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~~37-1340C~~
37-1342C

HWY. No. 407

LOCATION Culverts for Rainbow Creek Tributary (1. Martingrove Rd. Connection 2. 407 3. Kipling Ave.)

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FILE

Ministry
of
Transportation
Ontario

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 33-89-01 DIST 6

HWY 407 STR SITE 37-1342C

Rainbow Creek Tributary Culvert
at Kipling Avenue

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GEOCRES 30M13-100 DATE APR 04 1990

FOUNDATION INVESTIGATION REPORT
For
Rainbow Creek Tributary Culvert at Kipling Avenue
Highway 407, Vaughan Township
W.P. 33-89-01, Site No. 37-1342C
District 6, Toronto

INTRODUCTION

This report summarizes the results of a foundation investigation conducted for the proposed crossing of the Rainbow Creek tributary at Sta. 10+197 Kipling Avenue. The investigation was requested by Central Region Structural Section for a proposed culvert to conduct the Rainbow Creek tributary under Kipling Avenue.

SITE DESCRIPTION

The site is located approximately 200 m South of the proposed Highway 407 and Kipling Avenue Interchange, and approximately 50 m North of the existing Canadian National Railway tracks. The area lies within Vaughan Township and the York Regional Municipality. It lies within the physiographic region known as the South Slope (after Chapman and Putnam, 1984).

The topography of the surrounding area is indicative of an earlier large river valley, with the banks of the eroded valley rising to the North of the creek. To the immediate West of the proposed culvert, a significant slope failure has occurred on the North bank of the creek. This is likely due to a combination of undermining of the slope by the creek, rainfall and snowmelt runoff, and seepage through the face of the slope. Immediately South of the culvert is the embankment of the CNR tracks, which rises between 15 m and 18 m above the level of the creek bed.

The North side of the creek is densely covered by trees, brush and grass, while South of the creek the trees and brush are less dense.

The Rainbow Creek tributary flows primarily in an easterly to northeasterly direction at the proposed crossing. The creek bed consists mainly of sand

and gravel, with cobbles and occasional boulders. Water flow in the creek is quite variable, being dependent upon the season and precipitation quantities. At the time of the investigation the depth of water in the creek was approximately 0.2 m. However, on a site visit one week after drilling, the water level was observed to have risen to approximately 0.4 m. This was a result of 3 to 4 days of exceptionally mild winter weather and a rainstorm.

The land in the surrounding area is undeveloped at the present time.

INVESTIGATION PROCEDURES

i) Field

The field investigation for the Rainbow Creek tributary culvert at Kipling Avenue was carried out between 90 02 01 and 90 02 02. A track mounted auger machine equipped with hollow stem augers was used. One borehole (BH 9) was advanced, and two dynamic cone penetration tests performed (BH's 9 and 10) by the Foundation Design Section.

At BH 9 soil samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specifications of the Standard Penetration Test (ASTM D 1586).

Original elevations and co-ordinates of BH's 9 and 10 were provided by M.T.O.'s Central Region Surveys and Plans Office.

ii) Laboratory

Laboratory testing was carried out on representative samples of BH 9 to identify and determine the physical properties of the recovered material. Tests included Grain Size Distribution, Natural Moisture Content, and Atterberg Limits. The results of these tests are plotted on the Record of Borehole sheets.

iii) Office

Since samples were recovered from only one borehole, additional information was required to accurately assess the subsurface conditions along the length of the culvert. A previous foundation investigation was conducted by B.P. Walker Associates Limited for the proposed Canadian National Railway crossing at Kipling Avenue (W.P. 88-78-26), which lies just south of the Rainbow Creek tributary. Boreholes 6, 7, and 8 from that report were advanced immediately north of the CNR embankment, and lie in the vicinity of the culvert site. Information obtained from these previously advanced boreholes has been included in this Report to provide additional subsurface information.

SUBSURFACE CONDITIONS

The Record of Borehole sheets contained in the Appendix indicate the subsurface conditions encountered at each borehole location. The locations and elevations of the boreholes, as well as a stratigraphical profile of the borehole information are presented in Drawing No. 338901-A.

Soil descriptions are based on the information gathered from the samples recovered from four boreholes, ranging in depths from 8.1 m to 27.4 m. The soil descriptions provided in the original B.P. Walker report were condensed to give a more general description of the soil, and to remain consistent with the soil descriptions of the samples recovered by this office.

Generally, the subsurface conditions were found to be uniform across the site. This typically consists of a firm to stiff cohesive layer within the top 1.2 m to 3.4 m, followed by a sand and gravel deposit that extends to the limits of these boreholes. Within this sand and gravel deposit there exists a cohesive band of approximately 3 m thickness located at depths between 5.2 m to 10.1 m.

A detailed description of each soil layer encountered follows.

Silty Clay with Sand

A firm to stiff cohesive layer of soil was encountered from ground surface to depths varying between 1.4 m and 3.4 m at each location except BH 8. This layer exhibited traces of organics throughout, as well as occasional cobbles or boulders. N values ranging from 7 to 16 were obtained within this layer.

Gravelly Sand to Silty Sand

Below the surficial cohesive layer, a non-cohesive, loose to very dense sand based deposit was encountered. At the upper limit of this layer the grading includes a large percentage of gravel. The amount of gravel appears to generally decrease with depth, with the grading exhibiting more silt particles at greater depths.

The upper boundary of this sand deposit varied between 1.4 m and 3.4 m at BH's 6, 7, and 9, while at BH 8 it began at the surface. This layer continued to the termination of all boreholes, although it was interrupted by a relatively thin cohesive layer at BH's 6, 7, and 9, further described below.

The N values of the sand layer range from 7 to well over 100 blows/0.3 m.

Heterogeneous Mixture of Sand and Silt

In boreholes 6, 7, and 9 an isolated layer of slightly cohesive to cohesive material was encountered. It consisted of silt and sand, with traces of gravel, and occasional clay zones. The upper boundary of this layer varied in depth from 5.2 m to 10.1 m, with the lower boundary varying between 6.9 m to 13.1 m. This layer was not encountered in BH 8.

It appears that this soil deposit acts to confine a large aquifer with artesian pressures present in the underlying sand layer. However, there is also evidence to indicate that artesian conditions are present above this cohesive layer, although probably not as large as those found deeper.

The deposit was hard with N values consistently greater than 85 blows/0.3 m.

GROUNDWATER CONDITIONS

During advancement of BH 9, no artesian conditions were encountered to a depth of 7.6 m, or elevation 130.6 m. However, beyond this depth, water was observed rising slowly within the borehole, suggesting the presence of a pressurized aquifer at that depth or slightly below. A bentonite seal was immediately installed, and the hole was backfilled, making determination of the natural water table impossible at that location.

At BH 10, artesian flow was encountered upon withdrawal of the drill rods after the cone test. The cone hole was sealed with bentonite and plans for augering at that location were abandoned. Although the pressure head was not specifically determined it was estimated to be 0.5 to 0.6 m above ground level, or elevation 140.5 to 140.6 m.

Boreholes 6, 7, and 8, advanced during 89 12 27 to 90 01 10 by B.P. Walker Associates, included piezometers at BH's 7 and 8. Water level checks on 90 01 23 indicated the water level of BH 7 to be at elevation 141.0 m, while at BH 8 the water was frozen within the standpipe at ground surface, elevation 140.2 m. The water level upon completion of augering of BH 6 was at the ground surface, elevation 140.7 m.

These water levels are recorded on the Record of Borehole sheets, the stratigraphical sections, and are also summarized below.

BH	Originator	Offset from culvert centreline (m)	Water level elevation (m)	Comments
6	BPW	11.2 South	140.7	open borehole
7	BPW	7.0 South	141.0	piezometer reading
8	BPW	4.5 South	140.2	piezometer reading
9	MTO	8.6 North	Undetermined	aquifer suspected at elevation 130.3 m
10	MTO	7.5 North	140.6	estimated artesian level

DISCUSSION

It is proposed to construct a 6.0 m x 2.75 m concrete box culvert for the Kipling Avenue crossing of the Rainbow Creek tributary. This culvert forms a 25° counterclockwise skew with Kipling Avenue, and is 80 m in length. At the centreline of the proposed culvert, the top of pavement grade of Kipling Avenue is set at 148.2 m. The invert elevations of the proposed culvert are 140.3 m at the upstream (West) end, and 137.6 m at the downstream (East) end.

RECOMMENDATIONS

Structure Foundations

The subsurface material was found to be suitable for spread footing foundations. However, the soil conditions at the proposed invert elevations will not adequately support the culvert and fill material. Therefore, it is recommended that the unsuitable material be sub-excavated to the following elevations:

Culvert Inlet	139.0 m
Culvert Mid-span	138.5 m
Culvert Outlet	137.0 m

Sub-excavation depths between these points should be interpolated such that a continuous profile grade is maintained. For details of the the sub-excavation refer to Figure 3.

The exposed sub-excavated base should be proof-rolled to level any soft pockets. The sub-excavated material should be backfilled with compacted Granular 'A' to the proposed base of footing elevations.

The recommended bearing capacities for the culvert founded on a Granular 'A' pad, as per the O.H.B.D.C., are as follows:

Factored Bearing Capacity at U.L.S.	525 kPa
Bearing Capacity at S.L.S. Type II	200 kPa

Artesian conditions are present intermittently throughout the site. The shallowest depth at which these conditions were encountered was typically 4.3 m below the ground surface. The Contract documents should indicate this condition and the Contractor advised that he should avoid penetration into any artesian layer during excavation. In effect, the sub-excavation should not proceed below the elevations specified above, as this may result in disturbance of the founding soil.

The culvert footing should be constructed in the 'dry'. The natural ground water table can be considered to be at, or very near the ground surface across the site. Therefore, some type of dewatering scheme must be employed to lower the water table to a recommended 0.5 m minimum depth below the bottom of excavation. While the details of the dewatering scheme are the responsibility of the Contractor, one of the following two systems would probably be effective:

a) an oversize excavation utilizing perimeter ditches or drains, combined with a pump at the low end, or

b) a well point system.

Provision should be made for diversion of the creek during culvert construction.

It is recommended that excavation begin at the downstream end and proceed in the upstream direction to facilitate drainage. It is suggested that a pilot trench be incorporated in the excavation.

The slopes to the temporary excavation should be maintained at 1.5H:1V or flatter.

Backfill

Backfill to the culvert should be placed in accordance with OPSD 803.03. Backfill should consist of Granular 'A' or Granular 'B' having the following properties:

	φ	γ
Granular 'A'	35°	22.8 kN/m^3
Granular 'B'	30°	21.2 kN/m^3

Native material may be used as backfill and fill material above the elevation specified in the OPSD for backfill.

The backfill should be placed simultaneously on both sides of the culvert such that the maximum difference in backfill heights does not exceed 300 mm. In addition, the backfill should be placed in lifts not exceeding 300 mm in thickness.

Slope Stability

To achieve the profile grade of Kipling Avenue, fill heights of up to 9.5 m± are required in the vicinity of the culvert. Prior to placement of the fill, all surficial organic material should be removed under the plan limits of the embankments. The sub-excavation should not exceed the depth of the proposed culvert excavation because of the concerns with artesian conditions. The exposed excavation base should be proof rolled prior to placement of fill material. The sub-excavated material should be replaced with compacted granular backfill.

Because the subsurface conditions at this site are similar to those encountered during the investigation for the Kipling Avenue Overpass, the results of the Total Stress Analysis performed at the latter site were applied at the culvert site. No slope stability problems are anticipated provided that 2H:1V slopes are maintained and that a mid-height berm be incorporated where fill heights exceed 6.0 m. The berm width increases with the height of fill as charted in Figure 1. The berms may run out as quickly as is feasible in the area beyond which they are required for stability. If required, the culvert should be lengthened to accomodate any berms.

To protect the Kipling Avenue embankments from erosion, the slopes should be treated with a 600 mm granular blanket to the potential high water level approxiamte El. 143.6 m (as per Marshall Macklin Monaghan memo to Central Region Planning and Design dated 89 11 13). The granular blanket is not required if the embankment fill is composed of granular material. In addition, slope vegetation should be established as soon as possible after placement of the fill in order to control surficial erosion.

Refer to Figure 2 for a typical section of the slope geometry and treatment.

Settlement

Because of the extensive fills proposed at this site, it is possible that there will be minor settlement within the subsoil and also within the embankment fill. To compensate for anticipated settlements the culvert should be constructed with a 150 mm mid-span camber, with an articulated joint (Figure 3).

Culvert Treatment

A seal of cohesive material with a minimum thickness of 600 mm is recommended at the culvert inlet. The seal should comply with the requirements outlined in Form 1205 'Material Specification for Clay Seal'. It should extend over the backfill to the culvert from the projected high water level down to the creek bed and 3.0 m along the creek bed. Transversely, the seal should extend 3.0 m on either side of the culvert, and be placed under any granular blanket required for slope treatment. The clay seal should be overlain by a 600 mm thickness of rock protection to control surficial erosion.

The culvert outlet should be treated with rock protection as per OPSD 810.01 Type A.

MISCELLANEOUS

The fieldwork for the investigation conducted by the Foundation Design Section was carried out by C. Curtis, Trainee Engineer and K. Ahmad, Foundation Engineer. The equipment was owned and operated by Master Soil Investigation Limited of Toronto.

The report was prepared by Mr. C. Curtis and Ms. B. Bennett, Foundation Engineer, under the general supervision of Mr. D. Dundas, Sr. Foundation Engineer. The report was reviewed by Mr. D. Dundas and approved by Mr. M. Devata, Chief Foundation Engineer.

C. Curtis
Trainee Engineer

M.S. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_p$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE

e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No 6 1 OF 2 METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 846 841.6 , E 297 375.0 ORIGINATED BY B.P.W.

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test, SS Auger, HS Auger COMPILED BY CC

DATUM Geodetic DATE 89 12 27/28 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.7	Ground Surface						
0.0	occasional Boulders						
			1	SS	16		
	Silty Clay with Sand Firm to Stiff		2	SS	7		
	Trace Organics		3	SS	11		
137.3			4	SS	11		
3.4	Gravelly Sand to Silty Sand Trace Clay Compact to Very Dense		5	SS	15		10 86 (4)
			6	SS	90		
132.5			7	SS	82	/28cm	
8.2	Het. Mix. of Sand and Silt Trace Gravel occ. Clayey Zones Hard		8	SS	117		
129.4			9	SS	75	/15cm	4 58 32 6
11.3	Gravelly Sand to Silty Sand Trace Clay Dense to Very Dense		10	SS	49		
125.5			11	SS	85	/15cm	14 78 (8)
15.2	Continued						

ELEVATION SCALE: 140, 139, 138, 137, 136, 135, 134, 133, 132, 131, 130, 129, 128, 127, 126

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa 20 40 60 80 100
- o UNCONFINED
- + FIELD VANE
- ● QUICK TRIAXIAL
- × LAB VANE

136

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m^3

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 6 2 OF 2 METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 846 841.6 , E 297 375.0 ORIGINATED BY B.P.W.

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test, SS Auger, HS Auger COMPILED BY CC

DATUM Geodetic DATE 89 12 27/28 CHECKED BY DD

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
125.5	Continued									
15.2	Gravelly Sand to Silty Sand Trace Clay Very Dense		12	SS	112	/23cm	125 124 123			
			13	SS	87					
122.3			14	SS	100	/13cm				34 57 (9)
18.4	End of Borehole									

** Note
This Borehole information originally contained in report for W.P. 88-78-26 by B.P. Walker Associates

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 — 1 OF 2 — METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 846 833.0 , E 297 359.4 ORIGINATED BY B.P.W.

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test, HS Auger COMPILED BY CC

DATUM Geodetic DATE 90 01 09/10 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.7	Ground Surface										
0.0	Silty Clay with Sand Stiff occasional Boulders		1	SS	8		140	AUGER			
139.2			2	SS	7		139				
1.5			3	SS	35		138				
			4	SS	120	/28cm	137	100/ 25cm			
	Gravelly Sand to Silty Sand Trace Clay Loose to Very Dense		5	SS	96		136				10 76 5 9
			6	SS	92		135				22 54 21 3
			7	SS	53		134				
			8	SS	79		133				
130.6							132				
10.1	Het. Mix. of Sand and Silt Trace Gravel occ. Clayey Zones Hard		9	SS	87	/15cm	131				
			10	SS	91	PI	130				1 27 69 3
127.6							129				
13.1	Gravelly Sand to Silty Sand Trace Clay Very Dense		11	SS	83	/15cm	128				
125.5							127				
15.2							126				

Continued

$+^3$, $\times^5$; Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 7 2 OF 2 METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 848 833.0 , E 297 359.4 ORIGINATED BY B.P.W.

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test, HS Auger COMPILED BY CC

DATUM Geodetic DATE 90 01 09/10 CHECKED BY DD

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
125.5	Continued										
15.2	Gravelly Sand to Silty Sand Trace Clay Very Dense		12	SS	89	/15cm	125				
123.8			13	SS	100	/15cm	124				1 59 40 0
16.9	End of Borehole										

** Note
This Borehole information originally contained in report for W.P. 88-78-26 by B.P. Walker Associates

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	141.0

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 2 METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 846 826.2 , E 297 348.2 ORIGINATED BY B.P.W.

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test, HS Auger, BX Casing COMPILED BY CC

DATUM Geodetic DATE 90 01 02/09 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.2	Ground Surface									
0.0	occasional Boulders						140			
			1	SS	10		139	AUGER		
			2	SS	87		138	100/15cm		7 61 24 8
			3	SS	53		137			
			4	SS	98	P1	136			
	Gravelly Sand to Silty Sand Trace Clay Loose to Very Dense		5	SS	77		135			
			6	SS	105		134			
			7	SS	80	/13cm	133			
			8	SS	120		132			40 50 7 3
			9	SS	103	/26cm	131			0 51 46 3
			10	SS	91		130			
125.0 / 15.2	Continued						129			
							128			
							127			
							126			
							125			

Continued

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8 2 OF 2 METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 846 826.2 , E 297 348.2 ORIGINATED BY B.P.W.

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test, HS Auger, BX Casing COMPILED BY CC

DATUM Geodetic DATE 90 01 02/09 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
125.0 / 15.2	Continued		11	SS	89		124				
			12	SS	74	/15cm	123				
			13	SS	148	/26cm	122				
			14	SS	86	/15cm	121				
			15	SS	166	/15cm	120				
	Gravelly Sand to Silty Sand Trace Clay Loose to Very Dense						119				34 52 11 3
			16	SS	110	/15cm	118				
			17	SS	80	/5cm	117				
							116				8 47 41 4
			18	SS	114	/15cm	115				
							114				
112.7			19	SS	100	/3cm	113				
27.5	End of Borehole										

** Note
This Borehole information originally contained in report for W.P. 88-78-26 by B.P. Walker Associates

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	140.2

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9 — 1 OF 1 — METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 846 879.6 , E 297 387.4 ORIGINATED BY KA, CC

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test, HS Auger COMPILED BY CC

DATUM Geodetic DATE 90-02-01/02 CHECKED BY DD

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
136.2	Ground Surface							
0.0	Silty Clay with Sand							
	Firm							
	Trace Organics		1	SS	7	▽		
136.8							137	
1.4			2	SS	19			
							136	
			3	SS	20			38 54 (8)
	Gravelly Sand to Silty Sand							
	Trace Clay		4	SS	29		135	
	Compact to Dense							
			5	SS	38		134	
			6	SS	38			21 71 7 1
133.0							133	
5.2	Het. Mix. of Sand and Silt		7	SS	106	/28cm		3 37 47 13
	Trace Gravel							
	occ. Clayey Zones		8	SS	84	/28cm	132	
	Hard							
131.3								
6.9	Gravelly Sand to Silty Sand						131	
	Trace Clay							
130.1	Dense		9	SS	42			4 46 (50)
8.1	End of Borehole							

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

SHEAR STRENGTH kPa — o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) — 10 20 30

UNIT WEIGHT γ kN/m³

120/28cm

▲ Estimated level of water table is 0.8 m
Artesian conditions suspected at approx. 7.5 m

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 33-89-01 LOCATION Co-ords. N 4 846 861.6 , E 297 369.6 ORIGINATED BY KA

DIST 6 HWY Kipling Ave. BOREHOLE TYPE Cone Test COMPILED BY CC

DATUM Geodetic DATE 90 02 02 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS*	ELEVATION SCALE
140.0	Ground Surface						
0.0	Probable Silty Clay with Sand						139
138.5							138
1.5	Probable Gravelly Sand to Silty Sand Trace Clay						137
135.7							136
4.3	End of Cone Test						135
							134
							133
							132
							131
							130
							129
							128
							127

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

120/ 18cm

* Artesian conditions encountered during cone test, estimated head is 0.5 - 0.6 m above ground surface

$+^3$, $\times^5$; Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

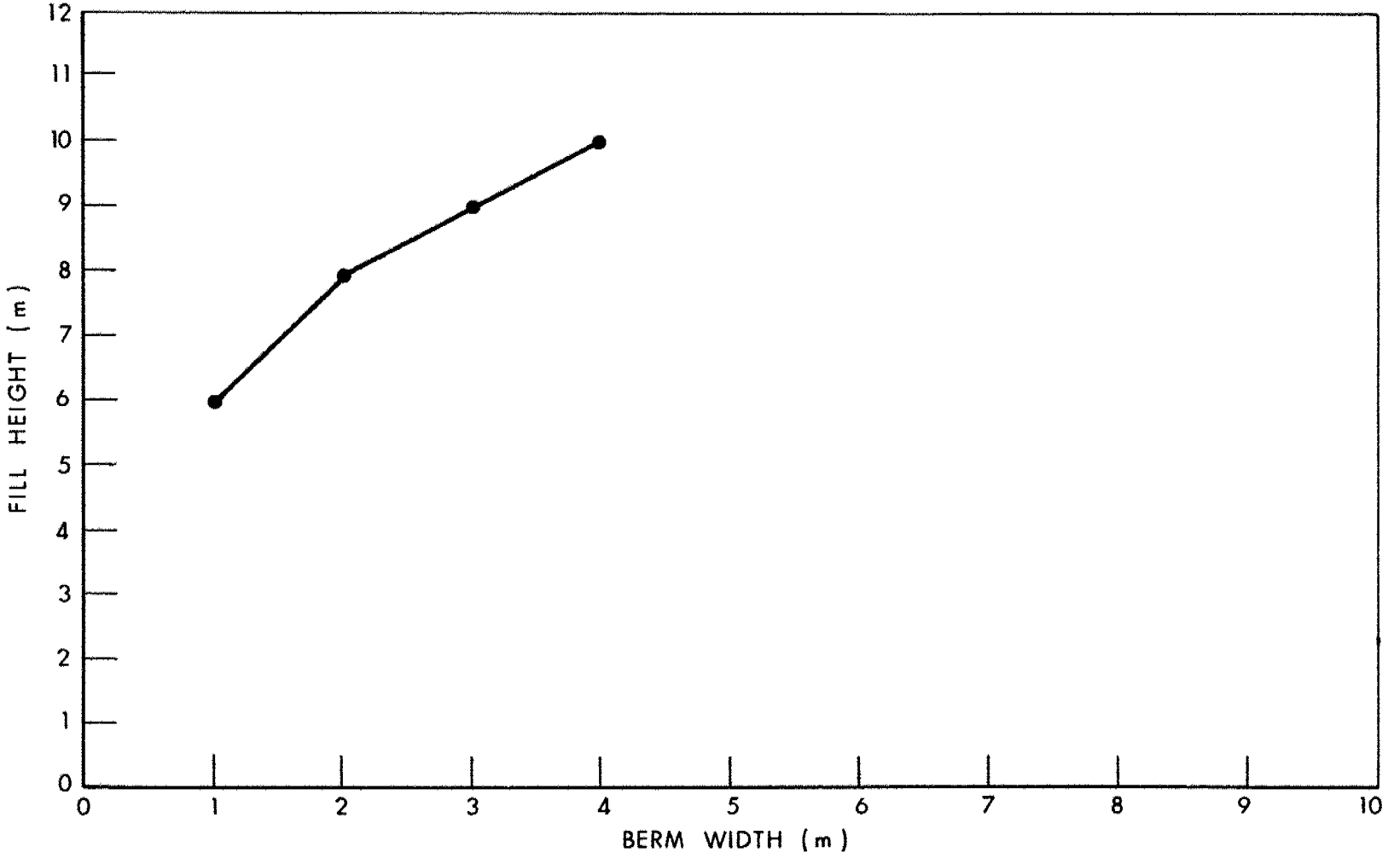
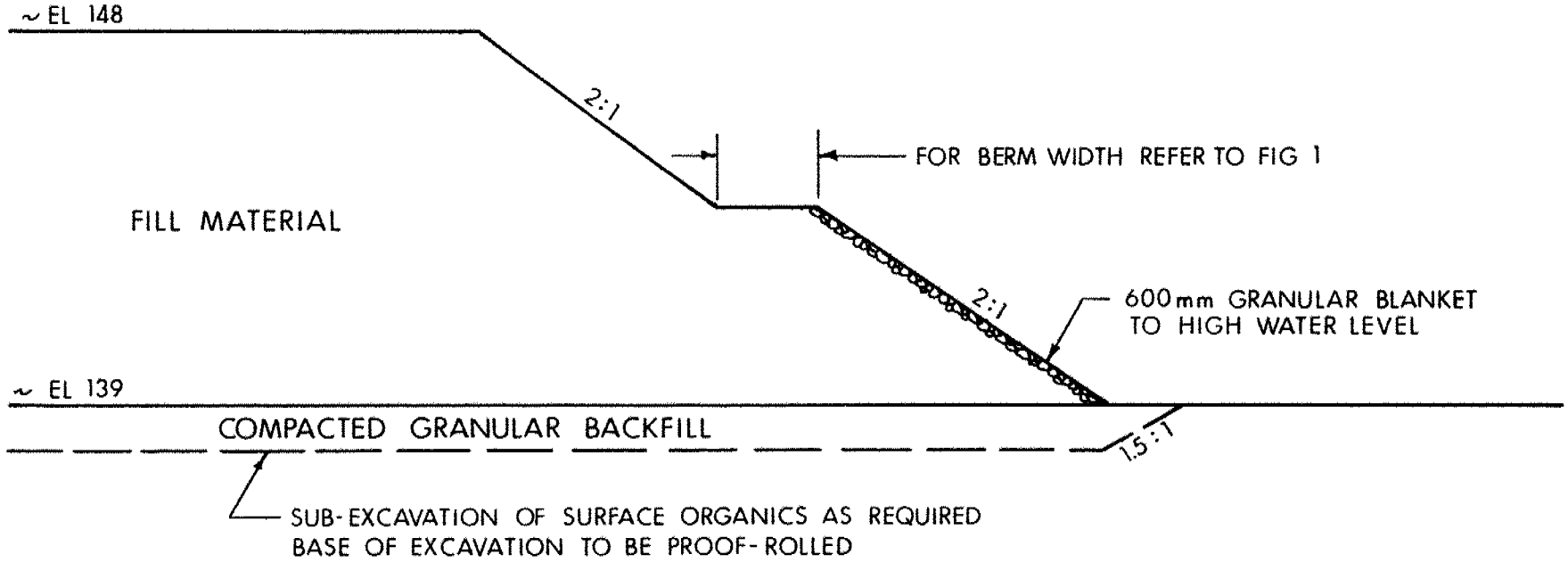


FIG 1 - FILL HEIGHT versus BERM WIDTH

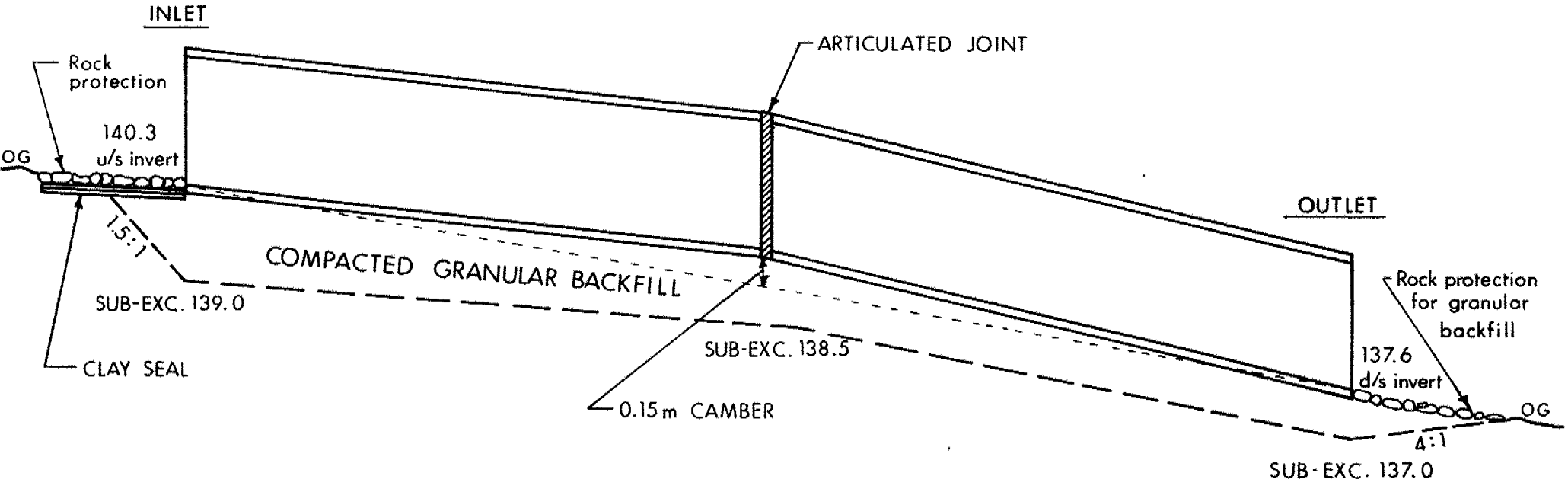
WP 33-89-01



NTS

FIG 2 - SLOPE GEOMETRY AND TREATMENT

WP 33-89-01



NTS

FIG 3 - CULVERT PROFILE
SUB-EXCAVATION AND MID-SPAN CAMBER CONSTRUCTION

WP 33-89-01

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 88 10

METRIC

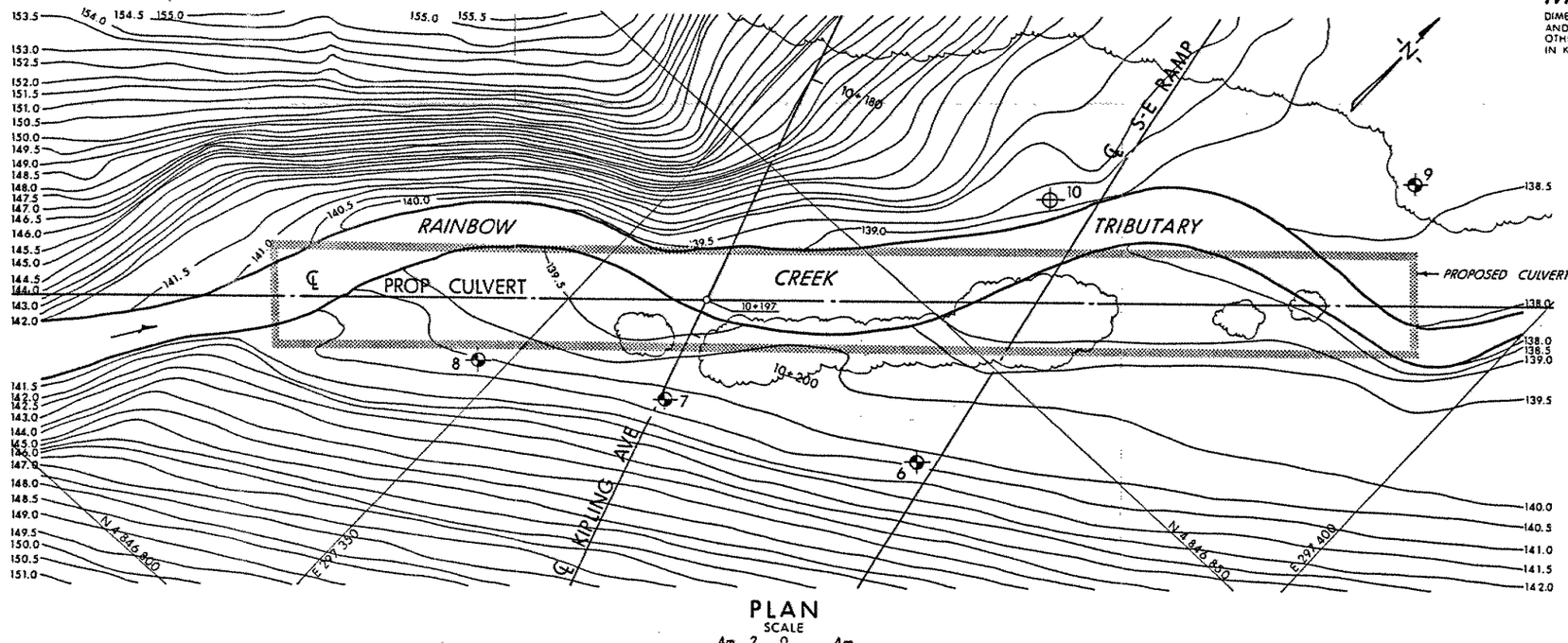
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 33-89-01

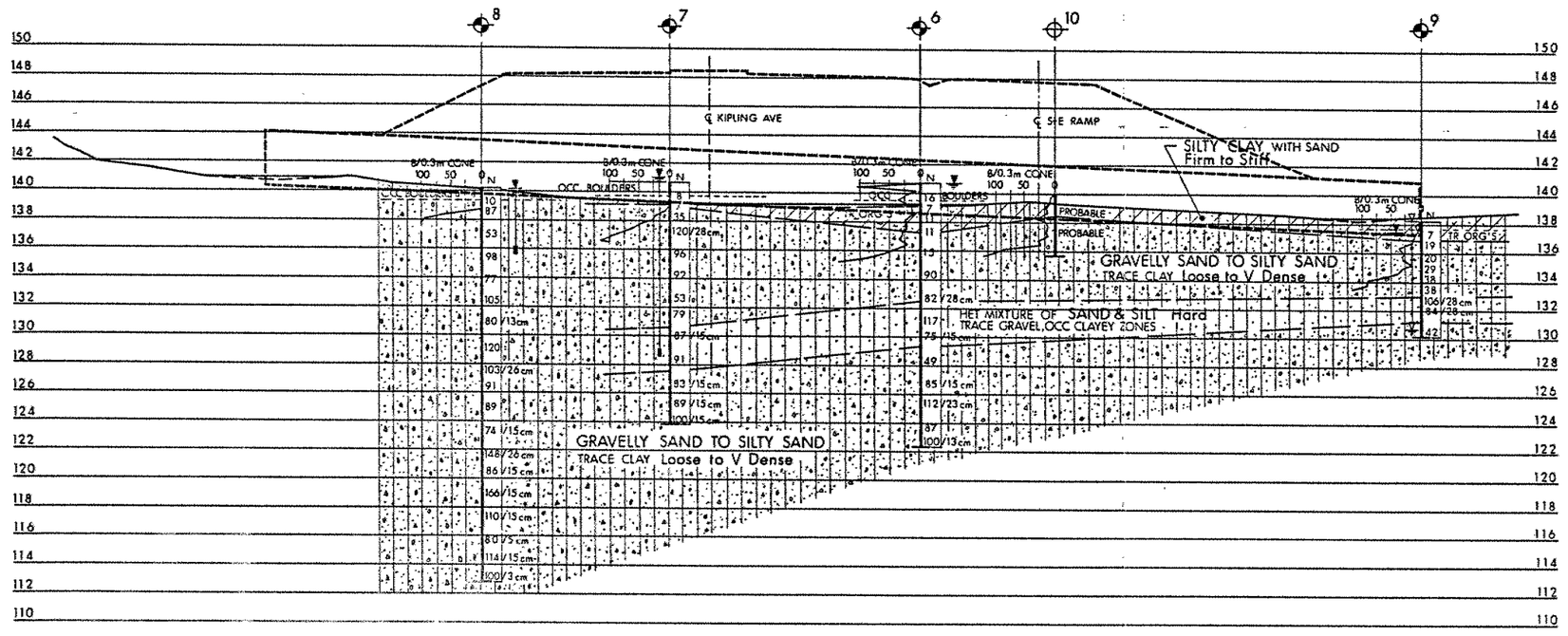
RAINBOW CR TRIBUTARY CULVERT AT KIPLING AVE

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

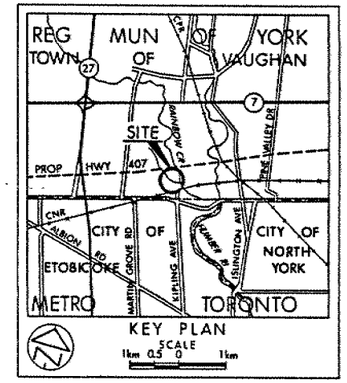


PLAN
SCALE
4m 2 0 4m



℄ PROFILE PROP CULVERT

SCALE
4m 2 0 4m



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 8912 & 9001
- WL in piezometer
- Head Encountered — Artesian condition

No	ELEVATION	CO-ORDINATES NORTH	EAST
6	140.7	4 846 841.6	297 375.0
7	140.7	4 846 833.0	297 359.4
8	140.2	4 846 826.2	297 348.2
9	138.2	4 846 879.6	297 387.4
10	140.0	4 846 861.6	297 369.6

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 30M13-100

HWY No 407		DIST 6
SUBM'D BB	CHECKED	DATE 1990 03 28	SITE 37-1342C
DRAWN SO	CHECKED	APPROVED	DWG 338901-A

REF NO E-73-407-14 1989 07