

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CP OVERHEAD REPLACEMENT AT WEBBWOOD**

Highway 17, Site 46-160

G.W.P 5198-06-00

Township of Hallam

Geocres Number: 41I-272

Report to

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed bridge replacement located south of Webbwood, Ontario. The existing structure carries Highway 17 over the CP tracks.

The purpose of the investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, records of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation, under the Ministry of Transportation Ontario (MTO) Assignment Number 5009-E-0032.

2. SITE DESCRIPTION

The site of this investigation is located at the crossing of Highway 17 over CP tracks, approximately 10.5 km west of Highway 6 and just south of the Town of Webbwood, Ontario. At present, the highway crosses the railway tracks on a skewed single span structure.

There is no residential or commercial development in the immediate vicinity of the bridge. A cemetery is located northeast of the structure. The surrounding area is relatively flat and heavily treed.

Photographs of the site included in Appendix G show the general nature of the surrounding land:

1. View of the west side of existing CPR overhead from railtrack
2. Existing slope conditions
3. Surficial erosion on the southeast embankment

4 and 5. Existing Highway 17 conditions at CPR overhead

Physiographically, the site lies within the Canadian Shield, characterized by Precambrian meta-volcanic and meta-sedimentary rocks intruded by later stage diabase dykes. In some areas the Precambrian rocks are covered by sedimentary rocks of the Huronian Supergroup. The bedrock is mantled by glaciolacustrine varved clays and sand and gravel deposits. Locally, however, the bedrock is mantled by deposits of silt and sand.

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out from October 17 to 24 and from October 29 to November 1, 2010 and consisted of drilling and sampling a total of six boreholes (numbered WB-01 to WB-06) at the site. Four boreholes were drilled at the existing bridge abutments and two boreholes at the approaches.

Dynamic Cone Penetration Tests (DCPTs) were conducted from the base of Boreholes WB-01, WB-03, WB-04 and WB-06 to depths ranging from 25.0 m to 55.5 m (elevations 150.6 to 181.1). Five additional DCPTs were also conducted in close proximity to the boreholes from surface to depths ranging from 19.8 m to 36.6 m (elevations 169.5 to 186.3).

The borehole locations and termination depths are indicated in Table 3.1.

Table 3.1 – Borehole locations and termination depths

Foundation Unit	Borehole/DCPT	Borehole termination depth/ elevation (m)	DCPT termination depth/elevation ⁽¹⁾ (m)
South Approach	WB-01	15.8/190.3	27.1/179.0
	WB-01D	-	30.5/175.7
South Abutment	WB-02	34.1/172.0	-
	WB-02D	-	19.8/186.3
	WB-04	34.1/171.9	37.8/168.3
	WB-04D	-	25.0/181.1
North Abutment	WB-03	49.4/156.7	55.5/150.6
	WB-03D	-	27.4/178.6
	WB-05	34.1/171.9	-
	WB-05D	-	36.6/169.5
North Approach	WB-06	15.8/190.2	25.0/181.1

⁽¹⁾ DCPTs were terminated upon cone refusal

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix H. Record of Sheets of Boreholes WB-01 to WB-06 drilled during the present investigation are attached in Appendix A.

The coordinates and elevations of Boreholes WB-01 to WB-06 are given on the drawing and on the individual Record of Borehole Sheets.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations. Road occupancy permits were obtained for boreholes drilled on the existing Highway 17 platform.

The drilling was carried out from the highway grade using a CME75 truck-mounted drill rig. A combination of hollow stem auger, NW casing and mud rotary drilling techniques were used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Two standpipe piezometers consisting of 19 mm PVC pipe with a slotted screen were installed in Boreholes WB-02 and WB-05. The locations and completion details of the boreholes and piezometers are shown in Table 3.2.

Table 3.2 – Borehole Completion Details

Foundation Unit	Borehole	Details	
		Piezometer Tip Depth/ Elevation (m)	Completion Details
South Approach	WB-01	None installed	Borehole caved to 12.8 m. Backfilled with cuttings from 12.8 m to 0.15 m, then asphalt to surface.
South Abutment	WB-02	34.1 / 172.0	Piezometer with 3.0 m slotted screen installed at 34.1 m with sand filter to 29.6 m, bentonite holeplug from 29.6 m to 0.15 m, then asphalt to surface. Flushmount casing installed.
	WB-04	None installed	Borehole backfilled with bentonite holeplug to 0.3 m, gravel from 0.3 m to 0.15m, then asphalt to surface.
North Abutment	WB-03	None installed	Borehole backfilled with bentonite holeplug to 0.3 m, gravel from 0.3 m to 0.15 m, then asphalt to surface.
	WB-05	33.5 / 172.6	Piezometer with 6.1 m slotted screen installed at 33.5 m with sand filter to 25.9 m, bentonite holeplug from 25.9 m to 23.2 m, sand and bentonite mixture from 23.2 m to 0.1 m, then asphalt to surface. Flushmount casing installed.
North Approach	WB-06	None installed	Borehole caved to 12.8 m. Backfilled with cuttings from 12.8 m to 0.15 m, then asphalt to surface.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were also subjected to gradation analysis and the results of this testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in this appendix and on the “Borehole Locations and Soil Strata” drawings in Appendix H. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

The stratigraphy encountered in the six boreholes drilled at this site generally consisted of pavement structure (asphalt and/or concrete) over very loose to compact sand fill. Deposits of native loose to compact sand overlying compact to dense sandy silt and silt were encountered below the sand fill.

5.1 Pavement structure

Pavement structure consisting of approximately 100 mm to 550 mm of asphalt overlying sand fill was encountered in all the boreholes, which were drilled on existing Highway 17 lanes.

Concrete was encountered below the asphalt in Boreholes WB-01 and WB-06, drilled at the south and north approaches, respectively. The thickness of the concrete was 100 mm to 500 mm.

5.2 Fill

Sand fill was encountered below the asphalt and/or concrete in all six boreholes advanced at this site. The sand fill is described as fine grained, light brown to brown and contains trace silt to silty, trace gravel and trace clay.

The thickness of the sand fill ranges from 6.8 m to 9.3 m.

The underside of the fill varies from 7.2 m depth (Elevation 198.9) in Borehole WB-02 drilled at the south approach to a maximum depth of 9.8 m (Elevation 196.3) in Borehole WB-03 drilled near the north abutment.

SPT N-values recorded in the sand fill ranged from 0 to 18 blows per 0.3 m penetration, indicating a very loose to compact relative density.

Measured moisture contents of the sand fill ranged from 5% to 31%.

Grain size distribution curves for samples of the sand fill tested are presented on the Record of Borehole sheets and on Figures B1 and B2 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0 to 2
Sand	71 to 93
Silt	11 to 27
Clay	1 to 2
Silt & Clay	7

5.3 Sand

A layer of native sand containing trace silt to silty, trace gravel and trace clay was encountered below the sand fill in all the boreholes, except in Borehole WB-03.

The thickness of the native sand ranges from 2.9 m to 4.7 m.

The depth to the base of the native sand ranged from 10.4 m to 13.4 m (Elevations 192.7 to 195.8).

Moisture content results for samples collected from this layer typically ranged from 8% to 25%.

The SPT N-values recorded in this layer ranged from 7 to 27 blows for 0.3 m penetration, indicating loose to compact relative density. An SPT-N value of 32 blows per 0.3 m of penetration, indicating dense relative density, was measured in Borehole WB-02 near 11.0 m depth (Elevation 195.1).

Grain size distribution curves for samples of the native sand tested are presented on the Record of Borehole sheets and on Figure B3 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0 to 1
Sand	66 to 97
Silt	7 to 30
Clay	2 to 4
Silt & Clay	3

5.4 Sandy Silt

In Boreholes WB-01 to WB-04, a layer of brown to grey sandy silt containing trace clay and sand seams was contacted below the native sand.

In Borehole WB-05, the sandy silt was contacted below a layer of native silt at 14.9 m depth (Elevation 191.1).

The thickness of the sandy silt ranges from 14.0 m to 18.3 m on the west side of the existing structure (Boreholes WB-02 and WB-03) and from 7.6 m to 7.7 m on the east side of the structure (Boreholes WB-04 and WB-05).

Borehole WB-01 was terminated within the sandy silt layer at 15.8 m depth (Elevation 190.3).

Measured moisture contents of this sandy silt layer ranged from 10% to 23%. A high moisture content of 46% was measured in Borehole WB-05 at 19.8 m depth (Elevation 186.3).

SPT N-values recorded in this layer ranged from 7 to 38 blows per 0.3 m penetration, indicating a loose to dense relative density.

Grain size distribution curves for samples of the sandy silt tested are presented on the Record of Borehole sheets and on Figures B4 and B5 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	21 to 52
Silt	45 to 72
Clay	3 to 8

5.5 Silt

Native grey silt containing trace sand, trace clay and occasional sandy layers was contacted below the sandy silt layer at 30.2 m, 23.8 m and 21.0 m depth (Elevations 175.9, 182.3 and 185.1) in Boreholes WB-02, WB-03 and WB-04, respectively. In Boreholes WB-05 and WB-06, the silt layer was contacted below the native sand at 11.9 m and 11.6 m depth (Elevations 194.2 and 194.5). In Borehole WB-05, a lower layer of silt was also contacted at 22.6 m depth (Elevation 183.5).

Clayey silt zones were contacted within the silt layer at various depths, 27.5 m, 36.8 m and 49.0 m (Elevations 178.5, 169.2 and 157.0) in Borehole WB-03.

Boreholes BW-02, BW-04 and BW-05 were terminated within the silt layer at 34.1 m depth (Elevations 172.0 and 171.9). Boreholes BW-03 and BW-06 were also terminated within the silt at 49.4 m and 15.8 m depth (Elevations 156.7 and 190.2), respectively.

Measured moisture contents of the silt layer ranged from 17% to 26%. A high moisture content of 40% was measured in Borehole WB-05 at 27.7 m depth (Elevation 178.4).

SPT N-values recorded in the silt layer ranged from 16 to 46 blows per 0.3 m penetration, indicating a compact to dense relative density. Locally, in Borehole WB-06 the SPT N-values were 7 and 13 blows per 0.3 m of penetration, indicating a loose to compact relative density.

Grain size distribution curves for samples of the silt layer tested are presented on the Record of Borehole sheets and on Figures B6 and B7 of Appendix B. Grain size distribution curves for the samples obtained from the clayey silt zone are presented in Figure B8 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	Silt (%)	Clayey silt zone (%)
Gravel	0	0
Sand	1 to 31	1 to 3
Silt	62 to 88	78 to 81
Clay	6 to 15	18 to 19

5.6 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. Two standpipe piezometers were installed in two boreholes to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.1, along with the measurements in the boreholes upon completion of drilling.

Table 5.1 – Water Level Measurements

Foundation Unit	Borehole	Date	Water Level (m)		Comment
			Depth Below	Elevation	
South Approach	WB-01	October 17, 2010	12.2	193.9	Open borehole
South Abutment	WB-02	October 23, 2010	12.2	193.9	Open borehole Piezometer Piezometer
		November 1, 2010	18.4	187.7	
		November 29, 2010	18.2	187.9	
	WB-04	October 29, 2010	12.8	193.3	Open borehole
North Abutment	WB-03	October 21, 2010	12.2	193.8	Open borehole
North Approach	WB-05	October 29, 2010	17.3	188.8	Piezometer
	WB-06	October 18, 2010	12.2	193.8	Open borehole

The piezometric readings indicate that the groundwater level ranges from Elevations 187.7 to 188.8.

All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.

6. MISCELLANEOUS

George Downing Estate Drilling Limited of Hawkesbury, Ontario supplied the drill rig and conducted the drilling, sampling and in-situ testing operations. A truck-mounted CME 75 drill rig was used for the investigation.

The drilling and sampling operations in the field were supervised by Mr. Ryan Kromer and Mr. Lukasz Gilarski of Thurber.

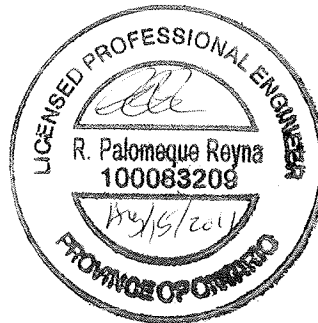
Mr. Lukasz Gilarski, directed the field operations.

Interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng., Ms. Lindsey Blaine, E.I.T. and Ms. R. Palomeque Reyna, P.Eng.

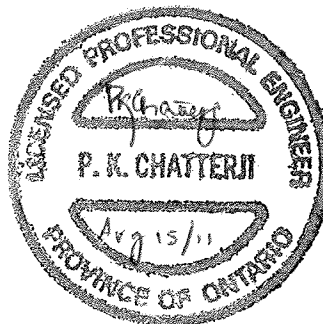
Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system and approach embankments for replacement of an existing bridge structure located at the Highway 17 crossing of the CP tracks in Webbwood, Ontario.

At present, Highway 17 crosses CP tracks on a 14-m long single-span, concrete rigid frame structure, supported on spread footings at or below a design footing base elevation of 196.1. The bridge is approximately 14.3 m wide in the direction of the track. The abutments are parallel to the railtrack.

Currently four retaining walls extend parallel to the railtrack adjacent to each corner of the rigid frame structure. It is anticipated that the existing retaining walls will also be replaced.

A visual inspection conducted on the site revealed that the existing approach embankments are in the order of 8.0 m to 9.0 m high with side slopes ranging from 1.3H:1V to 1.5H:1V.

The existing CP overhead structure will be replaced by staged construction, maintaining the same alignment and highway grade for the new structure.

The discussion and recommendations presented in this report are based on information provided by McCormick Rankin Corporation and on the factual data obtained in the course of this investigation.

8. STRUCTURE FOUNDATIONS

The stratigraphy identified in the course of the present investigation consisted of pavement structure (asphalt partially underlain by concrete) over a 6.8-m to 9.3-m thick layer of very loose to

compact sand fill. Deposits of native loose to compact sand overlying compact to dense sandy silt and silt were encountered below the fill.

The piezometric readings indicate that water level at this site ranges from 17.3 m to 18.4 m (elevations 187.7 to 188.8) below ground surface. During drilling, water level was observed at 12.2 m depth (elevations 193.8 and 193.9) in Boreholes WB-01 to WB-03 and WB-06 and at 12.8 m depth (elevation 193.3) in Borehole WB-04.

Based on available data and drawing, the spread footings of the existing CP overhead bridge are founded near elevation 196.1. Boreholes revealed that soils at this elevation consist of compact native sand and sandy silt.

The existing ground elevation of Highway 17 at the bridge location varies from 206.0 to 206.1. The embankment is approximately 7.0 m to 10.0 m high and consists of sand fill.

In the preparation of the geotechnical design recommendations for a new structure, consideration was given to the following foundation types

- Spread footings on native soils
- Spread footings on engineered fill
- Augered Caissons (drilled shafts)
- Driven piles

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix C.

8.1 Spread Footings on Native Ground

The new structure may be supported on spread footings bearing on competent undisturbed native soils.

At both abutments, the thickness of the approach fill varies from 7.2 m to 9.8 m. The existing fill generally consists of very loose to compact sand and it is not considered to be suitable for the support of spread footings.

The spread footings must be extended below the fill layer and bear on the underlying competent native soils. The competent native compact to dense sand and sandy silt layers were contacted at approximately 10.0 m to 11.0 m depth below the highway grade (elevation 195.5 to 196.0).

Provided a minimum footing width of 2 m is maintained, footings founded on the undisturbed compact sand and sandy silt layers at elevation 195.5, may be designed on the basis of the following geotechnical resistances:

- Factored geotechnical resistance of 375 kPa at Ultimate Limit States (ULS)
- Geotechnical resistance of 250 kPa at Serviceability Limit States (SLS)

The geotechnical resistances quoted above are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 10 mm across the width of the structure. Sub-excavation will be required to expose the undisturbed sand or sandy silt in areas where the existing fill extends below the desired footing founding elevations.

The sliding resistance of mass concrete poured on the sand/sandy silt may be computed on the basis of an ultimate coefficient of friction of 0.45. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

Temporary excavations required to construct these footings will not extend below the water table observed during the investigation. However, surface water and/or seepage may be experienced from perched zones in the granular fill. The Contractor must be prepared to pump from sumps to remove any remaining seepage water or surface water collecting in an excavation. Footings must be constructed in the dry to prevent disturbance of the footing base due to the inflow of groundwater. Unwatering must remain operational and effective until the footing excavation is backfilled.

The bases of the foundation excavations must be inspected by geotechnical personnel to confirm that the exposed surface conforms to the design requirements and has been adequately prepared to receive concrete. Where subexcavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using engineered fill or concrete of the same class as the footing. The engineered fill must consist of OPSS Granular “A” placed in 150 mm lifts, compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content.

All footings must be provided with a minimum of 2.0 m of earth cover over the footing base (founding elevation) as protection against frost action.

8.2 Spread Footings on Engineered Fill

Consideration may also be given to placing spread footings on engineered fill pads. If an engineered fill pad is used at this site, all fill or other deleterious materials must be stripped from the footprint of the engineered fill to expose competent native subgrade material.

At this site, the engineered fill will bear on native compact to dense sand and sandy silt layers. The highest permitted founding elevations at which engineered fill should be placed, are given in Table 8.1.

Table 8.1 – Highest Permitted Base Elevations for Engineered Fill

Foundation Unit	Borehole	Highest Permitted Engineered Fill Base		
		Depth below existing highway grade (m)	Fill Base Elevation (m)	Soil
South Abutment	WB-02	10.6	195.5	Dense sand
	WB-04	10.1	196.0	Compact sand
North Abutment	WB-03	10.5	195.5	Compact sandy silt
	WB-05	10.6	195.5	Compact sand

The engineered fill must consist of OPSS Granular “A” placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content and generally conforming to the geometry illustrated in Figure 1 in Appendix E. The thickness of engineered fill must be a minimum of 2.0 m.

Provided a minimum footing width of 2 m is maintained footings bearing on the well compacted engineered fill may be designed for the following values:

- Factored geotechnical resistance of 900 kPa at Ultimate Limit States (ULS)
- Geotechnical resistance of 350 kPa at Serviceability Limit States (SLS)

These resistance values are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

For footings designed on the basis of the geotechnical resistance values given above, total settlement under a footing is expected to not exceed 25 mm. Differential settlements are not expected to exceed 20 mm across the width of the structure.

The lateral resistance of the footings founded on engineered fill may be computed using an unfactored friction of 0.6. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

The highest permitted engineered fill base elevation given in Table 8.1 is above the groundwater table on this site. However, if a lower elevation is required or if surface water and/or seepage occurs during construction, local groundwater controls such as, filtered sumps and pumps, will be required to remove water collecting in the excavation. The fill pad and the footing must be constructed in the dry and to prevent sloughing of the sides or

disturbance of the base of the excavation due to the inflow of groundwater. Unwatering must remain operational and effective until the footing is constructed and backfilled.

8.3 Augered Caissons (Drilled Shafts)

Augered caisson foundations were also considered for the support of the structure. However, the use of augered caissons is not recommended at this site since the caissons will have to be installed through water bearing cohesionless soils and in view of the depth to suitable bearing material typically ranging from 25 m to over 35 m from highway grade. Construction of caissons will require use of a liner sealed below the sand and silt layers and/or slurry methods to control ground water, support the sidewalls of the shaft, and prevent basal heave. Sealing of the caisson liner into the founding stratum will be difficult and base boiling will be encountered.

Accordingly, this alternative has not been developed further.

8.4 Driven Piles

The subsurface conditions at this site are considered suitable for the design of foundations supported on driven steel H-piles. However, no layer of very dense soil that would permit the piles to be designed as end-bearing elements was encountered in the boreholes. Accordingly, the piles have been assumed to develop most of their resistance from shaft friction. For initial design purposes, a pile length of 25 m below the ground surface at the track level has been assumed. The approximate elevation at which the piles are expected to develop the required resistance is 170.5. This elevation should be used for estimating purposes only.

The actual pile tip Elevations will be controlled as described in Section 8.4.4 Pile Driving.

8.4.1 Axial Resistance

The vertical, factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical resistances at Serviceability Limit States (SLS) for HP 310x110 piles 25 m long are presented in Table 8.2.

Table 8.2 – Axial Resistance of Pile Sections Founded on Dense Soils

Foundation Unit	Pile Section	
	HP 310 x 110	
	ULS (Factored) (kN)	SLS (kN)
South and North Abutments	1,400	1,200

The structural resistance of the pile should be checked by the structural designer.

8.4.2 Pile Installation

Pile installation must be in accordance with OPSS 903, November 2009.

To facilitate pile installation, any new fill placed to raise the embankment, through which piles will be driven must not contain oversize material, i.e. no particles exceeding 75 mm in size.

A NSSP to this effect is attached in Appendix F.

8.4.3 Pile Driving

The first pile driven at the site must be evaluated as a test pile to confirm that the design resistance is achieved. The pile should be driven to the anticipated tip elevation 170.5 and then be tested. The evaluation must be carried out using a dynamic test procedure that conforms to ASTM D-4945 “Standard Method for High Strain Testing of Piles”. After testing has confirmed that the pile has achieved the specified resistance, a minimum of 10% of the production piles in each group must be tested by the same method.

The ultimate resistance to be proved by dynamic testing is shown in Table 8.3.

Table 8.3 – Ultimate Geotechnical Resistance of Piles

Pile	Ultimate Resistance (R) (kN)
HP 310x110	2,800

8.4.4 Downdrag

Downdrag on the piles is not considered to be an issue at this site.

8.4.5 Abutment Type Considerations

From a geotechnical perspective, the soil conditions encountered at this site are suitable for conventional, semi-integral or integral abutments.

8.4.6 Lateral Resistance

For the cohesionless soils encountered, the lateral resistance of the pile may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h \cdot z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \cdot \gamma \cdot z \cdot K_p \quad (\text{kPa})$$

where	z	=	depth of embedment of pile in metres
	D	=	pile width in metres
	n_h	=	value from Table 8.4
	γ	=	unit weight (Table 8.4)
	K_p	=	passive earth pressure coefficient (Table 8.4)

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, K , for analysis may be obtained by the expression, $K = k_s \cdot L \cdot D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m³), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} \cdot L \cdot D$. This represents the ultimate load at which the pile fails and will not support any additional lateral load at greater displacements. It is recommended, however, that the total lateral resistance in one pile be limited to no more than 120 kN at ULS and 50 kN at SLS. Parameters for lateral pile resistance are shown in Table 8.4.

Table 8.4 – Parameters for Lateral Pile Resistance

Location	Elevation	n_h (kN/m ³)	S_u kPa	K_p	Unit Weight (kN/m ³)	Soil Conditions
South Abutment	OGI to 196.9	2,000	-	3.0	21	Very loose to loose sand fill
	196.9 to 193.4	4,000	-	3.0	21	Compact to dense sand
	Below 193.4	6,000	-	3.0	11*	Compact to dense sand, silt
North Abutment	OGI to 196.3	2,000	-	3.0	21	Very loose to loose sand fill
	196.3 to 194.0	5,000	-	3.0	21	Compact to dense sand/sandy silt
	Below 194.0	6,000	-	3.0	11*	Compact to dense sand, silt

*Buoyant unit weight below the water table.

Pile interaction should be considered with reference to CHBDC Clause 6.8.9.2.

For lateral soil/pile group interaction analysis, the modulus of subgrade reaction (k_s) may have to be reduced based on the pile spacing.

Where a pile group is oriented *perpendicular* to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Pile Spacing Perpendicular to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
4 D*	1.00
1 D*	0.50

* D is the width of the pile, and spacing is measured centre to centre

Where a pile group is oriented *parallel* to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Pile Spacing Parallel to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
8 D	1.00
6 D	0.70
4 D	0.40
3 D	0.25

Intermediate values may be obtained by interpolation.

For conventional abutments, the lateral resistance may be provided by battered piles.

8.5 Recommended Foundation

From a geotechnical perspective, and based on current information, it is recommended that foundations for the bridge structure (abutments) be supported on spread footings founded on compact to dense soils.

8.6 Frost Cover

Frost protection should be provided for the undersides of all foundation elements and should consist of a minimum of 2.0 m of soil cover.

9. RETAINED WALLS

9.1 Cantilever wall

The existing retaining walls are cantilever walls founded on native compact to dense sand and sandy silt. The replacement walls may also be designed on cantilever walls. The founding elevations and geotechnical resistances for the wall foundations will be the same as those provided for spread footings option in Section 8.1. Design earth pressure parameters are provided in Sections 15 and 16 of this report.

9.2 Retained soil system

If Retained Soil System (RSS) walls are incorporated in the design, the soil conditions encountered at the site are considered suitable for the support of RSS walls at the north and south approaches/abutments. Excavation will be required to penetrate the existing sand fill and found the RSS walls on native undisturbed soils. Native competent soils were contacted at depths ranging from 10.0 m to 11.0 m below existing Highway 17 grade.

Details of RSS walls were not provided at the time of preparation of this report.

The RSS walls used on this project must be specified to be “High Performance” and “High Appearance”. Therefore it is important that the RSS walls be founded on soil capable of supporting the imposed loading and limiting settlements under the RSS wall to acceptable magnitudes. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

The performance of a RSS is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to settlement and distortion of the RSS and, in severe cases, to possible failure of the system. It is critical that the RSS walls are not subject to settlement due to compression of the foundation soils and embankment fill. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

To provide an acceptable foundation performance, the RSS mass must be founded on the native undisturbed soils. The highest base levels for the underside of the wall and the soil type at the base levels are indicated in Table 9.1.

Table 9.1 – Maximum Elevation at Underside of Wall Base or Granular A Fill

Foundation Element	Borehole	Depth below existing Highway 17 grade ⁽¹⁾ (m)	Elevation (m)	Soil
Southwest	WB-02	10.6	195.5	Dense sand
Southeast	WB-04	10.1	196.0	Compact sand
Northwest	WB-03	10.5	195.5	Compact sandy silt
Northeast	WB-05	10.6	195.5	Compact sand

⁽¹⁾ Approximate maximum height of existing Highway 17 embankment fill is 9 m.

A RSS wall founded on native compact to dense sand and sandy silt at or below elevations shown in Table 9.1 should be designed for a factored bearing resistance of 375 kPa at ULS and a bearing resistance of 250 kPa at SLS.

Alternatively, the RSS may be founded on engineered fill founded on the native soils contacted at the above elevations. Engineered fill placed under the RSS mass to achieve the design founding level should consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC 2006 Section 6.7.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall on engineered granular fill may be estimated using an ultimate friction coefficient of 0.55. For an RSS block founded on native cohesionless soils, coefficient of sliding friction of 0.45 may be used.

Topsoil, loose fill, and any soft/wet native material should be stripped from the footprint of the RSS. The native soil under the RSS foundation should be proofrolled to detect and replace any soft/loose areas.

If a RSS wall system is selected, the global stability must be analyzed after the location of the wall is known. The global stability of the RSS wall is dependent on the characteristics of the embankment fill and the foundation soils, the geometry of the embankment and location of the RSS within the embankment. Global stability should not be a concern for a RSS wall founded on the native soils at this site.

10. EXCAVATION

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). Temporary excavation for footing construction will extend through the very loose embankment sand fill and into the native loose to compact sand.

For the purposes of the OHSA, the existing embankment fill is classed as Type 3 soil above the water table. The native soils within the probable depth of excavation at this site may be classed as Type 3 soils.

It is expected that excavation will not extend below the groundwater level, which was measured in the piezometers at depths ranging from 17.3 m to 18.4 m (elevations 187.7 to 188.8). Excavation below the water level must not be carried out without prior dewatering.

The excavation of the cohesionless foundation soils and backfilling for foundations must be carried out in accordance with OPSS 902, November 2010.

11. UNWATERING

Piezometers installed in boreholes revealed that the groundwater level is near elevations 187.7 to 188.8. However, seepage may be experienced from perched zones in the granular fill, or from the sand and silt layers.

If spread footings are the selected design for foundations, it is anticipated that excavation will not extend below groundwater table. However, the Contractor should be prepared to pump from sumps to remove any seepage water or surface water collecting in an excavation. No excavation should be undertaken below the water level without prior dewatering. Placement of concrete or

compacting granular engineered fill must be done in the dry. Unwatering must remain operational and effective until the foundation is constructed and backfilled.

The design of the dewatering system that may be required is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility.

12. APPROACH EMBANKMENTS

Currently, the embankment side slope in the approach areas of CP overhead structure are generally sloped at an angle varying from 1.4H:1V to 1.5H:1V. In the immediate approach area (within 10 m behind the abutment walls), the slope is steeper at 1.3H:1V.

12.1 Visual Inspection

A visual inspection of the existing embankment slopes was conducted on November 12, 2010.

The visual inspection revealed:

- No signs of global instability such as bulging at the embankment toe.
- No evidence of tension cracks on the embankment.
- Local surficial erosion on the south embankment east slope face, approximately 27.0 m to 37.0 m south of the Webbwood south abutment.

The potential factors contributing to soil erosion on the embankment slope are:

- Highway drainage discharging over the edge of embankment.
- Loss of vegetation aggravating erosion.
- Steepness of the embankment slope.

12.2 Stability

The global, internal and surficial stability of the approach embankment fills depends on the slope geometry and also to a large degree on the material used to construct the embankments.

The foundation soils governing stability of the approach embankments consist of existing native compact sand or silt. Currently at the site, the embankment height ranges from 7.0 m to 10.0 m. It is anticipated that the existing highway grade will be raised 0.4 m.

An evaluation of the slope stability of the existing approach embankments was conducted. The stability of the embankments was also checked under seismic loading assuming an acceleration of 0.08g. The computed factors of safety are as shown in Table 12.1. Slope stability computation outputs are included in Appendix D.

Table 12.1 Computed Factors of Safety

Location / Material	Condition	Factor of Safety	Figure (Appendix D)
Slope 1.4H : 1V , 10.4 m high embankment			
Earth Fill	Normal	1.2	1
Earth Fill	Seismic = 0.08g	1.0	2
Slope 2H : 1V , 10.4 m high embankment			
Earth Fill	Normal	1.5	3
Earth Fill	Seismic = 0.08g	1.2	4

In the case of normal loading with a 1.4H:1V slope, the factor of safety against global failure was 1.2. Under the assumed seismic loading, the minimum factor of safety calculated was 1.0. The computed factor of safety of 1.2 is less than 1.3, which is the minimum acceptable value for a factor of safety. However, the existing embankment bearing on the foundation soils present at this site has performed well under the existing conditions.

As the factor of safety at the existing slope inclination does not meet the MTO criteria, it is recommended that the inclination of the side slopes do not exceed 2H:1V. At existing locations where slope is steeper than 2H:1V, flattening of the slope is recommended.

If placement of new fill is required, the existing slope surfaces should be appropriately benched, as per OPSD 208.010, after stripping of vegetation, topsoil, organics, soft soils or otherwise unsuitable overburden materials.

Where earth fill embankments are higher than 8 m, mid-height berms should be incorporated in each 8 m vertical interval. The berms should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2% positive grade to shed run-off water.

If additional fill is needed to be placed on the existing slopes, the settlement induced by the placement of new fill is considered negligible.

12.3 Erosion

Surficial erosion was observed on the abutment slope during the visual inspection. The stability of the slope can be at risk if surficial erosion is allowed to progress to a significant level.

In order to minimize surficial erosion on the approaches, the following items should be considered in the design/contract:

- Upgrade the highway drainage to prevent flow over the edge of the shoulder.
- Discharge the highway drainage to the toe of slope by means of lined channels.
- Revegetate the eroded areas. Seeding/mulching, sodding and erosion control blankets could also be considered to minimize erosion at this site.
- Regrading/flattening the slope.
- Benching the slopes may be used to intercept and control the surface runoff, hence, reducing erosion.

In general, earth fill embankment slopes must be provided with erosion protection in accordance with OPSS 804, November 2010.

13. BACKFILL TO ABUTMENTS

In the case of conventional, integral or semi-integral abutments, backfill to the abutment must be granular material.

Backfill to the abutments should consist of Granular A or Granular B Type II material meeting the requirements of Special Provision 110S13 “Amendment to OPSS 1010, April 2004”. The backfill must be in accordance with OPSS 902 dated November 2010, and placed to the extents shown in OPSD 3101.150.

All new embankment earth fill should be placed in regular lifts and be compacted in accordance with OPSS 501 dated November 2010. Also, compaction equipment to be used adjacent to retaining structures must be restricted in accordance OPSS 501 dated November 2010.

The design of the abutment must incorporate a subdrain as shown in OPSD 3101.150 or OPSD 3101.200, as applicable.

14. ROADWAY AND RAILWAY PROTECTION

During the new bridge construction, temporary excavation of existing embankments in the abutment areas will be required. The bridge replacement will be done in stages in order to keep at least one highway lane operational. Roadway and rail track protection will have to be implemented to facilitate staging of removals and support the existing Highway 17 and the rail tracks adjacent to the excavation.

An item titled “Protection System” as per OPSS 539 should be included in the contract documents. It is recommended that for rail protection, Performance Level 1 as per Clause 539.04.01.01 and the alignment of the shoring be specified on the contract drawings. However, discussions with the railway authorities should be carried out also to determine the required level of protection. Performance Level 2 may be specified for roadway protection along Highway 17.

Conventional steel soldier pile and timber lagging walls is one option to provide temporary support to the soils during excavation. Timber lagging boards should be installed as soon as the soil face is exposed and properly prepared.

The following parameters apply for design of the temporary shoring system.

γ	=	20 kN/m ³	(bulk unit weight)
γ_w	=	10 kN/m ³	(submerged unit weight under groundwater table)
K_a	=	0.33	(Active pressure coefficient for road embankment fill)
	=	0.33	(Active pressure coefficient for sand)
K_p	=	3.0	(Passive pressure coefficient for road embankment fill)
	=	3.0	(Passive pressure coefficient for sand)
h_w	=	0	(assuming that the groundwater is maintained below the base of the excavation and that there is no hydrostatic pressure build-up behind a presumably permeable wall, soldier pile and lagging)

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system.

Temporary groundwater and surface water control measures will be required during construction.

The design of roadway protection should be the responsibility of the Contractor. All shoring systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system (e.g. cantilever piles or tie-backs, deadman anchors or on the other side of the embankment).

15. EARTH PRESSURE

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K(\gamma h + q)$$

Where:

P_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see table below)

γ = unit weight of retained soil (see table below)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 15.1.

The factors in Table 15.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the Canadian Highway Bridge Design Code.

Table 15.1 – Earth Pressure Coefficient (K)

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.48*
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

*For wing walls.

16. SEISMIC CONSIDERATIONS

16.1 Seismic Design Parameters

The site is treated as lying in Seismic Zone 1. The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Horizontal Acceleration 0.08

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 1.0 should be used in seismic design.

16.2 Liquefaction Potential

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method¹.

Using this method, it is estimated that under the existing conditions the foundation soils at both abutments are not prone to liquefaction.

The embankments themselves will be constructed above the groundwater level and are not considered to be in danger of undergoing liquefaction.

16.3 Retaining Wall Dynamic Earth Pressures

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading.

For the design of retaining walls, the coefficients of horizontal earth pressure in Table 16.1 may be used.

Table 16.1 – Earth Pressure Coefficient (K) for Earthquake Loading

Wall Condition	Granular A or Granular B Type II $\phi = 35^\circ$ $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ$ $\gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (K_{AE})*	0.3	0.47	0.34	0.58
Passive (K_{PE})	3.6	-	3.2	-
At Rest (K_{OE})**	0.53	-	0.58	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

17. ADJACENT AND BURIED UTILITIES

Fibre optics cables or buried utilities might be present in the vicinity of the new foundation areas, particularly near CP tracks. It is recommended that the exact locations of any utilities be established by the designer, and compared with the extent of the potential work zones related to the foundations of the proposed structure and associated works. These utilities should not be

¹ Seed, H.B. and Idriss, I.M. 1971, "Simplified Procedure for Evaluating Soil Liquefaction Potential" *Journal of Soil Mechanics and Foundations Division*, ASCE, Vol. 101, No. SM9, September, pp. 1249-1273.

undermined or damaged during new footing construction. It may be prudent to expose the fibre optics cables and protect them during construction of the new foundations.

Relocation of, and/or special protective measures for affected utilities may be required.

18. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

1. Destabilization of excavations

Seepage may be encountered within the sand fill. The impact of seepage or surface water could destabilize the sides and or base of the excavation. The Contractor's unwatering plan must be available for rapid implementation should the need arise. Proper groundwater and surface water control measures must be in place prior to commencing excavation. All footings must be constructed in the dry.

2. Staging construction

Care must be taken during footing excavation to avoid disturbing and undermining travelled lanes of the roadways that will remain open.

3. Excavations

Care must be exercised during excavation to avoid disturbing the founding subgrade. The exposed subgrade soils should be expeditiously inspected, approved and protected from disturbance.

4. Existing slopes

The side embankment slopes should be inspected after construction for surficial disturbance. Where necessary, erosion control measures must be implemented.

5. Existing underground utilities

Any information on the location of the buried CP telecommunication cables should also be carefully reviewed. All new foundation footprints must be clear of any buried utility. Vibration and settlement monitoring for buried utilities, where required, should be provided by qualified personnel.

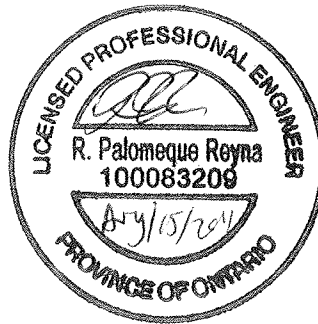
19. CLOSURE

Engineering analysis and preparation of the report were carried out by Ms. R. Palomeque Reyna, P.Eng. and Mr. Alastair E. Gorman, P.Eng.

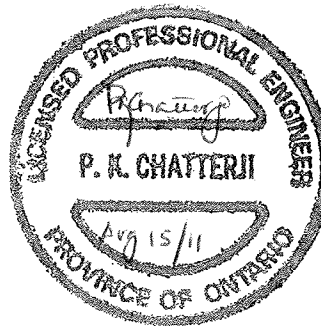
The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



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



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

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	12 or less	Less than 2
Soft	12 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 RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$



Water Level

C_{pen}

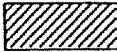

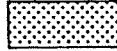

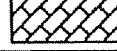
Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

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			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION		SYMBOLS	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength (MPa) (psi)		Field Estimation of Hardness*
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No WB-01

1 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 323.2 E 235 356.6 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM DATE 2010.10.17 - 2010.10.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
206.1								20	40	60	80	100						
0.0	ASPHALT: (100mm)																	
0.1	CONCRETE: (100mm)																	
0.2	SAND, fine grained, silty, trace clay Very Loose to Compact Light Brown Moist (FILL)		1	SS	16													
			2	SS	11													
			3	SS	2													
			4	SS	1													
	Trace silt and clay		5	SS	1													
			6	SS	0													
			7	SS	1													
			8	SS	2													
199.0																		
7.2	SAND, fine grained, trace silt and clay, some silt seams Loose to Compact Light Brown Moist		9	SS	18													
			10	SS	8													

ONTMT4S 1185.GPJ 3/22/11

Continued Next Page

+³.X³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-01

3 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 323.2 E 235 356.6 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM DATE 2010.10.17 - 2010.10.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE	WATER CONTENT (%) 20 40 60			
186												
185												
184												
183												
182												
181												
180												
179.0												
27.1	END OF BOREHOLE AT 27.1m. WATER LEVEL AT 12.2m UPON COMPLETION OF DRILLING. BOREHOLE CAVED TO 12.8m, BACKFILLED WITH CUTTINGS TO 0.15m, THEN ASPHALT TO SURFACE.											

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-01D

2 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 323.2 E 235 356.6 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.10.17 - 2010.10.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
Continued From Previous Page														
							196							
							195							
							194							
							193							
							192							
							191							
							190							
							189							
							188							
							187							

ONTMT4S 1185.GPJ 3/22/11

Continued Next Page

+ 3 . X 3 : Numbers refer to
Sensitivity 20
15 10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-01D

3 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 323.2 E 235 356.6 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.10.17 - 2010.10.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
Continued From Previous Page														
							186							
							185							
							184							
							183							
							182							
							181							
							180							
							179							
							178							
							177							

ONTMT4S 1185.GPJ 3/22/11

Continued Next Page

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-01D

4 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 323.2 E 235 356.6 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.10.17 - 2010.10.17 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60					
	Continued From Previous Page						176								
175.7 30.5	END OF DCPT AT 30.5m UPON CONE REFUSAL.														

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RECORD OF BOREHOLE No WB-02

1 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 315.4 E 235 353.8 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
DATUM DATE 2010.10.22 - 2010.10.23 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
206.1														
0.0	ASPHALT: (350mm)						206							
205.7														
0.4	SAND, fine grained, some silt, trace clay Very Loose to Loose Brown (FILL)		1	SS	7		205							0 88 11 1
			2	SS	3		204							
			3	SS	3		203							0 82 16 2
			4	SS	2		202							
			5	SS	2		201							
			6	SS	4		200							
			7	SS	3		199							
	Becoming wet		8	SS	1		198							0 91 7 2
198.9							197							
7.2	SAND, fine grained, trace silt, trace clay Loose Brown Wet		9	SS	7									
			10	SS	7									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-02

2 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 315.4 E 235 353.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.22 - 2010.10.23 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
194.2	SAND, fine grained, trace silt, trace clay Dense Brown Wet		11	SS	32												
11.9	Sandy SILT, trace clay Compact to Dense Grey Wet		12	SS	23												
			13	SS	26												
			14	SS	38												
			15	SS	32												
			16	SS	27												

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Continued Next Page

+ 3 X 3 Numbers refer to
Sensitivity 20 15 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-02

3 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 315.4 E 235 353.8 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
DATUM DATE 2010.10.22 - 2010.10.23 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							20 40 60 80 100	20 40 60 80 100	20 40 60					
Continued From Previous Page														
	Sandy SILT, trace clay Compact to Dense Grey Wet		17	SS	28		186							
							185							
			18	SS	29									0 22 72 6
							184							
			19	SS	34		183							
							182							
			20	SS	30									
							181							
			21	SS	23		180							
						179								
		22	SS	25										
						178								
		23	SS	34		177							0 21 71 8	

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Continued Next Page

+ 3 . X 3 : Numbers refer to 20
Sensitivity 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-02

4 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 315.4 E 235 353.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.22 - 2010.10.23 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
Continued From Previous Page														
175.9	SILT, trace sand, trace clay Compact to Dense Grey Wet						176							0 5 88 7
30.2			24	SS	40									
			25	SS	27									
172.0			26	SS	43		173							
34.1	END OF BOREHOLE AT 34.1m. WATER LEVEL AT 12.2m UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov. 01/10 18.4 187.7 Nov. 29/10 18.2 187.9													

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-02D

1 OF 2

METRIC

W.P. 5198-06-00 LOCATION N 5 125 315.4 E 235 353.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.10.24 - 2010.10.24 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
206.1 0.0	Start DCPT from surface.						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	20 40 60				kN/m ³	GR SA SI CL	
206														
205														
204														
203														
202														
201														
200														
199														
198														
197														

Continued Next Page

+ 3 × 3: Numbers refer to 20 15 10 Sensitivity (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-02D

2 OF 2

METRIC

W.P. 5198-06-00 LOCATION N 5 125 315.4 E 235 353.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.10.24 - 2010.10.24 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)			
	Continued From Previous Page											
196												
195												
194												
193												
192												
191												
190												
189												
188												
187												
186.3												
19.8	END OF DCPT AT 19.8m.											

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-03

1 OF 6

METRIC

W.P. 5198-06-00 LOCATION N 5 125 297.7 E 235 351.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.19 - 2010.10.21 CHECKED BY LRB

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)						
206.0								20 40 60 80 100			W _P W W _L			GR SA SI CL	
0.0	ASPHALT: (550mm)						206								
205.5															
0.5	SAND, fine grained, some silt, trace clay Loose to Very Loose Brown Wet (FILL)		1	SS	6		205								
			2	SS	1		204								
			3	SS			203								
			4	SS	1		202								
			5	SS	2		201								
			6	SS	2		200								
			7	SS	2		199								
			8	SS	1		198								
	Trace gravel		9	SS	1		197								
			10	SS	0										
196.3															
9.8	Sandy SILT, trace clay														

ONTMT4S 1185.GPJ 3/22/11

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-03

3 OF 6

METRIC

W.P. 5198-06-00 LOCATION N 5 125 297.7 E 235 351.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.19 - 2010.10.21 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page		17	SS	21		186							
							185							
			18	SS	30									
							184							
			19	SS	34		183							
182.3														
23.8	SILT, trace sand, trace clay, occasional sandy layers Compact to Dense Grey Wet		20	SS	20		182							
							181							
			21	SS	16		180							
	Occasional silty clay seams		22	SS	19		179							
							178							
			23	SS	31		177							

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-03

4 OF 6

METRIC

W.P. 5198-06-00 LOCATION N 5 125 297.7 E 235 351.8 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
DATUM DATE 2010.10.19 - 2010.10.21 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) w _p w w _L
Continued From Previous Page							20 40 60 80 100						
	SILT, trace sand to sandy, trace clay Dense Grey Wet						176						0 31 63 6
			24	SS	46								
	Clayey silt zones		25	SS	36		172						0 3 78 19
			26	SS	30		169						
							168						
							167						
			27	SS	30								

Continued Next Page

+ 3 . X 3 : Numbers refer to 20
Sensitivity 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-03

5 OF 6

METRIC

W.P. 5198-06-00 LOCATION N 5 125 297.7 E 235 351.8 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
DATUM DATE 2010.10.19 - 2010.10.21 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
							20 40 60 80 100	20 40 60 80 100	20 40 60					
Continued From Previous Page														
	SILT, some clay, trace sand Compact to Dense Grey Wet						166							
							165							
							164							
			28	SS	39		163							
							162							
							161							
			29	SS	43		160							0 1 87 12
							159							
							158							
							157							0 1 81 18
156.7	Clayey silt zones		30	SS	26									
49.4	End of sampling at 49.4m and start DCPT													

Continued Next Page

+ ³ . X ³ : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-03

6 OF 6

METRIC

W.P. 5198-06-00 LOCATION N 5 125 297.7 E 235 351.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.19 - 2010.10.21 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
								20 40 60 80 100				20 40 60	
								WATER CONTENT (%)					
								20 40 60 80 100					
150.6							156						
55.5	END OF BOREHOLE AT 55.5m. WATER LEVEL AT 12.2 UPON COMPLETION DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.30m, GRAVEL TO 0.15m THEN ASPHALT TO SURFACE.						155						
							154						
							153						
							152						
							151						

RECORD OF BOREHOLE No WB-03D

2 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 297.7 E 235 351.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.10.21 - 2010.10.21 CHECKED BY LRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
196													
195													
194													
193													
192													
191													
190													
189													
188													
187													

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-03D

3 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 297.7 E 235 351.8 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.10.21 - 2010.10.21 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
178.6							186							
							185							
							184							
							183							
							182							
							181							
							180							
							179							
27.4	END OF DCPT AT 27.4m.													

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RECORD OF BOREHOLE No WB-04

1 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 303.7 E 235 361.9 (Webbwood Bridge) ORIGINATED BY LG
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.29 - 2010.10.29 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
206.1													
0.0	ASPHALT: (200mm)						206						
0.2	SAND, fine grained, trace gravel, some silt, trace clay Very Loose Brown Moist (FILL)												
			1	SS	3								
							205						
			2	SS	2								
							204						
							203						
							202						
			3	SS	1								
							201						
							200						
			4	SS	1								
							199						
			5	SS	1								
							198						
			6	SS	3								
							197						
			7	SS	3								
196.9													
9.1	SAND, some silt to silty, trace clay, trace gravel Loose to Compact Brown Moist		8	SS	8								

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Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-04

2 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 303.7 E 235 361.9 (Webbwood Bridge) ORIGINATED BY LG
HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
DATUM DATE 2010.10.29 - 2010.10.29 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page											
192.7	SAND, some silt to silty, trace clay Compact Brown to Grey Moist		9	SS	16		196					
			10	SS	23		195					0 66 30 4
			11	SS	18		194					
			12	SS	18		193					
13.4	Sandy SILT, trace clay Compact to Dense Grey Moist		13	SS	25		192					
			14	SS	31		191					0 52 45 3
	Layer of silty sand		15	SS	31		189					
			16	SS	31		188					
							187					

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15 0.5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-04

3 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 303.7 E 235 361.9 (Webbwood Bridge) ORIGINATED BY LG
HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
DATUM DATE 2010.10.29 - 2010.10.29 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
185.1	Sandy SILT, trace clay Compact Grey Moist		17	SS	25		186							
21.0	SILT, some sand, trace to some clay Compact to Dense Grey Moist		18	SS	26		185							0 15 79 6
							184							
							183							
							182							
			19	SS	31		181							
							180							
							179							
			20	SS	22		178							0 12 77 11
							177							

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Continued Next Page

+ ³, × ³: Numbers refer to 20
Sensitivity 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-04

4 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 303.7 E 235 361.9 (Webbwood Bridge) ORIGINATED BY LG
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.29 - 2010.10.29 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
								20 40 60 80 100				
171.9	SILT, trace to some sand, some clay Compact to Dense Grey Moist		21	SS	19		176					
							175					
							174					
							173					
			22	SS	39		172					0 7 78 15
34.1	End of sampling at 34.1m and start DCPT						171					
							170					
168.3							169					
37.8	END OF BOREHOLE AT 37.8m. WATER LEVEL OBSERVED AT 12.8m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.30m, GRAVEL TO 0.15m THEN ASPHALT TO SURFACE.											

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-04D

1 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 303.7 E 235 361.9 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.11.01 - 2010.11.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
206.1														
0.0	ASPHALT: (200mm)						206							GR SA SI CL
0.2	Start DCPT at 1.5 m						205							
							204							
							203							
							202							
							201							
							200							
							199							
							198							
							197							

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15 5
 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-04D

2 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 303.7 E 235 361.9 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.11.01 - 2010.11.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60 w _p w w _L						
196														
195														
194														
193														
192														
191														
190														
189														
188														
187														

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-04D

3 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 303.7 E 235 361.9 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.11.01 - 2010.11.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
	Continued From Previous Page						186							
							185							
							184							
							183							
							182							
181.1														
25.0	END OF DCPT AT 25.0m. BACKFILLED WITH SAND TO 0.2m, THEN ASPHALT TO SURFACE.													

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-05

1 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 321.4 E 235 363.9 (Webbwood Bridge) ORIGINATED BY LG
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.30 - 2010.10.31 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
206.1												
0.0	ASPHALT: (200mm)						206					
0.2	SAND, fine to medium grained, some silt to silty, trace gravel, trace clay Very Loose to Loose Brown Moist (FILL)						205					
			1	SS	6		204					
							203					
			2	SS	6		202					
							201					
			3	SS	2		200					
							199					
			4	SS	7		198					
							197					
			5	SS	2							
197.1												
9.0	SAND, some silt, trace clay, trace gravel Compact Grey Moist		6	SS	10							

Continued Next Page

+ ³ × ³ : Numbers refer to
Sensitivity

20
15
10
5
0
5
10
15
20
(%) STRAIN AT FAILURE

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-05

2 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 321.4 E 235 363.9 (Webbwood Bridge) ORIGINATED BY LG
 HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
 DATUM DATE 2010.10.30 - 2010.10.31 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page											
194.2	SAND, some silt, trace clay Compact Grey Moist		7	SS	27		196					
							195					
11.9	SILT, trace sand, trace clay Compact Grey Wet		8	SS	18		194					0 7 87 6
							193					
			9	SS	27		192					
191.1												
14.9	Sandy SILT, trace clay Compact Grey Wet		10	SS	21		191					
							190					
			11	SS	26		189					
							188					
			12	SS	29							0 37 59 4
							187					

Continued Next Page

+ ³ , × ³ : Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-05

4 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 321.4 E 235 363.9 (Webbwood Bridge) ORIGINATED BY LG
HWY 17 BOREHOLE TYPE Mud Rotary/NW Casing COMPILED BY AN
DATUM DATE 2010.10.30 - 2010.10.31 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80					
	Continued From Previous Page															
	SILT, some sand to sandy, trace to some clay Dense to Compact Grey Wet		17	SS	45		176									0 28 62 10
							175									
							174									
							173									
171.9			18	SS	29											
34.1	END OF BOREHOLE AT 34.1m Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 6.08m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov. 29/10 17.3 188.8						172									

ONTMT4S 1185.GPJ 3/22/11

RECORD OF BOREHOLE No WB-05D

1 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 321.4 E 235 363.9 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.11.01 - 2010.11.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
206.1														
0.0	ASPHALT						206							
0.2	Case from 1.5m to facilitate DCPT						205							
	Start DCPT at 1.5m.						204							
							203							
							202							
							201							
							200							
							199							
							198							
							197							

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-05D

2 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 321.4 E 235 363.9 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
DATUM DATE 2010.11.01 - 2010.11.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
							196							
							195							
							194							
							193							
							192							
							191							
							190							
							189							
							188							
							187							

Continued Next Page

+³, X³; Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-05D

3 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 321.4 E 235 363.9 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM DATE 2010.11.01 - 2010.11.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
Continued From Previous Page								20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
186														
185														
184														
183														
182														
181														
180														
179														
178														
177														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-05D

4 OF 4

METRIC

W.P. 5198-06-00 LOCATION N 5 125 321.4 E 235 363.9 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
DATUM DATE 2010.11.01 - 2010.11.01 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page						176	20 40 60 80 100	20 40 60					
							175							
							174							
							173							
							172							
							171							
							170							
169.5 36.6	END OF DCPT AT 36.6m.													

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RECORD OF BOREHOLE No WB-06

1 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 292.6 E 235 359.6 (Webbwood Bridge) ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM DATE 2010.10.18 - 2010.10.18 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
206.0	ASPHALT: (100mm)						206							
0.0	CONCRETE													
0.1														
205.4														
0.6	SAND, fine grained, trace clay, some silt, trace gravel Very Loose to Compact Light Brown (FILL)		1	SS	14		205							
			2	SS	14		204							
			3	SS	8		203							0 79 19 2
			4	SS	18		202							
			5	SS	4		201							
			6	SS	7		200							
			7	SS	7		199							
			8	SS	1		198							2 80 16 2
			9	SS	0		197							
197.4														
8.7	SAND, fine to very fine grained, trace to some silt, trace clay Compact Light Brown Moist		10	SS	10									

Continued Next Page

+ ³, x ³: Numbers refer to Sensitivity
20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WB-06

3 OF 3

METRIC

W.P. 5198-06-00 LOCATION N 5 125 292.6 E 235 359.6 (Webbwood Bridge) ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM DATE 2010.10.18 - 2010.10.18 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100			
	Continued From Previous Page											
181.1							186					
							185					
							184					
							183					
							182					
25.0	END OF BOREHOLE AT 25.0m. WATER LEVEL AT 12.2m UPON COMPLETION OF DRILLING. BOREHOLE CAVED TO 12.8m, BACKFILLED WITH CUTTINGS TO 0.1m, THEN ASPHALT TO SURFACE.											

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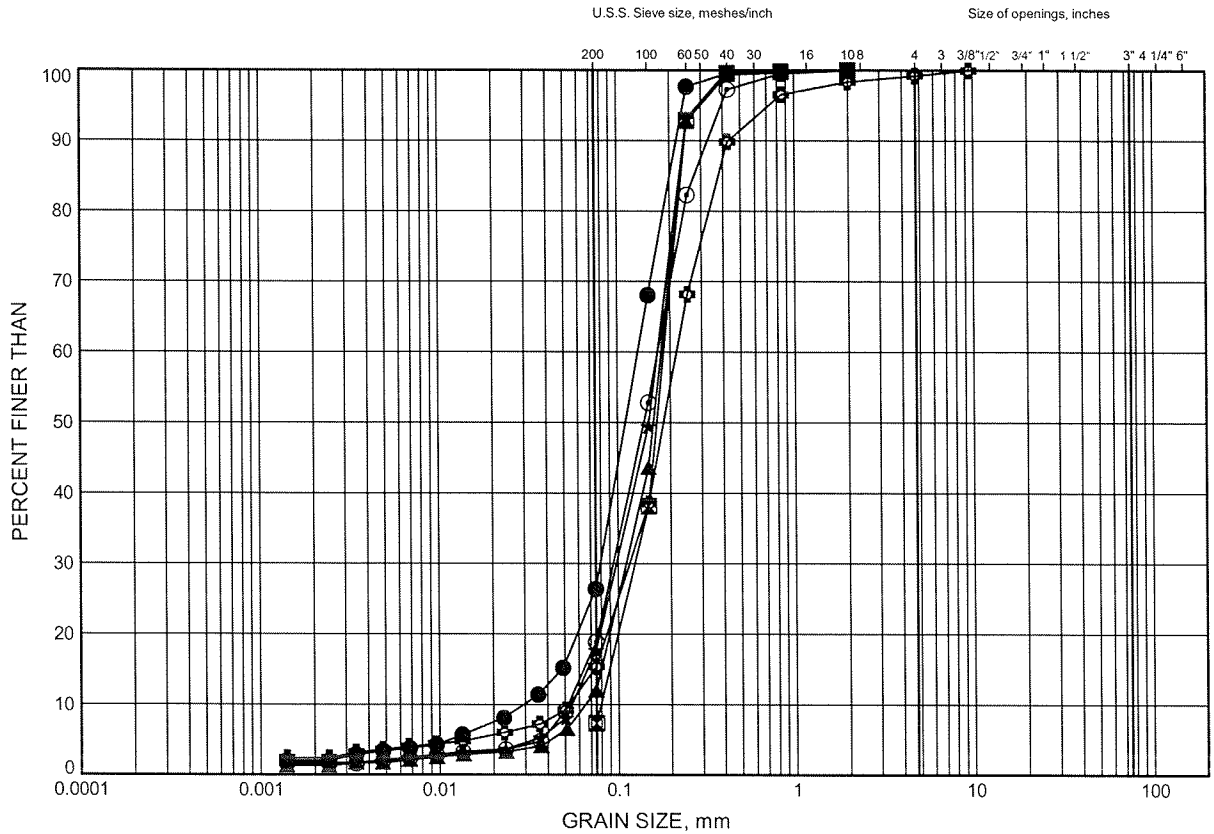
Appendix B

Laboratory Test Results

Ten Bridge Rehabilitations and Two Bridge Replacements
GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-01	1.83	204.30
⊠	WB-01	4.11	202.02
▲	WB-02	1.07	205.03
★	WB-02	3.35	202.74
⊙	WB-03	4.88	201.16
⊕	WB-03	6.40	199.64



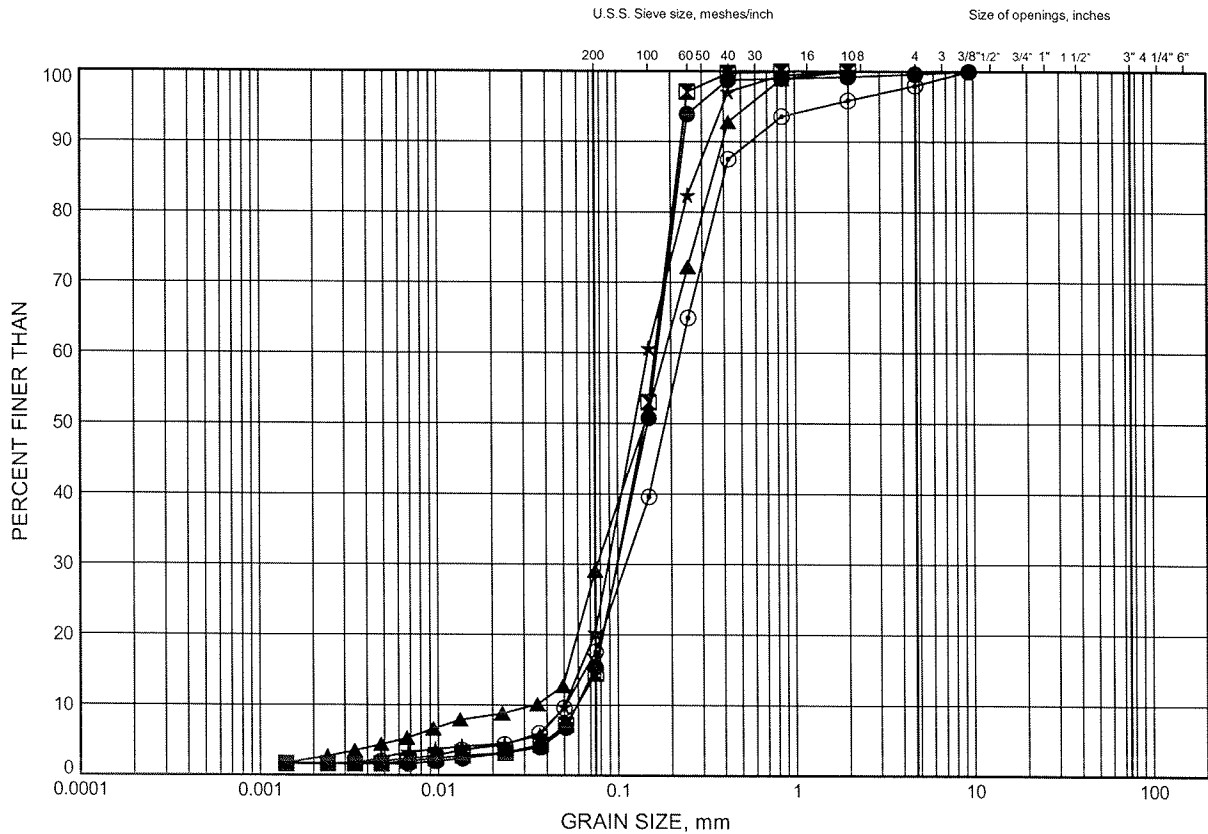
W.P.# 5198-06-00
 Prepared By AN
 Checked By RPR

Ten Bridge Rehabilitations and Two Bridge Replacements

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-04	6.40	199.68
⊠	WB-04	7.92	198.16
▲	WB-05	6.40	199.67
★	WB-06	2.59	203.46
⊙	WB-06	5.64	200.41

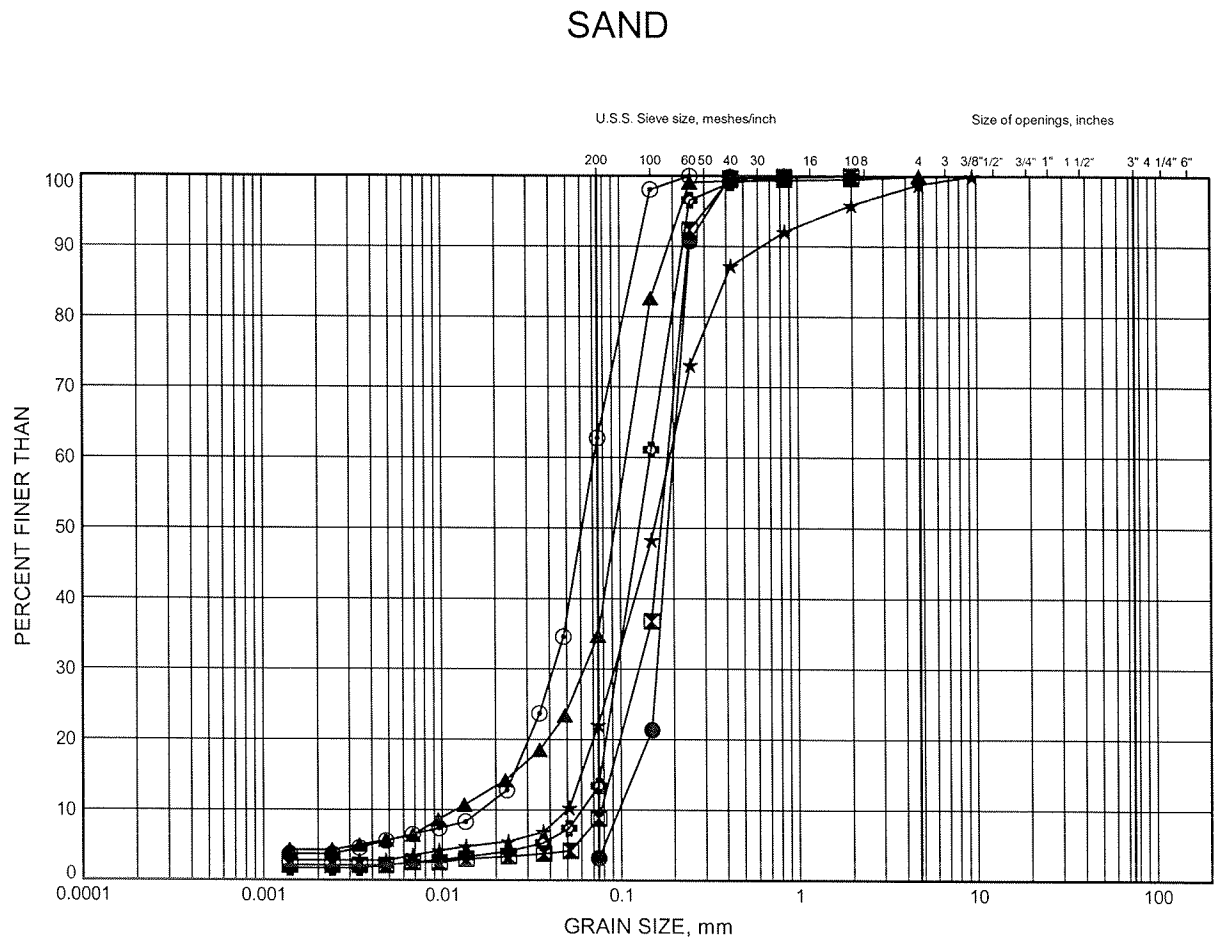


W.P.# 5198-06-00
 Prepared By AN
 Checked By RPR

Ten Bridge Rehabilitations and Two Bridge Replacements

GRAIN SIZE DISTRIBUTION

FIGURE B3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-01	9.45	196.68
⊠	WB-02	7.92	198.17
▲	WB-04	10.97	195.11
★	WB-05	9.45	196.62
⊙	WB-05	18.59	187.48
⊕	WB-06	10.97	195.07

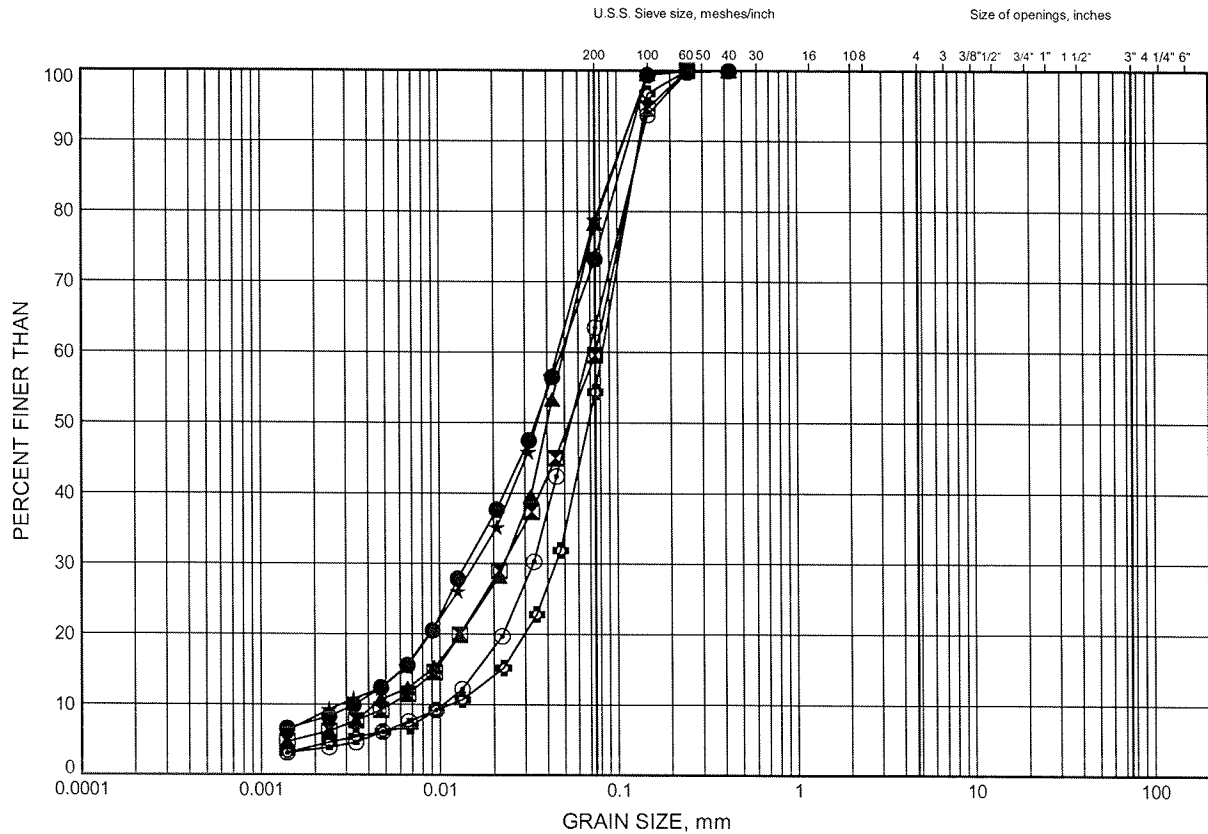


W.P.# 5198-06-00
 Prepared By AN
 Checked By RPR

Ten Bridge Rehabilitations and Two Bridge Replacements
GRAIN SIZE DISTRIBUTION

FIGURE B4

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-01	14.02	192.11
⊠	WB-02	15.54	190.55
▲	WB-02	21.64	184.46
★	WB-02	29.26	176.84
⊙	WB-03	12.50	193.54
⊕	WB-03	17.07	188.97



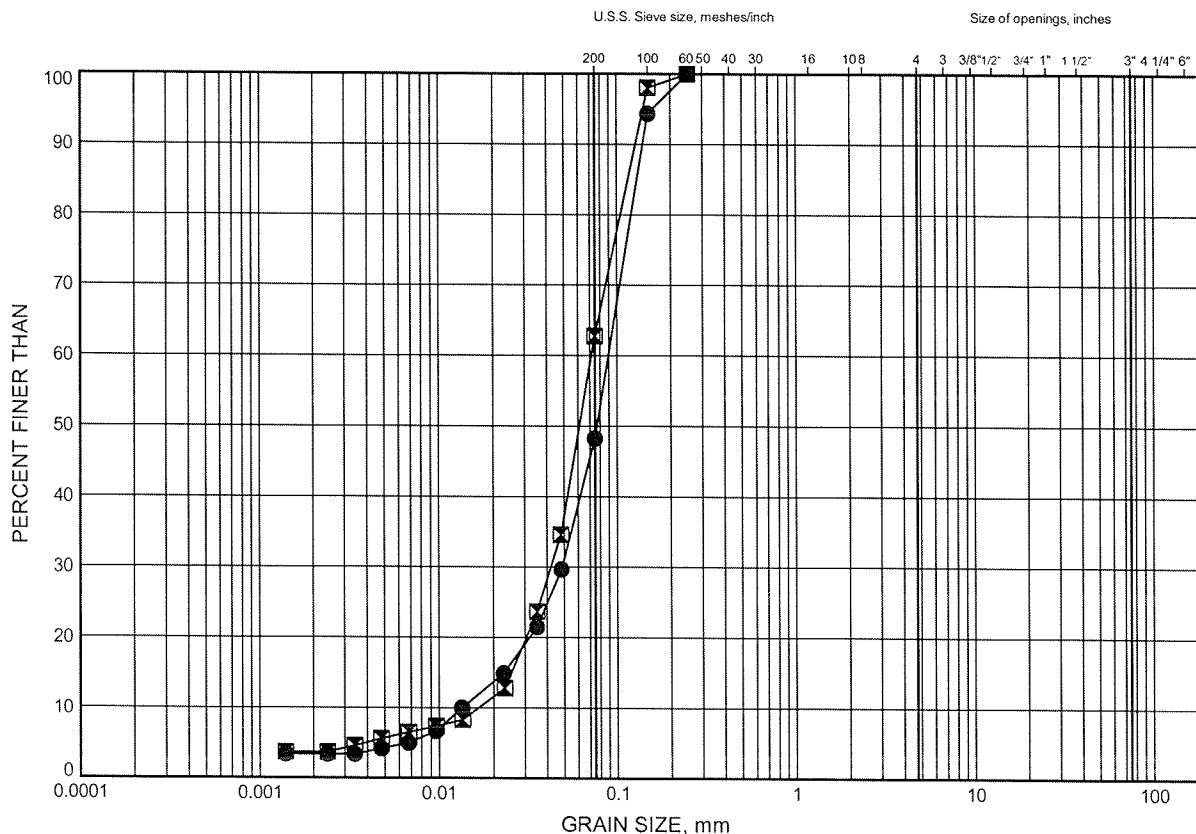
W.P.# 5198-06-00.....
 Prepared By AN.....
 Checked By RPR.....

Ten Bridge Rehabilitations and Two Bridge Replacements

GRAIN SIZE DISTRIBUTION

FIGURE B5

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-04	15.54	190.54
⊠	WB-05	18.59	187.48

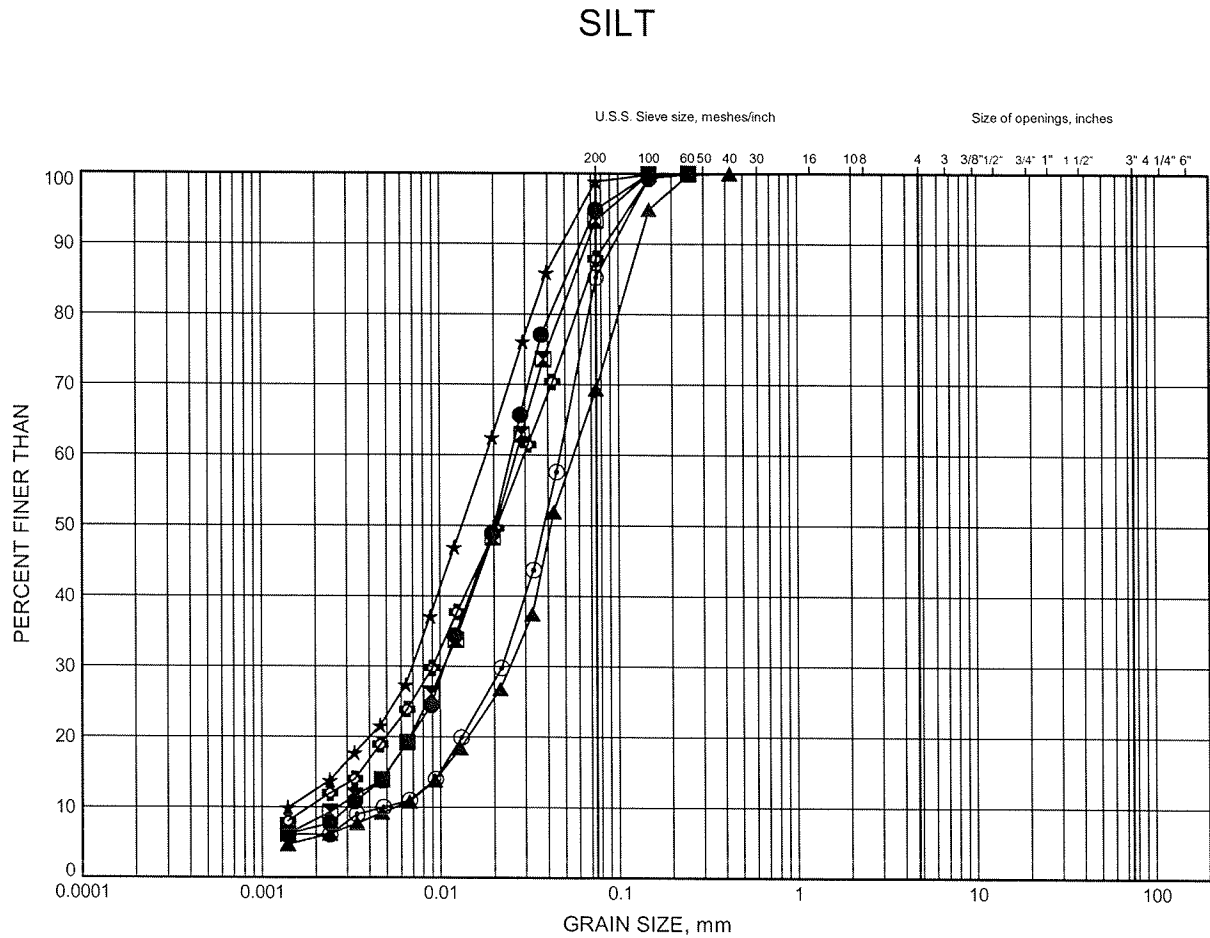


W.P.# .5198-06-00.....
 Prepared By .AN.....
 Checked By .RPR.....

Ten Bridge Rehabilitations and Two Bridge Replacements

GRAIN SIZE DISTRIBUTION

FIGURE B6



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-02	32.31	173.79
⊠	WB-03	24.69	181.35
▲	WB-03	30.78	175.25
★	WB-03	46.02	160.01
⊙	WB-04	21.64	184.44
⊕	WB-04	27.74	178.35

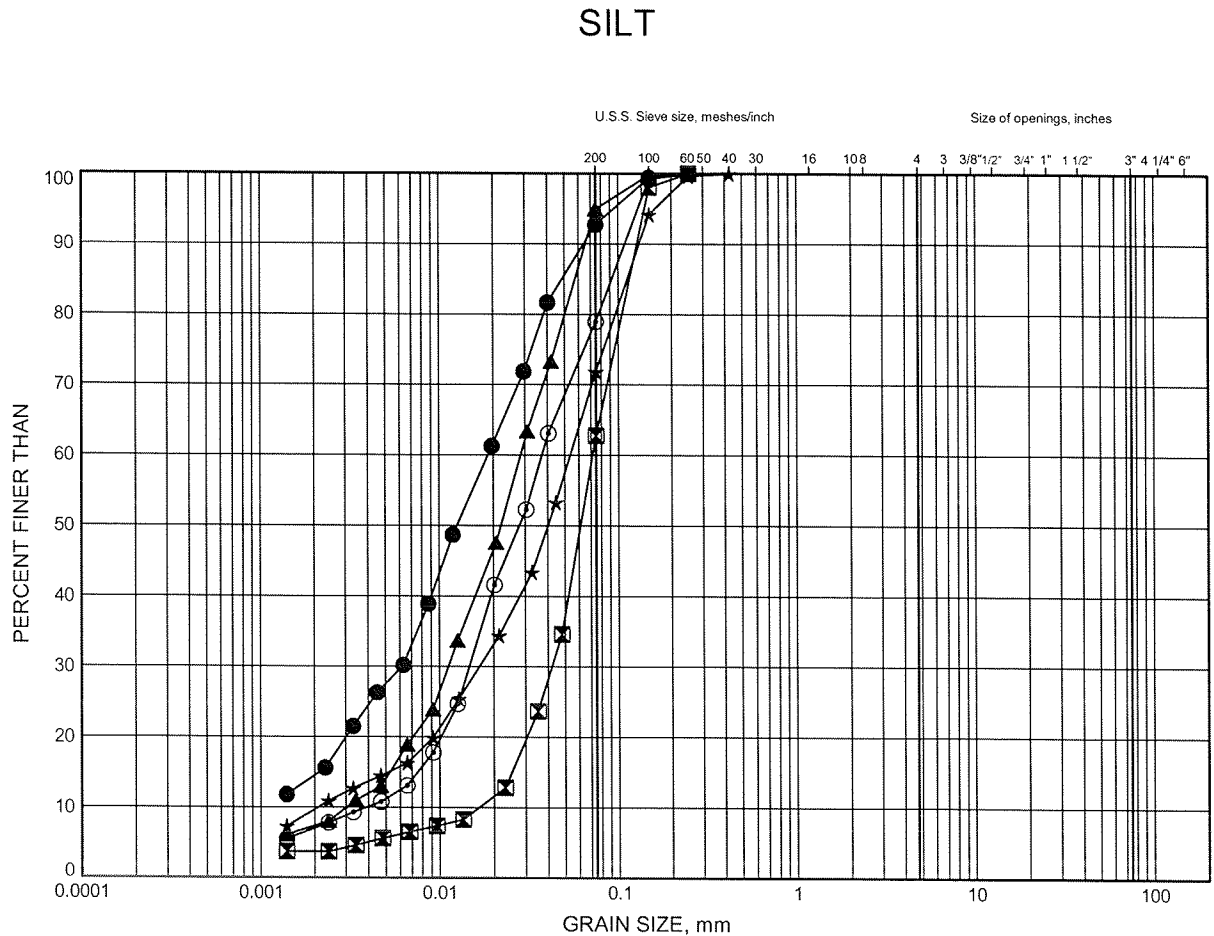


W.P.# 5198-06-00
 Prepared By AN
 Checked By RPR

Ten Bridge Rehabilitations and Two Bridge Replacements

GRAIN SIZE DISTRIBUTION

FIGURE B7



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-04	33.83	172.25
⊠	WB-05	18.59	187.48
▲	WB-05	24.69	181.38
★	WB-05	30.78	175.28
⊙	WB-06	14.02	192.03



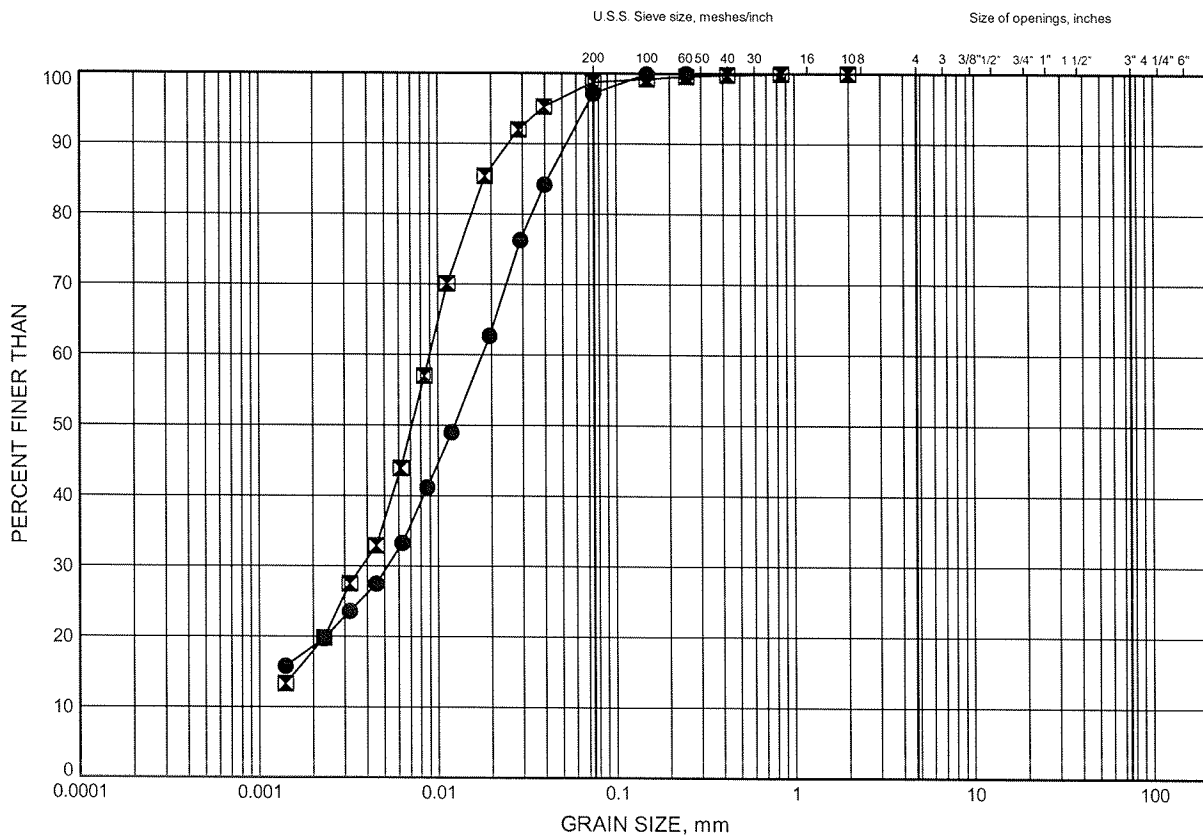
W.P.# 5198-06-00
 Prepared By AN
 Checked By RPR

Ten Bridge Rehabilitations and Two Bridge Replacements

GRAIN SIZE DISTRIBUTION

FIGURE B8

CLAYEY ZONE



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WB-03	36.88	169.16
■	WB-03	49.07	156.97



W.P.# 5198-06-00
 Prepared By AN
 Checked By RPR

Appendix C

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Footings on Native Soil	Spread Footings on Engineered Fill	Driven H-Piles
ABUTMENTS	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Ease of construction. ii. Lower cost than deep foundations. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. Founding level can be adjusted. iii. Higher bearing resistance than native soils at this site. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. High geotechnical resistance available. ii. Allow for the construction of an integral abutment structure. iii. Independent of groundwater conditions. iv. Foundation construction requires less volume of excavation than footings
	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Subexcavation will be required to penetrate fill. ii. If used for abutments, longer stems will be required. 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Cost of engineered fill placement ii. Subexcavation will be required to penetrate fill. 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. Long piles (at least 25 m) will be required to achieve the axial resistance indicated in the report.
	RECOMMENDED	FEASIBLE	NOT RECOMMENDED

Appendix D
Slope Stability Output

Thurber Engineering Ltd. - Toronto
 19-1351-185
 CP Overhead Replacement at Webbwood
 July 22, 2011
 Hwy 17, Site 46-160
 Height 10.4 m , Slope 1.4:H1V

	Gamma C	Phi	Min	Piezo
	kN/m ³	deg	c/p	Surf.
Earth Fill	21	30	0	1
Silt	20	30	0	1

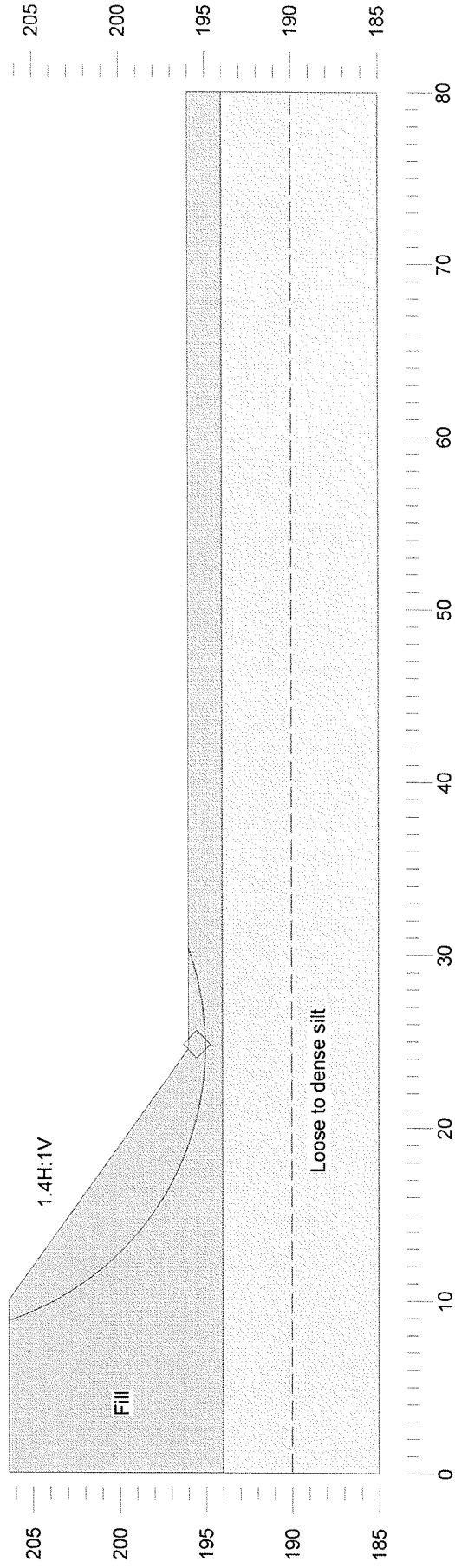
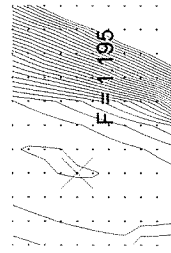


FIGURE 1

Thurber Engineering Ltd. - Toronto
 19-1351-185
 CP Overhead Replacement at Webbwood
 July 22, 2011
 Hwy 17, Site 46-160
 Height 10.4 m , Slope 1.4:H1V

	Gamma	C	Phi	Min	Piezo
	kN/m ³	kPa	deg	c/p	Surf.
Earth Fill	21	0	30	0	1
Silt	20	0	30	0	1

Seismic coefficient = 0.08

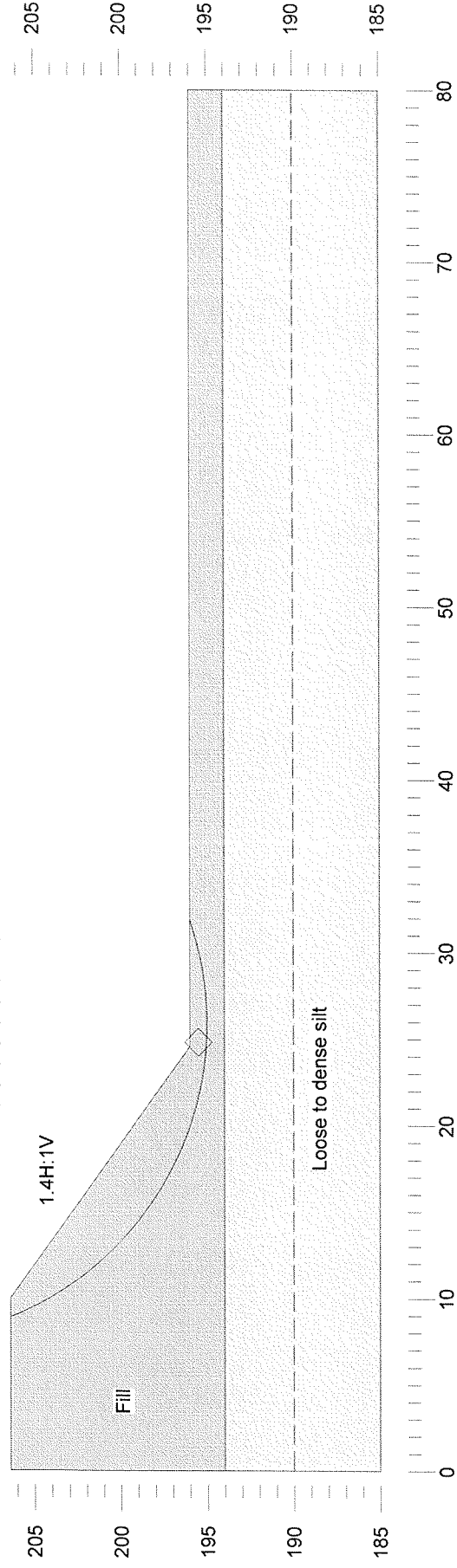
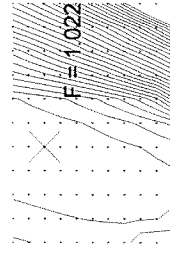


FIGURE 2

Thurber Engineering Ltd. - Toronto
 19-1351-185
 CP Overhead Replacement at Webbwood
 July 22, 2011
 Hwy 17, Site 46-160
 Height 10.4 m , Slope 2H:1V

	Gamma	C	Phi	Min	Piezo
	kN/m ³	kPa	deg	c/p	Surf.
Earth Fill	21	0	30	0	1
Silt	20	0	30	0	1

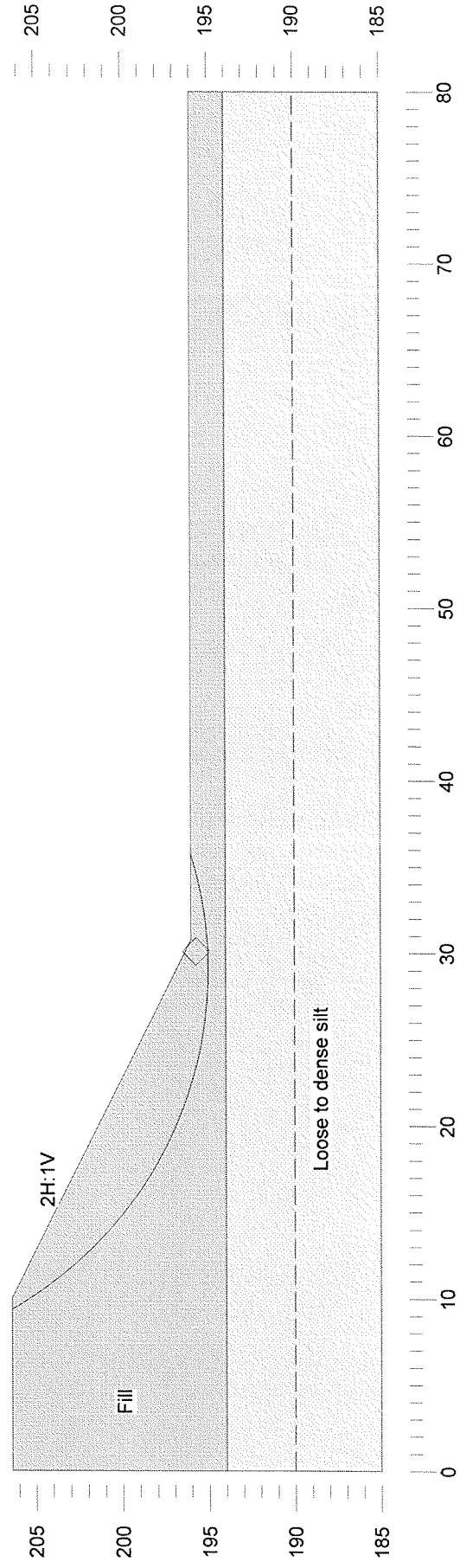
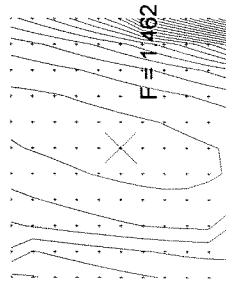


FIGURE 3

Thurber Engineering Ltd. - Toronto
 19-1351-185
 CP Overhead Replacement at Webbwood
 July 22, 2011
 Hwy 17, Site 46-160
 Height 10.4 m , Slope 2H:1V

	Gamma	C	Phi	Min	Piezo
	kN/m ³	kPa	deg	c/p	Surf.
Earth Fill	21	0	30	0	1
Silt	20	0	30	0	1

Seismic coefficient = 0.08

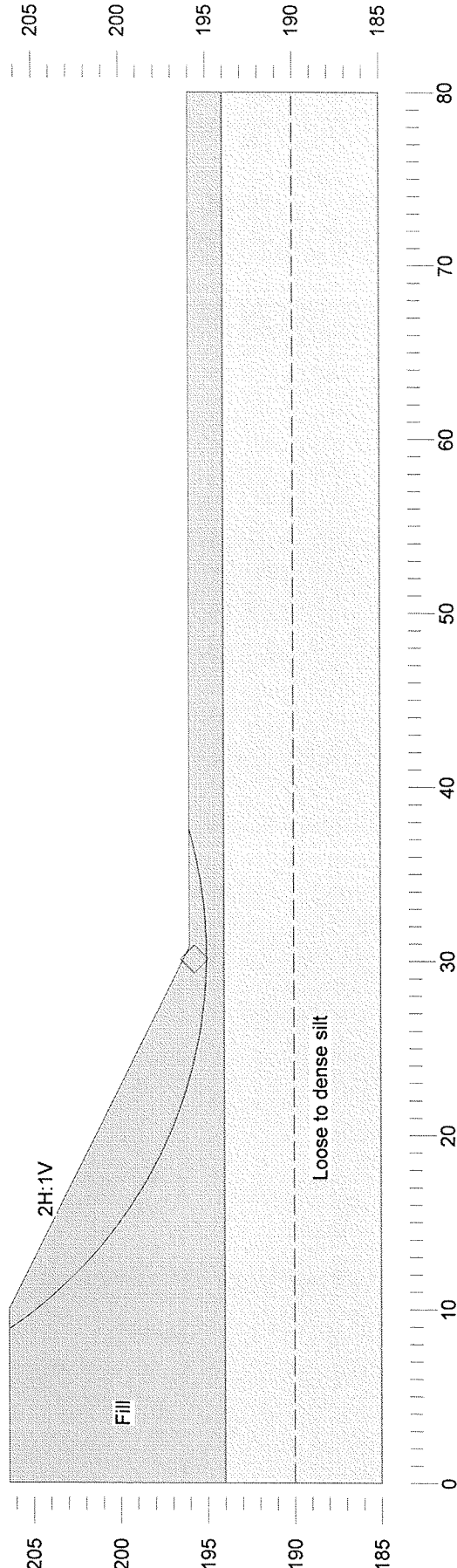
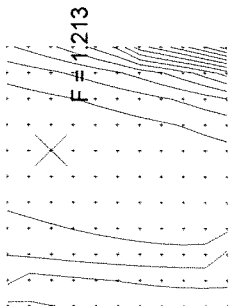
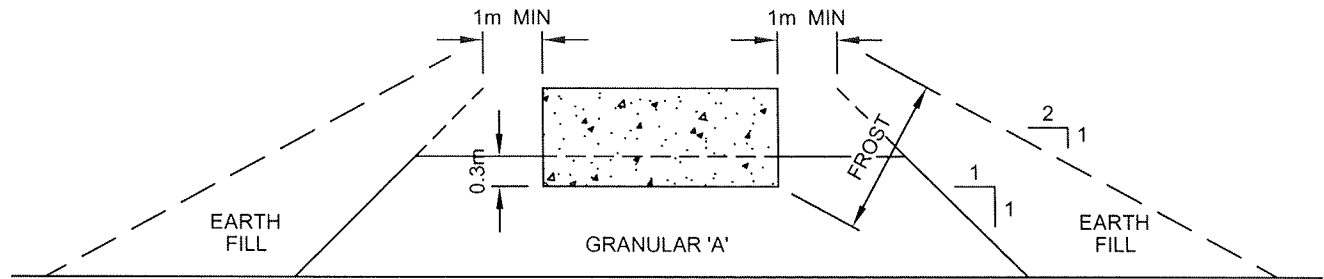


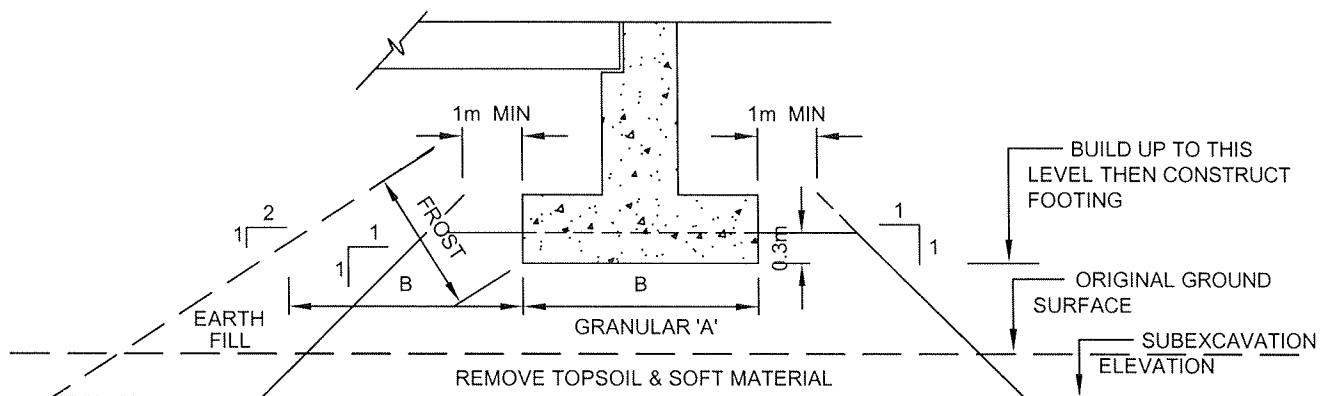
FIGURE 4

Appendix E

Figure 1



CROSS-SECTION



LONGITUDINAL SECTION

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ABUTMENT ON COMPACTED FILL SHOWING
GRANULAR 'A' CORE



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER: RPR	DRAWN: MFA	APPROVED: -
DATE: FEBRUARY 2011	SCALE: N.T.S.	DRAWING No: FIGURE 1

Appendix F

LIST OF SP's and OPSS

1. List of Special Provisions and OPSS Documents Referenced in this Report

The following Special Provisions documents are referenced in this report:

- OPSS 903
- OPSD 3000.100
- OPSS 902, November 2010
- OPSD 208.010
- OPSS 804, November 2010
- OPSS 1010, April 2004
- OPSD 3101.150.
- OPSS 501 dated November 2010
- OPSD 3101.150 or
- OPSD 3101.200
- OPSS 539

2. Suggested text for a NSSP on Pile Installation

A possible impact on the installation of piles at the site that must be taken into consideration is:

Any new and existing embankment fill, through which piles will be driven must not contain oversize material, i.e. no particles exceeding 75 mm in size to facilitate pile installation.

Appendix G

Selected Photographs



Photograph 1 – View of the west side of existing CPR overhead from railtrack



Photograph 2 – Existing slope conditions



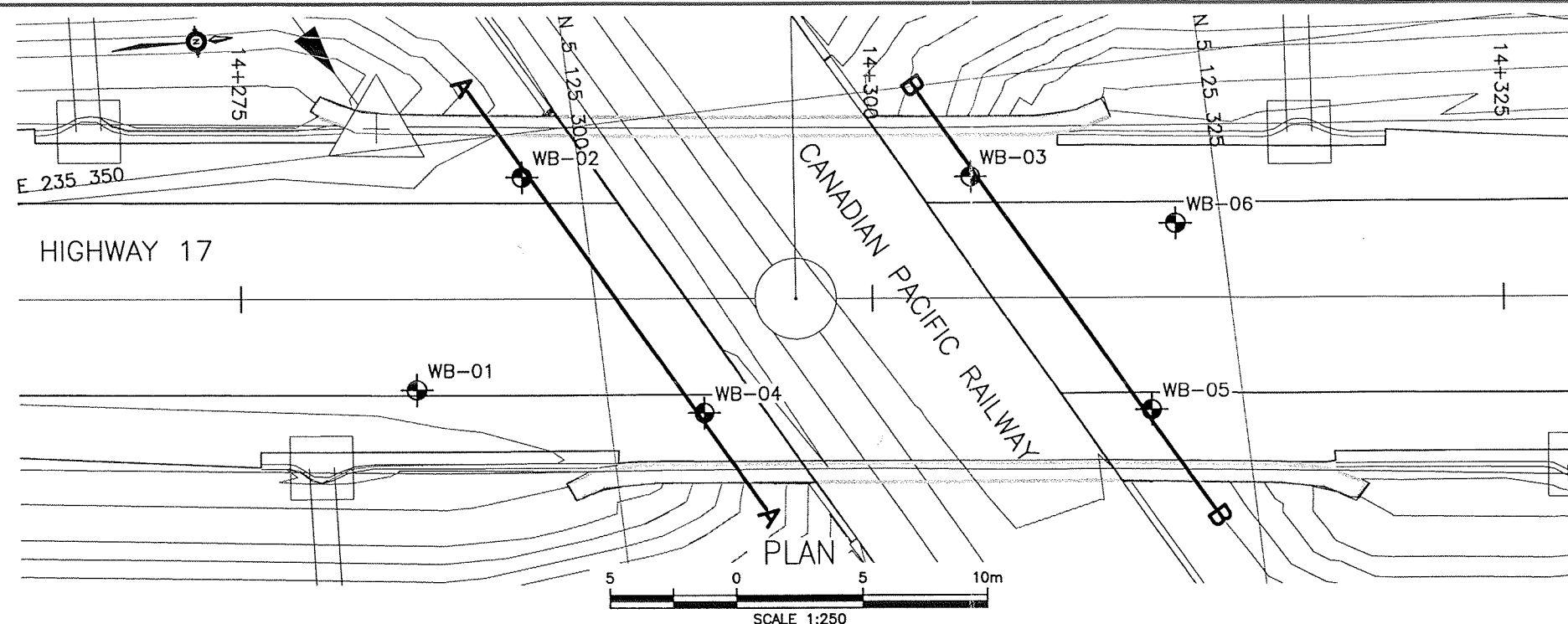
Photograph 3 – Surficial erosion on the southeast embankment



Photographs 4 and 5 – Existing Highway 17 conditions at CPR overhead (Webbwood), looking north

Appendix H

Drawing “Borehole Locations and Soil Strata”



METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 5198-06-00

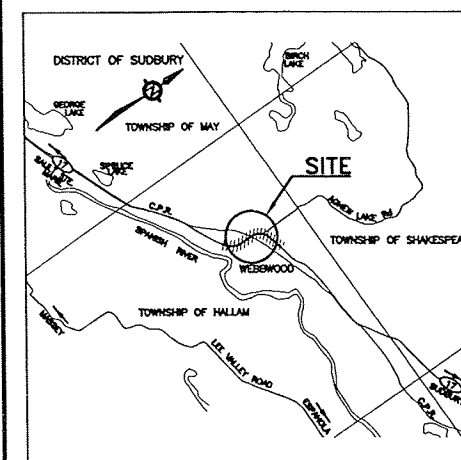
HIGHWAY 17
WEBBWOOD C.P.
OVERHEAD REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA



McCORMICK RANKIN
CORPORATION







THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

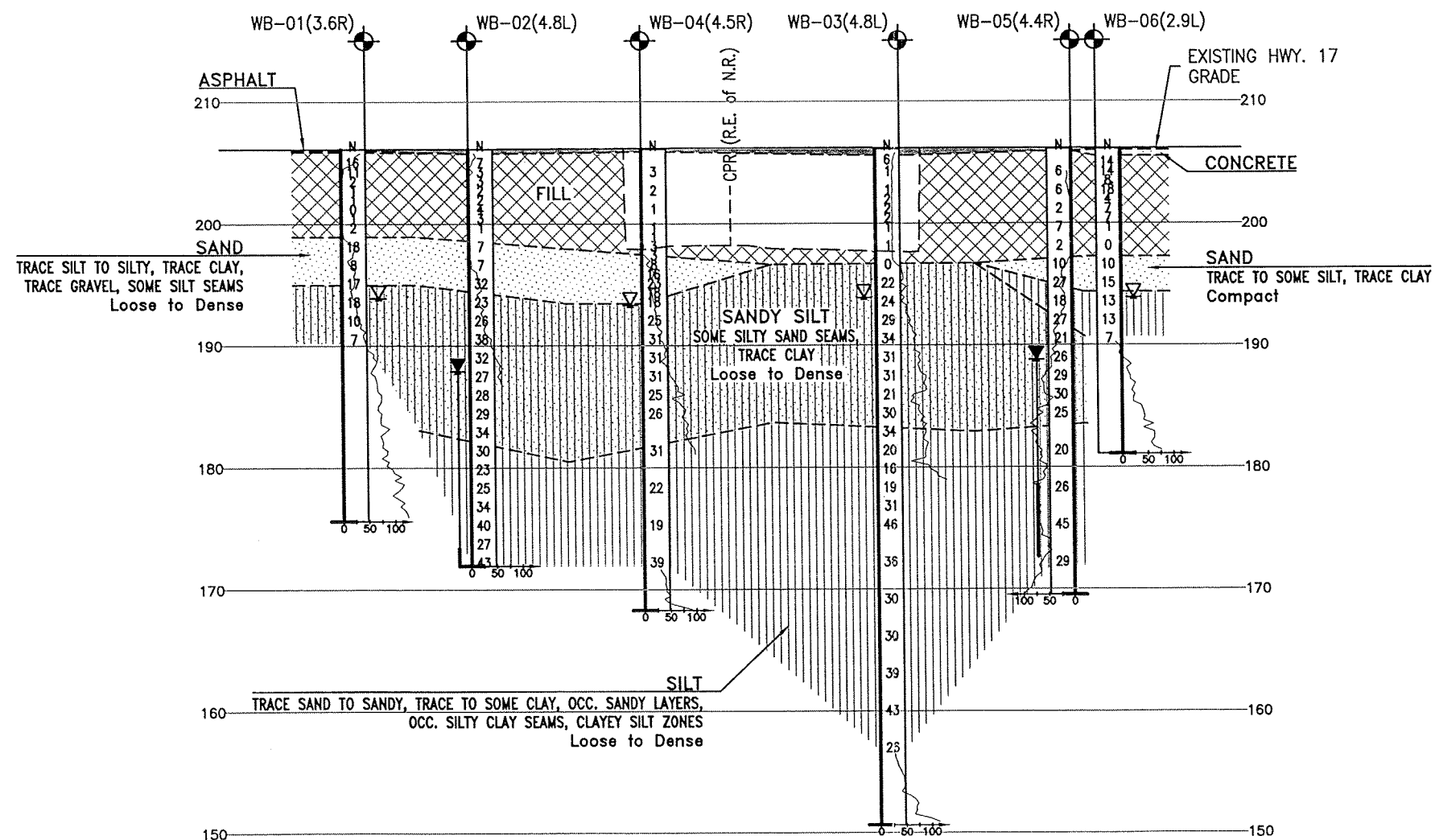
- | | |
|---|---------------------------------------|
|  | Borehole |
|  | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |
| | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

NO	ELEVATION	NORTHING	EASTING
WB-01	206.0	5 125 292.6	235 359.6
WB-02	206.0	5 125 297.7	235 351.8
WB-03	206.1	5 125 315.4	235 353.8
WB-04	206.1	5 125 303.7	235 361.9
WB-05	206.1	5 125 321.4	235 363.9
WB-06	206.1	5 125 323.2	235 356.6

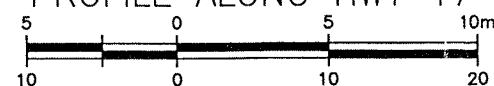
-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 411-272

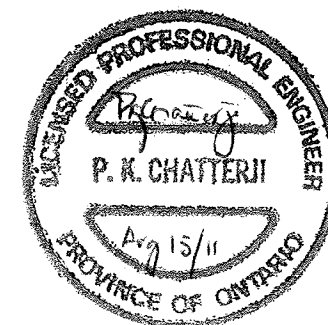


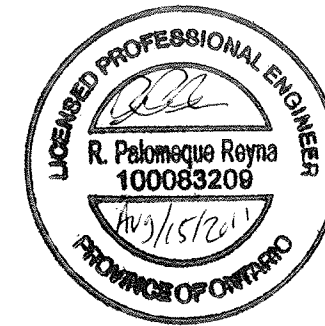
PROFILE ALONG HWY 17



H 1:250

V 1:500

[illegible]

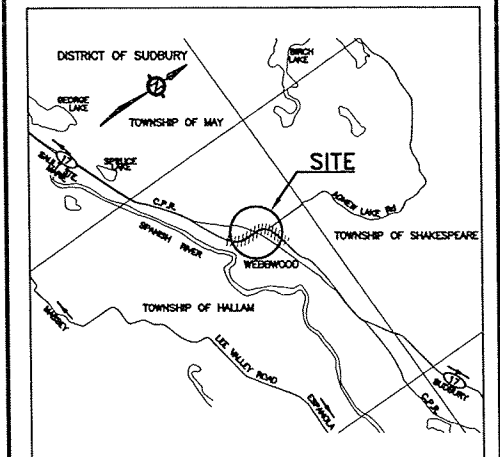


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 5198-06-00

HIGHWAY 17
WEBBWOOD C.P.
OVERHEAD REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN LEGEND

●	Borehole
◆	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

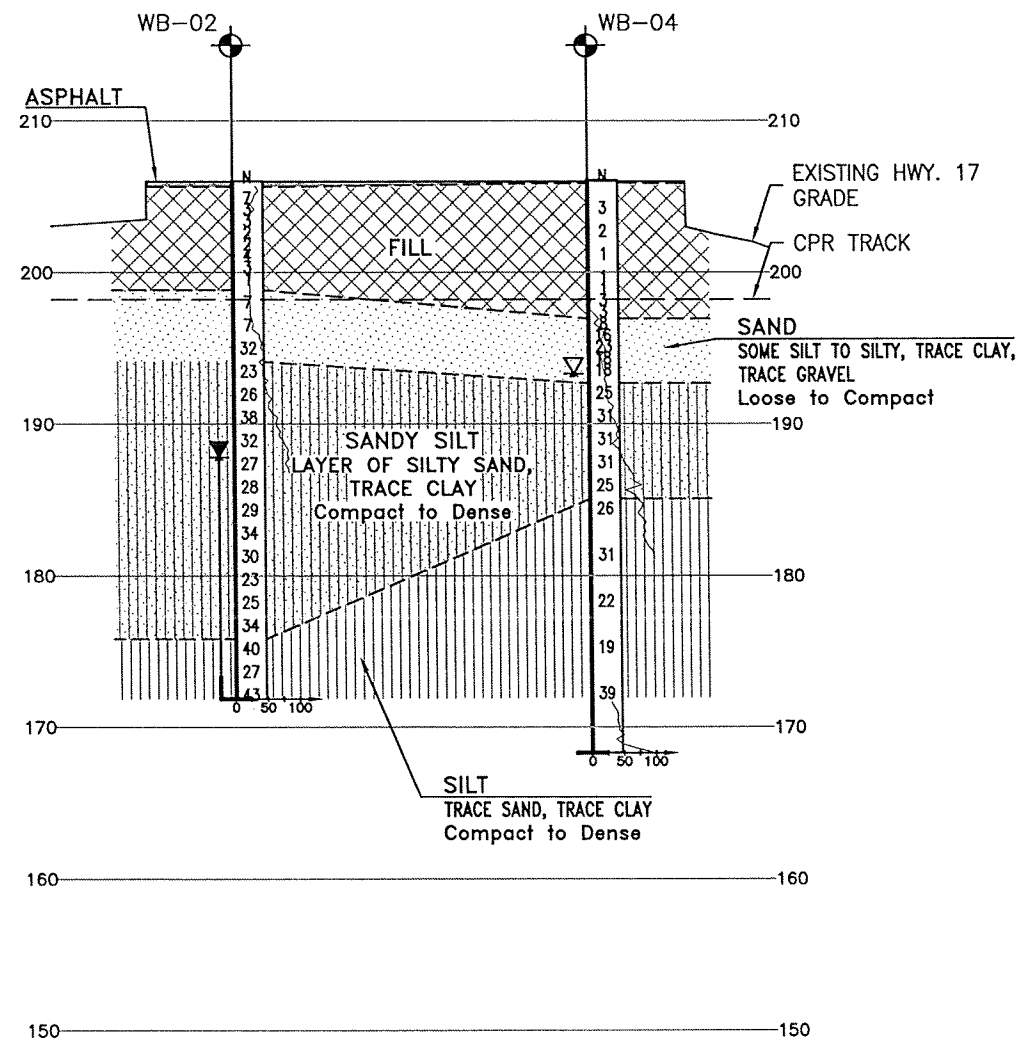
NO	ELEVATION	NORTHING	EASTING
WB-01	206.0	5 125 292.6	235 359.6
WB-02	206.0	5 125 297.7	235 351.8
WB-03	206.1	5 125 315.4	235 353.8
WB-04	206.1	5 125 303.7	235 361.9
WB-05	206.1	5 125 321.4	235 363.9
WB-06	206.1	5 125 323.2	235 356.6

-NOTES-

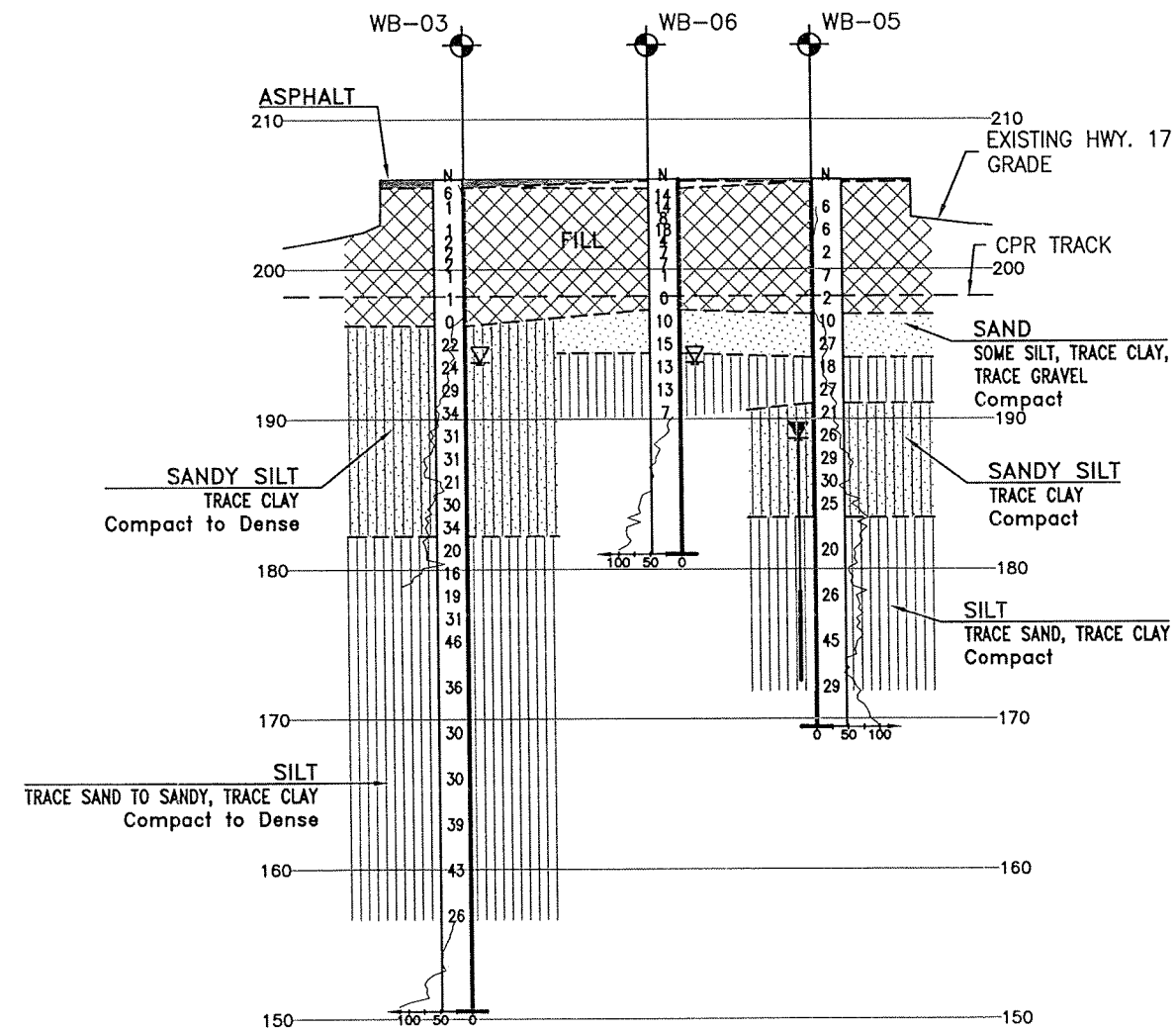
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCREs No. 411-272

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK	CODE
DRAWN	MFA	CHK	RPR
STRUCT	ISTRUCT	ISTRUCT	DWG 2
DATE	JUN. 2011		



PROFILE ALONG HWY 17
H 1:250
V 1:500



PROFILE ALONG HWY 17
H 1:250
V 1:500