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7262

May 20, 1990

Canada-Newfoundland
  Flood Damage Reduction Program
Department of Environment and Lands
P.O. Box 8700
4th Floor
Confederation Bldg., West Block
St. John's, Newfoundland
A1B 4J6

Attention: Mr. Robert Pico
  Project Engineer

Gentlemen:

Re: Trout River Flood Risk Mapping Study

We are pleased to submit our final report on the above mentioned study. The comments and suggestions from the Technical Committee on previous draft sections of this report have been incorporated in this version.

Yours very truly

CUMMING COCKBURN LIMITED

H. S. Belore, P. Eng.
Director of Water Resources

TS:mb
Encl.

ISLAND ENGINEERING CO. LTD.

John E. Carlson, P. Eng.
President

ASSOCIATION OF
PROFESSIONAL ENGINEERS
PROVINCE OF
NEWFOUNDLAND
H. S. BELORE
1990
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Canada – Newfoundland
Flood Damage Reduction Program

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24/8

August 23, 1990

Dr. Wasi Ullah
Director, Water Resources Division
Department of Environment and Lands

Re: Trout River Flood Risk Mapping Study

Dear Dr. Ullah:

On behalf of the Canada-Newfoundland Flood Damage Reduction Program I am pleased to present you with a copy of the recently completed report entitled "Flood Risk Mapping Study of the Trout River Area".

The results of the study are now being used to produce flood risk and public information maps of the area. These maps will be available in a few months.

If you have any questions on the report please call our Project Engineer for the program, Mr. Ken Rollings at 576-2553.

Yours truly,

David G. Jeans, P.Eng.
Assistant Deputy Minister
 - Environment
Cochairman
Steering Committee

KR/

FLOOD RISK MAPPING STUDY

OF

TROUT RIVER

MAY, 1990

by Island Engineering Ltd.
In Association With
Cumming Cockburn Limited

TROUT RIVER REPORT

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EXECUTIVE SUMMARY

Introduction

The Community of Trout River has had a history of flooding from Trout River and Feeder Brook in the westerly part of the Community. In recent years, there has also been flooding at the easterly side of town from Emmanuel's Brook.

On May 22, 1981, the Province of Newfoundland and the Government of Canada entered into a General Agreement Respecting Flood Damage Reduction. The main objective of this Agreement is to reduce the potential for flood damages in floodplains and along the shores of lakes, rivers and the sea. This Agreement also recognizes that the potential for future flood damages can be reduced by controlling future development in the areas prone to flooding.

The main objective of this study was to develop the 20 and 100 year return period flood peaks and associated backwater profiles for the study area.

The study area extended from the outlet of Trout River to Lower Trout River Pond, approximately 500 metres up Feeder Brook from its confluence with Trout River, and Emmanuel's Brook for approximately 200 metres from its outlet into Trout River Bay.

The main report and associated appendices describe in detail the methodology and findings of the hydrotechnical investigations. Additional background information and documentation of field surveys is provided in an accompanying supplementary report.

Field surveys were undertaken for Trout River in May, 1989 and for Emmanuel's Brook in April, 1990. The field survey program included surveying cross-sections, taking photographs and interviewing local residents to gather background information on flooding events, and to determine peak flood elevations during the January, 1990 flood. Photographs were also taken on January 29, 1990 to document the January 27th flooding.

Main Findings

Computer simulation and statistical techniques were utilized in order to estimate the peak flow rates and associated flood levels in the study area, taking into account hydrologic conditions at upstream locations and the effects of lake, reservoir and channel routing.

The following points briefly summarize the main findings of the hydrotechnical investigations:

1. Peak flow estimates for Trout River at its outlet to Trout River Bay were found to be 144 and 118 m^3/s for the 100 and 20 year peak flows respectively. These estimates were determined by means of a regional flood frequency equation and were verified by comparison to secondary estimates.

2. Peak flow estimates for Feeder Brook at its confluence with Trout River were 41 and 31 m^3/s for the 100 and 20 year peak flows respectively. The estimates were determined by using the OTTHYMO computer program.

3. Preliminary peak flow estimates for Emmanuel's Brook were found to be 32.2 m^3/s for the 100 year storm. This estimate was determined by means of an uncalibrated OTTHYMO model.

4. Corresponding 20 and 100 year flood profiles were determined and plotted on available mapping at a scale of 1:2500.

5. A potential for ice jams was found to exist along Feeder Brook. Ice jam flood levels were found to exceed open water flood conditions upstream of the Feeder Brook Bridge.

6. Flooding of Emmanuel's Brook appears to be caused by ice jamming at the outlet of the brook. This ice is probably a combination of ice pack in Trout River Bay and ice washed down the brook by the high flows. Snow drifted into the channel is also a contributing factor. Water backs up behind the ice dam, overtops the timber cribbing and flows down the road flooding the depression.

7. Several homes are subject to flooding in the Emmanuel's Brook area. A few homes are also subject to flooding along Trout River.

Remedial Measures

Flooding of the Community of Trout River from Feeder Brook may be alleviated by the installation of snow boards, regular cleaning of the bridge and culverts or by enlarging the bridge and culverts.

Flooding from Emmanuel's Brook would be reduced by replacing cribbing with new cribbing built to a higher elevation.

1.0 INTRODUCTION

1.1 General

Historically, the development of urban centres in many areas of Canada, including Newfoundland, has taken place on floodprone lands. These lands were developed by the first settlers due to ease of access, etc. These early uses of the floodplain have evolved into present day highly urbanized communities which still attempt to utilize floodplain lands. An increasing trend towards urban developments in Canada has resulted in an increased potential for higher flood losses. A nation-wide survey of potential flood hazards has indicated that more than 200 communities in Canada have some developments located in flood hazard areas. Floods in Newfoundland, and more specifically in Trout River, are relatively frequent.

On May 22, 1981, the Province of Newfoundland and the Government of Canada entered into a General Agreement Respecting Flood Damage Reduction. The main objective of this Agreement is to reduce the potential for flood damages in floodplains and along the shores of lakes, rivers and the sea. This Agreement also recognizes that the potential for future flood damages can be reduced by controlling the areas prone to flooding.

The General Agreement Respecting Flood Damage Reduction allows the two levels of government to enter into a number of other agreements on specific aspects of flood damage reduction, including but not limited to, land use planning, flood proofing, flood risk mapping, flood forecasting, flood control works and flood studies.

To provide for the identification and delineation of flood prone areas in Newfoundland, the "Agreement Respecting Flood Risk Mapping" was also signed on May 22, 1981. Under the terms of this agreement, a number of flood prone areas in the province are to be mapped and flood risk zones delineated and utlimately designated as areas where the federal and provincial governments will agree to restrict their funding for new development. These agreements were amended in May 1983 and a related "Studies Agreement" was signed in June 1983. (In this report, projects completed under these agreements are referred to as work done under the Canada Newfoundland Flood Damage Reduction Program; CNFDRP for short.) The agreements were again amended in 1988; three additional areas were added and the agreements were combined in a "Flood Risk Mapping and Studies Agreement".

1.2 Authorization and Scope of Study

The agreements previously mentioned provide for the establishment of two committees; the Steering Committee which is responsible for general administration of the agreements and the Technical Committee which provides technical support to the Steering Committee. On April 3, 1989, Island Engineering Company Limited, in association with Cumming Cockburn Limited, were commissioned by the Newfoundland Department of the Environment and Lands to undertake a "Hydrotechnical Study of Trout River". As described in the Terms of Reference, the main objective of this investigation was to develop the 20 and 100 year return period flood hydrographs and associated backwater profiles for the study area.

The following points summarize the overall scope of the investigations:

1. Review of background information to characterize the flooding problem;
2. Evaluate the significance of various factors affecting flooding in Trout River;
3. Design, coordinate and manage a field program for the purpose of collecting hydrologic and hydraulic data for model calibration;

4. Determine 20 and 100 year recurrence interval backwater profiles from the outlet of Trout River to Lower Trout River Pond;
5. Produce the 20 and 100 year flood profiles and plot the 20 and 100 year return period flood lines on topographic maps to determine the areal extent of flood prone areas;
6. Undertake sensitivity analyses of peak flow estimates and backwater profiles;
7. Assess the significance of ice jamming and other hydraulic factors affecting flood lines; and
8. Identify possible remedial measures for flood management and flood damage reduction which may be analysed as required in possible future phases of the flood hazard investigations.

The scope of the study is described in detail in the Terms of Reference.

During the course of these investigations, the need for undertaking a preliminary evaluation of the floodplain along the lower portion of Emmanuel's Brook in the Community of Trout River was also identified.

1.3 Study Area Description

The Community of Trout River is located on the Gulf of St. Lawrence near the southwestern boundary of Gros Morne National Park. Feeder Brook is a small tributary joining Trout River just south of the town at Route 431 (see Figure 3.1). Emmanuel's Brook flows into the gulf on the eastern side of the community. Flooding occurs in the residential section of town along the east bank of the river and along the downstream portion of Emmanuel's Brook. The flooding is caused by ice jams in Feeder Brook and Trout River upstream of the floodprone area, and by ice along Emmanuel's Brook. Flooding also occurs along the lower portion of Emmanuel's Brook (see Section 5.0).

1.4 Overview of Study Methodology

As indicated previously, the basic purpose of this investigation was to provide the 20 and 100 year open water flood profiles and floodplain extent for Trout River. The accurate determination of flood profiles along the study reach depends on several hydrological and hydraulic factors, including the following:

- historical flood conditions in the study area;
- climatological characteristics of the Trout River watershed, including rainfall and snowmelt characteristics;
- land use in the watershed;
- peak discharge rates associated with the 20 and 100 year return period floods;
- effects of tides, ice jams, debris jams and other hydraulic factors along the study reach;
- existing stream channel and floodplain hydraulic characteristics and man-made changes such as bridge and channel constrictions, berms and dyking, etc.
- natural and artificial flood storage in the study area.

The complex interrelationships between the above mentioned factors have been considered in the course of undertaking our climatologic, hydrologic and hydraulic investigations.

The first step in the investigation was the collection and review of available background information and existing data on climatologic and flood characteristics. These are discussed in Chapter 2.0, entitled "Background", and in the "Survey and Monitoring Report" under separate cover.

The next step was the determination of appropriate 20 and 100 year peak discharge rates. Alternative estimates by statistical and deterministic analyses were derived and compared as discussed in Chapter 3.0, "Hydrologic Analyses". Where appropriate, this included model calibration and sensitivity and error analyses in order to achieve an appropriate level of accuracy for the discharge estimates.

Thirdly, the peak flow estimates were converted to flood water levels (profiles) along the study reaches by means of a computer model of hydraulic characteristics. This is discussed in Chapter 4.0. This also includes sensitivity testing of the most important hydraulic parameters and relevant model calibration and verification using documented events.

Finally, the approximate extent of the flood hazard areas was plotted on copies of new topographic mapping for the study area. It was then possible to identify potential remedial measures which might be considered in more detail in the future for alleviating the potential for future flood losses. These measures are identified in Chapter 6.0.

As required by the Terms of Reference, the "Hydrologic and Hydraulic Procedures for Floodplain Delineation" and "Survey and Mapping Procedures for Floodplain Delineation", developed by Environment Canada were used as basic guidelines throughout the course of these investigations.

2.0 BACKGROUND

2.1 Interviews

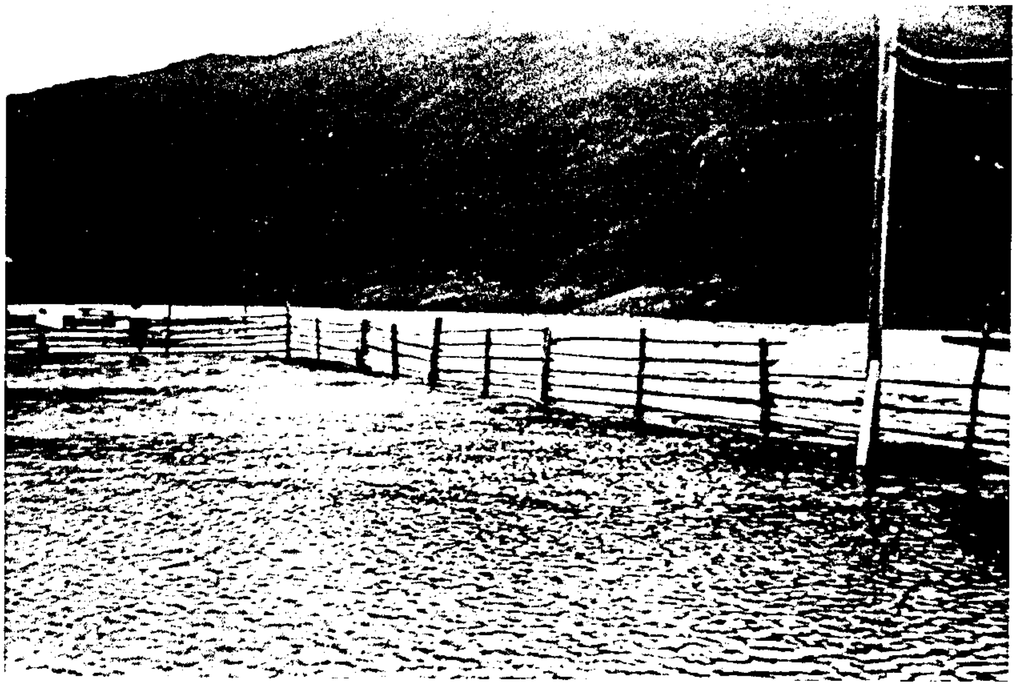
On May 8, 9 and 10, 1989 interviews were held with residents of Trout River and other people knowledgeable of the area. Further interviews were held in June and July, 1989.

Mr. David Hann of Trout River indicated there is frequent flooding on the road. Some years the ice in the Lower Trout River Pond melts in place, staying in the pond as it did in 1989 and 1990. Other years the ice breaks up and flows down the river, jamming at downstream locations. Precise locations of these ice jams were not indicated.

Mr. Isaac Crocker has lived in the first house upstream of the bridge, on the east side of the river, west of the road, for the past 40 years. Before that he lived on the other side of the river. He has seen ice pans two to three feet thick and twenty feet long going past his house. They do not jam up and cause flooding at the bridge. He has not been flooded from the river since a retaining wall (approximately 1 m high) was installed along the river with fill placed behind it.

Mr. Fred Crocker lives near Mr. Isaac Crocker but approximately 35 m east of the road, further from the river. He indicated that some ice occasionally backs up at the bridge, but never enough to cause flooding. The tide comes up as far as the bridge but does not seem to make the problem any worse.

Mr. Fred Crocker said that flooding in town (he has had water in his yard) is caused upstream at the confluence of the Feeder Brook and Trout River. Ice comes down the Feeder and backs up at the bridge and culverts. Water flows across the road, and down the road through the town. This is the first year (1989) he has not seen it flood the road.



Looking upstream across the river from near the present location of the school.

-1959-

Looking upstream along the road from the riverside downstream of existing bridge

-1959-

Looking downstream along the road

-1959-

FIGURE 2.1

Ice flowing down Trout River also accumulates in the shallows at the confluece with Feeder Brook and combines with ice from the Feeder causing water backup.

Mr. Walter Crocker lives in the first house downstream of the Feeder, on the east side of the road. Mr. Crocker says that the road has not flooded since the new bridge was built (about 1976) and the four culverts placed at the location of the old bridge. With the old bridge, sheet ice from the Feeder used to back up at the bridge and flood the road. This conflicts with statements by other residents.

Mr. Barnes said that the largest flood ever was in 1938. That year, a barn at the fork in the road (with Route 431) was washed away with the spring flood.

Mrs. Mary Crocker said there was another big flood about 30 years ago (1959). Photographs taken at that time by a local resident are shown on Figure 2.1.

Mr. Murdock Brake, an elderly resident of Trout River has lived most of his life in a house located on the east side of the river, west of the road, about 600 metres north of the Big Feeder Brook. Mr. Brake indicated that the last two large floods he could recall occured in 1976 and 1983 respectively. He has seen ice jams at the Trout River bridge, but has not seen any flooding of the town as a result of this since the retaining wall was built. Mr. Brake said that the major cause of flooding in the last 15 years has been from the Big and Small Feeder Brooks.

Discussion with Mr. H. Smith, Public Works Canada, in Rocky Harbour indicated that Public Works has no information concerning the Trout River flooding problems.

A meeting was also held with Mr. P. Caines, Chief Park Warden for Gros Morne National Park. After discussion with other staff members, it was determined that Parks Canada had no photographs or records on Trout River. When the new bridge was built at Lower Trout River Pond, some assessment was done into high water marks but all information was verbal.

2.2 Historical Floods

2.2.1 History of Flooding

Winter 1985/86: According to Mr. Howard Crocker, the Mayor of Trout River, ice which formed on Feeder Brook broke up and was flushed downstream to jam at the confluence of Feeder Brook with Trout River. In this incident a local road was closed due to water and ice flowing across it. There were no reports of any property damage. Mr. Crocker stated that this type of flooding occurs every two or three years.

1980-82: Floods have also occurred as a result of ice jams near the island in Trout River. Sometime between 1980 and 1982 an ice jam near this island resulted in the grounds surrounding the local school being flooded. There were no reports of property damage from this flood. According to residents this type of flooding occurs less frequently than the type of event noted above.

Spring 1976: The Trout River bridge was damaged by ice and high water. Scouring was reported around the centre pier and settling resulted. Ice also damaged the planking on the nose of the piers. No other damage was reported.

2.2.2 Nature of Flooding

The known floods which have occurred in the Trout River area appear to have been as a result of ice jams, usually at the confluence of Feeder Brook with Trout River, and less frequently at the island in the river or near the bridge in the community. There have been no reports of floods from high fresh water flows or of floods related to high tides.

We have been informed by the residents of Trout River that the flooding in the last 15 years has not been caused by Trout River but by two small tributaries which flow into the river known as the Big and Small Feeder brooks. Before 1975 the runoff was handled by the two Feeder Brooks and each brook contained its own bridge. In 1975 or 1976 the Deparment of Transportation tried to rechannel all of the runoff into Big Feeder Brook by eliminating the bridge on the Small Feeder and placing four 1.2 metre culverts in its place. Eighty metres down from the pump house where the Big Feeder and Small Feeder intersect a gravel retaining wall was constructed to eliminate the flow of water into the Small Feeder. A new bridge was then constructed over the Big Feeder. This was an attempt by the Department of Transportation to eliminate the problem of flooding caused by ice jamming at both of the old bridges. Ten to fifteen meters above the area where the gravel retaining wall was constructed a bend in the Big Feeder causes ice to block up during quick runoff. Water builds up behind the ice and flows over the gravel retaining wall into the Small Feeder down towards the four culverts. Snow buildup around the four culverts from snowfall and winter snow clearing causes the culverts to block up. The water that is flowing in the Small Feeder builds up behind the blocked culverts until it reaches a level where it flows onto the road and into surrounding fields. Ice building up at the Big Feeder bridge adds to the flooding problem.

Another area of problem is the confluence of Big Feeder Brook and

Trout River. If this area is blocked with ice from Trout River then ice flowing down the Big Feeder has nowhere to go and adds to the ice jam. Water builds up behind the ice, thus resulting in the surrounding area being flooded. This flooding does not seem to be as serious as the first one mentioned.

2.3 Previous Studies

A study was carried out with the objective of providing a technique for estimating the 20 and 100 year recurrence interval instantaneous flood flows for the Island of Newfoundland. The results are described in the report "Regional Flood Frequency Analysis for the Island of Newfoundland". These are extensively used in the estimation of flood flows for a variety of projects including flood risk mapping, remedial measures studies, the design of spillways, bridges, and other hydraulic structures.

2.4 Existing Data

2.4.1 Hydrometric Data

Data from five hydrometric stations in the area were considered appropriate for use or potential use in this study. These stations are:

1. 02YF001 Cat Arm River above Great Cat Arm
2. 02YJ001 Harry's River below Highway Bridge
3. 02YK002 Lewaseechjeech Brook at Little Grand Lake
4. 02YK003 Sheffield River near TCH
5. 02YK004 Hinds Brook near Grand Lake

Physiographic and hydrometric data for each of these stations is shown in Table 2.1.

TABLE 2.1 (Part 1)

PHYSIOGRAPHIC AND HYDROMETEOROLOGIC DATA BASE

STATION NAME AND NUMBER	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 OF BASIN DIVIDE IN VICINITY OF MAIN CHANNEL (m)	SLOPE OF MAIN CHANNEL (%)	DRAINAGE DENSITY (km/km^2)	SHAPE FACTOR	OVERBURDEN THICKNESS (m)
Cat Arm River above Great Cat Arm (02YF001)	611	51.39	28.91	420.69	110.01	30.17	250	.829	.582	1.86	2.19
Harry's River below Highway Bridge (02YJ001)	640	35.43	55.24	505.48	43.85	60.00	509	.848	1.120	1.81	4.62
Lewaseechjeech Brook at Little Grand Lake (02YK002)	470	46.47	29.05	258.25	136.23	54.88	560.8	1.022	.627	2.32	.98
Sheffield River near Trans Canada Highway (02YK003)	391	37.36	29.70	264.59	59.34	38.09	378	.992	.191	1.98	19.80
Hinds Brook near Grand Lake (02YK004)	529	62.54	125.41	186.26	154.79	49.29	320.1	.649	.637	1.78	12.50

TABLE 2.1 (Part 2)

PHYSIOGRAPHIC AND HYDROMETEOROLOGIC DATA BASE

STATION NAME AND NUMBER	AREA CONTROLLED BY LAKE & SWAMP (%)	MEAN ANNUAL RUNOFF (mm)	MEAN SNOWPACK WATER EQUIVALENT AT BASIN CENTROID ON MARCH 20 (mm)	24 HOUR, 25 YEAR RETURN PERIOD STORM RAINFALL AT CENTROID (mm)	QP_2 (m^3/s)	QP_{10} (m^3/s)	QP_{20} (m^3/s)	QP_{100} (m^3/s)	LATITUDE (°)	LONGITUDE (°)
Cat Arm River above Great Cat Arm (02YF001)	100	1420	430	84	271	379	417	499	50.160	57.050
Harry's River below Highway Bridge (02YJ001)	75	1321	250	82	321	530	617	825	48.747	58.000
Lewaseechjeech Brook at Little Grand Lake (02YK002)	100	1162	270	84	86.3	131	147	183	48.569	57.653
Sheffield River near Trans Canada Highway (02YK003)	94	856	260	78	74.0	98	103	113	49.282	56.597
Hinds Brook near Grand Lake (02YK004)	95	984	250	80	91.3	126	138	164	48.963	57.018

SOURCE: REGIONAL FLOOD FREQUENCY ANALYSIS FOR THE ISLAND OF NEWFOUNDLAND

2.4.2 Tidal Data

Hourly tidal data for the Lark Harbour station was obtained for the period 1963-1988. These data were provided by Environment Canada (Marine Environmental Data Service), Department of Fisheries and Oceans in hard copy tabular form (150 pages). (See Table A.6 for an example page of the data format.)

In addition two recent investigations by Martec Limited on tides and extreme water levels at Cox's Cove and Parson's Pond were obtained and reviewed. The results of these analyses are summarized in Tables A.7 to A.10.

No local tidal measurements were found. In the absence of local tidal measurement, tidal information was derived from the regional reference point at Harrington Harbour. Interpolation of results from Table A.7 to A.10 were then utilized and referred to for comparison purposes.

2.4.3 Field Surveys

Field surveys of channel and floodplain characteristics were carried out along the Trout River in the spring of 1989 by staff from Island Engineering and Cumming Cockburn Limited. These studies are discussed in Section 3.0 of this report and in the Survey and Monitoring Report.

3.0 HYDROLOGIC ANALYSES

3.1 General

Long term streamflow measurements are not available on the Trout River watershed. Therefore, the 20 and 100 year recurrence interval peak flows were determined for the Trout River watershed (Figure 3.1) using alternative estimating techniques:

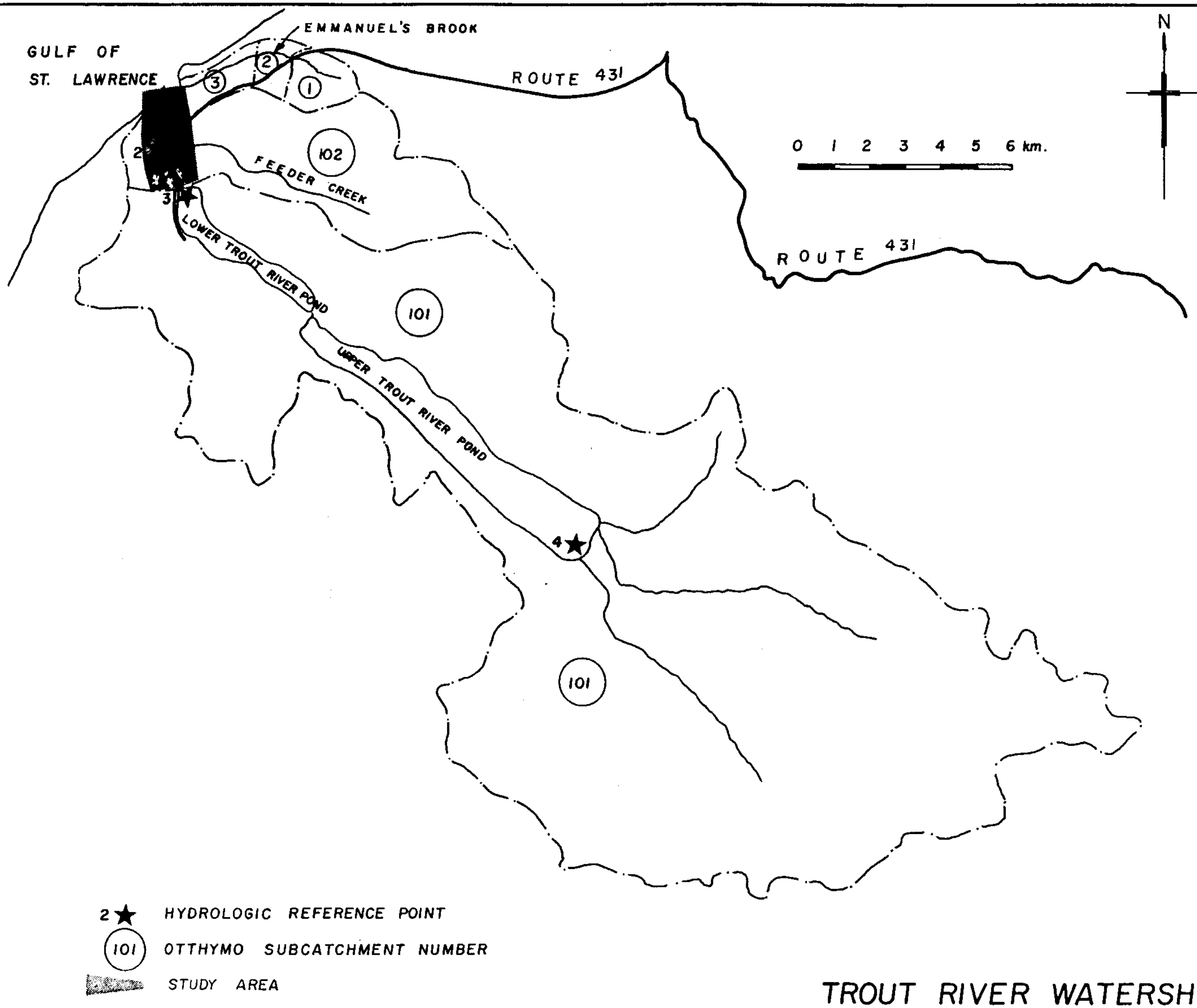
1) Statistical Analyses - Regional Flood Frequency Analysis
   - Single station estimate from nearby watersheds
2) Deterministic Analysis - Instantaneous Unit Hydrograph technique

These alternative estimating techniques were used for comparison purposes and in order to assess the reliability and accuracy of the available peak flow estimates.

To provide peak flow estimates, a regional flood frequency analysis was applied using procedures developed under the Canada-Newfoundland Flood Damage Reduction Program in 1983. For comparison purposes, the transfer of statistical estimates from nearby watersheds with hydrometric stations was made to estimate flows for the Trout River.

Also for the purpose of comparison and as a means of verifying the results of the regional estimates, a secondary peak flow analysis was undertaken utilizing the deterministic model OTTHYMO, as discussed in Section 3.3. Experience with this technique in other flood studies has proven its usefulness as a means of estimating peak flows for ungauged watersheds.

The following sections outline the procedures used in the development and application of these techniques for estimating peak discharges associated with the 20 and 100 year recurrence interval flood events.



TROUT RIVER WATERSHED

FIGURE 3.1

3.2 Statistical Analyses

3.2.1 Flood Flow Estimates

i) Regional Flood Flow Estimates

A Regional Flood Frequency Analysis has been completed under the Canada-Newfoundland Flood Damage Reduction Program (Env. Canada and Newfoundland Environment, 1983). The results of this analysis have been utilized in this study to derive Regional Flood estimates for the instantaneous flood flows on the Trout River.

The regression equations developed in the above noted study are based on a single station instantaneous flood frequency analysis at 11 hydrometric stations with at least 10 years of record located in southern and eastern parts of the Island of Newfoundland. The regression equations are developed in the following form:

$$\log_{10} QP_T = K + a \log_{10} DA + b \log_{10} MAR + c \log_{10} ACLS + d \log_{10} SHAPE \qquad (3.1)$$

where QP_T = T year maximum instantaneous peak flow

K,a,b,c,d = constants (refer to Appendix A for specific values)

DA = area controlled by lake and swamp (% of drainage area) from 1:50,000 NTS maps using criteria that lake or swamp with surface areas at least 1% of the drainage area to the lake or swamp outlet controls the area to the outlet

SHAPE = (0.28 x basin perimeter) $\sqrt{DA}$ (1/km) from Chow's Handbook on Hydrology

MAR = Mean Annual Runoff (mm) over the area

ACLS = Area controlled by lakes and swamps.

Since the drainage area of Trout River was outside the range of application of the equation developed for the Northern Region, the prediction equation developed for the entire island was used.

Regression equations and results for the entire Island and for the North Region for the 20 and 100 year storms are shown in Appendix A in Tables A.1 through A.4. The parameter range used for the analysis is given in Table A.5.

The peak instantaneous flow rates calculated are summarized in Table 3.2.

ii) Regional Flood Flow Estimates from Other Sites

To help verify peak flows as estimated by the Regional Flood Frequency Analysis on the Trout River, the average of the unit 100 year regional flood flow estimates for five nearby stations was calculated. The following stations were selected due to hydrologic similarity:

1) 02YF001 Cat Arm River above Great Cat Arm
2) 02YJ001 Harry's River below Highway Bridge
3) 02YK002 Lewaseechjeech Brook at Little Grand Lake
4) 02YK003 Sheffield River near TransCanada Highway
5) 02YK004 Hinds Brook near Grand Lake

Regional instantaneous flood flow rates for each of the five stations were taken from the Regional Flood Frequency Analysis using the equations for the entire Island of Newfoundland. The watershed parameters are summarized in Table 2.1 and the unit flow rates are summarized in Table 3.1.

The average unit flow rate was then applied to the Trout River Basin at the outlet of Lesser Trout River Pond and at the outlet of the Trout River. These peak flow rates are summarized in Table 3.2, column 2, for the 20 and 100 year return period storms.

TABLE 3.1

HYDROMETRIC STATION SUMMARY

Station	Area (km^2)	Entire Island Regression Analysis				Single Station Analysis			
		100 Year		20 Year		100 Year		20 Year	
		Q (m^3/s)	Q/Area $m^3/s/km^2$)	Q (m^3/s)	Q/Area ($m^3/s/km^2$)	Q (m^3/s)	Q/Area ($m^3/s/km^2$)	Q (m^3/s)	Q/Area ($m^3/s/km^2$)
02YF001	611	413	0.68	333	0.54	499	0.82	417	0.68
02YJ001	640	575	0.90	465	0.73	825	1.29	617	0.96
02YK002	470	189	0.40	155	0.33	183	0.39	147	0.31
02YK003	391	103	0.26	88.7	0.22	113	0.29	103	0.26
02YK004	529	186	0.35	158	0.30	164	0.31	138	0.26
Average Unit Flow ($m^3/s/km^2$)			0.52		0.42		0.62		0.50

TABLE 3.2

COMPARISON OF INSTANTEANEOUS FLOW RATES

(m^3/s)

Location	1*	2*		3*		4*
		$(A1/A2)^1$	$(A1/A2)^n$	$(A1/A2)^1$	$(A1/A2)^n$	
		**				
100 Year						
Upper Trout Pond	263	-		-		244
Lower Trout Pond	116	118/96		141/103		100
Outlet Trout River	144	131/107	157/126	157/114	188/134	127
20 Year						
Upper Trout Pond	208	-		-		186
Lower Trout Pond	91	97/80		113/86		88
Outlet Trout River	118	108/89	126/102	126/96	146/110	111

* Column 1 - Regional Regression Analysis (See Appendix A)
2 - Averaged Regional Flow from other stations
3 - Averaged Single Station analysis from other stations
4 - OTTHYMO simulation
n - Coefficient taken as 0.66 for 100 year and 0.69 for 20 year

** Average for 5 stations/Average of 4 stations - 02YJ001 removed

3.2.2 Single Station Statistical Analysis

Peak flow rates determined by single station statistical analysis for the stations listed in Table 3.1 were also used to determine an average unit flow rate (CNFDRP, 1983). The average unit flow rate was then applied to the Trout River Basin.

The average single station analysis produced flow estimates slightly higher than the Regional regression equations for the Trout River. Peak flow rates are compared to other methods in Table 3.2.

The secondary comparisons indicated that data available at the Harry River gauge may be resulting in high peak flow estimates. Therefore, for comparison purposes, this data was removed from the average presented in Table 3.2. This resulted in a lower overall average for the secondary comparisons. Overall, this tends to confirm that the use of the Regional Regression Estimates provide reasonable peak flow estimates for the study area.

3.3 Deterministic Analyses

3.3.1 Introduction

The 20 and 100 year peak flows were also estimated by using a synthetic unit hydrograph procedure known as OTTHYMO (University of Ottawa). The input requirements of this simulation technique include both meteorological (rainfall/snowmelt) data and physiographic characteristics (land use, time to peak values, constituent soil characteristics, etc.) of the study area.

The following sections describe the hydrologic procedures used in the development and application of the OTTHYMO model in the preliminary determination of secondary peak flow estimates for the Trout River watershed. A comparison of the deterministic and statistical estimates is given in Table 3.2 and discussed in Section 3.4.

3.3.2 OTTHYMO Model Structure

The OTTHYMO program is a hydrologic computer model used to simulate the surface runoff from a particular drainage area for a specific meteorological input. For transformation of the input into runoff hydrographs, the program uses a synthetic unit hydrograph technique and the Soil Conservation Service rainfall-runoff relationships (SCS, 1972).

The program generates a hydrograph for each selected sub-drainage area of the watershed, in this case, Trout River to Lower Trout River Pond, and the Feeder Brook watershed.

The reservoir routing effects of Upper and Lower Trout River Ponds were also modelled using the OTTHYMO program. The input requirements are the discharge/storage relationship for the ponds. Field measurements at the outlet of Lower Trout River Pond and available topographic maps were used to obtain these relationships. The model parameters are summarized in Appendix A.2.

3.3.3 Meteorological Data

The design storm patterns and total rainfall used in the deterministic computer model were determined for the Trout River area based on available meteorological data.

The time of concentration of the Trout River watershed, to the outlet of Lower Trout River Pond was found to be about 9 hours. Storms with durations of 6, 12 and 24 hour storms were modelled. The 6 hour storm produced the highest instantaneous peak flow from the watershed area upstream of the Upper Trout River Pond and the 24 hour storm produced the lowest. However, when the hydrographs were routed through Upper and Lower Trout River Ponds, the 24 hour storm caused the highest flow to the study reach of the Trout River. This is attributed to the higher runoff volume associated with the 24 hour storm event.

For this reason, the peak flows associated with the 24 hour storm were selected as a comparison to the Regional Regression Analysis. The model input/output and OTTHYMO simulation results are summarized in Appendix A.2.

3.4 Floodline Profile Sensitivity to Flows

A preliminary backwater model (HEC-2) was developed to test the sensitivity of the floodline to different flows. The flows used were those calculated using the average Single Station unit flow rates, the recommended Regional Analysis equations applied to Trout River, and the OTTHYMO computer model. The flows were highest for the Single Station and lowest for the OTTHYMO computations.

It was found that for the single station analysis, the higher 100 year flow caused a maximum 0.24 m increase in depth, and an average depth increase of 0.14 m along the study area.

The flow calculated by the OTTHYMO model produced flood levels less than those corresponding to the regional regression flows with a maximum depth about 0.16 m less (average 0.11 m less).

3.5 Main Conclusions and Recommendations of Hydrologic Analyses

1) A suitable long term record of discharge measurements is not available for Trout River.

2) The peak flows were computed by application of the Regional Flood Frequency equations developed by CNFDRP. Other peak flow estimating procedures resulted in comparable peak flows, however, the regional technique is considered to be more reliable. Therefore, it was concluded that the peak flows estimated by the application of the regional equations are reasonable estimates which can be utilized in undertaking backwater computations along the Trout River.

3) The OTTHYMO model was selected to provide secondary peak flow estimates. While no data was available to calibrate the model to Trout River, this model has previously proven capabilities for simulating peak flows in a number of other practical applications, including the Stephenville Hydrotechnical Study (4). OTTHYMO peak flow estimates confirmed use of the peak flow estimates by the Regional prediction equation.

4) Secondary peak flow estimates derived by transferring unit peak flows from selected stream gauge locations also confirmed the peak flow estimates by the Regional Flood Frequency Equation.

5) The peak 20 and 100 year flows at the outlet of the Trout River (Reference Point #1 on Figure 3.1) were found to be 118 and 144 m^3/s respectively. From the confluence of the Feeder Brook (Ref. Point #2) to Lower Trout River Pond (Ref. Point #3), they were found to be 91 and 116 m^3/s respectively. These flows, summarized in Table 3.3, are recommended for computation of the 20 and 100 year flood profiles along Trout River.

TABLE 3.3

RECOMMENDED PEAK FLOWS FOR TROUT RIVER

Location	Return Period	
	20 Year (m^3/s)	100 Year (m^3/s)
Outlet to Feeder Brook	118	144
Above Confluence of Feeder Brook	91	116

4.0 HYDRAULIC ANALYSES

4.1 Methodology

4.1.1 General Overview

The main purpose of the hydraulic analysis on the Trout River was to transform peak discharge estimates into flood profiles. This was undertaken for the 20 and 100 year flood events.

A backwater model was developed to simulate the existing hydraulic characteristics of the channel and floodplain as interpreted from the results of field topographic and reconnaissance surveys, and from existing 1:2500 mapping. These surveys are discussed in Section 4.2. The backwater model was calibrated using measured water levels and peak discharge collected as part of these investigations. The model calibration is discussed in Section 4.3.

The flood profiles associated with the 20 and 100 year peak discharge rates were then established based on the calibrated model, and the 100 year floodlines plotted on the 1:2500 scale mapping. The flood profiles are discussed in Section 4.4.

In order to define the degree of sensitivity of simulated flood profiles to variations in the hydraulic model input parameters sensitivity testing was undertaken. This aspect is discussed in Section 4.5.

4.1.2 Model Description

In order to estimate the flood levels associated with each of the required flood peaks, a mathematical backwater model was applied to simulate the hydraulic characteristics along the Trout River. The effects of channel and floodplain storage on flood profiles along the study reach were generally not considered to be significant due to the comparatively large volume of the flood hydrograph. In cases where the effects of storage are not significant, it is a standard practice to assume steady state flow conditions in the computation of the backwater profiles.

Where a steady state backwater computation is employed, the appropriate peak discharge input to the model is the instantaneous peak of the flood hydrograph.

In the case of gradually varied steady flow, the equations of continuity and momentum describing the one-dimensional flow can be simplified to the form of the well-known Bernoulli equation:

$$\frac{\partial h}{\partial x} = (S_o - S_f) \ / \ (1 - v^2/gh) \qquad (4.1)$$

where h = depth of flow (m)

x = distance in direction of flow (m)

S_o = bottom slope (m/m)

S_f = boundary frictional effect (m/m)

v = velocity in direction of flow (m/s)

g = acceleration due to gravity (m/s^2)

For natural channels, energy losses occur due to flow resistance. The resulting friction slope can be determined from the Manning's equation:

$$S_f = (nv/R^{2/3})^2 \qquad (4.2)$$

where n = Manning's roughness coefficient

R = hydraulic radius

The HEC-2 model (USCE, 1982) has been successfully used in many similar practical applications. Therefore, this model was selected since it is a well proven and well documented nonproprietary technique which is flexible to use. The model can be applied in the future to evaluate the effects of recommended hydraulic improvements and any proposed channelization or filling along the study reach.

The program calculates water surface profiles for flow in natural or manmade channels, assuming that such flow is steady and gradually varied. The simplified one-dimensional equations of continuity and motion are solved using the standard step method with energy losses due to friction evaluated by the Manning's equation.

In addition, the model can calculate critical depth at each cross-section and can compute profiles for supercritical flow, where required. Backwater profiles can be run for subcritical flow conditions by specifying a starting water level at the downstream end of a stream reach being simulated. For supercritical flow conditions flood profiles can be computed by starting the computation at a known water level at the upstream end of a given study reach.

The model can take into account the following factors:

1) Channel roughness
2) Floodplain roughness
3) Islands or flow divisions
4) Bends in the stream or floodplain
5) Cross-sectional area of the stream channel and floodplain
6) Slope of the channel and floodplain
7) Energy losses at hydraulic structures, including bridges, culverts, weirs, dams, etc.
8) Channel and floodplain expansion and contraction losses
9) Variation in discharge along the study reach (i.e. due to tributary inflows.)
10) The effect of ice cover on the stream or floodplain.

The model requires input of channel and floodplain cross-sections and associated hydraulic parameters at frequent locations along the study reach. The cross-sections are normally located where changes occur in slope, cross-sectional area or channel roughness, and at bridges or other hydraulic impediments to the flow.

A major advantage of the HEC-2 model is that the channel and floodplain roughness (Manning's 'n') can be varied for each cross-section in the program. This provides a means of describing the various local factors on which the roughness coefficient depends such as channel composition, type and extent of vegetation, etc.

Energy losses created at hydraulic structures, such as bridges and culverts, are computed in the program in two parts. First the energy losses due to expansion and contraction of the flow at the cross-section on the upstream and downstream sides of the structure are calculated, and second, the energy loss through the structure itself is computed by either using the special bridge or the normal bridge sub-routine in the HEC-2 model. Energy losses due to expansion and contraction of flow are calculated by employing expansion and contraction coefficients which are multiplied by the absolute difference in velocity heads between cross-sections to estimate the energy loss caused by the transition.

When the normal bridge subroutine is used the water level is computed at the bridge or culvert section in the same manner as normal river cross-sections, but excluding the cross-sectional area of any existing piers, deck or wingwalls below the water surface. When the water surface elevation exceeds the bottom chord, the wetted perimeter of the section is also adjusted. The special bridge routine computes losses through the structure for low flow or for any combination of weir flow and pressure flow.

The Trout River was modelled from the mouth of the river to the Lower Trout River Pond, a distance of approximately 2.6 km. Feeder Brook was also modelled for a distance of approximately 0.5 km from its confluence with Trout River.

The specific characteristics of the channel and floodplain modelled are discussed in detail later in this report.

4.2 Hydraulic Model and Input Data

4.2.1 Field Survey

Cross-sectional data were unavailable for the Trout River study reaches. Therefore, field surveys were undertaken as part of this investigation to measure typical channel and floodplain cross-sections.

All topographic information collected during the field surveys was related to geodetic elevation and where possible, all sections were located by means of reference to recognizable land marks located near the floodplain.

Floodplain and channel roughness coefficients were also assessed in the field utilizing procedures developed by the U.S. Dept. of Transporation (U.S. Dept. Transportation, 1984).

i) Cross-sections

A total of 15 cross-sections were field surveyed along the study reach. The complete inventory of cross-sections, including location and extent, is shown on the flood risk maps developed in conjunction with this study. Cross-section measurements were obtained at representative locations along the study reach, and were located based on changes in the slope, cross-sectional area or channel roughness. Additional measurements were taken near all bridge crossings along the study reach. Cross-section plots and the location of each surveyed location are given in the Field Survey report.

By means of a comparison of field surveys to the 1:2500 scale topographic mapping, it was evident that the elevations denoted on the mapping and determined from the surveys were, in general, similar along the study reaches. Therefore, it was decided that the mapping could be used to supplement the field surveys where necessary. The location of surveyed and map interpreted cross-sections is summarized in Appendix D.

A more detailed discussion of the physical characteristics of the stream channels and floodplain can be found in Section 4.2.2 of this report.

ii) Hydraulic Structures

Each of the hydraulic structures along the study reach represents a potential flow constriction which may have a pronounced effect on water surface profiles during flood periods. Therefore, the physical dimensions and elevations of all hydraulic structures were field surveyed as described in the Physical Surveys and Field Program report. These measurements included the size of the opening and the elevations of the soffit and bridge decks, etc. The data sheets for the bridges are included in this report as Appendix C.

iii) Crest Gauges

In order to collect peak water level data for the purpose of calibrating the hydraulic routing model, a total of 3 crest gauge stations were installed along the Trout River in 1989, under the direction of Island Engineering Company Limited and Cumming Cockburn Limited. Subsequent measurements of water levels were undertaken in order to collect data suitable for model calibration. Additional information on the data collected is included in the Survey and Monitoring Report.

The results of the field investigations and river and floodplain characteristics are discussed in the following section.

4.2.2 Channel and Floodplain Characteristics

i) General Hydraulic Characteristics

The channel and floodplain characteristics of the study reach were identified by means of field reconnaissance surveys. Generally, it was found that the west bank was steep and heavily wooded while the east bank was flat floodplain, approximately 1-2 m above the river. The overbanks are generally grassed adjacent to houses. More development exists in downstream areas with sparser housing upstream approaching Gros Morne National Park.

The river is relatively straight, with a few curves and a fairly constant width of 25 to 40 m. The riverbed consists of pebbles and boulders.

Manning's roughness coefficients were selected based on relative cover, type and amount of vegetation, channel configuration and natural physical constraints relative to the channel and overbank reaches along the watercourse (Chow, 1959). Typical roughness coefficients were then determined based on field observations of channel and overbank characteristics, experience in conducting similar investigations, and with reference to the classification techniques developed by the U.S. Department of Transportation (U.S. Dept. Transportation, 1984). A summary of typical Manning's roughness coefficients determined for various reaches of the study area are given in Table 4.1.

ii) Hydraulic Structures

The discharge and flood levels during peak flows are also influenced to some degree by two bridges along the Trout River. The bridge crossing Feeder Brook controls flood levels during peak flows.

TABLE 4.1

TROUT RIVER FLOOD STUDY

SUMMARY OF TYPICAL ROUGHNESS COEFFICIENTS

Cross-Section	Left Overbank 1 2	Right 1 2	Channel 1 2
0 + 045	0.055/0.095	0.055/0.085	0.045/0.050
0 + 810	0.045/0.055	0.090/0.090	0.045/0.050
1 + 035	0.035/0.040	0.075/0.075	0.045/0.045
1 + 485	0.045/0.045	0.085/0.085	0.040/0.045
1 + 700	0.045/0.045	0.080/0.080	0.045/0.045
1 + 805	0.045/0.045	0.090/0.090	0.045/0.045
2 + 805	0.030/0.030	0.095/0.095	0.045/0.045
2 + 300	0.045/0.045	0.100/0.100	0.045/0.045
2 + 600	0.045/0.045	0.045/0.045	0.065/0.055
2 + 620	0.035/0.035	0.035/0.035	0.045/0.045

NOTES: 1. Uncalibrated Roughness Coefficient
2. Calibrated Roughness Coefficient

4.2.3 Hydraulic Model Application

In order to simulate the flood levels associated with the 20 and 100 year peak flows, the available background and field data was input to the HEC-2 program.

With respect to input of available data, the following criteria were established in order to define cross-section locations and characteristics.

i) All sections are coded as if looking upstream along the watercourse.

ii) Field measured cross-sections used in the hydraulic model are referenced to the supplementary field report according to the sequential numbering system developed during the field surveys.

iii) In some cases, field measured cross-sections were used more than once as typical cross-sections along particular reaches. This is to facilitate the accurate coding of bridges and other such constraints at various locations on the watercourses, as described in the program documentation (USCE, 1982). Invert elevations were adjusted by applying the average slope between measured sections to the point of interest.

iv) All hydraulic structures are referenced to the field survey report through the use of comment cards in the HEC-2 computer listing.

Head losses through the bridges (see Appendix D for structure characteristics) were simulated using the special bridge method, as described in the HEC-2 Users Manual (USCE, 1982). This option allows a combination of pressure and weir flow to be modelled.

4.2.4 Starting Water Elevation

The starting water surface elevation for Trout River is determined by tidal influence. A discussion for the methodology in determining tide conditions and water elevations is included in Appendix E. The starting levels were found to be 1.92 m and 1.64 m for the design flood conditions (100 and 20 year respectively).

4.2.5 Ice Jam Analysis

A theoretical ice jam analysis was attempted as described in Appendix F. This analysis indicated that ice jams on the Feeder Stream would generally not be associated with flows greater than approximately 10 - 20 m^3/s.

Historically, ice jams have occurred which almost completely blocked the Feeder Stream Bridge. This led to the construction of four flood relief culverts near the bridge.

An hydraulic analysis was undertaken by assuming that the bridge and culverts were almost completely blocked with ice. It was found that flood water would overtop the road for flows above 5 m^3/s, assuming nearly complete blockage. The flood depths over the road for various flow rates are shown in Table 4.2.

An ice jam occurred in January of 1990 at this location. (See Appendix F and the Survey and Monitoring Report for photographic documentation.) Observations confirmed that nearly complete blockage of the bridge and culverts occurred as a result of upstream ice accumulation. Flooding was also apparently made worse by the height of accumulated roadside snow banks. Flow was observed to occur over the road, thus providing indirect confirmation of the hydraulic modelling results (although no discharge observations were available for this event).

TABLE 4.2

FLOOD DEPTHS AT FEEDER BROOK BRIDGE*

Flow (m^3/s)	Elevation (m)	Depth over Road (m)
2	5.09	-
5	5.67	0.29
10	5.77	0.37
15	5.83	0.43
20	5.89	0.49

* HEC-2 simulations with ice blockage on Feeder Brook Bridge

Comparison to open water flood levels will indicate that ice jam flooding is higher at this location.

Open water elevations for the 100 and 20 year events are 5.77 and 5.50 m respectively but all flow remains in Big Feeder Brook where the level is higher. Under ice conditions, water is forced into Small Feeder Brook farther upstream. The road elevation is lower near the culverts (±1.0 m) and flooding occurs at lower flows.

4.3 Model Calibration

4.3.1 General

In order to accurately reflect the potential flood conditions along the Trout River, an attempt was made to calibrate the HEC-2 model using field measured high water levels collected as part of a monitoring program conducted in 1989. The monitoring program and data collected are discussed in the Survey and Monitoring Report. The observed water levels were utilized in order to refine the backwater model parameters determined during the field reconnaissance phase of the study.

The general procedures for calibration of the HEC-2 model are summarized in the following section.

4.3.2 Methodology

The HEC-2 model calibration was undertaken by modifying the channel and floodplain roughness coefficients (Manning's "n") and other hydraulic parameters (e.g. expansion and contraction coefficients) until acceptable simulation accuracy was achieved. It was evident that the Manning's roughness coefficient was the most sensitive parameter with respect to calibration of water levels on the Trout River.

Discharge data used in the analysis was as recorded at the Lower Trout River Pond bridge and Feeder Brook bridge.

The following outlines the general procedures for calibration and verification of the HEC-2 model:

1) Water level measurements were collected by field survey in 1989, at predetermined locations along the Trout River (refer to 1:2500 mapping for gauging locations).
2) The sensitive hydraulic model parameters were selected.
3) Computed water levels were compared to those recorded from crest gauges.
4) Hydraulic parameters were varied, as required, until a suitable comparison between measured and computed water levels at the gauge locations was achieved.
5) Flows of 36.7 and 20.7 m^3/s on Trout River on May 17 and May 30, 1989 were used for calibration.

This peak flow has a frequency of occurrence of approximately once in 5 years. A summary of the calibration results can be found in Table 4.3, with a corresponding discussion of calibration results in Section 4.3.3 and 4.3.4.

Based on the findings of the model calibration, it was determined that the backwater model is a suitable representation of the hydraulic characteristics of the Trout River in the study area.

4.3.3 Model Calibration

Calibration was undertaken by modifying the channel and floodplain roughness coefficients as required. Water level and discharge observations recorded on May 17 and May 30, 1989 were used to calibrate the HEC-2 backwater model.

TABLE 4.3

TROUT RIVER FLOOD STUDY

SUMMARY OF BACKWATER MODEL CALIBRATION

Gauge No.	May 17, 1989 Q = 36.7 m^3/s		May 30, 1989 Q = 20.7 m^3/s	
	Measured	Simulated	Measured	Simulated
1	1.40	1.52	1.45	1.51
2	1.65	1.68	1.50	1.57
3	6.92	6.93	6.56	6.57

The initial uncalibrated backwater model utilized the hydraulic parameters as determined from the field reconnaissance surveys of the study area. The calibrated roughness values are summarized in Table 4.1.

Table 4.3 summarizes the results of the backwater model calibration on Trout River to conditions on May 17 and May 30, 1989.

4.3.4 Summary of Model Calibration

The available data base was inadequate to fully calibrate the model, most notably in the downstream areas influenced by tides and surges. However, the results of this preliminary calibration are adequate for the purpose of this study. Therefore, in our opinion, the calibrated backwater model can be used to accurately simulate the water surface profiles.

Additional model sensitivity testing is discussed in Section 4.5.

4.4 Design Flood Profiles

The main objective of this investigation was to determine flood profiles along the study reach for floods with a recurrence interval of 20 and 100 years.

The hydrologic analyses described in Section 3.0 resulted in the determination of the instantaneous peak discharge values for the study area for these events.

The HEC-2 backwater model was developed as discussed in Section 4.2. Channel and floodplain characteristics were determined as discussed in Section 4.2.2. The calibration undertaken has increased the level of confidence in the ability of the backwater model to accurately simulate flood profiles.

The model structure was discussed in Section 4.2. The following briefly outlines the main assumptions in the application of the calibrated model for the simulation of the flood profiles on the Trout River:

1) Water level profiles were computed assuming a subcritical flow condition.
2) The hydraulic coefficients used in the development of the 20 and 100 year flood profiles were those as calibrated to May 17 and May 30, 1989 conditions.
3) All bridges were assumed free of any temporary obstruction which may reduce the hydraulic discharge capacity.
4) Peak flows summarized in Table 3.3 were used in determining the flood profiles.

Numerical values for the various flood profiles are summarized in tabular form in Appendix D of this report.

The extent of the flooded areas associated with the 100 year flood profile was determined by plotting the floodline on topographic maps at a scale of 1:2500. Interpretation of the backwater profiles and associated computer output, together with an assessment of the extent of flooded areas was undertaken in order to identify flood hazard locations.

4.5 Sensitivity Testing on Design Flood Profiles

4.5.1 Methodology

In order to assess variations in the magnitude of various input parameters on flood profiles along the study reaches, various sensitivity simulations were undertaken.

Based on a review of the initial model simulations, the field reconnaissance survey, and on previous results of backwater modelling, the following parameters were determined to be of most importance with respect to definition of flood levels in the study area:

- the influence of initial water level variations
- peak discharge rates along the watercourse
- definition of channel and floodplain roughness coefficients (Manning's 'n')

During the sensitivity testing, the relative importance of model variables was determined by changing one variable within prescribed limits while holding the remaining variables and input parameters constant during a simulation. By noting the change in magnitude of computed water levels, the relative importance and sensitivity of each parameter was established. All sensitivity analyses were undertaken utilizing the calibrated model and the 100 year flow developed as part of these investigations.

4.5.2 Sensitivity to Peak Discharge

Sensitivity simulations were conducted utilizing the computed 100 year peak discharge versus the 100 year peak discharge plus or minus ten percent.

Variations in peak discharge had little effect on water levels. There were very small differences in the reach from the outlet to the bridge in town. This is attributed to tidal influences. Upstream of the bridge, differences in water level increased more. The greatest difference between the high and low flow was found to be 0.25 m.

The average difference in flood profile upstream of the bridge, for a variation of ±10% of peak discharge, was found to be approximately 0.16 m.

4.5.3 Sensitivity to Starting Water Levels

The HEC-2 model requires the definition of initial starting levels along the study reach. This, in turn, accounts for possible backwater effects on water levels in the lower portions of a channel reach. Sensitivity simulations were undertaken to determine the effect of variations in the initial water levels on flood levels in Trout River.

For the purpose of this investigation, the range of water levels at the outlet was chosen as 1.54 to 2.12 m. This represents the 95% confidence limits of the tide during the 100 year runoff event.

It was evident from this analysis that tidal influence is a significant factor with respect to water levels from the outlet to approximately 1,000 metres upstream, or 400 m below the confluence of Feeder Brook. Upstream of Feeder Brook there is no tidal influence during flood events. The average difference in the downstream water levels was about 0.47 m, ranging from 0.02 to 0.58 m (excludes starting level at downstream section).

4.5.4 Sensitivity to Roughness Coefficient

Manning's roughness coefficients for the channel and floodplain were determined as described in Section 4.2.2. The sensitivity of the flood profile computations to variations in roughness coefficient was undertaken as a means of further substantiating the accuracy of the backwater model subsequent to model calibration.

The range of Manning's "n" values applied in the analysis as a "mean value" are summarized in Table 4.1. The discharge value used in the sensitivity testing corresponded to the median 100 year estimate of peak flow as given in Table 3.3.

The range of "n" values given in Table 4.1 corresponds to the range of potential values as described by Chow (Chow, 1959) applied to the channel characteristics of the study reach. For the purposes of these sensitivity tests, it was determined that the roughness coefficients could vary ±20% about the "mean value".

The average difference in water levels from the mean were found to be about ±0.06 m corresponding to +20% and -20% changes in the roughness coefficients respectively. The corresponding range of differences were found to be about 0.00 m to 0.34 m and 0.00 to 0.20 m respectively. Similarly, the corresponding maximum difference between the upper and lower range was 0.37 m near Lower Trout River Pond.

4.5.5 Summary of Results and Conclusions of Sensitivity Analysis

The following points summarize the main findings and conclusions of the sensitivity analyses on computed flood profiles along the study watercourses (for the 100 year event).

1) The sensitivity of the flood profile along the watercourse to variation in peak discharge can be represented by the following:
   - average difference above the 100 year +10% limit was 0.06 m (range of 0.04 to 0.12 m)
   - average difference below the mean for -95% confidence limit was 0.07 m (range of 0.0 to 0.13 m).
2) The sensitivity of flood profiles along the Trout River to variation in roughness coefficient resulted in changes in flood elevations in the range of 0.37 m.
   - average difference above the mean for +20% change in n was +0.10 m (range of 0.00 to 0.17 m)
   - average difference below the mean for -20% was 0.06 m (range of 0.00 m to 0.19 m)

3) The influence of starting water levels is felt along the lower portion of the study reach downstream of the confluence with Feeder Brook.

4.6 Conclusions of Hydraulic Analysis

The HEC-2 backwater model was successfully utilized to determine flood profiles along the Trout River using channel and floodplain characteristics determined from the field surveys.

The following conclusions were derived from the hydraulic analysis:

1) The flood profiles were most sensitive to starting water surface elevation and variation in discharge and less sensitive to channel and floodplain roughness coefficients.

2) Testing of the backwater model by comparison to observed flood levels has confirmed the flood level simulations.

3) A potential for ice jams was found to exist along Feeder Brook. Ice jam flood levels were found to exceed open water flood conditions upstream of the Feeder Brook Bridge.

4) Design flood levels for the 20 and 100 year events were determined at each cross-section and are summarized in Appendix D.

5.0 EMMANUEL'S BROOK

5.1 Introduction

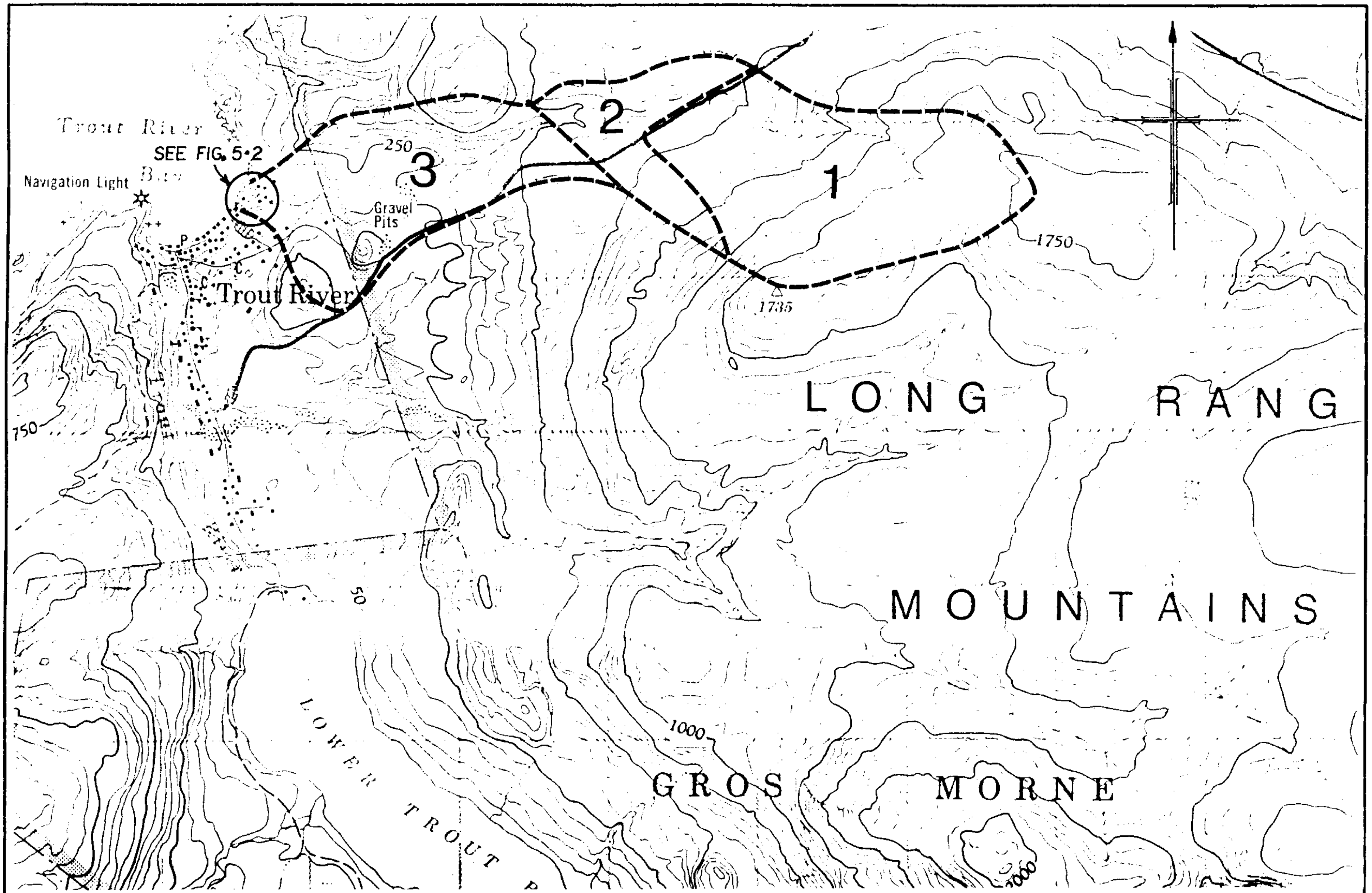
Emmanuel's Brook is a small stream at the east side of the Community of Trout River. The location of the watershed is shown on Figure 5.1. The watershed area is approximately 4.7 km^2. The brook has a very steep gradient with an average slope greater than 6%. The lower portion of the brook, about 220 metres in length from the beach to the house just upstream of the road, is much flatter with a slope of about 2.2%. In the past few years it has flooded several homes in the eastern part of Trout River during sudden thaws in late winter and early spring. In January 1990 Cumming Cockburn Limited was requested by the Technical Committee to undertake a preliminary study of the flooding of Emmanuel's Brook area as an addition to the Trout River Study.

5.2 Background and Interviews

This study was undertaken after discussion between the Department of Environment and Lands and residents of Trout River concerned with the recurring flooding of Emmanuel's Brook.

Emmanuel's Brook had flooded recently in March 1988 and again in March 1989. The 1988 flood was considerably worse than the 1989 flood, with water rising above the main floor on four houses (#3, 4, 6, 7). This was confirmed by several residents. (House numbers are shown on Figure 5.2.)

On January 27, 1990, a sudden thaw and rain occurred causing Emmanuel's Brook to flood again. According to most residents in the area, interviewed on April 16 and 17, 1990, this flood was worse than those in previous years with flood levels once more above several first floor levels. The following interview comments pertain mainly to the 1990 flood event except where noted.



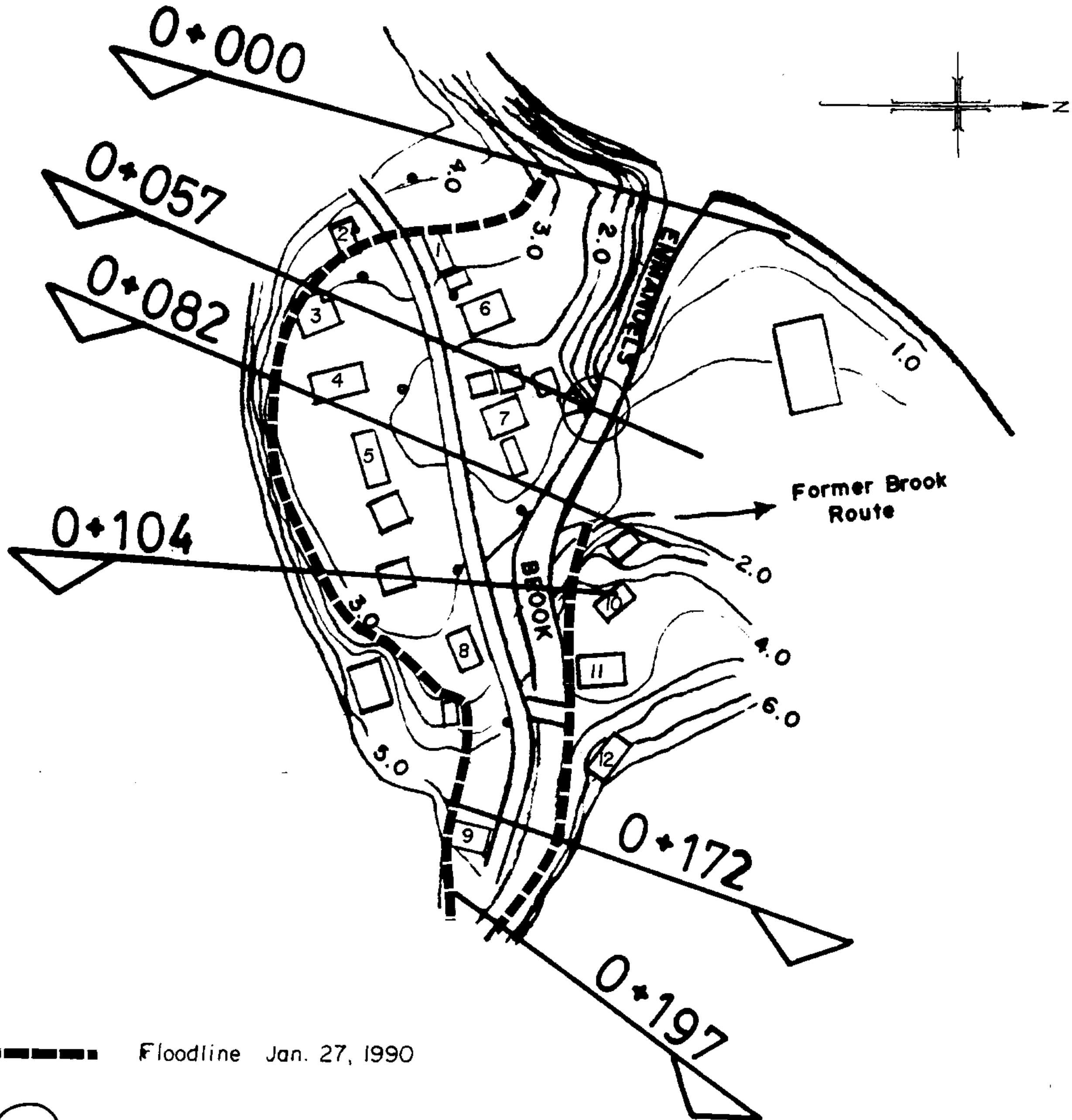
Cumming Cockburn Limited
Consulting Engineers and Planners

SCALE 1:35000

EMMANUEL'S BROOK WATERSHEDS

7262

FIGURE 5·1



Floodline Jan. 27, 1990

Historical location of Ice jam.

0 + 172 Section No.

Scale: 1:1670 approx.

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Consulting Engineers and Planners

EMMANUEL'S BROOK FLOODLINE

7262

FIGURE 5.2

Mr. Fred Crocker, who lives in the other side of town, has two brothers living in this area in houses 3 and 4. He said that the water level at house 3 (Mr. George Crocker) was just below the front door and the main floor level. House 4 had 3 to 4 inches of water over the main floor according to Mr. Fred Crocker. Mrs. Ellen Crocker, his sister-in-law, indicated that it was 6 to 8 inches over the floor. Fred Crocker also said that the water came just below the door on house 5 but was well above the main floor in houses 6 and 7. All the basements flooded.

In an earlier interview with the Department of the Environment, Mr. George Crocker (house 4) reported that there had been no flooding in recent years until 1988. He felt that flooding was a result of ice buildup on the bottom of the brook. Rain in a warm spell loosens the ice and washes it downstream where it jams up forming a dam. Water is then forced out over the cribbing and down the road to the low area flooding several houses. The location of the ice jams is shown on Figure 2.

Mr. Sam Snook (house 5) reported that the water rose to just below his front door, to the top of his bridge. In a CBC News interview Mr. Snook showed the water level just below the main floor in his basement. Mr. Snook raised this house in 1988 and avoided first floor damage in the 1990 flood. According to Mr. Snook, the houses suffering the most from flooding were houses 6 and 7 where carpets and mattresses had been ruined. He said that there had been no flooding until 1988.

A young lady at house 6 reported that the basement had flooded and that the carpets and cushion flooring in her home had been ruined by the flood waters. She said that the house next door (#7) had been flooded worse. They even lost their television and VCR. She felt that this had been happening every year "for a long time".

Mrs. John Young, of house 7, said that three mattresses, the TV and VCR were ruined by the high water. In addition, all furniture and clothes in dressers were soaked. The water was up to the front window of the house. (This appears to be about 25 cm above the floor.) The 1990 flood was worse, and caused more damage than the 1988 or 1989 flooding.

The residents of house 1 reported that they had only a few inches of water in the basement. The water was just at the basement window level.

Mr. Leonard White, of house 12, said that in January 1990 the lower end of the brook was filled with snow. When the thaw and rain came the water could not flow in the channel and overflowed onto the road. He stated that this has been happening for many years but has been getting worse recently. He feels that diverting the upper reaches of the brook to Long Pond (Wallace Brook) would help alleviate the flooding in Trout River.

Mr. White is also concerned about an erosion problem. Timber cribbing installed in 1973 is deteriorating and in places is collapsing. A portion of the crib wall immediately upstream of the bridge (his driveway) has collapsed and been covered with fallen earth. The stream is now eroding behind the upstream end of the crib. The erosion has just started in the past two years since some filling was done on the opposite side of the brook.

Mr. James Harris lives on the opposite side of Emmanuel's Brook in house 9. According to Mr. Harris, the ice forms a dam near the outlet of the brook. With the combination of the ice dam and ice buildup on the bottom of the brook, the water is forced over the bank. The upstream end of the spill begins just upstream of his house. The water flows around the house, but is not high enough to enter the house. In an effort to prevent this, he has added fill into Emmanuel's Brook, encroaching from 1 to 2.5 metres beyond the original cribbing. The filling has not raised the bank, it has only reduced the width of the brook. This has not stopped the flooding, but has altered the course of the brook enough to cause erosion on the opposite bank. Mr. Harris has lived in Trout River for sixty-five years and says the flooding of Emmanuel's Brook has been happening for many years. He thinks that the brook should be diverted to Long Pond further upstream, just below the Route 431 crossing.

5.3 Hydrology

A hydrologic model was developed using the OTTHYMO computer program to help determine a 100 year floodline without ice conditions. The 100 year storm was simulated for 2 hour, 6 hour, 12 hour and 24 hour durations. The two hour storm was used for the effect of the high peak.

The watershed was broken down into three subcatchments as shown on Figure 5.1. This was done to determine flow at Route 431, at the head of a small stream about 1300 m below the highway, and at the outlet of Emmanuel's Brook.

It was determined that approximately 48% of the flow in the brook is generated above the highway crossing. A total of 64% of the runoff to Emmanuel's Brook comes from subcatchments one and two. A summary of peak flows at each location is given in Table 5.1.

5.4 Hydraulics

Emmanuel's Brook was simulated utilizing the HEC-2 computer model from the outlet at Trout River Bay, upstream for a distance of about 200 m. Surveyed cross-sections were used to model the flat, downstream reach where flooding is a problem.

TABLE 5.1

SUMMARY OF 100 YEAR FLOWS (2 HOUR STORM)

Subcatchment	Peak Flow (m^3/s)
1	15.6
2	6.0
Sub-total	21.6
3	11.2
TOTAL	32.2

It was determined that the 100 year, 2 hour storm, with no ice at the outlet or in the channel, would be conveyed in the channel, filling it, but with no overflow, except at section 0+197. At this location the bank is overtopped and flooding would extend about 5 m out of the existing channel. Cross-sections 0+179 and 0+197 were then modified to represent the width of the channel before the infilling by Mr. Harris. It was found that all flow would be contained within the channel to just below the top of the bank. Both hydrologic and hydraulic models are uncalibrated and approximate.

5.5 Field Survey and Floodline Delineation

In order to produce mapping of this part of Trout River, a field survey was conducted to determine ground elevations, first floor elevations, and reported flood elevations, as well as the location of structures, utility poles, Emmanuel's Brook, and other features affected by flooding. This survey was tied in with the existing 1:2500 mapping of the Trout River on the opposite side of town.

From the results of this survey, and discussions with concerned residents, an approximate floodline for the January 27, 1990 flood has been plotted (see Figure 5.2). The March 2, 1988 flood was not quite as severe as the more recent one. It would appear that peak flood elevations were about 0.1 to 0.2 m lower in 1988. Because of the shape of the depression, the areal extent of the 1988 flood would be almost as much as that of the 1990 flood.

5.6 Conclusions and Recommendations

From discussions with residents and photographic evidence taken just after the flood, it was determined that the peak flood elevation of January 27, 1990 was 3.5 to 3.6 m in the depressed area.

Flooding of Emmanuel's Brook appears to be caused by ice jamming at the outlet of the brook. This ice is probably a combination of ice pack in Trout River Bay and ice washed down the brook by the high flows. Snow drifted into the channel is also a contributing factor.

Water backs up behind the ice dam, overtops the timber cribbing and flows down the road flooding the depression.

If the 100 year flood levels were to rise less than 0.3 meters in the area above the bridge, water would flow into the low area.

The homes subject to flooding from Emmanuel's Brook are located in a depression.

It appears that the infilling undertaken by Mr. James Harris may aggravate the flooding but does not cause it. The infilling, however, is causing erosion of the opposite bank.

6.0 REMEDIAL MEASURES

6.1 General

Broadly speaking, the basic elements for a flood damage reduction plan can be classified as:

a) Structural Measures which directly affect the flood characteristics, and
b) Non-structural Measures which are intended to modify the loss burden, either by reducing the potential for continued development in flood prone lands or by providing some form of economic relief from flood losses.

A detailed analysis of possible remedial measures was beyond the scope of the present investigations. However, based on the results of the study, it has been possible to identify a number of alternative remedial measures for future detailed consideration. These are briefly identified in the following sections.

6.2 Identification of Structural Measures

6.2.1 Trout River

Flooding on Feeder Brook is presently aggravated due to blockage of the flood overflow channel and overflow culverts by snow accumulation. Snow boards could be installed along the edge of the roadway above the culverts and bridge opening in an effort to reduce the amount of snow which is plowed from the road back into the creek at these locations. Creation of snow banks along the edge of the road at this location also tend to aggravate flood conditions and should be avoided.

Provision of a larger emergency floodway opening at the overflow culverts should be given series consideration. This could be accomplished by considering construction of culverts with larger openings or a second bridge at this location.

6.2.2 Emmanuel's Brook

Several potential remedies to the Emmanuel's Brook flooding were mentioned by residents of Trout River.

Some suggested that the brook be diverted northward to Wallace Brook. There are two locations where topography suggests that this would be possible.

One location is about 1300 metres downstream of the Route 431 crossing. About 64 percent of the total flow in Emmanuel's Brook could be diverted at this point.

The other site is immediately downstream of the Route 431 crossing. The channel could be diverted to flow in a more northerly direction to Long Pond and on to Wallace Brook. This site is much more accessible. This would reduce the flow in Emmanuel's Brook by about 48 percent.

Another suggestion was to repair the cribbing in the downstream section of the brook. A complete rebuild would be more realistic with higher sides and removal of fill that has been placed in the past few years. This would have to be continued as far as the existing crib on the south side of the river. The cribbing would actually be a dyke to prevent flooding onto the road.

Construction of a new, higher dyke would help prevent water from flooding the depression on the south side of the road. It would have to be high enough to allow the water to find its own route over the ice and snow in the channel. There should probably be some maintenance during the winter to keep the outlet and channel somewhat free.

6.3 Non-structural Flood Control Measures

In areas of potential future development, regulations should be implemented to restrict development and reduce the potential for continued increases in flood damages. In this case, a two-zone floodway flood-fringe concept is envisaged where zoning regulations would prohibit future development in the high hazard areas. Additional development might be permitted in the flood fringe areas, depending on the degree of hazard and the implementation of floodproofing measures to protect these developments. Other non-structural measures which might be considered include the following:

6.3.1 Trout River

Maintain a program of debris and snow clearing to keep the flood relief channel and flood relief culverts on the Feeder Brook clear of snow prior to the arrival of the spring freshet. This would help to avoid reduced flow conveyance in the flood relief channel during ice jam conditions.

Relocation of buildings and flood prone structures to prevent future flood damages.

Maintain equipment and personnel on standby for removal of ice jams and blockages on the Feeder Brook.

6.3.2 Emmanuel's Brook

Maintain equipment and personnel on standby to remove snow and ice from the channel to avoid blockage and flooding.

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APPENDIX A
HYDROLOGY

APPENDIX A.1
REGRESSION EQUATIONS

TABLE A.1

STEPWISE REGRESSION RESULTS FOR $\log_{10}QP_{20}$ ENTIRE ISLAND

$$\log_{10}QP_{20} = k + a \log_{10}DA + b \log_{10}MAR + c \log_{10}ACLS + d \log_{10}SHAPE$$

REGRESSION PARAMETER COEFFICIENT

Step Number	k	a	b	c	d	SE	Multiple R.
1	0.4679	0.6916	0.	0.	0.	0.29	0.86
2	-7.0661	0.7909	2.3776	0.	0.	0.14	0.97
3	-2.8270	0.7576	1.9228	-1.4188	0.	0.11	0.99
4*	-2.8741	0.7911	2.0077	-1.4736	-0.7031	0.09	0.99

Notes:

1. F = 4.5 (regression constant and coefficients are all significant at the 5% level.)
2. SE = Standard Error of Estimate in log units.
3. * + Accepted step.

SOURCE: REGIONAL FLOOD FREQUENCY ANALYSIS FOR THE ISLAND OF NEWFOUNDLAND

TABLE A.2

STEPWISE REGRESSION RESULTS FOR $\log_{10}QP_{100}$ ENTIRE ISLAND

$$\log_{10}QP_{100} = k + a \log_{10}DA + b \log_{10}MAR + c \log_{10}ACLS + d \log_{10}SHAPE$$

REGRESSION PARAMETER COEFFICIENT

Step Number	k	a	b	c	d	SE	Multiple R.
1	0.6300	0.6623	0.	0.	0.	0.31	0.84
2	-7.4743	0.7691	2.5576	0.	0.	0.15	0.97
3	-3.1059	0.7348	2.0889	-1.4621	0.	0.11	0.98
4*	-3.1500	0.7662	2.1684	-1.5134	-0.6581	0.10	0.99

Notes:

1. F = 4.5 (the regression constant and coefficients are all significant at the 5 percent level or better.)
2. SE = Standard Error of Estimate in log units.
3. * = Lowered F from 4.5 to 4.4 in order to retain SHAPE in equation, accepted step.

SOURCE: REGIONAL FLOOD FREQUENCY ANALYSIS FOR THE ISLAND OF NEWFOUNDLAND

TABLE A.3

STEPWISE REGRESSION RESULTS FOR $\log_{10}QP_{20}$ NORTH REGION

$$\log_{10}QP_{20} = k + a \log_{10}DA + b \log_{10}MAR + c \log_{10}LAT + d \log_{10}SHAPE + e \log_{10}BAREA$$

REGRESSION PARAMETER COEFFICIENT

Step Number	k	a	b	c	d	e	SE	Multiple R.
1	0.0169	0.8202	0	0	0	0	0.25	0.81
2	-7.3483	0.8583	2.4011	0	0	0	0.10	0.98
3*	-29.1468	0.9458	1.5655	14.2157	0	0	0.06	0.99
4	-34.2758	0.9802	1.6149	16.9861	0.6654	0	0.05	1.00

Notes:

1. F = 5.5 (the regression constant and coefficients are all significant at the 5 percent level or better.)
2. SE = Standard Error of Estimate in log units.
3. * = Accepted step.

SOURCE: REGIONAL FLOOD FREQUENCY ANALYSIS FOR THE ISLAND OF NEWFOUNDLAND

TABLE A.4

STEPWISE REGRESSION RESULTS FOR $\log_{10}QP_{100}$ NORTH REGION

$$\log_{10}QP_{100} = k + a \log_{10}DA + b \log_{10}MAR + c \log_{10}LAT + d \log_{10}SHAPE + e \log_{10}BAREA$$

REGRESSION PARAMETER COEFFICIENT

Step Number	k	a	b	c	d	e	SE	Multiple R.
1	0.2187	0.7759	0	0	0	0	0.27	0.77
2	-7.7740	0.8173	2.6057	0	0	0	0.10	0.98
3*	-30.2744	0.9076	1.7432	14.6735	0	0	0.06	0.99
4	-35.2997	0.9413	1.7915	17.3879	0.6520	0	0.04	1.00
5	-36.2564	0.9345	1.4831	18.4648	0.6556	0.0742	0.01	1.00

Notes:

1. F = 5.5 (the regression constant and coefficients are all significant at the 5 percent level or better.)
2. SE = Standard Error of Estimate in log units.
3. * = Accepted step.

SOURCE: REGIONAL FLOOD FREQUENCY ANALYSIS FOR THE ISLAND OF NEWFOUNDLAND

TABLE A.5

PARAMETER RANGE USED IN ANALYSIS*

				Values Used	
				To Pond Inlet	To River Outlet
Entire Island					
DA	3.9	to	4400 km^2	142	253.5
MAR	788	to	2124 mm	1170	1100
ACLS	55	to	100%	55	89.9
SHAPE	1.24	to	2.45	1.41	1.83
North Region					
DA	237	to	4400 km^2		
MAR	788	to	1420 mm		
LATITUDE	48.379	to	50.943°		
South Region					
DA	3.9	to	2640 km^2		
MAR	929	to	2124 mm		
ACLS	55	to	100%		
SHAPE	1.24	to	2.45		

* These parameter ranges are presented for general guidance only. If, when computing flood flows using the equations presented in this report, the value of the above parameters falls near the extremities of or outside these ranges, then the estimates of flood flows will be questionable.

Source: Regional Flood Frequency Analysis for the Island of Newfoundland

TABLE A.6

EXAMPLE OF LARK HARBOUR TIDE DATA

0 164LARK HARBOUR NFLD - NST -

0	1	164	93	55	21	-8	-28	-13	0	51	90	139	177	205-
0	1	164	214	200	165	127	92	66	56	76	98	129	142	153-
0	2	164	142	112	71	40	13	-1	11	33	80	119	157	201-
0	2	164	219	232	219	196	165	140	121	109	128	144	161	169-
0	3	164	167	157	126	89	55	29	13	18	39	69	111	141-
0	3	164	174	189	191	175	150	120	95	87	90	105	130	151-
0	4	164	168	169	164	134	109	82	56	53	56	79	100	133-
0	4	164	154	177	176	163	151	118	102	77	77	82	100	119-
0	5	164	137	152	156	150	132	112	93	76	73	80	97	114-
0	5	164	139	151	164	166	155	142	122	100	86	84	90	106-
0	6	164	127	139	153	158	155	141	120	101	82	73	71	83-
0	6	164	99	116	129	143	139	132	119	100	83	70	72	75-
0	7	164	97	108	124	135	145	143	133	119	106	95	92	95-
0	7	164	108	119	130	137	150	141	133	114	99	81	71	69-
0	8	164	77	89	101	119	131	138	136	128	116	98	84	75-
0	8	164	74	83	92	103	117	121	120	108	97	78	63	52-
0	9	164	57	60	76	96	113	132	144	147	140	127	113	94-
0	9	164	83	82	84	96	103	113	117	116	107	79	71	47-
0	10	164	39	40	48	71	89	123	147	162	163	160	157	132-
0	10	164	140	127	135	144	169	192	203	218	214	198	167	143-
0	11	164	114	90	80	79	97	111	136	155	165	156	142	126-
0	11	164	108	91	84	94	110	129	150	171	177	172	162	140-
0	12	164	119	97	87	89	103	127	154	179	192	196	183	162-
0	12	164	127	103	86	80	86	97	114	129	141	138	126	101-
0	13	164	71	43	30	30	37	68	105	135	166	179	184	168-
0	13	164	144	116	94	80	80	91	109	129	141	150	139	121-
0	14	164	95	66	46	37	46	66	99	142	173	183	204	210-
0	14	164	183	165	132	102	99	95	119	133	156	168	166	153-
0	15	164	122	90	59	41	35	42	72	105	148	171	189	193-
0	15	164	183	164	135	112	94	89	101	118	143	164	176	174-
0	16	164	154	124	92	62	45	44	61	91	126	157	187	197-
0	16	164	197	177	148	119	94	82	83	99	124	149	166	172-
0	17	164	169	145	112	82	60	52	59	83	117	151	179	200-
0	17	164	205	199	174	143	108	87	75	80	100	117	137	147-
0	18	164	141	123	96	68	43	26	22	34	63	98	134	165-
0	18	164	181	185	166	135	109	82	70	66	86	107	129	149-
0	19	164	153	151	130	101	73	51	41	42	60	85	116	145-
0	19	164	163	173	160	136	103	79	59	56	67	90	116	130-
0	20	164	147	142	134	109	87	58	45	44	52	80	104	134-
0	20	164	148	159	160	144	131	111	80	65	56	65	83	104-
0	21	164	130	140	150	142	127	108	84	64	58	63	84	96-
0	21	164	131	151	163	165	155	147	109	100	77	85	92	102-
0	22	164	132	149	170	179	176	168	147	126	103	98	89	102-
0	22	164	119	136	152	160	162	152	130	105	83	66	61	66-
0	23	164	88	108	130	150	166	168	160	142	127	105	92	90-
0	23	164	96	112	126	142	153	156	144	126	102	80	62	55-
0	24	164	63	80	105	127	149	167	171	164	149	130	108	89-
0	24	164	84	90	98	117	131	144	148	138	125	96	77	56-
0	25	164	52	56	70	99	130	154	178	181	176	155	134	107-
0	25	164	88	79	77	94	101	123	123	141	126	112	93	68-
0	26	164	61	44	50	82	125	161	201	233	242	233	203	172-

TABLE A.7

EXTREMAL ANALYSIS OF PARSON'S POND
WATER LEVEL DATA

Ordered Input Data (m above) Chart Datum	Geodetic Datum	Surge Year	Probability	Return Period
2.95	1.06	1985	.041	24.342
2.91	1.02	1970	.095	10.511
2.86	.97	1983	.149	6.703
2.81	.92	1966	.203	4.920
2.81	.92	1968	.257	3.887
2.80	.91	1971	.311	3.212
2.78	.89	1973	.365	2.737
2.76	.87	1977	.419	2.384
2.75	.86	1969	.474	2.112
2.74	.85	1982	.528	1.895
2.72	.83	1974	.582	1.719
2.71	.82	1981	.636	1.573
2.71	.82	1972	.690	1.450
2.70	.81	1965	.744	1.344
2.69	.80	1986	.798	1.253
2.69	.80	1979	.852	1.174
2.60	.71	1978	.906	1.104
2.57	.68	1967	.960	1.042

	Input Data	Three-Parameter Lognormal Transformation
mean	2.7512	0.2908
standard deviation	0.1000	0.0714
coefficient of skew	0.2170	-0.0016
coefficient of kurtosis	3.9594	3.9506

Source: Martec Limited, "Historical Flooding Review and Flood Risk Mapping Study for Parson's Pond", Canada-Newfoundland Flood Damage Reduction Program, Newfoundland Department of Environment, Environment Canada, December 1988.

TABLE A.8

WATER LEVEL AT PARSON'S POND FOR SELECTED RETURN PERIODS

Three-Parameter Lognormal Distribution fitted by Maximum Likelihood

Return Period (year)	Estimate (m above)		90% Confidence Limits (m above)	
	Chart Datum	Geodetic Datum	Chart Datum	Geodetic Datum
5	2.83	0.94	2.79 - 2.88	.90 - .99
10	2.88	0.99	2.82 - 2.93	.93 - 1.04
20	2.92	1.03	2.84 - 2.99	.95 - 1.10
50	2.96	1.07	2.87 - 3.05	.98 - 1.16
100	2.99	1.1	2.88 - 3.10	.99 - 1.21
200	3.02	1.13	2.88 - 3.15	.99 - 1.26

Source: Martec Limited, "Historical Flooding Review and Flood Risk Mapping Study for Parson's Pond", Canada-Newfoundland Flood Damage Reduction Program, Newfoundland Department of Environment, Environment Canada, December 1988.

TABLE A.9

EXTREMAL ANALYSIS OF LARK HARBOUR/COX'S COVE
WATER LEVEL DATA

Ordered Input Data (m above) Chart Datum	Geodetic Datum	Surge Year	Probability	Return Period
2.79	1.75	1970	.041	24.342
2.58	1.54	1981	.095	10.511
2.57	1.53	1966	.149	6.703
2.56	1.52	1983	.203	4.920
2.56	1.52	1985	.257	3.887
2.51	1.47	1968	.311	3.212
2.49	1.45	1977	.365	2.737
2.49	1.45	1969	.419	2.384
2.47	1.43	1971	.474	2.112
2.44	1.40	1965	.528	1.895
2.42	1.38	1979	.582	1.719
2.39	1.35	1982	.636	1.573
2.37	1.33	1974	.690	1.450
2.35	1.31	1972	.744	1.344
2.33	1.29	1978	.798	1.253
2.30	1.26	1986	.852	1.174
2.30	1.26	1967	.906	1.104
2.28	1.24	1973	.960	1.042

	Input Data	Three-Parameter Lognormal Transformation
mean	2.4556	-1.1956
standard deviation	.100	.4041
coefficient of skew	.7935	-.1260
coefficient of Kurtosis	4.6276	2.9764

Source: Martec Limited, "Historical Flooding Review and Flood Risk Mapping Study for Cox's Cove", Canada-Newfoundland Flood Damage Reduction Program, Newfoundland Department of Environment, Environment Canada, December 1988

TABLE A.10

WATER LEVEL AT LARK HARBOUR/COX'S COVE FOR SELECTED RETURN PERIODS

Three-Parameter Lognormal Distribution fitted by Maximum Likelihood

Return Period (year)	Estimate (m above)		90% Confidence Limits (m above)	
	Chart Datum	Geodetic Datum	Chart Datum	Geodetic Datum
5	2.55	1.52	2.47 - 2.63	1.45 - 1.59
10	2.63	1.60	2.52 - 2.74	1.49 - 1.71
20	2.71	1.68	2.56 - 2.87	1.52 - 1.83
50	2.82	1.78	2.59 - 3.05	1.56 - 2.01
100	2.90	1.86	2.61 - 3.19	1.57 - 2.16
200	2.98	1.95	2.61 - 3.35	1.58 - 2.31

Source: Martec Limited, "Historical Flooding Review and Flood Risk Mapping Study for Cox's Cove", Canada-Newfoundland Flood Damage Reduction Program, Newfoundland Department of Environment, Environment Canada, December 1988

TABLE A.11

PHYSIOGRAPHIC PARAMETERS FOR SUB-WATERSHEDS

Basin Nos.	Area (km^2)	Length (km)	Height (m)	Recession Parameter (hrs) (K)	Time to Peak Parameter (hrs) T_p	Average Soil Cover Complex No. (CN)
Trout R.						
101	227.6	35.0	450	5.5	5.5	86
103	1.5	1.2	76	0.3	0.3	86
Feeder Bk						
102	24.5	9.8	610	0.7	0.9	86
Emmanuels Brook						
1	2.2	2.9	305	0.23	0.28	92
2	0.8	1.3	90	0.23	0.21	92
3	1.7	2.6	180	0.30	0.31	92

TABLE A.12

RAINFALL DISTRIBUTION

12 Hour Time (hrs)	12 Hour % Rain	24 Hour Time (hrs)	24 Hour % Rain
1	5	1	1
2	8	2	1
3	8	3	2
4	10	4	3
5	10	5	5
6	14	6	4
7	13	7	5
8	8	8	5
9	10	9	6
10	8	10	7
11	4	11	5
12	2	12	4
		13	6
	100	14	7
		15	5
		16	6
		17	3
		18	3
		19	4
		20	4
		21	5
		22	6
		23	1
		24	2
			100

TABLE A.13

PRECIPITATION SUMMARY

Return Period (yrs)	Rainfall* (mm) 6 hr	12 hr	24 hr
2	35.88	45.48	56.4
5	47.94	58.08	72.29
10	55.98	66.48	82.8
20	62.4	74.6	93.4
25	66.06	77.04	96.24
50	73.50	84.84	106.08
100	80.94	92.64	115.92

* Based on AES analysis at Stephenville meteorological station (13 years data)

APPENDIX A.2
OTTHYMO - TROUT RIVER
AND FEEDER BROOK
EMMANUEL'S BROOK

```
1  ****************************************************************************************
   **                                                                                    **
   **                     M I C R O H Y M O --- 3                                        **
   **                                                                                    **
   **                     (P . C . O T T H Y M O)                                        **
   **                                                                                    **
   **                     V E R S I O N  2.0                                             **
   **                                                                                    **
   **                                                                                    **
   **                     ADAPTED FOR MICROCOMPUTER BY                                   **
   **                                                                                    **
   **                     ANDREW  BRODIE  ASSOCIATES  INC.                               **
   **                                                                                    **
   **                                                                                    **
   **                                                                                    **
   **CUMMING-COCKBURN ASSOCIATES LTD                                                     **
   **                                                                                    **
   ****************************************************************************************
    THE METRIC UNITS OPTION HAS BEEN SPECIFIED

 ***************************************
 *  TROUT RIVER, NEWFOUNDLAND          *
 *                                     *    ******************************
 *  ROUTING THROUGH UPPER AND LOWER    *    *                            *
 *  TROUT RIVER PONDS                  *    *  100 YEAR, 24 HOUR STORM   *
 *                           CCL 7262  *    *                            *
 *                           SEPT/89   *    ******************************
 ***************************************
 *                                            07262B24   WS AT 7.5 m
 *
 *
 START                  0.0 HOURS
 COMPUTE HYD            ID 1   HYD 101   DT=0.25   DA=22750 HA
                        AA=0.0 AB=0.0    CN=86     IA=4.0 mm
                        K=5.5  TP=5.5    NI=96
                         1.16  1.16  1.16  1.16
                         1.16  1.16  1.16  1.16
                         2.32  2.32  2.32  2.32
                         3.48  3.48  3.48  3.48
                         5.80  5.80  5.80  5.80
                         4.64  4.64  4.64  4.64
                         5.80  5.80  5.80  5.80
                         5.80  5.80  5.80  5.80
                         6.96  6.96  6.96  6.96
                         8.11  8.11  8.11  8.11
                         5.80  5.80  5.80  5.80
                         4.64  4.64  4.64  4.64
                         6.96  6.96  6.96  6.96
                         8.11  8.11  8.11  8.11
                         5.80  5.80  5.80  5.80
                         6.96  6.96  6.96  6.96
                         3.48  3.48  3.48  3.48
                         3.48  3.48  3.48  3.48
                         4.64  4.64  4.64  4.64
                         4.64  4.64  4.64  4.64
                         5.80  5.80  5.80  5.80
                         6.96  6.96  6.96  6.96
                         1.16  1.16  1.16  1.16
                         2.32  2.32  2.32  2.32
     SHAPE CONSTANT, N =    3.53
     UNIT PEAK =      145.88 CMS

     SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       3.98

     PEAK DISCHARGE =   243.610 CMS   RUNOFF VOLUME =   80.76 MM TIME TO PEAK =   23.500 HRS

     TOTAL RAINFALL =   115.98 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .70

 *
 ROUTE RESERVOIR        ID 6   HYD 104   INID 1
                           Q  cms    S  ha-m
                             0.0          0
                             1.1          2
                             8.9          4
                            22.4          6
                            42.5          8
                            68.6         10
                            96.6        710
                           118.6       1420
                           118.6       1420
```

```
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
                              118.6         1420
   PEAK DISCHARGE =     99.6286 CMS  RUNOFF VOLUME= 80.6351 MM
 *
 COMPUTE HYD            ID 2   HYD 102   DT=0.25   DA=2450 HA
                        AA=0.0 AB=0.0    CN=86     IA=4.0 **
                        K=0.7  TP=0.9    NI=96     RAIN=-1
   SHAPE CONSTANT, N =   4.62
   UNIT PEAK =       117.50 CMS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       4.00

   PEAK DISCHARGE =    41.153 CMS   RUNOFF VOLUME =   81.79 MM TIME TO PEAK =   14.250 HRS

   TOTAL RAINFALL =   115.98 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .71

 ADD HYD                ID 3   HYD 302   6  2
   PEAK FLOW =     125.277 CMS     RUNOFF VOLUME =     80.75 MM     TIME TO PEAK= 22.25 HOURS
0          ADD HYD       ID=3      HYD NO=302     ID I=6          ID II=2
 *
 COMPUTE HYD            ID 4   HYD 103   DT=0.25   DA=150 HA
                        AA=0.0 AB=0.0    CN=86     IA=4.0 **
                        K=0.3  TP=0.3    NI=96     RAIN=-1
   SHAPE CONSTANT, N =   3.53
   UNIT PEAK =        17.63 CMS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       3.97

   PEAK DISCHARGE =     2.740 CMS   RUNOFF VOLUME =   81.13 MM TIME TO PEAK =   14.000 HRS

   TOTAL RAINFALL =   115.98 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .70

 ADD HYD                ID 5   HYD 303   3  4
   PEAK FLOW =     126.973 CMS     RUNOFF VOLUME =     80.75 MM     TIME TO PEAK= 22.25 HOURS
0          ADD HYD       ID=5      HYD NO=303     ID I=3          ID II=4
```

```
*
*                                         ****************************
*                                         *                          *
*                                         *  20 YEAR, 24 HOUR STORM  *
*                                         *                          *
*                                         ****************************
*
*
COMPUTE HYD            ID 1   HYD 101   DT=0.25   DA=22750 HA
                       AA=0.0 AB=0.0    CN=86     IA=4.0 mm
                       K=5.5  TP=5.5    NI=96
                        0.93 0.93 0.93 0.93
                        0.93 0.93 0.93 0.93
                        1.87 1.87 1.87 1.87
                        2.80 2.80 2.80 2.80
                        4.67 4.67 4.67 4.67
                        3.74 3.74 3.74 3.74
                        4.67 4.67 4.67 4.67
                        4.67 4.67 4.67 4.67
                        5.60 5.60 5.60 5.60
                        6.54 6.54 6.54 6.54
                        4.67 4.67 4.67 4.67
                        3.74 3.74 3.74 3.74
                        5.60 5.60 5.60 5.60
                        6.54 6.54 6.54 6.54
                        4.67 4.67 4.67 4.67
                        5.60 5.60 5.60 5.60
                        2.80 2.80 2.80 2.80
                        2.80 2.80 2.80 2.80
                        3.74 3.74 3.74 3.74
                        3.74 3.74 3.74 3.74
                        4.67 4.67 4.67 4.67
                        5.60 5.60 5.60 5.60
                        0.93 0.93 0.93 0.93
                        1.87 1.87 1.87 1.87
   SHAPE CONSTANT, N =   3.53
   UNIT PEAK =     145.88 CMS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       3.98

   PEAK DISCHARGE =   185.581 CMS   RUNOFF VOLUME =   60.34 MM TIME TO PEAK =   23.750 HRS

   TOTAL RAINFALL =    93.39 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .65

*
ROUTE RESERVOIR        ID 6   HYD 104   INID 1
                          Q  cms    S  ha-m
                           0.0          0
                           1.1          2
                           8.9          4
                          22.4          6
                          42.5          8
                          68.6         10
                          96.6        710
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
                         118.6       1420
   PEAK DISCHARGE =      88.1393 CMS  RUNOFF VOLUME= 60.2322 MM
*
COMPUTE HYD            ID 2   HYD 102   DT=0.25   DA=2450 HA
                       AA=0.0 AB=0.0    CN=86     IA=4.0 mm
                       K=0.7  TP=0.9    NI=96     RAIN=-1
   SHAPE CONSTANT, N =   4.62
   UNIT PEAK =     117.50 CMS

   SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       4.00

   PEAK DISCHARGE =    31.091 CMS   RUNOFF VOLUME =   61.13 MM TIME TO PEAK =   14.250 HRS
```

```
        TOTAL RAINFALL =    93.39 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .65

     *
     ADD HYD              ID 3   HYD 302   6  2
        PEAK FLOW =    109.230 CMS    RUNOFF VOLUME =    60.32 MM     TIME TO PEAK= 22.25 HOURS
0             ADD HYD        ID=3     HYD NO=302     ID I=6          ID II=2
     *
     COMPUTE HYD          ID 4   HYD 103   DT=0.25    DA=150 HA
                          AA=0.0 AB=0.0    CN=86      IA=4.0 mm
                          K=0.3  TP=0.3    NI=96      RAIN=-1
        SHAPE CONSTANT, N =   3.53
        UNIT PEAK =       17.63 CMS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       3.97

        PEAK DISCHARGE =     2.082 CMS   RUNOFF VOLUME =   60.63 MM TIME TO PEAK =   14.000 HRS

        TOTAL RAINFALL =    93.39 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .65

     *
     ADD HYD              ID 5   HYD 302   3  4
        PEAK FLOW =    110.550 CMS    RUNOFF VOLUME =    60.32 MM     TIME TO PEAK= 22.25 HOURS
0             ADD HYD        ID=5     HYD NO=302     ID I=3          ID II=4


     *
     FINISH                                                                        *
```

```
1       ################################################################################
        ##                                                                            ##
        ##                       M I C R O H Y M O --- 3                              ##
        ##                                                                            ##
        ##                       (P . C . O T T H Y M O)                              ##
        ##                                                                            ##
        ##                       V E R S I O N  2.0                                   ##
        ##                                                                            ##
        ##                                                                            ##
        ##                       ADAPTED FOR MICROCOMPUTER BY                         ##
        ##                                                                            ##
        ##                       ANDREW  BRODIE  ASSOCIATES  INC.                     ##
        ##                                                                            ##
        ##                                                                            ##
        ##                                                                            ##
        ##CUMMING-COCKBURN ASSOCIATES LTD                                             ##
        ##                                                                            ##
        ################################################################################
         THE METRIC UNITS OPTION HAS BEEN SPECIFIED

    ######################################
    #  TROUT RIVER, NEWFOUNDLAND         #
    #                                    #    ############################
    #  EMMANUEL'S BROOK                  #    #                          #
    #                                    #    #  100 YEAR,  2 HOUR STORM #
    #                          CCL 7262  #    #                          #
    #                          APRIL/90  #    ############################
    ######################################
    #                                                 DEM02HR
    START                 0.0 HOURS
    COMPUTE HYD           ID 1   HYD 1      DT=0.167  DA=217 HA
                          AA=0.0 AB=0.0     CN=92     IA=4.0 mm
                          K=0.23 TP=0.28    NI=12
                           2.66  10.63  26.58  45.19  71.77  37.21
                          29.24  18.61  13.29   5.32   2.66   2.66
        SHAPE CONSTANT, N =   4.35
        UNIT PEAK =      32.01 CMS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       6.03

        PEAK DISCHARGE =    15.601 CMS   RUNOFF VOLUME =   26.30 MM TIME TO PEAK =    1.002 HRS

        TOTAL RAINFALL =    44.39 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .59

    #
    COMPUTE HYD           ID 2   HYD 2      DT=0.167  DA=84 HA
                          AA=0.0 AB=0.0     CN=92     IA=4.0 mm
                          K=0.23 TP=0.21    NI=12     RAIN=-1
        SHAPE CONSTANT, N =   3.23
        UNIT PEAK =      13.11 CMS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       5.92

        PEAK DISCHARGE =     6.035 CMS   RUNOFF VOLUME =   25.80 MM TIME TO PEAK =    1.002 HRS

        TOTAL RAINFALL =    44.39 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .58

    ADD HYD               ID 3   HYD 302   1  2
        PEAK FLOW =      21.635 CMS     RUNOFF VOLUME =     26.16 MM     TIME TO PEAK=  1.00 HOURS
0               ADD HYD        ID=3      HYD NO=302     ID I=1         ID II=2
    #
    COMPUTE HYD           ID 4   HYD 3      DT=0.167  DA=172 HA
                          AA=0.0 AB=0.0     CN=92     IA=4.0 mm
                          K=0.30 TP=0.31    NI=12     RAIN=-1
        SHAPE CONSTANT, N =   3.65
        UNIT PEAK =      20.09 CMS

        SUM OF THE UNIT HYDROGRAPH CO-ORDINATES =       6.00

        PEAK DISCHARGE =    11.249 CMS   RUNOFF VOLUME =   26.17 MM TIME TO PEAK =    1.169 HRS

        TOTAL RAINFALL =    44.39 MM   RUNOFF VOLUMETRIC COEFFICIENT =   .59

    ADD HYD               ID 5   HYD 303   3  4
        PEAK FLOW =      32.240 CMS     RUNOFF VOLUME =     26.17 MM     TIME TO PEAK=  1.17 HOURS
0               ADD HYD        ID=5      HYD NO=303     ID I=3         ID II=4
    FINISH
```

APPENDIX B

PHOTOGRAPHS

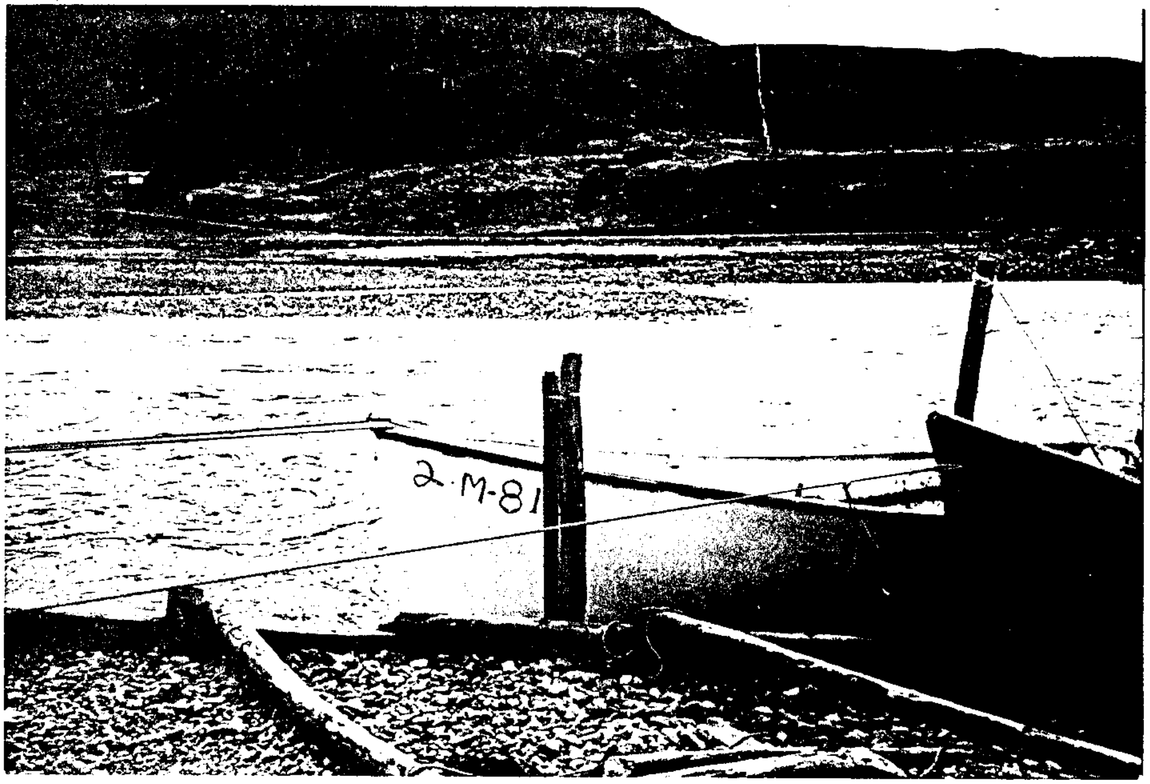


PHOTO 2-13
Crest gauge #1 attached to wooden retaining wall near X-Section Line #2, May 9, 1989.

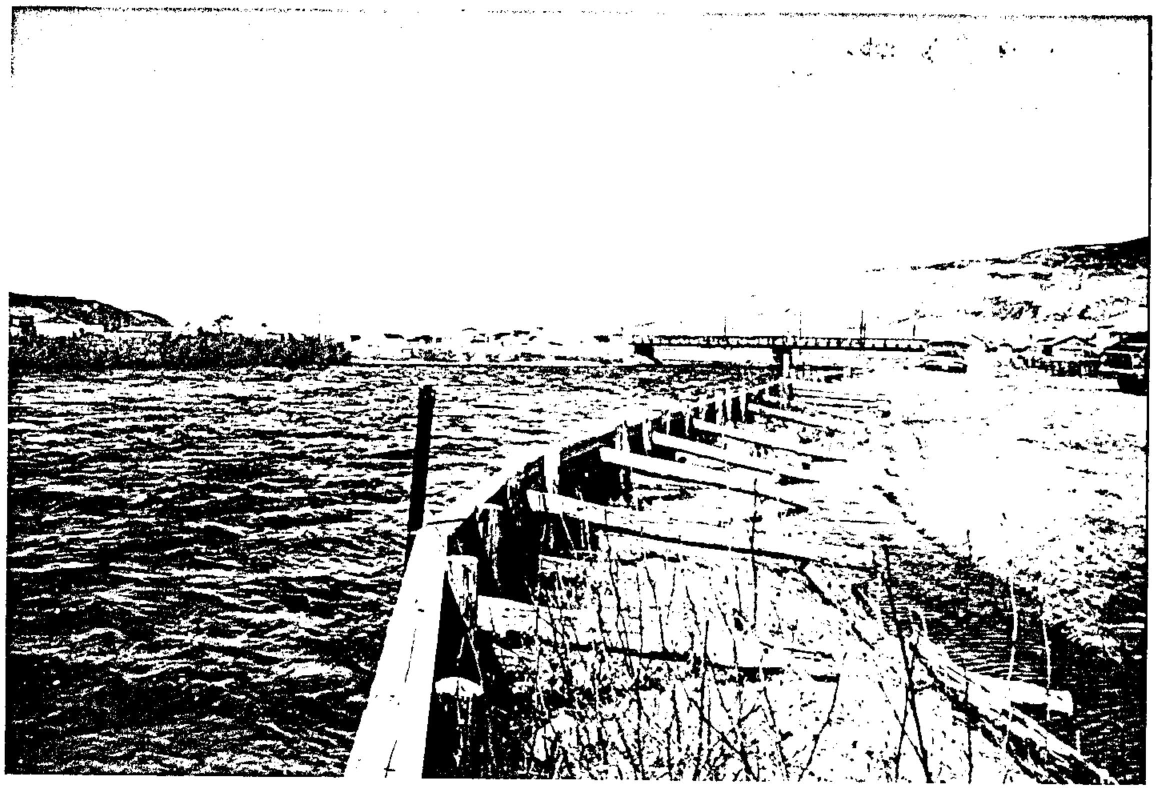


PHOTO NO. 2-18
Crest gauge #2 attached to wooden retaining wall 30 m north of Jakeman Central High School. May 9, 1989.

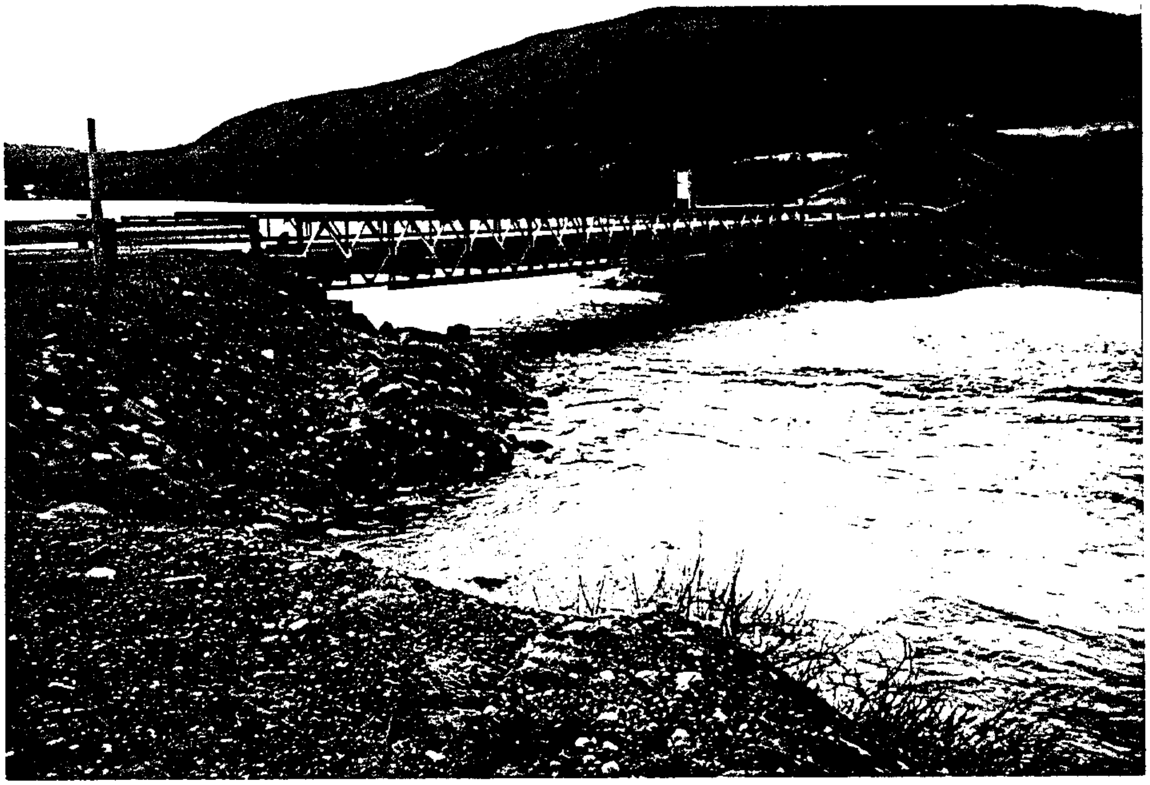


PHOTO 1-25
Looking upstream along Trout River toward the bridge over Trout River at the mouth of Lower Trout River Pond, May 8, 1989.

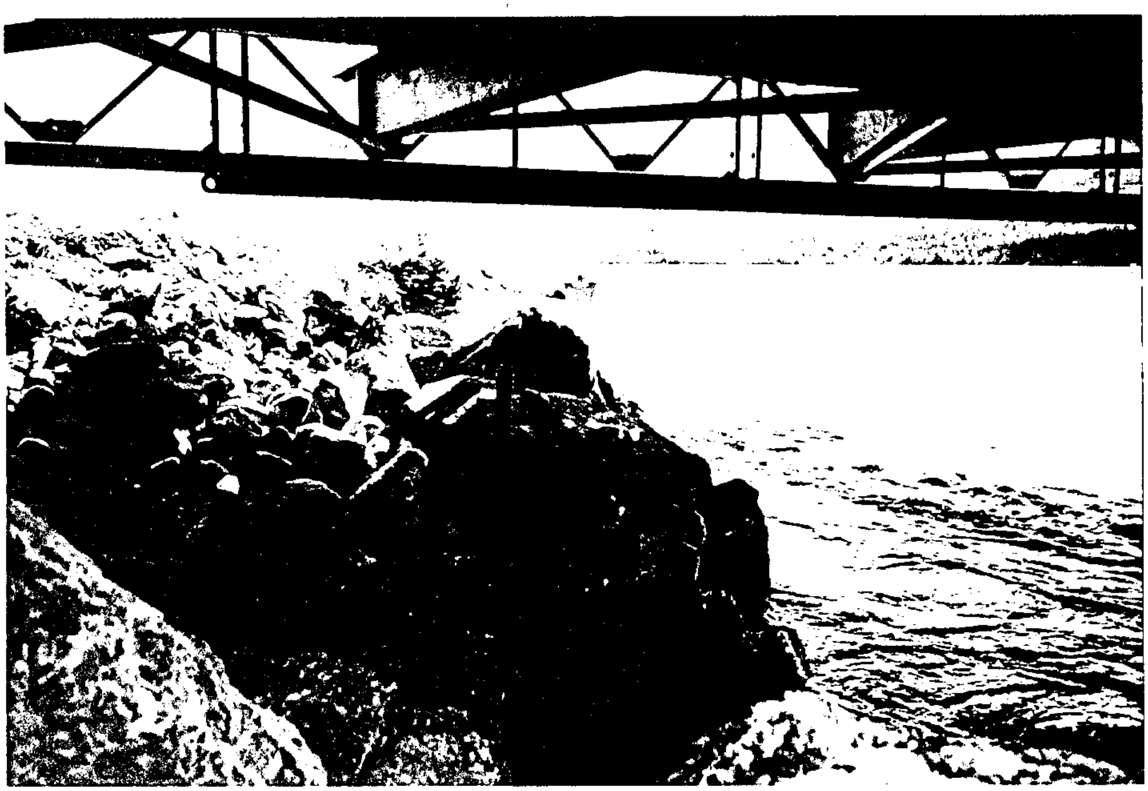


PHOTO 2-19
Crest gauge #3 set between rocks underneath the bridge over Trout River at the mouth of Trout River Pond, May 9, 1989.

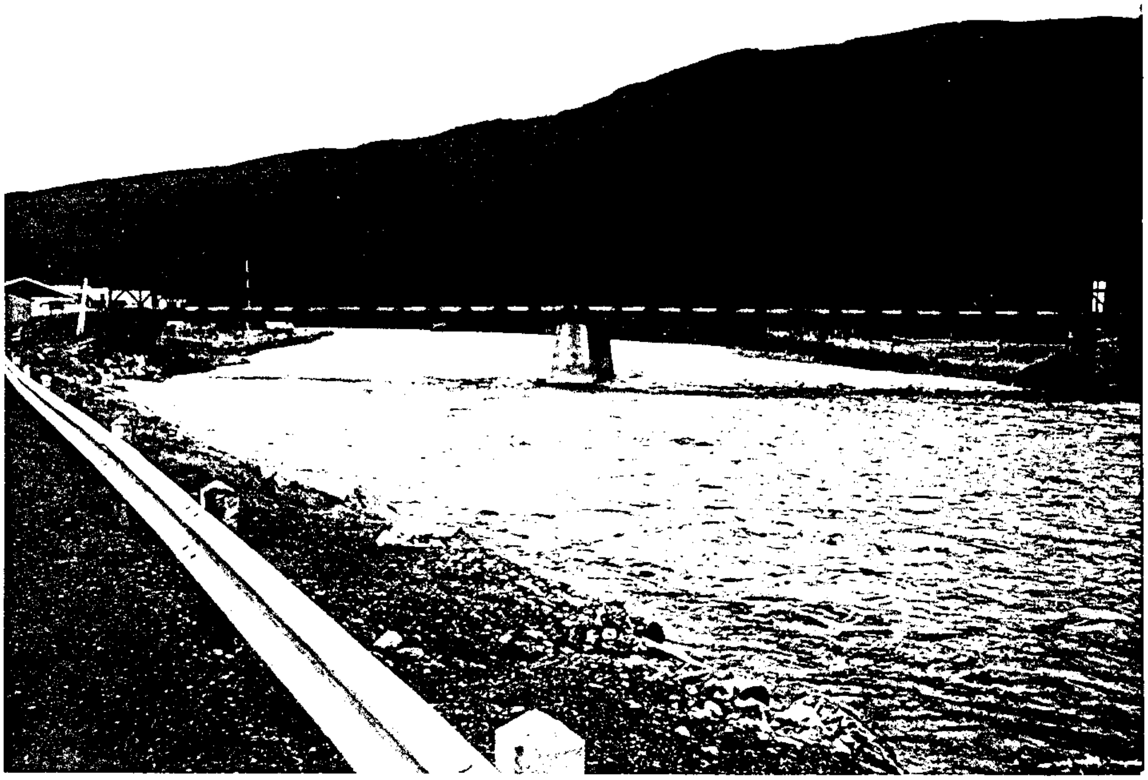


PHOTO 1-1
Looking upstream at bridge over Trout River along X-section Line #3. Note the angle of the bridge to the river. May 8, 1989.

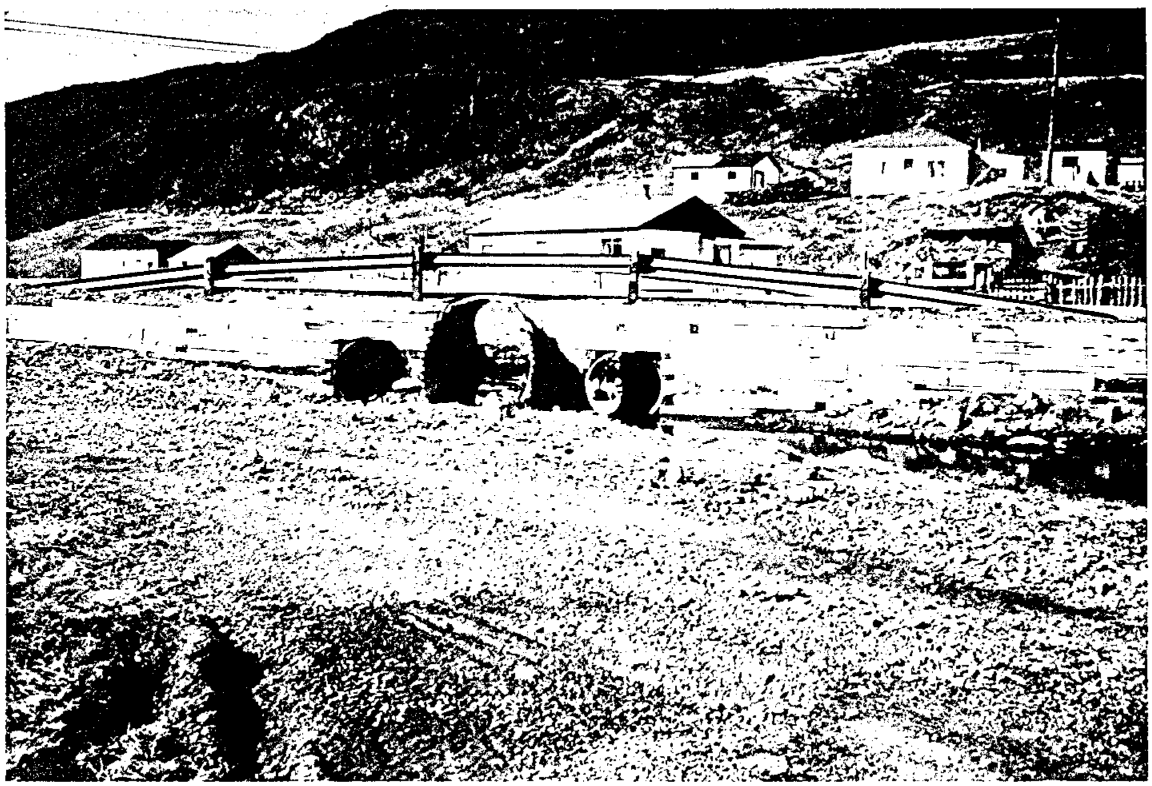


PHOTO 3-10
Looking northwest at culverts under the road which connects the banks of Trout River along X-section line #3. May 8, 1989.

PHOTO 3-25
Looking downstream at Feeder Brook toward the small islands at the intersection of Trout River and Feeder Brook. May 9, 1989.

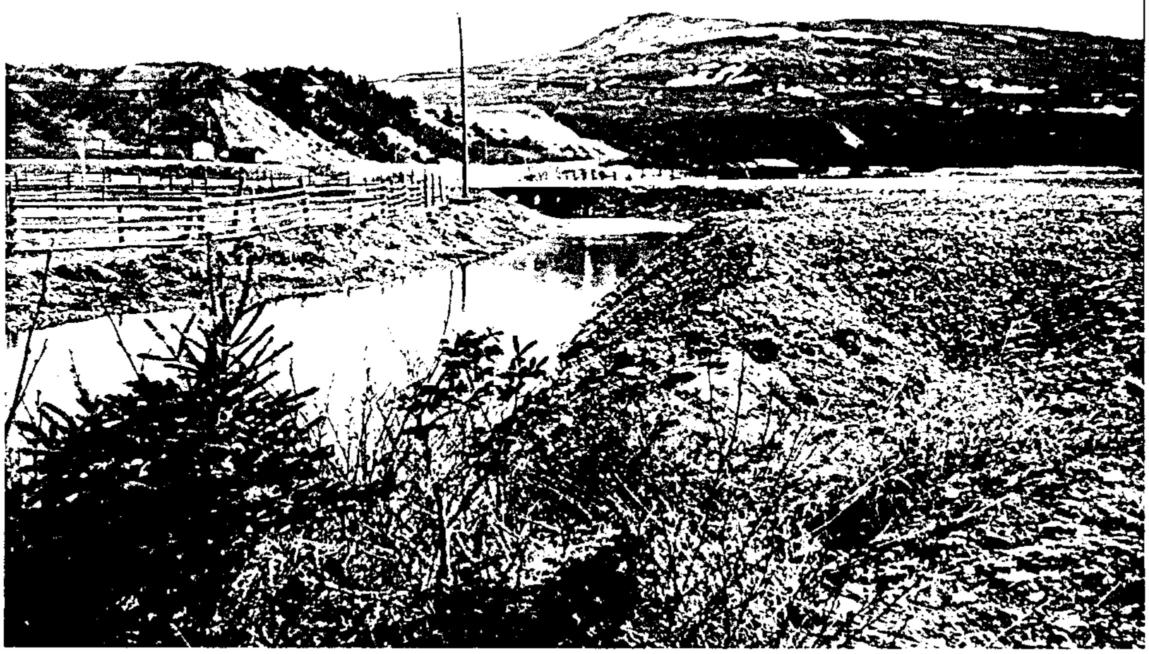


PHOTO 3-15
Looking north east toward the culverts under the road through Trout River 50 north of the bridge over Feeder Brook, May 9, 1989.

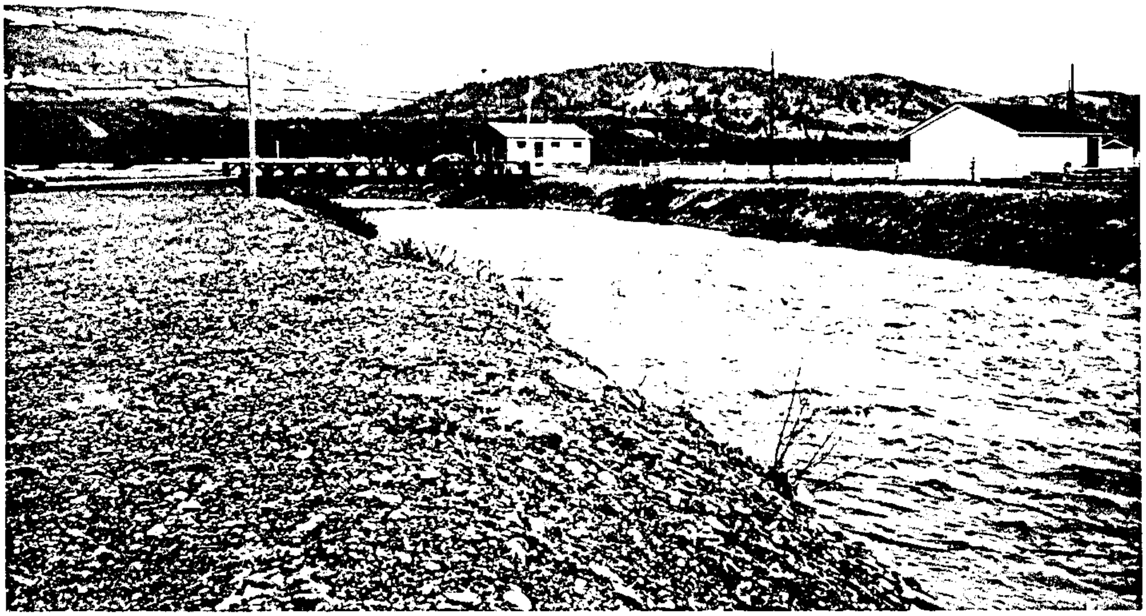


PHOTO 1-18
Looking upstream along Feeder Brook toward the bridge over Feeder Brook, May 8, 1989.

PHOTO 4-8
Looking upstream along Trout River toward big island at X-section #8, May 10, 1989.

PHOTO 1-7
Looking seaward at the harbour, May 8, 1989.

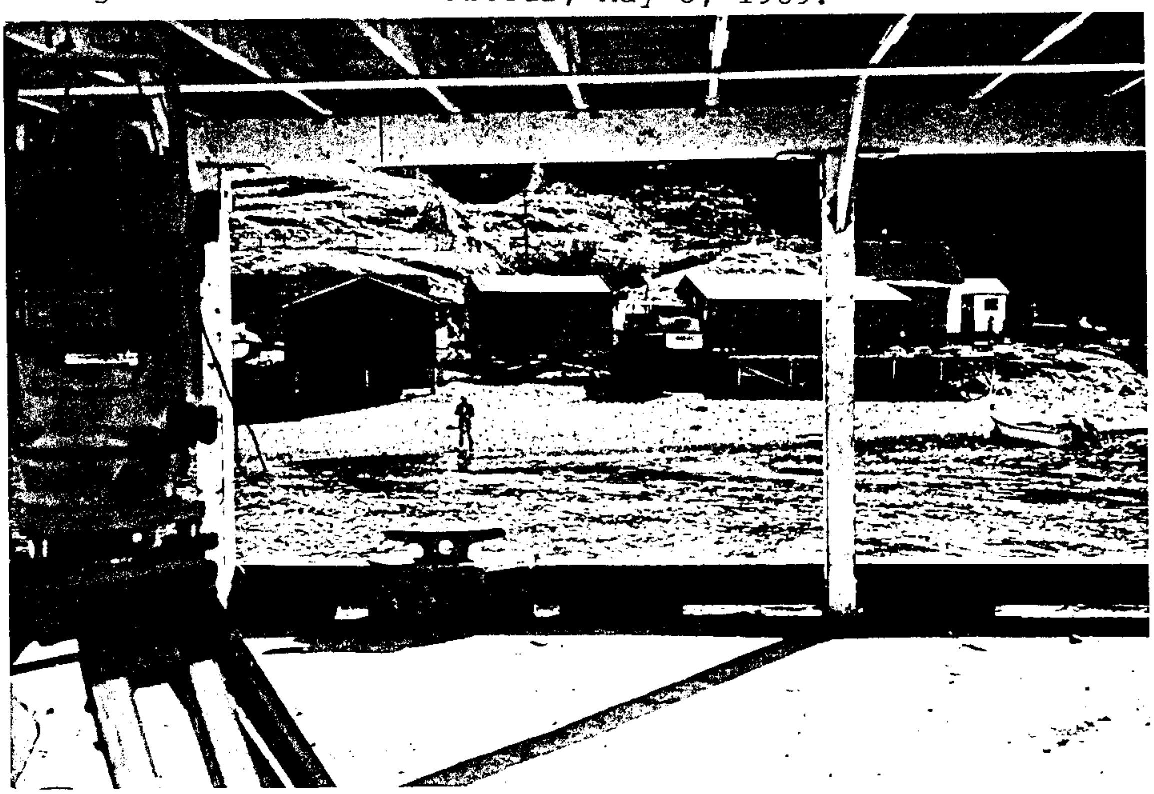


PHOTO 3-3
Looking south west along X-section Line #1 at convergance of Trout River and the harbour, May 8, 1989.

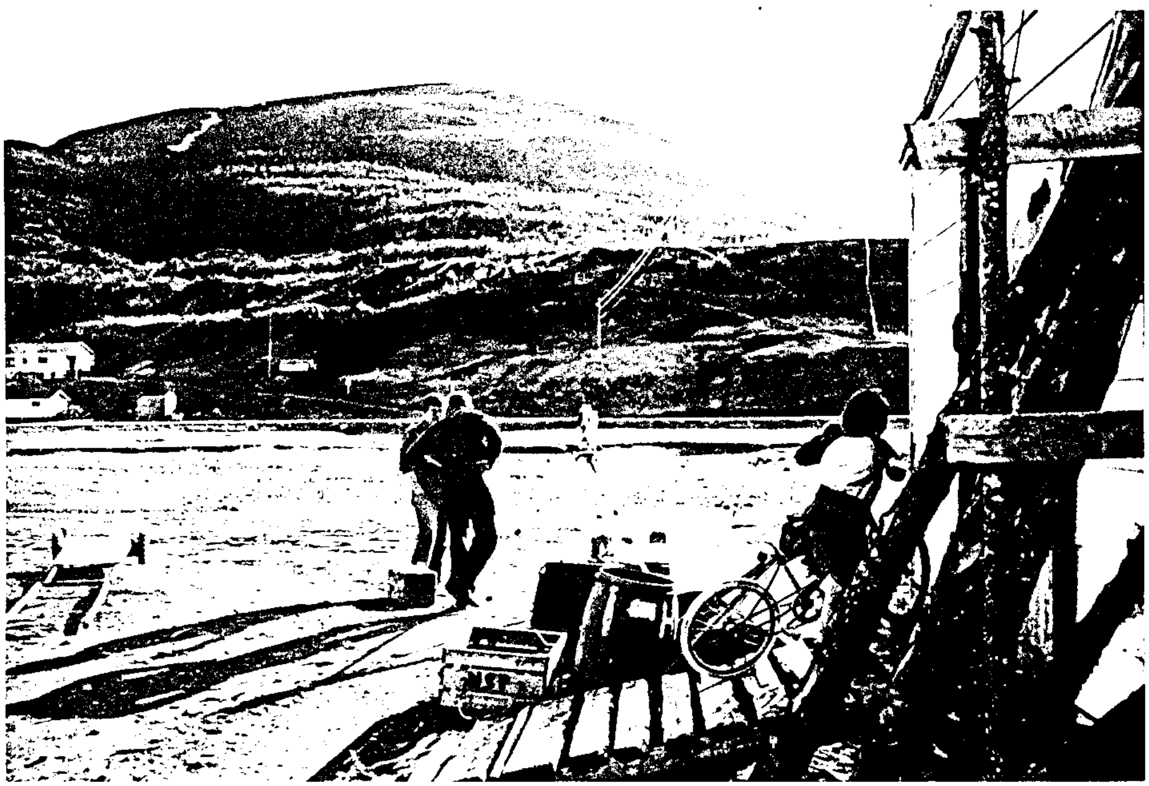


PHOTO 3-4
Looking west along X-section Line #2, May 9, 1989.

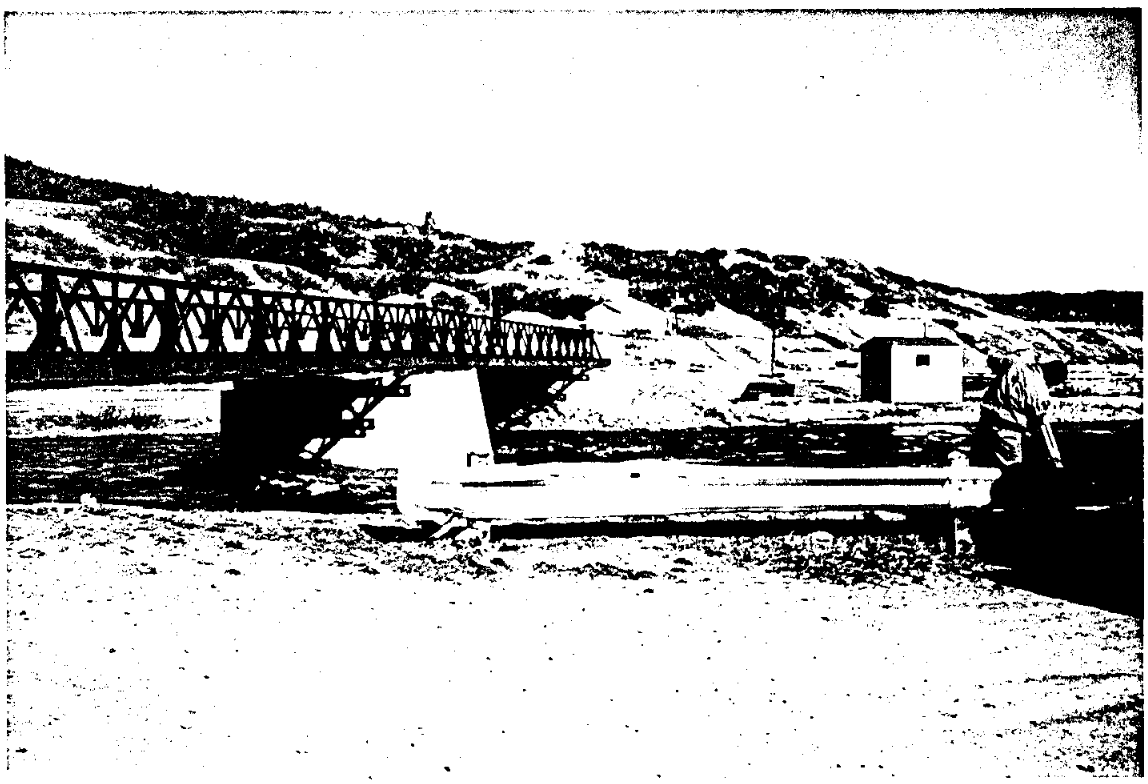


PHOTO 3-7
Looking west across Trout River to houses on west side of harbour at X-section line #3, May 8, 1989.

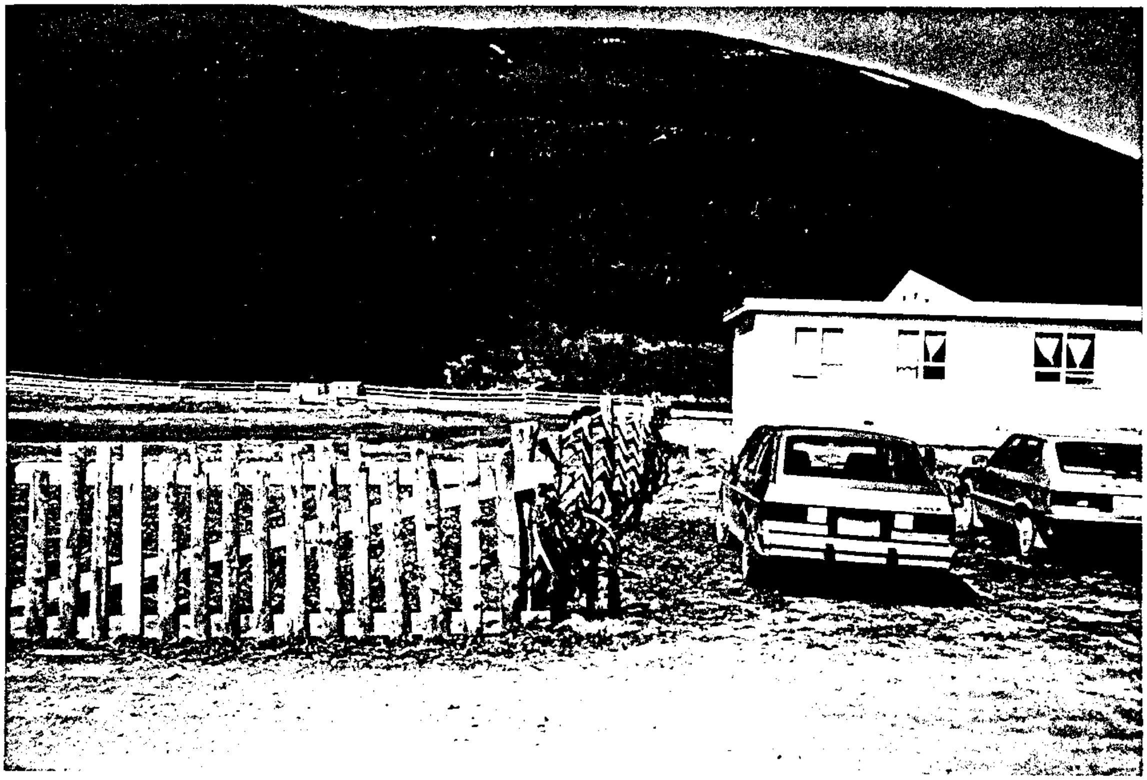


PHOTO 3-12
Looking west toward Trout River along X-section Line #4, May 8, 1989.

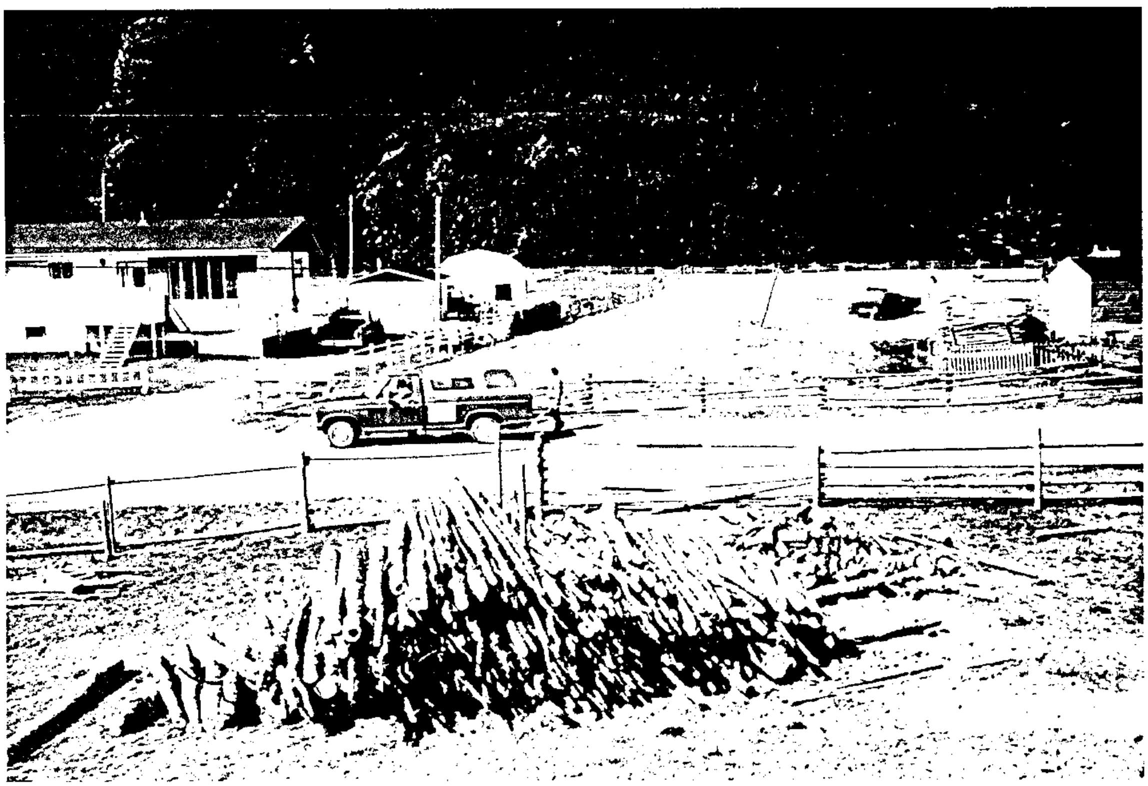


PHOTO 3-14
Looking west toward Trout River along X-section Line #5, May 8, 1989.

PHOTO 4-21
Looking east toward X-section Line #6 which runs across island at middle right of photo, May 10, 1989.

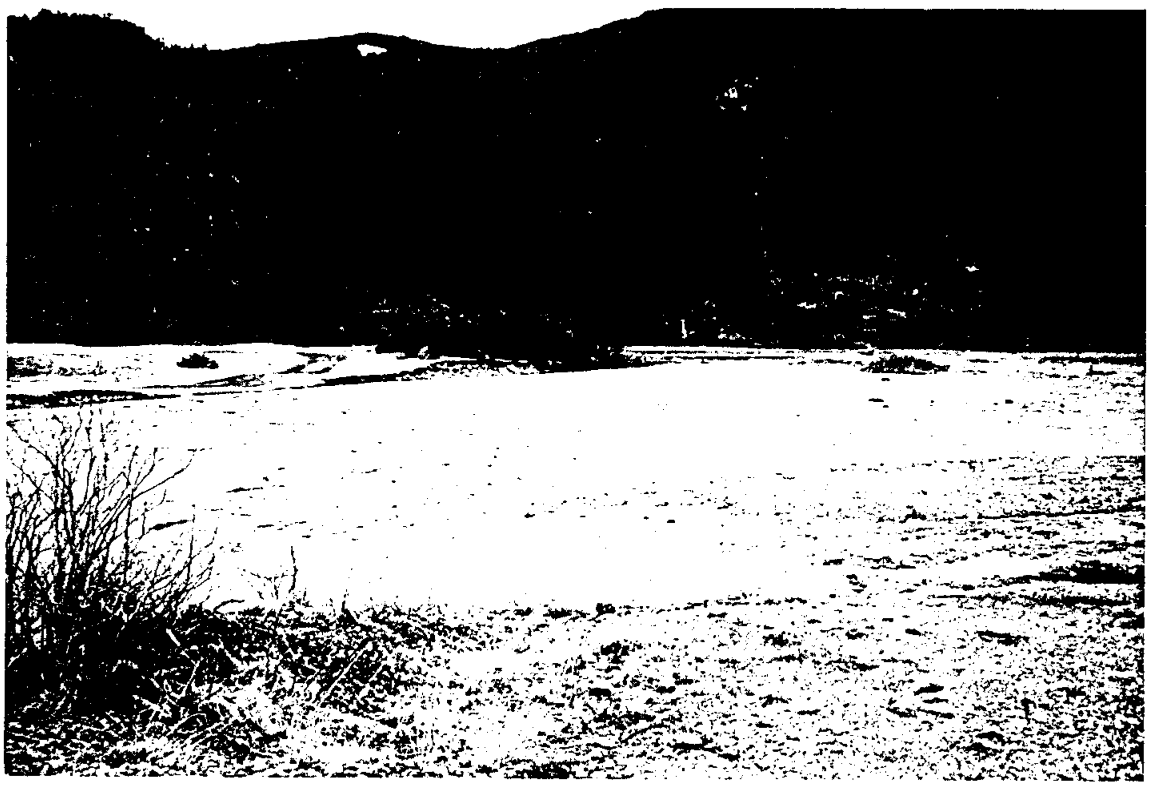


PHOTO 1-16
Looking south west along X-section line #7 toward Intersection of Feeder Brook and Trout River, May 8, 1989.

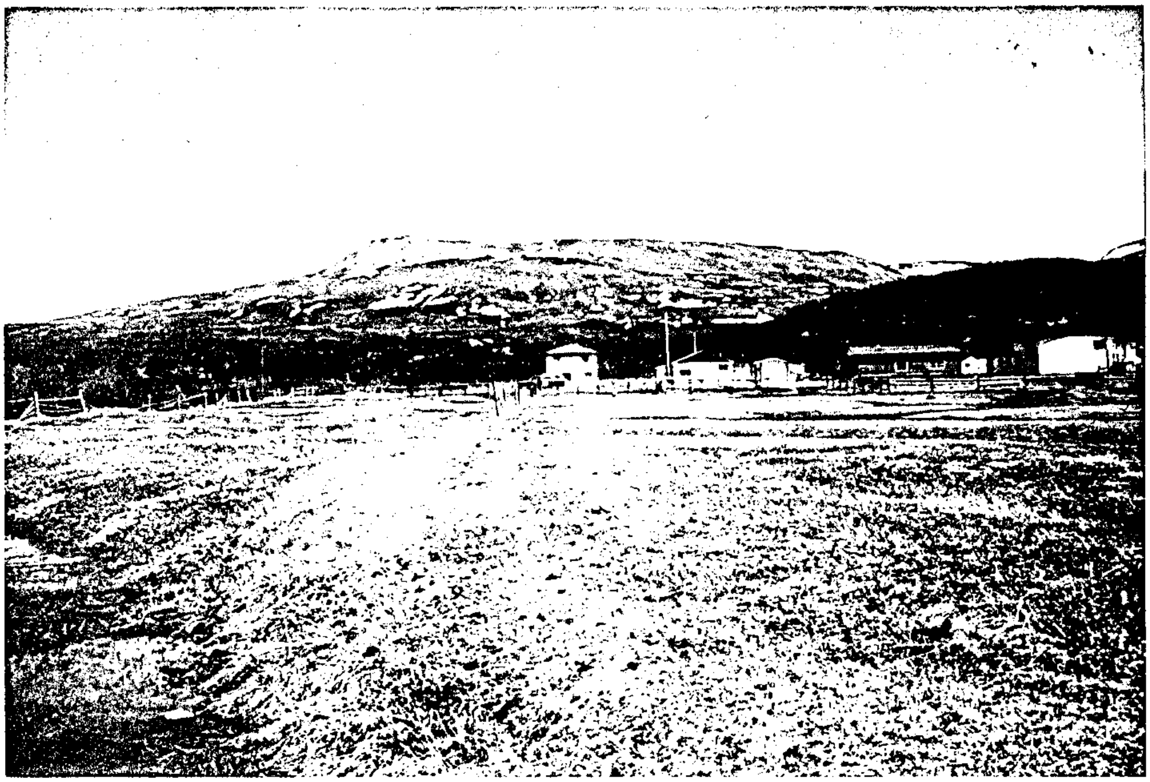


PHOTO 4-9
Looking north east from the west bank of Trout River along X-section Line #8. May 10, 1989.

PHOTO 4-12
Looking north east from west bank of Trout River along X-section Line #9, May 10, 1989.

PHOTO 2-22
Looking south west toward Trout River along X-section #10, May 9, 1989.

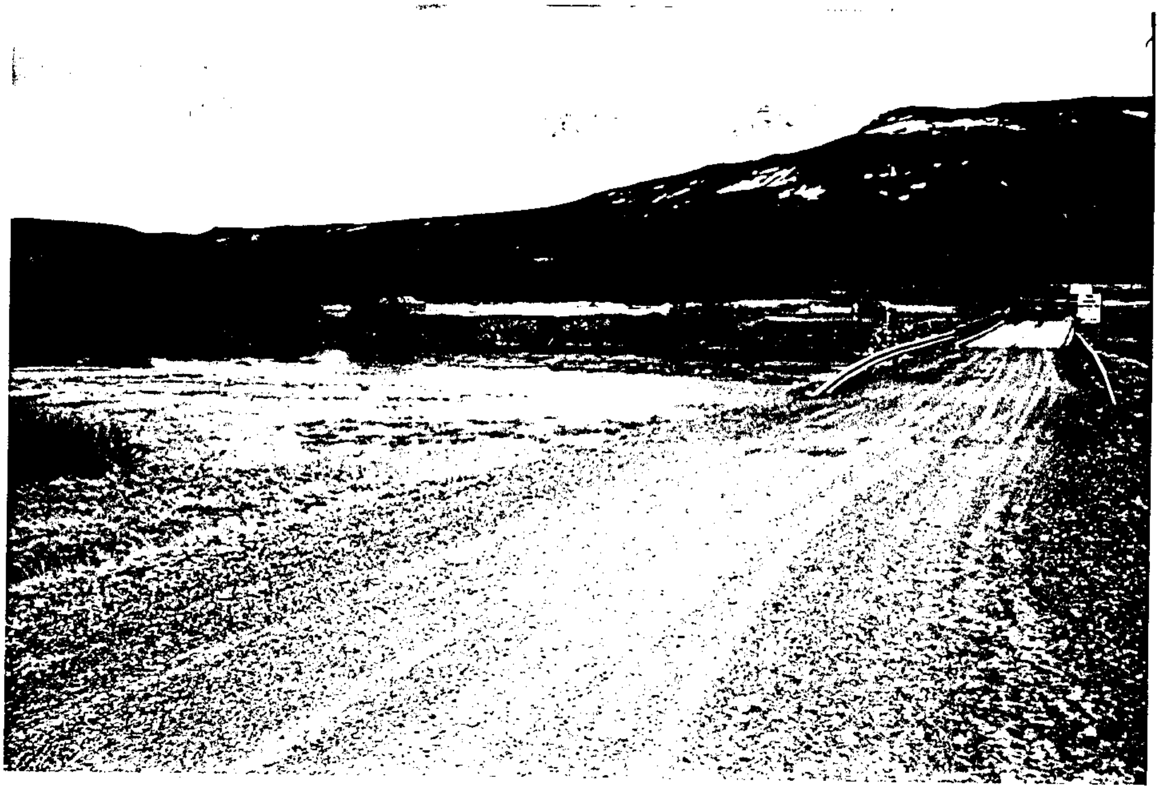


PHOTO 2-5
Looking north east along X-section #11 toward Bridge #1 over Trout River at mouth of Little Trout River Pond. May 9, 1989.

PHOTO 3-16
Looking north east upstream toward bridge over Feeder Brook.
X-section Line #1 ± 10 m downstream from bridge. May 9, 1989.

PHOTO 3-24
Looking north east upstream along Feeder Brook X-section Line #2 runs left to right across barren section middle right of photo. May 9, 1989.

APPENDIX C
HYDRAULIC STRUCTURES

BRIDGE DATA

WATERCOURSE Trout River

MAP SHEET NO FR-TR-2

LOCATION Trout River

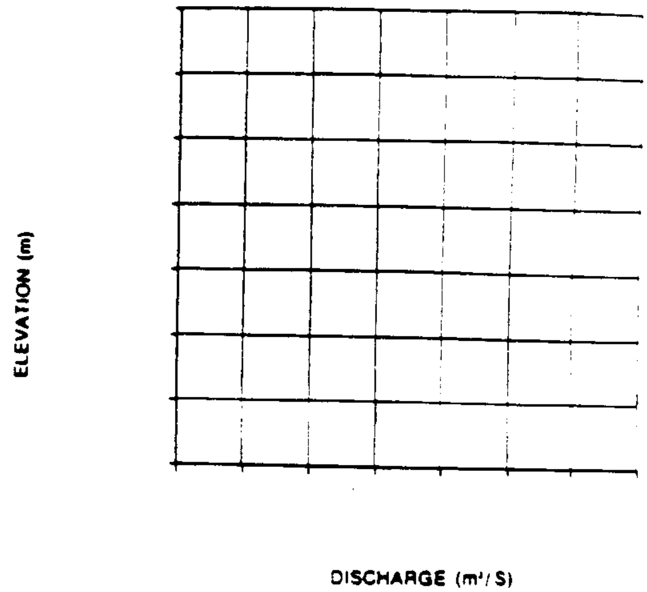
U.T.M. GRID REFERENCE 5,481,900 N
331,600 E

STRUCTURE B1

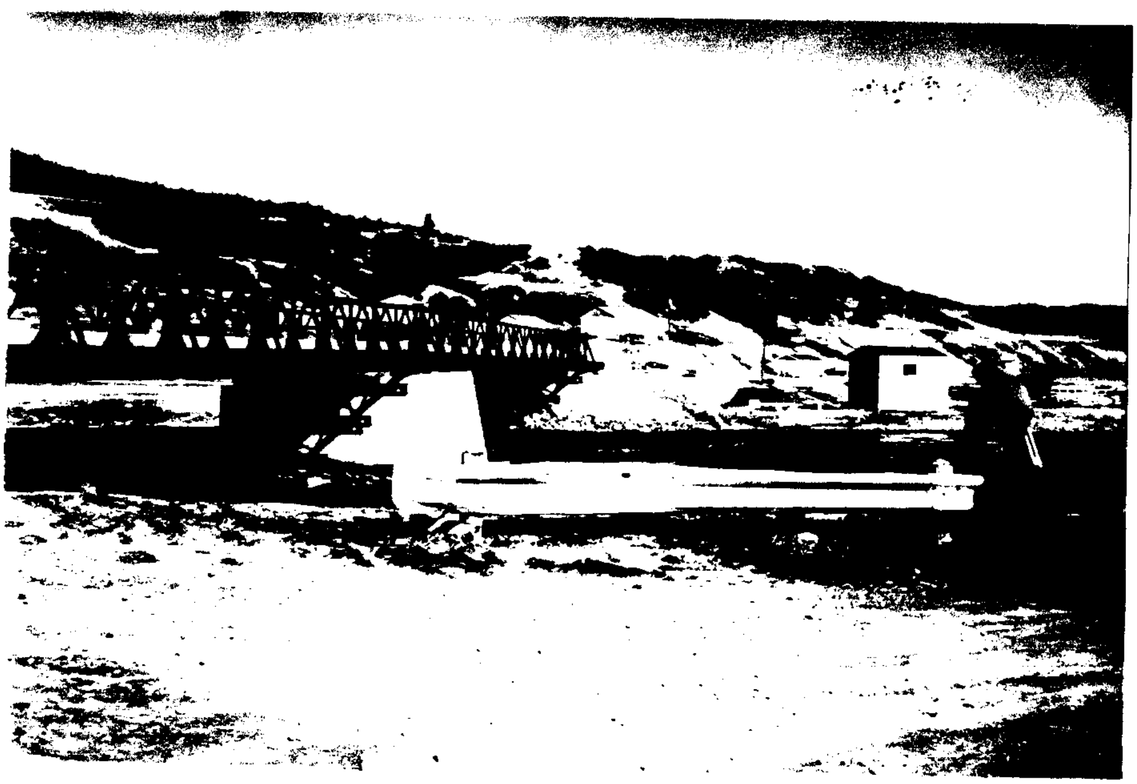
A. SPECIFICATIONS

Span	40.5	m
Length of Structure	4.1	m
Top of Road Elevation	3.6	m
Low Chord (Soffit) Elevation	2.9	m
Upstream Invert Elevation	-1.5	m
Effective Flow Area	105	m^2

B. STAGE DISCHARGE CURVE



C. PHOTOGRAPHIC PRESENTATION



BRIDGE DATA

WATERCOURSE Trout River

LOCATION Lower Trout River Pond

STRUCTURE B2

MAP SHEET NO. FR-TR-1

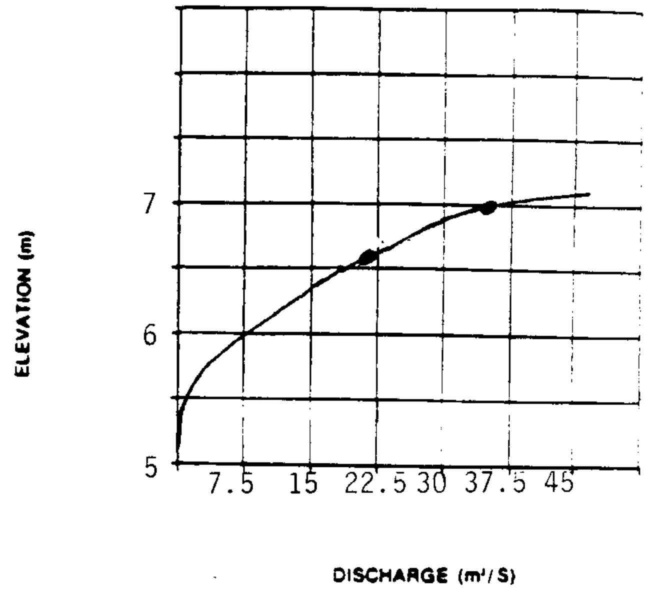
U.T.M. GRID REFERENCE 5,480,100 N

332,280 E

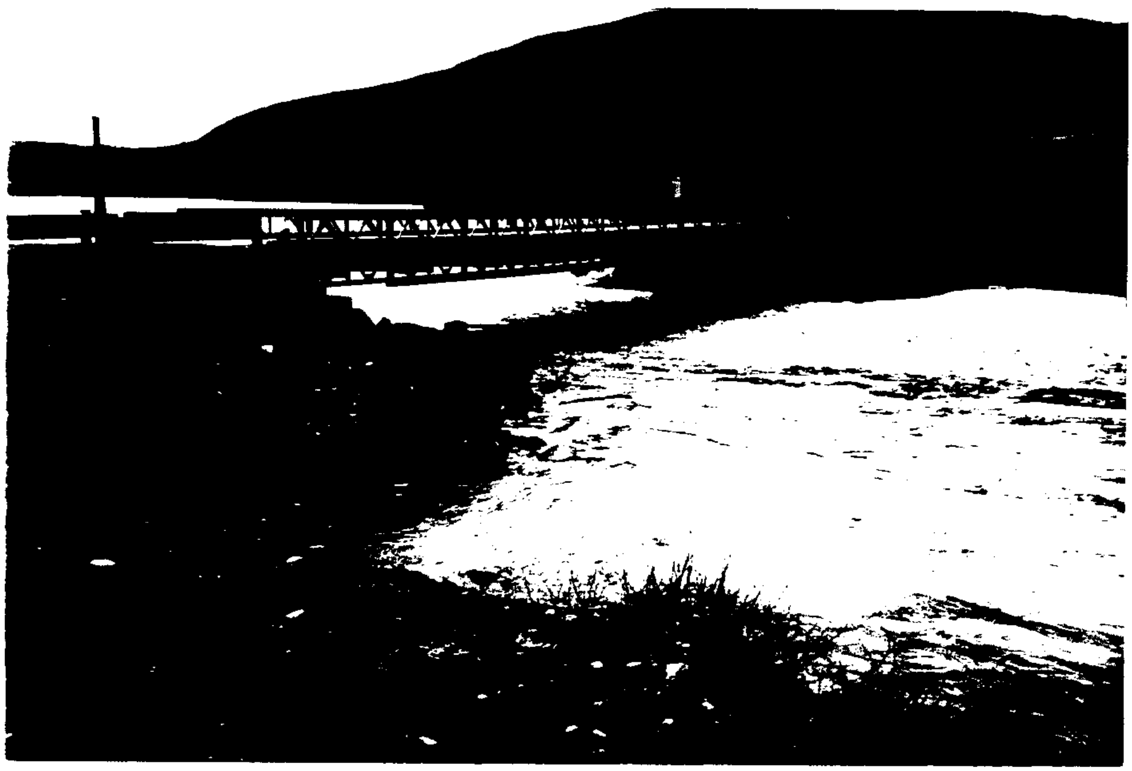
A. SPECIFICATIONS

Span	20	m
Length of Structure	3.0	m
Top of Road Elevation	9.8	m
Low Chord (Soffit) Elevation	8.8	m
Upstream Invert Elevation	5.1	m
Effective Flow Area	74	m^2

B. STAGE DISCHARGE CURVE



C. PHOTOGRAPHIC PRESENTATION



BRIDGE DATA

WATERCOURSE Feeder Brook

LOCATION Bailey Bridge

STRUCTURE B3

MAP SHEET NO. FR-TR-1

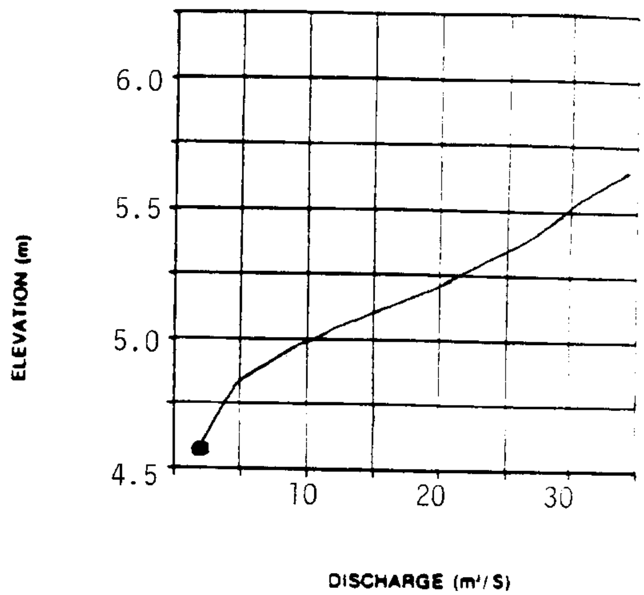
U.T.M. GRID REFERENCE 5,481,120 N

331,900 E

A. SPECIFICATIONS

Span	15.0	m
Length of Structure	5	m
Top of Road Elevation	7.6	m
Low Chord (Soffit) Elevation	7.0	m
Upstream Invert Elevation	4.7	m
Effective Flow Area	34	m^2

B. STAGE DISCHARGE CURVE



C. PHOTOGRAPHIC PRESENTATION

APPENDIX D

HEC-2 RESULTS

APPENDIX D.1

SUMMARY TABLE

TABLE D.1
HEC-2 SUMMARY OF CROSS-SECTIONS AND FLOOD ELEVATIONS

TROUT RIVER		FEEDER BROOK WITH ICE		EMMANUEL'S BROOK	
Section Number	Elevation (m)	Section Number	Elevation (m)	Section Number	Elevation (m)
45	1.92	7150	4.35	0	0.36
45	1.64	7150	4.23		
135	1.95	7230	5.02	57	2.08
135	1.67	7230	4.92		
300	2.07	7250	5.92	82	2.38
300	1.77	7250	5.86		
550	2.15	7255	6.08	104	2.84
550	1.86	7255	6.00		
575	2.16	7272	6.14	137	3.52
575	1.88	7272	6.06		
579.1	2.17	7315	6.26	143	4.03
579.1	1.89	7315	6.16		
595	2.25	7355	6.70	158	4.19
595	1.98	7355	6.54		
810	2.49	7400	7.21	172	4.49
810	2.25	7400	7.03		
1035	2.98	7450	7.81	197	5.51
1035	2.80	7450	7.62		
1290	3.86	7500	8.11		
1290	3.74	7500	7.97		
1400	4.32	8530	8.40		
1400	4.21	8530	8.25		
1485	4.85				
1485	4.74				
1635	5.87				
1635	5.70				
1700	6.08				
1700	5.91				
1805	6.14				
1805	5.98				
2085	6.43				
2085	6.26				
2300	6.93				
2300	6.74				
2600	7.74				
2600	7.54				
2620	7.76				
2620	7.57				
2623	7.78				
2623	7.59				
2640	8.02				
2640	7.77				

NOTE: FLOWS ARE FOR 100 AND 20 YEAR EVENTS EXCEPT EMMANUEL'S BROOK IS FOR 100 YEAR ONLY.

TABLE D.2

Sections	Survey	Mapping	Mapping & Survey
Trout River			
0 + 045	√		
0 + 135	√		
0 + 300	√		
0 + 550			√
0 + 575	√		
0 + 595		√	
0 + 810	√		
1 + 035	√		
1 + 290	√		
1 + 400	√		
1 + 485		√	
1 + 635			√
1 + 700	√		
1 + 805			√
2 + 085	√		
2 + 300	√		
2 + 600		√	
2 + 620	√		
Feeder Brook			
7 + 250			√
7 + 272			√
8 + 230			√
8 + 530			√
All other sections interpreted from mapping			
Emmanuel's Brook			
All sections surveyed			

APPENDIX D.2
TROUT RIVER

```
1*********************************************************          **************************************
*  WATER SURFACE PROFILES                                 *          *  U.S. ARMY CORPS OF ENGINEERS
*  VERSION OF SEPTEMBER 1988                              *          *  THE HYDROLOGIC ENGINEERING CENTER
*                                                         *          *  609 SECOND STREET, SUITE D
*                                                         *          *  DAVIS, CALIFORNIA 95616
*  RUN DATE    3/ 9/90   TIME   15:49:24                  *          *  (916) 756-1104
*********************************************************          **************************************


                              X     X  XXXXXXX   XXXXX              XXXXX
                              X     X  X        X     X            X     X
                              X     X  X        X                        X
                              XXXXXXX  XXXX     X          XXXXX    XXXXX
                              X     X  X        X                  X
                              X     X  X        X     X            X
                              X     X  XXXXXXX   XXXXX             XXXXXXX
END OF BANNER
1
    3/ 9/90      15:49:24                                                                PAGE    1


                                                          THIS RUN EXECUTED  3/ 9/90    15:49:24
**************************************************
  HEC2 RELEASE DATED SEPT 88

**************************************************


T1      CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM
T2      100 YEAR FLOOD
T3      TROUT RIVER                                            B7262E

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

       0         2                             0         1                            1.92

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

      1                   -1


J3  VARIABLE CODES FOR SUMMARY PRINTOUT

      38         1        43        25        42        40        26         5         4

J6  IHLEQ     ICOPY     SUBDIV    STRTDS    RMILE

      1


NC     .095      .085      .050       0.5       0.8
QT        2     143.5     117.5
       **** CROSS-SECTIONS LOOK UPSTREAM ****
X1      045        14       118       163
GR      2.5       100       2.0       105       1.8       118      -2.4     118.1      -4.1       133
GR     -4.3       138      -3.8       142      -1.2       147      -0.6       155       0.0       157
GR      0.9       163       2.9       185       5.2       190       9.0       201

X1      135         8        24        60        90        90        90
GR      2.5         0       1.5        16       1.5        24      -2.0        25      -3.0        40
GR     -1.5        50       1.5        60       2.5        81

X1      300        20       150       287       190       115       155
GR      6.4       100       2.3       110       1.3       130       1.3       150       0.2       157
GR     -1.6     157.3      -2.0       163      -2.3       168      -2.0       171      -0.8       179
GR     -0.6       181      -0.3       200       0.7       214       0.6       255      -0.4       260
GR     -0.7       270      -0.6       279       1.3       287       1.5       294       9.2       312

X1      550        16       237       280       255       155       250
X4        1       1.6       190
GR      4.5       100       2.5       130       2.0       148       1.7       229       1.7       237
```

GR	0.8	240	-1.2	248	-2.0	260	-1.7	264	-0.7	269
GR	0.5	272	1.0	280	1.0	390	1.8	392	1.8	395
GR	5.0	435								

**** BRIDGE IN TROUT RIVER ****

X1	575	21	152	190	22	15	25			
X3	10							1.8	1.2	
GR	7.1	0	2.8	11	1.8	125	1.8	135	2.0	140
GR	3.6	152	1.4	152.1	-0.3	155	-0.5	173.4	3.6	173.5
GR	3.6	175	-0.5	175.1	-0.7	180	-1.5	184	-0.8	187
GR	1.4	189.6	3.6	190	1.8	236	1.2	274	1.2	308
GR	4.0	320								
SB	1.20	1.5	1.5		31	1.5	105	1	-0.3	-0.3
X1	579.1				4.1	4.1	4.1			
X2			1	2.9	3.6					
X3	10							1.8	1.2	
BT	-11	0	7.1	0	11	2.8	0	125	1.8	0
BT		135	1.8	0	140	2.0	0	152	3.6	2.9
BT		190	3.6	2.9	236	1.8	0	274	1.2	0
BT		308	1.2	0	320	4.0				
X1	595	15	155	203	25	25	20			
GR	7.5	0	2.5	17	2.0	25	1.5	55	1.8	134
GR	1.8	140	1.5	155	-0.4	159	-1.0	170	-1.0	190
GR	-0.4	200	1.0	203	1.0	280	1.5	296	7.5	312
NC	.055	.090	.050							
X1	810	9	212	263	190	230	215			
GR	9.3	0	3.1	53	1.8	212	1.0	214	0.1	255
GR	0.5	259	0.9	263	1.8	263	8.5	274		
NC	.040	.075	.045							
X1	1035	11	192	226	225	225	225			
GR	9.4	0	5.1	13	3.3	27	3.2	49	2.3	192
GR	1.1	194	0.4	206	0.5	212	0.8	217	2.5	226
GR	5.2	235								
X1	1290	14	219	281	255	255	255			
GR	12.2	0	6.6	45	5.3	81	4.6	129	3.5	143
GR	3.2	183	4.1	192	3.5	219	2.8	228	2.8	254
GR	2.0	265	2.5	279	3.4	281	6.1	311		

**** CONFLUENCE OF FEEDER BROOK ****

X1	1400	15	250	365	110	110	110			
GR	8.0	4	7.9	29	7.4	63	5.9	65	5.0	117
GR	5.5	118	5.5	124	4.4	181	4.4	224	3.7	250
GR	3.3	321	2.8	337	3.0	350	3.7	365	6.0	378
NC	.045	.085	.045							
BT	2	112	91							
X1	1485	13	475	515	100	85	85			
GR	9.0	100	8.5	125	8.5	190	7.5	220	7.4	245
GR	7.0	251	5.0	360	5.0	450	4.5	475	3.3	484
GR	3.8	502	4.5	515	10.0	528				

X1	1635	19	460	512	110	155	150			
GR	9.0	100	8.0	170	7.6	220	7.6	266	7.5	285
GR	6.0	370	6.0	426	4.9	460	4.6	465	4.1	470
GR	4.2	481	4.7	490	4.7	502	4.4	509	4.4	510
GR	4.7	512	5.0	520	7.5	540	10.0	551		
NH	5	.045	363	.045	398	.090	447	.045	470	.08
NH	480									
X1	1700	19	363	476	75	45	65			
GR	9.5	18	7.9	117	5.4	360	5.4	363	4.8	366
GR	4.4	370	4.2	379	4.3	392	4.6	397	5.1	398
GR	5.1	415	5.5	447	4.1	452	3.5	456	3.5	458
GR	3.8	463	4.7	470	6.8	476	10.0	480		
NC	.045	.090	.045							
X1	1805	17	340	407	110	120	105			

```
GR      10          0        9.5         30        6.0        283        5.5        324        5.0        340
GR     4.5        348        4.1        350        3.8        356        3.7        364        4.2        379
GR     4.2        390        3.6        394        3.6        396        4.1        407        5.0        412
GR     5.5        440       10.0        450

NC    .030       .095       .045
X1    2085         13         57         99        240        280        280
X4       1        6.7         40
GR    12.2          6       10.3         23        6.7         31        6.4         42        5.7         57
GR     5.0         58        4.5         62        4.4         74        4.4         86        4.7         91
GR     5.4         98        5.7         99       12.5        114

NC    .045       .100       .045
X1    2300         14         96        126        210        215        215
GR    15.2          4       15.2         34        8.4         47        8.0         79        7.7         83
GR     6.0         87        6.0         96        5.7         98        4.9        108        4.4        113
GR     4.4        115        4.5        117        5.8        126       12.1        134

NC    .045       .045       .055
X1    2600         14        167        200        310        260        300
GR    12.5          0       12.0          4       10.0        125        9.0        160        8.0        163
GR     6.7        167        5.8        179        5.0        183        5.3        194        6.7        200
GR     7.0        210        7.0        250       10.0        283       12.5        300

NC    .035       .035       .045
      **** BRIDGE AT LOWER TROUT RIVER POND ****
X1    2620         28        223        251         18         24         20
X3      10                                                                       8.8        8.8
GR    13.6          7       13.5         35       11.5         63       11.4         94       10.5        154
GR     9.8        223        8.8        223        8.0        224        6.6      226.7        5.9        227
GR     6.2        228        5.3        229        5.1        230        5.2        232        5.1        234
GR     5.3        235        5.3        239        5.4        242        5.5        243        5.8        245
GR     6.1        246        6.3        247        6.5        248        8.0        251        8.8        251
GR     9.8        251       10.1        395       15.0        438
```



```
SB                  1.5        1.5        200         20          0       74.1                   5.3        5.3
X1    2623                                              3          3          3
X2                               1        8.8        9.8
X3      10                                                                       9.8        9.8

X1    2640         11        185        225         14         19         17
GR    12.5         20       11.0         31        8.5        185        7.0        192        5.9        197
GR     5.2        200        5.2        212        6.5        216        7.0        225       10.0        250
GR    12.5        290
```



```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


*PROF 1

IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
DETAILS.
0

CCHV=     .500 CEHV=     .800
*SECNO 45.000
      **** CROSS-SECTIONS LOOK UPSTREAM ****
    45.00     6.22      1.92       .00      1.92      1.95       .03       .00       .00      1.80
     144.       0.      143.        1.        0.      190.        6.        0.        0.       .90
      .00      .02       .75       .12      .095      .050      .085      .000     -4.30    110.20
  .000240       0.        0.        0.         0         0         0       .00     64.02    174.22
0
*SECNO 135.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   135.00     4.95      1.95       .00       .00      2.01       .06       .04       .03      1.50
     144.       1.      143.        0.        5.      130.        2.       15.        6.      1.50
      .02      .13      1.09       .11      .095      .050      .085      .000     -3.00      8.85
```

.000604	90.	90.	90.	1	0	0	.00	60.53	69.38

0

*SECNO 300.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

300.00	4.37	2.07	.00	.00	2.08	.01	.04	.03	1.30
144.	2.	141.	1.	21.	306.	5.	52.	25.	1.30
.12	.11	.46	.12	.095	.050	.085	.000	-2.30	114.59
.000185	190.	155.	115.	2	0	0	.00	180.74	295.33

0

*SECNO 550.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

550.00	4.15	2.15	.00	.00	2.18	.03	.08	.01	1.70
144.	5.	101.	37.	39.	118.	131.	123.	74.	1.00
.21	.13	.86	.29	.095	.050	.085	.000	-2.00	142.34
.000495	255.	250.	155.	0	0	0	.00	257.13	399.47

0

1

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 575.000

3265 DIVIDED FLOW

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

**** BRIDGE IN TROUT RIVER ****

575.00	3.66	2.16	.00	.00	2.23	.07	.02	.03	3.60
144.	2.	118.	24.	12.	93.	61.	127.	78.	3.60
.22	.15	1.27	.39	.095	.050	.085	.000	-1.50	84.54
.001482	22.	25.	15.	0	0	0	.00	177.88	312.09

0

SPECIAL BRIDGE

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
1.20	1.50	1.50	.00	31.00	1.50	105.00	1.00	-.30	-.30

*SECNO 579.100

3265 DIVIDED FLOW

CLASS A LOW FLOW

3420 BRIDGE W.S.= 2.15 BRIDGE VELOCITY= 1.84 CALCULATED CHANNEL AREA= 78.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	2.24	.01	0.	144.	105.	105.	2.90	3.60	0.

579.10	3.67	2.17	.00	.00	2.24	.07	.00	.00	3.60
144.	2.	118.	24.	13.	94.	62.	128.	79.	3.60
.22	.15	1.26	.38	.095	.050	.085	.000	-1.50	82.97
.001445	4.	4.	4.	0	0	0	.00	179.98	312.15

0

*SECNO 595.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

595.00	3.25	2.25	.00	.00	2.27	.02	.01	.02	1.50
144.	10.	105.	28.	74.	140.	113.	134.	84.	1.00
.23	.14	.75	.25	.095	.050	.085	.000	-1.00	21.03
.000351	25.	20.	25.	2	0	0	.00	276.97	298.00

0

1

```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA      LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

 *SECNO 810.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

    810.00      2.39      2.49       .00       .00      2.57       .09       .25       .05      1.80
      144.       11.      132.        0.       29.       97.        0.      182.      127.      1.80
       .28       .40      1.35       .22      .055      .050      .090      .000       .10    128.08
   .001990      190.      215.      230.         2         0         0       .00    136.05    264.13
0
 *SECNO 1035.000
   1035.00      2.58      2.98       .00       .00      3.12       .14       .51       .04      2.30
      144.       23.      121.        0.       37.       68.        0.      208.      158.      2.50
       .32       .62      1.77       .25      .040      .045      .075      .000       .40     83.75
   .002561      225.      225.      225.         2         0         0       .00    143.85    227.60
0
 *SECNO 1290.000

 3265 DIVIDED FLOW

   1290.00      1.86      3.86       .00       .00      3.98       .11       .84       .01      3.50
      144.       24.      119.        0.       26.       74.        1.      235.      194.      3.40
       .37       .92      1.59       .32      .040      .045      .075      .000      2.00    138.39
   .004048      255.      255.      255.         4         0         0       .00    134.64    286.13
0
 *SECNO 1400.000
            **** CONFLUENCE OF FEEDER BROOK ****
   1400.00      1.52      4.32       .00       .00      4.39       .08       .40       .02      3.70
      144.        5.      139.        0.        7.      111.        1.      247.      209.      3.70
       .39       .65      1.25       .35      .040      .045      .075      .000      2.80    227.11
   .003296      110.      110.      110.         2         0         0       .00    141.37    368.48
0
 *SECNO 1485.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   1485.00      1.55      4.85      4.78       .00      5.21       .36       .59       .23      4.50
      112.        2.      110.        0.        3.       41.        0.      254.      218.      4.50
       .40       .82      2.69       .41      .045      .045      .085      .000      3.30    457.87
   .014315      100.       85.       85.         3         8         0       .00     57.94    515.81
0
1
     3/ 9/90       15:49:24                                                                      PAGE   8

   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA      LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

 *SECNO 1635.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   1635.00      1.77      5.87       .00       .00      5.95       .08       .60       .14      4.90
      112.       10.       97.        6.       14.       72.       11.      264.      228.      4.70
       .43       .67      1.34       .51      .045      .045      .085      .000      4.10    430.18
   .002371      110.      150.      155.         2         0         0       .00     96.74    526.92
0
 1490 NH CARD USED
 *SECNO 1700.000
 1530 MANNINGS N VALUES FOR CHANNEL COMPOSITED
   1700.00      2.58      6.08       .00       .00      6.10       .02       .12       .03      5.40
      112.       11.      101.        0.       24.      147.        0.      273.      238.      6.80
       .46       .44       .69       .00      .045      .068      .000      .000      3.50    294.60
   .001514       75.       65.       45.         2         0         0       .00    179.32    473.92
0
 *SECNO 1805.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   1805.00      2.54      6.14       .00       .00      6.16       .02       .06       .00      5.00
      112.        9.       96.        7.       31.      140.       33.      293.      256.      4.10
       .51       .29       .68       .21      .045      .045      .090      .000      3.60    272.93
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   .000352     110.      105.      120.         2         0         0       .00    168.49    441.42
0
 *SECNO 2085.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   2085.00     2.03      6.43       .00       .00      6.53       .10       .31       .06      5.70
      112.       4.      108.        0.        6.       76.        1.      332.      287.      5.70
       .56      .76      1.42       .22      .030      .045      .095      .000      4.40     41.79
   .001865     240.      280.      280.         2         0         0       .00     58.82    100.61
0
 *SECNO 2300.000
   2300.00     2.53      6.93       .00       .00      7.09       .16       .51       .05      6.00
      112.      10.      102.        0.        9.       56.        1.      348.      297.      5.80
       .60     1.10      1.83       .32      .045      .045      .100      .000      4.40     84.83
   .002986     210.      215.      215.         2         0         0       .00     42.59    127.42
0
1
    3/ 9/90      15:49:24                                                                                                    PAGE    9

     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 *SECNO 2600.000
   2600.00     2.74      7.74       .00       .00      7.80       .06       .66       .05      6.70
      112.       1.       80.       31.        2.       66.       41.      374.      317.      6.70
       .67      .59      1.22       .76      .045      .055      .045      .000      5.00    163.84
   .001806     310.      300.      260.         1         0         0       .00     94.15    257.99
0
 *SECNO 2620.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=         8.80 ELREA=          8.80

        **** BRIDGE AT LOWER TROUT RIVER POND ****
   2620.00     2.66      7.76       .00       .00      8.01       .25       .06       .15      9.80
      112.       0.      112.        0.        0.       51.        0.      375.      318.      9.80
       .67      .00      2.20       .00      .000      .045      .000      .000      5.10    224.46
   .004317      18.       20.       24.         2         0         0       .00     26.07    250.52
0

 SPECIAL BRIDGE

 SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
       .00       1.50       1.50     200.00      20.00        .00      74.10        .00       5.30       5.30

 *SECNO 2623.000

 6070,LOW FLOW BY NORMAL BRIDGE

 EGPRS=       .000  EGLWC=      8.164  ELLC=      8.800  PCWSE=      7.762  ELTRD=      9.800

 3370 NORMAL BRIDGE, NRD=   0 MIN ELTRD=      9.80 MAX ELLC=      8.80


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=         9.80 ELREA=          9.80

   2623.00     2.68      7.78       .00       .00      8.02       .24       .01       .00      9.80
      112.       0.      112.        0.        0.       52.        0.      375.      318.      9.80
       .67      .00      2.17       .00      .000      .045      .000      .000      5.10    224.41
   .004150       3.        3.        3.         2         0         0       .00     26.17    250.58
0
1
    3/ 9/90      15:49:24                                                                                                    PAGE   10

     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 *SECNO 2640.000
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3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

  2640.00     2.82     8.02      .00      .00     8.13      .11      .05      .06     8.50
     112.       0.     108.       4.       0.      72.       4.     377.     319.     7.00
      .68      .00     1.51      .81     .000     .045     .035     .000     5.20   187.24
  .002011      14.      17.      19.        2        0        0      .00    46.27   233.51
0
1
    3/ 9/90      15:49:24                                                                         PAGE   11

T1      CANADA-NEWFOUNDLAND FLOOD DAMAGE REDUCTION PROGRAM
T2      20 YEAR FLOOD
T3      TROUT RIVER

J1  ICHECK     INQ       NINV      IDIR      STRT      METRIC    HVINS     Q        WSEL      FQ

      0         3                             0          1                          1.64

J2  NPROF      IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW      CHNIM     ITRACE

     15                   -1


1
    3/ 9/90      15:49:24                                                                         PAGE   12

   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*PROF 2

IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
DETAILS.
0

CCHV=      .500 CEHV=      .800
*SECNO 45.000
          **** CROSS-SECTIONS LOOK UPSTREAM ****
    45.00     5.94     1.64      .00     1.64     1.66      .02      .00      .00     1.80
     118.       0.     117.       0.       0.     177.       3.       0.       0.      .90
      .00      .00      .66      .09     .000     .050     .085     .000    -4.30   118.00
  .000202       0.       0.       0.        0        0        0      .00    53.14   171.14
0
*SECNO 135.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   135.00     4.67     1.67      .00      .00     1.72      .05      .03      .02     1.50
     118.       0.     117.       0.       1.     120.       0.      14.       5.     1.50
      .03      .07      .98      .05     .095     .050     .085     .000    -3.00    13.47
  .000539      90.      90.      90.        0        0        0      .00    49.85    63.32
0
*SECNO 300.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   300.00     4.07     1.77      .00      .00     1.78      .01      .05      .02     1.30
     118.       1.     116.       0.      12.     265.       3.      45.      22.     1.30
      .12      .08      .44      .08     .095     .050     .085     .000    -2.30   120.55
  .000204     190.     155.     115.        2        0        0      .00   174.09   294.64
0
*SECNO 550.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   550.00     3.86     1.86      .00      .00     1.90      .03      .10      .02     1.70
     118.       1.      92.      25.      13.     105.      96.     102.      68.     1.00
      .21      .08      .88      .26     .095     .050     .085     .000    -2.00   162.73
  .000598     255.     250.     155.        1        0        0      .00   233.02   395.75
0
1
    3/ 9/90      15:49:24                                                                         PAGE   13
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     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

  *SECNO 575.000

  3265 DIVIDED FLOW


  3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

          **** BRIDGE IN TROUT RIVER ****
     575.00     3.38      1.88       .00       .00      1.96       .07       .03       .03      3.60
      118.        0.      105.       12.        1.       83.       38.      105.       71.       3.60
       .22       .06      1.27       .32      .095      .050      .085      .000     -1.50    116.71
   .001670       22.       25.       15.         0         0         0       .00    132.88    310.88
0

  SPECIAL BRIDGE

  SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
        1.20       1.50       1.50        .00      31.00       1.50     105.00       1.00       -.30       -.30

  *SECNO 579.100

  3265 DIVIDED FLOW

  CLASS A LOW FLOW

  3420 BRIDGE W.S.=        1.87 BRIDGE VELOCITY=       1.71     CALCULATED CHANNEL AREA=        69.

   EGPRS      EGLWC       H3       QWEIR       QLOW       BAREA    TRAPEZOID      ELLC      ELTRD      WEIRLN
                                                                    AREA
        .00       1.96       .01         0.       118.       105.      105.       2.90       3.60         0.


     579.10     3.39      1.89       .00       .00      1.96       .07       .01       .00      3.60
      118.        0.      105.       13.        1.       84.       39.      106.       72.       3.60
       .22       .07      1.25       .32      .095      .050      .085      .000     -1.50    114.74
   .001617        4.        4.        4.         0         0         0       .00    135.80    310.96
0
  *SECNO 595.000

  3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

     595.00     2.98      1.98       .00       .00      2.00       .02       .01       .02      1.50
      118.        4.       94.       19.       38.      126.       87.      110.       77.       1.00
       .23       .09       .75       .22      .095      .050      .085      .000     -1.00     26.44
   .000392       25.       20.       25.         2         0         0       .00    270.83    297.27
0
1
     3/ 9/90      15:49:24                                                                                       PAGE   14

     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

  *SECNO 810.000

  3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

     810.00     2.15      2.25       .00       .00      2.34       .09       .29       .05      1.80
      118.        4.      113.        0.       12.       85.        0.      148.      116.       1.80
       .28       .32      1.33       .18      .055      .050      .090      .000       .10    156.89
   .002282      190.      215.      230.         2         0         0       .00    106.85    263.74
0
  *SECNO 1035.000
    1035.00     2.40      2.80       .00       .00      2.94       .14       .56       .04      2.30
      118.       10.      107.        0.       20.       62.        0.      168.      141.       2.50
       .32       .52      1.72       .19      .040      .045      .075      .000       .40    112.24
   .002754      225.      225.      225.         2         0         0       .00    114.77    227.01
0
  *SECNO 1290.000
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 3265 DIVIDED FLOW

   1290.00      1.74      3.74       .00       .00      3.85       .11       .89       .02      3.50
    118.         15.       102.        0.       19.        67.        1.      189.      171.       3.40
     .37         .81      1.52       .27      .040      .045      .075      .000      2.00    139.89
   .004209      255.      255.      255.         4         0         0       .00    125.35    284.82
0
 *SECNO 1400.000
         **** CONFLUENCE OF FEEDER BROOK ****
   1400.00      1.41      4.21       .00       .00      4.28       .07       .41       .02      3.70
    118.          3.      114.        0.        5.        99.        1.      200.      186.       3.70
     .39         .58      1.16       .31      .040      .045      .075      .000      2.80    231.09
   .003331      110.      110.      110.         2         0         0       .00    136.79    367.88
0
 *SECNO 1485.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   1485.00      1.44      4.74       .00       .00      5.04       .30       .57       .19      4.50
     91.          1.       90.        0.        1.        37.        0.      206.      194.       4.50
     .40         .64      2.45       .01      .045      .045      .085      .000      3.30    462.81
   .013602      100.       85.       85.         2         0         0       .00     52.76    515.58
0
1
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    SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
    Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 *SECNO 1635.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   1635.00      1.60      5.70       .00       .00      5.78       .07       .62       .11      4.90
     91.          6.       81.        4.       10.        64.        9.      215.      204.       4.70
     .44         .60      1.27       .47      .045      .045      .085      .000      4.10    435.12
   .002488      110.      150.      155.         2         0         0       .00     90.52    525.64
0
 1490 NH CARD USED
 *SECNO 1700.000
 1530 MANNINGS N VALUES FOR CHANNEL COMPOSITED
   1700.00      2.41      5.91       .00       .00      5.93       .02       .13       .03      5.40
     91.          5.       86.        0.       14.       129.        0.      222.      212.       6.80
     .46         .39       .66       .00      .045      .068      .000      .000      3.50    310.62
   .001661       75.       65.       45.         2         0         0       .00    162.83    473.45
0
 *SECNO 1805.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   1805.00      2.38      5.98       .00       .00      5.99       .02       .06       .00      5.00
     91.          5.       81.        5.       21.       129.       28.      239.      230.       4.10
     .52         .25       .62       .18      .045      .045      .090      .000      3.60    285.08
   .000328      110.      105.      120.         2         0         0       .00    155.97    441.05
0
 *SECNO 2085.000

 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   2085.00      1.86      6.26       .00       .00      6.34       .08       .30       .05      5.70
     91.          2.       89.        0.        3.        68.        0.      274.      258.       5.70
     .58         .60      1.30       .18      .030      .045      .095      .000      4.40     45.15
   .001805      240.      280.      280.         1         0         0       .00     55.07    100.22
0
 *SECNO 2300.000
   2300.00      2.34      6.74       .00       .00      6.88       .14       .49       .04      6.00
     91.          7.       84.        0.        7.        50.        1.      288.      268.       5.80
     .61         .94      1.68       .28      .045      .045      .100      .000      4.40     85.27
   .002907      210.      215.      215.         2         0         0       .00     41.92    127.19
0
1
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    SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
```

```
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*SECNO 2600.000
  2600.00     2.54     7.54      .00      .00     7.60      .06      .69      .04     6.70
      91.       1.      70.      20.       1.      60.      30.     310.     287.     6.70
      .69      .53     1.18      .66     .045     .055     .045     .000     5.00   164.41
  .001936     310.     300.     260.        1        0        0      .00    91.55   255.96
0
*SECNO 2620.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=         8.80 ELREA=         8.80

        **** BRIDGE AT LOWER TROUT RIVER POND ****
  2620.00     2.47     7.57      .00      .00     7.77      .20      .06      .11     9.80
      91.       0.      91.       0.       0.      46.       0.     311.     289.     9.80
      .69      .00     1.96      .00     .000     .045     .000     .000     5.10   224.80
  .003760      18.      20.      24.        1        0        0      .00    25.36   250.17
0

SPECIAL BRIDGE

SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
       .00      1.50      1.50    200.00     20.00       .00     74.10       .00      5.30      5.30

*SECNO 2623.000

6070,LOW FLOW BY NORMAL BRIDGE

EGPRS=       .000  EGLWC=       7.934  ELLC=       8.800  PCWSE=       7.573  ELTRD=       9.800

3370 NORMAL BRIDGE, NRD=   0 MIN ELTRD=     9.80 MAX ELLC=     8.80


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=         9.80 ELREA=         9.80

  2623.00     2.49     7.59      .00      .00     7.78      .19      .01      .00     9.80
      91.       0.      91.       0.       0.      47.       0.     311.     289.     9.80
      .69      .00     1.95      .00     .000     .045     .000     .000     5.10   224.79
  .003709       3.       3.       3.        2        0        0      .00    25.39   250.18
0
*SECNO 2640.000
  2640.00     2.57     7.77      .00      .00     7.87      .10      .05      .05     8.50
      91.       0.      89.       2.       0.      62.       2.     312.     289.     7.00
      .70      .00     1.43      .69     .000     .045     .035     .000     5.20   188.40
  .002076      14.      17.      19.        2        0        0      .00    43.02   231.42
0
1
    3/ 9/90      15:49:24                                                                                    PAGE   17


                                                                                THIS RUN EXECUTED  3/ 9/90    15:49:34
**************************************************
  HEC2 RELEASE DATED SEPT 88


**************************************************


NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST


TROUT RIVER

SUMMARY PRINTOUT


      SECNO     CWSEL       Q       AREA     ELMIN     ELTRD      VCH      10*KS    TOPWID

     45.000      1.92    143.50    195.85    -4.30       .00       .75      2.40     64.02
     45.000      1.64    117.50    180.07    -4.30       .00       .66      2.02     53.14

*   135.000      1.95    143.50    137.59    -3.00       .00      1.09      6.04     60.53
*   135.000      1.67    117.50    121.67    -3.00       .00       .98      5.39     49.85

*   300.000      2.07    143.50    332.25    -2.30       .00       .46      1.85    180.74
```

	SECNO	CWSEL	Q	AREA	ELMIN	ELTRD	VCH	10*KS	TOPWID
*	300.000	1.77	117.50	279.38	-2.30	.00	.44	2.04	174.09
*	550.000	2.15	143.50	287.08	-2.00	.00	.86	4.95	257.13
*	550.000	1.86	117.50	213.41	-2.00	.00	.88	5.98	233.02
*	575.000	2.16	143.50	166.17	-1.50	.00	1.27	14.82	177.88
*	575.000	1.88	117.50	122.15	-1.50	.00	1.27	16.70	132.88
	579.100	2.17	143.50	168.64	-1.50	3.60	1.26	14.45	179.98
	579.100	1.89	117.50	124.47	-1.50	3.60	1.25	16.17	135.80
*	595.000	2.25	143.50	326.73	-1.00	.00	.75	3.51	276.97
*	595.000	1.98	117.50	252.01	-1.00	.00	.75	3.92	270.83
*	810.000	2.49	143.50	126.62	.10	.00	1.35	19.90	136.05
*	810.000	2.25	117.50	98.01	.10	.00	1.33	22.82	106.85
	1035.000	2.98	143.50	105.42	.40	.00	1.77	25.61	143.85
	1035.000	2.80	117.50	82.24	.40	.00	1.72	27.54	114.77
	1290.000	3.86	143.50	102.12	2.00	.00	1.59	40.48	134.64
	1290.000	3.74	117.50	86.80	2.00	.00	1.52	42.09	125.35
	1400.000	4.32	143.50	119.24	2.80	.00	1.25	32.96	141.37
	1400.000	4.21	117.50	104.34	2.80	.00	1.16	33.31	136.79

	SECNO	CWSEL	Q	AREA	ELMIN	ELTRD	VCH	10*KS	TOPWID
*	1485.000	4.85	112.00	43.83	3.30	.00	2.69	143.15	57.94
*	1485.000	4.74	91.00	38.35	3.30	.00	2.45	136.02	52.76
*	1635.000	5.87	112.00	97.53	4.10	.00	1.34	23.71	96.74
*	1635.000	5.70	91.00	82.54	4.10	.00	1.27	24.88	90.52
	1700.000	6.08	112.00	171.26	3.50	.00	.69	15.14	179.32
	1700.000	5.91	91.00	143.05	3.50	.00	.66	16.61	162.83
*	1805.000	6.14	112.00	204.62	3.60	.00	.68	3.52	168.49
*	1805.000	5.98	91.00	177.89	3.60	.00	.62	3.28	155.97
*	2085.000	6.43	112.00	82.24	4.40	.00	1.42	18.65	58.82
*	2085.000	6.26	91.00	72.05	4.40	.00	1.30	18.05	55.07
	2300.000	6.93	112.00	65.70	4.40	.00	1.83	29.86	42.59
	2300.000	6.74	91.00	57.85	4.40	.00	1.68	29.07	41.92
	2600.000	7.74	112.00	108.06	5.00	.00	1.22	18.06	94.15
	2600.000	7.54	91.00	90.93	5.00	.00	1.18	19.36	91.55
*	2620.000	7.76	112.00	51.00	5.10	.00	2.20	43.17	26.07
	2620.000	7.57	91.00	46.40	5.10	.00	1.96	37.60	25.36
	2623.000	7.78	112.00	51.70	5.10	9.80	2.17	41.50	26.17
	2623.000	7.59	91.00	46.61	5.10	9.80	1.95	37.09	25.39
*	2640.000	8.02	112.00	76.01	5.20	.00	1.51	20.11	46.27
	2640.000	7.77	91.00	64.85	5.20	.00	1.43	20.76	43.02

SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO= 135.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 135.000 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 300.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 300.000 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 550.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 550.000 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

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WARNING SECNO=    575.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    575.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    595.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    595.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    810.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    810.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   1485.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=   1485.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   1635.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=   1635.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   1805.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=   1805.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   2085.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=   2085.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   2620.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   2640.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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APPENDIX D.3

FEEDER BROOK

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!            !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! WATER SURFACE PROFILES                                   !            ! U.S. ARMY CORPS OF ENGINEERS           !
! VERSION OF SEPTEMBER 1988                                !            ! THE HYDROLOGIC ENGINEERING CENTER      !
!                                                          !            ! 609 SECOND STREET, SUITE D             !
!                                                          !            ! DAVIS, CALIFORNIA 95616                !
! RUN DATE    3/ 7/90   TIME   13: 3:13                    !            ! (916) 756-1104                         !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!            !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!


                              X     X  XXXXXXX   XXXXX              XXXXX
                              X     X  X        X     X            X     X
                              X     X  X        X                        X
                              XXXXXXX  XXXX     X         XXXXX     XXXXX
                              X     X  X        X                  X
                              X     X  X        X     X            X
                              X     X  XXXXXXX   XXXXX             XXXXXXX
END OF BANNER
1
    3/ 7/90      13: 3:13                                                                       PAGE    1


                                                                      THIS RUN EXECUTED  3/ 7/90    13: 3:13
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
  HEC2 RELEASE DATED SEPT 88

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!


T1      TROUT RIVER   100 YEAR
T2      BRIDGE AND CULVERTS COMPLETELY BLOCKED
T3      FEEDER BROOK                                          B7262BS1

J1  ICHECK    INQ      NINV      IDIR      STRT      METRIC    HVINS     Q        WSEL      FQ

      0        2                  0         -1         1                           4.8

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH      FN       ALLDC     IBW      CHNIM     ITRACE

     1                  -1


J3  VARIABLE CODES FOR SUMMARY PRINTOUT

     38        1        43        25         42        41        40        26         5         4

J6  IHLEQ     ICOPY    SUBDIV    STRTDS     RMILE

     1


QT       7        41        31        20        15        10         5         2
NC    .040      .035      .035       0.3       0.5
X1    7150        17       179       209
GR     5.5        80       5.0        84       4.9       118       4.3       140       3.7       158
GR     3.9       160       5.0       167       5.5       170       6.0       172       6.1       175
GR     6.1       176       6.0       179       4.5       184       3.5       190       3.4       200
GR     4.5       204       6.0       209

X1    7230        15       168       192        65        65        65
X3      10                                                                    6.6
GR     7.5         0       6.0        25       5.4        50       5.5        85       5.0       102
GR     5.0       129       4.0       132       4.0       139       6.0       142       6.5       146
GR     6.6       154       6.5       168       4.0       175       4.0       187       7.1       192

X1    7250        14       163       168        15        15        15
X3      10                                                                    5.4       7.6
GR     7.5         0       6.0        27       5.4        50       5.5        75       6.1       114
GR     6.3       120       7.0       132       7.5       144       7.6     162.9       7.0       163
GR     5.0     165.7       5.1       167       7.0       168       7.6     178.1

SB                 1.5       1.5                 0.1                0.01                6.9       6.9
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X1     7255                                6         6         6
X2                       1       7.0      5.4
X3       10                                                           5.4       7.6
BT      -12        0      7.5              27       6.0                50        5.4
BT                75      5.5             114       6.1               120        6.3
1
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BT               132      7.0             144       7.5              162.9      7.6
BT               163      7.6     5.0     168       7.6      5.1     178.1      7.6

X1     7272       18      142     169      15        15       15
GR      8.0        0      7.5       3      6.5       15      6.0       50       6.0       81
GR      5.0       89      4.6      92      4.6       96      5.0       98       6.0      104
GR      6.5      112      6.0     136      6.0      142      5.0      150       4.4      153
GR      4.5      161      5.0     164      7.5      169

NC     .045     .045     .045
X1     7315       20      129     148       30       48       43
X3       10                                                           6.7
GR      8.0       50      7.5      66      6.0       70      5.5       80       4.9       83
GR      4.9       88      5.5      90      6.0       94      6.5      105       6.7      111
GR      6.7      112      6.5     125      6.5      129      6.0      130       5.5      134
GR      4.9      138      5.0     143      5.5      148      7.5      152       8.0      169

X1     7355       20       91     109       50       40       40
X3       10                                                           7.6
GR      8.5       50      7.5      54      5.5       57      5.2       60       5.5       62
GR      5.5       69      6.5      74      7.0       79      7.5       82       7.6       83
GR      7.5       84      6.0      91      5.5       94      5.5      103       6.0      105
GR      7.0      109      7.0     122      7.5      130      7.5      143       8.5      146

X1     7400       13       78      90       45       45       45
X3       10                                                           8.0
GR      8.5       50      6.0      60      5.5       61      5.5       65       6.0       67
GR      8.0       72      6.5      78      5.8       80      5.9       88       6.5       90
GR      7.5      100      8.0     120      8.5      142

X1     7450       11       76      99       50       50       50
GR      9.0       50      8.0      58      7.5       60      6.8       65       7.5       72
GR      9.5       76      6.5      84      6.4       92      7.5       99       8.5      130
GR      9.5      132

X1     7500       13       76     100       50       50       50
GR       10       50      8.5      59      7.4       63      8.5       70       9.8       75
GR      9.8       76      7.5      82      6.8       88      6.8       95       8.0      100
GR      9.0      107      9.0     116       10      121

X1     8530       11       73      99       30       30       30
GR       10       50      9.5      58      8.4       65      9.0       70       9.0       73
GR      7.5       79      7.2      81      7.2       90      9.0       99       9.0      122
GR       10      129
1
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```
   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN     SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID    ENDST

*PROF 1

IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
DETAILS.
0

CCHV=     .300 CEHV=     .500
*SECNO 7150.000

3265 DIVIDED FLOW

3720 CRITICAL DEPTH ASSUMED
  7150.00     .95     4.35     4.35     4.80     4.58      .23      .00      .00     6.00
      41.     11.      30.       0.       8.      13.       0.       0.       0.      6.00
      .00    1.35     2.36      .00     .040     .035     .000     .000     3.40   138.20
  .011314      0.       0.       0.        0       18        0      .00    43.21   203.45
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0
*SECNO 7230.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       6.60 ELREA=        7.10

  7230.00     1.02     5.02      .00      .00     5.43      .41      .76      .09     6.50
      41.       0.      41.       0.       0.      15.       0.       1.       2.     7.10
      .01      .00     2.82      .00     .000     .035     .000     .000     4.00   172.15
  .011996      65.      65.      65.        2        0        0      .00    16.50   188.64
0
*SECNO 7250.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       5.40 ELREA=        7.60

  7250.00      .92     5.92     5.92      .00     6.07      .15      .25      .04     7.00
      41.      37.       4.       0.      23.       2.       0.       1.       3.     7.00
      .01     1.60     2.32      .00     .040     .035     .000     .000     5.00    29.97
  .016630      15.      15.      15.       20       10        0      .00    75.47   167.43
0
1
    3/ 7/90      13: 3:13                                                                          PAGE    4

   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


SPECIAL BRIDGE

SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
       .00       1.50       1.50        .00        .10        .00        .01        .00       6.90       6.90

*SECNO 7255.000

6070,LOW FLOW BY NORMAL BRIDGE

EGPRS= **********  EGLWC=     7.969  ELLC=      7.000  PCWSE=      5.922  ELTRD=       5.400

3265 DIVIDED FLOW


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE


3370 NORMAL BRIDGE, NRD=  12 MIN ELTRD=     5.40 MAX ELLC=     7.00


4677 BRIDGE DECK DEFINITION ERROR AT STATIONS     165.70    167.00

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=       5.40 ELREA=        7.60

  7255.00     1.08     6.08      .00      .00     6.14      .06      .05      .02     7.00
      41.      38.       3.       0.      36.       2.       0.       2.       3.     7.00
      .01     1.06     1.59      .00     .040     .035     .000     .000     5.00    25.55
  .005146       6.       6.       6.        3        0        0     -.25    90.45   167.52
0
*SECNO 7272.000

3265 DIVIDED FLOW


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

  7272.00     1.74     6.14      .00      .00     6.17      .03      .02      .01     6.00
      41.      17.      24.       0.      28.      28.       0.       2.       5.     7.50
      .02      .59      .85      .00     .040     .035     .000     .000     4.40    40.09
  .000738      15.      15.      15.        2        0        0      .00   103.25   166.28
0
1
    3/ 7/90      13: 3:13                                                                          PAGE    5
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 7315.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=         6.70 ELREA=         5.50

 7315.00      1.36      6.26       .00       .00      6.52       .25       .23       .11      6.50
     41.        0.       40.        1.        0.       18.        1.        4.        7.      5.50
     .02       .00      2.25      1.12      .000      .045      .045      .000      4.90    129.48
 .010809       30.       43.       48.         0         0         0       .00     20.04    149.52
0
*SECNO 7355.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=         7.60 ELREA=         7.00

 7355.00      1.20      6.70       .00       .00      7.01       .31       .47       .03      6.00
     41.        0.       41.        0.        0.       17.        0.        4.        7.      7.00
     .03       .00      2.47       .00      .000      .045      .000      .000      5.50     91.00
 .012683       50.       40.       40.         2         0         0       .00     16.82    107.82
0
*SECNO 7400.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=         8.00 ELREA=         6.50

 7400.00      1.41      7.21       .00       .00      7.52       .32       .51       .00      6.50
     41.        0.       38.        3.        0.       15.        2.        5.        8.      6.50
     .03       .00      2.56      1.11      .000      .045      .045      .000      5.80     78.00
 .010142       45.       45.       45.         2         0         0       .00     19.03     97.03
0
*SECNO 7450.000

3265 DIVIDED FLOW


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

 7450.00      1.41      7.81       .00       .00      7.92       .12       .34       .06      9.50
     41.       10.       31.        1.        8.       19.        1.        6.       10.      7.50
     .04      1.16      1.61       .46      .045      .045      .045      .000      6.40     58.77
 .005105       50.       50.       50.         2         0         0       .00     41.90    108.56
0
1
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 7500.000

3265 DIVIDED FLOW

 7500.00      1.31      8.11       .00       .00      8.31       .20       .35       .04      9.80
     41.        3.       38.        0.        3.       19.        0.        8.       12.      8.00
     .05      1.03      2.02       .02      .045      .045      .045      .000      6.80     60.41
 .008775       50.       50.       50.         2         0         0       .00     27.50    100.78
0
*SECNO 8530.000

3265 DIVIDED FLOW

 8530.00      1.20      8.40       .00       .00      8.66       .26       .32       .03      9.00
     41.        0.       41.        0.        0.       18.        0.        8.       12.      9.00
     .05       .00      2.26       .00      .000      .045      .000      .000      7.20     65.00
 .012499       30.       30.       30.         2         0         0       .00     20.60     96.00
0
1
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T1      TROUT RIVER
T2       20 YEAR
T3      BIG FEEDER BROOK

J1  ICHECK    INQ      NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

       0        3                  0        -1         1                            3.64

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

     15                 -1
```

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1
    3/ 7/90       13: 3:13                                                                          PAGE    8

    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

 *PROF 2

 IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
 PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
 DETAILS.
0

 CCHV=     .300 CEHV=      .500
 *SECNO 7150.000

 3265 DIVIDED FLOW

 3720 CRITICAL DEPTH ASSUMED
   7150.00       .83      4.23      4.23      3.64      4.46       .23       .00       .00      6.00
       31.        7.       24.        0.        5.       11.        0.        0.        0.      6.00
       .00      1.20      2.29       .00      .040      .035      .000      .000      3.40    142.05
   .012472        0.        0.        0.         0        22         0       .00     37.48    203.02
0
 *SECNO 7230.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=          6.60 ELREA=          7.10

   7230.00       .92      4.92       .00       .00      5.22       .30       .72       .04      6.50
       31.        0.       31.        0.        0.       13.        0.        1.        2.      7.10
       .01       .00      2.42       .00      .000      .035      .000      .000      4.00    172.44
   .010004       65.       65.       65.         1         0         0       .00     16.03    188.47
0
 *SECNO 7250.000

 3265 DIVIDED FLOW

 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=          5.40 ELREA=          7.60

   7250.00       .86      5.86      5.86       .00      5.99       .13       .25       .00      7.00
       31.       27.        4.        0.       18.        2.        0.        1.        2.      7.00
       .01      1.49      2.24       .00      .040      .035      .000      .000      5.00     32.49
   .016820       15.       15.       15.        20        10         0       .00     68.56    167.40
0
1
    3/ 7/90       13: 3:13                                                                          PAGE    9

    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 SPECIAL BRIDGE
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SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
     .00      1.50      1.50       .00       .10       .00       .01       .00      6.90      6.90

*SECNO 7255.000

6070,LOW FLOW BY NORMAL BRIDGE

EGPRS= 733967.200  EGLWC=     7.887  ELLC=     7.000  PCWSE=     5.857  ELTRD=     5.400

3265 DIVIDED FLOW


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE


3370 NORMAL BRIDGE, NRD=  12 MIN ELTRD=     5.40 MAX ELLC=     7.00


4677 BRIDGE DECK DEFINITION ERROR AT STATIONS     165.70    167.00

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        5.40 ELREA=        7.60

   7255.00      1.00      6.00       .00       .00      6.06       .05       .05       .02      7.00
       31.       28.        3.        0.       29.        2.        0.        1.        3.      7.00
       .01       .97      1.51       .00      .040      .035      .000      .000      5.00     26.93
   .005065        6.        6.        6.         3         0         0      -.22     83.96    167.48
0
*SECNO 7272.000

3265 DIVIDED FLOW


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE

   7272.00      1.66      6.06       .00       .00      6.08       .02       .02       .01      6.00
       31.       12.       19.        0.       22.       26.        0.        2.        4.      7.50
       .02       .54       .71       .00      .040      .035      .000      .000      4.40     45.79
   .000562       15.       15.       15.         2         0         0       .00     92.17    166.12
0
1
     3/ 7/90      13: 3:13                                                                               PAGE   10

    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

*SECNO 7315.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        6.70 ELREA=        5.50

   7315.00      1.26      6.16       .00       .00      6.34       .18       .18       .08      6.50
       31.        0.       31.        0.        0.       16.        0.        3.        6.      5.50
       .02       .00      1.88       .92      .000      .045      .045      .000      4.90    129.66
   .008515       30.       43.       48.         1         0         0       .00     19.67    149.34
0
*SECNO 7355.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        7.60 ELREA=        7.00

   7355.00      1.04      6.54       .00       .00      6.79       .25       .41       .03      6.00
       31.        0.       31.        0.        0.       14.        0.        4.        7.      7.00
       .03       .00      2.20       .00      .000      .045      .000      .000      5.50     91.00
   .012053       50.       40.       40.         2         0         0       .00     16.20    107.20
0
*SECNO 7400.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        8.00 ELREA=        6.50

   7400.00      1.23      7.03       .00       .00      7.30       .27       .50       .01      6.50
       31.        0.       30.        1.        0.       13.        1.        4.        8.      6.50
       .03       .00      2.32       .92      .000      .045      .045      .000      5.80     78.00
   .010277       45.       45.       45.         1         0         0       .00     17.24     95.24
0
```

```
*SECNO 7450.000

3265 DIVIDED FLOW

  7450.00     1.22     7.62      .00      .00     7.74      .12      .40      .04     9.50
      31.       6.      25.       0.       6.      16.       0.       5.       9.     7.50
      .04     1.06     1.61      .26     .045     .045     .045     .000     6.40    59.55
  .006456      50.      50.      50.        1        0        0      .00    34.13   102.49
0
1
```



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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN     SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID    ENDST

*SECNO 7500.000

3265 DIVIDED FLOW

  7500.00     1.17     7.97      .00      .00     8.13      .16      .37      .02     9.80
      31.       1.      30.       0.       2.      16.       0.       6.      10.     8.00
      .05      .87     1.82      .00     .045     .045     .000     .000     6.80    60.92
  .008453      50.      50.      50.        2        0        0      .00    24.81    99.88
0
*SECNO 8530.000
  8530.00     1.05     8.25      .00      .00     8.46      .21      .31      .03     9.00
      31.       0.      31.       0.       0.      15.       0.       7.      11.     9.00
      .06      .00     2.05      .00     .000     .045     .000     .000     7.20    76.00
  .011886      30.      30.      30.        2        0        0      .00    19.25    95.25
0
1
```


THIS RUN EXECUTED 3/ 7/90 13: 3:18

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**************************************************
  HEC2 RELEASE DATED SEPT 88

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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

FEEDER BROOK

SUMMARY PRINTOUT

	SECNO	CWSEL	Q	AREA	ELMIN	ELLC	ELTRD	VCH	10*KS	TOPWID
*	7150.000	4.35	41.00	20.86	3.40	.00	.00	2.36	113.14	43.21
*	7150.000	4.23	31.00	16.14	3.40	.00	.00	2.29	124.72	37.48
	7230.000	5.02	41.00	14.53	4.00	.00	.00	2.82	119.96	16.50
	7230.000	4.92	31.00	12.81	4.00	.00	.00	2.42	100.04	16.03
*	7250.000	5.92	41.00	24.73	5.00	.00	.00	2.32	166.30	75.47
*	7250.000	5.86	31.00	20.00	5.00	.00	.00	2.24	168.20	68.56
*	7255.000	6.08	41.00	37.64	5.00	7.00	5.40	1.59	51.46	90.45
*	7255.000	6.00	31.00	31.01	5.00	7.00	5.40	1.51	50.65	83.96
*	7272.000	6.14	41.00	56.90	4.40	.00	.00	.85	7.38	103.25
*	7272.000	6.06	31.00	48.94	4.40	.00	.00	.71	5.62	92.17
*	7315.000	6.26	41.00	18.52	4.90	.00	.00	2.25	108.09	20.04
*	7315.000	6.16	31.00	16.70	4.90	.00	.00	1.88	85.15	19.67
	7355.000	6.70	41.00	16.63	5.50	.00	.00	2.47	126.83	16.82
	7355.000	6.54	31.00	14.06	5.50	.00	.00	2.20	120.53	16.20
	7400.000	7.21	41.00	17.41	5.80	.00	.00	2.56	101.42	19.03

	7400.000	7.03	31.00	14.17	5.80	.00	.00	2.32	102.77	17.24
*	7450.000	7.81	41.00	28.82	6.40	.00	.00	1.61	51.05	41.70
	7450.000	7.62	31.00	21.37	6.40	.00	.00	1.61	64.56	34.13
	7500.000	8.11	41.00	21.59	6.80	.00	.00	2.02	87.75	27.50
	7500.000	7.97	31.00	17.89	6.80	.00	.00	1.82	84.53	24.81
	8530.000	8.40	41.00	18.12	7.20	.00	.00	2.26	124.99	20.60
	8530.000	8.25	31.00	15.13	7.20	.00	.00	2.05	118.86	19.25

SUMMARY OF ERRORS AND SPECIAL NOTES

```
CAUTION SECNO=  7150.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=  7150.000  PROFILE=  2  CRITICAL DEPTH ASSUMED

CAUTION SECNO=  7250.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=  7250.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=  7250.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=  7250.000  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=  7250.000  PROFILE=  2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=  7250.000  PROFILE=  2  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=  7255.000  PROFILE=  1  BRIDGE DECK DEFINITION ERROR
WARNING SECNO=  7255.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION SECNO=  7255.000  PROFILE=  2  BRIDGE DECK DEFINITION ERROR
WARNING SECNO=  7255.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=  7272.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=  7272.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=  7315.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=  7315.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=  7450.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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APPENDIX D.4
EMMANUEL'S BROOK

```
 1*****************************************************          **************************************
 *  WATER SURFACE PROFILES                           *          * U.S. ARMY CORPS OF ENGINEERS       *
 *  VERSION OF SEPTEMBER 1988                        *          * THE HYDROLOGIC ENGINEERING CENTER  *
 *                                                   *          * 609 SECOND STREET, SUITE D         *
 *                                                   *          * DAVIS, CALIFORNIA 95616            *
 *  RUN DATE     5/ 3/90   TIME   14:33:50           *          * (916) 756-1104                     *
 *****************************************************          **************************************


                              X     X  XXXXXXX   XXXXX           XXXXX
                              X     X  X        X     X         X     X
                              X     X  X        X                     X
                              XXXXXXX  XXXX     X        XXXXX   XXXXX
                              X     X  X        X               X
                              X     X  X        X     X         X
                              X     X  XXXXXXX   XXXXX          XXXXXXX
 END OF BANNER
1
    5/ 3/90      14:33:50                                                                  PAGE   1


                                                                THIS RUN EXECUTED  5/ 3/90    14:33:50
 ******************************************
  HEC2 RELEASE DATED SEPT 88

 ******************************************


 T1      TROUT RIVER, NEWFOUNDLAND
 T2      100 YEAR EVENT                                     MAY/90
 T3      EMMANUEL'S CREEK                                   BEMAN

 J1  ICHECK    INQ     NINV     IDIR     STRT     METRIC    HVINS     Q      WSEL     FQ

        0        2               0                  1                         0.3

 J2  NPROF    IPLOT    PRFVS    XSECV    XSECH      FN     ALLDC     IBW     CHNIM    ITRACE

       1               -1

 J3  VARIABLE CODES FOR SUMMARY PRINTOUT

      38         1       43       25       42       26        5        4

 J6  IHLEQ    ICOPY    SUBDIV   STRTDS    RMILE

       1


 QT       1      32.2
 NC    .040      .050      .045       0.5      0.8
 X1     000         7        53        70
 GR       1         0       0.1        30      0.1       53      -0.7       55     -0.55      60
 GR    -0.4        65       1.1        70

 X1      57        11        45        53       57       57        57
 X3      10                                                               1.75      2.75
 GR       3         0         2         8      1.8       25      1.75       45      0.75      46
 GR     0.6        50       0.8      52.8     2.75       53      2.25       65      2.73     125
 GR     3.7       138

 NC    .050      .050      .045
 X1      82        12        20        45       25       25        25
 X3      10                                                               1.7       3.0
 GR       3        11      2.75        20      1.7       22       1.4       36       1.1      40
 GR    1.44        42       1.9        45     2.45       45       2.4       54       2.6      95
 GR     3.0       120       4.0       123

 X1     104        12        42        57       20       26        22
 X3      10                                                               3.9       3.8
```

GR	4.5	5	4.0	11	3.9	42	1.8	46	1.75	50
GR	2.1	56	3.8	57	3.14	52	3.14	67	2.3	32
GR	3.0	99	4.5	110						

X1	137	12	15	22.3	30	30	30			
X3	10							4.3	4.3	
GR	5.0	0	4.5	5	4.6	14.5	4.3	15	2.2	15.1
GR	2.2	22.2	4.3	22.3	4.6	23	4.4	28	3.5	32
GR	3.5	50	4.5	58						
SB		1.5	1.5		7.3		15.3		2.25	2.15
X1	143				6	6	6			
X2			1	4.3	4.6					
X3	10							4.5	4.5	
BT	-10	0	5	5	5	4.5	4.5	14.5	4.6	4.6
BT		15	4.6	4.3	22.3	4.5	4.3	23	4.5	4.5
BT		28	4.4	4.4	32	3.5	3.5	50	3.5	3.5
BT		58	4.5	4.5						
X1	158	9	5.8	14.3	15	15	15			
GR	5.0	0	4.4	5.8	2.9	6.0	2.65	10	3.0	14
GR	4.8	14.3	4.8	20	5.0	42	5.5	45		
X1	172	12	4	19	17	17	17			
X3	10							5.8	4.8	
GR	5.8	4	3.55	6	3.38	10	3.4	15	4.37	17
GR	4.8	19	4.8	23	5.5	23	5.5	33	4.63	33
GR	5.23	36	5.9	41						
X1	197	10	9	24	25	25	25			
GR	6.0	9	4.5	14.5	4.4	17.5	4.3	20	4.35	22.5
GR	4.62	22.5	5.45	24	5.45	26	5.6	35	5.75	37.5

```
  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
  Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN     SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID    ENDST

*PROF 1

IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
DETAILS.
0

CCHV=     .500 CEHV=     .800
*SECNO  .000
3720 CRITICAL DEPTH ASSUMED
      .00     1.06      .36      .36      .30      .55      .19      .00      .00      .10
      32.       8.      24.       0.       7.      11.       0.       0.       0.      1.10
      .00     1.10     2.16      .00     .040     .045     .000     .000     -.70     21.43
  .013419       0.       0.       0.        0        7        0      .00    46.10     67.52
0
*SECNO 57.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        1.75 ELREA=        2.75

    57.00     1.48     2.08     2.08      .00     2.28      .20      .53      .10      1.75
      32.       9.      23.       0.       9.      10.       0.       1.       3.      2.75
      .01      .97     2.26      .00     .040     .045     .000     .000      .60      7.39
  .009230      57.      57.      57.        5       11        0      .00    45.54     52.93
0
*SECNO 82.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        1.70 ELREA=        3.00

    82.00     1.28     2.38      .00      .00     2.50      .12      .18      .04      2.75
      32.       0.      32.       0.       0.      21.       0.       2.       3.      2.45
      .01      .00     1.53      .00     .000     .045     .000     .000     1.10     20.70
  .005990      25.      25.      25.        2        0        0      .00    24.30     45.00
0
*SECNO 104.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
1
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```
  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
  Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN     SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID    ENDST


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        3.90 ELREA=        3.80

   104.00     1.09     2.84     2.84      .00     3.28      .45      .50      .08      3.90
      32.       0.      32.       0.       0.      11.       0.       2.       4.      3.80
      .01      .00     2.96      .00     .000     .045     .000     .000     1.75     44.03
  .022658      20.      22.      26.       20       15        0      .00    12.41     56.43
0
*SECNO 137.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        4.30 ELREA=        4.30

   137.00     1.32     3.52      .00      .00     4.11      .59      .71      .12      4.30
      32.       0.      32.       0.       0.       9.       0.       2.       4.      4.30
      .02      .00     3.42      .00     .000     .045     .000     .000     2.20     15.04
  .024711      30.      30.      30.        0        0        0      .00     7.23     22.26
0
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SPECIAL BRIDGE

SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
      .00      1.50      1.50       .00      7.30       .00     15.30       .00      2.25      2.15

*SECNO 143.000

6070,LOW FLOW BY NORMAL BRIDGE

EGPRS=       .000  EGLWC=      4.117  ELLC=      4.300  PCWSE=      3.516  ELTRD=      4.600

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE


3370 NORMAL BRIDGE, NRD=  10 MIN ELTRD=     4.60 MAX ELLC=     4.30


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        4.50 ELREA=        4.50

   143.00     1.83      4.03       .00       .00      4.34       .31       .08       .14      4.30
      32.       0.       32.        0.        0.       13.        0.        2.        4.       4.30
      .02      .00      2.45       .00      .000      .045      .000      .000      2.20     15.01
  .009361       6.        6.        6.         4         0         0       .00      7.27     22.29
0
1
    5/ 3/90      14:33:50                                                                                     PAGE    5


   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


*SECNO 158.000
   158.00     1.54      4.19       .00       .00      4.60       .41       .18       .08      4.40
      32.       0.       32.        0.        0.       11.        0.        2.        4.       4.80
      .02      .00      2.84       .00      .000      .045      .000      .000      2.65      5.83
  .014795      15.       15.       15.         2         0         0       .00      8.37     14.20
0
*SECNO 172.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=        5.80 ELREA=        4.80

   172.00     1.11      4.49       .00       .00      4.91       .42       .30       .01      5.80
      32.       0.       32.        0.        0.       11.        0.        3.        5.       4.80
      .02      .00      2.88       .00      .000      .045      .000      .000      3.38      5.17
  .020574      17.       17.       17.         2         0         0       .00     12.37     17.54
0
*SECNO 197.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   197.00     1.21      5.51      5.51       .00      5.90       .39       .48       .03      6.00
      32.       0.       32.        0.        0.       12.        0.        3.        5.       5.45
      .02      .00      2.76       .36      .000      .045      .050      .000      4.30     10.79
  .019333      25.       25.       25.         2         8         0       .00     18.94     29.73
```

THIS RUN EXECUTED 5/ 3/90 14:33:52

****
HEC2 RELEASE DATED SEPT 88

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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

EMMANUEL'S CREEK

SUMMARY PRINTOUT

	SECNO	CWSEL	Q	AREA	ELMIN	VCH	10*KS	TOPWID
*	.000	.36	32.20	18.36	-.70	2.16	134.19	46.10
*	57.000	2.08	32.20	19.40	.60	2.26	92.30	45.54
	82.000	2.38	32.20	21.03	1.10	1.53	59.90	24.30
*	104.000	2.84	32.20	10.89	1.75	2.96	226.58	12.41
	137.000	3.52	32.20	9.42	2.20	3.42	247.11	7.23
*	143.000	4.03	32.20	13.12	2.20	2.45	93.61	7.27
	158.000	4.19	32.20	11.34	2.65	2.84	147.95	8.37
	172.000	4.49	32.20	11.18	3.38	2.88	205.74	12.37
*	197.000	5.51	32.20	11.89	4.30	2.76	193.33	18.94

1

SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION SECNO= .000 PROFILE= 1 CRITICAL DEPTH ASSUMED

CAUTION SECNO= 57.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 57.000 PROFILE= 1 MINIMUM SPECIFIC ENERGY

CAUTION SECNO= 104.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 104.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 104.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO= 143.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 197.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 197.000 PROFILE= 1 MINIMUM SPECIFIC ENERGY

APPENDIX E

TIDES

TIDES (Starting Water Levels)

1. INTRODUCTION/BACKGROUND INFORMATION

The water levels in the Gulf of St. Lawrence vary with the periodic tides and storm surges. The magnitudes of the latter depend on the friction between water and the atmosphere during storms and fluctuations in barometric pressure.

2. DESIGN TIDE CONDITIONS

The annual maximum water level (tide and surge) along the west coast of Newfoundland and in the Strait of Belle Isle generally occurs in the four month winter period of November through February from a combination of high tides and large storms.

For example, for the three locations in the Gulf of St. Lawrence closest to Trout River where historical water level data are available, the following historical maximum statistics have been extracted:

	Harrington Harb.		West St. Modeste		Lark Harbour	
Month	Water Level (m)	Max. Tide (m)	Water Level (m)	Max. Tide (m)	Water Level (m)	Max. Tide (m)
November	2.63	2.20	2.12	1.49	2.48	2.07
December	2.80	2.20	2.21	1.52	2.66	2.10
January	2.90	2.10	2.10	1.42	2.79	2.01
February	2.51	2.10	2.09	1.40	2.57	1.98

The water level is the maximum recorded in the period of record in the particular month. The maximum tide is the maximum for a particular month in 1989.

The above table gives the maximum water levels (tide plus surge) and the maximum tide level.

Previous investigations have determined that a temporal interdependency exists between maximum instantaneous water levels at Harrington Harbour and those that occur along the west coast of Newfoundland in the vicinity of Trout River (Martec Limited, 1988).

For example, on 27 January 1971, the maximum instantaneous water level at Harrington Harbour was 2.90 m; at Lark Harbour it was 2.79 m. On 21 November 1976, the largest November instantaneous water levels occurred at both locations. At Harrington Harbour the level was 2.63 m; at Lark Harbour it was 2.48 m.

Thus the magnitudes of the large tides are effectively the same along the coast and it can be assumed the storm surge magnitudes are effectively the same outside and to seaward of narrowing bays and inlets where the primary storm surge results from the large fetch across the Gulf of St. Lawrence which corresponds to the prevailing westerly winds. Therefore, the Lark Harbour water level data accurately represents the tide water levels at the mouth of Trout River and was used to determine water levels in Trout River Bay.

3. ESTIMATION OF GEODETIC DATUM

The geodetic datum at most locations in Canada is set at the mean sea level. For a tidal region this would be the mean tide level. The chart datum is an arbitrary level selected so that most tides never fall below that level or according to the explanation given in the preamble of the 1989 Canadian Tide and Current Tables, it is by international agreement, a plane below which the tide will seldom fall. The Canadian Hydrographic Service has adopted the plane of lowest normal tides as Chart Datum.

At Parson's Pond the chart datum is 2.83 m and at Cox's Cove/Lark Harbour it is 2.55 m. The respective geodetic levels (mean tide) are 0.94 and 1.52 metres.

The difference between the two levels at Parson's Pond is 1.89 m and at Cox's Cove/Lark Harbour it is 1.03 m. By using linear interpolation with distance along the northwest Newfoundland coast, the difference between the two levels at the entrance into Trout River is 1.07 metres.

Martec Limited gives these levels and associated frequency statistics in its report on Flood Risk Mapping for Cox's Cove (see Table A.10).

The Cox's Cove values were, therefore, adjusted taking into account the estimated variation in maximum tide levels along the coast. The resulting geodetic 20 and 100 year tidal elevations were estimated to be approximately 1.64 and 1.92 m respectively.

APPENDIX F
ICE JAM ANALYSIS

APPENDIX F
ICE JAM ANALYSIS

INTRODUCTION

No records on ice jams, or related discharge or water level conditions, were found for the Trout River or for the Feeder Stream. However, anecdotal information indicated that ice generally melts in place on the Lower Pond and hence does not move into the study area or cause ice jams which could aggravate flooding problems.

On the other hand, blockage of the bridge at crossing Feeder Brook has previously caused flooding of the highway. It is not clear whether this was due to ice jams or accumulation of snow due to road plowing, etc. at this location. Flow relief culverts were subsequently built as discussed in Section 2.0. For the present study, an analysis was undertaken in an attempt to characterize potential ice jam characteristics at this location.

METHODOLOGY

The following calculations were undertaken in an attempt to assess the potential for ice jams on the Feeder Stream:

- discharge and meteorological records were examined for nearby watersheds
- thermal calculations were undertaken to predict river freeze-up dates; the corresponding flow on that date was assumed to represent the breakup discharge
- thermal calculations were undertaken to estimate the date of potential ice disappearance compared to the estimated breakup date
- a joint probability analysis of open water discharge and ice jam discharge conditions was attempted
- hydraulic characteristics of the river channel for Feeder Brook just upstream of the Feeder Brook Bridge were determined to assess the potential for ice jams at this location.

ICE BREAKUP FLOWS

For floodline elevation determinations, one needs to know which annual flows occurred under ice conditions and which occurred during ice-free conditions. These were determined by using the Deer Lake mean daily air temperature reading (average of two readings a day), and determining the intervals in each year when the streams would be ice covered. It is assumed that the air temperatures along the Trout River will be the same as those observed at Deer Lake. It is also assumed that an ice cover will form when an accumulation of -40°C degree days has occurred and thickness of the ice cover on any day can be calculated from the following:

$$t = 0.0342\ \alpha_1 \sqrt{DD} - 0.0342\ \alpha_2 \times DD$$

where α_1 and α_1 empirically represent the various physical and thermal properties of the ice.

α_1 = the coefficient that is applicable during the ice accumulation period and was taken to be 0.45 to represent an average river with snow

α_2 = the coefficient that is applicable during the ice melting period and was taken to be 0.80 to represent a windy lake with no snow

t = ice thickness in metres.

The dates of ice freeze-up and ice melt for each winter were compared with the date of annual maximum flow for the Upper Humber River. The common period of record of both annual maximum flows and air temperatures is 1933 to 1986.

It was generally found that the maximum flow occurred when the stream was ice-free. Therefore, the occurrence of flooding associated with ice jams would occur with flows of a lower magnitude than the design flows for open water conditions.

RESULTS

A reasonable joint probability analysis was not found to be possible. This was likely due to the underlying assumptions and errors in data transfer. For example, the use of Deer Lake temperature data may not be valid. Also, the use of discharge data transferred from the Upper Humber River to the Feeder Stream leads to some error due to the large difference in size of drainage area.

However, the analysis indicated that the maximum flow in the spring generally occurs when the Feeder Stream is ice-free. The analysis also indicated that ice jams on the Feeder Stream would generally not be associated with peak discharge rates in excess of 10-20 m^3/s.

The hydraulic analysis indicated the following velocities and Froude numbers for the indicated discharge rates:

Q m^3/s	V*	Fr*
2	1.17	0.86
5	1.70	1.00
10	2.14	1.01
15	2.42	1.01
20	2.12	1.00

* Location : Feeder Brook upstream of the bridge.

The hydraulic analysis, therefore, confirms a potential for ice jams on the Feeder Stream for all discharge rates up to at least 20 m^3/s.

FLOOD LEVELS ASSOCIATED WITH ICE JAMS

Measurements of ice jam characteristics on the Feeder Brook are not available. However, ice jams are known to have occurred upstream of the bridge. A flow relief channel (4 culverts) was previously constructed for the reach from the highway bridge up to the vicinity of the pump house. The hydraulic analysis confirms the potential for ice jams in the reach.

Therefore, for the purposes of this analysis, ice jam flooding conditions were computed assuming complete blockage (i.e. over 90% blockage) of this reach associated with various ice jam related peak flow conditions, 2, 5, 10, 15 and 20 m^3/s. The flood levels for the 2 m^3/s flow did not exceed the road elevation while levels for all other ice jam conditions exceeded the road elevation (see Table 4.2).

This analysis indicated that ice jam flood conditions are generally expected to be more severe compared to flood conditions related to open water. This was confirmed by observation of ice jam flooding which occurred in January of 1990.

ICE JAM OF JANUARY 1990

A severe ice jam occurred upstream of the Feeder Bridge on Feeder Brook in January of 1990. The four flood relief culverts were almost completely blocked and the channel was blocked upstream of the bridge opening. A photo inventory of the ice and flood conditions is given in the Field Report. The flooding was made worse by snowbanks along the road. Flood relief was provided by excavation of the snowbanks and part of the road deck above the culverts.