Cumming Cockburn Limited
Consulting Engineers and Planners

7157
October 21, 1987

Nottawasaga Valley Conservation Authority
R.R. #1
Angus, Ontario
L0M 1B0

Attention: Mr. D. White
General Manager

Gentlemen:

Re: Pretty River Flood Control Study
Town of Collingwood

We take pleasure in submitting herewith our final report on the above referenced study.

The methodology and main findings of our investigations are discussed herein, along with our recommendations on potential remedial measures.

We appreciate the opportunity to have been of assistance to you on this most interesting assignment.

Yours very truly,

CUMMING COCKBURN LIMITED

H. S. Belore, P. Eng.
Manager, Water Resources Division

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BRP:mb
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THE NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

PRETTY RIVER DYKES

PRELIMINARY ENGINEERING STUDY

TOWN OF COLLINGWOOD

OCTOBER, 1987

Cumming Cockburn Limited
145 Sparks Avenue
Willowdale, Ontario
M2H 2S5

NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

PRETTY RIVER DYKES

PRELIMINARY ENGINEERING STUDY

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1.0 INTRODUCTION

1.1 Purpose and Objectives

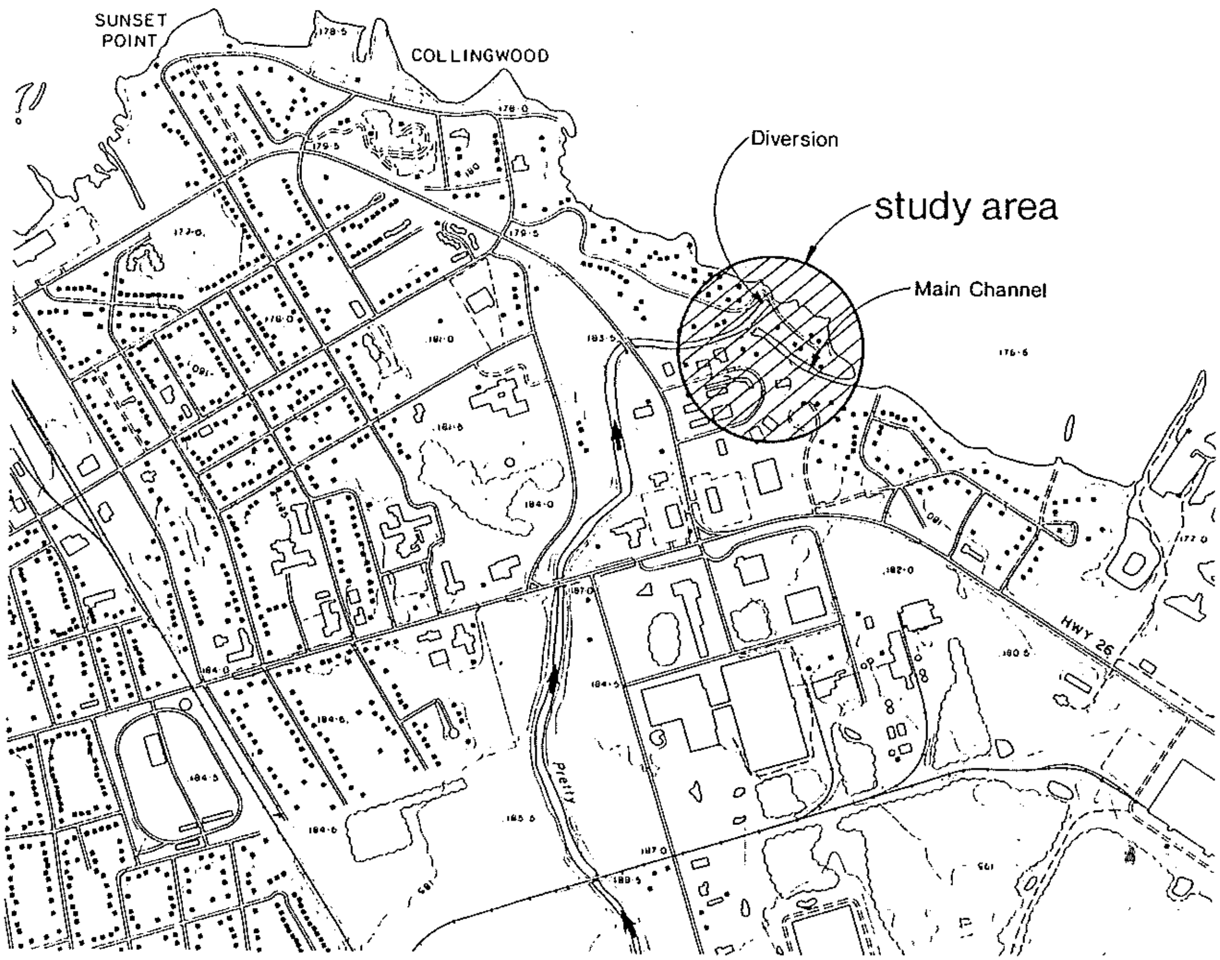
In 1975, a system of dykes was constructed along the entire length of the Pretty River within the Municipal boundaries of the Town of Collingwood. This flood mitigative scheme, designed to handle flows in the order of a Regional Storm event has effectively provided floodproofing protection for the Town. With the recent high lake levels annual nuisance flooding from ice jam occurrences at the outlet have resulted in an expression of concern by the local property owners. The area in question is identified on Figure 1.1.

In recognition of this concern, the Nottawasaga Valley Conservation Authority retained the firm of Cumming Cockburn Limited to undertake a comprehensive assessment of the flooding problems at the outlet of the Pretty River.

The objectives of the proposed investigation were two-fold. Firstly, identify the causative factors and the severity of the flood hazards associated with various design storm and snowmelt/ice jam events for the area located in the immediate vicinity of the Pretty River outlet; secondly, having established the severity of the flood hazard condition which prevails, assess alternative flood mitigative measures (including both structural and non-structural approaches). The detailed Terms of Reference as prepared by the Client are included in Appendix I.

1.2 Study Area

With the construction of a diversion, a small parcel of land located at the outlet of the Pretty River was virtually isolated from the mainland. This property as identified on Figure 1.1 is bounded by the main channel of the Pretty River to the south, the diversion to the west and Nottawasaga Bay to the north and east.



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NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

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TOWN OF COLLINGWOOD

Location Plan

FIGURE **1.1**

Within the subject site, there are fourteen privately owned parcels of land. The dwellings, total seven in number, and include both seasonal and permanent use.

Access to the island is from the northwest via a concrete ford. This ford crosses the Pretty River diversion and represents the only vehicle route to the site.

1.3 Background Review

Background information utilized during the course of this investigation was obtained from two primary sources, namely previous engineering reports and discussions with local residents (six of the fourteen residents were contacted) and Town officials. The latter represented the most fruitful source of information.

In 1975 a system of dykes was constructed along the Pretty River to provide flood proofing protection for the Town of Collingwood. The original Terms of Reference for the design of the dykes called for the north limits of the dykes to end at the junction of the new diversion channel and the original channel at the mouth of the river.

In March, 1973, a report (1) was published which addressed the problem of access to the island. Of the five possible access routes identified in the report and analysed, the two most reasonable solutions were found to be the construction of a low concrete ford spanning the diversion channel and the construction of a completely new access using the east dyke. The first alternative was the scheme selected and constructed.

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(1) Ainley and Associates Limited, Pretty River Flood Relief Project, Report on Access to Island, dated March, 1973

In order to better appreciate the flooding problems which prevail within the study area, discussions were held with local residents and representatives from the Town. Details regarding observed ice formations and behaviour are described in Section 2.0.

Based on this preparatory investigation, the following pertinent items were noted:

1. The high lake levels presently being experienced have had a significant impact on the severity of the flooding condition (magnitude and periodicy) which is being experienced at the outlet of the Pretty River
2. The severity and frequency of the flooding problems experienced by the inhabitants of the island appear to have been aggravated since the construction of the dykes.
3. Flooding has historically been more prevalent during the spring freshet period
4. Access to the island is interrupted during the spring freshet period due to either ice buildup and/or overflow (over the ford).
5. Ice jams occur annually at the outlet of the diversion. These ice jams are considered to be the causative factors for the flooding experienced within the subject site.
6. The hazards which the islanders are being subjected to includes both public safety and property damage.
7. Removal of the snow and ice ridge which forms just offshore has helped to alleviate the flooding problems. The effect of this approach to flood control is dependent on timing.

1.4 Historical Ice Jam Conditions

The evaluation of the Pretty River ice conditions which contribute to ice jamming and subsequent flooding at the river mouth is based on conversations with local residents, representatives from the Town and a written "Damage Analysis Questionnaire" submitted by affected property owners. A sample questionnaire is included in

Appendix V. Photographs were also provided by the Conservation Authority and a local resident. A number of them have been included in Appendix II. No ice monitoring, including timing, buildup and release has been undertaken. During the course of the study (spring, 1987), no ice jams were noted.

In February, 1985, serious flooding occurred to the properties located on the island (land east of the outlet to the Pretty River). Water and ice backed up at the mouth of the river causing spill to occur in an easterly direction along Oliver Crescent. According to a local resident, two to three ice events have occurred in the last 15 years with the worst event occurring in 1985, with water and ice one metre deep being noted on the road. Each year the ice creates a problem of varying magnitude. However, the problem has been the most severe since the lake levels have been high. Before construction of the dykes and concrete ford in 1973, road washouts had occurred.

The ice problem at the outlet appears to be a function of the discharge, ice volume, rate of breakup, the proximity of buildup of shore ice on the lake to the mainland, which is a function of lake level, and the geometry at the outlet, including the dykes.

Based on the data collected as part of the preparatory investigations, it is apparent that a large ridge of ice forms offshore due to ride-up (over-riding), buckling and crushing of the lake ice sheet moving onshore under wind and wave action) and spray due to wave action. Local residents have quite correctly noted that the location (distance offshore) of the ice ridge is a function of lake level. The distance offshore varies from 15 to 60 m. This is due to the relationship between depth and ice thickness which governs the point at which grounding and over-riding of the ice sheet will start. The depth is probably in the range of 0.6 to 1.2 m. The closer the ice ridge is to the shoreline, the greater the probability that an ice jam will occur.

The Town of Collingwood attempts to clear a path for the ice and water through the "berm" of ice each spring. The cost of the program is roughly $2,000/year. The channel is cleared with conventional construction equipment driven out on the ice (see photos in Appendix II). The current program is more of a nuisance than a major expense. If conducted too early, it must be repeated. Flooding can be serious if the program is completed too late. Generally, the ice clearing is started in mid-February, when the weather is monitored for the start of a thaw. There is some danger involved if flows rise during the clearing operation and work must be conducted in 0.3 to 0.6 m of water.

Another characteristic of the ice conditions is the grounded ice sheet between the offshore ridge of ice and the shoreline. The ice sheet is broken and runoff flows over the rafted ice sheet into cracks in the ice cover, and carries out into the lake. Ice floes carried downriver plug the holes in the ice cover and are grounded on the ice sheet, causing the ice and water to back up and turn east along Oliver Crescent. Flows which do not have the force to carry the ice beyond the river mouth are diverted easterly causing more serious flooding to properties along the shoreline.

The rate of breakup and volume of ice are also factors which affect the buildup of ice at the river mouth. For the Pretty River system, the sudden wave of water and ice floes from the upstream area is more than the outlet can handle.

Another factor which affects ice buildup and flooding appears to be the snowbanks which build up along the ford from the snowploughing activity. With this ridge of snow, the momentum of the breakup ice is reduced, creating a backup closer to the river mouth at the end of the dykes. The effect of the ford and concrete sill upstream on ice jam initiation have been questioned by various persons interviewed. Considering the low height of these structures (less than 0.5 m), it is unlikely that, at breakup discharges, they would have a significant effect on ice transport downstream. The backup of ice appears to originate at the offshore ice ridge and the grounded ice sheet. Photographs taken in February 1985 (refer to Appendix II) show broken ice extending to the ice ridge. There was sufficient ice volume and momentum to clear the ford and push out to the ice ridge. There was then sufficient ice volume remaining to cover much of the roadway and spill onto properties flooded by the redirected flow from the river mouth. It should be noted that the flow was contained somewhat by snowbanks along the roadway.

The ice removed by the Town after the flood event was roughly 2 m thick between the river mouth and the ice ridge (the ice ridge was higher - possibly 3 m). The ice was broken into smaller pieces, up to 0.6 m thick and 2 m in diameter and was left grounded on the roadway.

The effect of the culverts and outlet through the original river channel have been investigated. Based on our preparatory investigations, it is apparent that ice hangs up on the culverts and that the capacity of the original outlet channel is much less than the culverts. Photographs confirm some minor accumulation of ice in that channel, backed up from the lake ice cover. No evidence was found indicating that water or ice had travelled over the banks to the adjacent properties. No observations of ice behaviour have been made at the culverts due to the limited time frame of the study. Judging from the ice volume in the original river channel and normal ice behaviour observed on other rivers, it is apparent that with or without modification to the culvert openings, most ice and flow would travel straight downstream along the diversion. With an ice barrier at the mouth, part of the flow and ice might turn through the culverts, providing some flow and ice relief.

TABLE 2.1

Summary of Structure Inventory

Property Owner *		Elevation First Floor (m)	Elevation Ground (m)	Type of Structure
#26	D. Travola and S. Kellow	180.73	179.38	One storey wood structure with basement
#27	R. Gigeroff and M. Ansell	178.73	177.78	One storey wood structure No basement
#29	M. McMahon	178.42	177.94	One storey cottage No basement
#30	D. Burton	178.30	178.02	Two storey, no basement
#25	R. Bainard	178.47	178.49	Two storey, no basement
#31	D. Kitchener	178.61	177.98	One storey cottage No basement
#32	M. Dickson	179.66	178.66	Two storey, no basement

* Refer to Figure 4.6 for location

2.0 FIELD INVESTIGATIONS

2.1 General

Field reconnaissance and topographic surveys were undertaken in order to determine the physiographic characteristics of the main channel and diversion and to facilitate the inventory of flood prone dwellings. This information was used to supplement the available 1:2000 topographic mapping of the area.

2.2 Inventory of Flood Susceptible Structures

As part of the field investigation, a survey of flood susceptible structures was undertaken. The first floor elevation of each potential flood structure was surveyed in order to provide background for potential flood damages in the area, and in order to supplement the existing 1:2000 scale topographic mapping. The results would provide the base reference point for damage assessment on each structure, and to better distinguish the level of flood susceptibility of the existing development within the study area. A summary of the property owners and their first floor elevations and type of structure is given in Table 2.1.

2.3 Inventory of Hydraulic Structures

Under a low flow condition the discharge along the Pretty River is accommodated by the main channel. Three pipe arch culverts convey the flow past the easterly dyke. Under a more severe runoff condition (e.g. annual spring runoff), the flow is split between the main channel and a diversion. A low concrete weir controls somewhat the direction of flow. This diversion becomes active only when the depth of flow in the main channel exceeds approximately 0.8 metres.

At the outlet of the diversion a low head concrete ford was constructed to allow access to the island. Three 0.3 m diameter culverts drain the area between the ford and the upstream weir.

2.4 Flood Damage Assessment

In order to obtain a better appreciation for the damages resulting from a flood event, a damage questionnaire was prepared and submitted to the seven landowners with residential dwellings. Six responses were received from the seven owners who have dwellings on their property.

Results of the damage questionnaire are given in Table 2.2. Identification numbers have been assigned to the questionnaire to retain confidentiality. The estimate of damages that were received from the residents do not appear to be unrealistic when compared to results from previously completed flood damage assessment reports.

Based on the information received, it is apparent that flood damages occur annually. Isolation of the island (vehicle traffic only) from the mainland has also been noted to occur for time periods in the order of 48 hours. The hazard associated with this isolation in addition to that of the ice breakup has raised serious concerns with the local residents.

TABLE 2.2

Inventory of Historic Flooding and Flood Damage Estimates

Identification No.**	Direct Damage Estimates* 0.15 m Flood Depth	Direct Damage Estimates* 0.6 m Flood Depth	Previous Flood Damage Experienced: Direct Damage	Previous Flood Damage Experienced: Indirect Damage	Frequency of Flooding Experienced in Last 5 Years (1981 - 1986)
1	2,000	4,000	Yes	Yes	5 times
2	5,000	10,000	Yes	No	4 "
3	2,000	4,000	Yes	No	Once
4	15,000	25,000	Yes	Yes	5 times
5	N.R.	N.R.	Yes	No	5 "
6	N.R.	N.R.	yes	No	Once

* Damages as estimated by owners related to raw materials, furnishings, finished materials (does not include structural damage)

N.R. - No Response

** For confidentiality assumed identification numbers have been given.

3.0 HYDROTECHNICAL ANALYSES

3.1 Hydrologic Analysis

In order to assess the feasibility of implementing flood damage reduction measures for the study watercourse, a detailed analysis of the peak flow and water level characteristics was undertaken. Specifically, the 1:5, 1:10, 1:20, 1:50 and 1:100 year design and Regional flood events were assessed. This information was used in conjunction with historical storm events on the watercourse to help define the flood hazard characteristics associated with the study area.

The hydrologic analysis completed on the study system involved the application of Regional regression equations previously developed by our firm for the Ministry of Natural Resources. Results of this investigation were then compared to results of a hydrology study presently being completed by the Conservation Authority.

In view of the size of the Pretty River watershed, it was deemed necessary that estimates for the spring runoff conditions be established for the main channel. As streamflow information does not exist on which to complete a statistical analysis, a Regional flood frequency approach was utilized. For this assessment, results from a study completed by Cumming-Cockburn & Associates Limited in 1985 for the Conservation Authorities and Water Management Branch was utilized. The equation considered most applicable for the study area is given as follows:

$$\text{Mean Daily} = -1.7253 + 0.9015 \log DA - 1.4937 \log ACLS + 0.6853 \log MAR$$

$$\text{Maximum Instantaneous} = -1.5012 + 0.8977 \log DA - 2.0254 \log ACLS + 0.8061 \log MAR + 0.1230 \log EQSLP$$

where: log DA = Logarithm of Drainage Area (DA = 76.1 km^2)
log ACLS = Index of area controlled by lakes and swamps (ACLS = 1.107)
log MAR = Index of mean annual runoff at gauge location (mm) expressed in logarithms
log EQSLP = Equivalent channel slope (m/m) expressed in logarithms (EQSLP = 1.438×10^{-2})

Results of the flood frequency analysis are summarized in Table 3.1. A comparison of the flows generated by application of the Regional equation with that from the computer simulations (refer to Table 3.1) indicate that for the more infrequent events, the results were comparable.

As directed by the Conservation Authority, results of the watershed hydrology investigation were utilized in the hydraulic analysis.

3.2 Hydraulic Analysis

3.2.1 Hydraulic Model

The main purpose of the hydraulic analysis is to transform peak discharge estimates into flood profiles along the study reach. This was undertaken by utilizing a mathematical model to simulate water surface profiles corresponding to the 1:5, 1:10, 1:20, 1:50, 1:100 year and Timmins Storm events.

For use in simulating both open-water and ice jam conditions along the study reaches, the HEC-2 model was utilized. It is a well-proven and well-documented non-proprietory technique which is flexible to use and can be applied to evaluate the effects of any potential hydraulic improvements or channelization along the study reaches, etc., as done for the current study.

The program calculates water surface profiles for flow in natural or man-made channels, assuming that such flow is steady and

TABLE 3.1

Comparison of Pretty River Design Flows

Design Flood (yr)	Regional* Analysis (m^3/s)	Computer** Simulation (m^3/s)
1:5	36.2	57.3
1:10	45.6	69.7
1:20	55.1	78.5
1:50	70.9	86.2
1:100	83.9	90.1
Regional Storm (Timmins)	N.C.	227

* Based on application of Regional flood frequency equations

** Taken from Watershed Hydrology Study presently being completed

N.C. Not computed

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.

The model can take into account the following factors:

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

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 culverts.

For commencement of the backwater computations, a mean annual lake level (all years considered) in Georgian Bay of 176.4 m (IGLD) as supplied by Environment Canada was used. The mean for the last ten years would be approximately 0.3 - 0.4 m higher. The assumed starting condition does not, therefore, represent the worst scenario.

3.2.2 Simulations

i) Main Channel

To determine the flow distribution at the confluence of the diversion and main channel, HEC-2 simulations were performed along both conveyance facilities. The estimated flow distribution as summarized in Table 3.2 indicates that for events up to a 1:100 year flood, the split is approximately 45% along the main channel and 55% along the diversion. For the more infrequent events (e.g. Regional Flood), a larger percentage of the flow would be accommodated by the diversion (74%). The 1:100 and 1:10 year floodlines are identified on Figure 3.1.

The capacity of the main channel downstream of the diversion is estimated to be 30 m^3/s which is approximately equal to a 1:10 year event. For flows greater than the 30 m^3/s, sheet flow would occur in a northeasterly direction across the island. The depth of flooding under a 1:100 year event is estimated to be less than 0.4 metres. Upstream of the diversion the main channel (dyked portion) can handle a flow in the order of a Regional Storm event.

The flow distribution calculations are based on the assumption that the flow capacity of the culverts are not affected by any debris blockage (at the twin culverts) or abnormally high lake levels. The existence of either condition would have an impact on the amount of flow being conveyed by the main channel (diversion taking a greater portion of the flow than expected). This would explain why the island has not been experiencing flooding from the main channel on a more frequent basis.

ii) Spill Analysis (at mouth of Diversion)

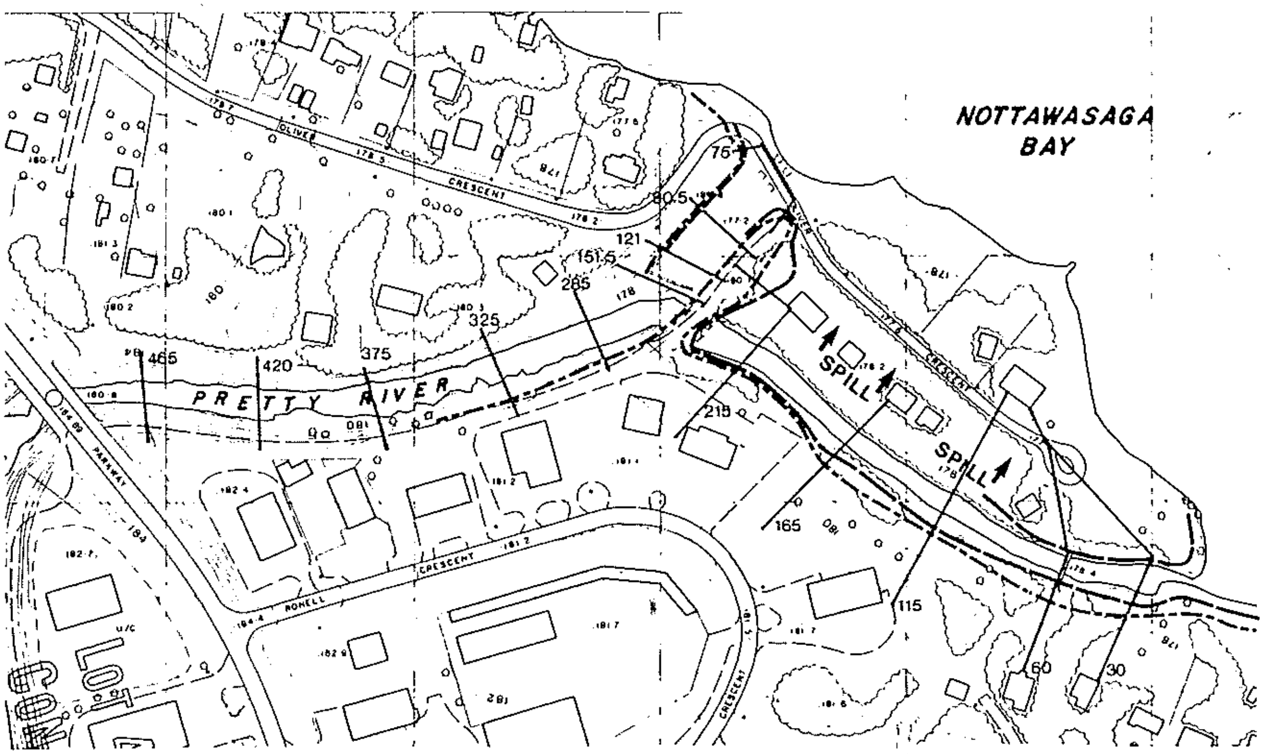
With the northerly limit of the earth dykes being just south of Oliver Crescent, spill occurs in an easterly direction once the concrete ford is overtopped. Although much of the flow spills into

TABLE 3.2

Flow Distribution

Design Flood (Year)	Conveyance Facility: Channel (m^3/s)	Channel (% of Total)	Diversion (m^3/s)	Diversion (% of Total)	Total Flow (m^3/s)
1:5	26.3	46	31	54	57.3
1:10	31.7	45	38	55	69.7
1:20	34.5	45	44	55	78.5
1:50	39.2	45	47	55	86.2
1:100	40.1	45	50	55	90.1
Reg.	59.0	26	168	74	227.0

37.5 62.5



NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

PRETTY RIVER DYKES

TOWN OF COLLINGWOOD

1:10 Year Floodline

1:100 Year Floodline

165 Cross Section Location

Existing Condition Floodlines

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FIGURE 3.1

the bay, a portion of it would flow in a southeasterly direction along Oliver Crescent towards the existing development. Under an open water condition, this sheet flow is not considered to be of significant volume. Under a 1:100 year event the spill depth is estimated to be 0.22 m. The spill flow for this depth is estimated to be in the order of 2 m^3/s. A summary of the computed depths of spill at the crossing under existing open water conditions is given in Table 4.1.

Depending on the type of ice formation which exists at the outlet of the diversion, the spill can increase significantly. The greater the backwater effect from the ice ridge, the greater the spill to the east. With record high lake levels, the ridge has been forming closer inland, thus increasing the frequency and magnitude of the spill occurrences along Oliver Crescent. It should be noted that under a spring melt condition, the spill flow also conveys chunks of ice. As observed, the impact of this ice floe can cause significant damage to anything within its path.

For the hydraulic analysis of an ice related condition a 1.5 metre high ice jam was assumed to occur immediately downstream of the concrete ford (Oliver Crescent crossing). Based on the historic information (i.e. photographs), this is not considered to be an unrealistic assumption. Under this assumed condition, the computed depth of spill along Oliver Crescent increased significantly from that of the open water condition. The depth ranged from 1.57 m for the 1:10 year event to 1.72 m for the 1:100 year event (see Table 4.1). Because of the numerous variables (e.g. ice grounding, size of ice floes, etc.) which exist, the amount of spill can vary significantly at the same depths. An estimate of the volume of spill could, therefore, not be established. A summary of the computed spill depths under the assumed ice jam condition is given in Table 4.1.

It should be noted that if the ice jam height was greater than that assumed (1.5 m), the severity of the flooding condition upstream would be significantly greater than that being assessed. As the depth of the ice jam is based on numerous parameters, including lake level, volume of ice floes, volume of water, etc., a height which is considered average was adopted for the study. The undertaking of a monitoring program is required in order to get a more accurate estimate of the ice jam height.

4.0 IDENTIFICATION AND ASSESSMENT OF ALTERNATIVE FLOOD MITIGATIVE MEASURES

4.1 General

Based on both the historical information (e.g. photos, discussions), and the hydrotechnical analyses (hydrologic, hydraulic), it is evident that the study area is subjected to a flood risk on an almost annual basis. This risk is a result of both the magnitude of runoff from the upstream catchment area and ice conditions which prevail at the outlet of the diversion.

The adoption of either a floodplain management policy to control potential future development within the area, or the implementation of a structural remedial works scheme for flood control should, therefore, be given serious consideration.

Results of the hydrotechnical analyses indicated that a high flood potential exists along the study reach for spring runoff events. Backwater computations indicate that the island is flood susceptible for runoff events equal to or greater than the 1:10 year event. Although the diversion was found to handle a large percentage of the flow, the capacity of the three pipe arch culverts that convey the flow beneath the earth dyke exceeds that of the channel downstream.

In addition to a high potential for flooding from peak outflows, historic information confirms that a high hazard exists also during the spring freshet period from ice jam conditions. The mechanics of the ice jams at the diversion outlet are described in Section 1.4. The end result is a severe flooding condition. As a result of the above, all remedial work considered for the study reach should be designed to maximize the conveyance capacity of the main system and diversion while minimizing future ice jam occurrences.

For the study reach, a number of alternative approaches for flood control and ice manaagement were considered with focus on the above factors. These included; structural measures to modify the existing configuration (e.g. geometry, gradient, dyking, diversion) of the outlet including both the main channel and diversion.

When considering structural preventative measures for ice and flood control, two alternative approaches exist. The first method considered involves an improvement to the conveyance capacity of the channel and its floodplain by eliminating or reducing possible causes for ice jam occurrences (e.g. culverts, lake effects) and/or the severity of the flooding through the construction of floodproofing measures (e.g. dykes). Based on a preliminary review of possible alternatives, this approach was considered worthy of a further analysis. The second method is to reduce the total volume of water and/or ice floes generated from the upstream catchment area by the construction of storage facilities (e.g. flood flow reduction and ice retention facilities). Based on a review of the upstream conditions, this approach was not considered feasible.

In addition to structural measures for flood control, non-structural measures were also considered. They involved the implementation of a snow and ice removal program.

The following sections of this chapter provide a descriptive assessment of the schemes considered for the study area. The methods of controlling both magnitude of runoff (open water conditions) and ice jam occurrences are described separately.

4.2 Flood Control (Open Water Condition)

At the present time, the Pretty River main channel downstream of the diversion can handle flows in the order of 30 m^3/s which is approximately a 1:8 year event. When this flow is exceeded, spill occurs over the northerly channel bank. Upstream of the diversion the river system can handle a Regional Storm event.

To provide flood proofing protection for an open water condition, the following schemes were assessed:

Scheme 1 - Construction of dykes
Scheme 2 - Flow constrictions

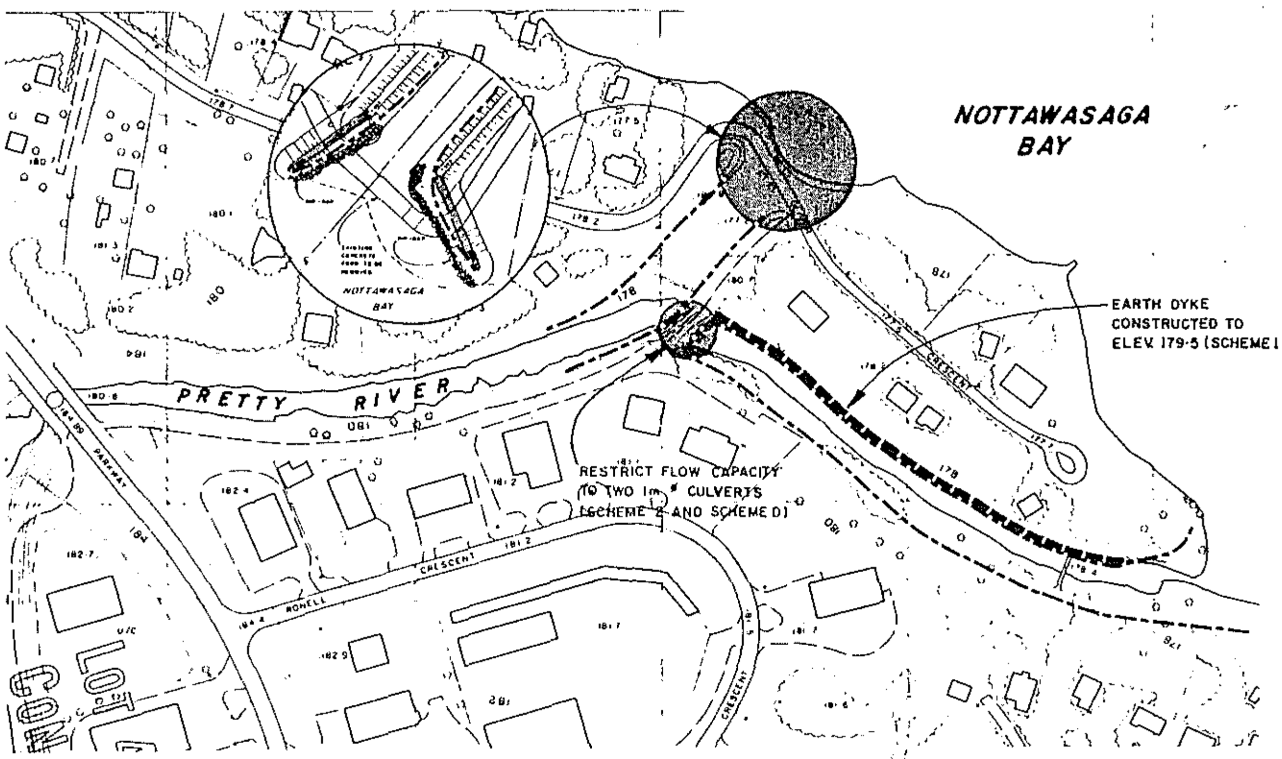
The following provides a brief description of each:

i) Scheme 1 - Construction of Dykes at Ford

In order to prevent spill from occurring along both the main channel and the diversion, construction of a system of earth dykes (see Figure 4.1) was considered. To contain the flow along the main channel, a 1.3 m high earth dyke paralleling the north shore is required. This dyke which would have a one metre top width and 3:1 side slopes would require a 9 metre easement. It would appear that sufficient lands exist to accommodate the structure. It would, however, have an impact on the size of the rear yards which back onto the Pretty River. To prevent spill from occurring at the concrete ford (Oliver Crescent crossing), extension of the existing dykes is required. Details of the outlet works as given in Figure 4.1 include extension of the existing dykes to the lake at an elevation of 178.80 m (0.5 m above existing). The effectiveness of this scheme as summarized in Table 4.1 is to provide floodproofing protection for all open water events up to and including the 1:100 year event. When considering ice related flooding, the level of protection would be less than a 1:10 year event.

ii) Scheme 2 - Flow Constriction

This scheme is similar to that of Scheme 1 and would yield comparable results in terms of flood proofing protection. With this scheme, one of the existing three culverts (refer to Figure 4.1 for location) would be blocked. This would limit the flows along the main channel to its bankfull capacity (30 m^3/s). With this scheme 1:100 year protection would be provided. The revised flows along



1:100 Year Floodline

NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

PRETTY RIVER DYKES

PRELIMINARY ENGINEERING STUDY

TOWN OF COLLINGWOOD

Flood Control Schemes
Schemes 1 & 2

FIGURE **4.1**

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*Athol Dickson * 180.94 with berm
** 181.43

TABLE 4.1

Spill Analysis

Oliver Crescent

Condition	Elevation Containing Height of Land (m)	Flow Condition	Regional Flood Elev. (m)	Regional Depth of Spill (m)	1:100 Yr. Flood Elev. (m)	1:100 Yr. Depth of Spill (m)	1:50 Yr. Flood Elev. (m)	1:50 Yr. Depth of Spill (m)	1:10 Yr. Flood Elev. (m)	1:10 Yr. Depth of Spill (m)
Existing	178.33	Open Water	179.48	1.15	178.55	0.22	178.53	0.20	178.45	0.12
	178.33	Ice Jam	181.20	2.87	180.05	1.72	180.02	1.69	179.90	1.57
Scheme 1 & 2	178.80	Open Water	179.43	0.23	178.52	Nil	178.49	Nil	178.42	Nil
	178.80	Ice Jam	181.13	1.93	180.08	0.88	180.05	0.85	179.95	0.75
Scheme A	179.20	Open Water	179.43	0.23	178.52	Nil	178.49	Nil	178.42	Nil
	179.20	Ice Jam	181.13	1.93	180.08	0.88	180.05	0.85	179.95	0.75
Scheme B	179.80	Open Water	179.17	Nil	178.41	Nil	178.39	Nil	178.33	Nil
	179.80	Ice Jam	180.87	1.07	179.97	0.17	179.93	0.13	179.85	0.05
Scheme C	179.20	Open Water	179.23	0.03	178.47	Nil	178.45	Nil	178.37	Nil
	179.20	Ice Jam	180.93	1.73	180.01	0.81	179.98	0.78	179.89	0.69
Scheme D	180.70	Open Water	178.01	Nil	177.62	Nil	177.62	Nil	177.62	Nil
	180.70	Ice Jams	179.32	Nil	178.72	Nil	178.70	Nil	178.64	Nil

NOTE: 1.5 m Ice Jam Condition assumed at Ford for ice jam simulations the main channel and diversion are summarized in Table 4.2. The 1:100 year flood limit is shown on Figure 4.1. Although this scheme would provide open water flood proofing protection, the protection against ice jam occurrences would be limited to less than a 1:10 year event.

Based on the HEC-2 simulation, there would be no significant increase in the flood levels upstream of the culvert.

4.3 Ice Management

4.3.1 General

The ice management problem experienced on the Pretty River is associated with the location and volume of ice jamming at its mouth. For ice control, there are numerous methods which can be considered. A list of the possible schemes is given in Table 4.3.

The ice jam problem at the river mouth can be approached in two ways:

1. Retain or delay ice movement to the river mouth by ice control structures, ice booms, etc. at upstream locations
2. Improve the river channel at the mouth to lower water levels and/or move the ice jams further offshore.

Design of an ice control zone or structure at an upstream location would involve considerable construction expense and field and analytical studies to select a suitable location. Experience on other rivers eliminates ice control zones, dams or weirs to control flow and/or ice at upstream locations. Ice booms without a weir or channel obstructions would not be successful in steep upstream reaches as that characteristic of the Pretty River. The remaining structural measures to be considered are:

- channelization

TABLE 4.2

Scheme 2 - Flood Control

Summary of Flow Distribution

Design Storm (yr)	Main Channel (m^3/s)	Diversion (m^3/s)	Total (m^3/s)
1:5	17.5	39.8	57.3
1:10	21.1	48.6	69.7
1:20	24.0	56.0	80.6
1:50	26.1	60.1	86.2
1:100	26.8	63.3	90.1
Regional	42.0	154.0	196.0

10 / Reg. 1:1.99.

20 / Reg 1:1.75

10' 1100 1:1.27

20' 1100 1: 1.11

TABLE 4.3

Summary of Ice Control Measures

Ice Control at Freeze-up: 3.1.1 Structural	Ice Control at Freeze-up: 3.1.2 Non-Structural	Ice Control at Break-up: 3.1.3 Structural	Ice Control at Break-up: 3.1.4 Non-Structural
Flow Control Dam (large)	Mechanical Ice Removal	Flow Control Dam (large)	Ice Cutting
Ice Control Dam (small)	Flow, Turbulence, Heat Flux Inducers	Ice Control Dam (small)	Blasting
Weirs	Thermal Waste	Weirs	Mechanical ice removal
Ice Booms	Revised Operational Procedures	Ice Booms	Surface Treatment
Channelization	Floodplain Zoning	Channelization	Ice Breaking
Ice/flow Diversion channels, sluices or skimmers	Relocation	Ice/flow Diversion channels, sluices or skimmers	Flow Inducers
Ice Storage Zones		Ice Storage Zones	Thermal Waste
Dykes		Dykes	Revised Operational Procedures
Channel Width Constriction from Shoreline		Channel Width Constriction from Shoreline	Floodplain Zoning
Surface Obstructions		Surface Obstructions	Relocation
Channel Width Constriction in Channel		Channel Width Constriction in Channel	Forecasting
Closure with Border Ice Bridge		Floodproofing	
Expermental Measures:			
Frazil Collector Lines			
Fence Boom			
Floodproofing			

Source: Cumming-Cockburn & Associates Limited (1986)
Ice Jams on Small Rivers - Remedial Measures and Monitoring

- ice/flow diversion channels
- dykes

The following provides a description of the various non-structural and structural schemes assessed:

4.3.2 Non-structural Measures

Of the non-structural measures, the thermal methods (flow inducers, thermal waste surface treatment) are not suitable for removal of the grounded, thick ice ridge being formed at the river mouth. Blasting grounded ice in shallow water is also not effective and is more dangerous than mechanical removal. Similarly, because the depth is limited, ice breaking vessels would have no effect on grounded ice.

Mechanical ice removal to open a path from the shore ice ridge to the ford is considered to be the most effective ice control non-structural measure. The costs based on discussions with representatives from the Town are in the order of $2,000 per year which does not appear to be excessive. This procedure has been adopted by the Town of Collingwood.

Better forecasting of breakup to ensure that the program is complete and conducted under safe conditions is a prerequisite for the effectiveness of this sheme. The Conservation Authority should consider monitoring the date of breakup and relate that to rainfall and degree-days thawing. An early start date might be more expensive if repeated clearing is required, but a conservative approach is preferable. It should be emphasized that it is difficult to predict with a high level of accuracy the timing of ice jam occurrence.

It should be noted that at the time of the original design for the Pretty River diversion, little information was available on ice. This, combined with the unexpected high lake levels, has resulted in a reduction in the floodproofing benefits associated with the diversion scheme. Until other measures are undertaken and their effectiveness confirmed, further development at the outlet of the Pretty River should be postponed.

The optimum non-structural measure would be the outright purchasing of the affected properties. Acquisition of twelve properties would be required in order to remove the flood risk. Although this approach would provide complete protection, it would exhibit a severe disruption to the social community.

4.3.3 Structural Measures

When considering structural preventive measures for ice and flood control, two alternative approaches exist. The first method involves an improvement to the conveyance capacity of the channel and its floodplain, both at its outlet and along its length, by eliminating or reducing possible causes for ice jam occurrences and/or the severity of the flooding through the construction of floodproofing measures (e.g. dykes). The second approach is to reduce the total volume of water and ice floes generated from the upstream catchment area by the construction of storage facilities (e.g. ice booms, flood flow reduction and ice retention facilities). As discussed in Section 4.2, a suitable location for the construction of a detention facility is not available. With much of the length of the Pretty River within the Town of Collingwood being dyked, the structure would have to be located a significant distance upstream of its outlet. Sufficient ice volumes would, therefore, be generated along the downstream reach to cause ice jam occurrences at the outlet. The effectiveness of an upstream ice control structure is therefore limited.

The following describes the alternative structural preventive measures assessed and their associated advantages and disadvantages.

i) Extension of Dykes with Road Realignment

The most obvious method of providing floodproofing protection at the outlet is to extend the existing dykes to the bay. The main problem, however, with this approach is that the only access to the island is via the concrete ford which is located at the outlet. The roadway would, therefore, have to be included as an integral part of the design.

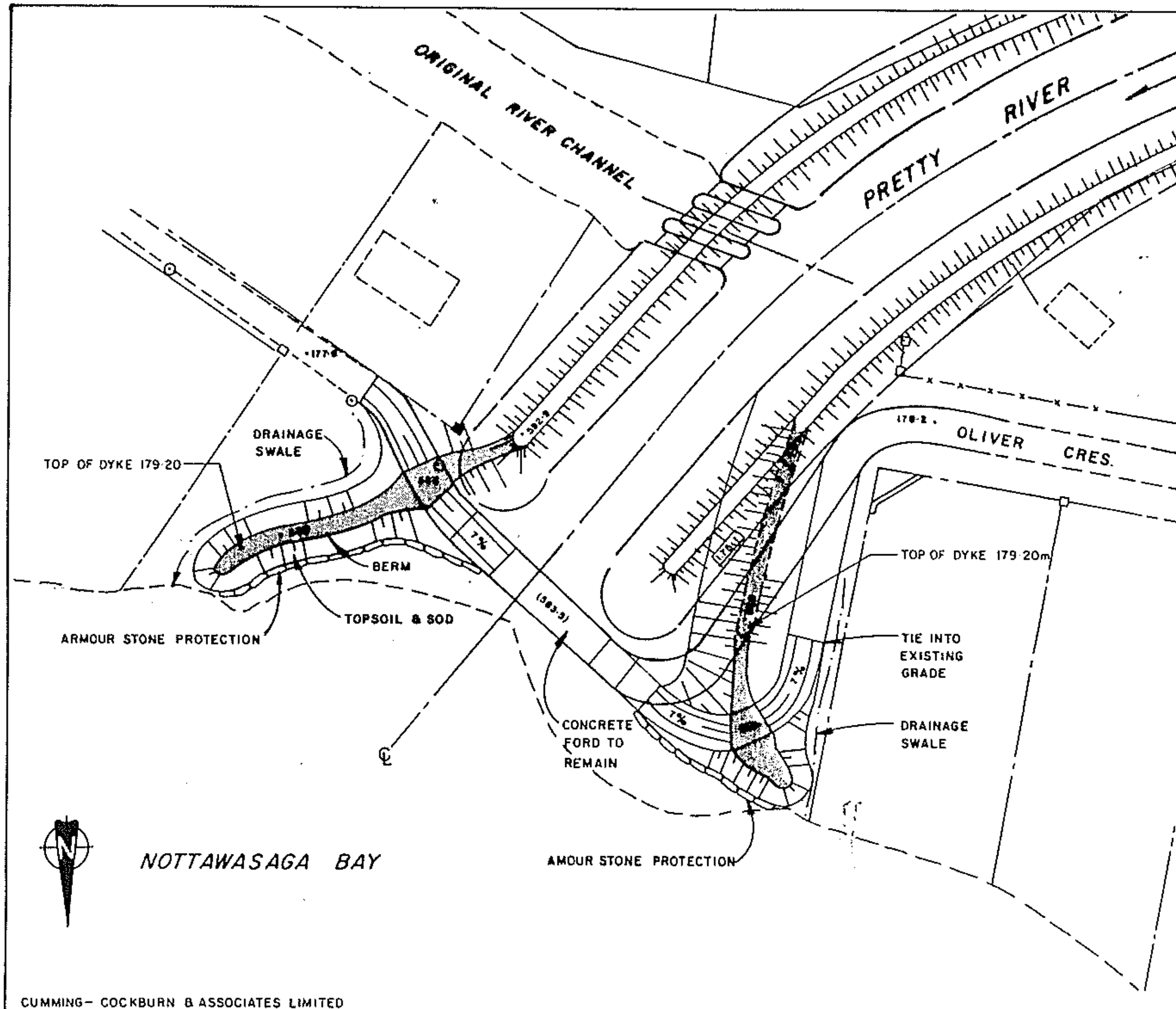
With this scheme there are numerous combinations which could be considered. The most feasible ones are described as follows:

Scheme A : Extension of Dykes with Road Realignment #1

Extension of the dykes to the bay will not only prevent flow from spilling towards the existing development to the southeast but also the ice floes. It would also minimize the impact of snow ploughing activities which leaves a ridge of snow and ice running adjacent and parallel to the concrete ford. The berms would accommodate increased water levels upstream which will help to destroy any sort of barrier created by the snow accumulation.

The maximum allowable height of the dyke is governed by both the land and roadway constraints. As the parcel of land located to the northeast of the ford is owned by the Conservation Authority and that to the northwest by the Town of Collingwood, it would be advantageous for economic reasons to limit the construction activity to these areas only. Scheme A, details of which are shown on Figure 4.2, would utilize the lands presently under public ownership.

Realignment of the northwest dyke would significantly increase the conveyance capacity of the diversion at its outlet and thus help to minimize the impact of any ice jams. (Flow could spill around any ice jams.) The adoption of a design elevation of 179.20 m also allows for mild road grades to be used in the vicinity of the dykes.



NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

PRETTY RIVER DYKES
PRELIMINARY ENGINEERING STUDY

TOWN OF COLLINGWOOD

0 50 100
SCALE IN FEET

Scheme A
Extension of Dykes with Road Realignment #1

FIGURE 4.2

The protection provided by Scheme A as summarized in Table 4.1 is estimated to be 1:100 years for an open water condition and less than a 1:10 year for an ice related event (based on a 1.5 m high ice jam occurring at the outlet.

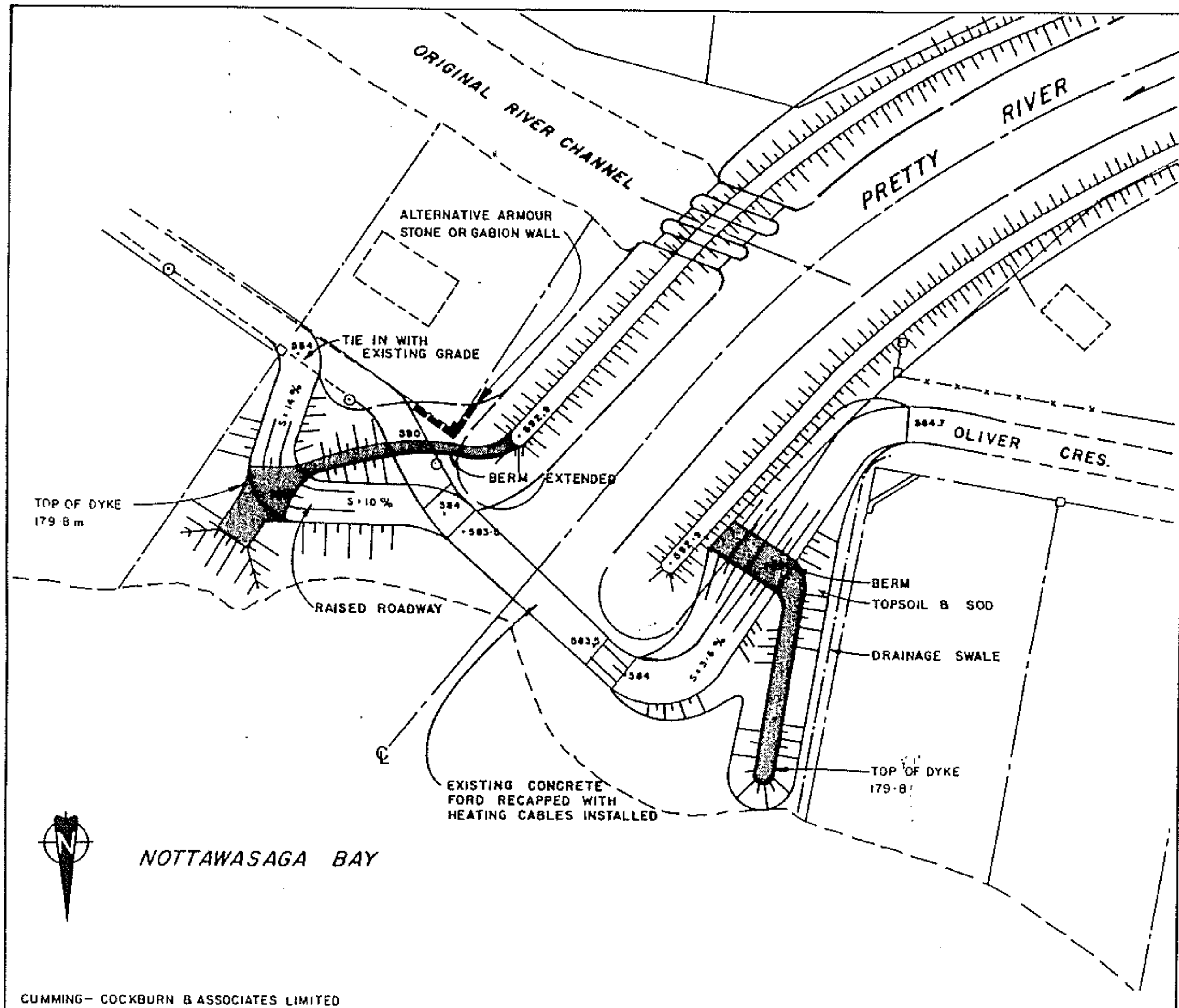
It should be noted that with Scheme A, the concrete ford would still be overtopped under peak runoff periods. Closure of the roadway would be required under the extreme runoff conditions. The existing safety hazards which include possible inaccessibility to the island by either fire trucks or ambulances and safety in vehicle crossing when being overtopped would still exist with this scheme.

From discussions with local residents, it is evident that ice builds up on the concrete ford making it treacherous to cross during the winter months. To reduce this hazard, the installation of heating cables along the concrete ford should be considered. Their installation would, however, have little impact on minimizing ice jam occurrences.

Scheme B : Dyke Extension with Road Realignment #2

In order to improve the level of protection beyond that of Scheme A (1:10 year), the height of the dyke extension would have to be increased. To accommodate any increase, a realignment of the roadway would be required. For Scheme B, which has a top of dyke elevation of 179.80 m (0.6 m higher than Scheme A), the road alignment as shown on Figure 4.3 would be required.

With this scheme the height of the new dyke could be extended to within one metre of the existing one. With this height the level of protection would be in the order of a Regional Storm for an open water condition. Based on an assumed ice jam thickness of 1.5 metres, only minor overtopping would occur for all events up to and including the 1:100 year event with this scheme in place. Of the three dyke extension schemes assessed, this one provides the



NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

PRETTY RIVER DYKES

PRELIMINARY ENGINEERING STUDY

TOWN OF COLLINGWOOD

0 50 100

SCALE IN FEET

Scheme B

Dyke Extension with Road Realignment #2

FIGURE 4.3

greatest protection against both ice jam occurrences and magnitude of flow.

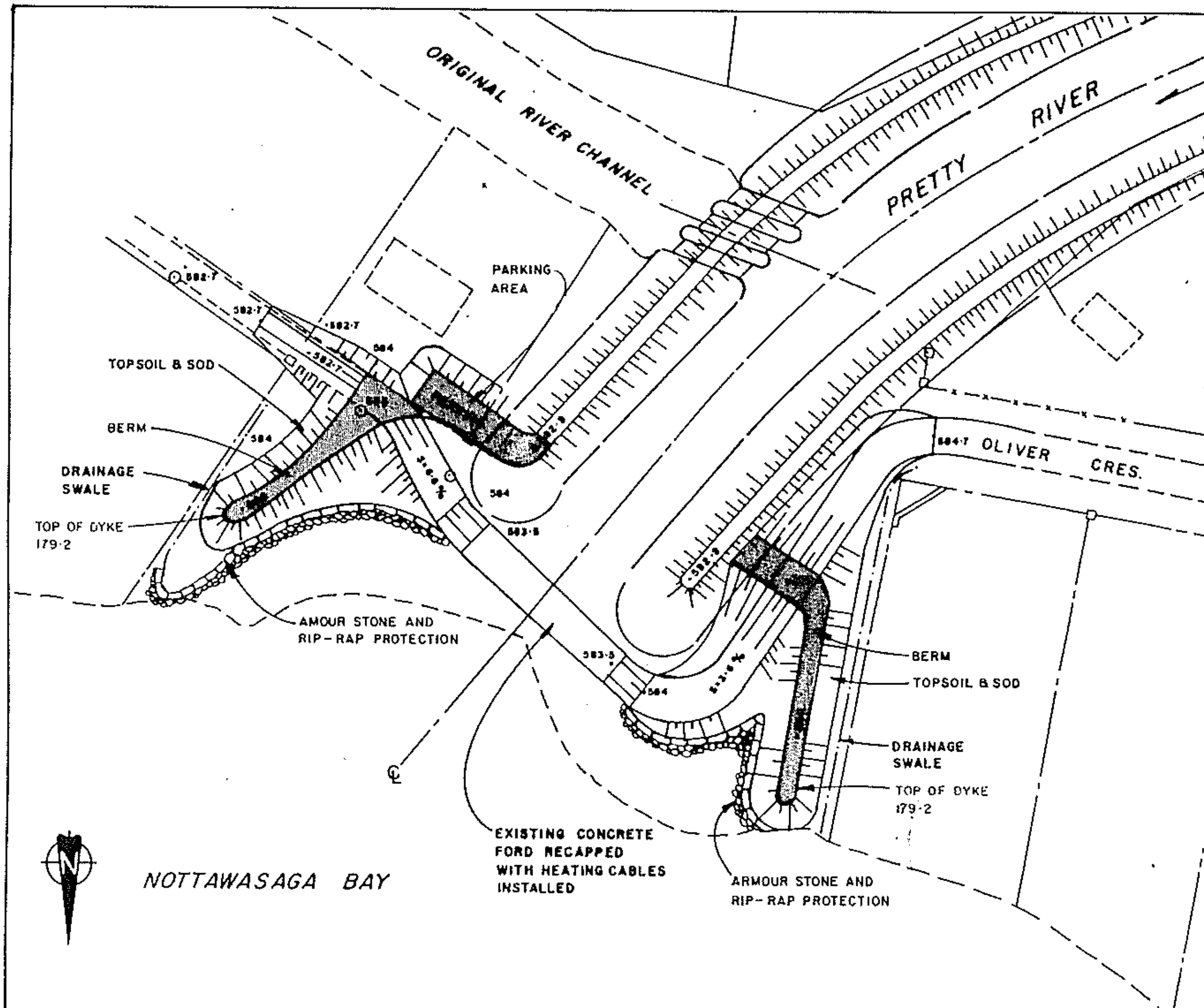
To accommodate the proposed easterly dyke, some property acquisition may be required. It could, however, be minimized by the construction of a low vertical wall either of armour stone or gabion construction (see Figure 4.3). As with Scheme A, access to the island is still via the ford. The safety problems associated with crossing the ford in the springtime would still be prevalent.

Scheme C : Extension of Dykes

Unlike Schemes A and B, this approach to providing flood proofing protection does not require any realignment of the existing roadway. However, to accommodate the increase in roadway elevation, some modifications to the parking facilities for the private property located immediately to the southeast is required. The extent of the modifications are shown on Figure 4.4. As with the other schemes, berming is also required west of the ford.

The height of the proposed berm is 179.2 m. This provides Regional Storm protection under an open water condition. Under an ice jam condition, the level of protection is less than a 1:10 year event (based on the assumed ice jam condition). As with the previous schemes, safety problems associated with crossing the ford during the spring runoff period would still be prevalent.

A benefit of this scheme over that of Scheme A which has an identical top of dyke elevation is that the width of the conveyance channel at the ford crossing is approximately 40% greater. This has resulted in a reduction in the upstream water levels for the design storm events considered.



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PRETTY RIVER DYKES
PRELIMINARY ENGINEERING STUDY

TOWN OF COLLINGWOOD

0 50 100
SCALE IN FEET

Scheme C
Extension of Dykes

FIGURE 4.4

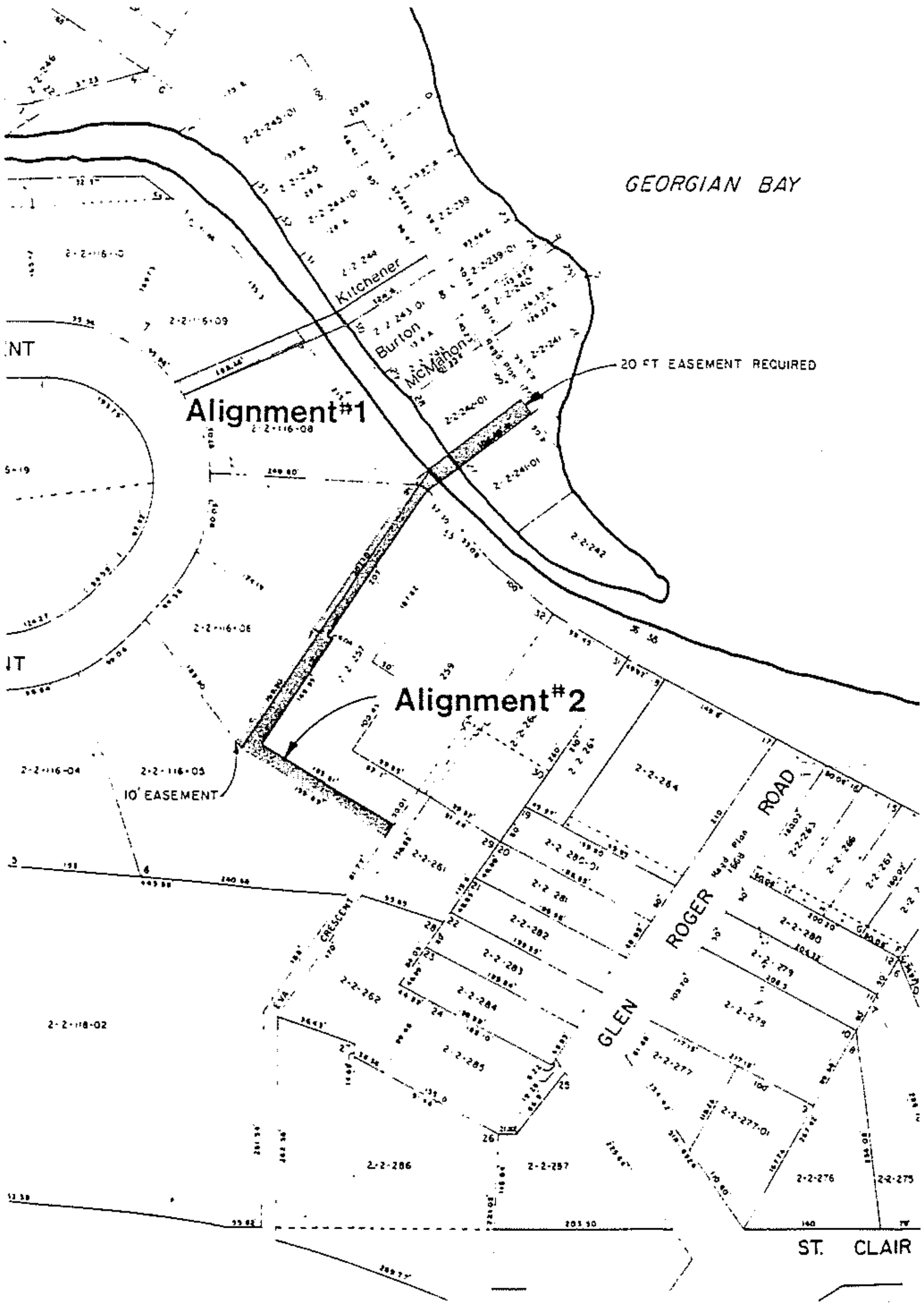
i) Extension of Dykes with New Access (Scheme D)

The major drawback associated with the previous schemes (Schemes A, B and C) is that access to the island whether it be for accommodations or in the event of an emergency (fire, accident, etc.) is restricted to the ford crossing. Although some precautions have been taken to minimize the hazards associated with it, there is no doubt that on occasion, crossing will not be feasible. The alternative is to provide an access to the island which is not influenced to the same degree as the present one.

Two possible access routes have been identified which would yield minimum disruption to the existing development. These routes are identified on Figure 4.5. Both alignments would require the purchase of private property in addition to the construction of a new bridge to cross the main channel.

Alignment No. 1 as shown on Figure 4.5 would connect Oliver Crescent with Ronell Crescent. Property acquisition would be required from two private landowners. The total length of the roadway is approximately 110 m (360 ft). The land required is presently undeveloped.

Alignment No. 2 connects Oliver Crescent with Eva Crescent. Although its length is significantly greater (estimated to be 230 m, 760 ft.), it appears from the property plan that an easement already exists between Eva Crescent and the Pretty River. This easement varies in width from 3 to 5 metres. As this width is not sufficient to accommodate a roadway, the purchase of an additonal three metres along its entire length would be required. A detailed property search is required in order to confirm the ownership of this property. North of the Pretty River a permanent easement would be required from one property owner. The property required for the right-of-way is presently wooded.



Scheme D
Alternative Road
Alignment # 1 & 2

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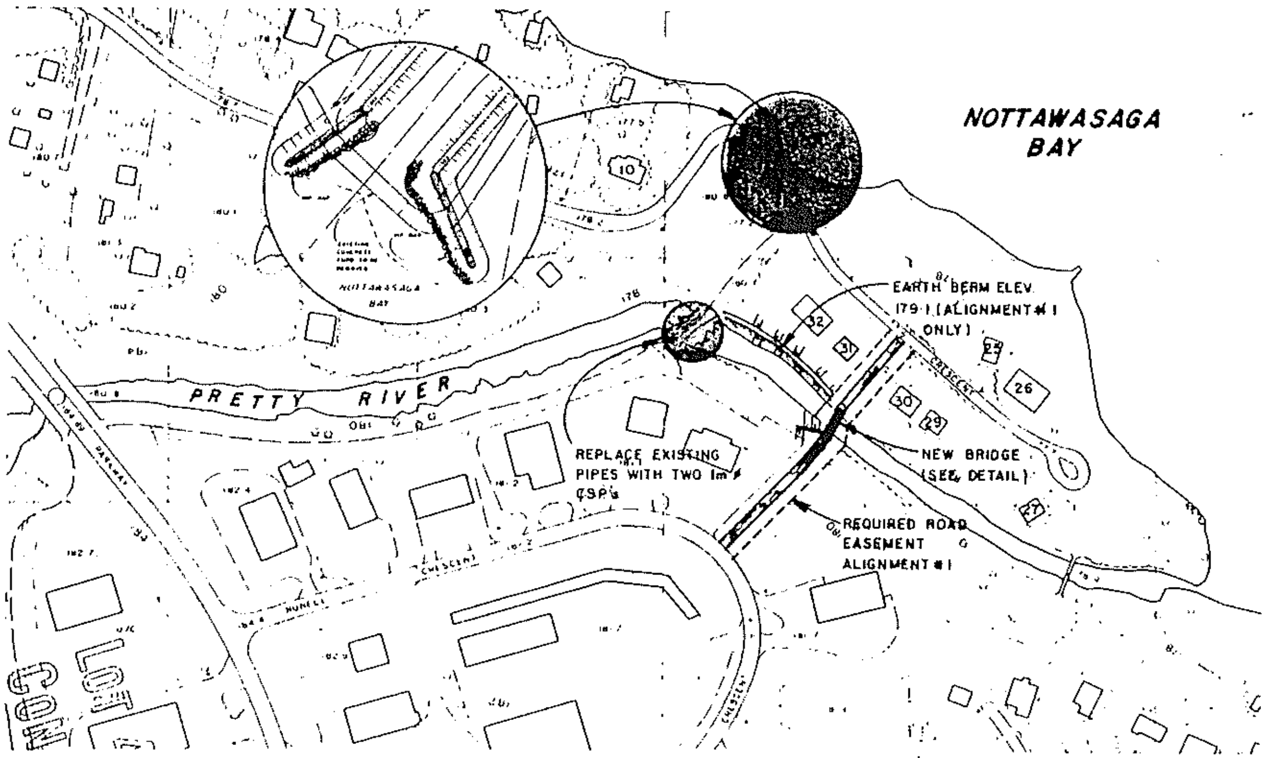
FIGURE **4.5**

To ensure that the flow is directed to the diversion and not to the main channel, the existing three 1.5 m x 2.0 m multiplate pipe arches are to be replaced with two one metre diameter pipes. This would involve capping off one of the three existing pipe arches and the insertion of a one metre pipe in each of the other two culverts. Particular attention would have to be paid to providing the proper seepage barriers. Reducing the effective flow area will also ensure that all ice floes proceed downstream along the diversion.

At the proposed river crossing, four one metre diameter pipes are being proposed. For Alignment No. 1 only, an earth berm set at an elevation of 179.1 m running parallel to the north channel bank is recommended. Its presence would ensure that there is no spill to the north resulting from the new downstream bridge crossing. An earth berm is not required for Alignment No. 2 because of its close proximity to the lake. Any spill at this location would not have a significant impact on the flood hazard.

It should be noted that the proposed crossing for Scheme D may, due to its close proximity to the Lake, be subjected to some siltation problems. Some maintenance would be required.

Removal of the concrete ford and extension of the existing dykes to the bay, as shown on Figure 4.6, would provide flood proofing protection in the order of a Regional Storm for an open water condition and in excess of a 1:100 year event for an ice jam condition. Results of the hydraulic analysis for open water and ice jam occurrences are summarized in Table 4.1. Removal of the ford and consequently the impact of the snow ploughing activity on ice jam conditions will also have a significant impact on ice jam occurrences.



26 HOUSE IDENTIFICATION

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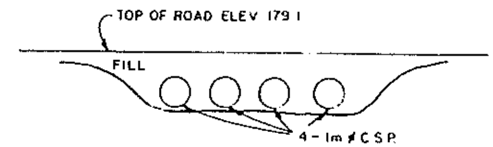
TOWN OF COLLINGWOOD



TYPICAL BRIDGE SECTION DETAIL

Scheme D

Dyke Extension with Alternative Road Alignment No.1

FIGURE 4.6

4.4 Estimated Cost of Remedial Work

Construction cost estimates were determined for each of the selected non-structural and structural flood mitigative measures discussed in Section 4.4. They include:

i) Non-structural
   - Property Acquisition

ii) Structural
   - Scheme A : Extension of Dykes with Road Realignment #1
   - Scheme B : Dyke Extension with Road Realignment #2
   - Scheme C : Extension of Dykes
   - Scheme D : Dyke Extension with New Access

In evaluating the costs, it must be realized that they are engineering estimates based upon a preliminary study of alternatives and the consideration of preliminary engineering concepts. It is felt that the costs as summarized in Table 4.4 are realistic estimates for budgeting purposes and should be reasonable "order of magnitude". It should be noted that the estimated costs include preliminary allowances for land acquisition (should it be required) and engineering design time. Details of the construction costs are given in Appendix III.

It must be noted that land costs can change dramatically. To obtain a more firm estimate of the value of land, it is recommended that an appraiser be retained. The established costs do not include any allowance for demolition.

4.5 Non-structural Measures

At the present time the Town of Collingwood has adopted a work program which involves removal of a portion of the ice ridge that forms just offshore. This allows the outflow from the Pretty River which would include ice floes to escape to the bay without any ice jam occurrences. Although this can be a very effective method of

TABLE 4.4

Summary of Construction Cost Estimates

i)	Non-structural	
	- Property Acquisition	$ 1,100,000
ii)	Structural Mitigative Scheme	
	A. Flood Control	
	Scheme 1 - Dykes along Main Channel	$ 75,825
	Scheme 2 - Flow Constriction and Dyking	56,075
	B. Ice Management	
	Scheme A - Extension of Dykes with Road Realignment #1	$ 98,600
	Scheme B - Dyke Extension with Road Realignment #2	104,625
	Scheme C - Extension of Dykes	106,550
	Scheme D - Dyke Extension with New Access - Alignment #1	168,450
	Scheme D - Dyke Extension with New Access - Alignment #2	176,540

flood and ice control, it is considered to be an interim measure only. Past experience would suggest that although every attempt is made to ensure that the timing for the ice removal is correct, mother nature is not predictable. There will be occasions where sufficient lead time is not available on which to complete the required work. In addition, the uncertainty of lake levels and the potential for strong northwest winds will also have an impact on the effectiveness of this approach.

While in economic terms maintenance of the status quo may prove attractive compared to other schemes, the existing tangible and intangible hazards still remain for any given year. The potential hazard associated with the ford crossing is enhanced by the fact that it represents the only link with the mainland. The estimated cost for the existing plan for flood and ice protection is estimated to be $2,000 yearly. The work is presently being undertaken by Town staff.

It should be noted that the current lake levels are at an all time high. As there is a correlation between the lake level and the probability of ice jam occurrences, the condition presently being experienced represents one of the worst scenarios to date.

5.0 FLOOD DAMAGES AND BENEFIT-COST ANALYSIS

5.1 Flood Damages

5.1.1 Methodology

The basic principle upon which the benefit-cost analyses is based is that damage to an individual structure, group of structures, or floodplain reach can be estimated by evaluating the dollar value of independent damage causing events and by estimating the frequency of each flood depth. For a single known event, the damage caused is estimated directly from a depth (stage)-damage relationship. When it is required to compute the average damage expected in any year, then the damage corresponding to each event is weighted by the percent chance of each event occurring (damage caused by more infrequent events being weighted the least). The sum of the weighted damage represents the expected annual damage.

In the case of flood investigations, the total damage is the expected total economic loss from flooding and ice effects over the subject reach related to the life expectancy of the remedial work scheme. These estimates are based on average annual flood damages discounted over the project life.

The procedure followed for the benefit cost analysis was in accordance with the guidelines for Conservation Authority Flood and Erosion Control Projects. This procedure evaluates not only the monetary benefits and costs, but describes in the best terms possible the intangible benefits and costs.

In order to determine the expected annual damage, the HEC-EAD model was used. The input to the model was in the form of flow-frequency data, stage-flow data and stage-damage curves for each selected reach. The computations are based on a 50 year life expectancy for the remedial work scheme and a discount rate of 7%.

The following briefly outlines the procedure for undertaking the economic analyses:

1. Examine the flood and ice hazards
2. Determine damage categories by land use
3. Identify damage centres in the floodprone area based on the limits and/or degree of potential remedial schemes
4. Select the time horizon based on the life expectancy of the remedial work scheme (50 years)
5. Select an appropriate discount rate (7%)
6. Using the uniform series Present Worth Factor for the interest rate and time horizon selected, prorate the benefits over the project time frame
7. Determine the expected annual damage under existing conditions resulting from the erosion/sedimentation process
8. Discount the total expected annual damage from each flooding over the associated project life of the remedial measure and sum the values. This represents the expected total damage over the project life
9. Repeat steps 4 through 6 for various potential remedial work schemes and subtract the expected total damages for the remedial work scheme from the do-nothing alternative. This gives the expected total benefit over the project life.
10. Compare the benefits with the costs of the capital works. If the ratio of benefit/cost is greater than 1.0, then the scheme is feasible from an economic viewpoint.

As noted in a previous section of this report, to establish the correct floor elevations of all structures located within the Regional Storm floodline, a detailed field topographic survey was completed. Results of this survey (see Table 5.1) would ensure that the correct flood depths were used at each of the structures when determining the expected flood damage. A field reconnaissance survey was also undertaken at which time a detailed documentation of the type of structure (i.e. wood or brick frame, one or two storey, etc.) and its current use (i.e. residential, commercial, etc.) was made.

TABLE 5.1

Summary of Flood Susceptibility

Main Channel Flow

Structure No.*	Basement	Entry Eleva. (m)	1st Floor (m)	Regional Elev. (m)	Regional Flood Depth (m)	1:100 Yr. Elev. (m)	1:100 Yr. Flood Depth (m)	1:50 Yr. Elev. (m)	1:50 Yr. Flood Depth (m)	1:25 Yr. Elev. (m)	1:25 Yr. Flood Depth (m)	1:5 Yr. Elev. (m)	1:5 Yr. Flood Depth (m)
25	No	178.47	178.47	178.48	0.01	178.27	Nil	178.26	Nil	178.19	Nil	178.04	Nil
26	Yes	180.73	180.73	178.48	Nil	178.27	Nil	178.26	Nil	178.19	Nil	178.04	Nil
27	No	178.73	178.73	178.35	Nil	178.01	Nil	178.00	Nil	177.92	Nil	177.74	Nil
29	No	178.42	178.42	178.48	Nil	178.27	Nil	178.26	Nil	178.19	Nil	178.04	Nil
30	No	178.30	178.30	178.69	0.39	178.31	0.04	178.32	0.02	178.28	Nil	178.63	Nil
31	No	178.61	178.61	178.69	0.08	178.34	Nil	178.32	Nil	178.26	Nil	178.13	Nil
32	No	178.66	178.66	179.21	0.55	178.80	0.14	178.78	0.12	178.70	0.04	178.51	Nil

* Refer to Figure 4.6 for location

5.1.2 Damage Assessment

Damages associated with a flooding condition can be classified as being either direct or indirect. Direct damages are damages that result from physical contact with water. They include losses such as physical damage to an existing structure (e.g. building, roadway, etc.) and its contents, if applicable. Indirect flood damages, on the other hand, are costs or losses which are not the result of direct physical contact. They include; disruption of residential living conditions, loss of sales and production to business firms, loss of wages, increased transportation costs and lost travel time, etc. As the ford represents the only access to the island every day of its closure would represent a lost day of wages.

Direct flood damages were determined as physical damages, and where applicable, included estimates of production loss. To estimate the potential damage to a structure and its contents, results from other flood investigations were used. This represents up-to-date damage information and state-of-the-art techniques in estimating flood damages.

While indirect damages which include infrastructures, highways, utilities, employment losses, administrative costs, costs of evacuation, recreation potential, etc. were included, they are difficult to accurately predict. For the purpose of this study, average annual damages were increased by 20 percent to account for the indirect damages. Intangibles, or those desirable benefits to which a dollar value could not be attached are naturally not reflected in the damage computations. These intangibles include:

1. Public Safety
2. Adverse effects on health and feelings of increased social and economic insecurity among floodplain residents.

For the study site, safety is an important issue as the island is virtually isolated from the mainland during a flood event. The problem with ice jams and the sudden release of ice floes towards the existing development (as previously experienced) also represents a major threat to the safety of the residents. Unfortunately, an economic value cannot be assigned to this item.

The damage to which the island is being subjected is a result of not only overtopping from the main channel but the occurrence of a spill condition at the ford crossing. For overtopping of the main channel, the associated damages were based on the computed height of water in relation to the first floor elevation of the structures. A summary of the computed water surface elevations for the various design storm events and the depth of flooding at the existing structures is given in Table 5.1. The estimated damages ranged from approximately $2,000 to $23,600 for the 1:20 and Regional Storm events respectively. The mean annual damage considering open water condition is computed to be $341.

Based on historic information, it is apparent that the above estimate of mean annual damage may be on the low side. The creation of an ice barrier offshore of the ford significantly impacts the quantity of flow being diverted towards the developed portion of the island. As that portion of the flow being diverted is dependant on a number of conditions, including height and strength of barrier, its proximity to the ford, quantity of ice floe and the condition of the ice cover on the bay, a prediction of its impact on the flooding condition being experienced cannot be accurately established. In view of this, a second analysis was completed utilizing the available information on claims made by the local residents. It should be noted that all information used to establish the mean annual flood and ice damages, which were estimated to be $810 per year, was closely screened to confirm its appropriateness. Including the annual cost for ice removal (cost based on discussions with representatives from the Town), the mean annual damage increases to $2,810. Table 5.2 gives a summary of the mean annual damages computed based on the damage questionnaire.

As Schemes B and D yielded the greatest floodproofing protection, it has been assumed that the ice removal program could be terminated. For Floodproofing Schemes 1 and 2, A and C, this assumption was not considered valid. A monitoring program would have to be established after construction to assess their effectiveness. For the benefit cost analysis, it has been assumed that the ice removal program would not be a requirement for either Schemes B or D.

For the purpose of this investigation, and in order to examine the "ultimate benefit" of the proposed remedial scheme in reducing the damages associated with flooding in the study reach, it is assumed that all contributing factors are conducive to the optimum elimination of flooding from both magnitude of flow and ice jam occurrences at the affected sites. Assuming this ultimate scenario in conjunction with the proposed flood mitigative measures, the resultant benefit would be complete protection to the study area.

5.2 Benefit Cost Analysis

Results of the Benefit-Cost analysis as summarized in Table 5.3 indicate that the schemes proposed for flood and ice control yielded the highest benefit cost ratios. The most economically feasible proposal was Scheme B with a ratio of 0.37.

Of the three structural ice management schemes considered (Scheme A, B and C) which were based on extension of dykes and maintenance of the existing access to the island, Scheme B would represent the optimum proposal. It provided the greatest protection against both open water and ice related events.

The ultimate structural proposal for protection of the island is represented by Scheme D. Not only is the island protected to a design condition equivalent to that adopted for the Pretty River

TABLE 5.2

Summary of Mean Annual Damages

Based on Questionnaire

Property Damage	$ 4,800	
Lost Work Time	500	
Clean-up Costs	1,500	
Indirect Damage (20%)	1,360	
Average Annual Damage	810	
Average Cost for Ice Removal	2,000	
Total Average Annual Cost		$ 2,810
Total Benefit (7%, 50 year)		38,780

TABLE 5.3

Results of Benefit Cost Analysis

Mitigative Scheme	Avg. Annual Benefit ($)	Total Benefit ($)	Estimated Construction Cost ($)	B/C Ratio
i) Non-structural				
Property Acquisition	$ 2,810	$38,780	$1,100,000	0.035
ii) Structural				
A. Flood Control*				
Scheme 1 - Dykes along Main Channel	193*	2,664	75,825	0.035
Scheme 2 - Flow Constriction and Dyking	193*	2,664	56,075	0.047
B. Ice Management				
Scheme A - Extension of Dykes with Road Realignment #1	193*	2,664	98,600	0.027
Scheme B - Dyke Extension with Road Realignment #2	2,810**	38,780	104,625	0.37
Scheme C - Extension of Dykes	193*	2,664	106,550	0.025
Scheme D - Dyke Extension with New Access				
- Alignment #1	2,810**	38,780	168,450	0.23
- Alignment #2	2,810**	38,780	176,540	0.22

* Based on open water flood control

** Based on open water and ice control

dyking project, but it also minimizes the hazards associated with access. The benefit cost ratio for this scheme was estimated to be 0.23 (Alignment No. 1).

The non-structural scheme considered, which involved the acquisition of all affected properties, yielded a benefit-cost ratio (B/C = 0.035, much lower than that of the structural alternatives.

5.3 Selected Remedial Works Scheme

As the island residents are being subjected to a hazard from both magnitude of flow and ice jam occurrences, the recommended scheme should address both issues. Of the various structural schemes assessed for ice management, that considered to be the most feasible from an economics viewpoint would be Scheme B with a benefit cost ratio of 0.37.

This scheme, however, would not alleviate the safety hazard which presently exists to the inhabitants of the island nor the problem with access. When taking this into consideration, Scheme D, Alignment No. 1 represented the optimum solution.

The ultimate solution to the problem would be the acquisition of all properties presently being impacted. However, as previously discussed, this scheme would have a significant impact on the social environment.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 General

The analysis undertaken was based on experience in conducting similar flood control studies and involved the application of the most up-to-date state-of-the-art computational methods. Where possible, historic information was used to improve/confirm the accuracy of the evaluations completed. The following points itemize the conclusions and recommendations established based on the comprehensive analyses undertaken.

6.2 Conclusions

1. Construction of the Pretty River dykes has effectively provided the Town of Collingwood with floodproofing protection. However, its construction, combined with the high lake levels, has aggravated the flooding problems which exist at the outlet (study area).

2. In 1973 a study was completed which addressed the issue of access to the island. The report recommended a number of schemes. Construction of a new access, a low concrete ford spanning the diversion channel was undertaken.

3. Frequent ice jam occurrences have been noted to occur at the outlet of the Pretty River diversion.

4. A large ridge of ice forms offshore due to ride-up. The distance offshore varies from 15 to 60 m depending on the lake level. This ridge represents a barrier to both the flow and ice floes. With the recent high lake levels, this ridge has been forming just offshore. This represents a long-term problem as it is uncertain when and how often high lake levels will be experienced.

5. The Town of Collingwood attempts to clear a path at the diversion outlet for the ice and water prior to the spring breakup. The effectiveness of this approach is dependent on the clearing activity being undertaken at the right time. If completed too early it must be repeated, if too late, then it provides little relief. To date this approach to ice management has had some success.

6. Historic documentation indicates that the island has been subjected to a high potential hazard from both magnitude of flow and ice jam occurrences. The most recent event was in the spring of 1985.

7. In addition to the potential economic damage, a high hazard to the safety of the local residents also exists. This hazard is associated with crossing the concrete ford under adverse conditions (e.g. flow overtop, ice covered) and isolation of the island from vehicle traffic for extended periods of time.

8. Because of the low height of the concrete ford, it is not anticipated that its presence has a significant impact on the ice jam occurrences.

9. The existing channel capacity of the Pretty River downstream of the diversion is estimated to be 30 m^3/s (approximately a 1:8 year runoff event). The island is subjected to a flooding condition when this flow is exceeded.

10. The flow capacity of the existing three pipe arch culverts exceed that of the downstream channel.

11. Under existing conditions, the diversion handles approximately 45% of the discharge under a low flow condition. The percentage increases to 75% for the more infrequent events.

12. For flood control (open water condition), Scheme 2 was considered to be the most appropriate structural course of action. It involved closure of one of the pipe arch culverts which traverse the existing earth dyke and extension of the earth dykes to the bay. Details are given in Figure 4.1. The cost for Scheme 2 is estimated to be $56,075. As the island is not being subjected to a significant flood damage under an open water condition, the benefit-cost ratio for this scheme was 0.047.

13. In view of the high potential for ice jam occurrences, it was concluded that an increased level of protection from that of an open water condition was warranted.

14. The optimum structural scheme for ice control, assuming the access route does not change, is Scheme B. The cost of this scheme, details of which are given in Figure 4.3, is estimated to be $104,625 (B/C = 0.37).

15. The optimum structural scheme for safety and flood/ice protection is represented by Scheme D - Alignment #1 (refer to Figure 4.5 for details). The cost for this scheme is estimated to be $168,450 (B/C = 0.23). It should be noted that because of the recent surge in real estate values, the cost of land acquisition should be thoroughly assessed prior to any detailed engineering analysis.

16. The one scheme which would totally resolve the flood hazard problem involves property acquisition. This scheme, however, would exhibit a major disruption to the social environment. The estimated cost for property acquisition is in the order of $1,100,000. Should this scheme be selected as the optimum course of action, it is recommended that a legal appraiser be retained to accurately establish the value of the subject lands.

17. Results of the Benefit Cost Analysis indicate that the established structural schemes are not feasible from an economic viewpoint. The highest B/C ratio was 0.37, associated with Scheme B. However, the analysis completed could not take into account safety and the potential problems if the island is isolated from the mainland (e.g. inaccessibility under a fire or accident situation). This potential problem should be thoroughly considered when weighing the advantages and disadvantages of the various schemes.

6.3 Recommendations

1. Although the island may have always been subjected to a potential flood hazard, the severity of the condition has worsened since the construction of the Pretty River dykes and the high lake levels. It is recommended, therefore, that any program of flood mitigation at the outlet be considered as an extension to the original program.

2. In view of the safety hazards and the protential property damage, it is recommended that either a non-structural or structural flood mitigative scheme be considered.

3. The ultimate solution to the problem is considered to be property acquisition at a total estimated cost of $1,100,000.

4. To provide the island residents with complete damage and hazard protection against ice and flow, Scheme D - Alignment #1 is recommended. As this scheme requires land acquisition, additional research should be completed to determine what implications it may have on the construction works.

5. Due to the rapid changes in real estate values, the cost of property acquisition should be thoroughly researched prior to any final design activities.

6. If a structural scheme is not adopted, it is recommended that the Conservation Authority monitor the effectiveness of dyking and ice clearing with respect to lake levels, rate of thawing, ice jam thickness, ice thickness, rainfall, etc. and re-evaluate the need to clear shore ice and adjust dyke extension levels.

7. It is recommended that the Conservation Authority monitor breakup dates to forecast the ice clearing operation.

8. It is recommended that every attempt be made to ensure that the snow ploughing activities along Oliver Crescent do not have a detrimental impact on the flow of water and ice.

APPENDICES

APPENDIX I

TERMS OF REFERENCE

TERMS OF REFERENCE

MAJOR MAINTENANCE
PRETTY RIVER DYKES - STAGE I
Town of Collingwood

PURPOSE

To provide the necessary engineering services for major maintenance to the Pretty River Dykes and investigate the engineering feasibility of providing flood protection to the properties located immediately east of the relief channel at the mouth of the Pretty River.

STUDY AREA

The study area is located in the Town of Collingwood and the site location is shown as Exhibit "A" to these terms of reference and more particularly described as the Pretty River from the bridge at the Pretty River Parkway to the mouth including those lands located south-east of the relief channel.

BACKGROUND

The Nottawasaga Valley Conservation Authority undertook the dyking of the diversion channel as Stage I of the Pretty River Dyking project in the early seventies. Inspection of the works in this location has revealed that the rip-rap stone is of poor quality and appears to be undersized to the point where the clay core is exposed at some locations.

There is also an erosion problem at the outlet pipes to the old riverbed and scouring of the concrete weir located immediately downstream of the above mentioned culverts.

A concern related to the maintenance works is trees and brush growing on the top and on the slopes of the dyke at various locations. These obstructions will have to be removed as part of major maintenance and the potential impact of the dead root systems on the clay core of the dyke will have to be assessed. It is anticipated that the foregoing be undertaken as phase "B" of the engineering services. The approximate areas of concern are detailed on a site plan of Stage I of the Pretty River Dykes attached as Exhibit "B" to these terms of reference.

.../2

Phase "A" is intended to be an investigation and preliminary engineering of the ice-related flooding problems that occur almost on an annual basis affecting properties immediately to the east of the ford that allows access to these properties over the relief channel.

INFORMATION AVAILABLE

The following represents a listing of data available which are relevant to the site. The listing should not be considered as exhaustive or in any way limit the consultant in obtaining data which may be pertinent to the study from any other source.

1) Engineering Report - Pretty River Dykes, Stage I

2) Construction Drawings - Pretty River Dykes, Stage I

3) Inspection Report - Pretty River Dykes, Stage I (May 1985)

4) Miscellaneous Information on File (N.V.C.A. Office)

PROPOSAL AND AWARD OF CONTRACT

1) Due to the fact that the engineering services required for Phase "A" is somewhat of a complex assignment, a consultants meeting will be scheduled to discuss the consultant's methodolgy to be used, relevant experience, staff commitment, scheduling and cost estimate. A consultant, if selected by the process of the initial meeting will be required to submit a proposal based on the specific terms of reference. The Authority is not necessarily required to award a contract from this procedure. In such an event, the consultant will be advised promptly.

2) The consultant will be required to sign an engineering agreement with the Nottawasaga Valley Conservation Authority. The terms of reference and the consultant's proposal will form part of this agreement.

.../3

SPECIFIC TERMS OF REFERENCE

PHASE A:

1) Review terms of reference and proposed study with N.V.C.A.

2) Review all existing studies, reports, plans, maps, hydrologic and hydraulic data related to the study area.

3) Identify flooding problems by field observation and field surveys if required.

4) Evaluate all site specific observed data such as lake conditions, lake levels, etc.

5) Investigate feasible alternative remedial measures for the control of flooding caused by ice build-up and determine the effectiveness of each alternative.

6) Alternative remedial measures must include but not be limited to the following:

   a) dyking (extension of dyking)
   b) floodproofing
   c) channel improvements
   d) property acquisition, demolition, etc.
   e) ice maintenance program
   f) "do nothing" alternative.

7) Carry out detailed hydrologic calculations for various flood conditions including ice jam to determine the effectiveness of proposed remedial works.

8) Carry out detailed hydraulic calculations for various design storms using the most current version HEC - 2 computer program to determine the effectiveness of remedial measures for ice jam conditions. Hydraulic calculations shall include the determination of ice jam conditions and its effect on flooding.

.../4

9) Contact all property owners in the study area and Officials of the Town of Collingwood to survey their perception of flooding due to ice jams.

10) Evaluate the current program of ice maintenance both at the site and any other areas where similar ice problems exist.

11) The consultant shall evaluate a number of alternative remedial measures upon completion of works included in Items #1 to #10. The consultant shall present to the Conservation Authority the proposed alternative including his recommendation. The presentation shall also include benefit/cost analysis results for each alternative in accordance with the Ministry of Natural Resources Benefit/Cost Analysis Guidelines (November, 1983).

12) Upon receiving initial comments from the Conservation Authority, the Town and the Ministry of Natural Resources, the Consultant shall proceed with the preparation of three copies of a draft Preliminary Engineering Report.

13) The consultant shall maintain regular contact with the Authority during the progress of the study and submit progress reports as required. The consultant shall make allowances for a minimum of four meetings and a formal presentation to the Town of Collingwood and the Authority and a public meeting if required with the landowners.

14) Finalize.the draft report upon formal notice by the N.V.C.A. and submit five (5) copies of the final report.

The Preliminary Engineering Report together with all computer models, originals of all drawings, plans, etc. related to the report shall become the property of the Conservation Authority.

PHASE B: 1) Review terms of reference and proposed study with N.V.C.A.

2) Review all existing studies, reports, plans, maps, hydrologic and hydraulic data related to the study area.

3) The consultant shall identify the existing problems (e.g. erosion, scouring, growth of trees, slope failures, etc.) at the affected areas of the dyke by field observation and field surveys, if required.

4) Based on the most up-to-date field information, provide a base plan with an adequate number of cross sections to properly delineate the study area showing all relevant information such as property boundaries and location of trees and shrubs planted on dykes. The maximum distance between two consecutive cross sections shall not be more than 10 meters.

5) Assess the impact of removal of coniferous trees and shrubs on the clay core of the dyke.

6) Prepare a preliminary design to stabilize the slopes and prevent further erosion of the dykes including preliminary cost estimates, kind and types of material to be used, related environmental concerns, construction problems and access routes.

   The preliminary design report shall address problems related to sediment controls during construction and their satisfactory solutions.

7) Upon approval of the preliminary design report, the consultant shall prepare final drawings, cost estimates etc. and produce a draft tender document for review and approval of the Conservation Authority.

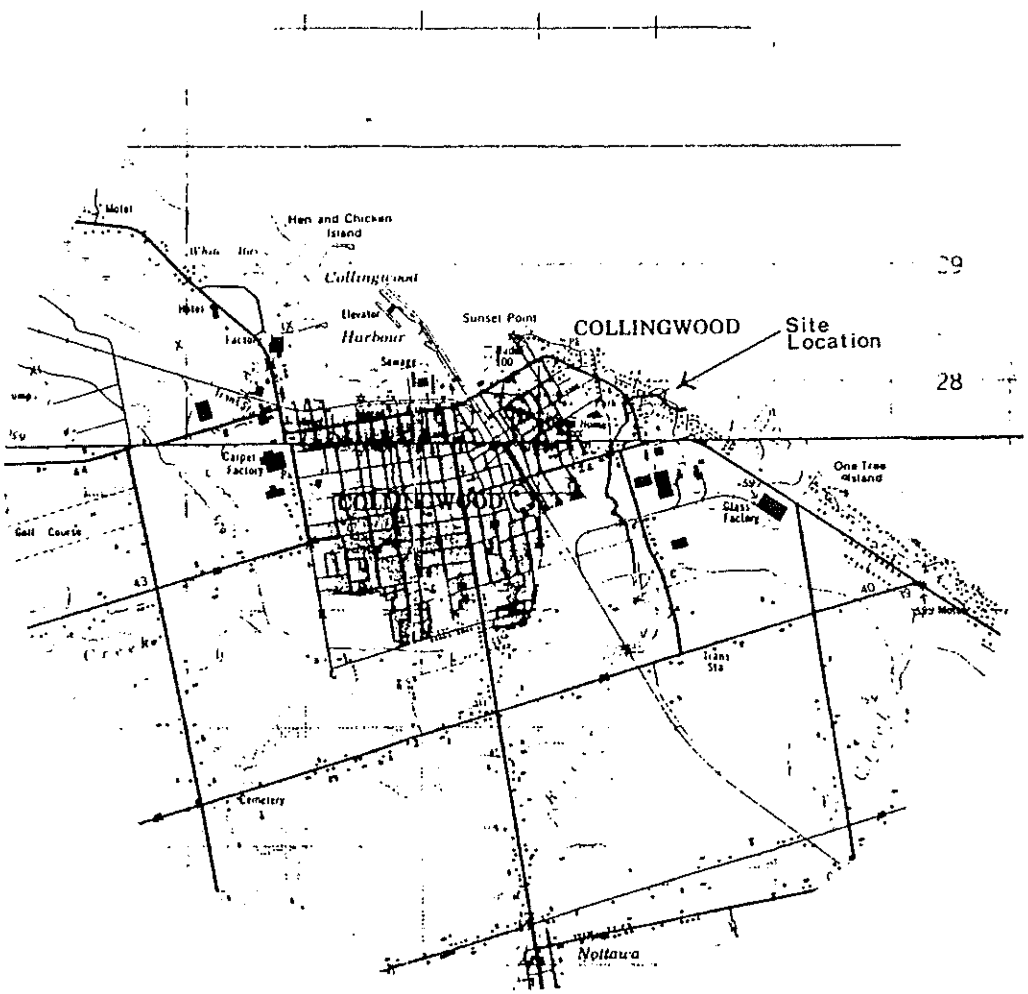
8) Provide for the preparation of tender notice, review and analysis of tenders received including a recommendation for a contractor and preparation of contract documents.

9) Following award of contract, to provide for contract administrration and site supervision during construction.

The contract administration shall include but not be limited to, the following:

- pre-construction site meeting
- site layout
- construction schedule review
- minutes of site meetings
- change/extra work orders preparation
- payment certificates preparation
- inspections: substantial and final stages
- as-constructed drawings and report.

10) The consultant should provide an upset limit which is not to be exceeded without prior written approval of the N.V.C.A. Site supervision cost may be an estimated cost and should be based on actual time spent during construction.



CUMMING-COCKBURN & ASSOCIATES LIMITED

NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

PRETTY RIVER DYKES

PRELIMINARY ENGINEERING STUDY

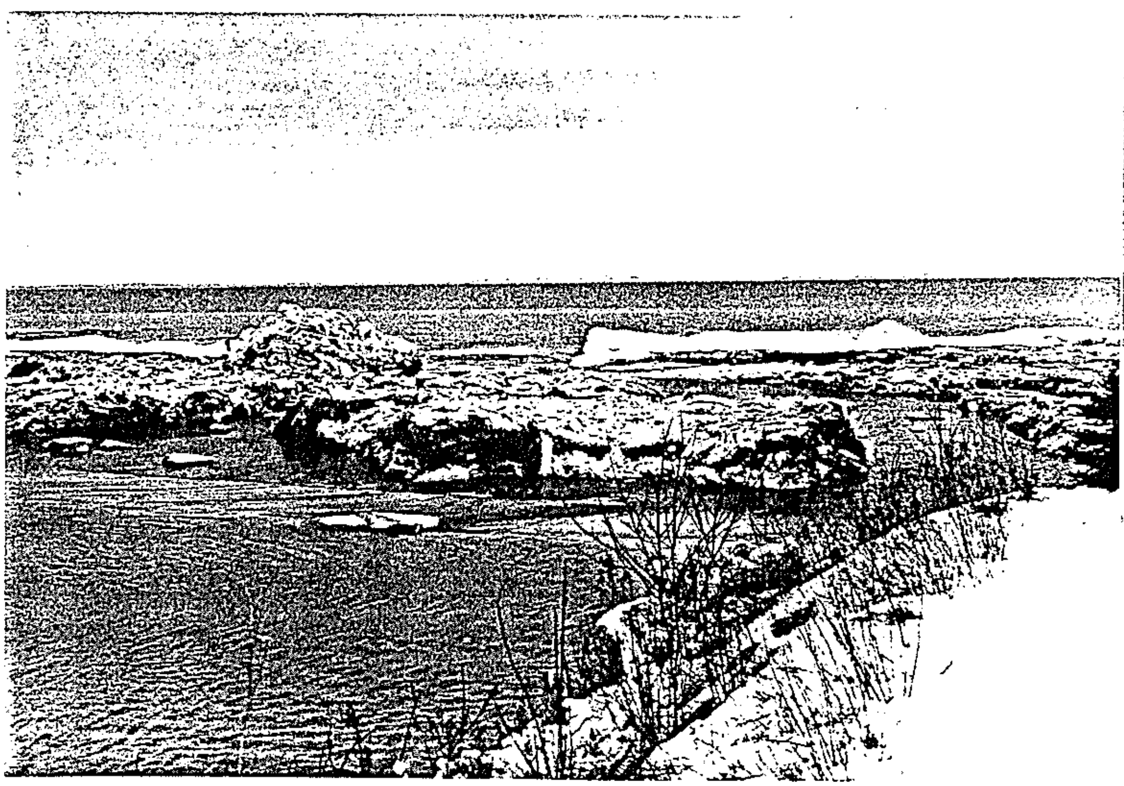
TOWN OF COLLINGWOOD

Exhibit 'A'

Location Plan

APPENDIX II
PHOTOGRAPHIC
DOCUMENTATION

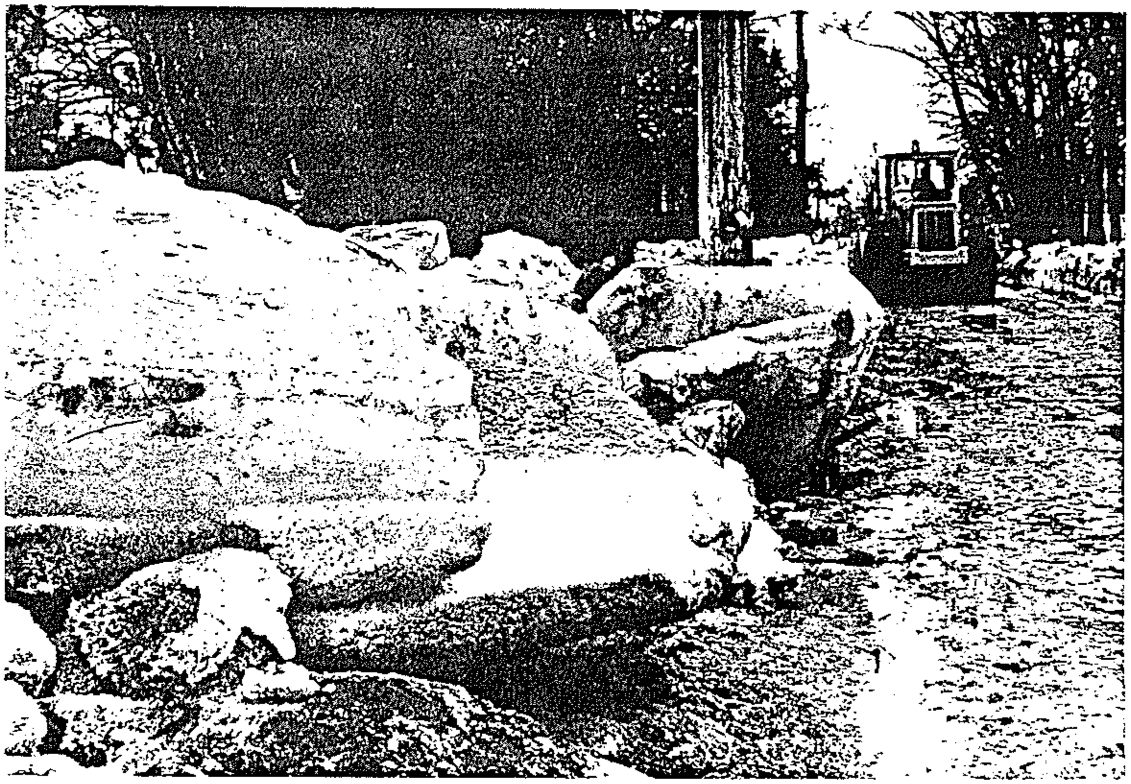
Ice Removal Operation at Outlet



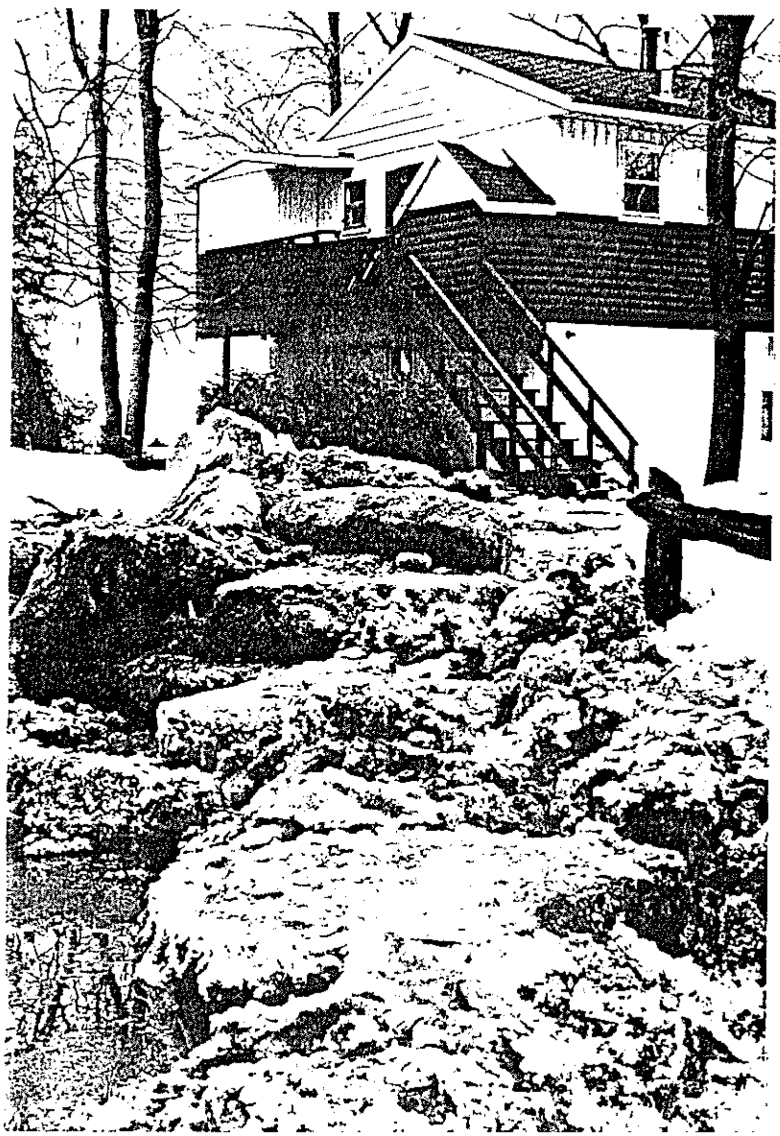
Ice Removal Operation at Outlet

Ice Removal Operation within area of development

View looking east along Oliver Crescent



Grounded Chunk Ice
Oliver Crescent



Grounded Chunk Ice
Encompassing Residential
Dwelling

View of Ford Crossing

View looking downstream towards ford

APPENDIX III
CONSTRUCTION
COST ESTIMATES

CONSTRUCTION COST SUMMARY

SCHEME 1

FLOOD CONTROL

Item	Description	Quantity	Unit Price	Total
1.	Site Preparation and Restoration	L.S.	L.S.	3,000
2.	Supply, Place and Grade required fill material for dyke extension	1300 m^3	$10	13,000
3.	Supply and place rip rap material	58 m^3	$45	2,610
4.	Supply and install filter cloth	130 m^2	$ 3	390
5.	Supply and place topsoil and sod for dyke extension	900 m^2	$ 5.50	4,950
6.	Raise roadway along right and left banks	250 m^3	$12.50	3,125
7.	Supply and place fill material required for earth berm along Pretty River	1500 m^3	$10	15,000
8.	Supply and place topsoil and sod for earth berm along Pretty River	2500 m^2	$ 5.50	13,750
9.	Supply and place armour stone as required	L.S.	L.S.	5,000
	Sub-total			$ 60,825
	Engineering and Contingency			15,000
	TOTAL			$ 75,825

CONSTRUCTION COST SUMMARY

SCHEME 2

FLOOD CONTROL

Item	Description	Quantity	Unit Price	Total
1.	Site Preparation and Restoration	L.S.	L.S.	5,000
2.	Supply, Place and Grade required fill material for dyke extension	1300 m^3	$10	13,000
3.	Supply and place rip rap material	58 m^3	$45	2,610
4.	Supply and install filter cloth	130 m^2	$ 3	390
5.	Supply and place topsoil and sod	900 m^2	$ 5.50	4,950
6.	Raise roadway along right and left banks: i) Granular Fill	250 m^3	$12.50	3,125
7.	Block off one culvert under Pretty River dykes	L.S.		7,000
8.	Supply and place armour stone protection as required	L.S.		5,000
	Sub-total			$ 41,075
	Engineering and Contingency			15,000
	TOTAL			$ 56,075

CONSTRUCTION COST SUMMARY

ICE MANAGEMENT

SCHEME A

Extension of Dykes with Road Realignment #1

Item	Description	Quantity	Unit Price	Total
1.	Site Preparation and Restoration	L.S.	L.S.	3,000
2.	Supply, Place and Grade required fill material for dykes	2300 m^3	$10	23,000
3.	Supply and place rip rap material	220 m^3	$40	8,800
4.	Supply and place topsoil and sod	1000 m^2	$ 5.50	5,500
5.	Raise roadway along right and left banks:			
	i) Granular Fill	496 m^3	$12.50	6,200
	ii) Asphalt	1000 m^2	$16	16,000
6.	Realignment of Oliver Crescent:			
	i) Excavation	140 m^3	$ 8	1,100
	ii) Granular Fill	400 m^3	$12.50	5,000
7.	Supply and place armour stone protection along lakeshore	L.S.		10,000
	Sub-total			$ 78,600
	Engineering and Contingency			20,000
	TOTAL			$ 98,600

CONSTRUCTION COST SUMMARY

ICE MANAGEMENT

SCHEME B

Extension of Dykes and Road Realignment #2

Item	Description	Quantity	Unit Price	Total
1.	Site Preparation and Restoration	L.S.	L.S.	3,000
2.	Supply, Place and Grade required fill material for dykes and raised roadway:			
	i) Left Bank			
	- Earth (clay)	3540 m^3	$10	35,400
	- Granular	950 m^3	$12.50	11,875
	ii) Right Bank			
	- Earth (clay)	550 m^3	$10	5,500
	- Granular	450 m^3	$12.50	5,625
3.	Supply and place topsoil and sod	1750 m^2	$ 5.50	9,625
4.	Rip rap protection	80 m^3	$45	3,600
5.	Supply and place armour stone protection along lakeshore	L.S.	L.S.	10,000
	Sub-total			$ 84,625
	Engineering and Contingency			20,000
	TOTAL			$104.625

CONSTRUCTION COST SUMMARY

ICE MANAGEMENT

SCHEME C

Extension of Dykes

Item	Description	Quantity	Unit Price	Total
1.	Site Preparation and Restoration	L.S.	L.S.	3,000
2.	Modifications to Shoreline:			
	i) Excavation	625 m^3	$ 8	5,000
	ii) Supply and Place filter cloth	165 m^2	$ 3	500
	iii) Supply and Place rip rap material	85 m^3	$40	3,400
	iv) Supply and Place armour stone protection	L.S.	L.S.	8,000
3.	Supply, place and grade fill material (clay) for dykes	2900 m^3	$10	29,000
4.	Supply and place topsoil and sod	1000 m^2	$ 5.50	5,500
5.	Supply and placement of granular fill for parking area	200 m^3	$12.50	2,500
6.	Increase height of roadway east and west of existing dykes			
	i) Granular Fill	980 m^3	$12.50	12,250
	ii) Asphalt	900 m^2	$16	14,400
7.	Block off one culvert under Pretty River dykes	L.S.	L.S.	3,000
	Sub-total			$ 86,550
	Engineering and Contingency			20,000
	TOTAL			$106,550

CONSTRUCTION COST SUMMARY

ICE MANAGEMENT

SCHEME D

Dyke Extension with New Access - Alignment #1

Item	Description	Quantity	Unit Price	Total
1.	Site Preparation and Restoration	L.S.	L.S.	5,000
2.	Removal of Existing Concrete Ford and upstream concrete weir	L.S.	L.S.	8,000
3.	Lengthen existing dykes			
	i) Fill requirements (clay)	2000 m^3	$10	20,000
	ii) Supply and Place filter cloth	650 m^2	$ 3	1,950
	iii) Supply and Place rip rap	340 m^3	$50	17,000
	iv) Topsoil and sod	800 m^2	$ 5.50	4,400
	v) Supply and Place armour stone protection	390 tonne	$40	15,600
4.	Construction of new bridge crossing			
	i) Fill material	275 m^3	$ 8.50	2,300
	ii) Supply and place filter cloth	65 m^2	$ 3	200
	iii) Supply and Place rip rap	80 m^3	$40	3,200
	iv) Supply and Install 4 - 1.0 m Ø CSP's	L.S.	L.S.	9,000
	v) Supply and Place asphalt	150 m^2	$16	2,400
5.	Construction of new access road (Alignment #1)			
	i) Excavation	480 m^3	$10	4,800
	ii) Supply and place granular fill	600 m^2	$12.50	7,500
	iii) Topsoil and sod	400 m^2	$ 5.50	2,200
6.	Construction of earth berm along north river bank (Alignment #1)			
	i) Supply and place fill	450 m^3	$10	4,500
	ii) Supply and place topsoil and sod	800 m^2	$ 5.50	4,400
7.	Supply and place armour stone protection as required along lakeshore	L.S.	L.S.	3,000
8.	Block off culverts under Pretty River dykes and install two 1 m Ø pipes	L.S.	L.S.	8,000
	Sub-total			$123,450
	Engineering and Contingency			25,000
	Land acquisition			20,000
	TOTAL			$168,450

CONSTRUCTION COST SUMMARY

ICE MANAGEMENT

SCHEME D

Dyke Extension with New Access - Alignment #2

Item	Description	Quantity	Unit Price	Total
1.	Site Preparation and Restoration	L.S.	L.S.	5,000
2.	Removal of Existing Concrete Ford and upstream concrete weir	L.S.	L.S.	8,000
3.	Lengthen existing dykes			
	i) Fill requirements (clay)	2000 m^3	$10	20,000
	ii) Supply and Place filter cloth	650 m^2	$ 3	1,950
	iii) Supply and Place rip rap	340 m^3	$50	17,000
	iv) Topsoil and sod	800 m^2	$ 5.50	4,400
	v) Supply and Place armour stone protection	390 tonne	$40	15,600
4.	Construction of new bridge crossing			
	i) Fill material	275 m^3	$ 8.50	2,300
	ii) Supply and place filter cloth	65 m^2	$ 3	200
	iii) Supply and Place rip rap	80 m^3	$40	3,200
	iv) Supply and Install 4 - 1.0 m Ø CSP's	L.S.	L.S.	9,000
	v) Supply and Place asphalt	150 m^2	$16	2,400
5.	Construction of new access road (Alignment #2)			
	i) Excavation	1040 m^3	$10	10,400
	ii) Supply and place granular fill	1300 m^2	$12.50	16,250
	iii) Topsoil and sod	880 m^2	$ 5.50	4,840
6.	Supply and place armour stone protection as required along lakeshore	L.S.	L.S.	3,000
7.	Block off culverts under Pretty River dykes and install two 1 m Ø pipes	L.S.	L.S.	8,000
	Sub-total			$131,540
	Engineering and Contingency			25,000
	Land acquisition			20,000
	TOTAL			$176,540

APPENDIX IV
BENEFIT COST
ANALYSIS

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++++++++++++++++++++++++++++++++++++++++++
+ EXPECTED ANNUAL FLOOD DAMAGE COMPUTATION +
+ 761-X6-L7580              JANUARY 14, 1977 +
+ VERSION DATE              DECEMBER 7, 1978 +
++++++++++++++++++++++++++++++++++++++++++

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
     DEC 1978 - THIS VERSION CORRECTS A FEW ERRORS AND INCLUDES A SUMMARY.
                USERS MANUAL ADDITIONS -
                J1 CARD -
                 6  MDOLYR    +  MONTH AND YEAR OF DOLLARS AFTER THE DG CARDS
                                 HAVE BEEN MULTIPLIED BY THE PRICE LEVEL ADJUST-
                                 MENT FACTOR PLAF (J2.4).  ENTER ORDER NUMBER OF
                                 THE MONTH IN COL 42,43 AND THE YEAR IN COL 45-48.

                J2 CARD -
                 4    PLAF    +  PRICE LEVEL ADJUSTMENT FACTOR.  ALL DAMAGE
                                 DATA ON THE DG CARDS WILL BE MULTIPLIED BY
                                 THIS FACTOR.  MDOLYR (J1.6) MUST BE PROVIDED.

                PP CARD -
                     JDGPR   16  SUPPRESS SUMMARY OF EACH CATEGORY BY REACH
                             32  SUPPRESS GRAND SUMMARY-ALL CATEGORIES BY REACH
                             64  SUPPRESS ALL SUMMARY PRINTOUT

                RV CARD - NOW ACTIVE, BUT NOT FULLY TESTED

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


T1

**DAMAGE CATEGORY NAMES**
CN   1  RESIDNTL

**FLOOD PLAIN MANAGEMENT PLAN NAMES**
PN   1  EXISTING

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

REACH NAME-RN     1 ENTIRE REACH

++++ INPUT DATA ++++

**FREQUENCIES**
FR   1          5   10.00    4.00    2.00    1.00    0.40

**FLOOD STAGES**
SF              1    0.01    0.04    0.12    0.14    0.55

**STAGES FOR DAMAGE DATA**
SD     1        5    0.01    0.04    0.12    0.14    0.55

**FLOOD DAMAGE DATA**
DG   1          1    0.00 1966.00 6762.00 7037.0023612.00

**END OF INPUT DATA FOR PLAN  1 **
EJ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

***DAMAGE DATA FOR PLAN 1 - EXISTING

	FREQ	FLOW	STAGE	RESIDNTL	TOTAL
1	10.00	-1.	0.01	0.00	0.00
2	4.00	-1.	0.04	1966.00	1966.00
3	2.00	-1.	0.12	6762.00	6762.00
4	1.00	-1.	0.14	7037.00	7037.00
5	0.40	-1.	0.55	23612.00	23612.00
EXP ANNUAL DAMAGE				341.29	341.29

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* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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** GRAND SUMMARY BY CATEGORY **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING

GRAND SUMMARY - ALL DAMAGE CATEGORIES

DAMAGE CATEGORY	EXPECTED ANNUAL DAMAGE WITHOUT CONDITION (PLAN 1)
RESIDNTL	341.29
TOTAL	341.29

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END OF RUN

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++++++++++++++++++++++++++++++++++++++++++++
+ EXPECTED ANNUAL FLOOD DAMAGE COMPUTATION +
+ 761-X6-L7580             JANUARY 14, 1977 +
+ VERSION DATE             DECEMBER 7, 1978 +
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+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
     DEC 1978 - THIS VERSION CORRECTS A FEW ERRORS AND INCLUDES A SUMMARY.
                USERS MANUAL ADDITIONS -
                J1 CARD -
                 6  NDOLYR     +  MONTH AND YEAR OF DOLLARS AFTER THE DG CARDS
                                  HAVE BEEN MULTIPLIED BY THE PRICE LEVEL ADJUST-
                                  MENT FACTOR PLAF (J2.4).  ENTER ORDER NUMBER OF
                                  THE MONTH IN COL 42,43 AND THE YEAR IN COL 45-48.

                J2 CARD -
                 4    PLAF     +  PRICE LEVEL ADJUSTMENT FACTOR.  ALL DAMAGE
                                  DATA ON THE DG CARDS WILL BE MULTIPLIED BY
                                  THIS FACTOR.  NDOLYR (J1.6) MUST BE PROVIDED.

                PP CARD -
                     JDGPR    16  SUPPRESS SUMMARY OF EACH CATEGORY BY REACH
                              32  SUPPRESS GRAND SUMMARY-ALL CATEGORIES BY REACH
                              64  SUPPRESS ALL SUMMARY PRINTOUT

                RV CARD - NOW ACTIVE, BUT NOT FULLY TESTED

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TT

**DAMAGE CATEGORY NAMES**
CN   1  RESIDNTL

**FLOOD PLAIN MANAGEMENT PLAN NAMES**
PN   1  EXISTING

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REACH NAME-RN     1 ENTIRE REACH

++++ INPUT DATA ++++

**FREQUENCIES**
FR   1         5   10.00    4.00    2.00    1.00    0.40

**FLOOD STAGES**
SF             1    0.01    0.04    0.12    0.14    0.55

**STAGES FOR DAMAGE DATA**
SD     1       5    0.01    0.04    0.12    0.14    0.55

**FLOOD DAMAGE DATA**
DG   1         1    0.00    0.00    0.00    1.0023612.00

**END OF INPUT DATA FOR PLAN  1 **
EJ+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

++DAMAGE DATA FOR PLAN 1 -- EXISTING

	FREQ	FLOW	STAGE	RESIDNTL	TOTAL
1	10.00	-1.	0.01	0.00	0.00
2	4.00	-1.	0.04	0.00	0.00
3	2.00	-1.	0.12	0.00	0.00
4	1.00	-1.	0.14	1.00	1.00
5	0.40	-1.	0.55	23612.00	23612.00

EXP ANNUAL DAMAGE 148.43 148.43

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* *
 *

** GRAND SUMMARY BY CATEGORY **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING

GRAND SUMMARY - ALL DAMAGE CATEGORIES

DAMAGE CATEGORY	. EXPECTED ANNUAL DAMAGE . WITHOUT CONDITION (PLAN 1)
RESIDNTL	148.43
TOTAL	148.43

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END OF RUN

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+++++++++++++++++++++++++++++++++++++++++++
+ EXPECTED ANNUAL FLOOD DAMAGE COMPUTATION +
+ 761-X6-L7580             JANUARY 14, 1977 +
+ VERSION DATE             DECEMBER 7, 1978 +
+++++++++++++++++++++++++++++++++++++++++++

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
     DEC 1978 - THIS VERSION CORRECTS A FEW ERRORS AND INCLUDES A SUMMARY.
                USERS MANUAL ADDITIONS -
                J1 CARD -
                 6  NDOLYR     +  MONTH AND YEAR OF DOLLARS AFTER THE DG CARDS
                                  HAVE BEEN MULTIPLIED BY THE PRICE LEVEL ADJUST-
                                  MENT FACTOR PLAF (J2.4).  ENTER ORDER NUMBER OF
                                  THE MONTH IN COL 42,43 AND THE YEAR IN COL 45-48.

                J2 CARD -
                 4    PLAF     +  PRICE LEVEL ADJUSTMENT FACTOR.  ALL DAMAGE
                                  DATA ON THE DG CARDS WILL BE MULTIPLIED BY
                                  THIS FACTOR.  NDOLYR (J1.6) MUST BE PROVIDED.

                PP CARD -
                     JDGPR   16  SUPPRESS SUMMARY OF EACH CATEGORY BY REACH
                             32  SUPPRESS GRAND SUMMARY-ALL CATEGORIES BY REACH
                             64  SUPPRESS ALL SUMMARY PRINTOUT

                RV CARD - NOW ACTIVE, BUT NOT FULLY TESTED

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

TT

**DAMAGE CATEGORY NAMES**
CN    1  RESIDNTL

**FLOOD PLAIN MANAGEMENT PLAN NAMES**
PN    1  EXISTING

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REACH NAME-RN      1 ENTIRE REACH

++++ INPUT DATA ++++

**FREQUENCIES**
FR    1          5   10.00     4.00     2.00     1.00     0.40

**FLOOD STAGES**
SF               1     0.01     0.04     0.12     0.14     0.55

**STAGES FOR DAMAGE DATA**
SD     1         5     0.01     0.04     0.12     0.14     0.55

**FLOOD DAMAGE DATA**
DG    1          1     0.00 1966.00 6762.00 7037.0023612.00

**END OF INPUT DATA FOR PLAN  1 **
EJ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

++DAMAGE DATA FOR PLAN 1 -- EXISTING ++

	FREQ	FLOW	STAGE	RESIDNTL	TOTAL
1	10.00	-1.	0.01	0.00	0.00
2	4.00	-1.	0.04	1966.00	1966.00
3	2.00	-1.	0.12	6762.00	6762.00
4	1.00	-1.	0.14	7037.00	7037.00
5	0.40	-1.	0.55	23612.00	23612.00
EXP ANNUAL DAMAGE				341.29	341.29

* *
* *

** GRAND SUMMARY BY CATEGORY **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING

GRAND SUMMARY - ALL DAMAGE CATEGORIES

DAMAGE CATEGORY	. EXPECTED ANNUAL DAMAGE . WITHOUT CONDITION (PLAN 1)
RESIDNTL	341.29
TOTAL	341.29

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END OF RUN

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APPENDIX V

DAMAGE ANALYSIS

QUESTIONNAIRE

PRETTY RIVER
FLOOD CONTROL STUDY

CUMMING-COCKBURN & ASSOCIATES LIMITED

Damage Analysis Questionnaire

GENERAL

1. Name of Owner: ______________________________

2. Name of Respondent: same as above ( ) or ______________________________

3. Address: _________________________

   ____

   ____

   (property located on attached photocopy)

4. Years owned: ___________

5. Number of residents: _____

LAND USE

6. What is the land-use of the property:

   (a) residential _____

   (b) recreational _____

7. Number of buildings on property _________

8.

	Dimension	Description	Condition *	Age
1)	______ x ______	____________________	A B C	______
2)	______ x ______	____________________	A B C	______
3)	______ x ______	____________________	A B C	______
4)	______ x ______	____________________	A B C	______

NOTE: A: Good
B: Fair
C: Poor

9. Description of external construction material:

Building No.
same as above

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

10. Description of interior construction:

Building No.	Floor Material	Wall Material	Condition *
1)	____________	____________	A B C
2)	____________	____________	A B C
3)	____________	____________	A B C
4)	____________	____________	A B C

11. Is there a basement in the building(s)?

Building No.	Finished	Unfinished
1)	______	______
2)	______	______
3)	______	______
4)	______	______

Is the basement damp? ________

Are sump pumps used? ________

Has the basement flooded? _____ How many times? _____ To what depths _____

12. Type of heating for first floor:

Primary Building		Other
Forced air	________	______________
Hot water	________	______________
Electric	________	______________

13. Location of furnace if applicable:

Basement	________
First floor	________

14. Approximate replacement cost of basement contents if flooded:

Depth of Flooding	Items Affected	Total Estimated Damage
1 foot	______________	
	______________	$ ________
2 feet	______________	
	______________	$ ________

15. Approximate replacement cost of first floor contents if flooded:

Depth of Flooding	Items Affected	Total Estimated Damage
6 inches	______________	
	______________	$ ________
2 feet	______________	
	______________	$ ________
4 feet	______________	
	______________	$ ________

Approximate replacement cost of flooded items located outside of the main dwelling (i.e. garage, sheds, etc.):

Items Damaged	Total Estimated Cost
______________________________	
______________________________	$ __________
______________________________	
______________________________	$ __________
______________________________	
______________________________	$ __________

FLOODING HISTORY

16. Has property ever experienced flooding? ______ yes ______ no

17. If yes, how many times (frequency) has flooding occurred? _______

    ____

18. What years did flooding occur? ________________________________

19. Was there any damage due to flooding? ______ yes ______ no

    (If yes, go to question 20, if no, go to question 22)

20. What was the estimated cost of damage and provide a brief description of the damage: $ ____________

    ____

    ____

21. Was a claim filed for the damages? ______ yes ______ no

    If so, what was claimed? $ ____________

    what was paid? $ ____________

    Agency which paid: ________________________

22. Was the flood water: (a) fast flowing __________

(b) ponding __________

23. If flooding occurred, was access to the property cut off? _____ yes _____ no

24. Was work missed due to flooding (i.e. due to cut-off access routes, or time off for clean-up)? ______ yes ______ no

If yes, what is the estimated value of missed work $ ___________

How many hours were missed _________

25. Do you consider the flooding problem a threat to life? _____ yes _____ no

26. Any further comments with respect to flooding and incurred damage:

____

____

____

____

____

____

____