the metropolitan toronto and region conservation authority

Preliminary Engineering Report for Flood Protection on the Duffin Creek in the Pickering Ajax Area

1982

Simcoe
Simcoe Engineering Limited
Consulting Engineers

PRELIMINARY ENGINEERING STUDY

FOR

FLOOD PROTECTION ON THE DUFFIN CREEK

IN THE PICKERING AJAX AREA

FOR THE

METROPOLITAN TORONTO & REGION CONSERVATION AUTHORITY

Prepared by

SIMCOE ENGINEERING LIMITED
Consulting Engineers
Pickering, Ontario

SEPTEMBER, 1982

Letter of Transmittal

Simcoe

82 09 22
RC 262.01

Metropolitan Toronto & Region
Conservation Authority
5 Shoreham Drive
Downsview, Ontario
M3N 2S6

Attention: Mr. J. C. Mather, P. Eng.
Head
Flood Control Section
Water Resources Division

Dear Mr. Mather:

Re: Preliminary Engineering Study
Duffin Creek at Pickering and Ajax

In accordance with your instructions, we are pleased to submit herewith our preliminary engineering study and results of our analysis of flood protection for the Duffin Creek Valley in the Ajax/Pickering area. The major areas considered in this study are as follows:

1. A review of the existing problem, taking into consideration the need for the improvements.

2. The development of flood lines for different return periods for the study area in question, assuming no improvements are made to the area.

3. A review of possible methods of protection that might be undertaken to reduce and/or eliminate the flooding involved.

4. A review of the proposed alternatives considered, taking into consideration the effects of additional stage discharge, environmental concerns, etc.

5. A review of proposed monitoring programs during design, construction and operation of the proposed facility.

6. A financial analysis of the cost of the alternative chosen to determine what level of protection can be economically justifiable.

Simcoe

This report is presented to you in two parts, commencing with the detailed summary, followed by a complete technical report, including all plans, figures, graphs, etc. It is anticipated that the complete document will be useful to the MTRCA and its staff for considering the work proposed and for making representation to the various authorities involved. We have included under separate cover, Appendix 6, which is a photographic display of the potentially flooded properties involved.

Throughout the preparation of this report, we have received excellent co-operation and assistance from the members of your staff, as well as from the Town of Ajax and the Town of Pickering and other municipal bodies.

We trust that this report will provide the MTRCA with the necessary information for it to provide flood protection of the properties in question. We will be pleased to discuss this report with you or your staff in detail, and provide any additional information which might be required.

Yours very truly,

SIMCOE ENGINEERING LIMITED

R. L. Smith, P. Eng.
Project Manager

T. Sloley

Report Summary

PRELIMINARY ENGINEERING REPORT

FOR

FLOOD PROTECTION ON THE DUFFIN CREEK

IN THE PICKERING AJAX AREA

REPORT SUMMARY

General

This preliminary engineering report investigates the possible methods, effects, and costs associated with providing flood protection for the Duffin Creek Damage Centres 2 and 3. There are approximately 110 structures within the limits of these two damage centres. Past experience has indicated that flooding is a common and costly occurrence in this area.

Environmental Considerations

The environmental aspects for this report were investigated by the Metropolitan Toronto and Region Conservation Authority and reported on in "A Biological Inventory with Recommendations for Duffin Creek Flood Damage Centres 2 and 3". The proposed solution has been designed to minimize effects on the existing environment.

Alternatives Considered

Structural and non-structural methods, as well as the 'Do Nothing' option for flood protection, are examined in terms of sound engineering, environmental, social and economic aspects.

Chosen Alternative

A system of two dykes to provide flood protection to the

area under study is the preferred solution. The locations of the proposed dykes are indicated on Drawing No. 1 located in the rear pocket of this report. The first dyke will be constructed in order to protect residential properties east of Duffin Creek, north of Highway 401 on Church Street. It is proposed that this dyke be capable of protection to the 18 per cent risk, or 1 in 500 year flood. The second dyke has been proposed to be constructed in the area north of Highway No. 2, south and west of Duffin Creek and east of Brock Road. The proposed dyke will protect residential and commercial properties in this area to the level of the 1 in 500 year flood.

No dyke has been proposed for the area west of Duffin Creek between Highway 401 and Highway No. 2, since very minimal damage occurs under a 1 in 500 year flood throughout this area.

The height of the proposed dyke located west of Church Street will vary from approximately 1 metre to 2.5 metres, depending on the ground elevation. The top elevation of the dyke will be 82.3 metres.

The maximum height of the dyke north of Highway No. 2 will be approximately 1.3 metres.

Internal Drainage

Internal drainage to the areas enclosed by the dykes will be provided for by culverts equipped with backflow preventers (flap gates). The locations of these drainage facilities are indicated on Drawing No. 1. The gates will have to be periodically inspected to ensure that they are operating satisfactorily.

Estimated Costs

The estimated cost of providing protection up to the 1 in 500 year flood event is only slightly greater than providing protection to the 1 in 150 year event. Protection to the 1 in 150 year flood event is the minimum acceptable level of protection required by the Metropolitan Toronto and Region Conservation Authority.

The estimated cost of the Church Street dyke is $103,700. The estimated cost of the Highway No. 2 to Brock Road dyke is $204,500.

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INTRODUCTION

1.1 PURPOSE OF THE STUDY

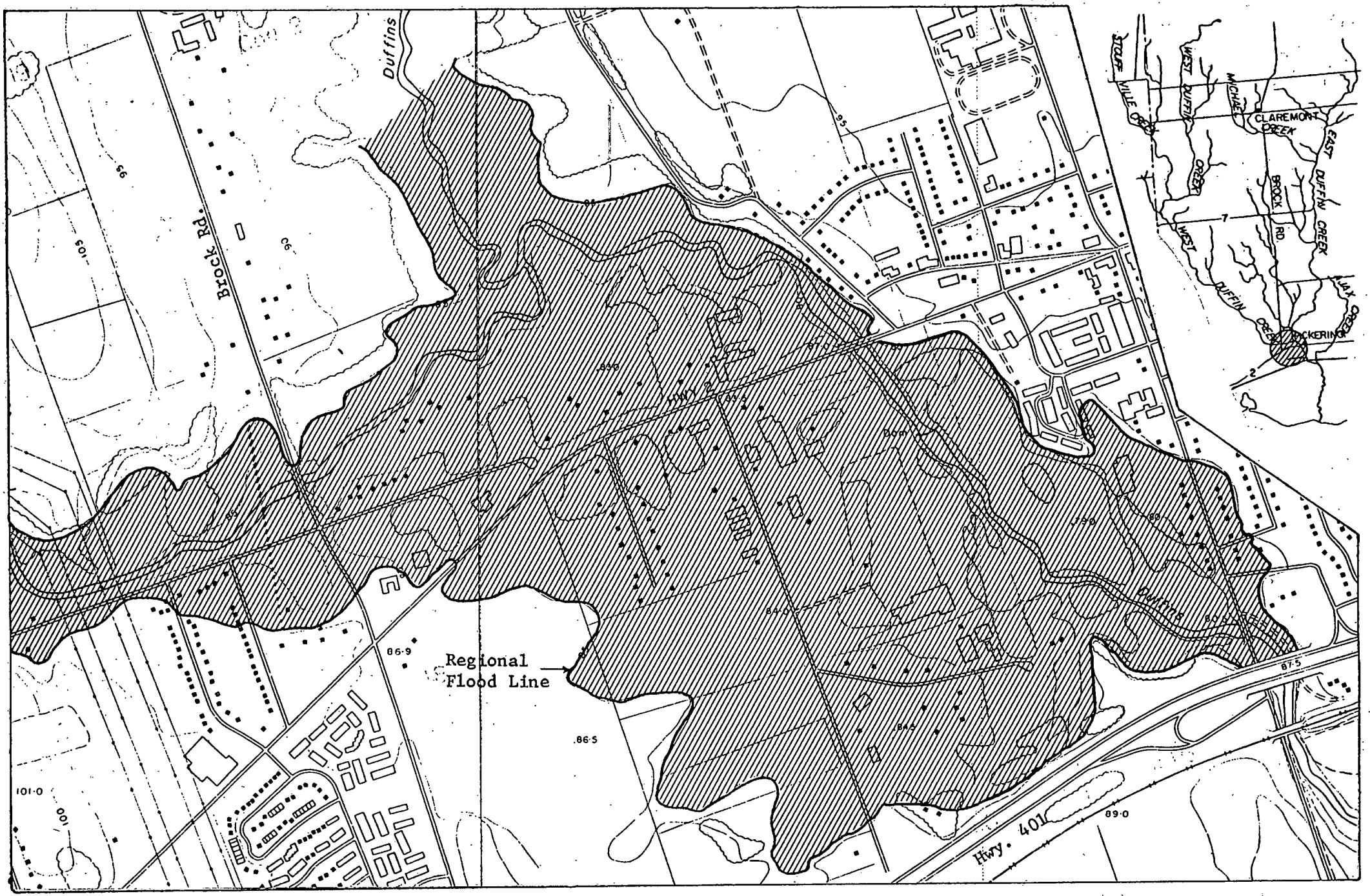
Flooding of existing properties and the potential for hazard to life and property damage have raised concern with the Metropolitan Toronto & Region Conservation Authority, with respect to the Lower Duffin Creek Valley.

The purpose of this assignment is to carry out a preliminary engineering study of the remedial measures for the reduction of flood hazards in localized areas of the Town of Pickering and the Town of Ajax in the Regional Municipality of Durham. This study reviewed various alternative solutions and makes recommendations for the most feasible solution based on sound technical, economic, social and environmental evaluations. These latter environmentally related issues were studied by the Authority's own staff and their findings were provided to the consultant. Reference to "A Biological Inventory with Recommendations for Duffin Creek Flood Damage Centres 2 and 3" should be made for details of these findings.

1.2 THE STUDY AREA

The study area generally can be described as that area within the Duffin Creek flood plain which would be inundated by the Regional Flood*, on the main branch and the west branch from Highway No. 401 in the south to approximately 600 metres west of Brock Road. The total length of the river valley considered is approximately 2500

*The Regional Flood is defined as the flood produced by a Regional Storm which is a specific storm event used for regulatory purposes.



LOCATION OF STUDY AREA

FIGURE 1

meters. The study area straddles the border between the Towns of Pickering and Ajax and is partially within the urban centre known as Pickering Village. Approximately 110 houses and other types of buildings are within the Regional flood plain limits in this area. The study area was identified as the Duffin Creek Damage Site 2 between the Highway No. 401 and Highway No. 2 and Duffin Creek Damage Site 3 north of Highway No. 2 in the MacLaren report entitled "Flood Damage Analysis and Remedial Work Study". Figure 1 indicates the study area and its relative location within the Duffin Creek watershed. On the enclosed Drawing No. 1, we have indicated the overall study area.

1.3 GENERAL DESCRIPTION OF PROPOSED WORKS

The flood control works proposed by the report involve a system of two dykes and drainage culverts equipped with flap gates to prevent reverse flow. The proposed dykes will provide protection within the damage centres up to the 18 per cent risk (500 year return period) flood. One proposed dyke would protect those hazard lands north of Hwy. No. 2 and east of Brock Road, while the other would protect the properties adjacent to Church Street. Proposed outlet culverts would allow natural drainage of the properties. Flap gates located on the river side will not allow reverse flow through the dyke.

1.4 RATIONALE FOR THE WORKS

Flood plain management is the planning and implementation of measures intended to balance the needs of nature for flood water conveyance and flood storage with the demands of the community for use of the valley system. The Authority, through its Flood Control

Program, has implemented a comprehensive flood plain management program including the construction of protective works, the acquisition of flood plain lands, and the application of regulations adopted under Section 27(1) of The Conservation Authorities Act.

The Authority have defined for flood damage centres, on a priority basis, protection that will reduce the risk of flooding to less than 50% over the life (100 years) of the affected structure(s). Protection to a higher level will be provided if economically and/or socially justified.

Within a damage centre, all new structures or buildings must be protected to the degree that the risk of flooding is no higher than that established by policy. As a general guideline, structures or buildings will not be subjected to flooding under the Regional Storm. However, where it is demonstrated that this level of protection is technically not achievable, then as a minimum, structures or buildings will not be subjected to a risk of flooding over their assumed life of 100 years, in excess of 25%. Several flood damage reduction techniques may be applied to achieve this level of risk, including both structural and non-structural measures.

Structural measures include storage, diversions, dykes and floodwalls, channel modifications and bridge and culvert alterations. Non-structural measures include items such as structural removal, flood damage reduction measures, flood warning and forecasting systems, land management, floodplain regulations etc.

It is understood that the Authority's rationale for the undertaking in this particular case, can primarily be considered to protect property against flood damage. Flooding can substantially damage or destroy buildings and their contents. Property owners are

TABLE 1

TOTAL COST VS DEGREE OF FLOOD PROTECTION

LEVEL OF PROTECTION	COST OF ALTERNATIVE ($)
to 49% risk flood	281,400
to 25% risk flood	301,200
to 18% risk flood	308,200

frequently faced with expensive clean-up "costs" in flood prone areas.

On the basis of the Authority's criteria, there is some chance of loss of life in parts of the study area, since in some instances there are depths in excess of one metre. The flood protection work, therefore, would also reduce the potential for loss of life.

All practical alternative solutions to flood control were examined, taking into consideration technical, social, environmental and economical aspects.

The most suitable alternative was one of dyking with backflow prevention devices installed on the drainage culverts. This alternative provides the benefit of minimizing the interference with the hydraulics of the creek during normal flow conditions and consequently does not disturb the aquatic life. The alternative also fits harmoniously into the existing terrestrial environment.

The total cost of protection versus the degree of protection provided for both damage centres is given in Table 1. There is approximately a 10 per cent increase in cost to provide protecion to the 18 per cent risk flood over the 49 per cent risk flood.

1.5 CONDITIONS FOR COMPLIANCE WITH THE ENVIRONMENTAL ASSESSMENT ACT

The proposed flood control works may be subject to the application of the Environmental Assessment Act. This report will be part of the submission to The Ministry of the Environment under the Act and consequently must address the concerns set out in the Act. Environmental considerations have been integrated into the planning

and decision making process throughout the preparation of this report and are also a major component of the recommendations arising from this Study.

2

Study Approach

SECTION 2

STUDY APPROACH

2.1 STUDY PROCESS

To satisfy the objectives of this study in terms of engineering, environment, and economics, a study process was adopted that would address all of the major issues that are significant with respect to development of a practical solution to the flooding problem in the study area.

The approach to the study was as follows:

1. Problem identification and examination.

(a) A Biological Inventory of the site was prepared by the Metropolitan Toronto & Region Conservation Authority.

(b) Information with respect to each property within the particular damage sites was collected to assess the potential damage which could be incurred from flooding.

(c) The existing condition of buildings, floodways, etc. along the course of the Duffin Creek in the two damage centres were, for the most part, documented through the use of photographs.

(d) The physical cross sections as prepared by James F. MacLaren Limited for their report of June, 1980, including major constrictions, such as bridges, were confirmed to ensure that the information utilized for flood plain mapping was adequate.

(e) The existing flood lines as prepared for different return periods by the James F. MacLaren Limited report of June, 1980 were confirmed and analyses of the 50%, 25%, and 18% risk of flooding were performed.

(f) Discussions were held with the local & Regional Municipalities with respect to drainage, road systems and the projected plans for the study area.

2. Identification, evaluation and comparison of alternative solutions

(a) Taking into consideration the local municipalities comments, the environmental inventory and practical approaches to developing alternatives, a number of alternatives were identified.

(b) Evaluation of these alternatives were undertaken to determined the most viable and environmentally acceptable solution.

3. Detailed design of preferred solution

(a) Protection to levels above the 150 year return period were examined for their technical feasibility.

(b) A detail cost/benefit analysis was prepared to determine whether or not levels of protection above the 150 year return period might be economically warranted.

(c) Mitigating measures that would lead to the most effective methods of construction while being least damaging to the existing environment were examined.

4. Documentation for review and approval

(a) This report was prepared documenting the study process, its conditions and recommendations.

2.2 INTERNAL INVOLVEMENT

The study was prepared by Simcoe Engineering Limited with guidance and assistance from the Water Resource Division of the Metropolitan Toronto & Region Conservation Authority. The Flood Control Section of the Division provided information based on their experience with flooding on Duffins Creek as well as elsewhere. Valuable guidance was provided by the Planning and Environmental Section with respect to biological, physical and cultural aspects of the study area.

2.3 EXTERNAL INVOLVEMENT

Other agencies involved in the study included:

The Regional Municipality of Durham in which the Study area is located;

The local Municipalities of Ajax and Pickering works and planning departments;

The Ajax Historical Board.

3

Problem Definition

SECTION 3

PROBLEM DEFINITION

3.1 DESCRIPTION OF THE WATERSHED

The Duffin Creek watershed has a drainage area of approximately 295 square kilometres and is located generally in the Towns/Townships of Pickering, Uxbridge, Whitchurch-Stouffville, Markham and Ajax.

The creek has two main branches; the west branch rises north-east of Stouffville and drains 124 sq. km to the point of confluence with the east branch which rises approximately 2 km north-west of Glen Major in the Oak Ridges Moraine. The two principle branches flow southerly with a slope of 10 m/km on the west branch and between 8 m/km and 4 m/km on the east branch. Downstream of Pickering, the gradient becomes very mild, approximately 1 m/km. The upstream portions of the watershed are characterized by many lakes, depressions and marsh lands. The Village of Goodwood is located at a depression from which flood waters are pumped to the nearby stream for disposal. Soils in this area are highly pervious and a high proportion of the area is wooded; this results in a relatively low flood protential from this area. The soils in the central area of the watershed are less permeable and the topography is flatter and more open with mostly agricultural land use. One notable feature of the Duffin Creek watershed is the high base flow associated with its main branches. A recent study of the ground water resources of the basin indicate that over 60% of the total flow in this stream is derived from ground water. This high base flow component appears to be

TABLE 2

DUFFIN CREEK: LAND USES SUMMARY BY PERCENTAGE OF AREAS

LOCATION	REF. NO.	AREA km^2	PRESENT CONDITION LAND USE CATEGORY			FUTURE CONDITIONS LAND USE CATEGORY		
			RES.	IND.	OPEN	RES.	IND.	OPEN
West Duffin Creek at Pickering	12.1	123.7	2	0	98	10	7	83
East Branch at Pickering	16.4	138.7	2	0	98	13	1	86
Duffin Creek at Lake Ontario	28.4	294.0	3	0	97	17	4	79[1]

1. This includes most of the land use for the proposed new Toronto International Airport. The area covered by terminal buildings, etc. was estimated and treated as industrial. The remainder of runways and airfields were treated as open space.

related to the occurence of high ground water levels in several areas of the basin and with the high percentage of area covered with sand and gravel deposits. Evidence of the latter is found in the many sand and gravel pits operated within the boundaries of this watershed.

Land use in the watershed has been extracted herewith and included as Table 2 from the James F. MacLaren report dated October, 1979. Most of the watershed is rural at present and residential development has, in general, taken place only in the southern end of the watershed in the Pickering and Ajax areas. Small communities are scattered throughout the watershed, but they do not affect the overall runoff.

Further development in the watershed, at present, is still under consideration. Plans for the North Pickering Community and the proposed new Toronto International Airport would both be within this watershed. The land use conditions used for the analysis in this report are similar to those utilized in the James F. MacLaren report entitled "Report on Hydrologic Model Study - Humber, Don, and Rouge Rivers, Highland, Duffin, Petticoat and Carruthers Creeks".

3.2 HISTORY OF THE PROBLEM

The attached Drawing No. 1 indicates the study area which is described during the course of this report. Development has occurred over a number of years within the Regional Flood Plain as indicated on this plan. The flood plain is of a wide shallow nature. There are approximately 110 buildings in this area, including residential, commercial and industrial structures. It has been estimated that the total net worth of all property within the flood

TABLE 3

NUMBER OF STRUCTURES AFFECTED BY FLOODS
WITH SPECIFIED OCCURENCE RISKS

RETURN PERIOD	RISK OF FLOODING*	NUMBER OF STRUCTURES AFFECTED BY FLOODS WITH SPECIFIED OCCURRENCE RISKS
150 yr.	49%	23
350 yr.	25%	30
500 yr.	18%	32
Regional (Assumed 750 yr.)	12%	108

* Assuming a 100 year period for possible occurrence.

plain is of the order $24,000,000. as summarized in Appendix 4. The estimated net worth can be broken down as follows:

Residential	$ 3,000,000.00
Industrial/Commerical	11,000,000.00
Apartment Building at 92 Church St.	10,000,000.00

Table 3 indicates the return period and probable risk of flooding of these various properties. Although it is reasonable to assume that the properties in question would not be totally destroyed or even inundated during a Regional flood, different levels of flooding would result in property damage to the area in question.

Previous floods, including the one documented in the attached photo Appendix 1, indicate flooding, particularly in the area north of Highway No. 2. Flooding in the area north of Highway No. 2 and just west of Church Street occurs almost on a seasonal basis. Property damage and personal inconvienence are common to the areas.

3.3 PREVIOUS STUDIES

Originally, the Plan for Flood Control and Water Conservation as prepared by the Metropolitan Toronto & Region Conservation Authority in 1959 proposed two large flood control dams, one on each branch of the Duffin Creek upstream of Pickering to protect flood vulnerable areas downstream. Channelization through Ajax and Pickering was also recommended to produce a complete system that would protect the existing properties within the now identified study area. In the subsequent update of the MTRCA's Flood Control Program in 1979, it was determined that the dams could not be justified. In view of the flood risk in the Towns of Pickering and Ajax, specific

work should be considered to provide an adequate level of protection. The MTRCA Flood Control Program has the objective of providing in defined flood damage centres, on a priority basis, protection by means of remedial works to reduce the risk of flooding to less than 50% over the life (100 years) of the affected structures. Specifically, the MTRCA policy for Flood Drainage Centres states the following:

> "The Authority will identify the location and extent of damage centres in the watersheds and will undertake a program of remedial works and/or acquisition to provide protection to a level such that the risk of flooding does not exceed 50% and to a maximum of the Regional Flood if such protection can be economically and socially justified. The criteria for these areas are as follows:
>
> a) The location and extent of damage centres will be determined by the Authority in consultation with the appropriate municipality(ies).
>
> b) Within a damage centre, all new structures or buildings must be protected to the degree that the risk of flooding is no higher than that established by policy. As a general guideline, structures or buildings will not be subjected to flooding under the Regional Storm. However, where it demonstrated that this level of protection is technically not achievable, then as a minimum, structures or buildings will not be subjected to a risk of flooding over their assumed life of 100 years, in excess of 25%. Several flood damage reduction techniques can be applied to achieve this level or risk, including filling, elimination of openings, and strengthening of foundations.
>
> c) Notwithstanding criterion (b), no development, redevelopment or additions will be permitted where they will be subjected to flows which due to their velocity and/or depth would be a hazard to life or susceptible to major structural damage as a result of flood less than or equal to the Regional Storm."

Several studies have been undertaken to determine solutions to the problems in this area, included the following:

1. "Duffin Creek Report on Flood Control and Water Conservation" by R. T. Kilborn and Associates, December 1962. This report examined the whole question of flood protection and conservation on the Duffin Creek and indicated that protection could be provided for the Duffin Creek area, specifically the

Pickering/Ajax area, by two flood control dams on the upstream branches of the Duffin Creek. In addition, it was also recommended that a floodway be constructed in the flood vulnerable areas since there were insufficient storage sites in the remainder of the basin to effectively retain the flood runoff and to completely eliminate flooding in the riverside areas. Channel relocations and a dyke along the Riverside area and the clearing and removal of all obstructions from the section of the channel from the Canadian National Railway to the north confluence of the east and west branches were recommended. The estimated cost of the two upstream dams was $3.24 Million in 1968 and the estimated cost of the work in the Pickering area was $537,000.00. It is evident that although these works would have corrected the protential flooding problems, the cost for doing so would have been very high, and the detrimental effects on the natural environment would have been significant.

2. "Hydrologic Model Study - Humber, Don and Rouge Rivers, Highland, Duffin, Petticoat and Carruthers Creeks" dated October, 1979 by James F. MacLaren Limited. This study calculated flows for the 5, 10, 25, 50 and 100 year and Regional flood events.

3. "Flood Damage Analysis and Remedial Works Study" dated June, 1980 by James F. MacLaren Limited. This report examined the Regional flood lines and identified thirty-one flood damage centres. The extent of damage in these areas was calculated to determine the level of remedial action felt to be appropriate. The MTRCA then undertook a conceptual study for all flood

damaged centres. The purpose of this study was to:

a) Review the flood susceptibility of each damage centre;

b) Establish potential monetary losses as a result of flood damage;

c) Undertake preliminary site environmental inventories to determine the environmental sensitivity of the areas; and

d) Undertake a preliminary evaluation of the proposed remedial measures based on established MTRCA Policies and Site Damage.

Of a total of 14 flood damage centres not presently protected to the MTRCA's minimum protection criteria, the Duffin Creek site at Pickering was given an overall priority of four. Studies have already been undertaken and remedial works in some instances have commenced with respect to the other particular sites. The previously recommended approach to correcting the problem in this area in the conceptual study was the use of dykes, at an estimated cost at the time of preparation of that report of $100,000.

4. "Environmental Evaluation Of Flood Damage Centres" by Proctor & Redfern Group, November, 1979. This study identified potential effects of various remedial works proposed in the previous report.

For the Duffin Creek Damage Centre 2 the report addressed the effect of channelization and dyking. Concern has been expressed with respect to the terrestrial and aquatic habitat. Specifically, references are made to a northern dyke, the location of which has been indicated in the Report "A Biological Inventory

with Recommendations for Duffin Creek Flood Damage Centres 2 and 3". A southern dyke has also been assumed necessary. At Damage Centre No. 3, reference is made to severe environmental impact that would result from the construction of a dyke. It would appear that no alternative locations, other than a narrow strip adjacent to the channel, have been considered for the dyke in this area. Aquatic and terrestrial value has been rated as high for this area; however, it appears that very little thought has been given to alternate approaches for dyking in this area.

5. "Environmental Effects of Erosion Control Structures" by the Environmental Applications Group, December 1980. This study identifies various concepts to be considered when reviewing potential erosion control structures for watercourses within MTRCA authority.

6. "Environmental Effects of Flood Control Structures" by The Environmental Applications Group dated January, 1981. This study indicates the considerations to be adopted when investigating potential flood control structures, during the course of the study within properties owned by the MTRCA.

4

Site Inventory And Development Constraints

SECTION 4

SITE INVENTORY AND DEVELOPMENT CONSTRAINTS

4.1 ENVIRONMENTAL INVENTORY

A detailed inventory and analysis of the exisiting site conditions was undertaken in 1981 by the MTRCA and Simcoe Engineering Limited. The following summarizes the findings:

4.1.1 Physical

The topography at both damage centres is a mixture of flat areas, gentle undulations and steep eroded river slopes. Soils include Iroquois clay, sand and gravel. A low natural levee appears to be present in damage centre no. 3 running approximately parallel to and north of Hwy No. 2 just upstream from the confluence of the west branch with the north branch of the Duffin Creek. Damage centre No 2. contains two large earthen ramps use by the brick factory. The ramp to the north is no longer in use by the factory and the MTRCA has installed a level monitoring station on the top of it.

4.1.2 Biological

The terrestrial habitat as described in the MTRCA Biological Inventory is diverse containing a several vegetation communities, such as immature and mature field shrub, immature and mature woods, mixed mature woods, and manicured areas. The mixed mature woods north of the creek at damage centre 3 is indicated to be important because of the diversity of tree species such as Cedar, White Ash, Sugar Maple, Hemlock and Black Cherry. The area provides excellent wildlife habitat, as indicated by the diversity of bird

species noted, including Ruffed Grouse, Green Heron, and Great Blue Heron. A white tailed deer was also sited during the inventory. The aquatic habitat is indicated to be excellent for the spawning of salmon and trout. The Duffin Creek has the ability to support a visible cold water fishery. Erosion contributes to siltation within the watercourse which could affect invertibrates such as Grey fish and May flies. The bank instability has caused many streamside trees to slide into the watercourse, causing considerable wood debris and potential obstructions; some of the obstructing debris should be removed, while the remaining wood could be left to enhance stream cover.

4.1.3 Socio Economic and Cultural

Both adults and children use the watercourse for angling, particularly for rainbow trout. Footpaths are common throughout the wooded areas along the north and south banks, indicating good recreational potential for the area.

The Ajax Historical Board commented that there was no known items of significant historical interest that would require special consideration within the confines of the study area.

The present land uses include a mixture of residential, commercial and industrial. Most of the industrial/commercial uses are grouped together in Damage Centre 2 on the west bank of the Duffin Creek.

4.2 HYDROLOGIC AND HYDRAULIC ANALYSIS

Hydrologic analyses prepared by James F. MacLaren Limited, 1979 developed flow estimates for different return periods, including the 5, 10, 25, and 100 year and the Regional Storm for the Duffin

TABLE 4

FLOW IN DUFFIN CREEK FOR FLOODS
WITH SPECIFIED OCCURRENCE RISKS

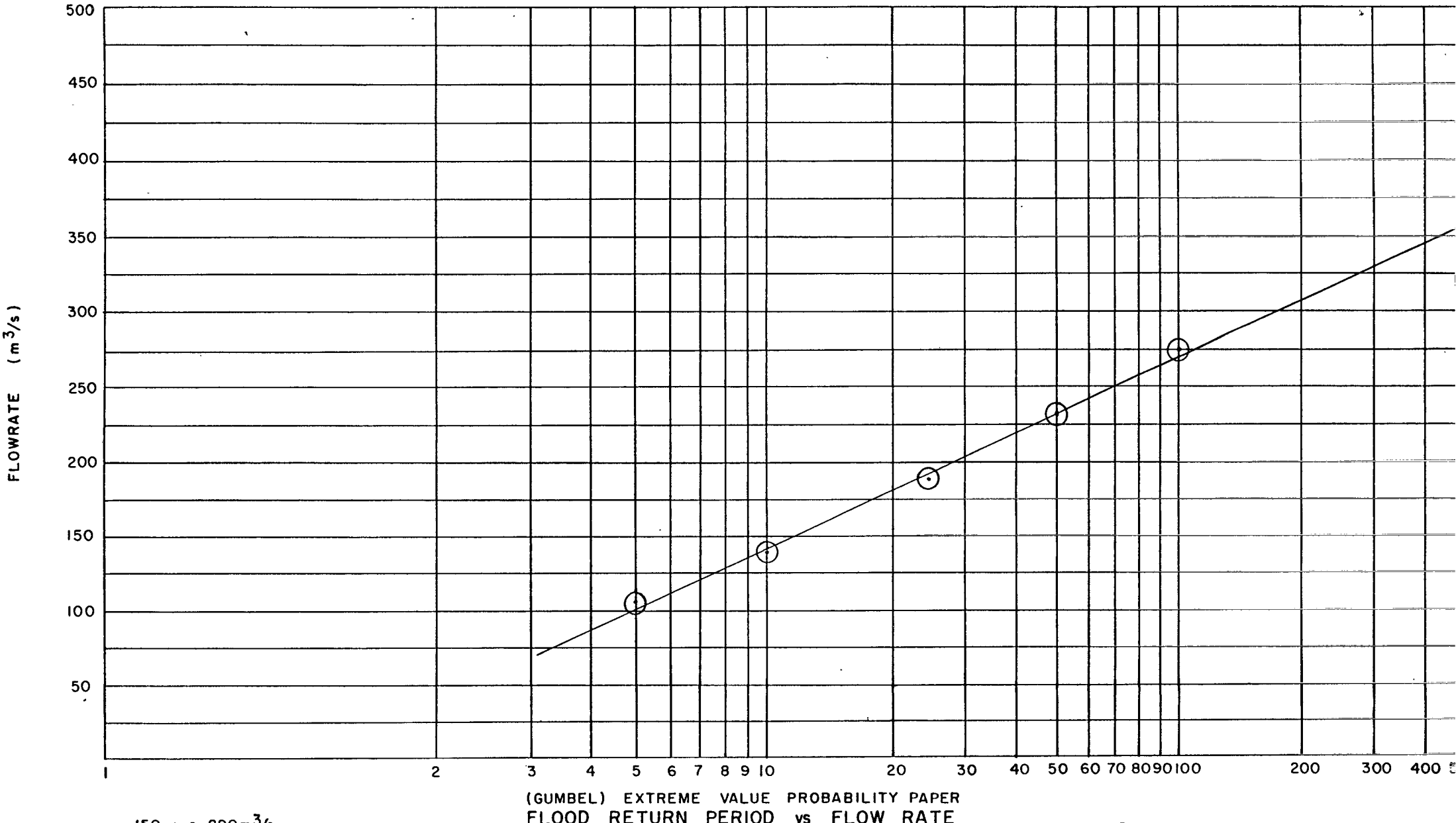
RETURN PERIOD	RISK OF FLOODING*	FLOW AT HWY. 401 (m3/sec)	FLOW IN WEST BRANCH OF CONFLUENCE (m3/sec)
150 yr.	49%	290	123
350 yr.	25%	342	143
500 yr.	18%	360	150

* Assuming a 100 year period for possible occurrence.

Creek watershed. The previously developed flood frequency curves for the study area were then plotted to provide estimates of design flows for higher return periods, including the 150, 350, and 500 year floods. These curves are illustrated in Figures 2 and 3. Table 4, summarizes the return periods, flows and risk factors for various flows within the study area for key locations. This information has been utilized as the basis of the hydraulic analysis during the course of this study.

A computerized Hec-2 backwater model from the mouth of the Duffin Creek to beyond the study area was obtained from the MTRCA. Cross sections of the floodplain were examined to determine if they accurately represented existing field conditions. These cross sections were representative of the physical nature of the floodplain in question. These cross sections have been plotted in a separate document which outlines the cross sections as utilized for the hydraulic computations.

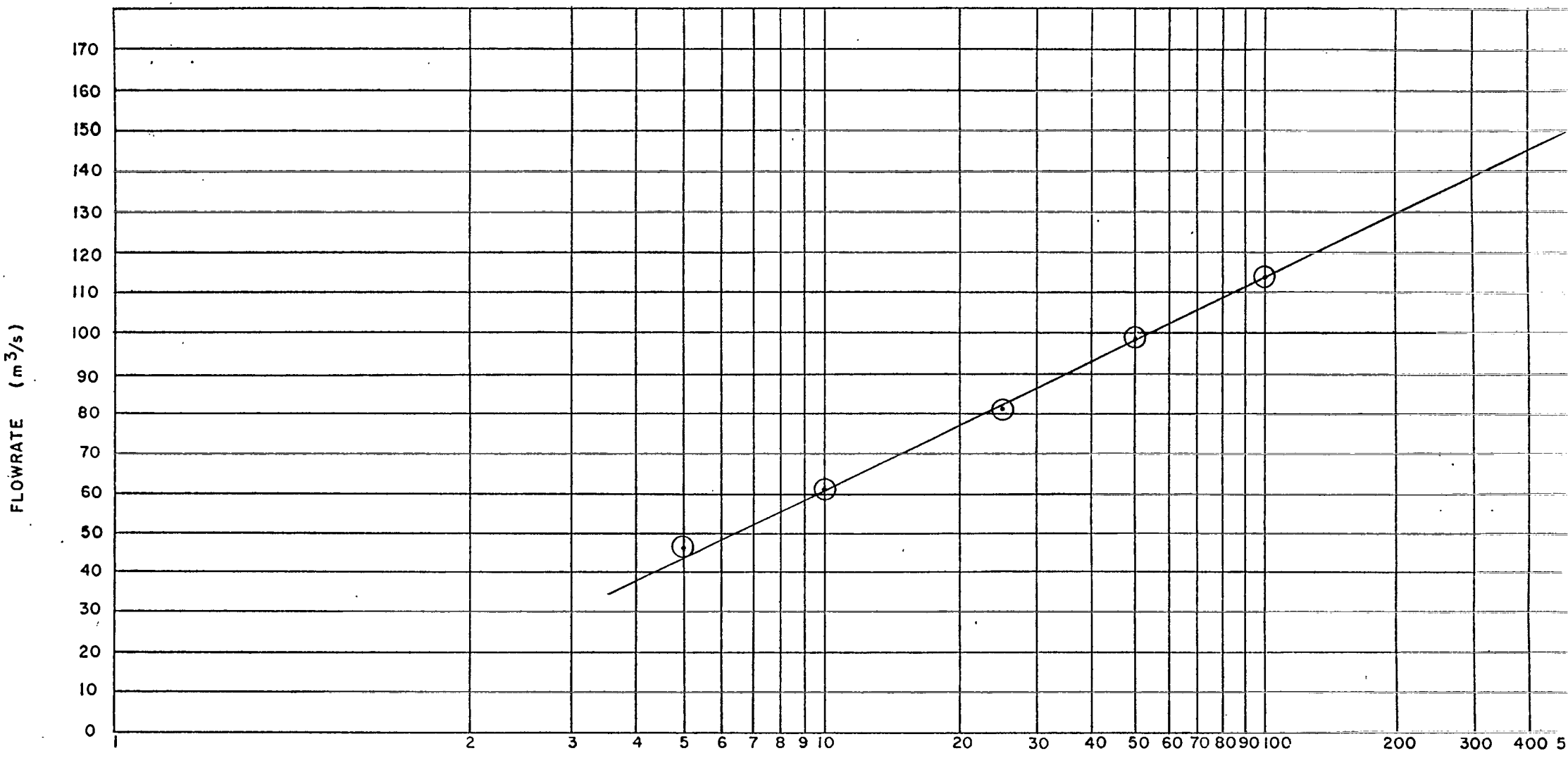
Based on this information, the backwater curves for the various return periods have been calculated, including the 50, 25 and 18 per cent risk flows (150, 350 and 500 year return periods). At various major locations along the water course these levels have been summarized and the locations of each of these cross sections has been indicated on the attached Drawing No. 1. Figure No. 4 illustrates the rise in water level for different return periods for a typical cross section.



150 yr. = $290 m^3/s$
350 yr. = $342 m^3/s$
500 yr = $360 m^3/s$

DUFFIN CREEK MAIN BRANCH

FIGURE 2



150 yr. = 123 m^3/s
350 yr. = 143 m^3/s
500 yr. = 150 m^3/s

⊙ KNOWN VALUES

(GUMBEL) EXTREME VALUE PROBABILITY PAPER

FLOOD RETURN PERIOD vs FLOW RATE

DUFFIN CREEK WEST BRANCH

FIGURE 3

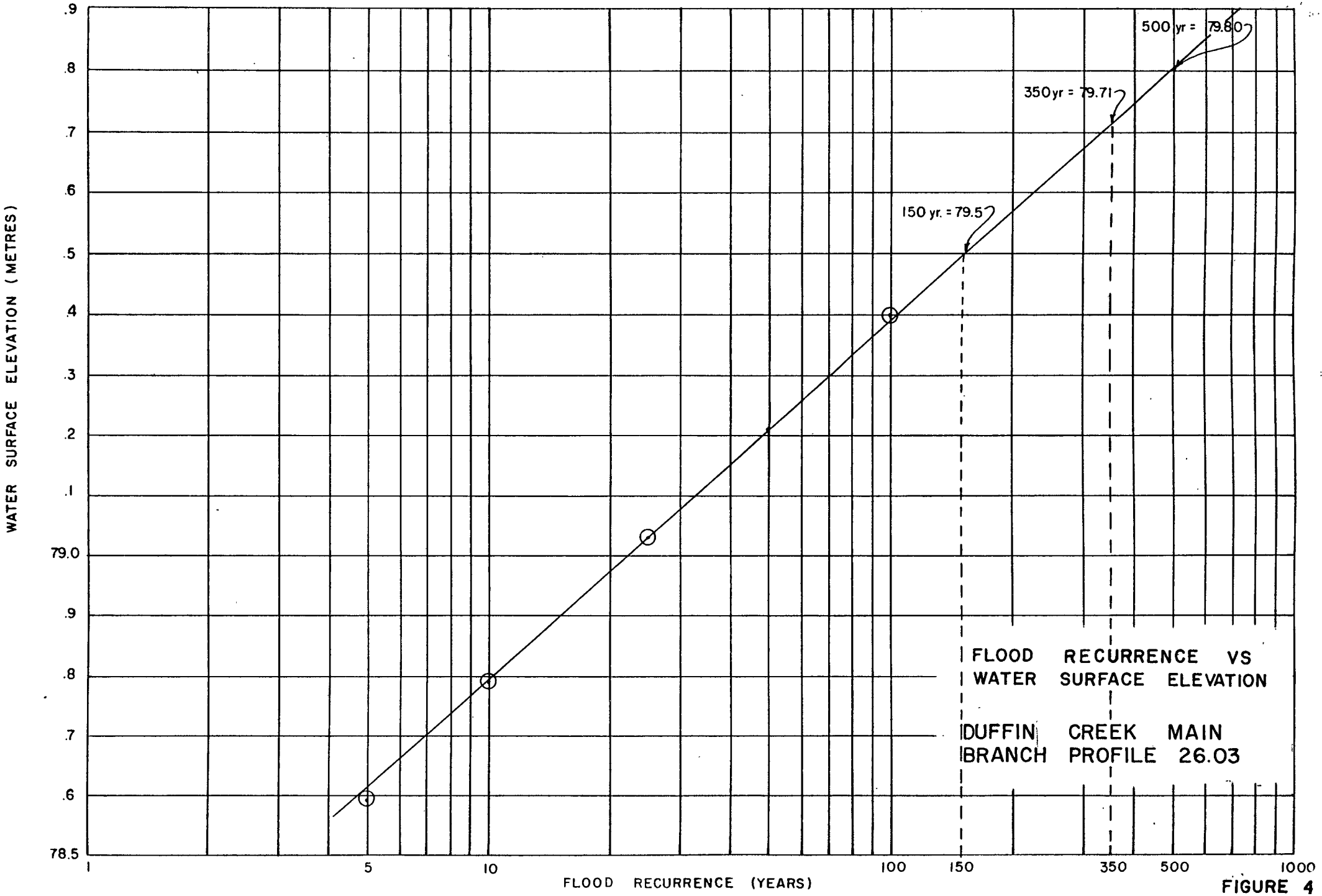

WATER SURFACE ELEVATION (METRES)
.9
.8
.7
.6
.5
.4
.3
.2
.1
79.0
.9
.8
.7
.6
78.5
500 yr = 79.80
350 yr = 79.71
150 yr. = 79.5
1
5
10
100
150
350
500
1000
FLOOD RECURRENCE (YEARS)
FLOOD RECURRENCE VS
WATER SURFACE ELEVATION
DUFFIN CREEK MAIN
BRANCH PROFILE 26.03

FIGURE 4

5

Alternative Solutions To The Problem

SECTION 5

ALTERNATIVE SOLUTIONS

A wide range of alternatives were considered in the study. These include:

5.1 DO NOTHING OPTION

In all cases, the 'do nothing' option is considered first and must review the impact of doing nothing on, public safety, loss of property, future costs and resource depletion. This is essentially an 'is it worth it' decision.

5.2 STRUCTURAL MEASURES

Alternatives of this type involve construction of a physical work within the watershed. Typically, they involve the construction of dykes, retention ponds, channel linings, diversion channels, etc., or the modification of existing bridges, culverts, or channel linings, etc.

5.3 NON-STRUCTURAL MEASURES

This type of alternative includes planning or regulatory controls emergency programs or land or acquistion as a means of providing flood protection.

5.4 COMBINATION OF STRUCTURAL AND NON-STRUCTURAL ALTERNATIVES

Many alternatives combine both structural and non-structural flood protection devices. Channel improvements may include removal of obstructing debris as well as widening and bank protection.

6

Evaluation And Comparison Of Alternatives

SECTION 6

EVALUATION AND COMPARISON OF ALTERNATIVES

6.0 GENERAL

Each alternative was examined in light of its technical, environmental and economic implicatons. The following section summarizes the evaluation.

6.1 DO NOTHING OPTION

The consequences of the 'do nothing' alternative are unacceptable due to the policy of the MTRCA. In part, the policies indicate the following:

"The Authority will identify the location and extent of damage centres in the watersheds and will undertake a program of remedial works and/or acquisition to provide protection to a level such that the risk of flooding does not exceed 50% and to a maximum of the Regional Flood if such protection can be economically and socially justified. The criteria for these areas are as follows:

a) The location and extent of damage centres will be determined by the Authority in consultation with the appropriate municipality(ies).

b) Within a damage centre, all new structures of buildings must be protected to the degree that the risk of flooding is no higher than that established by policy. As a general guideline, structures or buildings will not be subjected to flooding under the Regional Storm. However, where it demonstrated that this level of protection is technically not

TABLE 5

NUMBER AND VALUE OF STRUCTURE INUNDATED
BY FLOODS WITH SPECIFIED OCCURRENCE RISKS

RETURN PERIOD	RISK OF FLOODING*	NUMBER OF STRUCTURES FLOODED	VALUE OF FLOODED STRUCTURES ($)
150 yr.	49%	23	1,217,000
350 yr.	25%	30	1,512,000
500 yr.	18%	32	1,607,000
Regional (assumed 750 yr.)	12%	108	22,760,000

* Assuming a 100 year period for possible occurrence.

achievable, then as a minimum, structures or buildings will not be subjected to a risk of flooding over their assumed life of 100 years, in excess of 25%. Several flood damage reduction techniques can be applied to achieve this level of risk, including filling, elimination of openings, and strengthening of foundations.

c) Notwithstanding criterion (b), no development, redevelopment or additions will be permitted where they will be subjected to flows which due to their velocity and/or depth would be a hazard to life or susceptible to major structural damage as a result of flood less than or equal to the Regional Storm."

6.2 NON STRUCTURAL ALTERNATIVES

6.2.1 Acquisition

The feasibility of acquiring those structures potentially affected by the 150-year return period flood was considered. It was estimated that twenty-three structures, with a total replacement value of $1,217,000.00 excluding land value, fall within this category. Of these structures, eighteen are private homes. Removal of the individuals from their residences would cause significant social disruption. Table No. 5 indicates the value of property potentially flooded for different return periods.

6.2.2 Flood Damage Reduction Measures

It is possible for individual property owners to make certain structural changes to the buildings on their properties which will reduce potential flood damage. This approach is referred to as flood-proofing. Such measures can be divided into two categories:

a) Techniques for preventing the entry of flood water.

b) Techniques for protecting of utilities and contents in the event that flood water does enter the building.

A variety of flood damage reduction measures are available to prevent entry of flood waters: installation of backwater valves to prevent sanitary sewer backup, sump pumps to remove the water that enters the basement through foundation openings, waterproof seals installed at structural joints, and the elevation of openings so as to raise their first floor above the flood stage. It is important to emphasize that the critical requirement for a structure is its ability to withstand the external hydrostatic foces that would be applied to the walls and basement floors. If existing construction is not capable of withstanding hydrostatic forces, a realistic alternative is to intentionally allow flooding in order to equalize the hydrostatic forces and retain the structural integrity of the building and minimize the entry of objectional materials associated with flooding. It is also possible to contemplate an emergency evacuation program for the contents of the building. Flood vulnerable contents can be temporarily moved out of the building or to higher floors in order to minimize damage.

Such measures are contingent upon an early warning system and, in addition, the feasibility of relocating owner's contents. Due to the number and type of properties involved, it is not believed that this approach would be a satisfactory solution.

6.3 STRUCTURAL ALTERNATIVES

6.3.1 Channel Improvements

Channel improvements, such as widening, deepening, addition of rip rap, gabions, concreting, or sheet piling could possibly

increase the potential carrying capacity of the existing channel. Significant changes would have to be made to the channel to allow for any significant improvement in the carrying capacity of the channel. Deepening and/or widening of the channel would be required. In addition structural changes would be required to the bridges along the channel to accommodate the flow. An increase in cross-sectional area of approximately 400 per cent from 30 square metres to 120 square meters would be required to attain the carrying capacity for the 150-year storm.

These changes would have a significant impact on the acquatic environment particularly cold water fisheries. Adjacent terrestrial communities would also be affected during construction.

Channel improvements would however address the existing erosion problems.

6.3.2 Channel Re-alignment

A channel re-alignment would involve a change to the natural stream course, designed to increase hydraulic capacity of the system. The potential for re-alignment in this area has been examined and the conclusions are that there would be no significant improvements to hydraulic carrying capacity. Changes in the natural flow regimes caused by channel re-alignment could significantly harm the existing aquatic environment. Re-alignment would also affect the terrestrial environment and might possibly affect the social environment also. Accordingly, this alternative can be eliminated due to its many disadvantages.

TABLE 6

CHANGE IN WATER SURFACE ELEVATIONS
DUE TO BRIDGE CONSTRICTIONS

Bridge	Flood Return Period	Rise in Water Surface Elevation (m)
CNR Bridge	150	0.2
	350	0.2
	500	0.2
	Regional	2.9
401	150	-
	350	-
	500	-
	Regional	0.1
Church Street	150	0.3
	350	0.4
	500	0.4
	Regional	0.2
Hwy. No. 2	150	0.8
	350	0.8
	500	0.8
	Regional	1.3
Brock Road	150	0.2
	350	0.2
	800	0.3
	Regional	0.5

6.3.3 Diversions

The function of a diversion is to intercept potentially damaging flood waters at a point upstream of a flood-prone region and route them to an area outside of the flood prone-section. A by-pass channel is created which normally carries water only when the maximum capacity of the natural stream course is reached. The potential of utilizing the diversion technique in this area has been examined; however, there is no advantage to such a solution in this case, since there is no feasible location for a diversion around the study area.

6.3.4 Bridge and Culvert Alterations

The effect of major culverts and bridges on the flood levels for different return periods was examined, as indicated in Table No. 6. The bridges have a significant constricting effect on the watercourse only during the Regional storm. The CNR bridge at the southern limit of the study area causes almost a 3 metre increase in level upstream of the bridge during the Regional flood. The bridge at Highway No. 2 causes an increase of approximately 1.3 metres during the Regional flood.

Bridges and/or culverts under highways and railways often significantly affect upstream and downstream flood stages and may aggravate existing problems or create new flood hazards. The adverse effect of such structures may be avoided by increasing the size of the waterway opening. In a 150-year flood, the CNR bridge is not expected to have a very significant effect of the flood levels. The Highway No. 2 bridge will however cause a 0.8 metre increase in surface water elevation. Since cost of changing either of these

bridges would be very high, it was concluded that changes to the bridges would not be of sufficient benefit to be economically justified since the floodplain would still be inundated at high flow rates.

6.3.5 Dyking

Earthen dykes are a structural means of containing flood waters and preventing overland flow from the channel into developed areas. It is essential that if this technique is to be applied, that sufficient space be available between the watercourse and the area to be protected to accommodate an earthen structure. Although dykes are effective, they can create associated problems. For example, during major flood events, the modified river channel will cause higher water levels which may affect the operation of the drainage system as a whole. Mechanisms, such as backwater gates, to prevent reverse flow must be incorporated into the overall design of the structures.

The dyking alternative can be made acceptable in terms of environmental impact as long as precautions are taken during the construction stage. Low impact results on the terrestrial environment after the initial construction stage is over. Impact on the aquatic environment will be minimal since the dyke does not interfere with the normal flow regime of the creek. No buildings will have to be acquired, and consequently, people will not have to be relocated as a result of this alternative.

The cost of this type of protection is also more reasonable than the other alternatives considered in this study.

On these grounds the dyking alternative was chosen as the preferred method of flood protection for Damage Centres 1 and 2 on Duffin Creek.

7

Detailed Design Of Preferred Alternative

SECTION 7

DETAILED DESIGN OF PREFERRED ALTERNATIVE

7.1 PROPOSED LOCATION OF DYKES

Based on the examination of the existing floodlines for various return periods, as indicated on Drawing No. 1, two sections of dyking have been proposed.

- Location of Dyke for Damage Centre 2

For Damage Centre 2, it should be noted that there is substantially little or no potential for flood damage caused by the 150 year storm in the area west of the Duffin Creek. In the economic analyses in Section 7.2, it is indicated that there is no cost benefit to protecting this area up to the Regional storm. Therefore, it is recommended that no dyke be constructed for this area.

In the area east of the Duffin Creek, there are four homes that can be affected by the 1 in 150 return period flood. In addition, there are fourteen houses, a townhouse block and an apartment building that will be flooded to some extent during a Regional storm.

Detailed discussions were held with the MTRCA for examination and consideration of effects upon the terrestrial environment that the alignment of the proposed dyke would have in this area. The preferred alignment for the Church Street dyke, is shown on Drawing No. 1. This location would by-pass most of the existing woodlot and follow a manicured area without

TABLE 7

COMPARISON OF WATER LEVELS FOR DIFFERENT RETURN PERIODS
BOTH WITH AND WITHOUT DYKE PROTECTION

Major Construction Locations		WATER SURFACE ELVATIONS (metres)						
		Return Period - Unprotected			Return Period - With dyke Protection			
		150 yr.	350 yr.	500 yr.	150 yr.	350 yr.	500 yr.	Regional
	Profiles MAIN BR.							
	26.03	79.50	79.71	79.80	79.50	79.71	79.80	81.24
	26.04	79.56	79.77	79.86	79.56	79.77	79.86	81.35
	26.05	79.59	79.80	79.89	79.59	79.80	79.89	81.36
	26.06	79.63	79.84	79.92	79.63	79.84	79.92	81.32
	26.07	79.62	79.78	79.85	79.62	79.78	79.85	80.73
CN O/P	26.08	79.72	79.92	80.00	79.72	79.92	80.00	82.84
	26.09	79.80	80.05	80.15	79.80	80.05	80.15	83.64
	26.10	79.98	80.24	80.34	79.98	80.24	80.34	83.72
	26.11	80.05	80.31	80.41	80.05	80.31	80.41	83.73
HWY.401	26.12	80.06	80.32	80.42	80.06	80.32	80.42	83.74
	26.13	79.69	79.94	80.07	79.69	79.94	80.07	83.69
	26.14	80.31	80.58	80.66	80.31	80.58	80.66	83.81
	26.15	80.30	80.61	80.68	80.30	80.61	80.68	83.76
Church St.	26.16	80.34	80.72	80.82	80.34	80.72	80.82	83.84
	26.17	80.34	80.75	80.86	80.34	80.75	80.86	83.75
	26.18	80.61	81.00	81.11	80.59	81.00	81.11	84.04
	26.19	80.67	81.04	81.15	80.76	81.06	81.17	84.09
	26.20	80.83	81.15	81.25	80.89	81.18	81.28	84.12
	26.21	81.12	81.37	81.45	81.15	81.39	81.47	84.18
	26.22	81.60	81.74	81.78	81.60	81.74	81.78	84.07
	26.23	81.60	81.74	81.78	81.60	81.74	81.79	83.95
Hwy. 2	26.24	81.62	81.94	81.92	81.62	81.77	81.83	84.56
	26.25	81.61	81.92	81.90	81.61	81.75	81.80	84.40
	26.26	82.25	82.53	82.58	82.41	82.65	82.74	85.48
	26.27	82.37	82.62	82.66	82.76	83.00	83.09	85.82
	26.28	82.50	82.71	82.76	82.89	83.14	83.22	85.92
	26.29	82.60	82.80	82.84	82.97	83.23	83.31	85.97
	WEST BR.							
	12.00	82.67	82.85	82.88	83.04	83.28	83.35	86.03
	12.01	82.86	82.99	83.02	83.11	83.33	83.39	86.00
	12.02	82.98	83.10	83.14	83.22	83.48	83.54	86.15
	12.03	83.58	83.67	83.70	83.61	83.78	83.83	86.21
	12.04	84.11	84.20	84.23	84.10	84.36	84.40	86.50
	12.05	84.35	84.46	84.50	84.34	84.52	84.55	86.56
Brock Rd.	12.06	84.35	84.47	84.51	84.35	84.53	84.56	87.04
	12.07	84.32	84.46	84.50	84.32	84.52	84.56	87.06
	12.08	85.18	85.31	85.31	85.18	85.29	85.32	87.10
	12.09	86.40	86.57	86.63	86.40	86.57	86.63	87.82
	12.10	87.10	87.24	87.28	87.10	87.24	87.28	88.52
	12.11	87.29	87.42	87.47	87.29	87.42	87.47	88.80

disrupting the roadway access. It should be noted that this manicured area is, in fact, a sanitary sewer easement. No problems are expected with utilizing this sanitary sewer easement for the construction of the proposed dyke provided the dyke is not directly over the sanitary sewer. It may be necessary, however, to raise some of the manholes. The effects of the proposed dyke location on the stage discharge relationship in this area are indicated in Table 7. From this table, the maximum increase in stage discharge is approximately 90 mm (3 inches) for the 150 year return period. The immediate upstream effect of the dyke is an additional flood level of approximately 10 mm (3/8 inch). In summary, this dyke does not significantly affect the overall stage discharge relationship of the creek.

- Location of Dyke for Damage Centre No. 3

In the area north of Highway No. 2, a number of locations for this dyke were examined. Factors considered in the location proposed are as follows:

1. The effect the dyke will have on the natural environment.
2. The effect of the dyke on stage discharge/stage storage.
3. Ease of access for construction.
4. Land ownership.
5. Estimated cost.

The preferred location indicated on Drawing No. 1 was reviewed and discussed with staff of the Authority. The reasons for

this location are as follows:

1. This location would appear to affect the terrestrial environment to a limited and minimal extent.
2. The dyke would be built almost totally on Authority property, thus property acquisition will be kept to a minimum.
3. The location is as far as possible from the natural channel, providing the maximum available storage in the floodplain.
4. The dyke is as far as possible from the natural channel, and the possibility of affecting the channel in terms of siltation during construction, or by other factors, will be minimized.

Two-thirds of the dyke would be located in manicured field habitats, with little expected impact. The remaining portion of the dyke would be located through an immature woodlot of Manitoba Maple, Balsam, Poplar, Spruce and Willow, a portion of a mature field and a portion of an immature mixed woodlot containing white cedar. It has been recommended for this area, that excessive clearing beyond that necessary to accomodate the dyke through the woodlots should be avoided and that both young and mature cedar and spruce trees be left untouched wherever possible.

With the dyke in place, a 1 in 500 year storm, would cause a total increase of approximately 1/2 metre in flood elevation at this location. It should be noted, however, that almost

immediately upstream of the Brock Road bridge, the levels are approximately equal to those without the addition of the dyke. The upstream effects, therefore, in either case are minimal.

7.2 ECONOMIC ANALYSIS OF CHOSEN ALTERNATIVE

The purpose of the financial analysis is to determine the optimum degree of protection assuming a positive cost/benefit. A positive cost/benefit is assumed when the Proven Worth of Benefits is greater than the estimated cost of construction of the proposed remedial works.

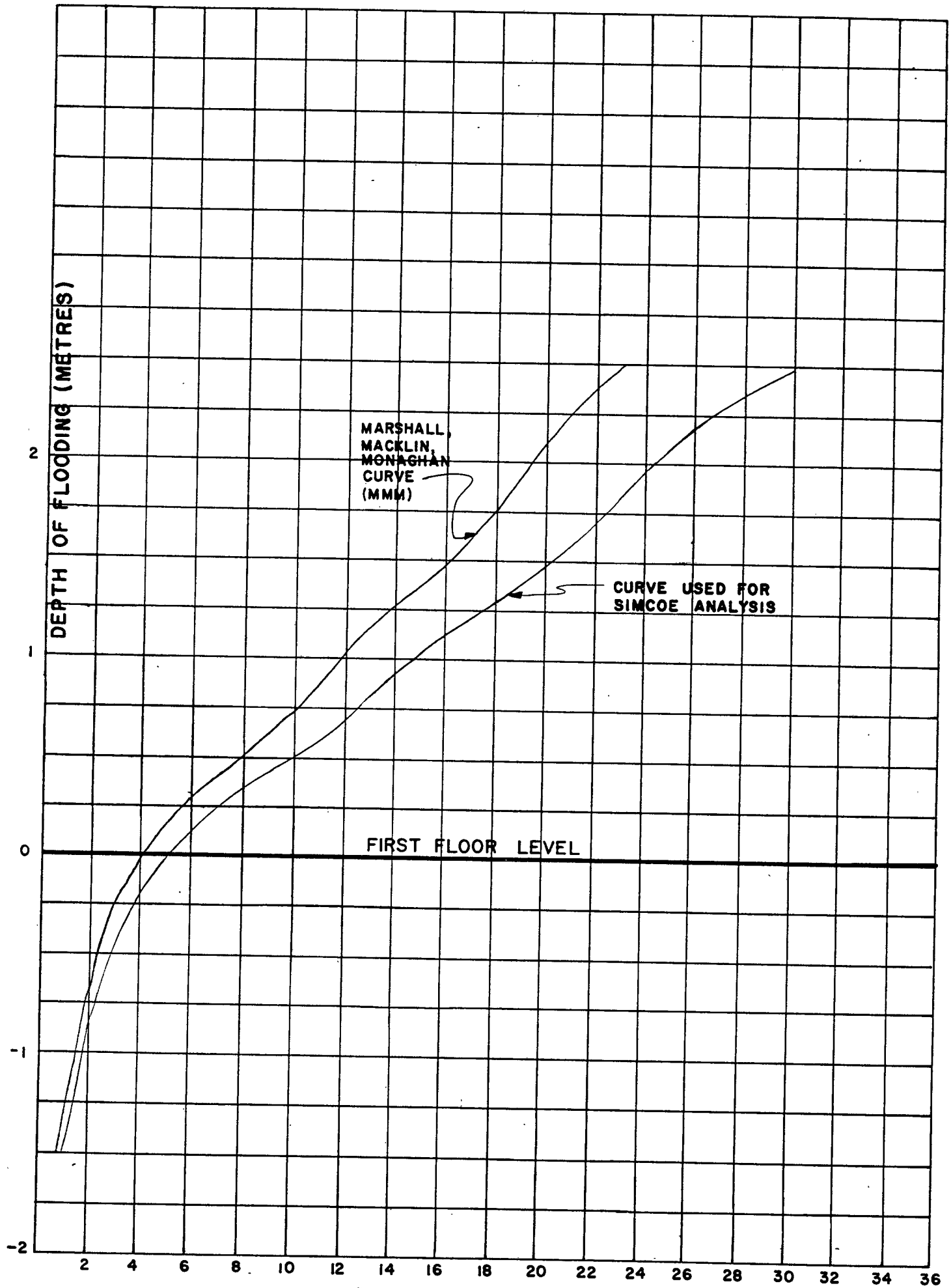
The analysis is carried out by comparing the estimated actual cost of the flood protection facility for a given return period, and the present worth[1] of the average annual damage reductions that would be expected for that facility. From a financial point of view, the level of protection to be provided for is the one with the least cost/benefit.

It is the policy of the Metropolitan Toronto & Region Conservation Authority to provide flood protection to at least the level of the 150 year return period flood (50% risk of flooding during a 100-year design life). Protection to a higher level will be provided if economically and/or socially justified.

7.2.1 Damage Estimation

The assessment of flood damage is based upon developing a relationship between the level of flooding for a particular structure and the damage done. In 1968, under the auspices of a task force

1. The amount of money that would have to be invested at a given interest rate at the outset of the project to provide for a series of payments each equal to the sum of annual costs for the projected design life.



DEPTH vs DAMAGE CURVES
FOR MODERATE VALUE BRICK HOMES

FIGURE 5

between the Governments of Canada and Ontario on water conservation projects in Southern Ontario, Acres Limited developed graphical relationships representing damage to buildings by various depths of flooding. These curves were developed for different classes of residential, commercial, and industrial structures. These curves, unfortunately, do not reflect todays economic conditions. While the principal shape remains the same, the costs of goods, materials and labour have increased markedly.

Marshall, Macklin, Monaghan Limited, in their Preliminary Engineering Study of Flood Protection for the Village of Bolton, March 1981, used curves based upon Acres work and those developed by the U. S. Federal Insurance Administration. For the purpose of this study it was felt that it would be suitable to use the curve developed by Marshall, Macklin, Monaghan for the damage caused to brick residential structures of moderate value, updated to 1981 dollars. This curve appears in Figure 5. The values of damage obtained by the use of this curve were factored to obtain the value of damages for homes of different quality. The factors were obtained by examining the difference in the value of damage done with respect to depth of flooding for the different classes of residential structures indicated by Acres. The factors utilized in this study are included in Table A4-1 of Appendix 4.

The values of damage to commercial and industrial structures were obtained by assuming a conservative total value of $\$325.00/m^2$ for each building and that damage due to flooding is linear from a depth of 0 metres to 2 metres where the maximum damage is achieved. To reflect the different value of contents, the value of

TABLE 8

SUMMARY OF ESTIMATED DAMAGES FOR

DIFFERENT RETURN PERIODS

RETURN PERIOD FLOOD IN YEARS	DAMAGE CENTRE 2	DAMAGE CENTRE 3	TOTAL
25	5,500	64,800	70,300
100	15,700	150,200	165,900
150	24,230	182,400	206,700
350	89,800	217,900	396,500
500	107,325	313,500	420,825
REGIONAL	7,925,300	2,656,400	10,581,700

damage obtained using this relationship was factored on an individual basis. The estimated damage done to structures for flood levels resulting from floods with return periods of 25 years, 100 years, 150 years, 350 years, 500 years, and the Regional flood, is given in Tables A4-2 through A4-7 by structure (Appendix 4). Table No. 8 summarizes the estimated damage by return period.

7.2.2 Estimation for Purchase Cost of Flood Control Structures

The construction costs of dyke protection for flood levels resulting from 150 year, 350 year, and 500 year, return periods were estimated. These estimates and a breakdown appear as costs according to activity in Table No. 9.

7.2.3 Methodology

The method used to analyze the cost benefit analysis was to review in detail each structure included on the attached Drawing No. 1, many of which were photographed and inventoried. For Damage Centres 2 and 3 for each storm frequency, the total monetary damage value was estimated. These are summarized in detail in Appendix 4. The total values for all structures were used to produce a damage versus frequency curve. This information was then used to compute expected average annual damages, as summarized herewith.

The expected average annual damages for the two centres were totalled and a present worth value of damages was obtained. This value represents the amount of money that would have to be invested today in order to make compensation payments each year, equal to the average annual damage value. This present worth is

TABLE 9

ESTIMATED COST OF FLOOD PROTECTION

Level of Protection	CHURCH STREET DYKE			HWY. 2 TO BROCK RD. DYKE		
	150 yr.	350 yr.	500 yr.	150 yr.	350 yr.	500 yr.
ACTIVITY						
Mobilization & Demobilization	2000	3000	3000	8000	9000	9000
Cleaning & Grubbing	5000	5000	5000	9000	9000	9000
Stripping & Storing Topsoil	2500	2500	2500	4500	4500	4500
Importing and Placing Material	40000	45000	47300	57000	65000	68100
Replacing Topsoil	6000	6000	6000	13500	13500	13500
Seeding, Sodding & Mulching	7000	7500	7500	15000	15500	15500
Restoration	2000	2000	2000	5000	5000	5000
Drainage Structures	10000	10000	10000	40000	40000	40000
Bonds & Insurance	3700	4050	4200	7600	8000	8200
Engineering & Contingency Allowance	14300	15650	16200	29300	31000	31700
TOTAL	92500	100700	103700	188900	200500	204500

NOTE: All units in dollars

calculated using the following formula:

$$P = \frac{(1 + i)^N - 1}{i(1 + i)} \cdot AAD$$

Where: P is the present worth
AAD is the average annual damage value
I is the interest rate
N is the number of years over which payments will be (i.e. life of the structure)

An interest rate of 18 per cent with a 100 year design lifetime was utilized for the calculations. This gives a factor of 5.556 by which the average annual damage value was multiplied. The summation of the average annual damages and their present worth has been given in Table No. 10. In this table, the different levels of protection provided by dykes for a 150 year, 350 year, and a 500 year return period flood was also considered. The average annual flood damage reduction as a result of these alternative dyke elevations, and protection levels are indicated as well. Utilizing the present worth factors, the present worth of benefits for the three alternative dyke elevations for the two locations has been determined. These present worth benefits were compared with the estimates of construction costs for these three alternative dykes.

As can be noted from these analyses, there is no economical advantage to any of the alternatives. It would appear to be difficult to justify economically the construction of dykes beyond the 150 year design period. It should be noted, however, that the difference in dyke elevation between a 150 year, and 500 year flood is only approximately 300 mm for the Brock Road location and 500 mm for the Church Street location. The estimated difference in cost between a 150 year dyke and a 500 year dyke is approximately $10,000.00 for the

TABLE 10

FLOOD CONTROL BENEFITS FOR ALTERNATIVE DYKES

ALTERNATIVE	AVERAGE ANNUAL FLOOD DAMAGE ($)	REDUCTION IN AVERAGE ANNUAL FLOOD DAMAGE ($)	PRESENT WORTH OF BENEFITS AT 18% INTEREST ($)	PRESENT WORTH OF AVERAGE ANNUAL DAMAGES AT 18% INTEREST ($)
CHURCH ST. DYKE				
Do Nothing	915	0	0	5 083
Protection to 150 yr. return period flood	546	369	2 050	3 033
Protection to 350 yr. return period flood	365	550	3 056	2 028
Protection to 500 yr. return period flood	294	621	3 450	1 633
HWY. NO. 2 TO BROCK ROAD DYKE				
Do nothing	9 600	0	0	53 333
Protection to 150 yr. return period flood	1 500	8 100	45 000	8 333
Protection to 350 yr. return period flood	950	8 650	48 056	5 278
Protection to 500 yr. return period flood	873	8 727	48 483	4 850

Church Street site and approximately $15,000.00 for the Brock Road site. It is evident from this analysis, that the additional cost of the higher dykes is minimal in relation to the additional protection that can be achieved. It is, therefore, recommended that the Authority give serious consideration to constructing dykes capable of protection, against the 500 year flood.

7.3 DETAILED DESIGN RECOMMENDATIONS

7.3.1 Details of the Dyke

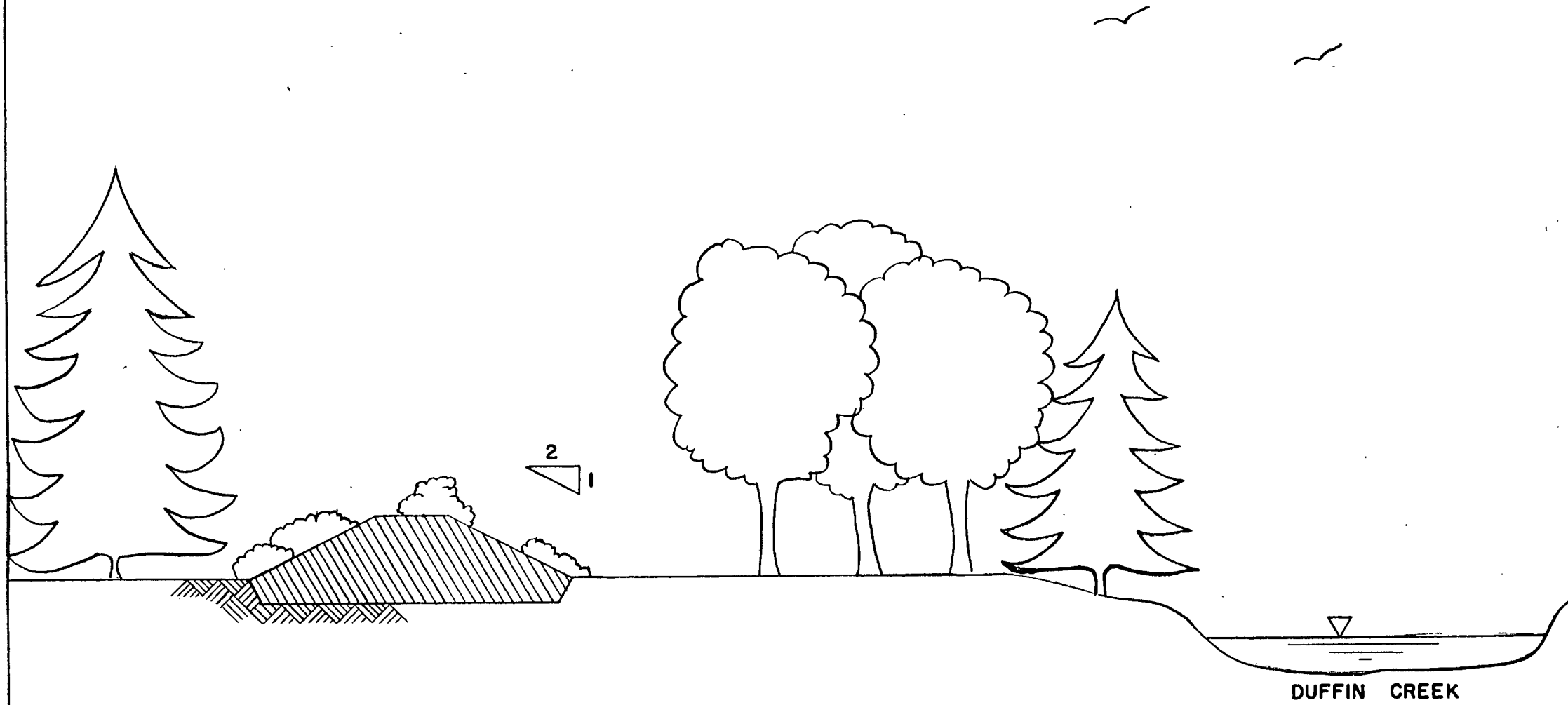
Figure No. 6 indicates a typical cross section through the dyke and flood plain. The top elevation of the dykes, will be capable of protection up to the 1 in 500 year flood.

- For the Church Street area, the top elevation of the dyke will be 82.3 metres. The height of the dyke will vary, depending on the ground elevation; however, in general the height will range from approximately 1 metre to 2.5 metres. The overall width of the dyke, therefore, would also vary, assuming a 2.0 metre level portion on top, from 5 to 12 metres in width at the base.
- For the dyke north of Highway No. 2, the maximum height of the dyke will be approximately 1.3 metres.

The dykes should be designed in such a way as to include the following:

1. The construction material for the dyke, should be reasonably impermeable to minimize the migration of water through the structure. This material and dyke should have the following characteristics:

   a) Be of a silty clay or clayey consistency.



Simcoe

CROSS SECTION OF DYKE AND FLOOD PLAIN

FIGURE 6

b) Contain a natural permeability of less than 10-4 centimetres per second.

c) Have a minimum density of 2000 Kg/m^3.

d) Be compacted to at least a 90 per cent Standard Proctor Density.

e) Have a minimum top width of 2.0 metres with a minimum freeboard of 300 mm above the 1 in 500 year flood.

f) Have side slopes no steeper than 2:1.

2. Ensure that the material is compacted in such a manner that the dyke will be capable of withstanding the hydrostatic pressures of the flood waters.

3. Restore the surface of the dyke with seeding and an erosion control matting in order to ensure that no subsequent siltation can occur in the creek.

4. Provide adequate landscaping to ensure that the dyke harmonizes with the surrounding area.

7.3.2 Internal Drainage

The internal drainage for the two proposed dykes has been considered and the conclusions are as follows:

1. With respect to the Church Street site, it is estimated that there would be run-off from approximately 5 hectares that would not have a natural drainage outlet as a result of the proposed dyke. Drainage on Church Street would be via a storm drain which discharges to the east of Church Street outside of the limits of the dyke. Since the roadway elevation is not affected substantially by the 1 in 500 year storm, no problems are foreseen with this particular outlet. The construction of an

outlet chamber with a suitable flap valve arrangement is recommended to drain the area to the west of Church Street.

2. The proposed dyke north of Highway No. 2 would enclose an area of approximately 20 hectares and prevent free surface drainage to the creek. At present there is a culvert just west of the proposed dyke under Highway No. 2 which drains the area in question. This culvert would allow reverse flow from the south side of the Highway No. 2 to the area in question. Therefore, the addition of a flap gate to this existing culvert under Highway No. 2 is recommended to prevent backup into this area. In addition, two small diameter drainage outlets should be placed through the dyke at points of low ground elevation, as shown on Drawing No. 1.

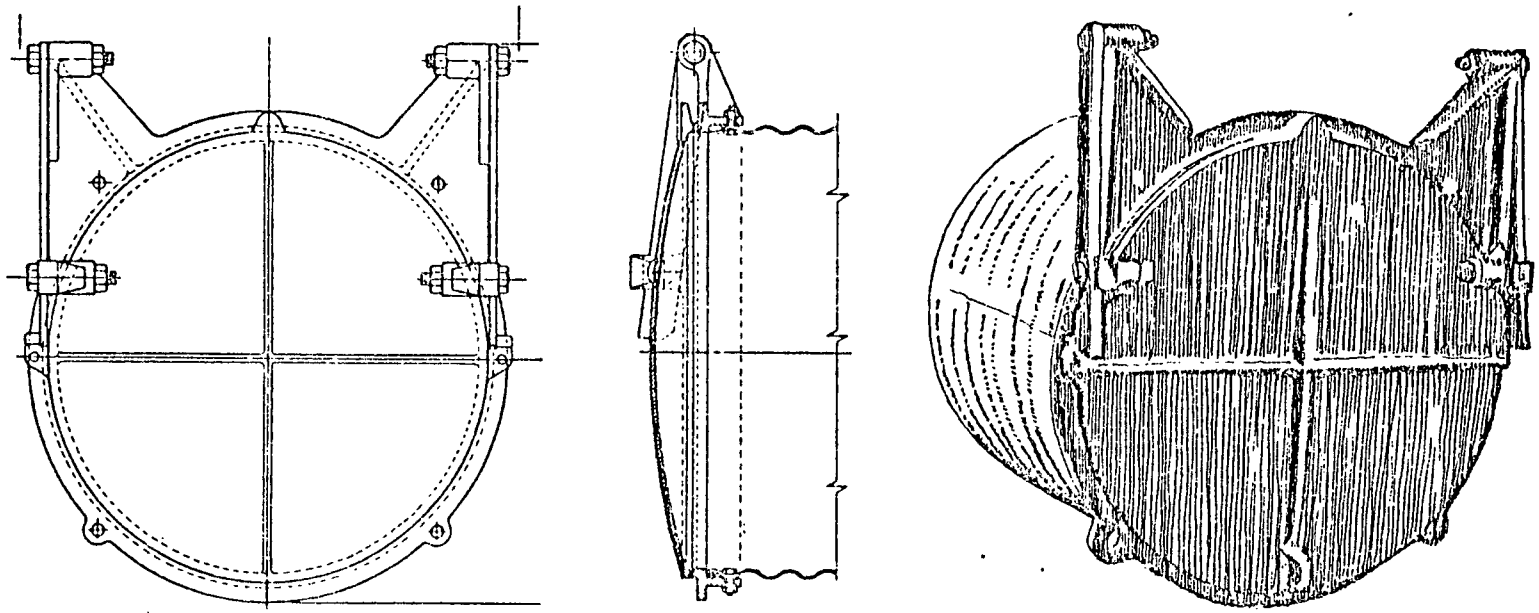
7.3.3 Property Requirements

The majority of the property required for the proposed dykes is owned by the MTRCA. Additional property requirements include:

- For the Church Street Dyke
  a) A small area of land adjacent to the Church Street right-of-way.
  b) A small area behind the apartment building at 92 Church Street.
- North of Highway No. 2
  a) A 6 metre wide strip of land immediately east of Brock Road.

7.3.4 Access Requirements

Access to property on the north side of Highway No. 2 will be required to enclose the dyke onto the Highway No. 2 embankment.



Typical Low Head Flap Gate

FIGURE 7

7.3.5 Construction Practices

In order to minimize impacts on the natural environment and private and public properties in the area, the MTRCA's General Guidelines for Planning and Construction of on-site Flood Control Structures Appendix 6 will be adherred to. In addition the following steps will be taken.

1. No construction should be allowed during winter. A construction period between mid-April and mid-November is acceptable.
2. Due to the location of the proposed dykes, there will be no need to encroach on or cross any branches of the Duffin Creek.
3. The use of any pesticide or herbicide would be strictly prohibited.
4. Dyke Construction

   Imported material for the dyke should be inspected in the field by the engineer to ensure that:

   a) it meets the specifications for design purposes; and
   b) no material unfit for utilization in a flood plain be included. This would include material such as garbage, broken pavement, concrete, etc.
5. Flap gates and head walls will be installed with the minimum of necessary excavation. A typical flapgate is shown in Figure No. 7. Materials utilized in the construction of these flapgate structures, such as, formwork, etc. will only be brought to the site when required and removed immediately after the completion of the work.
6. Final grading, topsoil, seeding and erosion control matting should follow closely behind the construction of the dyke and should be done on a continuous basis.

7. Any fences damaged during the course of construction will be repaired to their original condition.
8. Access routes and storage areas, etc. should be restored as nearly as possible to their original condition.

7.3.6 Post Construction Maintenance

Once construction has been completed, the site will be monitored to ensure the following:

1. Seeding and mulching has taken effect and sufficient grass cover has been established to ensure a minimum of erosion.
2. The dyke and any other disturbed areas should be checked for washouts and other evidence of potential erosion.
3. Ensure that other types of planted vegetation, such as trees, shrubs, etc. are obtaining sufficient moisture and fertilizer for proper growth.
4. Ensure that all gates and other structures included in the system are operating satisfactorily.

7.3.7 Approvals

In order to carry out the construction of the project, approvals will be required from a number of sources, including but not limited to the following:

1. Ministry of Transportation and Communications in terms of alteration to drainage and access to road embankments for dyke construction.
2. Regional Municipality of Durham in terms of alterations to drainage and access to roadways for construction.
3. Towns of Pickering and Ajax in terms of alterations to drainage and access to roadways for construction, permits for access to

construction, building permits, etc.

4. Approval to proceed will also have to be granted by the Ministry of the Environment, the Ministry of Natural Resources, and the Executive Committee of the Metropolitan Toronto and Region Conservation Authority.

8

Summary & Recommendations

SECTION 8

SUMMARY AND RECOMMENDATION

The findings of this report can be summarized as follows:

1. A number of alternative flood protection techniques have been considered. The use of dykes is the most appropriate in this instance.
2. For Damage Centre 2, it is recommended that a dyke be constructed on the northeast side of the Duffin Creek Flood-plain near Church Street. The total length of this section of dyke is only 400 metres but it will protect a number of properties that have been exposed to severe flooding in the past. No protection is proposed for the southwest side of the Duffin Creek Damage Centre No. 2 since the 150 year storm does not cause any significant property damage in this area.
3. With respect to Damage Centre No. 3, it is recommended that a dyke be constructed from just east of Moody's Motel northerly and thence westerly to Brock Road, as shown on the accompanying Drawing No. 1. This location would protect the properties in this area which are now flooded on a regular basis.
4. A number of alternative routes for the dykes have been considered. The routes proposed are intended to cause the least effect on the natural environment. The proposed routes, to the maximum extent possible, are located on land already owned by the Authority.

5. Because the additional cost of providing protection to the 500 year flood level is minimal, it is recommended that protection to this level should be seriously considered.

References

REFERENCES

1. ACRES LIMITED, "Guidelines for Analysis Streamflows, Flood Damages, Secondary Flood Control Benefits", August 1968

2. M. M. DILLON LTD. and JAMES F. MacLAREN LIMIED, "Flood Plain Criteria and Management Evaluation Study", December 1979

3. R. K. KILBORN & ASSOCIATES, "Duffin Creek Report on Flood Control and Water Conservation", December 1962

4. JAMES F. MacLAREN LIMITED, "Report on a Flood Damage Analysis and Remedial Works Study for the Metropolitan Toronto and Region Conservation Authority", June 1980

5. JAMES F. MacLAREN LIMITED, "Report on Hydrologic Model Study - Humber, Don and Rouge Rivers, Highland, Duffin, Petticoat and Carruther's Creeks for the Metropolitan Toronto and Region Conservation Authority", October 1979

6. MARSHALL, MACKLIN, MONAGHAN LIMITED, "Preliminary Engineering Study of Flood Protection in the Village of Bolton on the Humber River for the Metropolitan Toronto and Region Conservation Authority", March 1981

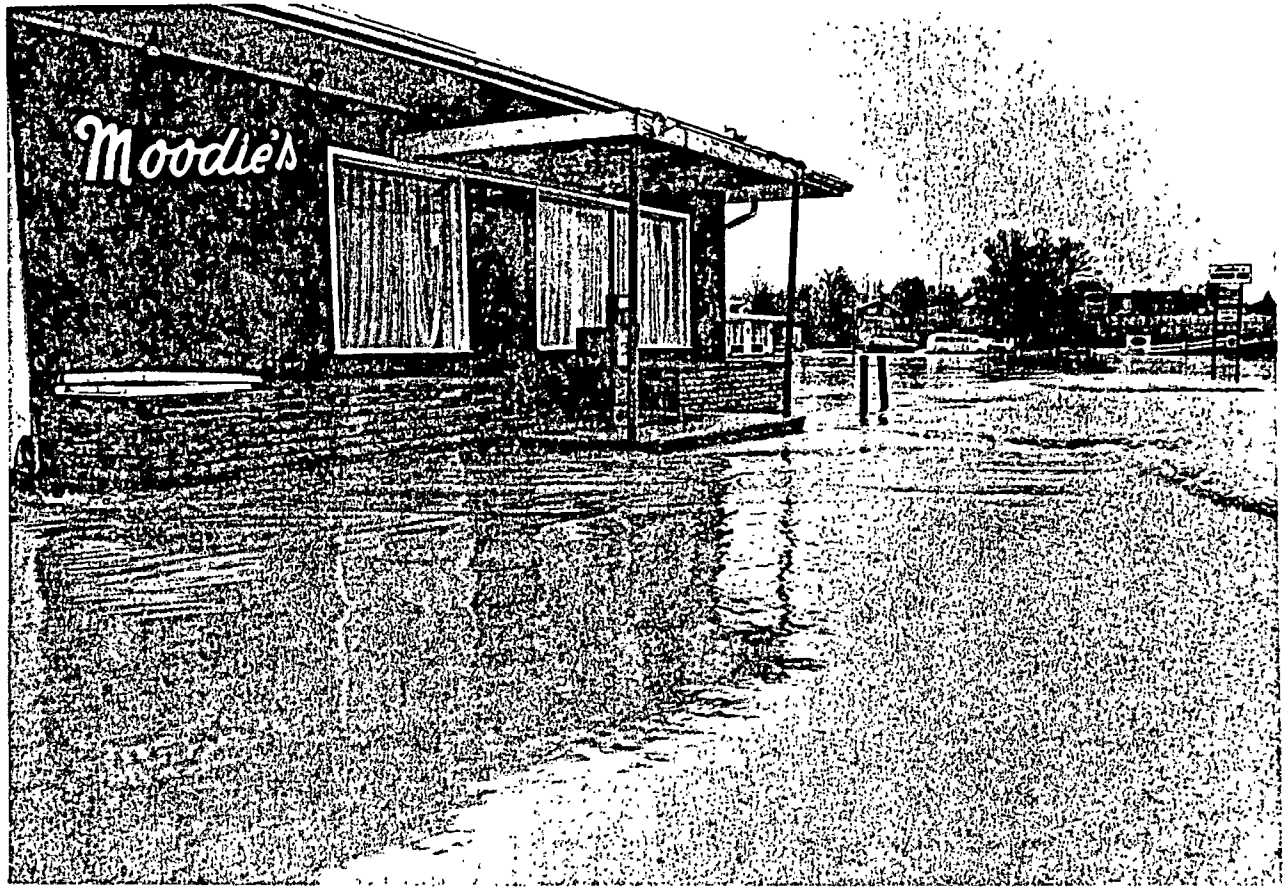
7. PROCTOR & REDFERN LIMITED, "Environmental Evaluation of Flood Damage Centres", November 1979

Appendix 1

Documented Flooding Spring of 1980

1. FLOODING AT CNR DUFFIN CREEK BRIDGE, LOOKING NORTH
   Photo Courtesy The News Advertiser

2. FLOODING AT FORMER USED CAR LOT NORTH OF HWY NO. 2
(Now a Home Video Centre)
Photo Courtesy The News Advertiser



3. FLOODING AT MOODIES MOTEL - HWY. NO. 2
Photo Courtesy The News Advertiser

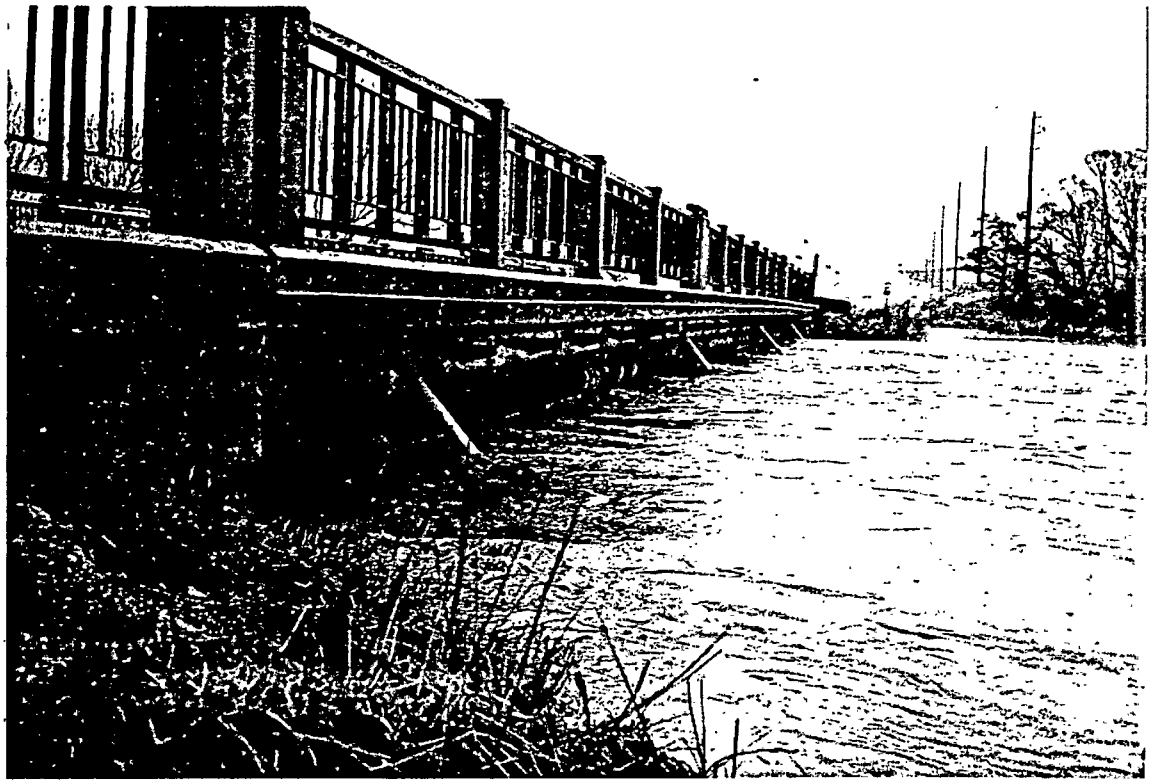
4. FLOODING AT STRUCTURE 36 - HWY No. 2
Photo Courtesy The News Advertiser

5. FLOODING AT BAYLY STREET, LOOKING WEST

6. FLOODING AT BAYLY STREET, LOOKING WEST

7. FLOODING AT BAYLY STREET LOOKING EAST

8. FLOODING AT BAYLY STREET LOOKING SOUTH



9. FLOOD LEVEL AT BAYLY STREET BRIDGE, DOWNSTREAM SIDE

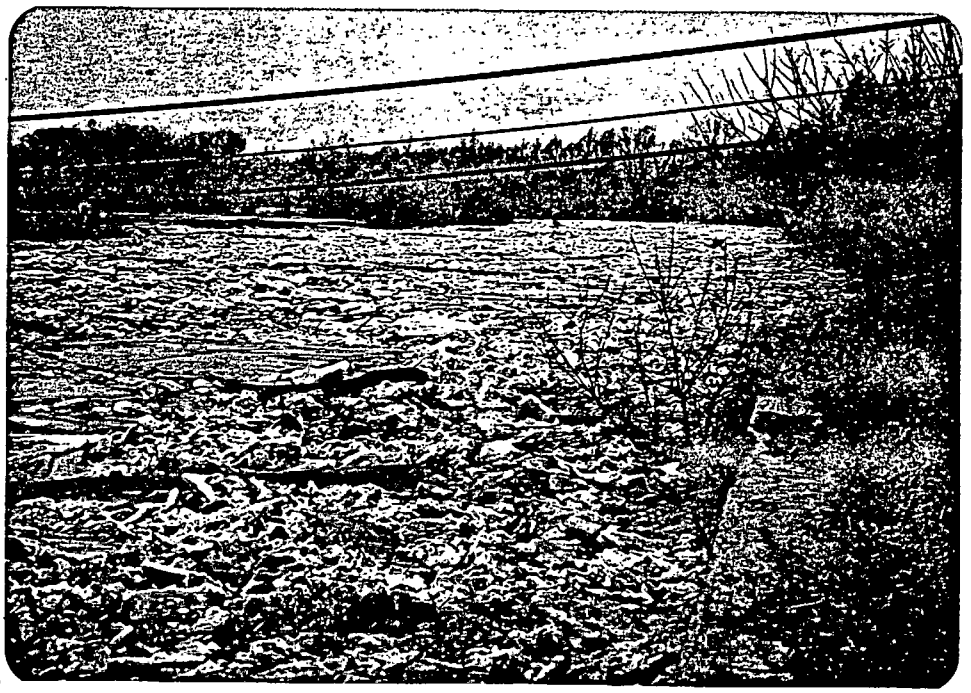
10. FLOOD LEVEL AT BAYLY STREET BRIDGE, UPSTREAM SIDE

PHOTOGRAPHS 11 to 24 COURTESY OF MTRCA

11. ICE JAM BELOW HWY. NO. 2

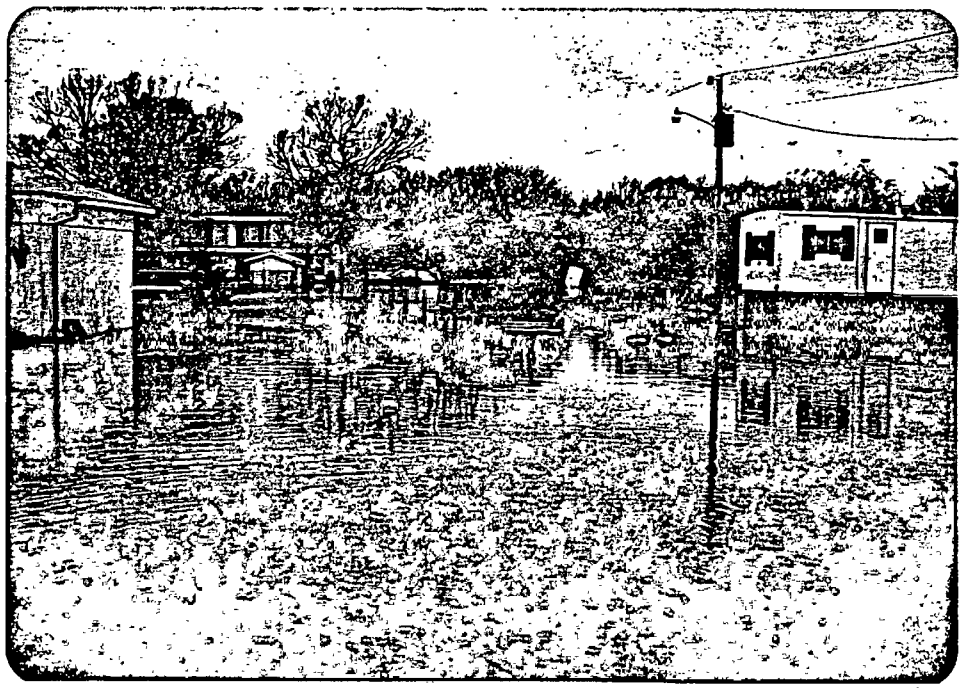
12. ICE JAM ABOVE HWY. NO. 2

13. FLOODING NORTH OF HWY NO. 2, LOOKING NORTHEAST

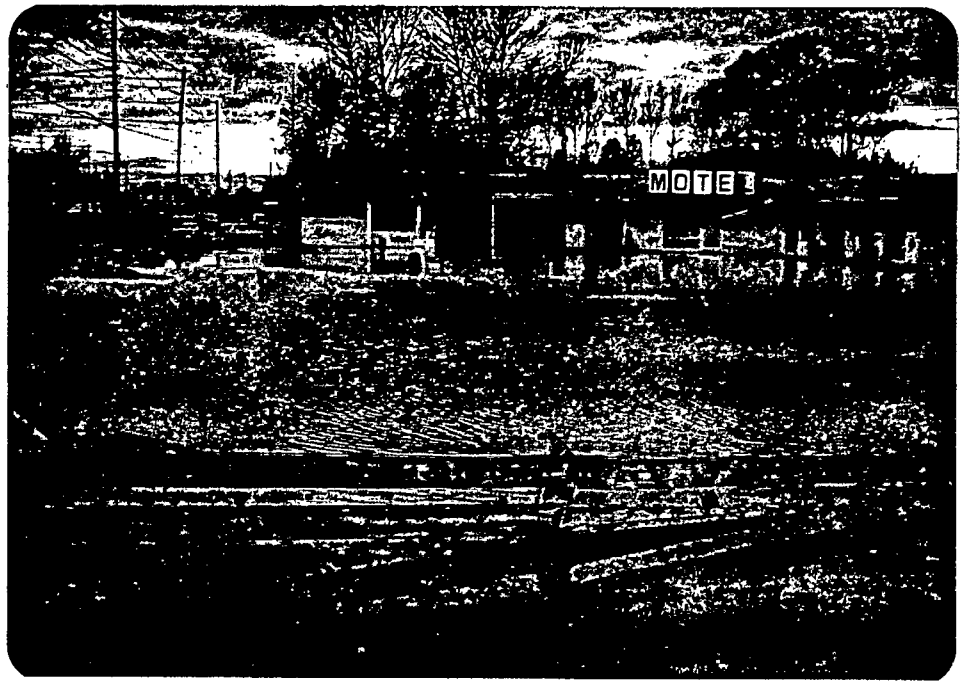


14. ICE JAM ABOVE HWY NO. 2

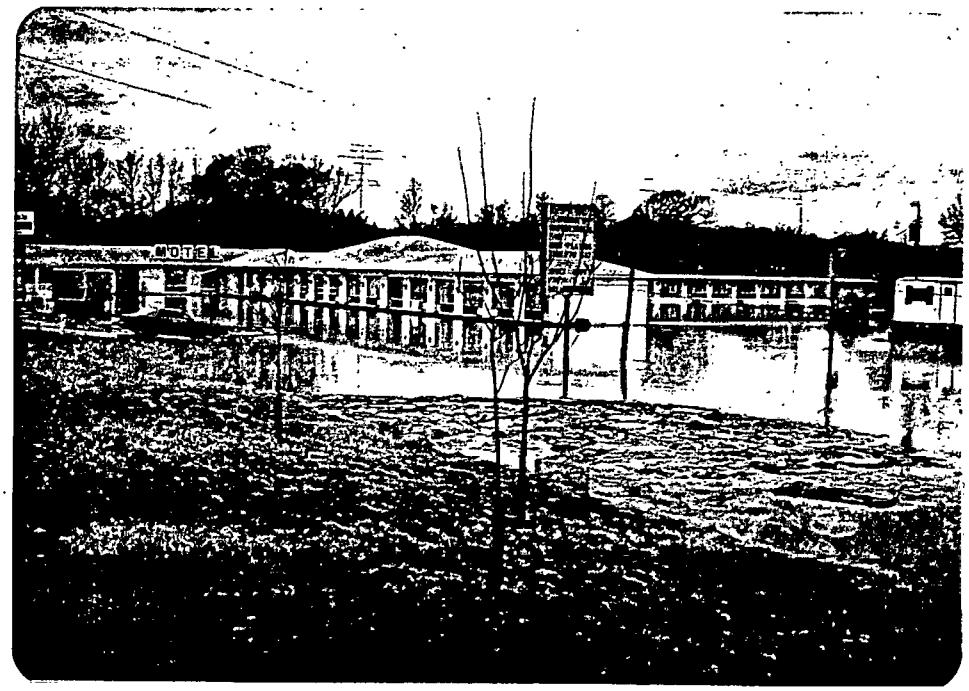
15. ICE AT CONFLUENCE OF NORTH AND WEST BRANCHES



16. FLOODING AT STRUCTURES 37, 38 and 39



17. FLOODING AT STRUCTURE 37



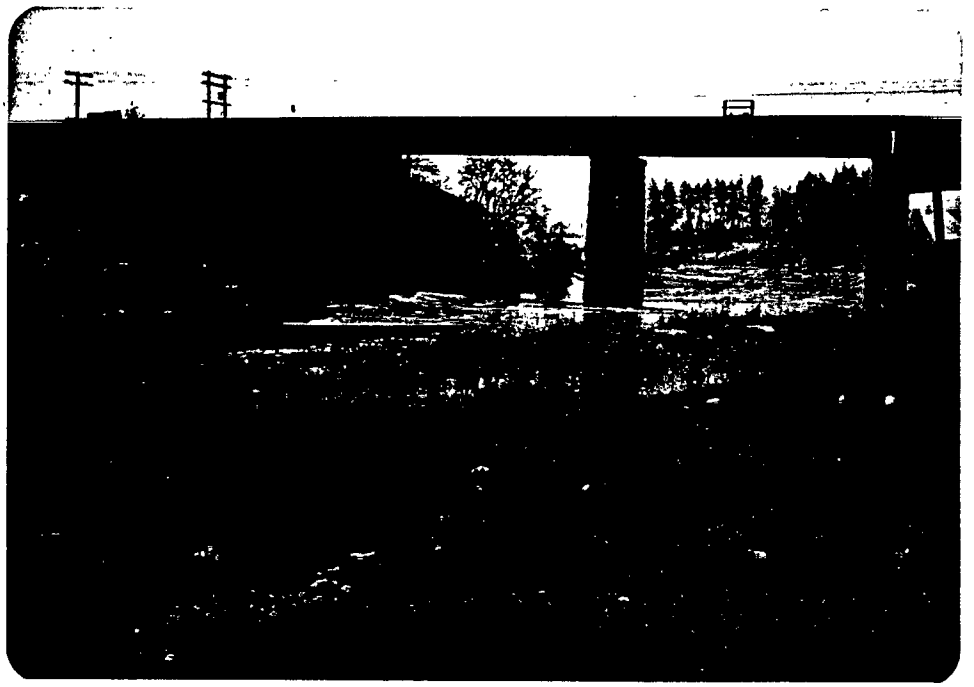
18. FLOODING AT STRUCTURES 37, 38 and 39

19. FLOODING AT STRUCTURE 37

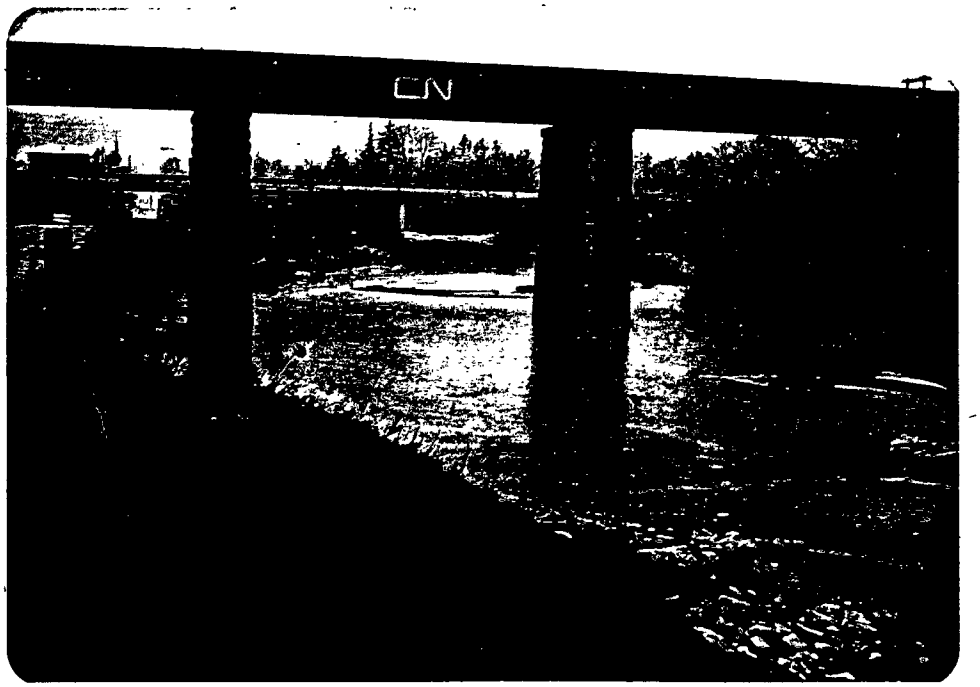
20. FLOODING AT STRUCTURES 37, 38 and 39

21. FLOODING AT STRUCTURE 39

22. FLOODING AT STRUCTURES 35 and 36



23. FLOODING AT CNR OVERPASS, LOOKING SOUTH



24. FLOODING AT CNR OVERPASS, LOOKING NORTH

Appendix 2

Responses of Interested Parties

Simcoe

81 09 09
RC 262.01

Mr. D. J. Low
Chief Administrative Officer
Town of Ajax
65 Harwood Avenue South
Ajax, Ontario
L1S 2H9

Dear Mr. Low:

Re: Metropolitan Toronto and Region
Conservation Authority
Preliminary Study for the Duffin Creek

We have recently been retained by the Metropolitan Toronto and Region Conservation Authority to undertake a preliminary engineering study on the protection of properties from flooding along the Duffin Creek, in the area generally north of Highway 401 and east of Brock Road. The attached plan generally indicates the lands which will be addressed in the study. In general, the purpose of our engagement is to study various methods of protection for existing and future properties within the flood plain.

To ensure that we can obtain up-to-date information on matters such as prospective development changes, and various municipal services, such as roads, storm sewers, etc., we would like to meet with the respective departments of the Town to discuss these matters as part of our engineering function. We would be grateful, therefore, if you could make the appropriate arrangements for us to do so.

Yours very truly,

SIMCOE ENGINEERING LIMITED

T. Fowle, P. Eng.
President

TF/jw

cc: Mr. D. Hailey, M.T.R.C.A.

RCS-

Simcoe

81 09 09
RC 262.01

Mr. N. C. Marshall
Town Manager
Town of Pickering
1710 Kingston Road
Pickering, Ontario
L1V 1C7

Dear Mr. Marshall:

Re: Metropolitan Toronto and Region
Conservation Authority
Preliminary Study for the Duffin Creek

We have recently been retained by the Metropolitan Toronto and Region Conservation Authority to undertake a preliminary engineering study on the protection of properties from flooding along the Duffin Creek, in the area generally north of Highway 401 and east of Brock Road. The attached plan generally indicates the lands which will be addressed in the study. In general, the purpose of our engagement is to study various methods of protection for existing and future properties within the flood plain.

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Yours very truly,

SIMCOE ENGINEERING LIMITED

T. Fowle, P. Eng.
President

TF/jw

cc: Mr. D. Hailey, M.T.R.C.A.

81 09 11
RC 262.01

Mr. D. R. Evans, P. Eng.
Chief Administrative Officer
Regional Municipality of Durham
Works Department
105 Consumers Drive
Whitby, Ontario
L1N 1C4

Dear Mr. Evans:

Re: Metropolitan Toronto and Region
Conservation Authority
Preliminary Study for the Duffin Creek

We have recently been retained by the Metropolitan Toronto and Region Conservation Authority to undertake a preliminary engineering study on the protection of properties from flooding along the Duffin Creek, in the area generally north of Highway 401 and east of Brock Road. The attached plan generally indicates the lands which will be addressed in the study. In general, the purpose of our engagement is to study various methods of protection for existing and future properties within the flood plain.

To ensure that we can obtain up-to-date information on matters such as prospective development changes, and various municipal services, such as roads, sewers, etc., we would like to meet with the respective departments of the Region to discuss these matters as part of our engineering function. We would be grateful, therefore, if you could make the appropriate arrangements for us to do so.

Yours very truly,

SIMCOE ENGINEERING LIMITED

T. Fowle, P. Eng.
President

TF/jw

cc: Mr. D. Hailey, M.T.R.C.A.

262.01

RECEIVED

SEP 24 1981

SIMCOE ENGINEERING LTD.

DURHAM

The Regional
Municipality
of Durham

605 Rossland Road East
P.O. Box 623,
Whitby, Ontario
Canada. L1N 6A3
(416) 668-7711

DONALD R. EVANS, M.A.Sc., P.Eng.
Chief Administrative Officer

September 22nd, 1981

RLS

Mr. T. Fowle, P.Eng.,
President,
Simcoe Engineering Limited,
345 Kingston Road,
PICKERING, Ontario
L1V 1A1

Dear Mr. Fowle:

Re: Metropolitan Toronto and Region
Conservation Authority
Preliminary Study for the Duffin Creek

In response to your letter to me of September 11, 1981 and our subsequent telephone conversation, I am attaching hereto a copy of an interoffice memorandum to the three departments of the Region that you wish to contact in connection with this study.

If my office can be of further assistance, please advise.

Yours truly,

D.R. Evans, P.Eng.,
Chief Administrative Officer.

nc
Encl.

262.01

THE TOWN OF PICKERING

1305 Sheridan Mall Parkway, Pickering, Ontario L1V 3P2
(416) 683-2760

RECEIVED
OCT 6 1981
SIMCOE ENGINEERING LTD.

Quote File A2160

1981 09 24

Simcoe Engineering Limited,
Consulting Engineers,
1355 Kingston Road,
Pickering, Ontario.

Attention: Mr. T. Fowle, P.Eng.,
President

Dear Sir:

Re: Metropolitan Toronto and Region Conservation Authority - Duffins Creek

A copy of your letter of September14th, 1981 addressed to the Town Manager has been passed to this department for response.

From the points noted in your letter it appears that your information would be obtained from both the Planning and the Public Works Departments.

If you wish to set up a joint meeting please advise the writer and we will endeavour to make arrangements at an early date.

Yours very truly,

R. J. Hutchinson

R.J. Hutchinson,
Director of Public Works.

RJH/wd.
c.c. Noel C. Marshall, Town Manager
T. Magi, Director of Planning

M E M O R A N D U M

TO: File 81 10 13

FROM: R. L. Smith RC 262.01

Re: Meeting with Town of Pickering

A meeting was held with Mr. Ray Hutchinison, Commissioner of Works, and Mr. Toni Magi, Director of Planning, for the Town of Pickering.

The nature of the study was explained. It was indicated that certain information would assist the overall preparation of this study.

1. Any special planning information to be considered.

2. Plans indicating drainage for the area.

3. Property owned by municipality.

4. Plans for reconstruction of roads, etc. in the area.

The following information was obtained:

a) Area south of Highway No. 2 east of Brock Road is being developed by Cadillac. Area north of Highway No. 2 and west of Brock Road is proposed for light commercial (2-storey maximum) and/or residential.

b) Existing drainage consists of ditches only.

c) No plans for any road reconstruction in the area.

d) Existing soils conditions north of Highway No. 2 allow for only 2-storey construction.

e) No property owned by Town other than Municipal Building.

81 10 13
RC 262.01

Town of Ajax,
65 Harwood Avenue South,
Ajax, Ontario.
L1S 2H9

Attention: Mr. L. G. Bradley,
Recreation Director
Parks & Recreation Department

Gentlemen:

Re: Engineering Study for Duffin Creek

We wish to thank you for our meeting of October 9th, 1981 to discuss our preliminary engineering study on the Duffin Creek.

As discussed at our meeting, the purpose of this study is to investigate methods of protection of properties in flood prone areas of the Duffin Creek, generally north of Highway 401 and east of Brock Road in the Town of Pickering.

In order to undertake this study, certain information from the Town would assist the overall preparation and presentation of this study. Included would be the following:

1. Any information with respect to planning additions, deletions, etc. with respect to the area in question.
2. Plans indicating details of drainage for the area and, in particular, storm sewers, including proposed outlets, inverts of these outlets, etc.
3. Property owned by the municipality in the area.
4. Any other plans for reconstruction, such as road reconstruction, etc. that might effect a study of this nature.

We will attempt to keep you informed during the course of the project to ensure that every aspect of this study is suitably reviewed and maintained.

Yours very truly,
SIMCOE ENGINEERING LIMITED

R. L. Smith, P. Eng.

RLS/jr

81 10 13
RC 262.01

Town of Ajax,
65 Harwood Avenue South,
Ajax, Ontario.
L1S 2H9

Attention: Mr. B. Martindale

Gentlemen:

Re: Engineering Study for Duffin Creek

We wish to thank you for our meeting of October 9th, 1981 to discuss our preliminary engineering study on the Duffin Creek.

As discussed at our meeting, the purpose of this study is to investigate methods of protection of properties in flood prone areas of the Duffin Creek, generally north of Highway 401 and east of Brock Road in the Town of Pickering.

In order to undertake this study, certain information from the Town would assist the overall preparation and presentation of this study. Included would be the following:

1. Any information with respect to planning additions, deletions, etc. with respect to the area in question.
2. Plans indicating details of drainage for the area and, in particular, storm sewers, including proposed outlets, inverts of these outlets, etc.
3. Property owned by the municipality in the area.
4. Any other plans for reconstruction, such as road reconstruction, etc. that might effect a study of this nature.

We will attempt to keep you informed during the course of the project to ensure that every aspect of this study is suitably reviewed and maintained.

Yours very truly,
SIMCOE ENGINEERING LIMITED

R. L. Smith, P. Eng.

RLS/jr
cc: Mr. F. J. Hall,
City Engineer

262.01

TOWN OF AJAX

OFFICE OF THE
PLANNING DIRECTOR
(416) 686-1141

65 HARWOOD AVENUE AJAX, ONTARIO, L1S 2H9

October 28, 1981

RECEIVED
OCT 29 1981
SIMCOE ENGINEERING LTD.

Mr. R.L. Smith, P. Eng.,
Simcoe Engineering Limited,
Consulting Engineers,
Simcoe Building,
345 Kingston Road,
Pickering, Ontario
L1V 1A1

Dear Mr. Smith:

Re: Engineering Study - Duffin's Creek

Further to your letter of October 13th, this will confirm our statement made at the October 9th meeting that the study area is predominantly developed as low-density residential east of the creek and heavy industrial west of the creek. Very limited in-filling may occur in the Orchard Road area subject to fill permits being obtained from Metro Toronto & Region Conservation Authority. On the west side of Church Street south of the apartment building some potential for re-development of the existing single family homes to medium density housing exists, subject to M.T.R.C.A. approval.

The Town does not own any property in the study area.

I assume the Director of Works is responding to questions 2 and 4 of your letter.

Yours truly,

R. Martindale,
Planning Director

RM/db

c.c. F.J. Hull, Director of Works

Simcoe

MEMORANDUM

TO: File 82 01 20

FROM: T. Sloley RC 262.01

PRELIMINARY ENGINEERING STUDY
MTRCA - DUFFINS CREEK IN PICKERING/AJAX

Minutes of a meeting held on Thursday, January 14, 1982, 1.00 p.m. at Duffin Creek in Pickering.

Present: T. Sloley, Simcoe; J. Doan, MTRCA.

A meeting was held to discuss possible changes in proposed berm alignment north of Hwy. # 2 and the incurring environmental impacts. The following comments were made:

1. The dead tree (woodpecker nesting site) mentioned in the Biological inventory could be removed to facilitate the construction of the berm, however, it should be pushed aside and left to rot rather than be removed from the site.

2. The walnut sapling mentioned in the Biological inventory was deemed of low environmental significance due to its poor condition and could be removed to facilitate construction of the berm.

3. The spruce saplings in the Zone of potential impact outlined in the Biological inventory were deemed important and that care should be taken to remove as few as is necessary to facilitate construction of the berm.

4. If an access road is required along the side of the berm during construction, it should be placed along the north side of the berm through the Zone of potential impact as shown in the Biological inventory to prevent further removal of spruce saplings.

5. Measures should be taken to prevent silt from entering Duffins Creek when constructing the berm. This will be critical where the berm is to be constructed beside Duffins Creek, near Brock Road.

6. The overall change in proposed alignment to follow Conservation Authorities property line is acceptable, however, it was stressed that care should be taken during construction to remove a minimum of trees.

7. It was agreed that the Biological inventory would be finalized, as soon as possible, so that it might be included in the Simcoe report.

c.c. Janice Doan, MTRCA
Don Haley, MTRCA

Ajax Historical Board

January 27, 1982

Mr. Tom Fowle,
Simcoe Engineering Limited,
345 Kingston Road,
PICKERING, Ontario.

Dear Mr. Fowle,

At the regular meeting of the Ajax Historical Board on January 14th, 1982, the Chairman reported on a study your firm is doing on Duffins Creek. The members noted the previous location of the Lockwood Mill, and the site of the Methodist Cemetary on Elizabeth Street.

However, it was decided that the Board had no imput to the study.

Yours truly,

J. Swenson,
Chairman.

JS mf

Appendix 3

Terms Of Reference

APPENDIX 3

TERMS OF REFERENCE

The proposed Terms of Reference as originally prepared for this study, include, but are not limited to the following items:

1. The consultant will become familiar with the various policies and criteria pertinent to the Flood Control Program of the Authority.

2. The consultant will review all available information, including the reports completed on this area.

3. The consultant will utilize the flows and flood lines prepared for the Authority.

4. The consultant will review the economic evaluation prepared by James F. MacLaren Limited for the Town of Pickering in terms of average annual flood damage and refine it, if necessary.

5. Utilizing the information regarding the level of flooding under various floods, and the expected range of flood damage, the consultant will identify and evaluate alternative methods of solving the flood problem and provide a minimum level of protection to the one in one hundred and fifty year flood. This evaluation must include technical, economic, social and environmental factors.

6. The consultant should indicate whether soil borings will be required.

7. The consultant will provide alternative solutions and associated costs for providing levels of protection greater than the minimum specified.

8. The consultant will evaluate any environmental concerns and include any mitigative measures necessary to protect sensitive or significant areas identified by the Authority. In view of the fact that the proposed solution may require a complete environmental assessment to meet the requirements of the Environmental Assessment Act, the consultant should discuss this aspect with the Authority at an early stage, to design a monitoring program, if necessary.

9. The consultant will discuss the alternative solutions with the staff of the Metropolitan Toronto & Region Conservation Authority and the Ministry of Natural Resources and in conjunction with the Metropolitran Toronto & Region Conservation Authority and the Ministry of Natural Resources, select the most appropriate. In light of technical, economic, social and environmental factors, the consultant will evaluate alternative construction measures and materials for undertaking the selected remedial measure.

10. The consultant will discuss the alternative construction techniques and materials with the staff of the Metropolitan Toronto & Regional Conservation Authority and the Ministry of Natural Resources and then in conjunction with the Metropolitan Toronto & Region Conservation Authority and the Ministry of Natural Resources, select the most appropriate means.

11. The level of design required for the selected alternative should be sufficient for accurate cost estimates. Definitive limits of property requirements must also be provided.

12. The consultant will prepare three copies of the draft report for approval by the Metropolitan Toronto & Region Conservation Authority and the Ministry of Natural Resources.

13. After receiving written approval from the Ministry of Natural Resources and the Metropolitan Toronto & Region Conservation Authority, the consultant will finalize the report and prepare twenty-five (25) copies of the report.

Appendix 4

Inventory of Structures & Flood Damages

TABLE A4-1

INVENTORY OF STRUCTURES IN REGIONAL FLOOD PLAIN

STRUCTURE NUMBER	LAND USE	TYPE OF STRUCTURE	DAMAGE FACTOR	COMMENTS
1	Residential	Wood Frame Garage		poor condition
2	Residential	CW	.78	
3	Residential	BB	1.0	
4	Residential	BB	1.0	
5	Residential	BB	1.0	
6	Residential	BB	1.0	
7	Residential	AW	2.14	
8	Residential	BB	1.0	duplex
9	Residential	AB	2.55	
10	Residential	BB	1.0	
11	Residential	AB	2.55	
12	Residential	BW	1.0	
13	Residential	BW	1.0	
14	Residential	BW	1.0	
15	Residential	BW	1.0	
16	Residential	CW	.78	
17	Residential	BB	1.0	Wooden outbuilding on property
18	Residential	BW	1.0	
19	Residential	BW	1.0	
20	Residential	BW	1.0	
21	Residential	AB	2.55	
22	Residential	BB	1.0	
23	Residential	BB	1.0	
24	Residential	AB	2.55	

TABLE A4-1 cont'd

STRUCTURE NUMBER	LAND USE	TYPE OF STRUCTURE	DAMAGE FACTOR	COMMENTS
25	Residential	BB	1.0	Wooden outbuilding on property
26	Residential	BB	1.0	Wooden outbuilding on propety
27	Residential	CW	.78	
28	Commercial	brick		Post office
29	Commercial	concrete block		Car dealership with approx. 200 car inventory
30	Residential	wood		Barns and garage
31	Residential	BW	1.0	
32	Residential	CW	.78	
33	Residential	BW	1.0	
34	Residential	BW	1.0	
35	Residential	BB	1.0	
36	Residential	BB	1.0	
37	Commercial	Concrete Block		Motel
38	Commercial	Concrete Block		Motel
39	Commercial	Trailer		Home Video Sales
40	Residential	BW	1.0	
41	Residential	BB	1.0	
42	Residential	BB	1.0	
43	Residential	BB	1.0	
44	Residential	AB	2.55	
45	Residential	AB	2.55	
46	Residential	AB	2.55	
47	Residential	BB	1.0	

STRUCTURE NUMBER	LAND USE	TYPE OF STRUCTURE	DAMAGE FACTOR	COMMENTS
48	Residential	BB	1.0	
49	Residential	AB	2.55	
50	Residential	BB	1.0	
51	Residential	AB	2.55	
52	Residential	AB	2.55	
53	Residential	AB	2.55	
54	Residential	BB	1.0	
55	Residential	AB	2.55	
56	Residential	BW	1.0	
57	Residential	BW	1.0	
58	Residential	BW	1.0	
59	Residential	AW	2.55	
60	Residential	BW	1.0	
61	Residential	AB	2.55	
62	Residential	BW	1.0	
63	Residential	BB	1.0	
64	Residential	BW	1.0	
65	Residential	BW	1.0	
66	Residential	BW	1.0	
67	Residential	BW	1.0	
68	Residential	BW	1.0	
69				Barn (abandoned)
70	Residential	AB	2.55	
71	Residential	AB	2.55	
72	Commercial			Lumber and building supplies
73	Industrial			
74	Commercial			

STRUCTURE NUMBER	LAND USE	TYPE OF STRUCTURE	DAMAGE FACTOR	COMMENTS
75	Commercial			Fencing company
76	Commercial			
77	Commercial			
78	Commercial			
79	Commercial			
80	Commercial			
81	Industrial			Appears to be vacant
82	Commercial			Appears to be vacant
83	Commercial			
84	Commercial			
85	Commercial			
86	Residential	BW		Abandoned
87	Commercial			
88	Industrial			Appears to be in disuse
89	Commercial			
90	Utility			Hydro substation
91	Industrial			
92	Commercial			
93	Industrial			
94	Commercial			
95	Industrial			
96	Commercial			
97	Industrial			
98	Utility			Abandoned WPCP
99	Residential	CW		Abandoned
100	Commercial			

STRUCTURE NUMBER	LAND USE	TYPE OF STRUCTURE	DAMAGE FACTOR	COMMENTS
101	Commercial			
102	Industrial			
103	Industrial			
104	Residential	CB		Abandoned
105	Industrial			Appears vacant
106	Commercial			Auto wreckers
107	Residential	BB		Condominium Townhouses
108	Residential			Apartment building

TABLE A4-2

STRUCTURES AFFECTED BY 25 YEAR FLOOD

STRUCTURE NO.	DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
25 out building	0	-
26 out building	0	-
32	0.3	5,600
33	0	5,000
34	0.3	7,200
35	0.3	7,200
36	0.3	9,800
37	0.3	15,000
38	0.3	15,000
39		0
2	0	5,000
1	0	500
		$70,300

TABLE A4-3

STRUCTURES AFFECTED BY 100 YEAR FLOOD

STRUCTURE NO.		DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
25	out building	0.1	500
26	out building	0.1	500
19		0.3	7,400
18		0	5,000
16		0.3	5,800
29		0	0
30		0.2	1,000
31		0	6,400
32		0.4	6,600
33		0.2	5,000
34		0.5	9,600
35		0.5	9,600
36		0.8	12,800
37		0.8	40,000
38		0.8	40,000
39	trailer	0	0
86		0	0
88		0.1	200
5		0	5,000
3		0	5,000
2		0	5,000
1		0.5	500
			$165,900

TABLE A4-4

STRUCTURES AFFECTED BY 150 YEAR FLOOD

STRUCTURE NO.	DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
88	0.1	200
86	0	0
39	0	0
38	1.0	50,000
37	1.0	50,000
36	1.0	14,500
35	0.7	12,000
34	0.7	12,000
33	0.4	6,600
32	0.6	8,600
31	0.4	8,500
30	0.2	1,000
16	0.3	5,800
18	0.0	5,000
19	0.3	7,400
25 (out building)	0.1	500
26 (out building)	0.1	500
1	0.7	500
2	0.6	8,600
3	0	5,000
4	0	5,000
5	0	5,000
29	0	-
		206,700

TABLE A4-5

STRUCTURES AFFECTED BY 350 YEAR FLOOD

STRUCTURE NO.	DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
1	1.2	1,500
2	1.0	11,300
3	0.4	8,400
4	0.4	21,400
5	0.4	21,400
6	0	5,000
13	0	5,000
14	0.3	7,400
15	0.3	7,400
20	0.3	7,400
21	0.1	14,300
22	0	5,000
29	0.1	24,400
88	0.4	1,000
86	0	-
39	0.2	2,100
38	1.5	75,000
37	1.5	75,000
36	1.5	20,000
35	1.0	14,500
34	1.0	14,500
33	0.6	11,000
32	0.8	10,000
31	0.6	11,000
30	0.4	1,500
16	0.4	6,600
18	0	5,000
19	0.4	8,400
25 (out building)	0.1	500
26 (out building)	0.1	500
		396,500

TABLE A4-6

STRUCTURES AFFECTED BY 500 YEAR FLOOD

STRUCTURE NO.	DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
1	1.3	1,500
2	1.1	12,100
3	0.5	9,800
4	0.5	25,000
5	0.5	25,000
6	0	5,000
12	0	5,000
13	0.1	5,700
14	0.4	8,500
15	0.4	8,500
20	0.3	7,400
21	0.1	14,300
22	0	5,000
29	0.1	24,400
88	0.5	1,225
86	0.2	-
34	0.3	3,200
38	1.5	75,000
37	1.5	75,000
36	1.5	20,000
35	1.0	14,500
34	1.0	14,500
33	0.6	11,000
32	0.8	10,000
31	0.6	11,000
30	0.4	1,500
16	0.4	6,600
18	0.1	5,700
19	0.4	8,400
25	0.1	500
26	0.1	500
17	0	5,000
		420,825

TABLE A4-7

STRUCTURES AFFECTED BY REGIONAL FLOOD

STRUCTURE NO.	DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
1	4.0	1,500
2	4.0	2,500
3	4.0	50,000
4	3.4	50,000
5	3.5	50,000
6	3.0	30,000
7	2.5	30,000
8	2.0	60,000
9	0.3	18,900
10	1.5	20,000
11	2.0	60,000
12	2.5	45,000
13	3.0	40,000
14	3.3	45,000
15	3.3	45,000
107	0	15,000
108	0.4	118,300
16	2.3	30,000
17	1.7	22,000
18	1.8	22,500
19	1.8	22,500
20	2.0	30,000
21	1.5	51,000
22	1.3	17,800
23	1.0	14,600
24	1.0	37,200
25	1.0	14,600
26	0.9	13,600
27	0.6	8,600
28	0.5	121,900
29	1.9	1,702,100
59	0	12,800
60	0	5,000
61	0.6	28,000
62	0.3	7,400
62	0.3	7,400
64	0.4	8,400
65	0.5	9,700
66	0.4	8,400
67	0.3	7,400
68	0.2	6,400
69	0.4	-
30	2.5	16,000
31	2.7	35,000
32	2.8	15,000
33	2.6	30,000

TABLE A4-7
STRUCTURES AFFECTED BY REGIONAL FLOOD (cont'd)

STRUCTURE NO.	DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
34	2.7	40,000
35	2.7	45,000
36	2.9	45,000
37	3.0	100,000
38	3.0	100,000
39	2.0	21,100
40	0.6	11,000
41	0.6	11,000
42	0.1	5,700
43	0.1	5,700
44	0.2	16,300
45	0.6	28,000
46	0	12,800
47	0.6	11,000
48	0.6	11,000
49	0	12,800
50	1.0	5,700
51	0	12,800
52	1.0	36,700
53	1.3	48,500
54	1.3	19,000
55	1.6	53,500
56	2.0	55,000
57	2.2	45,000
58	2.5	45,000
70	2.1	60,000
71	2.3	60,000
72	2.4	650,000
73	2.2	136,500
74	2.2	10,000
75	1.2	76,700
76	1.2	70,200
77	1.0	68,300
78	1.0	146,250
79	1.0	68,300
80	1.0	73,200
81	1.0	29,250
82	2.8	52,000
83	2.1	130,000
84	2.0	1,508,000
85	2.0	292,500
86	2.9	-
87	2.5	224,300
88	3.0	4,900
89	1.5	380,300
90	1.4	100,000
91	1.2	1,113,800

TABLE A4-7
STRUCTURES AFFECTED BY REGIONAL FLOOD (cont'd)

STRUCTURE NO.	DEPTH OF FLOODING ABOVE 1ST FLOOR	DAMAGE (Dollars)
92	0.6	29,300
93	1.3	41,800
94	1.3	33,800
95	1.6	468,000
96	1.6	103,400
97	2.0	199,900
98	2.2	-
99	0.9	-
100	1.7	331,500
101	1.7	331,500
102	0.8	-
103	0	-
104	0.1	-
105	0.6	-
106	0.5	2,900
		10,581,700

Appendix 5

Environmental Considerations for the Planning & Construction of On - Site Flood Control Structures


LEGEND
Flood Line - 150 years
Flood Line - 350 years
Flood Line - 500 years
Convergence Of Flood Lines
M.T.R.C.A. Property Line
Dyke
Points Of Access
Drainage Structure
Area Protected By 500 year Flood Dyke
Regional Storm Flood Line
Fill Regulation Line
Connection To Road Embankment Required
Flow Gate Required At This Location To Prevent Backflow
Easement Requirement To Allow Connection To Existing Embankment
TOWN OF AJAX
TOWN OF PICKERING
CONTOUR INTERVAL 1 METRE: AUXILIARY CONTOUR INTERVAL .5 METRES
Scale 1:2000
Metres
Feet
the metropolitan toronto and region conservation authority
5 Shoreham Drive, Downsview, Ontario
M3N 1S4
PRELIMINARY ENGINEERING STUDY FOR FLOOD PROTECTION ON THE DUFFIN CREEK IN THE PICKERING - AJAX AREA.
Simcoe
Simcoe Engineering Limited • Consulting Engineers
N

ENVIRONMENTAL CONSIDERATIONS FOR THE PLANNING AND CONSTRUCTION OF ON-SITE FLOOD CONTROL STRUCTURES

ENVIRONMENTAL CONSIDERATIONS FOR THE PLANNING AND CONSTRUCTION OF ON-SITE FLOOD CONTROL STRUCTURES

Introduction

1. General Planning Considerations

(a) Method of Carrying Out the Undertaking

Where possible, the method of carrying out the undertaking should be the least environmentally damaging. The order of preference is as follows for channel improvements: grass; riprap; gabion basket; concrete. Other environmental considerations such as sensitive terrestrial vegetation or wildlife habitat near the stream may change the order of preference in specific cases. Drop structures that inhibit the movement of fish should be avoided unless no alternative exists.

(b) The following streams, or parts of, have been designated as sensitive (types 1, 2 and 3, Section II.3):

(i) Duffin Creek and its tibutaries;

(ii) Rouge River north of 25 Side Road;

(iii) Humber River, west branch, north of Bolton;

(iv) other areas as may be determined through investigation.

In the above areas, work can be carried out only during the period June 1 to September 1 to avoid interfering with fish migrations and spawning. In these areas where

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some environmental damage is unavoidable, the protection of the aquatic environment will take precedence over the terrestrial environment, unless some particularly sensitive component of the terrestrial environment will be affected. The opposite will occur in other areas.

(c) The natural stream configuration will be maintained where possible. If river realignment is required then natural stream features should be incorporated, to the extent possible.

2. Working Area Delineation

(a) The boundaries of the working area should be delineated through the use of stakes or snow fencing, as appropriate.

(b) Snow fencing should be placed where the access route is ill defined and any area identified in the Environmental Inventory to be protected. For trees and shrubs the snow fence should be installed no closer than the "drip-line."

(c) The access route to the site should be clearly identified and all traffic to and from the site should be restricted to the designated access route.

3. Construction Workyards

Construction workyards should be kept out of the valley area, be as small as possible and be restored after construction is completed. Mature trees should not be removed or damaged to establish a workyard.

4. Equipment Fueling and Maintenance

(a) Equipment fueling and maintenance should be done in such

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a manner that no fuels, oils, chemicals and other toxic chemicals can gain access to surface or ground waters.

(b) The cleaning of equipment in or near streams is prohibited.

(c) Exhaust emmissions from equipment should be minimized through efficient machine maintenance.

5. Dust and Particulate Control

Dust control measures should be undertaken to prevent dust nuisances resulting from any phase of construction operation. This may include the application of water, calcium chloride or oil. Calcium chloride and oil should not be used near watercourses.

6. Noise Control

(a) All vehicles should be equipped with efficient muffling devices and should be operated in a fashion to minimize noise levels.

(b) Construction should be restricted to daytime hours, or as outlined in local by-laws.

7. Site and Access Preparation

(a) If topsoil is stripped from access route and work site, it should be stockpiled so that it can be replaced following construction.

(b) Stockpiled material should be stored away from the water-course and if necessary protected to prevent erosion.

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(c) Materia ated from watercourse beds should be stockpi isposed of in a manner that will ensure minimum e siltation to the watercourse.

(d) All cle grubbed material should be removed from the sit sposed of at an appropriate disposal site.

8. Protection a enance of Terrestrial Environment

(a) Minimiz moval or damage of vegetation.

(b) If tree s need to be removed, remove flush and apply a paint.

(c) Do not uipment to compact soil within drip line of tree ubs.

(d) When ra ade in the vicinity of vegetation to be protect clean gravel 25 to 50 mm in diameter a minimum of 450 mm and 50 mm above finished grade prior t acement of fill. Do not leave fill in contact unk.

(e) When tr ing vegetation, prune roots and foliage well in and dig earth ball a minimum of twelve times t er of the tree at breast height.

9. Protection a enance of Aquatic Environment

(a) The rem riparian vegetation should be kept to a minimum laced with stock vegetation after constru s necessary.

(b) The use truction equipment on the steam bed should be kept nimum.

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(c) Unless excessive damage will be incurred to the terrestrial environment, construction should, where feasible, be carried out from the top bank rather than the river bed.

(d) Temporary Watercourse Crossing

(i) Time from construction to removal of crossings should be kept to a minimum.

(ii) The removal of vegetation from the slope approaches to the crossing should be kept to a minimum.

(iii) Culvert installation should be made on existing natural grade.

(iv) The fill material should consist of gravel only. A thin layer of fine material may be used on the surface to facilitate vehicle movement.

(v) The crossing should not restrict the normal flows.

(vi) Culverts should not be installed during periods when fish migrations are expected.

(vii) When no longer required, the crossing should be removed and the site restored.

(e) Surface Drainage

(i) Sediment traps consisting of material such as straw bales should be installed to collect sediment before it enters the watercourse.

(ii) Stockpiled material should be protected from erosion.

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(f) Dewatering

When dewatering of part of the stream channel is required to install revetments, coffer dams should be constructed of material that will not increase turbidity.

10. Site Restoration

(a) After the completion of construction activities, disturbed areas should be restored with ground cover, and shrubs or trees, if appropriate.

(b) Restoration should follow immediately after construction. If weather does not permit full restoration, then interim sediment control works should be carried out until such time as full restoration is possible.

(c) Stream crossings should be removed as soon as construction activities will permit. In addition, access roads should be removed and the site restored at such times as their use is no longer required.