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REPORT TO
GRAND RIVER CONSERVATION AUTHORITY

**PRELIMINARY ENGINEERING STUDY
GRAND RIVER VALLEY SLOPE FAILURE
COLBORNE STREET EAST
BRANTFORD, ONTARIO**

VOLUME I
SUMMARY DOCUMENT

Golder Associates
Philips Planning + Engineering Limited
McCormick, Rankin & Associates Limited
Ecologistics Limited

May 1987

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Golder Associates



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

May 21, 1987

Our ref: 861-3257

Grand River Conservation Authority
400 Clyde Road
CAMBRIDGE, Ontario
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ATTENTION: Dr. A.F. Smith, P. Eng., Chairman
Technical Coordinating Committee

**RE: PRELIMINARY ENGINEERING STUDY
GRAND RIVER VALLEY SLOPE FAILURE
COLBORNE STREET EAST
BRANTFORD, ONTARIO**

Dear Sirs:

This letter accompanies our report for the above noted study which is presented in two (2) volumes.

Volume I is a summary document and Volume II provides more detailed supportive information.

In arriving at the selected alternative, we have taken into consideration the recent (March, 1987) property acquisition proposal and the fact that there will be continued slope deformations and retrogression of the top of bank before commencement/implementation of any of the stabilization measures.

The Engineering Study Team would like to express its appreciation to the members of the Technical Coordinating Committee for their meaningful input and direction during the course of this study.

Yours truly

GOLDER ASSOCIATES

John L. Seychuk, P. Eng.
Study Team Director

**Preliminary Engineering Study
Grand River Valley Slope Failure
Colborne Street East
Brantford, Ontario**

SUMMARY AND RECOMMENDATIONS

Summary

On the evening of May 20, 1986, a major slope failure occurred on the Grand River Valley slope adjacent to Colborne Street East in the City of Brantford. This massive landslide directly affected several residential and commercial properties plus the CP Rail (T.H. & B.) tracks located near the toe of the slope.

The landslide was largely caused by:

- oversteepening of the clay slopes due to river erosion at the toe of the slope;
- high groundwater levels within the weak clay soils which form the valley wall slope.

This preliminary engineering study was carried out to evaluate alternative remedial measures to stabilize and protect the 1.3 kilometres of affected valley slopes. These measures were designed to protect life and property within the study area, shown on the enclosed site plan.

The study examined six different alternatives and assessed their relative economic, social and environmental costs and benefits associated with protecting life and property. The alternatives considered were:

1) Do Nothing Alternative

In this alternative, the natural process of erosion and slope failure would carry on unchecked. The top of slope would eventually regress past Colborne Street causing major property loss and the loss of Colborne Street itself.

2) Relocate Colborne Street Alternative

Similar to 1) except that Colborne Street is relocated.

3) Fill Only Alternative

The valley slope is stabilized by adding fill mainly to the lower portion of the slope and maintaining the existing top of bank. The river is widened or relocated. Tableland property and Colborne Street are protected.

4) Cut and Fill Alternative

This alternative stabilizes the slope by a combination of filling at the bottom and trimming back the existing slope on top. The river is widened or relocated. Remaining property and Colborne Street is protected.

5) Cut Only Alternative

The valley bank is stabilized by extensive cutting back and flattening of the slope. There is major property loss and encroachment into Colborne Street.

6) Oxbow Cut Off Alternative

River diverted upstream to eliminate further toe of slope erosion in the study area. Scheme does not solve existing slope instability problem. Requires addition of stability measures 3, 4 or 5. Most expensive of all schemes.

Further evaluation, plus the continued erosion of the existing bank, led to the selection of Alternative 4, the Cut and Fill scheme. This scheme consists of three components: Slope Stabilization and River Works, Land Acquisition, and Planning Controls.

Recommendations

A. The Recommended Plan

1. It is recommended that the cut and fill scheme as described in the following recommendations be implemented.

B. Slope Stabilization and River Works

1. It is recommended that the Valley slope be protected by fill placement at the toe and excavation trimming at the upper portion of the slope, with provision of adequate river erosion protection at the toe of the stabilized slope.

2. It is recommended that if a phased approach is used in constructing the slope that the river channel be relocated and erosion protection be provided on the river banks and along the toe of the stabilized slope.

C. Land Acquisition

1. It is recommended that all the property south of Colborne Street within the study area be acquired to reduce the risk of life.

At the request of the City of Brantford, the GRCA has embarked upon a property acquisition scheme on the south side of Colborne Street to provide a safeguard until stabilization measures are completed.

D. Planning Controls

1. It is recommended that the existing Interim Control By-law be used to freeze land use and prohibit building in the study area south of Colborne Street until remedial works are carried out.

The present interim by-law can only be extended until August, 1988.

2. It is recommended that the study area south of Colborne Street be designated in a special hazard category in the new Official Plan, and a similar amendment made to the Zoning By-law, which prohibits excavating, filling, construction and development.
3. It is recommended that when the slope stabilization measures are completed, final land use controls be carried out through amendments to the Official Plan and Zoning By-law to establish the eventual City of Brantford planning policies in the study area.
4. It is recommended that the City of Brantford request the GRCA to register fill lines within the study area pursuant to Ontario Regulation 154/86 under the Conservation Authorities Act.

This will prevent indiscriminate dumping or placing of fill in the study area.

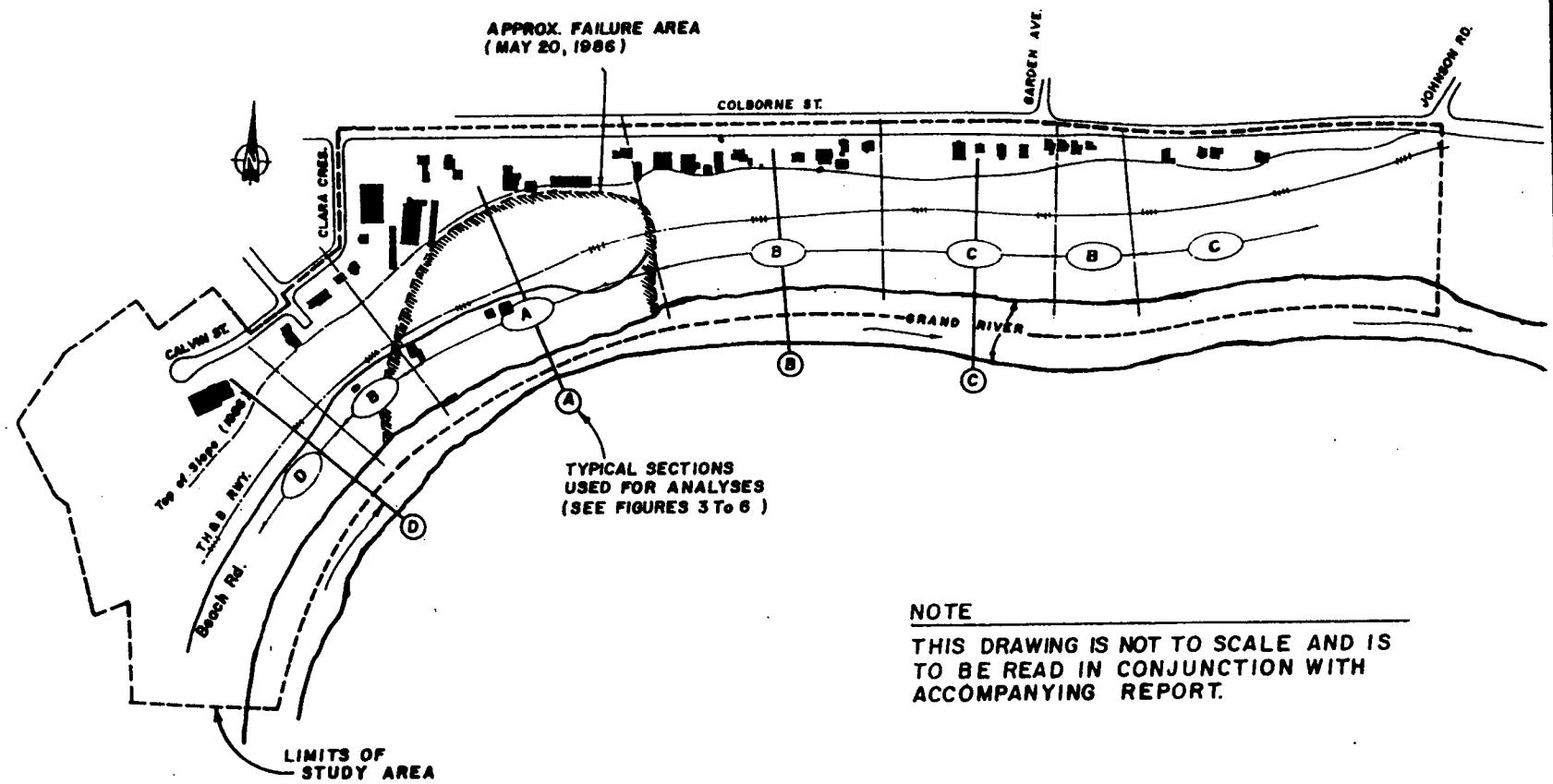
Construction Cost

The cost of the recommended scheme, depending upon the selected river option, is:

	<u>OPTION 1</u>	<u>OPTION 2</u>
	Constructed Immediately (River Widened)	Phased Construction (Channel Relocated)
1) Property Acquisition	2.7	2.7
2) River Channelization	4.2	5.9
3) Municipal Utility	0.2	0.2
4) Slope Stabilization	4.7	5.5
5) Railway Line Reinstatement	0.6	0.6
Total Cost	\$12.4 Million	\$14.9 Million

Date MAY 20, 1987
Project 861-3257

Goldier Associates



TYPICAL SECTIONS
USED FOR ANALYSES
(SEE FIGURES 3 To 6)

NOTE
THIS DRAWING IS NOT TO SCALE AND IS
TO BE READ IN CONJUNCTION WITH
ACCOMPANYING REPORT.

SITE PLAN

Drawn
Chkd
WVF

VOLUME I

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1. INTRODUCTION

This report summarizes the results of our preliminary engineering study of various stabilization measures for the recent slope failure and adjacent area(s) along the Grand River Valley bank beside Colborne Street East in the City of Brantford, Ontario.

The report for this study is presented in two (2) volumes. Volume I is the summary document and Volume II provides more detailed supportive data.

1.1 General

The consulting Engineering Team responsible for carrying out this study consists of:

- Golder Associates
 - prime consultant role and geotechnical input
- Philips Planning + Engineering Limited
 - land use/property, benefit cost analyses and river engineering
- McCormick Rankin & Associates Limited
 - transportation and municipal engineering
- Ecologistics Limited
 - environmental and economics input

Their respective detailed reports form the various sections of Volume II.

A Technical Coordinating Committee (TCC) was established to periodically meet with the Engineering Team to provide direction and review during the six month study period.

TCC COMPOSITION

- Grand River Conservation Authority
 - A.F. Smith, Director of Water Management
 - R. Moulton, Manager of Engineering
 - I. Kao, Assistant General Manager
- City of Brantford
 - A. Gretzinger, City Engineer
 - T. Spiers, Environmental Planning Engineer
 - J.P. Atcheson, Director of Planning
- Ministry of Natural Resources
 - Q. Alam, Construction Maintenance Engineer
- CP Rail
 - S.K. Chopra, Engineer - Bridges and Structures
 - M.J. Klassen, Design Engineer
- Ministry of Transportation and Communications
 - K. Selby, Chief Foundations Engineer
- Township of Brantford
 - J.F. Longley, Township Engineer

1.2 Background Information

On May 20, 1986, a major slope failure occurred along approximately 300 metres of the north valley wall of the Grand River between about MN 915 and 945 Colborne Street

East, in the City of Brantford, Ontario. The location of the failure (encompassing several houses and a railway line) is shown on Figure 1, together with the extent of the present study area.

The valley wall is about 30 metres in height, has an overall inclination of about 14 to 16½ degrees to the horizontal and is of irregular topography. The slope typically consists of a lower and upper portion separated by a narrow, horizontal bench. The Toronto, Hamilton and Buffalo Railway (now CP Rail) tracks extend along the bench. Beach Road is located below the tracks.

A preliminary geotechnical assessment carried out by Golder Associates immediately following the failure in June, 1986 concluded that the primary causes of the massive instability were:

- oversteepening of the slope as a result of ongoing erosion of the river bank
- high groundwater levels within the weak clayey soils which form the valley wall slope

The report concluded that unless adequate remedial work was undertaken, there remains a strong possibility of future slides of similar proportions. Several alternatives for slope stabilization measures were outlined and a scheme, consisting of cut and fill, was identified for conceptual design of remedial works.

Following the failure, an investigation was also carried out by CP Rail. In this regard, detailed post-slide topographical mapping of the study area was obtained and, in addition, an extensive geotechnical investigation and stability evaluation programme was performed (by Trow Geotechnical Ltd.), together with the installation of field instrumentation for a slope movement and groundwater level monitoring programme. This information was made available to the Study Team and was used in this current study.

Our review and evaluation of the CP Rail information confirms the earlier findings in the 1986 Golder overview as to the cause of failure. The mode of failure was regressive and deep seated with the lower portion of the slope failing first followed by the upper section of the slope, as illustrated on Figure 2.

1.3 Terms of Reference

The present engineering study involves the examination of several alternative slope stabilization schemes with the objective that, at the end of the comparison process, a recommendation for the most appropriate alternative will evolve. The six (6) schemes to be considered include a "Do Nothing" approach, a full programme of slope stabilization and a major river diversion.

The complete Terms of Reference are included in Volume II of this report.

2. MAJOR CONSIDERATIONS

This section provides a brief, generalized overview of the significant features/considerations which impact on, or are affected by, the slope stability problem and the stabilization measures, under the following categories.

2.1 River Regime

The Grand River flows along the base of the high valley slope adjacent to Colborne Street. The river channel forms a big bend through the study area which is known locally as "The Oxbow". Erosion at the toe of the slope has been identified as the principal contributor to bank instability, and is discussed in more detail in Section 2.2.4 of this report. Debris from the slope failure of May, 1986 has encroached into the river channel creating a constriction to flow with a resultant increase in flow velocity, variation in flow direction and a marginal increase in upstream flood levels.

In order to restore the flow capacity of the river and also to incorporate some of the slope stabilization measures, river rechannelization would be required. In addition, to maintain the long term stability of the slope, erosion protection along the bank of the river is required.

2.2 Geotechnical

2.2.1 Categorization of Study Area

For geotechnical evaluation purposes, the valley wall slopes in the study area have been characterized, primarily on the basis of slope geometry, into four (4) zones.

The four (4) zones, designated as A, B, C and D, are delineated on Figure 3.

Zone A corresponds to the area of the catastrophic movements of the May 20, 1986 failure and is characterized by a gently rising lower slope and an oversteepened, actively regressing upper slope.

Zones B and C comprise other sections of the valley wall within the study area with a geometry resembling the pre-failure geometry in zone A. While some deformations were observed in these zones during and subsequent to the May, 1986 failure, the magnitude of the movements has been relatively small. The inclination of the lower slopes varies between 2.5 and 4.0 horizontal to 1 vertical; however, typically the overall inclination of the lower slopes approaches 4 horizontal to 1 vertical. The inclination of the upper slopes ranges from about 1.7 to 3.0 horizontal to 1 vertical.

Zone D is essentially a transition zone between the inherently unstable slopes in zones A, B and C and the flatter, more stable slopes west of the study area.

2.2.2 Subsurface Conditions

The 30 metre high valley wall is comprised of a complex interlayering of clayey silt, silt and silty clay which extends to the rock surface which is at a depth of about 6 to 8 metres below the riverbed. A relatively thin layer of silty sand was encountered in the study area at about mid-height between the tableland and the rock surface.

For the purpose of geotechnical analyses, the soil stratigraphy in the valley wall has been simplified into two discrete clayey layers, as indicated on Figure 4.

The groundwater regime within the valley wall, simplified on Figure 4 for analytical purposes, is complex. The phreatic surface typically parallels the ground surface at shallow depth. The piezometric level associated with the bedrock results in artesian conditions in the area of the lower slope and beneath the riverbed. The groundwater levels in zone A have remained high relative to the stabilized levels indicated for the remainder of the study area.

2.2.3 Stability Analyses

Slope stability analyses have been carried out for the representative valley wall geometries, based on the simplified subsurface conditions shown on Figure 4. The results of these analyses indicate that the stability of the lower valley wall slopes in zones B and C is not markedly dissimilar from that computed for the pre-1986 failure conditions in zone A. Summarized results of the analyses for the simplified existing geometry for zone B are shown on Figure 5. Typically, a factor of safety ranging from about 1.1 to 1.2 is indicated for the upper slopes with a factor of safety of between unity and 1.1 for the lower slopes. A factor of safety of less than unity is obtained for the present upper slope in zone A and also for the case of localized toe failures in zone A.

2.2.4 Erosion

Based on a comparison of the historical topographical mapping available for the study area, an apparent erosion rate of about 0.4 metres per year has been indicated for zone A, with a somewhat erratic pattern for the other sections of the study area.

The continued, and apparently recently increasing, rate of erosion indicated for zone A, together with the high groundwater levels and weak clayey soils, have been identified as the primary causes of the 1986 failure. The encroachment of the recent failure debris into the river channel in zone A has resulted in an increased river flow velocity and variations in stream flow vectors. Rapid erosion of the slide debris is anticipated, increasing the potential for continual and accelerated creep of the lower slope in zone A.

In addition, the erosion exposure to the other zones may have increased as a result of the changes to the river flow characteristics caused by the May, 1986 landslide. Irrespective of the factors of safety indicated, the potential for large scale movements in all sections of the study area should therefore be recognized and, as a consequence, appropriate measures taken in the interests of public safety. This hazard will continue to exist until such time as appropriate mitigative measures have been completed.

2.3 Environmental

The terrestrial and aquatic biological resources in the study area include vegetation, wildlife and fish. The potential impacts on these natural environment features of the river bank instability and the various alternatives of dealing with the problems were assessed and given due consideration. As outlined in Appendix V of Volume II of this report, there are no significant impacts for the viable alternatives under consideration. This evaluation was carried out in accordance with the requirements of the Class Environmental Assessment for Water Management Structures (Association of Conservation Authorities of Ontario, 1986).

2.4 Property

In addition to the properties along Beach Road, a number of properties along the south side of Colborne Street adjacent to the top of the slope were affected by the May, 1986 failure. With time, further property will be lost south of Colborne Street and Clara Crescent due to continued retrogression of the slope to the north. There are a total of about 39 properties within the study area, not including those on the north side of Colborne Street.

An evaluation was carried out for each of the properties to assist in establishing land costs for each of the alternative stabilization schemes.

2.5 Transportation

2.5.1 Road (Colborne Street East)

Although Colborne Street East has not been visibly affected to date by the slope failure it is expected that, if nothing is done to stabilize the slope and if the erosion of the toe of the slope continues at its historical rate, the top of the slope will have extended northerly into the road allowance within about 50 years.

2.5.2 Railroad (CP Rail)

The Canadian Pacific Railway (formerly the Toronto, Hamilton and Buffalo Railway) line was established in 1895. This line has continued in operation since that time even though slope instability problems have been experienced for many years. The slope failure of May 1986 removed this line from service and it is expected that service will not resume until the slope instability situation is corrected.

2.6 Municipal Services

The only municipal service affected by the May 1986 slope failure was the storm sewer outfall from Colborne Street East to the Grand River. This damaged outfall, which was temporarily repaired, will have to be replaced in the near future. If the slope is not stabilized, the storm sewer outlet should be relocated outside of the area of instability.

The other utilities located within the Colborne Street East right-of-way, which have not been affected to date, are expected to be placed in jeopardy in the future if stabilization measures are not implemented.

2.7 Land Use Planning

The municipal planning affecting the study area permits development below the top of the unstable slope down to the railway line. Although interim temporary control measures place a moratorium on any development in the area, it is important that permanent controls be implemented so that future development is not permitted on or near the slope after the remedial works have been completed. Such development controls will ensure that the integrity of the slope stabilization works is maintained.

2.8 Economics/Benefit vs Cost Analysis Approach

The simplest approach to estimating the total cost of a project is to use the capital costs. This may be appropriate for simple projects of short duration which have no social or other impacts. However, the project under consideration has many impacts which are of importance and, therefore, these must be considered in the comparison of schemes.

Each proposed scheme for stabilizing the slope will have benefits associated with it, along with costs. Some of the costs related to the various schemes, such as annual maintenance costs, require expenditures some time in the future. An economic analysis takes these future amounts

and translates or relates them back into present values. This allows the future costs to be evaluated in terms of present-day dollars. The economic analysis thus puts all costs on an equal basis for comparison purposes.

Although it is relatively easy to compare the capital cost of a scheme with, say, the savings in value of properties that would be lost if further slope failures were allowed to occur, many other impacts may result from the implementation of a scheme. An example of an impact to which a dollar value cannot be assigned is risk to life and limb. If one scheme minimizes that risk, while another, slightly less costly scheme does not, the one which minimizes risk should be preferred.

In order to fairly and equitably evaluate each proposed scheme, a benefit versus cost analysis has been undertaken in accordance with the Ministry of Natural Resources guidelines. This analysis enables the comparison of each scheme relative to its adverse and beneficial impacts. In this way, each alternative is assessed fairly and the ranking of the schemes represents a consideration of all aspects related to the project. The results of the benefit versus cost analysis provide a guideline consisting of a relative rating of the schemes, in order of preference, from which the proponent can select the one which is deemed most suitable.

3. ALTERNATIVE REMEDIAL MEASURES

3.1 Schemes Considered

In accordance with the Terms of Reference, the six (6) alternatives being considered to address the hazardous conditions which presently exist in the study area are:

<u>Scheme</u>	<u>Description</u>
(1)	Do Nothing
(2)	Relocate Colborne Street only
(3)	Stabilize slopes by filling only
(4)	Stabilize slopes by cutting and filling
(5)	Stabilize slopes by cutting only
(6)	Divert river isolating "The Oxbow" area

The first two (2) schemes represent a "passive" approach in which river erosion is unchecked and the valley slope is allowed to regress unimpeded. In the second scheme, major public works would be relocated away from the hazard area. In the next three (3) "pro-active" approaches, major civil engineering works would be carried out to arrest toe erosion and stabilize the slopes. Rechannelization works, erosion control works and slope regrading are common to these three (3) schemes. The final scheme considers constructing a major upstream river diversion which would cut off the large meander and remove the erosion potential.

A capsule summary of the schemes is given in Table I. The following is a brief description of the salient features/impacts of each alternative.

3.1.1 Scheme 1 - Do Nothing

- is the base assumption and forms the basis for the comparison of other schemes
- natural process of erosion and slope failure/regression would carry on, unchecked

- no protection is provided for the lands and buildings on the south side of Colborne Street and abandonment will be necessary
- possible eventual retrogression of top of slope into Colborne Street would jeopardize vehicular use of the road and utilities
- the extent of retrogression estimated for a 50 year period is shown on Figure 6
- unlikely that railway line would be restored to service with an acceptable degree of risk against failure
- further failures could block the existing river channel and increase potential flooding upstream

3.1.2 Scheme 2 - Relocate Colborne Street

- similar, in most respects, to the above scheme in that the slope instability problem is not solved
- realizing that the integrity of Colborne Street is in jeopardy, the long term serviceability of the road in the study area would be ensured by relocation to the north
- the relocation of Colborne Street would also require the extension/replacement of the CP Rail grade separation structure to the east.
- in addition to eventual property loss on the south side of Colborne Street, property would have to be acquired on the north side for road and utility reconstruction purposes

3.1.3 Scheme 3 - Fill Only

- in a total fill scheme, the present (May, 1986) location of the top of the bank is maintained with the exception of some minor upper slope trimming, and remedial works are designed to arrest any future regression
- the slope is regraded to a stable inclination primarily by filling at the toe and, where required, on the upper slope
- with encroachment of the fill into the river, as shown on Figure 7, major rechanneling (relocation or widening) of the river would be required
- provision of suitable erosion protection at the toe of the slope and river banks would be required to preserve long term stability
- preservation of property on top of the slope would be maximized and Colborne Street would not be jeopardized
- the provision of a bench on the slope would permit reinstatement of the railway line within its present right-of-way
- a schematic section through zone B illustrating the slope geometry and extent of filling is shown on Figure 8

3.1.4 Scheme 4 - Cut and Fill

- a stable slope geometry is achieved by a combination of fill placement at the toe and excavation trimming of the upper portion of the slope
- the probable limits of the cut and fill are shown on Figure 9

- this scheme results in less encroachment into the existing river channel but involves loss of tableland and some property at the top of the slope
- as with the previous scheme, some river rechannelization would be required and erosion protection works would be a key component of the work
- properties not required for slope trimming would be protected and Colborne Street would be safeguarded
- reinstatement of the railway line within the regraded, stabilized slope would be feasible
- a schematic section showing the extent of regrading for this scheme is presented on Figure 10

3.1.5 Scheme 5 - Cut Only

- in this scheme the existing (pre-May 1986 failure) toe of river bank would be re-established, and a stable inclination achieved by removal of the recent slide debris in the river and by cutting into the existing slope
- removal of existing slide debris may precipitate additional large slope movements
- no major river rechannelization work would be required, except for erosion protection works to maintain the re-established toe of slope
- the cut required to achieve stable geometry would result in substantial encroachment at the top of the slope
- the top and toe of slope lines for this scheme are shown on Figure 11

- all property south of Colborne Street would be lost and Colborne Street and utility relocation to the north (as in scheme 2) would be required
- a northerly lateral shift of the railway line would be required outside of the existing right-of-way
- in addition, a new railway grade separation for Colborne Street would be required to accommodate the new railway alignment and grade requirements
- the resultant geometry for this scheme is shown schematically on Figure 12

3.1.6 Scheme 6 - Oxbow Cutoff

- this scheme isolates the large river meander known locally as "The Oxbow" by construction of a major river diversion channel some 3 kilometres upstream, across the neck of the meander, as shown schematically on Figure 13
- continued toe erosion of the slope in, and outside of, the study area would essentially be eliminated
- however, a hazard would still exist due to the unstable condition of the slopes, as indicated within schemes 1 and 2, above
- to be fully effective, this scheme would have to be considered with one of the pro-active slope regrading schemes (3, 4 or 5) to ensure stability, otherwise there would be a continued threat to life and property on top of the slope and eventually to Colborne Street itself

3.2 Comparison of Schemes

3.2.1 General

A brief description and a summary of the impacts of each of the six (6) schemes is presented on Table II. A qualitative examination of whether each of the schemes meets the objective(s) of solving the various components/considerations of the problem caused by instability within the study area, is given in Table III.

In addition, Table IV provides a ranking as to the effectiveness of each scheme in improving the situation under the same categories as considered in the previous tables.

The above evaluation/comparison exercise indicates that, on basically a qualitative assessment basis, the total fill scheme (3) followed by the cut and fill combination (4) rank the highest in meeting the stated objectives.

3.2.2 Property Costs

The south side of Colborne Street through the study area is unique, since there is no base data to determine the market value of the properties following the May, 1986 slope failure. Therefore, the pre-failure market value was determined for each property within the study area. The results of the appraisal are summarized in Figure 14 for each of the land areas involved in the alternatives being considered. The quantum shown does not make any allowance for railway property.

The property costs are of the order of \$1.7 Million for the Total Fill scheme (3) taking the top of bank line as it was immediately after the May, 1986 failure. All of the property south of Colborne Street and Clara Crescent, within the potentially unstable area on top of the bank, is some \$3.8 Million. In addition, the property north of Colborne Street, which would be involved in a total relocation of the road, is approximately \$6.7 Million.

3.2.3 Construction Costs

A capital cost estimate for each of the alternatives is outlined in Table V. From a comparison of the "pro-active" schemes, it is apparent that the total construction cost for schemes 3 and 4 is of the same order of magnitude (about \$12 Million, excluding railway re-establishment costs) and that both these schemes are the cheapest.

3.2.4 Benefit vs Cost Analysis

A detailed benefit versus cost analysis was carried out for each of the alternatives assuming the conditions following the May, 1986 slope failure. Table VI provides a summary of the impact factors considered in this analysis.

The impacts for each alternative form the base information for a benefit versus cost analysis which is discussed in detail in Appendix VII of Volume II of this report.

The benefit versus cost analysis undertaken suggests the Total Fill - River Widening scheme as the preferred option, primarily due to benefits accrued as a result of tableland preservation, lower land acquisition costs and lesser social impacts associated with property acquisition.

3.2.5 Recent Developments/Considerations

The Fill Only scheme relates specifically to post-slide (May, 1986) conditions which have since changed due to continual retrogression of the top of the bank. Furthermore, the evaluation process has not dealt with possible delay of stabilization measures due to phasing/staging of construction over a number of years, as discussed in section 4.1 of this report.

The top of bank will naturally retrogress with additional property loss and potential danger to life until remedial works are completed. Accordingly, at the request of the City of Brantford, the Grand River Conservation Authority has embarked upon a property acquisition programme on the south side of Colborne Street within the study area. Primarily, this is an attempt to alleviate the risk to life that will exist prior to any remedial works being completed.

With continued slope instability and top of bank retrogression prior to implementation of remedial works, the Fill Only scheme (3) becomes unrealistic. This is because the top of bank location used in the evaluation process is based on immediate post-slide conditions which have since changed due to erosion. Therefore, a modified benefit versus cost analysis was undertaken, with appropriate modifications, to reflect this situation.

4. RECOMMENDED ALTERNATIVE

The results of the revised benefit cost analysis, based upon the factors noted in the preceding section, indicate that scheme (4), the Cut and Fill alternative (with river channel widening) evolves as the most appropriate and beneficial scheme.

4.1 Phased Implementation

Potential fiscal constraints may necessitate phased implementation of stabilization measures over a number of years. Staging, in practical terms, means that the actual top of bank would be still further back than it is at present.

Therefore, in addition to carrying out the complete stabilization measures immediately, an examination was also made of phasing/staging the remedial measures over a period of time. It was concluded that, in order to minimize risk to life due to continued instability, it would be necessary to prioritize the work with the phased approach as follows:

- initially acquire the property on top of the bank in the study area
- widen or construct a new river channel to the south of the existing river (rather than river widening)
- thence • stabilize, over a period of time, the slope (top to bottom) in selected sections

Benefit versus cost analyses indicate that the longer the phasing period, the more beneficial a complete channel relocation becomes.

River relocation would cost approximately \$1.7 million more to construct than a channel widening. However, the river widening design, as proposed, cannot be implemented if the slope is stabilized in a series of vertical strips. For a phased approach, river widening would require interim erosion protection which would significantly increase the costs. In addition, with a channel widening scheme, there remains a risk of further channel constriction as a result of additional/continual slope failures during the phased construction period.

The river relocation scheme has been configured to utilize a portion of the existing river channel as a secondary flow channel, thereby reducing the size of the new channel as detailed in Appendix III of Volume II of this report. Alternatively, the existing river channel can be filled in completely and the size of the new relocated channel increased to accommodate all flows. The total cost of either configuration is virtually the same.

4.2 Cost of Recommended Alternative

The recommended cut and fill alternative has two river channel options.

Option 1, the channel widening scheme, considers the slope stabilization being carried out immediately.

Option 2, the channel relocation considers the slope stabilization phased over a period of 5 years. The capital costs are based upon early 1987 construction costs and are given below:

The costs include an engineering design and supervision allowance.

	<u>OPTION 1</u>	<u>OPTION 2</u>
	Constructed Immediately (River Widened)	Phased Construction (Channel Relocated)
1) Property Acquisition	2.7	2.7
2) River Channelization	4.2	5.9
3) Storm Sewer Repairs	0.2	0.2
4) Slope Stabilization	4.7	5.5*
5) Railway Line Reinstatement	0.6	0.6
Total Cost	\$12.4 Million	\$14.9 Million

*includes increased mobilization and temporary erosion protection costs

4.3 Preliminary Design

Preliminary design information for the Cut and Fill scheme, incorporating river channel relocation and river widening options, is provided in Appendix IX of Volume II. Additional information on the preliminary design aspects of the project, including filling in of the existing channel in conjunction with construction of a new channel, is contained in Appendices II and III of Volume II of the engineering report. The concepts of the design are illustrated on the enclosed Figures 15 and 16.

4.4 Land Use Controls/Regulations

In addition to the implementation of the engineered works required to stabilize the slope, it is also necessary to provide the regulatory agencies with the "tools" required to ensure that land use activities at the top of the slope can be restricted to those which are considered compatible and safe. To do so, a review of existing land use policies and controls was carried out and general recommendations made with regard to the formation and provision of such controls.

In order to prevent any undesirable construction above and below the top of the bank, it is suggested that a Zoning By-law amendment be passed that will prohibit building within an engineered distance from the top of slope (6 metres as suggested in Appendix II of the Volume II report). Such zoning should also restrict land use below the top of bank in accordance with the recommendations for changes in the proposed Official Plan. In addition to zoning controls, a Fill line, as recommended by the Municipality, should be established by the Conservation Authority under their regulations to restrict the placement of fill to the south of the engineered setback.

The suggested controls will take time to implement and, by necessity, require detailed information as to the final top of slope in order to dictate the engineered line for control. The extension of the existing Interim Control By-law restricting development is therefore recommended. The Interim Control By-law may, however, lapse prior to the remedial work being carried out. Therefore, in order

to ensure that proper planning controls are in effect in the study area, it is further recommended that the area be designated in a special hazard category in the new Official Plan. The recommended wording for the proposed modification to the Official Plan is detailed in the following section (4.4.1) of this report.

In addition to modifying the Official Plan, the Zoning By-law should be amended prior to expiration of the Interim Control By-law as specifically outlined in section 4.4.2 of this report.

Furthermore, if the acquired lands remain in public ownership following construction, it may be desirable to zone the lands as conservation/open space.

It is further recommended that the re-zoning of the lands and the Fill line designation in accordance with the Conservation Authorities Act proceed immediately following the identification of the final top of the slope to ensure that the necessary controls are in place, should the lands remain in public ownership or be acquired into private ownership after the construction period.

4.4.1 Official Plan Proposed Modification

- (a) Section 7 is amended by adding a new subsection 7.2.5.11, as follows:

"Area 24 - Colborne Street Slope Failure Area

The major slope failure that occurred in this area in May, 1986 and other minor failures are the result of the Grand River eroding its channel into the toe of the original slope combined with the characteristics of the slope and its constituent materials, as reported in two independent studies carried out in 1986 for the Canadian Pacific Railway and the Grand River Conservation Authority. Unless remedial measures are carried out, there will be ongoing slope failures which pose a serious risk to life and property above the top of the existing slope. Golder Associates have been retained by the Grand River Conservation Authority to prepare recommendations for the resolution of this problem. After a decision is made concerning this Study's recommendation, a further detailed engineering study will be required to prepare the necessary plans for the remedial works, and the required funding will have to be resolved. Following this the necessary construction work will be required to be carried out so that the risk can be removed.

Due to the uncertainty regarding the results of the engineering studies and work, and the period of time that will elapse until the area above the slope is rendered safe for human habitation and occupation, the lands in Area 24 cannot be designated in a final land use category. Within this area, therefore, only existing land uses are permitted until such time as the lands above the slope are deemed safe by a competent qualified professional engineer, and

an appropriate amendment has been made to this Plan to designate these lands in a final category or categories. Council's policy for this interim period is to implement this policy by an amendment to the City's Zoning By-law which will permit only the existing uses, buildings and structures, and will not permit any extensions."

- (b) Section 7 is further amended by adding a new subsection 7.3.7.9, as follows:

"Special Policy Area

Area 24 - Colborne Street Slope Failure Area

The policy for this area is set out in subsection 7.2.5.11 of this Plan."

4.4.2 Proposed Zoning By-law Amendment

PROPOSED AMENDMENT TO THE BRANTFORD
ZONING BY-LAW NO. 3649

WHEREAS certain lands south of Colborne Street East sloping to the Grand River are at risk of slope failure which can result in loss of life, personal injury and loss of real property, and such lands can only be protected by slope rehabilitation and related engineering work;

AND WHEREAS the City of Brantford's By-law No. 152-86 imposed an interim control on such lands pursuant to Section 37 of the Planning Act and such By-law will cease to have effect as of August 5, 1988;

AND WHEREAS remedial work to stabilize the slope will require more time to carry out;

AND WHEREAS it is deemed expedient to impose strict land use controls on the area;

NOW THEREFORE the Council of the Corporation of the City of Brantford enacts as follows:

1. The zoning on Sheet 9 of By-law No. 3649 of the lands within the defined area shown on attached Schedule "A", which is hereby declared to form part of this By-law, is changed from:
 - (a) Single Family No. 2 Zone (SF-2),
 - (b) Multi-Family Zone (MF),
 - (c) General Business Zone (GB), and
 - (d) Conservational Zone (CONS)to Development Constraint Zone (DC).
2. By-law No. 3649 is amended by adding a new subsection 13.B. as follows:

"SECTION 13.B: DEVELOPMENT CONSTRAINT ZONE (DC)

In a Development Constraint Zone, no building or structure shall be used and no land shall be used except for such purposes and in accordance with such standards as were existing on the date of passing hereof, provided however that the foregoing shall not apply to prevent the carrying out of:

- (a) municipal or public works by the City or the Grand River Conservation Authority, or
 - (b) construction or repair of the Canadian Pacific Railway (T.H. & B. Railway) in order to restore or impose rail service through the Zone."
3. This By-law shall take effect on the day of passing, subject to the approval of the Ontario Municipal Board if required.

ENACTED this ____ day of _____, 198__.

Mayor

Clerk

NOTE: The existing Hazard Lands (HL) Zone is excluded from this amending by-law as it is adequate for land use control in the southeasterly section of the Study Area. Although it would be possible to utilize the Hazard Lands Zone for the entire Study Area, it was considered that a distinctive zone would be preferable since it is intended to apply only until the engineering work is completed and will be repealed and replaced with final zoning controls.

TABLE I

SUMMARY OF ALTERNATIVES

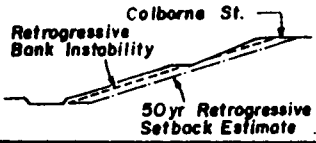
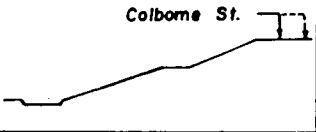
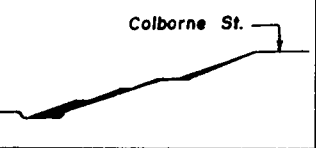
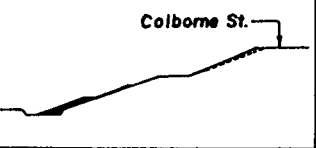
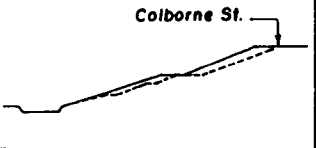
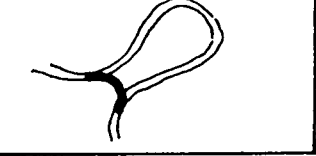
<p>1. DO NOTHING</p> 	<p>No stabilization improvements undertaken. Top of slope eventually retrogresses into Colborne Street - thus jeopardizing property, vehicular use of Road and Municipal Services.</p>
<p>2. RELOCATE COLBORNE ST.</p> 	<p>Nothing done to stabilize slope. Colborne Street and Municipal Services relocated to the north. Continued retrogression of top of bank and loss of property.</p>
<p>3. FILL ONLY</p> 	<p>Slope instability problem solved by widening the river, adding fill in mainly the lower portion of the slope and maintaining (with minimal trimming) the existing top of bank. Property and Colborne Street protected.</p>
<p>4. CUT & FILL</p> 	<p>Slope stabilized by a combination of filling at the bottom and trimming back the existing slope on top and widening the river channel. Remaining property and Colborne Street protected.</p>
<p>5. CUT ONLY</p> 	<p>River re-established to pre-slide location. Valley bank stabilized by extensive cutting back and flattening of slope. Major property loss and encroachment into Colborne Street requiring re-location of road and utilities.</p>
<p>6. OXBOW CUT OFF</p> 	<p>River diverted upstream to eliminate further toe of slope erosion in study area. Scheme does not solve existing slope instability problem and retrogression of top of bank will continue unless slope stabilization measures (as in 3, 4, or 5) undertaken.</p>

TABLE II
REMEDIAL MEASURE CONSIDERATIONS / IMPACTS

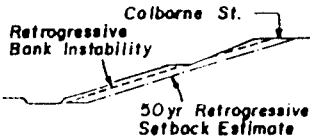

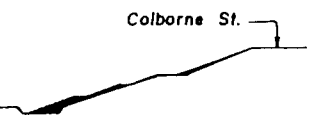
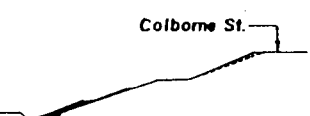

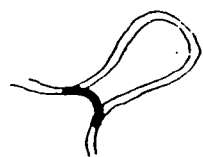
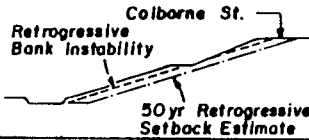
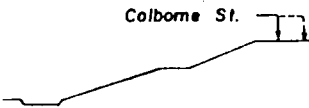
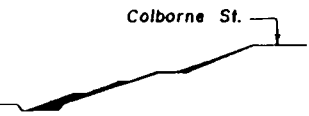
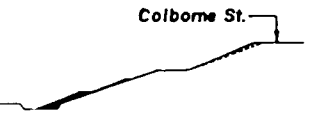

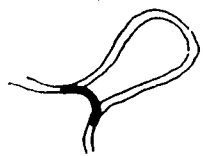
SCHEME & SCHEMATIC ILLUSTRATION	SLOPE	RIVER	RAILWAY	PROPERTY	COLBORNE ST. AND UTILITIES	ENVIRONMENTAL	
						TERRESTRIAL	AQUATIC
1. DO NOTHING 	<ul style="list-style-type: none"> - NOTHING IS DONE - CONTINUING RETROGRESSIVE INSTABILITY 	<ul style="list-style-type: none"> - NOTHING IS DONE - CONTINUING TOE EROSION OF BANK 	<ul style="list-style-type: none"> - ABANDON RAILWAY OR RISK FURTHER FAILURES 	<ul style="list-style-type: none"> - EVENTUAL MAJOR PROPERTY LOSS (ABANDONMENT) 	<ul style="list-style-type: none"> - EVENTUAL ABANDONMENT 	<ul style="list-style-type: none"> - EVENTUAL LOSS OF RESOURCES WHEN SLOPE FAILS - NO POTENTIAL TO RESTORE RESOURCES 	<ul style="list-style-type: none"> - EVENTUAL BANK FAILURES WILL RELEASE SEDIMENTS - POTENTIAL NEGATIVE IMPACT ON RARE FISH, SPORTS FISH AND SPAWNING AREAS
2. RELOCATE COLBORNE ST. 	<ul style="list-style-type: none"> - NOTHING IS DONE - CONTINUED RETROGRESSIVE INSTABILITY 	<ul style="list-style-type: none"> - NOTHING IS DONE - CONTINUED TOE EROSION OF BANK 	<ul style="list-style-type: none"> - ABANDON RAILWAY OR RISK FURTHER FAILURES 	<ul style="list-style-type: none"> - EVENTUAL MAJOR PROPERTY LOSS (ABANDONMENT) 	<ul style="list-style-type: none"> - RELOCATION TO NORTH REQUIRED - WIDEN / RELOCATE RAILWAY GRADE SEPARATION STRUCTURE 	<ul style="list-style-type: none"> - EVENTUAL LOSS OF RESOURCES WHEN SLOPE FAILS - NO POTENTIAL TO RESTORE RESOURCES 	<ul style="list-style-type: none"> - EVENTUAL BANK FAILURES WILL RELEASE SEDIMENTS - POTENTIAL NEGATIVE IMPACT ON RARE FISH, SPORTS FISH AND SPAWNING AREAS
3. FILL ONLY 	<ul style="list-style-type: none"> - COMPLETE RESHAPING & REGRADING 	<ul style="list-style-type: none"> - RIVER WIDENING OR COMPLETE CHANNEL RELOCATION, PLUS EXTENSIVE BANK EROSION PROTECTION 	<ul style="list-style-type: none"> - RECONSTRUCTION AT EXISTING LOCATION 	<ul style="list-style-type: none"> - MINIMAL - MAINTAIN EXISTING TOP OF BANK AS MUCH AS POSSIBLE 	<ul style="list-style-type: none"> - DO NOTHING EXCEPT REPAIRS TO STORM SEWER OUTLET ETC. 	<ul style="list-style-type: none"> - LOSS OF RESOURCES - POTENTIAL TO RESTORE RESOURCES AFTER STABILIZATION 	<ul style="list-style-type: none"> - NO IMPACT IF PROPER CONSTRUCTION TECHNIQUES ARE USED.
4. CUT & FILL 	<ul style="list-style-type: none"> - EXTENSIVE RESHAPING & REGRADING 	<ul style="list-style-type: none"> - RIVER WIDENING OR COMPLETE CHANNEL RELOCATION, PLUS EXTENSIVE BANK EROSION PROTECTION 	<ul style="list-style-type: none"> - RECONSTRUCTION AT EXISTING LOCATION 	<ul style="list-style-type: none"> - SOME UPPER SLOPE TRIMMING - SOME PROPERTY ACQUISITION REQUIRED 	<ul style="list-style-type: none"> - DO NOTHING EXCEPT REPAIRS TO STORM SEWER OUTLET, ETC. 	<ul style="list-style-type: none"> - PARTIAL LOSS OF RESOURCES - POTENTIAL TO RESTORE RESOURCES AFTER STABILIZATION 	<ul style="list-style-type: none"> - NO IMPACT IF PROPER CONSTRUCTION TECHNIQUES ARE USED
5. CUT ONLY 	<ul style="list-style-type: none"> - TOTAL REMOVAL & RESHAPING 	<ul style="list-style-type: none"> - SAME LOCATION - RE-ESTABLISH OLD CHANNEL - EXTENSIVE BANK EROSION PROTECTION 	<ul style="list-style-type: none"> - IMPOSSIBLE TO RECONSTRUCT AT EXISTING LOCATION - SUBSTANTIAL ALIGNMENT CHANGE TO NORTH - REPLACE EXISTING GRADE SEPARATION TO EAST 	<ul style="list-style-type: none"> - MAJOR PROPERTY ACQUISITION REQUIRED (ALL PROPERTY ON SOUTH SIDE OF COLBORNE ST. PLUS NORTH SIDE FOR EASTERN 1/3 OF STUDY AREA) 	<ul style="list-style-type: none"> - RELOCATION OF COLBORNE ST. REQUIRED IN STUDY AREA. - REPAIR / RELOCATE STORM SEWER OUTLET - WIDEN / RELOCATE RAILWAY GRADE SEPARATION STRUCTURE 	<ul style="list-style-type: none"> - LOSS OF RESOURCES - POTENTIAL TO RESTORE RESOURCES AFTER STABILIZATION 	<ul style="list-style-type: none"> - NO IMPACT IF PROPER CONSTRUCTION TECHNIQUES ARE USED
6. OXBOW CUT OFF 	<ul style="list-style-type: none"> - NO FUTURE TOE EROSION OF RIVER BANK - NO TOE PROTECTION REQUIRED IN STUDY AREA - EXISTING INSTABILITY PROBLEM CONTINUES 	<ul style="list-style-type: none"> - MAJOR RECHANNELING & ENERGY DISSIPATION & EROSION CONTROL WORKS REQUIRED - INCREASED RIVER VELOCITIES DOWNSTREAM 	<ul style="list-style-type: none"> - CAN BE RE-ESTABLISHED IF BANK STABILIZED AS IN SCHEMES 3,4 OR 5 - NO TOE PROTECTION REQUIRED IN STUDY AREA 	<ul style="list-style-type: none"> - CONTINUED PROPERTY LOSS IF BANK NOT STABILIZED AS IN SCHEMES 3,4 OR 5 	<ul style="list-style-type: none"> - EVENTUAL LOSS OF COLBORNE ST. IF BANK NOT STABILIZED AS IN SCHEMES 3,4 OR 5 (PARTICULARLY IN EASTERN 1/3 OF STUDY AREA) 	<ul style="list-style-type: none"> - EVENTUAL LOSS OF RESOURCES WHEN SLOPE FAILS - NO POTENTIAL TO RESTORE RESOURCES - LOSS OF TERRESTRIAL HABITAT AT LOCATION OF CUT. - CREATION OF UNVEGETATED AREA IN OLD CHANNEL 	<ul style="list-style-type: none"> - LOSS OF APPROXIMATELY 7km. OF FISH HABITAT - POTENTIAL DAMAGE TO DOWNSTREAM AQUATIC RESOURCES DUE TO SILTATION AND/OR INCREASED WATER VELOCITY

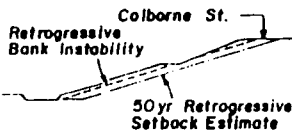
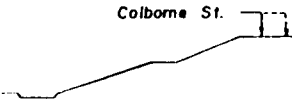

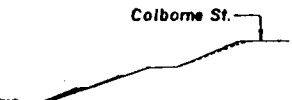
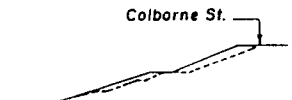

TABLE III
OPPORTUNITIES TO ACHIEVE OBJECTIVES

SCHEME & SCHEMATIC ILLUSTRATION	STABILIZE SLOPE	REMOVE FLOODING POTENTIAL	SAFE TRANSPORTATION ENVIRONMENT - COLBORNE ST.	SAFE LAND USE DEVELOPMENT	SAFE TRANSPORTATION ENVIRONMENT - RAILWAY	PROTECT NATURAL ENVIRONMENT		PRESERVE TABLE LANDS SOUTH OF COLBORNE ST.	PROPERTY & CONSTRUCTION COSTS
						TERRESTRIAL	AQUATIC		
1. DO NOTHING 	NO	NO	NO	NO	NO	NO	NO	NO	NIL
2. RELOCATE COLBORNE ST. 	NO	NO	YES	NO	NO	NO	NO	NO	INTERMEDIATE
3. FILL ONLY 	YES	YES	YES	YES	YES	YES	YES	YES	LOW
4. CUT & FILL 	YES	YES	YES	YES	YES	YES	YES	NO(+)	LEAST
5. CUT ONLY 	YES	YES	YES	YES	YES	YES	YES	NO	HIGH
6. OXBOW CUT OFF 	NO	YES	NO	NO	NO	NO	NO	NO	VERY HIGH

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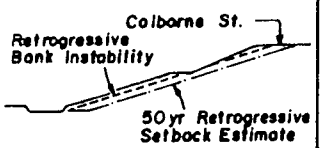
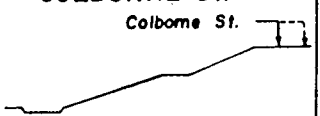

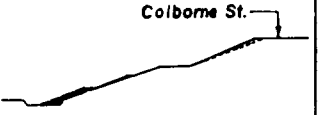


TABLE IV
COMPARISON OF ALTERNATIVES

861-3257

SCHEME & SCHEMATIC ILLUSTRATION	SLOPE STABILITY	RIVER PERFORMANCE	ROAD & UTILITIES PROTECTION	RAILWAY COMPANIES	PROPERTY OWNERS DISLOCATION	EFFECT ON ENVIRONMENT	CONSTRUCTION & PROPERTY COSTS	TOTAL
1. DO NOTHING 	1	1	1	1	1	3	3	11
2. RELOCATE COLBORNE ST. 	2	2	3	2	3	2	4	18
3. FILL ONLY 	6	5	6	6	6	5	5	39
4. CUT & FILL 	5	4	5	5	5	6	6	36
5. CUT ONLY 	4	3	4	4	4	4	2	25
6. OXBOW CUT OFF 	3	6	2	3	2	1	1	18

NOTES: (i) Effectiveness ranking is on a 1 to 6 point scale
(ii) Number 6 denotes highest effectiveness and Number 1 least effectiveness
(iii) The same ranking number is not used twice in a comparison

CAPITAL COST ESTIMATE (\$ MILLION) - COMPARISON OF ALTERNATIVES

SCHEME & SCHEMATIC ILLUSTRATION	SLOPE	RIVER	ROAD & UTILITIES	GRADE SEPARATION STRUCTURE	RAILWAY LINE REINSTATEMENT	PROPERTY	TOTAL
1. DO NOTHING 	-	-	-	-	-	3.8 (SOUTH SIDE COLBORNE ST.)	3.8 (PLUS EVENTUAL LOSS OF COLBORNE ST.)
2. RELOCATE COLBORNE ST. 	-	-	4.2	1.0	-	6.7 (NORTH SIDE COLBORNE ST.)	11.9 (PLUS ABOVE)
3. FILL ONLY 	6.0	4.2 * (RIVER WIDENING)	0.2 (STORM SEWER REPAIRS)	-	0.6	1.7	12.7
4. CUT & FILL 	4.7	4.2 * (RIVER WIDENING)	0.2 (STORM SEWER REPAIRS)	-	0.6	2.7	12.4
5. CUT ONLY 	5.2	2.2	4.2	1.0	0.6	3.8 + 6.7	23.7
6. OXBOW CUT OFF 	-	50.0	-	-	-	0.1	50 +

* ADDITIONAL COST OF \$ 1.7 MILLION FOR COMPLETE RIVER RELOCATION OPTION .

May 1987

TABLE VI

861-3257

SUMMARY OF IMPACT FACTORS CONSIDERED IN THE BENEFIT/COST ANALYSIS

TANGIBLE COSTS	TANGIBLE BENEFITS	INTANGIBLE COSTS	INTANGIBLE BENEFITS
-\$	+\$	-?	+?
<ul style="list-style-type: none">- River Training- Bank Stabilization- Environmental Protection- Road Reinstatement- Storm Sewer Repairs- Railway Reinstatement- Services Relocation- Engineering and Supervision- Property Acquisition- Legal- Planning and Approvals- Normal Project Maintenance- Major Project Maintenance	<ul style="list-style-type: none">- Flood Hazard- Railway Maintenance Costs- Railway Operating Costs- Storm Sewer Maintenance- Road Maintenance- Fill for Landfill/Dyking- Increased Property Values	<ul style="list-style-type: none">- Loss of Business Income- Personal Disruption- Relocation Costs- Construction Noise, Dust, Etc.- Disruptions to the Community- Disruption of Services- Terrestrial Environmental Impact- Aquatic Environmental Impact- Traffic Disruption	<ul style="list-style-type: none">- Flow velocity Maintenance Immediately Downstream.- Fiscal Planning- Reduced Risk to Life and Limb- Economic Benefits During Construction.

LEGEND

- ⊕ BOREHOLE LOCATIONS
 - ⊕ PROBEHOLE LOCATIONS
- BOREHOLE INFORMATION
SUPPLIED BY C.P. RAILWAY.

REFERENCE

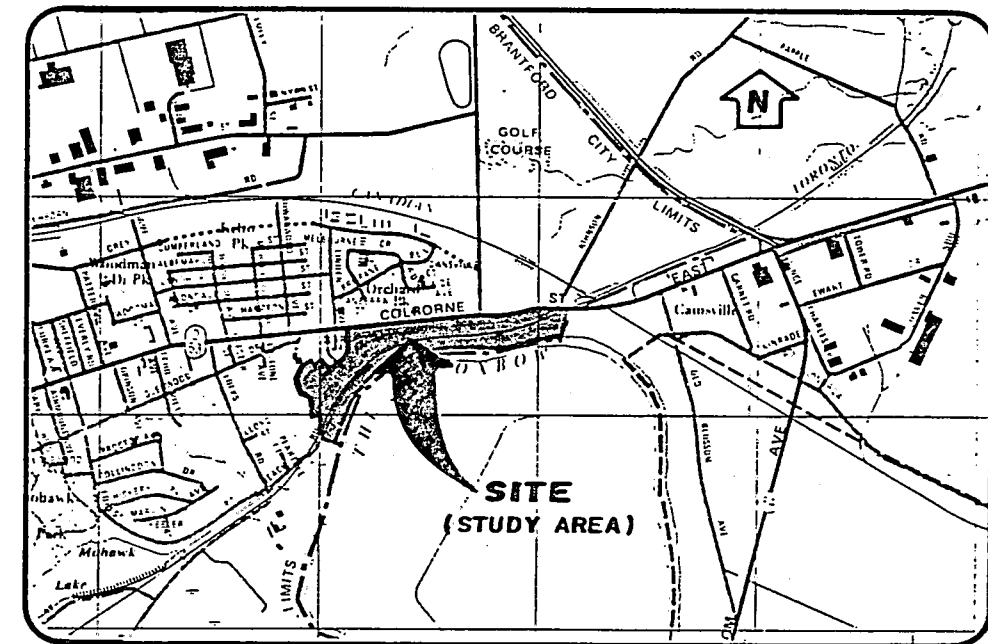
- 1) TOPOGRAPHIC MAPPING PREPARED BY
NORTHWAY MAP TECHNOLOGY LIMITED
FOR CANADIAN PACIFIC (JUNE 1986)
- 2) DRAWING BY TROW GEOTECHNICAL LTD.
GENERAL SITE PLAN DWG. No. 2
PROJ. No. G86-0266A/G DATED AUG. /86.

NOTES

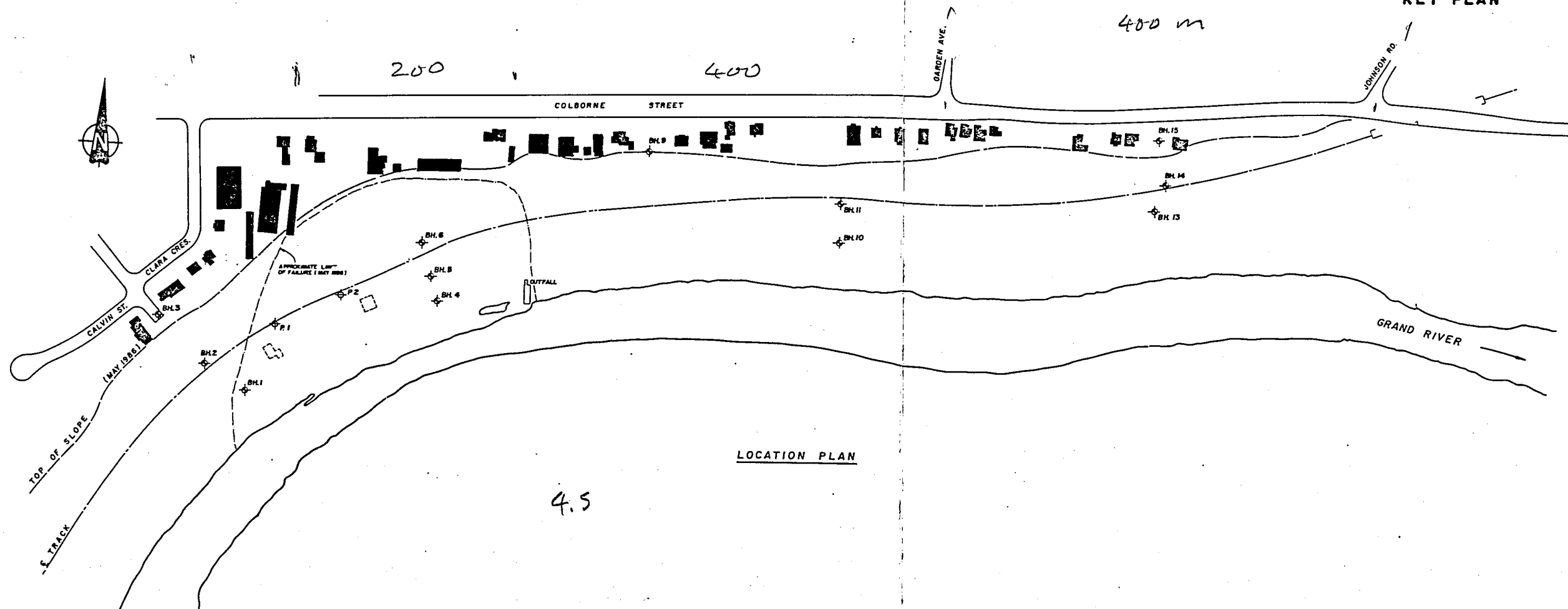
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH
ACCOMPANYING REPORT.

LOCATION PLAN

FIGURE 1.



KEY PLAN



LOCATION PLAN

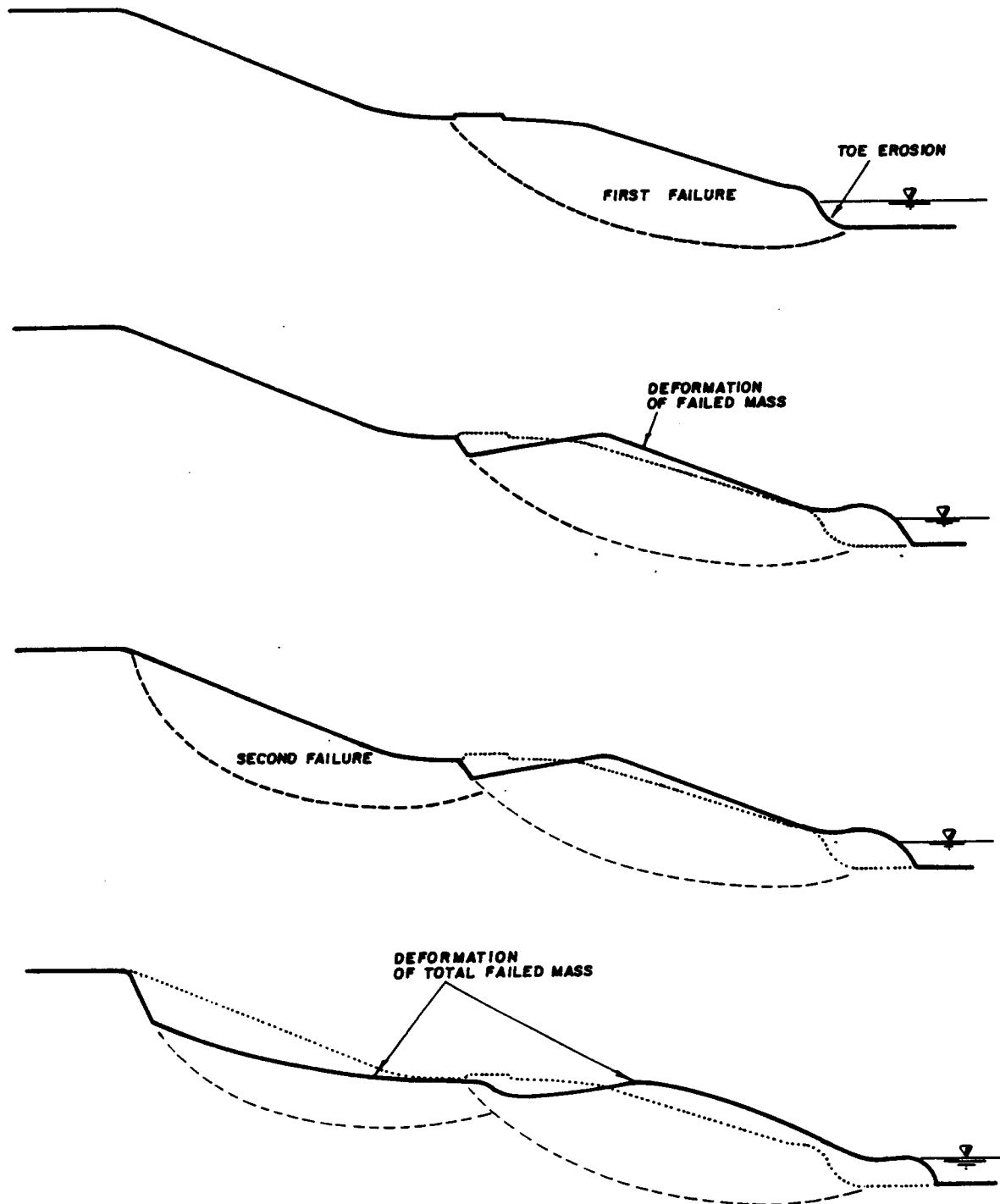
Date. MAY 20, 1987
Project. 861 - 3257

Golder Associates

Drawn. B.G.
Chkd.

SCHEMATIC REPRESENTATION OF POSTULATED FAILURE MECHANISM

FIGURE 2



NOTE

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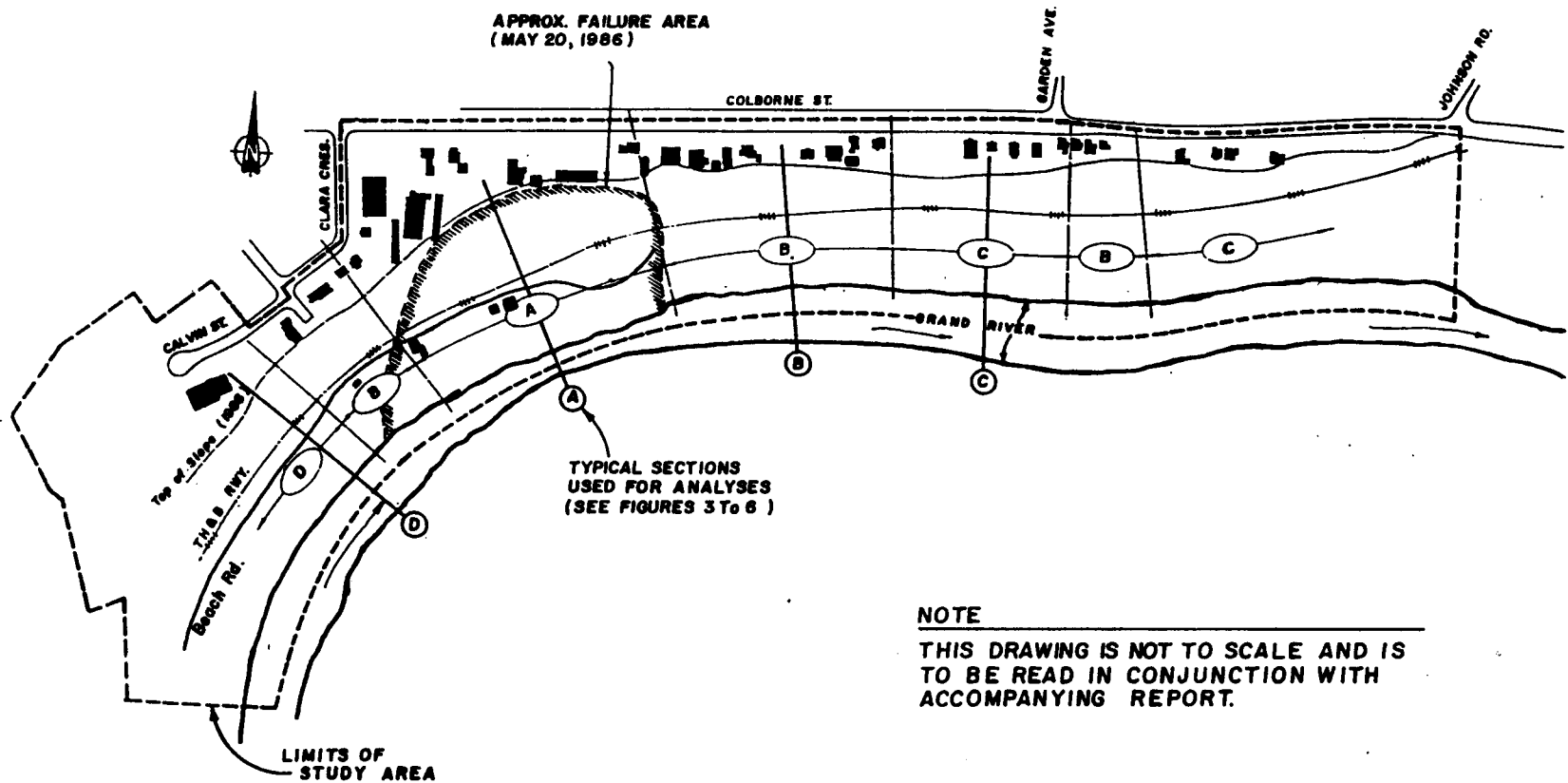
Date MAY 20, 1987
Project 861-3257

Golder Associates

Drawn WF
Chkd. [Signature]

SITE PLAN & STUDY AREA

FIGURE 3



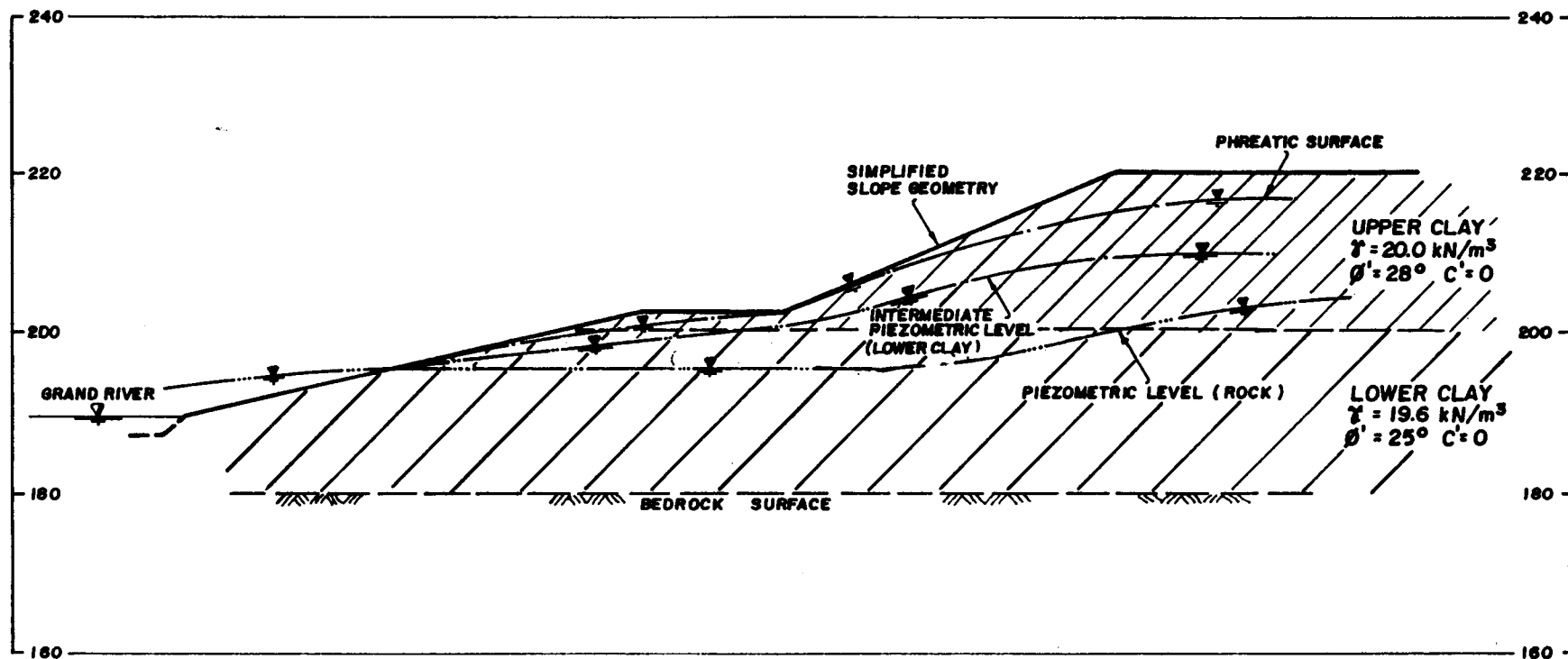
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Chkd MA

Date MAR 26 1987
 Project 861.3257

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 Chkd ---

SIMPLIFIED CONDITIONS
 USED FOR STABILITY ANALYSES

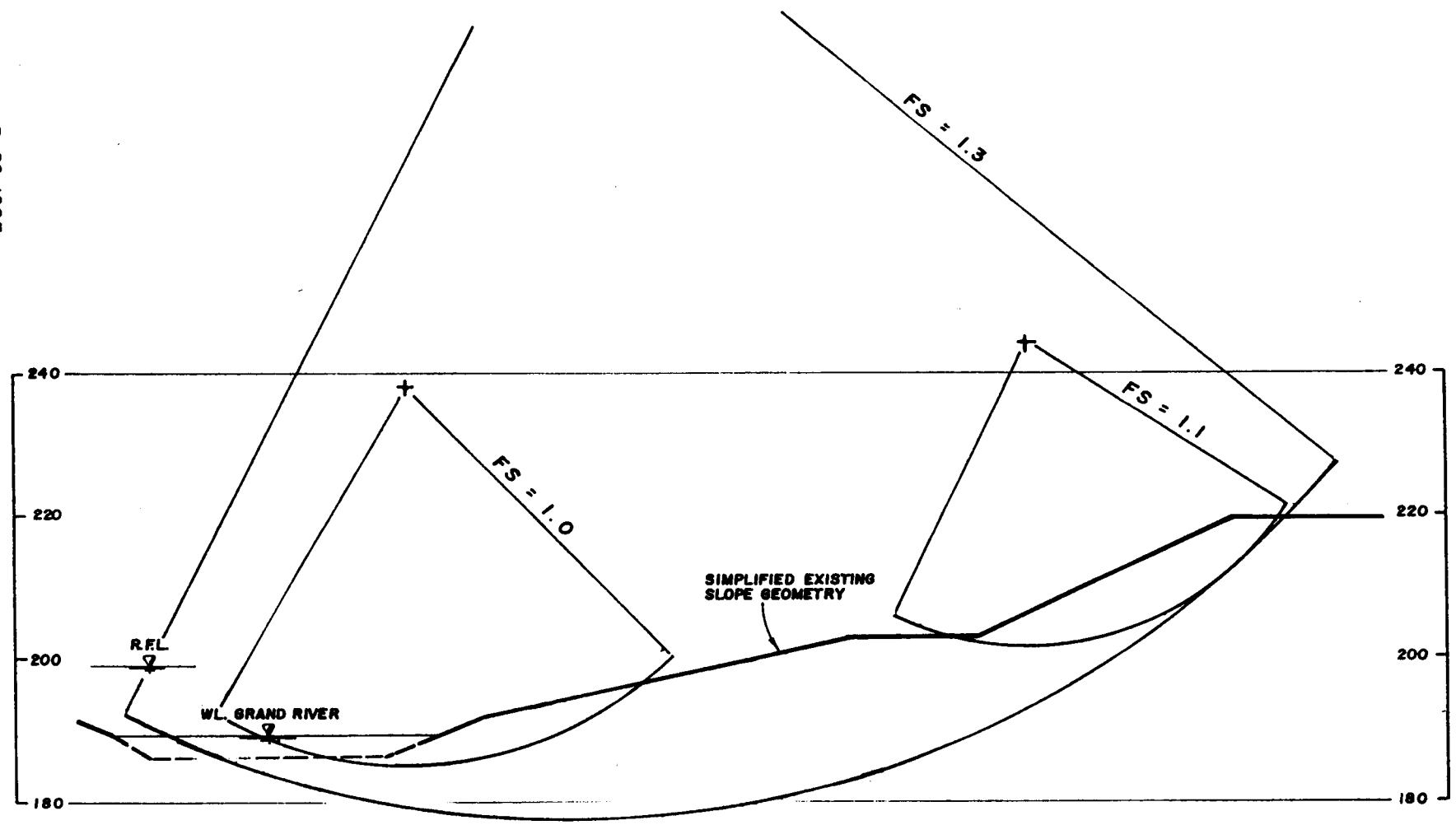
FIGURE 4

STABILITY ANALYSES - ZONE B

FIGURE 5

Date MAR 26, 1987
Project 861-3257

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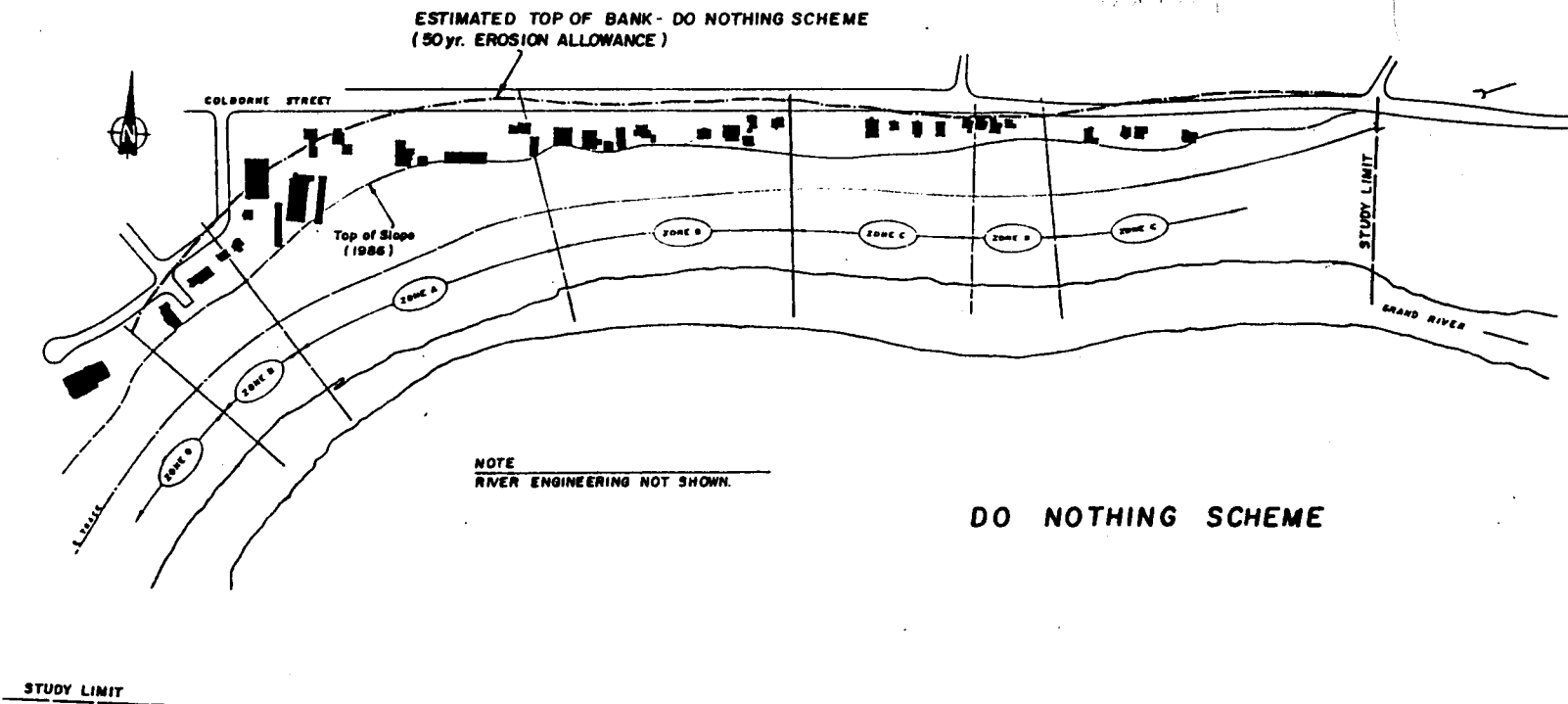
NOTE

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Drawn W/F
Chkd W/F

LOCATION PLAN (DO NOTHING SCHEME)

FIGURE 6



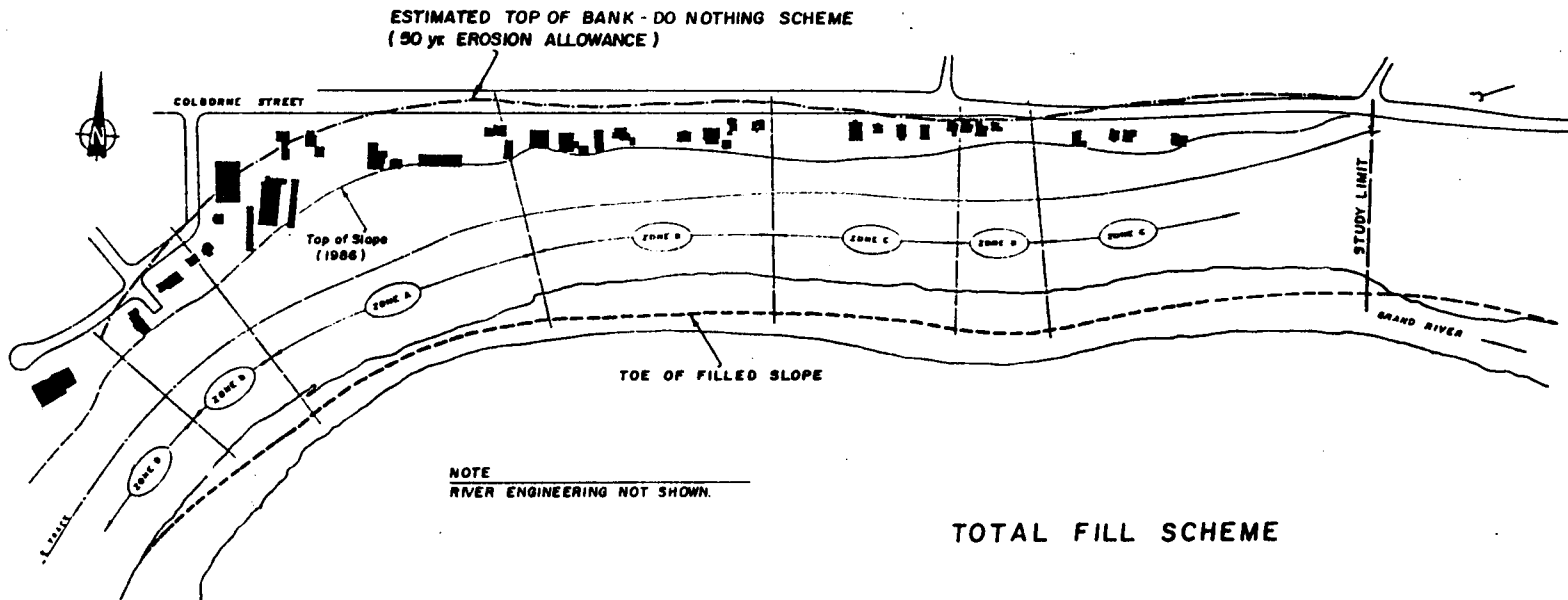
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Project 861-3257

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Chkd W.

LOCATION PLAN (TOTAL FILL SCHEME)

FIGURE 7.



TOTAL FILL SCHEME

Date MAR. 30, 1987
Project 861 - 3257

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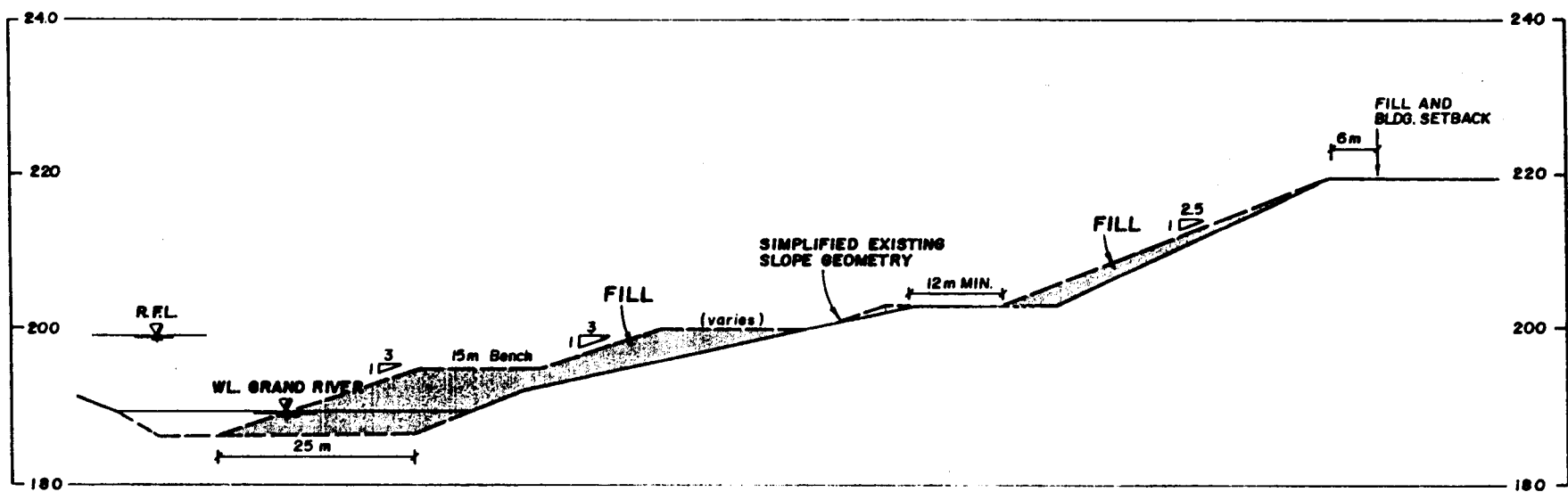
Drawn B.G.
Chkd M

SCHEMATIC SECTION - ZONE B (TOTAL FILL SCHEME)

FIGURE 8

Date MAR 26, 1987
Project 86/3257

Golden Associates



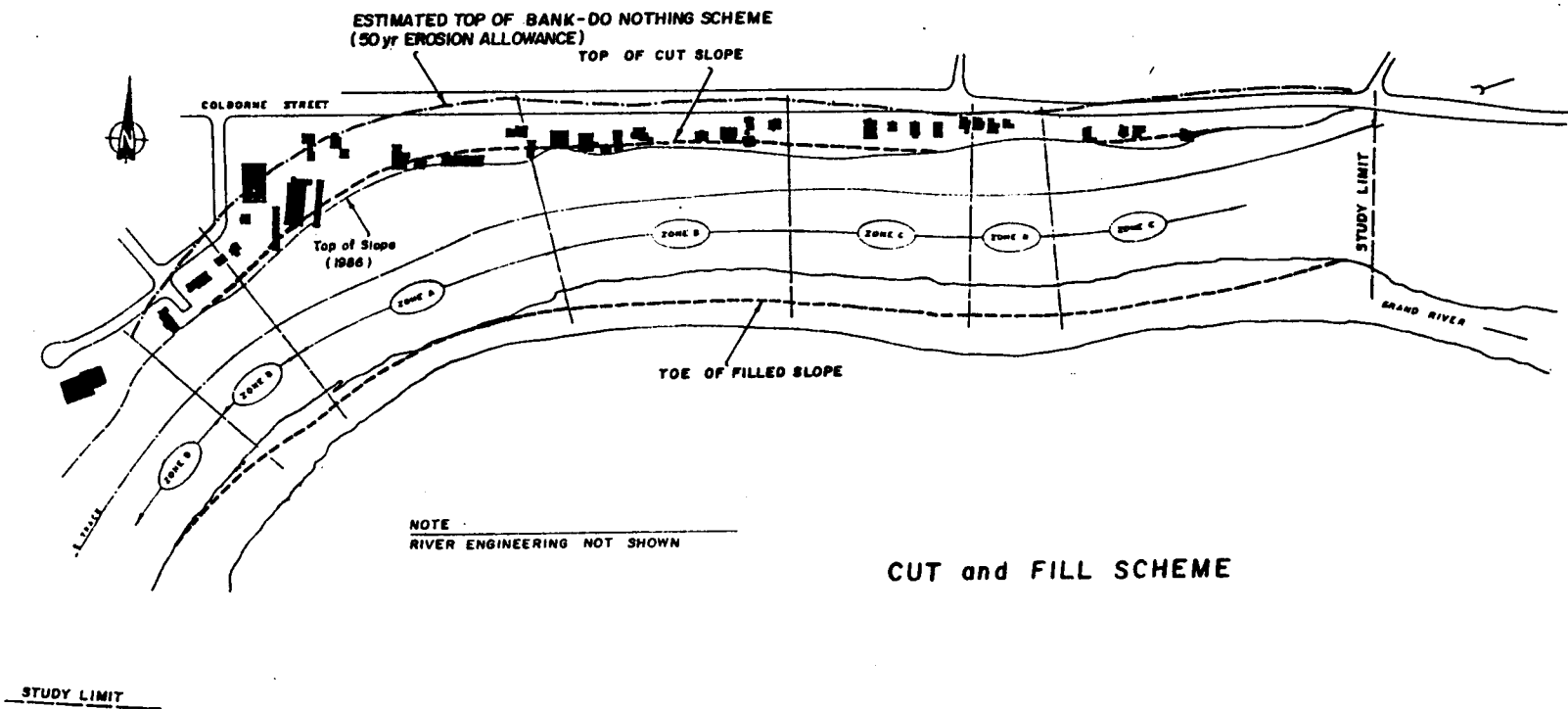
NOTE

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Ck'd M

LOCATION PLAN (CUT and FILL SCHEME)

FIGURE 9



CUT and FILL SCHEME

Date MAR. 30, 1987
Project 861-3257

Golder Associates

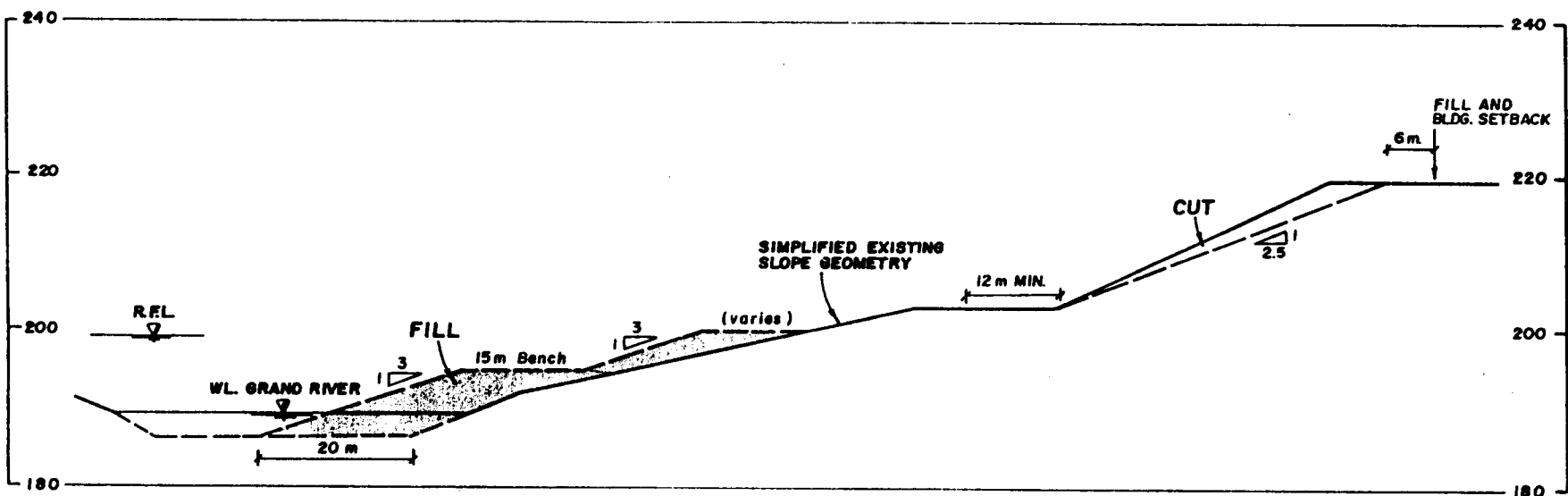
DROWN B.G.
CHKD.

SCHEMATIC SECTION - ZONE B (CUT & FILL SCHEME)

FIGURE 10

Date MAR. 26, 1987
Project 861-3257

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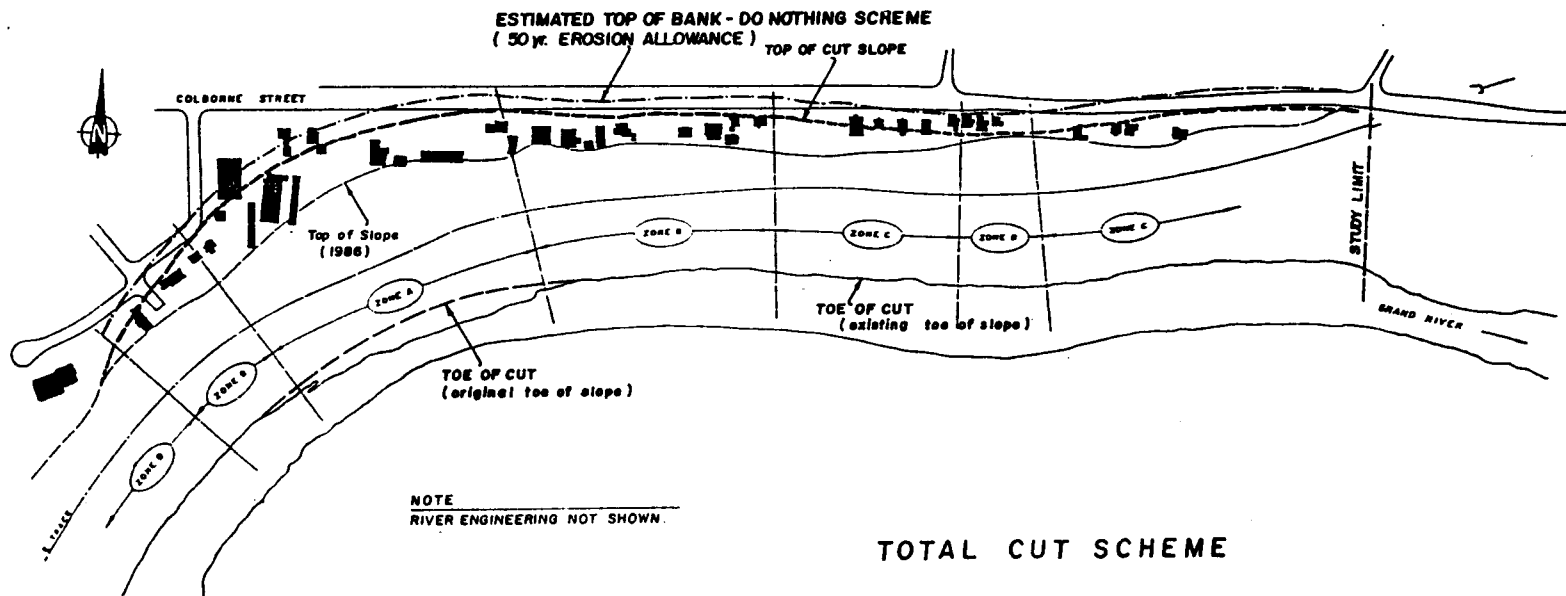
NOTE

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Drawn I/F
Chkd. M

LOCATION PLAN (TOTAL CUT SCHEME)

FIGURE II



TOTAL CUT SCHEME

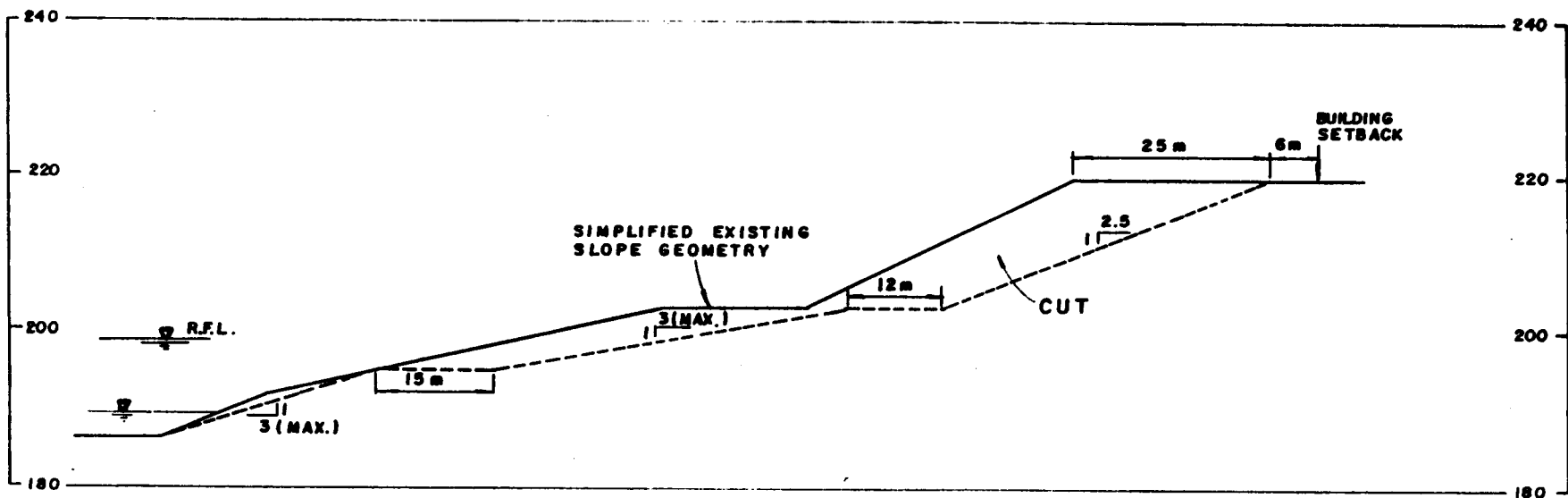
Date MAR. 30, 1987
Project 861-3257

Golder Associates

Drawn B.G.
Ckd M.

SCHEMATIC SECTION - ZONE B (TOTAL CUT SCHEME)

FIGURE 12



NOTE

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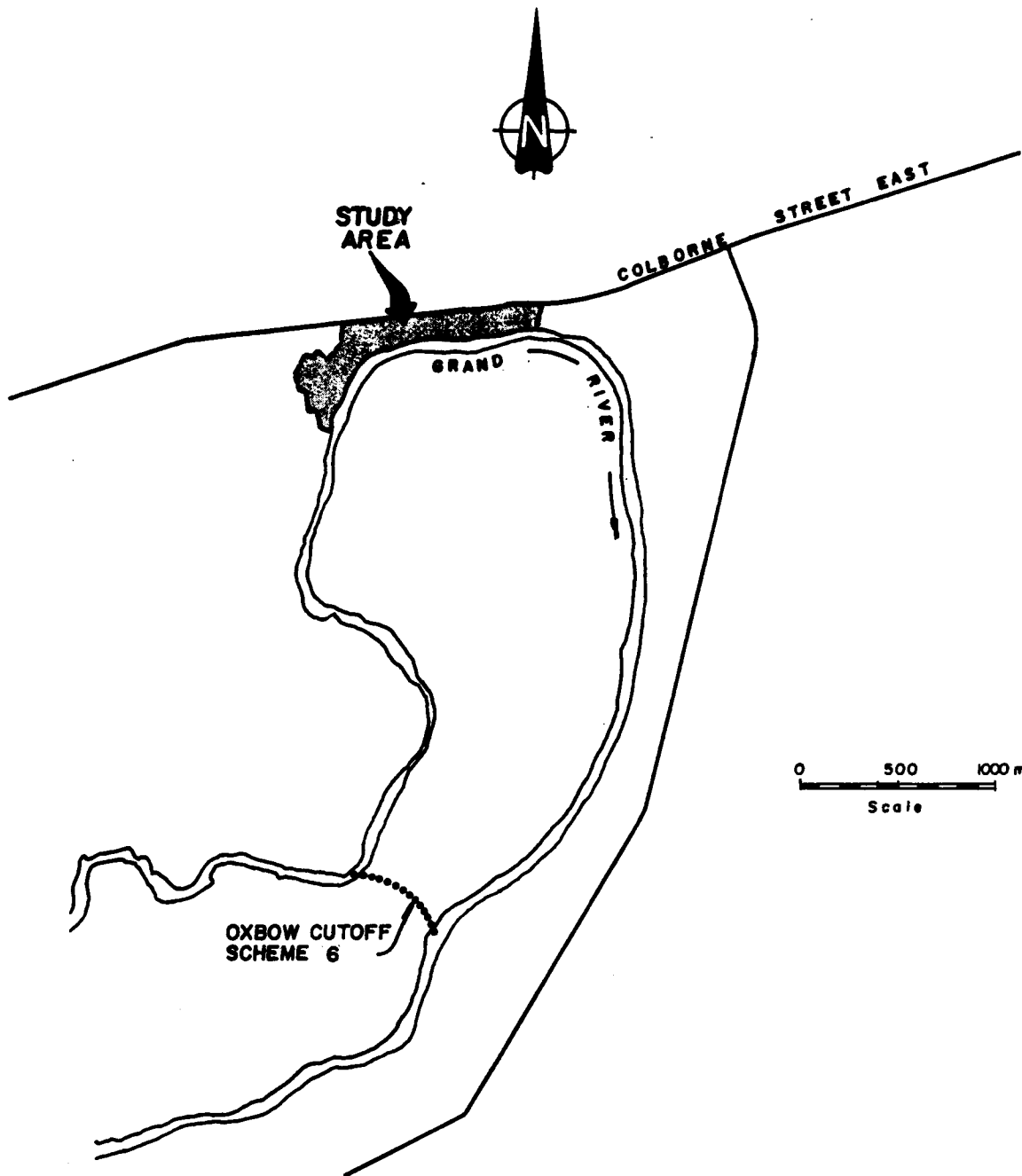
Date MAR. 26, 1987.
Project 861.3257

Golder Associates

Drawn B.G.
Checked M.

LOCATION PLAN (OXBOW CUTOFF)

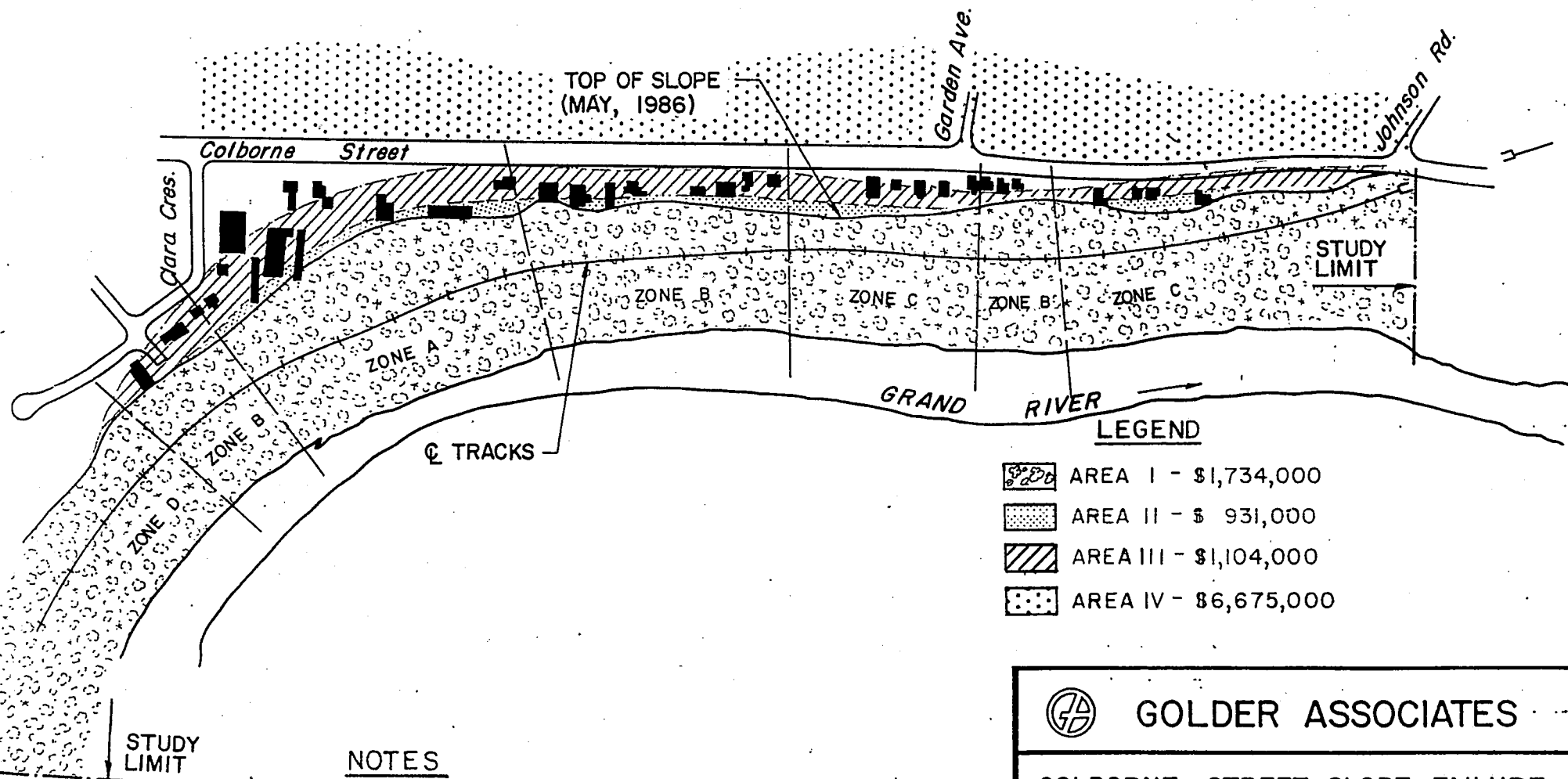
FIGURE 13



Date MAR. 30, 1987
Project 861- 3257

Golder Associates

Drawn B.G.
Chkd. [Signature]



NOTES

TOTAL CUT OPTION	= I + II + III	= \$ 3,769,000
PARTIAL FILL OPTION	= I + II	= \$ 2,665,000
TOTAL FILL OPTION	= I	= \$ 1,734,000
NORTH OF COLBORNE STREET		= \$ 6,675,000



GOLDER ASSOCIATES

COLBORNE STREET SLOPE FAILURE

PROPERTY VALUATION SUMMARY



Philips
Planning
+ Engineering
Limited

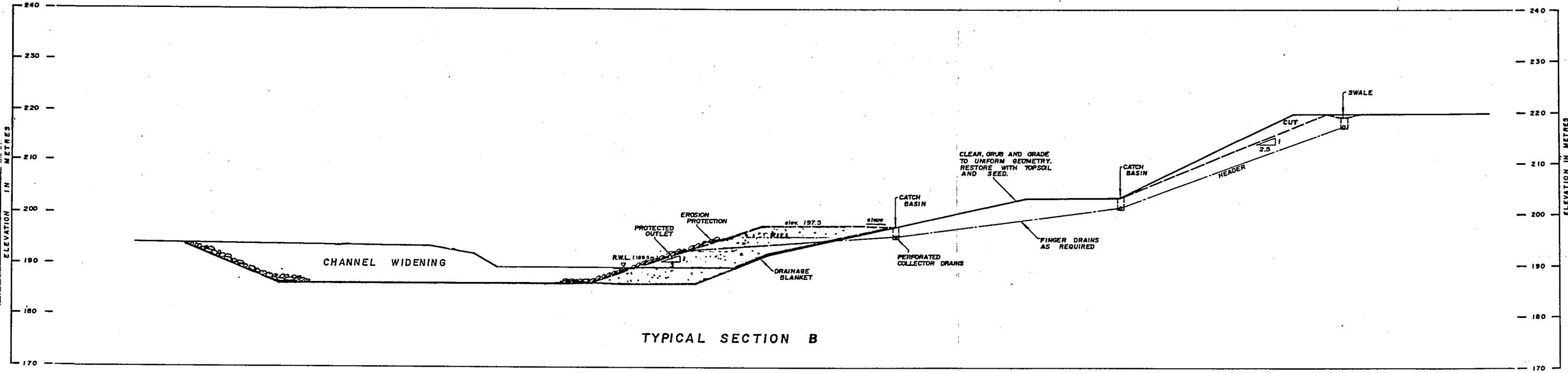
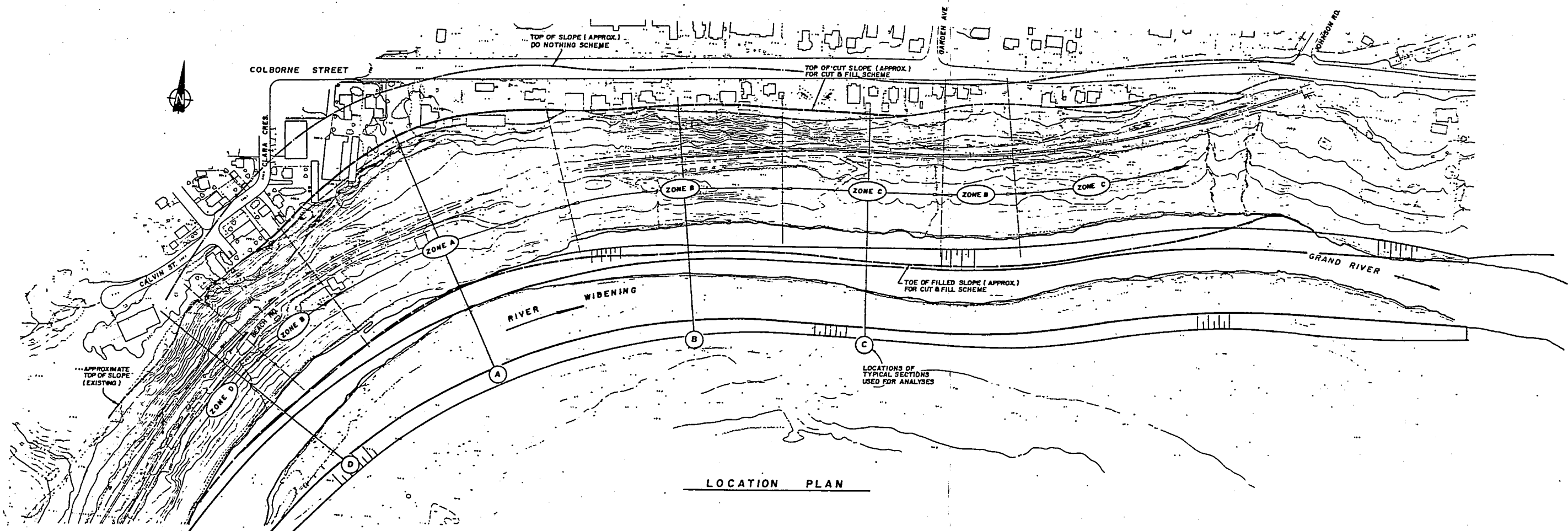
PROJECT N^o
86105
DATE
APRIL/87

FIGURE N^o

14

PLAN & TYPICAL SECTION
CUT & FILL SCHEME
RIVER WIDENING OPTION .

FIGURE 15



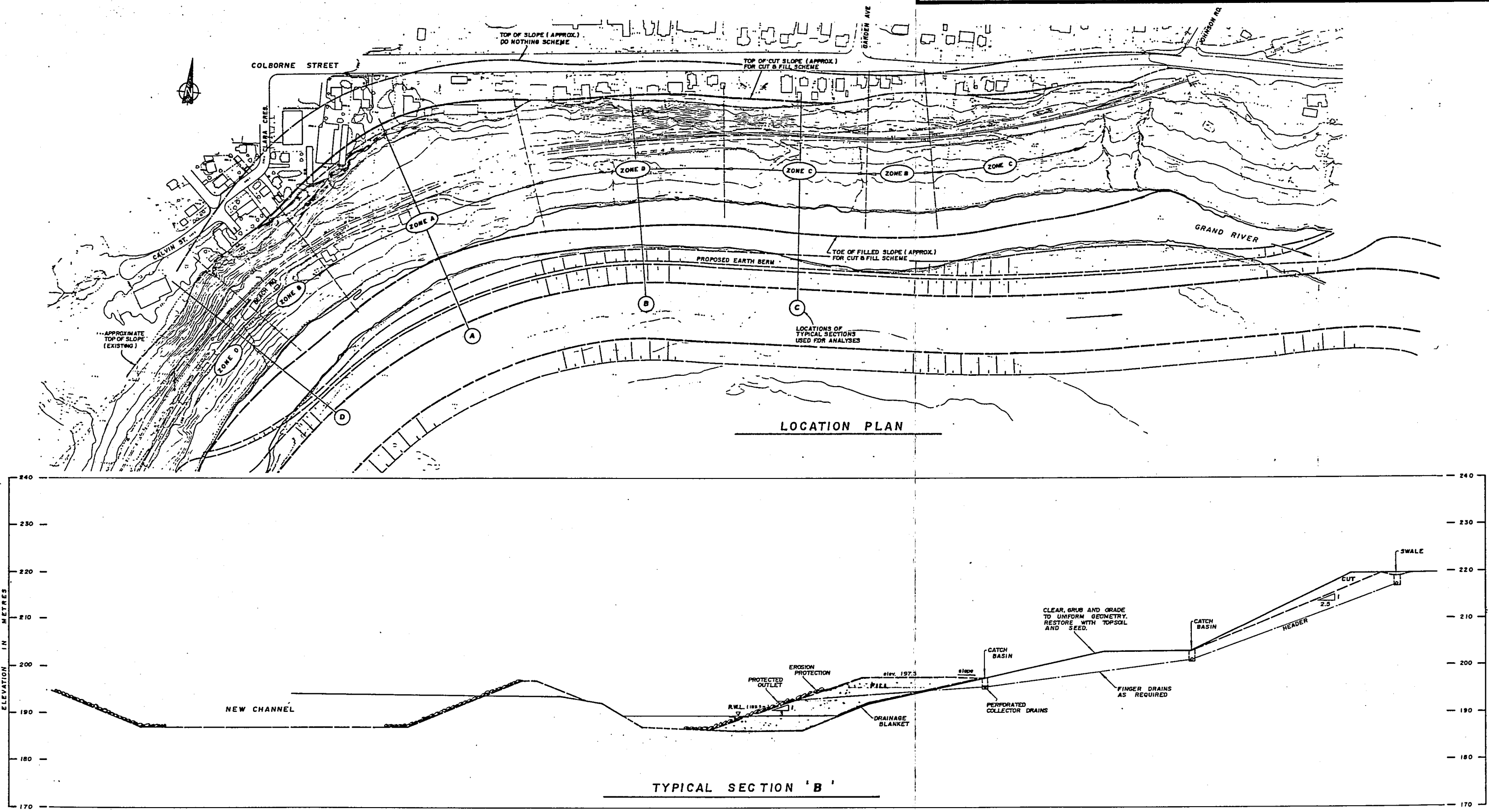
Date... MAY 21, 1987
Project... 861-3257

Golder Associates

Drawn... B.G.
Chkd... [Signature]

PLAN & TYPICAL SECTION
CUT & FILL SCHEME
RIVER RELOCATION OPTION.

FIGURE 16



Date MAY 21, 1987
Project 861-3257

Golder Associates

Drawn W.D.F.
Chkd [Signature]

November 6, 1987



Mr. B. D. Riddell, Regional Director,
Ministry of Transportation & Communications,
3rd Floor, 5000 Yonge Street,
WILLOWDALE, Ontario.
M2N 6E9

Dear Mr. Riddell:

RE: Brantford Colborne Street Slope Failure
Proposed Remedial Works

We enclose a copy of a resolution passed by the Council of the Corporation of the City of Brantford on September 21, 1987. You will note that, subject to certain conditions, the City Council has selected for implementation the Option 2 (river relocation) of the Cut and Fill Alternative outlined in Golder's Summary Report dated May, 1987.

Copies of the Volume I - Summary Report - and Volume 2 - a more detailed preliminary engineering report, have been forwarded to Mr. K. G. Selby, Chief Foundation Engineer, your Ministry's representative on the Technical Co-Ordinating Committee. An Executive Summary of the Golder's Report is attached.

We also enclose a copy of a City Staff Report, together with a supplementary report entitled "City of Brantford - Colborne Street East Investigation, August 20, 1987" prepared by McCormick, Rankin for the City of Brantford.

The latter deals with the potential property and business losses and highway relocation costs that could occur if no remedial measures are undertaken.

The City request was considered by the Executive Committee of the Grand River Conservation Authority and referred to Authority staff for review and consultation with all agencies involved. The Authority staff will then report back to the Executive Committee with recommendations.

At this stage we would like your comments on the selected alternative. We are most interested in your plans for the protection of the highway, also if you Ministry would be willing to participate financially if the work is carried out by this Authority.

COPY

- 2 -

We would be pleased to provide further information if so requested and meet with you at your convenience.

Yours very truly,



Ilmar Kao,
Assistant General Manager,
Grand River Conservation Authority.

cc. Mr. K. G. Selby, Chief Foundation Engineer, MTC
Mr. A. J. Percy, District Engineer, MTC



THE CORPORATION OF THE CITY OF BRANTFORD

CITY HALL - 100 WELLINGTON SQUARE - BRANTFORD - ONTARIO - N3T 2M3
TELEPHONE 519-759-4150



September 25, 1987

TO WHOM IT MAY CONCERN:

I hereby certify that the following is a true and correct copy of a resolution passed by the Council of The Corporation of the City of Brantford at its regular meeting held Monday, September 21, 1987:

THAT implementation of remedial works be carried out as outlined under Option 2 of the Cut and Fill Alternative outlined in Golder's Report dated May, 1987, subject to the G.R.C.A., the Ministry of Natural Resources and the Ministry of Transportation and Communications providing funding for this project; and further

THAT the G.R.C.A. be requested to proceed with this project following receipt of approval of funding presently before the Minister of Natural Resources; and further ,

THAT appropriate funds be included in the City's Capital Budget upon receipt of funding approval from the G.R.C.A., the Ministry of Natural Resources and the Ministry of Transportation & Communications.


CITY CLERK

Preliminary Engineering Study
Grand River Valley Slope Failure
Colborne Street East
Brantford, Ontario

SUMMARY AND RECOMMENDATIONS

Summary

On the evening of May 20, 1986, a major slope failure occurred on the Grand River Valley slope adjacent to Colborne Street East in the City of Brantford. This massive landslide directly affected several residential and commercial properties plus the CP Rail (T.H. & B.) tracks located near the toe of the slope.

The landslide was largely caused by:

- oversteepening of the clay slopes due to river erosion at the toe of the slope;
- high groundwater levels within the weak clay soils which form the valley wall'slope.

This preliminary engineering study was carried out to evaluate alternative remedial measures to stabilize and protect the 1.3 kilometres of affected valley slopes. These measures were designed to protect life and property within the study area, shown on the enclosed site plan.

The study examined six different alternatives and assessed their relative economic, social and environmental costs and benefits associated with protecting life and property. The alternatives considered were:

1) Do Nothing Alternative

In this alternative, the natural process of erosion and slope failure would carry on unchecked. The top of slope would eventually regress past Colborne Street causing major property loss and the loss of Colborne Street itself.

2) Relocate Colborne Street Alternative

Similar to 1) except that Colborne Street is relocated.

3) Fill Only Alternative

The valley slope is stabilized by adding fill mainly to the lower portion of the slope and maintaining the existing top of bank. The river is widened or relocated. Tableland property and Colborne Street are protected.

4) Cut and Fill Alternative

This alternative stabilizes the slope by a combination of filling at the bottom and trimming back the existing slope on top. The river is widened or relocated. Remaining property and Colborne Street is protected.

5) Cut Only Alternative

The valley bank is stabilized by extensive cutting back and flattening of the slope. There is major property loss and encroachment into Colborne Street.

6) Oxbow Cut Off Alternative

River diverted upstream to eliminate further toe of slope erosion in the study area. Scheme does not solve existing slope instability problem. Requires addition of stability measures 3, 4 or 5. Most expensive of all schemes.

Further evaluation, plus the continued erosion of the existing bank, led to the selection of Alternative 4, the Cut and Fill scheme. This scheme consists of three components: Slope Stabilization and River Works, Land Acquisition, and Planning Controls.

Recommendations

A. The Recommended Plan

1. It is recommended that the cut and fill scheme as described in the following recommendations be implemented.

B. Slope Stabilization and River Works

1. It is recommended that the Valley slope be protected by fill placement at the toe and excavation trimming at the upper portion of the slope, with provision of adequate river erosion protection at the toe of the stabilized slope.

2. It is recommended that if a phased approach is used in constructing the slope that the river channel be relocated and erosion protection be provided on the river banks and along the toe of the stabilized slope.

C. Land Acquisition

1. It is recommended that all the property south of Colborne Street within the study area be acquired to reduce the risk of life.

At the request of the City of Brantford, the GRCA has embarked upon a property acquisition scheme on the south side of Colborne Street to provide a safeguard until stabilization measures are completed.

D. Planning Controls

1. It is recommended that the existing Interim Control By-law be used to freeze land use and prohibit building in the study area south of Colborne Street until remedial works are carried out.

The present interim by-law can only be extended until August, 1988.

2. It is recommended that the study area south of Colborne Street be designated in a special hazard category in the new Official Plan, and a similar amendment made to the Zoning By-law, which prohibits excavating, filling, construction and development.
3. It is recommended that when the slope stabilization measures are completed, final land use controls be carried out through amendments to the Official Plan and Zoning By-law to establish the eventual City of Brantford planning policies in the study area.
4. It is recommended that the City of Brantford request the GRCA to register fill lines within the study area pursuant to Ontario Regulation 154/86 under the Conservation Authorities Act.

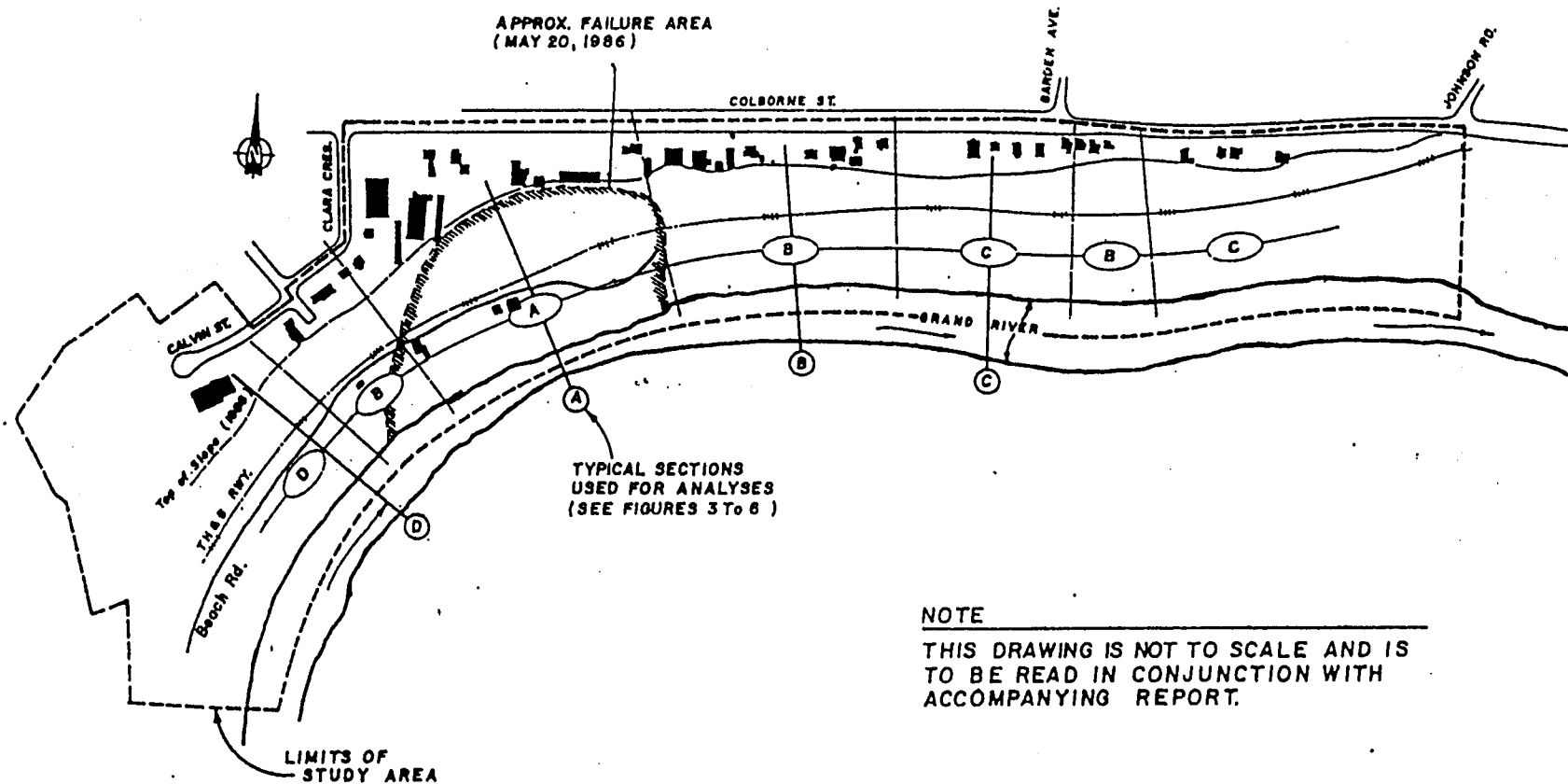
This will prevent indiscriminate dumping or placing of fill in the study area.

Construction Cost

The cost of the recommended scheme, depending upon the selected river option, is:

	<u>OPTION 1</u>	<u>OPTION 2</u>
	Constructed Immediately (River Widened)	Phased Construction (Channel Relocated)
1) Property Acquisition	2.7	2.7
2) River Channelization	4.2	5.9
3) Municipal Utility	0.2	0.2
4) Slope Stabilization	4.7	5.5
5) Railway Line Reinstatement	0.6	0.6
Total Cost	\$12.4 Million	\$14.9 Million

SITE PLAN



Date MAY 20, 1987
Project 861-3257

Golden Associates

Drawn IVE
Chkd M



THE CORPORATION OF THE CITY OF BRANTFORD

CITY HALL - 100 WELLINGTON SQUARE - BRANTFORD - ONTARIO - N3T 2M3

TELEPHONE 519-759-4150



CITY ENGINEER'S OFFICE

TELEPHONE (519) 759-1350

A. GRETZINGER, P.ENG.
CITY ENGINEER

1987-08-26

File No. 30-06-20-02

Prepared by: W.D. Wood, P.Eng.,
Deputy City Engineer.

REPORT TO: Mayor D. Neumann and Members
of City Council.

FROM: A. Gretzinger, P.Eng.,
City Engineer.

SUBJECT: Colborne Street East and Slope Failure

Introduction:

Council of the Corporation of the City of Brantford gave direction to City staff to consider the potential for the closure of Colborne Street East immediately adjacent to the slope failure area as an alternative to undertaking remedial measures to stabilize the slope in order to ensure continuity in the Colborne Street transportation corridor.

The Corporation of the City of Brantford gave direction to McCormick, Rankin, a consulting engineering firm to prepare a brief report in regard to the impact that a closure of Colborne Street East, adjacent to the landslide area would have on the Corporation of the City of Brantford. This firm was providing Engineering input to the overall Landslide Study undertaken by the Grand River Conservation Authority in conjunction with the City.

Specific direction was given in regard to estimating the potential financial impact upon the Municipality assuming that Colborne Street was to be closed as a through arterial street. In addition, the consultant was requested to examine potential transportation alternatives in terms of the road network to Colborne Street as an arterial street.

The consultant completed their investigations and provided the attached report as documentation of their investigations. Staff of the Engineering Department have reviewed the report of McCormick, Rankin in detail and concur with their observations and conclusions contained herein.

The following issues and conclusions included in the report are highlighted for your information.

1. Estimated Cost

The total financial impact upon the municipality assuming that Colborne Street was to be closed, utilities relocated and an alternate transportation corridor provided is in the order of \$14,350,000.00. However, it is important to note that this estimate does not include lost taxation.

It is estimated by staff of the City of Brantford that the reduction in taxation based upon 1987 dollars would be in the amount of approximately \$547,800.00 annually.

2. Social Costs

The social impact of the closing of Colborne Street, although not quantitative, would in all likelihood be very significant. Colborne Street has traditionally been the main entrance to the City from the east. The nature of the street is such that a high vehicular capacity is provided to minimize delays and the danger to the general public. In addition, adjacent development has occurred generally subsequent to the establishment of Colborne Street as the main east-west arterial. Development immediately adjacent to Colborne Street is compatible with the established transportation use of the Colborne Street corridor. The closing of this corridor and the complementary opening of the Grey Street corridor as an alternative may have significant negative social impacts upon the residential areas adjacent to Grey Street. Development east of Park Road North and immediately adjacent to Grey Street developed as localized residential areas. The primary purpose of Grey Street was to provide access to and from such residential areas. The establishment of Grey Street as a through arterial would, in all likelihood, result in a negative transformation of the residential areas resulting in loss of revenue due to reduced property values, increased complaints associated with the impact of through traffic into and through the predominantly residential area and other social costs.

3. Environmental Assessment

The establishment of the Grey Street corridor as a transportation facility may be subject to the environmental assessment process. Recognizing that the impact of establishing Grey Street as an alternative to the Colborne Street corridor would have significant negative impacts upon the area north of Colborne Street, a request to the Minister of the Environment by affected private citizens may result in a requirement for a full environmental assessment report and associated hearing. It is suggested by staff that, in all likelihood, the project would receive at best limited support through the environmental assessment process. The adoption of Grey Street as an alternative to Colborne Street may result in the whole issue of the City's attitudes towards the landslide area being placed under review by the Ministry of the Environment.

4. Highway 403

The Province of Ontario, in conjunction with the Corporation of the City of Brantford, have considered Garden Avenue as a corridor that will provide access to the easterly portions of the City of Brantford from CAH 403. The closing of Colborne Street as a through corridor creates serious concerns in regard to the potential of the transportation system to adequately serve the needs of the municipality. In all likelihood, as indicated by the consultant, the closing of Garden Avenue, as a major connection to the Colborne Street corridor, would place additional transportation demands upon the Park Road North corridor. In all likelihood, as the municipality continues to grow, the need for further significant improvements beyond what is currently anticipated by the municipality would result in increased capital expenditures by the municipality.

5. Recommendation

Based upon a thorough review of the McCormick, Rankin study and the observations of City staff, it is the recommendation of the Engineering Department that the City continue to utilize the Colborne Street corridor as the main east-west arterial providing access to the City. This recommendation is based upon a consideration of the social impact of the closing, the estimated cost of closing Colborne Street and associated loss in property value and taxation and the comparative cost of closing the road versus protecting the embankment to stabilize the infringement of the slope into the Colborne Street right-of-way.

It is further recommended that the Grand River Conservation Authority be forwarded a copy of this summary report and the report prepared by McCormick, Rankin as well as the resolution of Council in this regard.

AG-WDW/js

CITY OF BRANTFORD

COLORNE STREET EAST

INVESTIGATION

AUGUST 20, 1987

CONTENTS

	<u>Page</u>
BACKGROUND	1
PROPERTY APPRAISAL AND LOSS OF BUSINESS ESTIMATES	1
RELOCATE/CONSOLIDATE COLBORNE STREET EAST UTILITIES AND SERVICES	3
DEVELOP ALTERNATE ROAD FACILITY	4
SUMMARY	4

APPENDIX 'A'

- 1) ESTIMATED UTILITY RELOCATION/CONSOL-
IDATED COSTS
- 2) ESTIMATED ROAD CONSTRUCTION COST

BACKGROUND :

On June 11, 1987, the City of Brantford requested McCormick Rankin to prepare a letter proposal which would outline the work required to undertake a study to determine the impact that a slope failure closure of Colborne Street East would have on the residential and commercial establishments within the City of Colborne Street East between Highway 403 and Park Road and the road and utilities located in the Colborne Street East road allowance.

McCormick Rankin's proposal of June 15, 1987 outlined a series of work activities which would (1) provide a "windshield" appraisal of all properties located on Colborne Street East between Highway 403 and Park Road, (2) provide an estimate of potential business losses, (3) prepare a preliminary cost estimate to relocate/consolidate the existing Colborne Street East utilities that are threatened by future slope failure, and (4) prepare preliminary cost estimates to provide an alternate route for the existing Colborne Street East traffic by using/upgrading/connecting local streets immediately to the north of Colborne Street East.

McCormick Rankin were authorized by a letter from the City Engineer dated June 18, 1987 to proceed with the study as outlined.

PROPERTY APPRAISAL AND LOSS OF BUSINESS ESTIMATES

To assist in the property appraisal aspect of the study, McCormick Rankin retained Mr. Louis A. Emsley, a Professional Real Estate Appraiser familiar with the Brantford area, to undertake a windshield appraisal of the properties located within the City on Colborne Street East between Highway 403 and Park Road.

This appraisal, which was undertaken on June 25, included not only estimating the market value of all of these properties but estimating the business losses that would be incurred by the commercial establishments located on this section of road if a road closure occurred. For study purposes, business losses were estimated to be relocation costs if the business had the potential for relocation or compensation for reduction in or complete loss of business as a result in the lack of exposure to a major thoroughfare.

Based on the recommendations contained in the April 1987 Draft Preliminary Engineering Study of the Grand River Valley Slope Failure, Colborne Street East, report prepared by Golder Associates, we are of the opinion that only those properties between a point about 90 metres east of Linden Avenue and Johnson Road as identified on Plate 1 would have to be acquired if the slope failure extends into the Colborne Street East road allowance. The estimated pre-failure value of the properties between Clara/Linden and Johnson is approximately \$7,700,000.

In addition to the above-noted property estimate, we are of the opinion that the majority of the business establishments, located on Colborne Street East between Highway 403 at Cainsville and Park Road North would incur losses if Colborne Street East had to be closed. These business losses were estimated by Mr. Emsley based on the following:

1. no losses for specialty shops which do not rely on the major arterial for their business.
2. minor losses for business which have been developed primarily to serve a local neighbourhood need.

3. relocation costs (including any business losses) for those businesses which rely on the street profile to a large extent for their business and are of a size that is practical to relocate.
4. complete business loss costs for those businesses which would experience a significant reduction in trade and are of a size or type of business which cannot, practically, be relocated.

The business loss or relocation costs for all of these establishments was estimated at approximately \$3,650,000.

RELOCATE/CONSOLIDATE COLBORNE STREET EAST UTILITIES

Based on the anticipated 50 year top of slope and engineering setback as indicated in the Golder Associate report, we are of the opinion that only 950 metres of the existing utilities and services that are presently located on the Colborne Street East right-of-way may have to be relocated/consolidated and that these utilities and services may be located north of the existing Colborne Street East right-of-way.

Although all of these utilities and services may not have to be relocated, we have assumed for estimating purposes that the following utilities and services would have to be replaced from a location about 150 metres east of Linden Avenue to just east of the Colborne Street East and T.H.&B.R. grade separation (a distance of about 950 metres).

- o sanitary sewers
- o gas mains
- o watermain
- o hydro lines
- o bell services

Our preliminary cost estimates to relocate/consolidate these utilities and services is \$1,250,000 (See Appendix 'A' for cost breakdown).

DEVELOP ALTERNATE ROAD FACILITY

After discussing the project with the City staff and undertaking a field review on June 25, it was decided that a logical alternate route for this area may be developed by completing the missing sections of Grey Street between Park Road North and Garden Avenue and constructing a new section from Garden Avenue to Colborne Street East as identified in Plate 3.

Our preliminary cost estimates to complete the construction of this 40+ foot wide section is \$1,300,000 with an additional \$450,000 being required for the acquisition of the road allowance. The cost estimates for the following road sections are detailed in Appendix 'A'.

1. Grey Street extension from the intersection of Colborne Street East and Johnson Road to the intersection of Garden Avenue and the new section of Grey Street.
2. Grey Street from Garden Avenue to Brisbane Boulevard.
3. Grey Street from Rowanwood Avenue to James Street.
4. Grey Street from Park Road North to 140 m east.

It should be noted that for estimating purposes we have assumed that a 26 metre wide right-of-way is required and that the existing sections of Grey Street are structurally adequate.

SUMMARY

In summary and based on the windshield appraisal of the potential property and business losses, the expenditure required to relocate and consolidate the

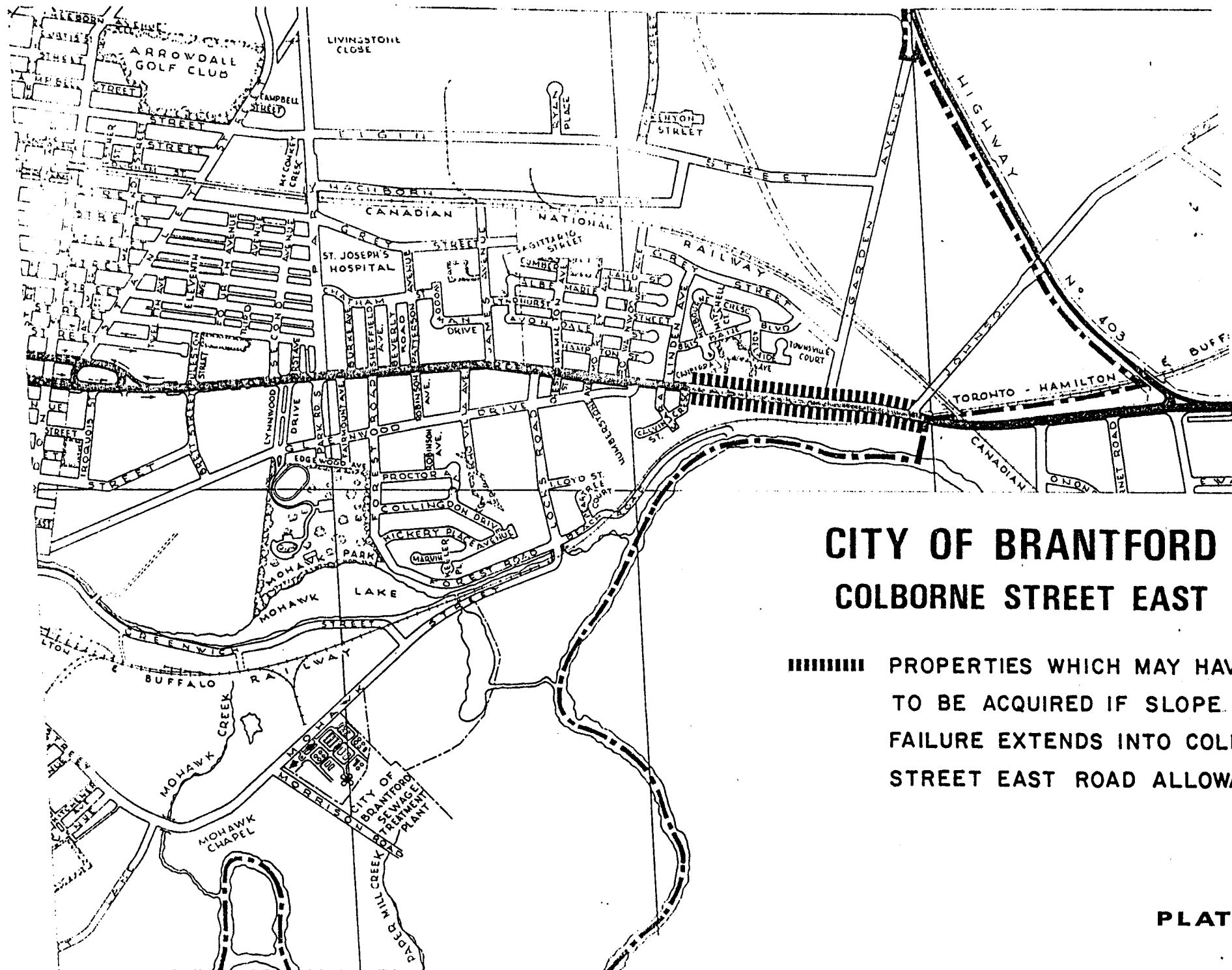
utilities and services and to provide an alternate roadway through the area, we estimate that a slope failure closure of Colborne Street East would have the following financial impacts.

Direct property costs (Clara/Linden to Johnson)	\$ 7,700,000
Indirect business costs (Park Road to Highway 403)	\$ 3,650,000
Relocate/Consolidate utilities and services for certain areas between Clara/Linden and Johnson	\$ 1,250,000
Construct alternate road facility (Grey St.)	<u>\$ 1,750,000</u>
TOTAL	\$14,350,000

This total financial impact of \$14,350,000 takes into consideration only expenditures and does not take into consideration the loss in tax revenue which would be generated by \$341,000 residential, \$88,000 commercial and \$30,000 business assessment. This \$14,350,000 impact may be compared to the total capital cost estimate of \$12,400,000 for the cut and fill option as outlined in Golder Associates report of April 1987. Another significant fact in comparing these two figures is that the \$14,350,000 does not solve the slope failure problem while the \$12,400,000 stabilizes the slope and protects the upstream property owners from flooding problems which may occur as a result of future slope failures in this area.

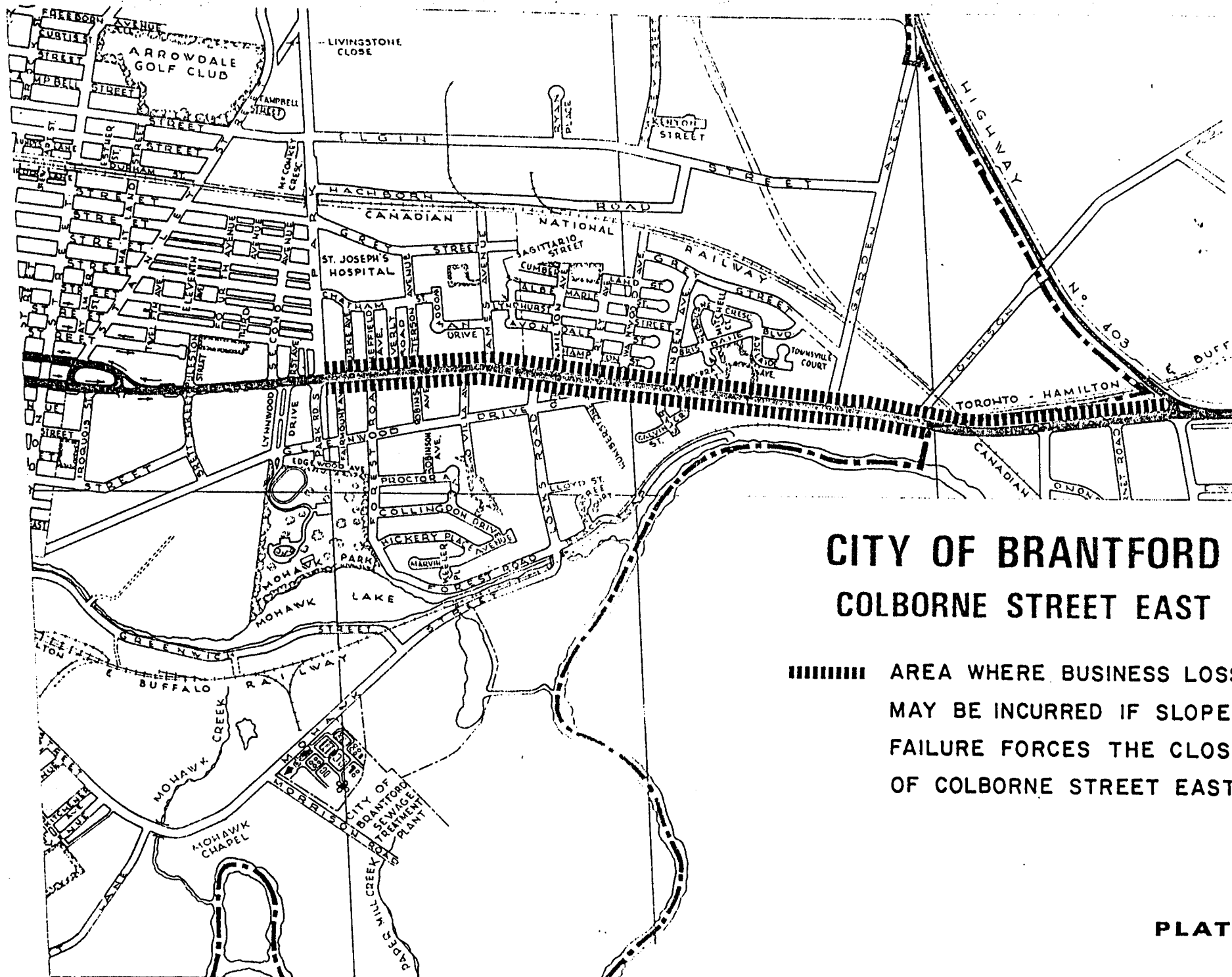
As mentioned, our estimate of \$14,350,000 does not include a figure for loss of tax revenue to the City nor does it take into consideration the impact on the residences of Grey Street who will not only have the on-street parking prohibited but will see their road change from its present local street environment to a major collector or arterial street environment.

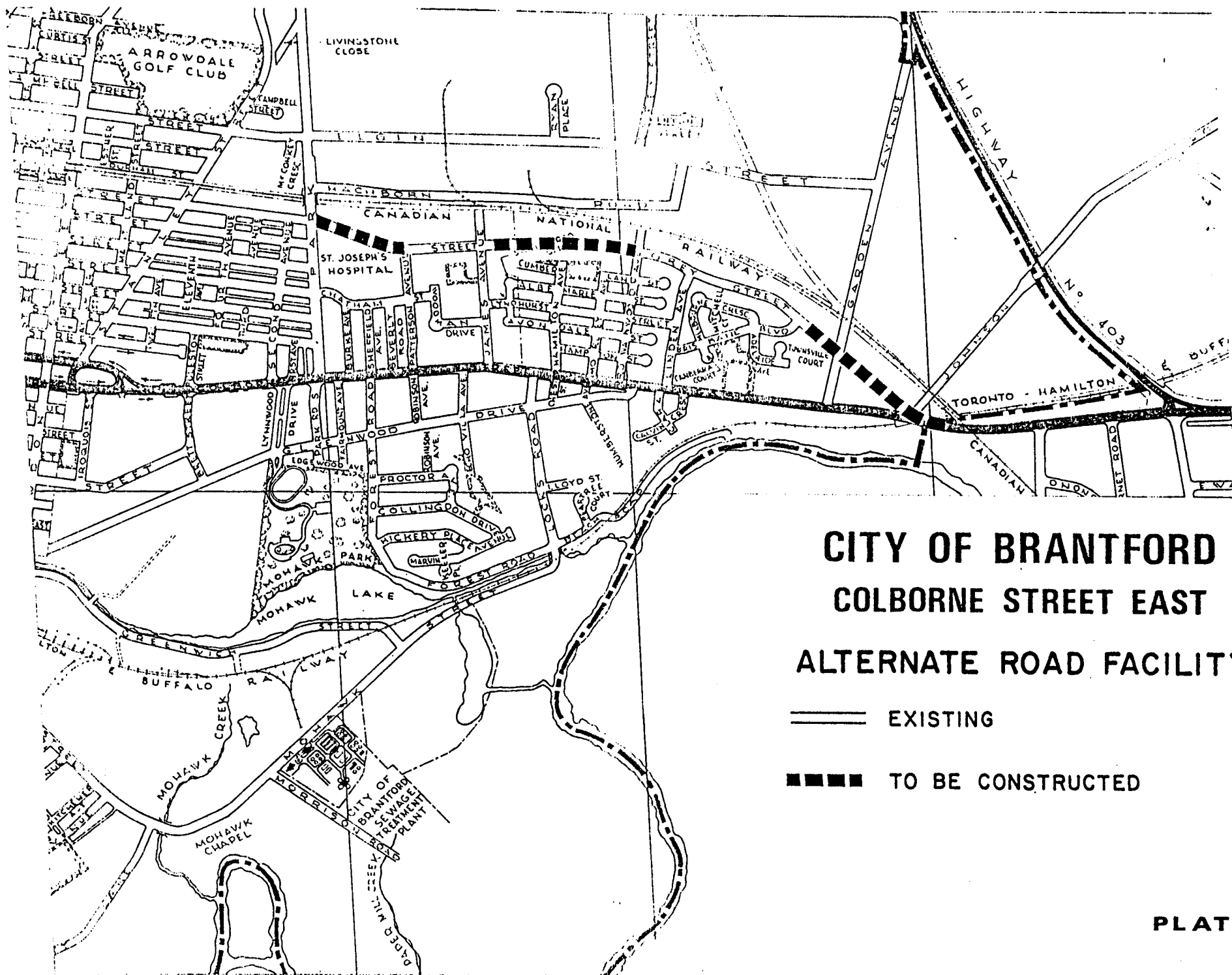
From a transportation perspective the loss of Colborne Street East would remove Garden Avenue as a desirable access to the future Highway 403 and therefore result in an increase in traffic on Park Road North.



CITY OF BRANTFORD **COLBORNE STREET EAST**

■■■■■■■■ PROPERTIES WHICH MAY HAVE
 TO BE ACQUIRED IF SLOPE
 FAILURE EXTENDS INTO COLBORN
 STREET EAST ROAD ALLOWANCE





CITY OF BRANTFORD **COLBORNE STREET EAST** **ALTERNATE ROAD FACILITY**

== EXISTING

■■■■ TO BE CONSTRUCTED

APPENDIX 'A'

ESTIMATED UTILITY RELOCATION/CONSOLIDATION COSTS

ESTIMATED ROAD CONSTRUCTION COSTS

CITY OF BRANTFORD
COLBORNE STREET EAST STUDY

ASSUME 950 M OF COLBORNE STREET EAST
UTILITIES TO BE RELOCATED/CONSOLIDATED
NORTH OF EXISTING ROAD ALLOWANCE

SANITARY SEWER @ \$200/METRE

950 x \$200 = \$ 190,000

GAS MAIN @ \$100/METRE

950 x \$100 = 95,000

WATERMAIN INCLUDING HYDRANTS AND SERVICES
@ \$220/METRE

950 x \$220 = 209,000

HYDRO AND BELL @ \$600/METRE

950 x \$600 = 570,000

SUB-TOTAL \$ 1,064,000

ENGINEERING AND CONTINGENCIES 186,000

TOTAL UTILITY RELOCATION/CONSOLIDATION
COSTS EST. \$ 1,250,000

CITY OF BRANTFORD
COLBORNE STREET EAST STUDY

ESTIMATED CONSTRUCTION COSTS TO COMPLETE
THE MISSING LINKS ON GREY STREET

ASSUME 1. RIGHT-OF-WAY IS AVAILABLE

2. 4 LANE CONSTRUCTION COSTS OF \$ 890,000/km

FROM COLBORNE ST. EAST AND JOHNSON RD. TO GARDEN AVE. AT GREY ST.	400 m
GREY STREET FROM GARDEN AVE. TO BRISBANE BLVD.	220 m
GREY STREET FROM ROWANWOOD AVE. TO JAMES STREET	640 m
GREY STREET FROM PARK ROAD NORTH TO 140 m EAST	<u>140 m</u>
TOTAL IMPROVEMENT LENGTH	1,400 m
CONSTRUCTION COST 1.4 x \$890,000 =	\$ 1,258,460
MISCELLANEOUS	41,540
PROPERTY	<u>450,000</u>
TOTAL	\$ 1,750,000