

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CYPRESS RIVER BRIDGE REHABILITATION
HIGHWAY 17
DISTRICT OF THUNDER BAY, ONTARIO**

G.W.P. 6069-09-00, Site No. 48C-16

Geocres Number: 42E-15

Report to

**McCormick Rankin
A member of MMM Group**

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the location of the bridge carrying Highway 17 over Cypress River located approximately 35 km east of Nipigon, between Gurney Point Road and Nipigon Bay Road in the District of Thunder Bay, Ontario.

The purpose of this 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, 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, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

In the preparation of this report and in addition to the boreholes drilled under the current assignment, reference has been made to information on subsurface conditions contained in a previous report. The title of the previous report is listed as follows:

- Department of Highways of Ontario, Foundation Investigation Cypress River Crossing, T.C.H. No. 17, District of Thunder Bay No. 19, Project J260, Geocres No. 58-F-279C, Prepared by Trow, Soderman and Associates, dated November 14, 1958. (Reference 1).

2 SITE DESCRIPTION

The Cypress River bridge is located on Highway 17 approximately 35 km east of Nipigon, between Gurney Point Road and Nipigon Bay Road in the District of Thunder Bay, Ontario. Gurney Point Road is approximately 250 m west of the bridge.

At present, the highway crosses Cypress River on a single-span structure supported on two abutments. The bridge span is 21.3 m and the width is 10.5 m. Rock fill, cobbles and boulders are present at the abutments and along the river channel. At the site, Cypress River flows southerly towards Nipigon Bay.

The lands surrounding the bridge site are relatively level and heavily wooded. A railway runs parallel to Highway 17, crossing Cypress River on a bridge approximately 40 m to the south.

Photographs in Appendix D show the general nature of the site.

The site lies within the Quetico Subprovince of the Superior Province of the Canadian Shield. The local area is characterized by Mesoproterozoic sedimentary rocks of the Sibley Group mantled by varying thicknesses of native soils. At this site, the native soils above the bedrock primarily consist of fluvial sands and gravels overlying an extensive deposit of glaciolacustrine silty clay.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out during the period of October 24 to November 6, 2011 and consisted of drilling and sampling four boreholes (numbered CYP-01 to CYP-04) through the highway embankment at the abutments and approaches. Boreholes CYP-02 and CYP-03 were drilled near the abutments and terminated at 34.0 m and 34.1 m depth (elevations 158.0 and 157.7), respectively. Boreholes CYP-01 and CYP-04 were drilled through the approach embankments and terminated at 31.4 m and 31.9 m depth (elevations 160.6 and 159.9), respectively.

Bedrock was proved in Boreholes CYP-02 and CYP-03 by NQ size diamond coring advanced 3.7 m and 3.0 m into bedrock. Boreholes CYP-01 and CYP-04 were terminated upon auger refusal on probable bedrock.

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

The drilling was carried out using a CME 75 truck-mounted drill rig. Wash boring methods with NW-casing were used to advance the boreholes with the exception of the upper 2.1 m in Borehole CYP-03 where hollow stem augers were employed. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was carried out to assess the undrained shear strength of soft to firm cohesive deposits. NQ coring methods were used to recover core samples from the bedrock.

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 and rock samples for transport to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Two standpipe piezometers consisting of 19 mm PVC pipe with slotted screen and enclosed in filter sand were installed at this site to permit longer term groundwater level monitoring. The piezometers were subsequently decommissioned in general accordance with MOE Regulation 903. Boreholes without piezometers were backfilled in general accordance with Regulation 903. The installation and completion details of the boreholes and piezometers are summarized in Table 3.1.

Table 3.1 – Borehole and Piezometer Completion Details

Location	Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
West Abutment/ Approach	CYP-01	None installed	Borehole backfilled with bentonite grout to 1.9 m, auger cuttings to 0.15 m, then asphalt to surface.
	CYP-02	30.5/161.5	Bentonite grout from 34.0 m to 30.5 m, sand from 30.5 m to 28.7 m, bentonite grout from 28.7 m to 1.5 m, concrete from 1.5 m to surface.
East Abutment/ Approach	CYP-03	25.9/165.9	Bentonite grout from 34.1 m to 25.9 m, sand from 25.9 m to 22.9 m, bentonite grout from 22.9 m to 1.8 m, filter sand from 1.8 m to 0.5 m, concrete from 0.5 m to surface.
	CYP-04	None installed	Borehole backfilled with bentonite grout to 1.9 m, auger cuttings to 0.15 m, then asphalt to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

Point load tests were carried out on selected samples of intact bedrock to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the rock core samples are included in Appendix B and on the Record of Borehole sheets in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing in Appendix F. 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. It must be recognized that soil conditions may vary between and beyond borehole locations.

In general terms, the stratigraphy encountered at this site consists of pavement structure overlying sand and gravel fill. Below the fill, an upper layer of native compact to dense sand to sand and gravel was encountered, overlying an extensive deposit of varved silty clay. A lower layer of sand to sand and gravel was contacted below the silty clay. Sandstone and shale bedrock was contacted below the lower sand/gravel layer at depths ranging from 30.3 m to 31.9 m (elevations 159.9 to 161.7).

More detailed descriptions of the individual strata are presented below.

5.1 Asphalt and Concrete

All boreholes were drilled through the pavement structure on Highway 17. In Boreholes CYP-01, CYP-03 and CYP-4, a 115 mm to 125 mm thick layer of asphalt was encountered. In Borehole CYP-02 drilled through the approach slab, a 100 mm thick layer of asphalt was encountered over 300 mm of concrete. Granular fill was encountered below the asphalt and concrete.

5.2 Sand and Gravel Fill

A layer of brown sand and gravel fill containing trace silt and clay, occasional cobbles and boulders was contacted below the pavement structure in all boreholes. Occasional rockfill was noted in Boreholes CYP-03 and CYP-04, drilled near the east abutment and approach. Rockfill is also visible on the forward and side slopes below the existing abutments.

The thickness of the sand and gravel fill varied from 3.7 m to 6.1 m. The depth to the base of the granular fill ranged from 3.8 m to 6.5 m (elevations 188.0 to 185.5).

SPT N-values recorded in the sand and gravel fill ranged from 13 to 69 blows per 0.3 m of penetration, indicating a compact to very dense relative density. Higher values of 50 blows per 0.1 to 0.15 m of penetration were obtained in Borehole CYP-03. The presence of cobbles, boulders and rockfill within the fill may account for some high blow counts. Auger grinding was noted while advancing the borehole through the sand and gravel fill in Borehole CYP-03.

The moisture content of samples of the sand and gravel fill generally ranged from 2% to 11%.

Grain size distribution curves for the sand and gravel fill are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Sand and Gravel Fill Percentage (%)
Gravel	41 to 43
Sand	50 to 55
Silt and Clay	2 to 9

5.3 Upper Layer of Sand to Sand and Gravel

An upper layer of native sand to sand and gravel was encountered below the sand and gravel fill. The native sand to sand and gravel was brown to grey in colour and contained trace to some silt and clay and occasional cobbles. In Borehole CYP-01 drilled on the north approach, occasional wood fragments were noted near elevation 186.2.

The thickness of the upper sand to sand and gravel layer ranged from 1.3 m to 3.2 m. The depth to the base of this layer ranged from 5.1 m to 8.5 m (elevations 186.7 to 183.5).

SPT N-values recorded in the upper layer of sand to sand and gravel on the west side of the bridge (Boreholes CYP-01 and CYP-02) ranged from 35 blows per 0.3 m to 50 blows per 0.15 m of penetration, indicating a dense to very dense relative density. At the east side of the bridge, the SPT N-values ranged from 2 to 5 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The moisture content of samples of the sand to sand and gravel generally ranged from 9% to 16%.

A grain size distribution curve for a sample of the sand and gravel is presented on the Record of Borehole sheets and on Figure B2 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Upper Layer of Sand and Gravel Percentage (%)
Gravel	33
Sand	48
Silt and Clay	19

5.4 Silty Clay

Native grey silty clay was encountered below the upper layer of sand to sand and gravel in all boreholes, at depths ranging from 5.1 m to 8.5 m (elevations 186.7 to 183.5). The thickness of the silty clay deposit ranged from 19.7 m to 26.8 m.

The depth to the base of the silty clay ranged from 28.2 m to 31.9 m (elevations 163.8 to 159.9). Borehole CYP-04 was terminated below the silty clay upon auger refusal on probable bedrock.

SPT N-values recorded in the silty clay typically ranged from 0 to 2 blows for 0.3 m of penetration, indicating a very soft consistency. N-values of 4 to 10 blows for 0.3 m (firm to stiff) were obtained in the upper 2 m of this deposit in Boreholes CYP-01 and CYP-04 and in the lower 5 to 6 m of this deposit in Boreholes CYP-01 to CYP-03. Higher SPT N-values of 22 to 36 blows per 0.3 m of penetration, indicating a very stiff to hard consistency, were recorded in Boreholes CYP-03 and CYP-04 between elevations 165.0 and 162.0.

In-situ vane shear tests performed at depths where low N-values were recorded typically indicated undrained shear strengths ranging from 32 kPa to 56 kPa. Locally near elevation 167.5 in Boreholes CYP-01 and CYP-02, undrained shear strengths of 68 kPa and 70 kPa were measured.

The moisture content of samples collected from the silty clay layer varies between 21% and 65%, typically 40 to 60%.

Grain size distribution curves for selected silty clay samples are presented in Appendix B, Figures B3 to B5. The results are also summarized on the Record of Borehole sheets included in Appendix A. Atterberg Limits test results are presented in Figures B6 to B8 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Silty Clay Percentage (%)
Gravel	0
Sand	0 to 4
Silt	16 to 56
Clay	40 to 84

Index Property	(%)
Liquid Limit	28 to 60
Plastic Limit	15 to 24

The above results show that the silty clay is generally of medium to high plasticity with group symbols of CI-CH. Two silty clay samples from Boreholes CYP-03 and CYP-04, recovered at 30.0 m and 27.1 m depth revealed low plasticity with a symbol of CL.

5.5 Lower Layer of Sand to Sand and Gravel

A lower layer of sand to sand and gravel was encountered in Boreholes CYP-01 to CYP-03, below the native silty clay at depths ranging from 28.2 m to 30.4 m (elevations 161.4 to 163.8). The lower layers of sand to sand and gravel were brown, grey and reddish brown in colour and contained trace to some silt and clay. Occasional bedrock fragments

were observed in Borehole CYP-01. The thickness of the lower sand to sand and gravel layer ranged from 0.7 m to 2.6 m.

The depth to the base of the lower sand to sand and gravel layer ranged from 30.3 m to 31.4 m (elevations 161.7 to 160.6). Borehole CYP-01 was terminated below the lower sand and gravel layer upon auger refusal on probable bedrock.

SPT N-values recorded in the lower sand to sand and gravel layer were 21 blows per 0.3 m of penetration and 100 blows per 0.15 m of penetration, indicating a compact to very dense relative density.

The moisture content of samples of the lower sand to sand gravel ranged from 8% to 14%.

A grain size distribution curve for a sample of the lower sand and gravel are presented on the Record of Borehole sheets and on Figure B2 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Lower sand and gravel Percentage (%)
Gravel	36
Sand	44
Silt and Clay	20

5.6 Bedrock and Refusal

The soils described above are underlain by bedrock consisting of grey sandstone and red shale. Bedrock was proved by coring in Boreholes CYP-02 and CYP-03. Boreholes CYP-01 and CYP-04 were terminated upon auger refusal on probable bedrock. Table 5.1 summarizes the depths and elevations to the top of bedrock and auger refusal encountered in the boreholes.

Table 5.1 – Depths and Elevations of Top of Bedrock and Auger Refusal

Foundation Element	Borehole	Top of Bedrock/Auger Refusal	
		Depth (m)	Elevation (m)
West Abutment/Approach	CYP-01	31.4	160.6
	CYP-02	30.3*	161.7
East Abutment/Approach	CYP-03	31.1*	160.7
	CYP-04	31.9	159.9

*Bedrock proved by coring

Total Core Recovery (TCR) in the bedrock was 100%. The RQD values ranged from 81% to 100%, indicating a good to excellent rock quality.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 5.

The unconfined compressive strength of the rock interpreted from point load tests conducted on cores recovered from Borehole CYP-02 ranged from 70 MPa to 118 MPa, indicating a strong to very strong rock. The interpreted compressive strengths of cores recovered from Borehole CYP-03 ranged from 30 MPa to 40 MPa, indicating a medium strong rock.

The unconfined compressive strengths interpreted from point load tests are indicated on the Record of Borehole sheets in Appendix A. The Point Load Test Sheets are provided in Appendix B.

5.7 Water Levels

Water was added into the drill casing during wash-boring and therefore natural groundwater levels were not measured during drilling. Standpipe piezometers were installed in Boreholes CYP-02 and CYP-03 to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Foundation Unit	Borehole	Date	Water Level (m)		Comments
			Depth	Elevation	
West Abutment	CYP-02	November 5, 2011	3.8	188.2	In piezometer
		November 6, 2011	3.8	188.2	
		November 30, 2011	3.4	188.6	
		May 29, 2012	3.8	188.2	
East Abutment	CYP-03	November 4, 2011	3.6	188.2	In piezometer
		November 5, 2011	3.6	188.2	
		November 30, 2011	2.8	189.0	
		May 29, 2012	2.6	189.2	

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The groundwater levels will also be affected by the water level in the river. A water level at elevation 187.0 in October 2012 and a high water level at elevation 188.2 in August 1959 are indicated on the preliminary GA drawing dated February 2013.

5.8 Previous Investigation (Reference 1)

A foundation investigation was conducted at this site in 1958 for construction of the existing bridge (Reference 1). The borehole logs, laboratory testing, borehole location plan and soil profiles prepared for the previous investigation are reproduced in Appendix C. The approximate locations of the previous boreholes (Boreholes 1 to 4) are included on the drawing in Appendix F.

In general, the subsurface conditions documented during the 1958 investigation are consistent with the conditions encountered during the current investigation, comprising the following:

- A layer of embankment fill consisting of sand, gravel and boulders extending to depths of 4.9 m to 7.0 m below the road grade (elevations 186.6 to 184.3). It was noted in the report that the fill depth was greater than the embankment height of about 3.0 m, possibly as a result of timber crib installation for a previous bridge, and/or the lower portion of this material may have comprised native ground.
- A 0.6 m to 2.7 m thick layer of native silty to clayey sand underlying the embankment fill.
- An extensive deposit of varved silty clay extending to depths of 27.6 to 29.9 m (elevations 163.7 to 161.5). The thickness of the silty clay ranged from 20.0 m to 22.3 m.
- A 0.3 to 2.7 m thick layer of red sand with gravel below the silty clay.
- Red and grey bedrock contacted below the sand and gravel at the following depths and elevations:

Table 5.3 – Depths and Elevations of Top of Bedrock (Previous Investigation)

Foundation Element	Borehole	Top of Bedrock/Auger Refusal	
		Depth (m)	Elevation (m)
West Abutment	2	30.3	161.0
	4	30.8	160.4
East Abutment	1	31.2	160.2
	3	30.2	161.2

The water level observed in the boreholes was approximately 4.3 m below the highway grade, near elevation 186.9 to 187.2.

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. MMM Group Limited surveyed the borehole locations and provided the co-ordinates and the ground surface elevations.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a truck mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations were supervised in the field on a full time basis by Mr. Jason Mei and Mr. Stephane Loranger, C.E.T. of Thurber Engineering Ltd.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

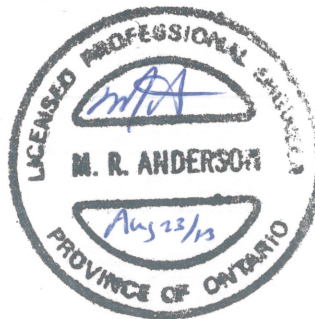
Overall planning and supervision of the field program was conducted by Mr. Mark Farrant, P. Eng.

Interpretation of the data and preparation of the report was carried out by Ms. R. Palomeque Reyna, P.Eng. and Mr. Murray Anderson, 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., M.Eng.
Geotechnical Engineer

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer



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



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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 provides geotechnical recommendations for the proposed rehabilitation of the existing Cypress River bridge on Highway 17 between Gurney Point Road and Nipigon Bay Road in the District of Thunder Bay, Ontario.

At present, Highway 17 crosses Cypress River on a single-span structure with a span of 21.3 m and a width of 10.5 m. Construction drawings from 1959 indicate that each abutment of the existing bridge is supported on 18 steel H-piles (BP 12-53[#]) driven to bedrock. The supplied piling length was 30.5 m and the design load per pile was 355 kN (40 tons).

Based on the preliminary GA drawing dated May 2013, rehabilitation of the bridge will consist of replacement of the existing deck slab and steel girders with a new deck comprising precast prestressed concrete box girders. The rehabilitation will include modification of the tops of the abutments and wingwalls, and replacement of the approach slabs. Highway grade revisions or widening are not planned.

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

8 ASSESSMENT OF EXISTING ABUTMENT FOUNDATIONS

We understand from McCormick Rankin that the replacement superstructure will be approximately 30% heavier than the existing superstructure. The total increase in load carried by the foundations will be less than that value however, as the dead load of the substructure and the live loads will not change. The maximum loads per pile for the rehabilitated structure as estimated by McCormick Rankin are 625 kN at ULS and 540 kN at SLS.

The archive drawings indicate that the piles supporting the existing bridge abutments were to be driven to bedrock. Pile lengths of 30.5 m were supplied and the pile cut-off elevation was 187.9. Design load per pile was 355 kN (40 tons).

The subsurface stratigraphy encountered at this site generally consists of sand and gravel fill underlain by a relatively thin layer of sand to sand and gravel, overlying an extensive deposit of typically very soft silty clay, and a lower layer of sand to sand and gravel. Sandstone and shale bedrock was contacted at depths of 30.3 m to 31.9 m (elevations 159.9 to 161.7).

Based on the soil conditions above the bedrock, the bedrock surface elevations, the length of pile supplied and the pile cut-off elevations, it is probable that the existing piles achieved refusal on the bedrock and were not terminated within soils above the bedrock surface.

The recommended axial, factored geotechnical resistance at Ultimate Limit States (ULS_f) for BP 12-53[#] (HP 310x79) H-piles driven to bedrock is 1,450 kN per pile. The SLS condition will not govern for piles founded on the bedrock.

The anticipated pile loading of 625 kN per pile at ULS is below the factored geotechnical resistance at ULS, and therefore the increase in vertical load due to superstructure replacement is not expected to impact the performance of the existing foundations.

The structural adequacy of the pile section under the increased loads must be checked by the structural designer.

Since the highway grade will not be raised and no new fill will be placed during rehabilitation of the bridge, downdrag is not an issue at this site.

The design depth of frost penetration at this site is 2.2 m.

9 ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the modified abutment and wing walls should be in accordance with OPSS 902 and consist of Granular A or Granular B Type II material. Granular backfill should be placed to the extents shown in OPSD 3101.150. All granular material should meet the specifications of OPSS 1010 as amended by Special Provision 110S13. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501.

Lateral earth pressures acting on the abutments/wing walls may be assumed to be distributed triangularly and to be governed by the characteristics of the wall 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 9.1)

γ = unit weight of retained soil (see Table 9.1)

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

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill and the existing material adjacent to the wall. Typical values are given in Table 9.1.

Table 9.1 – Earth Pressure Coefficients (K)

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Existing Granular Fill $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At Rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

* For wing walls.

The use of a material with a high friction angle and low active pressure coefficient (Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 9.1 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 C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

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 at a depth of 1.7 m for Granular A or Granular B Type II.

10 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.0
- Acceleration Related Seismic Zone 0
- Zonal Acceleration Ratio 0.0
- Peak Horizontal Acceleration 0.02

The soil profile type at this site has been classified as Type IV. Therefore, according to Table 4.4 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 2.0 should be used in seismic design.

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. The coefficients of horizontal earth pressure for seismic loading presented in Table 10.1 may be used:

Table 10.1 – Earth Pressure Coefficients for Earthquake Loading

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 or Existing Granular Fill $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.28	0.32
Passive (K_{PE})	3.7	3.2
At Rest (K_{OE})**	0.45	0.50

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

** After Woods

The potential for liquefaction of the foundations soils was assessed using the Bray et al. (2004) criteria, based on Figure 6.15 of the Canadian Foundation Engineering Manual (CFEM, 2006) for fine-grained soils. Using this method, it is estimated that the foundation soils at the abutments are not susceptible to liquefaction.

11 SCOUR AND EROSION CONTROL

Rock fill presently lines the river banks in front of the bridge abutments as well as the sides of the approach embankments. It is recommended that the rock fill be maintained and if necessary enhanced to provide protection against erosion and scour.

A vegetation cover should be maintained and/or established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

12 EXCAVATION AND GROUNDWATER CONTROL

Excavation for modification of the abutments is expected to be limited to the existing sand and gravel fill adjacent to the structure. It must be noted that cobbles, boulders and rockfill were encountered within the existing embankment fill.

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the sand and gravel fill above the water level is classified as a Type 3 soil and Type 4 soil below the water table.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should be inspected regularly for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

The groundwater levels measured in piezometers on site ranged from elevation 188.2 to 189.2, and river levels at elevation 187.1 and 188.2 are indicated on the preliminary GA drawing for October 2012 and August 1959, respectively. It is expected that work at the abutments will not require excavation below the groundwater level. However, if bridge rehabilitation operations involve excavation below the river water level, dewatering will be required. The design of the dewatering system should be the responsibility of the Contractor and the Contract Documents should alert him to this responsibility.

The Contractor should be prepared to pump from sumps to remove any seepage water or surface water collecting in an excavation.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902.

13 APPROACH EMBANKMENTS

Highway grade revisions or placement of new fill are not planned for the rehabilitation program. Therefore, no settlement or stability issues are anticipated at this site.

14 ROADWAY PROTECTION

The bridge rehabilitation will be done in stages in order to keep at least one highway lane operational. Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2.

Conventional steel soldier pile and timber lagging walls or continuous sheet pile wall are two options to provide temporary support to the roadway during excavation. However, the existing embankment fill contains occasional cobbles, boulders and rockfill which may interfere with installation of soldier piles or sheet piles. The ultimate choice of a roadway protection system should be left to the Contractor.

The 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.

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.

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

15 CONSTRUCTION CONCERNS

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

- The existing embankment fill contains occasional cobbles, boulders and rockfill which may interfere with installation of soldier piles or sheet piles for roadway protection.
- The existing approach embankments are underlain by very soft silty clay. The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing embankments to support the proposed construction equipment, and the effects of any proposed excavation or additional fill placement (i.e, as a pad for crane support) on the stability of the embankment.

16 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Ms. R. Palomeque Reyna and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Rocio Palomeque Reyna, P.Eng., M.Eng.
Geotechnical Engineer

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer

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



Appendix A

Record of Borehole Sheets

EXPLANATION OF ROCK LOGGING TERMS


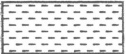



ROCK WEATHERING CLASSIFICATION

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

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
	(MPa)	(psi)	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
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 % 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.

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			

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

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 naked eye

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

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROX. SPT ⁽¹⁾ "N" VALUE
Very Soft	< 10	< 2
Soft	10 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	> 200	> 30

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

TERMS DESCRIBING DENSITY (COHESIONLESS SOILS)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50


HIERARCHY OF SOIL STRENGTH PREDICTION

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

LEGEND FOR TEST HOLE LOGS

 Shelby Tube
 A – Casing
  SPT
  Grab/Auger sample
  Core
  No Recovery

- MC – Moisture Content (% by Weight) as determined by sample

 Water Level
 C_{vane} Shear Strength Determination by Field Insitu Vane
 C_{pen} Shear Strength Determination by Pocket Penetrometer
 C_{lab} Shear Strength Determination using a Laboratory Vane Apparatus
 C_U Undrained Shear Strength determined by Unconfined Compression Test
 AS/GS/BS Auger Sample/Grab Sample/ Block Sample
 SS Split-spoon
 SC Soil core
 AED Oedometer test
 TXL Triaxial test

RECORD OF BOREHOLE No CYP-01

1 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 071.0 E 241 453.8 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.11.04 - 2011.11.05 CHECKED BY RPR

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		
192.0														
0.0	ASPHALT: (115mm)													
0.1	SAND and GRAVEL, trace silt and clay, occasional cobbles Dense to Compact Brown Moist (FILL)		1	SS	38		192							
	Wet		2	SS	22		191							
							190							
	Occasional cobbles		3	SS	46		189							41 50 9 (SI+CL)
			4	SS	24		188							
			5	SS	21		187							
187.3	No recovery						186							
4.6	SAND, trace gravel Dense Brown Wet		6	SS	35		185							
	Occasional wood fragments at 5.8m						184							
			7	SS	50/ 0.150		183							
184.2	Silty CLAY Firm Grey		8	SS	8									0 0 16 84

ONTMT4S 1197.GPJ 2012TEMPLATE(MTO).GDT 4/23/13

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15
10


(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CYP-01

2 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 071.0 E 241 453.8 ORIGINATED BY SLL
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2011.11.04 - 2011.11.05 CHECKED BY RPR

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 (%)			
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× LAB VANE	20	40	60
Continued From Previous Page																			
	Silty CLAY Very Soft Grey		9	SS	0		182												
								181		3.0									
			10	SS	0			180											
								179		4.0									
			11	SS	0			178											
								177											
			12	SS	0			176											
								175											
			13	SS	0			174											
								173											

Continued Next Page

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

RECORD OF BOREHOLE No CYP-01

3 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 071.0 E 241 453.8 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.11.04 - 2011.11.05 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L				
	Continued From Previous Page													
	Silty CLAY Very Soft Grey		15	SS	0		172							
							171							
							170							
							169							
	Stiff		16	SS	10		168							
							167							
							166							
			17	SS	10		165							
							164							
163.2							163							
28.8	SAND and GRAVEL , some silt and clay, occasional bedrock fragments Compact Brown Wet													

Continued Next Page

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

RECORD OF BOREHOLE No CYP-01

4 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 071.0 E 241 453.8 ORIGINATED BY SLL
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2011.11.04 - 2011.11.05 CHECKED BY RPR

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							SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
								WATER CONTENT (%)						
								20	40	60	80	100		
160.6			18	SS	21		162							36 44 20 (SI+CL)
31.4	END OF BOREHOLE AT 31.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO 1.9m, AUGER CUTTINGS TO 0.15m, THEN ASPHALT TO SURFACE.						161							

RECORD OF BOREHOLE No CYP-02

1 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 062.0 E 241 457.2 ORIGINATED BY JM
HWY 17 BOREHOLE TYPE NW Casing/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2011.10.24 - 2011.10.27 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
192.0														
0.0	ASPHALT: (100mm)													
0.1														
191.6	CONCRETE: (300mm)													
0.4	SAND and GRAVEL, trace silt and clay Dense to Compact Brown Moist (FILL)		1	SS	35		191							
			2	SS	15		190							43 55 2 (SI+CL)
			3	SS	25		189							
	Moist to Wet		4	SS	17		188							
			5	SS	21		187							
			6	SS	15		186							
185.5							185							
6.5	SAND and GRAVEL Dense Grey Wet		7	SS	44		184							
							183							
183.5														
8.5	Silty CLAY Soft Grey		8	SS	2									

Continued Next Page


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

RECORD OF BOREHOLE No CYP-02

2 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 062.0 E 241 457.2 ORIGINATED BY JM
 HWY 17 BOREHOLE TYPE NW Casing/Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2011.10.24 - 2011.10.27 CHECKED BY RPR

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 (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
Continued From Previous Page								20 40 60 80 100	20 40 60							
	Silty CLAY Very Soft Grey		9	SS	1		182									
								181	3.0							
			10	SS	0		180									
							179									
			11	SS	0		178	3.0								
							177									
			12	SS	1		176									
							175	3.0								
			13	SS	0		174									
							173	2.0								
			14	SS	1		172									
							171	4.0								
			15	SS	1		170									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CYP-02

3 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 062.0 E 241 457.2 ORIGINATED BY JM
 HWY 17 BOREHOLE TYPE NW Casing/Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2011.10.24 - 2011.10.27 CHECKED BY RPR

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						
	Continued From Previous Page													
	Silty CLAY Very Soft Grey		16	SS	1		172	3.0						
							171							
							170	3.0						
							169							
			17	SS	4		168							
							167							
							166	4.0						
	Firm		18	SS	8		165							
							164							
163.8 28.2	SAND, trace to some silt, trace gravel Very Dense Grey Wet						163							
			19	SS	100/									

Continued Next Page

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

RECORD OF BOREHOLE No CYP-02

4 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 062.0 E 241 457.2 ORIGINATED BY JM
HWY 17 BOREHOLE TYPE NW Casing/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2011.10.24 - 2011.10.27 CHECKED BY RPR

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												
161.7 30.3	SAND Very Dense Grey Wet BEDROCK , grey sandstone and red shale, occasional mechanical and vertical breaks Horizontal fractures at 32.5m and 32.9m Sub-horizontal fractures at 33.4m, 33.5m, 33.7m		1	RUN	0.150	162						FI	RUN #1 TCR=100% SCR=81% RQD=81% UCS=86MPa (Average)
			2	RUN		161						0	
						160						0	RUN #2 TCR=100% SCR=100% RQD=100% UCS=118MPa (Average)
			3	RUN		159						0	RUN #3 TCR=100% SCR=83% RQD=83% UCS=70MPa (Average)
158.0 34.0	END OF BOREHOLE AT 34.0m. BOREHOLE OPEN TO 34.0m AND WATER LEVEL AT 2.3m. 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.05/11 3.8 188.2 Nov.06/11 3.8 188.2 Nov.30/11 3.4 188.6 May 29/12 3.8 188.2												

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No CYP-03

2 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 049.4 E 241 490.7 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.11.02 - 2011.11.03 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT 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 80 100	20 40 60 80 100	W _P W W _L				
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%) 20 40 60				
Continued From Previous Page														
	Silty CLAY Very Soft Grey		9	SS	0		181							0 0 16 84
			10	SS	0		180							
							179	3.0						
			11	SS	1		178							
							177							
			12	SS	1		176	3.0						
							175							0 0 26 74
			13	SS	0		174							
							173	3.0						
							172							

Continued Next Page

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

METRIC

[illegible]

+ 3, × 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No CYP-03

4 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 049.4 E 241 490.7 ORIGINATED BY SLL
HWY 17 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.11.02 - 2011.11.03 CHECKED BY RPR

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		
	Continued From Previous Page													
161.4	Silty CLAY , trace sand Hard Grey		18	SS	36									
30.4	SAND , trace gravel, some silt Reddish Brown Moist													
160.7							161						FI	
31.1	BEDROCK , grey sandstone and red shale, occasional mechanical and vertical breaks		1	RUN			160						3	RUN #1 TCR=100% SCR=86% RQD=100% UCS=41MPa (Average)
	Sub-vertical joints at 32.6m, 33.5m												4	
													0	
													3	
													4	
													0	
													3	RUN #2 TCR=100% SCR=92% RQD=97% UCS=30MPa (Average)
			2	RUN			159						2	
													4	
													1	
157.7							158						1	
34.1	END OF BOREHOLE AT 34.1m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS:													
	DATE DEPTH (m) ELEV. (m)													
	Nov.04/11 3.6 188.2													
	Nov.05/11 3.6 188.2													
	Nov.30/11 2.8 189.0													
	May 29/12 2.6 189.2													

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

RECORD OF BOREHOLE No CYP-04

1 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 041.8 E 241 492.4 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.11.05 - 2011.11.06 CHECKED BY RPR

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								
191.8													
0.0	ASPHALT: (115mm)												
0.1	SAND and GRAVEL, occasional cobbles Compact to Very Dense Brown Moist (FILL)		1	SS	31		191						
			2	SS	13		190						
			3	SS	50		189						
	Occasional rockfill, cobbles		4	SS	66								
188.0							188						
3.8	SAND, trace to some silt Loose Grey Wet		5	SS	5		187						
	No recovery												
186.7							186						
5.1	Silty CLAY Firm Grey		6	SS	5		185						
			7	SS	5		184						
	No recovery		8	SS	0		183						
							182						

Continued Next Page

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

RECORD OF BOREHOLE No CYP-04

2 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 041.8 E 241 492.4 ORIGINATED BY SLL
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2011.11.05 - 2011.11.06 CHECKED BY RPR

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													
	Silty CLAY Very Soft Grey		9	SS	0									
							181							
			10	SS	0		180							
							179	4.0						
			11	SS	0		178							
							177							
			12	SS	0		176	3.0						
							175							
			13	SS	5		174							
							173	3.0						
			14	SS	0		172							

Continued Next Page

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

METRIC

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	W P W W L	WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
	Continued From Previous Page												
	Silty CLAY Very Soft Grey		15	SS	0		171						
							170	4.0					
							169						
			16	SS	0		168						
							167	4.0					
							166						
							165						
	Very Stiff, silt seams		17	SS	22		165					0 0 43 57	
							164						
							163						
							162						

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No CYP-04

4 OF 4

METRIC

W.P. 6069-09-00 LOCATION Cypress River Bridge N 5 422 041.8 E 241 492.4 ORIGINATED BY SLL
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2011.11.05 - 2011.11.06 CHECKED BY RPR

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		18	SS	2									
159.9							161							
31.9	END OF BOREHOLE AT 31.9m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO 1.9m, AUGER CUTTINGS TO 0.15m, THEN ASPHALT TO SURFACE.						160							

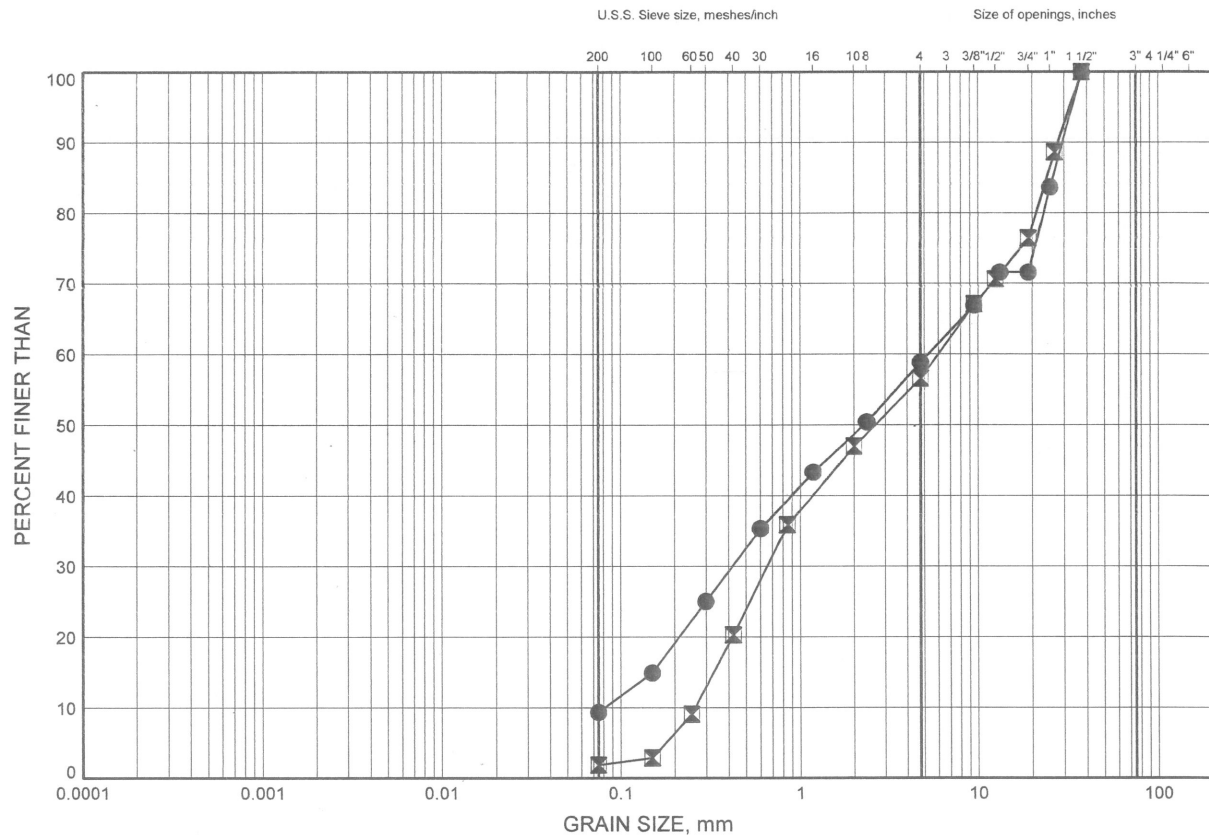
Appendix B

Laboratory Test Results

Cypress River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-01	2.59	189.41
■	CYP-02	1.83	190.17

Date May 2013
W.P. 6069-09-00

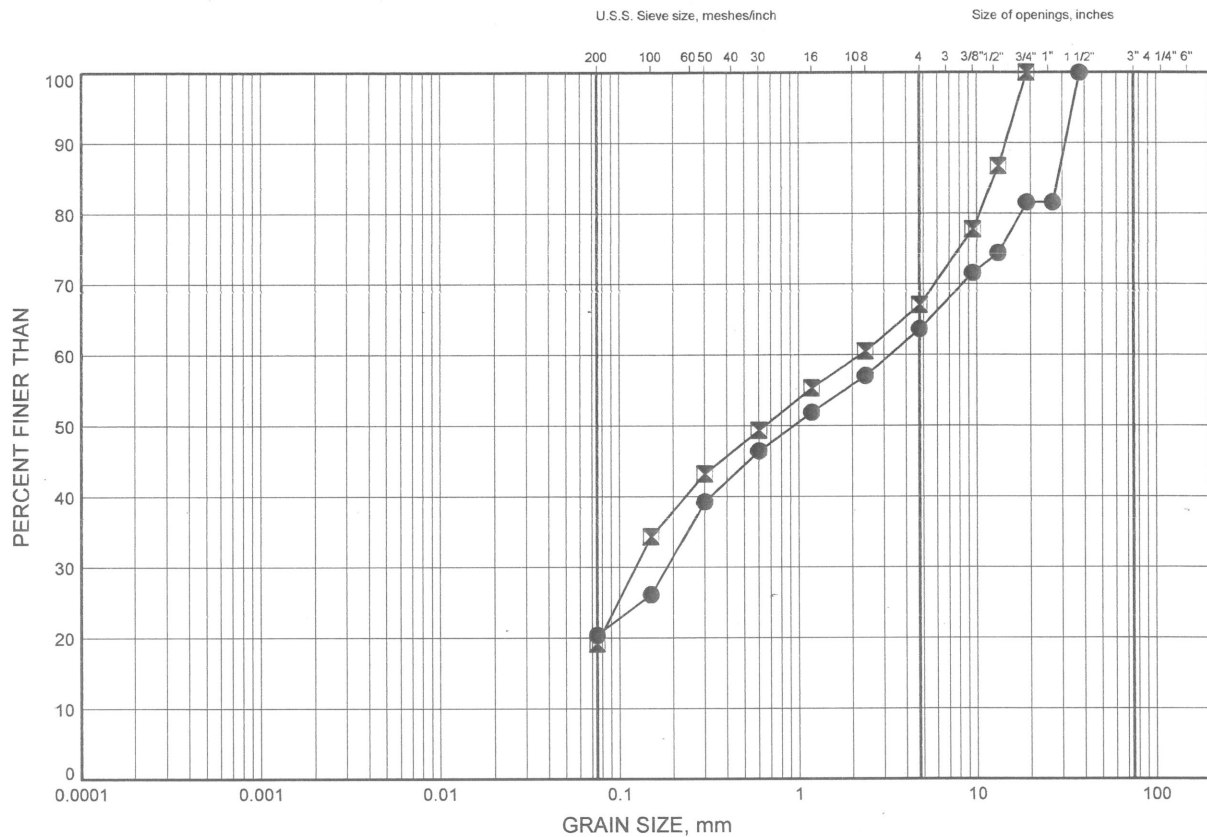


Prep'd AN
Chkd. RPR

Cypress River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND & GRAVEL



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

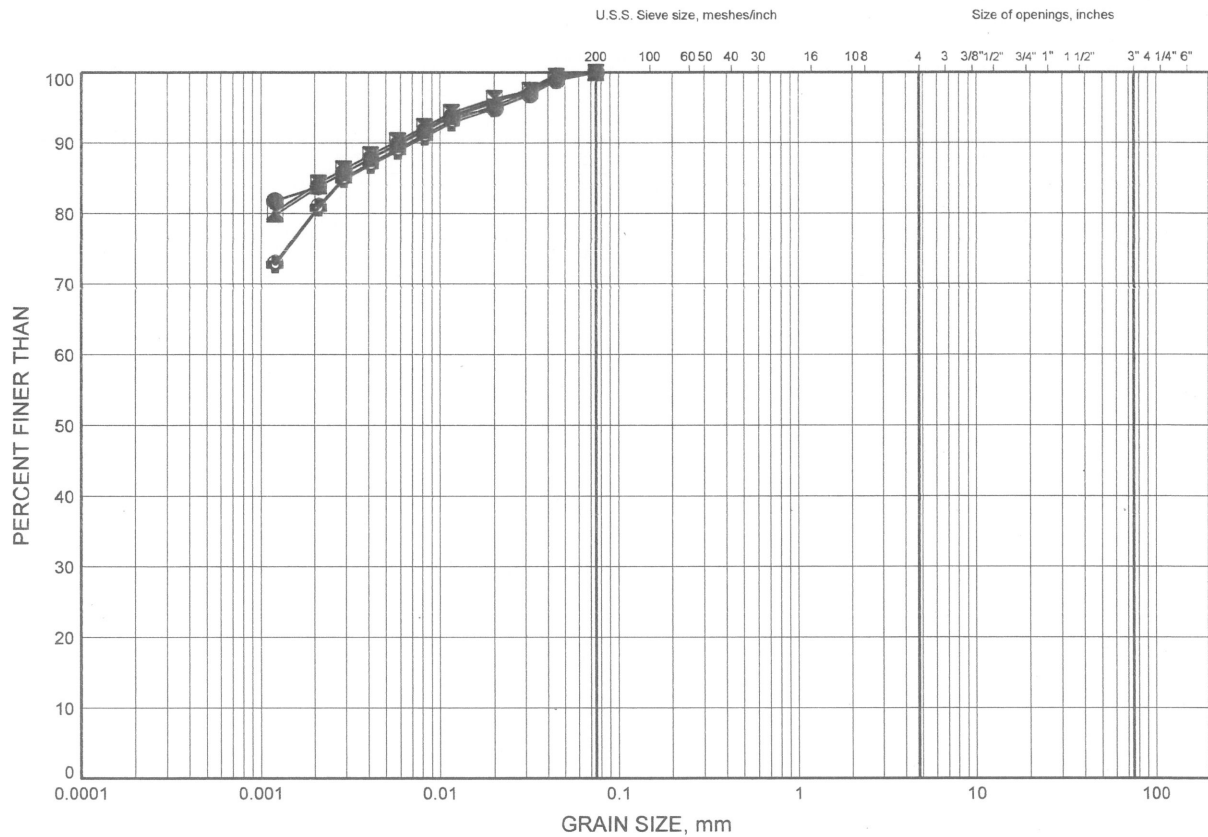
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-01	30.18	161.82
⊠	CYP-03	4.88	186.92

Cypress River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-01	8.84	183.16
⊠	CYP-01	13.41	178.59
▲	CYP-01	17.98	174.01
★	CYP-02	13.26	178.74
⊙	CYP-02	17.83	174.17
⊕	CYP-02	26.97	165.02

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 5/21/13

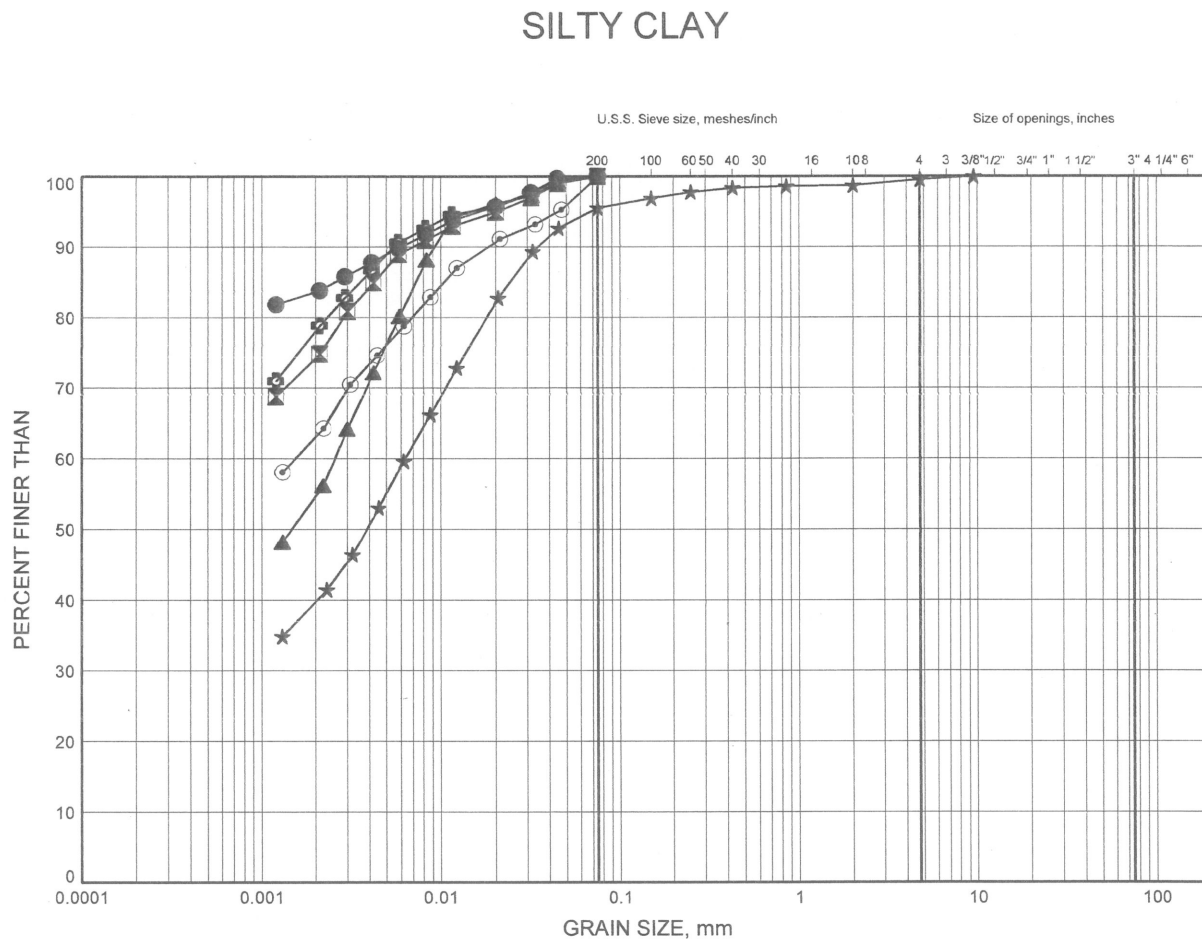
Date May 2013
W.P. 6069-09-00



Prep'd AN
Chkd. RPR

Cypress River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-03	11.28	180.52
⊠	CYP-03	16.46	175.34
▲	CYP-03	21.03	170.77
★	CYP-03	30.02	161.77
⊙	CYP-04	8.84	182.96
⊕	CYP-04	17.98	173.81

Date May 2013

W.P. 6069-09-00



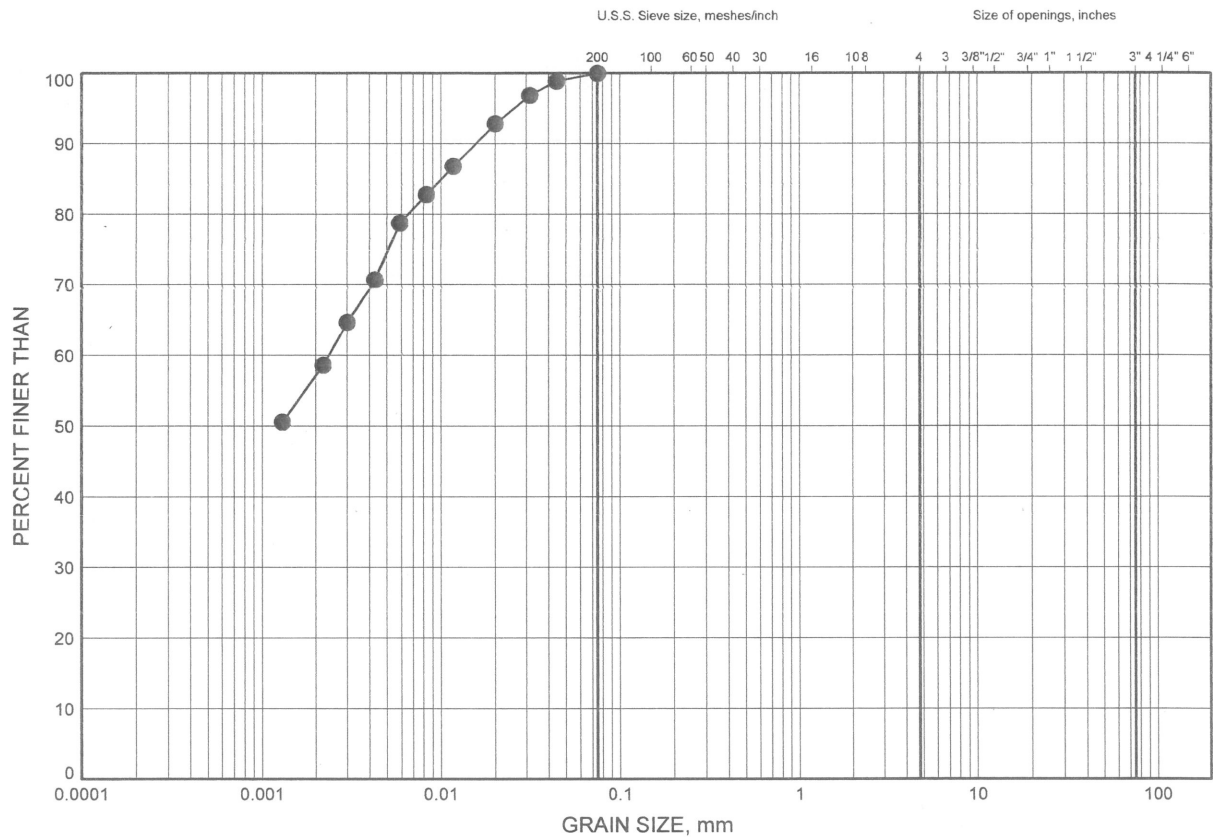
Prep'd AN

Chkd. RPR

Cypress River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-04	27.13	164.67

FIGURE B6

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-01	8.84	183.16
⊠	CYP-01	13.41	178.59
▲	CYP-01	17.98	174.01
★	CYP-02	13.26	178.74
⊙	CYP-02	17.83	174.17
⊕	CYP-02	26.97	165.02

THURBALT 1197.GPJ 5/21/13

Date May 2013
W.P. 6069-09-00

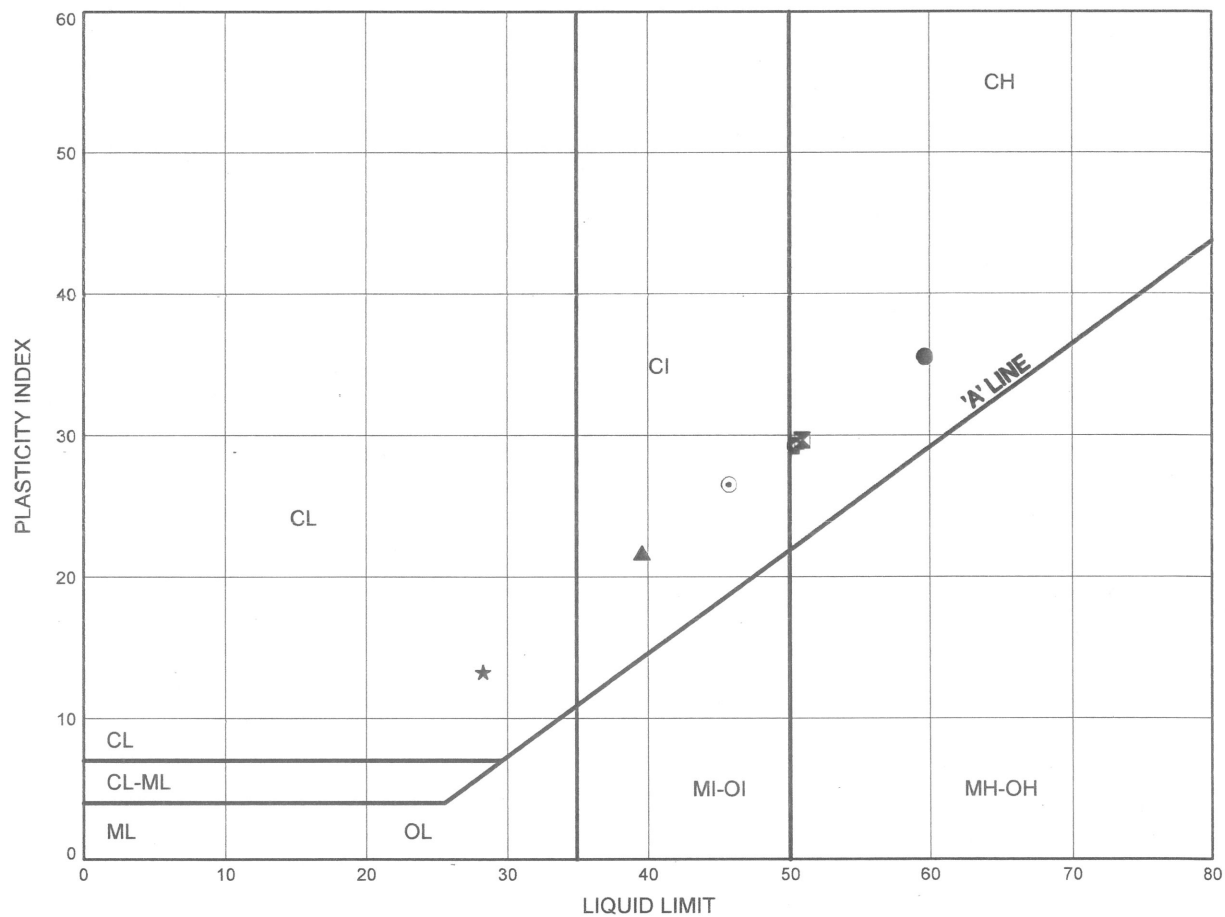


Prep'd AN
Chkd. RPR

Cypress River Bridge
ATTERBERG LIMITS TEST RESULTS

FIGURE B7

SILTY CLAY



LEGEND

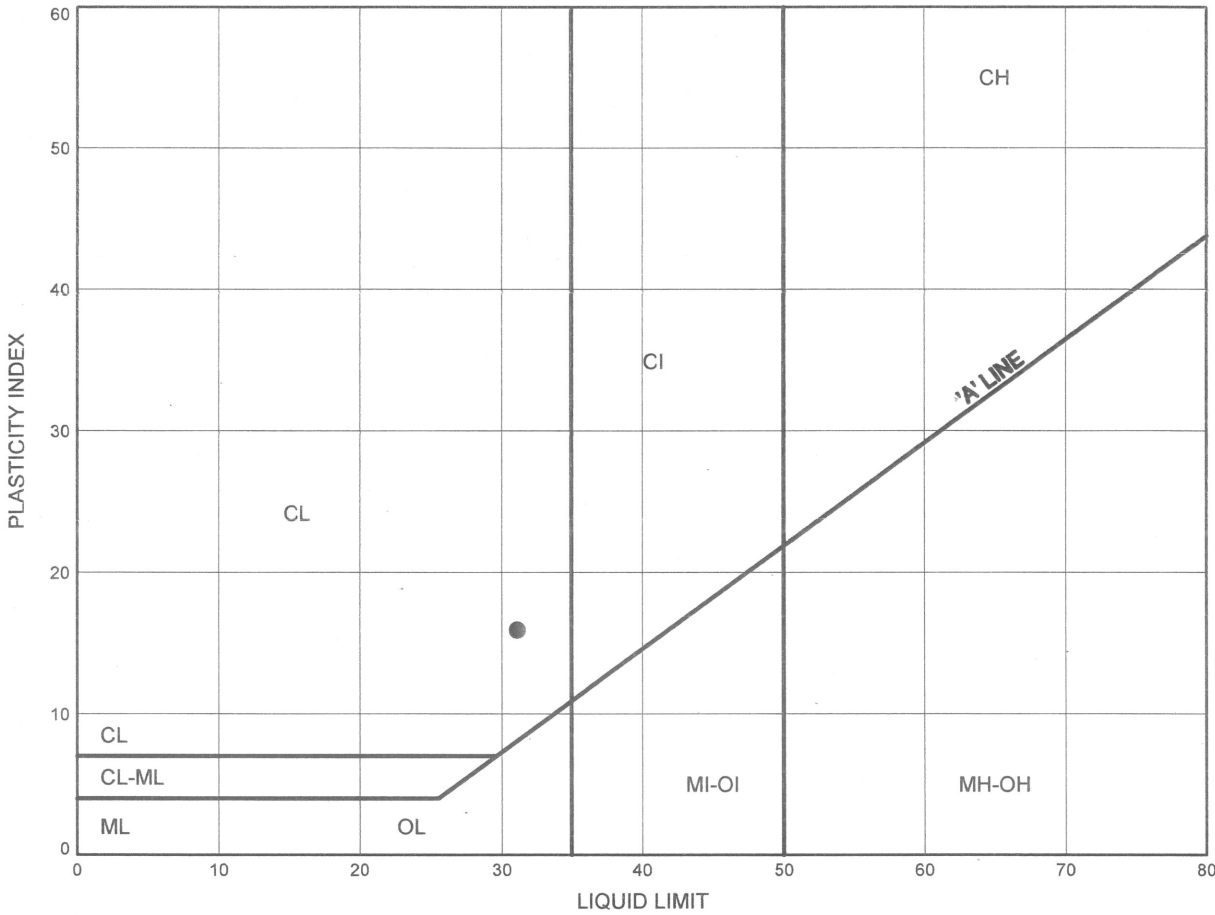
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-03	11.28	180.52
⊠	CYP-03	16.46	175.34
▲	CYP-03	21.03	170.77
★	CYP-03	30.02	161.77
⊙	CYP-04	8.84	182.96
⊕	CYP-04	17.98	173.81

Cypress River Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

SILTY CLAY



LEGEND

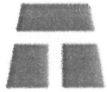
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CYP-04	27.13	164.67

THURBALT 1197.GPJ 5/21/13

Date May 2013
W.P. 6069-09-00



Prep'd AN
Chkd. RPR

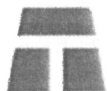


POINT LOAD TEST SHEET

Job No : 19-1351-197 Client : MRC
Date Drilled : October 27, 2011
Project Name : Cypress River Bridge Date Tested : November 29, 2011
Core Size : NQ BH No : CYP-03 Tester : DB

Test No.	Run No.	Depth (m)	Axial or Diametral	Force (kN)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	31.6	D	4.0	47.5	97.2	41.2	Sandstone/shale	Medium Strong
2	2	33.4	D	2.8	47.4	136.2	29.6	Sandstone/shale	Medium Strong
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have $0.7 \times D$ on either side of test point.



POINT LOAD TEST SHEET

Job No : 19-1351-197 Client : MRC
Date Drilled : October 27, 2011
Project Name : Cypress River Bridge Date Tested : November 29, 2011
Core Size : NQ BH No : CYP-02 Tester : DB

Test No.	Run No.	Depth (m)	Axial or Diametral	Force (kN)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	31.0	D	10.3	47.5	93.0	107.1	Sandstone/shale	Very Strong
2	1	31.4	D	6.3	47.5	79.7	65.5	Sandstone/shale	Strong
3	2	32.0	D	8.7	47.5	76.7	90.4	Sandstone/shale	Strong
4	2	32.5	D	10.6	47.5	88.8	110.3	Sandstone/shale	Very Strong
5	2	32.9	D	14.8	47.5	93.8	153.8	Sandstone/shale	Very Strong
6	3	33.5	D	6.8	47.5	82.4	70.7	Sandstone/shale	Strong
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

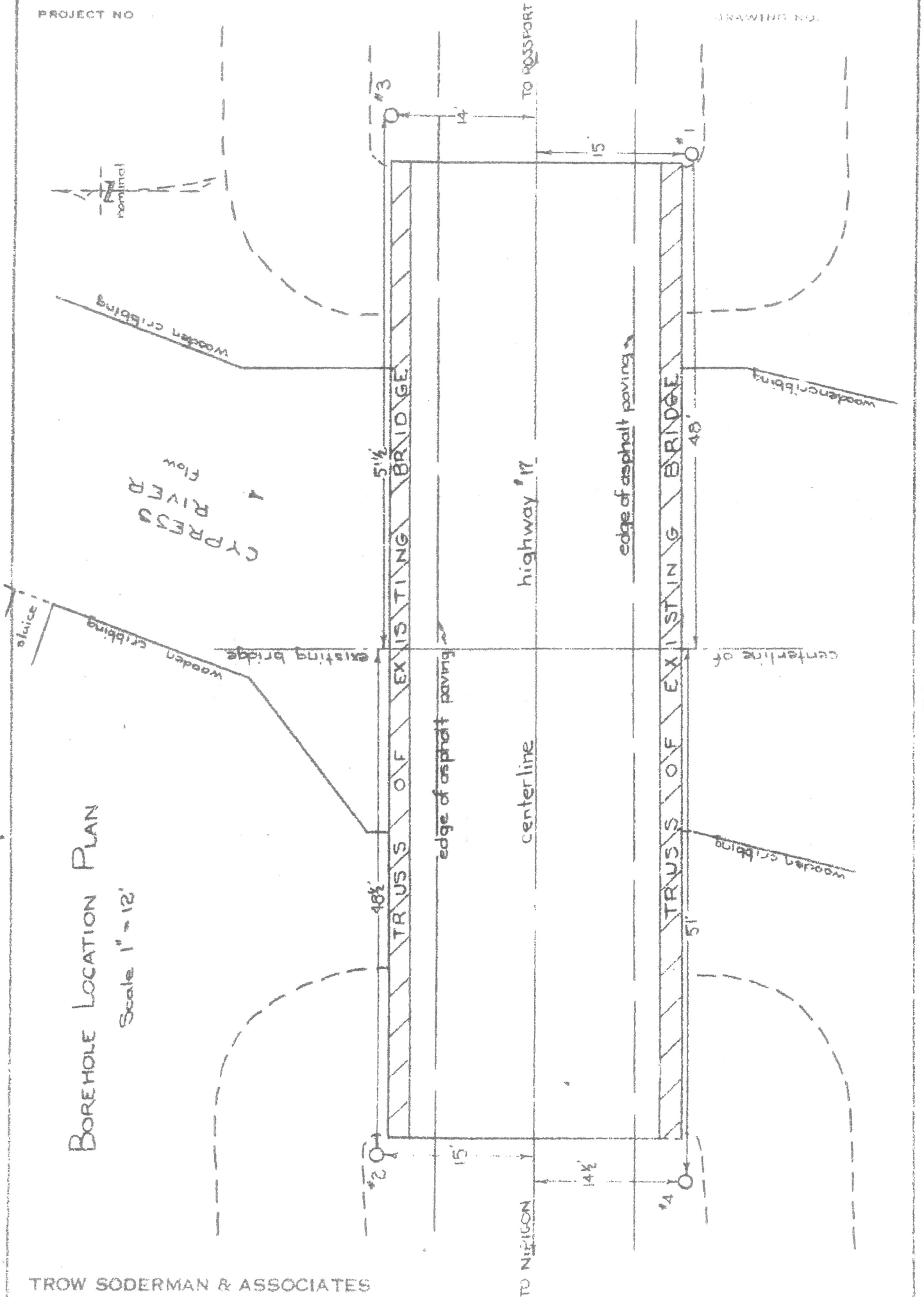
* Diametral Test should have $0.7 \times D$ on either side of test point.

Appendix C

Record of Borehole Sheets, Soil Profile and Laboratory Test Results From Previous Investigation

BOREHOLE LOCATION PLAN

Scale 1" = 12'



TROW SODERMAN AND ASSOCIATES

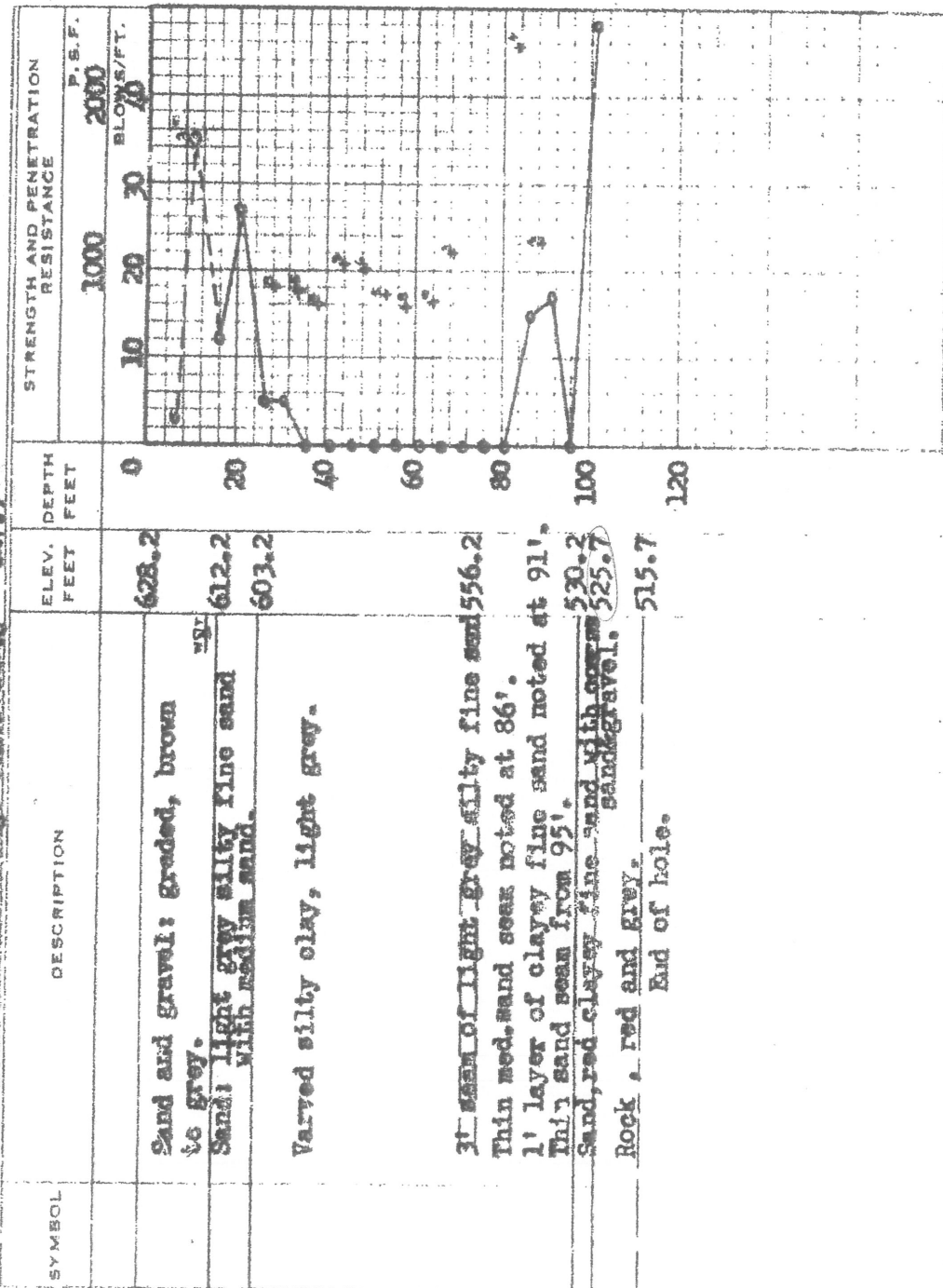
SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Cypress River Crossing T.C.H. No. 17
 LOCATION 24 miles east of Nipigon, Ont.
 HOLE LOCATION See dug. No. 1
 HOLE ELEVATION AND DATUM 628.2
 G.L. of bridge C.L. roadway = 627.9

BOREHOLE NO. 1
 FIELD SUPERVISOR D.S.
 DRILLER R.S.
 PREP. D.S.

LEGEND

2" DIA. SPLIT TUBE
 2" SHELBY TUBE
 2" SPLIT TUBE
 2" DIA. CONE
 CASING
 2" SHELBY
 1/2 UNCONFINED COMPRESSION (QU)
 VANE TEST (C) AND SENSITIVITY (S)
 NATURAL MOISTURE AND
 LIQUIDITY INDEX
 LIQUID LIMIT
 PLASTIC LIMIT



CONSISTENCY	SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.	SS1	
	SS2	
	SS3	
	SS4	
	SS5	
	SS6	
	SS7	
	SS8	
	SS9	
	SS10	
	SS11	
	SS12	
	SS13	
	SS14	
	SS15	
	SS16	
	SS17	
	SS18	
	SS19	
	SS20	

TROW SODERMAN AND ASSOCIATES

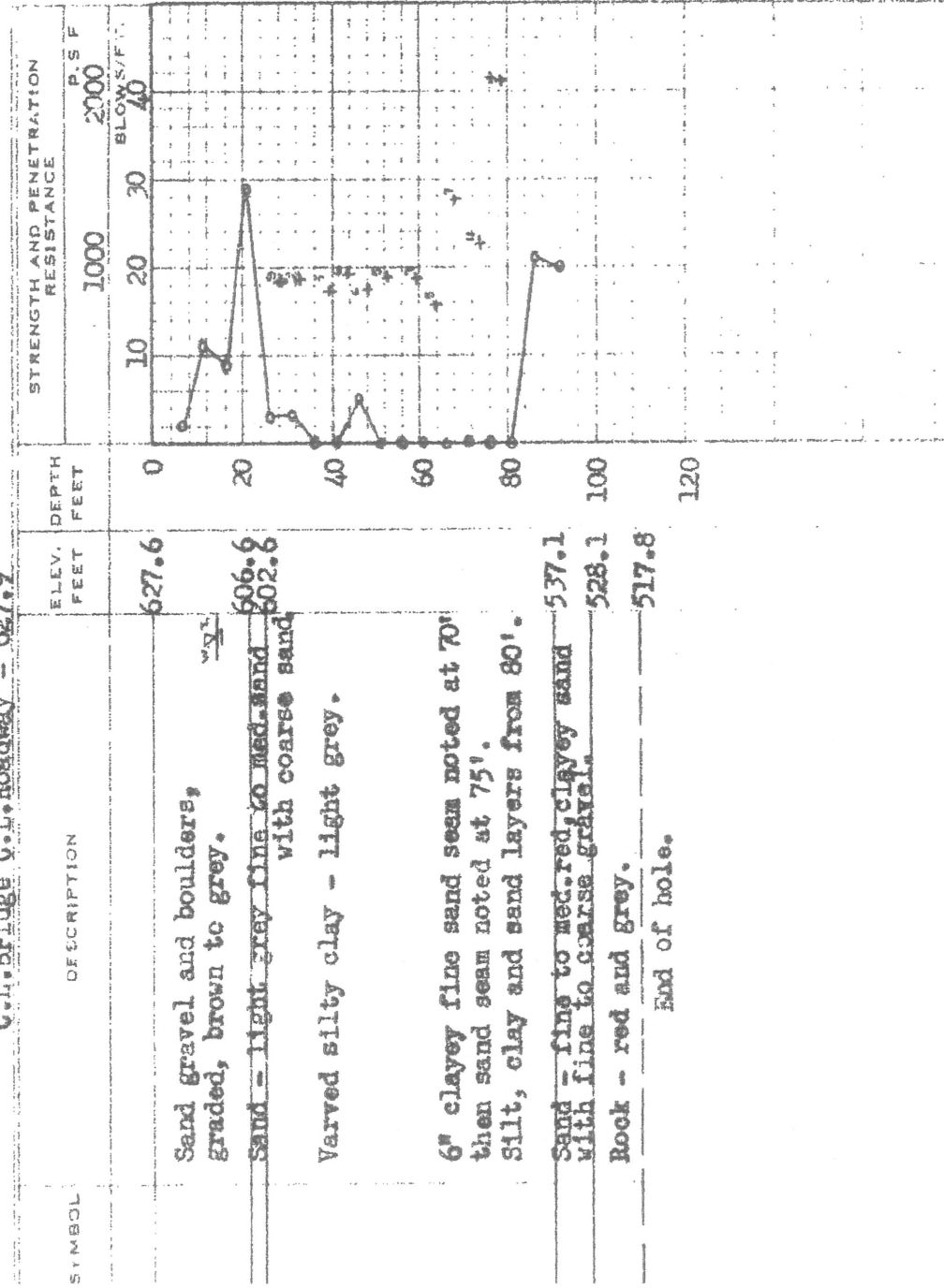
SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

LEGEND

- 1" DIA. SPLIT TUBE
2" DIA. SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONC.
CASING
3" SHELBY
1/2 UNCONFINED COMPRESSION (QU)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND
LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

PROJECT Cypress River Crossing T.C.H. No. 17
LOCATION 2 1/2 miles east of Nipigon, Ont.
HOLE LOCATION See dwg. No. 1
HOLE ELEVATION AND DATUM 627.6
C.L. Bridge G.L. Roadway = 627.9

BOREHOLE NO. 2
FIELD SUPERVISOR D.S.
DRILLER R.J.
PREP. D.S.



CONSISTENCY	SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.	281	
	282	
	283	
	284	
	285	
	286	
	287	
	288	
	289	
	290	
	291	
	292	
	293	
	294	
	295	
	296	
	297	
	298	
	299	
	300	

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

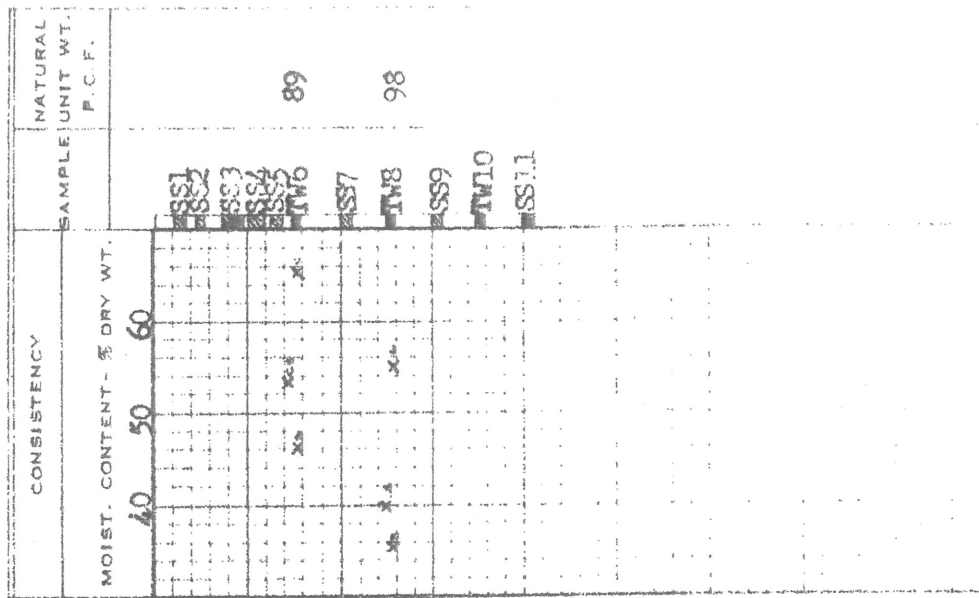
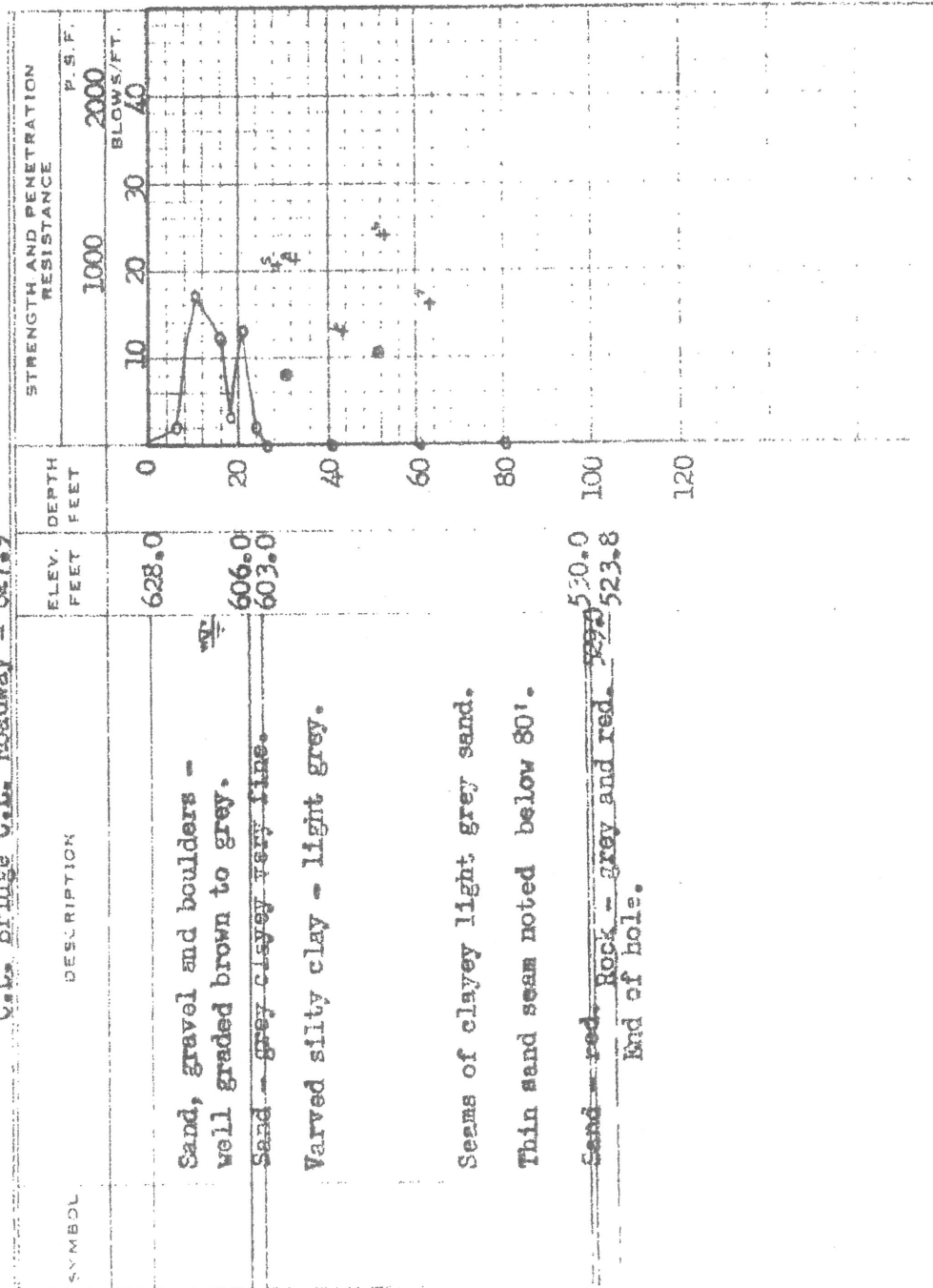
LEGEND

- 2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
CASING
2" SHELBY

PROJECT Cypress River Crossing T.C.R. No. 17
LOCATION 24 miles east of Nipigon, Ont.
HOLE LOCATION See dwg. No. 1
HOLE ELEVATION AND DATUM 628.0
C.L. Bridge C.L. Roadway = 627.9

BOREHOLE NO. 3
FIELD SUPERVISOR D.S.
DRILLER E.S.
PREP. D.S.

1/2 UNCONFINED COMPRESSION (Qu)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND
LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT



Natural Moisture: Ics - total sample
Xc - clay portion
Xs - silt portion

PROJECT NO.

J260

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Cypress River Crossing T.C.H. No. 17

LOCATION 24 miles east of Nipigon, Ont.

HOLE LOCATION See dwg. No. 1

HOLE ELEVATION AND DATUM 627.9

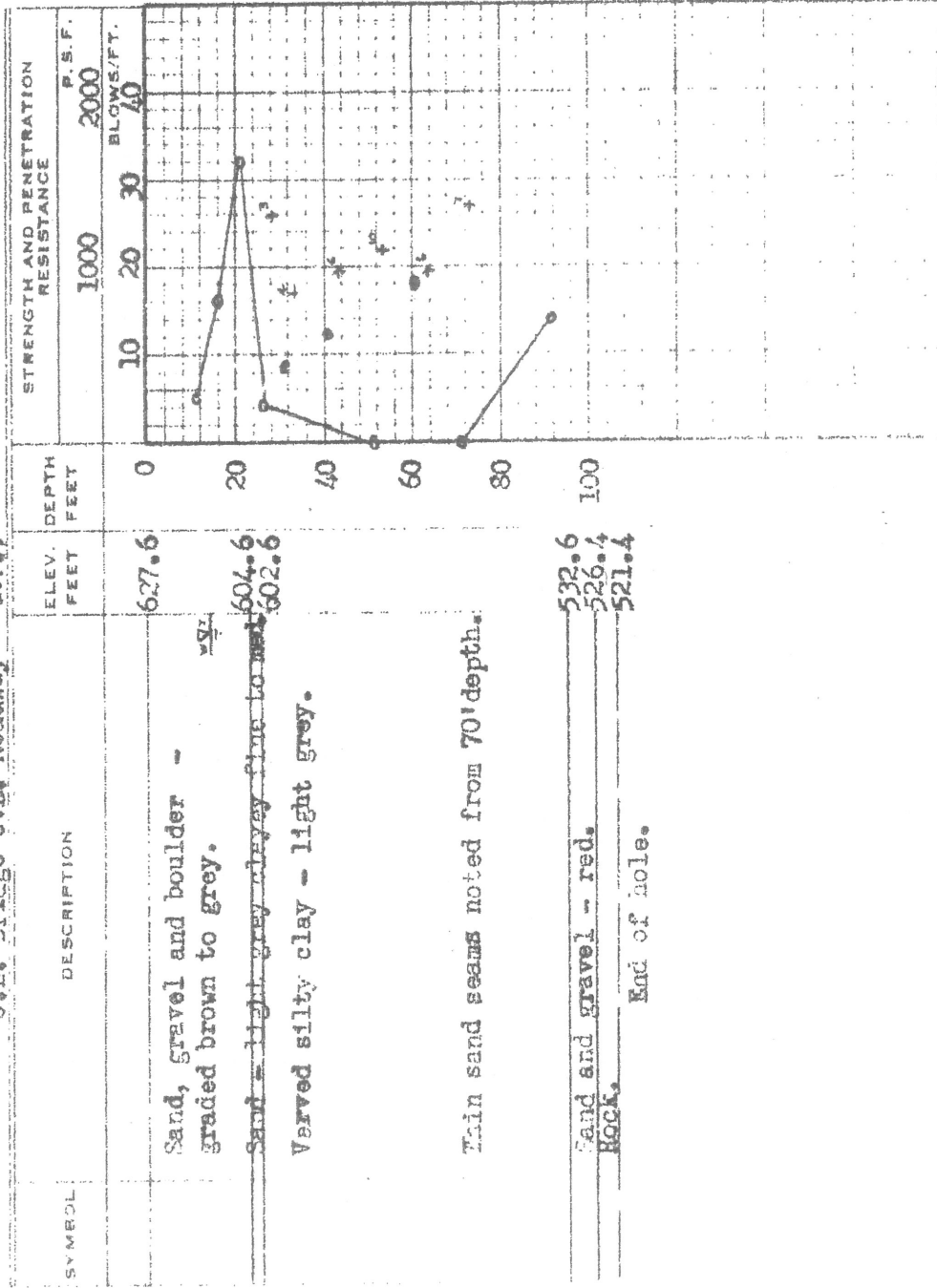
C.L. Bridge C.L. Roadway = 627.9

BOREHOLE NO. 4

FIELD SUPERVISOR D.S.

DRILLER H.J.

PREP. D.S.



DRAWING NO.

5

LEGEND

2" DIA. SPLIT TUBE

2" SHELBY TUBE

2" SPLIT TUBE

2" DIA. CONE

CASING

2" SHELBY

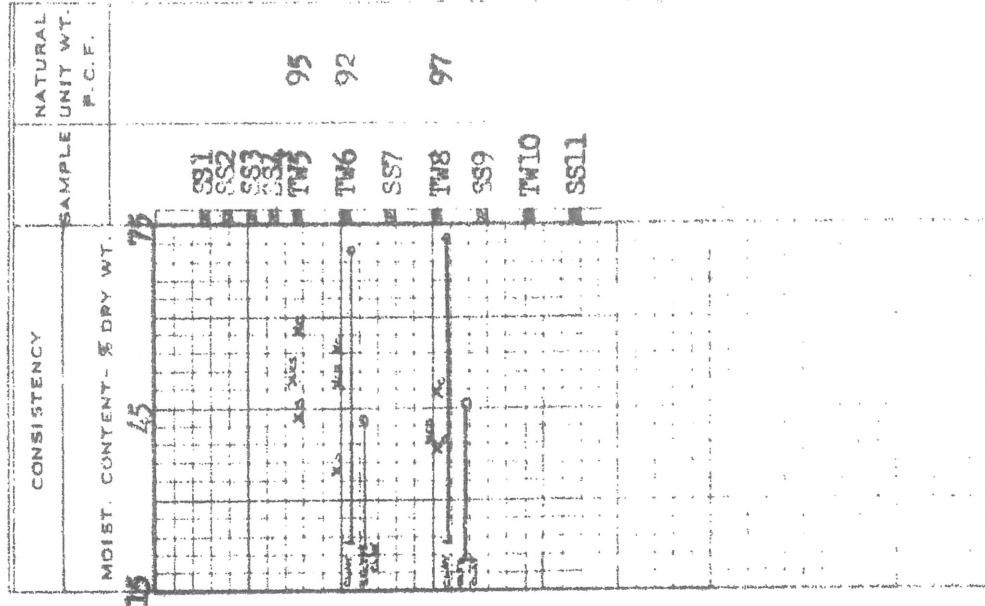
1/2 UNCONFINED COMPRESSION (QU)

VANE TEST (C) AND SENSITIVITY (S)

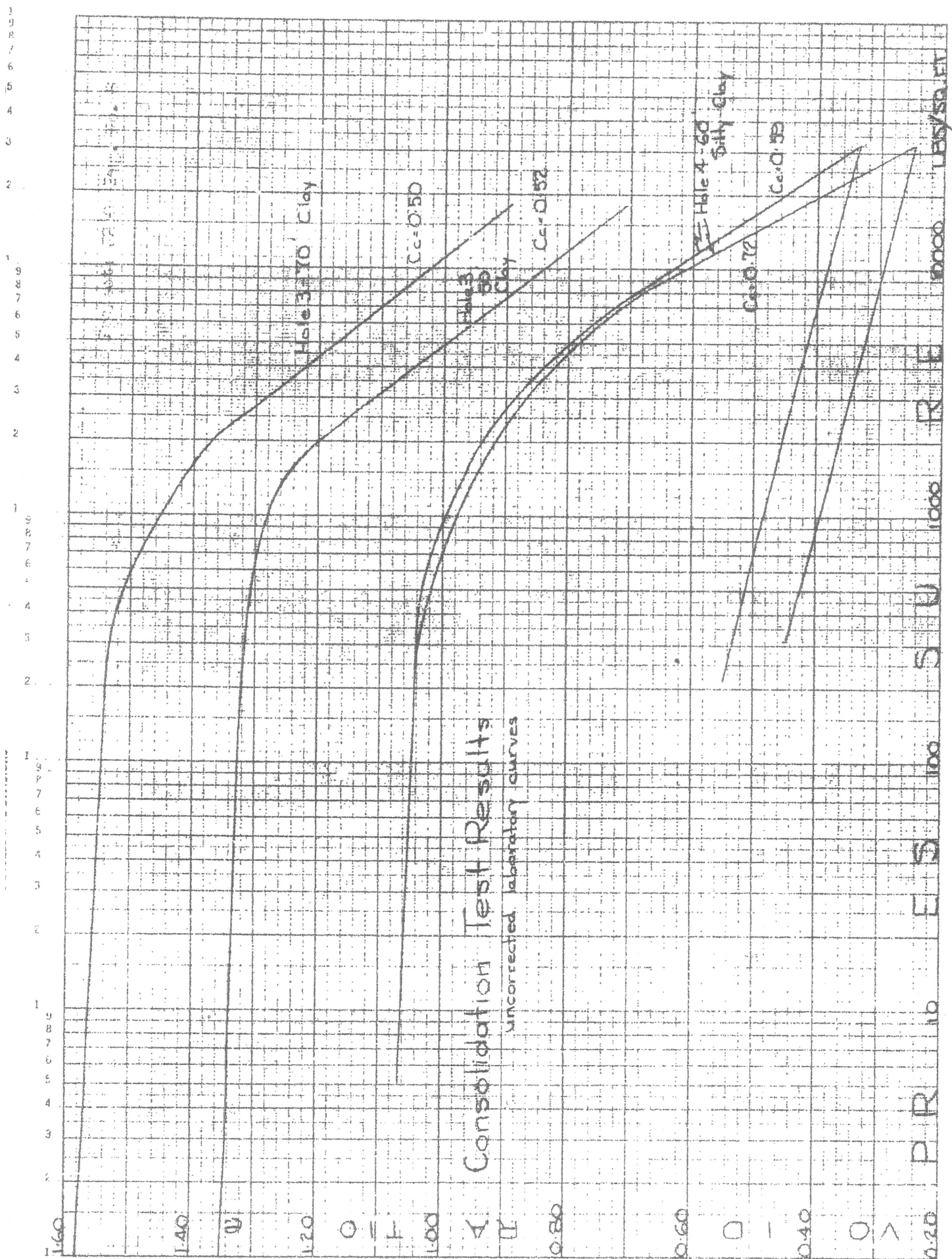
NATURAL MOISTURE AND LIQUIDITY INDEX

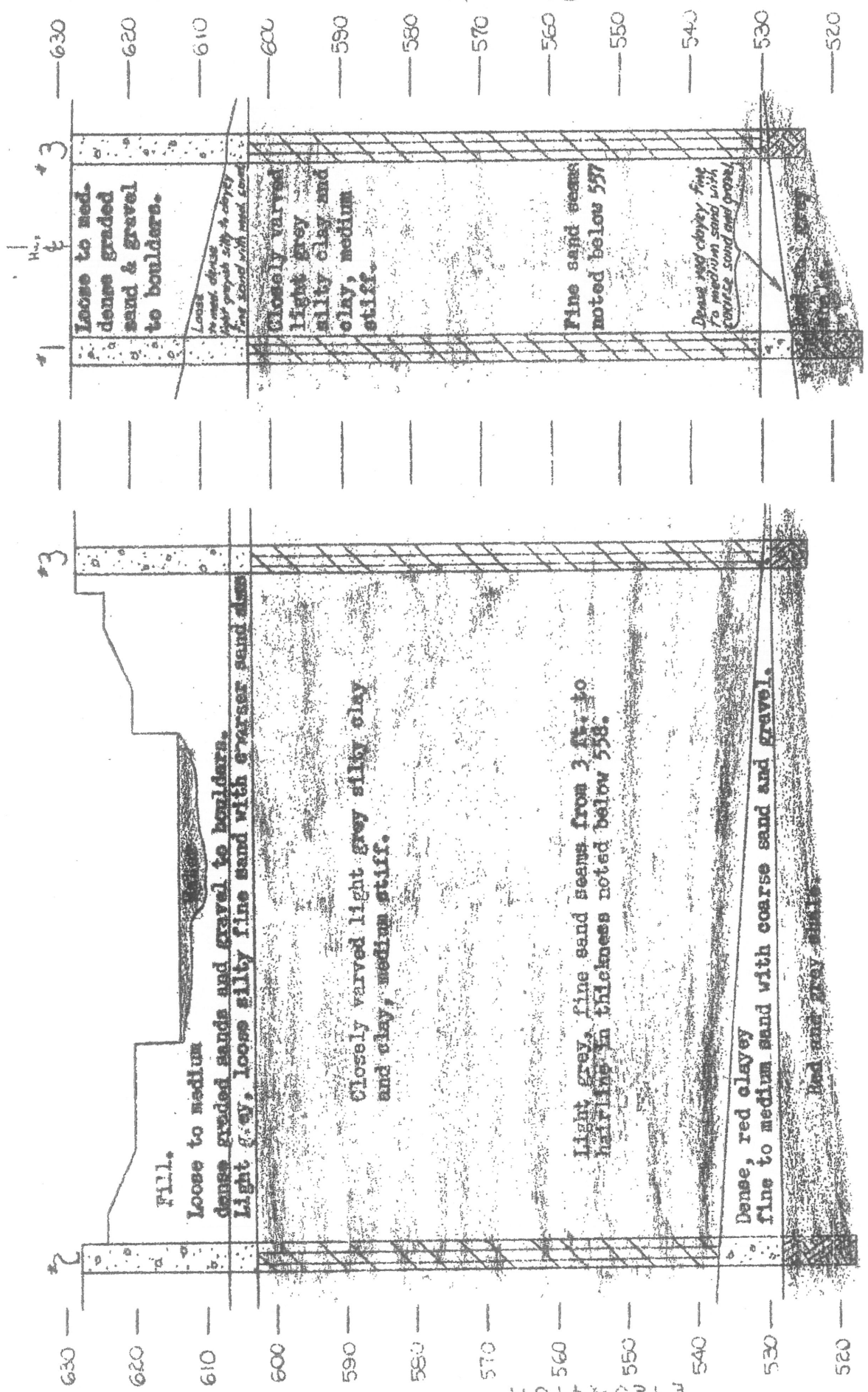
LIQUID LIMIT

PLASTIC LIMIT

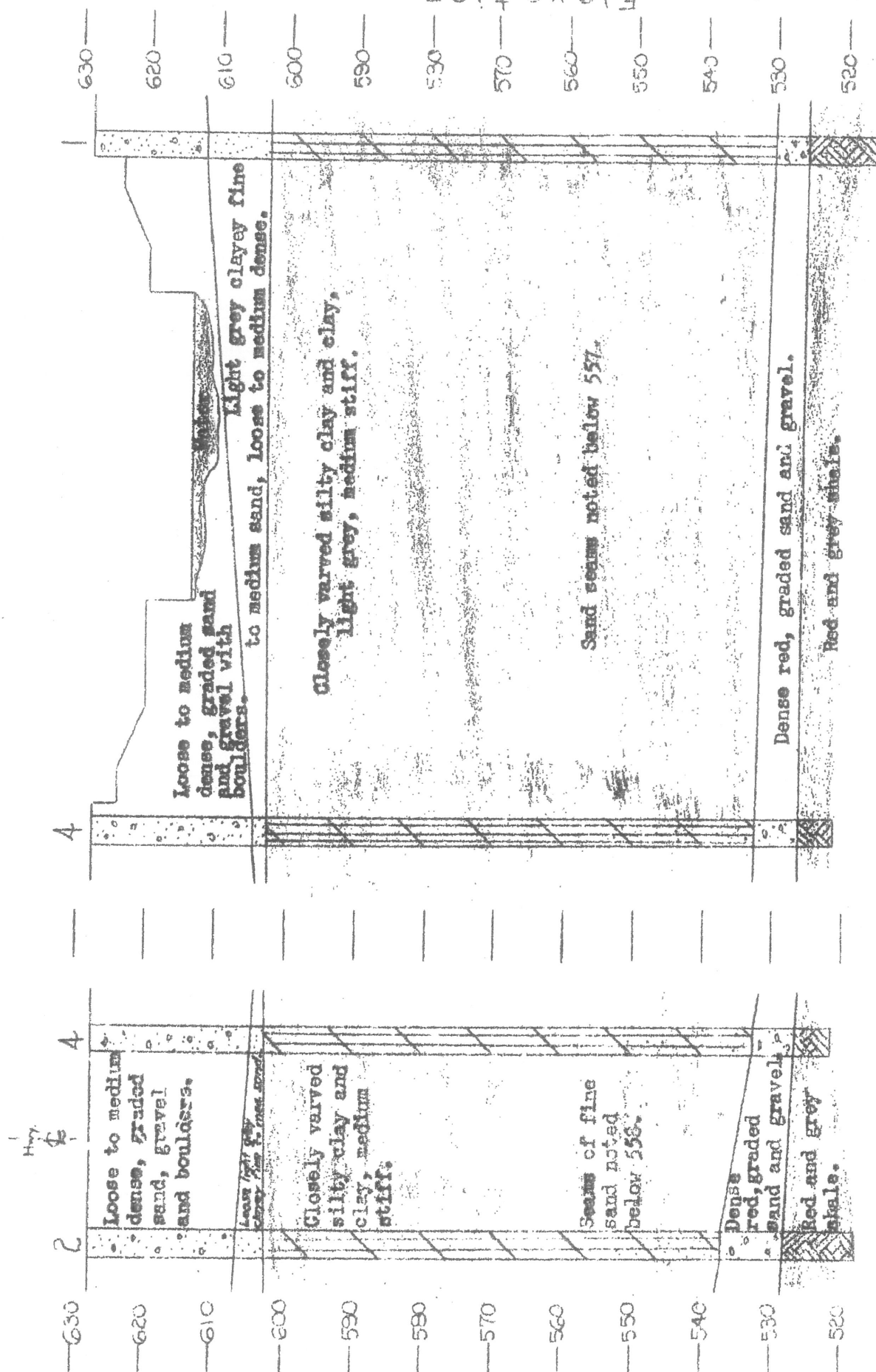


Natural Moisture: Xes - total sample
Xc - clay portion
Xs - silt portion





PROJECTED SOIL PROFILES
SCALE 1"=20'



Appendix D

Site Photographs



Photograph 1 – Highway 17 at Cypress River Bridge looking west



Photograph 2 – Highway 17 at Cypress River Bridge looking east



Photograph 3 – South side of Cypress River Bridge



Photograph 4 – Railway Bridge immediately south of Cypress River Bridge



Photograph 5 – Looking north from Cypress River Bridge

Appendix E

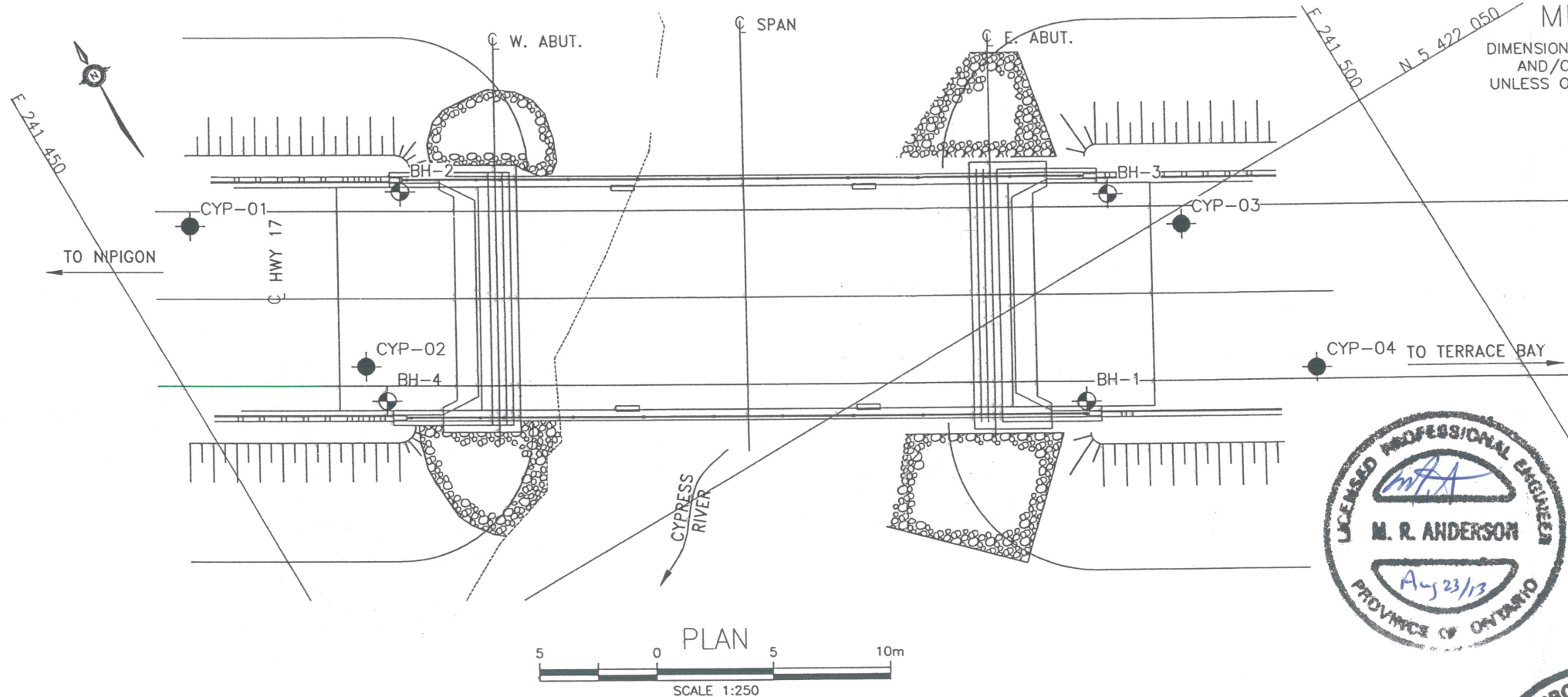
List of SPs and OPSS, and Suggested Text for Selected NSSPs

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

- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 101
- OPSD 3101.150
- Special Provision 110S13 “Amendment to OPSS 1010, April 2004”.

Appendix F

Drawing titled “Borehole Locations and Soil Strata”



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

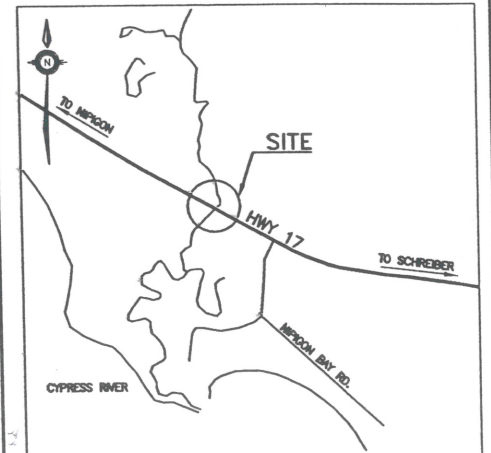
CONT No
WP No 6069-09-01

HIGHWAY 17
CYPRESS RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
S02

MRC
McCORMICK RANKIN
A member of MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN
LEGEND

- ◆ Borehole (Current Investigation)
- ◊ Borehole (Previous Investigation, 1958)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level During Drilling
- W Water Level In Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

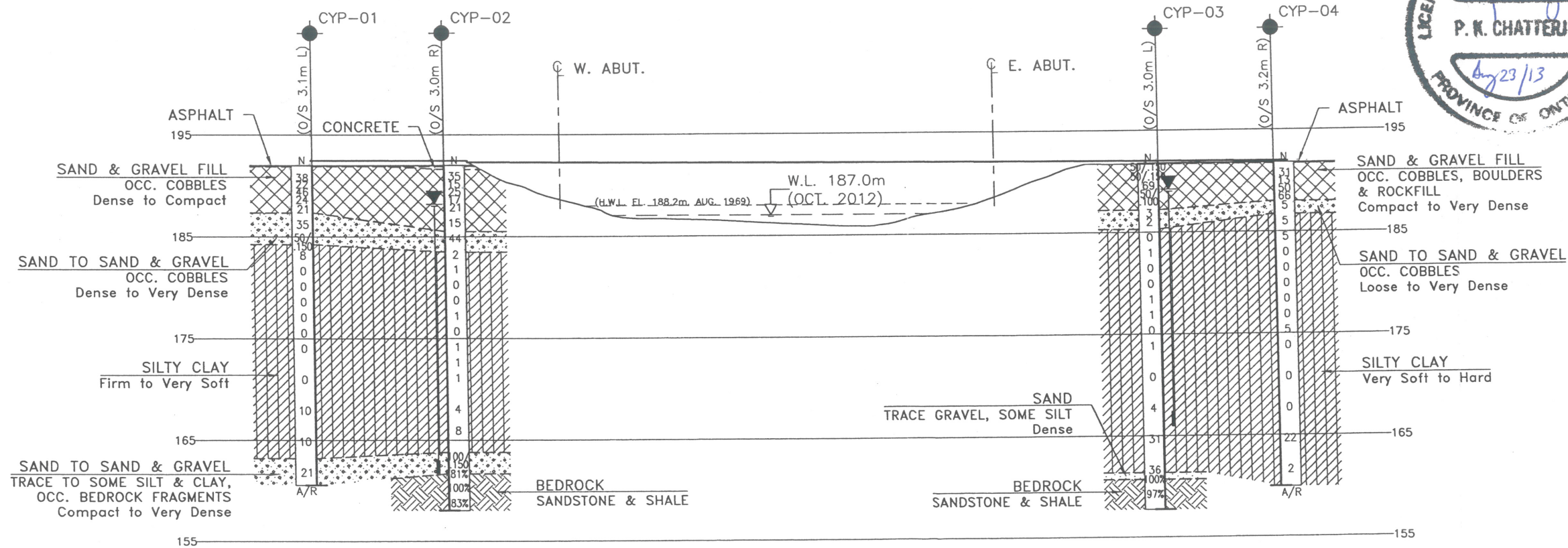
NO	ELEVATION	NORTHING	EASTING
CYP-01	192.0	5 422 071.0	241 453.8
CYP-02	192.0	5 422 062.0	241 457.2
CYP-03	191.8	5 422 049.4	241 490.7
CYP-04	191.8	5 422 041.8	241 492.4
BH-1	191.4	5 422 045.0	241 483.2
BH-2	191.4	5 422 067.7	241 462.4
BH-3	191.4	5 422 052.1	241 488.6
BH-4	191.4	5 422 060.3	241 457.3

-NOTES-

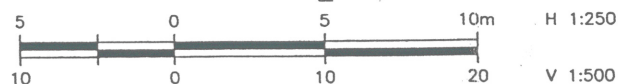
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCREs No. 42E-15

DATE	BY	DESCRIPTION
DESIGN	RPR	CHK RPR
DRAWN	AN	CHK
SITE	48C-16	STRUCT
DWG	2	



PROFILE ALONG C HWY 17



H 1:250

V 1:500