60-F-316C

W.P. 113-59

Hwy. # 401

South Raisin River

ONTARIO
DEPARTMENT OF HIGHWAYS

Memo to Mr. A. M. Toye, Bridge Engineer. *Date* February 10, 1960.

From Materials & Research Section. *Subject* FOUNDATION INVESTIGATION - by Racey, MacCallum & Associates.

Attention: Mr. S. McCombie.

Re: South Raisin River, Near Cornwall,
Lots 7 & 8, Hwy. #401, Ottawa, Ont.
District #9 -- W.P. 113-59.

Attached please find a copy of the foundation report for the above site, submitted by Racey, MacCallum & Associates.

Reference to the contents of this report shows that the subsoil stratigraphy consists of a deposit of sensitive, normally consolidated marine clay, extending from ground surface to a depth averaging 30 feet. This stratum is underlain by a layer of dense, glacial till, generally 15 to 20 feet in thickness. The till is underlain by sound limestone bedrock.

Artesian pressure was noted at the contact of the bedrock and glacial till.

Based on the information presented in this report, it is our recommendation that the structure be supported on small displacement 'H' piles driven to practical refusal in the underlying dense, glacial till stratum. Pile lengths should not exceed 45 feet. Small displacement piles are preferable to timber or monotube piles - particularly at the abutment locations, due to the sensitive marine clay.

If you have any questions regarding the contents of this report, or our foregoing comments, please do not hesitate to call our Office.

L. G. Soderman

L. G. Soderman,
PRINCIPAL SOILS & FOUNDATIONS ENGINEER

LGS/MdeF
Attach.
cc: Messrs. A. M. Toye (2)
H. A. Tregaskes
D. G. Ramsay
H. J. Ford
L. E. Walker
J. E. Gruspier
A. Watt
Foundations Office

Gen. Files.

BA 457-A.

RACEY, MacCALLUM AND ASSOCIATES
LIMITED

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Consulting Engineers
AND ASSOCIATED STAFF

MONTREAL VANCOUVER
TORONTO

DONALD C. MacCALLUM, B.ENG., M.E.I.C., P.ENG.
H. JOHN RACEY, B.SC., M.E.I.C., P.ENG.
GEORGE L. HOUGHTON, A.M.I.MECH.E., M.E.I.C., P.ENG.

TORONTO DIVISION
27 CARLTON STREET

Reference: S-500/T-2037
- Report -

9th February, 1960

60-F-316 C

Department of Highways for Ontario,
Materials and Research Section,
c/o Parliament Buildings,
TORONTO - Ontario.

Attention: Mr. L. G. Soderman

RE: SOIL INVESTIGATION AT
SOUTH RAISIN RIVER, NEAR CORNWALL
ONTARIO, W.P. 113-59

Dear Sir,

The enclosed report presents the results of our foundation investigation at the above location.

We hope the report is satisfactory to you; if you have any questions about it please do not hesitate to get in touch with us.

Thank you for this opportunity of being of service to you.

Yours very truly,
RACEY, MacCALLUM AND ASSOCIATES LIMITED,

J. J. Schoustra, P. Eng.,
Divisional Soil Engineer.

JJS/JP

Department of Highways for Ontario,
Materials and Research Section,
c/o Parliament Buildings,
Toronto - Ontario.

SOIL INVESTIGATION AT SOUTH RAISIN RIVER, NEAR CORNWALL ONTARIO, W.P. 113-59

Reference: S-500/3-2017
- Report -

Racey, MacCallum and Associates Limited.

9th February, 1960

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TORONTO DIVISION
27 CARLTON STREET

Reference: S-500/T-2037
- Report -

9th February, 1960

SOIL INVESTIGATION AT SOUTH RAISIN RIVER, NEAR CORNWALL ONTARIO, W.P. 113-59

INTRODUCTION :

The field investigation to determine the subsoil conditions at the site was carried out from 7th to 21st December, 1959 and consisted of seven borings and eight cone-penetrations tests. On arrival at the laboratory the samples were subjected to various tests to determine the strength and settlement characteristics of the soil.

The following paragraphs present a detailed description of the field and laboratory results and their consequences with regard to various subsoil problems. It is understood that a previous soil investigation had been conducted for the bridge structure proper and that a pile foundation had been decided on. No further study in this regard, therefore, was undertaken for this report. (It might be noted here, however, that some problems might occur if the piles are to be driven through the boulder till overlying the limestone bed rock.)

PRELIMINARY GEOLOGICAL STUDY :

The site under investigation is located in an area known as the St. Lawrence-Ottawa lowland. Following the recession of the last glacier, this area was covered by an arm of the sea, known as the Champlain Sea. The till plain was subsequently buried under the sediments of this sea. These water-lain deposits are deep silty-clays commonly known as "Leda" clays. With the removal of the glacier load, the uplift of the earth's crust together with the deposited sediments gradually progressed until exposed as the present-day clay plains.

SCOPE OF FIELD INVESTIGATION

The borings (locations are shown on Enclosure 1) were carried out using a standard diamond-drilling rig equipped for sampling with a 2 inch outside diameter split spoon and 2 inch inside diameter thin-walled Shelby tubes. Boreholes were advanced by driving BX casing and washing, with samples being taken at regular intervals. In addition to obtaining samples, several vane-torsional tests were carried out at various depths to obtain the in-situ soil shear strength both in the undisturbed and remoulded state. Once the dense till was reached the boring was advanced by running AX casing. In the underlying bed rock a core bit was used.

Adjacent to each borehole a 60 degree point angle cone was driven to obtain a continuous record of soil density. The driving energy for both the split spoon and cone penetrations was a 140 pound hammer at a 30 inch drop.

The results of the borings and cone tests are shown on Enclosures No. 2 to 9.

SCOPE OF LABORATORY WORK

Laboratory work consisted of Unconfined Compression and Triaxial tests to determine the strength characteristics of the silty-clay; and Consolidation and Atterberg Limit tests to determine the settlement characteristics.

The results of the strength tests and Atterberg tests are shown on Enclosures No. 2 to 9; and the results of the consolidation tests are plotted as "e-log. p" curves on Enclosures No. 10 and 11.

SUBSOIL CONDITIONS

A soil profile along the proposed centre-line is shown on Enclosure No. 1. The thickness of the soft sensitive silty-clay is approximately 25 feet in the vicinity of Borehole No. 1 and gradually diminishes to zero westward i.e. at Borehole No. 8. The clay layer is overlain by approximately 5 feet of silty-sand to silty-clays with sand; and is underlain by a dense gravelly-sand glacial till down to a sound limestone bed-rock. The glacial till just overlying the bed-rock has an

appreciable amount of boulders.

An artesian condition was encountered in all boreholes at approximately the inter-face of the bed rock and the overlying boulder till. The pressure head was to approximately 3 feet above ground level or Elevation 188.0 feet.

As wash water was used in advancing the borings, no accurate prediction of the ground water level could be made. However, other evidence such as grey colouring and saturation of the clay samples would seem to indicate that the lowest ground water table usually exists in the upper few feet of the silty-clay stratum.

DISCUSSION OF RESULTS :

The results of consolidation tests indicate that the clay had been pre-consolidated to approximately 2800 to 3000 psf. According to the geology of the area it is doubtful that the clay had been subjected to any drying or overburden load. It would seem probable therefore that as it is a marine clay, the pre-consolidation might be attributed to chemical action.

The shear strength of the clay subsoil is relatively uniform throughout the whole depth. Values of shear strength as determined by the in-situ vane-torsional tests average out to approximately 600 psf, whereas those determined by the laboratory unconfined compression tests average 300 psf. The large variation may possible be explained by some of the following factors.

i) A general structural distrubance caused by sampling and preparation procedures.

ii) A micro-structural disturbance not readily visible to the eye but which is in all probability present, as the silty-clay is quite sensitive.

iii) The removal or reduction of in-situ stresses during sampling.

It has been shown by various authorities that vane-torsional test results give higher values of shear strength

than those computed from unconfined compression tests and may be as much as twice the unconfined value.

From the foregoing considerations it may be concluded that soil shear strength as determined by the in-situ vane-torsional test to be the more correct value.

Remoulded shear strength values as determined by in-situ vane torsional tests indicate the silty-clay as being sensitive. This fact tends to confirm the foregoing argument in that it shows the soil as having the potential to be easily disturbed by ordinary sampling and testing procedures. This peculiar property however is characteristic of most sensitive clays and once the disturbing effect has stopped or is removed, the soil should recover most or all of its original strength within a period of one or two months.

EMBANKMENT SETTLEMENT :

Settlement calculations based on the results of the consolidation tests indicate that the settlement under the centre of the embankment fill will be approximately 9 inches, and approximately 3 inches under the edge of the fill. These values are in all probability greater than actual due to sample disturbance, as pointed out in the preceding paragraphs. The settlement will be 50% and 90% complete in approximately 2 and 9 months respectively.

In the calculations the following conditions were assumed;

i) Embankment height approximately 10 feet.

ii) Embankment average width 70feet.

iii) Unit weight of fill 140 pcf.

iv) Ground Water Table at ground surface.

EMBANKMENT STABILITY :

Stability analyses were carried out for both a general embankment fill and an abutment fill. Sketches of each case are shown on Enclosures No. 12 and 13. The results

of the various trial solutions are shown on the respective enclosure. From these results it can be seen that the Safety Factor is roughly 2.1 for the embankment fill and 2.2 for the abutment fill. A base failure was assumed for each case.

CONCLUSIONS AND RECOMMENDATIONS :

Summarizing the foregoing results and considerations the following conclusions and recommendation seem warranted.

1. The soil profile consists of a stratum of sensitive silty-clay averaging 25 feet on the east side of the river, decreasing gradually westward. Underlying there is a dense gravel-sand-boulder till over a sound limestone bed-rock.

2. Evidence indicates that the ground water table usually exists within a few feet of ground surface. An artesian condition was encountered at the interface of the boulder till and limestone bed rock, with a pressure head approximately 3 feet above ground level.

3. The settlement under the embankment fill will be approximately 9 inches at the centre and 3 inches at the edges.

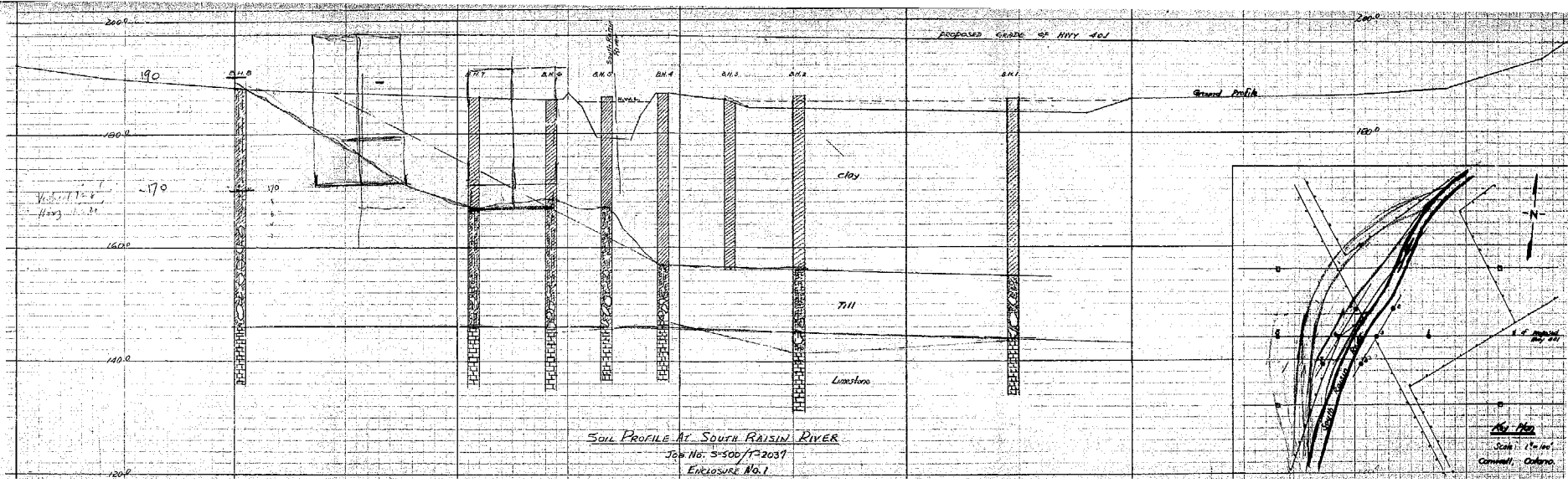
4. The Safety Factor against a slip-circle failure is roughly 2.1 under the road embankment fill and 2.2 under the abutment fill.

L. P. Winters

Lorne P. Winters, P.Eng.,
Project Engineer.

REGISTERED PROFESSIONAL ENGINEER
CIVIL
L. P. WINTERS
PROVINCE OF ONTARIO

LPW/JP



SOIL PROFILE AT SOUTH RAISIN RIVER

Job No. 5-500/17-2037

ENCLOSURE No. 1

RACEY MacCALLUM AND ASSOCIATES LTD.

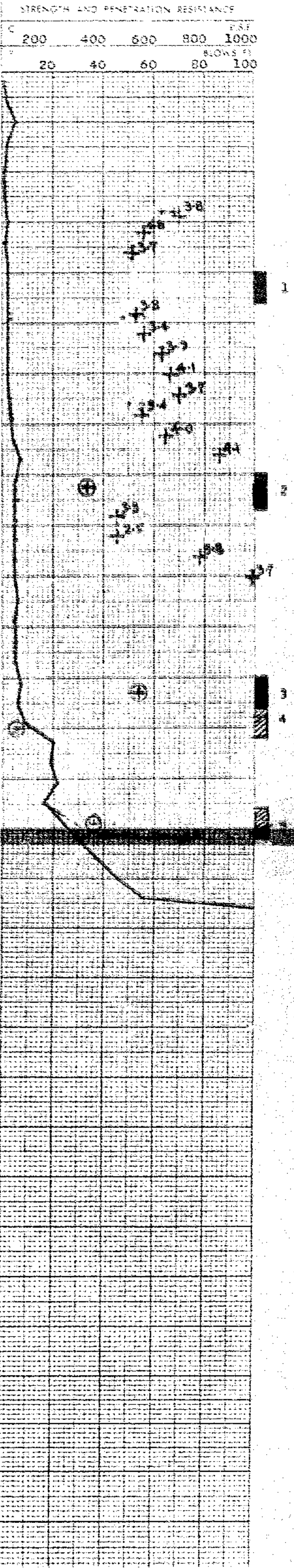
Foundation Engineering Division

Engineering Data Sheet for Borehole 1

Project: FOUNDN. INVEST. BRIDGE SITE OVER SOUTH RAISIN RIVER.
Location: CORNWALL, ONTARIO.
Hole Location: See Enclosure No 1.
Hole Elevation and Datum: 184.5 feet
Field Supervisor: J.W. Prep.: J.W.
Driller: M.G. Checked: Date:

LEGEND
Shear Strength C
Unconfined compression
Vane test und. sensitivity S.
Penetration Resistance P
2" Split tube
2" Dia. Cone
Casing

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Ground Surface	184.5	0
	Top soil.	183.9	
	Loose silty sand.	180.0	5
	Soft to medium grey silty clay.		
	Soft sandy clay with some fine gravel.	152.0	
	Grey, dense fine to medium sand with fine to coarse gravel (till form)	142.5	
	Limestone Bedrock (100% Recovery)	132.5	
	End of Boring		



LEGEND :

Thin walled sample

- Split spoon sample

Order No. S-500/T-2037

Enclosure No. 2

RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Borehole: 1

LEGEND

Consistency

Natural moisture and Liquidity Index (L) — × L

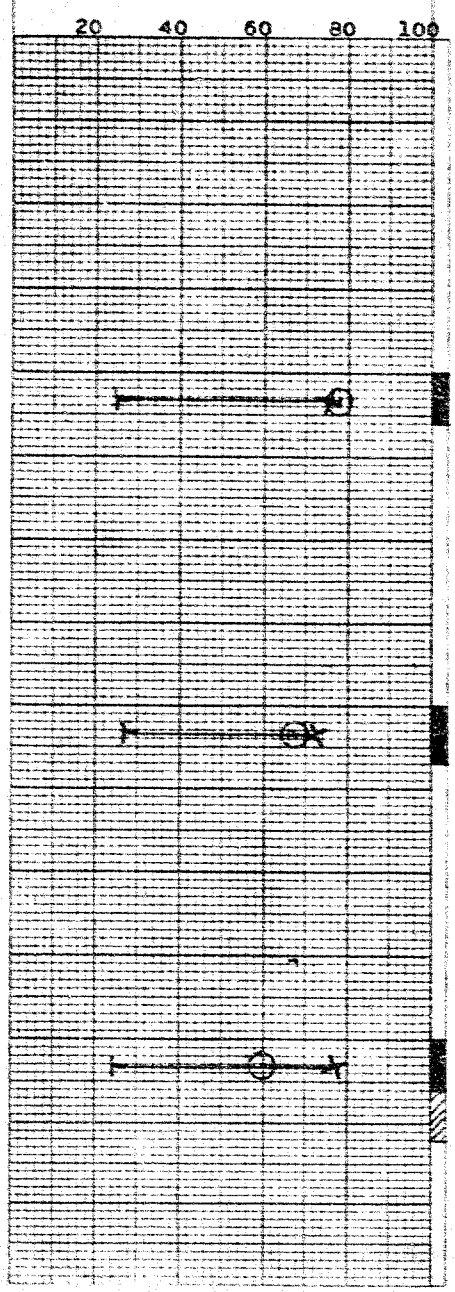
Liquid limit — O

Plastic limit — |

Sampling Method

2" Dia. split tube

2" Shelby tube



DEPTH FEET	CONSISTENCY — MOISTURE CONTENT % DRY WEIGHT	SAMPLE	NATURAL UNIT WT. P.C.F.	REMARKS
0				Ground Surface
10		1		
20		2	99.0	
30		3	100.5	
		4		

Order No. S-500/I-2037. Enclosure No. 3

RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

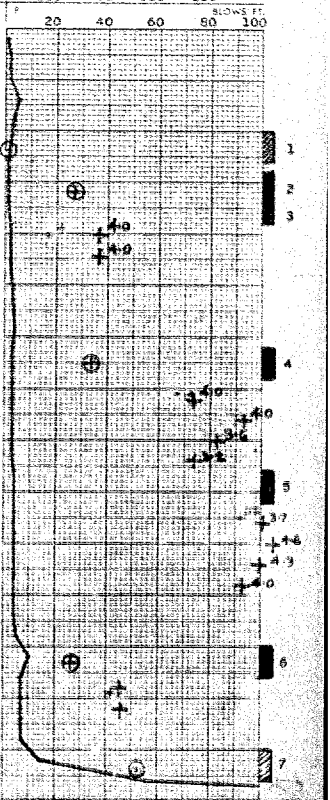
Engineering Data Sheet for Borehole: 2

Project: FOUNDN.INVEST.BRIDGE SITE OVER SOUTH RAISIN RIVER,
Location: CORNWALL, ONTARIO.
Hole Location: See Enclosure No 1.
Hole Elevation and Datum: 185.2 Feet
Field Supervisor: J.W. Prep.: J.W.
Driller: M.G. Checked: Date:

LEGEND
Shear Strength C
Undisturbed samples ○
Vane test and sensitivity S
Penetration Resistance P
2" Split tube
2" Dia. Cone
Casing

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Ground Surface.	185.2	0
	Top soil	184.2	
	Loose silty sand.		
		180.7	5
	Soft to medium stiff grey silty clay.		10
			15
			20
			25
			30
	Grey, medium stiff sandy clay to medium dense sand with some gravel.		35
	Grey silty sand to medium sand with fine to coarse gravel. (till form)		40
			45
	Limestone bedrock (100% recovery)		
	End of Boring	135.2	50

STRENGTH AND PENETRATION RESISTANCE
C 200 400 600 800 P.S.F.
P 20 40 60 80 100 BLOWS FT.



LEGEND :

■ – Thin walled sample

▨ – Split spoon sample

Order No. S-500/T-2037. Enclosure No. 3

RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Borehole: 2

LEGEND

Consistency

Natural moisture and Liquidity Index (I)

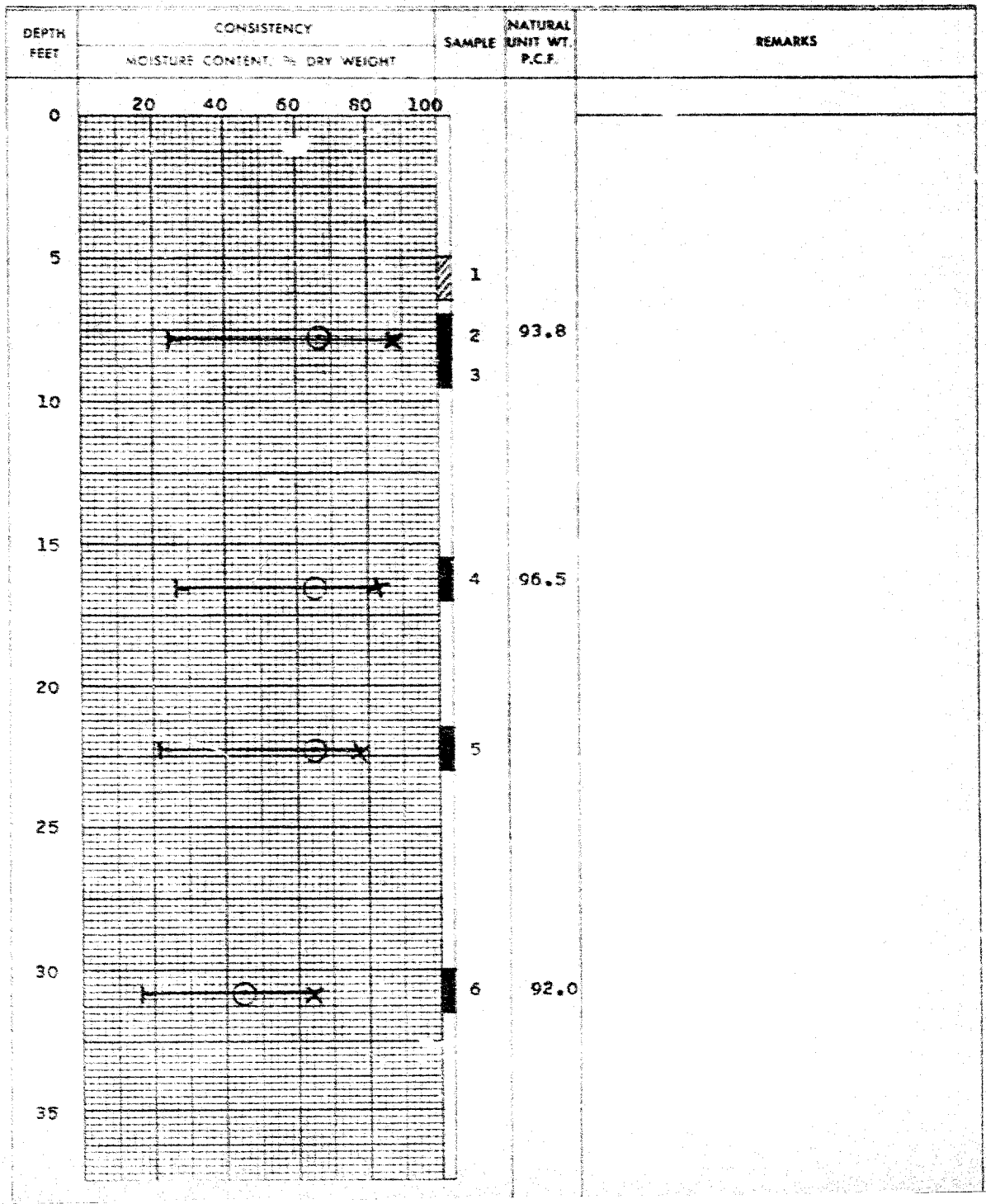
Liquid limit

Plastic limit

Sampling Method

2" Dia. split tube

2" Shelby tube



Order No. S-500/T-2037 Enclosure No. 4

RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Borehole: 3

Project: FOUNDN.INVEST.BRIDGE SITE OVER SOUTH RAISIN RIVER.
Location: CORNWALL, ONTARIO.
Hole Location: See Enclosure No 1.
Hole Elevation and Datum: 184.8 feet
Field Supervisor: J.W. Prep.: J.W.
Driller: M.G. Checked: Date:

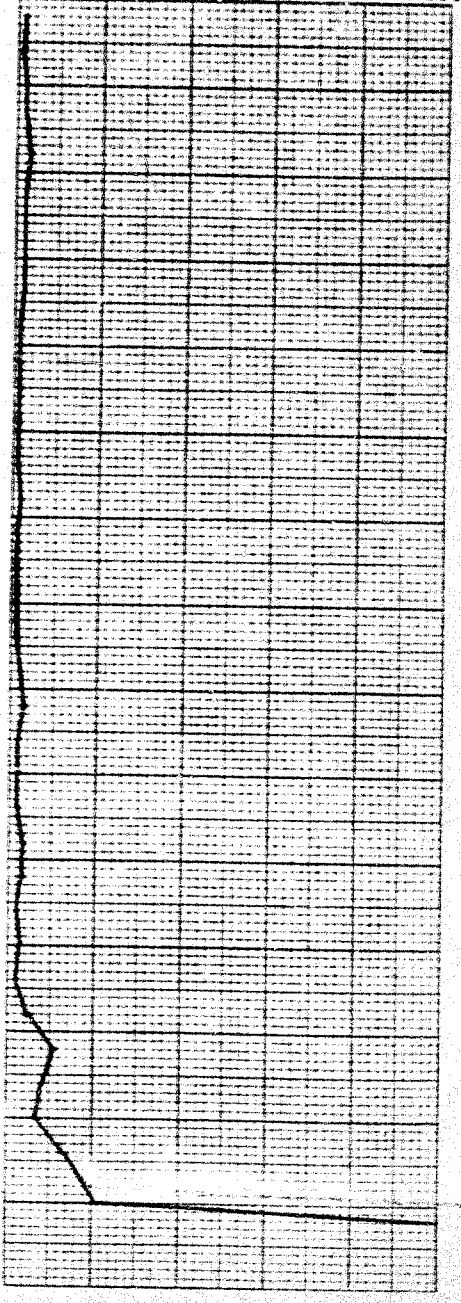
LEGEND
Shear Strength (C)
Unconfined compression ⊕
Vane test and sensitivity (S) +S
Penetration Resistance (P)
2" Split tube ⊖⊖
2" Dia. Cone
Casing .....

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Ground Surface	184.8	0
	Cone Refusal	149.3	35

STRENGTH AND PENETRATION RESISTANCE

C P.S.F
200 400 600 800

P BLOWS/ft
20 40 60 80 100



File No. G-5097-2037 [partly illegible] Borehole No. 5

LACEY MacCALLUM AND ASSOCIATES LTD.

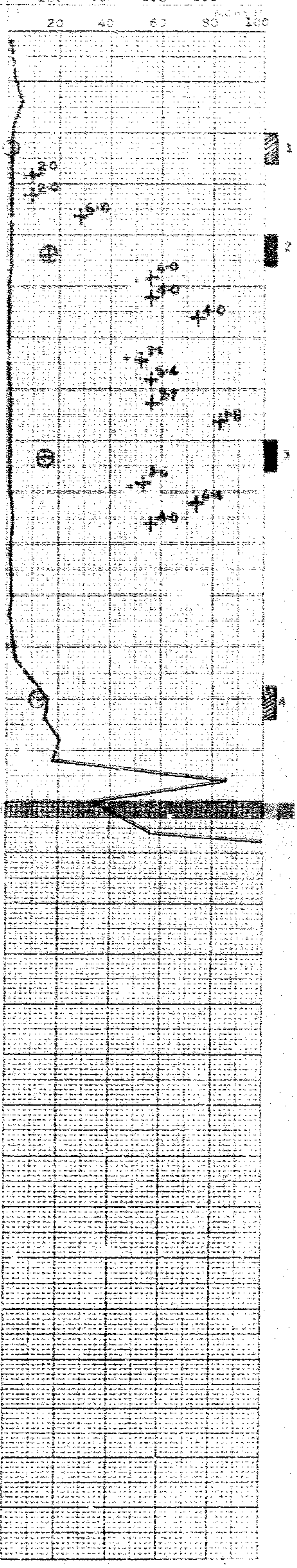
[illegible] Engineering [illegible]

[illegible] Data Sheet for Borehole 4

Project: [illegible] BRIDGE SITE OVER [illegible] RAISIN RIVER.
Location: [illegible], ONTARIO
Hole Location: See Enclosure No. 1
Hole Elevation and Datum: 184.8 feet
Field Supervisor: J. F. Prep: J. M.
Driller: M. D. Checked: Date:

Symbol	Description	Elev. feet	Depth feet
	Ground Surface	184.8	0
	Top soil	183.8	
	Soft to medium stiff grey silty clay.		5
	Brownish medium sand.	[illegible]	
	Soft to medium stiff grey silty clay.		10, 15, 20, 25
		154.8	30
	Medium dense to very dense gravelly-sand with some clay in top of stratum and odd boulder at bottom of stratum. [illegible]		35
		144.8	40
	Limestone bedrock (100% recovery)		45, 50
	End of Boring	133.8	55

Strength and Penetration Resistance



Order No. S-500/I-2037

Enclosure No. 5

RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Borehole: 4

LEGEND

Consistency

Natural moisture unit

Boundary Index (L)

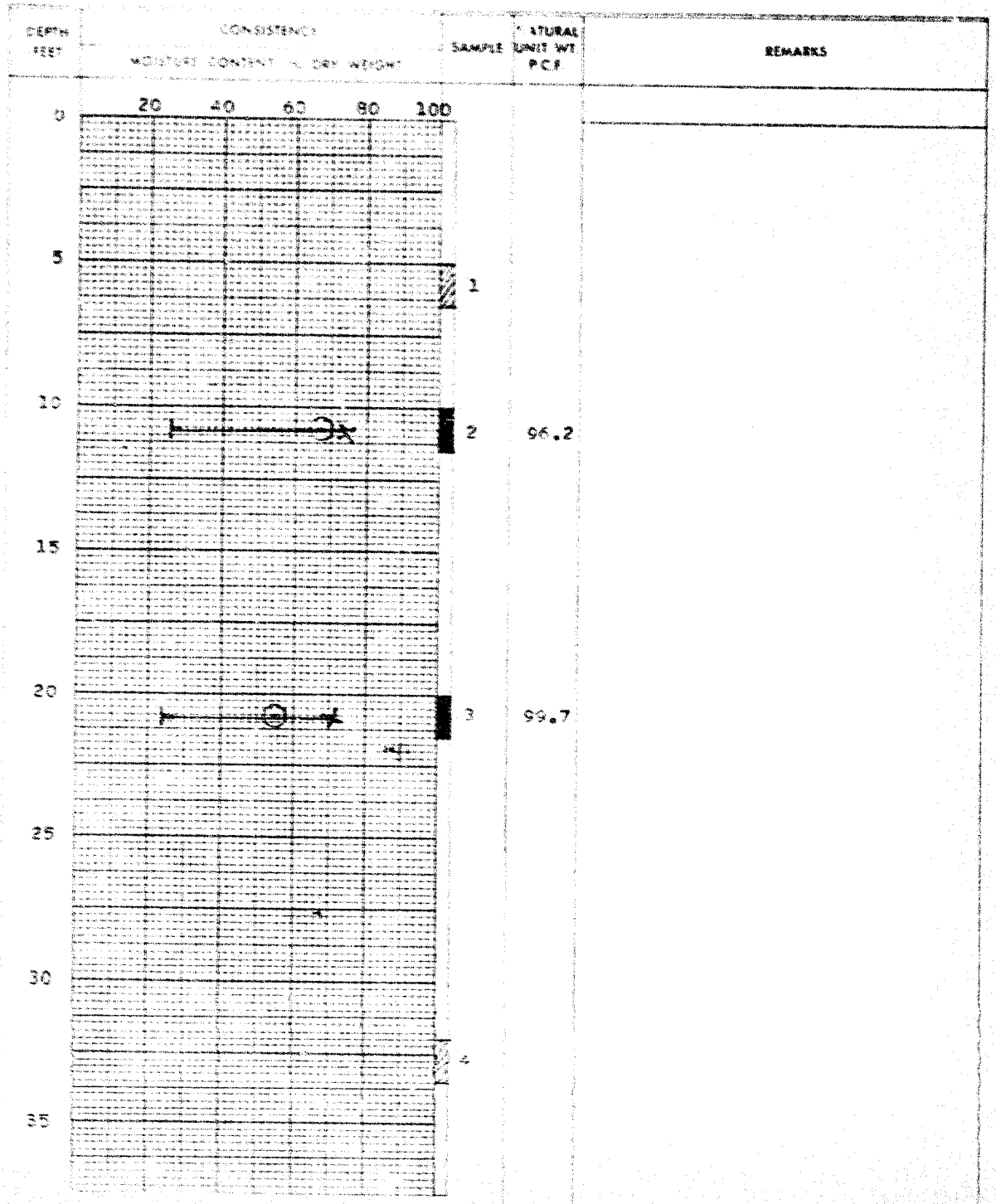
Liquid Limit

Plastic Limit

Sampling Method

2" Dia. split tube

3" Shelby tube



Borehole No. 5

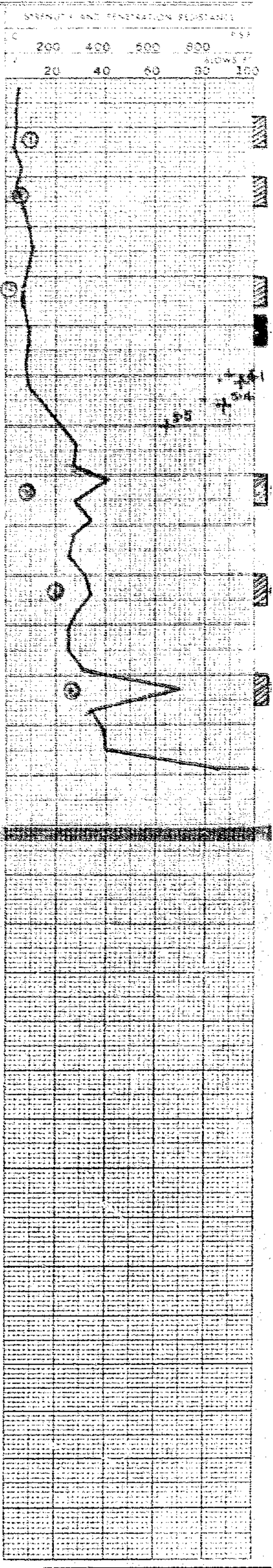
RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering [illegible]

Engineering Data Sheet for Borehole 5

Project: [illegible] RIVER.
Location: [illegible], ONTARIO.
Hole Location: [illegible]
Hole Elevation and Datum: 186.0 feet.
Field Supervisor: [illegible] Prep. J.W.
Driller: [illegible] Checked: Date:

Description	Elev. Feet	Depth Feet
Ground Surface	186.0	0
Top soil	185.0	
Soft to medium stiff, mottled grey-brown silty clay with organic and traces of sand.	181.0	5
Medium to coarse sand with silt and clay.	179.5	
Soft to medium stiff grey silty clay.		
Dense to very dense gravelly-sand with some clay in upper portion. (till form)		
Limestone bedrock (100% recovery).	136.5	50
End of Boring		



RACEY MacCALLUM AND ASSOCIATES LTD.

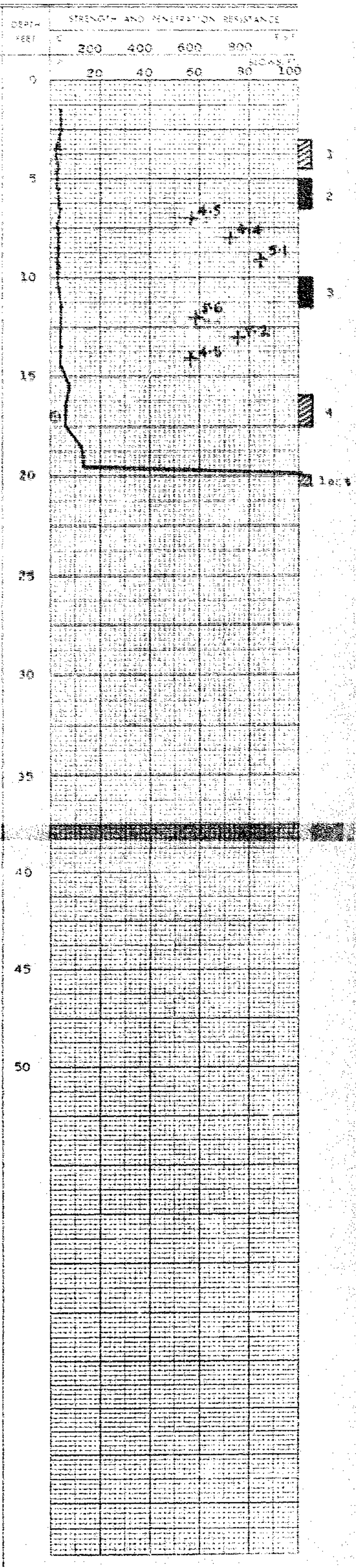
Foundation Engineering Division

Engineering Data Sheet for Boring No. 6

Project: FOUNDN. INVEST. [illegible] OVER SOUTH RAISIN RIVER.
Location: CORNWALL, ONTARIO.
Hole Location: See Enclosure No 1.
Hole Elevation and Datum: 185.3 feet
Field Supervisor: J.W. Prep: J.W
Driller: M.G. Checked: Date:

Legend: Shear Strength: Unconfined compression [illegible]; Penetration Resistance: Split tube, [illegible] Cone, Casing

SYMBOL	DESCRIPTION	ELEV. FEET
	Ground Surface.	185.3
	Top soil	184.3
	Loose medium to fine sand with silts.	182.3
	Soft mottled brown clayey silt with some sands.	180.3
	Soft to medium stiff grey silty clay.	167.8
	Very dense gravelly-sand with boulders at lower depths. (till form)	144.3
	Limestone bedrock (100% recovery).	133.7
	End of Boring	

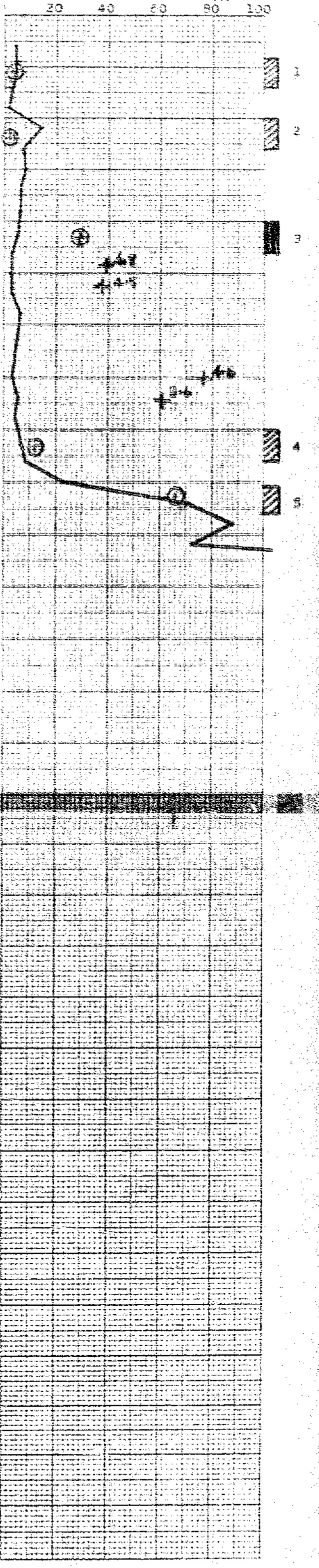


RACEY MacCALLUM AND ASSOCIATES LTD.

Project: [illegible] BRIDGE SITE [illegible] SOUTH RAISIN RIVER.
Location: [illegible]ALL, ONTARIO.
Hole Location: See Enclosure No 1.
Hole Elevation and Datum: 185.3
Field Supervisor: J.W. Prep: J.W.
Driller: M.G. Checked: Date:

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Ground Surface	185.3	0
	Top soil	184.3	
	Medium stiff, mottled brown silty clay with some sand.	176.3	5
	Soft to medium stiff grey, silty clay	165.3	10, 15, 20
	Very dense gravelly-sand with boulders. (till form)	145.3	25, 30, 35, 40
	Limestone bedrock (100% recovery).	13[illegible].3	45, 50
	End of Boring		

STRENGTH AND PENETRATION RESISTANCE



Order No. S-500/T-2037 Enclosure No. 8

RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Borehole: 7

LEGEND

Consistency

Natural moisture and Liquidity Index (I)

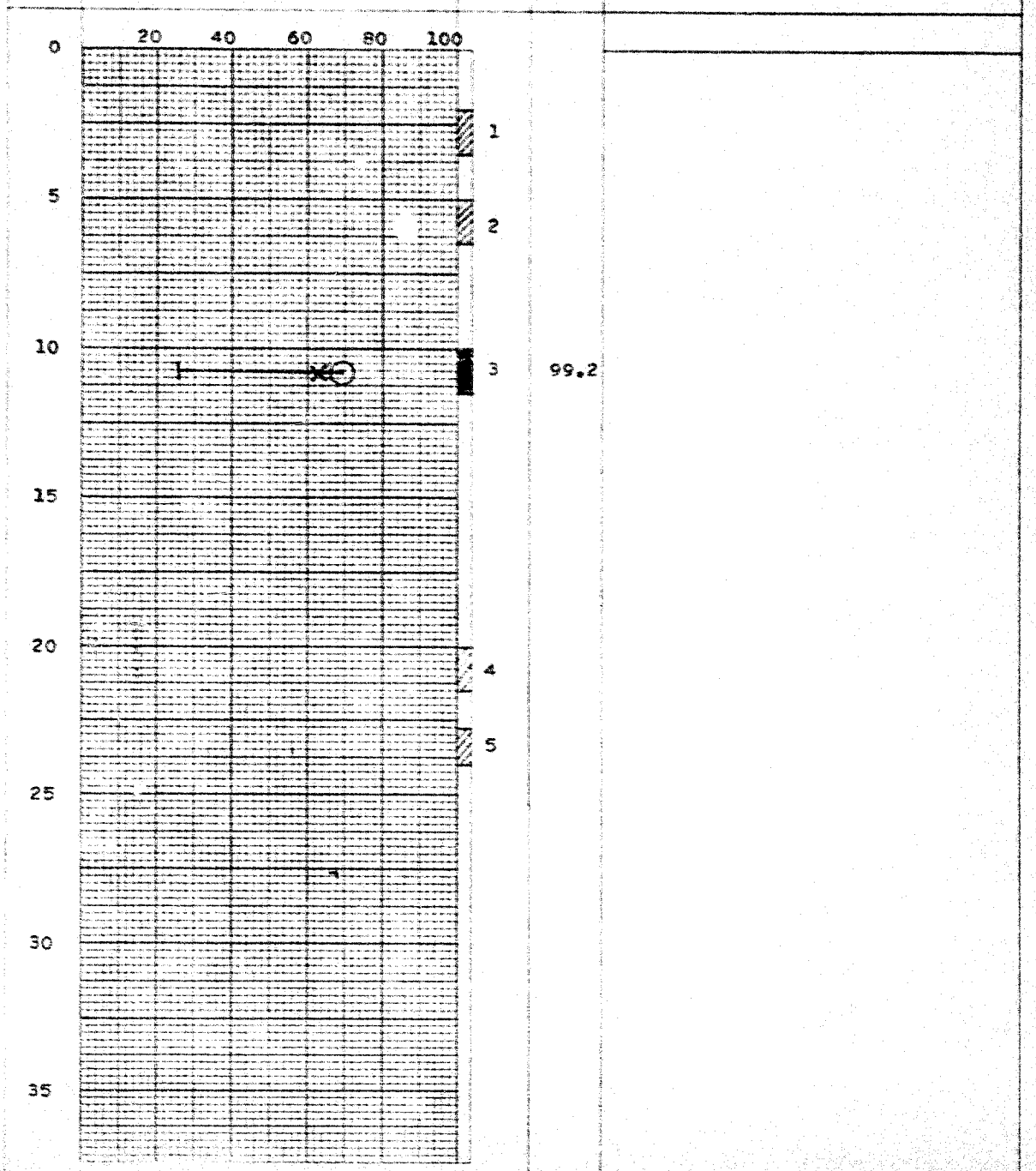
Liquid limit

Plastic limit

Sampling Method

2" Dia. split tube

2" Shelby tube



Order No. S-570/T-2037 Enclosure No. 9

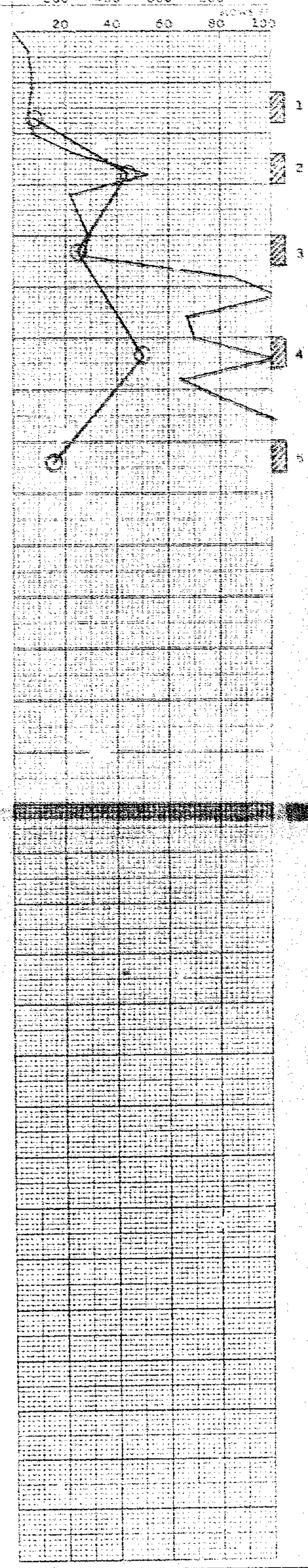
RACEY MacCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Boring 8

Project: FOUNDN. INVEST. BRIDGE SITE DUFF SOUTH RAISIN RIVER
Location: [illegible], ONTARIO.
Hole Location: See Enclosure No 1.
Hole Elevation and Datum: 187.6
Field Supervisor: J.M. Prep: [illegible]
Driller: [illegible] Checked: Date:

Symbol	Description	Elev. Feet	Depth Feet
	Ground surface	187.6	0
	Medium stiff mottled grey-brown clayey silt with some organic and fine sand.	182.6	5
	Dense to very dense grey gravelly-sand with some clay; some boulders at lower depths (till form)	144.4	
	Limestone bedrock (100% recovery.)	137.6	50
	End of Boring		

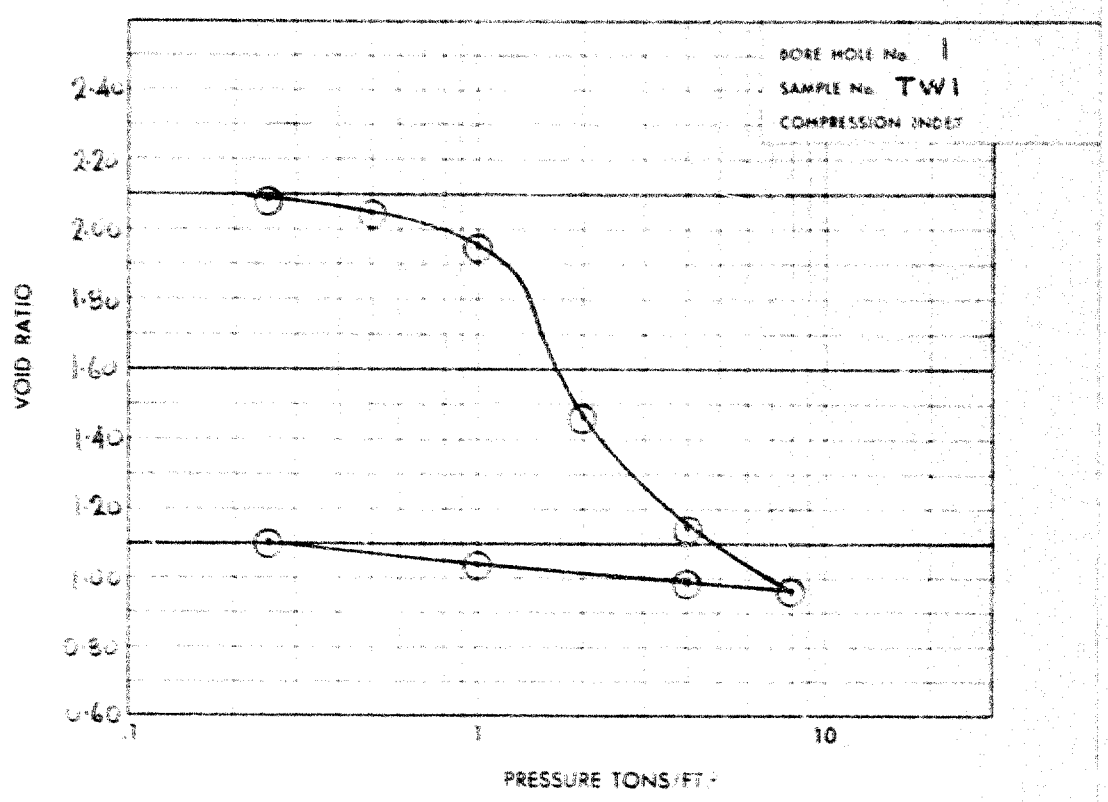


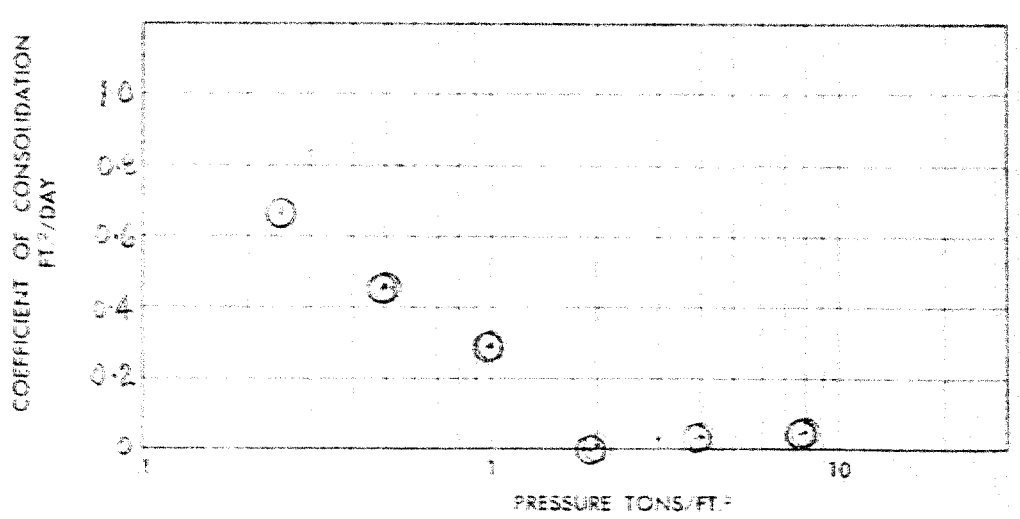
Order No. S-500/T-2037

Enclosure No. 10

RACEY MacCALLUM AND ASSOCIATES LTD.

CONSOLIDATION TEST



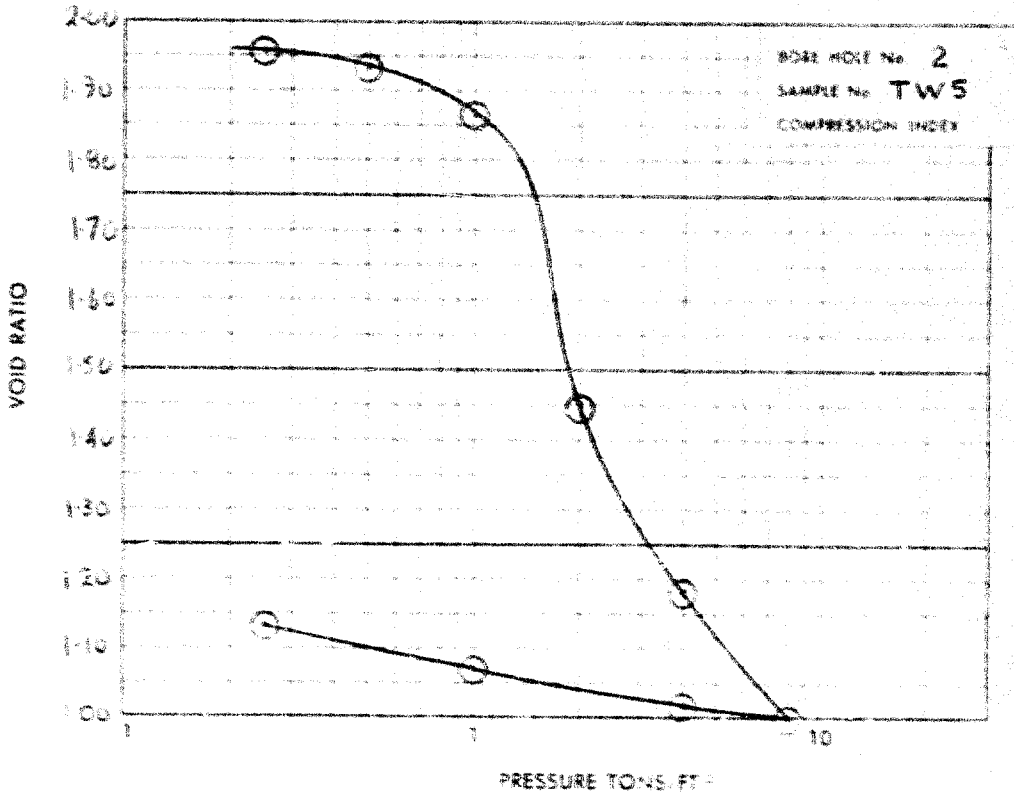


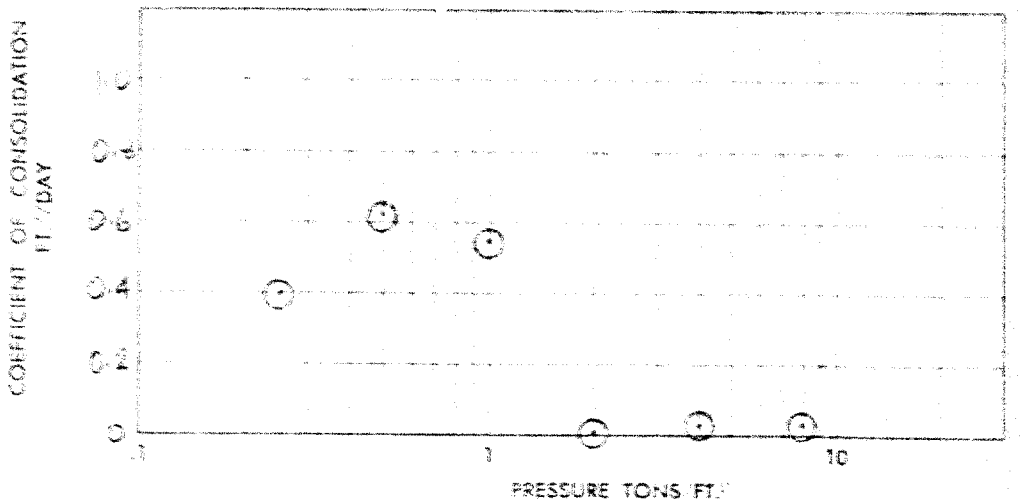
Order No. S-500/T-2037

Enclosure No. 11

RACEY McCALLUM AND ASSOCIATES LTD.

CONSOLIDATION TEST

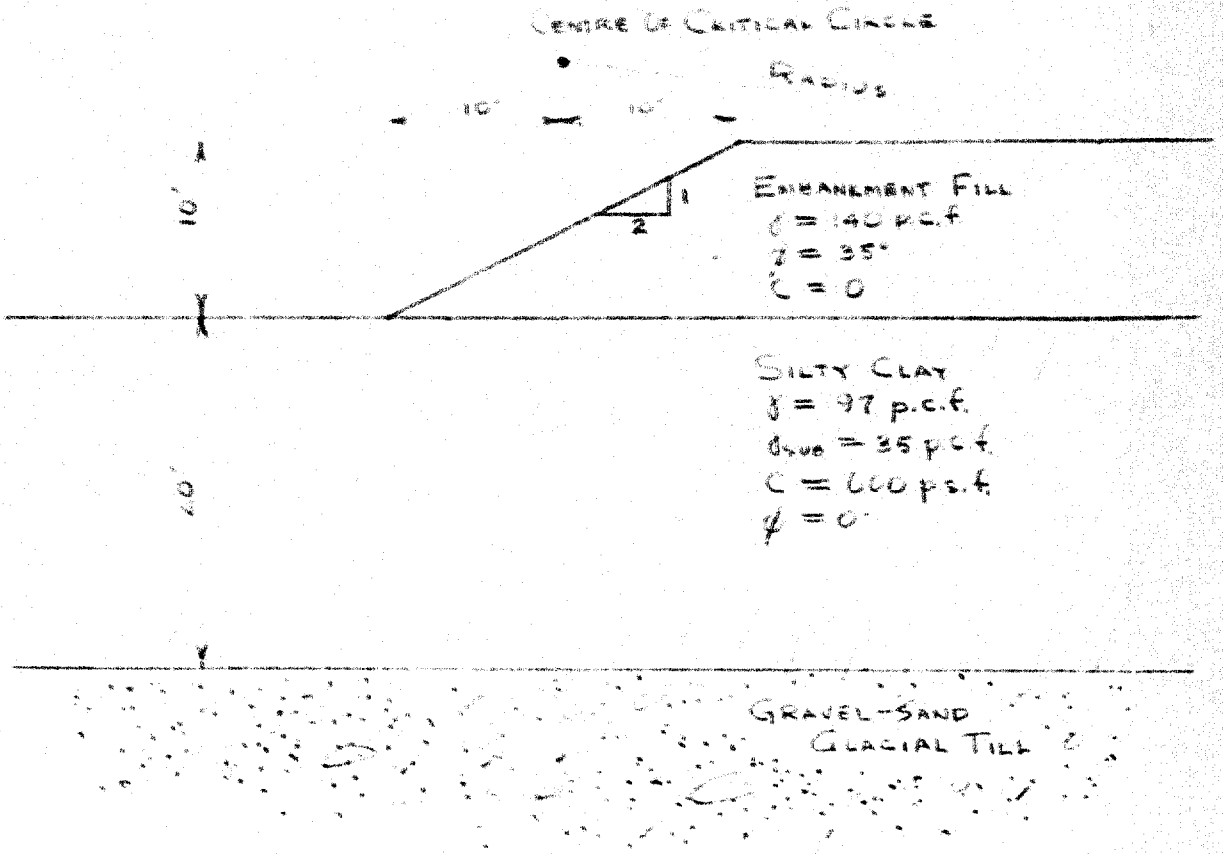




Order No. S-500/T-2037 Enclosure No. 12

Prep. By L.P.W.

CASE 1 - STABILITY UNDER EMBANKMENT FILL



TRIAL SOLUTIONS

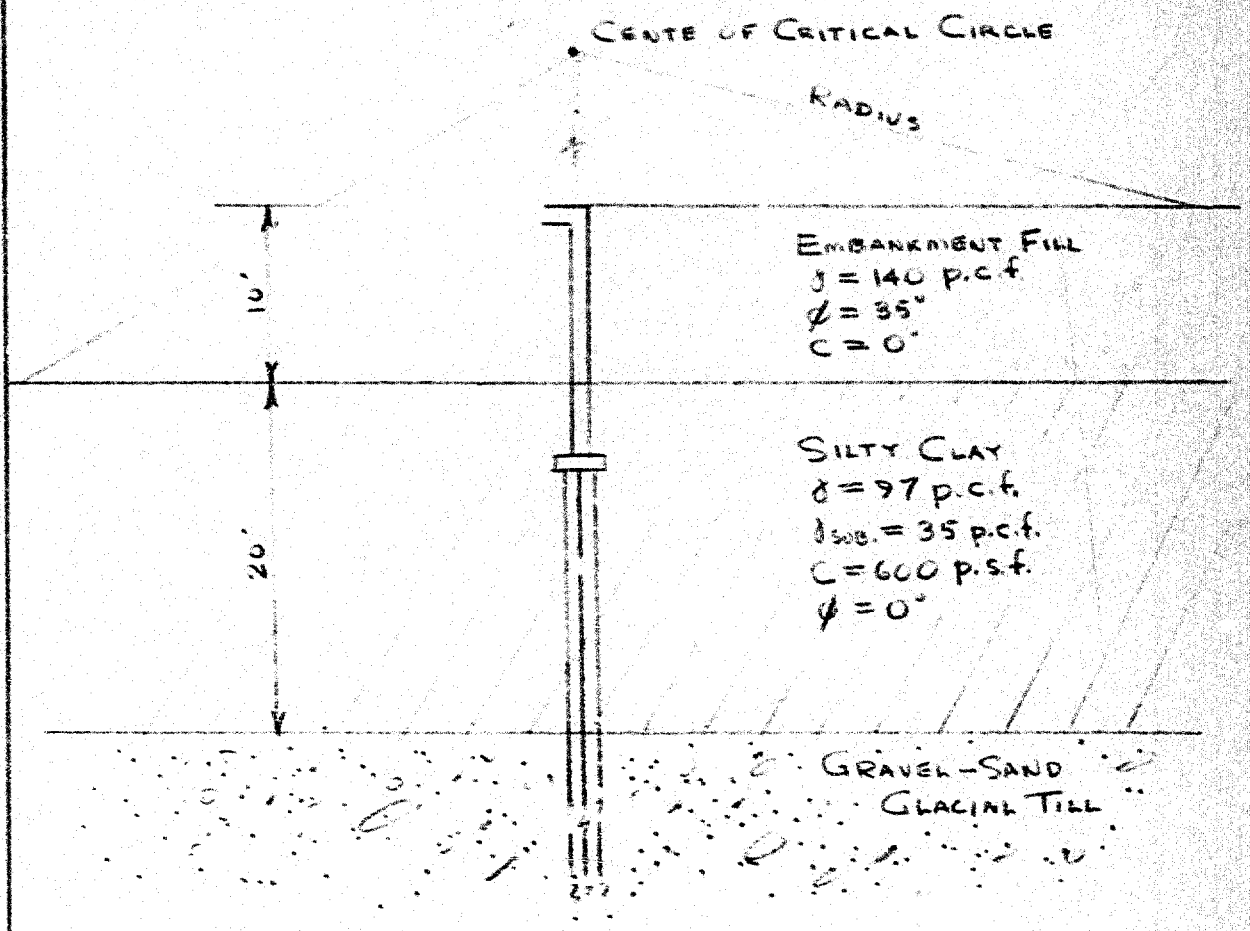
	RADIUS	DISTANCE FROM E SLOPE	SAFETY FACTOR
	30'	"	2.35
*	35'	"	2.11
	44'	"	2.20
	55'	"	2.22
	35'	5' INWARDS	2.25

* APPROXIMATE CRITICAL CIRCLE

Order No. S-500/T-2037 Enclosure No. 13

Prep. By L.P.W.

CASE 2.— STABILITY AT ABUTMENT



TRIAL SOLUTIONS

RADIUS	DISTANCE FROM ℄ ABUTMENT	SAFETY FACTOR
30'	0	2·27
40'	0	2·24
* 50'	0	2·18

* APPROXIMATE CRITICAL CIRCLE