

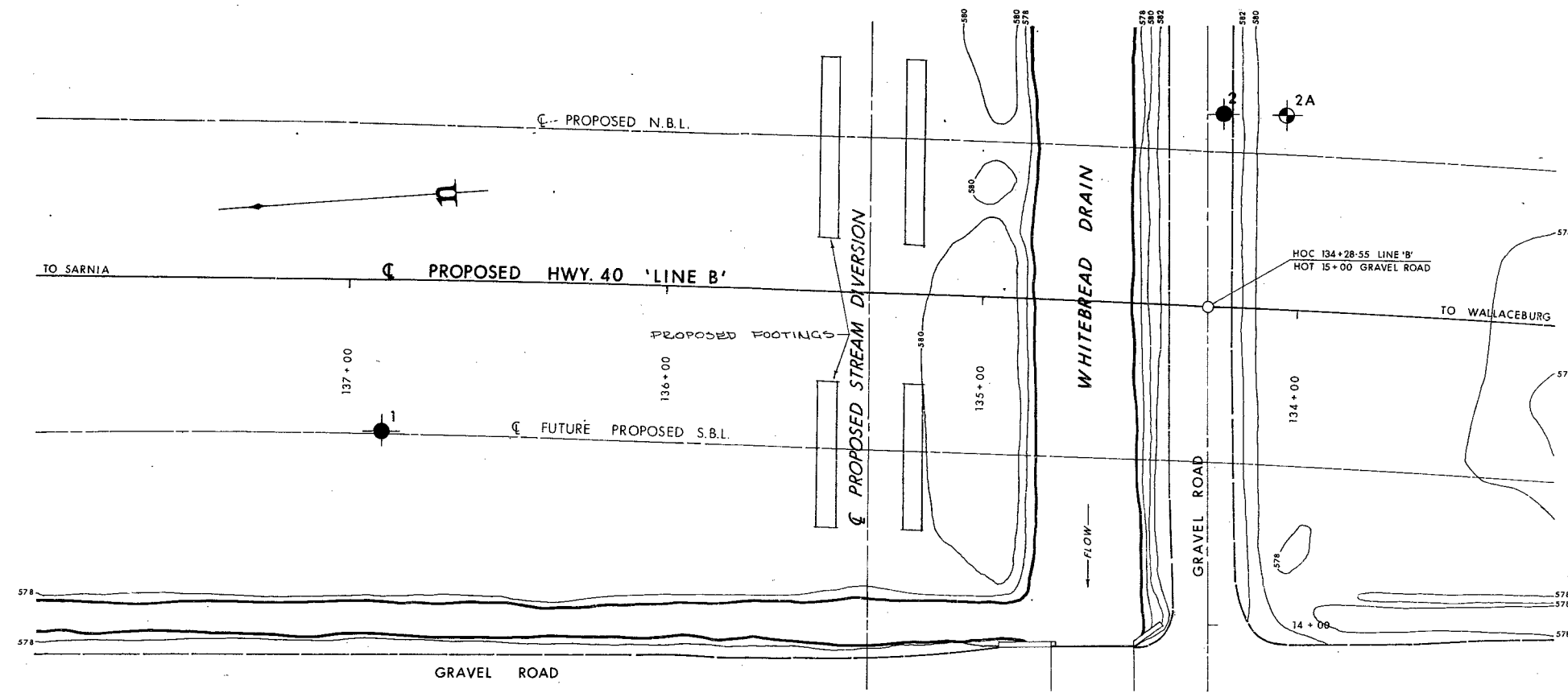
#67-F-36

W.P.# 70-67

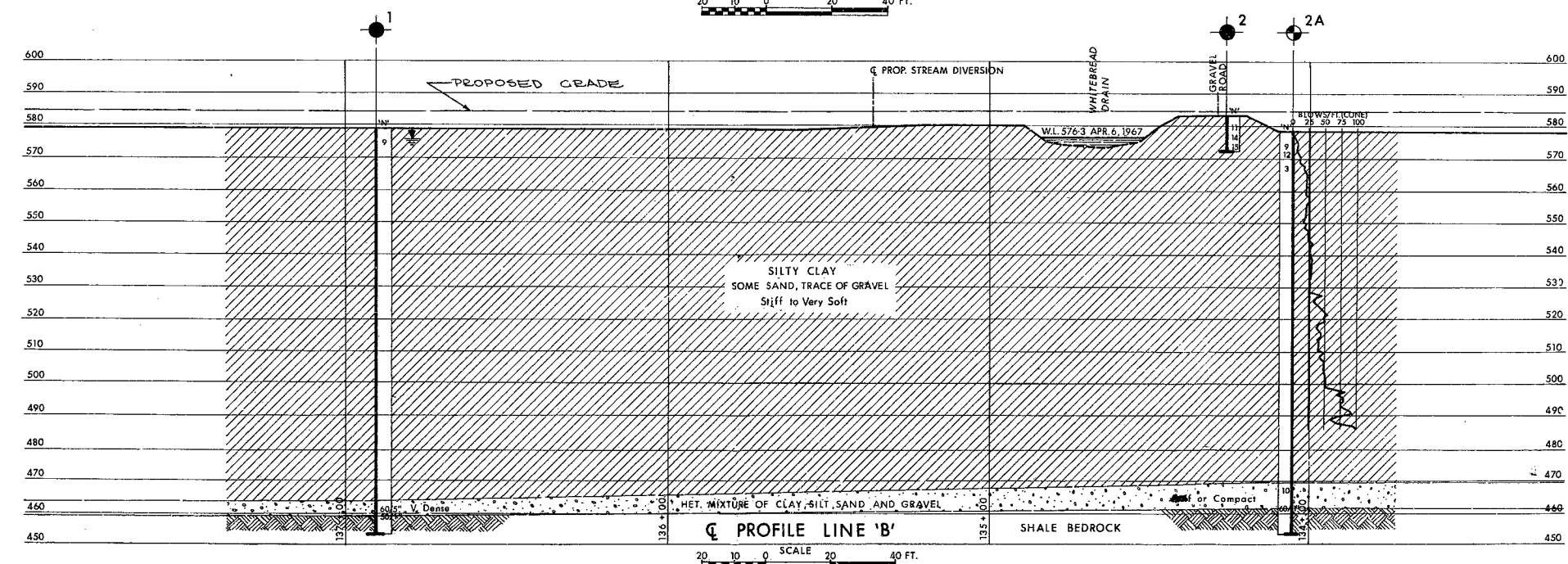
Hwy. # 40

WHITEBREAD

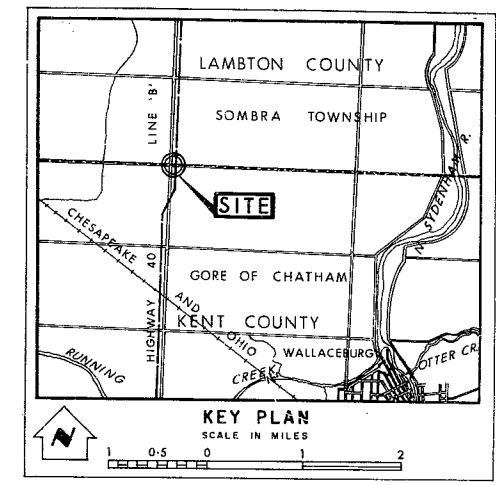
DRAIN



PLAN  
SCALE  
20 10 0 20 40 FT.



PROFILE LINE 'B'  
SCALE  
20 10 0 20 40 FT.



LEGEND			
	Bore Hole		
	Cone Penetration Hole		
	Bore & Cone Penetration Hole		
	Water Levels established at time of field investigation. April 1967		
NO.	ELEVATION	STATION	OFFSET
1	579.0	136+90	48' LT.
2	583.6	134+26	60' RT.
2A	578.6	134+06	60' RT.

**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING DIVISION - FOUNDATION SECTION

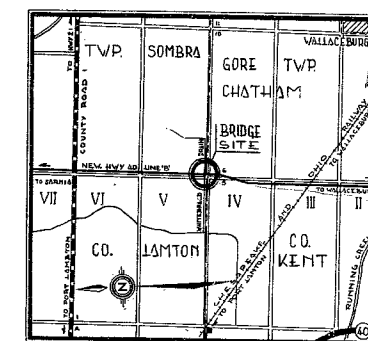
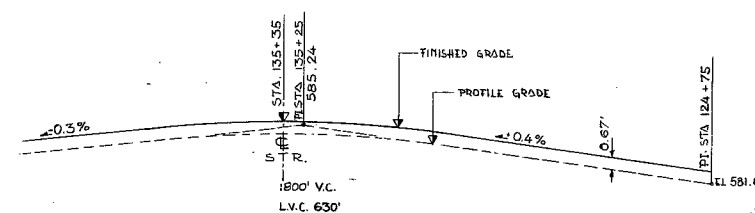
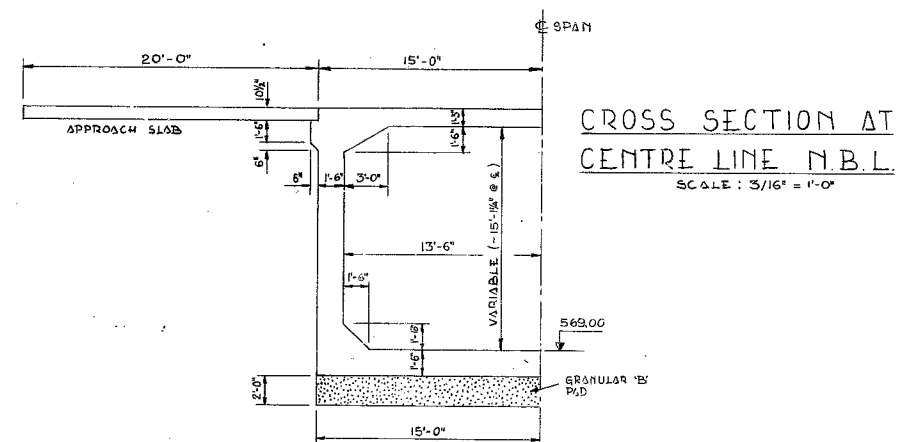
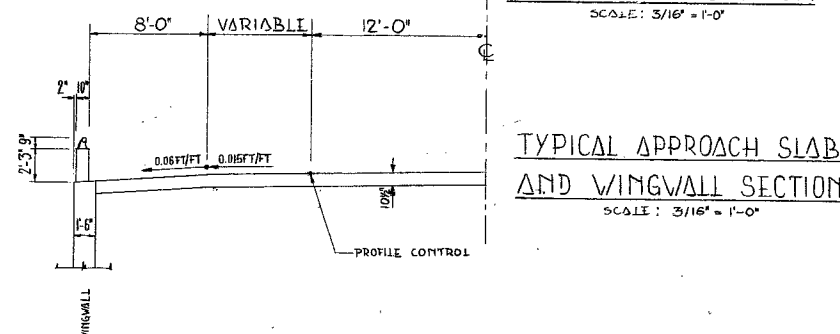
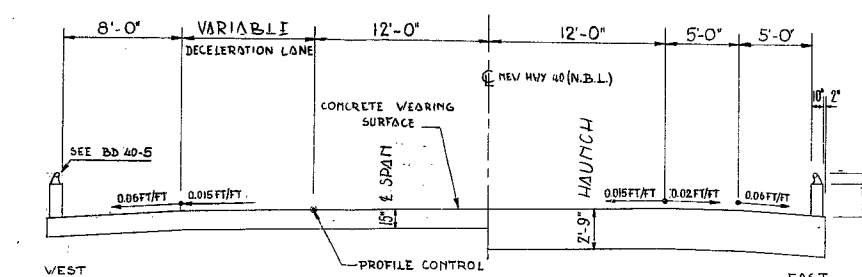
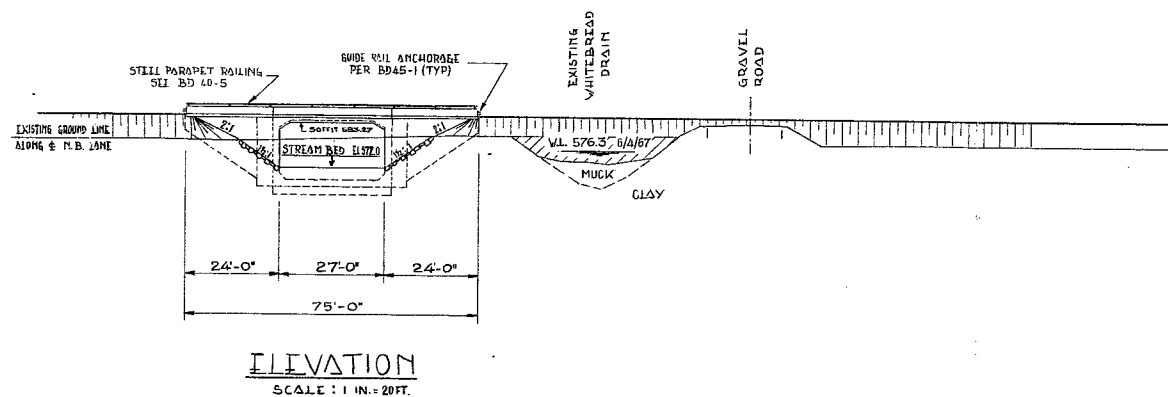
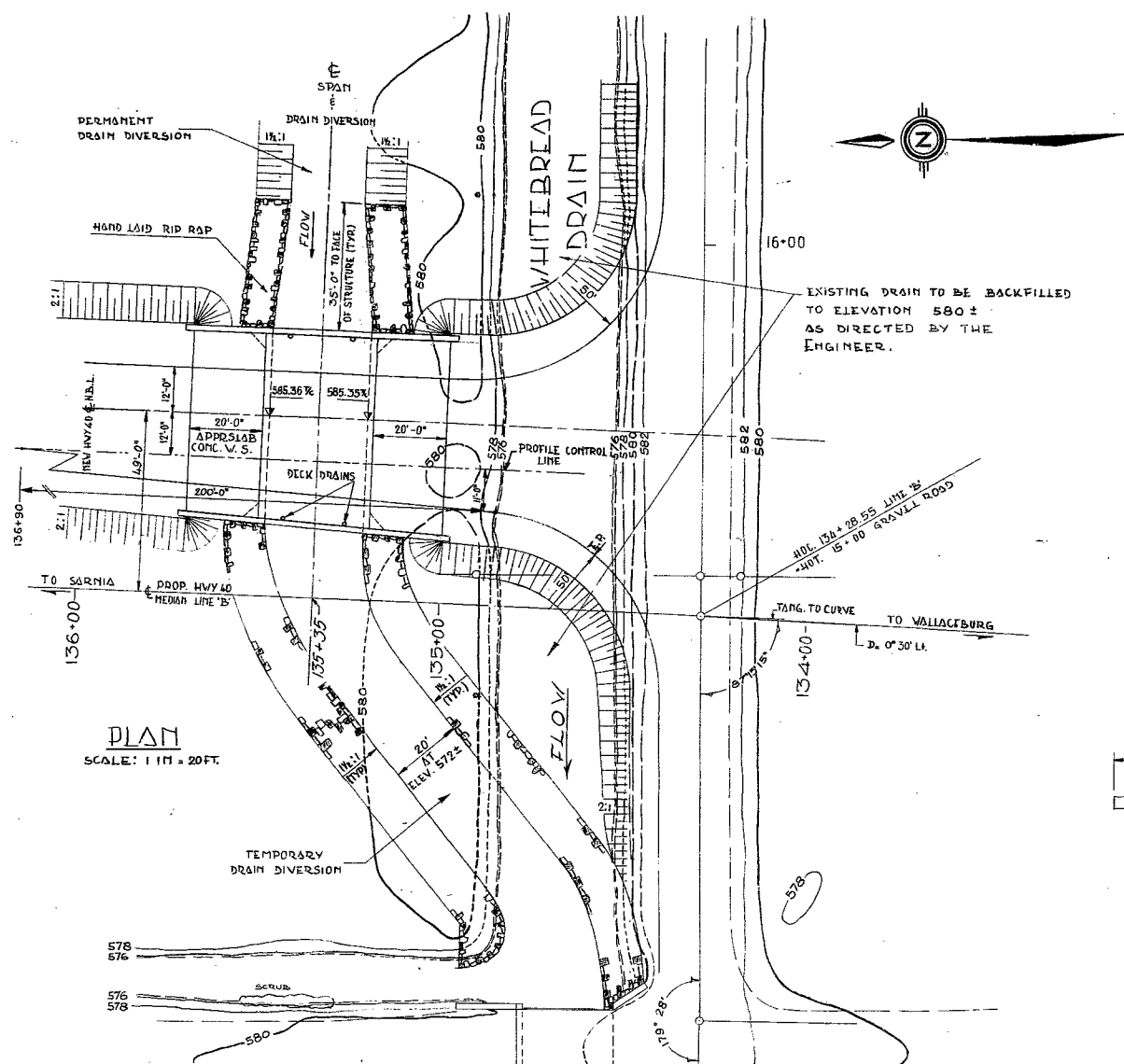
**WHITEBREAD DRAIN**

KING'S HIGHWAY NO. 40 LINE 'B' DIST. NO. 1  
CO. LAMBTON  
TWP. SOMBRA LOT 6 CON. 5

**BORE HOLE LOCATIONS & SOIL STRATA**

SUBMD. J.M. CHECKED <input checked="" type="checkbox"/>	W.P. NO. 70 - 63	M.B.T. DRAWING NO.
DRAWN P.G.O. CHECKED <input checked="" type="checkbox"/>	JOB NO. 67 - F - 36	67 - F - 36A
DATE MAY 29, 1967	SITE NO.	BRIDGE DRAWING NO.
APPROVED <i>[Signature]</i>	CONT. NO.	

PRINT RECORD	NO.	FOR	DATE



G.B.M. N° 366 Elev. 583.059

CHESAPEAKE & OHIO R.V. BRIDGE OVER A DRAINAGE CANAL AT STATION. NORTHWEST CONCRETE ABUTMENT, SOUTHWEST END OF SOUTHEAST FACE, 1 FOOT 8 INCHES ABOVE BRIDGE SEAT. BOLT SET HORIZONTALLY.

CLASS OF CONCRETE

DECK, PARAPET WALL	- 4000 P.S.I.
REMAINDER	- 3000 P.S.I.

CLEAR COVER ON REINFORCING STEEL

FLOOR SLAB } 3" DECK { TOP 2 1/2"  
VINGWALLS } PARAPET WALL 2" BOTTOM 2"

<b>REVISIONS</b>			
	<b>DATE</b>	<b>BY</b>	<b>DESCRIPTION</b>

DEPARTMENT OF HIGHWAYS BRIDGE DIVISION			
WHITEBREAD DRAIN BRIDGE			
1.8 MILES S. OF LAMBTON COUNTY ROAD #1			
KING'S HIGHWAY No. <u>NEW 40</u>		DIST. No. <u>1</u>	
CO. <u>LAMBTON</u>			
TWP. <u>SOMBRA</u>	LOT <u>6</u>	CON. <u>5</u>	
PRELIMINARY PLAN			
APPROVED		SITE No. <u>14-239</u>	W.P. No. <u>70-6</u>
BRIDGE ENGINEER		CONTRACT No.	
DESIGN <u>N.T.H.</u>	CHECK		
DRAWING <u>J.P.M.</u>	CHECK		
DATE <u>SEP 67</u>	LOADING <u>145 20-44</u>	DRAWING No.	<u>D-6280-P1</u>

MEMORANDUM

To: Mr. B. R. Davis,  
Bridge Engineer,  
Bridge Division,  
Admin. Bldg.  
Attention: Mr. S. McCombie

FROM: Foundation Section,  
Materials & Testing Div.,  
Room 107, Lab. Bldg.

DATE: May 30, 1967

Our File Ref.

IN REPLY TO

JUN 2 1967

SUBJECT:

FOUNDATION INVESTIGATION REPORT  
For  
Proposed Crossing at Whitebread Drain  
And  
Proposed Hwy. #40, Line 'B'  
District #1 (Chatham)  
W.J. 67-F-36 -- W.P. 70-67

Attached, we are forwarding to you, our detailed foundation investigation report on the subsoil conditions existing at the above structure site.

We believe that you will find the factual data and recommendations contained therein, adequate for your design requirements. Should additional information be required, please feel free to contact our Office.

AGS/MdeF  
Attach.

cc: Messrs. B. R. Davis (2)  
H. A. Tregaskes  
D. W. Farren  
A. Gater  
F. C. Brown  
A. P. Watt  
J. Roy  
B. A. Singh

Foundations Files  
Gen. Files ✓

*A. G. Sternac*  
A. G. Sternac  
PRINCIPAL FOUNDATION ENGINEER

## TABLE OF CONTENTS

1. INTRODUCTION.
  2. DESCRIPTION OF SITE AND GEOLOGY.
  3. DESCRIPTION OF FIELD AND LABORATORY WORK.
  4. SUBSOIL CONDITIONS:
    - 4.1) General.
    - 4.2) Silty Clay with some Sand and traces of Gravel.
    - 4.3) Heterogeneous Mixture of Clay, Silt, Sand and Gravel.
    - 4.4) Bedrock (Shale).
  5. GROUNDWATER.
  6. DISCUSSION AND RECOMMENDATIONS.
  7. SUMMARY.
  8. MISCELLANEOUS.
-

FOUNDATION INVESTIGATION REPORT  
For  
Proposed Crossing at Whitebread Drain  
And  
Proposed Hwy. #40, Line 'B'  
District #1 (Chatham)  
W.J. 67-F-36    --    W.P. 70-67

---

1. INTRODUCTION:

The Foundation Section was requested to initiate an investigation at the site of new Highway #40, Line 'B' and relocated Whitebread Drain. The present proposal is to build only the northbound lanes, with provision to construct the southbound lanes in the future. The site is situated approximately 4 miles in a northwesterly direction from the City of Wallaceburg. The request for the investigation was contained in a memo from Mr. A. P. Watt, Regional Bridge Location Engineer, dated May 16, 1967.

An investigation was carried out by this Section to determine the subsoil conditions at the site. Presented in this report are the results of our investigation, together with the recommendations pertaining to the design of the bridge foundations and approach embankments.

2. DESCRIPTION OF SITE AND GEOLOGY:

The site lies within the physiographic region known as the "St. Clair Clay Plain". The topography on either side of Whitebread Drain is mainly flat.

Whitebread Drain runs from east to west, draining into the St. Clair River. A gravel road running north and south between lots 5 and 6, crosses the drain by means of a 26-foot single-span, simply supported, steel and concrete bridge. The width of this bridge is 23 feet, and clearance between top of opening and bottom of creek is approximately 5 feet on the east side. The abutments, wingwalls and concrete deck, all show signs of weathering.

2. DESCRIPTION OF SITE AND GEOLOGY: (cont'd.) ...

The banks of the drain at this location are 5 feet high on the north side and 10 feet high on the south (due to the County Line Rd.). The existing banks were constructed with approximately 1:1 side slopes and exhibit no signs of instability.

3. DESCRIPTION OF FIELD AND LABORATORY WORK:

The field work for this investigation was carried out by means of conventional diamond drilling equipment adapted for soil sampling purposes. A total of 3 sampled boreholes and one dynamic cone penetration test was carried out at the new bridge site. The borings were advanced in NX and BX casing size to depths of approximately 120 feet.

Samples were recovered by means of a 2" O.D. split-spoon sampler and by 2" I.D. Shelby tube sampler. The dimensions of the split-spoon sampler and the energy used to drive it, conform to the requirements of the Standard Penetration Test. In-situ vane tests were made wherever possible, in order to determine the shear strength of the cohesive deposits.

Detailed logs of each boring are given on the Record of Borehole sheets following the text of this report. The locations and elevations of all the boreholes, together with a section of the inferred soil stratigraphy across the site, are given on Dwg. 67-F-36A.

At the time of the field investigation, the exact details of the proposed crossing were not available. Boreholes were therefore put down at the northern and southern limits of the probable structure locations. Since the subsoil conditions were found to be uniform, it is our opinion that no additional boreholes will be required for any possible crossing in the general area.

cont'd. /3 ...

3. DESCRIPTION OF FIELD AND LABORATORY WORK: ( cont'd.) ...

Samples taken were visually examined and identified in the field as well as in the laboratory. Tests were carried out in the laboratory on a selection of both disturbed and undisturbed samples to determine: natural moisture content, Atterberg limits, grain-size distribution, and undrained shear strengths, where applicable.

Laboratory and field test results have been summarized and are included under Appendix I of this report.

The borehole elevations in this report were obtained by hand level sightings referred to the bench mark of geodetic origin on the S.E. wingwall of the existing structure on the gravel road.

4. SUBSOIL CONDITIONS:

4.1) General:

The subsoil at the site mainly consists of a deep deposit of silty clay. This deposit is underlain by a thin layer of a heterogeneous mixture of clay, silt, sand and gravel overlying shale bedrock. The boundaries between different deposits, together with detailed descriptions of the material in the deposits, are shown on the borelog sheets attached to this report. The estimated stratigraphical profile shown on Dwg. 67-F-36A, is based on this information. From ground level downward, the different soil types encountered are as follows:

4.2) Silty Clay with some Sand and traces of Gravel:

This deposit was encountered immediately below the ground surface and extends to a maximum depth of 115 feet in B.H. #1. The upper 8 to 10 ft. of this deposit is brown due to oxidation and has an increased shear strength due to desiccation. The physical properties of the overall deposit are summarized as follows:

cont'd. /4 ...



4. SUBSOIL CONDITIONS: (cont'd.) ...

4.2) Silty Clay with some Sand and traces of Gravel: (cont'd.)...

Liquid Limit	(W <sub>L</sub> %)	--	38	-	55%
Plastic Limit	(W <sub>p</sub> %)	--	19	-	29%
Moisture Content	(W %)	--	24	-	53%
Bulk Density	γ	--	105	-	121 p.c.f.
'N' Values		--	3	-	15 blows/foot

Undrained Shear Strengths

Unconfined Compression	--	200	-	680 p.s.f.
Quick Triaxial	--	210	-	1775 p.s.f.
In-situ Field Vane	--	380	->	2000 p.s.f.
Sensitivity	--	1.6	-	7.1

Based on the above results, the consistency of the deposit may be described as stiff in the crust, decreasing to very soft at a depth of 20 ft. and gradually increasing to stiff with depth.

4.3) Heterogeneous Mixture of Clay, Silt, Sand and Gravel:

A glacial till deposit (heterogeneous mixture of clay, silt, sand and gravel) was observed immediately below the silty clay deposit and above the shale bedrock. The thickness of this layer ranges from 5 feet in B.H. #1 to 7 feet in B.H. #2A. This deposit is cohesive and very stiff in B.H. #2A, whereas in B.H. #1 this may be described as a very dense granular deposit. In general, the 'N' values range from 10 blows/foot to 60 blows for 5 inches.

cont'd. /5 ...

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.4) Bedrock (Shale):

In boreholes #1 and #2A, the shale bedrock was proved by drilling 5- and 8-foot rock core samples, respectively. The percentage recovery of these samples ranges from 22% to 53% in B.H. #2A, and 98% in B.H. #1. This indicates that the bedrock is weathered above elevation 450 in B.H. #2A.

5. GROUNDWATER:

Observations carried out during the period of field investigation, indicated that the water level was approximately at elev. 576 which is some 3 ft. below the ground surface. In view of the relatively impermeable nature of the subsoil, the precise groundwater level was not established in B.H. #2A during the time of field investigation.

6. DISCUSSION AND RECOMMENDATIONS:

It is proposed to construct twin single-span structures to carry new Hwy. #40 (Line 'B') over relocated Whitebread Drain. The present proposals are to construct the Whitebread Drain some 65 ft. north of the existing location. According to available information, the northbound lanes of new Hwy. #40 will be constructed now, with provision to construct the southbound lanes in the future. Our recommendations, however, will be applicable for both the structures.

Subsoil at the site consists of a 115-ft. deposit of silty clay with some sand and traces of gravel, followed by a 5 to 7 ft. thick layer of glacial deposit (heterogeneous mixture of clay, silt, sand and gravel) underlain by shale bedrock.

The presence of stiff to soft silty clay immediately below the ground surface, raises the problem of low bearing capacity and excessive settlements. For these reasons, it is recommended that the proposed abutments of the new structure be

cont'd. /6 ...

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

supported on end-bearing piles driven to shale bedrock. Allowable loads will depend upon the pile section chosen (e.g., 14 BP 74 steel H-piles may be designed for 90 tons per pile.

In view of the deep pile foundation required for the proposed structure, consideration should be given to the use of an open box culvert or a flexible pipe arch culvert. In such a case, the proposed culvert should be founded on a pad, 2 ft. thick, of suitable granular material. For the open box culvert, a safe design load of 750 p.s.f. may be used.

The proposed embankments will be about 6 ft. higher than the existing ground on the approaches to the bridge, but the maximum height in the longitudinal direction will be in the order of 12 ft., since the creek bed is about 6 ft. deep. Based on an average shear strength of 375 p.s.f. for the underlying clay between elev. 565 and elev. 540, no stability problems are anticipated for the proposed approach fills with standard 2:1 slopes.

7. SUMMARY:

A foundation investigation of proposed twin single-span structures at new Hwy. #40 (Line 'B') and relocated Whitebread Drain is reported.

Subsoil at the site consists of a deep deposit of silty clay followed by a heterogeneous mixture of clay, silt, sand and gravel, underlain by shale bedrock.

It is recommended that the abutments of the proposed structure be founded on end-bearing steel H-piles driven to bedrock.

A flexible pipe arch culvert or open type box culvert should be considered as an alternative to the proposed structure.

No embankment stability problems are anticipated for the proposed approach fills with standard 2:1 slopes.

cont'd. /7 ...

8. MISCELLANEOUS:

The field investigation was carried out during the period April 24 - 28, 1967. Equipment used was owned and operated by Canadian Longyear Drilling Co. Ltd. Field investigation was carried out by Mr. J. I. McDougall, Project Foundation Engineer, who also prepared this report.

The entire project was carried out under the general supervision of Mr. M. Devata, Supervising Foundation Engineer, who also reviewed this report.

May 1967

**APPENDIX I**

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 57-F-36

LOCATION Hwy. 40, Line 'B', Sta. 136 + 90 48'lt.

ORIGINATED BY JM

W.P. 70-67

BORING DATE April 19, 24, 1967

COMPILED BY RT, JM

DATUM Geodetic

BOREHOLE TYPE Washboring NX and BX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE						LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY γ P.C.F.	REMARKS Gr.Sa.Si.Ol	
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.					WATER CONTENT %					
							+ Field Vane      ○ Unconfined ● Quick Triaxial					wp — w — WL 20      40      60					
579.0	GROUND LEVEL						500	1000	1500	2000	2500						
0.0	Silty Clay, Some Sand, Trace of Gravel.  Stiff to Very Soft  (Brown to Grey)		1	SS	9	570										WL. 576.1	
			2	TW	PM											121	0 1 60 39
			3	TW	PM											117	
			4	TW	PM	560										114	
			5	TW	PM											107	
			6	TW	PM											106	
			7	TW	PM	550										108.5	
			8	TW	PM												
			9	TW	PM											116	
			10	TW	PM	540										115	0 15 49 36
			11	TW	PM											117	
			12	TW	PM												
			13	TW	PM	530											
			14	TW	PM												
			15	TP	PM												
			16	TP	PM	520											
			17	TP	PM												
			18	SS	L												
464.0	Het. Mix of Clay, Silt Sand & Gravel Very Dense		19	SS	50/5"	460										5 16 36 43	
459.0			20	SS	50/1"												
453.9			21	RC BX	98%												
125.1	End of Borehole					450											



DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 2A

FOUNDATION SECTION

JOB 67-F-36

LOCATION Hwy. 40, Line 'B', Sta. 134 & 05 60' Rt.

ORIGINATED BY JM

W.P. 70-67

BORING DATE April 26-28/67

COMPILED BY RT & JM

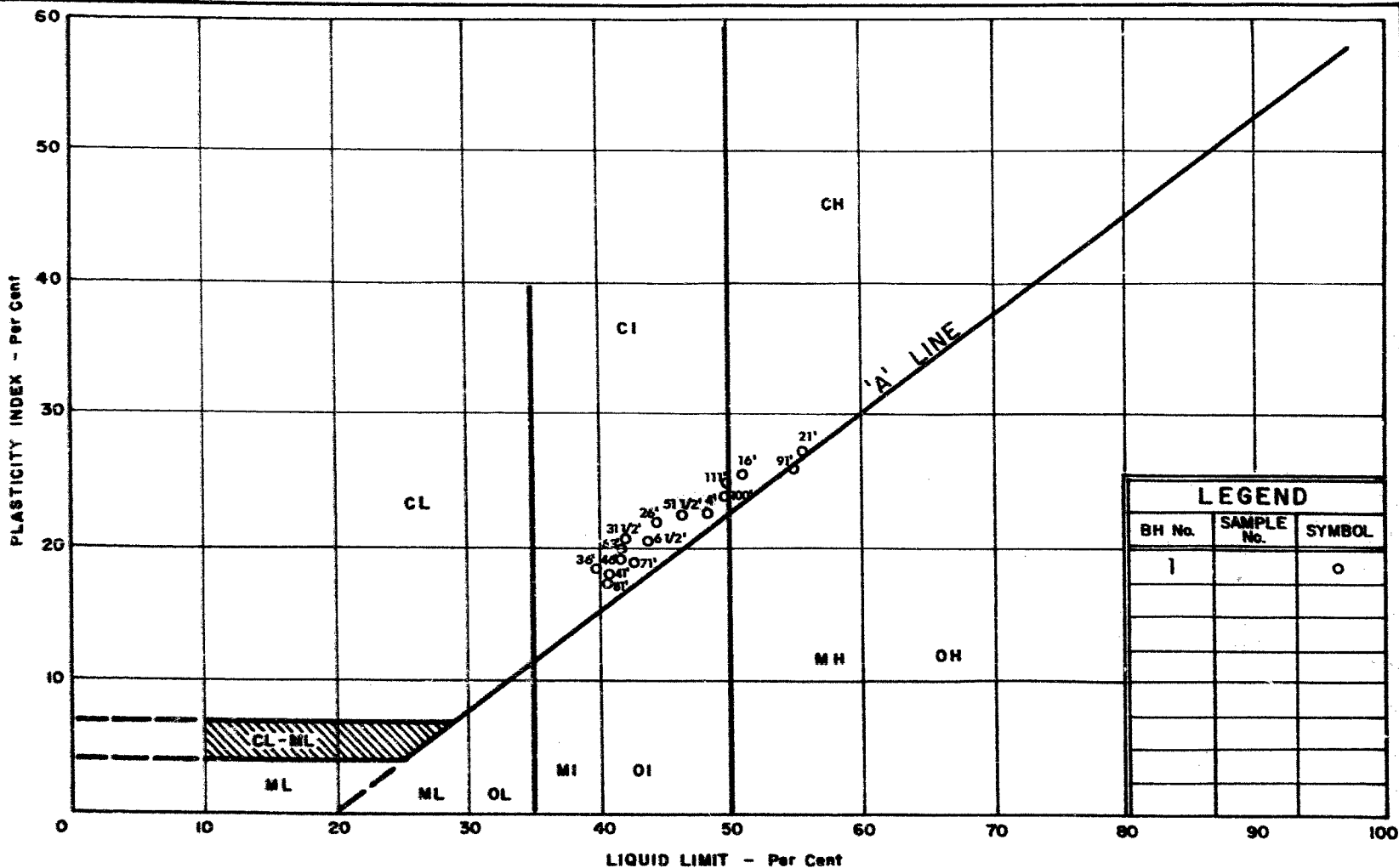
DATUM Geodetic

BOREHOLE TYPE Washboring, NX AND AX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT %					
							+ Field Vane    o Unconfined					20    40    60					
							• Quick Triaxial					20    40    60					
578.6	GROUND LEVEL						500	1000	1500	2000	2500						
0.0	Silty clay Some Sand Trace of Gravel  Stiff to Very Soft (Brown to Grey)		1	SS	9												
			2	SS	12												
			3	SS	3												
			4	TW	PM												
			5	TW	PM												
			6	TW	PM												
			7	TW	PM												
			8	TW	PM												
			9	TW	PM												
			10	TP	PM												
			11	TP	PM												
			12	TP	PM												
			13	TP	PM												
			14	TP	PM												
			15	TP	PM												
			16	TP	PM												
469.6			17	SS	10												
109.0	Het. Mix. of Clay, Silty sand & gravel. Stiff or Compact		18	SS	60/1"												
462.3			19	RC AX	223												
116.3	Bedrock (Black to Grey Shale)		20	RC AX	40%												
454.2			21	RC AX	53%												
124.4	End of Borehole																





LEGEND		
BH No.	SAMPLE No.	SYMBOL
1		o

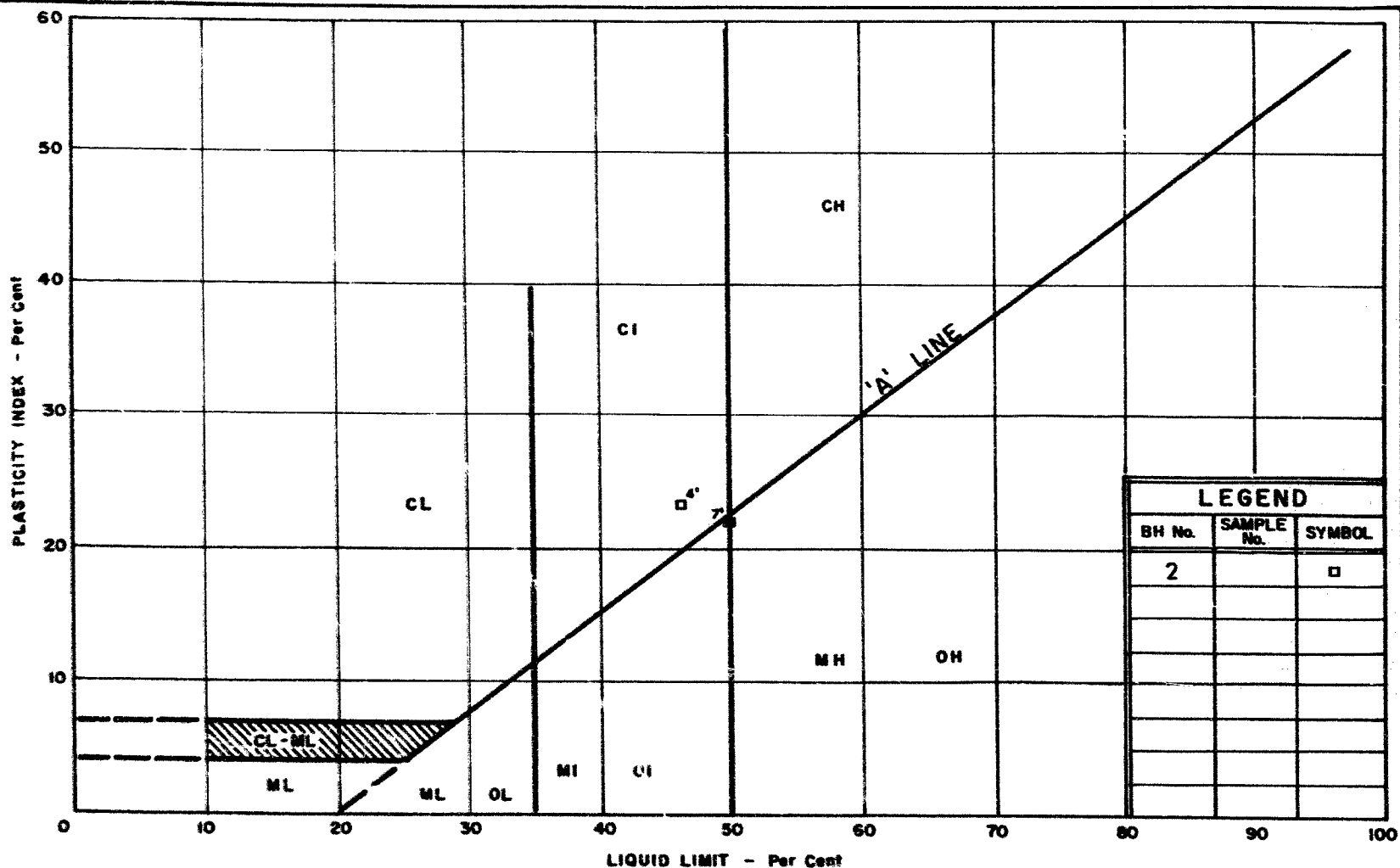


DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

## PLASTICITY CHART

WR No. 70 - 67

JOB No. 67 - F-36



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

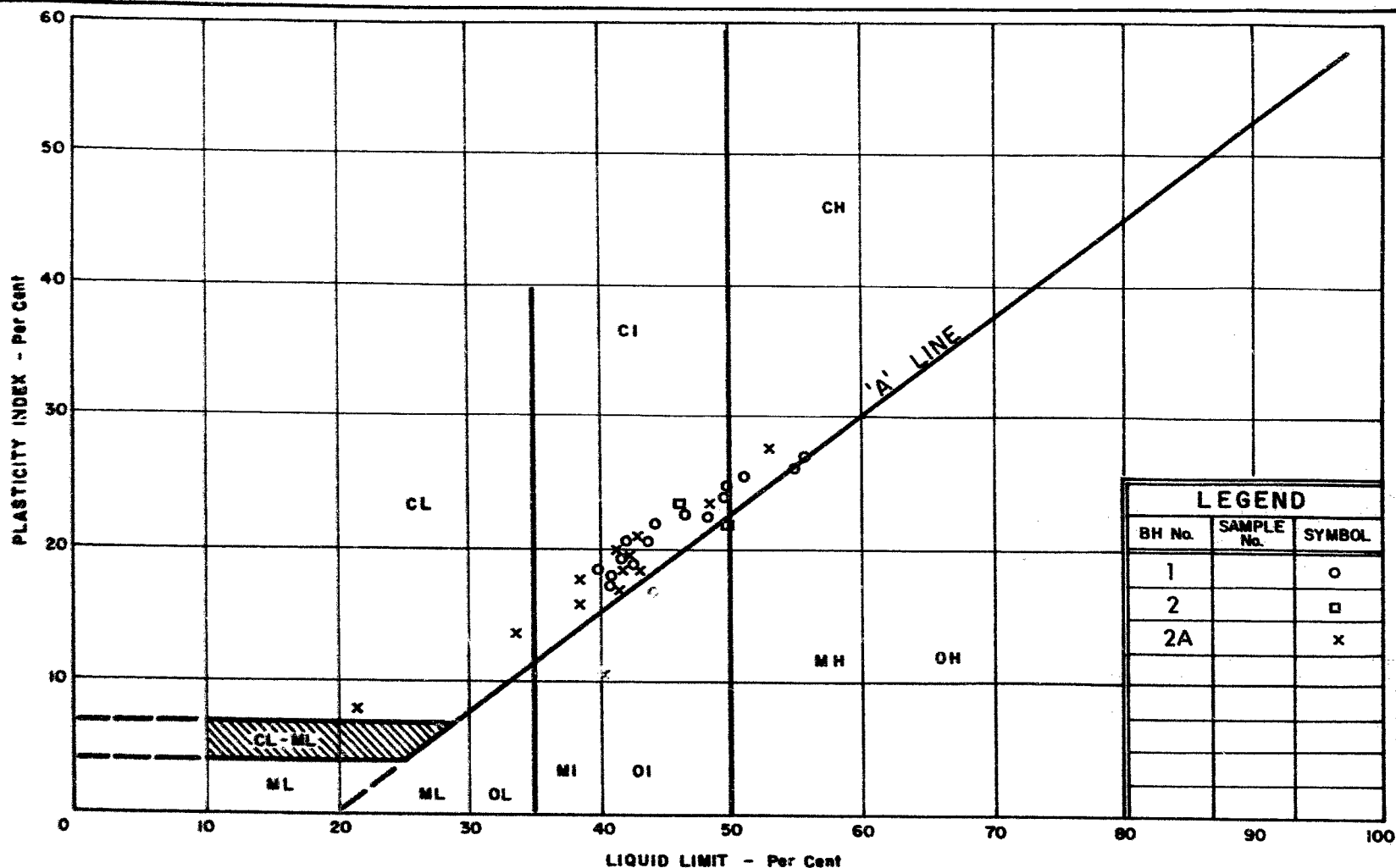
## PLASTICITY CHART

W.P. No. 70-67

JOB No. 67-F-36



W.P. No.	70 - 67
JOB No.	67 - F - 36



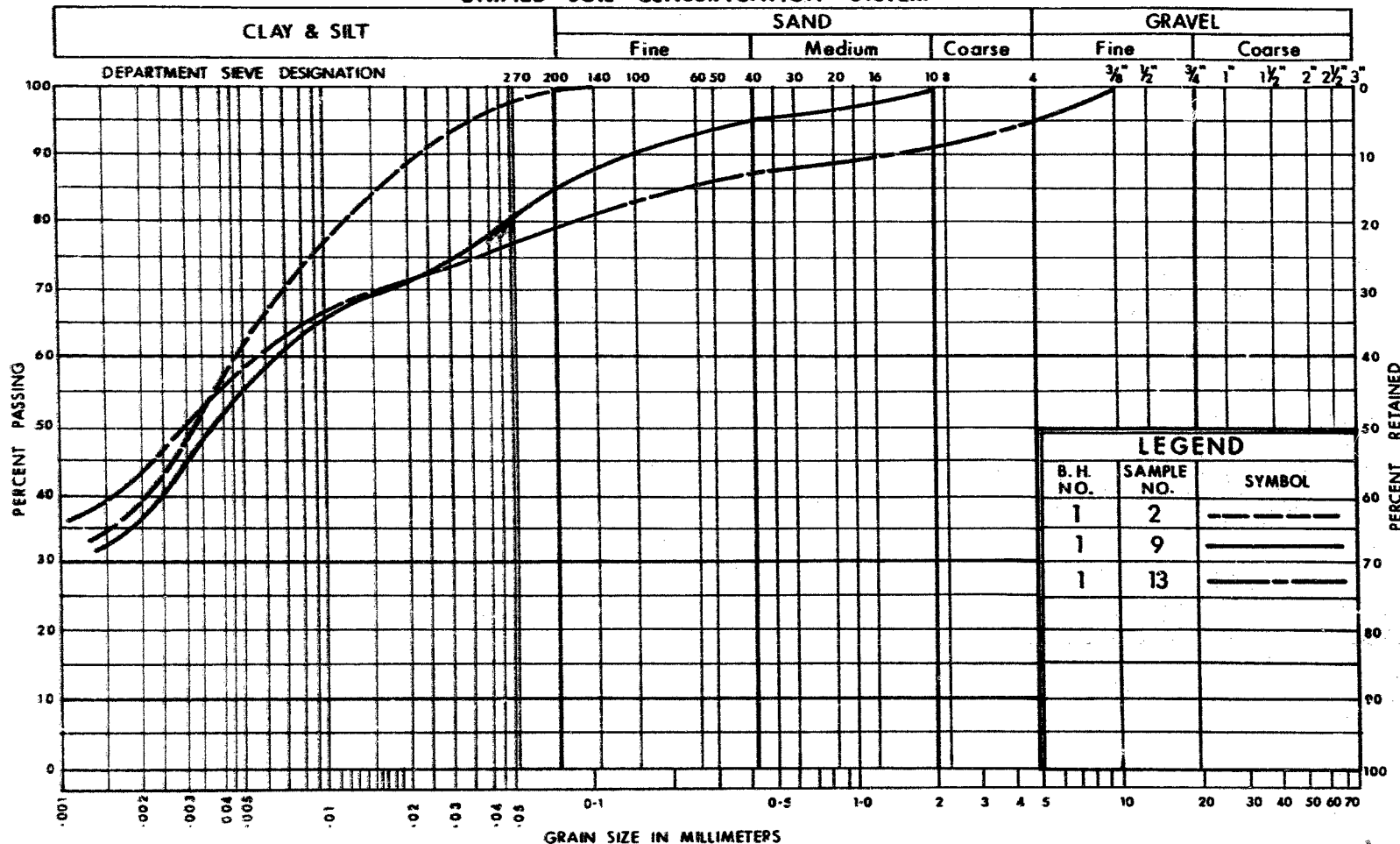
DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

# PLASTICITY CHART OVERALL RESULTS

W.P. No. 70 - 67

JOB No. 67 - F - 36

# UNIFIED SOIL CLASSIFICATION SYSTEM



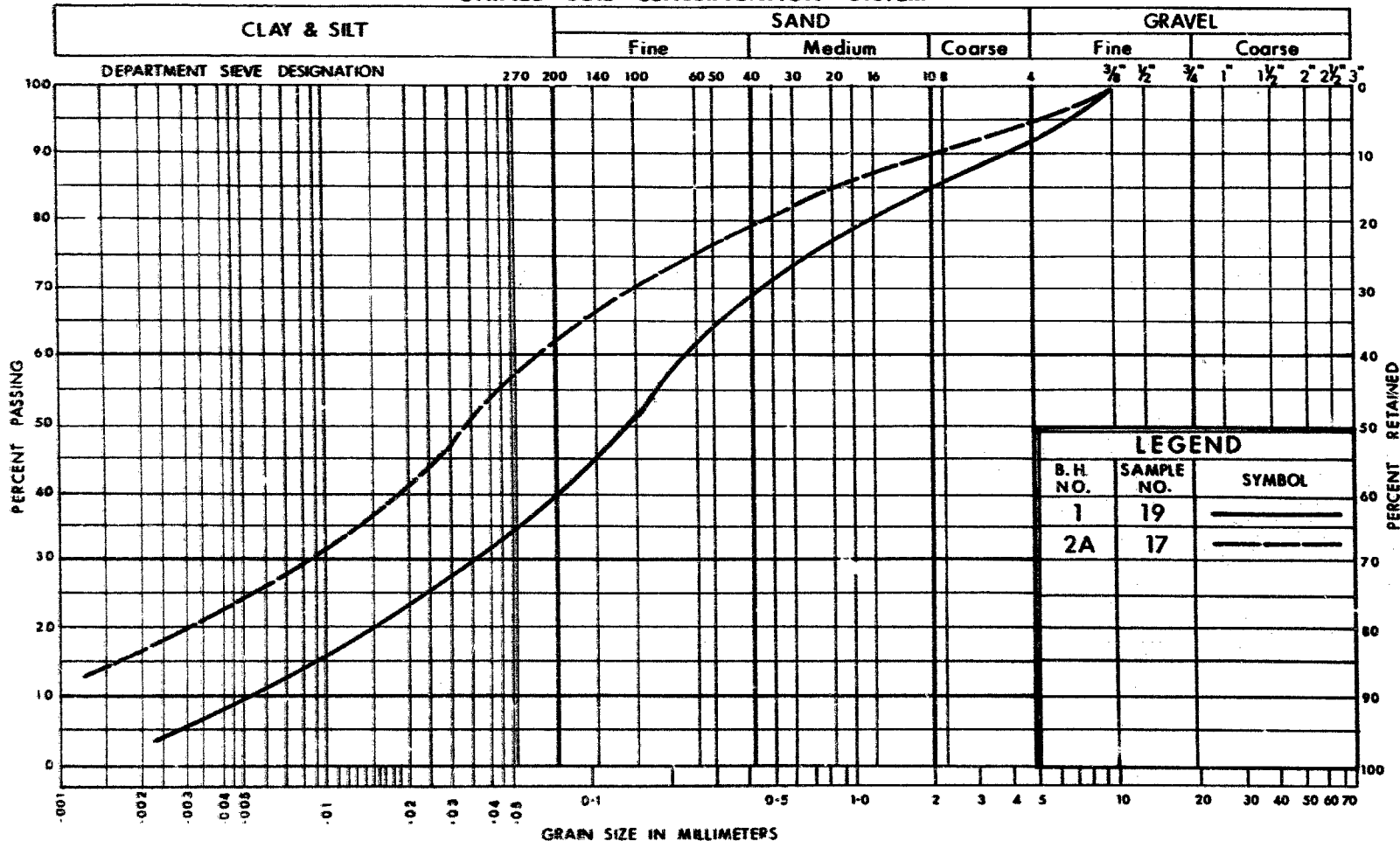
DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

**GRAIN SIZE DISTRIBUTION**  
**SILTY CLAY WITH SOME SAND**  
**AND TRACE OF GRAVEL**

W.P. No. 70 - 67

JOB No. 67 - F - 36

# UNIFIED SOIL CLASSIFICATION SYSTEM



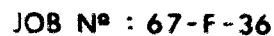
ONTARIO

DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

**GRAIN SIZE DISTRIBUTION**  
HETEROGENEOUS MIXTURE OF CLAY,  
SILT, SAND AND GRAVEL

W.P. No. 70-67

JOB No. 67-F-36



## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE / - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 90 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL. THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>± L.B. / 30 FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1500	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W	THINWALL OPEN
W.S	WASHED SAMPLE	T.P	THINWALL PISTON
S.B	SCRAPER BUCKET SAMPLE	O.S	OESTERBERG SAMPLE
A.S	AUGER SAMPLE	F.S	FOIL SAMPLE
C.S	CHUNK SAMPLE	R.C	ROCK CORE
S.T	SLOTTED TUBE SAMPLE		
	P.H	SAMPLE ADVANCED HYDRAULICALLY	
	P.M	SAMPLE ADVANCED MANUALLY	

### SOIL TESTS

Q <sub>u</sub>	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
q	UNDRAINED TRIAXIAL	F.V	FIELD VANE
Q <sub>cu</sub>	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q <sub>d</sub>	DRAINED TRIAXIAL	S	SENSITIVITY



# ABBREVIATIONS USED IN THIS REPORT

## SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
$G$	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
$e$	VOID RATIO
$n$	POROSITY
$w$	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
$z$	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$
$I_C$	CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOODEST STATE
$e_{min}$	VOID RATIO IN FINEST STATE
$I_D$	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
$h$	HYDRAULIC HEAD OR POTENTIAL
$q$	RATE OF DISCHARGE
$v$	VELOCITY OF FLOW
$i$	HYDRAULIC GRADIENT
$k$	COEFFICIENT OF PERMEABILITY
$j$	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma}$
$C_c$	COEFFICIENT OF CONSOLIDATION
$C_u$	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR $= \frac{C_v t}{d^2}$ ( $d$ , DRAINAGE PATH)
$U$	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c$	EFFECTIVE COHESION INTERCEPT
$\phi$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_g$	DENSITY

## GENERAL

$\pi$	$= 3.1416$
$e$	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF $\sigma$
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF $\sigma$ TO BASE 10
$t$	TIME
$g$	ACCELERATION DUE TO GRAVITY
$V$	VOLUME
$W$	WEIGHT
$M$	MOMENT
$F$	FACTOR OF SAFETY

## STRESS AND STRAIN

$u$	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
$E$	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
$G$	MODULUS OF SHEAR DEFORMATION
$K$	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

## EARTH PRESSURE

$d$	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
$K$	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

## FOUNDATIONS

$B$	BREADTH OF FOUNDATION
$L$	LENGTH OF FOUNDATION
$D$	DEPTH OF FOUNDATION BENEATH GROUND
$N$	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

## SLOPES

$H$	VERTICAL HEIGHT OF SLOPE
$D$	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\rho$	ANGLE OF SLOPE TO HORIZONTAL

## MEMORANDUM

To: Mr. A. G. Sternac  
Principal Foundation Engineer  
Lab Building  
D O W N S V I E W

FROM: A. P. Watt

DATE: May 16, 1967

Our File Ref.

IN REPLY TO

SUBJECT:

W.P. 70-67, Bridge Site 14-239,  
Whitebread Municipal Drain Bridge,  
1.8 miles south of Lambton Cty. Rd. #1,  
New Highway 40,  
District 1, Chatham.

-----

Would you kindly arrange to have a foundation investigation conducted at the above location. I have enclosed two copies of the site plan E-4803-1 with the probable footing locations marked in red.

*A. P. Watt*

A. P. WATT  
REGIONAL BRIDGE LOCATION ENGINEER

APW:gf  
Encl.

c.c. Mr. A. Crowley  
Mr. R. Forrest  
Mr. S. McCombie

Department of Highways Ontario

Copy for the information of

Mr. A. Stermac

Mr. A. Watt,  
Regional Bridge Location Engineer,  
London Regional Office,  
London, Ontario

Bridge Division,  
Toronto, Ontario

October 5, 1967

Whitbread Drain Bridge  
1.8 Miles S. of Lambton Ctg. Hi. #1  
W.P. 70-67, Site 14-239  
Highway 40 (New), District No. 1

67-F-36

Attached herewith are prints of the Preliminary Bridge Plan  
Drawing B-6080-F1 for the above-mentioned structure.

The estimated cost of the proposed structure is \$45,000.  
This cost includes tender, materials, engineering and sundry  
construction.

Any comments or revisions you may have should be submitted  
within three weeks.

GGG:rd

G.E. Grehski,  
Bridge Design Engineer

Attach.

C.C. E. McCombie  
A. Stermac (2)  
R. Forreast  
H. Gross

No comments  
D.N. Swada  
Oct 11/67