

23-65-86

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CONSULTING CIVIL ENGINEERS

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DE LEUW, CATHER & COMPANY OF CANADA LIMITED

REPORT ON SOIL INVESTIGATION FOR TREMBLAY ROAD RECONSTRUCTION

OTTAWA QUEENSWAY

INTRODUCTION

At the request of De Leuw, Cather & Company of Canada Limited, Consulting Engineers, we have carried out a soil investigation at the above site. The purpose of this investigation was to determine the limits of the peat deposit along Tremblay Road in the south-east portion of the Alta Vista Interchange and to comment on the treatment of this deposit to ensure a stable and satisfactory new pavement surface. The presence of the peat deposit in this area was indicated by borehole 6, the results of which are presented in our report 64104, dated September, 1964.

This report forms a supplement to and should be read in conjunction with our previous report 64104, dated September, 1964.

PROCEDURE

The field work for this investigation was carried out during the period December 7 to 9, 1964. A total of 11 boreholes (numbered 7 to 17, inclusive) were put down using a mobile power auger supplied and operated by the F.E. Johnston Drilling Company Limited of Ottawa. The borings were taken down to depths ranging from 9 to 19 feet below the ground surface and sealed standpipes were installed in three of the borings, following their completion, to determine the groundwater level. Details of the standpipe installations are given on the Records of Boreholes. Ten of the boreholes were taken to practical refusal which, based on our previous work in the area, was assumed to be in shale bedrock.

A detailed log for each boring is given on the Records of Boreholes following the text of this report. The locations of the borings are shown on Figure 1 and sections of the inferred soil stratigraphy across the site are shown on Figure 2.

The soil samples obtained during the investigation were brought to our laboratory for detailed visual examination. No laboratory testing was carried out on the samples.

The ground surface elevation at the borehole locations was supplied by De Leuw, Cather & Company of Canada Limited. It is understood that the elevations are referred to Geodetic datum.

SUBSOIL CONDITIONS

The factual details of the soil conditions encountered in this investigation are given on the Records of Boreholes and on Figure 2. Following is a summary account of the inferred subsoil conditions.

The borings put down through the shoulders of the existing Tremblay Road encountered up to about 8 feet of generally compact crushed stone road base material comprised of grey sand and gravel with some silt and a trace of clay sizes. In the remaining borings some 3 to 5 feet of fill, consisting of loose silty sand to sandy silt with a trace of clay, gravel, occasional pieces of wood and other debris, forms the surface deposit.

The fill at all the boring locations, except borehole 10, is underlain by a stratum of soft dark brown peat with shells and pieces of wood. The peat is up to about 4 feet in thickness. At several of the boreholes put down through the existing Tremblay Road gravel and cobbles were encountered within the upper portion of the peat. This material was probably punched into the soft peat during roadway filling operations.

The peat is generally underlain by a stratum of compact to dense glacial till consisting of silty sand and gravel

with a trace of clay. The till, where it was completely penetrated by the borings, ranges from about 2 to 8 feet in thickness and rests on weathered shale bedrock. Practical refusal to the auger drillrig was met within about 3 feet in the shale.

In boreholes 12, 13, and 15 a layer of generally compact sand and silt, some 5 to 9 feet thick, underlies the peat and overlies the till stratum.

Based on readings taken in the sealed standpipes and in open boreholes during the course of the field work, the groundwater level is at or below about elevation 192 and generally above the peat deposit.

DISCUSSION

It is understood that Tremblay Road adjacent to the proposed railway freight terminal is to be reconstructed as shown on Figure 1. The reconstruction to the west of the station entrance will consist of a new three lane roadway located to the south of and outside the limits of the existing roadway. The final roadway grade in this area is to be at about elevation 203 or some 8 to 9 feet above existing ground surface. In the eastern portion of the proposed reconstruction area the existing roadway will be widened to the south and the existing grade raised some 4 to 5 feet to about elevation 204.

The borings put down in this investigation show that the existing Tremblay Road and the proposed construction area are underlain by a deposit of peat. Due to its highly compressible nature the peat is not a suitable foundation material for the placing of a roadway, as evidenced by the cracking of the surfacing on the existing road. To minimize movements of the roadway and ensure a satisfactory pavement surface, either of the following construction procedures may be employed:

- (i) Complete removal of the peat deposit under the full width of the roadway embankment and replacement with suitable fill.
- (ii) Surcharging of the roadway embankment for a sufficient period to take out the major portion of consolidation settlement in the peat deposit.

The choice of method employed is dependent mainly on relative economics and the time element in the staging of construction.

The surcharging technique accelerates the consolidation settlement in the peat that would be realized under the roadway embankment at final grade over a longer period of time, by the application of a larger initial load. Surcharging takes out the major portion of settlement but it does not, however, completely eliminate long term settlement, even though the additional settle-

ment is of a minor magnitude, due to secondary compression characteristics of peat.

As the existing Tremblay Road is to be kept in service, removal of the peat in the eastern portion of the reconstruction area will not be feasible. The peat could be removed in that portion of this area where the road is to be widened, but excavation adjacent to the existing roadway could cause instability of the roadway, particularly if traffic is maintained. It is therefore suggested that the roadway embankment in the central and eastern sections of the proposed reconstruction area be surcharged.

It is recommended that 5 feet of earth surcharge be placed above the final grade level of the roadway embankment for a period of about 6 months prior to placing of the pavement. The surcharge need not be compacted. The settlement of the embankment fill and surcharge should be monitored by settlement plates and piezometers until the majority of the consolidation settlement in the underlying peat has taken place.

As mentioned in our previous report, surcharging will require the placing of up to some 12 feet of new fill above ground surface outside the area of the present roadway embankment. To prevent a possible shear failure of the soft peat under this height of fill, it is recommended that the area outside the present roadway embankment be initially filled to the same elevation as the existing

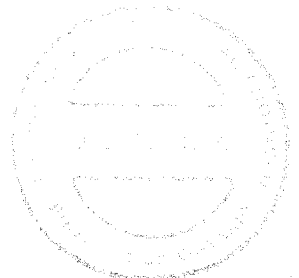
roadway. The fill should be allowed to remain at this height for several months in order to consolidate the soft peat sufficiently to increase its shearing strength so that it will be capable of supporting the surcharge height of fill without overall instability of the embankment.

In the western portion of the reconstruction area, where the proposed roadway embankment is to be placed completely outside the limits of the existing roadway, the peat may be removed and replaced with a more suitable fill, properly compacted in layers during placing. To prevent failure of the existing roadway due to vehicular traffic during sub-excavation of the peat nearby, the traffic should not be allowed in the lane nearest the excavation and a slow order issued. As excavations to remove the peat would be made below the measured groundwater level, control of groundwater will be necessary to place the roadway fill in the dry. This may be achieved by sump pumping.



JLS:HJB
64152

J. L. Seychuk, P.Eng.



GOLDER & ASSOCIATES

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

<i>AS</i>	auger sample
<i>CS</i>	chunk sample
<i>DO</i>	drive open
<i>DS</i>	Denison type sample
<i>FS</i>	foil sample
<i>RC</i>	rock core
<i>ST</i>	slotted tube
<i>TO</i>	thin-walled, open
<i>TP</i>	thin-walled, piston
<i>WS</i>	wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

<i>WH</i>	sampler advanced by static weight—weight, hammer
<i>PH</i>	sampler advanced by pressure—pressure, hydraulic
<i>PM</i>	sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) Cohesionless Soils

<i>Relative Density</i>	<i>N, blows/ft.</i>
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

<i>Consistency</i>	<i>c_u, lb./sq. ft.</i>
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

IV. SOIL TESTS

<i>C</i>	consolidation test
<i>H</i>	hydrometer analysis
<i>M</i>	sieve analysis
<i>MH</i>	combined analysis, sieve and hydrometer ¹
<i>Q</i>	undrained triaxial ²
<i>R</i>	consolidated undrained triaxial ²
<i>S</i>	drained triaxial
<i>U</i>	unconfined compression
<i>V</i>	field vane test

NOTES:

¹Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

²Undrained triaxial tests in which pore pressures are measured are shown as \bar{Q} or \bar{R} .

LIST OF SYMBOLS

I. GENERAL

π	= 3.1416
e	= base of natural logarithms 2.7183
$\log_e a$ or $\ln a$	natural logarithm of a
$\log_{10} a$ or $\log a$	logarithm of a to base 10
t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) Unit weight

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s / \gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) Consistency

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_s	shrinkage limit
I_L	liquidity index = $(w - w_P) / I_P$
I_C	consistency index = $(w_L - w) / I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density = $(e_{max} - e) / (e_{max} - e_{min})$

(c) Permeability

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

(d) Consolidation (one-dimensional)

m_v	coefficient of volume change = $-\Delta e / (1 + e) \Delta \sigma'$
C_c	compression index = $-\Delta e / \Delta \log_{10} \sigma'$
c_s	coefficient of consolidation
T_v	time factor = c_s / d^2 (d , drainage path)
U	degree of consolidation

(e) Shear strength

τ_f	shear strength
c'	effective cohesion
ϕ'	effective angle of shearing resistance, or friction
c_u	apparent cohesion*
ϕ_u	apparent angle of shearing resistance, or friction
μ	coefficient of friction
S_t	sensitivity

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

RECORD OF BOREHOLE 7

LOCATION See Figure 1 BORING DATE DEC. 7, 1964 DATUM GEDDETTIC
 BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5 INCHES
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FT. -----					COEFFICIENT OF PERMEABILITY k , CM. / SEC.					ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVATION DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FT.		SHEAR STRENGTH C_u , LB./SQ.FT.					WATER CONTENT, PERCENT w_p w w_L						

15-0-5 Percent axial strain at failure


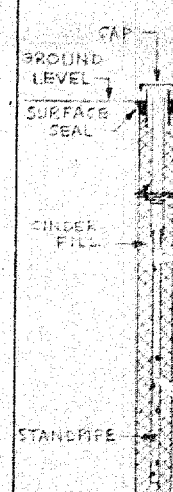
VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN See Figure 1
CHECKED See Figure 1

RECORD OF BOREHOLES 8 & 9

LOCATION See Figure 1 BORING DATE DEC. 7-8, 1964 DATUM GEODETIC
 BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5 INCHES
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----			COEFFICIENT OF PERMEABILITY k , CM./SEC.			ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
ELEV./ DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.		SHEAR STRENGTH C_u , LB./SQ. FT.			WATER CONTENT, PERCENT W_p W W_L					
104.0	GROUND LEVEL					105			8/					W.L. IN OPEN HOLE AT ELEV. 192.0 DECEMBER 9, 1964 	
0.0	LOOSE TO COMPACT SILTY SAND WITH SOME GRAVEL SMALL RUBBLE (FILL)		1	2'	5										
101.0			2	"	18										
2.0	SOFT DARK BROWN PEAT		3	"	21										
122.0			4	"	18										
5.0	COMPACT TO DENSE SILTY SAND AND GRAVEL SOME CLAY (TILL)					100									
124.0						98									
10.0	GREY WEATHERED SHALE														
180.0															
13.0	END OF HOLE REFUSAL TO ADVANCE					120									
104.0	GROUND LEVEL					125			9/						
0.0	LOOSE TO COMPACT BROWN SAND INCLUDING RUBBLE AND CINDER (FILL)		1	2'	4										
191.0			2	"	9										
3.0	SOFT DARK BROWN PEAT WITH SMALL PIECES OF WOOD AND RUBBLE		3	"	9										
195.7			4	"	17										
5.0	COMPACT TO DENSE SILTY SAND AND GRAVEL SOME CLAY (TILL)		5	"	12										
121.5						100									
12.5	GREY WEATHERED SHALE					180									
150.0															
14.0	END OF HOLE REFUSAL TO ADVANCE					175									
										Percent axial strain at failure					

15-0-5 Percent axial strain at failure

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN *Max*
CHECKED *A*

RECORD OF BOREHOLES 10 & 11

LOCATION See Figure 1 BORING DATE DEC 8, 1964 DATUM GEODETIC
 BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5 INCHES
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT -- LB. DROP -- INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----		COEFFICIENT OF PERMEABILITY k, CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEV./ DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH C_u , LB./SQ. FT.	WATER CONTENT, PERCENT W _p W W _L					
105.1 0.0	GROUND LEVEL					10/							
180.1 5.0	LOOSE TO COMPACT DARK GREY TO BR. W/ SILTY SAND AND SOME GRAVEL GRAVEL VISIBLE IN (FILL)		1	11	195								
			2	32	120								
			3	36	120								
	COMPACT TO DENSE GREY SILTY SAND AND GRAVEL WITH SOME CLAY (TILL)		4	30	185								
182.8 183.8 181.1	GREY WEATHERED SHALE												
14.0	END OF HOLE REFUSAL TO AUGER				180								
174.1 0.0	GROUND LEVEL				195	11/							
190.0 3.2	LOOSE BROWN FINE SAND R. SILTY SAND (FILL)		1	7	195								
182.1 5.0	SOFT BROWN PEAT		2	4	190								
			3	22	190								
			4	11	185								
	COMPACT TO DENSE GREY SILTY SAND AND GRAVEL TRACES OF SOME CLAY (TILL)				185								
181.1 180.1	GREY WEATHERED SHALE				180								
14.0	END OF HOLE REFUSAL TO AUGERING				175								
						15-8-10 Percent axial strain at failure							

15-10-5 Percent axial strain at failure

VERTICAL SCALE
 1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN
 CHECKED

RECORD OF BOREHOLE 12

LOCATION See Figure 1 BORING DATE DEC. 8, 1964 DATUM GEODETIC
 BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5 INCHES
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE		SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FT. -----				COEFFICIENT OF PERMEABILITY K, CM. / SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FT.	SHEAR STRENGTH c_u , LB. / SQ. FT.				WATER CONTENT, PERCENT					
											w_p w w_L					
98.1	GROUND LEVEL								12/							
96.0	LOOSE BROWN FINE SAND WITH TRACE OF SILT AND GRAVEL (FILL)		1	DO	4											
95.1			2	"	4	195										
93.0	SOFT DARK BROWN PEAT		3	"	6											
92.1			4	"	18											
90.0	COMPACT GREY SAND WITH TRACE OF SILT					190										
88.5			5	"	22											
86.8	COMPACT GREY SILT WITH TRACE OF SAND AND CLAY															
85.1						185										
83.0	DENSE GREY SILTY SAND WITH GRAVEL TRACE OF CLAY (TILL)															
83.8																
84.5	GREY WEATHERED SHALE															
80.3																
17.2	END OF HOLE REFUSAL TO ADVANCE					180										
						175										

15 5 10 Percent axial strain at failure

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN *ML*
CHECKED *AL*

RECORD OF BOREHOLE 13

LOCATION See Figure 1 BORING DATE DEC. 8, 1964 DATUM GEODETIC
 BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5 INCHES
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----		COEFFICIENT OF PERMEABILITY k, CM./SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEV./ DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER TYPE		BLOWS/FT.	SHEAR STRENGTH C _u , LB./SQ.FT.		WATER CONTENT, PERCENT W _p W W _L		
202.2	GROUND LEVEL									
197.7	COMPACT BEGGING LOOSE GREY SAND AND GRAVEL, TRACE SILT (CRUSHED STONE ROAD BASE)		1	2	12					
195.2	FIRM TO SOFT BROWN CLAYEY SILT, TRACE SAND (FILL)		2	3	6					
193.2	SOFT DARK BROWN PEAT (WELL DECOMPOSED)		3	5	5					
190.7	LOOSE LIGHT BROWN SILTY SAND BECOMING COMPACT LIGHT BROWN SILT, TRACE SAND AND CLAY		4	17						
188.4	FIRM GREY SILTY CLAY		5	15						
184.2	COMPACT GREY SILT WITH TRACE CLAY AND SAND TO SANDY SILT		6	20						
182.2	COMPACT TO DENSE GREY SILTY SAND AND GRAVEL, TRACE CLAY (TILL)									
180.0	GREY WEATHERED SHALE									
178.0	END OF HOLE REFUSAL TO ALTERNING									
					15 0 5 Percent axial strain at failure 10					

HOLE CAVED AT
ELEV. 192.2
W.L. IN OPEN HOLE
AT ELEV. 192.4
DECEMBER 9, 1964

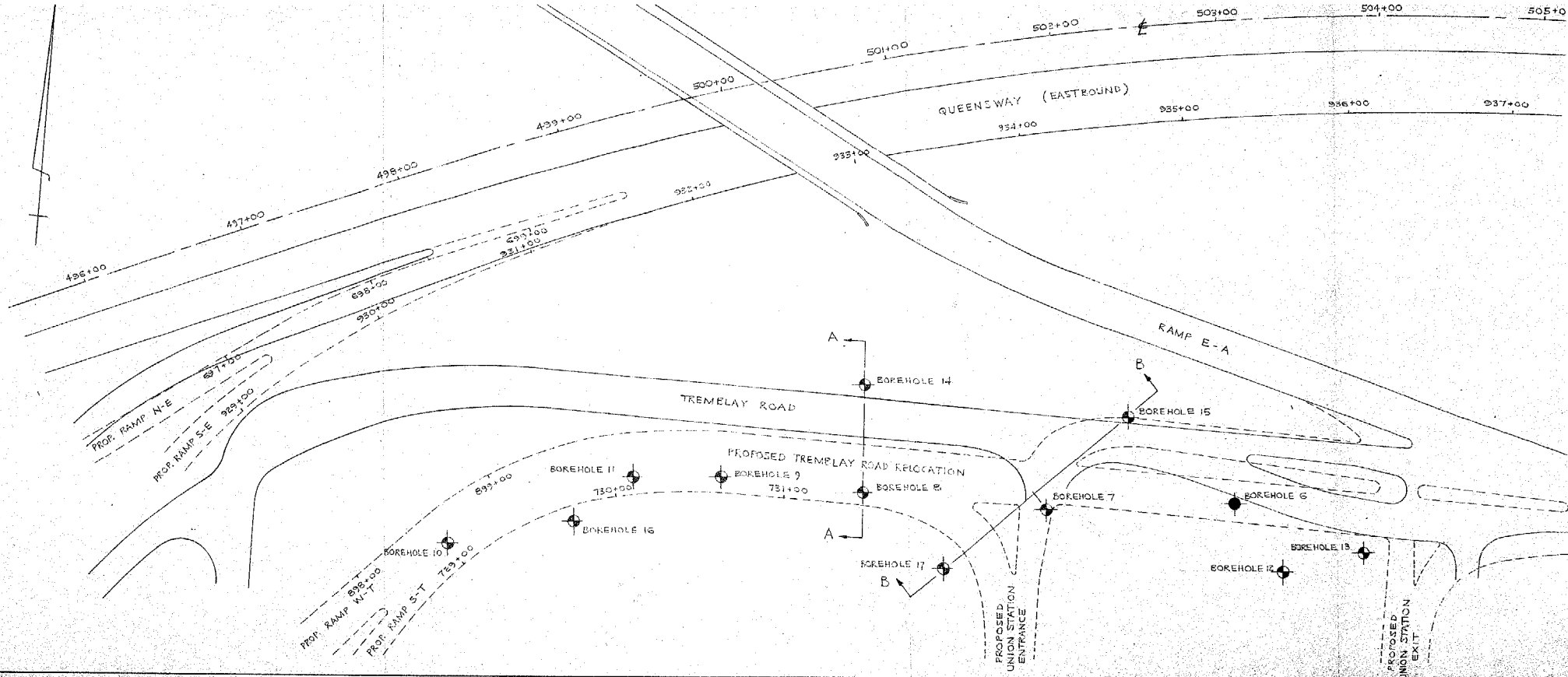
HOLE CAVED AT
ELEV. 192.2
W.L. IN OPEN HOLE
AT ELEV. 192.4
DECEMBER 9, 1964

15 0 5 Percent axial strain at failure
10



VERTICAL SCALE
1 INCH TO 5' - 0"

GOLDER & ASSOCIATES

DRAWN *[Signature]*
CHECKED *[Signature]*



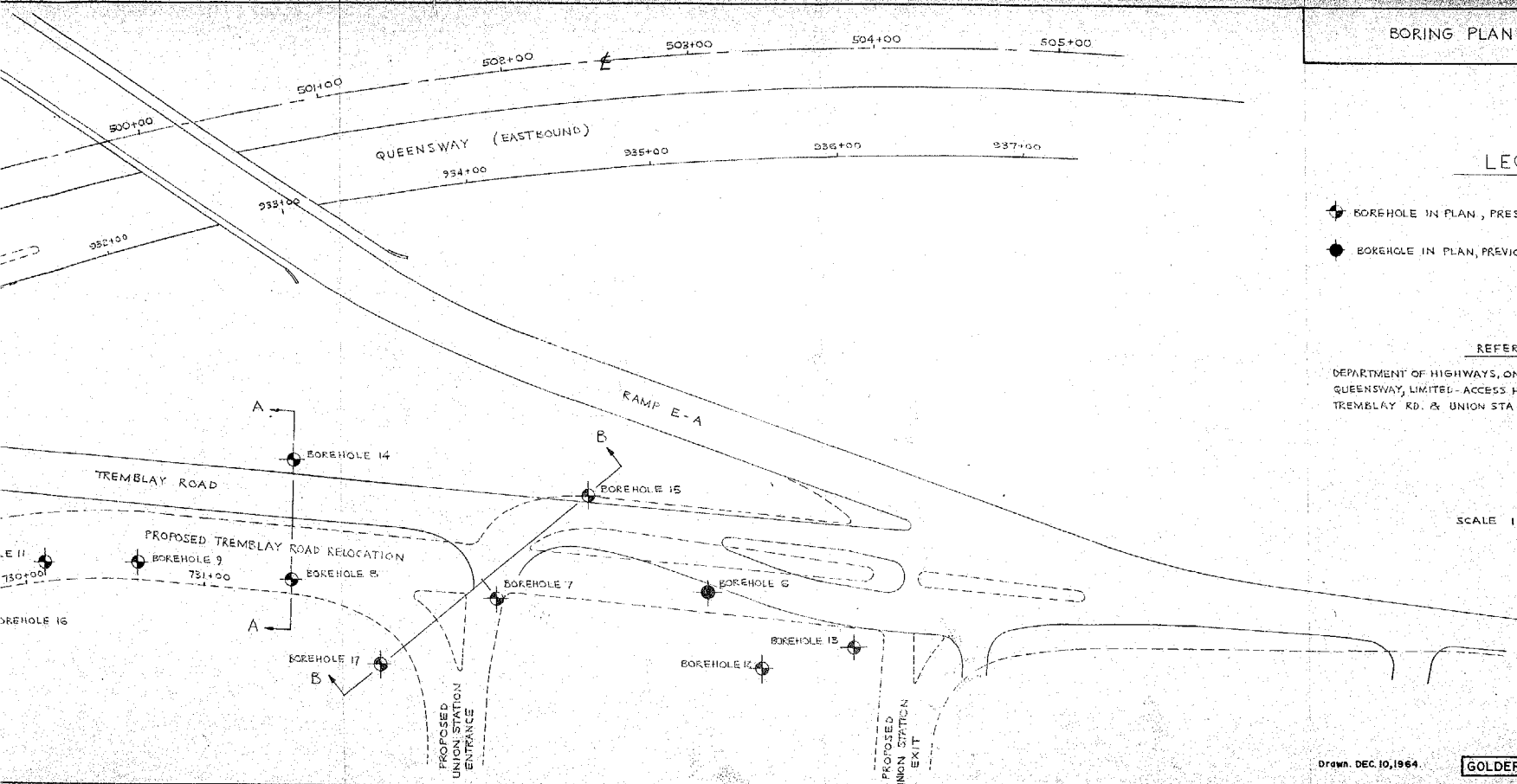
LEGEND

-  BOREHOLE IN PLAN, PRESENT INVESTIGATION.
 BOREHOLE IN PLAN, PREVIOUS INVESTIGATION (OUR REPORT 64104)

REFERENCE

DEPARTMENT OF HIGHWAYS, ONTARIO DRAWING C42 Y-2, OTTAWA:
 QUEENSWAY, LIMITED-ACCESS HIGHWAY, PRELIMINARY CHANNELIZATION,
 TREMBLAY RD. & UNION STA., PLAN AND ELEVATIONS; DATED; SEPT./64.

SCALE 1" TO 40'-0"



Drawn DEC. 10, 1964.

GOLDER & ASSOCIATES

Made *ML*
 Chkd. *SA*
 Appd. *ML*

LEGEND

12

BOREHOLE IN ELEVATION, PRESENT INVESTIGATION

12

WATER LEVEL, DECEMBER 9, 1964.

6

BOREHOLE IN ELEVATION, PREVIOUS INVESTIGATION (OUR REPORT 64104)

6

WATER LEVEL, AUG. 27, 1964.

STRATIGRAPHY

COMPACT GREY SAND AND GRAVEL WITH SOME SILT, TRACE CLAY
(CRUSHED STONE ROAD BASE)LOOSE BROWN TO GREY SILTY SAND TO SANDY SILT, TRACE OF
CLAY, TRACE TO SOME GRAVEL, OCCASIONAL PIECES OF WOOD (FILL)

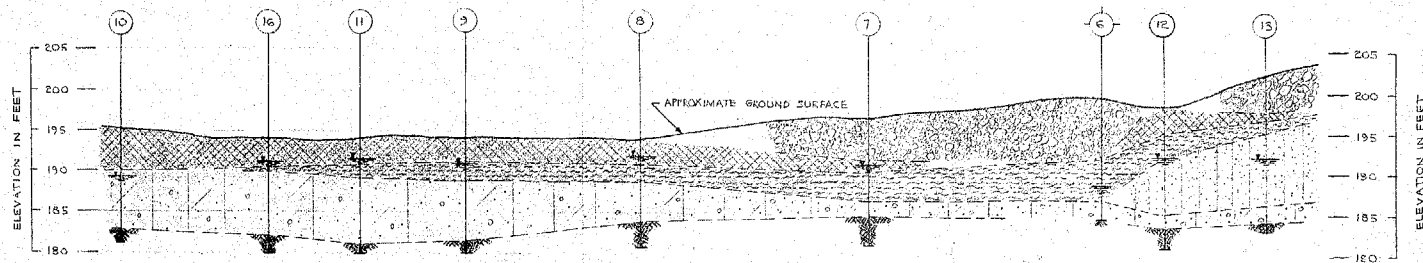
SOFT DARK BROWN PEAT WITH PIECES OF WOOD AND SHELLS

LOOSE TO COMPACT BROWN TO GREY SAND WITH SILT TO SILT, TRACE
OF SAND AND CLAYCOMPACT TO DENSE GREY SILTY SAND AND GRAVEL, TRACE CLAY
(GLACIAL TILL)

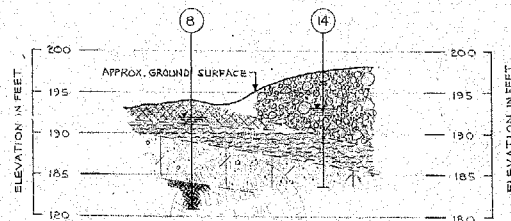
GREY WEATHERED SHALE

HORIZONTAL SCALE 1" TO 40' - 0"

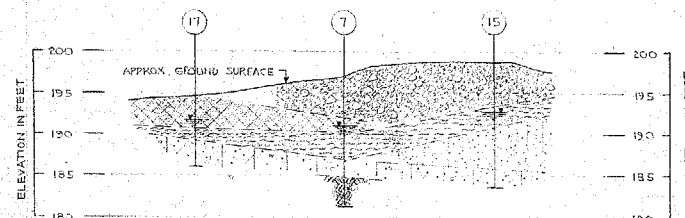
VERTICAL SCALE 1" TO 10' - 0"



SCHEMATIC SECTION ALONG CENTRELINE OF PROPOSED TREMBLAY ROAD



SECTION A-A



SECTION B-B

SPECIAL NOTE: DATA CONCERNING THE VARIOUS
STRATA HAVE BEEN OBTAINED AT BOREHOLE LOCATIONS
SHOWN. THE SOIL STRATIGRAPHY BETWEEN
BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL
EVIDENCE AND SO MAY VARY FROM THAT SHOWN.

Drawn: DEC. 15, 1964

GOLDER & ASSOCIATES

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CONSULTING CIVIL ENGINEERS

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REPORT

TO

DE LEUW, CATHER & COMPANY OF CANADA LIMITED

ON

SITE INVESTIGATION

PROPOSED BRIDGE NO. 44 AT TREMBLAY ROAD

OTTAWA QUEENSWAY

OTTAWA

ONTARIO

Distribution:

- 10 copies - De Leuw, Cather & Company of Canada Limited,
Ottawa, Ontario
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June, 1964

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Figure 2 - Grain Size Distribution Curve for Fill	
Figure 3 - Grain Size Distribution Curve for Till	

ABSTRACT

The results of a site investigation for Queensway Bridge No. 44 at Tremblay Road in Ottawa are reported.

It was found that the site was covered by fill from 3 feet in thickness to 8 feet where the proposed location encroached on an existing embankment. Beneath the fill is a dense till containing sand, silt and clay with some gravel. The till in the area of the proposed structure is 3 to 4.3 feet thick and is underlain by shale bedrock. Approximately the upper foot of the shale is weathered and broken, below that it is sound.

In the borehole to check on the soil under the proposed approach embankments a thin layer of silt and peat was encountered. This may be fill or the original surface deposit. The material encountered is not considered to be critical for embankment stability.

It is recommended that the bridge structure be founded directly on the unweathered shale or on steel piles driven to refusal in the shale.

Groundwater levels were measured in the boreholes and indicate some dewatering will be necessary in order to place footings directly on the shale.

INTRODUCTION

H. Q. Golder & Associates Ltd. were retained by De Leuw, Cather and Company of Canada Ltd., Consulting Engineers, to carry out a soil investigation at the site of the proposed Bridge No. 44 at Tremblay Road on the Queensway in Ottawa, Ontario. The purpose of this investigation was to determine the subsoil conditions at the site and to provide information relating to the foundation design.

PROCEDURE

The field work for this investigation was carried out during the period May 5 to May 8, 1964, using a mobile power auger and diamond drilling equipment. A total of five boreholes was put down at the site, four under the proposed abutments and piers and one about 125 feet south of the structure. Bedrock was proven in the four holes under the structure by diamond drilling approximately 10 feet into the rock. The fifth borehole was put down to check the soil under the embankment and to ensure that rock was at approximately the same elevation as in the other boreholes. Standpipes or piezometers were installed in the first four boreholes to allow the taking of water level readings.

A detailed log for each borehole is given on the Records of Boreholes following the text of this report. The

location of the borings and a section of the inferred soil stratigraphy across the site are given on Figure 1.

The samples obtained during the investigation were brought to our laboratory for examination and testing. Natural water contents, Atterberg limits and grain size analyses were carried out on six selected samples. The results of the water content and Atterberg limit tests are given on the Records of Boreholes and the results of the grain size analyses are given on Figures 2 and 3.

The elevations for the ground surface at the boreholes were supplied by De Leuw, Cather and Company of Canada Limited and are referred to Geodetic datum.

SITE AND SOIL CONDITIONS

The bridge site is on the proposed ramp from Alta Vista to the Queensway in the southeast quadrant of the proposed reconstruction of the Alta Vista interchange. The area is generally flat with evidence of groundwater near the surface. The bridge site is near the edge of an existing ramp leading to the Queensway and boreholes 2 and 4 are on the side slopes of the embankment for the ramp.

The boreholes showed that the site is generally underlain by fill varying from 3 to 8 feet in depth, below the fill is a brown sandy silty clay till varying in thickness from 3 to 4.3 feet under the structure and 9 feet thick at borehole 5, 125 feet south of the structure. Grey shale bedrock is present beneath the till.

The fill is variable but is largely silty or sandy till like soil with inclusions of sand and organic debris and in places crushed stone near the surface. It exists in a loose to dense state. A thin layer of silt and peat in borehole 5 may be fill or the original ground surface.

The till is a mixture of sand silt and clay with some gravel and is in a dense condition. The elevation of its top surface varies little in the boreholes put down and in the boreholes under the structure its thickness is quite uniform varying from 3.0 to 4.3 feet.

The bedrock is a grey shale with nearly horizontal bedding planes. Approximately the upper foot is weathered and broken up, below that the shale is sound with a few well healed joints. Boreholes 1 to 4 under the proposed structure indicate the surface of the shale to be nearly horizontal at approximately elevation 187 in the area of the structure. The shale surface is about 6 feet lower at borehole 5.

GROUNDWATER CONDITIONS

Standpipes were installed in boreholes 1, 2 and 3 and a piezometer in borehole 4 to measure the water levels. Measurements taken within a few days of the installation indicate the groundwater level to be between 1.8 and 8.8 feet below the surface or from 2 to 7.5 feet above the top of the shale. It is therefore probable that water will be encountered in any excavation for foundations.

DISCUSSION

Because of the proximity of the shale bedrock at the location of the bridge it is recommended that the pier footings be founded directly on the shale bedrock. If the upper weathered portion of the shale is removed and clean sound shale exposed a bearing load of 10 tons/sq.ft. may be used. It may be more economical to support the abutments on piles to bedrock rather than on footings on the rock. In this case if 10 inch steel H piles are used and driven to practical refusal in the shale a load of 70 tons per pile may be used.

Excavation to sound shale and proper construction of the foundation will require the removal of groundwater during the process. This can probably best be accomplished by surrounding the footing area with a small ditch in the weathered shale leading

to a sump in one corner from which the water can be pumped.

The till and overlying fill is suitable for supporting the approach embankments for the structure, however, a small amount of settlement under the weight of the additional fill is to be anticipated. To minimize differential settlement at the bridge structure, which will be on an unyielding foundation, it is recommended that the fill and any loose top portion of the till be removed for a distance from the structure equal to the height of the fill and that the slope of the excavation on the end opposite to the structure be not steeper than 3 horizontal to 1 vertical. The excavation should then be filled with good quality fill, equivalent to Department of Highways, Ontario Class B granular base course material, compacted in 6 inch layers to 95 percent standard (Proctor) compaction density.


F. A. DeLory, P.Eng.


V. Milligan, P.Eng.

FAD:ab
64047

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

<i>AS</i>	auger sample
<i>CS</i>	chunk sample
<i>DO</i>	drive open
<i>DS</i>	Denison type sample
<i>FS</i>	foil sample
<i>RC</i>	rock core
<i>ST</i>	slotted tube
<i>TO</i>	thin-walled, open
<i>TP</i>	thin-walled, piston
<i>WS</i>	wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

<i>WH</i>	sampler advanced by static weight—weight, hammer
<i>PH</i>	sampler advanced by pressure—pressure, hydraulic
<i>PM</i>	sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) Cohesionless Soils

<i>Relative Density</i>	<i>N, blows/ft.</i>
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

<i>Consistency</i>	<i>c_u, lb./sq. ft.</i>
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

IV. SOIL TESTS

<i>C</i>	consolidation test
<i>H</i>	hydrometer analysis
<i>M</i>	sieve analysis
<i>MH</i>	combined analysis, sieve and hydrometer ¹
<i>Q</i>	undrained triaxial ²
<i>R</i>	consolidated undrained triaxial ²
<i>S</i>	drained triaxial
<i>U</i>	unconfined compression
<i>V</i>	field vane test

NOTES:

¹Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

²Undrained triaxial tests in which pore pressures are measured are shown as \bar{Q} or \bar{R} .

LIST OF SYMBOLS

I. GENERAL

π	$= 3.1416$
e	$=$ base of natural logarithms 2.7183
$\log_e a$ or $\ln a$	natural logarithm of a
$\log_{10} a$ or $\log a$	logarithm of a to base 10
t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) Unit weight

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s / \gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) Consistency

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_S	shrinkage limit
I_L	liquidity index $= (w - w_P) / I_P$
I_C	consistency index $= (w_L - w) / I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e) / (e_{max} - e_{min})$

(c) Permeability

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

(d) Consolidation (one-dimensional)

m_v	coefficient of volume change $= -\Delta e / (1+e) \Delta \sigma'$
C_c	compression index $= -\Delta e / \Delta \log_{10} \sigma'$
c_v	coefficient of consolidation
T_v	time factor $= c_v t / d^2$ (d , drainage path)
U	degree of consolidation

(e) Shear strength

τ_f	shear strength
c'	effective cohesion
ϕ'	effective angle of shearing resistance, or friction
c_u	apparent cohesion*
ϕ_u	apparent angle of shearing resistance, or friction
μ	coefficient of friction
S_t	sensitivity

$\left. \begin{array}{l} \text{in terms of effective stress} \\ \tau_f = c' + \sigma' \tan \phi' \end{array} \right\}$

$\left. \begin{array}{l} \text{in terms of total stress} \\ \tau_f = c_u + \sigma \tan \phi_u \end{array} \right\}$

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

RECORD OF BOREHOLE 1

LOCATION See Figure 1

BORING DATE MAY 5-6, 1964

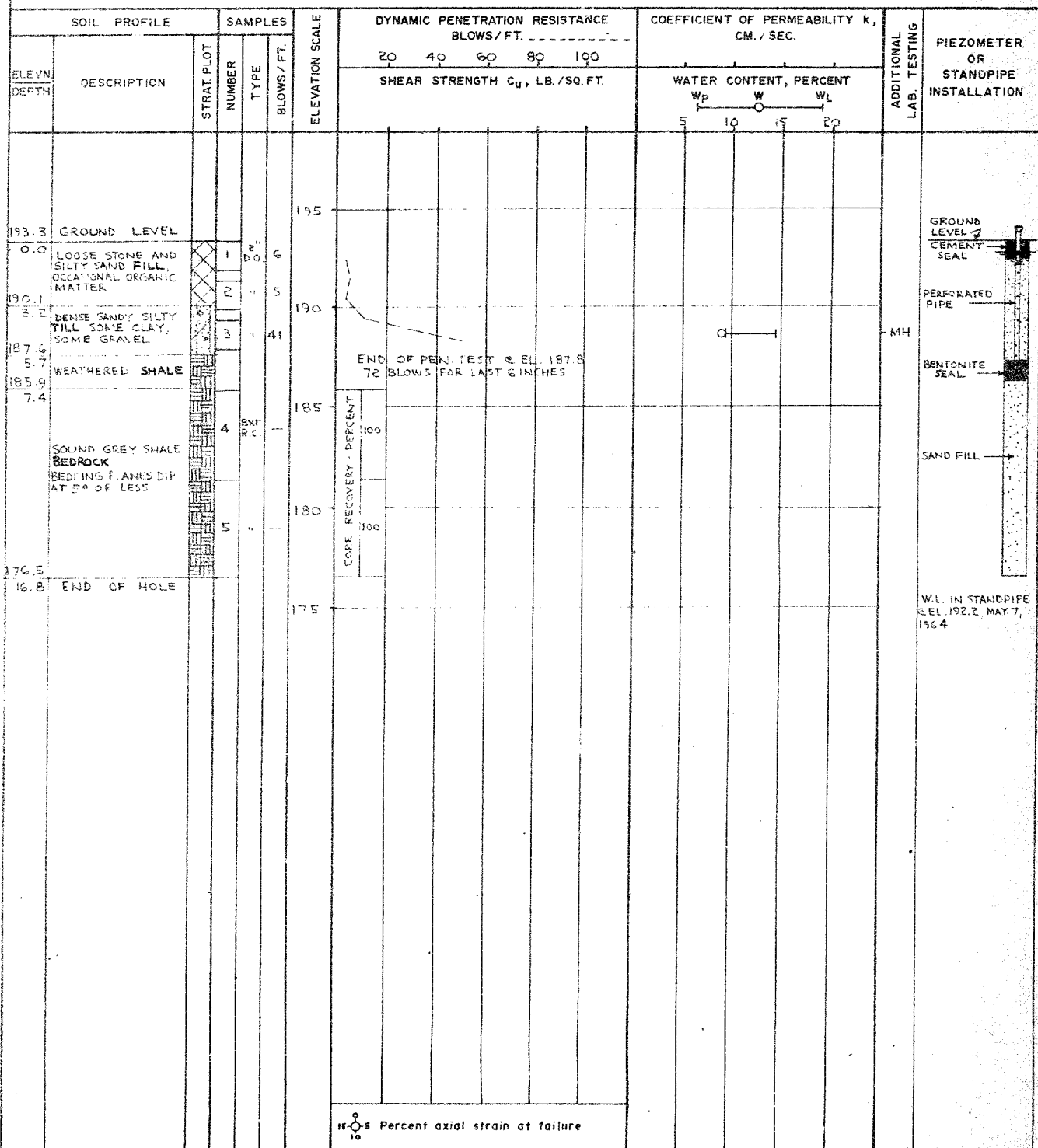
DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING

BOREHOLE DIAMETER 4.5" ± BxT CORE

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

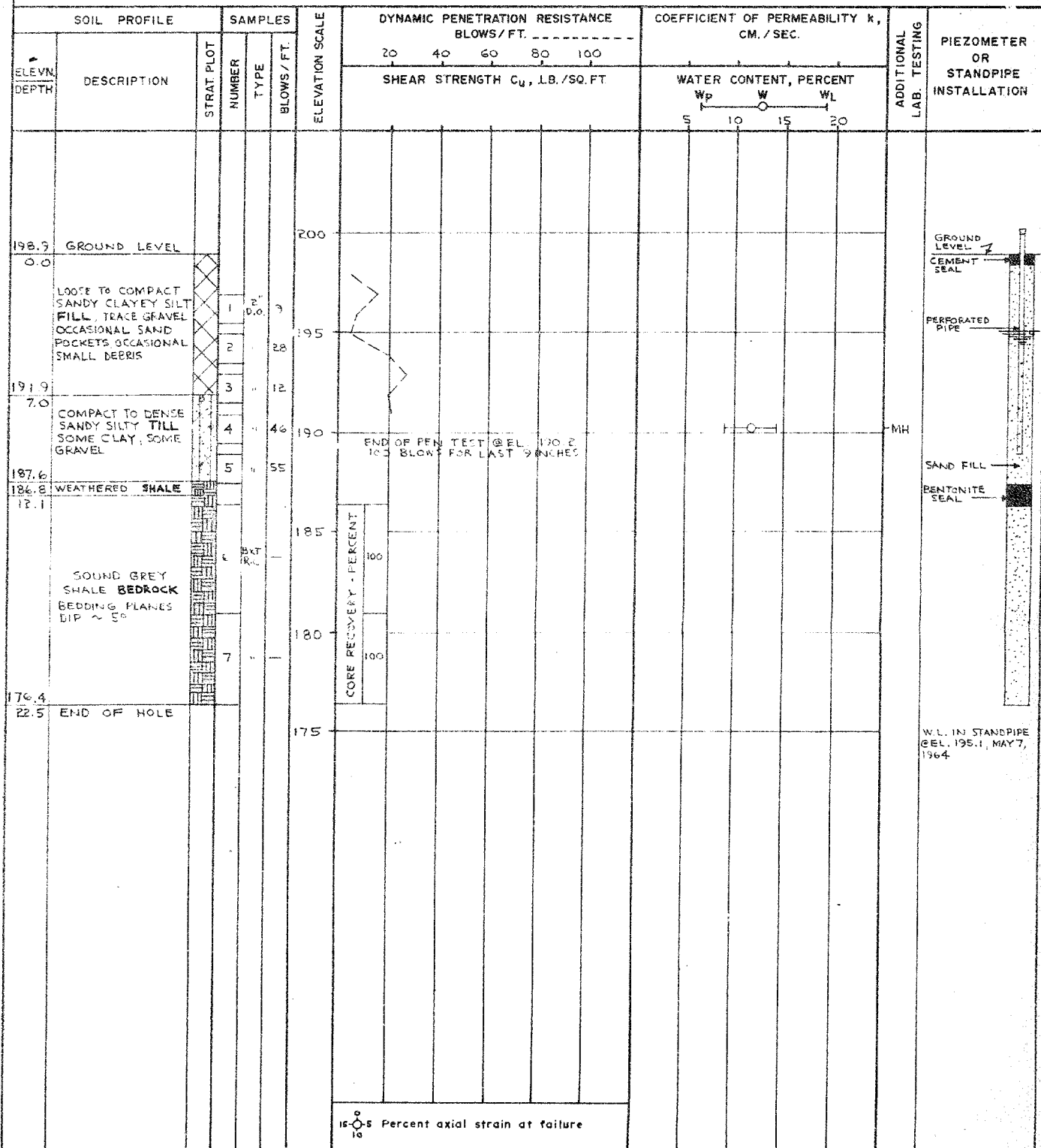


GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED F. D. L.

RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE MAY 5-7, 1964 DATUM GEODETIC
 BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING BOREHOLE DIAMETER 4.5" & BXT CORP
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



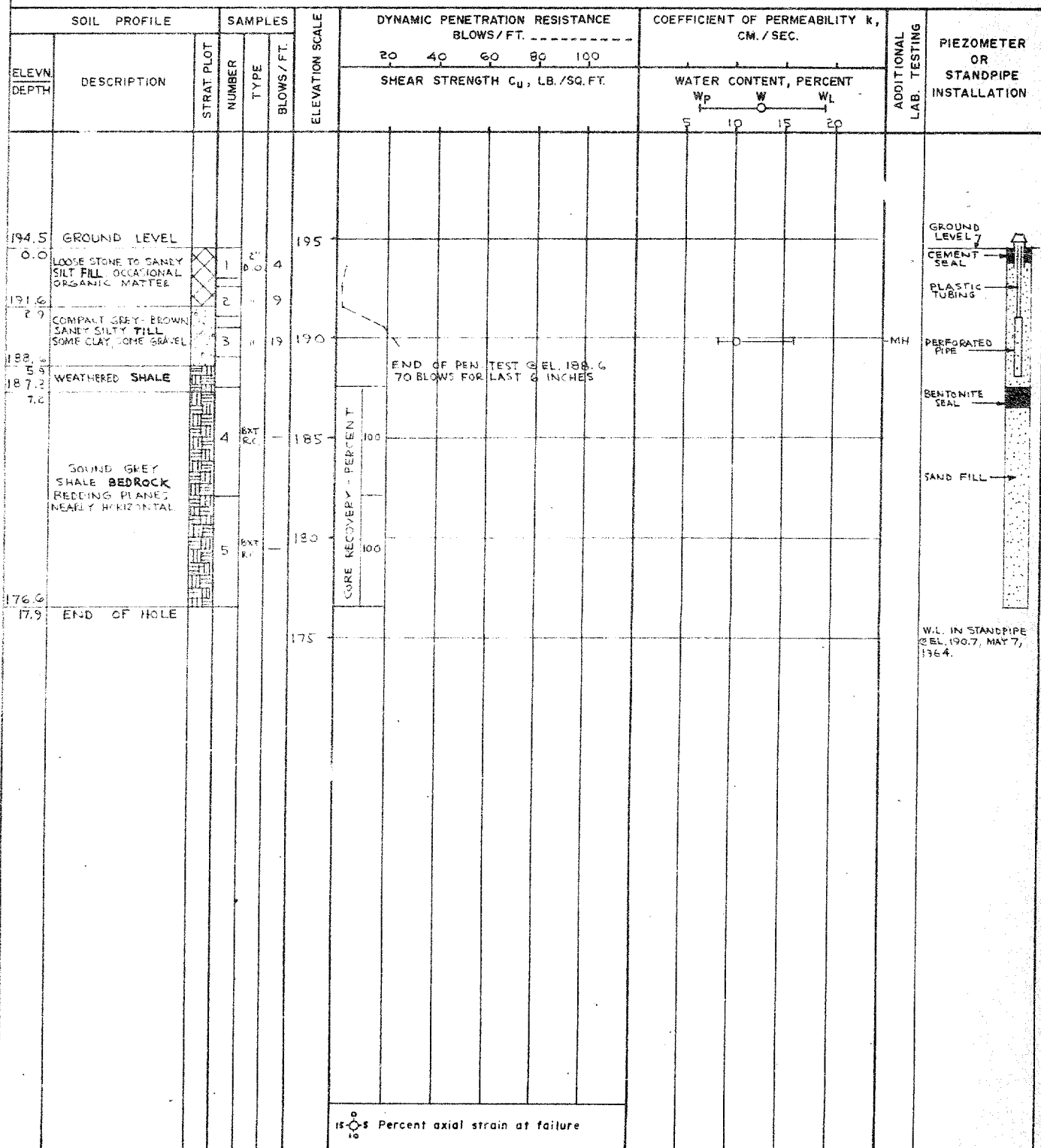
VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED F.D.L.

PROJECT NO. 100-100-100 RECORD OF BOREHOLE 3

LOCATION See Figure 1 BORING DATE MAY 5-7, 1964 DATUM GEODETIC
 BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING BOREHOLE DIAMETER 4.5" $\frac{1}{8}$ BXT CORE
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



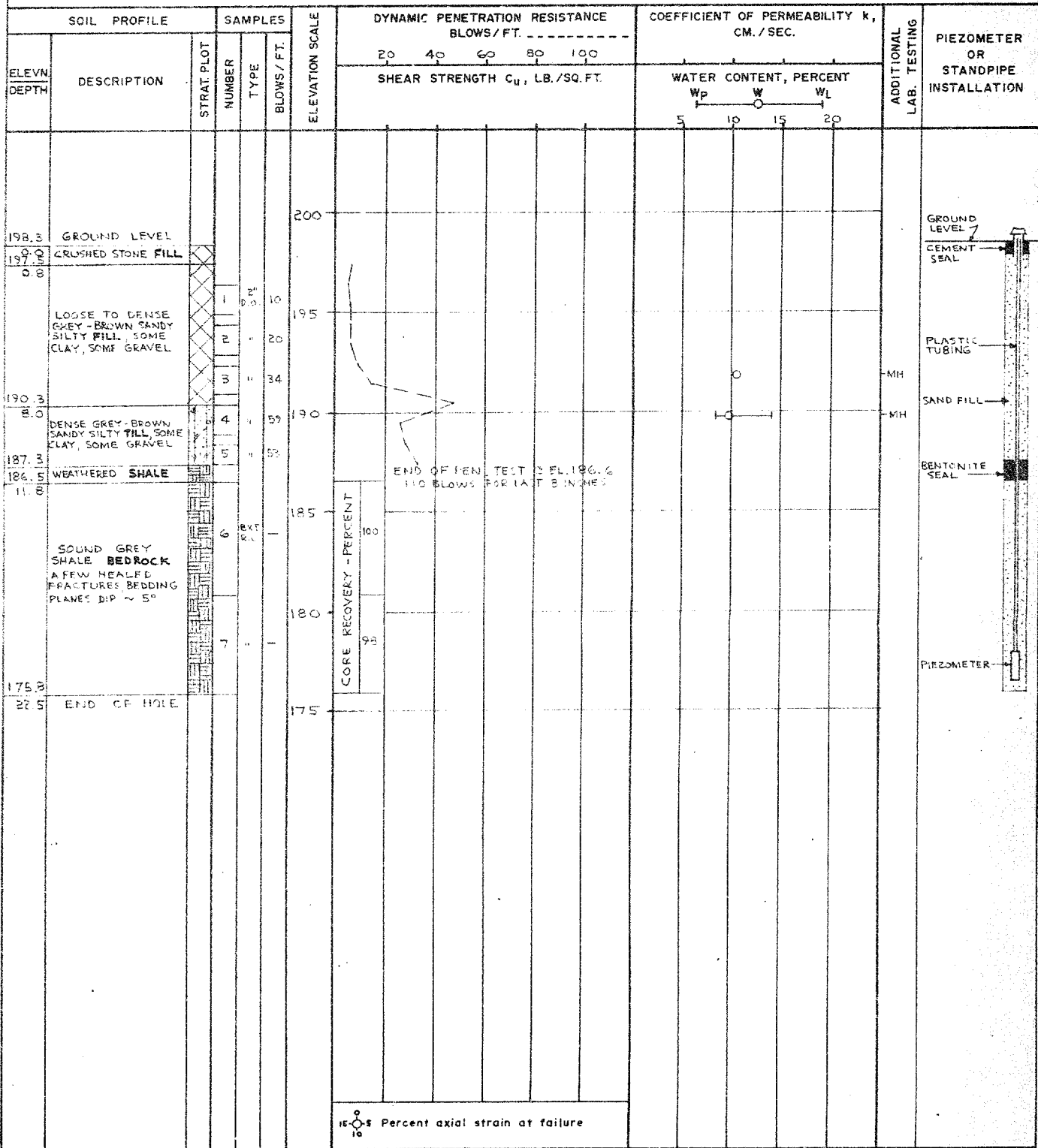
VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED F. DEL.

RECORD OF BOREHOLE 4

LOCATION See Figure 1 BORING DATE MAY 5-6, 1964 DATUM GEODETIC
 BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING BOREHOLE DIAMETER 4.5" $\frac{1}{2}$ BXT CORE
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE
1 INCH TO 5'-0"

COLDER & ASSOCIATES

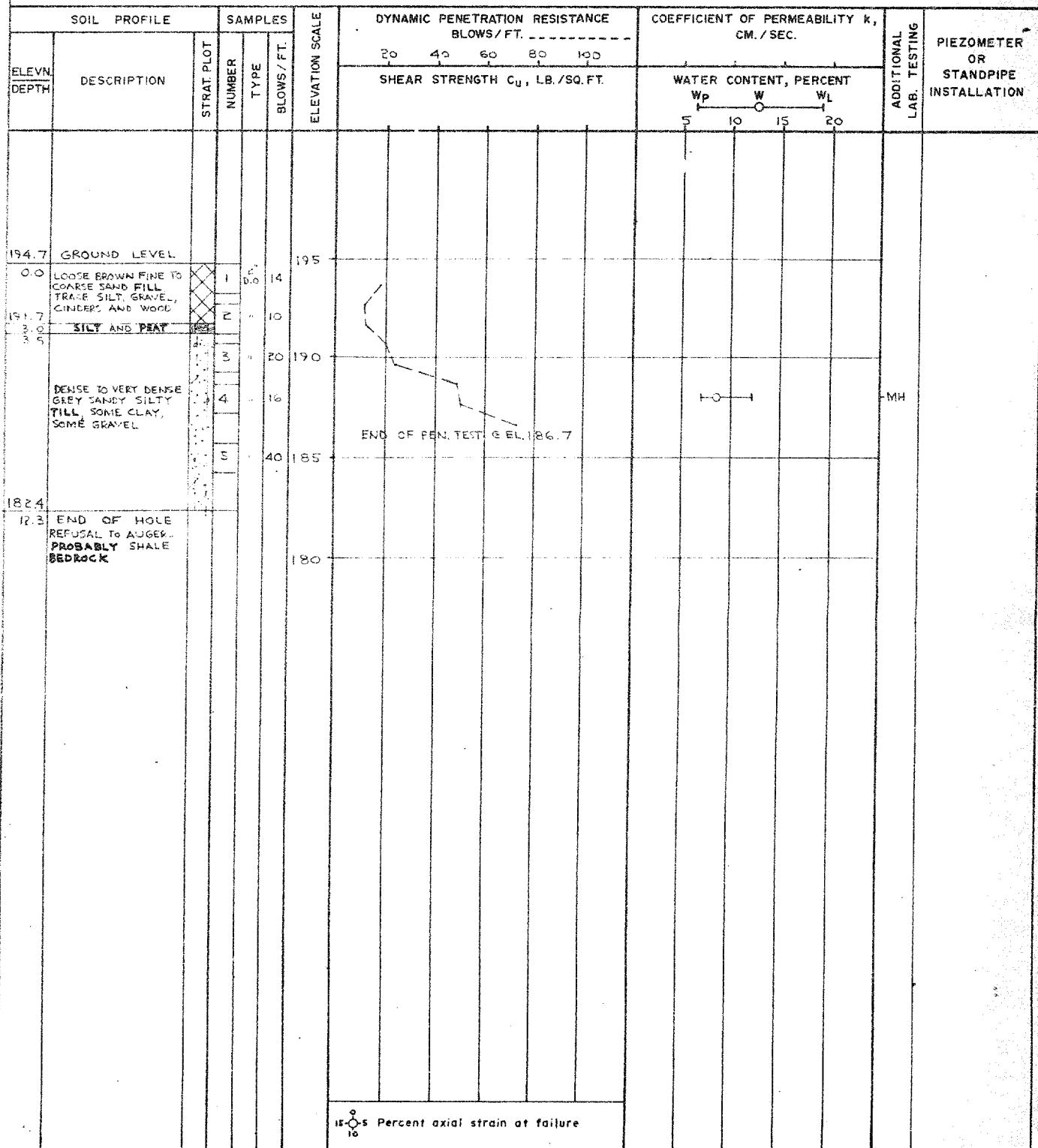
DRAWN J.A.
CHECKED F.D.L.

6

DATUM GEODETIC

BOREHOLE DIAMETER 4.5"

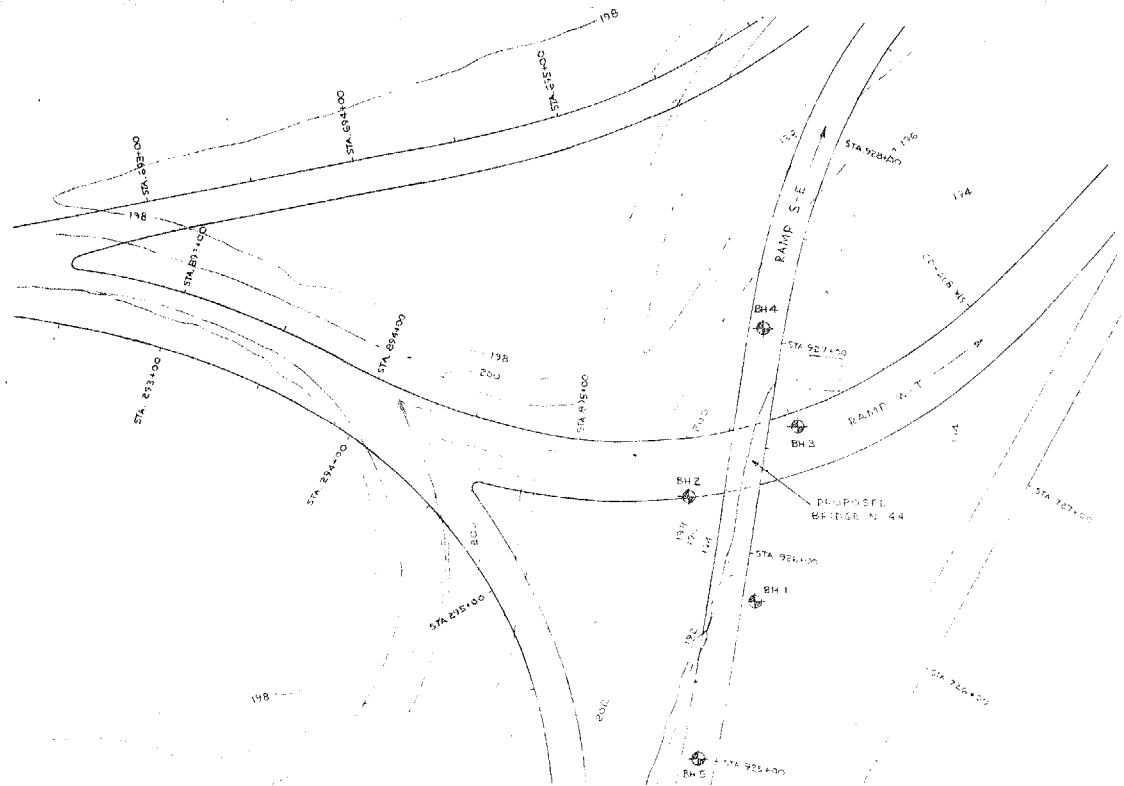
PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



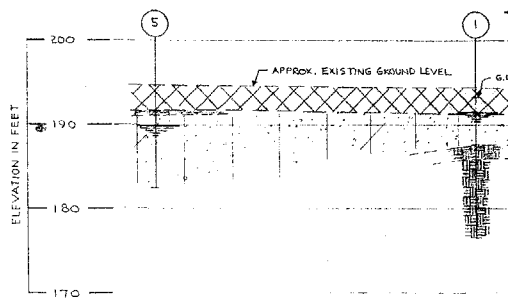
VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED F. DEL



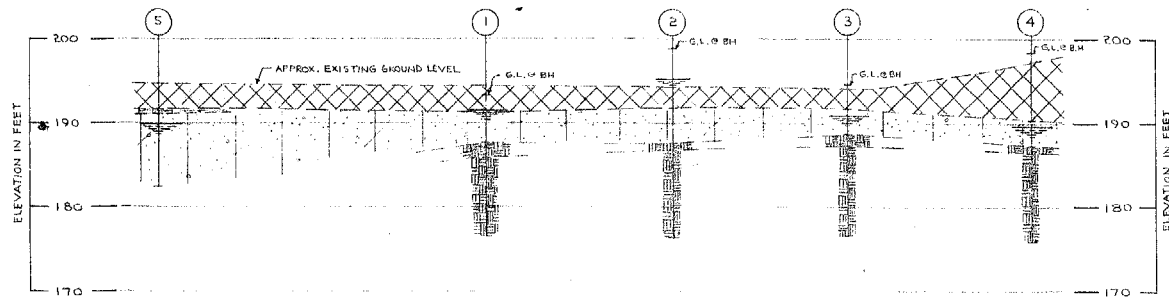
PLAN
SCALE 1" TO 40' 0"



SCHEMATIC SECTION






STRATIGRAPHY

- LOOSE TO DENSE SANDY SILTY FILL, SOME CRUSHED STONE, GRAVEL, CINDERS AND WOOD
- COMPACT TO VERY DENSE SANDY SILTY TILL, SOME CLAY AND GRAVEL
- SILT AND PEAT
- WEATHERED AND FRACTURED SHALE
- SOUND GREY SHALE BEDROCK






SCHEMATIC SECTION ALONG CENTRELINE - PROPOSED RAMP S-E

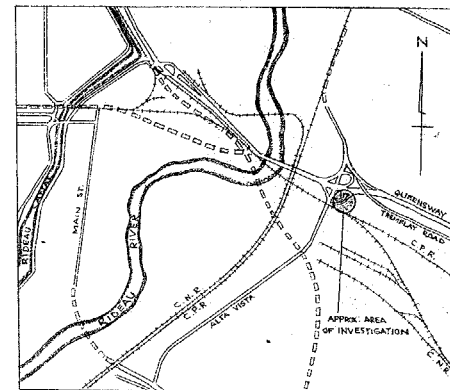
SCALE: HORIZ. 1" TO 20'-0"
VERT. 1" TO 10'-0"STRATIGRAPHY

-  LOOSE TO DENSE SANDY SILTY FILL, SOME CRUSHED STONE, GRAVEL, CINDERS AND WOOD.
-  COMPACT TO VERY DENSE SANDY SILTY TILL, SOME CLAY AND GRAVEL.
-  SILT AND PEAT
-  WEATHERED AND FRACTURED SHALE
-  SOUND GREY SHALE BEDROCK

LEGEND

-  BOREHOLE IN PLAN
-  BOREHOLE IN ELEVATION
-  W.L. IN BOREHOLE, MAY 7, 1964

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATIGRAPHIC CORRELATIONS AT BOREHOLE LOCATIONS SHOWN ON THIS BORING PLAN WERE INFERRED FROM GEOLOGICAL EVIDENCE AND MAY VARY FROM THAT SHOWN.



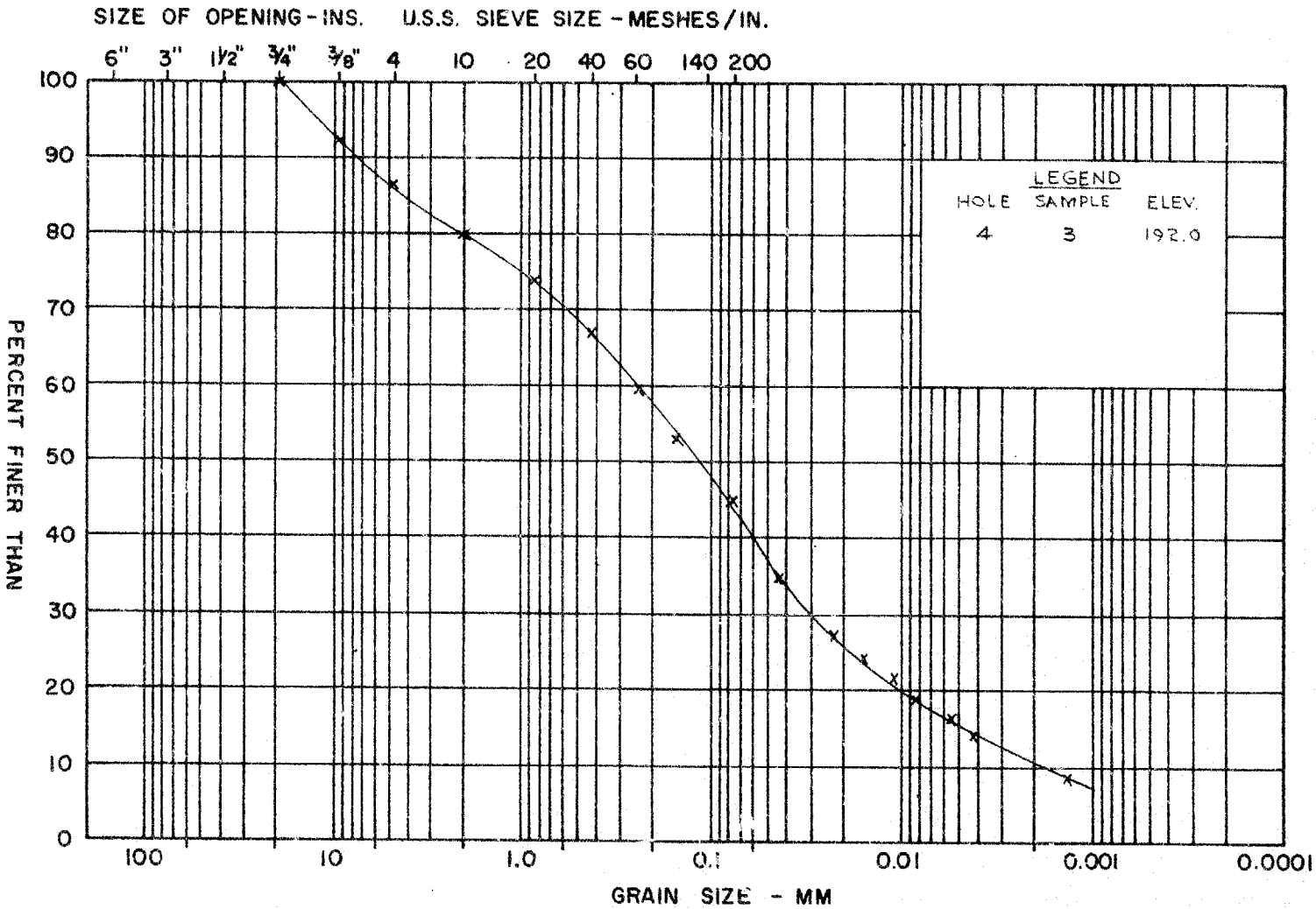
KEY PLAN

SCALE: 1" TO 2,200' (APPROX.)

REFERENCE

PLAN SUPPLIED BY DE LEUW, CATHER & COMPANY OF CANADA LIMITED, DATED MAY 25, 1964

M.I.T. GRAIN SIZE SCALE



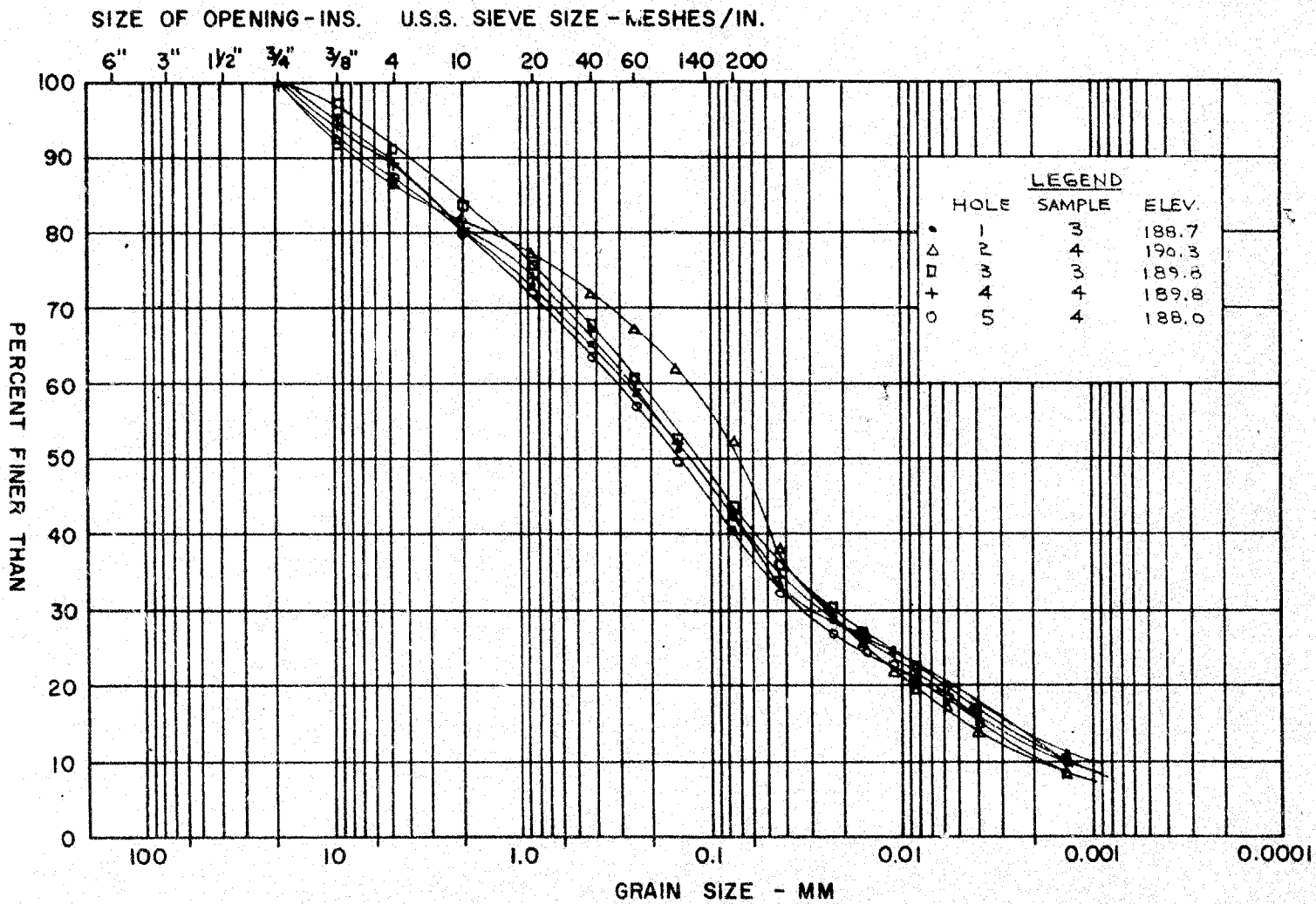
GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

FILL

FIGURE 2

M.I.T. GRAIN SIZE SCALE



GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
TILL

FIGURE 3

COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE	
	GRAVEL SIZE			SAND SIZE			FINE GRAINED			

DE LEUW, CATHER & COMPANY
OF CANADA LIMITED
CONSULTING ENGINEERS
TORONTO OTTAWA LONDON ST. JOHN'S

SUITE 206
2277 RIVERSIDE DRIVE
BILLINGS BRIDGE PLAZA
OTTAWA 8, ONTARIO
TELEPHONE 733-4160

Our Ref. Q-3b

June 24, 1964

Mr. F.I. Newson,
Consultant Liaison Engineer,
Bridge Division,
Department of Highways of Ontario,
DOWNSVIEW, Ontario.

Dear Sir:

Re: Ottawa Queensway
Bridge #44 at Tremblay Road
W.P. 944-64
District 9, Ottawa

Please find enclosed four (4) copies of the Site
Investigation report prepared by H.Q. Golder and Associates Ltd. for
the above structure.

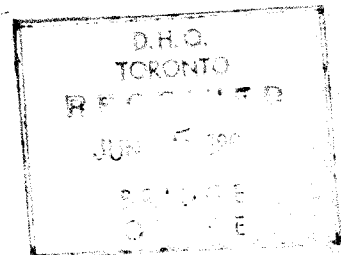
Would you please let us know your soils report number
assigned to this report.

Yours very truly,

DE LEUW, CATHER & COMPANY OF CANADA LTD.

B.B. Saunders
for L.J. Marshall, P.Eng.
Chief Bridge Engineer

GSS:cac
encl.



Mr. S. McComble,
Bridge Planning Engr.,
Bridge Division.

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

Attn: Mr. A. P. Watt,
Reg. Bridge Location Engr.

December 8, 1964

W.P. 944-64,
Tremblay Rd., Bridge #44,
Ottawa Queensway,
District #9.

Folder 64

We have reviewed the Preliminary Plan No.
D5503-P1, for the above-noted structure.

It appears that the designer has followed
the recommendations in the foundation report with respect
to the structure foundations. It should be noted, however,
that the foundation report recommends the removal of existing
loose fill material in the vicinity of the proposed structure.
This excavation is not shown on the Preliminary Plan.

H. L. Smith

KES/MdeF
cc: Foundations Office ✓
Gen. Files

A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. A. G. Stermac,
Principal Foundation Engineer,
Room 107, Lab. Bldg.

FROM: Bridge Division,
Downsview, Ontario.

DATE: June 3, 1964.

OUR FILE REF.

IN REPLY TO

SUBJECT: W.P. 944-64
Tremblay Rd. Bridge #44
Ottawa Queensway
District 9

Attached please find two preliminary bridge plans D 5503-P1 for the above structure.

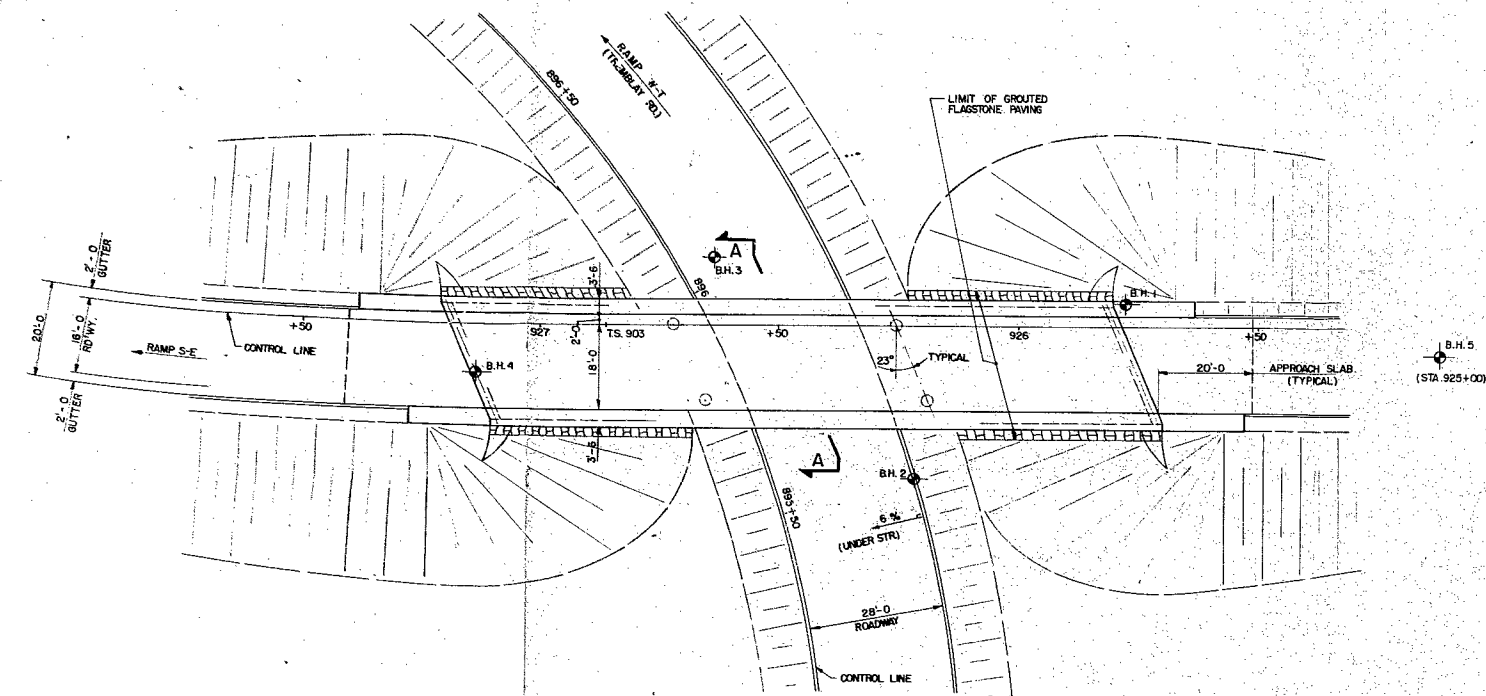
Would you kindly review the bridge foundations proposed and inform the Bridge Office if they are satisfactory.



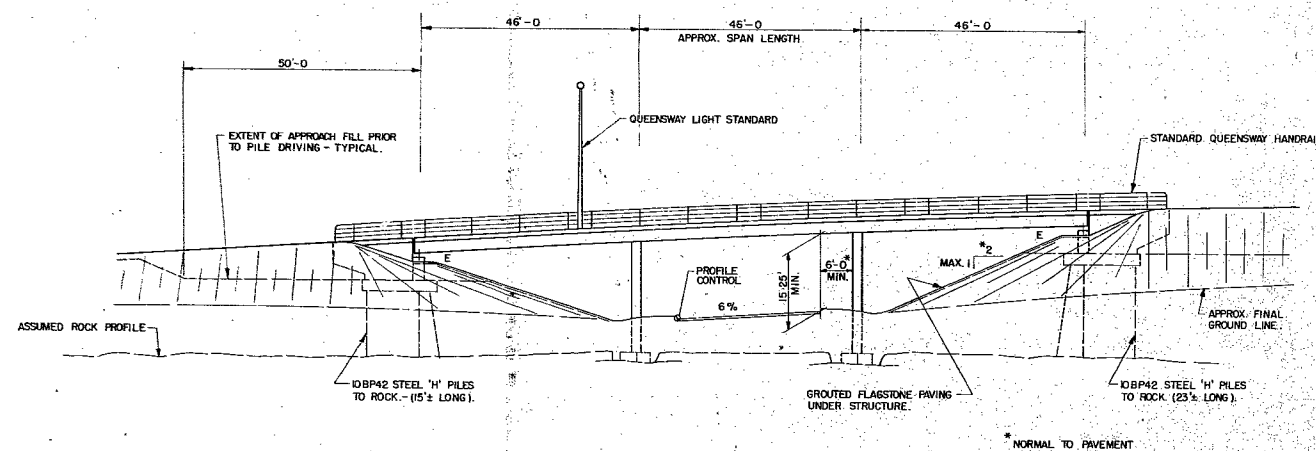
APW/im

A. P. Watt, - 3406
Regional Bridge Location Engineer.

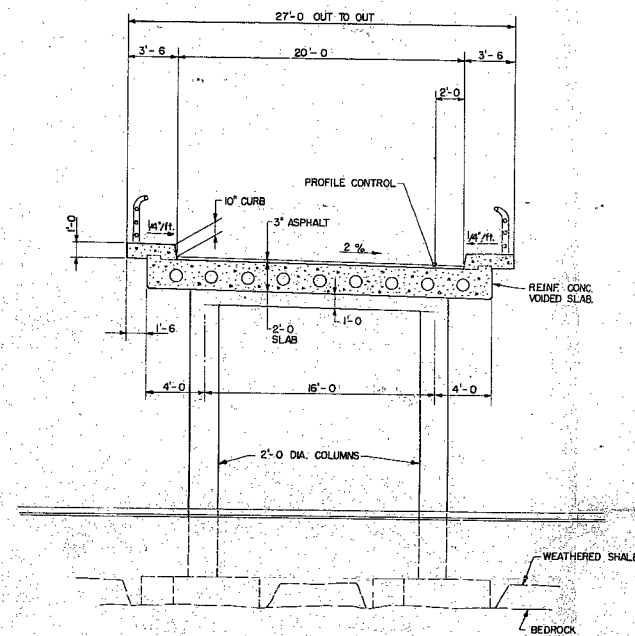
#64-F-222C
W.P. #944-64
OTTAWA
QUEENSWAY
BRIDGE #44
AT TREMBLAY RD.



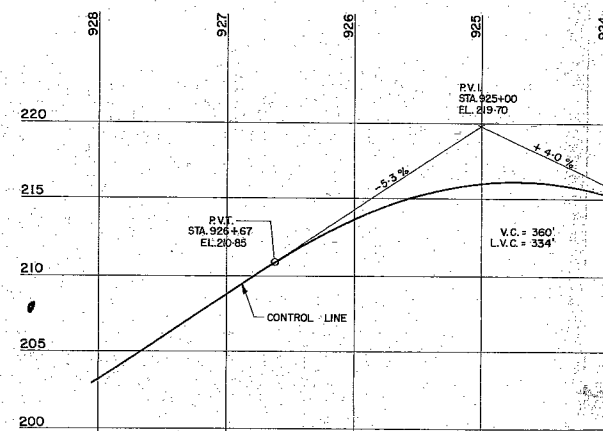
BRIDGE PLAN
SCALE: 1/16" = 1'-0"



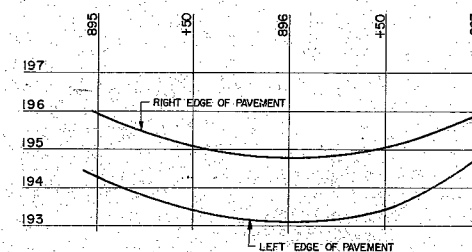
WEST ELEVATION
SCALE: 1/16" = 1'-0"



SECTION 'A-A'
SCALE: 3/16" = 1'-0"



RAMP S-E PROFILE
SCALE: HORIZ. 1" = 60'-0"
VERT. 1" = 5'-0"



RAMP W-T PROFILE (TREMBLAY ROAD)
SCALE: HORIZ. 1" = 60'-0"
VERT. 1" = 2'-0"

	B.H.1	B.H.2	B.H.3	B.H.4	B.H.5
200					
195		SILTY FILL		FILL	FILL
190	SANDY SILT	SILTY TILL	SILTY TILL	SILTY TILL	PEAT
185	SHALE	SHALE	SHALE	SHALE	SANDY CLAY SILTY TILL
180	BEDROCK	BEDROCK	BEDROCK	BEDROCK	
175					

BOREHOLE LOG

NOTES:

- DESIGN SPECIFICATIONS:
A.A.S.H.O. STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES 1961 AND D.H.O. BRIDGE DIVISION TENTATIVE STANDARDS AND MEMORANDUMS.
- LIVE LOAD:
H20-S16-44
- CONCRETE:
VOIDED SLAB AND COLUMNS - 3500 P.S.I. AT 28 DAYS.
ALL OTHER CONCRETE - 3000 P.S.I. AT 28 DAYS.
- SUPERSTRUCTURE:
REINFORCED CONCRETE VOIDED SLAB.
- FOUNDATIONS:
ABUTMENTS SUPPORTED ON STEEL BEARING PILES - 10 BP 42,
ALLOWABLE LOAD - 35 TONS.
BENTS FOUNDED ON BEDROCK - ALLOWABLE LOAD
BEARING PRESSURE.
- PRELIMINARY ESTIMATE OF COST:
\$44,000.

No. _____		Revisions _____		By _____	
DEPARTMENT OF HIGHWAYS OF ONTARIO					
OTTAWA QUEENSWAY LIMITED-ACCESS HIGHWAY OTTAWA CANADA					
BRIDGE No. 44 AT TREMBLAY ROAD PRELIMINARY BRIDGE PLAN					
DE LEUW CATHY & CO. OF CANADA LIMITED Consulting Engineers			DEPT. OF HIGHWAYS OF ONTARIO Director of Planning & Design		
Designed by G.S.S.		Date: APRIL 1964		DWG. No. D5503-PI	
Drawn by P.T. & A.G.Y.		Scale: AS SHOWN		Sheet 1 of 1	
Checked by L.J.M.					
CONTRACT NUMBERS		WORKS PROJECT No. 944-64		DISTRICT No. 9	