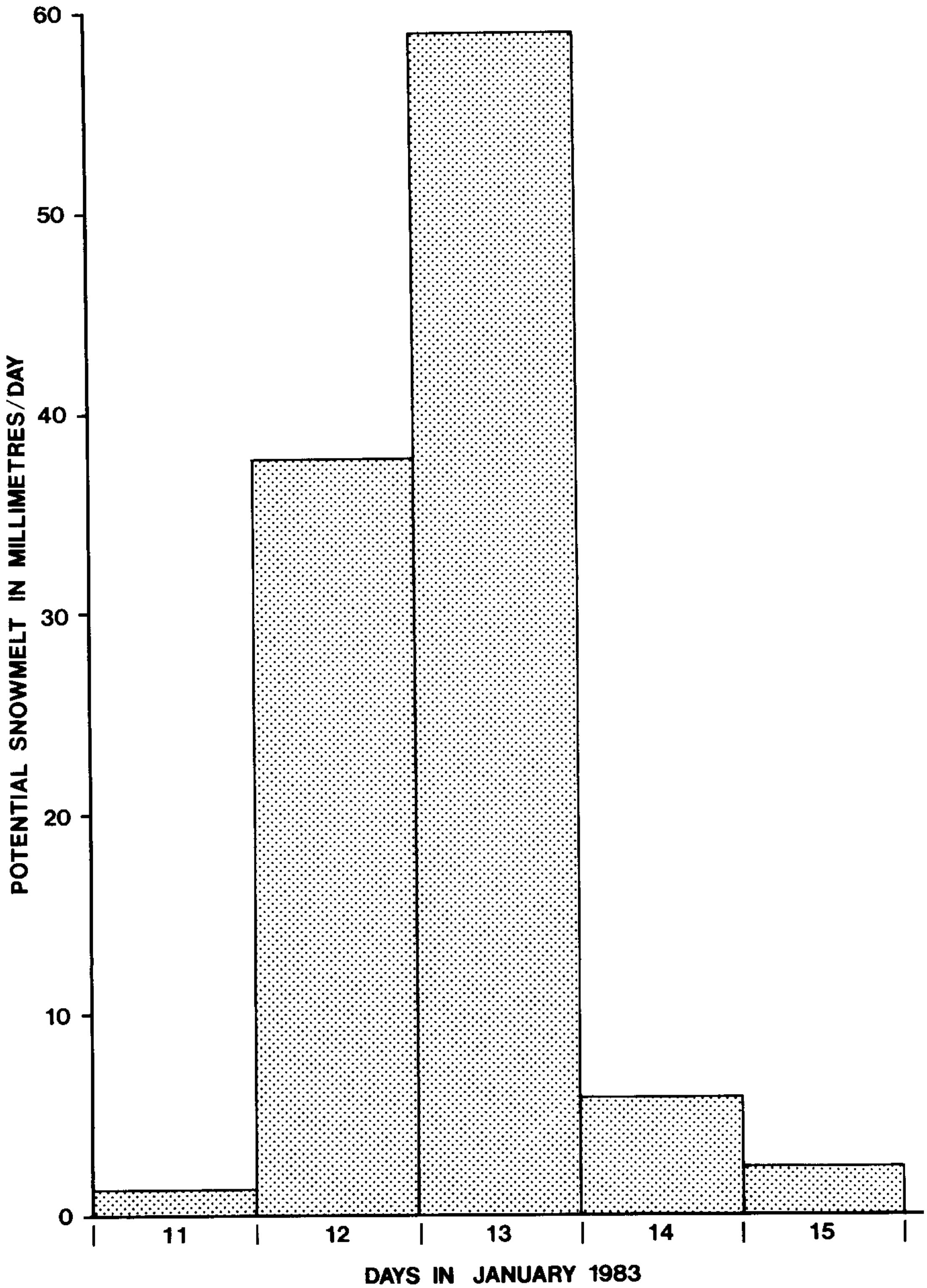



**Figure 3.3 Potential Snowmelt Rates for Exploits River Basin January 11-15,1983**

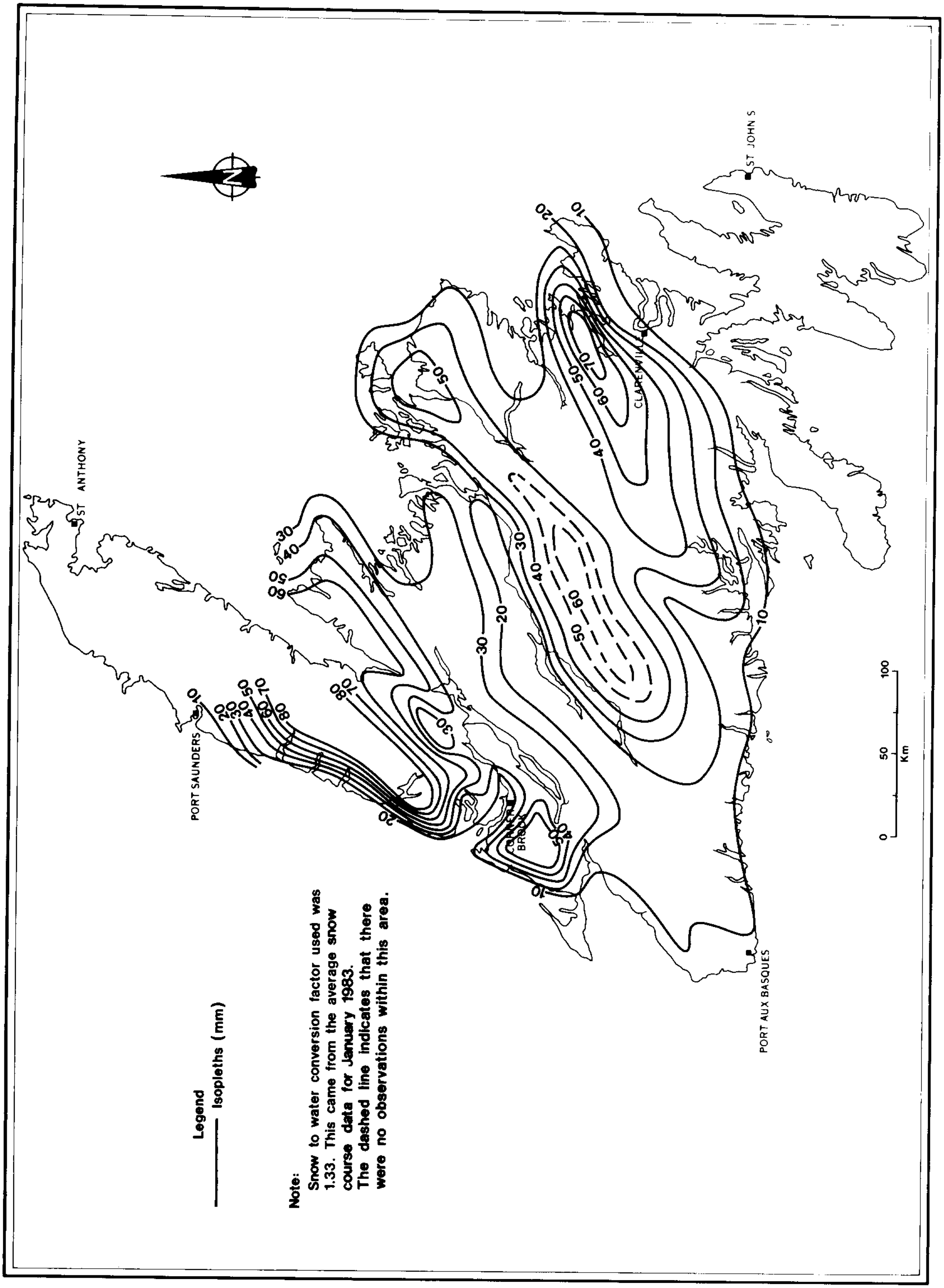



**Figure 3.4 Estimated Water Equivalent of Snow on January 11,1983**

For comparative purposes, the daily maximum and minimum temperatures at selected meteorological stations are shown on Figures 3.5a to 3.5e. These data show that the highest temperatures for the month occurred between January 10 and 15, and were centered on the 12th and 13th. For the entire Island, the greatest daily maxima ranged between $5^{o}C$ and $15^{o}C$ during that period. Concurrently, a low pressure system approaching the Island from the south, simultaneously brought very mild air and copious amounts of rain. Because of these two conditions, the rate of snowmelt was very high.

## 3.2 The Storm of January 11 - 14, 1983

On January 11, there was a complex low pressure area over the Great Lakes with an occluding frontal system near Massachusetts. The frontal system moved to the vicinity of Sable Island by the morning of the 12th. Rain associated with the front covered most of Newfoundland by 1200 GMT on the 12th (Figure 3.6). Another low south of Cape Cod on the morning of the 12th moved northeastward, and by Thursday morning, January 13, was located just east of Halifax (Figure 3.7). This new system had the effect of prolonging the precipitation which began on the 11th and 12th. By 1200 GMT on January 14 (Figure 3.8), the system was located northeast of the Island and only eastern regions reported significant precipitation. Throughout the period of the storm, a mild moist airflow prevailed over the Island and temperatures remained well above freezing, night and day.

By mid morning on the 12th, 20 to 40 mm of rain had fallen on an area extending from southwestern Newfoundland to the Hermitage Peninsula. Rainfall increased on the 12th and 13th as the storm became more organized and moved across the Island.

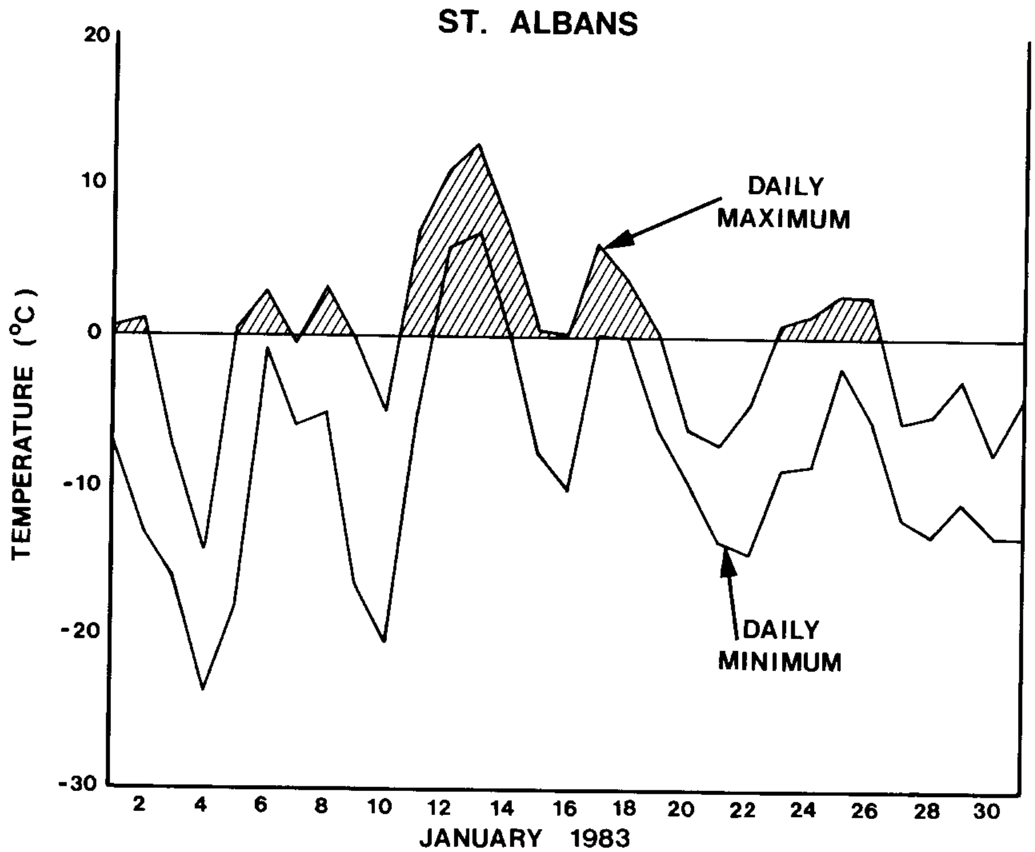



Figure 3.5a Daily Extremes of Temperature at St. Albans Meteorological Station

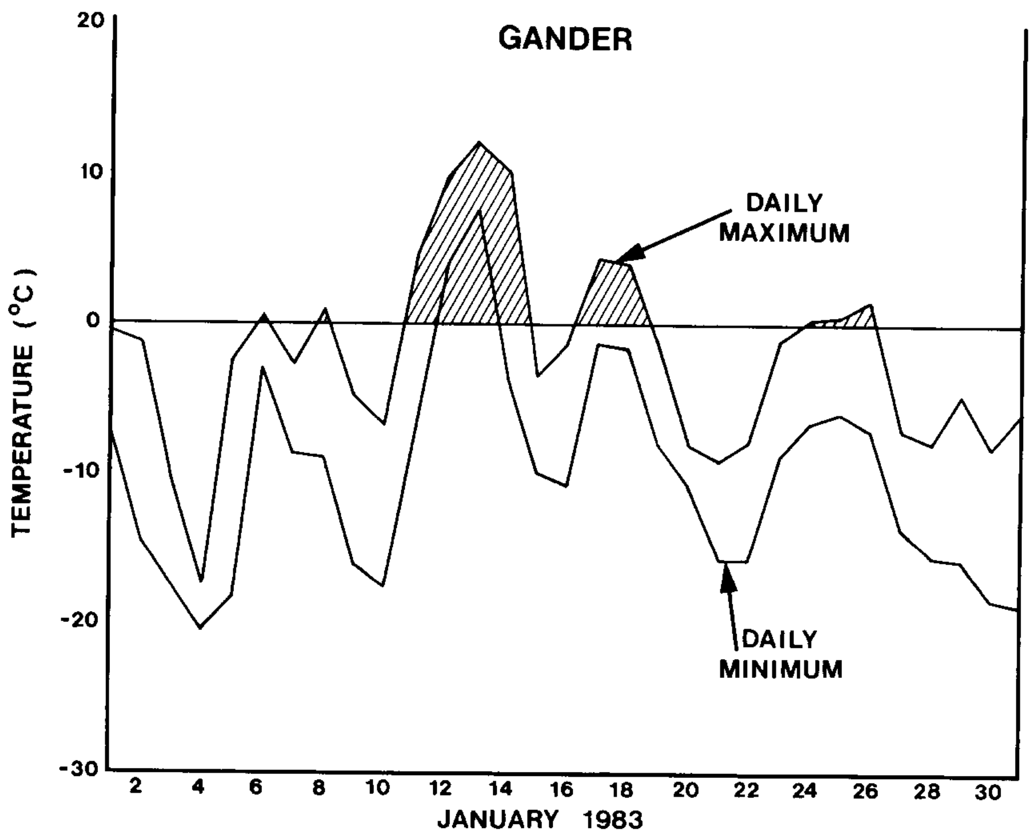



Figure 3.5b Daily Extremes of Temperature at Gander Meteorological Station

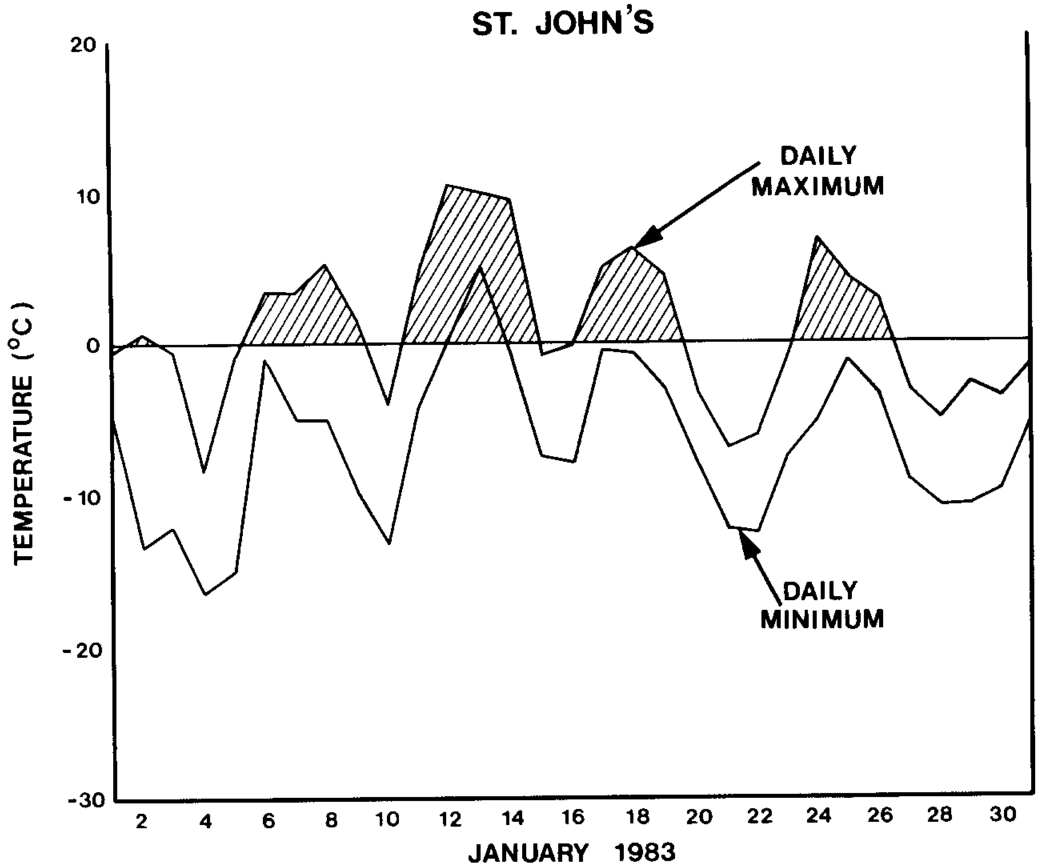



Figure 3.5c Daily Extremes of Temperature at St. John's Meteorological Station

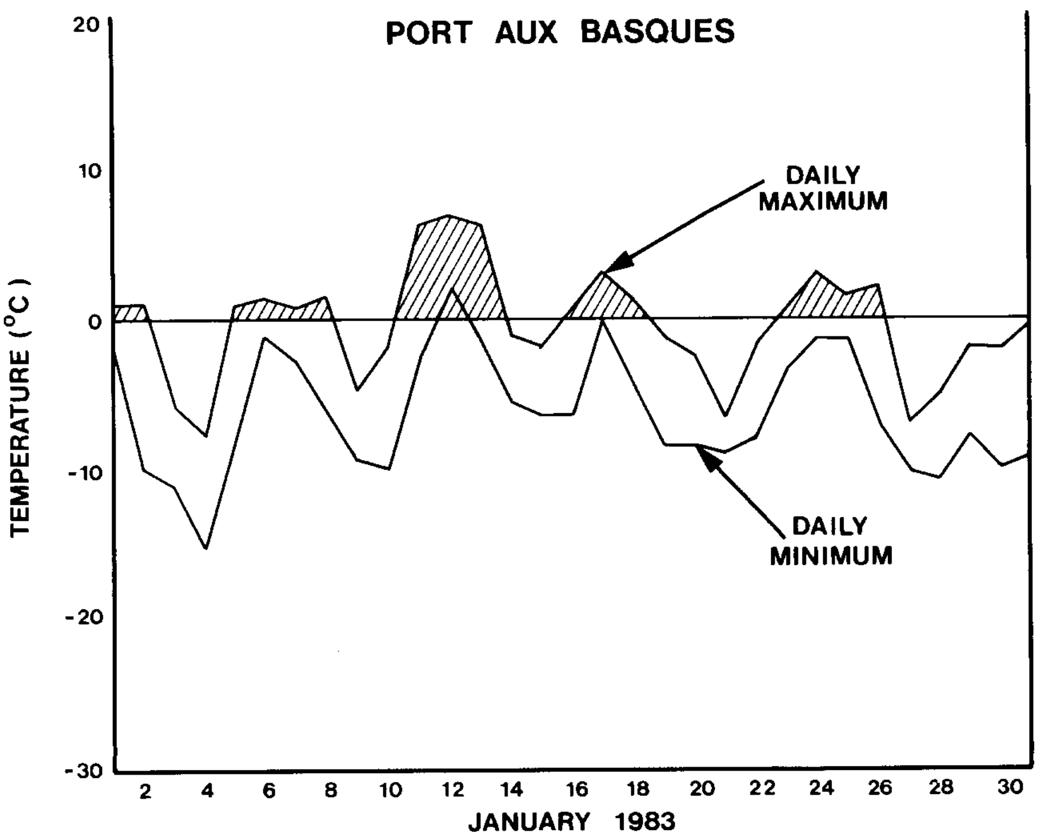



Figure 3.5d Daily Extremes of Temperature at Port Aux Basques Meteorological Station

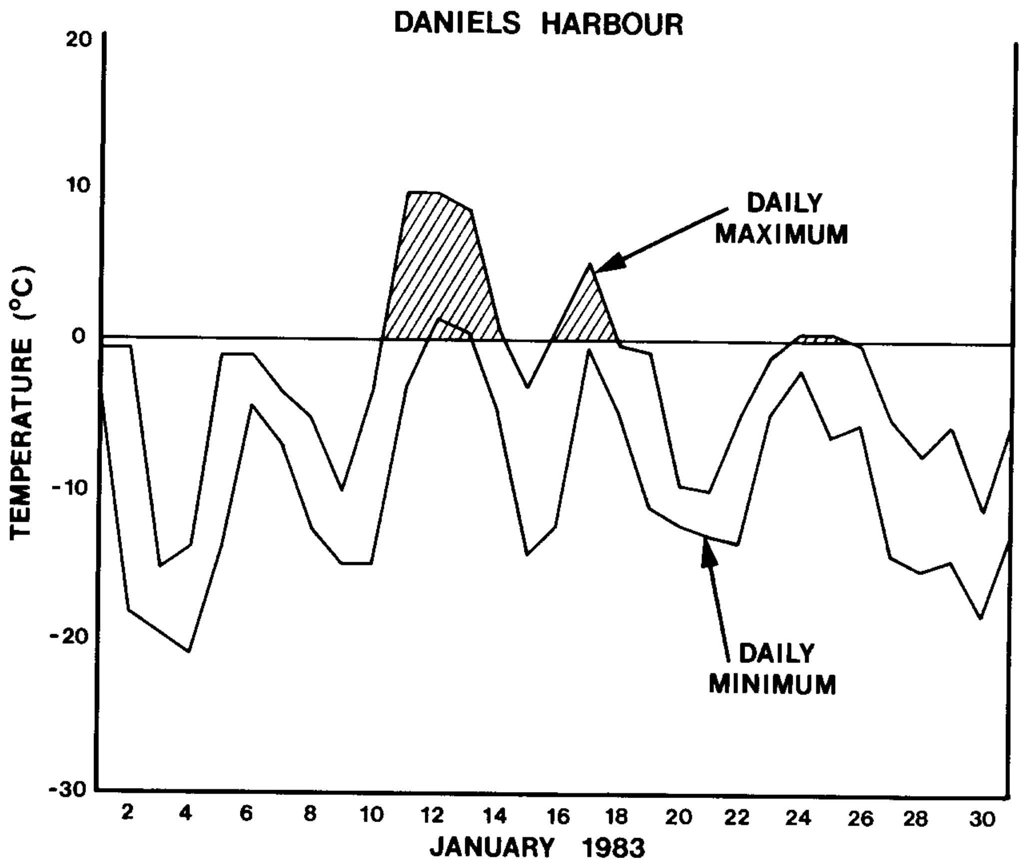



Figure 3.5e Daily Extremes of Temperature at Daniels Harbour Meteorological Station

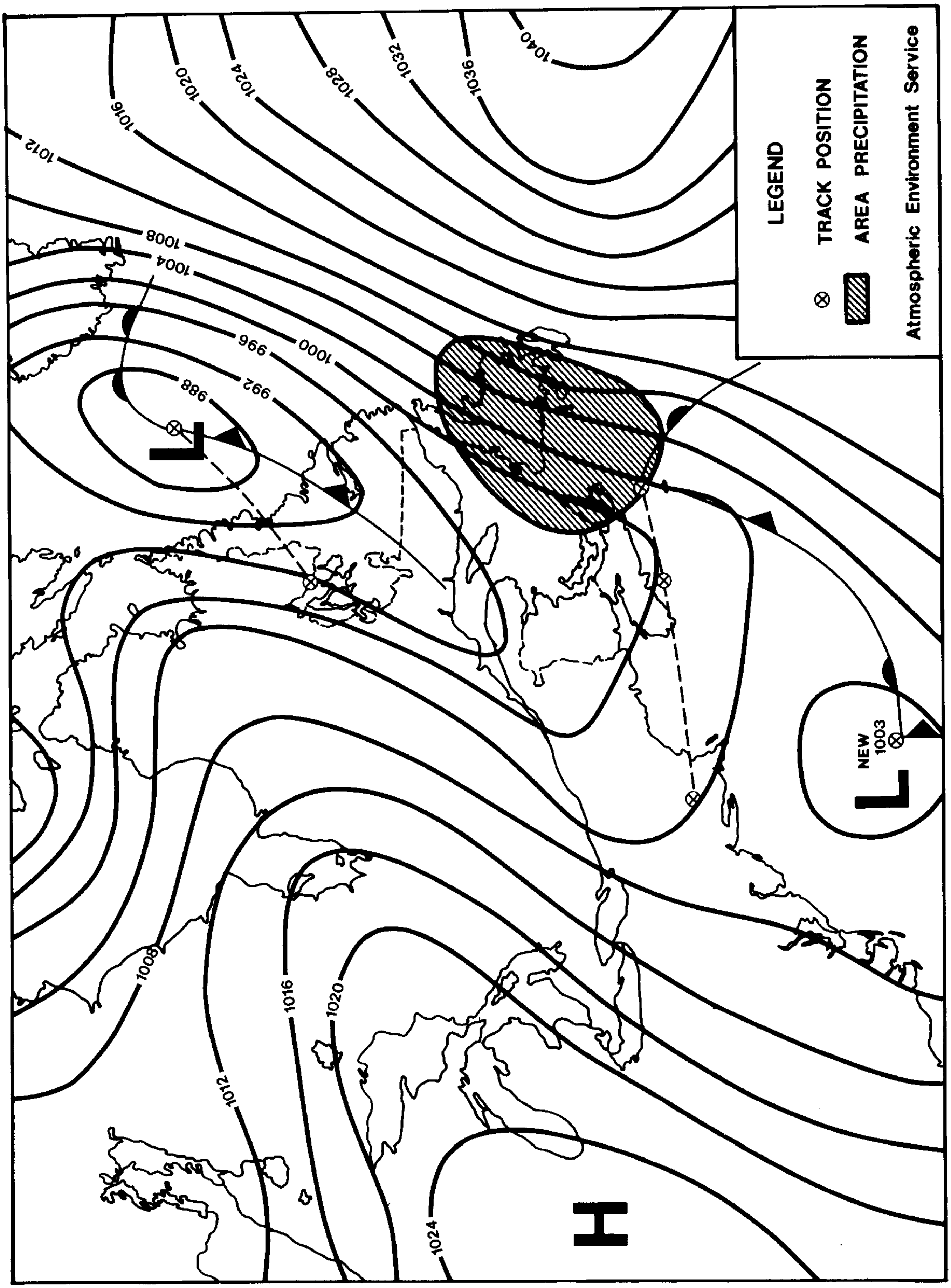



Figure 3.6 Surface Analysis, January 12, 1983, 1200Z, Newfoundland Weather Office

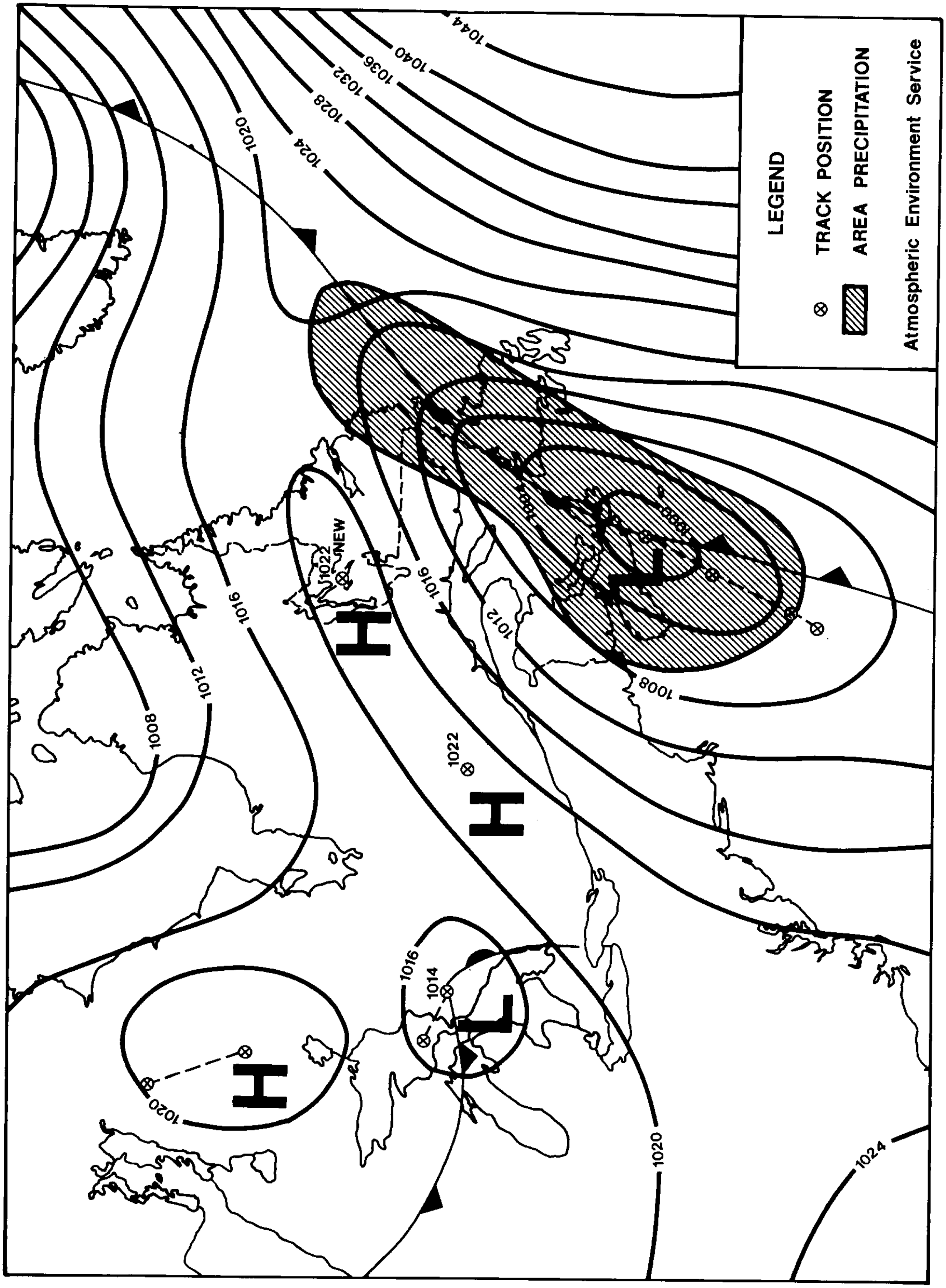



**Figure 3.7 Surface Analysis, January 13, 1983, 1200Z, Newfoundland Weather Office**

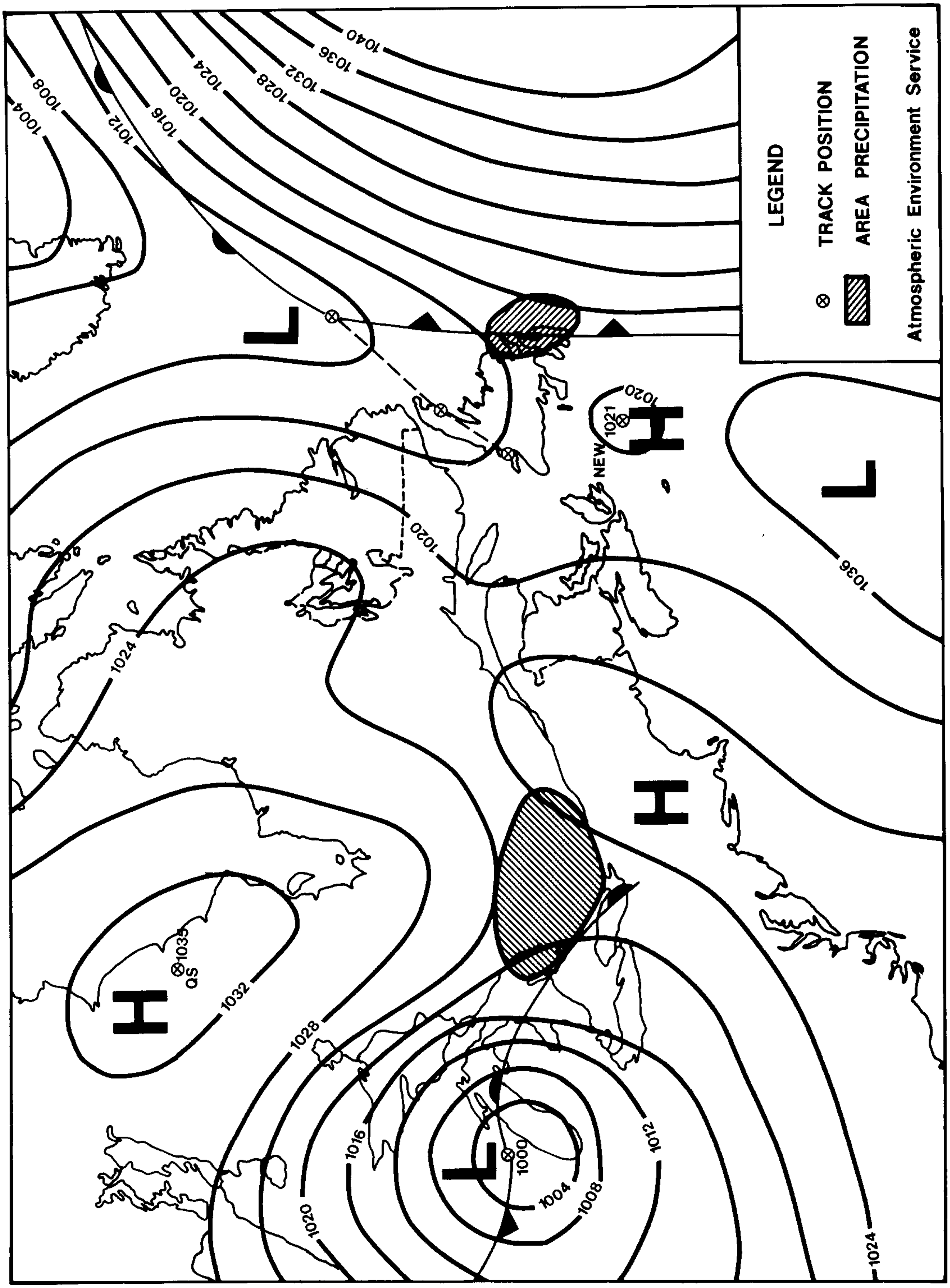



Figure 3.8 Surface Analysis, January 14, 1983, 1200Z, Newfoundland Weather Office

On the 12th, rainfall totals for the day amounted to 116 mm at St. Albans, 113 mm at Bay D'Espoir, 125 mm at Pools Cove and 77 mm at Upper Salmon. On January 13, rain continued unabated and even heavier at some locations. Totals for the day at St. Albans amounted to 141 mm, at Bay D'Espoir 126 mm, at Pools Cove 75 mm and at Upper Salmon 142 mm. Lesser amounts were recorded elsewhere. By mid morning on January 14, except for eastern Newfoundland, precipitation had ended.

The areal distribution of total rainfall for the storm is shown on Figure 3.9. The temporal distribution of rainfall at locations in the Exploits Basin and vicinity, equipped with ordinary rain gauges, is displayed as mass curves on Figure 3.10. Accumulated 6 hourly precipitation amounts are shown in Table 3.2 for selected AES synoptic stations. This information shows that precipitation totals in excess of 100 mm occurred in some watersheds. Also, in excess of 250 mm fell in the vicinity of St. Albans.

The relative magnitude of the storm is investigated by calculating rainfall frequencies at representative stations. Specific period rainfall-intensity-duration frequency data produced by the Atmospheric Environment Service for St. Albans and Burgeo are shown by Tables 3.3 and 3.4. These are areas where some of the heavier rainfalls occurred. Comparison of rainfall intensities during the January storm with these Tables indicates that the 24-hour rainfall return period was near 5 years for Burgeo and 25 years for St. Albans, while the 48 hour rainfall return period was 35 years for Burgeo and in excess of 100 years for St. Albans.

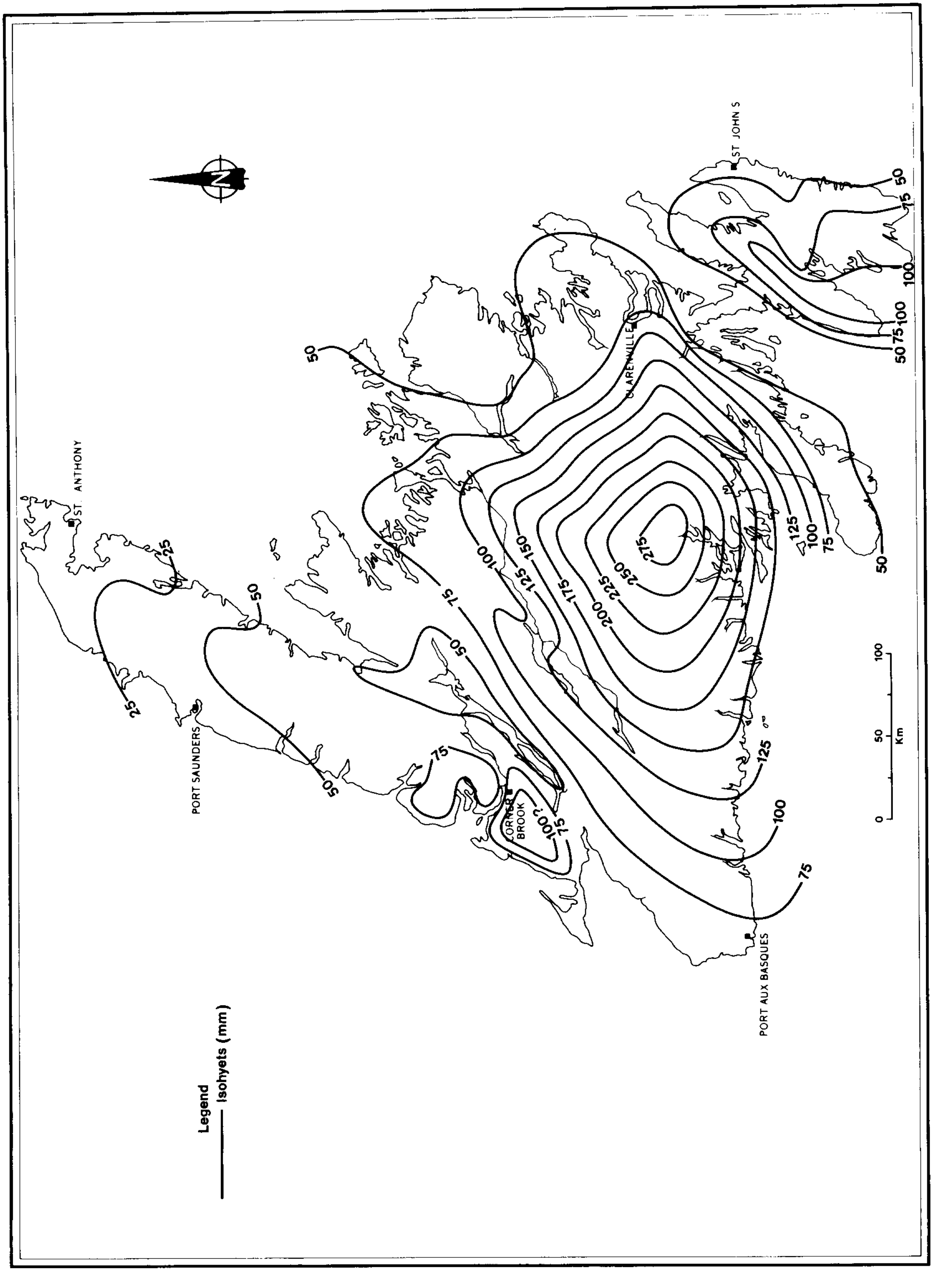



**Figure 3.9 Isohyetal Analysis: Storm of January 11-14, 1983**

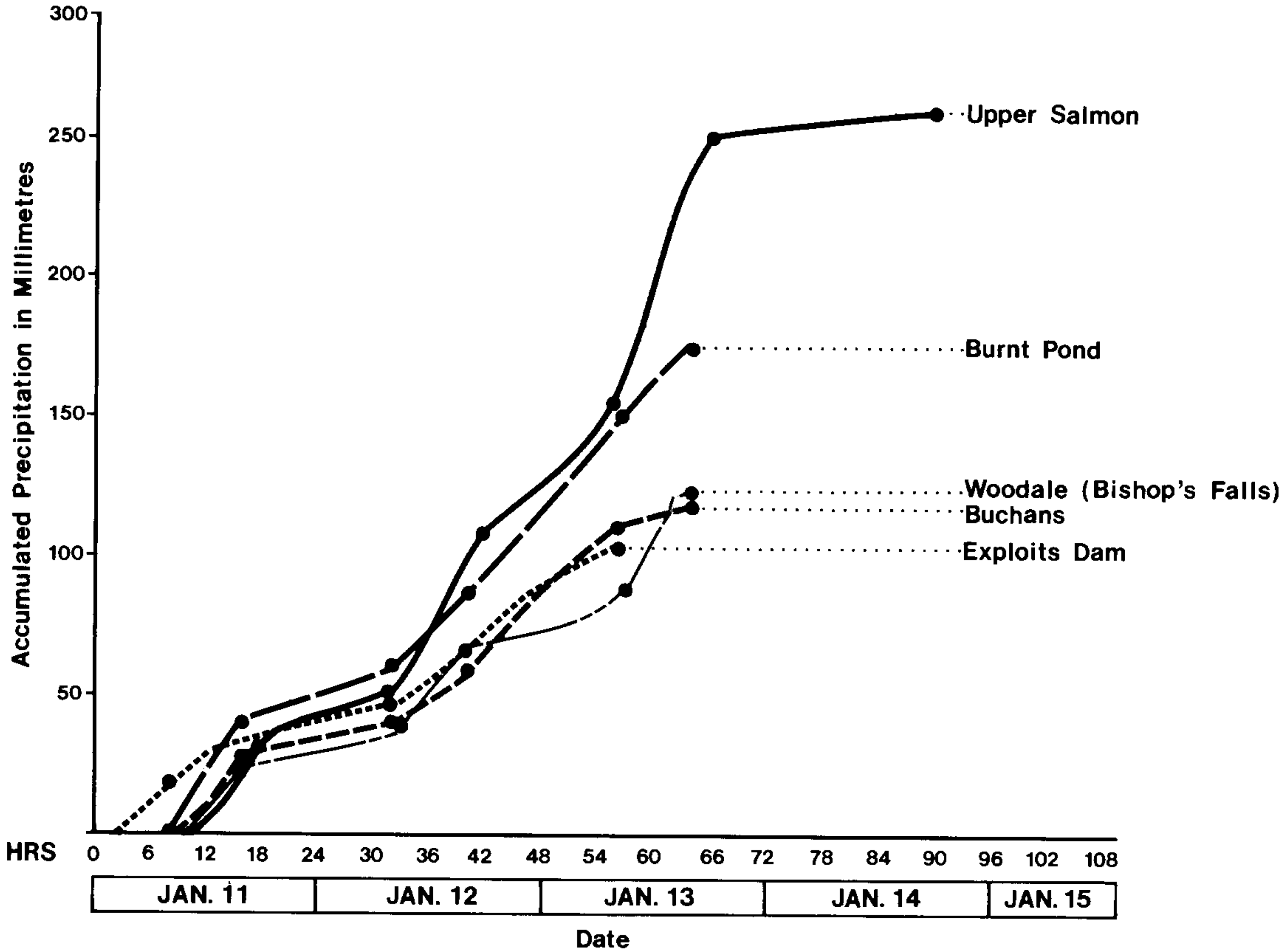



Figure 3.10 Mass Curves of Rainfall

**ACCUMULATED 6-HOURLY PRECIPITATION IN MILLIMETRES**

**AT SELECTED METEOROLOGICAL STATIONS IN NEWFOUNDLAND**

DATE
TIME

| STATION | JAN. 10 | JANUARY 11 | | | | JANUARY 12 | | | | JANUARY 13 | | | | JANUARY 14 | | | | JANUARY 15 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 18:24 | 00:06 | 06:12 | 12:18 | 18:24 | 00:06 | 06:12 | 12:18 | 18:24 | 00:06 | 06:12 | 12:18 | 18:24 | 00:06 | 06:12 | 12:18 | 18:24 | 00:06 | 06:12 | 12:18 |
| Daniel's Harbour | 2.0* | 0.2* | 0.2* | 0.0 | 0.0 | 6.8 | 7.4 | 10.6 | 3.8 | 0.0 | 3.0 | 6.8 | 1.0 | 3.0 | 1.6** | 0.2* | TR* | 0.2* | 0.6* | TR* |
| Stephenville | TR* | 0.0 | 0.0 | 0.3* | 0.0 | 8.4 | 7.0 | 4.4 | 1.8 | 3.8 | 16.0 | 16.7 | 0.8 | 0.6 | TR* | TR* | TR* | TR* | 0.0 | TR* |
| Port-aux-Basques | 0.0 | 0.0 | 0.0 | TR | TR | 9.8 | 15.0 | 6.7 | 0.5 | 9.2 | 18.8 | 12.4 | 0.2 | 0.2* | TR* | TR* | TR* | 0.0 | 0.0 | 0.0 |
| Deer Lake | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 4.2 | 7.8 | 1.4 | 3.2 | 19.2 | 14.2 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | TR* | TR* |
| St. Albans | 0.0 | 0.0 | TR* | TR* | 0.0 | 0.2 | 29.2 | 30.8 | 41.6 | 14.8 | 49.6 | 17.4 | 40.4 | 33.6 | TR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Burgeo | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.8 | 17.4 | 16.4 | 0.6 | 5.1 | 38.2 | 40.8 | 4.2 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Gander | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 8.4 | 3.8 | 1.8 | 13.0 | 2.2 | 3.2 | 9.8 | 0.4 | 0.0 | TR* | 0.4* | 5.4* | 0.2* |
| St. Lawrence | 0.0 | 0.0 | TR* | TR* | 0.0 | 0.0 | 0.0 | 6.4 | 4.6 | 19.8 | 0.4 | 0.0 | 1.2 | 8.6 | 0.4 | 0.0 | 0.0 | TR** | TR* | 0.0 |
| Argentia | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 6.8 | 5.0 | 0.3 | 0.0 | 0.0 | 3.0 | 4.4 | 0.6 | 3.8 | 17.** | 4.2** | 1.0* |
| St. John's | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | TR | 5.0 | 2.2 | TR | 0.0 | TR | TR | 4.8 | 6.4 | 11.6 | 7.4 | 13.** | 10.2* |

NOTE: All times are GMT.
* Denotes water equivalent of snow.
** Denotes water equivalent of rain and/or freezing rain and/or snow.
TR Denotes Trace

**TABLE 3.2**

RAINFALL INTENSITY - DURATION FREQUENCY ANALYSIS

ST. ALBANS

Return period Rainfall Amounts (mm)

| Duration | Return Period | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 yrs. | 5 yrs. | 10 yrs. | 25 yrs. | 50 yrs. | 100 yrs. | Years of Record |
| 6 hrs. | 47.82 | 53.70 | 57.61 | 62.53 | 66.17 | 69.80 | 12 |
| 12 hrs. | 65.20 | 78.47 | 87.28 | 98.39 | 106.62 | 114.81 | 12 |
| 1 day | 89.42 | 110.10 | 123.82 | 141.13 | 153.97 | 166.73 | 14 |
| 2 days | 94.11 | 119.67 | 136.63 | 158.02 | 173.89 | 189.66 | 14 |
| 3 days | 105.47 | 131.21 | 148.29 | 169.83 | 185.81 | 201.70 | 14 |
| 4 days | 115.59 | 140.98 | 157.83 | 179.08 | 194.84 | 210.51 | 14 |

TABLE 3.3

RAINFALL INTENSITY - DURATION FREQUENCY ANALYSIS

BURGEO

Return period Rainfall Amounts (mm)

| Duration | Return Period | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 yrs. | 5 yrs. | 10 yrs. | 25 yrs. | 50 yrs. | 100 yrs. | Years of Record |
| 6 hrs. | 50.07 | 60.40 | 67.25 | 75.90 | 82.31 | 88.69 | 14 |
| 12 hrs. | 62.09 | 74.07 | 82.01 | 92.04 | 99.47 | 106.86 | 14 |
| 1 day | 77.77 | 89.31 | 96.97 | 106.62 | 113.78 | 120.90 | 17 |
| 2 days | 91.15 | 108.33 | 119.73 | 134.11 | 144.77 | 155.37 | 17 |
| 3 days | 101.10 | 122.24 | 136.27 | 153.97 | 167.09 | 180.14 | 17 |
| 4 days | 111.37 | 136.72 | 153.54 | 174.75 | 190.47 | 206.11 | 17 |

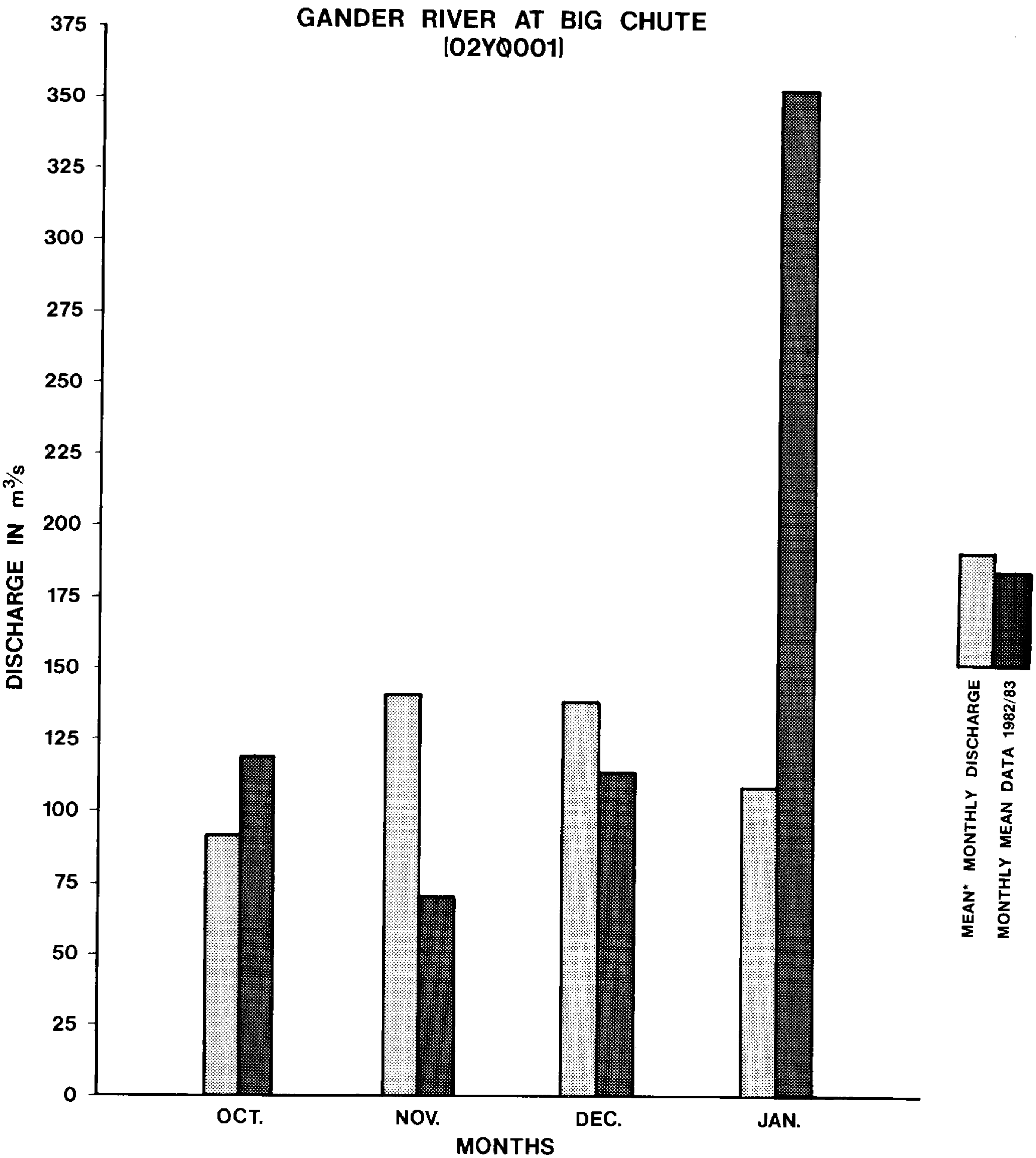
**TABLE 3.4**

## 4. PROGRESS OF THE FLOOD

It was pointed out in the preceding chapter that the snowcover conditions throughout Central Newfoundland were slightly above normal for early January. Streamflow conditions throughout Central Newfoundland prior to the storm were below normal. A comparison of the historical mean monthly flows recorded at the Gander River and the Exploits River streamflow gauges with the monthly means for October 1982 to January 1983 supports this statement. These comparisons are shown in Figures 4.1 and 4.2. Natural and man-made storage areas in the central part of the Island were also at low levels.

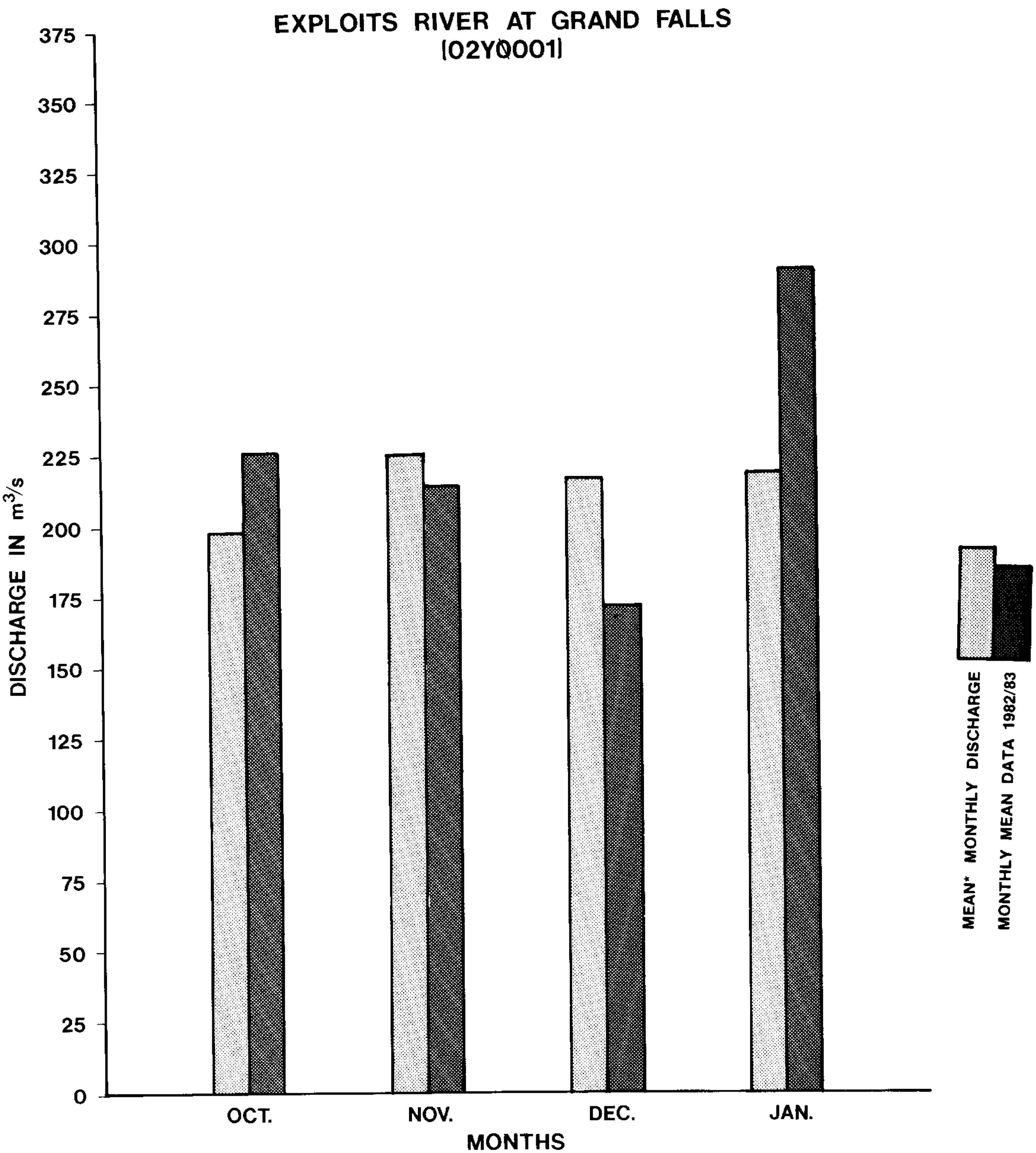
Hydrometric stations selected for study are displayed in Figure 4.3. Hydrographs of hourly discharges recorded at the Exploits and Gander River gauges are shown on Figures 4.4 to 4.5 respectively. The maximum instantaneous discharge recorded on the Exploits River below Stony Brook was 2400 $m^3/s$. This value is 68% greater than the previous record discharge set in 1969. On the Gander River at Big Chute, the maximum instantaneous discharge recorded was 47% greater than the value recorded in 1964.

The plotted hourly discharge data further illustrate that streamflow conditions were low prior to the flood. Most streams reached their peak discharge on January 14 and 15. The progression of the time of recorded peak flows moved from southwest to northeast, following the storm movement.




NOTE: MEAN* IS CALCULATED USING MONTHLY MEAN DATA FROM 1949-1982

Figure 4.1 Comparison of 1982/83 Monthly Mean Flows with Long Term Mean* Monthly Flows




NOTE: MEAN* IS CALCULATED USING MONTHLY MEAN DATA FROM 1962-1982

Figure 4.2 Comparison of 1982/83 Monthly Mean Flows with Long Term Mean* Monthly Flows

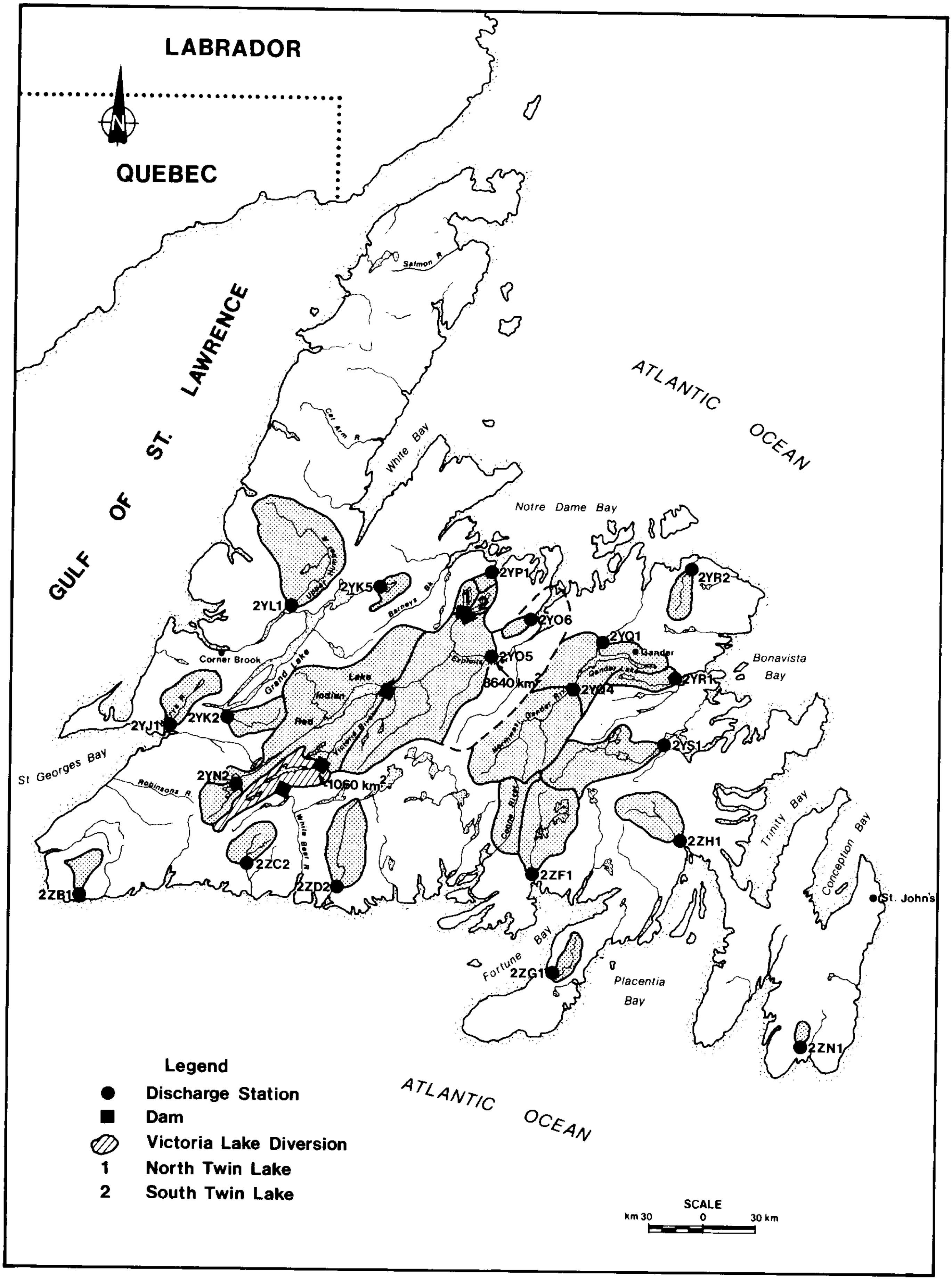



**Figure 4.3 Locations of Hydrometric Stations**

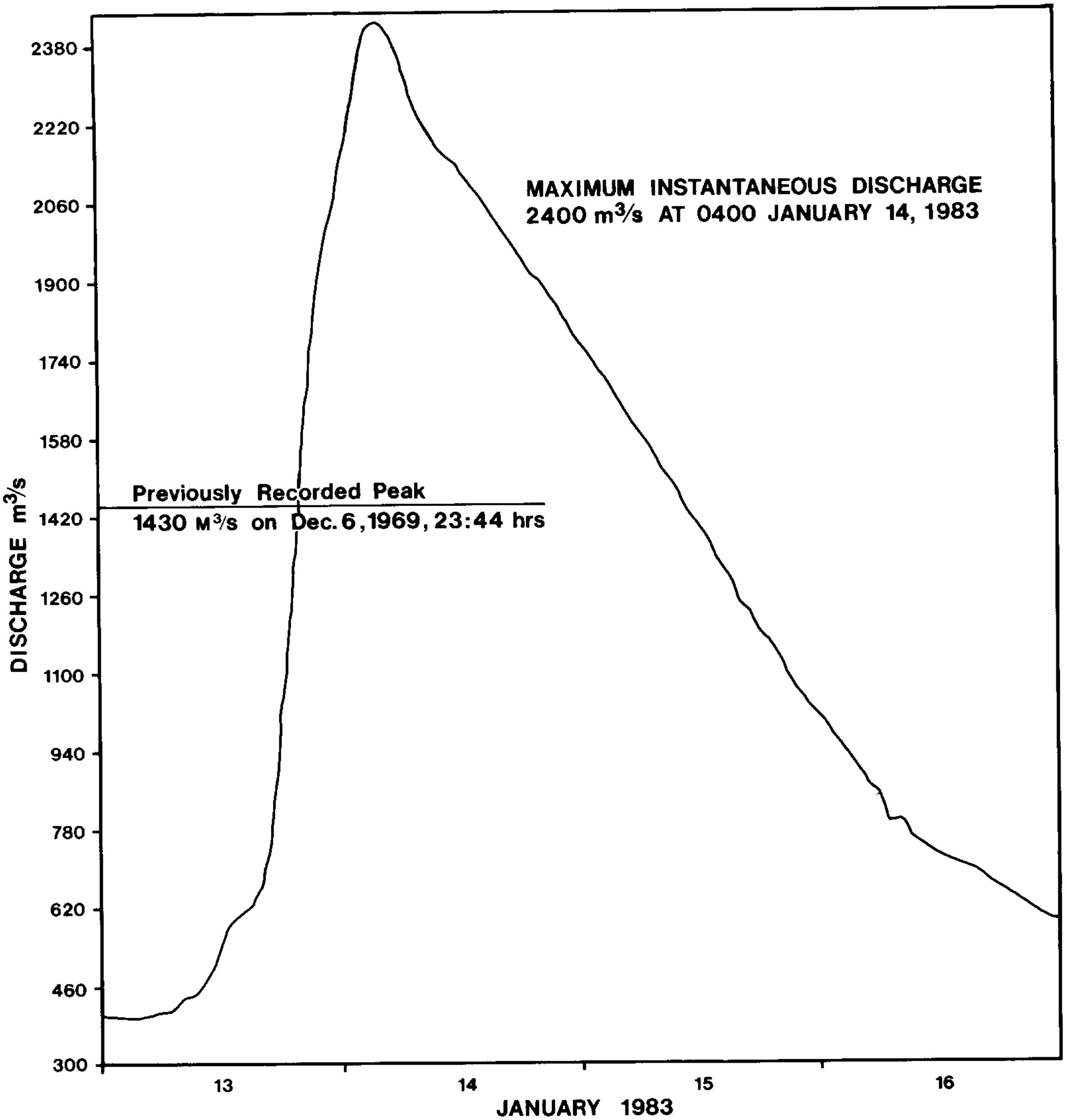



Figure 4.4 Hourly Hydrograph, Exploits River Below Stony Brook 02YØ005

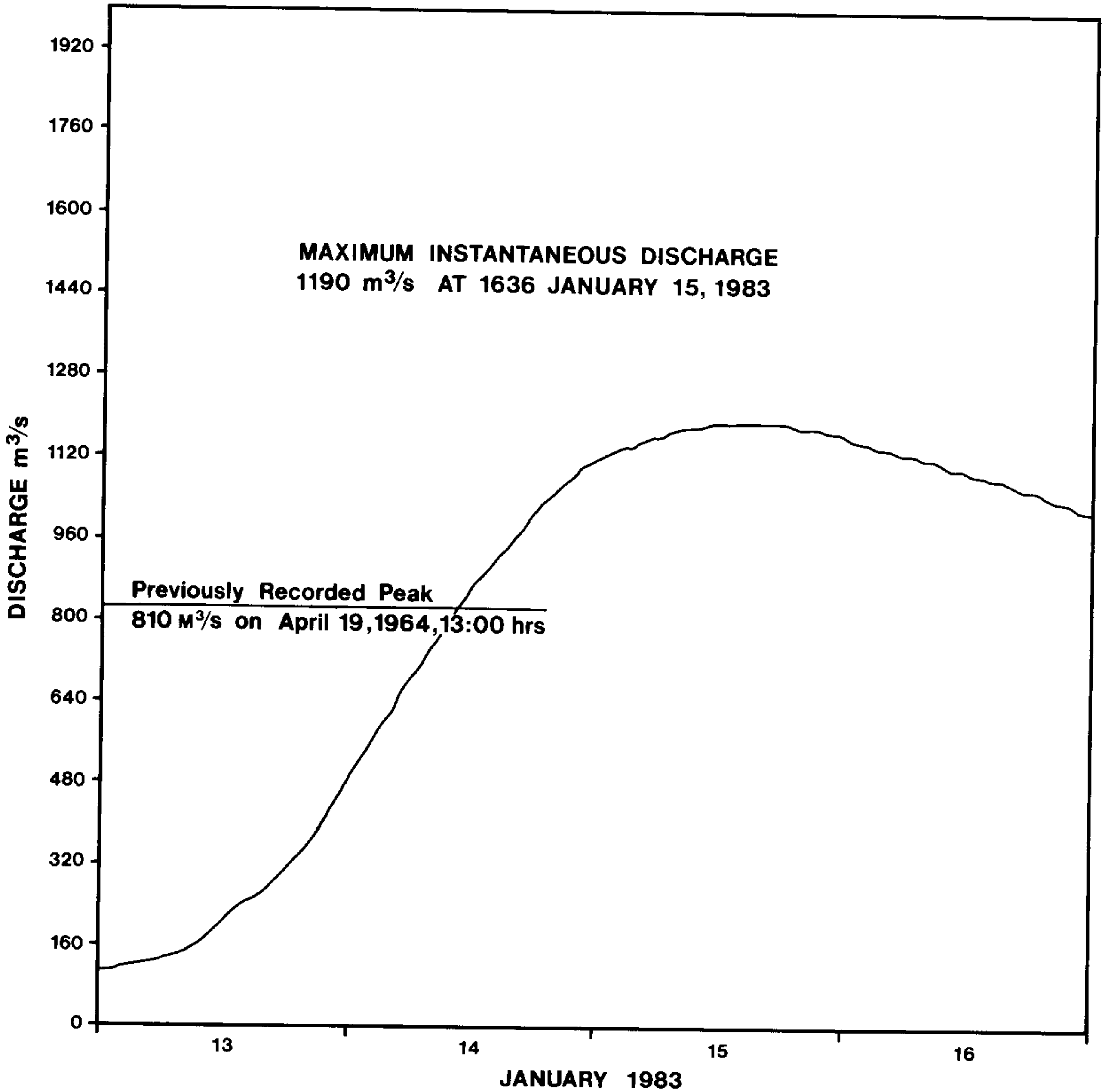



Figure 4.5 Hourly Hydrograph, Gander River at Big Chute 02YQ001

# 5. FLOOD MAGNITUDES

This chapter presents an analysis of the peak discharges observed as a result of the rainstorm, their estimated frequency of occurrence, the runoff volumes involved, and a comparison of the magnitude of the 1983 flood with past flood magnitudes.

## 5.1 Peak Discharges

Maximum instantaneous discharges recorded at selected gauging stations are given in Table 5.1. The maximum instantaneous discharge for the period of record prior to 1983 is included in Table 5.1 for comparative purposes.

The maxima of record were equalled or exceeded at most hydrometric stations in Central Newfoundland. Elsewhere in the western, northwestern and eastern basins, flood discharges were much less than the previously recorded maximum instantaneous discharges.

The maximum instantaneous discharge per unit of drainage area is also shown in Table 5.1. These maximum unit discharge values are useful for comparison with past flows in the same basin or in other basins, but the relative drainage area sizes must be considered when comparing large to small basins.

## 5.2 Flood Frequencies

The most widely accepted measure of the severity of a flood is its frequency expressed by a recurrence interval (or return period) in years. In order to estimate the recurrence interval of the January 1983 flood, frequency analyses were done for selected hydrometric stations with ten or more years of record. It was not the objective of this study

## SUMMARY OF PEAK DISCHARGES AT VARIOUS STREAM GAUGING STATIONS ON THE ISLAND OF NEWFOUNDLAND

| Station | Number | Drainage Area ($km^2$) | Period of Record | Number of Peaks Available | Maximum Instantaneous Discharge prior 1983 | | Maximum Instantaneous Discharge (January 1983) | | | Unit Discharge ($m^3/s/km^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Date | ($m^3/s$) | Date | Time* | ($m^3/s$) | |
| Harrys R. | 02YJ001 | 640 | 1968-83 | 14 | Aug 3/73 | 688 | Jan 13 | 1751 | 306 | 0.478 |
| Lewaseechjeech R. | 02YK002 | 470 | 1952-67, 1972-83 | 22 | Apr 30/82 | 169 | Jan 14 | 1800 | 146 | 0.311 |
| Upper Humber R. | 02YL001 | 2110 | 1928-83 | 55 | May 23/69 | 858 | Jan 15 | 0830 | 680 | 0.322 |
| Lloyds R. | 02YN002 | 469 | 1981-83 | 3 | May 1/82 | 210 | Jan 14 | 0926 | 305** | 0.650 |
| Exploits R. (Reg.) | 02YØ005 | 8640 | 1968-83 | 12 | Dec 6/69 | 1430 | Jan 14 | 0400 | 2400** | 0.533 |
| Peters R. | 02YØ006 | 177 | 1981-83 | 3 | Apr 23/82 | 42.2 | Jan 14 | 1310 | 152** | 0.859 |
| Shoal Arm Bk. | 02YP001 | 63.8 | 1982-83 | 2 | Apr 29/82 | 29.8 | Jan 14 | 0409 | 65.0** | 1.020 |
| Gander R. | 02YQ001 | 4400 | 1949-83 | 34 | Apr 19/64 | 810 | Jan 15 | 1636 | 1190** | 0.270 |
| Middle Bk. | 02YR001 | 267 | 1959-83 | 20 | Mar 6/62 | 50.7 | Jan | N/A | 32.6 | 0.122 |
| Terra Nova R. | 02YS001 | 1290 | 1951-83 | 30 | Apr 20/64 | 255 | Jan 16 | - | 355(E) | 0.215 |
| Isle aux Morts R. | 02ZB001 | 205 | 1962-83 | 22 | Dec 16/68 | 609 | Jan 13 | 1229 | 310 | 1.510 |
| Grey R. | 02ZD002 | 1340 | 1969-71, 1975-83 | 5 | Nov 6/80 | 850 | Jan 13 | 2156 | 1840** | 1.370 |
| Bay du Nord R. | 02ZF001 | 1170 | 1950-83 | 31 | Jan 16/78 | 348 | Jan 14 | 0258 | 635** | 0.543 |
| Garnish R. | 02ZG001 | 205 | 1958-83 | 25 | Feb 13/62 | 144 | Jan 14 | 2246 | 41.9 | 0.204 |
| Pipers Hole R. | 02ZH001 | 764 | 1952-83 | 31 | Apr 18/64 | 377(E) | Jan 13 | 0906 | 300 | 0.393 |
| Northwest Bk. | 02ZN001 | 53.3 | 1966-83 | 17 | Aug 8/70 | 57.2 | Jan 15 | 1443 | 42.2 | 0.792 |

* Time given is Newfoundland Standard Time (NST).
** The January 1983 Flow is the highest on record.
(E) Estimated.
Reg. denotes a regulated Basin
N/A Not available due to clock stoppage.
NOTE: (1) The Exploits River value of 2400 $m^3/s$ is the flow from below the dam at Red Indian Lake, a drainage area of 4500 $km^2$.
(2) Lewaseechjeech River maximum instantaneous value is not the instantaneous for the year. Maximum instantaneous, 177 $m^3/s$ at 1310 NST on August 8, 1984.

TABLE 5.1

to present a regional flood frequency analysis since such analyses have already been carried out in recent years for the area under consideration (6,7).

The frequency analyses were performed using annual maximum instantaneous flows and the computer program FDRPFFA (10). The analyses used the Three Parameter Log Normal (3LN) distribution with parameters estimated using the maximum likelihood method. The 3LN distribution was selected on the basis of a comparison of the sample or transformed sample statistics with the theoretical distribution statistics, and to be consistent with other recent investigations (7).

The data sets were checked for high and low outliers, through the use of the computer program OUTLIER (11). The data set used was similar to that used in the Regional Flood Frequency Study (7) plus the 1983 data; also all data were previously screened for independence, randomness and homogeneity.

The data sets for hydrometric stations on the Gander, Bay du Nord and Exploits Rivers have high outliers. All high outliers occurred as a result of the January 1983 flood. The data set for the gauges on the Gander and Terra Nova Rivers contained a low outlier.

When high outliers are detected in any time series of data, they should be investigated for accuracy and supporting historic information. If the high outlier is accurate and occurred previous to the latest concurrent period of record, the analyses may be made using program ISTORIC (15). If accurate and within the present concurrent period of record, the outlier should be retained and program FDRPFFA (10,11) may be used. No historic information was used in any of the frequency analyses. For the Gander River where both high and low outliers have been identified (11), and the Terra Nova River where a low outlier was identified, the frequency analysis performed was from Program LOWOUT (12), where a conditional probability function is used.

The resulting flood frequency curves for selected hydrometric stations are shown in Figures 5.1 to 5.7. A frequency analysis for the Exploits River was not attempted, since the Exploits River is significantly affected by regulation. Naturalizing of the flows is necessary to remove the effects of regulation. Also, the gauged discharge during this flood for the Exploits River represents only the runoff from the drainage area below the dam at Red Indian Lake. The runoff from the drainage area above the dam was stored and did not contribute to the flood.

The results of a preliminary frequency analysis of the regulated flow recorded at the hydrometric station below Stony Brook indicated that the flood flow in the Exploits River had a return period of about 500 years (Government of Newfoundland and Labrador, Department of Environment, 1983). The estimates of flows for various return periods based on the regional equations, shown in Table 5.2, support the results of the preliminary analysis. The flow in the Exploits River was extremely high considering the fact that only half of the basin contributed to this flow. It would have been a disaster of much higher magnitude if the entire basin would have contributed to this flow. Figure 5.8 is presented to show the 1983 annual maximum instantaneous flow relative to the period of record flows. The relative magnitude of the 1983 flow is obvious.

The frequency analyses are summarized in Table 5.2. The table shows the estimated recurrence interval of the annual maximum instantaneous discharge which occurred in January 1983. The estimated recurrence

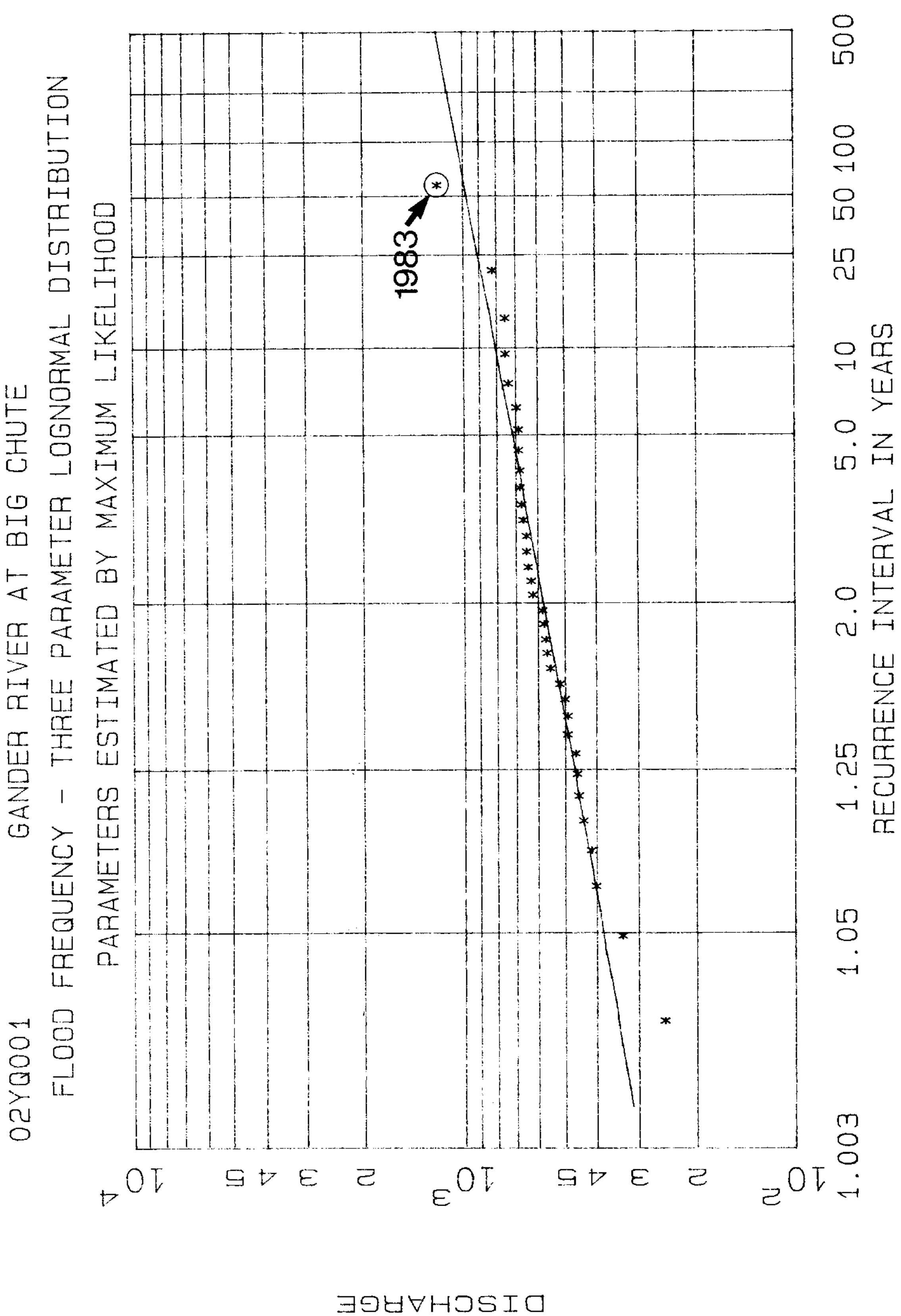



**Figure 5.1 Annual Maximum Instantaneous Flow Frequency Curve**

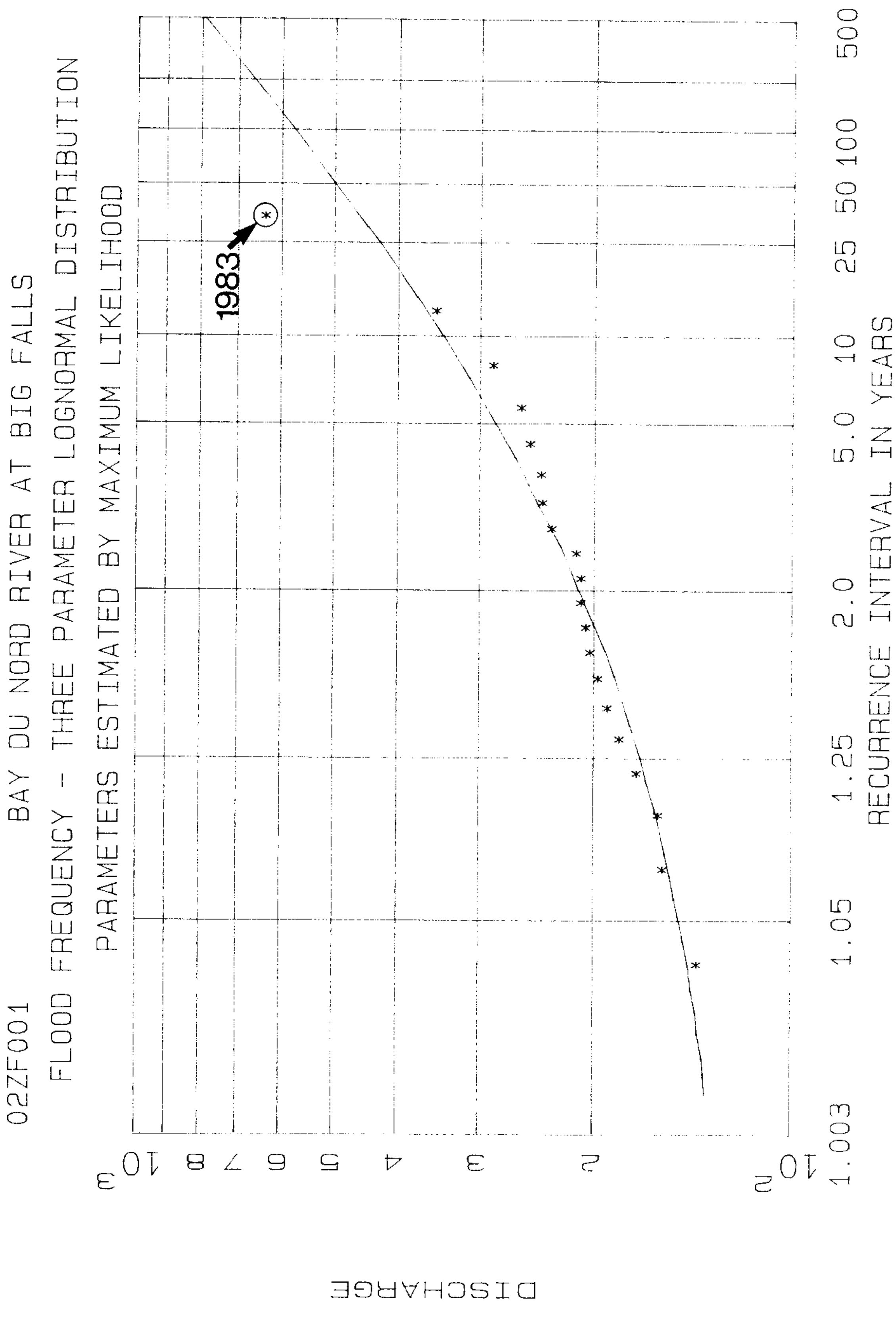



**Figure 5.2 Annual Maximum Instantaneous Flow Frequency Curve**

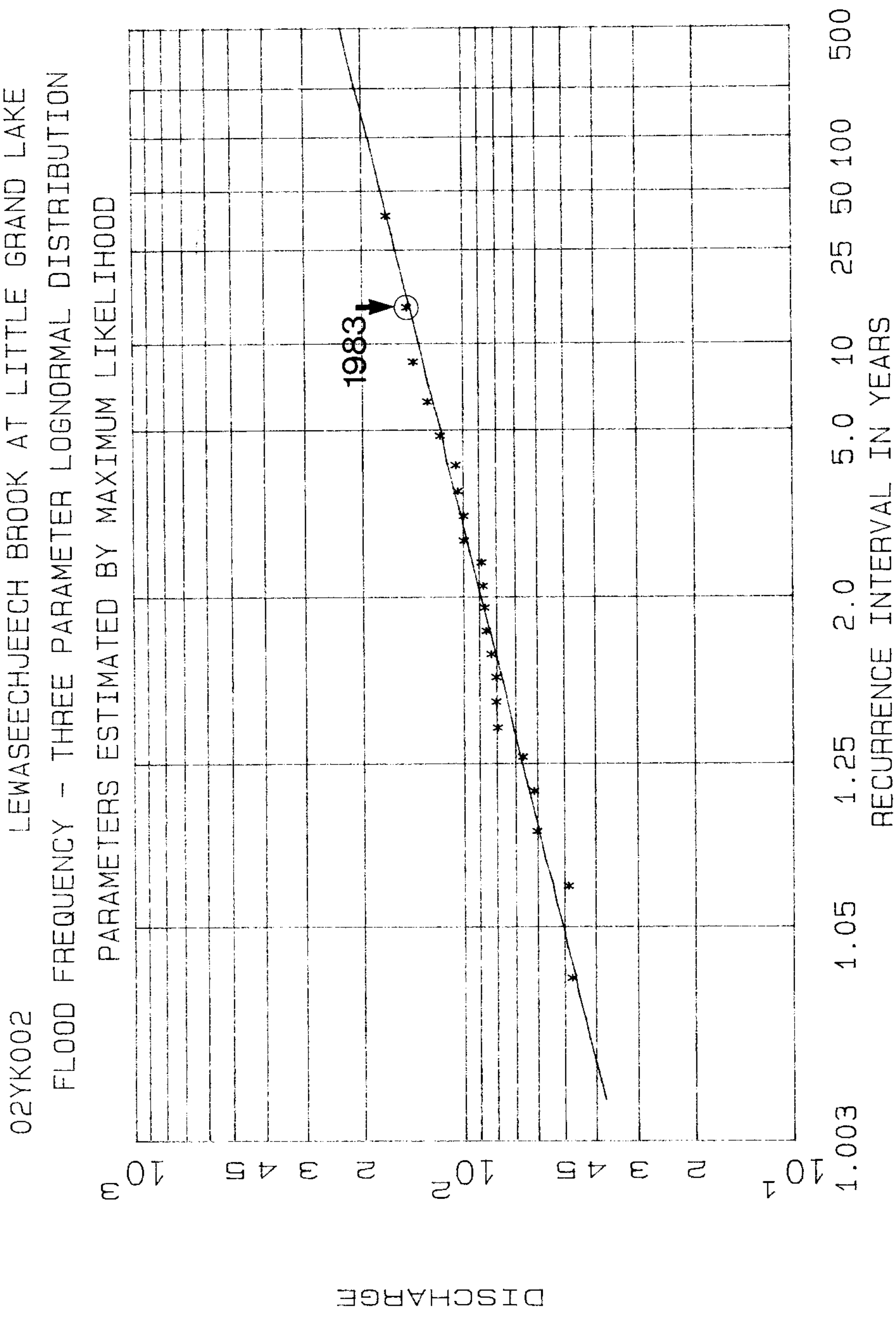



**Figure 5.3 Annual Maximum Instantaneous Flow Frequency Curve**

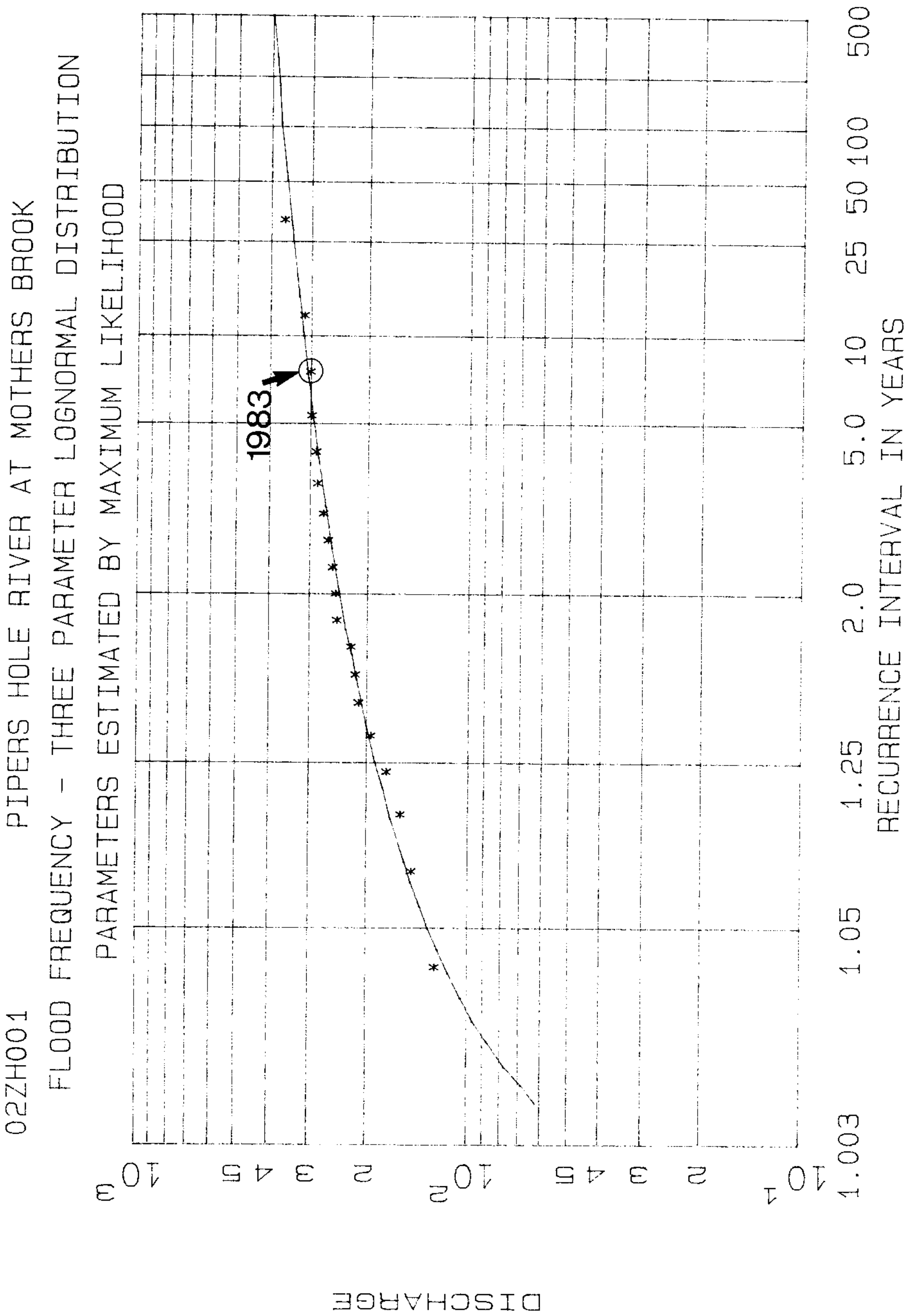



**Figure 5.4 Annual Maximum Instantaneous Flow Frequency Curve**

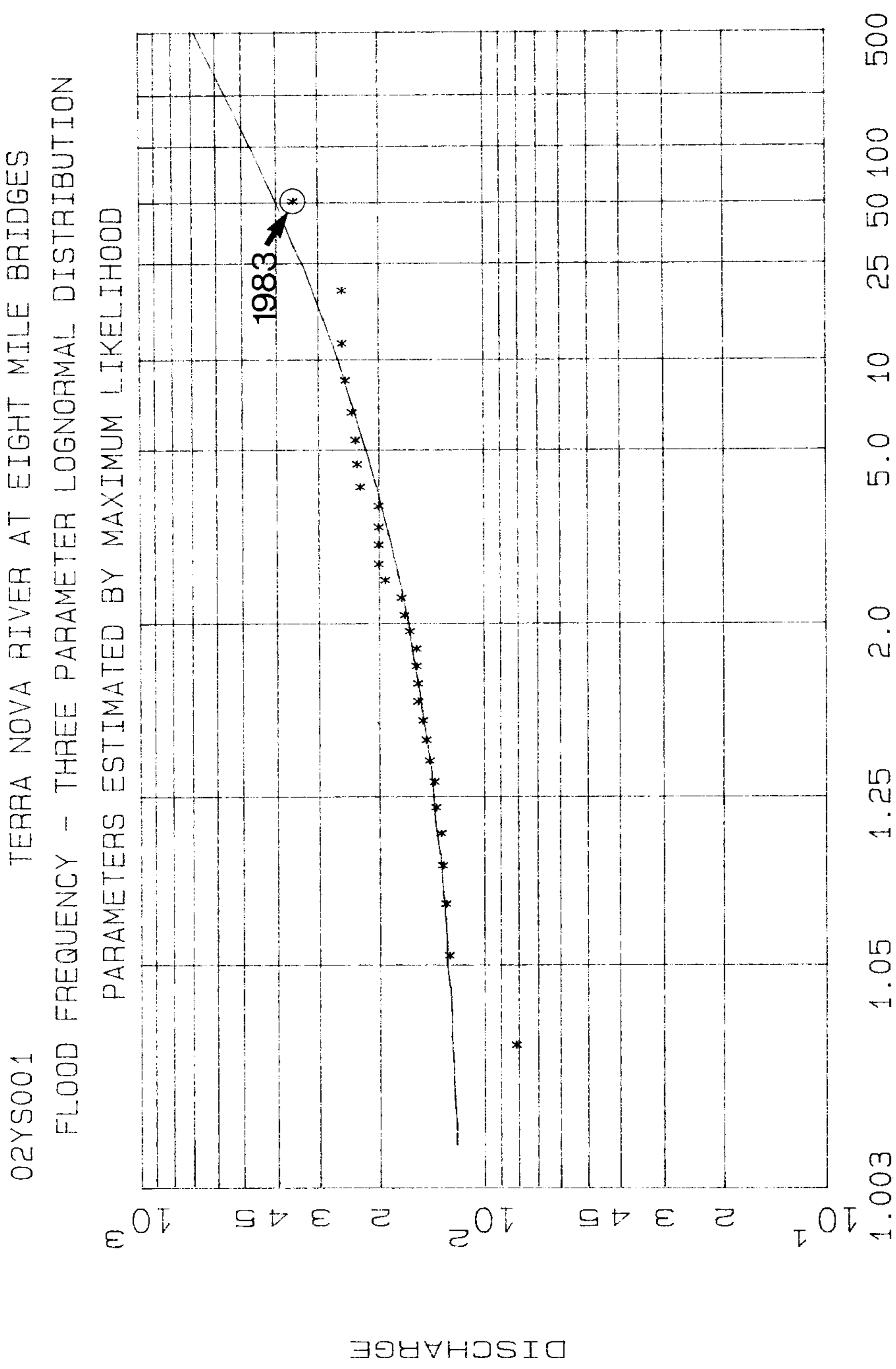



**Figure 5.5 Annual Maximum Instantaneous Flow Frequency Curve**

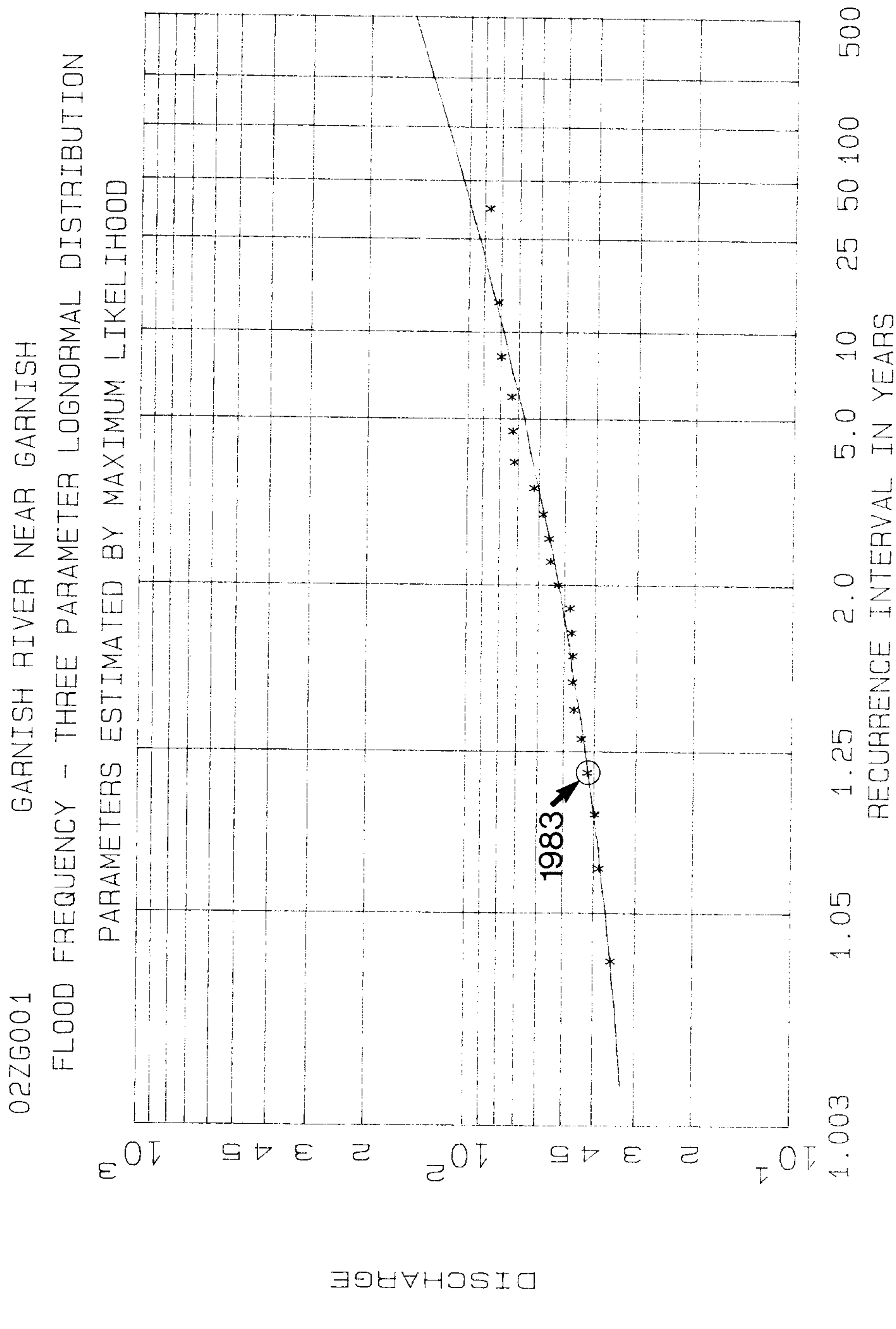



**Figure 5.6 Annual Maximum Instantaneous Flow Frequency Curve**

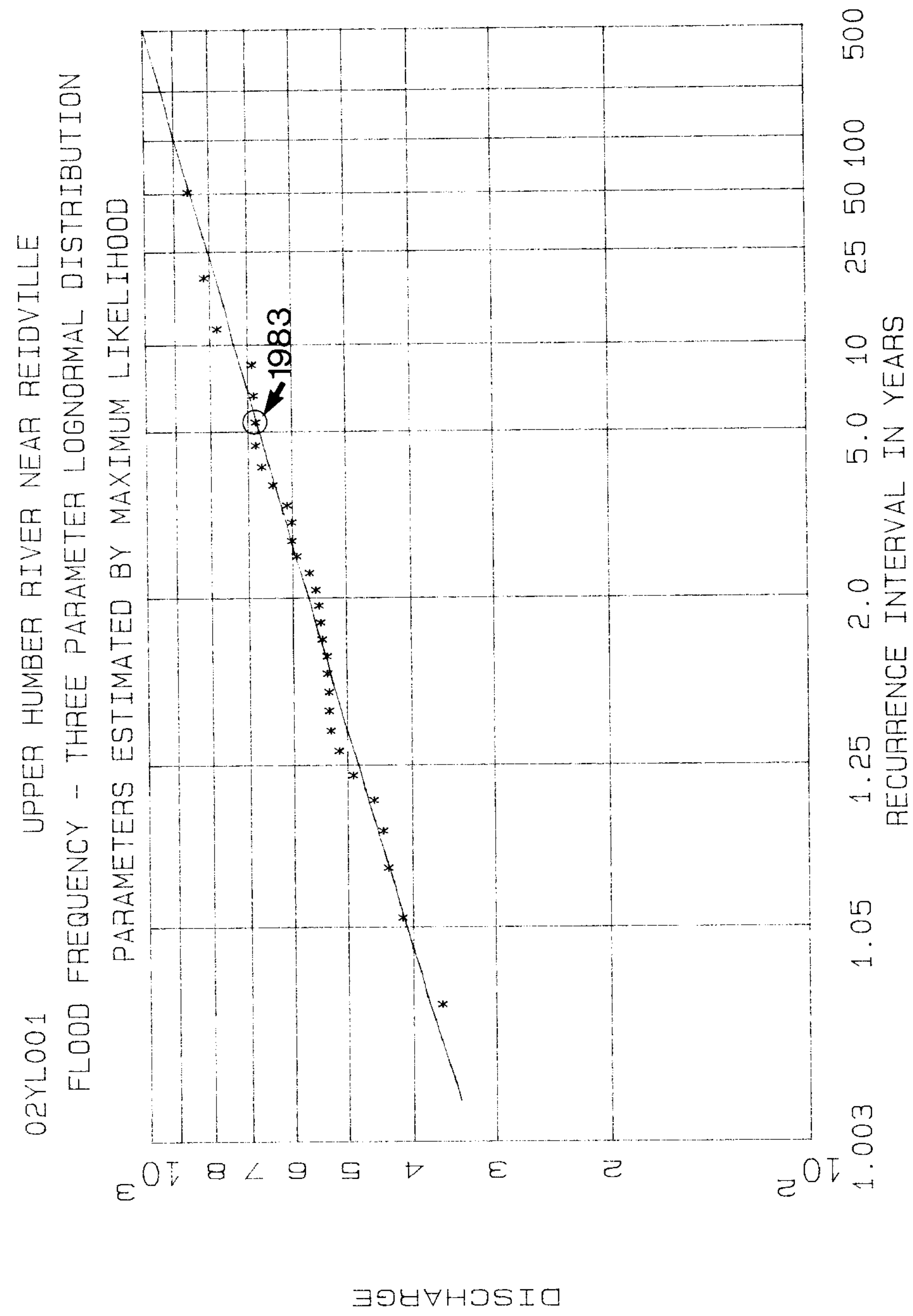



**Figure 5.7 Annual Maximum Instantaneous Flow Frequency Curve**

# ANNUAL MAXIMUM INSTANTANEOUS FLOWS, EXPLOITS RIVER BELOW STONY BROOK

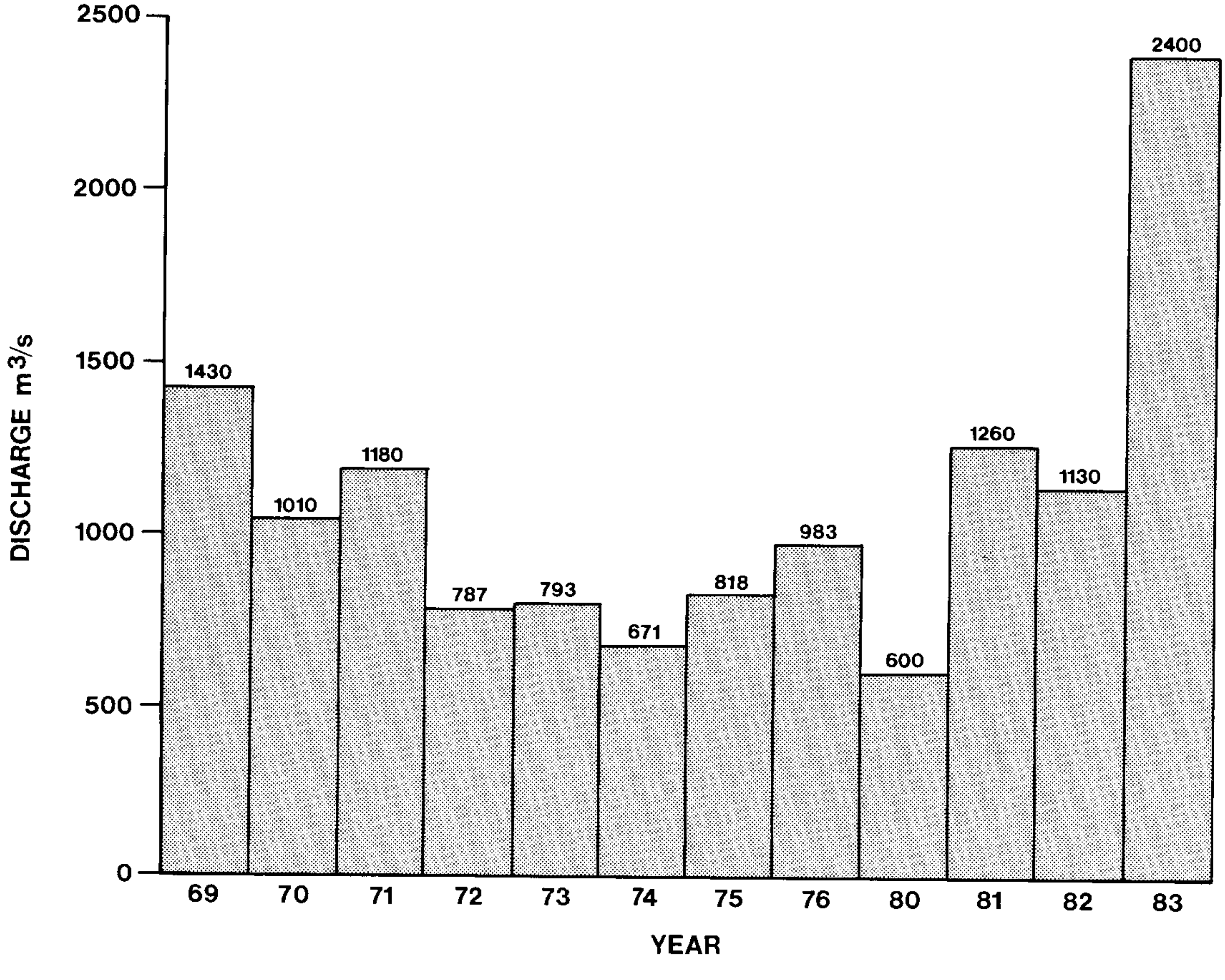



Figure 5.8 Annual Maximum Instantaneous Flows, Exploits River Below Stony Brook

interval is up to 200 years for the Bay du Nord River, while the flow recorded on the Gander River has a return period of up to 500 years. However, in the eastern and western basins, the recurrence interval drops to ten years or less for most hydrometric stations shown in Table 5.2.

Estimated 1:10, 1:100 and 1:500 year recurrence interval maximum instantaneous flows resulting from the single station frequency analyses are also presented in Table 5.2. The values shown for the Exploits River are estimated using updated (to include 1983 data) regional flood frequency regression equations found in reference 7. The values shown for the Exploits River are for the entire drainage area, above and below the Exploits Dam, to the hydrometric gauging station. Even though the drainage area parameter used in the regional flood frequency regression equations is outside the recommended range, the equations produced comparable results with a large basin in western Newfoundland, also having the drainage area parameter outside the recommended range. The flow estimated for a return period of up to 500 years is 2550 $m^3/s$. The flow recorded during the flood was up to 2400 $m^3/s$. This resulted from only 50% of the drainage area!

The return periods of flows from the area below Red Indian Lake were calculated using the regression equations. The physiographic parameter values used to solve the equation were: drainage area, 4500 $km^2$; mean annual runoff for the drainage area, 731mm; and the latitude of the centroid of the drainage area, $48.8^0$. The resulting 1:500 year return period flow was calculated to be 860 $m^3/s$. Again, comparing the recorded flow of 2400 $m^3/s$ to this calculated value, it is readily concluded that the return period of flows produced from the drainage area below Red Indian Lake is well in excess of 500 years. A specific return

**FLOOD FREQUENCY ANALYSIS FOR SELECTED STATIONS ON THE ISLAND OF NEWFOUNDLAND**

| Station | Number | No. of Peaks Used | Discharge ($m^3/s$) | | | Maximum Instantaneous Discharge January 1983 | |
|---|---|---|---|---|---|---|---|
| | | | Q10 | Q100 | Q500 | Discharge ($m^3/s$) | Recurrence Interval (years) |
| Harrys River | 02YJ001 | 14 | 518 | 790 | 995 | 306 | 1.25 to 2 |
| Lewaseechjeech R. | 02YK002 | 22 | 136 | 192 | 231 | 146 | 10 to 20 |
| Upper Humber River | 02YL001 | 30 | 734 | 898 | 998 | 680 | 5 to 10 |
| Exploits River | 02YØ005 | 12 | 1830E | 2280E | 2550E | 2400* | -- |
| Gander River | 02YQ001 | 34 | 801 | 1050 | 1210 | 1190* | 500** |
| Terra Nova River | 02YS001 | 30 | 265 | 474 | 685 | 355* | 20 to 50 |
| Isle aux Morts R. | 02ZB001 | 22 | 572 | 796 | 935 | 310 | 1.25 to 2 |
| Bay du Nord River | 02ZF001 | 20 | 341 | 577 | 791 | 635* | 100 to 200 |
| Garnish River | 02ZG001 | 21 | 78.1 | 117 | 148 | 41.9 | 1.05 to 1.25 |
| Pipers Hole River | 02ZH001 | 19 | 320 | 377 | 405 | 300 | 5 to 10 |
| Northwest Brook | 02ZN001 | 17 | 54.1 | 85.2 | 110 | 42.2 | 2 to 5 |

E Estimated using Regional Regression Equations (Values are for entire drainage to gauge).
* The January 1983 Flow is the highest on record.
** Approximately.
Q10 denotes the one in ten year probability discharge.
Q100 denotes the one in one hundred year probability discharge.
Q500 denotes the one in five hundred year probability discharge.
Column 3, No. of Peaks used is consistent with other recent investigations (7) plus the January 1983 data.

NOTES: EXPLOITS RIVER

(1) The peak discharge records are significantly affected by regulation; hence, no recurrence interval quoted.

(2) The value 2400 $m^3/s$ represents the recorded flow from below the dam at Red Indian Lake, drainage area approximately 4500 $km^2$.

**TABLE 5.2**

period is not given because of uncertainties associated with return periods of flows with such rare probabilities. Also, the data base on which the frequency analyses have been based contains only twelve (12) data points which are not considered adequate for this purpose.

## 5.3 Effects of Storage

It is important to consider the effects of storage in discussing the magnitude of the flood. The only gauged river with a major storage reservoir, affected by the storm, is the Exploits River.

The Exploits River drainage area (8640 $km^2$) does not include the Victoria Lake Diversion drainage area (1060 $km^2$). This portion of the Exploits drainage (Victoria Lake) is now diverted to the Bay d'Espoir power development. During the flood, there was no spillage to the Exploits watershed from the Victoria Lake Diversion. Also, North and South Twin Lakes are assumed to have had little effect, due to their small combined storage, on the magnitude of the flood flows in the Exploits River.

Red Indian Lake, the main storage in the Exploits River watershed, controls 4280 $km^2$ (50%) of the area monitored at the hydrometric gauge below Stony Brook. It is the main storage for the Abitibi-Price Plant at Grand Falls. The natural lake outlet upstream of the dam spillway structure takes over at an elevation of 146.6 m. The normal full supply level is at elevation 153.0 m with a calculated live storage of 1,140,000 cubic decametres ($dam^3$). Abitibi- Price has operated the spillway to elevation 153.6 m by stoplogging the spillway structure. The calculated live storage at this elevation is 1,250,000 $dam^3$.

During the January 1983 rainstorm, the Exploits Dam spillway elevation was 148.1 m on January 12, and reached a maximum elevation of

151.7 m on January 22, 1983. All gates were closed from midday January 13 to midday January 19. The change of spillway elevation between January 12 to 22 is 3.618 m. This represents a volume of 645,000 $dam^3$ of runoff, assuming vertical side storage over the Red Indian Lake surface area (193 $km^2$). The volume of runoff as a result of the storm was 589,000 $dam^3$, assuming 100% runoff. The difference in the runoff volumes can be partly explained by the baseflow input to storage. Because the dam was completely closed at the time of the peak, virtually all the runoff resulting from the storm went into storage in Red Indian Lake. Hence, the drainage basin above the Exploits Dam contributed nothing to the streamflow below the dam.

## 5.4 Precipitation and Runoff Volumes

To examine the relationships between the storm rainfall, rapid snowmelt and the resulting runoff, estimates are made of the magnitude of each of these parameters for selected basins affected by the storm. Four basins were selected for this purpose:

(1) The Exploits River from just below the dam at Red Indian Lake down to the hydrometric station below Stony Brook.

(2) Gander River down to the hydrometric station at Big Chute

(3) Bay du Nord River down to the hydrometric station at Big Falls

(4) Conne River down to a point near the highway Bridge. There is no hydrometric gauge on this river.

The amount of rainfall was computed from an isohyetal map, Figure 3.9, for the period January 11 to 14. A similar map, Figure 3.4, was used to estimate snowmelt volumes. Most areas were depleted of snow by day's-end on January 12.

Discharge hydrographs for the three gauged watersheds are shown in Figure 5.9

Comparisons of the calculated direct runoff volumes, determined from the hydrographs, with volumes of rainfall and snowmelt, are shown in Table 5.3. The ratio of runoff to rainfall plus snowmelt is also shown in this table.

The Exploits and Gander River ratios are nearly equal, however, the Bay du Nord River ratio is slightly over 1.0.

## 6. FLOOD WARNING AND EMERGENCY MEASURES

### 6.1 Extent of Flooding

The torrential rainfall and melting snow resulted in severe flooding which caused extensive damage to public and private properties and major inconvenience and dislocation to the affected communities.

Ground transportation came to a virtual standstill in many locations. The Sir Robert Bond Bridge on the Trans Canada Highway was closed to traffic as the Exploits River water level came close to overtopping it (see Photograph 7.1). The closure cut off Grand Falls, Windsor and Bishop's Falls from the rest of the Province. Many surrounding communities were also isolated. A 90 km stretch of the Trans Canada Highway, from Grand Falls to South Brook, was closed when it was flooded with water and ice from overflowing roadside lakes and marshes in intersecting streams and rivers. In some places, about .6 m of water had accumulated and sheets of ice were coming onto the highway.

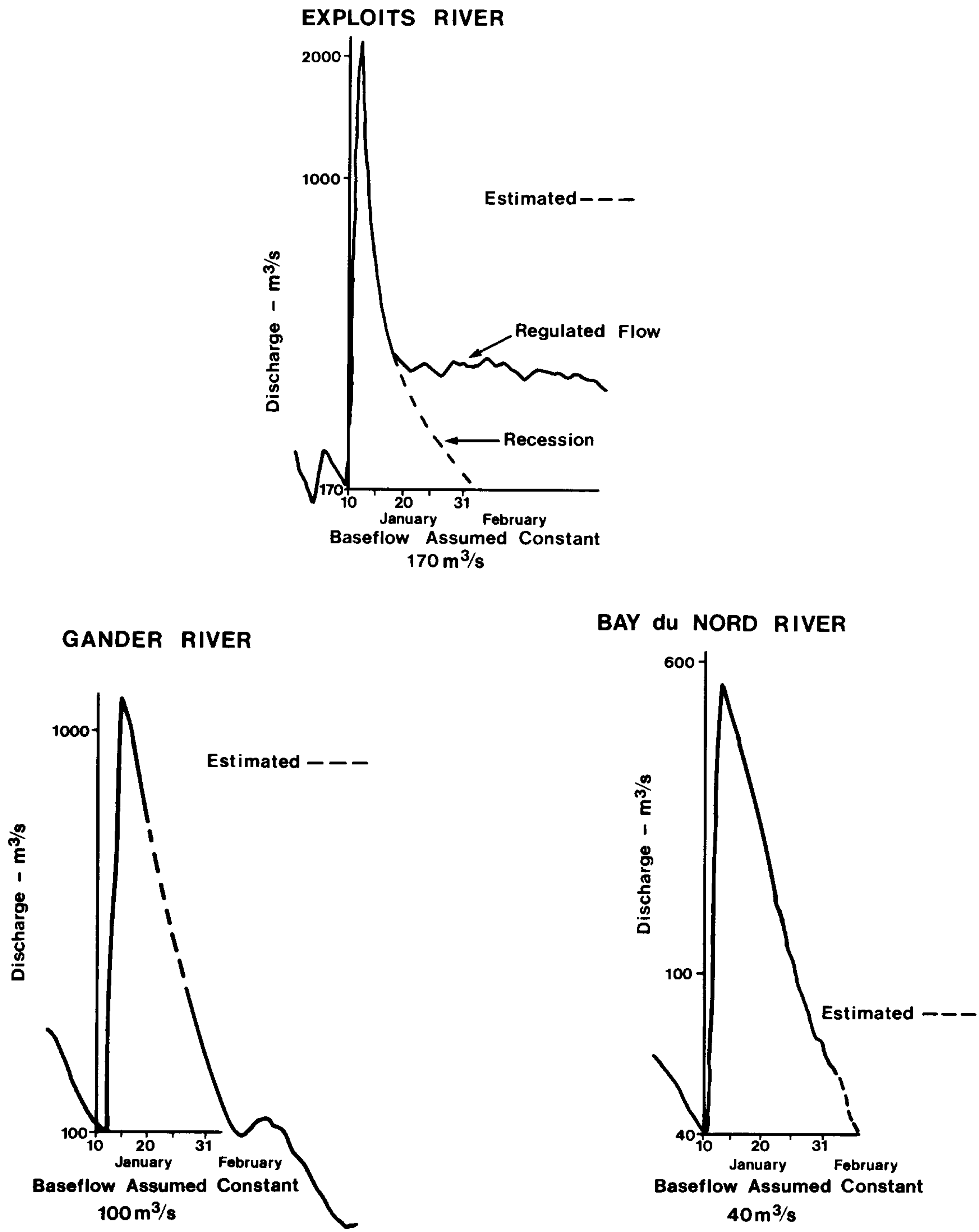



**Figure 5.9** Hydrographs of Daily Flow for the Exploits, Gander, and Bay du Nord Rivers
Flow Scale is Logarithmic

**RUNOFF -PRECIPITATION RATIOS**

| STATION | INPUT | | | Direct Runoff (mm) | Ratio of Direct Runoff to Rainfall & Snowmelt |
|---|---|---|---|---|---|
| | Rainfall (mm) | Snowmelt (mm) | Total (mm) | | |
| Exploits River | 129.2 | 37.2 | 166.4 | 128.8 | 0.77 |
| Gander River | 146.5 | 41.4 | 187.9 | 147.5 | 0.78 |
| Bay du Nord River | 230.8 | 41.1 | 271.9 | 287.8 | 1.06 |
| Conne River | 255.2 | 45.8 | 301.0 | - | - |

**TABLE 5.3**

Extensive washouts on the Bay d'Espoir Highway isolated the communities of Milltown, St. Albans and Morrisville. Several bridges and culverts were washed out and damaged by flood water along with road embankments. Sections of the Highway were inundated by flood water. In Milltown, a culvert was washed out creating a gorge 9 m deep and 9 m wide and causing extensive damage to road and adjoining land and the river channel downstream. In the St. Albans area, a brook overflowed its banks and flooded the highway.

Washouts on the Burgeo Road, Buchans Road, Roberts Arm Road, Kings Point Road, Harbour Breton Road, Point Leamington Road and Conne River Road eliminated the possibility of ground transportation to or from the respective communities. Reports of 37 washouts between Glenwood and Deer Lake forced Terra Transport to close the rail line.

## 6.2 BISHOP'S FALLS

It is ironic that Bishop's Falls, which experienced the worst flood disaster ever recorded in the Province, was not known to have any history of flooding. The magnitude and extent of flooding and the resulting flood damage at Bishop's Falls were large. The residents of Bishop's Falls witnessed the sudden disappearance of a section of the town.

### 6.2.1 Sequence of Events

The sequence of events as reported in the media and described by various persons was as follows:

The water level in the Exploits River started rising on Thursday, January 13, 1983 because of the unseasonal heavy rainfall that fell on the South Coast and Central Newfoundland on January 12 to 13. The increasing pressure of incoming water on the Exploit's River broke open the ice cover which was about 25 to 30 cm thick and covered the entire reservoir area upstream of the dam at Grand Falls. The ice breakup further raised the water level and created turbulence in the flow. The increasing flow in the Expoit's River and the floating ice chunks started spilling over the bank and flooding homes along Sydney Street, River Side Drive, Circular Road and the trailer court in the western section of Bishop's Falls. The extent of flooded area gradually increased as the flow in the Exploit's River increased. It is reported that 65 families were evacuated from the western section on Thursday afternoon and the evacuation continued until Friday night.

The water level behind the power plant at Bishop's Falls, the groundwood mill building and the Mill Road continued to increase because of the increasing flow in the Exploits River. By Friday morning, the flow in the Exploits River far exceeded the capacity of the spillway for the dam which is designed to carry a flow of 1982 $m^3/s$ (70,000 cfs). The water level was 6 to 8 m higher than normal water levels.

The raging flood swollen Exploits River with floating ice pieces ripped apart the old mill and the water flowed behind the dyke forming the powerhouse road (See photographs 7.2 to 7.5 inclusive) and cut across the Falls View Municipal Park, a recreational area opened last year. This led to the formation of a new channel which rapidly expanded, tearing up and eroding the pavement and ground. It is reported that the land downstream of the mill road and the mill (Fall View Municipal Park and other adjoining areas) contained fill materials, including wood chips which could not offer any resistance to the eroding action of the flow. The expanding new channel and the undermining action of the water behind the dyke caused the collapse of the dyke and the concrete wall. As soon as the dyke collapsed, the flow through the new channel substantially increased, and it was not too long before the entire Exploits River flow and the water stored behind the dam was flowing through the new channel. The original section became dry after the formation of the new channel sometime on Friday afternoon.

The torrential flow in the new channel swept away everything that came in its path. This lasted until the Friday evening. The formation of the new channel relieved the pressure on the western section of the Town because of the lowering of the water level in the reservoir.

When the peak flow passed, sometime on Friday evening, the destruction was over. The water began to subside on Saturday. The extent of damage was large. The flood losses have already been assessed by a Damage Assessment Committee appointed by the provincial government. The following listing will provide some indication of the flood losses suffered by the Town of Bishop's Falls (Newfoundland Environment, 1983).

### 6.2.2 FLOOD LOSSES

- About 180 families were evacuated from western and eastern sections of the Town over a period of 24 hours.
- Three homes, the Lions Club (see Photographs 7.6 to 7.9) and the Senior Citizens Club were washed away by the flood water.
- The Fall View Municipal Park (see Photograph 7.6), along with two historic 60 ton railway cars (from the famous Newfie Bullet) disappeared in the flood waters.
- The power plant, old groundwood mill building, and transmission lines were extensively damaged. The hydro plant provided 12% of the Abitibi-Price power requirement in addition to providing some power to the community of Botwood.

- About .08 $km^2$ (20 acres) of land is reported to have been swept away (see Figure 7.2) and become part of the new channel, which is estimated to be about 8 to 10 m deeper than the original ground. Assuming an average scouring depth of 15 m, the total amount of soil lost comes to about 1.23 million $m^3$ (4800 million lbs or 2.14 million tons).
- Seven houses were in danger of being lost if further erosion of the Exploit's River bank continues. Three houses were literally hanging on the edge of a 13 m high bank where solid ground existed before (see Photographs 7.12 and 7.13).
- The new channel has steep and high banks which are vulnerable to serious bank erosion and consequent loss of land and other buildings during the subsequent spring runoff (see Photograph 7.10) (Newfoundland Environment, 1983).

## 6.3 OTHER COMMUNITIES

The heavy rainfall caused some damage in Grand Falls. The Bank of Montreal on High Street was closed when rain water built up on the flat roof and caused leaks through the ventilation system. The computer terminals in the building sustained damage. The Stadium was also closed when water leaking through the roof caused the artificial ice to soften.

The Goodyear Dam on the Exploit's River located upstream of Grand Falls and the dam on Harbour Lake were partly damaged but power plant operation was not affected. The fishway on the Exploit's River at Grand Falls was also partly damaged.

In Windsor, six homes were evacuated on Main Street when a pond in Grand Falls overflowed its shoreline and flooded the adjoining low-lying areas. Some residents used boats for transportation to and from their homes. Some sections of both Grand Falls and Windsor suffered minor flooding due to overflowing manholes either due to blockage, back-up or insufficient capacity of the system.

Gander residents suffered some inconvenience when the Gander Lake rose 4 m above normal levels, flooding the pumping station and affecting the water supply. Residents were forced to ration their water supply for several days. The hospital in Gander had to be evacuated due to the water shortage.

In addition to Bishop's Falls, the communities of Glenwood and Appleton suffered the most damage during this flooding. These communities are located along the Gander River which peaked about 24 hours later than the Exploits River. The unusually high water levels in the Gander River flooded part of these communities to a depth of 2 m, marooning houses, cars, boats, etc., and covering roads and back and front yards, parking lots and driveways with broken ice sheets.

Forty basements were flooded. Twelve families (two in Appleton and ten in Glenwood) were evacuated to safer locations. The sewage treatment plant was partially submerged making it inoperable. The water supply system also became inoperable because of high water levels. A sawmill in Appleton was also submerged in the flood water.

## 6.4 EMERGENCY MEASURES AND FLOOD DAMAGE ASSESSMENT

The Town of Bishop's Falls was declared a disaster area for about 24 hours. The Town officials and the community displayed a remarkable sense of responsibility in taking care of themselves. They moved most of the affected families along with their belongings (whatever could be saved) to safe locations and arranged for their boarding and lodging. The

Provincial Emergency Measures Organization provided whatever assistance was needed by the Town for relocating the remaining affected families.

The provincial government appointed a "Flood Damage Assessment Committee" headed by Mr. Clarence Randall, Deputy Minister of the Department of Municipal Affairs. The Committee was charged with the responsibility of assessing the damage caused by this flood in all affected communities; relocating those families who lost their homes in Bishop's Falls; moving a few houses which were close to unstable banks along the Exploit's River in Bishop's Falls; providing water and sewer systems for the newly located homes; taking necessary action to stabilize the Exploits River bank; replacing the damaged storm and sanitary sewer systems; and co-ordinating the assessment process with the federal government under the Disaster Assistance Program.

## 7. FLOOD DAMAGES

This section presents an examination of the economic damages incurred during the course of the flood, as well as the costs of restoring conditions to a pre-flood state. The costs and damages are organized according to the sectors of the economy in which they were incurred; these being: Residential, Infrastructure and Recreational.

Table 7.1 presents a summary of these damages. The vast majority were centred in the Bishop's Falls area. Figure 7.1 shows the location of Bishop's Falls relative to the rest of the Exploits Basin, and Figure 7.2 identifies the area of Bishop's Falls affected by the flood. Only the direct costs of the flood are examined here. More in depth study would be required to identify indirect costs such as lost productivity, disruption of economic linkages, and the like. Details of the direct costs are provided below.

## 7.1 Residential Damages

Residential damages included damages to property and household, temporary accommodations, costs of restoring and relocating homes, and emergency relief items such as food, clothing and bedding.

The most extensive damage was in Bishop's Falls where the re-routed Exploits River channel washed away and destroyed three homes, left two overhanging a 15 m embankment and left several other homes dangerously close to the embankment. At one point, 150 to 170 houses were evacuated.

Damages in the residential sector documented by the Newfoundland Department of Municipal Affairs amounted to $565,021 within the Exploits Basin, primarily in Bishop's Falls, and $19,760 in areas outside the Basin, notably Glenwood and Point Leamington.

## 7.2 Infrastructure Damages

Damages documented for this sector include those to transportation facilities, hydro utilities (including Abitibi-Price), fisheries facilities and other municipal works.

### 7.2.1 Transportation

Many sections of road throughout the Exploits Basin and surrounding areas were flooded and washed out. In the period of most intensive

## SUMMARY OF DAMAGES

| | | Exploits Basin ($) | Outside Basin ($) |
|---|---|---|---|
| **Residential** | | | |
| Personal claims, temporary accommodations and related costs | | 429,683 | 18,973 |
| Structural and relocation costs | | 133,976 | - |
| Emergency relief | | 1,362 | 787 |
| | Sub-Total | 565,021 | 19,760 |
| **Infrastructure** | | | |
| Transportation: | Roads | 575,044 | 340,000 |
| | Bridges | 803,122 | 15,751 |
| | Railways | 225,700 | - |
| | | 1,603,866 | 355,751 |
| Hydro Utilities: | Abitibi-Price | 28,500,000 | - |
| | Newfoundland & Labrador Hydro | 500,000 | - |
| | Newfoundland Light & Power | 60,000 | - |
| | | 29,060,000 | - |
| Water, Sewers and Drainage | | 495,319 | - |
| River bank stabilization | | 473,448 | 2,381 |
| Fisheries facilities | | 525,000 | - |
| King's Road Subdivision | | 399,341 | - |
| Other municipal grants | | - | 427,836 |
| | Sub-total | 32,556,974 | 430,217 |
| **Recreational** | | | |
| Senior Citizens' Club | | 40,000 | - |
| Parks | | 100,864 | 9,877 |
| | Sub-total | 140,864 | 9,877 |
| **TOTAL** | | **33,262,859** | **815,605** |

TABLE 7.1

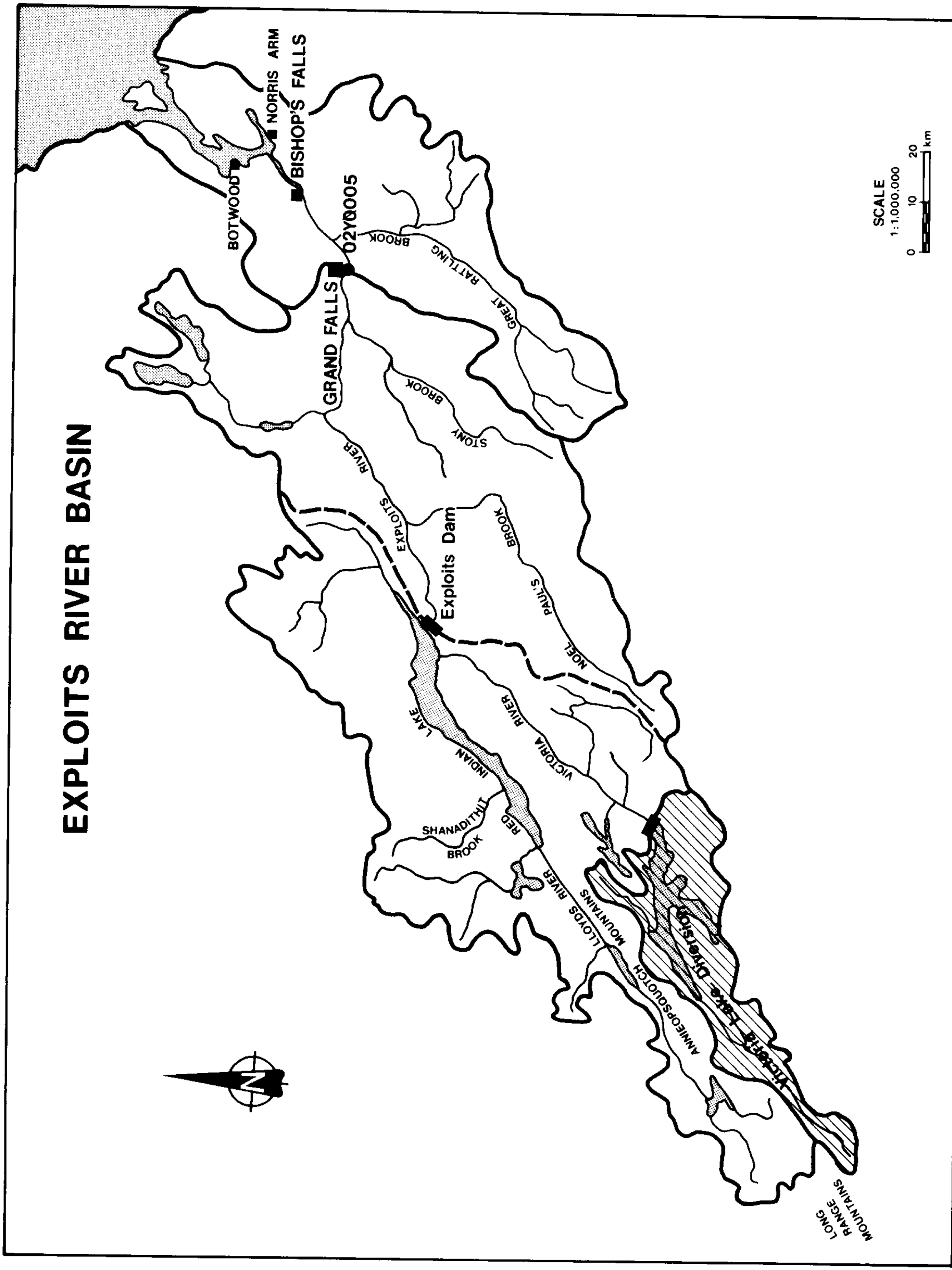



Figure 7.1 Exploits River Basin

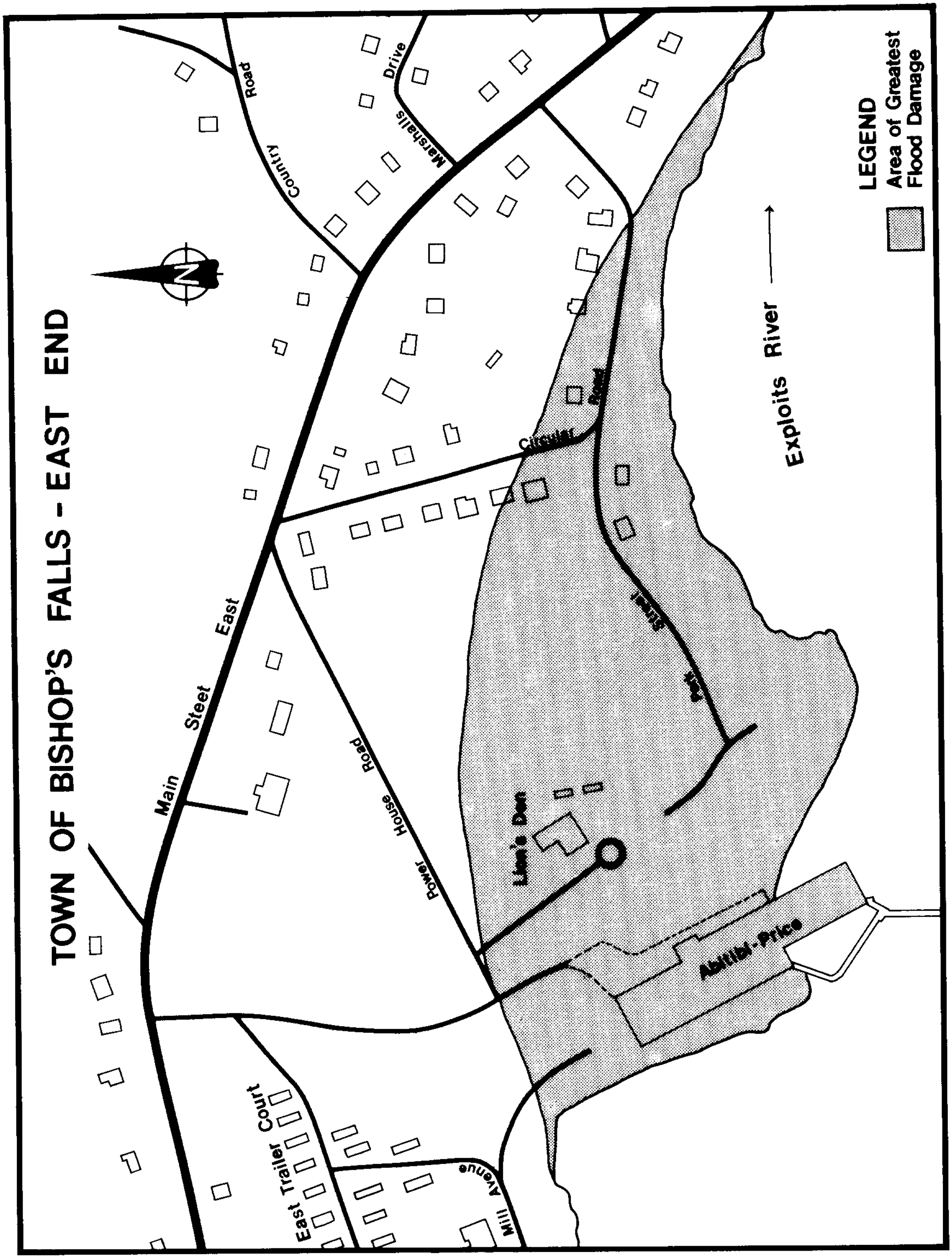



**Figure 7.2 Town of Bishop's Falls-East End**

flooding, the Trans Canada Highway at Rushy Pond and the Old Badger Road, which is normally an alternate route during floods were flooded and closed to traffic. Further south, outside the Basin, several sections of the Bay d'Espoir highway were either inundated or washed out, isolating some south coast communities for up to a week.

A number of bridges throughout the Exploits Basin suffered damage - notably an 18 m long bridge crossing Sandy Brook which was swept intact 20 km downstream. The damage figure for bridges includes provincial property as well as bridges and culverts belonging to Abitibi-Price.

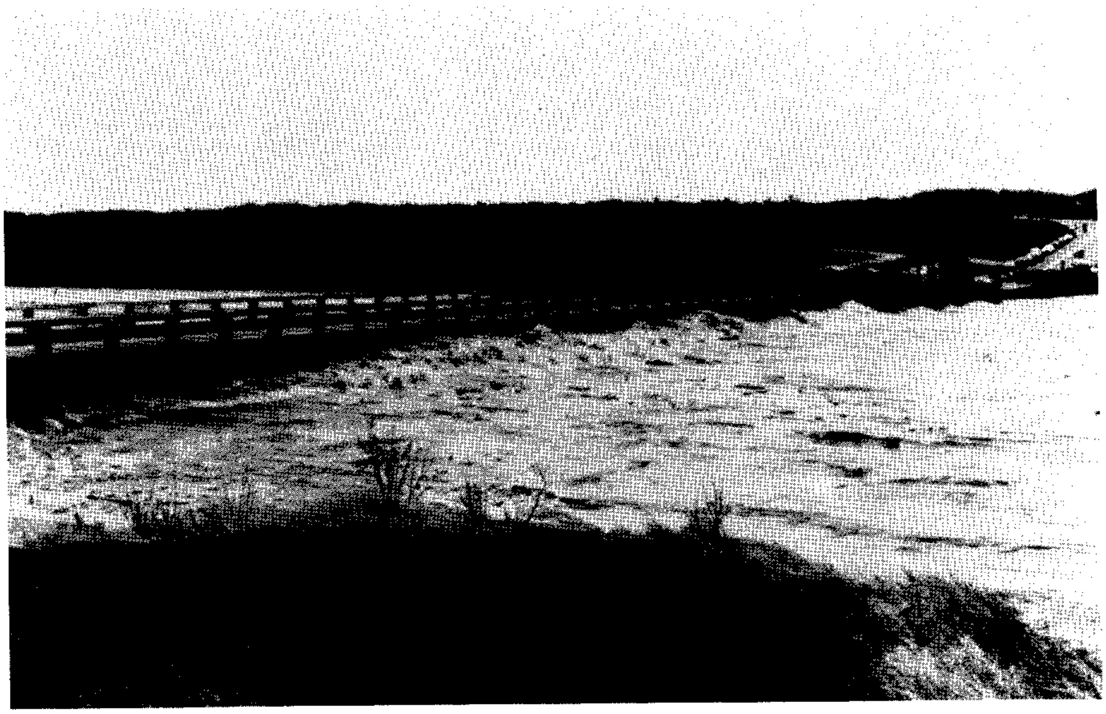
Damages to railways were estimated based on the amount of track length damaged during the January period of study (90% of which was in the Bishop's Falls area), compared to the total length and cost of track repair for the year.

Transportation damages as a whole, amounted to $1,603,866 within the Expoits Basin and $355,751 outside the Basin. The latter figure applies primarily to roads and to the Mill Brook Bridge in the Point Leamington area.

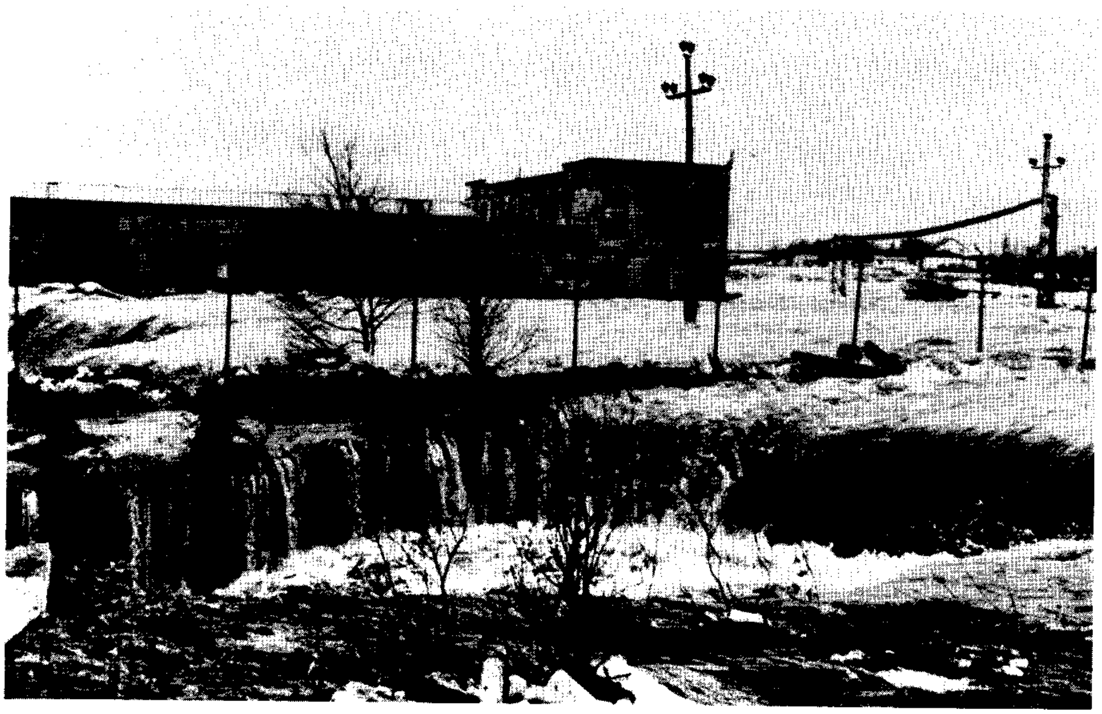
### 7.2.2 Hydro Utilities

The replacement cost of $28.5 million for the Abitibi-Price powerhouse and dam is the largest single cost incurred during the flood, and represents 86% of the total damages within the Exploits Basin. This figure also includes the cost of purchasing power by Abitibi-Price from Newfoundland Hydro for a ten month period.

Newfoundland and Labrador Hydro suffered damages to structures such as access roads, bridges, culverts and embankments, dikes, etc. in both Hinds Lake and Bay de Espoir project areas. They reported a substantial increase in the cost of annual maintenance.



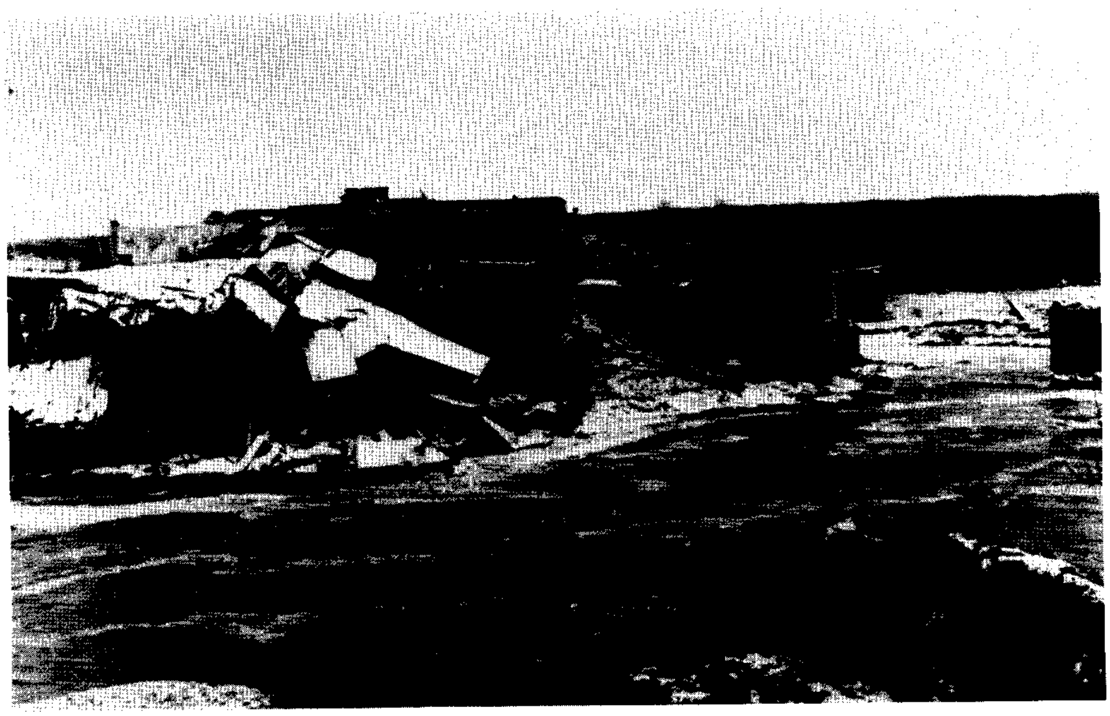
Photograph 7.1 - Sir Robert Bond Bridge downstream of Bishop's Falls - January 4, 1983 near the time of peak flow



Photograph 7.2 - Old Groundwood Mill at Bishop's Falls prior to collapse - midday on January 14, 1983

Photograph 7.3 - Abitibi-Price Powerhouse and Old Groundwood Mill at Bishop's Falls - January 14, 1983

Photograph 7.4 - Old Groundwood Mill at Bishop's Falls beginning to collapse, early afternoon, January 14, 1983

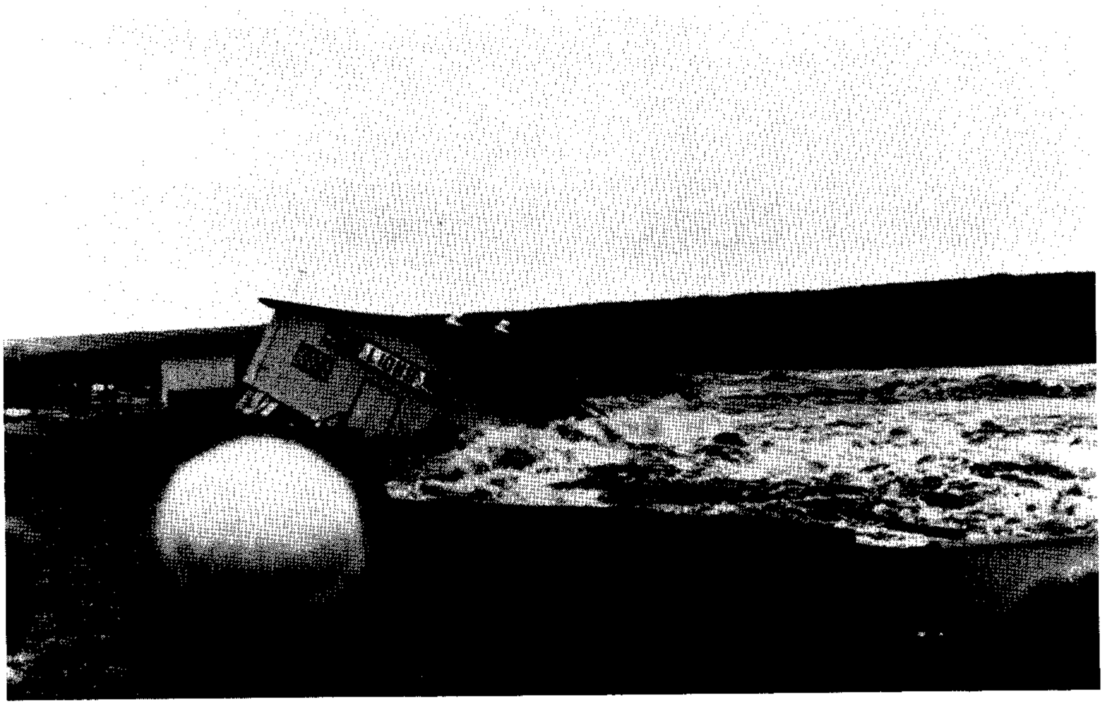


Photograph 7.5 - New River Channel around Abitibi-Price powerhouse at Bishop's Falls - January 16, 1983

Photograph 7.6 - Bishop's Falls' Lions Club located near the Municipal Park - early afternoon on January 14, 1983

Photograph 7.7 - Bishop's Falls' Lions Club just prior to its loss - January 14, 1983


Photograph 7.8 - Lions Club at Bishop's Falls being destroyed -
January 14, 1983

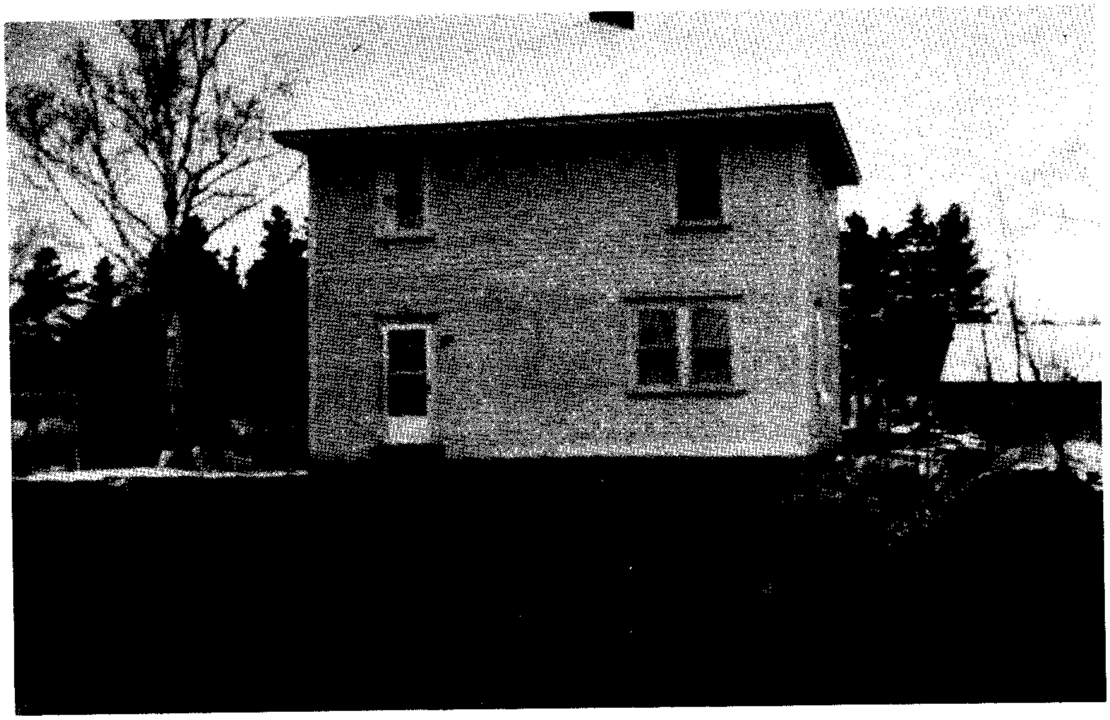


Photograph 7.9 - Lions Club at Bishop's Falls being destroyed
- January 14, 1983

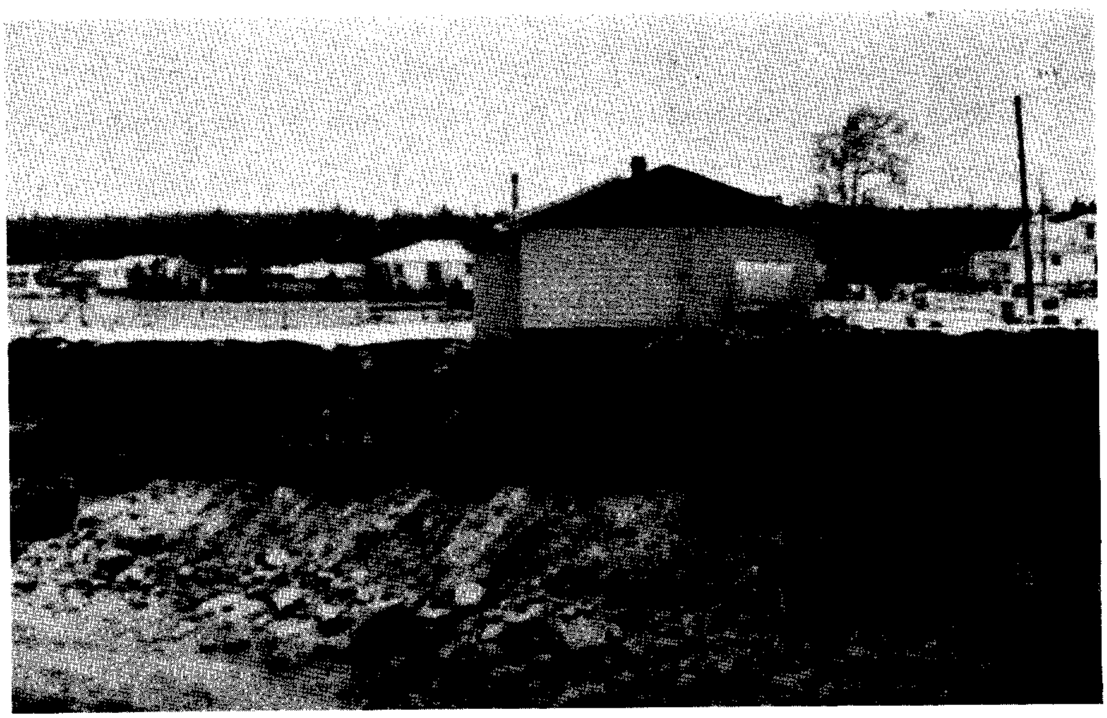
Photograph 7.10 - Downstream End of Bank Erosion, Bishop's Falls - January 14, 1983

Photograph 7.11 - Eroded Bank along New River Channel

Note: Remnants of Earth Filled Section of Abitibi-Price Dam.



Photograph 7.12 - Residence Perched on Eroded Bank of the Exploits River at Bishop's Falls - January 14, 1983



Photograph 7.13 - Residence Perched on Eroded Bank of the Exploits River at Bishop's Falls - January 14, 1983

Newfoundland Light and Power suffered damages at its Sandy Brook plant as well as lost revenue for a week's production.

Damages to hydro utilities as a whole amounted to $29,060,000 all of which were incurred within the Exploits Basin.

7.2.3 Other Infrastructure

Repair and construction of sewerage and drainage systems and damage to water supplies within the Exploits Basin amounted to $495,319 primarily in the Bishop's Falls area. Additionally, $473,448 was required for stabilization of heavily eroded river banks within the Basin. Outside the Basin, $2,381 was required for repairs to the Morrisville water supply.

Extensive damages were inflicted on fisheries facilities within the Basin, notably: destruction of the Noel Paul Spawning Channel and the Bishop's Falls fishway, as well as severe damage to the Grand Falls fishway and Camp 1 fishway. Total cost for these damages amounted to $525,000.

In order to accommodate the five new homes constructed as replacements for those lost in the flood, the King's Road Subdivision was developed and serviced. For the sake of efficiency, the Subdivision was completely serviced for future residential development. Costs for this undertaking amounted to $399,341.

Other grants and subsidies were provided for infrastructure repairs to municipalities outside the Exploits Basin, notably Glenwood, St. Alban's and Milltown. These amounted to $427,836.

Damages for the infrastructure sector as a whole amounted to $32,556,974 within the Exploits Basin, which represents 98% of total damages within the Basin. As noted earlier, this amount was comprised primarily of costs associated with the Abitibi-Price powerhouse and dam. Total infrastructure damages outside the Basin amounted to $430,217 which was primarily damage to roads.

7.3 Recreational Damages

In the recreational sector, $50,000 was required for replacement of the Bishop's Falls Park and $50,864 for repairs to a park in Botwood. Also within the Exploits Basin, the Grand Falls Country Club, the Bishop's Falls Lions Club and two railcars used as a museum were all damaged or lost. However, no costs were documented for these latter damages. Total documented recreational damages within the Basin amounted to $140,864. Outside the Basin, $9,877 were required for repairs to a Point Leamington park.

A number of additional costs which have not been accounted for include some recreational facilities itemized above, and eight (8) hectares of land washed away, as well as the costs of the relief effort provided by the EMO, militia, R.C.M.P. and volunteers.

As can be seen from Table 7.1, total documented direct damages for the January 1983 flood in central Newfoundland amounted to in the order of $33.3 million within the Exploits River Basin and approximately $815,000 in areas outside the Basin.

The uncalculated additional costs would not, however, substantially alter the order of magnitude of the damages outlined here.

# 8. SUMMARY AND LESSONS FOR THE FUTURE

## 8.1 Summary

This report on the flood of January, 1983 in Central Newfoundland, and the review of conditions associated with the flood has lead to some interesting insights to the hydrologic and hydraulic behaviour of streams in Newfoundland. Also, the review has given Federal/Provincial Water Management officials in the Atlantic Region, a better understanding of flood impacts. The increased knowledge 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 several hydrologic factors that acting together produced synergistic impacts on the drainage system. The most significant factors leading to the flooding and resulting damage are intense rainfall, rapid snowmelt, and streambank erosion. It is also interesting to note that this atmospheric disturbance was charted as it moved up the U.S. Eastern Seaboard, then offshore Nova Scotia to the Sable Island area, and again inland to where it covered a swath northeasterly across the central part of the Island of Newfoundland. The resulting flooding, therefore, affected all of the drainage areas in its path. The focus of this report, however, is only on the major basins in Central Newfoundland for which data exists, mainly the Exploits River Basin, the Gander River Basin and the Conne River Basin.

The snow accumulation during the winter of 1982-83 was generally not above average in most areas and within the range of minimum to mean for those data existing for the past 10 to 20 years. The snowfall for October to January, 1982-83, ranged from 120 percent of long-term average at Gander down to 55 percent at St. John's. However, the rainfall intensity associated with the storm of January 11 to 14, 1983, was considerably higher than normal.

Mass curves of precipitation resulting from the storm showed a range from about 100 mm at the Exploits Dam to 250 mm at Upper Salmon. The rainfall-intensity-duration frequency analyses for St. Albans and Burgeo, where some of the heavier precipitation occured, indicates that the 48 hour rainfall intensity is as high as the 100-year return period and 35 year return period, respectively.

These meteorological factors combined with the movement of the storm mass from the southwest to the northeast, ie. from the headwaters of the drainage basins downstream to Bishop's Falls and Gander, lead to unprecedented water levels in the Exploits, Gander and other Basins in that portion of the Island. Although, historic flood records indicate that flooding has not been a major problem in this part of Newfoundland, this event serves to illustrate that given the right set of conditions, any area is susceptible to flood damage. In this particular event, the high water levels and the resulting erosion that followed, lead to a high level of damages, interruption of services, and Public alarm. Considering the magnitude of the flood and the fury released by the swollen river waters, it is quite miraculous that it was only property damage that resulted, and that there was no loss of life associated with this disaster. It is speculated that no fatalities occured, because of good fortune, rather than any insight, advance warning, forecasting, or emergency measures taken, because the event was well in progress by the time the severity of it was recognized.

Since extreme floods of this type in Newfoundland are partly caused by rainfall, the ability to predict them in advance is limited by technology in the field of climate forecasting. Current technology in the field permits accurate flood warnings only 2 or 3 days in advance on large rivers and it will require ingenuity and new techniques for improvements to take place in the forseeable future. It is encouraging that the importance and need of forecasting floods and reducing flood damages is being considered by the Province at this time. The Province of Newfoundland and Environment Canada are currently engaged in negotiations for an Agreement to develop a flood forecasting system for the flood prone areas under the National Flood Damage Reduction Program. The agreement will provide for developing small scale low cost techniques and procedures specifically suited to small communities in the Province which are prone to periodic flooding. It is anticipated that this report will find uses in the areas of general flood damage reduction activities, floodplain management, dam inspection & maintenance, hydrologic & hydraulic design specifications, and river channel management.

The total economic cost of this flood event is estimated to be about $34 million. This includes only the direct cost of the flood as estimated by private, municipal, provincial, and federal agencies. Of this, about $30 million was made up by damages in the Bishop's Falls area. The bulk of this, $28.5 million was to a Hydro Facility, owned and operated by Abitibi-Price. The next largest loss was in the public sector related to transportation and water supply infrastructure. Compensation through the Federal Disaster Financial Assistance Arrangements (DFAA) is under consideration for those eligible damages by the Federal/Provincial Governments.

## 8.2 Lessons for the Future

The magnitude of losses and the associated personal hardships caused by this flood are sufficient to make us aware that consideration should be given to possible ways of minimizing flood damages in the future. Most of the losses took place on floodplains where various types of urban development such as water supply infrastructure, transportation facilities, and residential developments have occurred. To date, there has been little effort to direct this development in a way so as to minimize susceptibility of building to such flood damages.

It is interesting to note that the existing storage reservoirs in the Exploits River, especially Red Indian Lake, although, not intended for flood control, played a very important part in keeping damages down to that level experienced. There are two significant uses of water in the Exploits Basin that removed about 62 percent of the drainage area from contributing flow to the dam at Bishop's Falls. The storage and diversion facilities for the Victoria Lake Hydro Plant have diverted about 12 percent of the water from the Exploits back to the Bay d'Espoir Hydro Development. That, plus the operation of the Red Indian Lake storage facility by Abitibi-Price trapped runoff from another 50 percent of the drainage area.

The most obvious approach to minimizing future flood damages in Newfoundland is effective planning in regulation of the use of flood-plains. If such planning regulation is not undertaken, the potential for damage from floods such as the one of January, 1983, will continue to increase. There is also a need to consider ways of reducing flood damage to the existing developments on the floodplains. Flood forecasting and emergency measures operations can be effective in reducing some of the damages already mentioned. Considerable damage could have been avoided if some of the larger facilities had been flood proofed and/or the hydraulic capacity of some of the water conveyance structures had been larger. The experience gained from this flood has also identified a need for better Federal organization and response to administering the DFAA. Although Emergency Planning Canada has a well defined set of procedures for co-ordination of crisis management operations and damage claim review and processing; there is a need for a co-ordinated Federal role. Also the Federal/Provincial response mechanism and administration procedures for determining eligible claims needs improvement.

This report on the January, 1983, Flood in Central Newfoundland, has shown that Newfoundland has a significant flood problem. Although this flood was extreme, floods of equal or greater magnitude may occur in the future. Concentrated effort is required to minimize the affects of future floods. It is almost ironic that the better known flood vulnerable areas of Newfoundland were not affected by this event, but rather the Glenwood, Gander, and Bishop's Falls areas were previously considered of low flood potential. These towns experienced one of the most dramatic and damaging flooding events in the history of the Province. If this was a surprise to water managers and to the public, it only serves to illustrate how little we know about the nature and occurence of flooding in the Province. Accordingly, it should serve as a reminder that "Mans Works" must be considered vulnerable to the natural forces generated by "Mother Nature". The best that we can do is to offer some foresight as to where and when such events may occur, and take action to minimize the economic damages and human suffering from similar flooding events.

# 9. REFERENCES


1. Environment Canada, Technical Bulletin No. 81, New Brunswick Flood - April-May 1973, Inland Waters Directorate, Atlantic Region, Halifax, 1974.

2. Haurwitz, B. and J.M. Austin, Climatology, McGraw-Hill Book Co., 1944.

3. U.S. Army, Corps of Engineers, North Pacific Division, Snow Hydrology, Portland, Oregon, 1956.

4. U.S. Army Engineer Division, North Pacific, Program Description and User Manual for SSARR, Streamflow Synthesis and Reservoir Regulation, Program 724-K5-G00/0, Portland, Oregon, September 1972.

5. Environment Canada and Environment New Brunswick, The Flood of 1979, Saint John River Basin, New Brunswick, Report T-8101, March 1981.

6. Poulin, R.Y., Flood Frequency Analysis for Newfoundland Streams, Department of the Environment, Ottawa, 1971.

7. Environment Canada and Newfoundland Environment, Regional Flood Frequency Analysis for the Island of Newfoundland, 1984, Draft Report.

8. Environment Canada, Inventory of Canadian Freshwater Lakes, Inland Waters Directorate, Water Resources Branch, Ottawa, Canada, 1973.

9. Kindervater, A.D. supplied information for Effects of Storage, Chapter 5 of this report, Water Planning & Management Branch, Inland Waters Directorate, Atlantic Region,.

10. Condie, R. et al, Flood Damage Reduction Program Flood Frequency Analysis, Inland Waters Directorate, Environment Canada, Ottawa, January 1976.

11. Pilon, P.J. and R. Condie, Identification of High and Low OUTLIERS, Inland Waters Directorate, Environment Canada, Ottawa, November 1982.

12. Cheng, L.C. and R. Condie, Flood Frequency Analysis with Low OUTLIERS, Inland Waters Directorate, Environment Canada, Ottawa, April 1982.

13. Condie, R. and K.A. Lee, Flood Frequency Analysis with Historic Information, Program ISTORIC, Inland Waters Directorate, Environment Canada, Ottawa, February 1981.

14. Shawinigan and MacLaren Companies Ltd., Water Resources Study of the Province of Newfoundland, September, 1968.

15. Newfoundland Environment, A note on the Flooding at Bishop's Falls February, 1983.