

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 31C-149

DIST. 8 REGION

W.P. No. 1602-86-00

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 509

LOCATION CLARENDON SWAMP

NEAR CLARENDON STATION

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry
of
Transportation

FILE COPY

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 1602-86-00 DIST 8

HWY 509 STR SITE N/A

Clarendon Swamp - Highway 509

DISTRIBUTION

E.C. Lane (2)
S. Cheng
D.J. Kimmett (2)
D. Hogg (2)
K.G. Bassi
S.J. Dunham
E.A. Joseph
T.A. Kickey (Cover Only)
I. Bullen (Cover Only)
File ✓

FOUNDATION INVESTIGATION REPORT

For

Clarendon Swamp - Highway 509

W.P. 1602-86-00, Site No. N/A

District 8, Kingston

INTRODUCTION

This report presents the results of a foundation investigation carried out for the re-construction of a portion of Highway 509 which is constructed on a swamp and has experienced continuing maintenance problems and in some instances flooding, due to settlement.

SITE DESCRIPTION

The site is located at Highway 509, approximately 8 km north of Highway 7. The length of the highway under investigation is about 360 m (between Stations 12+000 and 12+360). At this location, the grade of the highway is often only marginally above the surrounding swamp.

There are rock outcrops on the immediately southeast side of the site. At the site, the north and south portions of the road are about 1.5 m higher than in the centre (Station 12+210 m) portion. There are swamps on the east and west sides of this section of Highway 509.

The site lies within the physiographic region known as the Algonquin Highlands. The area is described to be underlain by granite and other hard precambrian rocks. There are frequent outcrops of bare rock which amount to less than 5 percent of the total area. The soils are generally shallow but thickness over the bedrock varies greatly over short distances. Many of the valleys are floored with outwash sand and gravel. There are frequent swamps and bogs in hollows. (Reference: Chapman and Putnam, 'The Physiography of Southern Ontario; 3rd Edition, 1984).

INVESTIGATION PROCEDURES

A subsurface investigation was conducted between 90 07 31 and 90 08 08 at this site. A continuous flight auger machine equipped with 82 mm I.D. hollow-stem

augers was used to advance the boreholes. The investigation consisted of drilling eleven (11) boreholes. Soil samples were collected from each borehole. The boreholes were stopped either at a practical refusal (possibly bedrock) or they were terminated within non-cohesive material after information about overlying peat or any clay deposits had been obtained. The boreholes were supplemented by conducting dynamic cone penetration tests at 6 locations.

The boreholes are identified as BH 1 through BH 11. The results are presented in the Record of Borehole sheets (attached in the Appendix).

The sampling program consisted of split spoon supplemented with thin wall samples (shelby tubes). The Standard Penetration tests 'N' values were used for the assessment of the in situ state of compaction and also provided material for identification and testing. The thin wall samples provided relatively undisturbed samples for testing of the cohesive materials.

The boreholes were advanced to depths ranging from 2.9 m to 18.7 m. Information obtained from the Field Vane tests were used to determine the shear strength and sensitivity of the cohesive material.

Groundwater was monitored in the open boreholes.

The laboratory testing program for representative samples consisted of:

- 1) Grain Size Analyses
- 2) Atterberg Limit Analyses
- 3) Natural Moisture Content Determination, and
- 4) Unit Weight Determination

Survey details, such as borehole locations and ground surface elevation at each borehole location were interpolated from a plan provided by the Eastern Region, Geotechnical Section. The elevations given in this report are geodetic.

SUBSURFACE CONDITIONS

The Record of Borehole sheets in the Appendix (BH 1 to BH 11) illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 16028600-A.

The boreholes were drilled at the shoulders of Highway 509 in a zigzag pattern to maximize site coverage. The surficial material consists of gravelly sand to sand which ranged in thickness from 1.4 m to 3.7 m and is part of the pavement structure. The gravelly sand was generally underlain by a dark brown to black peat with occasional wood fragments. The peat deposit was found to be 1.5 m to 2.6 m thick with average thickness of 1.9 m. However, in BH 5 through BH 8 (central portion of the swamp along the highway alignment) a deposit of sawdust up to 4.3 m thick was discovered between the surficial gravelly sand and underlying peat deposit. The thickness of sawdust varied from 0.7 m to 4.3 m. The thickest sawdust was encountered near the centre of the road over the swamp (Station 12+210). The peat deposit was generally underlain by a silty sand to gravelly sand deposit. However, at some locations a deposit of silty clay (up to 6.1 m thick) or marl (up to 1.5 m thick) was encountered between the peat and silty sand deposit.

All boreholes, except BH's 6 and 7 were terminated within silty sand to sandy silt deposit or gravelly sand deposit. BH's 6 and 7 met practical refusal at depths 16.9 m and 12.6 m respectively and were terminated at probable bedrock surface.

Following are the detailed descriptions of the soil strata encountered.

Fill

A non-cohesive layer of fill material which consisted of gravelly sand to coarse sand was encountered in all boreholes. It is expected that the deposit was mainly a granular material and was placed for the construction of the highway. This layer ranged in thickness from 1.4 m to 3.7 m. The Standard Penetration test 'N' values ranged from 2 to more than 60 blows/0.3 m. Generally, the penetration resistance ranged from 10 blows to 30 blows/0.3 m, which indicates that the deposit is in a compact state.

Sawdust

A non-cohesive layer of sawdust, which consisted of wood fines and wood chips was encountered in BH's 5, 6, 7 and 8 (the central portion of swamp along the Highway 509 alignment). At BH 5 the sawdust was mixed with the underlying peat deposit (overall thickness of sawdust and peat deposit at BH 5 was 5.6 m) and it was difficult to estimate the exact thicknesses of sawdust and peat at this location. The overall thickness of sawdust ranged from 0.7 m to more than 4.3 m.

The Standard Penetration test 'N' values in the sawdust deposit ranged from 1 to 25 blows/0.3 m.

Peat

A slightly cohesive deposit of peat was encountered in all boreholes. This deposit was 1.5 m to 2.6 m thick and was situated below elevations ranging from 224.0 m to 230.2 m. This deposit consisted of dark brown to black decomposed vegetation. The Standard Penetration test conducted within this deposit determined 'N' values ranging from 1 to 6 blows/0.3 m. Occasional field vane tests were also performed within this deposit. Due to the fibrous nature of the peat, the information obtained in the vane tests was considered to be higher than the actual shear strength. It was therefore, estimated that the peat deposit is in soft to firm state.

Moisture content was determined on eight samples and was found to be ranging from 250 percent to 666 percent, with average moisture content at 450 percent.

Silty Clay to Clayey Silt and Marl

This cohesive deposit was underlying the peat deposit and was encountered in BH's 3, 4, 6, 7 and 11. The top elevation of this deposit ranged from 221.9 m (BH 6) to 231.0 m (BH 11). The layer thickness varied from 1.1 m (BH 11) to 6.1 m (BH 6). At BH 4 and 7 the peat deposit was underlain by marl instead of silty clay to clayey silt. The marl consisted of white silty clay mixed with shells.

The Standard Penetration test 'N' values in this deposit ranged from 0 to 7 blows/0.3 m. The field vane was used to determine the in situ undrained shear strength of the soil. Based on the result of field vane and 'N' values, the consistency of this deposit is soft to firm. Typical properties of the material, as determined by laboratory tests of representative samples from the boreholes, are summarized as follows:

	Range	Average
	<u>(%)</u>	<u>(%)</u>
Natural Moisture Content (w)	25-53	35
Liquid Limit (w _p)	23-40	25
Plastic Limit (w _L)	15-28	17
Plasticity Index (I _p)	7-16	11

Unit Weight was determined on one sample and found to be 17.1 kN/m³

Silty Sand to Sandy Silt

This non-cohesive stratum underlies the silty clay to clayey silt stratum. This layer was encountered in all boreholes except BH 9. The top elevation of this material ranged from 215.8 m (BH 6) to 229.9 m (BH 11). Most of the boreholes were terminated in this stratum. The thickness of this layer, at most of the boreholes was therefore, undetermined. At the few boreholes (BH's 4, 5, 7 and 11) where the boreholes penetrated the entire thickness of this material, the thickness ranged from 1.2 m to 9.2 m.

The Standard Penetration test 'N' values in this deposit ranged from 0 to more than 100 blows/0.3 m. The low penetration value is possibly due to an unbalanced hydrostatic condition. Based on the average 'N' value it is concluded that the material is in a compact to dense state.

Gravelly Sand

This non-cohesive stratum was found underlying silty sand to sandy silt stratum and was encountered in BH's 4, 5 and 11 only. These boreholes were terminated in this layer and the thickness of this layer remained undetermined. The top

elevation of this material ranged from 212.9 m (BH 5) to 228.7 m (BH 11). The Standard Penetration test 'N' values in this deposit ranged from 21 to more than 60 blows/0.3 m which suggested that the material is in a compact to dense state.

GROUNDWATER

The groundwater was measured in open boreholes. Generally, the groundwater in the borehole was found to be matching with the adjacent stagnant water in the swamp (beside the shoulders). The groundwater therefore, is within 0.5 m to 1.0 m below the surface of the pavement shoulder.

It should be noted that groundwater levels are subject to seasonal fluctuations and may therefore, change from what is described here.

DISCUSSION

It is proposed to repair or reconstruct a portion of existing Hwy. 509. This portion of Hwy. 509, which is constructed on a swamp, is located about 8 km north of Hwy. 7. The stretch of the highway under study is about 360 m long and lies between Stations 12+000 and 12+360.

It is understood that this portion of the Hwy. 509 (built on swamp) was constructed in the early 1960's. This portion of the highway experienced settlement and distress due to consolidation of weak and compressible peat and silty clay deposits, and therefore, several subsurface investigations and monitoring programs were carried out in the past by others and subsequently this portion of the highway was treated several times by utilizing several methods, including the placing sawdust as a light weight fill, in late 1960's.

The problem of settlement, although it may not be as severe as in past still exists. It is understood that in the spring thaw period or during heavy rainfall the pavement is flooded.

Our present subsurface investigation has confirmed the findings of the previous investigations which discovered the presence of soft compressible layers which led to maintenance requirement for settlement. There are a number of solutions to control this problem which will require evaluation on a cost benefit basis. Some of our proposals may require temporary closing of this portion of Hwy. 509. We have been advised by the Planning and Design Section of Eastern Region, that an old gravel road exists on the east side of the site which can be used as a detour with some minor improvements.

RECOMMENDATIONS

The following alternatives are recommended for the repair or reconstruction of the existing Hwy. 509, between Station 12+000 and 12+360.

Some of the solutions are long term solutions and will eliminate or minimize maintenance requirements, and some are short term solutions that will require

constant maintenance. The choice of alternative will depend on the required performance level for the highway and the relative costs (including maintenance).

The following alternatives are presented in order from least to most in terms of expense. The effectiveness of each alternative is discussed in summary.

Alternative No. 1

The road can be maintained by periodically repadding to keep it above the swamp. In this method, no significant improvement in the performance of the road over its present level is anticipated. It is however, expected that the rate of settlement will reduce over time.

Alternative No. 2

An approximate 1.5 m of existing roadbed material may be subexcavated and replaced with light weight backfill such as slag. The presence of sawdust under the central portion of the road indicates that in the past attempts were made to control the settlement problem by introducing light weight fill. Although, this approach was not totally ineffective, it is expected that some improvement in road performance should result.

Alternative No. 3

The existing road may be preloaded (surcharged) with 2 m of normal fill between Sta. 12+090 and 12+240 and 1 m fill in the remaining areas between Sta. 12+000 and 12+360, for as long as possible but for a minimum period of 3 months. After the surcharge is removed the excavation should be extended a further 1.5 m below the existing road surface. The removed material and the higher embankment then should be replaced by light weight fill (slag).

The surcharge load will induce extra pressure and will speed up the settlement process. When the light weight fill will be placed, the new pressure will be much smaller than the pressure that the subsoil would have experienced and therefore, future settlements will be minimized.

Alternative No. 4

Consideration may be given to constructing a corduroy road. The corduroy mat would be constructed after subexcavating to 1 m beneath the existing grade of the road.

The mat would consist of 2 layers of timber. Reference is made to Figure 1. The first layer would be parallel to the alignment with butts and tips alternating with at least 1.2 m of overlap at the log ends. These joints would be staggered. The logs would be evenly spaced (with gaps) at 0.7 m centre to centre. The second layer would be perpendicular to the alignment and placed directly on top of the first layer with butts placed along the edges of the mat, and butts and tips alternating. The tips would then be cut off to align with the butts, and the pieces would be used to fill in spaces in the mat. The logs in the second layer would be placed as tightly together as possible with little or no spacing.

The preferred timber would be delimbed spruce or equivalent with minimum butt diameters of 250 mm to 350 mm. A non-woven Class II geotextile would be placed over the timber mat, down its sides then over the swamp to the limit of deposition of an overlying granular material. A 0.3 m pad of Granular 'A' would then be placed with 2H:1V side slopes as illustrated in Figure 1. Then, while incorporating a 1 m bench on both sides of the roadway embankment an additional 0.6 m of Granular 'A' would be placed.

A modified corduroy treatment would be required at the culvert locations. A Tensar SR-2 geogrid would be placed under the culvert bedding and above the culvert corduroy mat (Figure 2). The geogrid would extend 20 m longitudinally (along the alignment) on both sides of the culvert under the roadway corduroy mat. Under the culvert, 3 layers of corduroy would be placed perpendicular to the roadway. The longitudinal logs in the first layer of the roadway corduroy mats would extend 20 m on each side of the culvert. Bedding and backfilling for the culvert would be as per OPSD 802.01 and 803.03.

During placement of the granular fill, the butt and tips of the timber mat should be monitored. Uplift of the ends may indicate failure of the underlying material in which case this office should be contacted for recommendations.

Alternative No. 5

If there was a firm bottom within 10 m of the surface, this solution could be considered as a comparatively permanent solution for any future settlement. Because of the uncertainty associated with underlying peat, sawdust, gravel and soft silty clay to clayey silt underlying the organic-material, the behaviour of the material and magnitude of the future settlement is unpredictable. Therefore, future maintenance due to settlement may still be required although very minor. However, if this alternative is considered the following steps should be followed:

Subexcavate as much of the weak and compressible material as possible (up to 8 m) and partially displace any remaining deposits with rockfill. In order to minimize post construction settlement, a surcharge would be applied by placing an additional rockfill thickness of 2 m above final grade as a rolling surcharge that would be advanced as the concurrent subexcavation/backfill operation progressed. Any mud waves that formed at the sides of the active area would be removed outside a plane of 2H:1V from the base of the subexcavation. Consideration was given to incorporating blasting to facilitate displacement. However, this option was not recommended due to concerns with the sensitivity of the underlying soils.

In our opinion Alternative No.'s 1 to 3 could be accomplished with staged construction techniques and would therefore, not require a detour. Alternative No.'s 4 and 5 would however, definitely require a detour.

Summary and Conclusions

The above-mentioned alternatives are in order from least to most in terms of expense. The choice of alternative should be based on its effectiveness. In our opinion the most effective solution is Alternative 3. Our opinion is based

on our experience at other similar sites and considering the practical aspects of the alternatives. Some of the advantages and disadvantages are as follows:

In alternative 1 the condition of the road will remain as it is at present. No significant improvement will be achieved. However, this alternative will be least expensive.

In alternative 2 although the vertical stress would be reduced but the reduction would not be substantial. Since most of the future settlement may be secondary settlement, i.e. due to decomposition of organic material, settlement may still take place and the improvement may be marginal. This alternative would be comparatively inexpensive.

Alternative 4 discusses construction of a corduroy road. Recently we experienced construction of a corduroy road in Kenora. In this method an initial settlement would be expected before the road is fully supported by the corduroy mat, and therefore, this alternative may not be appropriate for this site. In addition the road would have to be closed during construction.

Alternative 5 is considered to be an expensive alternative. Although in this method the objective of minimizing settlement may be partially achieved, due to uncertainties of the underlying material and their unpredictable behaviour, future settlement cannot be estimated. In addition during construction a detour would be required to divert the traffice.

Alternative 3 is considered to be the most feasible choice for this site. In this method the surcharge load would induce more vertical pressure than the subsoil would finally experience after the road is constructed. The excess vertical pressure would accelerate the settlement. The effectiveness of this method would be dependent on the duration of the surcharge.

It is therefore, desirable that surcharge load should be maintained for as long as possible, but not less than 3 months.

This method is also feasible because the road will be open to traffic during surcharge and traffic disruption will be minimized.

If alternative 3 is considered, Foundation Design Section would be interested in monitoring the settlement over a long period of time.

Stability and Slope Settlement

There would not be a deep seated problem if the foregoing methods are followed. We believe that the settlement at this site is due to the presence of organic deposit. Such settlement is very unpredictable. However, it is believed that much of the settlement would have already taken place during the last 30 years, and if no major changes in the grade takes place then the settlement will be minor. However, if the roadway is raised to prevent flooding, settlements will occur in proportion to the added weight.

Construction Considerations

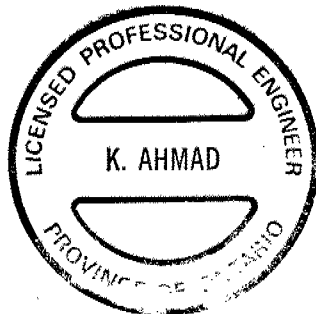
If excavation of the existing material is considered, the contractor should make sure that the excavation equipment is kept at a safe distance away from the excavation edge.

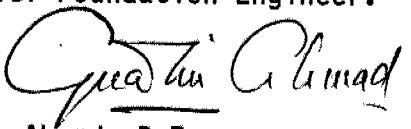
MISCELLANEOUS


The field work for this report was carried out under the supervision of Marie-Josée Roy, a summer student.

The equipment used was owned and operated by F.E. Johnston Drilling Co.

The report was written by Ken Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.




K. Ahmad, P.Eng.
Foundation 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 (RQD), 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

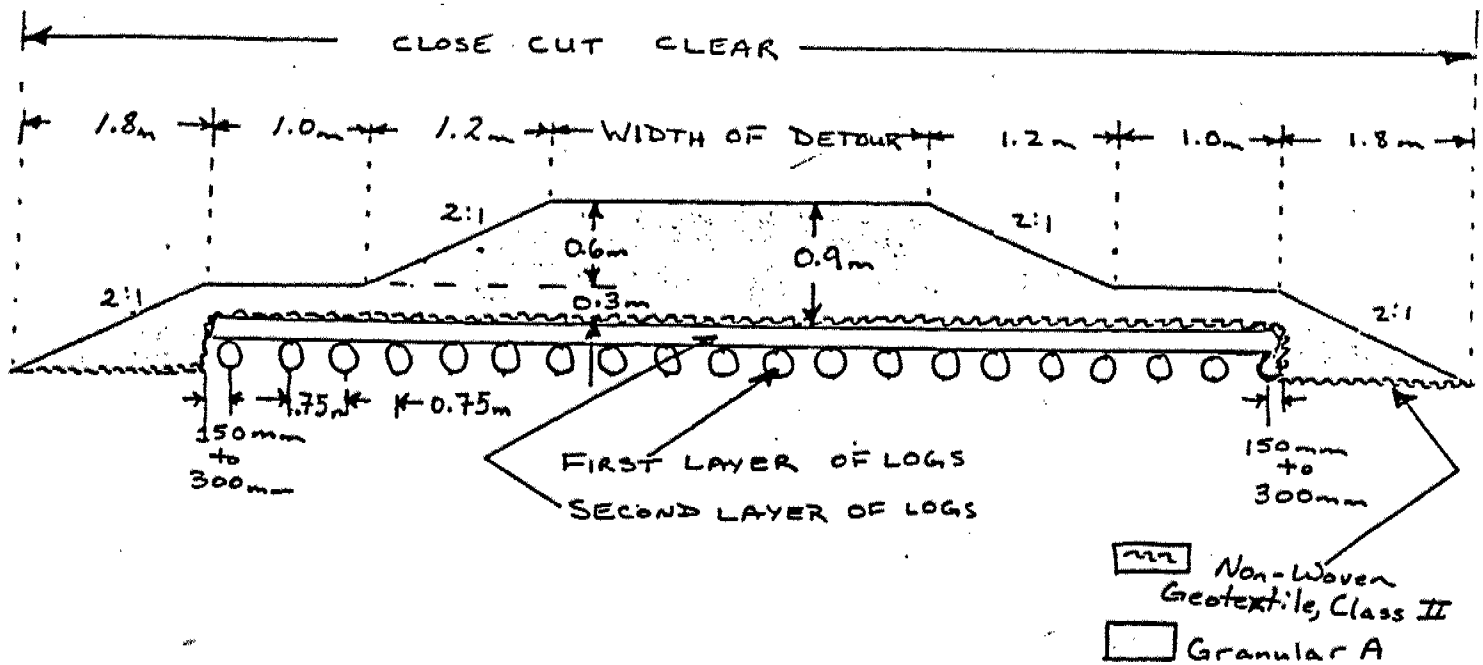
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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

MECHANICAL PROPERTIES OF SOIL

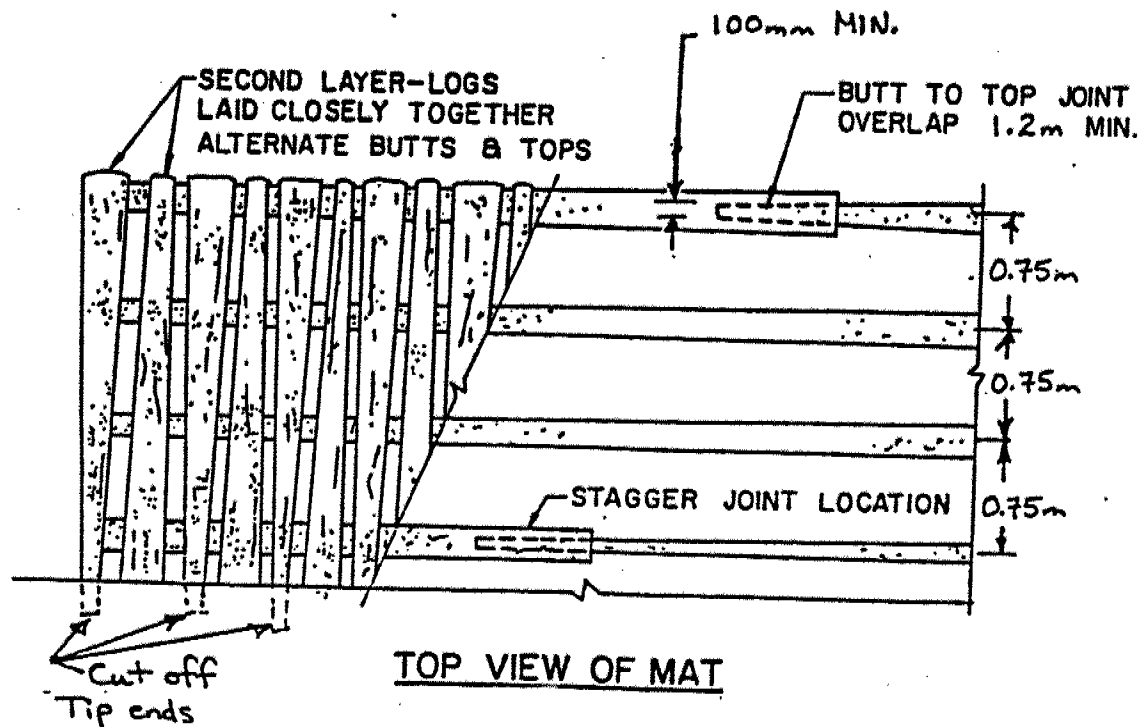
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



CROSS - SECTION



NOTE: DRAWINGS NOT TO SCALE

FIG 1 - CORDUROY TREATMENT

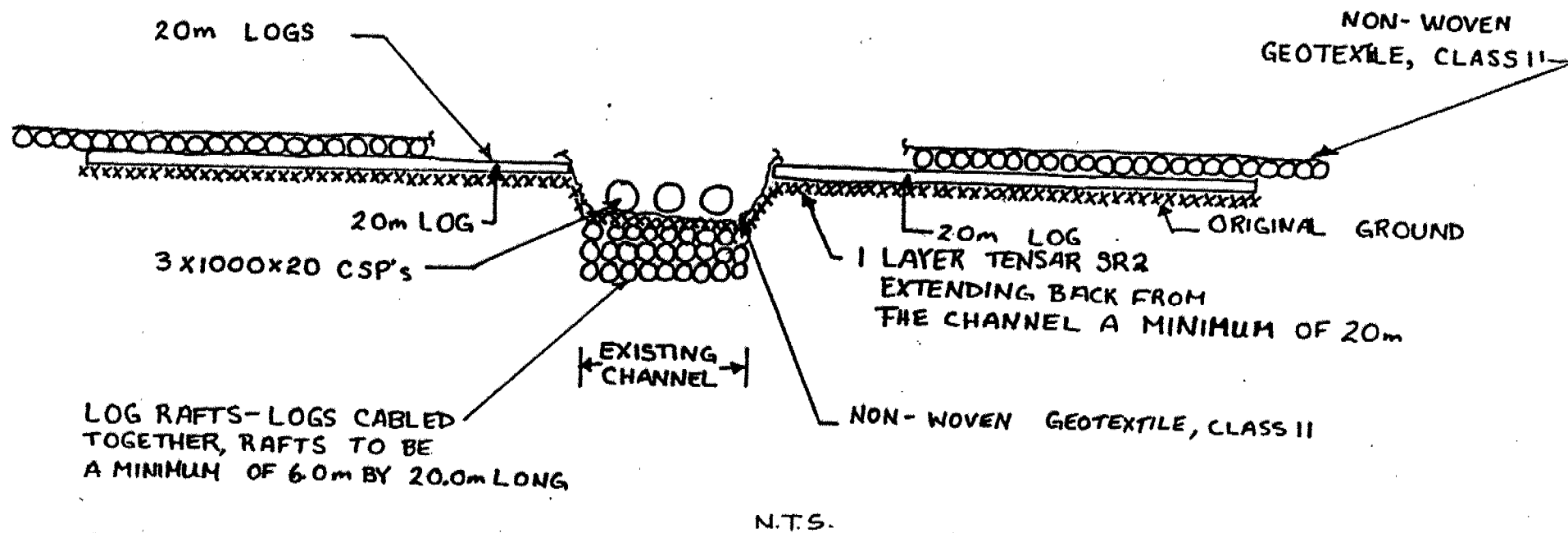


FIG 2 - DETOUR CULVERT LOCATION

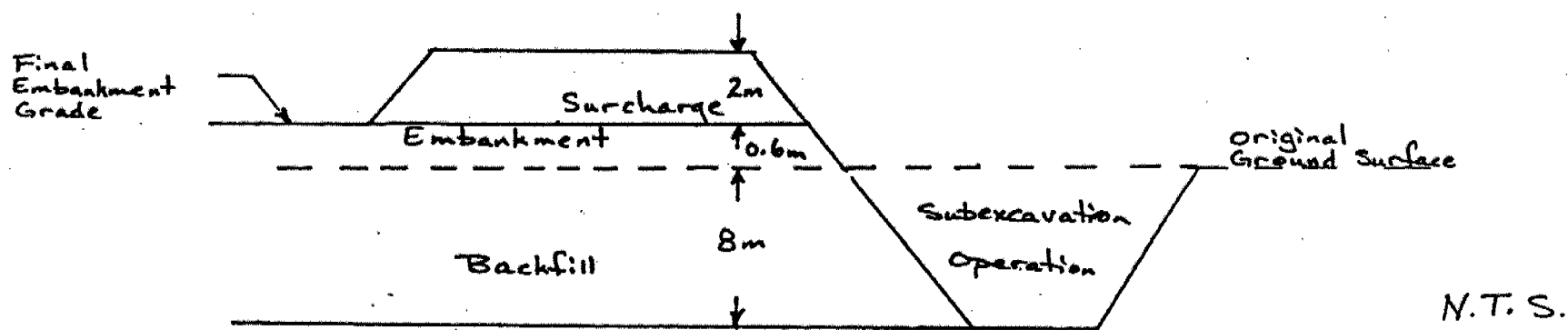


FIG 3 - SUBEXCAVATION AND SURCHARGE OPERATION

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 1502-86-00 LOCATION Sta. 12+010.0, o/s 5m Lt. ORIGINATED BY MJR
DIST 8 HWY 509 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 07 31 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
231.6	Pavement Shoulder													
0.0														
230.2	Brown Gravelly Sand Wet, Compact (Fill)		1	SS	10		231							39 56 (5)
1.4							230							
	Dk. Brown/ Black Peat with Wood Fragments Soft, Moist		2	SS	3									
			3	SS	2		229							
228.7							228							
2.9			4	SS	7									
	Brown Silty Sand to Sandy Silt Dense to V. Dense Saturated		5	SS	40		227							43 45 (12)
			6	SS	42									
226.0			7	SS	100	/8cm	226							
5.6	End of Borehole													

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 1602-86-00 LOCATION Sta 12+050, o/s 5m Rt. ORIGINATED BY MJR
DIST 8 HWY 509 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90.07.31 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100														
								SHEAR STRENGTH kPa										WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE														
231.1	Pavement Shoulder																					
0.0	Brown Gravelly Sand Occ. Wood Fragments Wet, Loose (Fill)		1	SS	7		231									16 73 (11)						
229.3			2	SS	1		230															
1.8	Dk. Brown/ Black Peat V. Soft, Wet		3	SS	1		229															
			4	SS	1		228															
226.7			5	SS	1		227															
4.4	Brown Silty Sand to Sandy Silt Trace Gravel Compact to Dense Saturated		6	SS	14		226									0 16 74 10						
			7	SS	11		225															
			8	SS	43		224															
222.9							223															
8.2	End of Borehole																					

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 1602-86-00 LOCATION Sta 12+090, o/s 5m Lt. ORIGINATED BY MJR
DIST B HWY 509 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 07 31 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
231.0	Pavement Shoulder													
0.0	Brown Gravelly Sand Saturated, Compact (Fill)		1	SS	13		230							
229.0	with Wood Fragments		2	SS	60	/8cm	229							
2.0	Dk. Brown/ Black Peat Soft, Wet		3	SS	2		228							
227.0			4	SS	2		227							
4.0	Brown Clayey Silt Firm		5	SS	4		226							0 6 56 38
225.5							225							
5.5	Brown Silty Sand to Sandy Silt Wet to Saturated Occ. Wood Fragments Compact		6	SS	17		224							
222.7			7	SS	15		223							
8.3	End of Borehole													

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 1602-86-00 LOCATION Sta 12+130, o/s 5m Rt ORIGINATED BY MJR
DIST 8 HWY 509 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR, BL
DATUM Geodetic DATE 90 08 01 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
230.7	Pavement Shoulder													
0.0														
	Brown Coarse Sand with Gravel Saturated Loose to Compact (Fill)		1	SS	13		230							
			2	SS	30		229							25 66 (9)
			3	SS	16		228							
			4	SS	6		227							4 84 (12)
227.0														
3.7	Dk. Brown Peat Occ. Wood Fragments Soft to Firm, Wet		5	SS	6		226						w=404	
			6	SS	3		225							
225.2														
5.5	Brown Silty Clay with Shell Fragments (Marl) V. Soft, Moist		7	SS	1		224							
							223							
223.7														
7.0							222							
							221							
							220							
	Brown Sandy Silt V. Loose Saturated		8	SS	1		219							
			9	TW	PM									
			10	SS	0									
219.1														
11.6	Gr. Brown Gravelly Sand some Silt													
	Saturated, Dense		11	SS	45									
218.1														
12.6	End of Borehole													

RECORD OF BOREHOLE No 5

1 OF 2

METRIC

W.P. 1602-86-00 LOCATION Sta 12+170.0, o/s 5m Lt. ORIGINATED BY MJR
DIST B HWY 509 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 08 01 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
230.6	Pavement Shoulder													
0.0														
	Brown Gravelly Sand Wet to Saturated Loose to Compact (Fill)		1	SS	16		230							
			2	SS	30		229							8 80 (12)
			3	SS	8		228							
227.7			4	SS	17		227							
2.9			5	SS	4		226							
	Coarse Sand some Gravel Saturated Loose to Compact		6	SS	22		225							14 80 (6)
	Layers of Saw Dust, Peat, Wood Fragments and Sand Wet (Fill)		7	SS	8		224							
			8	SS	2		223							
			9	SS	6		222							
222.1			10	SS	1		221							
8.5			11	TW	PM		220							0 1 63 36
	Greyish Brown Silt trace Clay Occ. Silty Clay layers V. Loose		12	SS	0		219							
			13	SS	0		218							
	Greyish Brown Silty Clay Firm						217							
							216							
215.4														

15.2 Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 5

2 OF 2

METRIC

W.P. 1602-86-00 LOCATION Sta. 12+170.0, o/s 5m Lt. ORIGINATED BY MJR
 DIST 8 HWY 509 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY MJR
 DATUM Geodetic DATE 90 08 01 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
215.4	Continued		14	SS	4		215										0 6 83 11
15.2							214										
212.9			15	SS	0		213										
17.7	Grayish Brown Coarse Sand Saturated V. Dense		16	SS	55		212										
211.9																	
18.7	End of Borehole																

RECORD OF BOREHOLE No 6

1 OF 2

METRIC

W.P. 1602-86-00 LOCATION Sta 12+210, o/s 5m Rt. ORIGINATED BY MJR
DIST B HWY 509 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 08 02 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
230.4	Pavement Surface													
0.0	Brown Gravelly Sand underlain by Sand trace Gravel		1	SS	18		230							20 72 (8)
	Saturated, Compact (Fill)		2	SS	13		229							
228.3														
2.1	Dk. Brown Saw Dust		3	SS	4		228							38 55 (7)
	Brown Gravelly Sand to Brown Sand trace Gravel		4	SS	25		227							
	Loose to Compact Moist to Saturated (Fill)		5	SS	15		226							
			6	SS	7									
	Dk. Brown Saw Dust Wood Chips Wet		7	SS	5		225					w=503		
224.0			8	SS	2		224							
6.4	Dk. Brown Peat Soft						223					w=666		
			9	SS	2									
221.9							222							
8.5			10	SS	0		221							0 4 73 23
	Greyish Brown Clayey Silt to Silty Clay Occ. trace Sand Soft to Firm						220							
			11	SS	0		219							
							218					w=53	17.1	0 0 55 45
			12	TW	PM		217							
			13	SS	2									
215.8							216							
14.6														
215.2														

15.2 Continued

+3, x⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 6

2 OF 2

METRIC

W.P. 1602-86-00 LOCATION Sta 12+210, o/s 5m Rt. ORIGINATED BY MJR
DIST 8 HWY 509 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 08 02 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
315.2	Continued																
15.2			14	SS	0		215										
213.5							214										
16.9	End of Borehole	16.9	15	SS	60	70cm											
	Probable Bedrock																

RECORD OF BOREHOLE No 7

1 OF 1 METRIC

W.P. 1602-86-00 LOCATION Sta 12+240.0, o/s 5m Lt. ORIGINATED BY MJR
 DIST 8 HWY 509 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY MJR
 DATUM Geodetic DATE 90 08 03 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
230.9	Pavement Surface													
0.0	Brown Coarse Sand trace Gravel													
229.5	Compact (Fill)		1	SS	10									
1.4	Grayish Brown Saw Dust with Sand and Dk. Brown Peat some Wood Fragments		2	SS	10									
228.0	(Fill)		3	SS	1									
2.9	Dk. Brown/ Black Peat V. Soft to Firm		4	SS	6									
226.5			5	SS	1									
4.4	Brown Silty Clay with Shell Fragments (Mori)		6	SS	0									
225.3	V. Soft													
5.6			7	SS	8									
	Grayish Brown Silty Clay to Clayey Silt		8	SS	0									
	V. Soft													
	Grayish Brown Silty Sand to Sandy Silt changing to Med. Sand with Gravel at greater depths		9	SS	17									
	Saturated Loose to Compact		10	SS	21									
218.3			11	SS	60	/5cm								
12.6	End of Borehole													
	Possible Bedrock													

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 1502-86-00 LOCATION Sta 12+270.0, e/s 5m Rt. ORIGINATED BY MJR
DIST 8 HWY 509 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 08 07 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
231.1	Pavement Shoulder																
0.0	Brown Sand trace Gravel Wet, Loose (Fill)		1	SS	6		230										
229.7																	
1.4	Saw Dust mixed with Peat and Sand (Fill)		2	SS	1		229										
229.0																	
2.1	Dk. Brown/ Black Peat Firm Wet		3	SS	1		228									w=348	
227.0			4	SS	2												
4.1	Brown to Grey Brown Silty Sand to Silt trace Sand trace Gravel Occ. Boulders		5	SS	53		227										
			6	SS	1		226										
	Greyish Brown Silty Clay Soft		7	SS	4		225										9 12 64 15
							224										
223.0	Gray Coarse Sand with Gravel Dense		8	SS	49												
8.1	End of Borehole																

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 1602-86-00 LOCATION Sta 12+313.0, o/s 5m Lt. ORIGINATED BY MJR
DIST B HWY 509 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 08 07 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
231.6	Pavement Shoulder										
0.0	Mixture of Black Peat, Wood Chips, and Sand (Fill)		1	SS	13		231				
230.2											
1.4	Dk. Brown Peat mixed with sandy silt Stiff		2	SS	4		230				
228.7							229				
2.9	End of Borehole							75/ 10cm			

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 1602-86-00 LOCATION Sta 12+336.0, o/s 5m Rt. ORIGINATED BY MJR
DIST 8 HWY 509 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 08 08 CHECKED BY KA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20	40	60	80	100	W _P	W		
232.0	Pavement Shoulder															
0.0	Brown Silty Sand to Gravelly Sand Damp to Wet V. Loose to Compact (Probable Fill)		1	SS	2											
			2	SS	6											
228.3			3	SS	11											
3.7	Greyish Brown Med. Sand some Gravel Dense		4	SS	35											
227.5																
4.5	End of Borehole															

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 1602-86-00 LOCATION Sta 12+363.4m, o/s 5m Lt. ORIGINATED BY MJR
DIST 8 HWY 509 BOREHOLE TYPE Cone test, Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90 08 08 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
232.8	Pavement Shoulder													
0.0	Brown Sand with Gravel Moist, Dense (Probable Fill)		1	SS	49		232							
231.0			2	SS	20		231							
1.8	Brown Silty Clay Firm		3	SS	7		230							4 8 71 17
229.9			4	SS	7		229							
2.9	Brown Silt trace Clay Loose						228							
228.7			5	SS	21		228							
4.1	Grey Gravelly Sand Saturated Compact to V. Dense		6	SS	60	/Bcm								
227.0														
226.8	End of Borehole													
6.0	End of Cone Test									120/25cm				

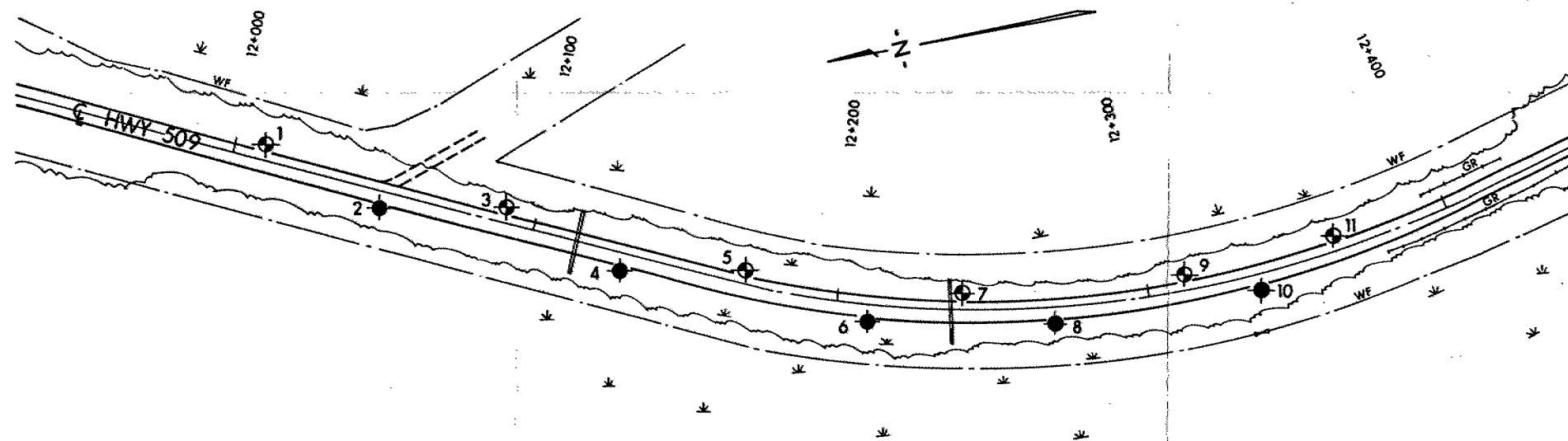
METRICDIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.CONT No
WP No 1602-86-00

CLARENDON SWAMP

BORE HOLE LOCATIONS & SOIL STRATA



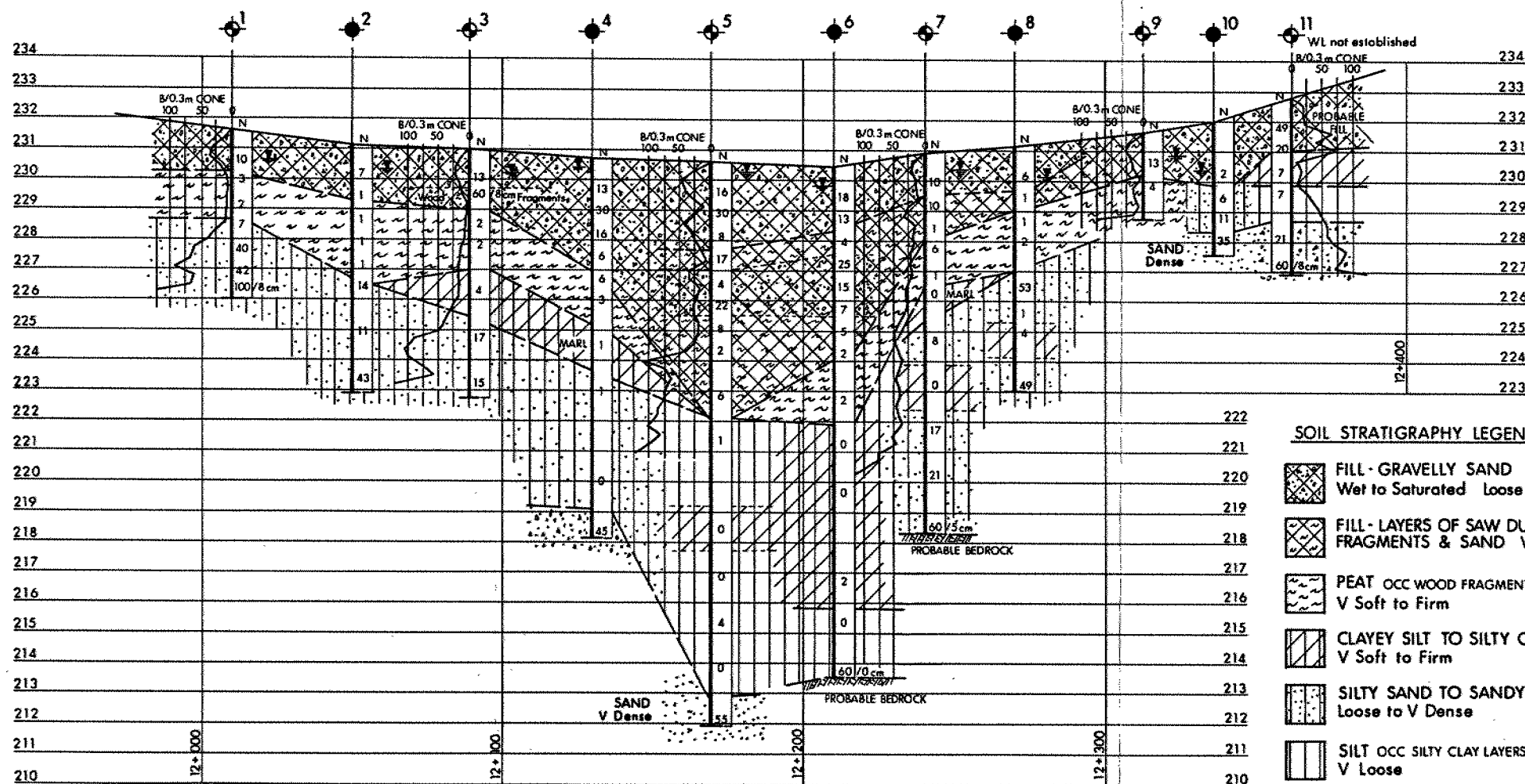
SHEET



PLAN

SCALE

20m 10 0 20m



PROFILE HWY 509

SCALE

20m 10 0 20m Hor
2m 1 0 2m Vert

SOIL STRATIGRAPHY LEGEND

- FILL - GRAVELLY SAND
Wet to Saturated Loose to Comp
- FILL - LAYERS OF SAW DUST, PEAT, WOOD
FRAGMENTS & SAND Wet
- PEAT OCC WOOD FRAGMENTS
V Soft to Firm
- CLAYEY SILT TO SILTY CLAY
V Soft to Firm
- SILTY SAND TO SANDY SILT
Loose to V Dense
- SILT OCC SILTY CLAY LAYERS
V Loose
- GRAVELLY SAND SOME SILT
Comp to V Dense

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 9007&08

No	ELEVATION	STATION	OFFSET
1	231.6	12+010.0	5 m LT
2	231.1	12+050.0	5 m RT
3	231.0	12+090.0	5 m LT
4	230.7	12+130.0	5 m RT
5	230.6	12+170.0	5 m LT
6	230.4	12+210.0	5 m RT
7	230.9	12+240.0	5 m LT
8	231.1	12+270.0	5 m RT
9	231.6	12+313.0	5 m LT
10	232.0	12+336.0	5 m RT
11	232.8	12+363.4	5 m LT

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
1			

Geocres No 31C-149

HWY No 509	SUBM'D K.A. CHECKED	DATE 1990.09.28	DIST 8
DRAWN SO	CHECKED	APPROVED	SITE
			DWG 16028600-A

memorandum



To: S. Cheng
Head, Geotechnical Section
Eastern Region

Date: 1991 02 21

From: Foundation Design Office
Room 315, Central Building

Re: Clarendon Swamp
W.P. 1602-86-00, Site N/A
Hwy. 509, District 8, Kingston

Further to our telephone conversation of January 31, 1991, this memo will document that we recommend that our Alternative 3 (preload/subexcavate lightweight fill) should be selected instead of our Alternative 4 (Corduroy Road). As discussed, the reason for this change is that some uncertainties have surfaced regarding the performance of a similar corduroy road in District 20. Consequently, in view of the high costs involved for either option, in our opinion it would be prudent to select Alternative 3.

If there are any questions, please call.

A handwritten signature in dark ink, appearing to read "D. Dundas".

D. Dundas, P. Eng.
Sr. Foundation Engineer

DD/mmj

memorandum



(613) 544-2220 Ext. 4163

M. Devata

To: Mr. B.D. MacKinnon
District Engineer
District 08, Kingston

Date: January 28, 1991

FROM: Geotechnical Section
Eastern Region, Kingston

RE: Clarendon Swamp, Highway 509
District 08, Kingston

The final Foundation Investigation and Design Report dated 90-12-07 differs somewhat from the interim report dated 90-09-17 which was intended to permit design to proceed. The differences are found in the length and depth of treatment and that the final report recommends Alternative 3 as being the most appropriate choice where as the interim report presented the Alternatives in order of increasing costs.

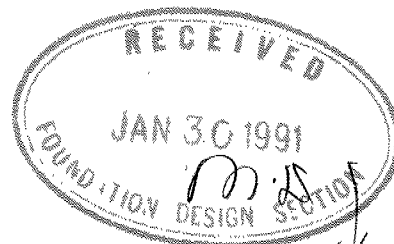
Subsequent to receipt of the interim report, I requested preliminary cost estimates from the Estimating Office and indicated in my memorandum of 90-11-08 (attached) that if Alternative 1 was not acceptable to the District, then the Regional Geotechnical Section recommends Alternative 4 (the least expensive of the remaining treatments).

After receipt of the final report, I again requested revised preliminary cost estimates from the Estimating Office. Below is a summary of initial and revised cost estimates for each alternative.

<u>Treatment Alternative</u>	<u>Initial Cost Estimate</u>	<u>Revised Cost Estimate</u>
1	\$ 5,000/Year	\$ 5,000/Year
2	\$ 325,000	\$ 488,000
3	\$ 380,000	\$ 555,000
4	\$ 275,000	\$ 275,000
5	\$1,100,000	\$1,100,000

The memorandum from the Estimating Office with revised cost estimates is attached.

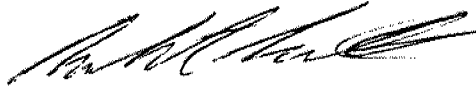
In view of the above, the Geotechnical Section continues to recommend Alternative 4 as the most cost effect solution should Alternative 1 not be acceptable to the District. However, should the District be successful in securing the funds required for Alternative 3, then the Geotechnical Section fully supports this alternative.



D.D. → Amy Vennart

-2-

Submitted for your consideration and action.



Robert J. Scott
Soils Supervisor

RJS/dka
Attachment

c.c.: T.A. Hickey
T. Murphy
S. Young

M. Devata ✓
D. Kimmett

MEMORANDUM

To: S. Cheng
Head
Geotechnical Section
Eastern Region

Attention: R. Scott

From: Foundation Design Section
Room 315, Central Building

Re: Clarendon Swamp
W.P. 1602-86-00, Site N/A
Hwy. 509, District 8, Kingston

Date: 90 09 17

The field investigation for the above-noted project has been completed. This memo provides recommendations that are intended to permit design to proceed.

The site is located approximately 8 km north of Highway 7, where Hwy. 509 crosses Clarendon Swamp. At this location, the grade of the highway is often only marginally above the surrounding swamp. The length of highway under investigation is $360 \pm$ m long.

Based on the field investigation, the surficial material along the highway consists of from 1.4 to 3.7 m of granular roadbed material. The roadbed is typically underlain by 1.5 to 2.6 m of peat, then by up to $6 \pm$ m of silty clay, although the thickness of the silty clay deposit is controlled by bedrock topography and is therefore quite variable. Near the central portion of the swamp, 0.7 to 4.3+ m of sawdust is directly underlying the granular roadbed material and overlying the peat and silty clay.

It is our understanding that the highway has experienced continuing maintenance problems and in some instances flooding, and that consequently it has been proposed to raise the existing grade by 0.6 to 1 m.

In our opinion, the distress to the roadway is a settlement problem caused by consolidation of the weak and compressible peat and silty clay deposits. The existence of the sawdust is an indication that lightweight material was used in an attempt to minimize settlement problems at some point in the past.

As we discussed in our telephone conversation of Sept. 17/90, there are a number of remedial alternatives. The selection of an alternative will depend on a comparison of costs/benefits in consideration of expectations of levels of performance for this portion of the highway. We suggest that maintenance costs should also be factored into the decision.

The following alternatives are presented in order from least to most in terms of expense and effectiveness:

- 1) Periodic routine maintenance, as required, to pad the road to keep it above the swamp. Of course, no significant improvement in the performance of the road over its present level is anticipated although the rate of settlement may reduce over time.
- 2) Subexcavation of $1\pm$ m of existing roadbed material and replacement with lightweight backfill such as slag. The presence of sawdust under the central portion of the road indicates that this approach was attempted somewhat ineffectively in the past. However, theoretically some improvement in road performance should result.
- 3) Preloading with $1\pm$ m of normal fill, for a minimum of 3 months, then subexcavation of $1\pm$ m of fill and replacement with lightweight fill such as slag. The intention of this method would be to preconsolidate the peat and silty clay to a level greater than required to adequately support the lightweight fill.
- 4) Construction of a corduroy roadbed. The corduroy mat would be constructed after subexcavating to $1\pm$ m beneath the existing grade of the road.

The mat would consist of 2 layers of timber. Reference is made to Figure 1. The first layer would be parallel to the alignment with butts and tips alternating with at least 1.2 m of overlap at the log ends. These joints would be staggered. The logs would be evenly spaced (with gaps) at $0.75\pm$ m centre to centre. The second layer would be perpendicular to the alignment and placed directly on top of the first layer with butts placed along the edges of the mat, and butts and tips alternating. The tips would then be cut off to align with the butts, and the pieces would be used to fill in spaces in the mat. The logs in the second layer would be placed as tightly together as possible with little or no spacing.

The preferred timber would be delimbed spruce or equivalent with minimum butt diameters of 250 mm to 350 mm. A non-woven Class II geotextile would be placed over the timber mat, down its sides then over the swamp to the limit of deposition of the granular material. A 0.3 m pad of Granular A would then be placed with 2H:1V side slopes as illustrated in Figure 1. Then, while incorporating a 1 m bench on both sides of the roadway embankment an additional 0.6 m of Granular A would be placed.

(Figure 2)
A modified corduroy treatment would be required at the culvert locations. A Tensar SR-2 geogrid would be placed under the culvert bedding and above the culvert corduroy mat. The geogrid would extend 20 m longitudinally (along the alignment) on both sides of the culvert under the roadway corduroy mat. Under the culvert, 3 layers of corduroy would be placed perpendicular to the roadway. The longitudinal logs in the first layer of the roadway corduroy mats would extend 20 m on each side of the culvert. Bedding and backfilling for the culvert would be as per OPSD 802.01 and 803.03.

During placement of the granular fill, the butt and tips of the timber mat should be monitored. Uplift of the ends may indicate failure of the underlying material in which case this office should be contacted for recommendations.

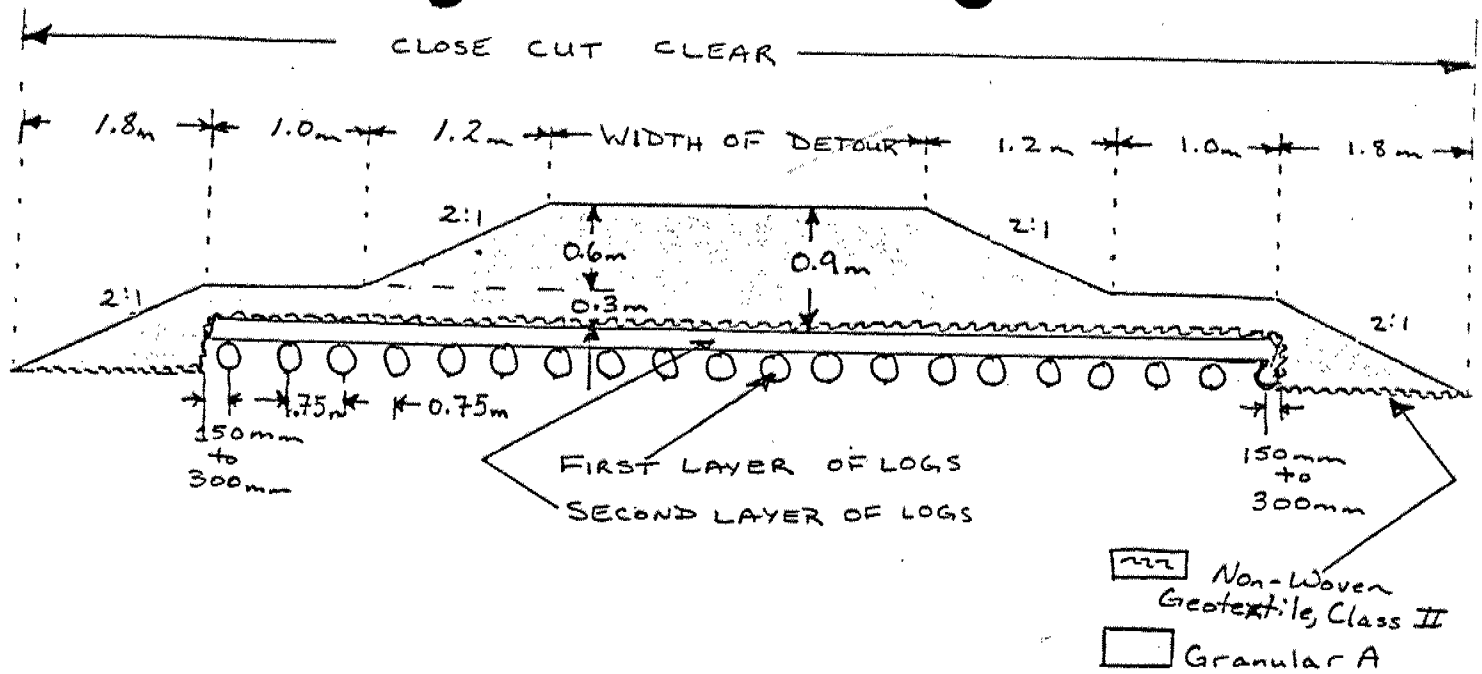
- 5) Subexcavation of as much of the weak and compressible material as possible (up to $8 \pm$ m) and partial displacement of any remaining deposits with rockfill. (Figure 3)
In order to minimize post construction settlement, a surcharge would be applied by placing an additional rockfill thickness of $2 \pm$ m above final grade as a rolling surcharge that would be advanced as the concurrent subexcavation/backfill operation progressed. Any mud waves that formed at the sides of the active area would be removed outside a plane of 2H:1V from the base of the subexcavation. Consideration was given to incorporating blasting to facilitate displacement. However, this option was not recommended due to concerns with the sensitivity of the underlying soils.

In our opinion Alternatives 1 to 3 could be accomplished with staged construction techniques and would therefore not require a detour. Alternatives 4 and 5 would however definitely require a detour.

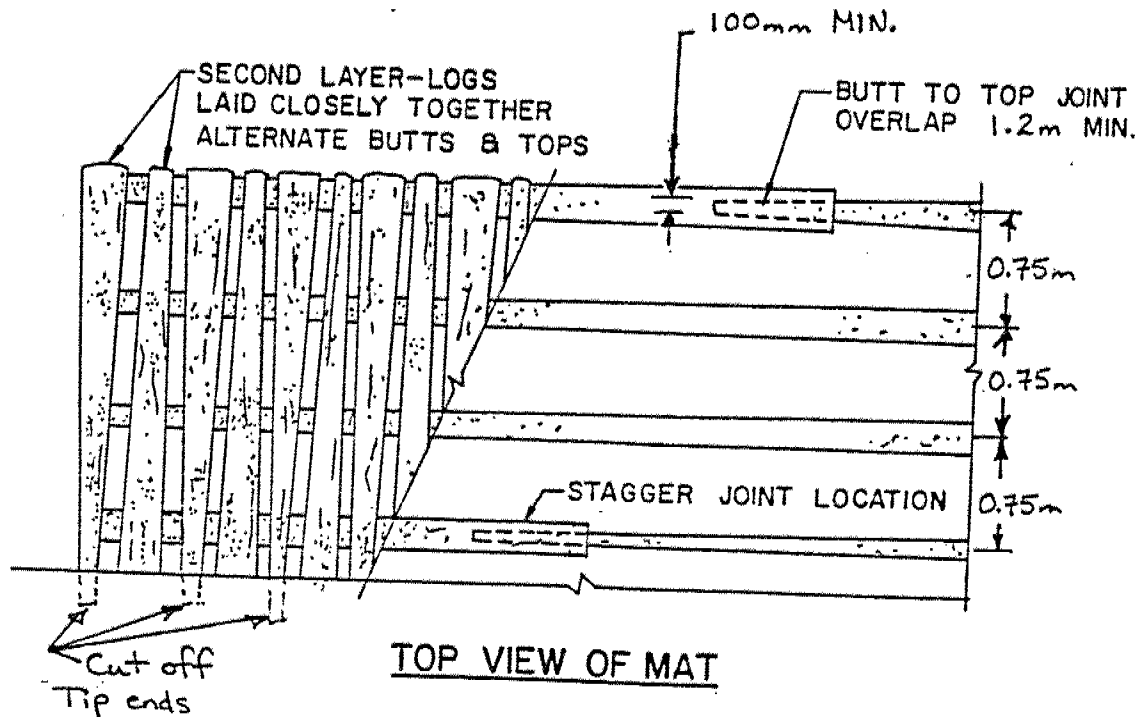
The complete Foundation Report will be submitted in the near future and will incorporate further details on these alternatives. However if any clarification of the recommendations in this memo are required before you receive the final report, or if there are any further questions please do not hesitate to call.



D. Dundas, P.Eng.
Sr. Foundation Engineer



CROSS-SECTION



NOTE: DRAWINGS NOT TO SCALE

Figure 1 Corduroy Treatment

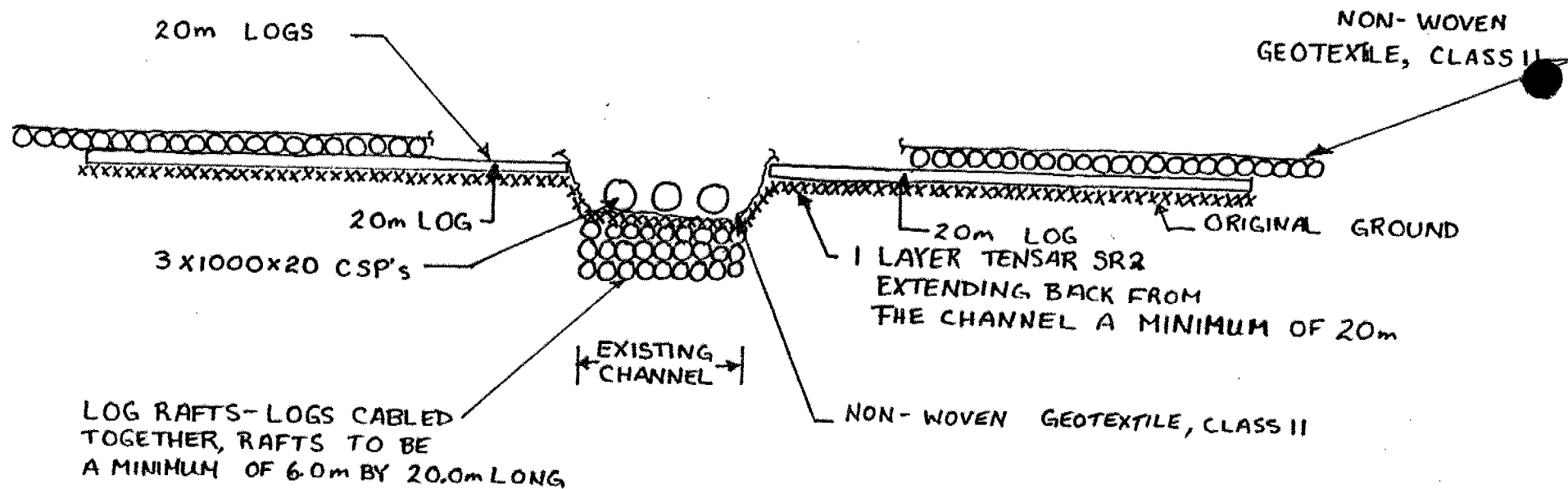


FIGURE 2: DETOUR CULVERT LOCATION (N.T.S.)

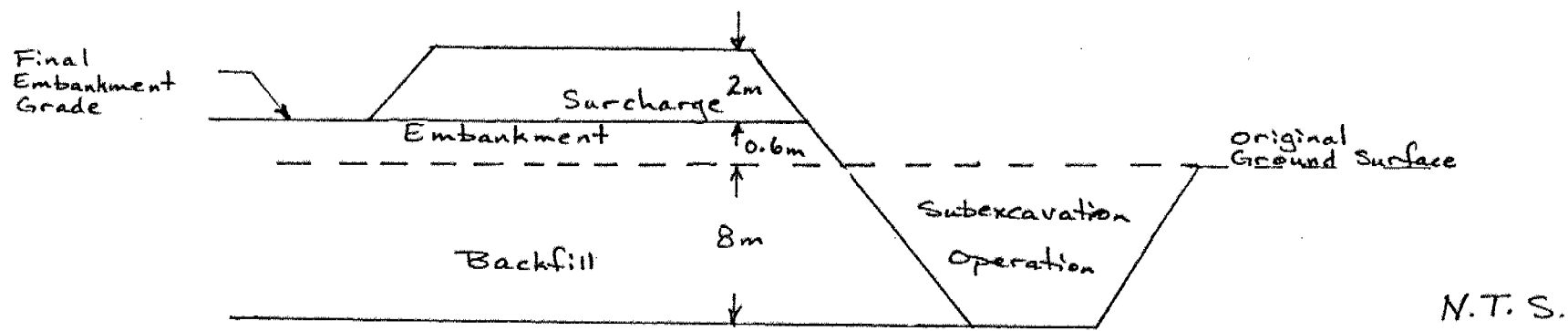


Figure 3. : Subexcavation and Surcharge Operation

Bob

(613) 544-2220 Ext. 4163

Mr. B.D. MacKinnon
District Engineer
District 08, Kingston

May 17, 1990

FROM: Geotechnical Section
Eastern Region, Kingston

RE: Day Labour Project, W.P. 1602-86-00
Highway 509, From 8.0 km North of
Highway 7, Northerly 4.5 km
District 08, Kingston

On 90-05-15, a site review of the above project was made with Mr. J. McEachern with respect to the proposed treatment of the "Clarendon Swamp" (+ 0.8 km South of Clarendon). During this review, it became apparent that the current project rehabilitation treatment may not be the most appropriate i.e. average 150 mm granular pad over moderately to severely distorted surface treatment.

Discussion

During our soils investigation of the adjacent capital projects (W.P. 220-86-00 & 219-86-00), surface treatment thicknesses 30-50 mm over variable granular depths were encountered. As there were very few locations where the proposed gradeline was coincidental with the existing gradeline, a minimum of 150 mm Granular 'A' padding over existing pavement was recommended.

However, on this project, the proposed gradeline is co-incidental with the existing gradeline and as such an average 150 mm granular pad over the roadway may not ensure satisfactory long term performance.

With respect to the Clarendon Swamp, past soils investigations indicate the swamp length is approximately 300 m and the maximum depth is 14.6 m consisting of 7.6 m of soft saturated brown fibrous muck over 7.0 m of a soft saturated grey silty clay. Various correspondence within our files are unclear as to the settlement rate and load bearing characteristics of this material.

RECOMMENDATIONS

In view of the above, the following is recommended:

1. Inplace processing of Bituminous pavements (S.P. 399F35) to a depth of 100 mm or as per designer note in the special provision and/or scarification of the pavement surface throughout the project limits should be undertaken.

.....2/

2. Re-shape and recompact the processed material in accordance with S.P. 399F35 except that fine grading of the processed surface is not required.
3. Provide for a 150 mm Granular 'A' pad over the processed material to ensure the new pavement structure has a uniform base material which will ensure the pavement design ~~lift~~^{life} is achieved with minimal maintenance.
4. Resurface with a Double Class 2 Surface Treatment consisting of two alternate applications of Binder and Class 2 Aggregate as specified in the attached N.S.S.P.

NOTE: Consideration should be given to a follow-up Single Class 1 Surface Treatment the following year.

5. The above treatment recommendations should also apply to the Clarendon Swamp. No construction or performance problems are expected with respect to construction equipment working in the area.

The Geotechnical Section will be requesting the Foundation Design Section conduct a field investigation and make the appropriate treatment recommendations for the swamp. It is also our intention to have those recommendations available such that treatment can be undertaken under adjacent capital project W.P. 220-86-00 scheduled for 1991 construction.

The Geotechnical files contain various correspondence and soils information which may be of assistance to your project staff. Please contact this section if any clarification of the above and/or any further assistance is required.

Robert Scott / aka

Robert Scott
Soils Supervisor

RS/dka

c.c.: T.A. Hickey
D. Kimmett
T. Murphy



SAWDUST SWAMP
S. OF ARDOCH RD.

↑
N