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Water Management Study

Of

South Raisin River

CRYSLER & LATHEM LTD.

consulting engineers

CCL CONSULTANTS

RAISIN REGION CONSERVATION AUTHORITY

WATER MANAGEMENT STUDY OF SOUTH RAISIN RIVER

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1.0 INTRODUCTION

By letter dated February 12, 1979, the firm of Crysler & Lathem Ltd. was retained by the Raisin Region Conservation Authority to carry out a water management study of the South Raisin River within the corporate limits of the City of Cornwall and the areas known as Lakeview Heights and Churchill Heights (Rosedale Terrace) outside the city limits. The purpose of the study was to identify areas prone to flooding under the regional storm flood and to develop measures which may be used to mitigate such flooding. These measures will be used to protect existing and proposed development within the study area. In addition, the study was to consider the influence of the Long Sault water diversion on the watershed under both low flow and high water conditions.

The study was based upon terms of reference prepared by the Raisin Region Conservation Authority in consultation with the Eastern Region of the Ontario Ministry of Natural Resources. These terms included the development of regional flood flows based upon the current provincial policy of the 100-year flood and the use of computer models to generate flows and to calculate flood elevations. Topographic maps prepared by J. D. Barnes Limited for the City of Cornwall in 1978 together with additional mapping prepared by Northway Survey Corporation Ltd. for the Raisin Region Conservation Authority at a 1:2000 scale were used for this study. The contour interval for the new mapping was 1 m with 0.5 m interpolations. Floodplain delineations and the consideration of alternate water management techniques were examined by computer modelling.

A partial list of the information used in this study is as follows:

(1) Rainfall records prepared by the Meteorological Branch of Environment Canada,

(2) Topographic maps at a scale of 1:25,000,

(3) Soil Survey of Stormont County, Report No. 20 of the Ontario Soil Survey,

(4) Design Report, Boales Drain, City of Cornwall, by McNeely Engineering Ltd. dated July, 1979;

(5) Raisin River Conservation Report, Department of Energy and Resources Management, 1966.

In addition to the above, information on proposed development for the area was obtained through discussions with the Authority and city staff. Data for estimating flood damage were obtained through discussion with the regional assessment office and real estate agencies in the area. Field surveys were also carried out in sufficient detail that they could be used to check the new topographic mapping for accuracy. Details of channels and hydraulic structures were obtained by transit and tape surveys.

A study of all the above data together with detailed engineering site inspections and engineering calculations has resulted in the findings which are presented in the report which follows.

2.0 SITE DESCRIPTION

The South Raisin River watershed encompasses a drainage area of about 103 km^2 (39.7 square miles). The headwater of the south branch is at Long Sault. From here, the river flows past Lakeview Heights through the City of Cornwall and on down to its confluence with the main branch of the Raisin River at Glendale. The basin of the South Raisin River lies within the Townships of Osnabruck, Cornwall and Charlottenburg within Stormont and Glengarry counties.

The headwaters are at an elevation of approximately 76.2 m (250 feet) above sea level and the river empties into the main branch at an elevation of 46.9 m (154 feet) above sea level. The total drop is 29.3 m (96 feet) in a distance of 33 km (20.5 miles) giving an average slope of 0.09% in the channel. This relatively flat channel gradient tends to impede the discharge of flood flows and increase the potential for flooding of valley lands.

Within the city limits there are three drains of concern to the Authority. They are the Henderson, Boales and the Cardinal Motel drains. In addition, the Eastman Drain immediately north of the city limits is of concern due to pressures for development. The capacities of these drains have been analyzed as part of this study.

3.0 HYDROLOGY OF THE WATERSHED

The science of hydrology deals with the occurrence of water on, in and under the earth's surface. In the present study, the major concern is with the water on the earth's surface and with its safe conveyance from and within an urban and urbanizing area.

The Raisin Region Conservation Authority through the Ontario Ministry of Natural Resources is responsible for the establishment of criteria whereby the floodplain areas and floodways can be delineated and controlled. The present criteria for floodplain control in the South Raisin River watershed is the 100-year flood.

Rainfall records for Cornwall have been obtained from the Hydrometeorologic Division of the Atmospheric Environment Service. The design storm for watersheds of this size is the 6-hour storm. Data for the various return frequencies used in the study area are tabulated in Appendix A. These storms have been superimposed on the watershed and the resultant flood flows have been derived using the hydrologic modelling technique developed by the Soil Conservation Service (SCS) in the United States. This method of runoff computation is widely used in Ontario and is found to provide realistic results.

For the detailed calculation of runoff from a given input of rainfall, the SCS model requires the determination of a soil complex number for each sub-area in the basin. In this case, 19 sub-basins in the disaggregation were used to model the watershed. These areas are shown on Figure 3-1. The soil complex numbers are derived from a combination of soil type and land use for each sub-area. The numbers vary from a low of 20 to a high of 100, with more pervious soils having lower numbers. Details of the soil classification and runoff curve numbers are shown on Table A-2 and Figure A-3, respectively.

Using the Soil Survey map of Stormont County together with field inspections, it was noted that the watershed consists of well drained, medium-textured till and loam. Essentially, the watershed can be classed as primarily 'BC' type soils which are well to imperfectly drained. The primary valley lands are in 'C' type or imperfectly drained soils with pockets of well drained or 'B' type soils interspersed along the valley.

In addition to the runoff curve numbers (Cn) for each of the sub-basins, physical data, such as area (A), length of watercourse (L), and elevation difference (H), are required for the generation of the flood hydrographs. The input data for the hydrologic model were obtained from the disaggregated watershed configuration as shown on Figure 3-1.

The rainfall data for the 6-hour design storms are the other major requirement for flood flow calculation. These data were obtained from the Atmospheric Environment Service hydrometeorological station in the City of Cornwall. From the records analyzed, the regional storm (6-hour, 100-year) rainfall total for this study is 94.2 mm (3.71 inches). For the application of the computer model, the watershed has been represented schematically by the diagram shown on Figure A-1. The rainfall for the 100-, 50-, 25- and 10-year return storms were systematically applied to the hydrologic model and their respective flood flows generated for the South Raisin River and its tributaries. A summary of the return flood flows for the South Raisin River at its confluence with the main branch is listed on Table 3-1.

Table 3-2 lists the breakdown for the regional flood (100-year storm) for each of the subwatersheds. For a more detailed breakdown of the hydrologic information, the reader is referred to Appendix A.

TABLE 3-1

RETURN FLOOD FLOWS AT OUTLET OF SOUTH RAISIN RIVER

Return Storm (Year)	Flood Flow (m^3/s)
100	38.98
50	31.28
25	24.27
10	15.33

4.0 HYDRAULICS OF THE WATERSHED

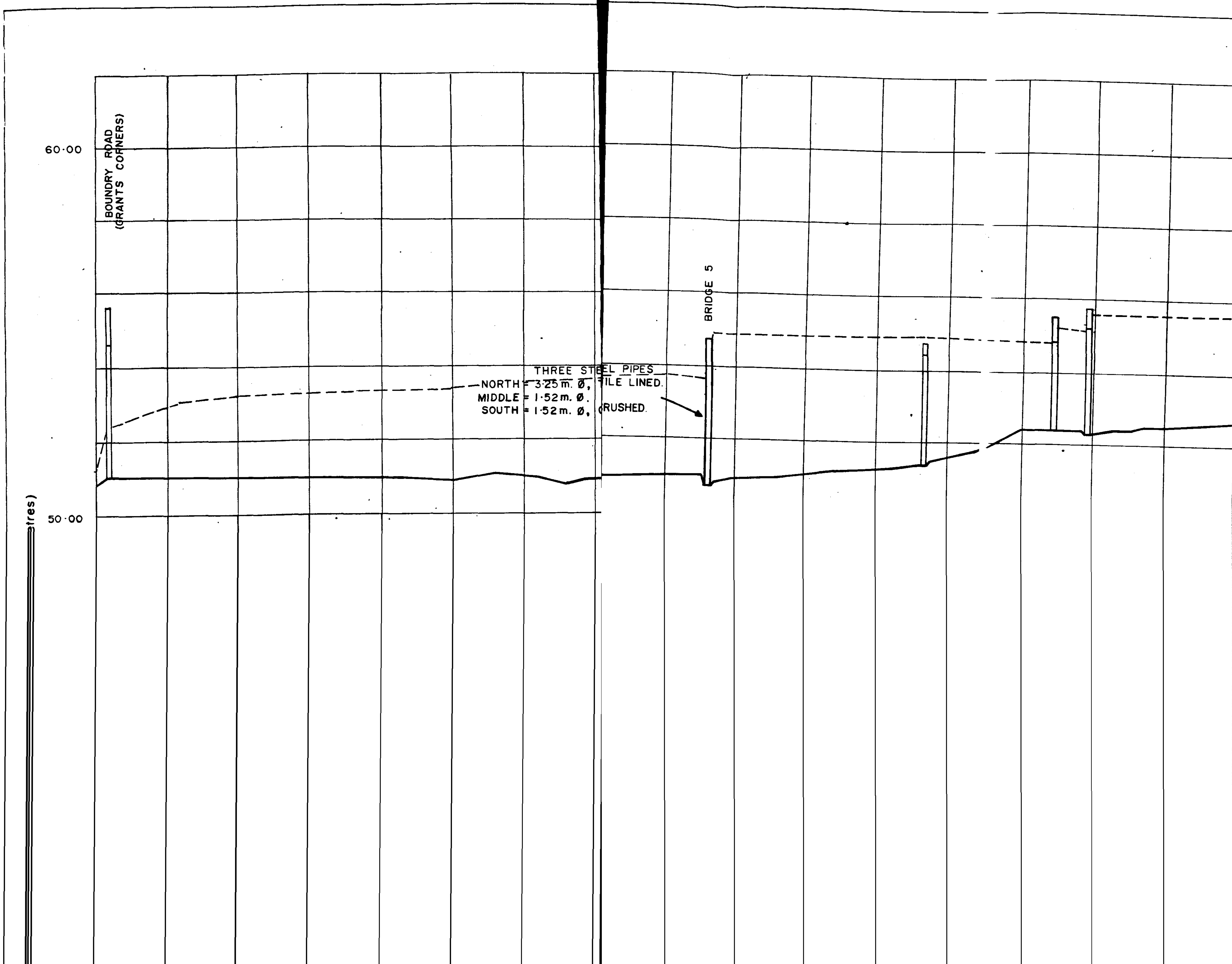
4.1 SOUTH RAISIN RIVER

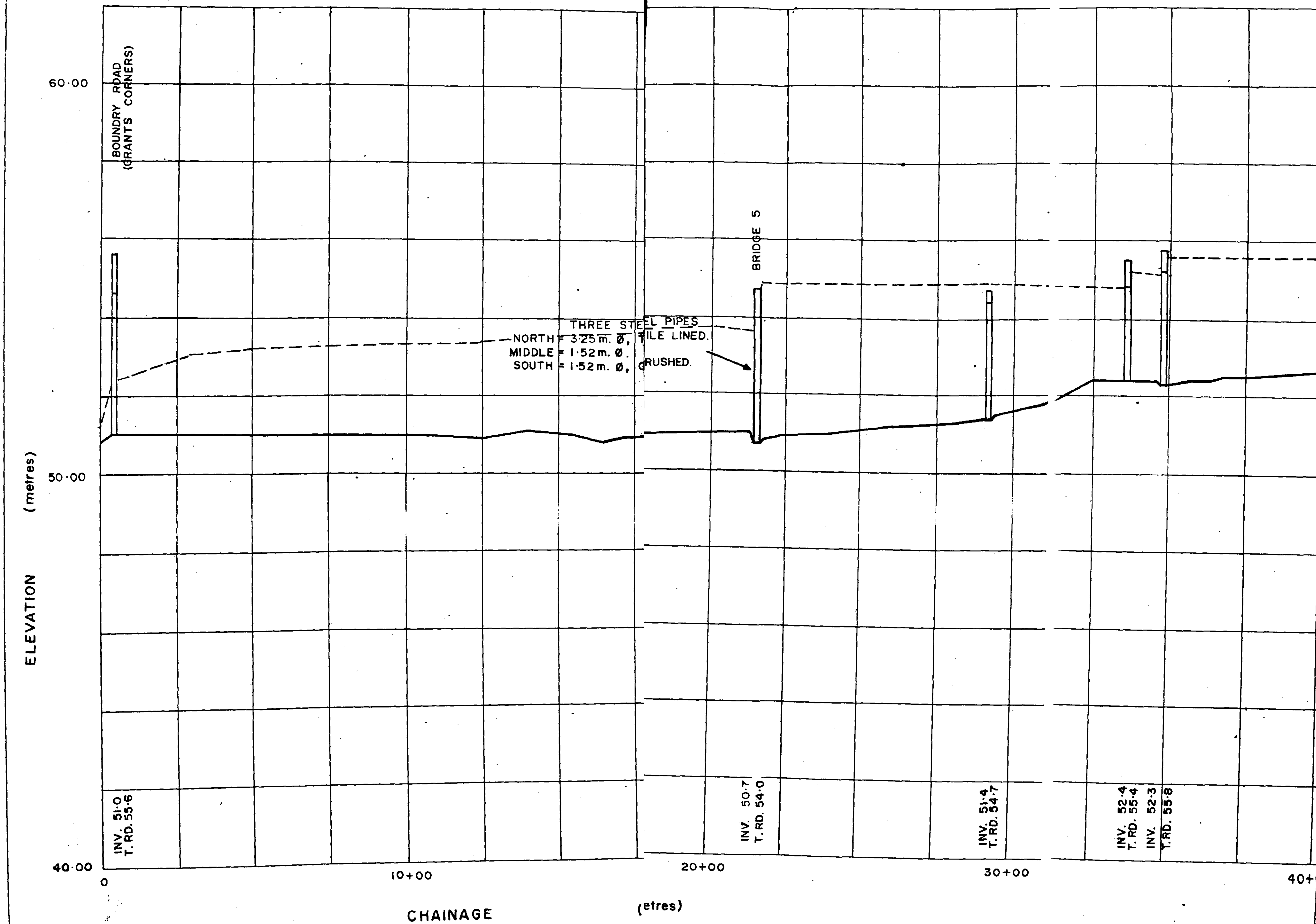
Reach I - Grants Corners to Highway 401

This section of the South Raisin River is under mainly agricultural land use. No buildings are subject to flooding under the regional flood (100-year storm) although extensive areas are flooded. The gradient in this reach is fairly good in comparison to the other reaches and to the tributaries studied and has a slope of 0.06%. The first constriction is at a farm crossing (Bridge No. B5). This structure contains three openings of varying sizes: a 3.25 m Ø, 1.52 m Ø, and another 1.52 m Ø CMP which has been crushed. Other structures downstream of this are timber crossings which have negligible constraint on high flows (Most of them will be washed out under high floods). The other structures all span the river with concrete or masonry abutments. Details are shown on Figures 4-1 and 4-2.

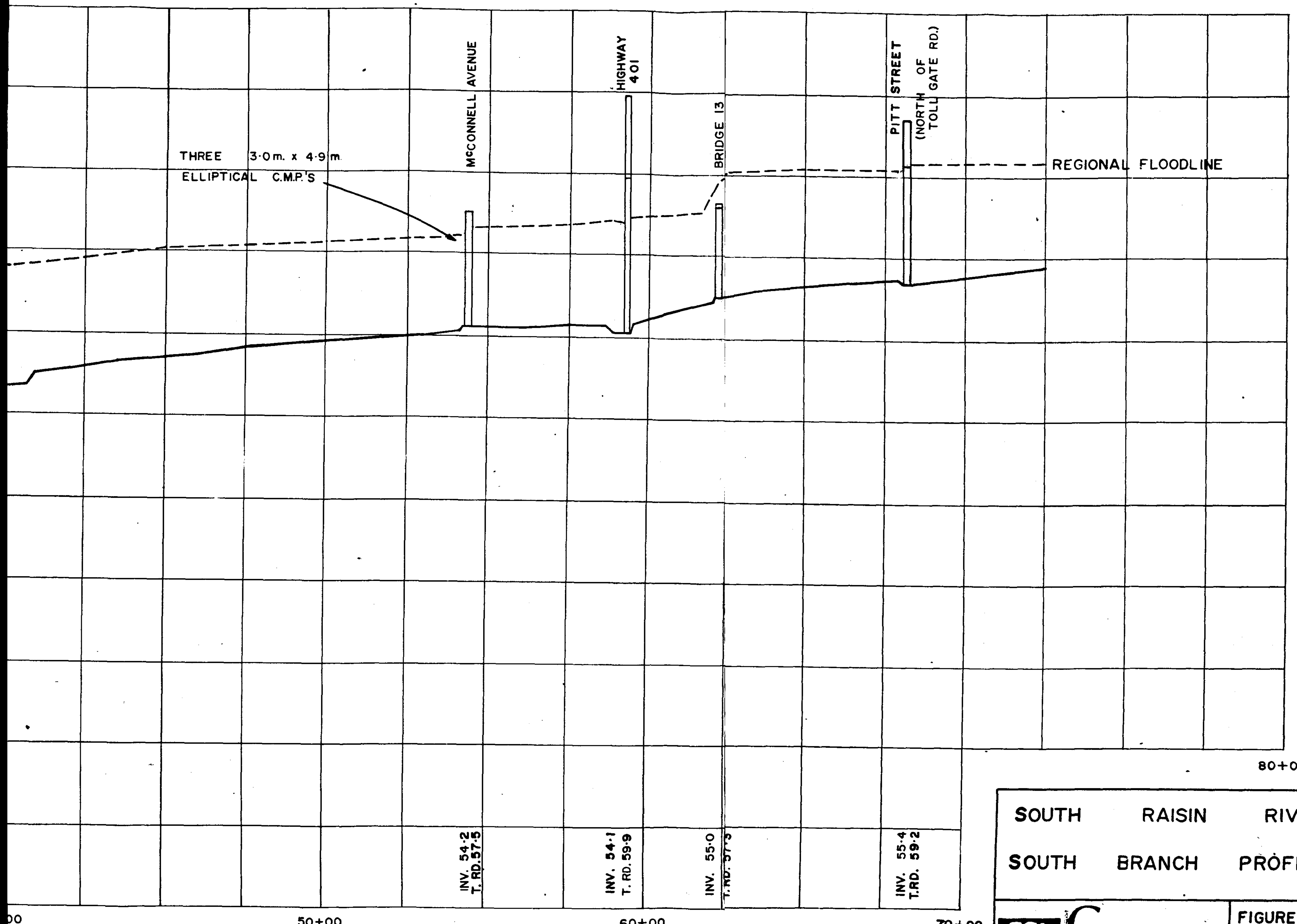
Reach II - Highway 401 to Brookdale Road

The Highway 401 structure (B12) is a large, 2-bay single-pier bridge with a 14.6 m opening and a high conveyance capacity. At the regional flow (55.5 m^3/s) only two-thirds of its capacity is used up. However, 250 m upstream, a farm lane crossing (B13) creates a major constriction. This


60·00
50·00
BOUNDRY ROAD
(GRANTS CORNERS)
BRIDGE 5
THREE STEEL PIPES
NORTH = 3·25m. Ø, TILE LINED.
MIDDLE = 1·52m. Ø.
SOUTH = 1·52m. Ø, CRUSHED.



BOUNDRY ROAD (GRANTS CORNERS)
BRIDGE 5
THREE STEEL PIPES
NORTH = 3·25 m. Ø, TILE LINED.
MIDDLE = 1·52 m. Ø.
SOUTH = 1·52 m. Ø, CRUSHED.
INV. 51·0 T. RD. 55·6
INV. 50·7 T. RD. 54·0
INV. 51·4 T. RD. 54·7
INV. 52·4 T. RD. 55·4
INV. 52·3 T. RD. 55·8
60·00
50·00
40·00
ELEVATION (metres)
0
10+00
20+00
30+00
40+
CHAINAGE (metres)

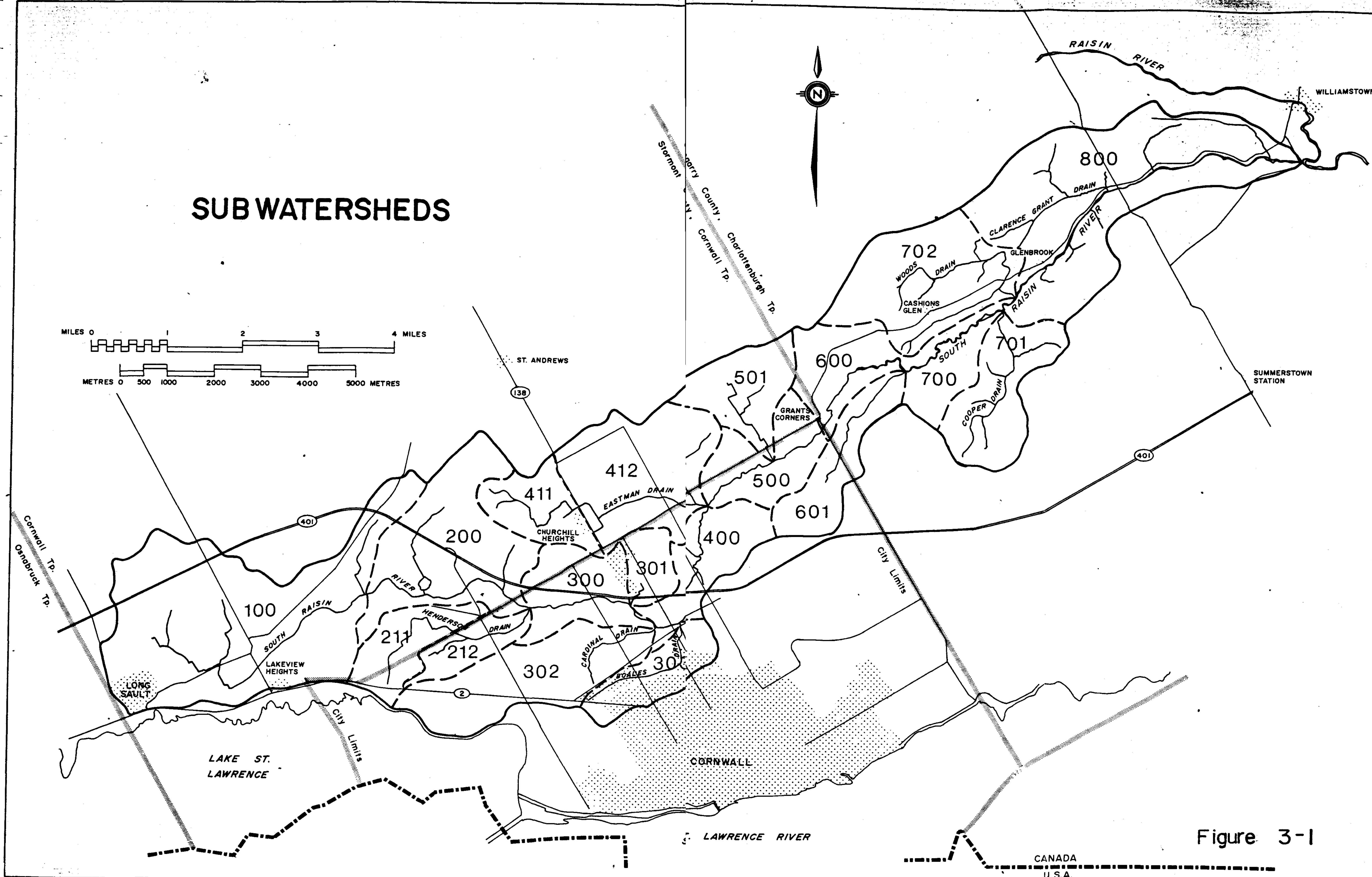


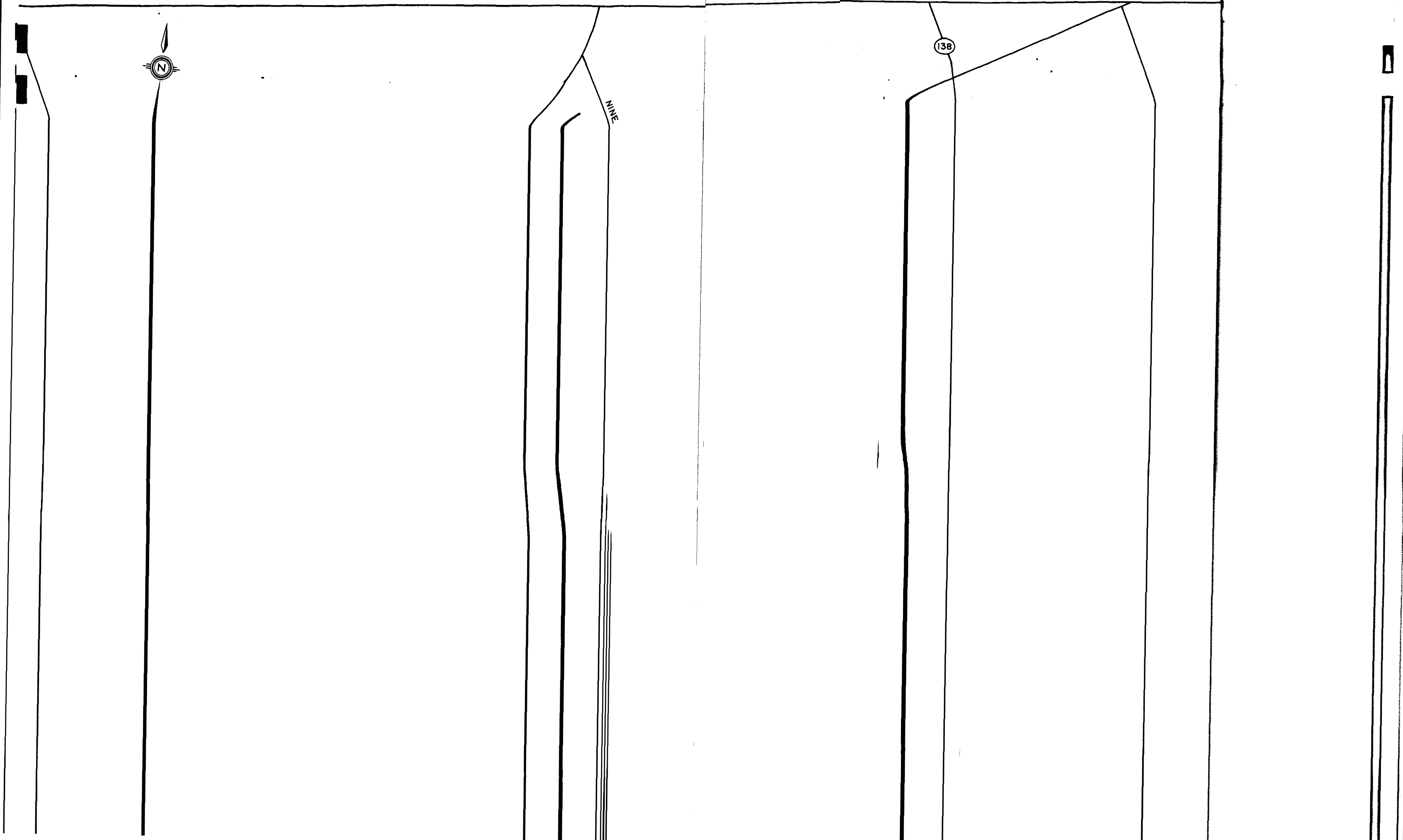
SOUTH RAISIN RIVER

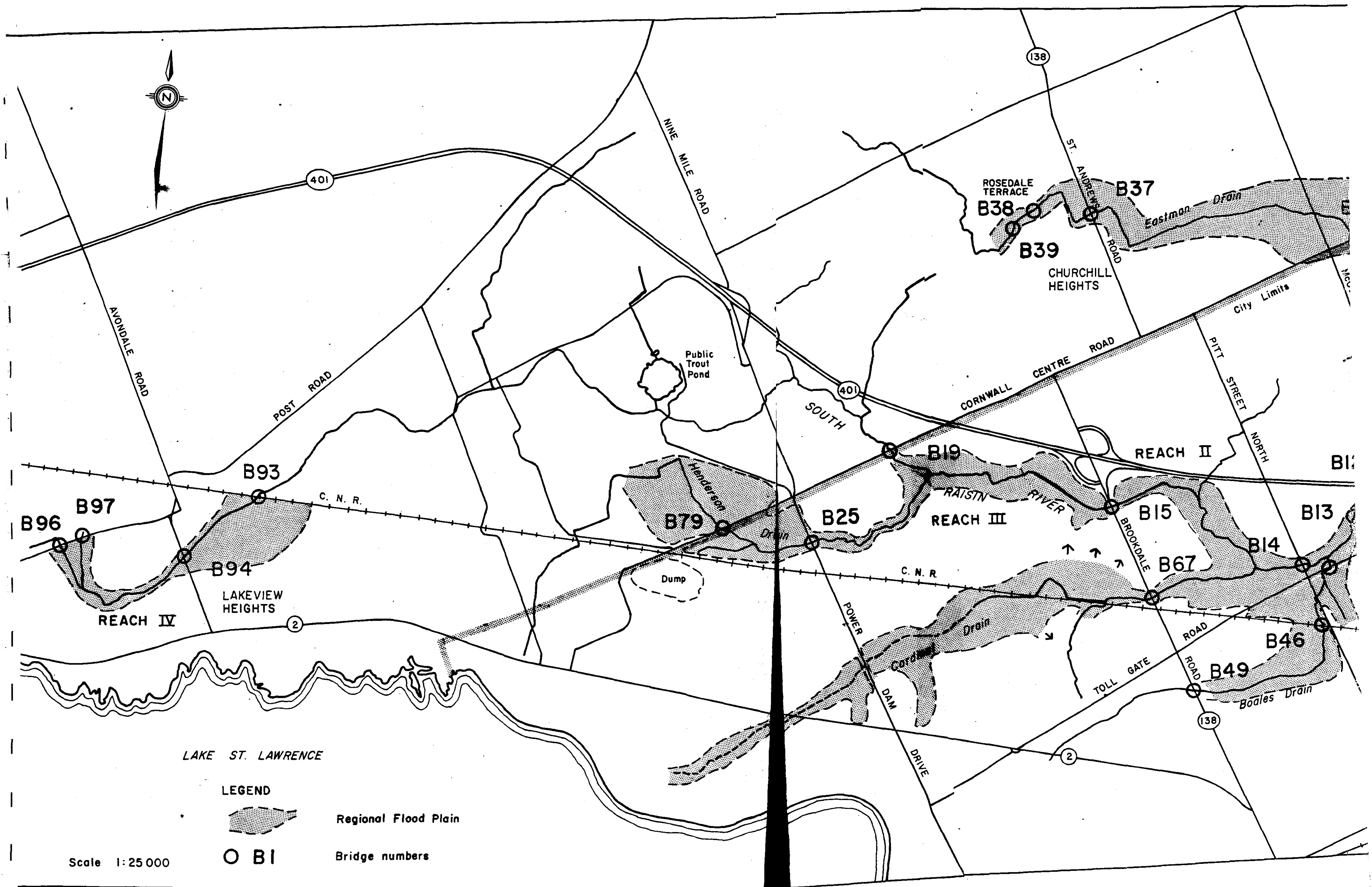
SOUTH BRANCH PROFILE

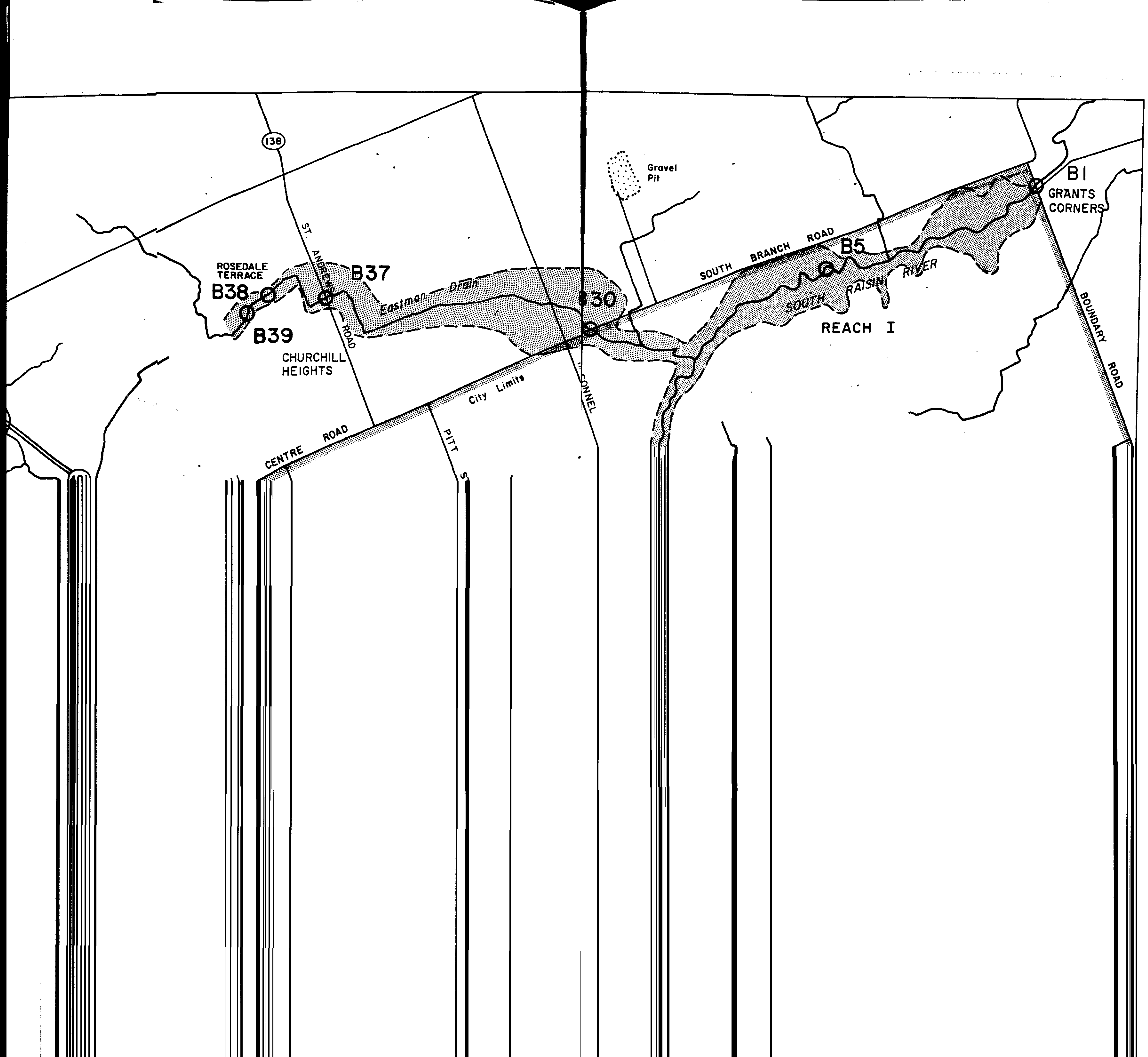
Crysler & Lathem Ltd.

FIGURE 4-1

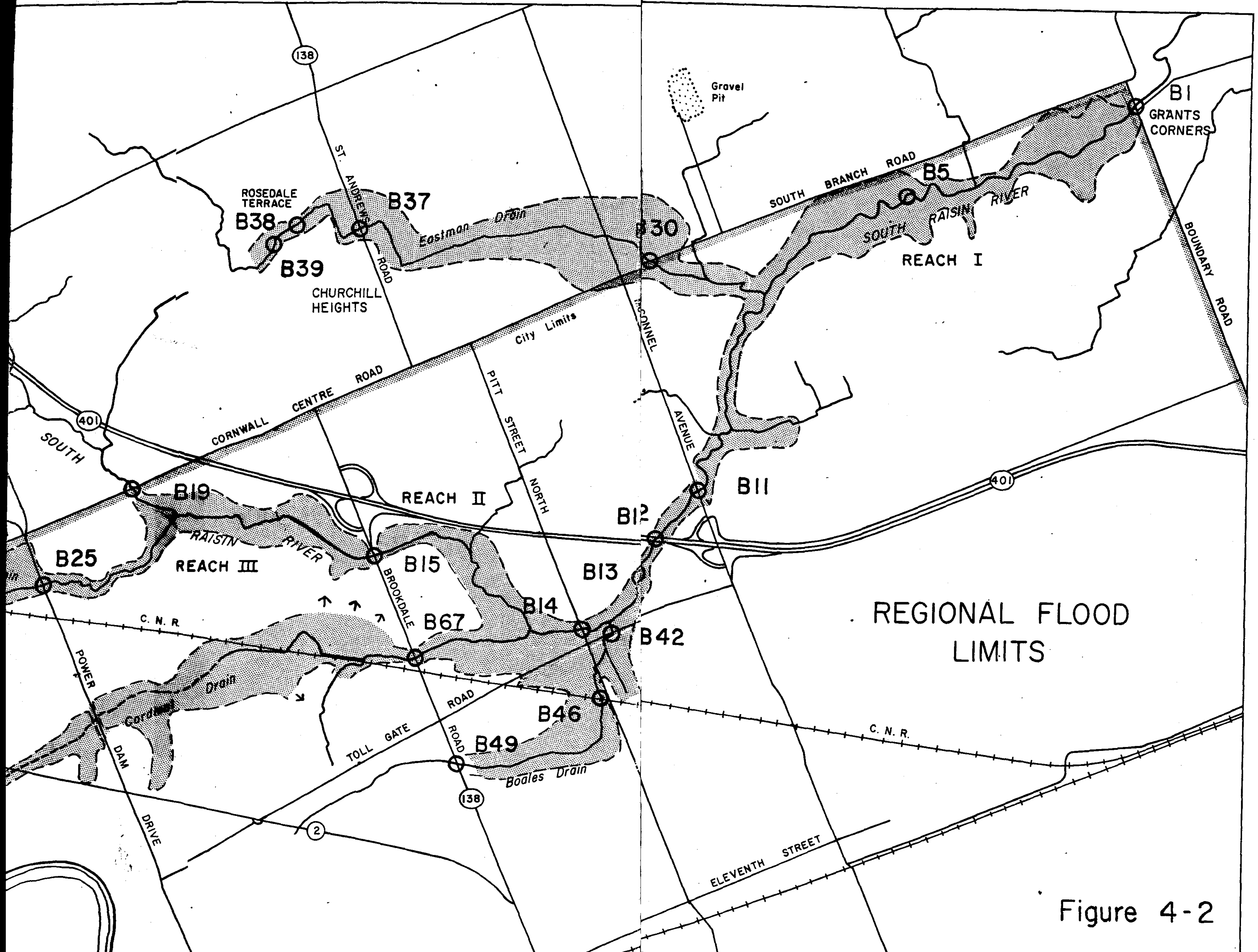

SUB WATERSHEDS
MILES 0 1 2 3 4 MILES
METRES 0 500 1000 2000 3000 4000 5000 METRES
RAISIN RIVER
WILLIAMSTOWN
800
CLARENCE GRANT DRAIN
GLENBROOK
SOUTH RIVER RAISIN
702
WOODS DRAIN
CASHIONS GLEN
701
600
700
COOPER DRAIN
501
GRANTS CORNERS
500
601
400
SUMMERSTOWN STATION
401
412
411
EASTMAN DRAIN
CHURCHILL HEIGHTS
ST. ANDREWS
138
200
300
301
100
SOUTH RAISIN RIVER
211
HENDERSON DRAIN
212
302
CARDINAL DRAIN
BOWLES DRAIN
LAKEVIEW HEIGHTS
LONG SAULT
2
Stormont County
Cornwall Tp.
Glengarry County
Charlottenburgh Tp.
Cornwall Tp.
Osnabruck Tp.
City Limits
LAKE ST. LAWRENCE
CORNWALL
LAWRENCE RIVER
CANADA
U.S.A.
Figure 3-1


N
NINE
138


N
401
NINE MILE ROAD
138
ST. ANDREWS ROAD
ROSEDALE TERRACE
B38
B37
B39
Eastman Drain
CHURCHILL HEIGHTS
City Limits
PITT STREET NORTH
CORNWALL CENTRE ROAD
AVONDALE ROAD
POST ROAD
Public Trout Pond
SOUTH
REACH II
B19
RAISIN RIVER
B93
C. N. R.
B97
B96
Henderson Drain
B79
B25
REACH III
B15
B13
B14
BROOKDALE
B67
B94
Dump
LAKEVIEW HEIGHTS
REACH IV
2
POWER DAM DRIVE
Cardinal Drain
ROAD
TOLL GATE ROAD
B46
B49
Boales Drain
LAKE ST. LAWRENCE
LEGEND
Regional Flood Plain
O B1 Bridge numbers
Scale 1:25 000



138
Gravel Pit
B1
GRANTS CORNERS
ROSEDALE TERRACE
B38
B37
B39
ST. ANDREWS ROAD
Eastman Drain
B30
SOUTH BRANCH ROAD
B5
SOUTH RAISIN RIVER
REACH I
BOUNDARY ROAD
CHURCHILL HEIGHTS
City Limits
CENTRE ROAD
PITT


REGIONAL FLOOD LIMITS
B1
GRANTS CORNERS
B5
SOUTH BRANCH ROAD
SOUTH RAISIN RIVER
REACH I
BOUNDARY ROAD
Gravel Pit
B30
MCCONNEL AVENUE
B11
401
B12
B13
B42
B14
B46
PITT STREET NORTH
City Limits
CORNWALL CENTRE ROAD
REACH II
ROSEDALE TERRACE
B38
B39
B37
ST. ANDREWS ROAD
Eastman Drain
CHURCHILL HEIGHTS
138
SOUTH
B19
RAISIN RIVER
REACH III
B25
B15
BROOKDALE ROAD
B67
C. N. R.
POWER DAM DRIVE
Cordwall Drain
TOLL GATE ROAD
B49
Boales Drain
2
ELEVENTH STREET
Figure 4-2

structure has only a 5.35 m opening. The major problem with this structure is the height of its concrete abutments and the laneway embankment which tend to act like a dam under high flood flows. The backwater created by this structure extends upstream past the Pitt Street crossing (B14) causing some flooding to adjacent buildings and affecting flow profiles in Boales Drain.

Reach III - Brookdale Road to City Limits

The Brookdale Road structure (B15) is another large concrete bridge with a centre pier with a 12.3 m opening. Flooding upstream is created mainly by the flatness of the topography and not by backwater. No buildings are subject to flooding in this reach of the river. There are several farm crossings which are low and do not affect flow conveyance. The next major structure is on Cornwall Centre Road (B19) which consists of twin arch culverts each having a span of 3.9 m and a rise of 2.5 m. The headwater increase from this structure is insignificant under the regional flood flow condition (22.3 m^3/s).

Reach IV - Lakeview Heights

This reach was included in the study in order to define the flood limits for the South Branch from the CNR tracks to the road north of the textile mill at Avondale Road. The floodplain between the CNR tracks (B93) and Avondale Road (B94) is extensive. This large floodplain is primarily the result of the flat topography. The CNR culvert has good capacity for flow with only a 0.25 m increase in elevation from the downstream to upstream side. The regional flood elevation of 66.92 m upstream is maintained all the way to Avondale Road. Most of the surrounding floodplain is at an average elevation of 66.1 m. The Avondale Road culvert (B94) is slightly overtopped under the regional flow (14.5 m^3/s) but is adequate for lesser flows. The floodplain upstream is well contained within the channel banks. There are no extensive floodplain lands to the Textile Road structures (B96, B97).

4.2 BOALES DRAIN

The City of Cornwall had commissioned two engineering studies, one in 1976, the other in 1979, to improve the drainage of Boales Drain. Under the existing drainage configuration, inadequate culvert capacities from Toll Gate Road (B42) to the CNR tracks (B46) increase the flood elevation by 1.2 m from that at the confluence with the South Branch (from 58.26 m to 59.58 m) for the regional flood flow (7.6 to 5.3 m^3/s). The backwater from the CNR culverts (B46) extends all the way up to Brookdale Road (B49). The existing drain, however, can convey up to the 25-year flood flow (3.10 m^3/s) without major flood damage to any buildings (some garages are affected slightly). With the proposed channelization and culvert replacements, the 100-year flow under the existing land use condition would be contained for the most part within the channel. Under future land use, overtopping of the channel banks would occur, however, no existing residential structures between the Canadian National Railway and Brookdale Avenue would be subjected to a potential flood hazard.

4.3 HENDERSON DRAIN

The flood flows in this drain are well contained within the channel up to Power Dam Road (B25). Upstream of this structure, the floodplain widens because of both a change in topography and inadequate culvert capacity. There is little change in floodplain area between the 100- and 25-year flood flows. The north branch of Henderson Drain above Cornwall Centre Road (B79)extends almost to its basin divide for all flows above the 25-year flood (5.5 m^3/s). The drain has, however, capacity for the 10-year flood flows (3.5 m^3/s). No buildings are affected. The city dump, where Cornwall Centre Road turns south, drains into the main branch of this channel.

4.4 CARDINAL DRAIN

The backwater from the South Branch affects the downstream capacity of this drain up to Brookdale Road (B67) which is a multi-span structure on columns and has no effect on the high flood flows. Immediately upstream of Brookdale Road, the drain ends and ditching takes over. At this point, the floodplain is extensive and flood flows from the 10-year to 100-year frequencies (4.2 to 11.7 m^3/s) spill into the South Branch. Upstream of this area, the land is extremely flat and marshy, and extensive flooding would occur even under small floods. Some spill from this area into the south tributary of the drain would occur, but no buildings are within the floodplain.

4.5 EASTMAN DRAIN

The floodplain for this drain from its confluence upstream to St. Andrews Road is quite extensive, although no residential buildings are presently affected. A portion of a barn at McConnell Avenue and Cornwall Centre Road is inundated under the higher flood flows, and the St. Andrews Road culvert (B37) is over-topped under the regional and 50 year flood flows (9.5 and 7.5 m^3/s). Although buildings downstream are built on sufficient fill material that they will not be damaged, some basement flooding is likely to occur under flows in excess of the 25-year flood (9.9 m^3/s).

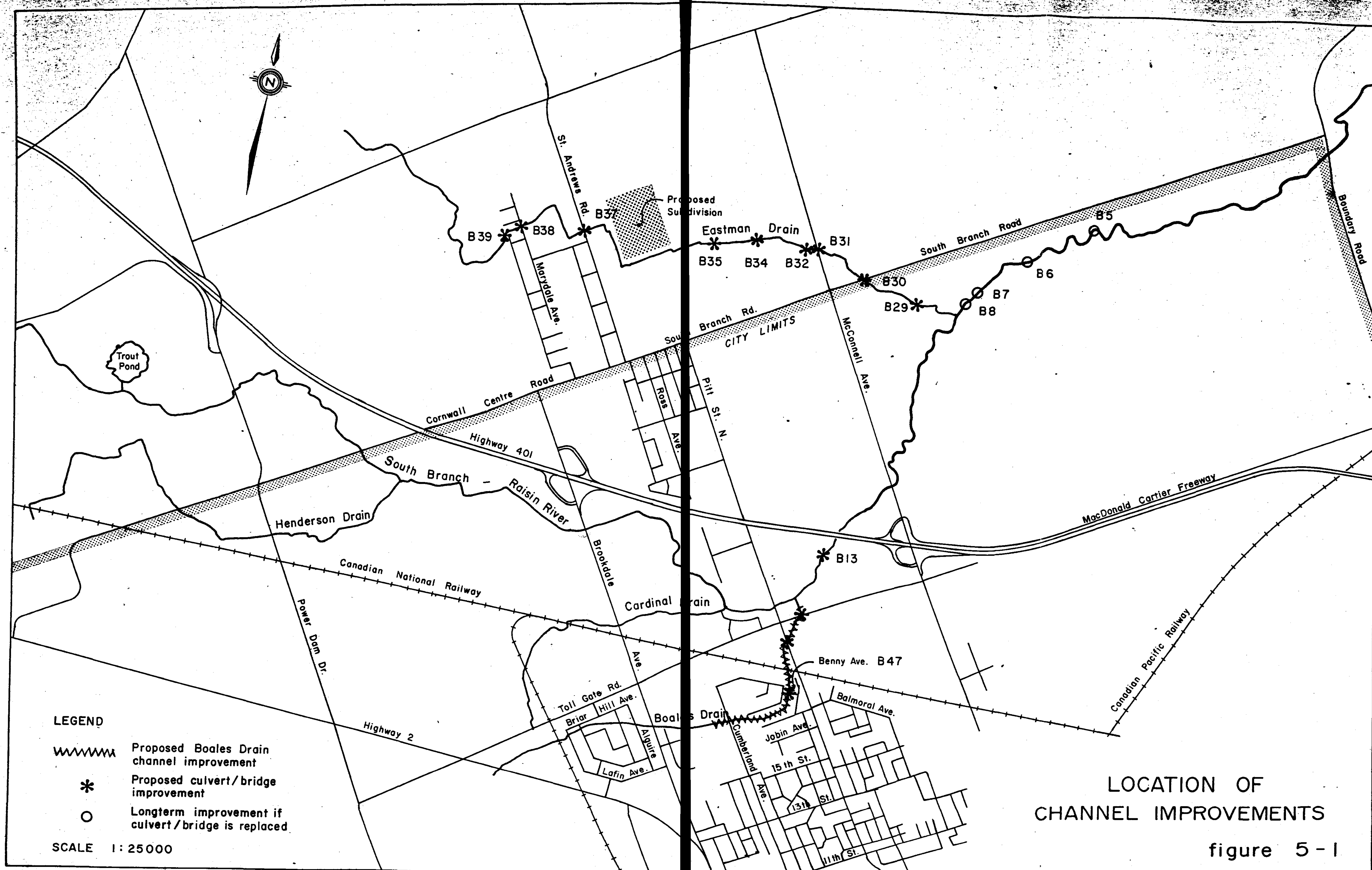
Marydale Avenue (B38) has a 1.07 m Ø CMP which is inadequate and causes backwater upstream, inundating nine buildings under the regional flood (9.5 m^3/s) and three buildings under the 50-year flood (7.5 m^3/s). This appears to be the only critical area on Eastman Drain.

5.0 WATER MANAGEMENT ALTERNATIVES

Floodplain limits and the basic reasons for flood levels throughout the South Raisin River in the study area have been discussed in previous sections of this report. This section of the report discusses these factors in greater detail and presents management alternatives which might be used to mitigate flooding and reduce potential damages. Figure 5-1 locates these alternatives.

Although watershed flooding is fairly extensive, there are two areas of particular concern because of the number of existing homes and/or valuable lands subjected to flooding. The first area of concern constitutes that area of the South Raisin River upstream of Highway No. 401 and the Boales Drain as shown on Figure 4-2. The second area is located along Eastman Drain where a large tract of land is subjected to flooding under regional flood flows.

As a general rule, there are significant areas of widespread flooding beyond the limits of the channel throughout a large part of the study area. These wide floodplain limits are created by the low-lying nature of surrounding lands and are further aggravated by a proliferation of undersized bridges and culverts. Because of the general lack of development and/or development proposals in these areas, no attempt is made to design remedial measures for these areas.



LOCATION OF CHANNEL IMPROVEMENTS

figure 5-1

There are three common techniques which might be used for the mitigation of floods as follows:

i) increase channel sizes and/or slopes (i.e., conveyance)
ii) divert flows to channels with greater capacities
iii) store excess flows and release them when downstream flow declines

Each of the above techniques depend upon the physical characteristics of the watershed. Storage areas can, generally, be eliminated because of a lack of well-defined valleys which would provide practical sites. Increases in channel slopes are difficult because of a general lack of adequate outlets and the long distances to which such construction would have to be carried. Flow diversion has been used in some parts of the Raisin River watershed in the past, but the location of flood prone areas adjacent to the City of Cornwall make diversion to the St. Lawrence River in this area infeasible. This leaves channel improvements in the form of widening and/or bridge replacement as the most feasible method of improvement.

5.1 SOUTH RAISIN RIVER - REACH II AND BOALES DRAIN

Regional flood (100-year) flows create flood levels up to 0.6 metres (2 feet) above general ground levels along the South Raisin River channel area west of Pitt Street North and along the Boales Drain channel (Figure 4-2). Bridge B-13, a farm crossing immediately upstream of Highway 401, increases flood levels by almost 1 m and adds to the extended flood levels. Replacement of this bridge can be expected to reduce flooding along the South Raisin River channel, as well as reduce outlet elevations at Boales Drain by approximately 0.6 metres, which will carry up that channel.

The City of Cornwall has obtained engineering studies of Boales Drain which propose improvement to the channel from the CNR crossing, under Pitt Street, and under Toll Gate Road to its confluence with the South Raisin River. Analysis of the proposed works indicates that the regional flood flow can be contained within the banks of the Boales Drain above Pitt Street, as proposed in these studies. While the study proposals mitigate flooding along the majority of the channel, it is noted that improvements are also required from the CNR culvert upstream towards Brookdale Avenue. Bridge 47 must be enlarged and the channel must be widened for the entire length within the subdivision.

With the improvements to the Boales Drain and Bridge B-13, both the Boales Drain and South Raisin Reach II (Figure 4-2) have reduced floodplains. The estimated construction cost of the work is tabulated as follows:

Table 5-1

Improvements to Boales Drain and Reach II

<u>Boales Drain</u>	
CNR to confluence - Channelization, improve Bridges at Pitt St. and Tollgate Rd.*	$150,000
CNR new culvert (B46) 2 m Ø x 50 m @ $1,000/m	50,000
Benny Ave. Bridge (B47) improve to 3.7 m width	30,000
Channel improvements - CNR to Cumberland Ave.	20,000
Sub-total Boales Drain	$250,000
<u>South Raisin River</u>	
Bridge 13 (Farm crossing) new culvert 4.4 m width	17,000

* Cost estimates from Design Report, Boales Drain, City of Cornwall, by McNeely Engineering Ltd., July 1979. Inflation allowance 20%.

5.2 EASTMAN DRAIN

Eastman Drain joins the South Raisin River near the South Branch Road (Figure 5-1). The drain follows an unnatural alignment with very angular changes in direction. At both Marydale Avenue and St. Andrews Road culverts, houses near the drain are subject to flooding during the regional storm. Downstream of St. Andrews Road, a subdivision is proposed within the floodplains, and there are three buildings affected in the vicinity of McConnell Avenue and the South Branch Road.

The proposed improvements to the drain can be divided into two categories as follows:

(a) Construction to protect existing buildings.

(b) Suggestions for the protection of future subdivisions.

Flooding at most existing buildings can be reduced by improvements to St. Andrews Road Bridge (B-37), Marydale Avenue Bridge (B-38), and Bridge B-39 (a private crossing).

The McConnell Avenue-South Branch Road buildings can be removed from the floodplain by improvements to the two road bridge crossings (B-30, B-31) and two farm bridge crossings (B-32 and B-34). Replacement of Bridge B-35 will reduce floodplain width, but does not affect any buildings.

Although the Authority may wish to discourage construction in the defined floodprone areas, it should be noted that a subdivision is proposed approximately 350 metres downstream of St. Andrews Rd. This development is to be constructed where ground elevations are consistently 59.6 m (195.5 ft.) and regional floodplain elevations average 59.8 m. The construction of a fully serviced subdivision generates a surplus of fill which permits the average elevation to be raised as much as 0.3 metres (1 foot). In order to provide a minimum of protection to future residents, the freeboard between the lowest building opening and the regional flood elevation should be at least 0.3 m (1 foot). In addition, the design of foundation drains and sewers must accommodate the flood elevations which are anticipated. By raising this land area, the overland flow capacity will be reduced and the Eastman Drain watercourse must be widened to a minimum width of 4 metres as it parallels the subdivision. Proposed improvements are as follows:

Table 5-2

Improvements to the Eastman Drain

South Branch Road	B-30	7 m width	$ 59,000
McConnell Avenue	B-31	5 m width	42,000
Farm Crossing	B-32	exist + 1.9 x 3.1 cmp	18,000
Farm Crossing	B-34	exist + 2.0 x 3.1 cmp	18,000
		Total	$137,000
Farm Crossing	B-35	improve exist	10,000
St. Andrews Rd	B-37	5 m width	42,000
Marydale Avenue	B-38	4 m width	31,000
Farm Crossing	B-39	4 m width	9,700
		Total	$ 82,700

5.3 SOUTH RAISIN RIVER - GENERAL IMPROVEMENTS

Numerous private and public crossings of the channels in the study area cause flood elevations to be artifically increased. However, most of this added floodplain land is presently used for agriculture and any regional flood damages could be judged to be minimal. Should the Municipality undertake a comprehensive plan of replacement, it is possible to reduce the floodplains in these areas.

The following table indicates the existing sizes of the culverts, the required sizes to minimize floodplain areas to those created by watershed topography, and cost estimates. The costs for the private crossings have been based on the most economical method of construction, that is, utilization of the landowners resources (i.e., manpower and equipment) without a formal tender procedure.

Table 5-3

General Crossing Improvements

Bridge	Location	Exist	Future	Cost
B-5	Farm Crossing	3.25 m Ø 2 x 1.52 m Ø	3 m x 6 m	$ 12,000
B-6	Farm Crossing	3 x 5.8	Exist + 2 x 6	14,000
B-7	" "	2.4 x 7.9	Exist + 2.9 x 5	12,000
B-8	" "	2.9 x 7.4	Exist + 2.9 x 5	12,000
B-29	" "	2.05 x 3.4	2.3 x 3	22,000

6.0 ENVIRONMENTAL STUDIES

6.1 ENVIRONMENTAL OVERVIEW

The lands above the St. Lawrence River within the study area are composed of flat-lying Ordovician limestones and shales overlain by glacial deposits and/or marine clays and sands which were deposited by the Champlain Sea during the late Pleistocene. Topography is largely determined by the bedrock surface which produces flat terrain and, consequently, poorly developed drainage patterns.

The South Raisin River rises near Long Sault and flows eastward through a 103 km^2 drainage basin to its confluence with Main Branch near Williamstown.

Early settlement and extensive clearing has had a profound effect on environmental quality. Removal of forest cover has reduced wildlife habitat. Private and public drainage schemes have drained wetlands, thereby decreasing waterfowl nesting capability. Clearing has also reduced the soil's water holding capacity, causing a decrease in the river's summer baseflow which, in turn, affects fish survival and productivity.

A review of 1966 Conservation Report indicates that some pollution problems also exist along the South Raisin River.

Low summer flows are the reason for the environmental problems in the river. At this time of peak biological activity, water volumes are insufficient to maintain a high quality of aquatic life or to provide for adequate dilution of pollutants. As a result, the channel becomes choked with aquatic weeds and emergents, leaving few open areas and restricting fish habitat. Dense weed growths occupy the entire length of the river.

The Raisin River Conservation Report indicates that low flows of 0.01 m^3/s (0.4 cfs) were prevelant in 1966. To augment flows, the Long Sault diversion was constructed in 1972. This allowed the introduction of water from the St. Lawrence River into the South Raisin's upper reaches. A 1973 MNR fisheries survey indicated that flow rates had improved to an average of .6 m^3/s (21.2 cfs) (G. Goodchild, personal communication). Although this seemingly represents a substantial increase in flow rate, the weed-choked character of the channel has not changed. Mean depth of the river is presently only 0.3 m (1 ft.) (G. Goodchild, personal communication). Low flow is still the factor which limits environmental quality in the river.

The diversion, however, would enhance summer quality to some extent and would lessen the stress on fish and other aquatic organisms. Since the diversion is not operative at the time of high flows, it would have no effect on the river at that time.

Of necessity, management of the South Raisin basin is geared toward agricultural production and the maintenance of farm-land. Concerns for the fish, wildlife and waterfowl are of secondary importance.

TABLE 6-1

WATER QUALITY
SOUTH RAISIN RIVER 1976-77

Parameter	1977 Glenbrook	1977 Cornwall	1976 Glenbrook	1976 Cornwall
Total Coliforms (MF/100 ml)	250	329	n/s	n/s
Pseudomonas (MF/100 ml)	2	2	n/s	n/s
Temperature (°C) mean	8.2	9.2	1.5	2.0
maximum	25.0	24.5	2.0	3.0
Dissolved Oxygen (mg/l) mean	8.8	9.3	10.5	10.0
minimum	6.0	4.0	9.0	7.0
B.O.D. (mg/l)	1.8	2.2	0.8	1.8
Total Phosphorus (mg/l)	0.051	0.071	0.028	0.06
Total Kjeldahl Nitrogen (mg/l)	0.412	0.573	0.400	0.5
Conductivity (umhos @ 25° C)	521	619	620	670
Turbidity (F.T.U.)	8.7	24.86	5.65	21.5

Note: (1) Data for only November and December of 1976 were available, however, 1977 data spans the full 12-month period.

(2) Figures indicate mean values except where otherwise noted.

(3) The Glenbrook station is actually 2 km west of Glenbrook, while the Cornwall Station is at McConnell Ave.

Source: Ministry of the Environment, 1976, 1977

Table 6-1 shows data from the Glenbrook station near the river mouth and from Cornwall. The latter has been included since hydrologic works are recommended within the city limits and quality data may be useful in gauging environmental impact.

Conditions at Glenbrook are typical of unurbanized areas on the river. Bacterial counts indicate low mean values for coliforms which are well within the limits for recreational usage. The presence of Psuedomonas bacteria indicates some contamination from human sources, such as leaky septic systems or the introduction of raw sewage. Dissolved oxygen levels of 6.0 mgl are adequate to maintain aquatic life, but are only slightly above the MOE limit of 5 mg/l. Nutrient levels represented by phosphorus and Kjeldahl nitrogen are indicative of excessive concentrations. Mean concentrations for total phosphorus and Kjeldahl nitrogen from flow stations on the river during 1977 yielded 0.069 and 0.509 mg/l respectively. Current standards indicate that concentrations in rivers exceeding 0.030 mg/l TP and 0.5 mg/l T.K.N. suggest eutrophic conditions (MOE, 1978; MOE, 1974).

This is considered problematic in that it may cause dissolved oxygen depletion and may also stimulate unsightly algal growth. Primary nutrient sources are likely to be fertilizers in agricultural runoff and garbage dump runoff. High conductivities are also indicate of eutrophic conditions, while turbidity values are acceptable.

Upon review of the same parameters for sites within the City of Cornwall (Table 6-1), it can be seen that water quality at the McConnel Street station is somewhat poorer. Although temperatures and dissolved oxygen are similar to the Glenbrook site, bacterial contamination is slightly higher. On one occasion, however, dissolved oxygen was observed to be 4 mg/l, one mg/l below the provincial standard. Total phosphorus shows almost a 50%

increase over the Glenbrook site, while turbidities have increased four-fold. Higher nutrient concentrations in urban areas are characteristically associated with street runoff.

Table 6-2 summarizes some of the data collected by MNR in 1973. The results generally support the above comments in that high conductivities and total dissolved solids relate to eutrophy. Of special note are stations 5 and 5a which were located on the Henderson Drain. Station 5a, which was above the Cornwall landfill site, showed high dissolved oxygen concentrations of 10.6 mg/l (125% saturation) while station 5 below the dump showed grossly depleted oxygen levels of 1.8 mgl (21% saturation). This low level is not sufficient to support aquatic animals. Oxygen depletion is thought to result from high oxygen demand in the dump runoff. Odour problems have also been reported to emanate from the Henderson Drain as a reuslt of contamination from the same source.

Table 6-3 shows the results of the consultant's field investigations. Water temperatures are again elevated but dissolved oxygen is adequate, with the exception of the Henderson Drain sample. This sample was taken from below the Cornwall dump and indicates low oxygen concentrations, thereby supporting the MNR results. As normally associated with limestone areas, hardness and alkalinity are high due to the solubility of limestone and the resultant release of calcium ions and trace metals.

Generally, water quality in the South Raisin River is marginal. The river functions primarily as a drain for agricultural land. As a result, nutrient concentrations are high and dissolved oxygen drops below acceptable limits at times. Water temperatures are high because of the open, shallow nature of the channel, but bacterial counts do not appear to represent a health hazard in terms of recreational usage. Low flow volumes tend to concentrate contaminants.

TABLE 6 - 3

WATER QUALITY
SOUTH RAISIN RIVER

CRYSLER & LATHEM LTD. 1979

PARAMETERS	Lakeview Heights	Henderson Drain	Eastman Drain	Grant's Corners
Temperature (°C)	31	21	24	24
Dissolved Oxygen (mg/l)	9.0	4.9	9.6	11.0
Total Hardness (mg/l)	188	359	291	291
pH	8.5	7.7	8.5	7.7
Alkalinity (mg/l)	171	257	257	222

The consultant's investigation revealed the presence of many small garbage dumps along the river as well as cattle using the stream. Both are considered detrimental to water quality.

6.4 FISH

Fish studies were conducted for the 1966 Conservation Report and again in 1973 by the Ministry of Natural Resources. Table 6-4 lists the species found in the South Raisin during the 1973 survey. In all, 19 species were identified with the following being of recreational importance: rock bass, northern pike, sunfish, carp, bullhead and white sucker. The remaining species are largely minnows. In general, fish populations are not large due to habitat restrictions. Water depths are low, channels tend to be choked with weeds and water quality is marginal. This tends toward the production of small, pollution-tolerant species.

It is the consultant's feeling that the river has never been very productive in terms of game fish, since depths are shallow. At present, habitat conditions are poor with dense communities of aquatic weeds, bottom siltation and limited quantities of benthic forage organisms. Spawning habitat is similarly poor for game fish, with the exception of pike which spawn in weedy shallows. Clean gravel and rubble areas are the preferred spawning sites for many game fish, but the bottom of South Raisin is generally rubble covered in silt, muck or sand. Some minnows, however, do use these substrates for spawning.

Water temperature is also important as a constraint to fish production. Since off-stream cover is limited, exposure to the sun causes high water temperatures.

TABLE 6 - 4

PRESENCE LIST OF FISH SPECIES IN THE SOUTH RAISIN RIVER IN 1973

NORTHERN PIKE	Esox lucius
ROCK BASS	Ambloplites rupestris
SUNFISH	Lepomis gibbosus
CARP	Cyprinus carpio
BROWN BULLHEAD	Ictalurus nebulosus
WHITE SUCKER	Catostomus commersoni
COMMON SHINER	Notropis cornutus
BLACKNOSE MINNOW	Notropis heterolepis
IOWA DARTER	Estheostoma exile
CENTRAL JOHNNY DARTER	Estheostoma nigrum
FANTAIL DARTER	Estheostoma flabellare
BLUNT-NOSE MINNOW	Pimephales notatus
FATHEAD MINNOW	Pimephales promelas
TADPOLE MADTOM	Naturus gyrinus
CENTRAL MUD MINNOW	Umbra limi
BANDED KILLIFISH	Fundulus diaphanus
LOG PERCH	Percina caprodes
CREEK CHUB	Semotilas atromaculatus
GOLDEN SHINER	Notemigonus crysoleucas

Source: G. Goodchild, Ministry of Natural Resources

Low dissolved oxygen has also been problematic. During the 1973 survey, three pike were found dead below the Cornwall dump in the Henderson Drain. The reader will recall that oxygen was depleted at that station, and is likely responsible for the fish kill.

6.5 WILDLIFE AND WATERFOWL

Apparently, the only mammal of commercial importance along the river is the muskrat. Some trapping is done during winter months.

The consultant's field investigations indicated that capability for waterfowl production along the river is low.

Periodic drawdown, due to closing the Long Sault diversion reduces water supply, the tightness of emergent vegetation clogging the channel reduces nesting opportunities, flatness of the topography reduces ponding potential and there appears to be a general lack of marsh edge.

Adverse downstream effects of the flood control measures in these three areas are not anticipated.

6.6 ENVIRONMENTAL IMPACT OF FLOOD CONTROL MEASURES

A) Eastman Drain

The consultant has proposed to enlarge two culverts on the Eastman Drain. Field inspections of this site indicate the stream contains some water from groundwater seepage during summer months, although no flow is detectible. No fish were seen in the stream and the area appeared sterile from the standpoint of the natural environment. The site is surrounded by farmland and residences.

7.0 THE BENEFITS AND COSTS OF THE FLOOD CONTROL ALTERNATIVES

In order to provide the Authority with as much information as possible to assist them in making decisions upon the recommendations presented in this report, it is necessary to include an analysis of the material costs and benefits for the alternative proposals. The preparation of benefits and costs connected to any project are calculated using the principles of economics as well as outlining the intangible factors which can be expected to affect the project.

In this section of the report, an economic analysis of the costs and benefits of the various options is presented. In the preparation of the analysis discussed herein, benefits have been estimated using experience and data presented in a publication by James and Lee*(in which structural flood damage is related to water depth around houses and other structures) and a publication by Sewell, Davis, Scott and Ross**.

The detailed analysis of site conditions and factors related to the computation of the benefits are outlined in this section and described in more detail in Appendix B. Prior

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* James, L. Douglas and Lee, Robert R.
Economics of Water Resources Planning,
McGraw-Hill Book Company, 1971

** Sewell, W.R.D., Davis, Scott, A.D., and Ross, D.W.,
Guide to Benefit-Cost Analysis, "Resources for Tomorrow"
Conference, Montreal, 1961

(C) Life Expectancy Factor

In order to discount future cost and benefits to the present, it is necessary to estimate the life expectancy of the flood and erosion control system.

While the life expectancy of certain components may vary as much as 100 percent, the normal life of hydraulic projects is taken to be 50 years. This value is used in the analysis.

7.2 COSTS

(A) Capital Cost Estimates

The costs of the alternative mitigational measures have been described in Section 5.

(B) Operating and Maintenance Costs

The recommended system for flood and erosion control in this study consists mainly of channelization and flood storage structures with minimal operation. As such, there are no large operating costs associated with the works. The maintenance costs are also ignored, since it is assumed that future structures would require no more maintenance than the present structures.

7.3 BENEFITS

Tangible benefits may be defined as those benefits which can be statistically predicted and to which definite monetary values can be assigned. Tangible benefits can be divided into direct and indirect benefits.

Direct benefits in this study are derived primarily from the difference between the cost of damages which would result after construction of remedial works and those which would result without remedial measures in place. These damages are evaluated for all the flood levels. Direct benefits may also arise partly from ancilliary effects such as spring and summer flow regulation, improved aquatic habitat, recreation, etc.

Indirect benefits arise from the avoidance or prevention of costs arising from flood relief, rehabilitation, disruption of business, damage to and disruption of public services.

The assessment of flood control benefits is difficult and caution must be exercised in order to ensure the validity of results. From experience on other studies, it has been the finding of the consultant that interviews with homeowners and an evaluation of potential damages is difficult and sometimes misleading. At best it is a very subjective approach to potential damage evaluation.

For this study the consultant has utilized an approach developed in the United States and outlined by James and Lee (op. cit.). In this procedure, the flood damage to structures and homes is related directly to the value of the property and the depth to which flood waters inundate the building. Reviews of numerous projects using this method have found it to be objective in providing reasonable estimates of actual damages.

After a careful analysis of the project, it is concluded that one of the major benefits to be derived would be the avoidance of flood damage. Another major benefit which is dependent on the selected alternative is the land enhancement benefit.

(A) Damages Avoided

If past floods had occurred and their damages had been carefully documented, they could have been used to predict future damage. This was not the case and, as a result, an empirical analysis based upon structure cost evaluation and potential flood depth has been used. This analysis is based upon the following relationship:

Direct Flood Damage = 0.14432 x Market Value of Structures ($) x Depth of Water at Building (m)

By plotting the flood-prone area on a plan, by estimating the value of each structure exposed to flooding (based on local real estate sales) and by applying the above formula, it is possible to evaluate the total direct damage under the 100-year flood. For details of the evaluation of the benefits associated with flood control, the reader is referred to Appendix B.

(B) Benefit to Cost Ratio

The benefit to cost ratio provides an economic basis for the selection or rejection of projects which compete for capital resources. The ratio is a direct measure of the economic viability of a project. When the ratio is less than 1.0, the costs of a project are greater than the benefits to be derived. It is therefore not an economically sound investment. Should the ratio be greater than 1.0, the project is economically sound and serious consideration should be given to its implementation. This is a very rigid interpretation which may be tempered by consideration of other tangible and intangible benefits and socio-political considerations.

The following table summarizes the total value of all present and future benefits and costs for the alternatives previously outlined. (See Table 7-1)

In some cases, the priorization of remedial works may be taken directly from the benefit-cost analysis. However, intangible costs such as hardship and inconvenience to flood victims cannot easily be assessed, and, in the Consultant's opinion, are of considerable importance. A second intangible which governs priorities is the availability of funds for such works. Rather than the priority suggested by benefit-cost study, the Consultant recommends the following sequence should funding be available.

(1) Boales Drain - although costs are high, the number of structures damages is similarly high. Flooding on the Boales Drain has been a constant problem and should be remedied first.

It is expected that indirect benefits from land enhancement would be substantial. By taking properties out of the floodplain, the value of lands bordering the drain are increased and some lands may be freed for additional development. Since much of this land is residential, increased property values are of considerable importance. Also, indirect benefits would result from the clean-up of existing environmental problems. Discarded refuse, stagnant waters, odour problems, algal scums, and the generally unsightly appearance of the drain would be remedied by the proposed engineering works.

(2) Eastman Drain - if flooding problems are not corrected in this area, extensive damage to the recently approved proposed subdivision could result.

(3) South Raisin - although the benefit-cost ratio for these works is most favourable, it should be undertaken last if considered as a separate project. However,

should funding allow, this project could be undertaken along with the Boales Drain to completely solve the flooding problems in the subject reach. The joint benefit-cost ratio of 0.44 is shown on Table 7-1.

Table 7-1

Benefit/Cost Ratio

Location	Existing		Proposed			Benefits	Costs	B/C
	Flood Elev.	No. Bldgs in Flood-plain	Flood Elev.	No. Bldgs in Flood-plain	Improvement	(Damage Avoided)		
*Boales Drain Toll Gate Road to Benny Ave. + 400 metres	59.59	117	58.03	3	Channelize Table 5-1	$ 89,100	$250,000	
*South Raisin Pitt Street + 800 metres	58.37	41	57.94	-	B-13	27,770	17,000	
						$116,870	$267,000	0.44
Eastman Drain South Branch Rd to McConnell Ave (201+00 to 219+00)	58.23	3	57.03	-	B-30, B-31, B-32, B-34 (Table 5-2)	7,462	137,000	0.054
Upstream of St. Andrews Rd (233+50 to 245+00)	63.79	7	62.72	-	B-37, B-38 B-39 (Table 5-2)	6,753	82,700	0.081

* Improvements to both B13 and Boales Drain must be undertaken in order to obtain any significant benefit.

8.0 CONCLUSIONS AND RECOMMENDATIONS

(1) It is concluded that three areas within the South Raisin River valley have buildings flooded under higher flood flow conditions. They are: (i) Reach II of the South Raisin River upstream of Pitt Street, (ii) Boales Drain upstream of the CNR tracks, and (iii) Eastman Drain upstream of Marydale Avenue. A total of 168 buildings (including 94 residences) are inundated by the regional flood.

(2) It is concluded that based on potential annual damage and the Consultant's evaluation of the three areas, the following priorization of remedial works should be considered: (i) Boales Drain, (ii) Eastman Drain, and (iii) Reach II of the South Raisin River.

(3) It is concluded that the proposed flood mitigation works for the Boales Drain as recommended by McNeely Engineering Ltd. would effectively eliminate flooding in the surrounding area.

(4) It is concluded that the remedial works recommended in this report would protect the buildings upstream of Marydale Avenue on the Eastman Drain to the regional flood limits.

(5) It is concluded that the South Raisin basin is managed for agricultural production. Concerns for fish, wildlife and waterfowl are secondary.

(6) It is concluded that the South Raisin River has a low capability to produce and sustain fish or waterfowl.

(7) It is concluded that water quality in the South Raisin River is marginal, owing primarily to low flows, high nutrient concentrations, and, at times, low dissolved oxygen levels. However, since bacterial counts are low, it may be considered for recreation.

(8) It is concluded that the largest source of nutrient input is likely from agricultural (non-point) sources rather than from industrial or domestic origin. The Cornwall dump, however, continues to be a problematic point source.

(9) It is concluded that the enlargement of the culverts at Churchill Heights and the channelization of the Boales Drain will have a positive impact on the total environment.

Therefore,

(1) It is recommended that the following remedial action be undertaken:

i) Boales Drain - channelization and enlargement of existing culverts;

ii) Eastman Drain - enlargement of the Marydale Avenue and the upstream culverts; and

iii) Reach II South Raisin River - replacement of farm bridge (B-13).

(2) It is recommended that the Authority apply the flood levels shown in this report (Drawings 7907-1 to -16) to any grade control plans for proposed development adjacent to the floodplain. Critical elevations would be contingent on proposals adopted for water management.*

(3) It is recommended that the Authority adopt the fill lines as presented in Drawings 7907-1 to -16, prepared as part of this study.

(4) It is recommended that further water quality studies be undertaken to determine the role of the Cornwall dump in the contamination of the Henderson Drain and the South Raisin River. The study should recommend remedial action.

(5) It is recommended that the Authority continue to manage the subject basin for agriculture, but should take a more active interest in preventing pollution of the South Raisin River.

(6) It is recommended that the Authority recommend to the City of Cornwall and the respective townships that they adopt a programme of annual clean-up of debris and general maintenance of the drains within their corporate limits.

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* For more detailed description of these recommendations, the reader is referred to Appendix C.

REFERENCES

1. Ministry of the Environment, Water Quality Data XI, 1976, Toronto, Ontario

2. Ministry of the Environment, Water Quality Data XII, 1977, Toronto, Ontario

3. Rowe, J.S., 1972, Forest Regions of Canada, Department of the Environment, Ottawa, Ontario

4. Department of Energy, Mines and Resources, 1966, Raisin River Conservation Report, Toronto, Ontario

5. Department of Energy, Mines and Resources, 1969, Raisin River Conservation Report, 1969, Toronto, Ontario

6. Ministry of the Environment, Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment, Toronto, 1978.

7. Ministry of the Environment, Water Quality Data - Ontario Lakes and Streams 1977, Toronto, 1977.

A P P E N D I X   A

APPENDIX A - HYDROLOGIC DATA

In order to develop design flows for the definition of floodplains, use has been made of the Soil Conservation Service method of hydrograph computation. The pertinent variables which were applied to this technique are outlined as follows:

(1) Rainfall

In order to provide a basis for floodplain definition and flood control, the Ontario Ministry of Natural Resources has defined the "regional storm" as the 100-year flood. This flood may be produced from rainfall, snowmelt or the combination of both. For watersheds with the drainage area of the South Raisin River the critical 100-year flood will be that from rainfall. The rainfall or storm duration recommended for use by the Ministry of Natural Resources is of 6-hour duration. The 50-, 25- and 10-year storms were also simulated to obtain their respective flood flows. The 6-hour storms for the regional (100-year) and other design storms are listed on Table A-1.

(2) Rainfall Distribution

In order to convert the rainfall totals into runoff volumes in the form of a hydrograph, it is necessary to distribute

TABLE A - 1

6-HOUR DESIGN STORMS AND DISTRIBUTION

Return Storm (Years)	Total Rainfall* (mm)	Total Rainfall* (inches)
100	94.2	3.71
50	84.8	3.34
25	75.4	2.97
10	62.4	2.46

Time (Hours)	Incremental Rainfall (%)	Accumulated Rainfall (%)
1	8	8
2	9	17
3	11	28
4	49	77
5	15	92
6	8	100

* Atmospheric Environment Service, Cornwall Ontario Hydro Station

the rainfall over a 6-hour period. This means that the rainfall does not fall all at once, nor does it fall evenly over the six hours, but it follows a statistically derived distribution. The distribution used in this study is also listed on Table A-1. By applying each of the rainfall totals with the distribution in the table on the hydrologic model the respective flood flows are thereby obtained.

(3) Soils

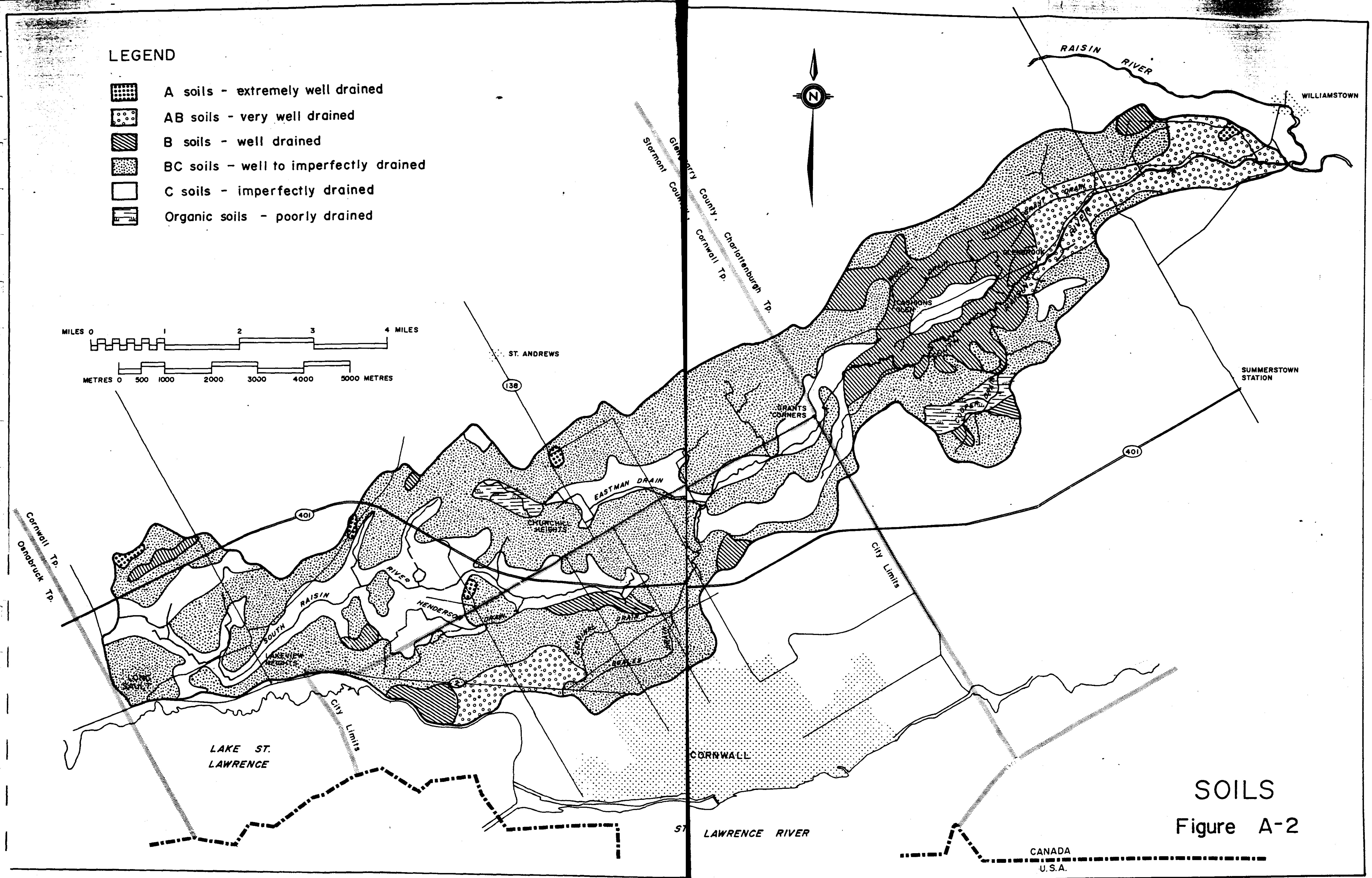
The soils of the South Raisin River basin are largely of well-drained, medium-textured till of Eamer loam with much of the river valley in poorly drained, fine-textured lacustrine deposits of North Gower clay loam with pockets of Allendale sandy loam. The general soil types and their distribution in the watershed are shown on Figure A-2.

(4) Land Use

Land use has an important influence on soils and their ability to absorb rainfall and produce runoff. In the South Raisin River basin, present land use may be described as rural, woodlot, pasture and row crop with some existing and proposed urban development within the city limits of Cornwall. Other areas under some development pressure are Lakeview Heights and Churchill Heights. Figure A-3 shows the existing land use of the study watershed.

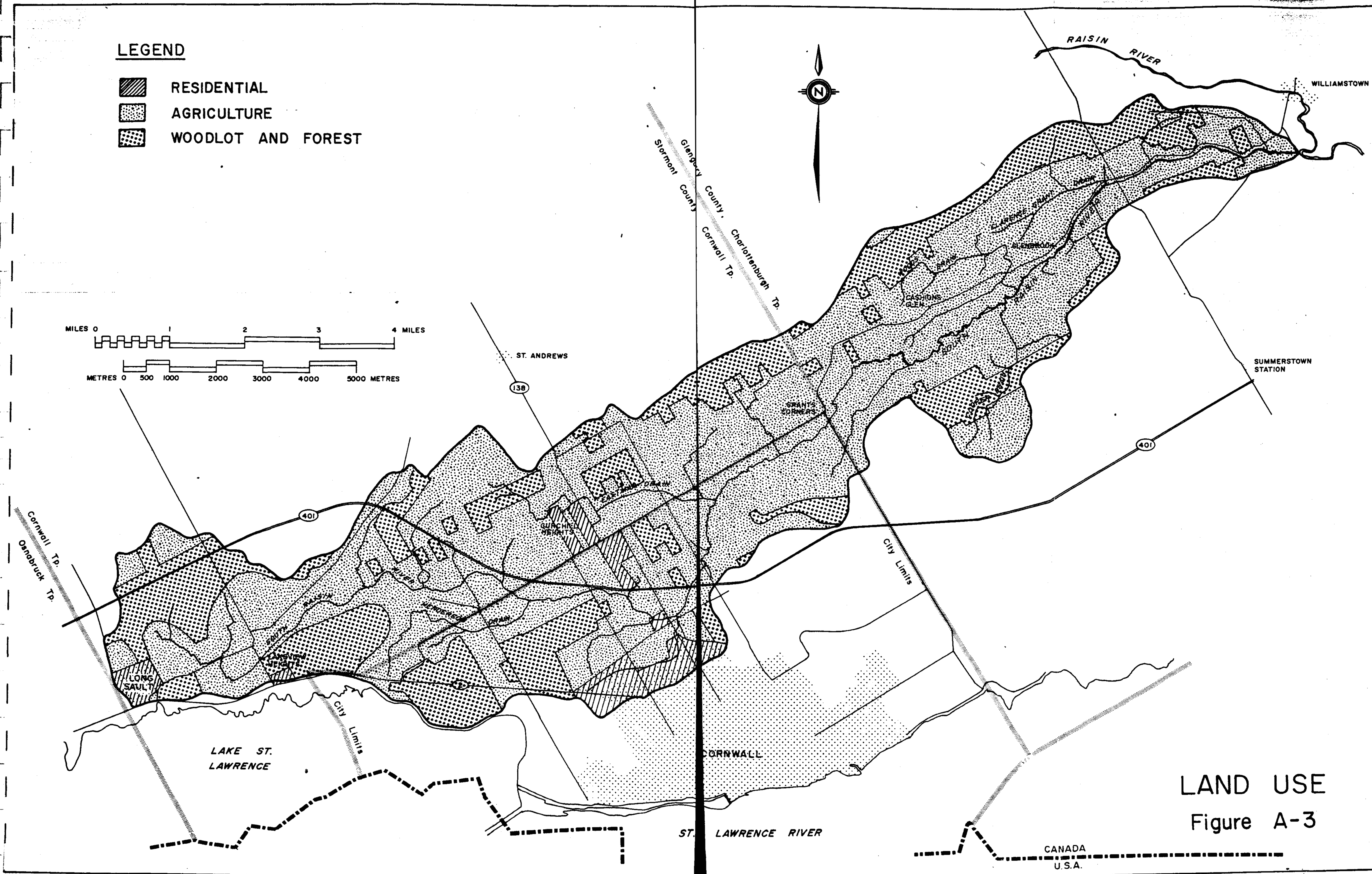
(5) Soil Complex Number

Using the soils data of Figure A-2 together with the land use data, the watershed has been broken down into 19



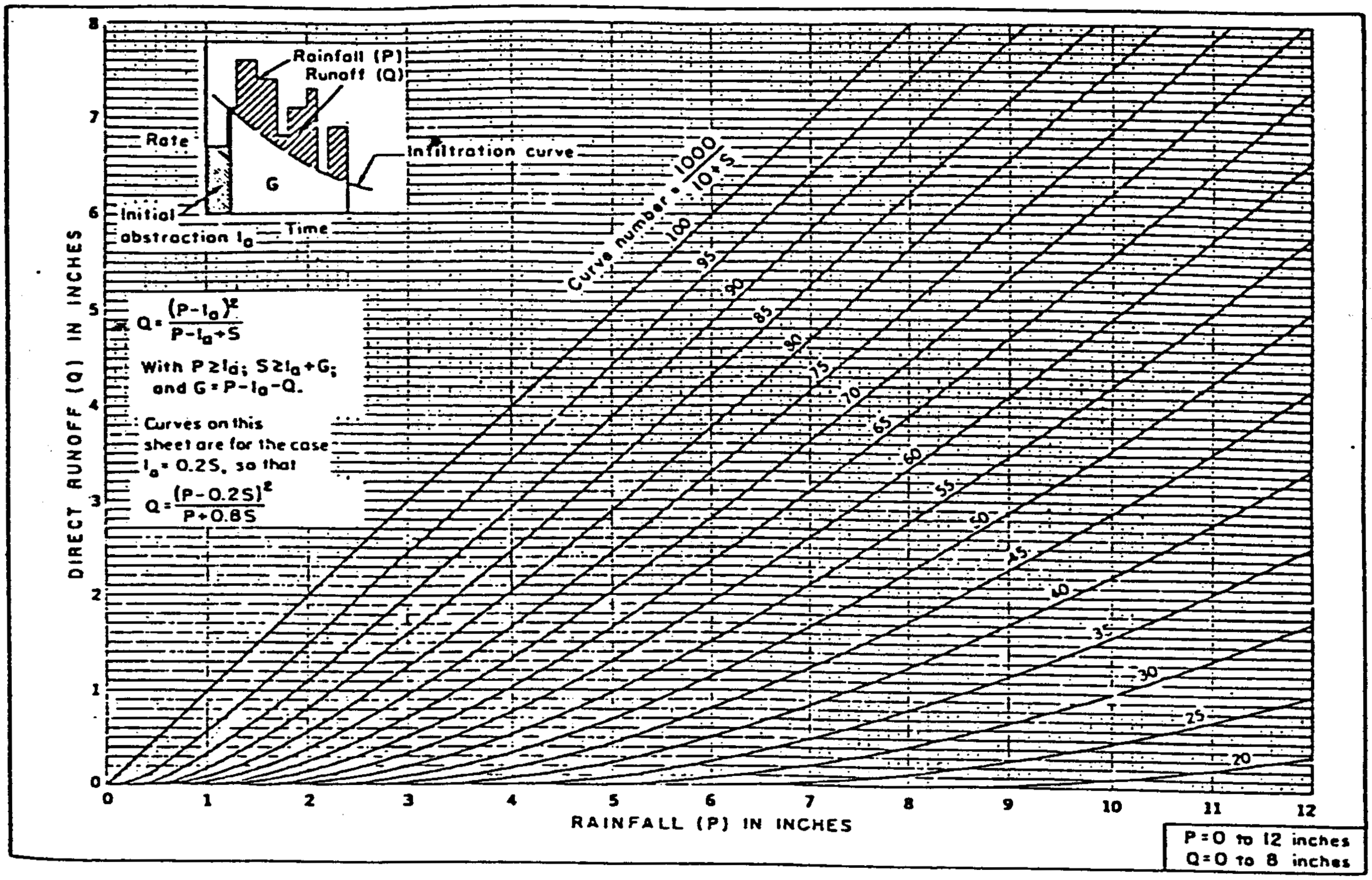
SOILS

Figure A-2



LAND USE

Figure A-3



Solution of runoff equation, $Q = \frac{(P - 0.2S)^2}{P + 0.8S}$. (Sheet 1 of 2.) (U.S. Soil Conservation Service.) 288–D–2549.

RAINFALL - RUNOFF CURVE

figure A-4

TABLE A-2

SOIL CLASSIFICATION TABLE

LAND USE	HYDROLOGIC SOIL GROUP						
	A	AB	B	BC	C	CD	D
Fallow (in special cases only)	77	82	86	89	91	93	94
Crop & other improved land	66*	70	74	78	82	84	86
Pasture & other unimproved land	58*	62*	66	71	76	79	81
Woodlots and forest	50*	54*	58	65	71	74	77
Impervious areas (paved)	98						
Water surfaces	100 (use in special cases only)						

Notes:

1) Figures are based on average antecedent moisture condition (AMC II) except those marked *, which are initially wet (AMC III) or partly wet. For relationship of AMC and rainfall see MTC text. To convert CN's from one AMC to another see MTC text.
2) Table is not applicable to frozen soils or to periods in which snow-melt contributes to runoff.
3) Source: SCS Handbook, Chapter 9 (1), with modifications.

PERCENT IMPERVIOUSNESS OF URBAN AREAS	
URBAN LAND USE	% IMPERVIOUSNESS
Business - Commercial	40 - 90
Industrial - Light	45 - 65
Industrial - Heavy	50 - 70
Residential - Low density	20 - 30
Residential - Medium density	25 - 35
Residential - High density	30 - 40

Source: SCS Handbook, Chapter 15 (1)

Note:

For more detailed values in urban areas see SCS Technical Release No. 55 (9).

TAKEN FROM MTC PUBLICATIONS

M.T.C.
Hydrology Section
Rev. June 1975
Rev. 25 June 1976

sub-basins, and a curve number (Cn) has been calculated for each sub-basin. For details of the curve numbers used on the individual basins the reader is referred to Figures A-1 and Table A-2.

(6) <u>Rainfall Excess</u>

Curves derived by the SCS of the U.S. Department of Agriculture are used in equating rainfall and soil complex data to rainfall-runoff, thereby generating the required hydrographs. This is shown on Figure A-4.

(7) <u>Flood Routing</u>

All routing of storm runoff is completed within the SCS hydrograph model by means of the CONVEX method. All reaches which require routing are depticted on the watersheds schematic shown on Figure A-1.

(8) <u>Flood Flows</u>

For a detailed tabulation of the peak flows for the watershed and its tributaries, the reader is referred to Tables 3-1 and 3-2.

A P P E N D I X   B

APPENDIX B - EVALUATION OF BENEFITS

For purposes of the South Raisin River Study, an empirical approach has been taken for the determination of benefits and flood damage. This approach was felt to be more objective and to provide more reliable results than a detailed field inspection and interview program.

In order to complete this analysis, it is necessary to evaluate structures prone to flooding and to estimate the depths of flood waters around the buildings. All structures in the floodplain were examined by field inspection and were evaluated in comparison to a set of selected "standard homes" from recent real estate transactions.

Having evaluated the houses and carried out hydraulic calculations to define flood depths, it remains to evaluate potential damages. Damages were calculated using the following extension which is outlined in James and Lee (op.cit.):

Cd = Kd x M x d

where:

Cd = flood damage in dollars

M = market value of structure in dollars

d = water depth at foundation in metres (feet)

Kd = factor determined by direct analysis of damage to similar structures. Through exhaustive studies on small streams in the United States an average value for built-up areas of 0.14432 (0.044) has been determined.

The value of structures exposed to flooding was found to average approximately $450/m^2$. Out-buildings were considered when values exceeded $3,000.

In addition to the direct damages, James and Lee (op. cit.) suggest that indirect damages due to flooding are computed as a percentage of direct values (See Table B-1).

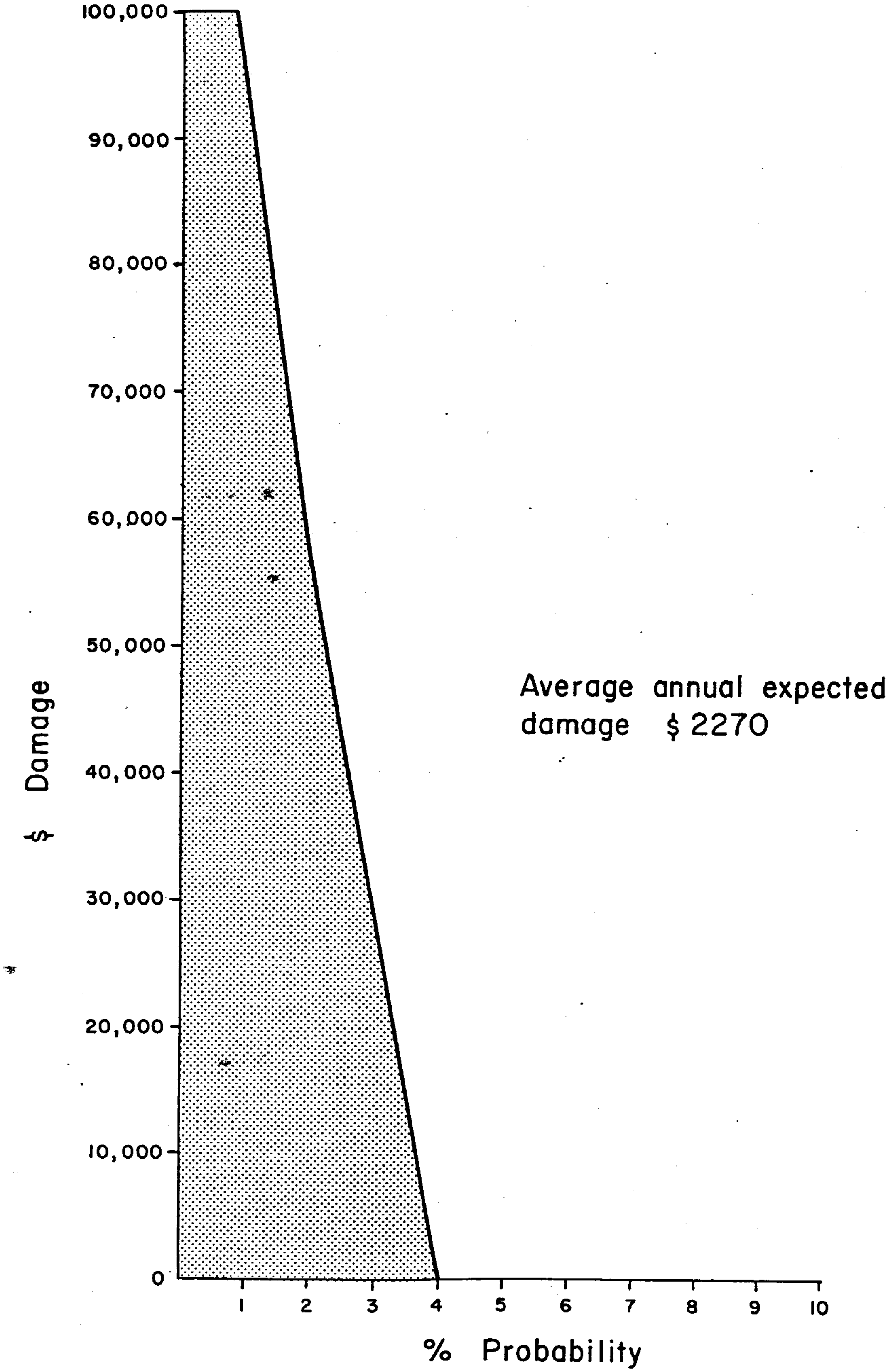
For this study, an indirect damage value equal to 20 percent of direct damages was estimated and used in the analysis.

From the foregoing analysis, the total damages for each storm event have been calculated and used in the calculation of potential damages for the study area. The results appear on the following figures (B-1, B-2 and B-3).

TABLE B - 1

INDIRECT DAMAGES DUE TO FLOODING

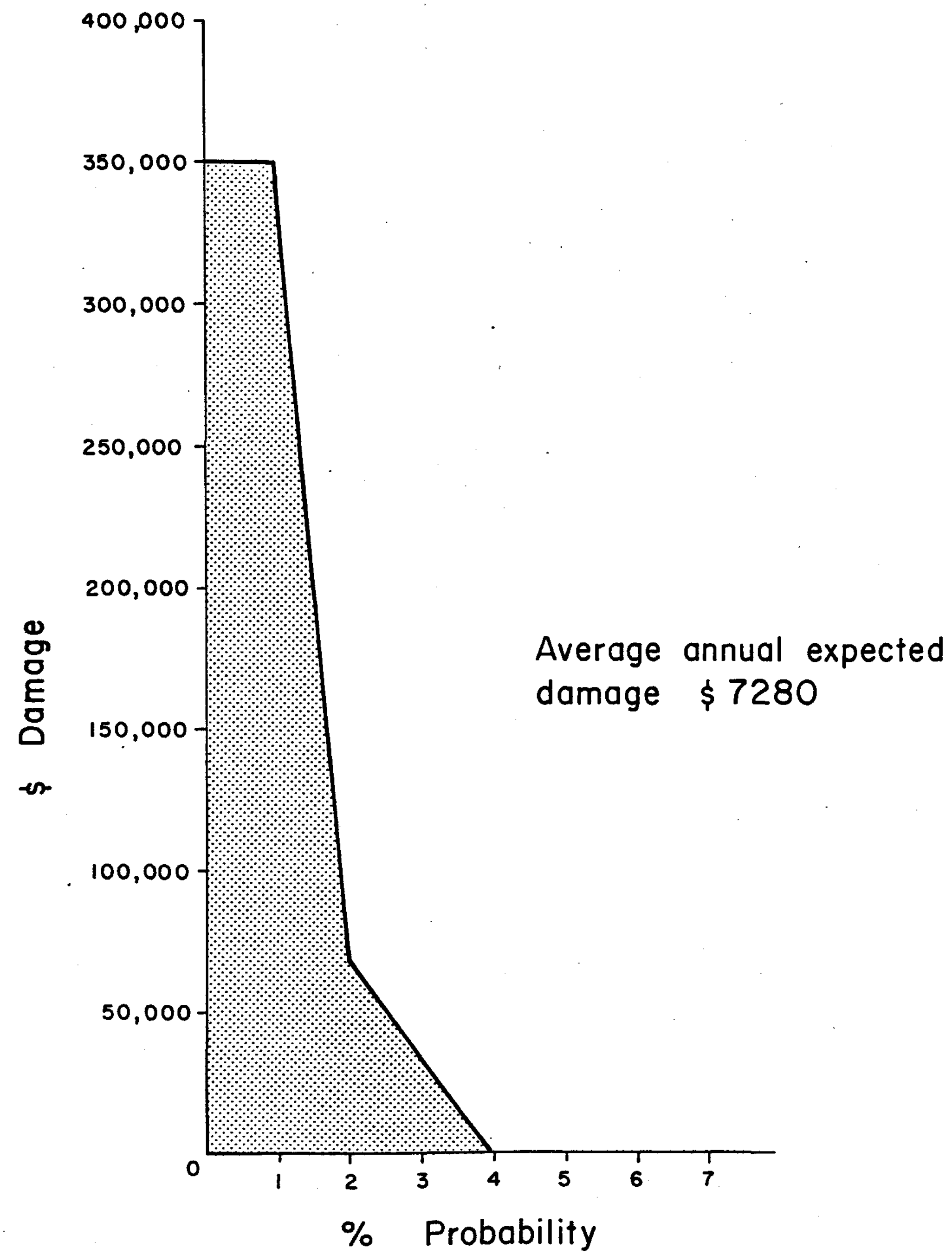
Type of Structure	% of Direct Damage
Residence	15
Public Utility	10
Roads	25
Railway	23



FLOOD DAMAGE VS. PROBABILITY

SOUTH RAISIN RIVER

figure B-1



FLOOD DAMAGE VS. PROBABILITY

BOALES DRAIN

figure B-2

APPENDIX C

APPENDIX C - DRAFT FLOOD AND FILL REGULATIONS FOR SOUTH RAISIN RIVER

C.1 FLOOD AND FILL LINES

Using the criteria and procedures described in the previous sections of this report, floodplains have been defined and illustrated on topographic maps. The flood lines are illustrated on Drawing Nos. 7907-1 to 16, prepared in conjunction with this report. These drawings, at a scale of 1 to 2000 with contour interval of 1 m and interpolations to 0.5 m, illustrate the estimated extent of floodplains adjacent to the channel reaches previously described.

In addition to the delineation of floodlines, the consultant was required to recommend fill lines. These lines are to define a control zone for building and construction purposes (minimum freeboard) and are intended to form the limit to which unregulated filling (by the Authority) should be permitted within the valley. The delineation of fill lines has resulted from a detailed consideration of engineering, environmental and planning information obtained in the course of this study.

In connection with filling in floodplain areas, reference is made to Section 27, Subsection 1, Clause f, of the Conservation Authorities Act, R.S.O. 1970, c.79. According to this regulation the Authority has the right to prohibit or regulate "the placing or dumping of fill of any kind in any defined part of the area over which the Authority has jurisdiction in which, in the opinion of the Authority, the control of flooding or pollution or the conservation of land may be affected by the placing or dumping of fill." Under amendment 1973, C-98, 5.8 (1.3), an individual applying to the Authority for permission to fill, and being refused by the Authority, now has the right to an appeal before the Minister of Natural Resources.

With the above factors in mind, the consultant has inscribed on the attached maps those areas which are subject to flooding based upon a purely technical evaluation of the regional design flood on the watershed. The consultant has further inscribed fill lines to delineate those areas beyond which filling or construction should be regulated by the Authority. Fill lines are based upon engineering judgement and their consistency has been assured by the development of an objective set of engineering principles related to natural hazards in valley lands. In this context, is should be clearly understood that the engineering principles mentioned above do not consider the quality of fill to be used in the valley nor its effect on the local environment, but merely the influence of the fill on valley hydrology. As a result, no responsibility can be accepted by the consultant for the deterioration of the environment of the Raisin River valley, due to poor quality of fill or to the placement of fill outside the recommended fill lines.

In conclusion, it is important for the Authority to realize that the flood and fill lines are provided for its guidance and should be used as such. A draft set of regulations are presented below. These regulations may be adopted and must be used with discretion. This is particularly necessary since portions of the valley may be subjected to mitigative water management measures which may alter the flood areas.

C.2 THE USE OF FLOOD PLAINS

There are three common methods of floodplain control: (i) floodplain purchase, (ii) flood proofing, or (iii) floodplain zoning. While floodplain zoning is the most acceptable policy from a planning point of view, it is the most difficult solution to the problem politically.

These three methods will have varying degrees of usage in the South Raisin River. The area south of Highway 401 between Pitt Street and Brookdale Road is subject to flooding and some consideration should be given to permit floodproofing of existing structures. Floodplain zoning should be applied to those areas where plan submission by individuals has not yet occurred. In those areas where draft plan submissions have received favourable response, it may be necessary to undertake a plan of purchase. In applying these three methods of control, the Authority must not only recognize its responsibilities to the public, but must respect the rights of individuals with respect to land ownership.

C.3 DRAFT REGULATIONS FOR THE SOUTH RAISIN RIVER

The following are outlined as recommendations which might be used as general policy statements by the Raisin Region Conservation Authority in granting fill permits on the South Raisin River within the study area.

A. Adoption of Report by Crysler & Lathem Ltd.

Whereas the Raisin Region Conservation Authority is charged with the responsibility for the protection of the South Raisin River within and beyond the corporate limits of the City of Cornwall and in the area known as Lakeview Heights; in particular the floodplain, and following general policies effective ____________________:

(1) General Policy Statements for South Raisin River

i) No encroachment shall be allowed beyond the floodline inscribed on Drawings 7907-1 to -16 prepared as part of the report by Crysler & Lathem Ltd.

ii) Applications for filling beyond the fill lines should be reviewed carefully. Supportive documents based on sound engineering and environmental principles shall be required as part of each application.

iii) The construction of buildings adjacent to the floodplain shall have all portions, except foundations, at an elevation of 0.305 m above that of the local floodplain.

iv) The construction of bridges, culverts and other structures which span the valley shall be the subject of special study by the Authority. The proponent of such a scheme should be required to provide data indicating the effect of such structures on the "local" floodplain, the amount of encroachment on the floodplain, the nature of the portion of the structure in the active floodplain, the discharge capacity of the waterway and plans for conveyance of water during construction.

(2) Specific Policy Statement for Developed Area

i) No encroachment should be allowed beyond the fill lines inscribed in the Crysler & Lathem Ltd. floodplain map, except for the filling required to floodproof existing structures within the floodplain.

(2) ii) Filling for the protection of existing structures in the floodplain should be limited to protection of structures used for human occupancy and the storage of perishable goods only.

In conclusion, the consultant would like to stress that the floodplain mapping, the comments contained in this report and the draft regulations are based upon purely technical decisions. It is hoped that by reviewing this information and applying good conservation and planning principles the Authority will be able to develop a clear-cut, defensible set of management principles. The consultant looks forward to providing further assistance in the development of these principles.

APPENDIX D