DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 40 P13 -10

W.P. No.

CONT. No.

W. O. No.

STR. SITE No. 2 - 286

HWY. No.

LOCATION RD. BRIDGE, WILLOUGHBY ST., LUCKNOW,

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. None

REMARKS:

D.H. 18 - 3

MR. B. M. ROSS
CONSULTING ENGINEER
GODERICH ONTARIO

STRUCTURE SITE No. 2-286

Report on

SOIL INVESTIGATION

for

ROAD BRIDGE

WILLOUGHBY STREET

LUCKNOW ONTARIO

by

DOMINION SOIL INVESTIGATION LIMITED
363 Queens Avenue
LONDON ONTARIO

Reference No. 4-2-L13
23 March, 1964

CONTENTS

ENCLOSURES

SUMMARY

The strata consist of compact to dense deposits, apparently of glacio-fluvial origin, to a depth of approximately 30 feet. At this level a hard glacial till was encountered.

It is recommended that the structure should be supported on spread footings at El.863.7 feet, designed for a gross soil pressure not exceeding 4000 p.s.f. The resulting total and differential settlements are not expected to exceed 1.0 and 0.75 inch respectively.

The bottom of the excavation must be prevented from "boiling". This can be done either by dewatering with well-points or by making the excavation within a sheet pile enclosure. The pile tips must be driven sufficiently deep to ensure hydraulic stability.

The use of timber piles as an alternative to spread footings is considered. The piles should be fitted with steel shoes to prevent damage during driving.

I INTRODUCTION

In accordance with a letter of authorization dated 5th March, 1964, from Mr. B. M. Ross, a soil investigation has been carried out at a site in the village of Lucknow where it is proposed to replace an existing road bridge with a new structure. The bridge forms part of Willoughby Street and spans the Lucknow River.

It is understood that the new structure will have a span of approximately 35 feet and will be located in the same position as the existing bridge.

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 the new foundations.

II FIELD WORK

Field work was carried out on the 3rd and 4th of March, 1964 and consisted of 2 boreholes at the locations shown on enclosure 2. The holes were advanced by washboring and lined with Bx (3-inch) casing. Standard Penetration tests were performed at frequent intervals to obtain a measure of the relative density or consistency of the soil and to recover disturbed samples.

Dynamic cone penetration tests were performed adjacent to each hole. This test gives a continuous record of penetration resistance. It enable the detection of abrupt changes in stratification and gives some indication of the resistance which might be encountered in the driving of piles.

The results of the field tests are recorded on geotechnical data sheets comprising enclosures 3 and 4.

III SUBSURFACE CONDITIONS

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

(a) Granular fill. This material makes up the road embankment, and is composed mainly of silty sand and fine gravel. Traces of clay and organics are also present. The deposit is in a loose to compact condition and has a low moisture content.

(b) Gravelly sandy silt. The level of this stratum corresponds to that of the stream bed, and conceivably it is the alluvial deposit of an earlier and larger river. The silt content is estimated to be 30%, and all sizes of sand and subangular gravel up to about 1 inch in

diameter are present. Occasional seams or traces of clayey material were also encountered. The deposit is dense and saturated.

(c) Sand. At borehole 1 the sand is well graded and contains all sizes of material from silt to fine gravel. At borehole 2 it consists mainly of fine material (minus No.50 mesh). The deposit is dense and pervious.

(d) Sand, silt and clay seams. This is a horizontally layered deposit, probably of glacio-fluvial origin. Seams of fine silty sand, generally 3 to 6 inches thick alternate with the other constituents which are generally 1/2 to 3 inches thick. The sand constitutes an estimated 50% of the volume with the clay and silt in roughly equal proportions. 'N'-values ranging from 7 to 23 indicate a compact or firm to stiff consistency.

(e) Silt till. This is a very dense cohesive material in which the boreholes were terminated. The transition between it and the overlying layered deposit is quite abrupt, as indicated by the cone penetration tests. The estimated proportions of the constituents are: silt (60%); gravel and sand (30%); clay (10%).

The stratification is quite consistent with the physiographic features of the area. The site lies in a spillway valley which cuts through the Wyoming Moraine and is now occupied by the Lucknow River. This is an extensive ridge of glacial debris running parallel to the Lake Huron shoreline. The till encountered near the bottom of the boreholes is presumably the material of which the moraine is comprised, while the overlying strata appear to be fluvial deposits of the original glacial river.

IV FOUNDATIONS

The use of a spread footing foundation will be considered first. The level of the bed of the creek is El.868.7 feet indicating a footing elevation of 863.7. The latter level lies within the dense gravelly silt layer (N=35) at borehole 1, and within the dense sand layer (N=23) at borehole 2. The shear strength of the soil below these strata diminishes with depth, but there is adequate strength to accommodate a loading of 4000 p.s.f. on a footing approximately 5 feet wide at El.863.0. For footings poured on a clean undisturbed grade, the total settlement under this loading is not expected to exceed one inch, and most of it will occur immediately as the loads are applied. The corresponding differential settlement is not likely to exceed 3/4 inch.

While the use of a spread footing design is recommended, it is most important that proper dewatering procedures should be used. There would be a tendancy for the bottom of an unprotected excavation to heave or "boil" when the water

level is lowered. The development of this condition must be prevented; otherwise, excessive settlement and a weakening of the subgrade are likely to result. Dewatering can be carried out by means of well-point drainage, in which case the dewatering should precede excavation. Some difficulties might be encountered in installing the points through the gravelly silt stratum. These are not insuperable but would add to the cost. Alternatively the excavation should be carried out within a sheet pile enclosure. The piles should be driven to such a depth that the distance from the pile tips to the footing grade is equal to the distance from the footing grade to the prevailing water table. The water level can then be lowered by pumping inside the excavation from sumps dug *below* the footing grade level.

Any disturbed soil at the footing level should be removed and replaced with concrete. Recompaction is not recommended in the generally silty conditions, and vibration caused by construction procedures should be kept to a minimum.

The coefficient of friction against horizontal sliding should be taken as 0.45.

For the purpose of comparison, the use of piles will be considered briefly. This might have some enconomic advantage if the cost of dewatering is high. Timber piles of nominal 12-inch diameter designed for a working load of 20 tons would be expected to find a satisfactory set within the following levels.

	Elevation
BH. 1	845 to 840
BH. 2	851 to 846

The piles would act mainly as end-bearing members, and settlement would be negligible. The pile tips should be fitted with steel shoes to prevent damage when they are driven through the gravelly silt stratum.

V 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 Soils, 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.

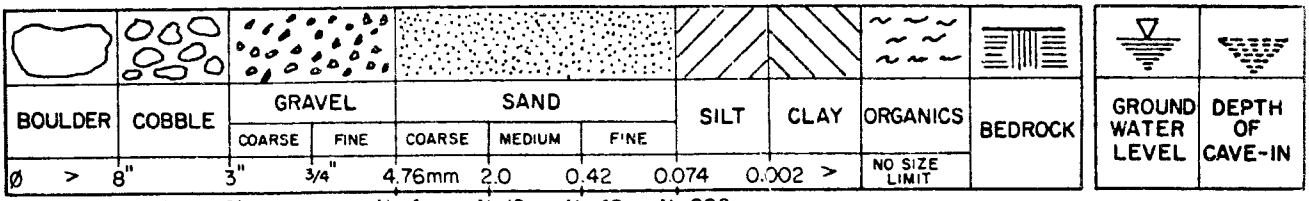
4. Terzaghi and Peck: Soil Mechanics in Engineering Practice. John Wiley and Sons, New York 1948.

DOMINION SOIL INVESTIGATION LIMITED

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

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.



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

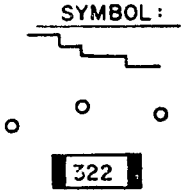
OBSERVATIONS MADE WHILE CORING: Steady pressure; No pressure; Intermittent pressure

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

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 COMPRESSION TEST ◉ St ●

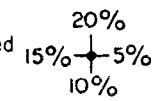
UNCONFINED TEST St

LABORATORY VANE TEST X St

FIELD VANE TEST + St

POCKET PENETROMETER TEST St

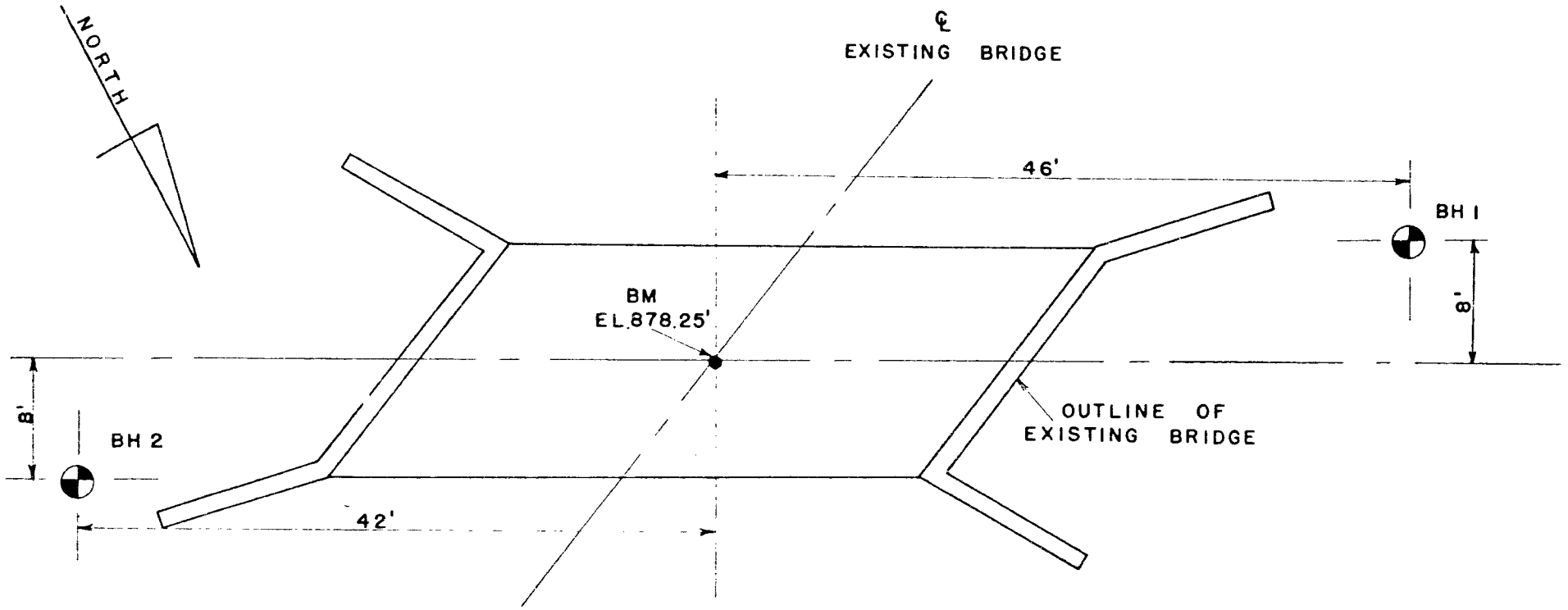
Strain at failure is represented by direction of stem



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

SOIL DESCRIPTION.

COHESIONLESS SOILS :	RD :	COHESIVE SOILS :	C lbs/sq.ft.
Very loose	0 – 15 %	Very soft	less than 250
Loose	15 – 35 %	Soft	250 – 500
Compact	35 – 65 %	Firm	500 – 1000
Dense	65 – 85 %	Stiff	1000 – 2000
Very dense	85 – 100 %	Very stiff	2000 – 4000
		Hard	over 4000

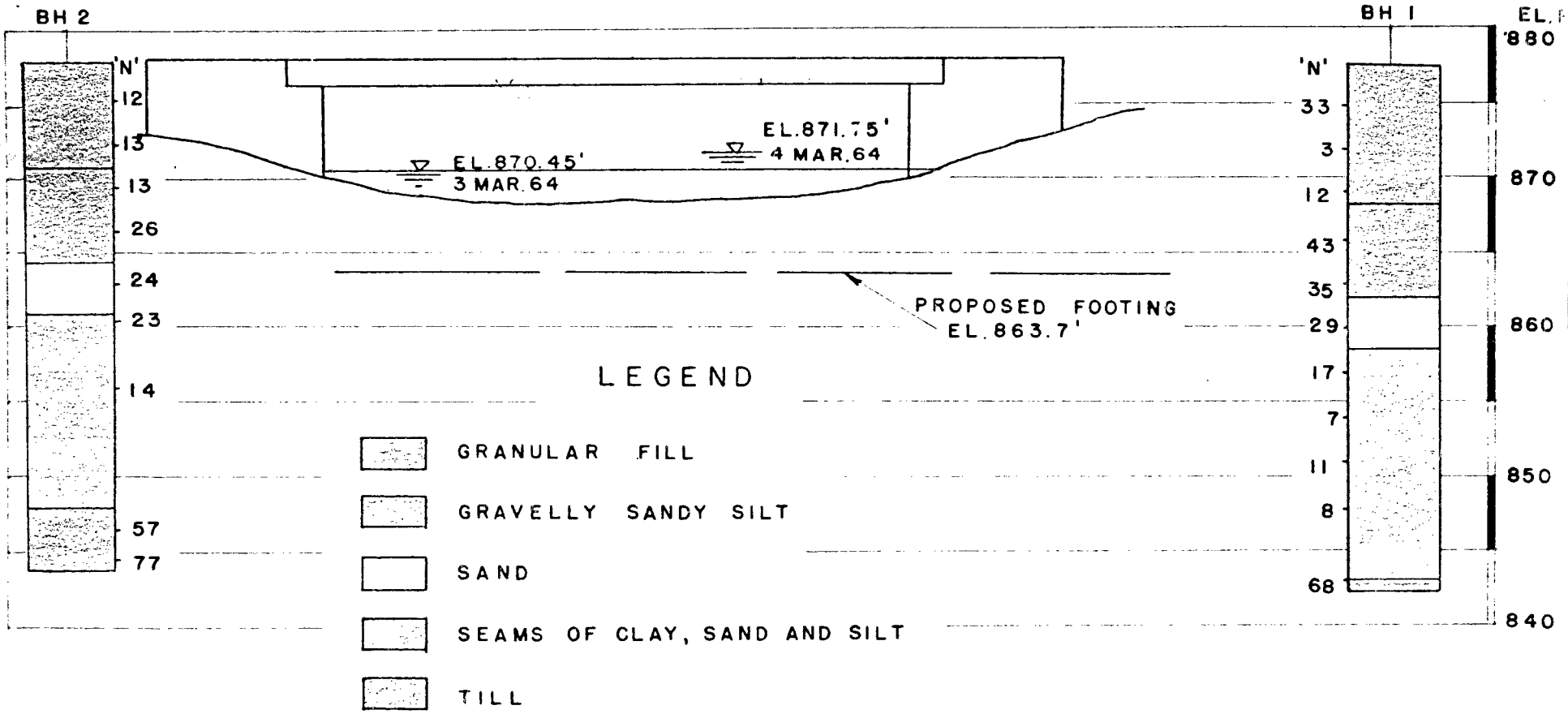


LOCATION OF BOREHOLES

SCALE: 1 INCH TO 10 FEET

BH 2

BH 1



SUBSURFACE PROFILE

SCALE: 1 INCH TO 10 FEET

OUR REF. No. 4-2-L13

DOMINION SOIL INVESTIGATION LIMITED

ENCLOSURE No. 2

GEOTECHNICAL DATA SHEET FOR BOREHOLE . 1 . . . .

OUR REFERENCE NO 4-2-L13

CLIENT Mr. B. M. Ross
PROJECT Bridge
LOCATION Lucknow
DATUM ELEVATION 875.25'(centre of existing bridge deck)

METHOD OF BORING Washboring
DIAMETER OF BOREHOLE Bx(3-inch)
DATE March 3, 1964.

ENCLOSURE NO 3

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	NUMBER	TYPE	N or Advancement of Sampler
877.4		Ground Surface			
	.5	Gravel			
875		Fine to medium clayey gravelly sand fill, trace of organics, loose to compact	1	SS	33
			2	SS	3
870			3	SS	12
	9.5	Gravelly sandy silt, few (1") seams of clayey silt, dense	4	SS	43
865			5	SS	35
	15.5	Fine to coarse sand, trace of silt and fine gravel, dense	6	SS	29
860	19.0		7	SS	17
855		Seams of brown silty clay, silt and fine silty sand, compact	8	SS	7
			9	SS	11
850			10	SS	8
845					
	34.5	Clayey gravelly silt till, very dense	11	SS	68
	35.4	End of borehole			

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

CONSISTENCY water content % PL W LL

E1.870.95' 4 Mar.,1964.

WL.in cree E1.871.75' 4 Mar.,1964

Proposed footin E1.863.7'

2" Ø cone

REMARKS

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: SB CH'D: JP

OUR REFERENCE NO 4-2-L13

GEOTECHNICAL DATA SHEET FOR BOREHOLE . 2 . . . .

CLIENT: Mr. B. M. Ross
PROJECT: Bridge
LOCATION Lucknow
DATUM ELEVATION 875.25' (centre of existing bridge deck)

METHOD OF BORING Washboring
DIAMETER OF BOREHOLE Bx (3-inch)
DATE: March 4, 1964.

ENCLOSURE NO. 4

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES N – or Advancement of Sampler	REMARKS
878.1		Ground Surface					
		Silty gravel trace of organics and sand fill, compact		1	SS	12	
				2	SS	13	
	7.6						
		Gravelly sandy silt, trace of clay, dense		3	SS	13	
				4	SS	26	
	13.5						
		Fine silty sand, dense		5	SS	24	
	17.0						
		Seams of brown silty clay, silt and fine silty sand, compact		6	SS	23	
				7	TW	p/t	
				8	SS	14	
	30.6						
		Clayey gravelly silt till, very dense		9	SS	57	
	34.0			10	SS	77	
		End of borehole					

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

CONSISTENCY
water content %
PL W LL

WL. in creek El. 871.75' 4 Mar., 1964

WL. on completion of borehole El. 872.75' 4 Mar., 1964

Proposed footing El. 863.7'

2" ϕ cone

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE SB CH'D JP