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G.I.-30 SEPT. 1976

GEOCRES No. 40 P15-27

DIST. 3 REGION southwestern

W.P. No.

CONT. No.

W. O. No.

STR. SITE No. '36-7' '36-8'

HWY. No.

LOCATION LOT 5 & 6 ~~[illegible]~~

CON 12 & 13 MINTO TWP.

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS: DOCUMENTS TO BE UNFOLDED BEFORE MICROFILMED

40P15

BA 1732

MR. B. M. ROSS
CONSULTING ENGINEER
GODERICH ONTARIO

40P15-27
GEOCRES No.

Report on

SOIL INVESTIGATION

for

ROAD BRIDGES
CONCESSIONS XII & XIII, LOTS 5 & 6
TOWNSHIP OF MINTO

by

DOMINION SOIL INVESTIGATION LIMITED
363 Queens Avenue
London Ontario
Reference No. 3-11-L6
November 1963

36-7 "West" Bridge (30' Exist)

36-8 "East" Bridge (70' Exist)

CONTENTS

ENCLOSURES

SUMMARY

The principal strata consist of 8 to 13 feet of pervious gravel and sand, 2'-6" to 5'-0" of hard clay or interlayered clay and silt seams, and a deep deposit of dense cohesionless silt in which occasional clay seams were encountered.

It is recommended that both structures should be supported on steel pipe piles. Piles designed for a safe working load of 60 tons are expected to reach a satisfactory set between Els. 60 and 55 feet.

No unusual construction problems are anticipated.

I INTRODUCTION

In accordance with verbal authorization received from Mr. B. M. Ross's office, a soil investigation has been carried out at the site of 2 adjacent road bridges in the Township of Minto. The existing bridges are a 30-foot concrete arch and a 70-foot steel truss which will be referred to in this report as the "west" bridge and "east" bridge respectively. The two structures are approximately 450 feet apart.

The 30-foot arch, which acts as a relief bridge for the larger span, will be replaced by a 60-foot rigid frame. The west abutment of the new span will lie approximately 4 feet west of the west abutment of the existing span. The 70-foot truss will be replaced by a 60- or 70-foot rigid frame which will be located close to or a few feet west of the existing structure.

The requirements of the project were discussed with Mr. K.G. Dunn who provided the foregoing information and specified the number of borings to be made. The precise locations and depths of the boreholes were determined on the site by Dominion Soil Investigation Limited. A plan of the site (drawing no. BR-80-1) was supplied by Mr. Ross's office.

The purpose of this investigation has been to reveal the subsurface conditions and to determine the necessary soil properties for the design and construction of foundations.

II PHYSIOGRAPHY

The site is located in the westerly part of the Dundalk Till Plain. This is a relatively flat area of ground moraine with a slightly fluted surface. The plain is drained by a number of spillway valleys which have been cut by glacial meltwaters. The gravelly surface deposits found at the site are terraces built by these early streams. The shallow valley in which the site is located is now occupied by the South Saugeen River which flows north-westward to join the main stream.

III FIELD WORK

Field work was carried out during the period 27th to 30th of November 1963, and consisted of 4 boreholes and 7 dynamic cone penetration tests at the locations shown on enclosures 2 and 5. The holes were advanced by wash boring and lined with Bx (3-inch) casing.

Standard Penetration tests were performed at frequent intervals of depth to determine the relative density or consistency of the soil, and to recover disturbed samples. The dynamic cone penetration tests provide a continuous record of penetration resistance and reveal abrupt changes in stratification. They also give a qualitative indication of the resistance which may be encountered by piling.

The results of the field tests are recorded on geotechnical data sheets comprising enclosures 3, 4 (west bridge) 6 and 7 (east bridge). Elevations have been referred to the top of the deck in the centre of the existing 70-foot truss, which is taken as El.100.0 feet.

IV SUBSURFACE CONDITIONS

Details of the stratification at each borehole are shown in the data sheets and a general picture of the subsurface conditions is given by the profiles on enclosures 2 and 5. The principal strata are as follows:

(a) A compact to dense deposit of fine silty sand and fine to coarse gravel extending to depths of 13 feet and 8 feet at the west and east bridges respectively. The material is generally well graded with about 50% of particles in both the sand and gravel sizes (± No. 4 mesh sieve). The gravel particles are mostly sub-angular and less than 2-inches in diameter.

The upper layers at borehole 1 have a small clay content giving the material a slight cohesion. The lower layers at borehole 3 and all of the material at borehole 7 is very silty and less well graded.

Almost all of this deposit is highly pervious.

(b) A dense deposit of clay and silt varying in thickness from 2'-6" to 5'-0". At borehole 1 the stratum is mainly silt with sufficient fine clay seams (less than 1 mm. thick) to give it cohesion. At borehole 3 it consists of silty clay with 1" to 3" seams of silt every 6 " (±). At borehole 5, very fine (less than 1 mm.) silt seams are present in the clay every 1/2" (±) and at borehole 7 the stratum is entirely hard silty clay.

The clay is impervious and the silt is cohesionless and relatively pervious. The stratum is very dense or hard (N = 40±) and has apparently been heavily preconsolidated by glacial ice.

(c) Very dense grey silt. This is mainly a cohesionless material. Horizontal clay seams were encountered at random within the deposit but with no regular pattern. The clay seams vary in thickness from 1/8 inch to 3 or 4 inches and the spacing from 3 inches upward. The total thickness of clay seams probably represents less than 5% of the depth of the stratum.

At borehole 7, seams of fine sand (approximately 1 inch thick) were found between depths of 24 to 28 feet, spaced at intervals of 8 to 12 inches. Between 28 feet and 33'-6" in this hole, the silt contains 20 to 30% of fine sand.

V FOUNDATIONS (West Bridge)

In considering the type of foundations to use, a critical factor is the deep hollow on the north side of the existing bridge. This extends to El.76 feet or possibly deeper, so that it would be necessary to place spread footings at or below El.70 feet. Construction at this level would involve coping with 20 or more feet of water in a cohesionless material where erosion is likely to be a major problem. Abutment walls would be in excess of 30 feet in height, and it would be necessary to brace such an excavation with steel sheet piling driven to some depth below the footing grade. The silty soil is inherently susceptible to disturbance and the problem of preserving hydraulic stability in the bottom of the excavation might be considerable.

The foregoing observations lead to the conclusion that the use of piles would probably be a cheaper solution, and would certainly involve fewer technical problems. At the time of preparing this report, the requirements of a hydrological analysis are not known, but it will be assumed that the pile tips should reach at least El.60 to 65 feet. Most of the strata above this level are quite dense and it is unlikely that timber piles could be driven without damage, even if steel shoes were fitted. It is therefore proposed that either steel pipe piles or H-piles should be used.

A 12-inch diameter steel pipe pile driven to El.60 feet has a theoretical ultimate bearing capacity of about 300 tons. This calculation has been made in accordance with Meyerhof's theory, and assumes erosion will take place to El.70 feet. In practice, it is anticipated that piles designed for a safe working load of 60 tons will reach a satisfactory set between Els.60 and 55 feet.

The use of steel H-piles has also been considered, and the following theoretical values obtained.

Pile Type	Ultimate Bearing Capacity (tons) Tip El.55 feet	Tip El.50 feet
BP10 (57 lb/ft.)	71	84
BP12 (74 lb/ft.)	90	105

While such calculations are only crude approximations, they serve as a basis for comparison. In the soil conditions encountered on this site, H-piles may be expected to penetrate considerably deeper than pipe piles, possibly far below the depth of the boreholes. This is particularly likely if the piles are driven in accordance with the Hiley formula using a factor of safety of 3, as is common practice.

The behaviour of pipe piles is more predictable and they are likely to be much shorter. For these reasons, their use is recommended in the present case. The only qualification put on this recommendation is that it may be difficult to drive the piles below El.55 feet if this is required for erosion protection.

Irrespective of any prediction made here as to the length and bearing capacity of piles, they should be driven to a satisfactory set in accordance with some accepted dynamic pile-driving formula.

VI FOUNDATIONS (East Bridge)

The comments made in the foregoing section dealing with the west bridge are generally also applicable in the case of the east bridge.

The elevation of the river bed at mid-stream is 83 feet (±) and may be deeper at the east abutment where sheet piling has been driven as a safeguard against erosion. It would be necessary to place spread footings at or below El.75 feet which lies within the cohesionless silt stratum. For the reasons stated previously it is recommended that steel piles should be used.

The strata at the east bridge are somewhat less dense than those at the west, and H-sections would penetrate even deeper. It is proposed again that steel pipe piles should be used. 12-inch diameter piles driven to Els. 60 and 55 feet have theoretical ultimate bearing capacities of 200 tons and 250 tons respectively. In practice it is expected that a pile designed for a safe working load of 60 tons will reach a satisfactory set between Els. 60 and 55 feet.

VII GENERAL

The settlement under load at either structure will not be appreciably more than the elastic deflection of the pile groups. The only construction problem which is likely to be encountered is the dewatering of the excavation for the pile caps. This will depend on the elevation at which they are located, but a large flow of water should be expected from the pervious upper granular strata. If the yield is too high to control by pumping, it can be reduced or eliminated by driving sheet piling into the top of the clay and silt strata.

VIII REFERENCES

1. The Physiography of Southern Ontario by L. J. Chapman and D. F. Putnam of the Ontario Research Foundation - University of Toronto Press 1951.

2. Procedures for Testing Soil, ASTM, April 1958. pp.186 to 198. (Unified Soil Classification System - by A. A. Wagner).

3. Proceedings of the 4th International Conference on Soil Mechanics and Foundation Engineering (Research on Determining the Density of Sands by Spoon Penetration Testing - by H. J. Gibbs and W. G. Holtz of the United States Bureau of Reclamation.) London, 1957.

4. Terzaghi and Peck: Soil Mechanics in Engineering Practice. John Wiley and Sons, New York 1948.

5. Standard Penetration Tests and Bearing Capacity of Cohesionless Soils, by G. G. Meyerhof, ASCE Paper 866, January 1956.

REGISTERED PROFESSIONAL ENGINEER
CIVIL
J. PARK
PROVINCE OF ONTARIO

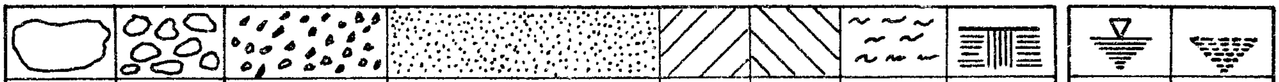
DOMINION SOIL INVESTIGATION LIMITED

James Park, M.Sc., P.Eng.

Enclosure No. 1.

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.



BOULDER	COBBLE	GRAVEL		SAND			SILT	CLAY	ORGANICS	BEDROCK	GROUND WATER LEVEL	DEPTH OF CAVE-IN
		COARSE	FINE	COARSE	MEDIUM	FINE						
Ø > 8"	3"	3/4"	4.76mm	2.0	0.42	0.074	0.002 >		NO SIZE LIMIT			

U.S. Standard Sieve Size: No.4 No.10 No.40 No.200

SAMPLE TYPES.

AS	Auger sample	RC	Rock core	TP	Piston, thin walled tube sample
CS	Sample from casing	%	Recovery	TW	Open, thin walled tube sample
ChS	Chunk sample	SS	Split spoon sample	WS	Wash sample

SAMPLER ADVANCED BY static weight : w
" pressure : p
" tapping : t

OBSERVATIONS MADE WHILE CORING
- Steady pressure
- No pressure
- Intermittent pressure
- Washwater returns
- Washwater lost

PENETRATION RESISTANCES.

SYMBOL:

DYNAMIC PENETRATION RESISTANCE: to drive a 2"ϕ, 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot.

STANDARD PENETRATION RESISTANCE, -N-: to drive a 2" outside dia, split spoon sampler 1 foot into the ground, expressed in blows per foot.

EXTRAPOLATED -N- VALUE 322

The energy for the penetration resistances is supplied by a 140 lb. hammer falling 30 inches

SOIL PROPERTIES.

W %	Water content	γ	Natural bulk density (unit weight)	k	Coeff. of permeability
LL %	Liquid limit	e	Void ratio	C	Shear strength — in terms of total stress
PL %	Plastic limit	RD	Relative density	ϕ	Angle of int. friction — in terms of total stress
PI %	Plasticity index	C_v	Coeff. of consolidation	C'	Cohesion — in terms of effective stress
LI	Liquidity index	m_v	Coeff. of volume compressibility	ϕ'	Angle of int. friction — in terms of effective stress

UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —

TRIAXIAL / UNCONFINED COMPRESSION TEST ◉ ●St

LABORATORY / FIELD VANE TEST X St + St

POCKET PENETROMETER TEST St

Strain at failure is represented by direction of stem: 20%, 15%, 5%, 10%

St : sensitivity = $\frac{\text{shear strength in undisturbed state}}{\text{shear strength in remoulded state}}$

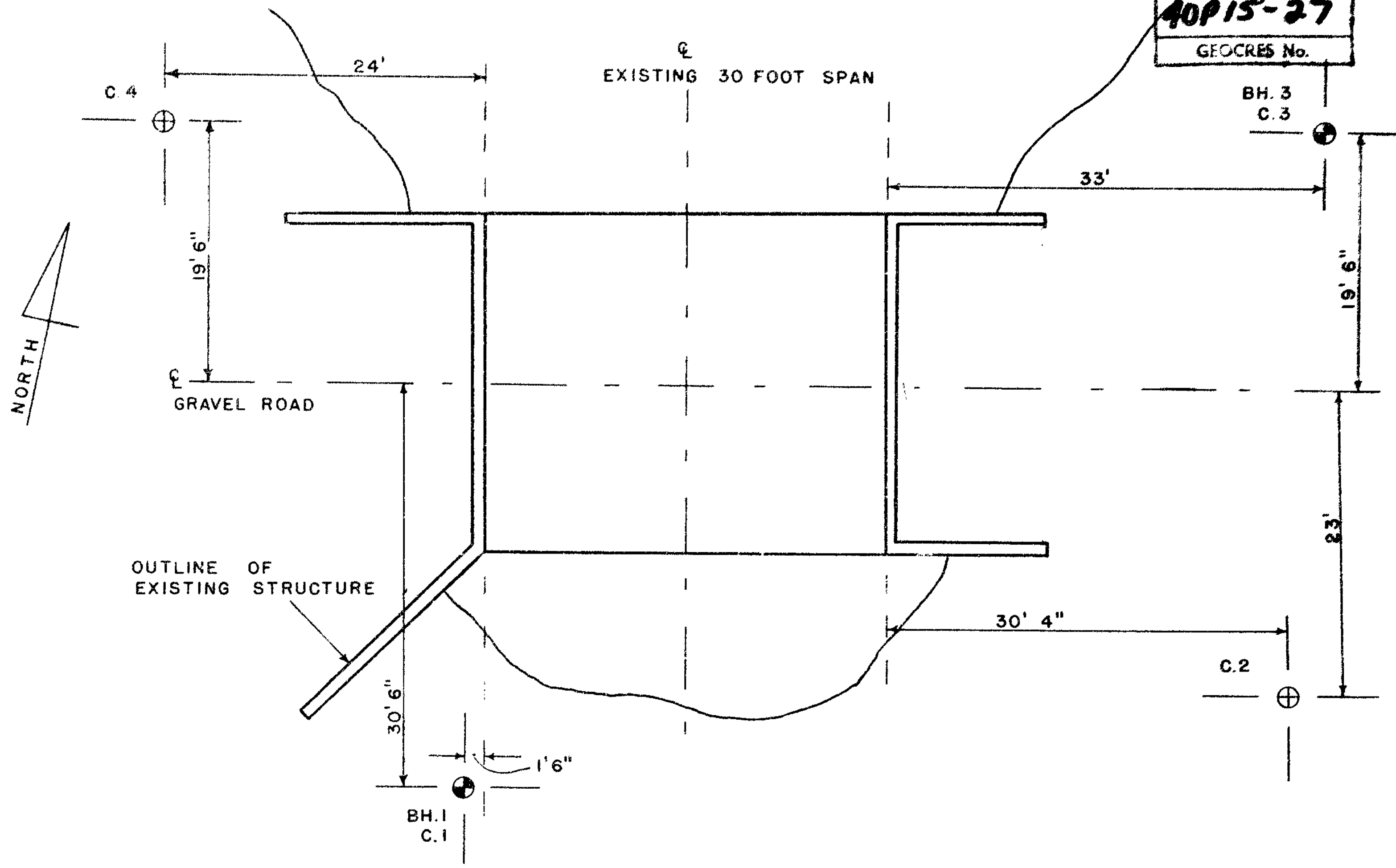
SOIL DESCRIPTION.

COHESIONLESS SOILS:	RD:
Very loose	0 – 15 %
Loose	15 – 35 %
Compact	35 – 65 %
Dense	65 – 85 %
Very dense	85 – 100 %

COHESIVE SOILS:	C lbs/sq.ft.
Very soft	less than 250
Soft	250 – 500
Firm	500 – 1000
Stiff	1000 – 2000
Very stiff	2000 – 4000
Hard	over 4000

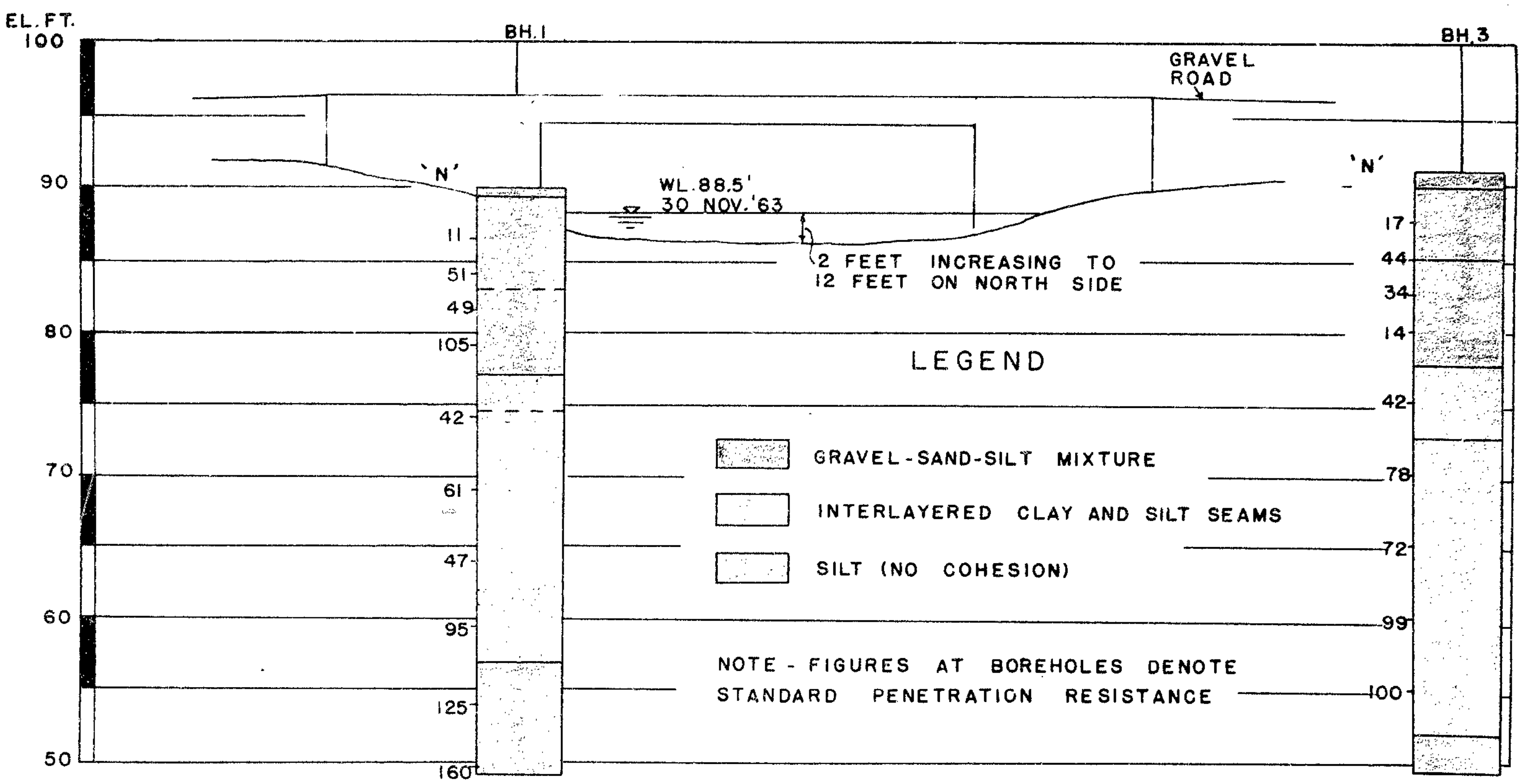
DOMINION SOIL INVESTIGATION LIMITED

40P15-27
GEOCRES No.



LOCATION OF BOREHOLES (WEST BRIDGE)

SCALE: 1 INCH TO 10 FEET



SUBSURFACE PROFILE

SCALE: 1 INCH TO 10 FEET

OUR REFERENCE NO. 3-11-L6

GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 1 . . .

40P15-27
GEOCRES No.

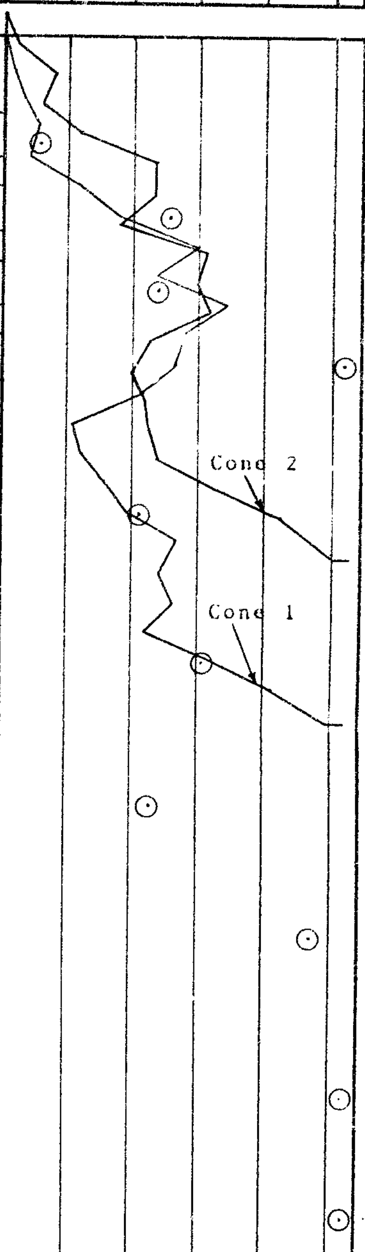
CLIENT: Mr. B. M. Ross
PROJECT: Bridge No. 80
LOCATION: Township of Minto, County of Wellington.
DATUM ELEVATION: 100.0' (deck of existing 70-foot truss)

METHOD OF BORING: Washboring
DIAMETER OF BOREHOLE: Bx (3-inch)
DATE: November, 1963.

ENCLOSURE NO. 3

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	SAMPLE NUMBER	TYPE	"N" or Advancement of Sampler	REMARKS
90	0	Ground Surface				
		Topsoil				
		Clayey, silty fine sand and fine to coarse gravel, compact.	1	SS	11	W.L. 89.0' 28 Nov.'63
85	5		2	SS	51	
		Fine silty sand-fine gravel mixture, well graded, dense.	3	SS	49	
80	10		4	SS	105	
75	15	Grey silt, many fine clay seams, dense.	5	SS	42	
70	20	Very dense grey silt with occasional clay seams, (silt has no cohesion).	6	SS	61	
65	25		7	SS	47	
			8	RC	Bxt	
60	30	seam of gravel sand and clay*	9	SS	95	* Chopping bit would not penetrate beyond 28'. Mixture of sand, silt, clay and fine gravel was recovered in Bxt core barrel.
55	35	Very dense gravelly sandy silt, slight cohesion.	10	SS	125	
50	40		11	SS	160	Extrapolated 'N' value, Sample 11: 36/6" 60/6" 50/3"
		End of borehole				

PENETRATION RESISTANCE blows per foot: 20 40 60 80 100 — SHEAR STRENGTH lbs/sq ft



CONSISTENCY water content % PL W LL

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: SB CH'D: JP

GEOTECHNICAL DATA SHEET FOR BOREHOLE ..3...

OUR REFERENCE NO. 3-11-16

40P15-27
GEOCRES No.

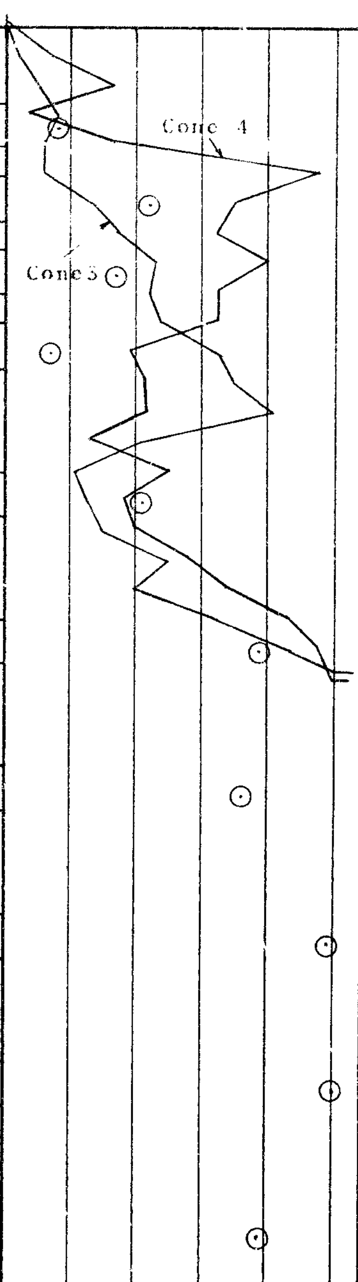
ENCLOSURE NO.

CLIENT Mr. D. M. Ross
PROJECT Bridge No. 80
LOCATION Township of Minto, County of Wellington.
DATUM ELEVATION 100.0' (deck of existing 70-foot truss)

METHOD OF BORING Washboring
DIAMETER OF BOREHOLE BX (3-inch)
DATE November, 1963.

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	N or Advancement of Sampler
91.4	0	Ground Surface			
		Topsoil			
		Fine silty sand, fine gravel mixture, well graded, compact.	1	SS	17
			2	SS	44
		Grey gravelly sandy silt, compact to dense slight cohesion.	3	SS	34
			4	SS	14
		Hard grey silty clay, with seams of cohesionless silt.	5	SS	42
			6	SS	78
			7	SS	72
		Very dense grey silt, no cohesion, very occasional clay seam.	8	SS	99
			9	SS	100
		Finely layered clay & silt deposit, very dense.	10	SS	78
		End of borehole			

PENETRATION RESISTANCE blow per foot 20 40 60 80 100 — SHEAR STRENGTH lbs/sq ft



CONSISTENCY water content % PL W LL

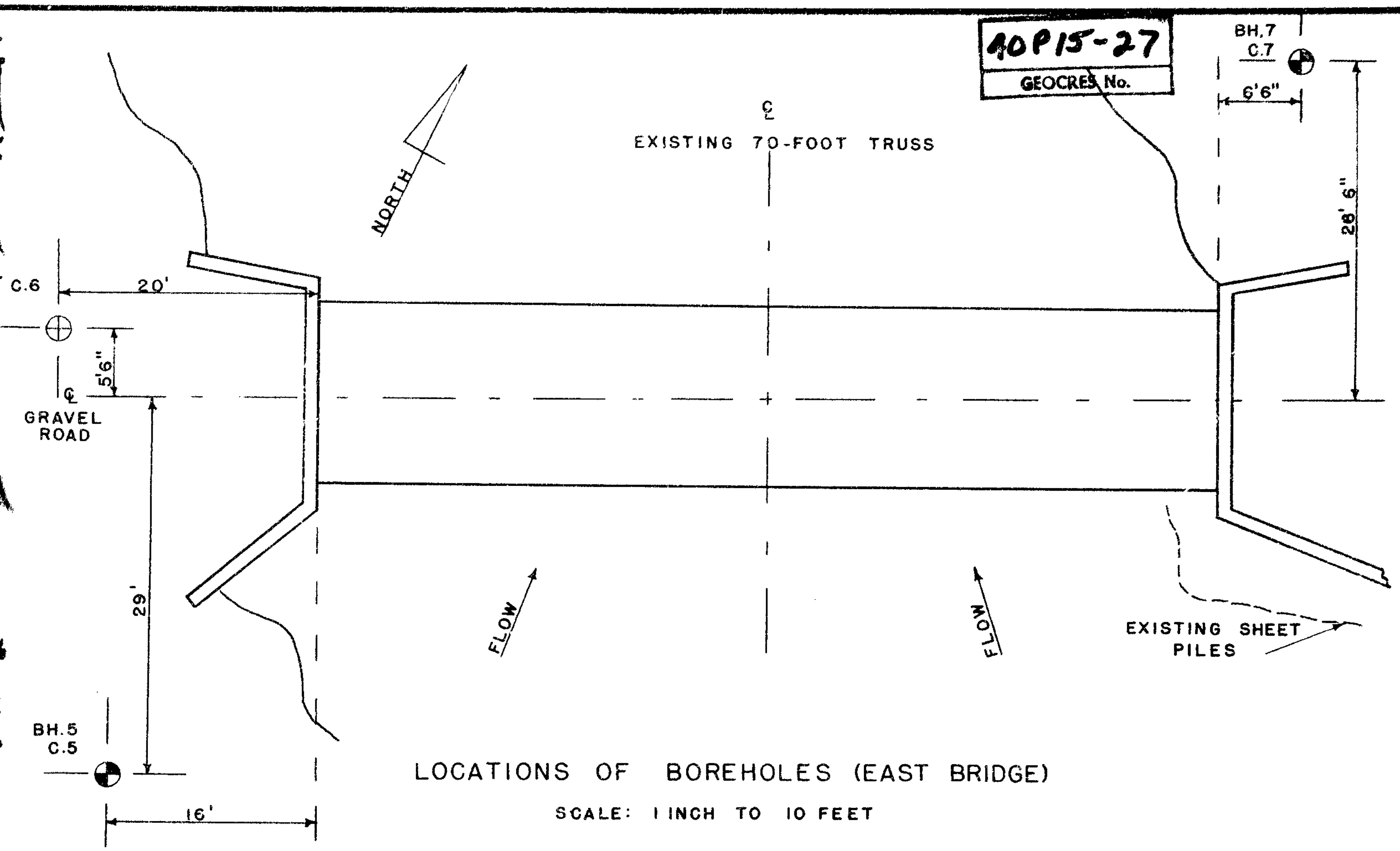
REMARKS

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

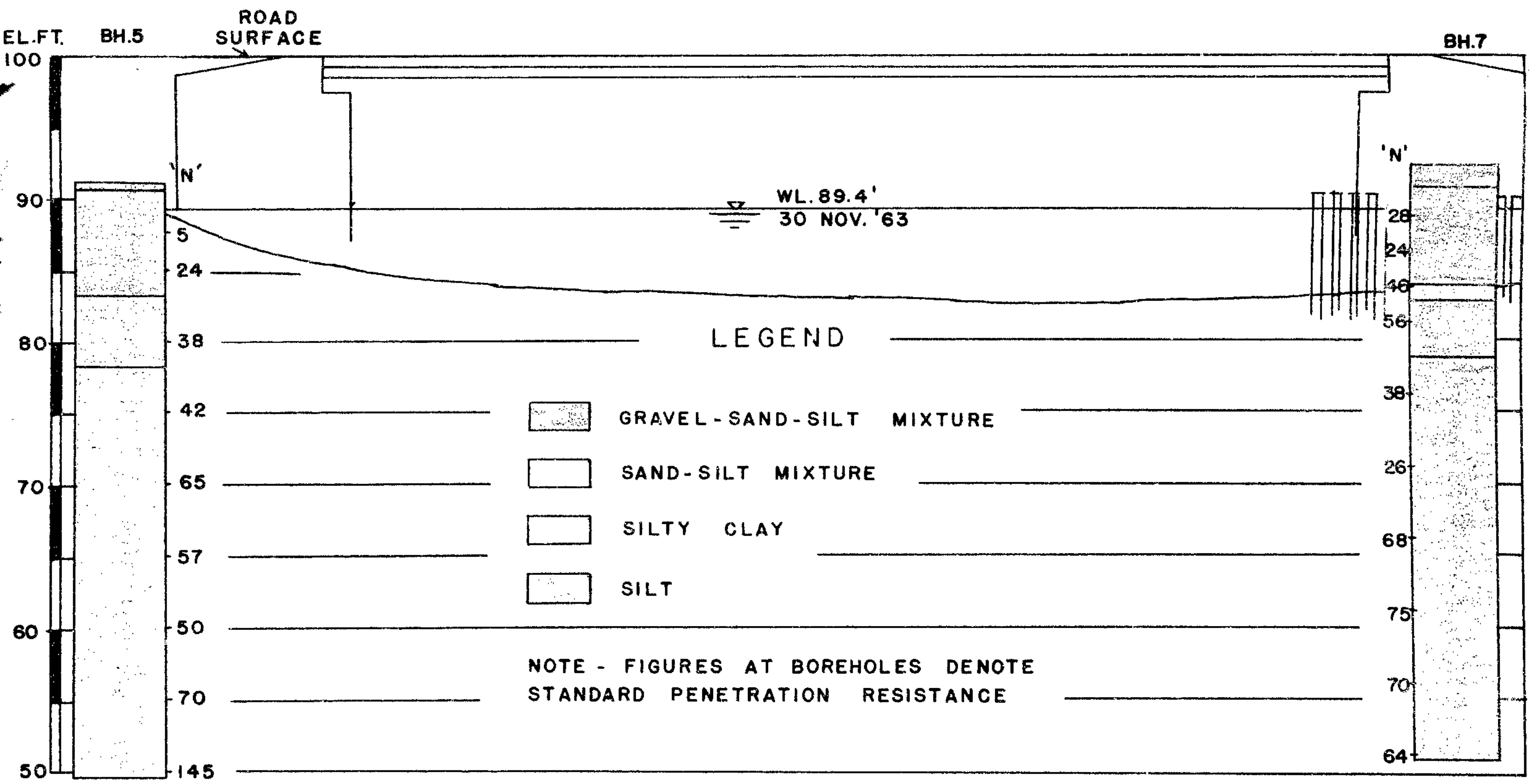
MADE: SB CH'D: JP

40P15-27
GEOCRES No.



LOCATIONS OF BOREHOLES (EAST BRIDGE)

SCALE: 1 INCH TO 10 FEET



SUBSURFACE PROFILE

SCALE: 1 INCH TO 10 FEET

40P15-27
GEOCRES No.

OUR REFERENCE NO. 3-11-16

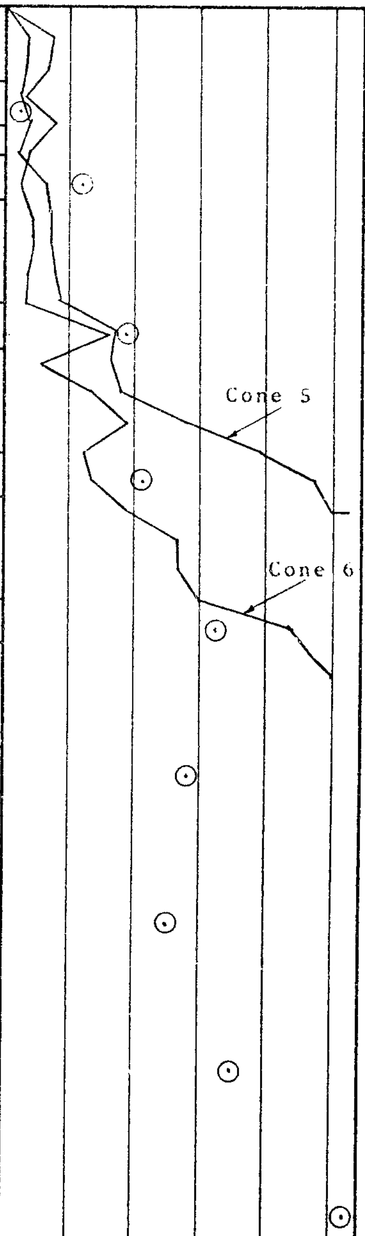
GEOTECHNICAL DATA SHEET FOR BOREHOLE 5

ENCLOSURE NO. 6

CLIENT: Mr. B. M. Ross
PROJECT: Bridge
LOCATION: Township of Minto, County of Wellington.
DATUM ELEVATION: 100.0' (deck of existing 70-foot truss)
METHOD OF BORING: washboring
DIAMETER OF BOREHOLE: Bx (3-inch)
DATE: November, 1965.

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES N or Advancement of Sampler	REMARKS
91.1	0	Ground surface					
		Topsoil					
		Silty sand - gravel mixture, well graded, (fine sand to coarse gravel) compact.		1	SS	5	El. 89.6' 29 Nov.65
				2	SS	24	Cone No. 6 was driven from El. 99.0'.
		Hard grey silty clay with very fine silt seams.		3	SS	38	
		Very dense grey silt, occasional clay seams, (silt has no cohesion).		4	SS	42	
				5	SS	65	
				6	SS	57	
				7	SS	50	
				8	SS	70	
				9	SS	145	
		End of borehole					

PENETRATION RESISTANCE blows per foot 20 40 60 80 100 — SHEAR STRENGTH lbs. sq. ft.



CONSISTENCY water content % PL W LL

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: SB CH'D: JP

GEOTECHNICAL DATA SHEET FOR BOREHOLE . 7 . . . .

OUR REFERENCE NO 3-11-L6

CLIENT: Mr. B. M. Ross
PROJECT: Bridge
LOCATION: Township of Minto, County of Wellington.
DATUM ELEVATION: 100.0' (deck of existing 70-foot truss)

METHOD OF BORING: Washboring
DIAMETER OF BOREHOLE: Bx (3-inch)
DATE: November, 1963.

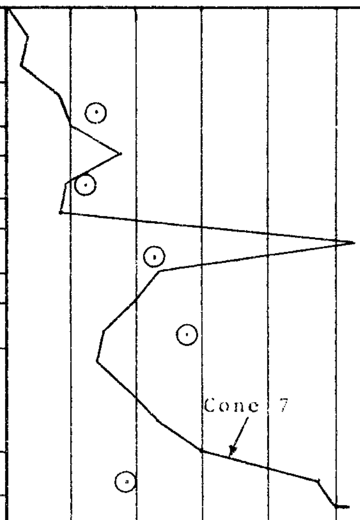
ENCLOSURE NO 7

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	SAMPLE NUMBER	TYPE	N or Advancement of Sampler	REMARKS
92.1	0	Ground Surface				
		Organic sandy topsoil.				
		Sandy silt - coarse gravel mixture, slight cohesion, compact.	1	SS	28	El. 89.1' 30 Nov.63
			2	SS	24	
		Dense grey sand-silt mixture	3	SS	46	
		Hard grey silty clay.	4	SS	56	
		Very dense grey silt — few clay seams	5	SS	38	
		Very dense grey silt	6	SS	26	
		Very dense grey silt — few sand seams	7	SS	68	
		Very dense grey silt — very sandy	8	SS	75	
		Very dense grey silt	9	SS	70	
		Very dense grey silt — few clay seams	10	SS	64	
		End of borehole				

Elevation scale: 90, 85, 80, 75, 70, 65, 60, 55, 50. Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40.

PENETRATION RESISTANCE blows per foot: 20 40 60 80 100 — SHEAR STRENGTH lbs/sq ft

CONSISTENCY water content %: PL W LL



VERTICAL SCALE: 1 IN TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: SB CH'D: JP