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DIST. 52 REGION _____

W.P. No. 464-96-01

CONT. No. _____

W. O. No. _____

STR. SITE No. 42-235

HWY. No. 11

LOCATION Novar Rd. Underpass

No of PAGES - 1

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____

FINAL FOUNDATION INVESTIGATION REPORT FOR NOVAR ROAD UNDERPASS HIGHWAY 11 FOUR LANING 6.7 km NORTH OF HWY 60 NORTHERLY 13 km W.P. 462-93-00, SITE 42-235 DISTRICT 52, HUNTSVILLE

Report

to

McCormick Rankin Corporation

Direction of fieldwork and engineering analysis by:
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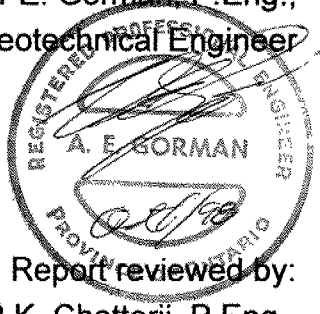

Report reviewed by:
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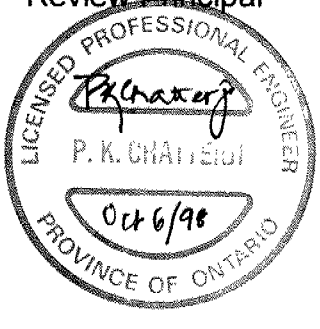
Review Principal



October 6, 1998
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FINAL FOUNDATION INVESTIGATION REPORT FOR NOVAR ROAD UNDERPASS HIGHWAY 11 FOUR LANING 6.7 km NORTH OF HWY 60 NORTHERLY 13 km W.P. 462-93-00, SITE 42-235 DISTRICT 52, HUNTSVILLE

1. INTRODUCTION

This report presents the results of the foundation investigation carried out by Thurber Engineering Ltd. (Thurber) at the site of the proposed bridge and approach fills at the intersection of the extended Novar Road with realigned Highway 11 in the Town of Huntsville. The purpose of the investigation was to explore the subsurface soil and groundwater conditions at the site and based on the data obtained provide borehole logs, soil profile and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation (MRC) under Ministry of Transportation (MTO) Agreement 9750 - 7424 - 5262.

2. SITE DESCRIPTION

2.1 Site Location

The structure forms part of the four-laning of Highway 11 north of Huntsville and is located at the intersection of the proposed extension of Novar Road and a realigned portion of Highway 11. The site lies at Station 26+040, approximately, C/L Median Highway 11.

Locally, the site may be described as lying east of the existing Highway 11, in a flat, low-lying, treed area opposite the existing intersection of Novar Road with Highway 11. Access to the site was directly from Highway 11 or along the ROW from Highway 592 a short distance to the north.

2.2 Physiography

Based on The Physiography of Southern Ontario, 3rd Edition, by Chapman and Putnam, the region surrounding the site consists of bedrock ridges with shallow overburden. The bedrock is undifferentiated igneous and metamorphic rock of early Precambrian age and is generally hard and massively jointed.

The Highway 11 corridor, however, lies in a long, narrow sand plain filling a deep valley within the region of shallow bedrock. The typical soils filling the deep valley in the corridor consist of sand and silt, with some gravel deposited as glacial outwash or in localized glaciolacutrine environments.

The nearby, meandering creek (Little East River) and several wetlands in the area suggest poor drainage and a high groundwater table. Locally the ground is relatively flat, wet at the surface and supports typical vegetative cover for wet areas.

3. INVESTIGATION PROCEDURES

3.1 Field Investigation

Between February 18 and 24, 1998, a Nodwell track mounted auger rig was used on site for drilling, Standard Penetration Testing (SPT) and dynamic cone penetration testing. One hole was drilled for each abutment, one for the central pier and one at each approach fill, giving a total of five sampled boreholes. The approximate locations of the boreholes are shown on Drawing 19-1351-7d-01.

The holes were initially advanced using hollow stem augers. Fine uniform sand and silt were encountered below a relatively high water table which caused heaving of the soil into the hollow stem auger when the pilot bit was withdrawn in preparation for SPTs. The hollow stem augers were kept full of drilling mud at all times to counteract the effect of an unbalanced head of groundwater.

When it became apparent that auger drilling had reached its effective depth limit, mud rotary drilling was implemented for the balance of the depth of the hole.

The boreholes were numbered D-98-1 through D-98-5. The depths of sampling in the five boreholes were as follows:

Borehole No.	Depth of Sampling (m)
D-98-1	5.2
D-98-2	56.1
D-98-3	63.7
D-98-4	30.9
D-98-5	5.2

Samples were recovered at intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT) (following the test procedure outlined in ASTM D 1586). Samples were generally recovered at intervals of 0.75 m in the upper 3.0 m and thereafter at intervals of 1.5 m to depths which vary between the holes. In some holes the sampling interval was increased to 3.0 m after stratigraphic continuity was established.

Dynamic cone penetration tests were conducted in, or adjacent to selected holes as follows

Borehole No.	Depth of Dynamic Cone Test
D-98-3	From ground surface to 13.7 m and from 15.0 to 22.8 m, adjacent to the hole
D-98-4	From the termination of sampling at 30.9 m to 34.4 m, from the bottom of the borehole.

Boreholes were not left open long enough for the groundwater to stabilize and this coupled with the constant addition of drilling fluid led to the decision not to report data on groundwater levels on completion of drilling. Based on the flat site and the consistent sand stratigraphy, one standpipe piezometer was installed in Borehole D-98-3 to monitor the groundwater level.

The boreholes were backfilled with drill cuttings except in Borehole D-98-3 where sand pack was installed around the piezometer tip and a bentonite plug was installed near the top of the hole.

All recovered samples were examined, identified and logged in the field and were transported to Thurber's Toronto laboratory by the field supervisor for further examination and laboratory analysis.

The result of the drilling and sampling are summarized on the borehole logs in Appendix A.

3.2 Laboratory Analysis

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all recovered samples. In addition, grain size analyses and pH and sulphate content testing were conducted on selected samples. The results of the laboratory testing are presented on the borehole logs in Appendix A, and in Figures B1 to B4 in Appendix B. The results of the pH and sulphate content are presented in Table B1.

4. DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Subsurface Soil Conditions

Detailed descriptions of the subsoil conditions encountered in the boreholes are presented on the borehole logs in Appendix A. The stratigraphic profile inferred from the borehole information is shown on Drawing No. 19-1351-7d-01.

In general, the boreholes indicate a surface layer of peat underlain by sand which extends to depths in the order of 34 m. The upper sand is underlain by a deposit of silt approximately 16 m thick, which in turn is underlain by a lower sand deposit.

Further description of these major soil units is provided in the following sections. The soils encountered all appeared to be lacustrine or fine outwash deposits and no evidence of boulders was found. However, the possibility of encountering boulders at random locations in the sand and silt deposits during construction must be recognized.

Peat

All boreholes encountered a layer of peat at the surface. The peat is fibrous, contains numerous roots and was noted as silty in Borehole D-98-3. The colour of the peat ranges from brown to dark brown to black. Measured moisture contents lie in the range of 70 to 564%.

The interpreted depths of peat at the boreholes are as follows:

Borehole No.	Depth of Peat (m)
D-98-1	1.6
D-98-2	1.2
D-98-3	1.8
D-98-4	1.5
D-98-5	1.1

Actual depths of peat to be stripped may vary from those interpreted at the borehole locations.

Upper Sand

Based on Boreholes D-98-2, D-98-3 and D-98-4, the upper sand layer extends to depths of approximately 34 m below existing ground level, or to

approximate Elevation 287.0 to 288.5.

The sand is fine grained and uniform and contains silt in proportions ranging from trace to some and to sand and silt in Boreholes D-98-4 and D-98-5. Grain size distributions for selected samples are shown in Figures B1 to B4. The deposit shows faint layering and is grey and wet.

Based on the SPT values, the density of the upper sand layer is variable from very loose to dense with N values ranging from 2 to 44. Below a depth of 28 m in Borehole D-98-4, the upper sand becomes very dense, with N values ranging from 44 to 57. The measured natural moisture contents ranged from 19 to 30%.

Boreholes D-98-1 and D-98-5, in the areas of the approach embankments, were terminated in the upper sand at depths of 5.2 m. Boreholes D-98-2 and D-98-3 fully penetrated the upper sand at depths of approximately 34 m. Sampling in Borehole D-98-4 was terminated at a depth of 30.9 m and the base of the upper sand layer was not established in this hole.

Silt

Below the upper sand, Boreholes D-98-2 and D-98-3 encountered a deposit of silt. The silt extends from Elevation 288.5 to 271.5 m in Borehole D-98-2 and from Elevation 287.0 to 271.5 m in Borehole D-98-3. The silt contains sand in proportions ranging from trace sand to sandy and also trace clay. The grain size distributions for selected samples are shown in Figures B1 to B4. The deposit shows faint layering, is grey and wet.

Based on the recorded SPT values, the silt is dense to very dense with N values ranging from 30 to 52. The measured natural moisture contents range from 21 to 29%.

Both boreholes fully penetrated the silt layer and into the underlying lower sand.

Lower Sand

Below Elevation 271.5, respectively, Boreholes D-98-2 and D-98-3 encountered a lower sand deposit which extended to the termination depths of the boreholes, 56.1 and 63.7 m, respectively. The sand is fine grained and uniform and contains some silt. Grain size distributions for selected samples are shown in Figures B2 and B3. The lower sand deposit shows faint layering and is grey and wet.

Based on the recorded SPT values of 63 for 0.30 m to 92 for 0.15 m of penetration, the lower sand is in a very dense state. The measured natural moisture contents ranged from 21 to 30%.

4.2 Groundwater

The following groundwater levels were recorded in the piezometer installed in Borehole D-98-3:

Date	Depth to Water (below existing ground surface)
May 24, 1998	0.0 m
July 15, 1998	0.2 m
July 31, 1998	0.3 m

Based on this data, the groundwater lies close to the ground surface or at Elevation 321.3. The water level may fluctuate throughout the year, and in particular surface flooding may occur after Spring thaw or periods of heavy rain.

STATEMENT OF GENERAL CONDITIONS

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering or environmental consulting practices in this area. No other warranty, expressed or implied, is made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS "APPROVED USERS". The contents of the Report remain our copyright property and we authorize only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make the Report, or any portion thereof, available to any party without our written permission. Any use which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. We accept no responsibility for damages suffered by any third party resulting from unauthorized use of the Report.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgemental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

(see over...)

INTERPRETATION OF THE REPORT *(continued)*

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of persons providing information.

6. RISK LIMITATION

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause an accidental release of those substances. In consideration of the provision of the services by us, which are for the Client's benefit, the Client agrees to hold harmless and to indemnify and defend us and our directors, officers, servants, agents, employees, workmen and contractors (hereinafter referred to as the "Company") from and against any and all claims, losses, damages, demands, disputes, liability and legal investigative costs of defence, whether for personal injury including death, or any other loss whatsoever, regardless of any action or omission on the part of the Company, that result from an accidental release of pollutants or hazardous substances occurring as a result of carrying out this Project. This indemnification shall extend to all Claims brought or threatened against the Company under any federal or provincial statute as a result of conducting work on this Project. In addition to the above indemnification, the Client further agrees not to bring any claims against the Company in connection with any of the aforementioned causes.

7. SERVICES OF SUBCONSULTANTS AND CONTRACTORS

The conduct of engineering and environmental studies frequently requires hiring the services of individuals and companies with special expertise and/or services which we do not provide. We may arrange the hiring of these services as a convenience to our Clients. As these services are for the Clients' benefit, the Client agrees to hold the Company harmless and to indemnify and defend us from and against all claims arising through such hirings to the extent that the Client would incur had he hired those services directly. This includes responsibility for payment for services rendered and pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. In particular, these conditions apply to the use of drilling, excavation and laboratory testing services.

8. CONTROL OF WORK AND JOBSITE SAFETY

We are responsible only for the activities of our employees on the jobsite. The presence of our personnel on the site shall not be construed in any way to relieve the Client or any contractors on site from their responsibilities for site safety. The Client acknowledges that he, his representatives, contractors or others retain control of the site and that we never occupy a position of control of the site. The Client undertakes to inform us of all hazardous conditions, or other relevant conditions of which the Client is aware. The Client also recognizes that our activities may uncover previously unknown hazardous conditions or materials and that such a discovery may result in the necessity to undertake emergency procedures to protect our employees as well as the public at large and the environment in general. These procedures may well involve additional costs outside of any budgets previously agreed to. The Client agrees to pay us for any expenses incurred as the result of such discoveries and to compensate us through payment of additional fees and expenses for time spent by us to deal with the consequences of such discoveries. The Client also acknowledges that in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed and the Client agrees that notification to such bodies by us will not be a cause of action or dispute.

9. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on our interpretation of conditions revealed through limited investigation conducted within a defined scope of services. We cannot accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes decisions made to either purchase or sell land.

APPENDIX A

APPENDIX A

BOREHOLE LOGS

- Symbols and Terms Used on Borehole Logs

- Unified Soil Classification

- Borehole Logs D-98-1 to D-98-5

THURBER

BOREHOLE GRAPHIC SYMBOLS

SOILS

FILL
ORGANICS
CLAY
SILT
SAND
GRAVEL
COBBLES

SILTY CLAY
CLAYEY SILT
SILTY SAND
SAND & GRAVEL
CLAYEY SILT TILL
SILTY CLAY TILL
SANDY SILT TILL

ROCK

SHALE
LIMESTONE

SILTSTONE
GRANITE

OTHER

CEMENT GROUT
BENTONITE GROUT

CONCRETE
WATER

BENTONITE SEAL

THURBER

TTCHTCH2 6209 85/03/14

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] "N" VALUE
Very Soft	Less than 10	Less than 2
Soft	10 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR TEST HOLE LOGS

SYMBOLS FOR SAMPLE TYPE

■	Shelby Tube		A - Casing
⊘	SPT	▯▯	Grab/Auger sample
⊠	No Recovery	▯▯	Core

- • MC - Moisture Content (% by Weight) as determined by sample]
- ▼ Water Level
- C_{vane} Shear Strength Determination by Field Insitu Vane
- C_{pen} Shear Strength Determination by Pocket Penetrometer
- C_{lab} Shear Strength Determination using a Laboratory Vane Apparatus
- C_U Undrained Shear Strength determined by Unconfined Compression Test

(1) SPT Standard Penetration Test - refers to the number the blows from a 63.5kg hammer falling through 0.76m to advance a 60 degree truncated cone 0.3m.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W_L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W_L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W_L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W_L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No D-98-1 1 OF 1 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 959.1 E 324 636.4 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.22 - 98.02.22 CHECKED BY AEG

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
322.2											
0.0	**PEAT**, fibrous, dark brown		1	SS	1		322				
			2	SS	1		321				
320.6											
1.6	**SAND**, fine grained, some silt, compact to loose, brown, wet: (SP/SM)		3	SS	11		320				0 83 17
			4	SS	11						
			5	SS	4		319				0 88 12
							318				
317.0			6	SS	7						
5.2	END OF BOREHOLE AT 5.18m.										

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

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

RECORD OF BOREHOLE No D-98-2 1 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.0								20 40 60 80 100	10 20 30		
0.0	**PEAT**, brown		1	SS	1		322				
320.8			2	SS	1		321				
1.2	**SAND**, fine grained, trace to some silt, layered, loose, grey, wet: (SP)		3	SS	6		320				
			4	SS	10		319				
			5	SS	7						0 90 10
							318				
			6	SS	9		317				
			7	SS	7		315				
			8	SS	3		314				
	becoming compact		9	SS	11		312				0 91
			10	SS	9		309				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-2 2 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

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						
	SAND - continues as above						307				
			11	SS	17		306		○		
							305				
							304				
			12	SS	15		303		○		
							302				
							301				
			13	SS	20		300		○		
							299				
							298				
			14	SS	32		297		○		
							296				
							295				
	becoming dense, grey		15	SS	29		294		○		
							293				

Continued Next Page

+ 3, × 3 : Numbers refer to Sensitivity

20
15 ⊕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No D-98-2 3 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	SAND continues as above						292				
			16	SS	38		291		○		0 92 8
							290				
288.5							289				
33.5	SILT, trace sand, trace clay, layered, dense, grey, wet						288				
			17	SS	37		287		○		
							286				
							285				
			18	SS	35		284		○		0 4 92 5
							283				
							282				
			19	SS	46		281		○		
							280				
							279				
			20	SS	52		278		○		

Continued Next Page

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

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

RECORD OF BOREHOLE No D-98-2 4 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

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						
	SILT - continues as above						277				
							276				
			21	SS	38				○		0 64
							275				
							274				
							273				
			22	SS	46				○		
271.5							272				
50.5	**SAND**, fine grained, some silt, uniform, very dense, grey, wet						271				
							270				
			23	SS	63				○		0 81 19
							269				
							268				
							267				
			24	SS	65				○		
266.0							266				
56.1	END OF BOREHOLE AT 56.08m.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-3 1 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 ○ 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
321.6											
0.0	**PEAT**, silty, dark brown to black		1	SS	3		321		551.780		
			2	SS	1						
319.8			3	SS	9		320				
1.8	**SAND**, some silt to sand and silt, layered, loose to very loose, grey, wet		4	SS	7		319				
			5	SS	9		318				0 51
			6A	SS	4		317				
			6B	SS	3		316				
			7	SS	8		315				
			8	SS	7		314				
			9	SS	8		313				0 89 11
			10	SS	16		312				
	becoming compact		11	SS	16		311				
			12	SS	9		310				
							309				
							308				
							307				0 81 19

Continued Next Page

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

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

RECORD OF BOREHOLE No D-98-3 2 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	SAND - contonues as above						306				
			13	SS	5		305		○		
			14	SS	18		304		○		
			15	SS	21		303		○		
			16	SS	27		302		○		0 42
			17	SS	44		301		○		
			18	SS	24		300		○		0 38 62
			19	SS	20		299		○		0 92 8
			20	SS	17		298		○		
			21	SS	28		297		○		
							296		○		
							295		○		
							294		○		
							293		○		
							292		○		

Continued Next Page

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

$15 \overset{20}{\Phi} 5$ $\underset{10}{}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D-98-3 3 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 ○ 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
			22	SS	33		291				
			23	SS	27		290		○		0 93 7
			24	SS	38		289		○		
	becoming dense						288				
287.0			25	SS	49		287		○		
34.6	**SILT**, some sand to sandy, trace clay, layered, dense, , grey, wet		26	SS	43		286		○		
			27	SS	40		285		○		0 15
			28	SS	30		284		○		
			29	SS	40		283		○		
			30	SS	36		282		○		
							281				
							280				
							279				
							278				
							277				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-3 4 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	SILT - continues as above		31	SS	31		276		○		0 29 67 4
							275				
							274				
			32	SS	42		273		○		
							272				
271.5							271				
50.1	**SAND**, some silt, layered, very dense, grey, wet		33	SS	66		270		○		0 80 20
							269				
							268				
			34	SS	92/ .150		267				
							266				
							265				
			35	SS	81		264				
							263				
							262				

Continued Next Page

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

$15 \overset{20}{\oplus} 5$ $\underset{10}{}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D-98-3 5 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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						
			36	SS	67		261				
							260				
							259				
257.9			37	SS	73		258				
63.7	END OF BOREHOLE AT 63.70m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LELVEL READINGS:

DATE	DEPTH (m)
24/05/98	0.0
15/07/98	0.2
31/07/98	0.3

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

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

RECORD OF BOREHOLE No D-98-4 1 OF 3 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 945.3 E 324 737.5 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
321.4											
0.0	**PEAT**, fibrous, with roots, brown		1	SS	1		321				
319.9			2	SS	1						
1.5	**SAND**, some silt to sand and silt, layered, very loose to compact, layered, grey, wet		3	SS	10		320				
			4	SS	6		319				0 42 54 4
			5	SS	4		318				
			6	SS	5		317				
			7	SS	2		316				
			8	SS	11		315				
			9	SS	7		314				
			10	SS	2		313				0 77
			11	SS	8		312				
			12	SS	17		311				
							310				
							309				
							308				
							307				

Continued Next Page

+ 3, × 3 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-4 2 OF 3 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 945.3 E 324 737.5 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

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 (○ 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
	SAND - continues as above										
			13	SS	13		306		○		
							305				
			14	SS	6				○		
							304				
			15	SS	33		303		○		
	becoming dense						302				
			16	SS	28				○		
							301				
			17	SS	32		300		○		0 88 12
							299				
			18	SS	30				○		
							298				
			19	SS	25		297		○		
							296				
			20	SS	39				○		
							295				
			21	SS	52		294		○		0 86 14
	becoming very dense						293				
			22	SS	44				○		
							292				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-4 3 OF 3 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 945.3 E 324 737.5 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

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						
	SAND - continues as above						291				
290.5			23	SS	57				○		
30.9	END OF BOREHOLE AT 30.9m.										
	Dynamic cone driven to 34.4m										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-5 1 OF 1 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 940.8 E 324 765.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
321.3								20 40 60 80 100	10 20 30		GR SA SI CL
0.0	**PEAT**, fibrous, with roots, brown		1	SS	1		321	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	w_P w w_L	γ kN/m^3	
320.2			1	SS	1						
1.1	**SAND**, trace silt to silt and sand, loose to compact, grey, wet: (SP/SM)		3	SS	9		320				0 95 5
			4	SS	10		319				
			5	SS	10		318				
							317				
316.1			6	SS	5						0 37
5.2	END OF BOREHOLE AT 5.2m.										

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

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

APPENDIX B

APPENDIX B

LABORATORY TEST RESULTS

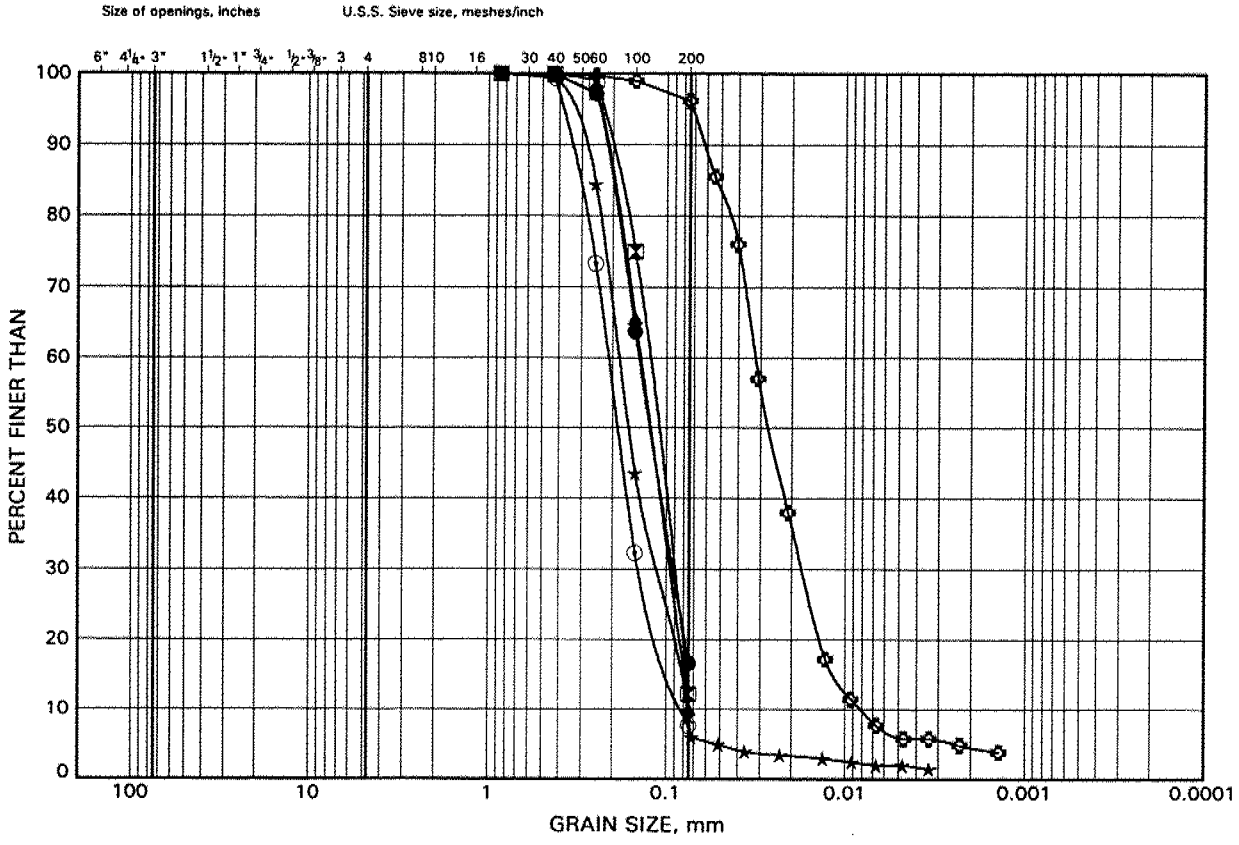
- Figures B1 to B4 - Grain Size analyses

- Table B1 - pH and Sulphate

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B1



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-1	1.83	320.37
⊠	D-98-1	3.35	318.85
▲	D-98-2	3.35	318.69
★	D-98-2	10.06	311.98
⊙	D-98-2	31.39	290.65
✿	D-98-2	37.49	284.55

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

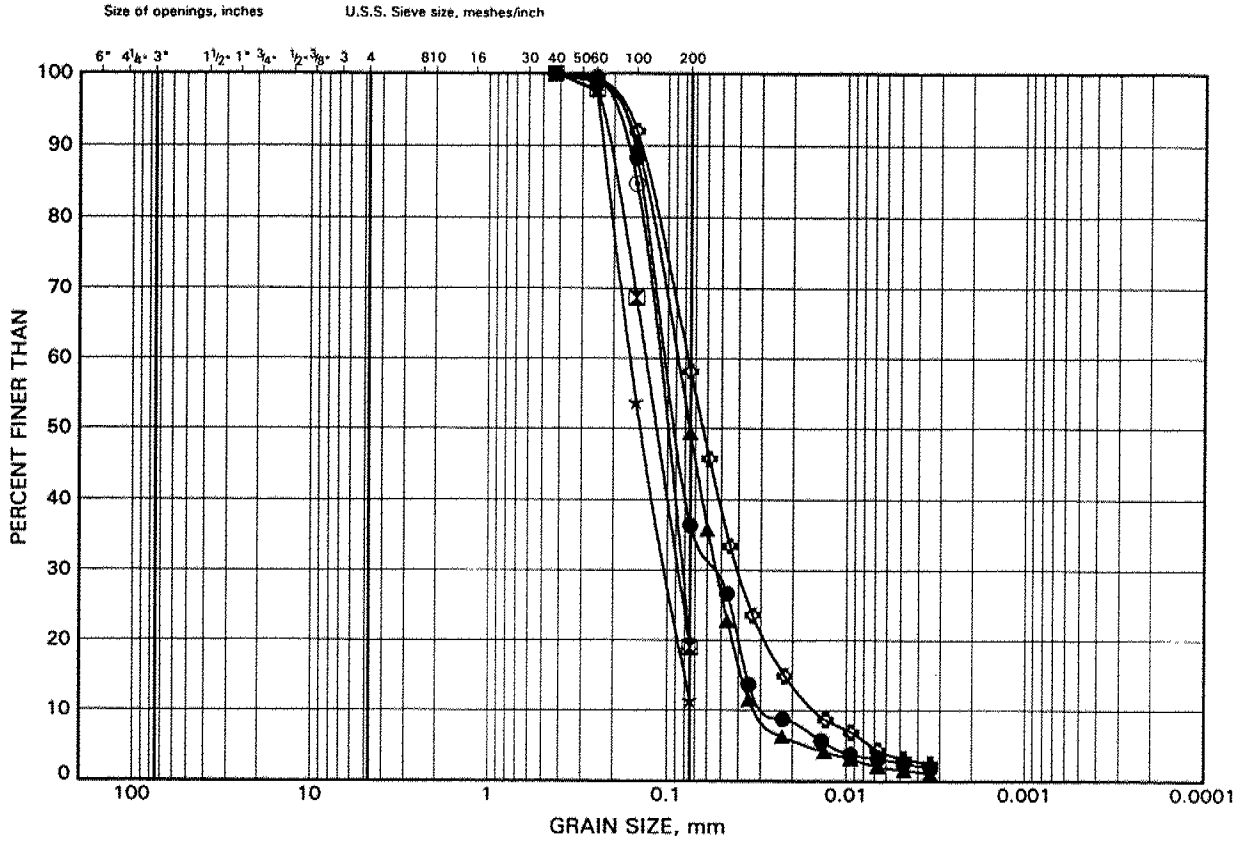
Chkd. AEG

THURBGSD 3517 98/10/06

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B2



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-2	46.63	275.41
⊠	D-98-2	52.73	269.31
▲	D-98-3	3.35	318.25
★	D-98-3	10.05	311.55
⊙	D-98-3	14.63	306.97
✿	D-98-3	19.50	302.10

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

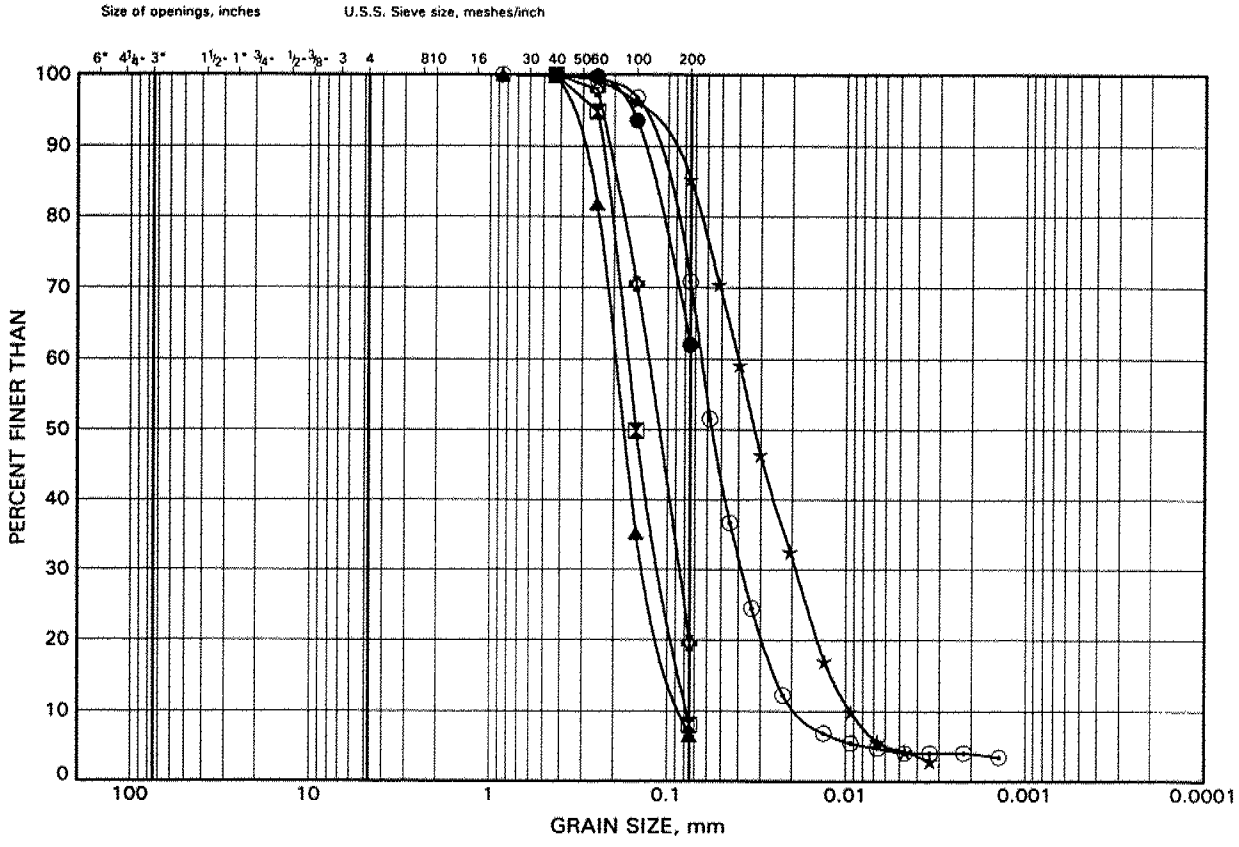
Chkd. AEG

THURBGSD 3517 98/10/06

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B3



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-3	23.77	297.83
⊠	D-98-3	25.30	296.30
▲	D-98-3	31.39	290.21
★	D-98-3	37.50	284.10
⊙	D-98-3	45.11	276.49
✿	D-98-3	51.20	270.40

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

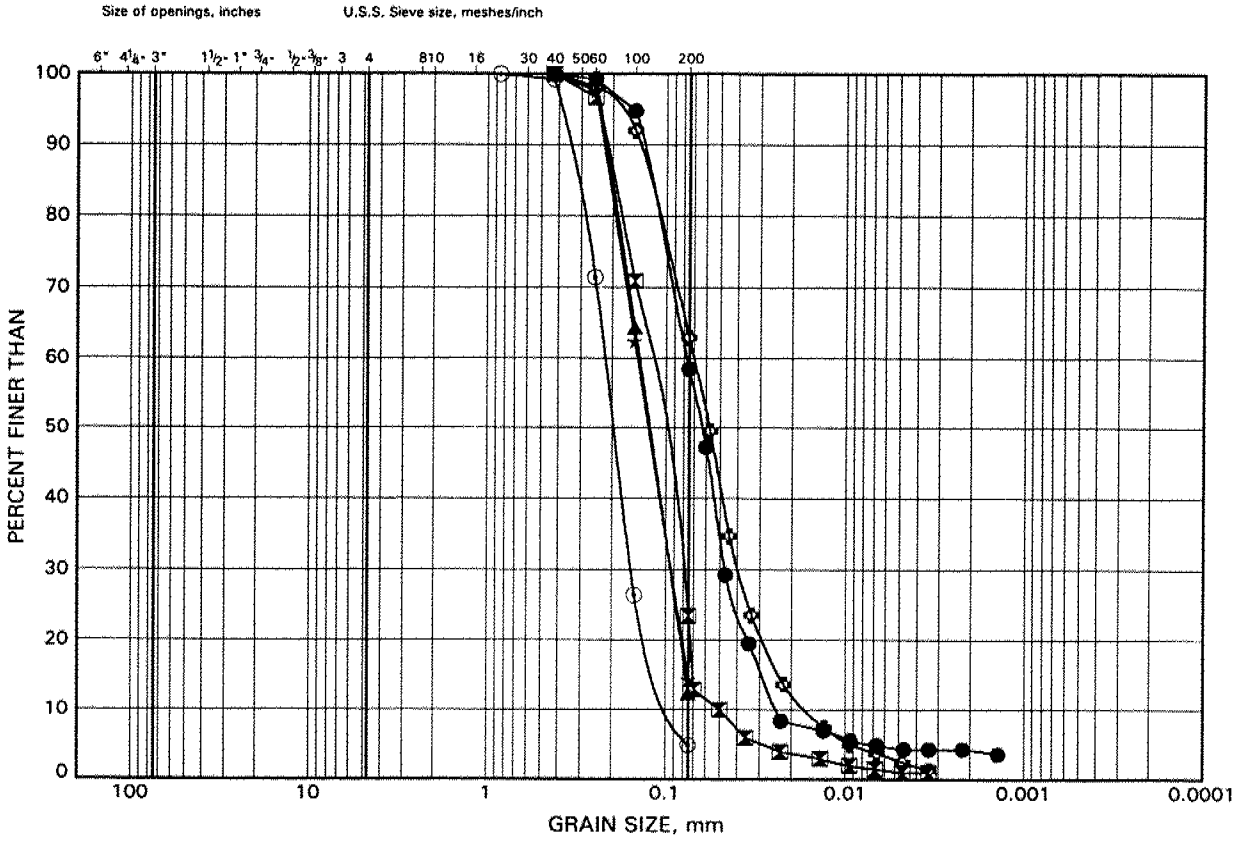
Chkd. AEG

THURBGSD 3517 98/10/06

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B4



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-4	2.59	318.81
⊠	D-98-4	9.37	312.03
▲	D-98-4	21.64	299.76
★	D-98-4	27.66	293.74
⊙	D-98-5	1.75	319.55
✿	D-98-5	4.88	316.42

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

Chkd. AEG

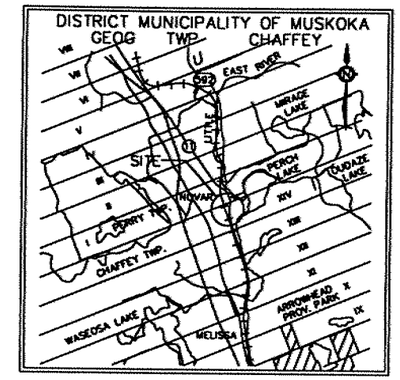
THURBGSD 3517 98/10/06

Table B1

Results of pH and Sulphate Testing

Sample	Depth (m)	pH	Sulphates (ppm)
D-98-2, SA3	1.5 - 2.1	4.2	178
D-98-4, SA3	1.5 - 2.1	3.1	1,150

DIST 52	
CONT No	
WP No 458-93-00	
HWY 11 – FOUR LANING NOVAR ROAD	SHEET
THURBER ENGINEERING LTD.	



KEY PLAN

1500m 0 3000 6000m

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

PLAN BASED ON PLAN E-625-11-9 SUPPLIED BY CLIENT

No	ELEV.	LOCATION	
		NORTHING	EASTING
D-98-1	9+940	5 033 959.1	324 636.4
D-98-2	9+962	5 033 956.9	324 657.8
D-98-3	10+000	5 033 951.6	324 697.2
D-98-4	10+041	5 033 945.3	324 737.5
D-98-5	10+070	5 033 940.8	324 765.8

19-1351-7d-01

BOREHOLE LOCATION PLAN

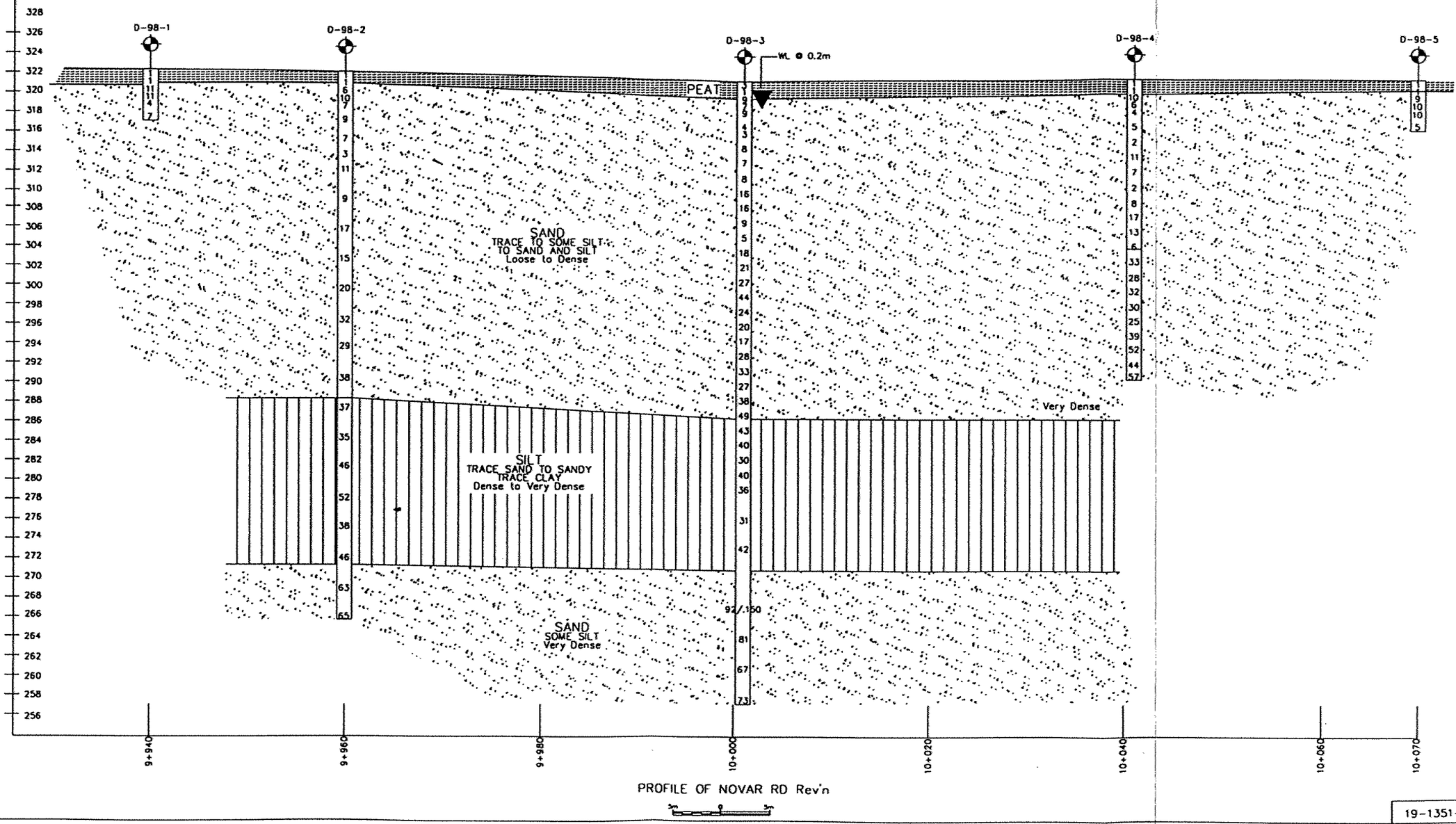
METRIC

DIMENSIONS ARE IN METRES AND / OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST 52	
CONT No	
WP No 458-93-00	
HWY 11-FOUR LANING NOVAR ROAD	SHEET
THURBER ENGINEERING LTD.	

LEGEND

- Borehole
- WL July 15, 1998
- 'N' Blows/0.3m (Std Pen Test)



PROFILE OF NOVAR RD Rev'n

19-1351-7d-02

THURBER ENGINEERING LTD.

Suite 101, 170 Evans Avenue
ETOBICOKE, Ontario M8Z 5Y6
Phone (416) 503-3600
Fax (416) 503-3010

THURBER

December 3, 1998 File: 19-1351-7

McCormick Rankin
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

Attention: Mr. Reno Radolli, P. Eng.

Re: Novar Road Underpass, Highway 11
Pile Capacity and Length

Dear Sir:

Further to our recent meeting with MTO where they expressed a concern regarding the recommended pile capacity and lengths for the Novar Road Underpass, we have reassessed the pile design. The results of this reassessment are summarized in Table 1 attached. Table 1 indicates that the piles may have to be driven deeper than indicated in our original design.

We understand that the drawings for the Novar Road underpass have not been issued for Tender yet and the pile driving note for Novar Bridge should be modified as follows :

Piles to be driven in accordance with Standards SS 103-10 or SS 103-11 using an ultimate capacity of 2520 kN but must be driven below the following elevations for the various foundation elements:

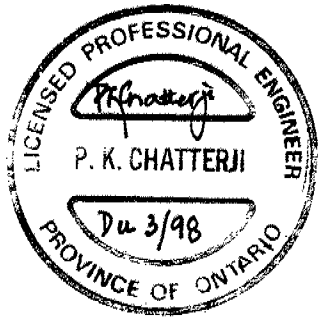
Foundation Element	Elevation of Base of Abutment Stem or Pile Cap	Piles Must be Driven Below Elevation
West Abutment	324.8	281.8
Central Pier	318.5	275.5
East Abutment	326.3	283.3

The revised ultimate resistance corresponding to Hiley's Formula is based on the stated MTO policy (refer to MTO letter dated September 9, 1998 on Little East River) in which ultimate resistance is taken as two (2) times the Factored ULS Capacity.

Continued....

We trust the contents of this fax clarify the results of our reassessment which addresses the concerns of the MTO foundation section. Please do not hesitate to call if you require any additional clarification.

Yours very truly,
Thurber Engineering Ltd.



P.K. Chatterji, P. Eng.
Review Principal

Paulo Branco, P. Eng.
Principal

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Continued....

Table 1
Pile Design Reassessment : Novar Road Underpass, Hwy 11

Bridge	Foundation Element	No. of Piles	SLS Capacity per pile (kN)	Factured ULS Capacity per pile (kN)	Ultimate Pile Capacity for control of driving based on Hiley's Formula (kN)	Most likely pile depth based on our reassessment (m below abutment stem or pile cap)
Novar	West Abutment	8	820	1260	2520	43
	Central Pier	8	820	1260	2520	43
	East Abutment	8	820	1260	2520	43

MEMORANDUM

Ontario

To: V. Minassin
Senior Project Engineer
Northern Region

November 4, 1998

From: Pavements and Foundations Section
Room 315, Central Bldg.

Tel: (416) 235-5267
Fax: (416) 235-5240

Re: Draft Foundation Investigation and Design Report Review
Novar Road Underpass
WP 464-96-01, Site 42-235

As requested in your memorandum dated October 20, 1998, our office has completed a review of the Final Foundation Investigation Report and Final Factual Investigation Report for the Novar Road Underpass. Our review comments are provided in this memorandum under the corresponding heading in the report.

Factual Component of the Report

Figures

Figures B1 to B4 are not to MTO standards. The figures should present the different soil strata separately.

Discussion and Recommendations Component of the Report

The Foundation Investigation and Design Report only partially addresses the terms of reference for the design and construction of structure foundations and related earthworks. In view of the absence of a competent end bearing material within the practical depth of the investigation, special attention is required in the design and construction of the structure foundations. Comments regarding the axial capacity of the pile particularly and other comments as well are given in this memorandum.

Structure Foundations

Pile Capacity

1. Static analysis has been employed to predict the axial resistance of the piles. Static analysis is not the most accurate method of predicting axial pile capacity. Based on pile load test data available in the MTO Foundations Pile Load Test database report, lower axial capacities were obtained at a site with similar subsurface conditions and pile type. The merit of verifying the recommended axial pile capacities by reviewing pile load test data or perhaps conducting a site specific pile load test should be discussed with the Consultant.

2. The lateral capacity of the pile was given at SLS only. A lateral pile capacity at ULS is required.

   In the computation of lateral resistance, the coefficient of horizontal subgrade reaction is a parameter required when finite element modelling techniques are employed. Horizontal subgrade reaction parameters have not been included in the report.

Integral Abutment Design

The surficial soils at the site are comprised of peat and loose sand. The report recommends that the surficial layer of peat be completely stripped and replaced with compacted earth fill. In addition, the report states that the annular space surrounding the top 3.0 m length of pile be filled with loose sand. In view of the existing native loose sand, the Consultant should review the need for importing fill material beneath the peat material that is going to be excavated.

Pile Driving

1. The ultimate resistance of a driven pile using the Hiley Dynamic Formula is taken as two(2) times the Factored Capacity at ULS.

2. Pile Tip Elevations are given as minimum values. For piles as required at the site, there exists a risk that the axial capacity at the design tip elevation will not be achieved. This leaves the potential for significantly larger embedment lengths than estimated. It is recommended that a note be included in the contract drawings that states that piles shall not be driven beyond the design tip elevation without approval from the Design Engineer.

Pile Installation

Appropriate special provisions shall be included in the contract documents to ensure the quality assurance of the installation of the deep foundation units. An end result special provision for Piling that includes a requirement for a certificate of conformance can be obtained from our office.

Earth Pressure

The report presently recommends a Granular B, Type 1 backfill material. Consideration should be given to including a Granular A backfill material as an alternative. Soil parameters should be provided accordingly.

It is recommended that heavy compaction equipment be restricted within close proximity of the abutment and wingwalls to avoid inducing unnecessary pressures on the walls. An NSSP should be included in the Contract Documents that restricts the equipment size and type adjacent to the walls.

Embankment Design

The Consultant has recommended an embankment geometry of 3H:1V or 2H:1V with 2 m wide midheight berms for common earth fill and Selected Subgrade material respectively. This geometry recommendation applies to fill heights exceeding 8 metres provided that the peat material is completely subexcavated. For the conditions described in the report we have conventionally recommended a 2H:1V embankment geometry for either common earth fill or selected subgrade material.

Excavation and Groundwater Control

It is recommended that an NSSP be included in the Contract Documents that alerts the Contractor of the subsurface and groundwater conditions at the site and that the Contractor is responsible for (a) the necessary subexcavation and construction of foundations in the dry and (b) proper placement of embankment fill on the native subsoils.

We trust these comments are sufficient for your purposes. If you require additional assistance, please do not hesitate to contact our office.

T. Sangiuliano, P. Eng.
Foundation Engineer

for

D. Dundas, P. Eng.
Senior Foundation Engineer

cc. T. Kazmierowski

MEMORANDUM

Ontario

To: V. Minassin
Senior Project Engineer
Northern Region

July 29, 1998

From: Pavements and Foundations Section
Room 315, Central Bldg.

Tel: (416) 235-5267
Fax: (416) 235-5240

Re: Draft Foundation Investigation and Design Report Review
Novar Road Underpass
WP 464-96-01, Site 42-235

As requested in your memorandum dated July 22, 1998, our office has completed a review of the Foundation Investigation Report. Our review comments are provided in this memorandum under the corresponding heading in the report.

Site Description

Site Layout

Normally, a description of the proposed structure is not included in the Site Description section of the report

Investigation Procedure

Conventionally, the Field Investigation and Laboratory Analyses are included within this subsection of the report.

Field Investigation

The depths of the boreholes advanced should be given.

The Standard Penetration Test(SPT) was conducted both as an in situ test to evaluate the strength of the soil and also as a method of sample retrieval. An appropriate reference for the test procedure should be included in the report (ASTM D1586).

The penetration depths of the Dynamic Cone Tests should be included in this section of the report.

The method of measuring the groundwater levels should be clarified. Presently, it appears that the groundwater levels were taken only at BH D 98-3. If water levels were not taken at the other boreholes, an explanantion shall be given.

The backfilling of boreholes, storage and transportation of samples should also be included in the

Field Investigation component of the *Investigation Procedure.*

Borehole Logs

The coordinates of the boreholes have not been identified on the individual borehole logs.

Figures

Figures B1 to B4 are not to MTO standards. In fact, the title of Figures B1 to B4 identify the CNR Overhead structure.

Expanation of Terms Used in the Report

The symbols and terms used on the Borehole Logs are not to MTO standards. Our office can supply the terms and symbols that are conventionally used in MTO reports

If you require additional information, please do not hesitate to contact our office.

T. Sangiuliano, P. Eng.
Foundation Engineer

for

D. Dundas, P. Eng.
Senior Foundation Engineer

cc. P. Stuart
T. Kazmierowski

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 31E-184

DIST. 52 REGION

W.P. No. 464-96-01

CONT. No.

W. O. No.

STR. SITE No. 42-235

HWY. No. 11

LOCATION Novar Rd. Underpass

No of PAGES - 1

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

GEOCRES #31E-184

FINAL FOUNDATION DESIGN REPORT FOR NOVAR ROAD UNDERPASS HIGHWAY 11 FOUR LANING 6.7 km NORTH OF HWY 60 NORTHERLY 13 km W.P. 462-93-00, SITE 42-235 DISTRICT 52, HUNTSVILLE

Report

to

McCormick Rankin Corporation

Thurber Engineering Ltd.
170 Evans Avenue, Suite 101
Etobicoke, Ontario
M8Z 5Y6
Phone: (416) 503 3600
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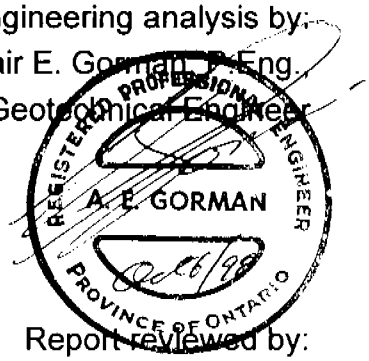
Direction of fieldwork and engineering analysis by:
Alastair E. Gorman, P.Eng.
Senior Geotechnical Engineer



Report reviewed by:
P.K. Chatterji, P.Eng.,
Review Principal

October 6, 1998
File: 19-1351-7d
AEG/C:\19\1351\7\7D\7D-FND FIN

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FINAL FOUNDATION DESIGN REPORT FOR NOVAR ROAD UNDERPASS HIGHWAY 11 FOUR LANING 6.7 km NORTH OF HWY 60 NORTHERLY 13 km W.P. 462-93-00, SITE 42-235 DISTRICT 52, HUNTSVILLE

1. INTRODUCTION

This report presents the results of the foundation investigation carried out by Thurber Engineering Ltd. (Thurber) at the site of the proposed bridge and approach fills at the intersection of the extended Novar Road with realigned Highway 11 in the Town of Huntsville. The purpose of the investigation was to explore the subsurface soil and groundwater conditions at the site and based on the data obtained provide borehole logs, soil profile and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation (MRC) under Ministry of Transportation (MTO) Agreement 9750 - 7424 - 5262.

2. SITE DESCRIPTION

2.1 Site Location

The structure forms part of the four-laning of Highway 11 north of Huntsville and is located at the intersection of the proposed extension of Novar Road and a realigned portion of Highway 11. The site lies at Station 26+040, approximately, C/L Median Highway 11.

Locally, the site may be described as lying east of the existing Highway 11, in a flat, low-lying, treed area opposite the existing intersection of Novar Road with Highway 11. Access to the site was directly from Highway 11 or along the ROW from Highway 592 a short distance to the north.

2.2 Physiography

Based on The Physiography of Southern Ontario, 3rd Edition, by Chapman and Putnam, the region surrounding the site consists of bedrock ridges with shallow overburden. The bedrock is undifferentiated igneous and metamorphic rock of early Precambrian age and is generally hard and massively jointed.

The Highway 11 corridor, however, lies in a long, narrow sand plain filling a deep valley within the region of shallow bedrock. The typical soils filling the deep valley in the corridor consist of sand and silt, with some gravel deposited as glacial outwash or in localized glaciolacutrine environments.

The nearby, meandering creek (Little East River) and several wetlands in the area suggest poor drainage and a high groundwater table. Locally the ground is relatively flat, wet at the surface and supports typical vegetative cover for wet areas.

3. INVESTIGATION PROCEDURES

3.1 Field Investigation

Between February 18 and 24, 1998, a Nodwell track mounted auger rig was used on site for drilling, Standard Penetration Testing (SPT) and dynamic cone penetration testing. One hole was drilled for each abutment, one for the central pier and one at each approach fill, giving a total of five sampled boreholes. The approximate locations of the boreholes are shown on Drawing 19-1351-7d-01.

The holes were initially advanced using hollow stem augers. Fine uniform sand and silt were encountered below a relatively high water table which caused heaving of the soil into the hollow stem auger when the pilot bit was withdrawn in preparation for SPTs. The hollow stem augers were kept full of drilling mud at all times to counteract the effect of an unbalanced head of groundwater.

When it became apparent that auger drilling had reached its effective depth limit, mud rotary drilling was implemented for the balance of the depth of the hole.

The boreholes were numbered D-98-1 through D-98-5. The depths of sampling in the five boreholes were as follows:

Borehole No.	Depth of Sampling (m)
D-98-1	5.2
D-98-2	56.1
D-98-3	63.7
D-98-4	30.9
D-98-5	5.2

Samples were recovered at intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT) (following the test procedure outlined in ASTM D 1586). Samples were generally recovered at intervals of 0.75 m in the upper 3.0 m and thereafter at intervals of 1.5 m to depths which vary between the holes. In some holes the sampling interval was increased to 3.0 m after stratigraphic continuity was established.

Dynamic cone penetration tests were conducted in, or adjacent to selected holes as follows

Borehole No.	Depth of Dynamic Cone Test
D-98-3	From ground surface to 13.7 m and from 15.0 to 22.8 m, adjacent to the hole
D-98-4	From the termination of sampling at 30.9 m to 34.4 m, from the bottom of the borehole.

Boreholes were not left open long enough for the groundwater to stabilize and this coupled with the constant addition of drilling fluid led to the decision not to report data on groundwater levels on completion of drilling. Based on the flat site and the consistent sand stratigraphy, one standpipe piezometer was installed in Borehole D-98-3 to monitor the groundwater level.

The boreholes were backfilled with drill cuttings except in Borehole D-98-3 where sand pack was installed around the piezometer tip and a bentonite plug was installed near the top of the hole.

All recovered samples were examined, identified and logged in the field and were transported to Thurber's Toronto laboratory by the field supervisor for further examination and laboratory analysis.

The result of the drilling and sampling are summarized on the borehole logs in Appendix A.

3.2 Laboratory Analysis

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all recovered samples. In addition, grain size analyses and pH and sulphate content testing were conducted on selected samples. The results of the laboratory testing are presented on the borehole logs in Appendix A, and in Figures B1 to B4 in Appendix B. The results of the pH and sulphate content are presented in Table B1.

4. DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Subsurface Soil Conditions

Detailed descriptions of the subsoil conditions encountered in the boreholes are presented on the borehole logs in Appendix A. The stratigraphic profile inferred from the borehole information is shown on Drawing No. 19-1351-7d-01.

In general, the boreholes indicate a surface layer of peat underlain by sand which extends to depths in the order of 34 m. The upper sand is underlain by a deposit of silt approximately 16 m thick, which in turn is underlain by a lower sand deposit.

Further description of these major soil units is provided in the following sections. The soils encountered all appeared to be lacustrine or fine outwash deposits and no evidence of boulders was found. However, the possibility of encountering boulders at random locations in the sand and silt deposits during construction must be recognized.

Peat

All boreholes encountered a layer of peat at the surface. The peat is fibrous, contains numerous roots and was noted as silty in Borehole D-98-3. The colour of the peat ranges from brown to dark brown to black. Measured moisture contents lie in the range of 70 to 564%.

The interpreted depths of peat at the boreholes are as follows:

Borehole No.	Depth of Peat (m)
D-98-1	1.6
D-98-2	1.2
D-98-3	1.8
D-98-4	1.5
D-98-5	1.1

Actual depths of peat to be stripped may vary from those interpreted at the borehole locations.

Upper Sand

Based on Boreholes D-98-2, D-98-3 and D-98-4, the upper sand layer extends to depths of approximately 34 m below existing ground level, or to

approximate Elevation 287.0 to 288.5.

The sand is fine grained and uniform and contains silt in proportions ranging from trace to some and to sand and silt in Boreholes D-98-4 and D-98-5. Grain size distributions for selected samples are shown in Figures B1 to B4. The deposit shows faint layering and is grey and wet.

Based on the SPT values, the density of the upper sand layer is variable from very loose to dense with N values ranging from 2 to 44. Below a depth of 28 m in Borehole D-98-4, the upper sand becomes very dense, with N values ranging from 44 to 57. The measured natural moisture contents ranged from 19 to 30%.

Boreholes D-98-1 and D-98-5, in the areas of the approach embankments, were terminated in the upper sand at depths of 5.2 m. Boreholes D-98-2 and D-98-3 fully penetrated the upper sand at depths of approximately 34 m. Sampling in Borehole D-98-4 was terminated at a depth of 30.9 m and the base of the upper sand layer was not established in this hole.

Silt

Below the upper sand, Boreholes D-98-2 and D-98-3 encountered a deposit of silt. The silt extends from Elevation 288.5 to 271.5 m in Borehole D-98-2 and from Elevation 287.0 to 271.5 m in Borehole D-98-3. The silt contains sand in proportions ranging from trace sand to sandy and also trace clay. The grain size distributions for selected samples are shown in Figures B1 to B4. The deposit shows faint layering, is grey and wet.

Based on the recorded SPT values, the silt is dense to very dense with N values ranging from 30 to 52. The measured natural moisture contents range from 21 to 29%.

Both boreholes fully penetrated the silt layer and into the underlying lower sand.

Lower Sand

Below Elevation 271.5, respectively, Boreholes D-98-2 and D-98-3 encountered a lower sand deposit which extended to the termination depths of the boreholes, 56.1 and 63.7 m, respectively. The sand is fine grained and uniform and contains some silt. Grain size distributions for selected samples are shown in Figures B2 and B3. The lower sand deposit shows faint layering and is grey and wet.

Based on the recorded SPT values of 63 for 0.30 m to 92 for 0.15 m of penetration, the lower sand is in a very dense state. The measured natural moisture contents ranged from 21 to 30%.

4.2 Groundwater

The following groundwater levels were recorded in the piezometer installed in Borehole D-98-3:

Date	Depth to Water (below existing ground surface)
May 24, 1998	0.0 m
July 15, 1998	0.2 m
July 31, 1998	0.3 m

Based on this data, the groundwater lies close to the ground surface or at Elevation 321.3. The water level may fluctuate throughout the year, and in particular surface flooding may occur after Spring thaw or periods of heavy rain.

5. RECOMMENDATIONS FOR STRUCTURE FOUNDATIONS

5.1 Type of Structure

The proposed structure will be a two-span bridge carrying Novar Road over the re-aligned Highway 11. Geotechnical recommendations are required for the design of foundations at:

a. the west abutment
b. the central pier
c. the east abutment

The west and east spans of the proposed structure will be 38.0 and 39.0 m long, respectively, and it is understood that an integral abutment design is preferred, if the foundation conditions are suitable.

Geotechnical recommendations are also required for the approach fills to the bridge.

5.2 Foundation Soil Conditions

The factual description of the foundation soils is presented in Section 4. of the report. A discussion of the soil conditions is presented below.

The foundation conditions encountered in the Boreholes D-98-2 and D-98-4 consist of deep deposits of fine sand and silt. These soils are considered suitable for the design of an integral abutment bridge with each abutment supported on a single row of H-piles driven to sufficient depth to achieve fixity well below the depth required to provide for movement of the abutment. The surficial layer of peat should be stripped as discussed in Section 7. Embankment Design.

For the proposed two span bridge, no movement is required at the central pier and the foundation can be considered to be effectively fixed. The near surface soils are too loose to support a spread footing and it is recommended that the central pier be supported on a piled foundation.

5.3 Piled Foundations

5.3.1 Axial Capacity

The foundations of both the abutments and the central pier should be supported on HP 310X110 piles.

Axial resistance analysis has been carried out for the HP 310X110 pile using the soil parameters described in the Foundation Investigation Report and assuming both skin friction and end bearing.

Abutments

In the analysis of the vertical geotechnical resistance developed by the piles at the abutments, the following assumptions were made:

- the underside of the abutment stems will be approximately at Elevation 324.8 at the west abutment and 326.3 at the east abutment
- the surficial layer of peat will be completely stripped and replaced by compacted earth fill
- the top 3.0 m length of pile was assumed to be surrounded by loose sand and not to contribute to the vertical resistance.

For the abutments, analysis indicated that an HP 310X110 pile driven to a total depth of 33 m below the base of the abutment stem would have a factored geotechnical resistance at ULS of 1,600 kN and an SLS resistance of 1,000 kN. This is expected to correspond to a pile tip elevations of approximately 292 at the west to 293 at the east.

The geotechnical resistance should be checked against the structural capacity of the pile.

Central Pier.

The underside of the pile cap is estimated to lie at Elevation 318.5.

At the central pier, there is no requirement for lateral movement and the full depth of the pile below the pile cap was assumed to contribute to the axial resistance, provided no peat remains below the pile cap. To ensure this condition, the contract should specify that all peat and similar deleterious material should be removed for a distance of 5.0 m beyond the pile cap. if necessary, the area may be backfilled to the underside of the pile cap using earth fill or granular fill at the contractors discretion.

For the pier, analysis showed that an HP 310X110 pile driven to 31 m below the underside of the pile cap will have a factored geotechnical resistance at ULS of 1,600 kN and an SLS resistance of 1,000 kN. This is expected to correspond to a pile tip elevation of approximately 288.

The geotechnical resistance should be checked against the structural capacity of the pile.

5.3.2 Lateral Resistance

ULS ?

The lateral resistance of the HP 310X110 pile was analyzed assuming flexure in the weak direction and the computed value is 40 kN at SLS.

5.3.3 Pile Installation

The piles should be provided with driving shoes in accordance with OPSD 3301.00.

320 kN ?

Pile driving should be carefully monitored and controlled employing the Hiley Dynamic Pile Driving Formula in accordance with MTO Standards SS 103-10 or SS 103-11 and assuming an ultimate resistance of 3,000 kN.

The piles supporting the two abutments should be installed in holes pre-augered to depths of 3.0 m which should then be backfilled with fine to medium grained, uniformly graded, loose sand. The grading requirements for the sand are shown in Table C1 in Appendix C. In order to prevent collapse of the pre-augered hole and contamination of the sand backfill, a 600 mm diameter sleeve may be placed in the pre-augered hole.

The pile driving should be carried out using a hammer delivering energy in the order of 50 kJ per blow.

During the driving process, piles which have already been driven should be monitored to determine if they are heaving due to the effects of driving adjacent piles. If this phenomenon occurs, the affected piles must be re-driven.

5.3.4 Pile Driving Note

The pile driving note to be added to the drawings should be Note 2 in Clause 2.5.11 of the Structural Manual. The ultimate resistance to be used is 3,000 kN. The elevations below which the piles must be driven are::

- west abutment - Elevation 292
- east abutment - Elevation 293
- central pier - Elevation 288

6. EARTH PRESSURE

The lateral earth pressures to be used in design should be computed in accordance with Section 6-7 of the OHBDC .

Granular backfill should be placed behind the abutment walls and wing walls to conform to the minimum requirements illustrated in OPSD 3501.00. The granular backfill should conform to Ontario Provincial Standard Specifications (OPSS) 1010 for Granular B, Type 1. The fill should be placed in accordance with OPSS 501. A perforated subdrain should be installed behind the base of the walls as shown in OPSD 3501.00 to maintain the granular fill in a drained condition. The subdrain should be provided with a positive outlet to the highway drainage system.

For the above backfill and drainage conditions, the abutment walls and wing walls may be designed based on the following unfactored earth pressure distributions:

$P_h = K \gamma h$

where;

K = earth pressure coefficient, use value from table below.

γ = unit weight of soil, = 21.2 kN/m^3 for Granular B

h = depth below top of wall, m

Wall Type	Earth Pressure Coefficient (K)	
	OPSS Granular B $\phi' = 30°$	
	Horizontal Ground Surface Behind Wall	Sloping Ground Surface (2H:1V)
Abutment Walls (Restrained Wall)	0.50	-
Wing Walls (Unrestrained Wall)	0.33	0.55

If an integral abutment design is used, the abutments will be cast integrally with the deck and therefore the abutment walls should be treated as restrained. If the wing walls will not be connected to the abutments and therefore will be able to accommodate some rotation they may be treated as unrestrained. The above also assumes a horizontal ground surface behind the abutment walls. If concrete approach slabs are not provided, an additional load equivalent to 600 mm of fill should be superimposed on the wall loadings to account for traffic surcharge loading.

Additional lateral pressure must be added to account for compaction induced forces. The additional pressure must be computed in accordance with Section 6-7.4.3 of the OHBDC.

Restriction of heavy equipment behind wall

7. EMBANKMENT DESIGN

Based on Plan E-625-11-9, Sheet 2 of 2, the driving lanes of Highway 11 will be constructed on embankments with a finished grade 3 to 4 m above existing ground level. At the abutments, the Novar road approach embankments will be 10 to 12 m above existing ground level.

As shown on the borehole logs, a surface layer of peat was encountered at the boreholes which measured 1.1 to 1.8 m in thickness. Prior to construction, all peat below the immediate approach embankment footprint should be stripped from the toe of the forward slope to a distance of at least 10 m behind the abutment. Beyond these limits, stripping should be coordinated with the recommendations of the Pavement Design Report. This stripping is recommended mainly to minimize differential settlement between the embankment and the structure and also to eliminate downdrag on the piles created by consolidation of the peat after the piles have been driven and the approach fills completed.

Based on the groundwater level lying close to the ground surface, the base of the stripped area will lie below water, unless prior steps are taken to lower the groundwater level. If fill is to be placed on a wet or flooded subgrade, fine grained earth fill is not recommended at the lower levels since it will be very difficult to compact this material. If these wet conditions are allowed to exist, the contract should specify the use Select Subgrade Material (SSM) to a level 1 m (±) above the prevailing water table.

Above the water table, earth fill may be used in embankment construction, subject to the Non Standard Special Provision (NSSP) in Appendix D.

Embankments for Novar Road constructed of common earth fill should generally have side slopes not steeper than 3:1, and all peat must be stripped from below the embankment. If these embankments are specified to be constructed of Select Subgrade material (SSM), then side slopes not steeper than 2:1 may be used, provided all peat is stripped.

The forward slope under the bridge may be constructed at 2:1 provided it is covered with concrete slope paving and earth fill meeting the NSSP in Appendix D

is used.

In either of the above cases, where the embankment height will exceed 8.0 m, a berm 2.0 m wide should be provided on the embankment side slopes in each 8.0 m vertical interval. Provided the forward slope does not exceed 8.0 m in height, measured from the toe to the point where it intersects the face of the abutment, the berm on the side slope need not be carried into the forward slope. In this case, the side slope berm may be transitioned from 2.0 m at the end of the wing wall to zero width at the concrete slope paving on the forward slope. The transition from a 3:1 side slope to a 2:1 forward slope may also occur in this zone.

Embankment fill should be placed in appropriate lift thicknesses and be compacted in accordance with OPSS 501.

8. EXCAVATION AND GROUNDWATER CONTROL

The groundwater level established by piezometer readings at the central pier is at Elevation 321.3, very close to existing ground level.

At the two abutments, long term dewatering will not be required. Short term dewatering may be required, depending on the decision made regarding backfilling. After the embankment is constructed, there will be no further need for groundwater control at the abutments.

At the central pier, the underside of the pile cap is expected to be at Elevation 318.5. The excavation required to construct the pile cap will be carried out in saturated sand and will extend approximately 3.0 m below the stabilized groundwater level. Groundwater seepage into such an excavation would create boiling and unstable base conditions and caving of the side slopes, and it is recommended that positive groundwater control measures be implemented prior to excavation being carried out for construction of the pile cap.

The method of positive groundwater control should be selected by the contractor, subject to approval, but should produce a stable working base free of boiling or quick conditions. Typically, the required performance will be achieved under the site conditions by using vacuum well points or driven, interlocking steel sheeting

or a combination of both.

The groundwater control measures should be kept in place until construction of the pile cap has been completed and the excavation has been backfilled.

All excavations must be carried out in accordance with the Occupational health and Safety Act.

No permanent groundwater control measures are required for the proposed piled foundation.

9. FROST PROTECTION

The design depth of frost penetration for this project is 1.8 m. All pile caps and footings designed for this site must be provided with a minimum depth of soil cover of 1.8 m to protect against the penetration of frost below the foundation elements.

10. CONSTRUCTION CONCERNS

Construction of the pile cap for the central pier will be carried out from a subgrade level that will be created by excavation into a presently saturated sand stratum. It is important that the groundwater level be depressed at least 1.0m below the excavation base prior to pile cap construction.

Similarly, stripping and construction of the approach embankments may experience difficulty with high groundwater levels.

11. CONSTRUCTION INSPECTION AND MONITORING

During construction, all foundation installation, excavation and embankment construction activities should be monitored by geotechnical personnel to confirm that the foundation recommendations and design are being correctly implemented and that the soil conditions encountered do not differ materially from the interpretation used in this report.

STATEMENT OF GENERAL CONDITIONS

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering or environmental consulting practices in this area. No other warranty, expressed or implied, is made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS "APPROVED USERS". The contents of the Report remain our copyright property and we authorize only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make the Report, or any portion thereof, available to any party without our written permission. Any use which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. We accept no responsibility for damages suffered by any third party resulting from unauthorized use of the Report.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgemental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of persons providing information.

6. RISK LIMITATION

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause an accidental release of those substances. In consideration of the provision of the services by us, which are for the Client's benefit, the Client agrees to hold harmless and to indemnify and defend us and our directors, officers, servants, agents, employees, workmen and contractors (hereinafter referred to as the "Company") from and against any and all claims, losses, damages, demands, disputes, liability and legal investigative costs of defence, whether for personal injury including death, or any other loss whatsoever, regardless of any action or omission on the part of the Company, that result from an accidental release of pollutants or hazardous substances occurring as a result of carrying out this Project. This indemnification shall extend to all Claims brought or threatened against the Company under any federal or provincial statute as a result of conducting work on this Project. In addition to the above indemnification, the Client further agrees not to bring any claims against the Company in connection with any of the aforementioned causes.

7. SERVICES OF SUBCONSULTANTS AND CONTRACTORS

The conduct of engineering and environmental studies frequently requires hiring the services of individuals and companies with special expertise and/or services which we do not provide. We may arrange the hiring of these services as a convenience to our Clients. As these services are for the Clients' benefit, the Client agrees to hold the Company harmless and to indemnify and defend us from and against all claims arising through such hirings to the extent that the Client would incur had he hired those services directly. This includes responsibility for payment for services rendered and pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. In particular, these conditions apply to the use of drilling, excavation and laboratory testing services.

8. CONTROL OF WORK AND JOBSITE SAFETY

We are responsible only for the activities of our employees on the jobsite. The presence of our personnel on the site shall not be construed in any way to relieve the Client or any contractors on site from their responsibilities for site safety. The Client acknowledges that he, his representatives, contractors or others retain control of the site and that we never occupy a position of control of the site. The Client undertakes to inform us of all hazardous conditions, or other relevant conditions of which the Client is aware. The Client also recognizes that our activities may uncover previously unknown hazardous conditions or materials and that such a discovery may result in the necessity to undertake emergency procedures to protect our employees as well as the public at large and the environment in general. These procedures may well involve additional costs outside of any budgets previously agreed to. The Client agrees to pay us for any expenses incurred as the result of such discoveries and to compensate us through payment of additional fees and expenses for time spent by us to deal with the consequences of such discoveries. The Client also acknowledges that in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed and the Client agrees that notification to such bodies by us will not be a cause of action or dispute.

9. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on our interpretation of conditions revealed through limited investigation conducted within a defined scope of services. We cannot accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes decisions made to either purchase or sell land.

APPENDIX A

APPENDIX A

BOREHOLE LOGS

- Symbols and Terms Used on Borehole Logs

- Unified Soil Classification

- Borehole Logs D-98-1 to D-98-5

THURBER

BOREHOLE GRAPHIC SYMBOLS

SOILS

FILL
ORGANICS
CLAY
SILT
SAND
GRAVEL
COBBLES

SILTY CLAY
CLAYEY SILT
SILTY SAND
SAND & GRAVEL
CLAYEY SILT TILL
SILTY CLAY TILL
SANDY SILT TILL

ROCK

SHALE
LIMESTONE

SILTSTONE
GRANITE

OTHER

CEMENT GROUT
BENTONITE GROUT

CONCRETE
WATER

BENTONITE SEAL

THURBER

TTCHTCH2 6209 85/03/14

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] "N" VALUE
Very Soft	Less than 10	Less than 2
Soft	10 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR TEST HOLE LOGS

SYMBOLS FOR SAMPLE TYPE

■	Shelby Tube		A - Casing
☑	SPT	▯▯	Grab/Auger sample
☒	No Recovery	▯▯	Core

- • MC - Moisture Content (% by Weight) as determined by sample]
- ▼ Water Level
- C_{vane} Shear Strength Determination by Field Insitu Vane
- C_{pen} Shear Strength Determination by Pocket Penetrometer
- C_{lab} Shear Strength Determination using a Laboratory Vane Apparatus
- C_U Undrained Shear Strength determined by Unconfined Compression Test

(1) SPT Standard Penetration Test - refers to the number the blows from a 63.5kg hammer falling through 0.76m to advance a 60 degree truncated cone 0.3m.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W_L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W_L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W_L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W_L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No D-98-1 1 OF 1 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 959.1 E 324 636.4 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.22 - 98.02.22 CHECKED BY AEG

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 ○ 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
322.2											
0.0	**PEAT**, fibrous, dark brown		1	SS	1		322				
			2	SS	1		321				
320.6											
1.6	**SAND**, fine grained, some silt, compact to loose, brown, wet: (SP/SM)		3	SS	11		320				0 83 17
			4	SS	11						
			5	SS	4		319				0 88 12
							318				
317.0			6	SS	7						
5.2	END OF BOREHOLE AT 5.18m.										

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

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

RECORD OF BOREHOLE No D-98-2 1 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

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 ○ 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
322.0							322				
0.0	**PEAT**, brown		1	SS	1						
320.8			2	SS	1		321				
1.2	**SAND**, fine grained, trace to some silt, layered, loose, grey, wet: (SP)		3	SS	6		320				
			4	SS	10						
			5	SS	7		319				0 90 10
			6	SS	9		318				
			7	SS	7		317				
			8	SS	3		316				
	becoming compact		9	SS	11		315				0 91
			10	SS	9		314				
							313				
							312				
							311				
							310				
							309				
							308				

Continued Next Page

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

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

RECORD OF BOREHOLE No D-98-2 2 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

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						
	SAND - continues as above						307				
			11	SS	17		306		○		
							305				
							304				
			12	SS	15		303		○		
							302				
							301				
			13	SS	20		300		○		
							299				
							298				
			14	SS	32		297		○		
							296				
							295				
	becoming dense, grey		15	SS	29		294		○		
							293				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-2 3 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

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 ○ 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
	SAND continues as above						292				
			16	SS	38		291		○		0 92 8
288.5							290				
33.5	SILT, trace sand, trace clay, layered, dense, grey, wet						289				
			17	SS	37		288		○		
							287				
			18	SS	35		286				
							285		○		0 4 92 5
							284				
			19	SS	46		283				
							282		○		
							281				
			20	SS	52		280				
							279		○		
							278				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D-98-2 4 OF 4 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 956.9 E 324 657.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.23 - 98.02.24 CHECKED BY AEG

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 (○ 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
	SILT - continues as above						277				
							276				
			21	SS	38				○		0 64
							275				
							274				
							273				
			22	SS	46				○		
271.5							272				
50.5	SAND, fine grained, some silt, uniform, very dense, grey, wet						271				
							270				
			23	SS	63				○		0 81 19
							269				
							268				
							267				
266.0			24	SS	65				○		
56.1	END OF BOREHOLE AT 56.08m.						266				

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

$\overset{20}{15}\Phi\overset{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D-98-3 1 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 ○ 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
321.6											
0.0	**PEAT**, silty, dark brown to black		1	SS	3		321				
			2	SS	1						
319.8							320				
1.8	**SAND**, some silt to sand and silt, layered, loose to very loose, grey, wet		3	SS	9						
			4	SS	7		319				
			5	SS	9						0 51
							318				
			6A	SS	4		317				
			6B	SS	3						
							316				
			7	SS	8		315				
							314				
			8	SS	7						
							313				
			9	SS	8		312				0 89 11
							311				
			10	SS	16		310				
	becoming compact						309				
			11	SS	16						
							308				
			12	SS	9		307				0 81 19

Continued Next Page

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

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

RECORD OF BOREHOLE No D-98-3 2 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	SAND - contonues as above						306				
			13	SS	5		305				
			14	SS	18		304				
			15	SS	21		303				
			16	SS	27		302				0 42
			17	SS	44		301				
			18	SS	24		300				0 38 62
			19	SS	20		299				0 92 8
			20	SS	17		298				
			21	SS	28		297				
							296				
							295				
							294				
							293				
							292				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

$15 \overset{20}{\oplus} 5$ $\overset{}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D-98-3 3 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 ○ 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
			22	SS	33		291				
			23	SS	27		290		○		0 93 7
			24	SS	38		289		○		
	becoming dense						288				
287.0			25	SS	49		287		○		
34.6	SILT, some sand to sandy, trace clay, layered, dense, , grey, wet		26	SS	43		286		○		
			27	SS	40		285		○		0 15
			28	SS	30		284		○		
			29	SS	40		283		○		
			30	SS	36		282		○		
							281				
							280				
							279				
							278				
							277				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity $\frac{20}{16 \oplus 8}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No D-98-3 4 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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: ○ 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
	SILT - continues as above		31	SS	31		276		○		0 29 67 4
							275				
							274				
			32	SS	42		273		○		
							272				
271.6							271				
50.1	**SAND**, some silt, layered, very dense, grey, wet		33	SS	66		270		○		0 80 20
							269				
							268				
			34	SS	92/ .150		267				
							266				
							265				
			35	SS	81		264				
							263				
							262				

Continued Next Page

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

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

RECORD OF BOREHOLE No D-98-3 5 OF 5 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 951.6 E 324 697.2 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.19 - 98.02.22 CHECKED BY AEG

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
			36	SS	67		261				
							260				
							259				
257.9			37	SS	73		258				
63.7	END OF BOREHOLE AT 63.70m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LELVEL READINGS:

DATE	DEPTH (m)
24/05/98	0.0
15/07/98	0.2
31/07/98	0.3

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

$16 \overset{20}{\underset{10}{\oplus}} 6$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D-98-4 1 OF 3 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 945.3 E 324 737.6 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

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						
321.4											
0.0	**PEAT**, fibrous, with roots, brown		1	SS	1		321				
			2	SS	1						
319.9							320				
1.5	**SAND**, some silt to sand and silt, layered, very loose to compact, layered, grey, wet		3	SS	10						
			4	SS	6		319				0 42 54 4
			5	SS	4		318				
			6	SS	5		317				
			7	SS	2		316				
			8	SS	11		315				
			9	SS	7		314				
			10	SS	2		313				0 77
			11	SS	8		312				
			12	SS	17		311				
							310				
							309				
							308				
							307				

Continued Next Page

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

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

RECORD OF BOREHOLE No D-98-4 2 OF 3 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 945.3 E 324 737.5 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	SAND - continues as above		13	SS	13		306		○		
							305				
			14	SS	6				○		
							304				
			15	SS	33		303		○		
	becoming dense						302				
			16	SS	28				○		
							301				
			17	SS	32		300		○		0 88 12
							299				
			18	SS	30				○		
							298				
			19	SS	25		297		○		
							296				
			20	SS	39				○		
							295				
			21	SS	52		294		○		0 86 14
	becoming very dense						293				
			22	SS	44				○		
							292				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20
16 ⊕ 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D-98-4 3 OF 3 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 945.3 E 324 737.5 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (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
	SAND - continues as above						291				
290.5			23	SS	57				o		
30.9	END OF BOREHOLE AT 30.9m.										
	Dynamic cone driven to 34.4m										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No D-98-5 1 OF 1 METRIC

W.P. 462-93-00 LOCATION SITE 42-235, N 5 033 940.8 E 324 765.8 ORIGINATED BY EK

DIST 52 HWY 11 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY WM

DATUM GEODETIC DATE 98.02.18 - 98.02.18 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
321.3							
0.0	**PEAT**, fibrous, with roots, brown		1	SS	1		321
320.2			1	SS	1		
1.1	**SAND**, trace silt to silt and sand, loose to compact, grey, wet: (SP/SM)		3	SS	9		320
			4	SS	10		319
			5	SS	10		318
							317
316.1			6	SS	5		
5.2	END OF BOREHOLE AT 5.2m.						

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
	0	95		5
	0	37		

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

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

APPENDIX B

APPENDIX B

LABORATORY TEST RESULTS

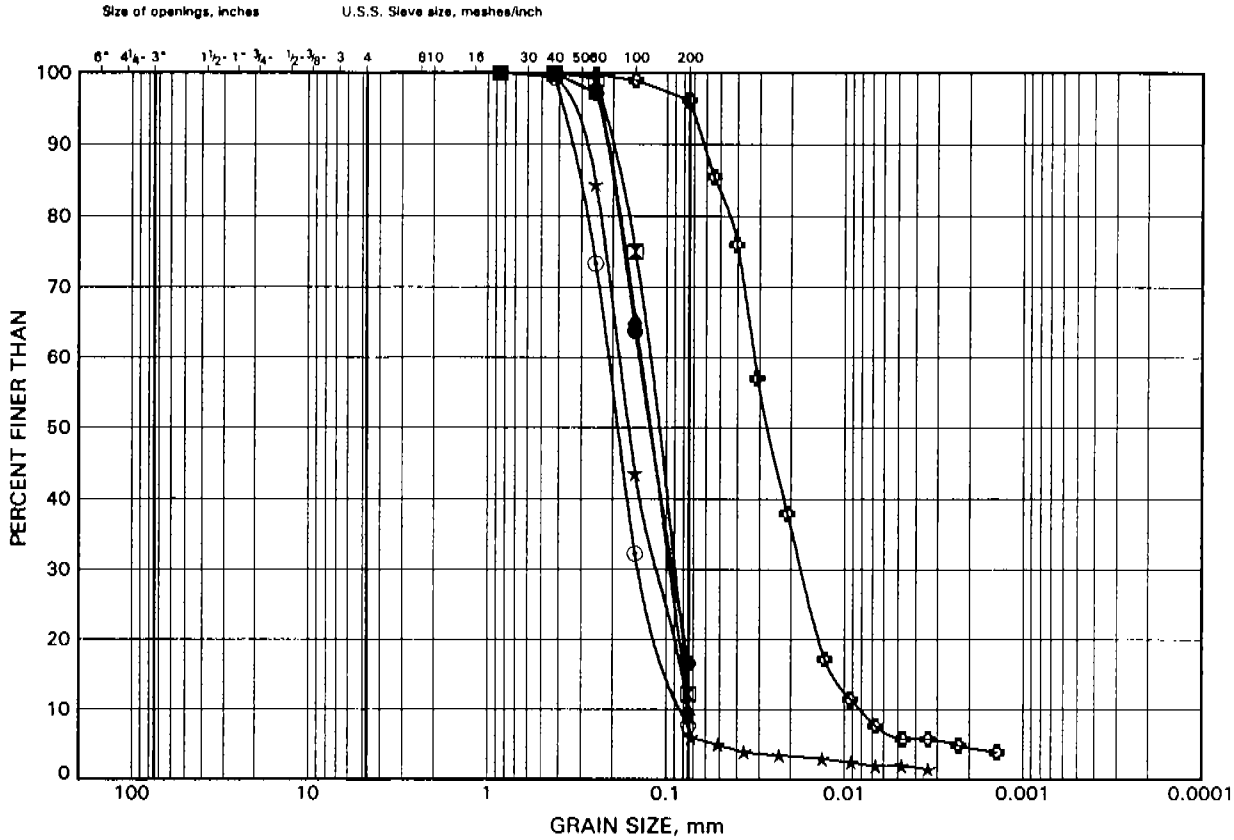
- Figures B1 to B4 - Grain Size analyses

- Table B1 - pH and Sulphate

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B1



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-1	1.83	320.37
⊠	D-98-1	3.35	318.85
▲	D-98-2	3.35	318.69
★	D-98-2	10.06	311.98
⊙	D-98-2	31.39	290.65
✿	D-98-2	37.49	284.55

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

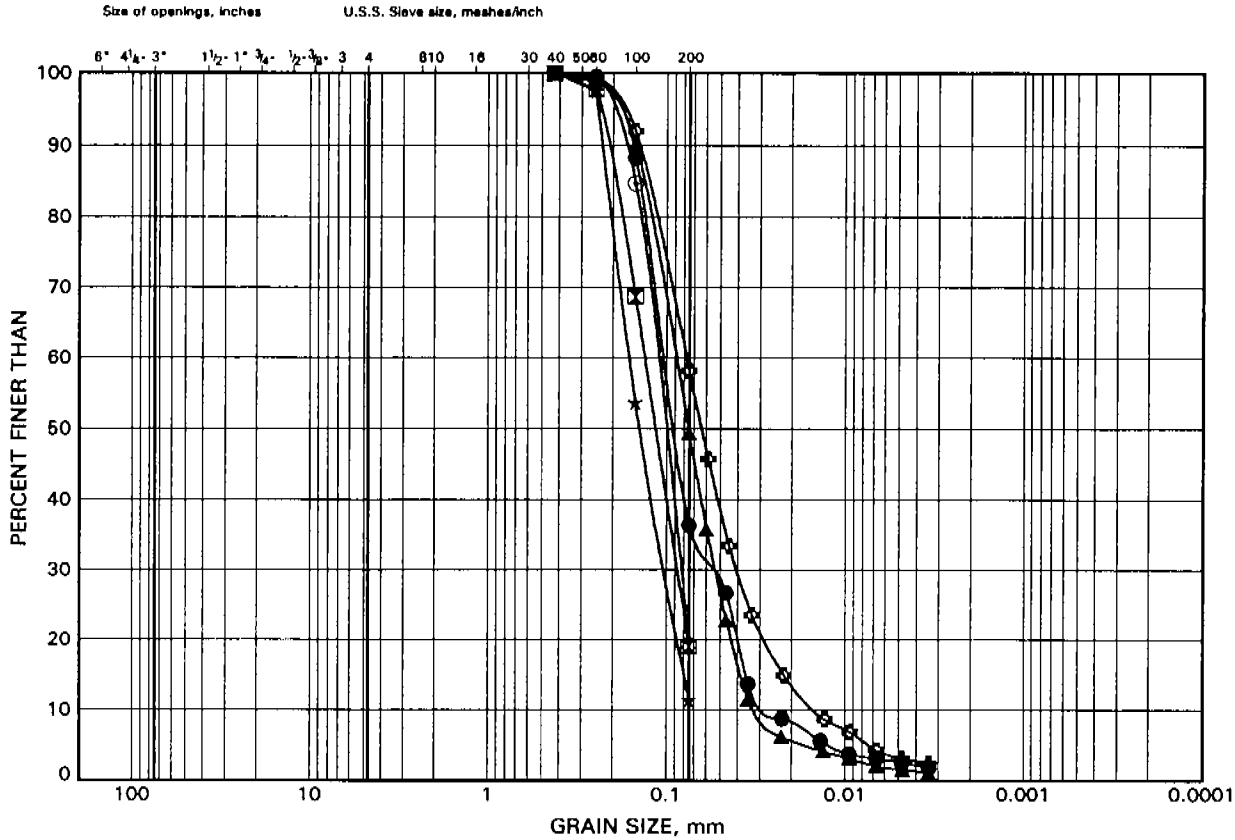
Chkd. AEG

THURBGSD 3517 98/10/06

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B2



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-2	46.63	275.41
⊠	D-98-2	52.73	269.31
▲	D-98-3	3.35	318.25
★	D-98-3	10.05	311.55
⊙	D-98-3	14.63	306.97
✿	D-98-3	19.50	302.10

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

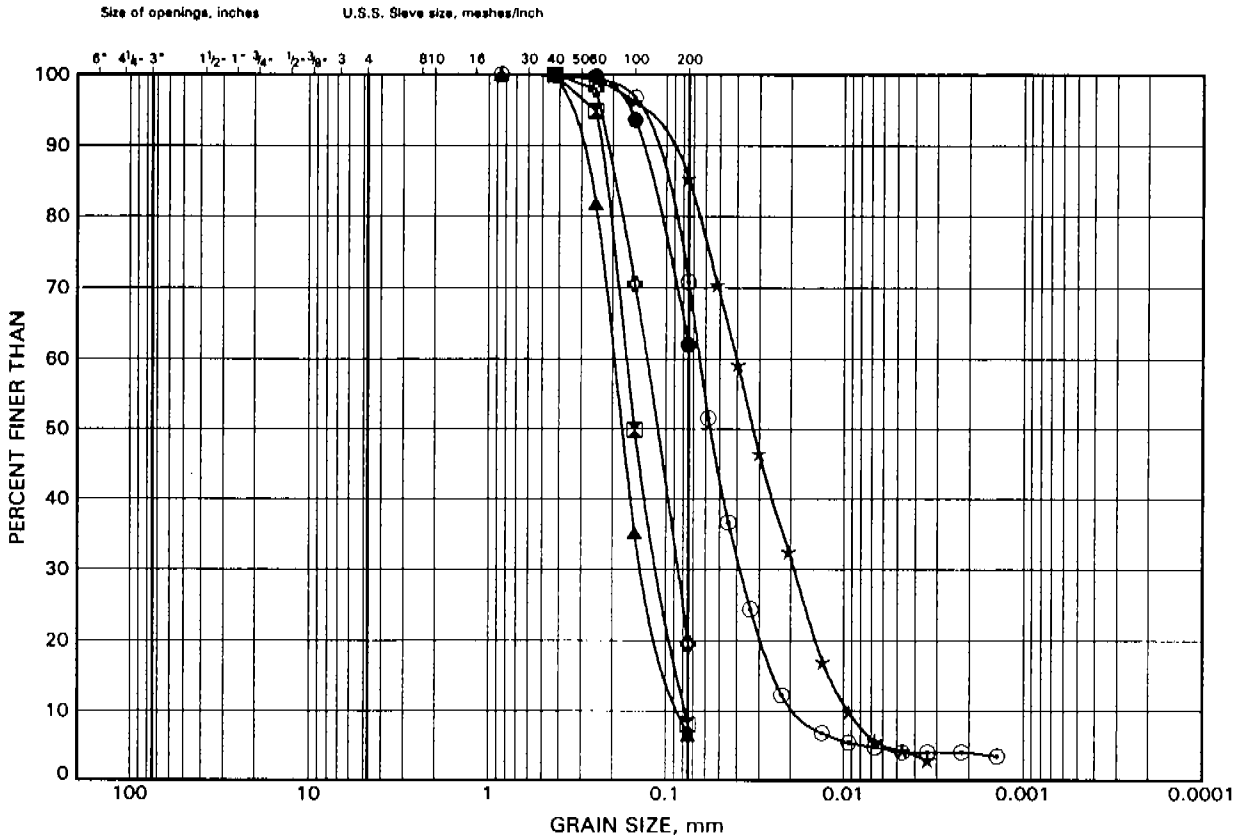
Chkd. AEG

THURBGSD 3517 98/10/06

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B3



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-3	23.77	297.83
⊠	D-98-3	25.30	296.30
▲	D-98-3	31.39	290.21
★	D-98-3	37.50	284.10
⊙	D-98-3	45.11	276.49
✿	D-98-3	51.20	270.40

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

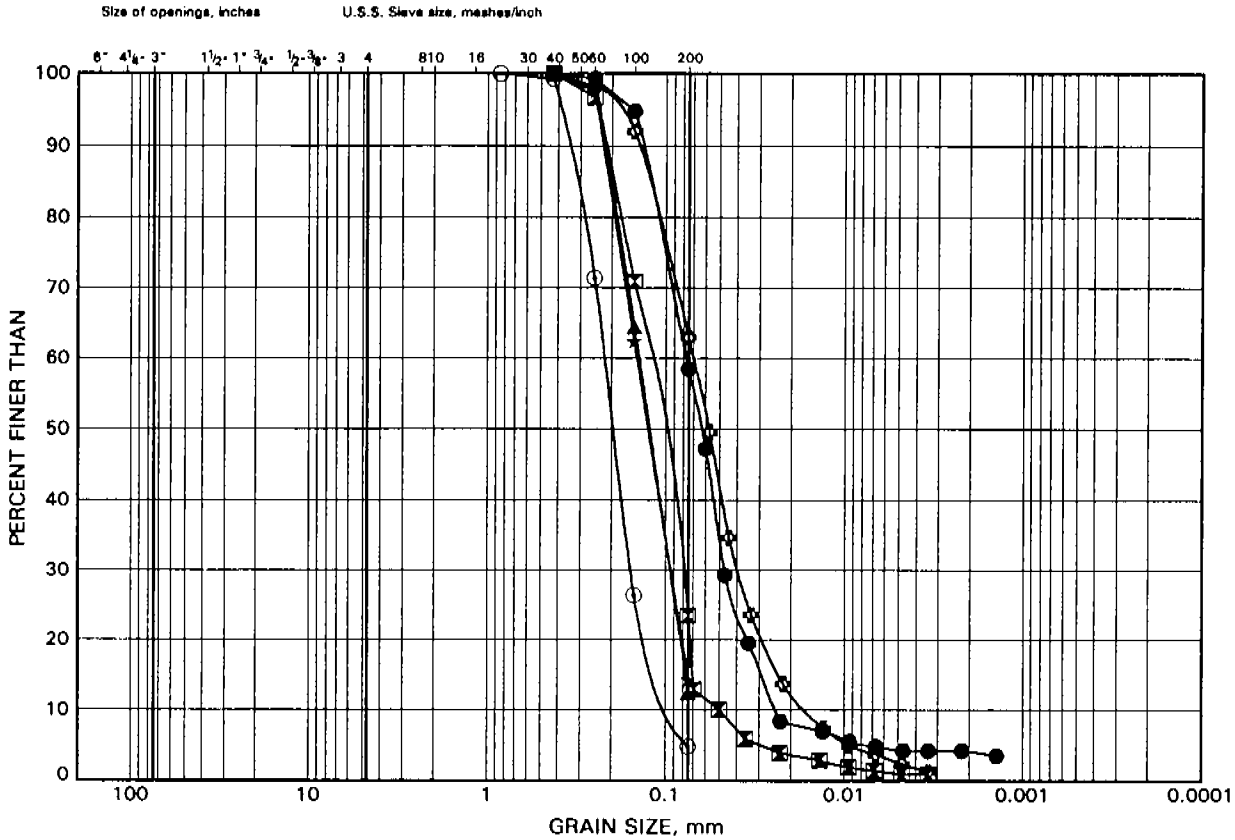
Chkd. AEG

THURBGSD 3517 98/10/06

NOVAR ROAD UNDERPASS

GRAIN SIZE DISTRIBUTION

FIGURE B4



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	D-98-4	2.59	318.81
⊠	D-98-4	9.37	312.03
▲	D-98-4	21.64	299.76
★	D-98-4	27.66	293.74
⊙	D-98-5	1.75	319.55
✪	D-98-5	4.88	316.42

Date October 1998

Project 462-93-00

THURBER

Prep'd WM

Chkd. AEG

THURBGSD 3517 98/10/06

Table B1

Results of pH and Sulphate Testing

Sample	Depth (m)	pH	Sulphates (ppm)
D-98-2, SA3	1.5 - 2.1	4.2	178
D-98-4, SA3	1.5 - 2.1	3.1	1,150

APPENDIX C

APPENDIX C

- Table C1 - Grain Size Distribution for Uniform Sand Around Piles

Table C1

Grain Size Distribution for Uniform Sand Around Piles

MTO Sieve Designation		Percentage Passing by Mass
2 mm	#10	100%
600μm	#30	80 - 100%
425μm	#40	40 - 80%
250μm	#60	5 - 25%
150μm	#100	0 - 6%

APPENDIX D

APPENDIX D

NON STANDARD SPECIAL PROVISION

LIMITATIONS ON USE OF EARTH MATERIAL FROM CUTS

NON-STANDARD SPECIAL PROVISION

DATE: 1998 08 04

WP No.: 482-93-00 CONTRACT No.: DISTRICT No.: 52 HWY No.: 11
LOCATION: 6.7 km North of Highway 60, Northerly 13.6 km

1. This SP is new

This non-standard special provision outlines the requirements for on-site earth embankment fill Materials

2.

Item	Spec No.	Title or Item Description
		On-Site Earth Fill Requirements

Earth fill materials shall be free from organic material and foreign objects. Boulder content shall conform to OPSS 206.

Earth fill material which has more than 50 percent of the particles smaller than 75 μm, as determined by LS-702, shall not be used if the field moisture content is higher than:

A. The optimum moisture content, as determined by LS-706, plus 1 percent for soils with a Plasticity Index, as determined by LS-704, of 7 percent or less, or

B. The optimum moisture content, as determined by LS-706, plus 5 percent for soils with a Plasticity Index, as determined by LS-704, of more than 7 percent.

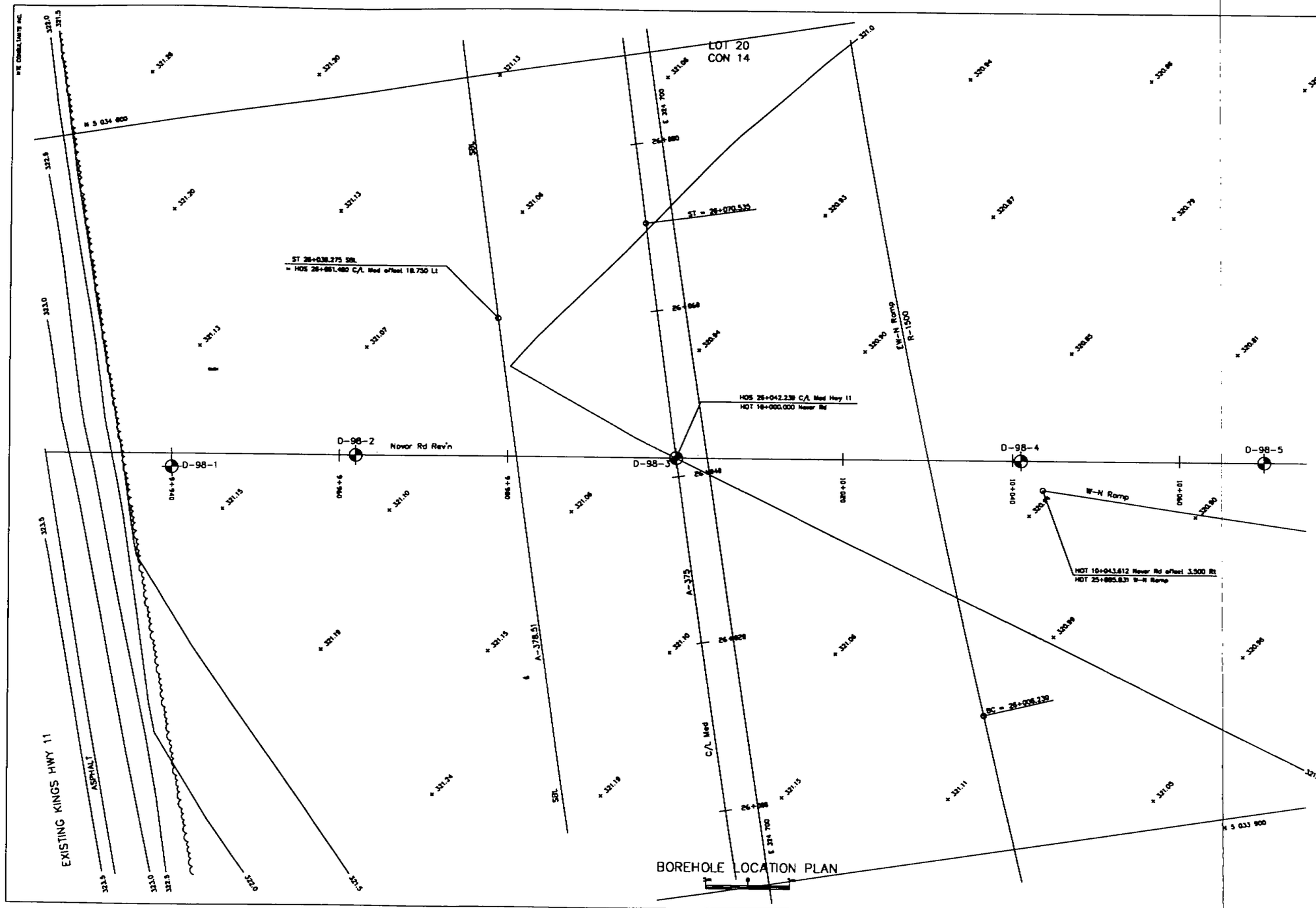
Earth material which has more than 50 percent of the particles smaller than 75 µm as determined by LS-702, shall not be used as fill in embankments having side slopes steeper than 2.5H:1V.

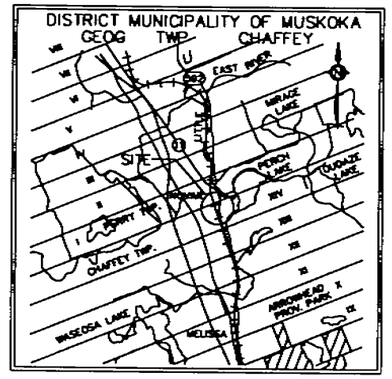
Earth fill material with 50 percent or more of the particles between 5 μm and 75 μm in size, as determined by LS-702, shall not be used within 1.8 m of the top of pavement elevation.

3.

Initiated By _____ Detailed By _____ Approved By _____

DIST 52	
CONT No	
WP No 458-93-00	
HWY 11 – FOUR LANING NOVAR ROAD	SHEET
THURBER ENGINEERING LTD.	





KEY PLAN

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLAN BASED ON PLAN E-625-11-9
SUPPLIED BY CLIENT

No	ELEV.	LOCATION	
		NORTHING	EASTING
D-98-1	9+940	5 033 959.1	324 636.4
D-98-2	9+962	5 033 956.9	324 657.8
D-98-3	10+000	5 033 951.6	324 697.2
D-98-4	10+041	5 033 945.3	324 737.5
D-98-5	10+070	5 033 940.8	324 765.8

19-1351-7d-01

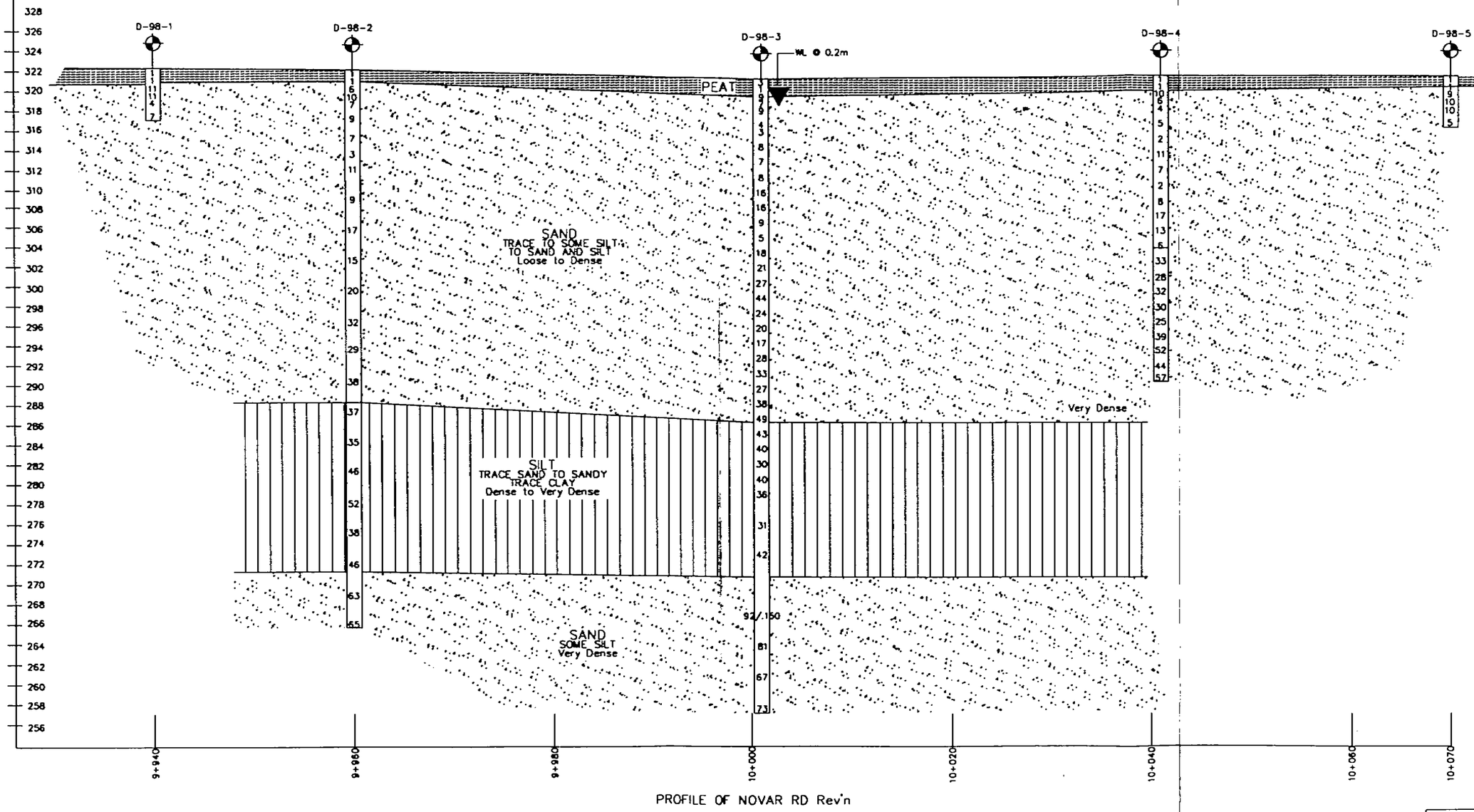
METRIC

DIMENSIONS ARE IN METRES AND / OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST 52	
CONT No	
WP No 458-93-00	
HWY 11-FOUR LANING NOVAR ROAD	SHEET
THURBER ENGINEERING LTD.	

LEGEND

- Borehole
- WL July 15, 1998
- 'N' Blows/0.3m (Std Pen Test)



PROFILE OF NOVAR RD Rev'n

19-1351-7d-02