

DETAIL
FOUNDATION INVESTIGATION AND DESIGN REPORT
RAPID RIVER BRIDGE REPLACEMENT
HIGHWAY 129, DISTRICT OF ALGOMA
G.W.P.5321-04-00, W.P. 14-74-07, SITE: 38S-013

Geocres Number: 41J-74

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 the proposed replacement bridge to carry Highway 129 over the Rapid River in Algoma, Ontario.

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, stratigraphic profile and cross-sections, 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.

A Preliminary Foundation Investigation was completed by Thurber in the spring of 2007. The factual information obtained in the course of that investigation has been combined with that obtained in the course of the current investigation.

Dominion Soil Investigation Inc. reported a previous investigation in 1977 for a crossing of the Rapid River on an alignment that lay further east than the alignment investigated in the current assignment. The factual data from that investigation is included in Appendix C but it has not been used directly in the analysis or preparation of recommendations contained in this report.

Thurber carried out the investigation as a sub-consultant to Marshall Macklin Monaghan, under the Ministry of Transportation Ontario (MTO) Agreement Number 5005-E-0042.

2 SITE DESCRIPTION

The Rapid River is an east to west flowing tributary of the Mississagi River and it crosses Highway 129 approximately 49 km north of the junction with Highway 554 and approximately 100 m upstream from the confluence with the Mississagi. The Mississagi River runs from north to south. At the site the river is approximately 10 m wide and 1 m deep and is fast flowing in a boulder strewn channel. The river level was recorded as Elevation 317.8 in June 1996 and as Elevation 318.3 in October 2006.

Approximately 250 m south of the bridge site, and again 300 m north, Highway 129 lies close to the top of the east bank of the Mississagi River. The ground rises relatively steeply to the east of the highway.

At 95 m north of the bridge, Lumber Lost Road runs west off Highway 129 and crosses the Mississagi River.

The banks of the rivers are boulder strewn and an exposure immediately north of the bridge reveals a sand and gravel soil containing numerous cobbles and boulders.

Immediately west of the existing bridge are the remnants of two abutments and roadbed from an earlier crossing of the river.

There is no development in the immediate vicinity of the bridge.

Photographs of the site are included in Appendix E and show the existing bridge, the approaches and the soil exposure north of the bridge site.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field-testing for detail design of this project was carried out between September 7 and September 11, 2007. At the structure, four sampled boreholes were drilled to supplement those drilled during the preliminary investigation during the period January 24 to February 17, 2007. The new boreholes were number 07-RR15 through 07-RR18 and ranged in depth from 4.7 to 12.6 m

Six foundation boreholes (numbered 07-RR1 to 07-RR6) that were drilled on three alternative alignments during the preliminary investigation. The depths of these boreholes ranged from 10.7 m to 12.4 m. All six boreholes have been included for reference, though BH 07-RR5 and BH 07-RR6 are the most relevant to the foundations on the selected alignment.

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

In addition to the ten boreholes drilled at the abutment locations and immediate approaches, a total of eight sampled boreholes were drilled at locations within the project limits to investigate soil conditions affecting embankment realignment. These boreholes are numbered 07-RR7 through 07-RR14. The depths of these boreholes ranged from 0.8 to 3.1 m.

The Record of Borehole sheets for all the boreholes are included in Appendix A and the locations of the boreholes have been plotted on the Borehole Location and Soil Strata drawing.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area.

A combination of hollow-stem auger drilling and diamond coring 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. At each abutment one or more standpipe piezometers consisting of 19 mm PVC pipe with a slotted screen were installed and enclosed in filter sand to permit longer term groundwater level monitoring. The locations and completion details of the piezometers are shown in Table 3.1. Boreholes without piezometer installations were grouted with bentonite upon completion. The borehole completion details are shown in Table 3.1. Along the embankment alignment, boreholes less than 3 m deep were backfilled with drill cuttings.

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

Table 3.1 – Borehole Completion Details

Borehole Location	Piezometer Tip Depth/ Elevation (m)	Completion Details
07-RR1 South Abutment	10.5/310.0	Piezometer with 1.5 m slotted screen installed with sand filter to 8.3 m, bentonite seal from 8.3 m to ground surface.
07-RR2 North Abutment	11.0/309.3	Piezometer with 1.5 m slotted screen installed with sand filter to 9.1 m, bentonite seal from 9.1 m to ground surface.
07-RR3 South Abutment	No Installation	Bentonite grout to ground surface.
07-RR4 North Abutment	No Installation	Bentonite grout to ground surface.
07-RR5 South Abutment	10.7/309.9	Piezometer with 1.5 m slotted screen installed with sand filter to 8.3 m, bentonite seal from 8.3 m to ground surface.
07-RR6 North Abutment	4.6/315.7	Piezometer with 1.5 m slotted screen installed with sand filter to 2.7 m, bentonite seal from 2.7 m to ground surface.
07-RR15 South Abutment	12.3/307.6	Piezometer with 1.5 m slotted screen installed at 12.3 m with sand filter to 9.8 m, bentonite seal to 8.7 m, grout to 0.2 m and gravel to ground surface.
07-RR16 North Abutment	12.2/308.9	Piezometer with 1.5 m slotted screen installed at 12.2 m with sand filter to 9.8 m, bentonite seal to 9.5 m, grout to ground surface.
07-RR17 South Abutment	No Installation	Bentonite grout to ground surface.
07-RR18 North Abutment	No Installation	Bentonite grout 300 mm, sand and gravel to ground surface.

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 in Appendix A. Selected samples were also subjected to gradation analysis and 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.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy along the alternate alignments are presented in this appendix 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.

The description presented below relates to the selected alignment and is based on the boreholes specifically drilled on that alignment.

In general, the site is underlain by granular fill overlying cohesionless deposits of sand and gravel with cobbles and boulders.

5.1 Topsoil

Topsoil was encountered at the south abutment location and south approach (RR5, RR15 and RR17) ranging from 50 mm to 200 mm in thickness. Topsoil was also encountered at the north approach (RR18) in a thickness of 150 mm. Topsoil was not encountered at the road alignment boreholes (RR7 to RR14).

5.2 Fill

Sand and gravel fill was encountered at the north abutment in thickness ranging from 1.4 to 2.4 m and the underside of the fill layer was recorded at elevations between 317.9 m and 319.7 m.

‘N’ values ranging from 26 to greater than 100, derived from Standard Penetration Tests conducted in the sand and gravel fill, indicate a compact to very dense relative density. In some cases, the high SPT values may reflect the presence of cobbles or boulders.

Moisture content ranged from approximately 8 to 19 %.

The results of laboratory tests carried out on four samples were as follows:

Gravel (%)	0 to 37
Sand (%)	53 to 70
Silt and Clay (%)	10 to 43

The grain size distribution curves for the samples tested are shown in Figure B1 in Appendix B.

Fill was encountered in all alignment boreholes except for RR9 and RR12. Thicknesses vary from 0.3 m to 2.1 m. Borehole RR10 terminated in this layer at Elevation 317.9. The fill material predominantly consisted of layers of sand and sand and gravel that exhibited

compact to very dense relative density. Silty clay and silty sand fill was encountered from 0 to 1.5 m in RR7, the underside of the fill layer was recorded at elevation 316.0.

5.3 Peat

A layer of amorphous peat was encountered in alignment borehole RR9 from ground level to termination of the borehole on auger refusal at 0.8 m. Moisture content of 109 % was recorded. The extent of peat was not established.

5.4 Sand and Gravel

Sand and gravel with cobbles and boulders was encountered at both the north and south abutment locations and at the north and south approaches. At the south approach and one borehole at the south abutment, a layer of hard, silty, organic (peaty) clay is interbedded in the sand and gravel.

The overall thickness of sand and gravel recorded on the preferred alignment ranged from 2.2 m at the north abutment to 12.3 m at the south abutment. The elevations of the base of the layer ranged from 315.7 to 311.3, where it was fully penetrated.

SPT 'N' values generally between 38 and greater than 100 were recorded in this stratum, indicating dense to very dense relative density. Occasional lower SPT values were recorded, typically in the fill, but are not considered to influence the design. In some cases, the high SPT values may reflect the presence of cobbles or boulders.

The results of laboratory tests carried out on eighteen samples were as follows:

Gravel (%)	7 to 54
Sand (%)	36 to 87
Silt (%)	1 to 29

The grain size distribution curves for the samples tested are shown in Figures B2 to B4 in Appendix B.

The natural moisture content ranged from 5 to 40%.

The alignment boreholes encountered layers of sand and sand and gravel that predominantly exhibited compact to very dense relative density.

5.5 Clay mixed with Sandy Silt and Peat

At the east side of the south abutment and in the south approach, Boreholes 07-RR15 encountered a 1.5 m thick layer of hard, silty clay mixed with and interbedded with peat. At the south approach, Borehole 07-RR17 penetrated 2.3 m into this soil and was terminated in this layer.

The deposit contains layers of hard, amorphous peat and rootlets and is black in colour.

SPT values greater than 100 blows for 0.3 m of penetration indicate that the clay is hard.

The results of laboratory tests carried out on two samples were as follows:

Gravel (%)	0 to 4
Sand (%)	2 to 38
Silt (%)	29
Clay (%)	29 to 69

The grain size distribution curves for the samples tested are shown in Figure B5 in Appendix B.

5.6 Sand

A layer of sand was encountered below the sand and gravel layer at the north and south abutments and at the north approach. The thickness of the sand layer proved in the boreholes ranged from at least 1.5 to greater than 6.3 m. Based on SPT values ranging from 29 to greater than 100 blows for 0.3 m of penetration, the deposit is described as compact to very dense. The sand is very dense below Elevation 314 in all boreholes.

The results of laboratory tests carried out on four samples were as follows:

Gravel (%)	1 to 15
Sand (%)	49 to 97
Silt (%)	2 to 32
Clay (%)	0 to 17

The grain size distribution curves for the samples tested are shown in Figure B6 in Appendix B.

Moisture content ranged from 15 to 26 %.

5.7 Groundwater Conditions

Standpipe piezometers were installed in selected boreholes and water levels were measured after completion of drilling, prior to demobilization from the site and again on September 12, 2007. The water level readings are presented in Table 5.2.

The data collected indicates that the groundwater level was stabilizing close to Elevation 314.7. This elevation is below the level of the Rapid River, recorded at Elevation 317.8 in October 2006. This is an unexpected result and may indicate under-drainage of the site, controlled by the lower level of the Mississagi River, which lies at approximately Elevation 314.2 at the confluence with the Rapid River.

Due to the proximity of the river, local groundwater levels must be assumed to be at the river level for design and construction.

Based on these observations, local groundwater levels exist at Elevations 317.1 m to 314.7 m. All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.

6 MISCELLANEOUS

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

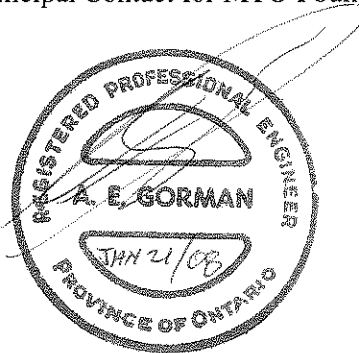
The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger and Mr. George Azzopardi of Thurber.

The coordinates for the boreholes and the ground surface elevations were provided by Marshall Macklin Monaghan.

Mr. Alastair E. Gorman, P.Eng. directed the field operations and prepared the Foundation Investigation Report.

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

Thurber Engineering Ltd.



Alastair E. Gorman, P.Eng.,
Senior Foundations Engineer



Report Reviewed by:
P.K. Chatterji, P.Eng.,
Review Principal, Designated MTO Contact

Table 5.2: Water Level Measurements at Bridge Abutments

Date	BH 07-RR1		BH 07-RR2		BH 07-RR5		BH 07-RR6		BH 07-RR15		BH 07-RR16	
	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.
07-01-31							1.5	318.8				
07-02-01			4.9	315.5								
07-02-03			4.9	315.5			Dry					
07-02-05	1.7	318.8										
07-02-07			5.0	315.4			Dry					
07-02-14			5.3	315.1			2.6	317.7				
07-02-28	3.7	316.8			3.7	316.9						
07-03-14	4.6	315.9	Blocked		3.7	316.9	Blocked					
07-09-08	5.7	314.8			3.4	317.2						
07-09-12	5.8	314.7			3.5	317.1			3.8	316.1	1.9	319.2

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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 the new permanent structure.

It is understood that Highway 129 will cross the Rapid River on a single span structure that will lie on a new alignment immediately east of the existing.

It is anticipated that the grade of the highway as it crosses the new structure will be in the range of Elevation 322.8 to Elevation 323.0. The resulting approach embankments will be 2 to 3 m above the original ground level.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of this investigation.

8 STRUCTURE FOUNDATIONS

The stratigraphy identified in the course of the investigations consisted of dense to very dense sand or sand and gravel with cobbles and boulders. Localized hard, organic clay was also identified. The native soil was overlain by generally dense cohesionless fill also containing cobbles and boulders, presumably placed during past road construction activities.

The foundations of the existing Bailey bridge are not visible but it is expected that they are spread footings, possibly timber cribs. The bridge is shown in Photo 3 in Appendix E. These foundations appear to be performing satisfactorily. Immediately to the west of the Bailey bridge are the remnants of the abutments of an earlier bridge. These abutments appear to have performed satisfactorily and are still intact, though some undermining is visible, see Photo 4 in Appendix E.

In the preparation of the geotechnical design recommendations for a structure on the selected alignment immediately east of the existing bridge, consideration was given to the following foundation types:

- Spread footings bearing on native soil
- Steel H-piles driven into the very dense soil
- Drilled shafts founded in the very dense soil

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

8.1 Spread Footings on Native Soil

Based on the relative density of the native sand and gravel soils underlying the site, the abutments could be supported on spread footings. However, constructability issues must be taken into account as described later.

The dense to very dense soils encountered during the investigation, will provide adequate geotechnical resistance to permit the design of spread footings to support the structure. Assuming a 3 m wide footing, the geotechnical resistance values to be used for design are 450 kPa at factored ULS and 300 kPa at SLS.

Based on the stratigraphy encountered in the boreholes, the highest permissible founding elevations are:

- South abutment – 315.0
- North abutment - 318.0

If spread footings are used, the final design must contain provisions to prevent the footings being undermined by scour.

The stated bearing resistance is for vertical, concentric loads. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC, 2006 Clause 6.7.3 and Clause 6.7.4.

The coefficient of sliding resistance to use in design is 0.55.

The excavation must be unwatered prior to placing concrete, which will be difficult to achieve for excavations below the groundwater/river level.

In view of the probable founding elevation below scour depth and the expected unwatering problems, spread footings are not the recommended foundation system for this site.

8.2 Steel H-Piles

The foundations may be supported on steel H-piles bearing in the very dense native soil.

It is recommended that the H-piles be founded in very dense native soil and that the pile tips be driven to a depth of at least 6 m below the depth of scour likely to be developed at the site within the design life of the structure.

8.2.1 Axial Resistance

The axial geotechnical resistances of an HP 310 X 110 pile in the native soil are:

- 1 600 kN at factored ULS
- 1 400 kN at SLS

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

The highest recommended tip elevations for the H-piles are as follows:

- North abutment – 312.0
- South abutment – 312.0

These elevations are based on the present depth of the river channel. If hydraulic analysis shows that significant scour may develop, the elevations should be lowered accordingly.

8.2.2 Downdrag

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

8.2.3 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for the design of conventional, semi-integral or integral abutments.

8.2.4 Pile Installation

Pile installation should be in accordance with Special Provision No. 903S01.

The soils encountered consist of generally dense to very dense sand and gravel, with SPT values of 100 blows for 0.3 m of penetration being recorded at shallow depths in most of the boreholes drilled at potential abutment locations. However, these boreholes were drilled and sampled to depths of 10 to 12 m to provide an adequate depth of exploration for pile design recommendations. The results of drilling and sampling indicate the presence of cobbles and boulders in the soil and this is confirmed by the quantity of boulders in the streambed and by the soil exposure immediately north of the site.

Based on the evidence of boulders at the site, and assuming an integral abutment design, the following pile installation procedure is suggested:

1. At each pile location, pre-drill a cased borehole of sufficient diameter and to sufficient depth to allow installation of the CSP required for integral abutment bridge design.
2. From the level of the underside of the CSP, pre-drill or pre-auger to a level 2.0 m above the anticipated pile tip elevation. The purpose of this drilling/augering is to loosen the upper, very dense soil and to break or dislodge cobbles or boulders that

might impede pile driving. It is recommended that a 300 mm drill/auger be used for this lower portion of drilling.

3. If material has to be removed below the level of the CSP, backfill the borehole to the level of the base of the CSP.
4. Install the CSP and withdraw the casing and backfill any space around the CSP using sand. (The sand specified in Table 8.6 is suitable). Do not backfill the CSP at this stage.
5. Drive the piles as specified and then fill the space around the piles inside the CSP using sand as specified in Table 8.6.

The fill below the CSP can be sand as per Table 8.6 or OPSS Granular "B" with a maximum particle size of 75 mm.

8.2.5 Pile Driving

Pile driving should be controlled by the Hiley Formula and an ultimate pile resistance to be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile". "R" must have a minimum value shown of 3,200 kN.

8.2.6 Lateral Resistance of Piles

The lateral resistance of the piles 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 = coefficient of horizontal subgrade reaction (Table 8.1)

γ = unit weight (Table 7.4)

K_p = passive earth pressure coefficient (Table 8.1)

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, $K = k_s \times L \times D$ (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, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} \times L \times D$.

Table 8.1 – Parameters for Lateral Pile Resistance

Location	Elevation	n_h (kN/m ³)	K_p	Unit Weight (kN/m ³)
South Abutment	OGI to 318	10,000	3.3	21
	318 to 307	10,000	3.3	11
North Abutment	OGI to 318	10,000	3.3	21
	318 to 308	10,000	3.3	11

The modulus of subgrade reaction may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 8.2. Intermediate values may be obtained by linear interpolation.

Table 8.2 – Subgrade Reaction Reduction Factors for Pile Spacing

Condition	Pile Spacing, Centre to Centre*	Reduction Factor
Pile group oriented <i>perpendicular</i> to direction of loading	4D	1.0
	1D	0.5
Pile group oriented <i>parallel</i> to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

* where D is the breadth of pile

In the case of conventional abutments, i.e. not integral, horizontal loads may be resisted by means of battered piles.

8.3 Drilled Shafts

Initial consideration was given to the use of drilled shafts to support the structure. Drilled shafts must be founded in the very dense soil at depths below the potential scour level equal to at least 3 shaft diameters. Although high geotechnical resistances might be available, the installation of drilled shafts will be problematic due to:

- Difficulty advancing the shaft due to cobbles and boulders in the soil
- The high groundwater table in the pervious soil that will hinder maintaining a stable side or base as the shaft is advanced
- The practical difficulties in unwatering the shaft, leading to placement of concrete below water.

In view of these potential problems and in the absence of any significant technical advantage, drilled shafts are not recommended and were not analyzed.

8.4 Recommended Foundation

From a geotechnical perspective, the recommended foundation consists of steel H-piles driven into the very dense native soil.

8.5 Abutment Type

From a geotechnical perspective, the subsurface conditions at this site are considered to be suitable for the construction of conventional, semi-integral or integral abutments. However, the recommended foundation system of H-piles makes integral abutments a feasible option.

The integral abutment design requires that the piles possess flexibility in the upper 3 m of the pile length. At this site, the native soil typically consists of very dense sand and gravel with cobbles and boulders. Accordingly, to provide the required flexibility in the piles, the upper 3 m of the piles should be surrounded by one of the following systems:

- For a “conventional” integral abutment supported on top of the piles - a 600 mm diameter CSP filled with loose sand, or
- For “false abutment” - concentric CSPs in accordance with standard integral abutment design procedures.

The sand must be placed in the CSP after the pile has been driven to avoid the danger of the sand being densified by pile driving.

Backfill sand should meet the gradation shown in Table 8.6.

Table 8.6 – Integral Abutment Sand Grading

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

Depending on the final configuration of the bridge, it is possible that at least part of the sand column will be saturated and subject to freezing in the winter. The impact of the frozen saturated backfill on the performance of the integral abutment must be assessed during design.

8.6 Frost Protection

The depth of earth cover required to provide frost protection for footings and pile caps at this site is 2.0 m.

It is possible to reduce the thickness of earth cover by the substitution of synthetic insulation, with 25 mm of rigid, extruded polystyrene insulation being equivalent to 600 mm of earth cover. Synthetic insulation must be covered to provide protection where it is used.

At this site, where a footing or pile cap is underlain by a minimum of 1.0 m of free-draining rock fill, frost protection is not considered to be an issue.

9 EXCAVATION

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils within the probable depth of excavation at this site may be classed as Type 3 soils above the water table. Excavation slopes should not be steeper than 1V:1H above the groundwater level.

Excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause boiling and sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work.

Prior to excavation below the natural groundwater level, the groundwater must be depressed to a level below the deepest excavation level sufficient to maintain a stable base and prevent soil disturbance by construction traffic.

Due to the proximity of the river, control of groundwater in an open excavation will be difficult and consideration may have to be given to excavating inside a cofferdam. The design of the cofferdam is the responsibility of the Contractor. The Contract Documents should alert him to the requirement to maintain a stable excavation and to the fact that any shoring system should be designed by a specialist, taking account of the need to control groundwater and prevent basal instability within the excavation. The Contract should also require the placement of a 150 mm concrete mud slab.

10 UNWATERING

Based on the preliminary GA for the bridge structure, it is anticipated that excavation at the abutments will penetrate 0.5 to 1.0 m below the groundwater level.

The design of any unwatering system that may be required should be the responsibility of the Contractor and the Contract Documents should alert him to this responsibility and the need to engage a dewatering specialist. While the responsibility for dewatering should remain with the Contractor, suitable systems that might be employed include pumping from filtered sumps for penetration in the order of 0.5 m below the groundwater level and the use of vacuum wellpoints for

deeper penetration below the groundwater level. The installation of wellpoints may be difficult at this site.

The design of the unwatering system should be coordinated with the design of the cofferdam, where required.

11 BRIDGE APPROACHS AND EMBANKMENTS

Based on the total of the four boreholes drilled at the structure location and eight boreholes drilled along balance of the alignment, the soils at the site are all non-cohesive sand and gravel with cobbles and boulders. In general, the native soils are described as dense to very dense sand and gravel with cobbles and boulders.

No long-term settlement problems are anticipated for approach embankments built at this site. Similarly, the 2 to 3 m high embankments likely to be constructed will be stable at side slopes of 2H:1V and no overall stability issues are expected provided the new embankment does not encroach on the river bank.

For long-term stability, either allowance should be made for possible erosion of the river bank or the river bank must be armoured to prevent erosion and migration towards the embankment.

12 RETAINED SOIL SYSTEMS

RSS walls used in conjunction with bridge abutments must be “High Performance” and, typically, “High Appearance”. The geotechnical parameters that can be used for the design of RSS walls at this site are presented in Table 12.1.

Table 12.1 – RSS Design Parameters

Parameter	South Abutment	North Abutment
Bearing resistance on native dense soil	ULS _f = 400 kPa SLS = 250 kPa	ULS _f = 400 SLS = 250
Coefficient of sliding resistance	0.6	0.6
Estimated settlement in foundation soils	20 mm	20 mm

If RSS is used, it must conform to the requirements of SP599S22.

13 BACKFILL TO ABUTMENTS

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

In the case of a conventional abutment, granular backfill is recommended but rock backfill can be permitted. A NSSP is required to specify grading limits for the rock fill. The rock fill used as backfill to the abutment should be limited to fragments no greater than 150 mm.

In all cases where the approach embankment consists of rock fill and granular backfill is used behind the abutment wall, the granular backfill must consist of OPSS Granular "B" Type II.

The backfill to the abutment walls must be in accordance with OPSS 902 as amended by Special Provision 902S01. Granular backfill must be placed to the extents shown in OPSD 3101.150, and rock backfill must be placed to the extents shown in OPSD 3101.200.

Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with SP 105S10.

The design of the abutment must incorporate a subdrain as shown in OPSD 3102.100.

14 EARTH PRESSURE COEFFICIENTS (ABUTMENTS)

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 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 14.1.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall. In the case of integral abutments, material with a lower passive pressure coefficient (e.g. Granular B Type I) might be preferred as it results in lower forces acting on the ballast wall as the wall moves toward the soil mass.

The factors in Table 14.1 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 14.1 – 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 $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$		Rock Fill (Limited to 300 mm size) $\phi = 42^\circ, \gamma = 19 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H:1 V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H:1 V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.43*	0.2	.30*
At rest (Restrained Wall)	0.43	-	0.47	-	.33	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	5.0	-

* For wing walls.

15 SEISMIC CONSIDERATIONS

The site is treated as lying in Seismic Zone 0. Accordingly, seismic design is not an issue at this site.

16 CONSTRUCTION CONCERNS

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

1. Pile Installation

The presence of cobbles and boulders in a very dense matrix of sand and gravel may present difficulties in installing the piles to the specified depth and to the specified tolerances for location and verticality. Pre-drilling at each pile location is recommended as a means to mitigate these

problems and the Contract should allow an item for this. One suggested procedure is described in Section 8.2.4 of this report.

2. Excavation

Excavations of limited extent, such as will be required to reach the underside of the abutments, may be difficult in the very dense sand and gravel containing cobbles and boulders. If excavations advance below the existing groundwater level, groundwater control measures may have to be implemented in order to maintain stable sides and base in the excavation.

3. Unwatering

The pervious nature of the soils encountered at this site and the proximity to the river will make unwatering of excavations difficult. Depending on the locations of the abutments, steps may have to be taken to control the river and exclude it from the excavations.

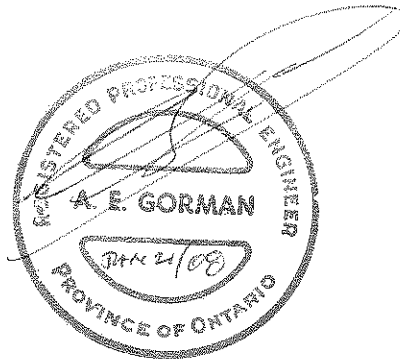
17 CLOSURE

Engineering analysis and preparation of the report were carried out by 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.

Alastair E. Gorman, P.Eng.,
Senior Foundations 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
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		Field Estimation of Hardness*
			(MPa)	(psi)	
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 07-RR01

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 388.06 E 350 901.97 ORIGINATED BY SLL
 HWY 129 BOREHOLE TYPE Hollow Stem Auger / NQ Core Barrel COMPILED BY JHL
 DATUM Geodetic DATE 2007.02.14 - 2007.02.16 CHECKED BY AEG

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					
	Continued From Previous Page						20 40 60 80 100						
309.8	Moist SAND, silty, trace gravel, occasional cobbles Very Dense Grey Moist		9	SS	100/	310							
10.7	END OF BOREHOLE AT 10.67 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 05/02/07 1.70 318.80 14/03/07 4.63 315.87 08/09/07 5.67 314.83 12/09/07 5.80 314.70				.150								

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10
5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR02

1 OF 2

METRIC

G.W.P. 5321-04-00

LOCATION Rapid River N 5 178 397.60 E 350 919.23

ORIGINATED BY GA

HWY 129

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY JHL

DATUM Geodetic

DATE 2007.01.28 - 2007.01.30

CHECKED BY AEG

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		
320.4														
0.0	SAND AND GRAVEL, occasional cobbles Dense Brown Dry (FILL)		1	SS	30		320							
			2	SS	28		319							
			3	SS	64									
318.1			4	SS	50		318							
2.3	SAND AND GRAVEL, occasional cobbles and boulders Dense to Very Dense Brown Wet		5	SS	69		317							
	Boulder: (600 mm)		6	SS	33		316							
			7	SS	32		315							
			8	SS	103		314							
							313							
							312							
311.2			9	SS	102		311							
9.1	SAND, medium to coarse grained Very Dense Brown Wet													

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR02

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 397.60 E 350 919.23 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JHL
 DATUM Geodetic DATE 2007.01.28 - 2007.01.30 CHECKED BY AEG

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 80 100	20 40 60 80 100	W _P W W _L	20 40 60					
	Continued From Previous Page															
309.3			10	SS	118		310									
11.0	END OF BOREHOLE AT 11.05m. BOREHOLE OPEN TO 11.05m. WATER LEVEL AT 2.74m UPON COMPLETION. BOREHOLE GROUTED WITH BENTONITE TO 0.91m AND BACKFILLED WITH HOLEPLUG TO SURFACE. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 01/02/07 4.93 315.47 03/02/07 4.94 315.46 07/02/07 5.00 315.40 14/03/07 BLOCKED AT SURFACE 08/09/07 DESTROYED															

METRIC

ORIGINATED BY GA

COMPILED BY JHL

CHECKED BY AEG

+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 07-RR3

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 382.95 E 350 905.45
 HWY 129 BOREHOLE TYPE Hollow Stem Auger
 DATUM Geodetic DATE 2007.02.02 - 2007.02.04
 ORIGINATED BY GA
 COMPILED BY JHL
 CHECKED BY AEG

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	20	40	60	80	100	W _p	W		
	Continued From Previous Page															
309.5			10	SS	140											39 60 1
11.0	END OF BOREHOLE AT 10.97 m. BOREHOLE OPEN TO 9.14 m AND WATER LEVEL AT 3.05 m UPON COMPLETION. BOREHOLE GROUTED WITH BENTONITE TO 1.83 m AND BACKFILLED WITH HOLEPLUG TO SURFACE. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 04/02/07 3.05 317.35															(SI+CL)

METRIC

CHECKED BY AEG

Continued Next Page

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR4

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 392.46 E 350 922.13 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger / NQ Core Barrel COMPILED BY JHL
 DATUM Geodetic DATE 2007.01.24 - 2007.01.27 CHECKED BY AEG

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												
	Continued From Previous Page							20	40	60	80	100								
			10	SS	102		310													
							309													
308.3			11	SS	107/												21 75 4			
12.4	END OF BOREHOLE AT 12.42 m. BOREHOLE OPEN AND WATAER LEVEL AT 2.74 m UPON COMPLETION. BOREHOLE GROUTED WITH BENTONITE TO SURFACE. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 27/01/07 2.74 317.96				.075												(SI+CL)			

RECORD OF BOREHOLE No 07-RR05

1 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 369.20 E 350 910.60 ORIGINATED BY SLL
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JHL
 DATUM Geodetic DATE 2007.02.17 - 2007.02.17 CHECKED BY AEG

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	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L	20 40 60			
320.6	TOPSOIL: (50 mm)												
	SAND AND GRAVEL, with cobbles												
		1	SS	90/ .175									
		2	SS	50/ .050									
	Very Dense Brown Wet	3	SS	50/ .125									35 36 29 (SI+CL)
		4	SS	50/ .125									
		5	SS	50/ .075									
		6	SS	50/ .125									
	Boulder	7	SS	50/ .125									
		8	SS	100/ .275									22 59 19 (SI+CL)
311.3	SAND, trace to some gravel Very Dense Grey Moist												

Continued Next Page

+ ³ × ³ : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR05

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 369.20 E 350 910.60 ORIGINATED BY SLL
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JHL
 DATUM Geodetic DATE 2007.02.17 - 2007.02.17 CHECKED BY AEG

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 (%)			
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					20 40 60 W _P W W _L					
	Continued From Previous Page															
309.8			9	SS	50/	310										2 49 32 17
10.8	END OF BOREHOLE AT 10.79 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 14/03/07 3.70 316.90 08/09/07 3.67 316.93 12/09/07 3.52 317.08				.125											

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR06

1 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 381.26 E 350 933.03 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JHL
 DATUM Geodetic DATE 2007.01.31 - 2007.02.01 CHECKED BY AEG

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 (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)				
								20 40 60 80 100								20 40 60				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
320.3																				
0.0	SAND AND GRAVEL, occasional cobbles Compact Dark Brown Wet (FILL)		1	SS	26															
			2	SS	27															
	Boulder		3	SS	50/ .050															
317.9																				
2.4	SAND AND GRAVEL, trace to some cobbles and boulders		4	SS	38															
	Dense to Very Dense Brown Wet		5	SS	50/ .175															
315.7																				
4.6	SAND, trace to some gravel, trace silt, occasional cobbles and boulders Compact to Very Dense Brown Wet		6	SS	29															
				7	SS	76														
				8	SS	112/ .275														
			9	SS	133															

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR06

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 381.26 E 350 933.03 ORIGINATED BY GA
HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JHL
DATUM Geodetic DATE 2007.01.31 - 2007.02.01 CHECKED BY AEG

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 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60					
	Continued From Previous Page																
309.4			10	SS	108/		310										
10.9	<p>END OF BOREHOLE AT 10.87 m. BOREHOLE OPEN TO 10.67 m AND WATER LEVEL AT 1.52 m UPON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS FROM 10.9m TO 4.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.</p> <p>WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 31/01/07 1.52 318.78 14/03/07 BLOCKED AT 2.78 08/09/07 DRY but only 12" of pipe 12/09/07 DRY</p>				200												

RECORD OF BOREHOLE No 07-RR07

1 OF 1

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 274.17 E 350 729.23 ORIGINATED BY CA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY WM
 DATUM Geodetic DATE 2007.02.07 - 2007.02.07 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
317.5								20	40	60	80	100		
0.0	Silty CLAY, trace sand, trace gravel Very Stiff Brown (FILL)		1	SS	19									
317.0														
0.5	SAND and SILT, trace clay Dense Moist (FILL)		2	SS	31									
316.0														
315.5	SAND, trace silt, trace gravel Very Dense Wet		3	SS	50/ .150									
1.7	END OF BOREHOLE AT 1.68 m. AUGER REFUSAL AT 1.68 m. BOREHOLE OPEN TO 1.68 m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.													

+ 3, X 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR8

1 OF 1

METRIC

G.W.P. 5321-04-00

LOCATION

Rapid River N 5 178 302.14 E 350 773.00

ORIGINATED BY GA

HWY 129

BOREHOLE TYPE

Hollow Stem Auger

COMPILED BY WM

DATUM Geodetic

DATE

2007.02.07 - 2007.02.07

CHECKED BY AEG

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		
317.8														
0.0	SAND and GRAVEL, trace to some silt Dense Brown Dry (FILL)		1	SS	38									
			2	SS	40		317							32 58 10 (SI+CL)
316.3														
1.5	SAND and GRAVEL, trace silt Compact Brown to Grey Damp		3	SS	24		316							
315.5														
2.3	END OF BOREHOLE AT 2.29 m. AUGER REFUSAL AT 2.29 m. BOREHOLE OPEN TO 2.29 m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.													

+ 3 . x 3 .

Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR9

1 OF 1

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 325.10 E 350 816.42 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY WM
 DATUM Geodetic DATE 2007.02.07 - 2007.02.07 CHECKED BY AEG


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y 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 x LAB VANE 20 40 60 80 100									
319.4 0.0	PEAT, amorphous, some rootles, frequent cobbles and boulders Compact Black Wet		1	SS	20		319										
318.6 0.8	END OF BOREHOLE AT 0.76 m. AUGER REFUSAL AT 0.76 m. BOREHOLE OPEN TO 0.76 m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BOREHOLE CUTTINGS.																

RECORD OF BOREHOLE No 07-RR10

1 OF 1

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 345.70 E 350 861.75 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY WM
 DATUM Geodetic DATE 2007.02.07 - 2007.02.07 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20 40 60 80 100							
320.0															
0.0	SAND, trace silt, trace gravel, occasional cobbles Compact Brown Dry to Damp (FILL) Gravelly SAND, some silt Dense to Very Dense Moist (FILL)		1	SS	29										
319.4															
0.6															
			2	SS	41										
			3	SS	84										
317.9															
2.1	END OF BOREHOLE AT 2.13 m. AUGER REFUSAL AT 2.13 m. BOREHOLE OPEN TO 2.13 m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.														

RECORD OF BOREHOLE No 07-RR11

1 OF 1

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 395.65 E 350 948.39 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY WM
 DATUM Geodetic DATE 2007.01.31 - 2007.01.31 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
321.5 0.0	SAND and GRAVEL, occasional asphalt fragments, trace silt Compact Brown Moist (FILL)		1	SS	22		321										
			2	SS	20												
320.0							320										
1.5	SAND and GRAVEL, some silt, occasional cobbles and boulders Very Dense Brown Damp		3	SS	86												
			4	SS	78/ 200		319										30 57 13 (SI+CL)
318.4			4	SS	507												
3.1	END OF BOREHOLE AT 3.15 m. BOREHOLE OPEN TO 2.13 m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG AND DRILL CUTTINGS TO SURFACE.				100												

RECORD OF BOREHOLE No 07-RR12

1 OF 1

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 407.13 E 350 999.32 ORIGINATED BY GA
HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY WM
DATUM Geodetic DATE 2007.01.31 - 2007.01.31 CHECKED BY AEG

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			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
322.4							20	40	60	80	100	20	40	60	kN/m ³				
0.0	SAND AND GRAVEL, trace silt, occasional rootlets Compact to Very Dense Brown Dry to Damp		1	SS	16														
	trace to some cobbles and boulders		2	SS	16														
			3	SS	86														
320.1			4	SS	50/ .000														
2.3	END OF BOREHOLE AT 2.29 m. AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE BACKFILLED WITH HOLEPLUG AND DRILL CUTTINGS TO SURFACE.																		

RECORD OF BOREHOLE No 07-RR13

1 OF 1

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 446.34 E 351 034.22 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY WM
 DATUM Geodetic DATE 2007.01.31 - 2007.01.31 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
321.3														
0.0														
321.0														
0.3	SAND, some gravel, some silt Dense Brown (FILL)		1	SS	42		321							13 70 17 (SI+CL)
	SILT, some sand, some gravel Very Dense Dark Brown Dry to Damp		2	SS	90									
319.8							320							
1.5	END OF BOREHOLE AT 1.52 m. BOREHOLE OPEN TO 1.22 m AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS TO SURFACE.													

+ 3, X 3: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR14

1 OF 1

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 460.13 E 351 084.86 ORIGINATED BY GA
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY WM
 DATUM Geodetic DATE 2007.01.31 - 2007.01.31 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
320.2 0.0	SAND, some gravel, some silt Very Dense Brown Dry (FILL) SAND AND GRAVEL, trace silt, occasional cobbles and boulders Very Dense Brown Dry		1	SS	51		320							
319.9 0.3			2	SS	50/ .075		319							
318.8 1.4	END OF BOREHOLE AT 1.37 m. AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE BACKFILLED WITH DRILL CUTTINGS TO SURFACE.													

METRIC

ORIGINATED BY SU

COMPILED BY ES

CHECKED BY AEG

Continued Next Page

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR15

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 367.47 E 350 916.47 ORIGINATED BY SU
 HWY 129 BOREHOLE TYPE Hollow Stem Auger COMPILED BY ES
 DATUM Geodetic DATE 2007.09.09 - 2007.09.10 CHECKED BY AEG

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	W _p	W	W _L			
	Continued From Previous Page																
			2	RUN													
			3	RUN													
307.6																	
12.3	END OF BOREHOLE AT 12.3m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 09/12/07 3.80 316.10																

+³ × 3³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR16

1 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 387.22 E 350 932.58 ORIGINATED BY SU
 HWY 129 BOREHOLE TYPE Hollow Stem Auger/ NW Casing COMPILED BY ES
 DATUM Geodetic DATE 2007.09.08 - 2007.09.07 CHECKED BY AEG

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		
321.1														
0.0	SAND, trace gravel, occasional cobbles and boulders Dense Brown Moist (FILL)		1	SS	32		321							
319.7							320							
1.4	SAND and GRAVEL, occasional cobbles and boulders Very dense Brown Moist		2	SS	50/ .125		319							
			3	SS	50/ .075		318							
	HSA to 3.05m then switched to NW Casing		4	SS	75/ .125		317							
			5	SS	50/ .100		316							
			6	SS	55		315							
	More frequent cobbles and boulders below elev. 315.0		7	SS	100/ 250		314							
			8	SS	100/ 225		313							
							312							

Continued Next Page

+³ × 3³ Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR16

2 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 387.22 E 350 932.58 ORIGINATED BY SU
HWY 129 BOREHOLE TYPE Hollow Stem Auger/ NW Casing COMPILED BY ES
DATUM Geodetic DATE 2007.09.08 - 2007.09.07 CHECKED BY AEG

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			20	40	60	80	100		
	Continued From Previous Page												
			9	SS	100/ 275								
308.5			10	SS	147								
12.6	END OF BOREHOLE AT 12.65m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 12/09/07 1.90 319.20												

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

ORIGINATED BY SU

COMPILED BY ES

CHECKED BY _____ AEG


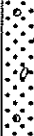























+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 07-RR18

1 OF 2

METRIC

G.W.P. 5321-04-00 LOCATION Rapid River N 5 178 392.50 E 350 946.44 ORIGINATED BY SU
HWY 129 BOREHOLE TYPE Hollow Stem Auger/ NW Casing COMPILED BY ES
DATUM Geodetic DATE 2007.09.09 - 2007.09.09 CHECKED BY AEG

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 (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								20 40 60 80 100									
321.1																	
0.0	TOPSOIL (150mm) Organics						321										
0.2	SAND and GRAVEL, occasional cobbles and boulders Very dense Brown Moist Boulder and cobble																
	Switched to NW Casing		1	SS	62												
																	
			2	SS	73/ 225												
																	
			3	SS	50/ .075												
	Boulder (300mm)																
			4	SS	50/ .075												
																	
																	
																	
																	
																	
																	
																	
																	
																	
																	
																	
315.0																	
6.1	SAND, trace gravel Very dense Brown Wet		5	SS	70		315										
																	
			6	SS	50/ .150												
																	
																	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-RR18

2 OF 2

METRIC

G.W.P. 5321-04-00

LOCATION

Rapid River N 5 178 392.50 E 350 946.44

ORIGINATED BY SU

HWY 129

BOREHOLE TYPE

Hollow Stem Auger/ NW Casing

COMPILED BY ES

DATUM Geodetic

DATE

2007.09.09 - 2007.09.09

CHECKED BY AEG

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			20	40	60	80	100	w _p	w	w _L		
	Continued From Previous Page																
	BENTONITE TO 300mm THEN FILLED WITH SAND TO SURFACE																

+ 3, X 3: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

Appendix B

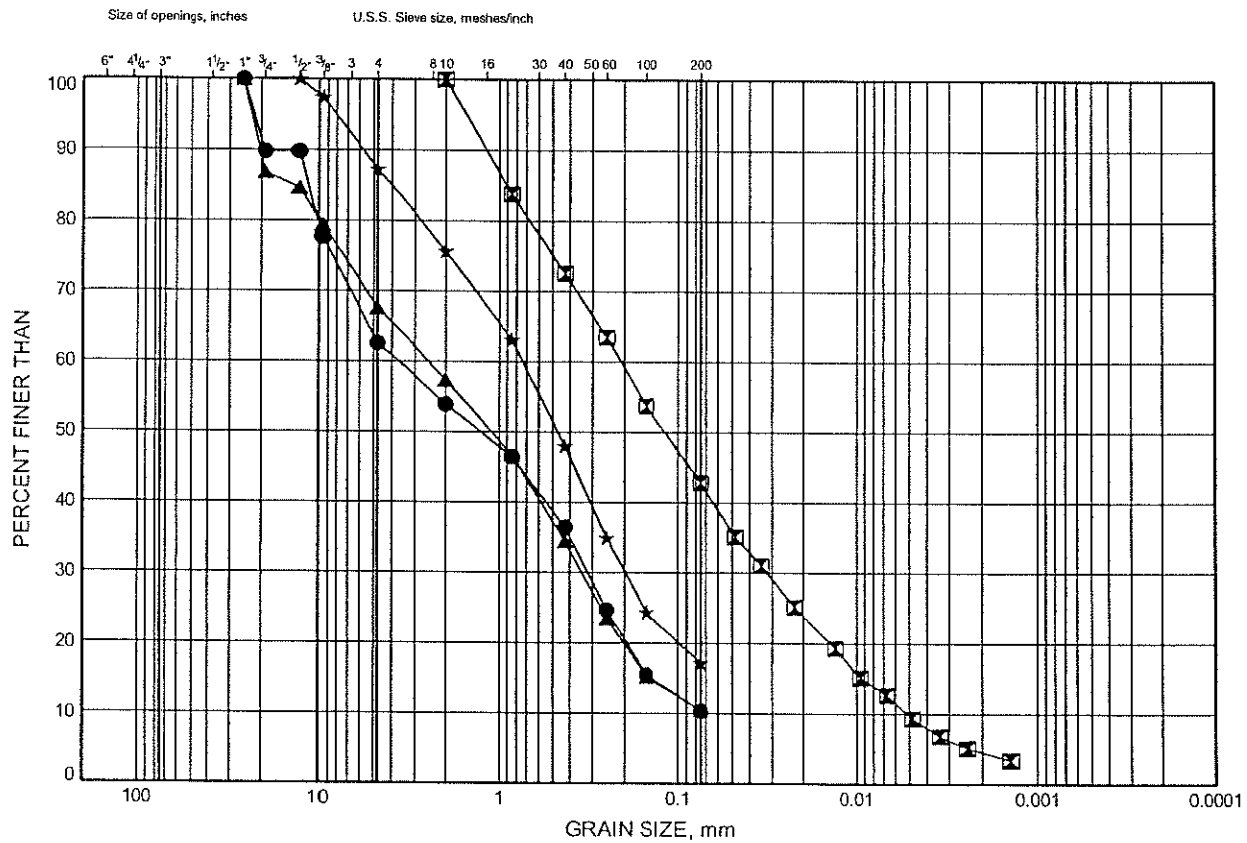
Laboratory Test Results



Rapid River GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	07-RR02	1.07	319.29
□	07-RR07	1.07	316.43
▲	07-RR08	1.07	316.73
★	07-RR13	0.38	320.92



Date November 2007

Project 5321-04-00

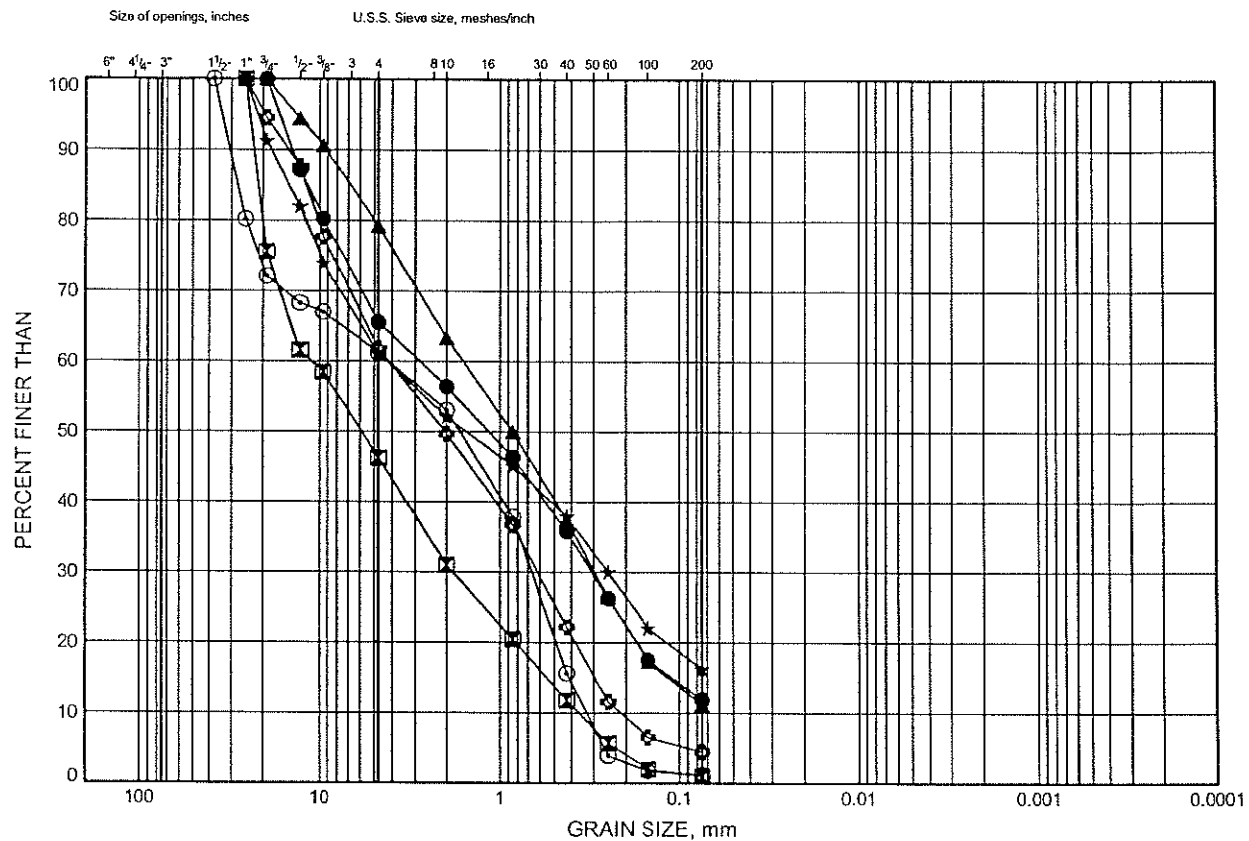
Prep'd MFA

Chkd. AEG

Rapid River GRAIN SIZE DISTRIBUTION

FIGURE B2

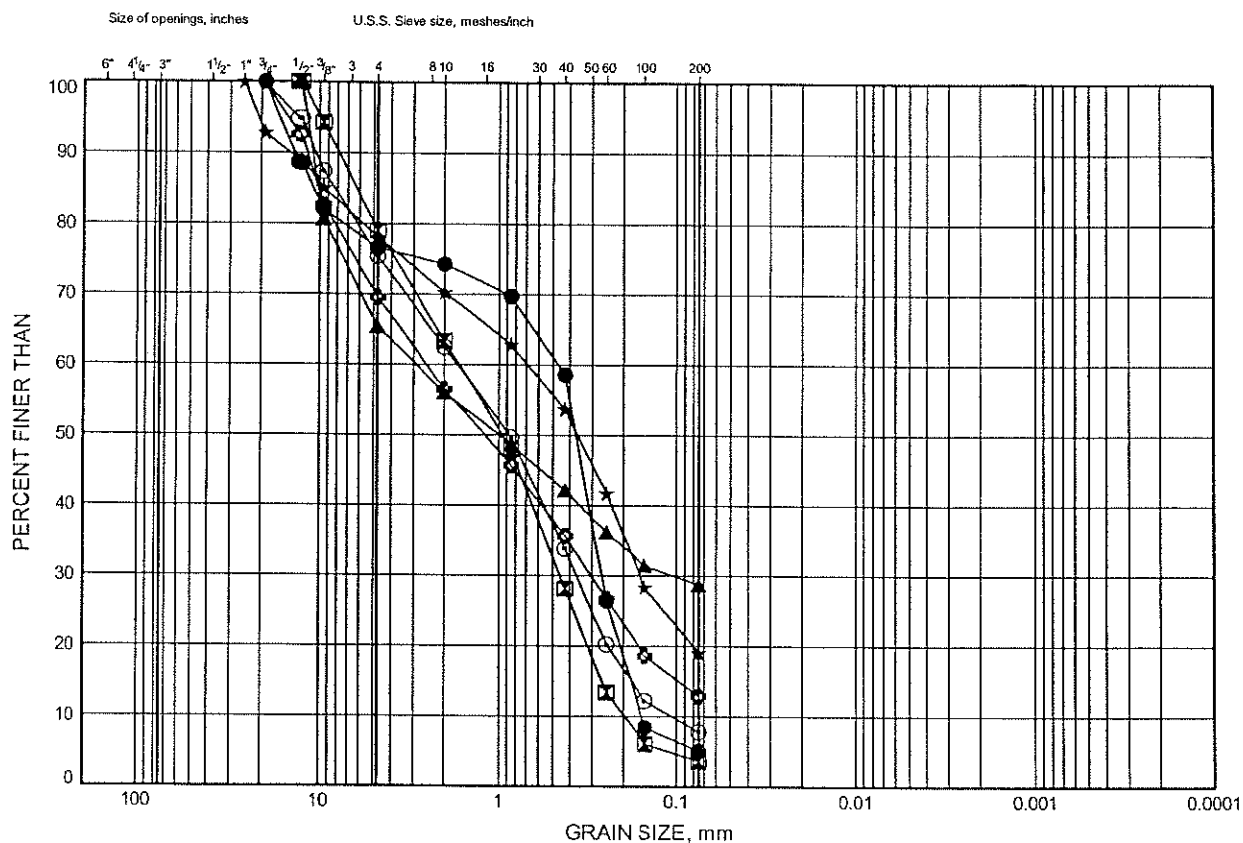
SAND AND GRAVEL



Rapid River GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND AND GRAVEL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	07-RR04	7.92	312.82
⊠	07-RR04	12.31	308.43
▲	07-RR05	2.43	318.17
★	07-RR05	9.37	311.23
⊙	07-RR06	2.59	317.70
⊗	07-RR11	2.59	318.91

Date November 2007

Project 5321-04-00



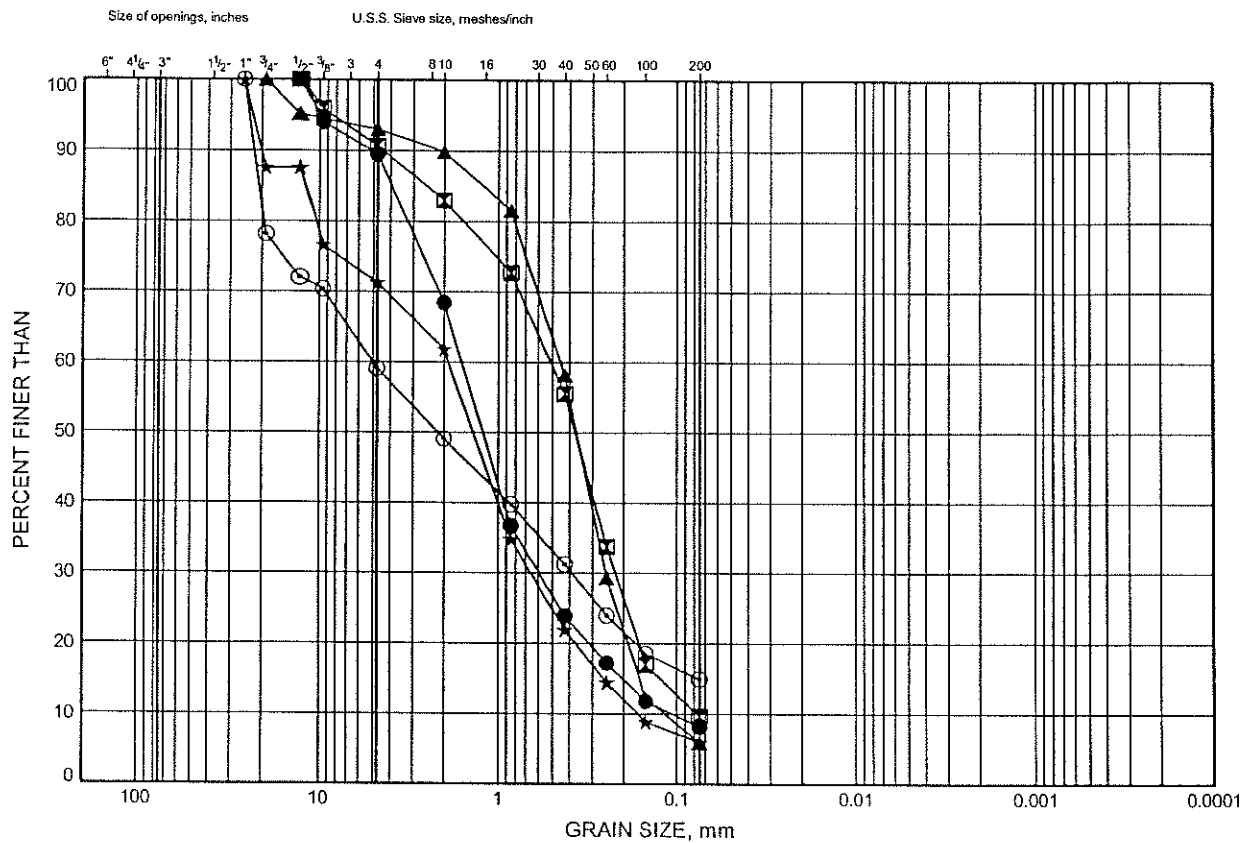
Prep'd MFA

Chkd. AEG

Rapid River GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND AND GRAVEL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	07-RR15	4.61	315.25
⊠	07-RR16	3.19	317.93
▲	07-RR16	6.40	314.72
★	07-RR16	9.33	311.79
⊙	07-RR18	2.59	318.53

THURSGSD 2333.GPJ 08/1/18

Date January 2008

Project 5321-04-00



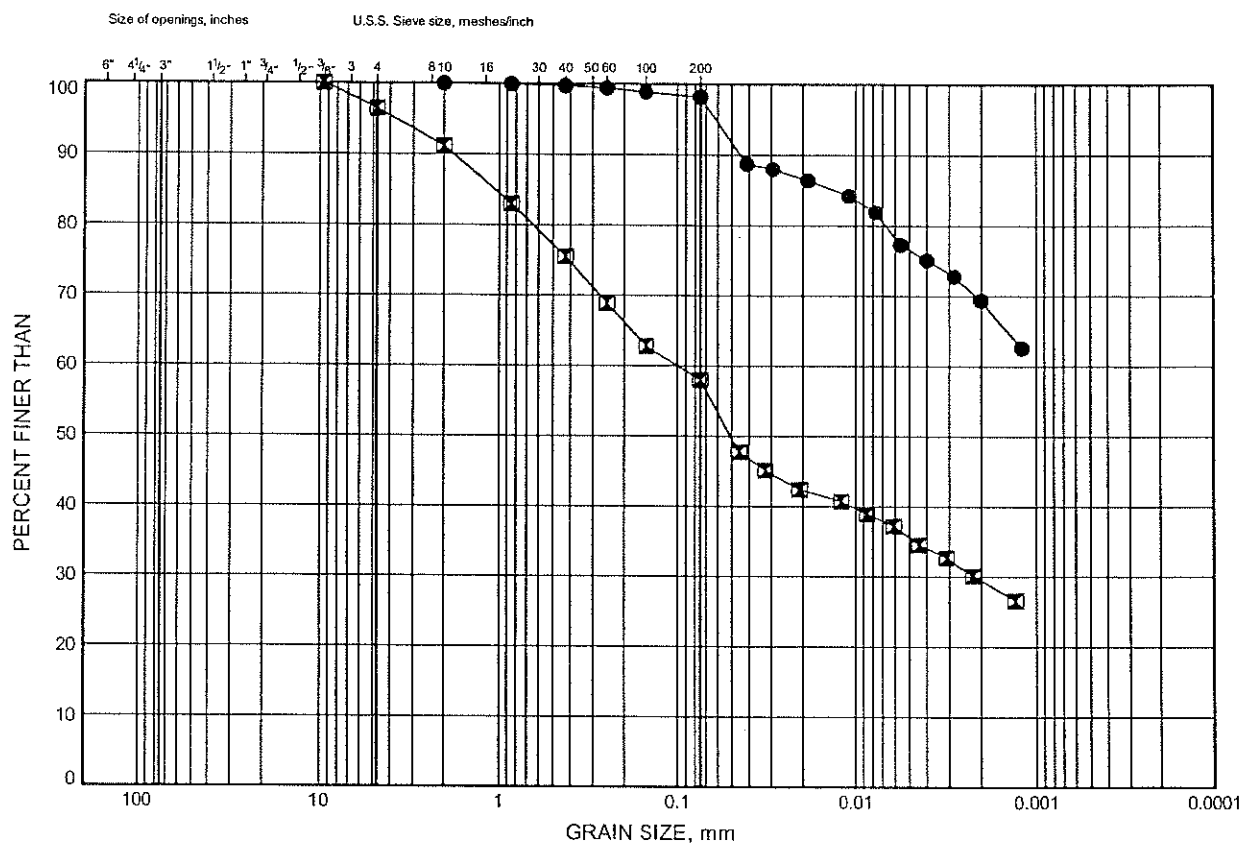
Prep'd MFA

Chkd. AEG

Rapid River GRAIN SIZE DISTRIBUTION

FIGURE B5

CLAY



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	07-RR15	3.19	316.67
◻	07-RR17	3.26	317.08



Date November 2007

Project 5321-04-00

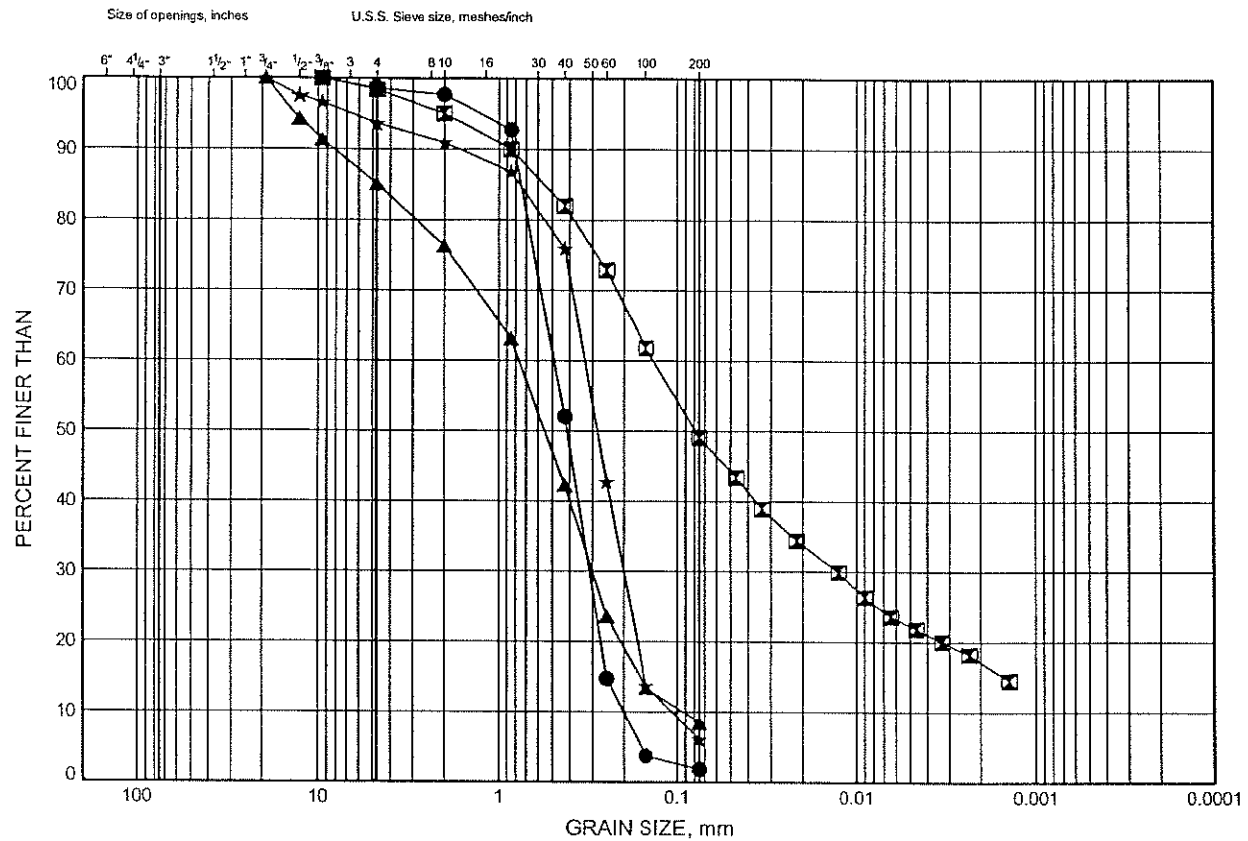
Prep'd MFA

Chkd. AEG

Rapid River GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	07-RR02	9.45	310.91
⊠	07-RR05	10.73	309.87
▲	07-RR06	4.88	315.41
★	07-RR06	7.92	312.37



Date November 2007

Project 5321-04-00

Prep'd MFA

Chkd. AEG

Appendix C

Factual Information from the Dominion Soil Investigation Inc. Report



DOMINION SOIL INVESTIGATION INC. RECORD OF BOREHOLE NO 1

WP 14-74-07

DIST 18 HWY 129

LOCATION Station 259 + 90, 5' LT. E Line 'H'

DATUM Geodetic

BORING DATE June 5 and 6, 1977

BOREHOLE TYPE Augering and Washboring (N-size)

ORIGINATED BY N. McC.

COMPILED BY I.R.

CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	SHEAR STRENGTH				
												O UNCONFINED + FIELD VANE • QUICK TRIAXIAL X LAB VANE				
1049.3	Ground Surface															
0	Loose Boulders with Peat Filler														% GR S A S I CL	
1047.3															Hole Caved-in at El. 1048. after casing withdrawn	
2.0	Very Dense Sand and Gravel with numerous Boulders and a trace to some Silt		1	SS	75	9"										
			2	SS	50	3"										
			3	SS	105											
			4	SS	98	1040 9"										
			5	SS	100	4"										
			6	SS	100	7"										
			7	SS	82	1030										
			8	SS	165	10"										
1018.8			9	SS	127	1020 5"										
30.5	END OF BOREHOLE														30, 52, 18-	

CHECKED BY I.P.L.

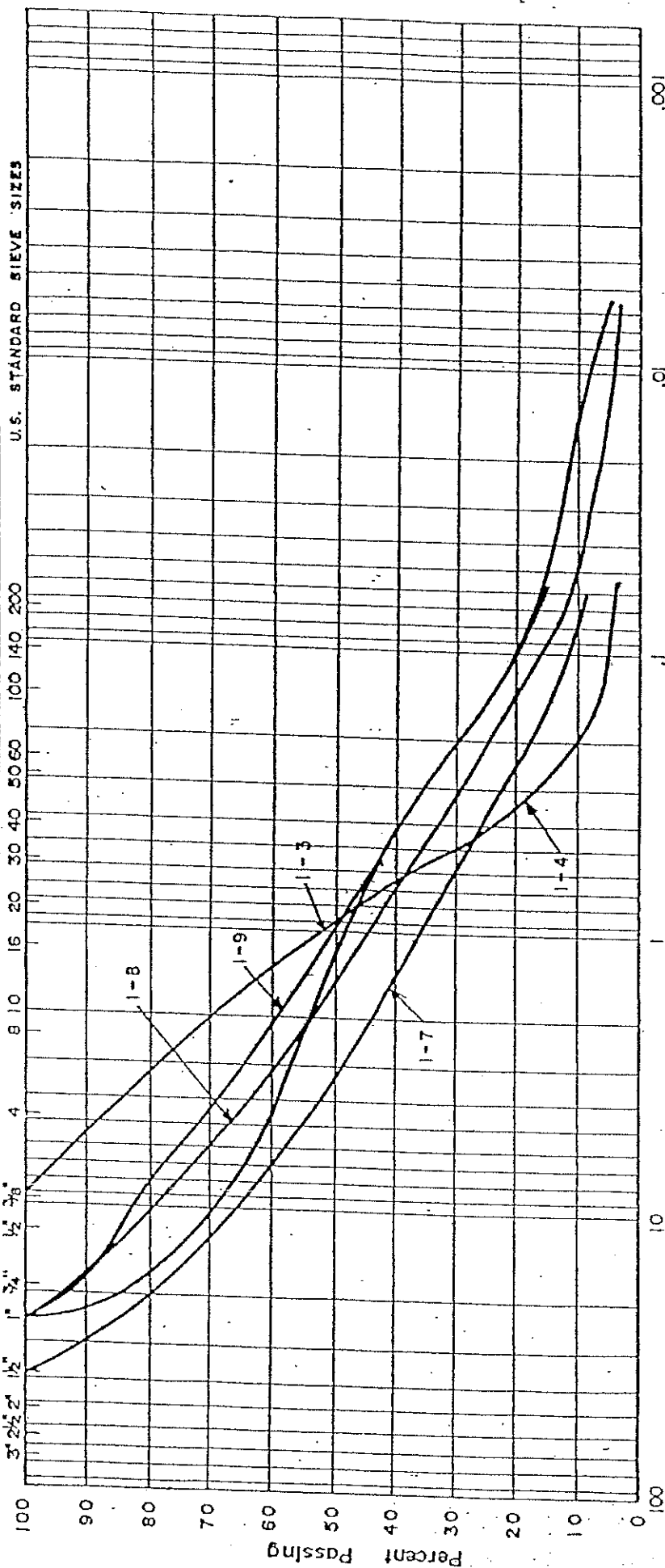
15 $\frac{20}{5}$ % STRAIN AT FAILURE
10

DOMINION SOIL INVESTIGATION LIMITED GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 77-5-16

UNIFIED SOIL CLASSIFICATION SYSTEM
SILT & CLAY

GRAVEL			SAND			FINE			SILT & CLAY		
COARSE	1"	3/4"	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE
3"	2 1/2"	2"	1 1/2"	1"	3/4"	3/8"	3/16"	1/8"	100	140	200



ENCLOSURE NO. 3

PLASTIC PROPERTIES
LIQUID LIMIT % ■ N/A.
PLASTIC LIMIT % ■
PLASTICITY INDEX % ■
MOISTURE CONTENT % ■

Classification of Sample and Group Symbol:

SAND & GRAVEL

with a trace to some silt.

PROJECT: BRIDGE OVER RAPID RIVER.
LOCATION: HWY. 129.
BOREHOLE NO: 1 1 1 1 1 1
SAMPLE NO: 3 4 7 8 9
DEPTH: 8.5' 11' 21' 25' 30'
ELEVATION: 1041' 1038' 1028' 1024' 1019'

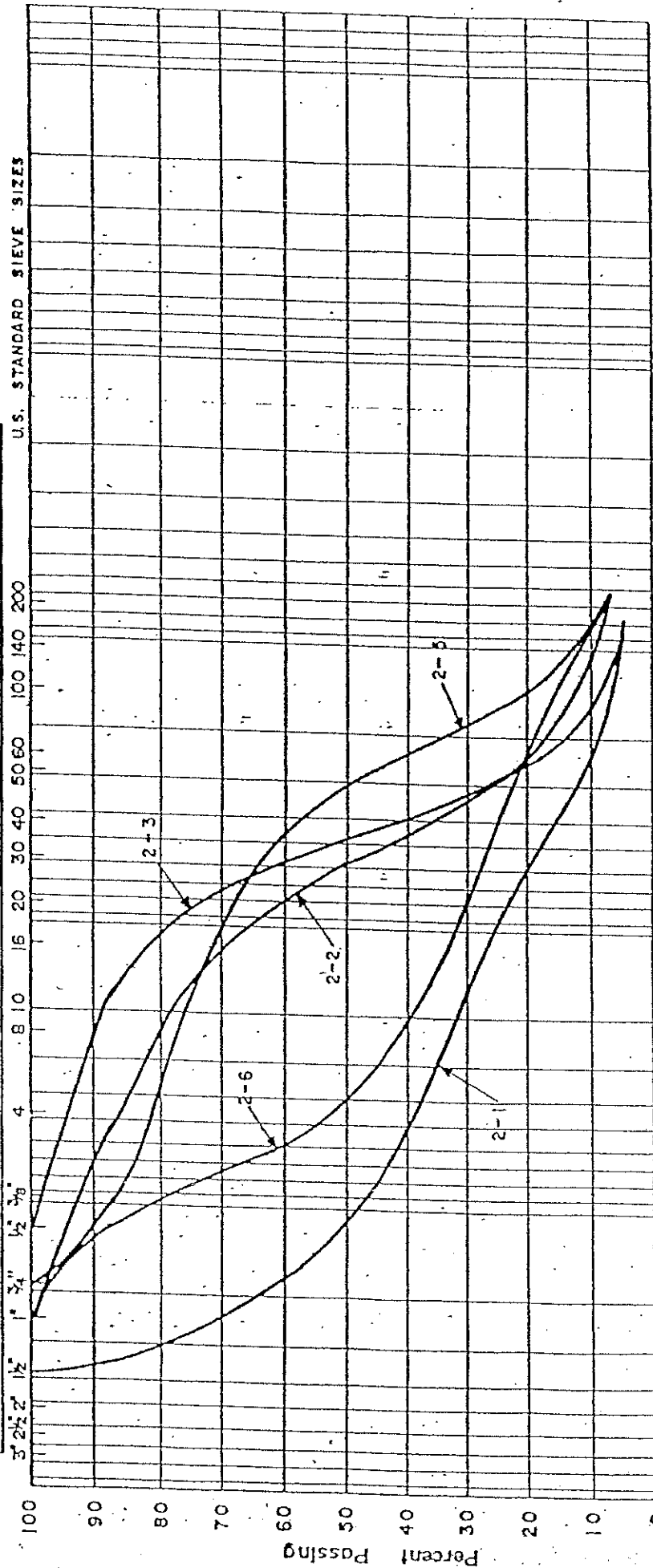
DOMINION SOIL INVESTIGATION LIMITED GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 77-5-1

GRAVEL		SAND			SILT & CLAY		
COARSE	FINE	COARSE	MEDIUM	FINE			

UNIFIED SOIL CLASSIFICATION SYSTEM

U.S. STANDARD SIEVE SIZES



Grain Size in Millimeters

PROJECT: BRIDGE OVER RAPID RIVER. COEFFICIENT OF UNIFORMITY: 4 - 7.5

LOCATION: HWY. 129. COEFFICIENT OF CURVATURE:

BOREHOLE NO. 2 2 2 2 2 2

SAMPLE NO. 1 2 3 5 6

DEPTH: 125' 16' 19' 23' 26'

ELEVATION: 1040' 1036' 1033' 1029' 1026'

Classification of Sample and Group Symbol:

SAND & GRAVEL with a trace to some silt.

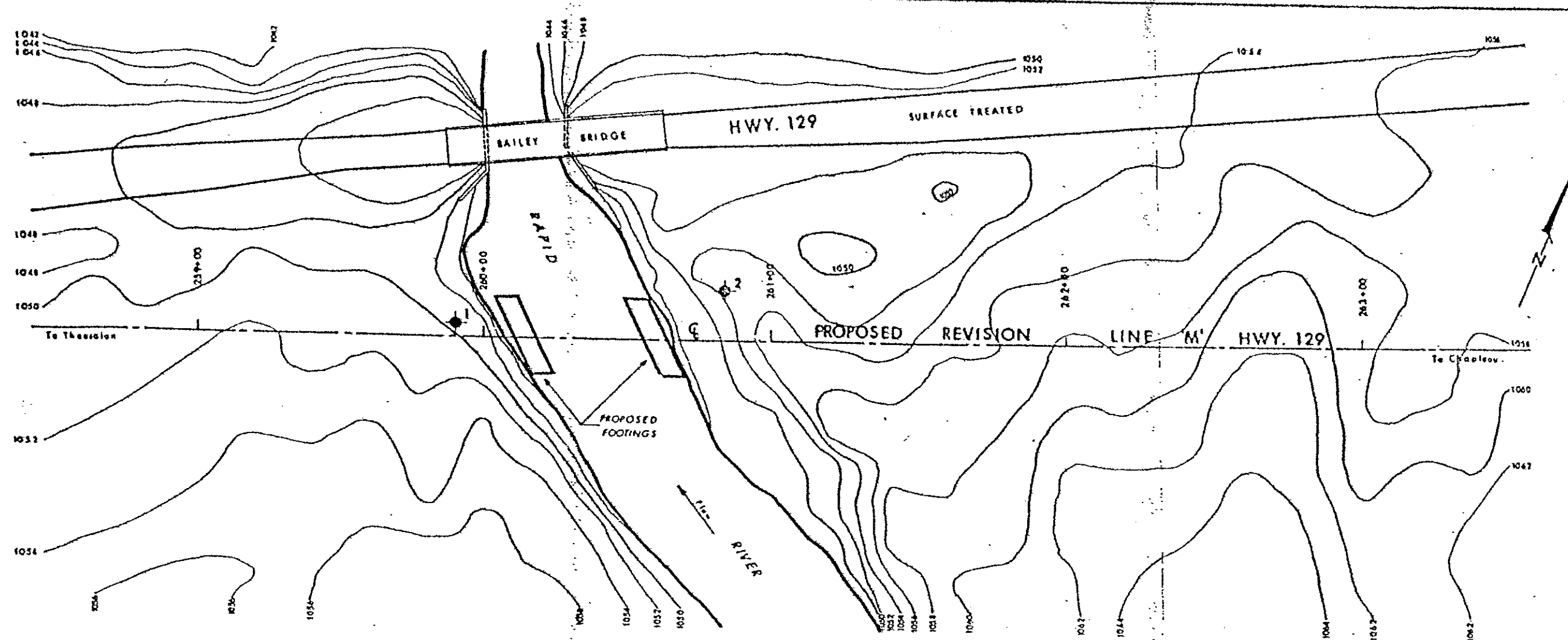
PLASTIC PROPERTIES

LIQUID LIMIT % N/A

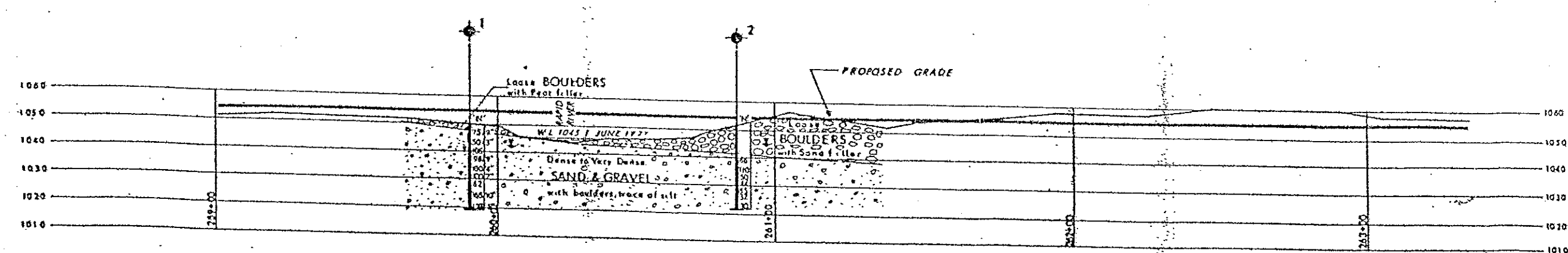
PLASTIC LIMIT %

PLASTICITY INDEX %

MOISTURE CONTENT %



PLAN
SCALE 20 10 0 20 40 FT.



PROFILE LINE 'M'
SCALE 20 10 0 20 40 FT.

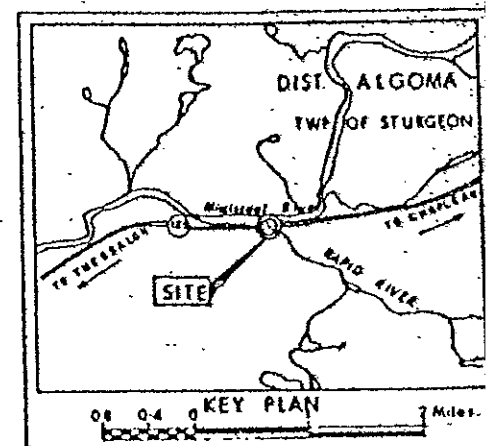
CONT No
WP No 14-74-07

RAPID RIVER

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

DOMINION SOIL INVESTIGATION INC.



LEGEND			
◆	Bore Hole		
⊕	Dynamic Cone Penetration Test (Cone)		
⊗	Bore Hole & Cone		
N	Blows/ft (Std Pen Test 350 ft lbs energy)		
CONE	Blows/ft (60° Cone, 350 ft lbs energy)		
W	WL at time of investigation June 1977		
No	ELEVATION	STATION	OFFSET
1	1049.3	259+90	5' LT.
2	1052.4	260+84	16' LT.

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



REVISIONS	DATE	BY	DESCRIPTION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

GEOPRES # 413-58

HWY No 129 LINE 'M' REVISION 1051 10

SUBMITTAL CHECKED DATE JUNE 12 1977 SITE 385-1

DRAWN BY L. A. MACGREGOR DWG 14740

Appendix D

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Piles	Drilled Shafts
Abutments	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. It may be difficult to form an undisturbed foundation subgrade due to the presence of cobbles and boulders ii. Erosion concerns may dictate placing the founding level below the scour level. iii. Deeper excavations required as a result of scour protection will be difficult to dewater and maintain in an undisturbed condition. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance may be developed by driving the piles into very dense soil. ii. Comparatively short abutment stem possible iii. Permits integral abutment design iv. Relatively short pile lengths required to reach bearing stratum. v. Readily permits founding below the scour depth <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. Potential difficulties and added costs associated with installation through very dense soil containing cobbles and boulders. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance is potentially available using deep shafts <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher costs compared to spread footings. Probably higher costs compared to driven piles. ii. Difficulties advancing through very dense sand and gravel containing cobbles and boulders. iii. High risk of not being able to maintain undisturbed shaft walls and base below the groundwater level. iv. An integral abutment design is not an available option v. It may be necessary to place concrete by tremie methods.
	NOT RECOMMENDED	RECOMMENDED	NOT RECOMMENDED

Appendix E

Special Provisions, NSSP, etc.

The following have been referenced in the report:

SP 105S10

SP 902S01

SP 903S01

SS 103-11

OPSS 1010

OPSD 3101.150

OPSD 3101.200

OPSD 3102.100

If rock fill is allowed as backfill behind the abutments, the contract package must include a note on the drawings, or an NSSP, that limits the maximum size of rock fill used to material not exceeding 150 mm.

Appendix F

Site Photographs

Rapid River Bridge Replacement
Highway 129, Algoma



Photo 1. Looking south from Rapid River Bridge.



Photo 2. Looking north from Rapid River Bridge. Lost Lumber Road on right just below signs at start of guiderail.

Rapid River Bridge Replacement
Highway 129, Algoma



Photo 3. Existing Rapid River Bridge from the northwest. Old south abutment at right.



Photo 4. Old north abutment from earlier bridge west of existing bridge.

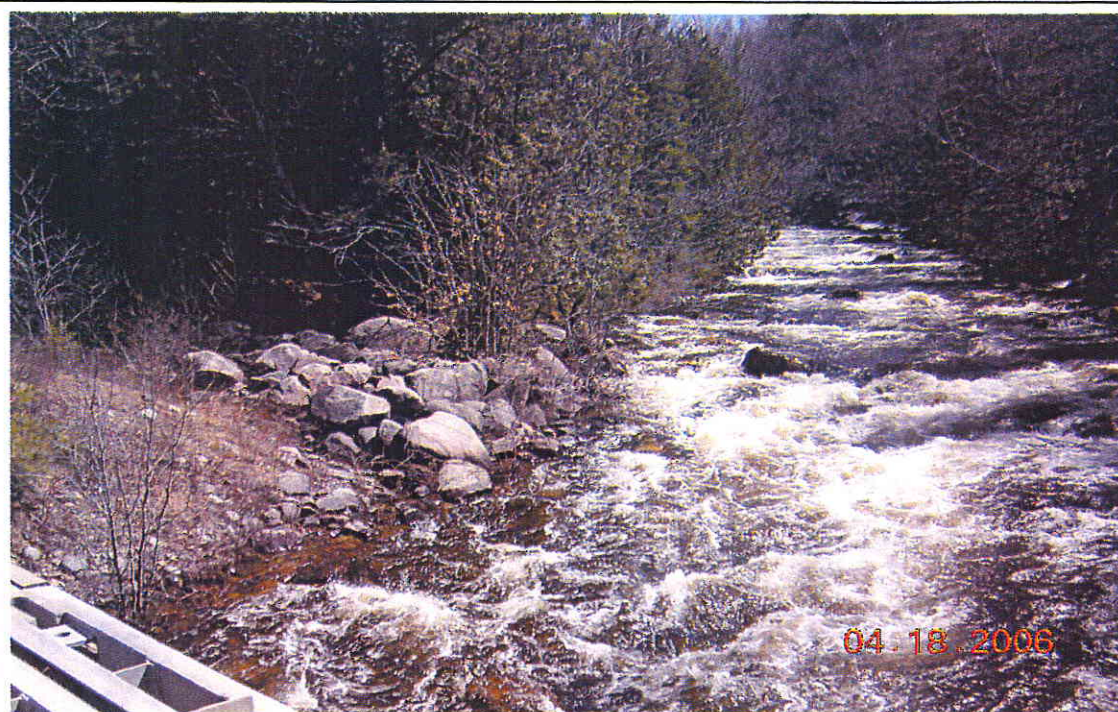


Photo 5. Rapid River upstream, to the east, of the existing bridge.



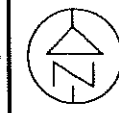
Photo 6. Soil exposure immediately north of the bridge site, east side of Hwy 129.

Appendix G

Drawings

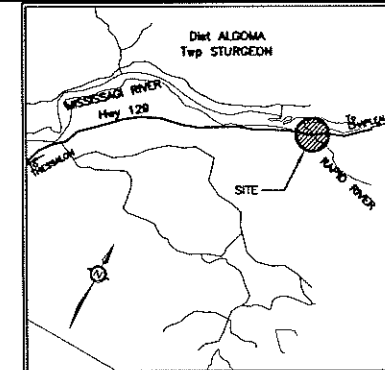
METRIC
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No 512-00-00
GWP No



SHEET

RAPID RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATION PLAN



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

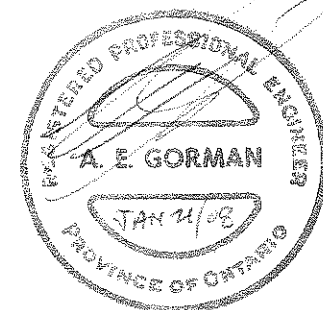
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07-RR2	320.36	5 178 397.6	350 919.2
07-RR3	320.44	5 178 383.0	350 905.5
07-RR4	320.74	5 178 392.5	350 922.1
07-RR5	320.60	5 178 369.2	350 910.6
07-RR6	320.30	5 178 381.3	350 933.0
07-RR7	317.50	5 178 274.2	350 729.2
07-RR8	317.80	5 178 302.1	350 773.0
07-RR9	319.40	5 178 325.1	350 816.4
07-RR10	320.00	5 178 345.7	350 861.8
07-RR11	321.50	5 178 395.7	350 948.3
07-RR12	322.40	5 178 407.1	350 999.3
07-RR13	321.30	5 178 446.3	351 034.2
07-RR14	320.20	5 178 460.1	351 084.9
07-RR15	319.86	5 178 367.5	350 916.5
07-RR16	321.12	5 178 387.2	350 932.6
07-RR17	320.34	5 178 363.5	350 897.8
07-RR18	321.12	5 178 392.5	350 946.4

-NOTES-

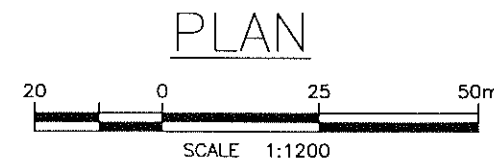
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

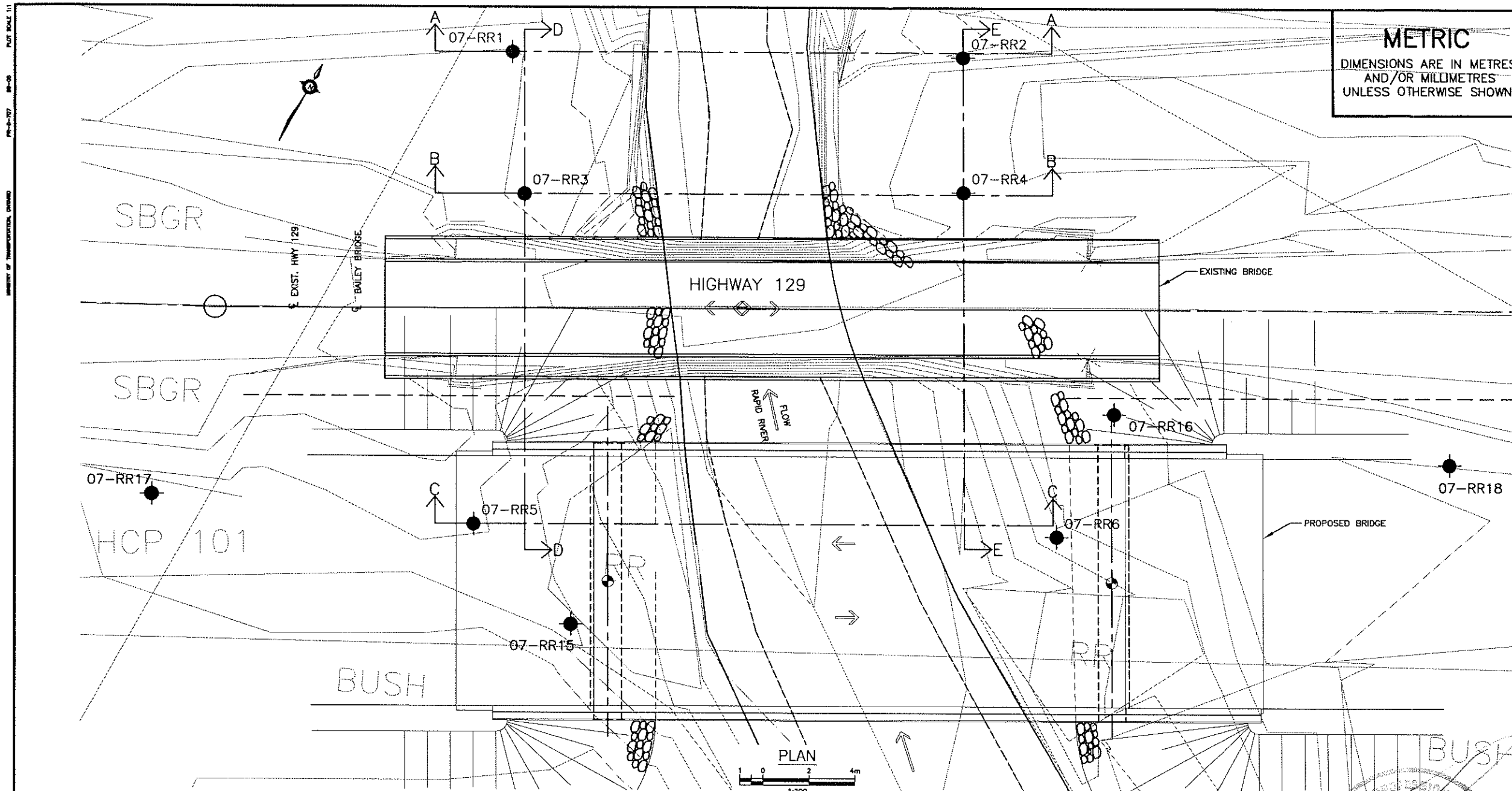
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DRAWN	MFA	CHK PKC	SITE
LOAD			
STRUCT			
DWG			



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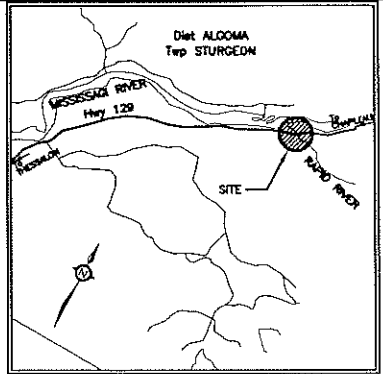
CONT No
GWP No.5321-04-00

RAPID RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATION PLAN AND SOIL
STRATA

Marshall Macklin Monaghan
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

SHEET



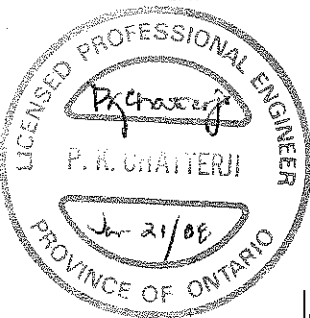
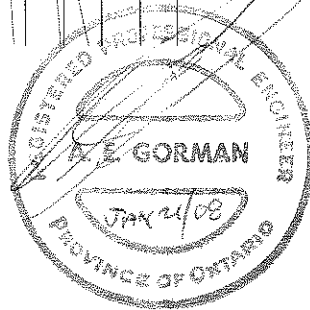
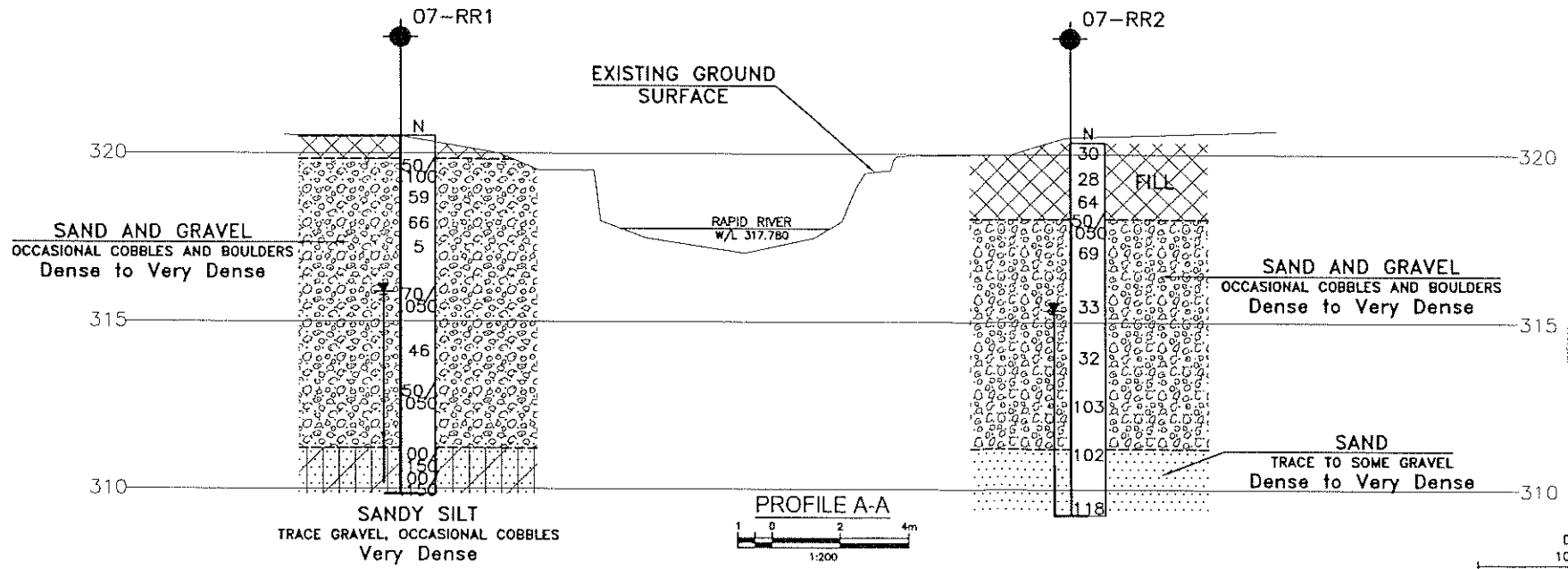
KEYPLAN
LEGEND

- 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
07-RR1	320.51	5 178 388.1	350 902.0
07-RR2	320.36	5 178 397.6	350 919.2
07-RR3	320.44	5 178 383.0	350 905.5
07-RR4	320.74	5 178 392.5	350 922.1
07-RR5	320.60	5 178 369.2	350 910.6
07-RR6	320.30	5 178 381.3	350 933.0
07-RR15	319.86	5 178 367.5	350 916.5
07-RR16	321.12	5 178 387.2	350 932.6
07-RR17	320.34	5 178 363.5	350 897.8
07-RR18	321.12	5 178 392.5	350 946.4

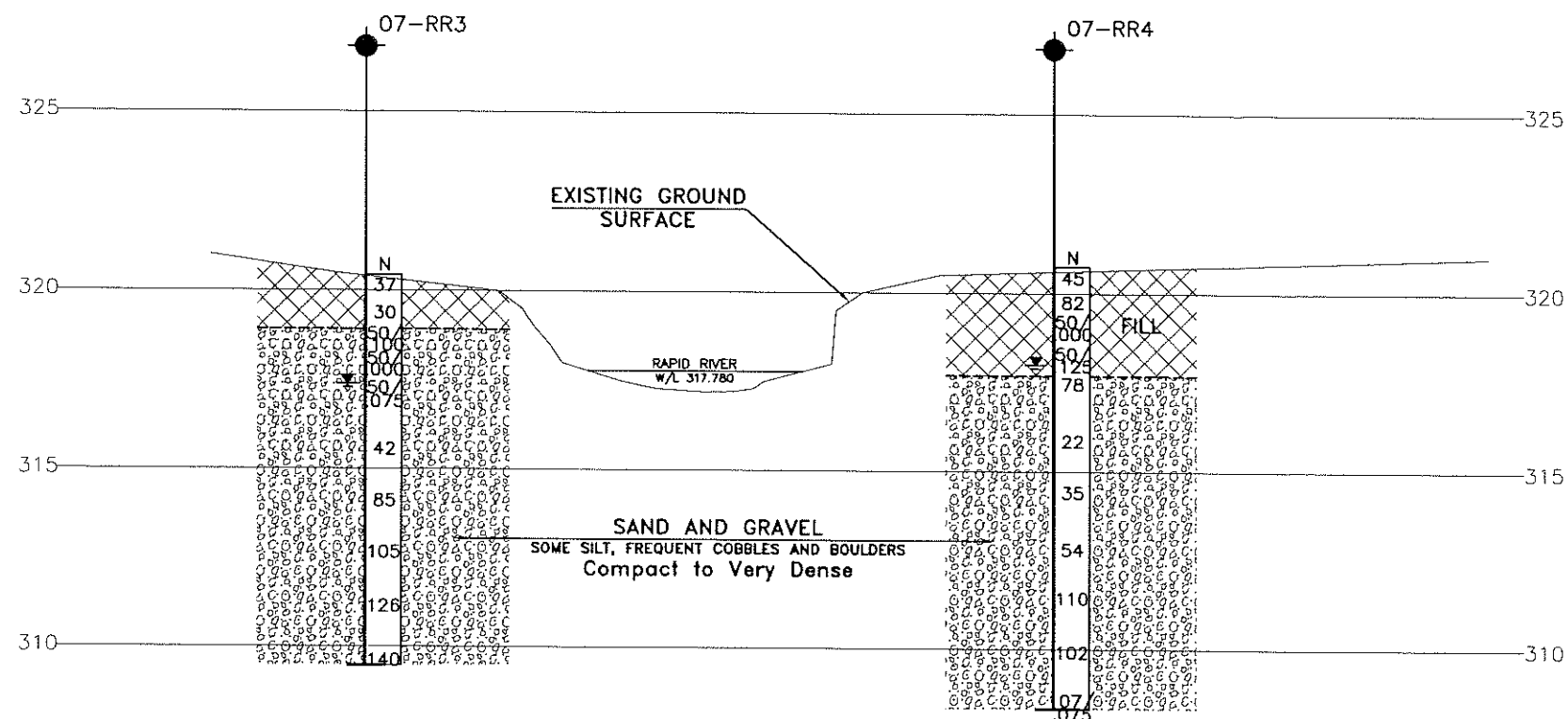
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GEOCREs No. 41J-74



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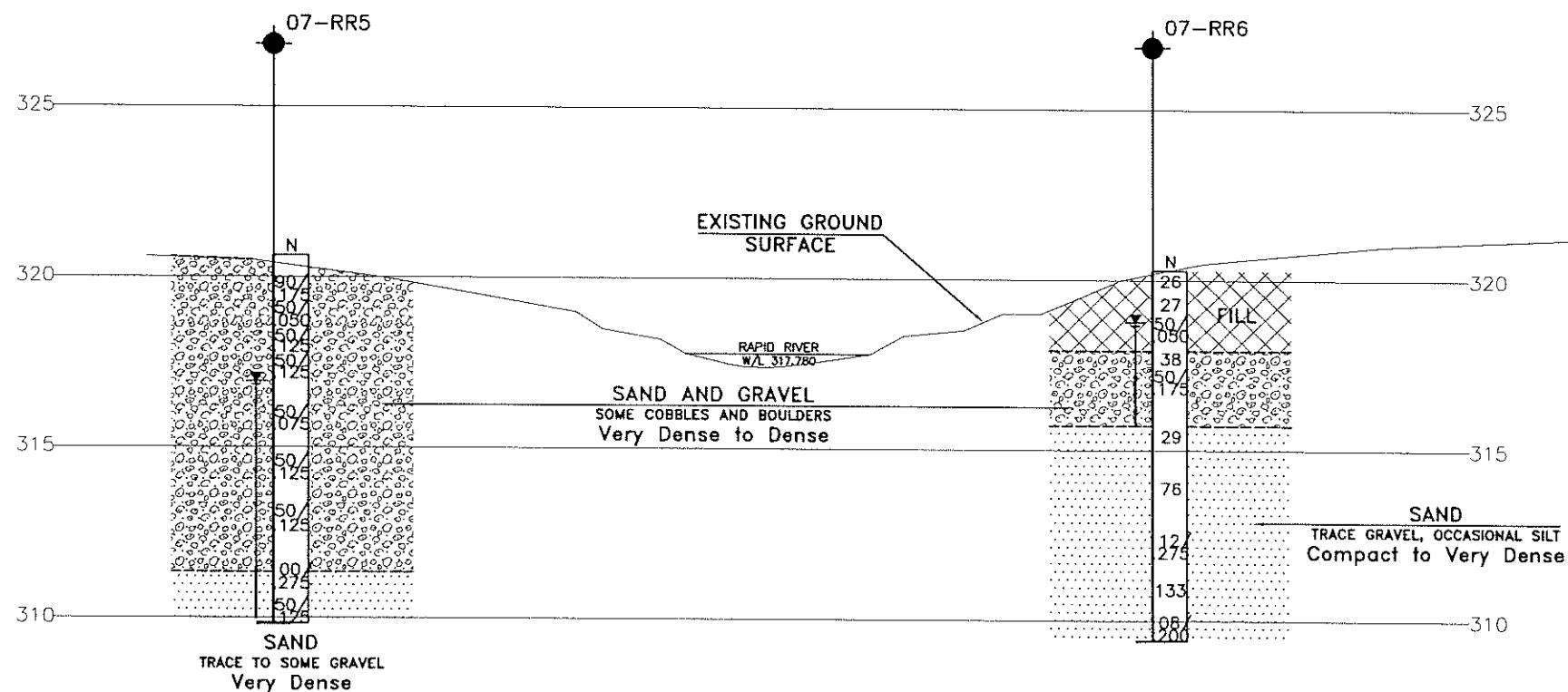
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DESIGN	AEG	CHK PKC	CODE
DRAWN	MFA	CHK PKC	SITE 385-013
			STRUCT
			DATE MAR 2007
			DWG



PROFILE B-B

1 0 2 4m

1:200



PROFILE C-C

1 0 2 4m

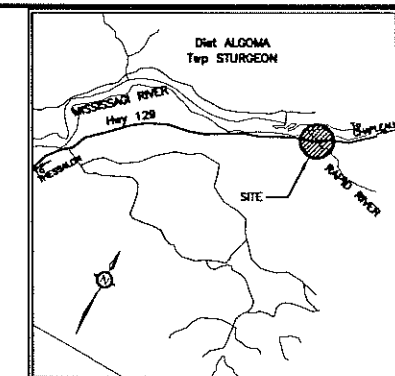
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No.5321-04-00






RAPID RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATION PLAN 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 |
|  | Water Level |
|  | Head Artesian Water |
|  | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

NO	ELEVATION	NORTHING	EASTING
07-RR1	320.51	5 178 388.1	350 902.0
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07-RR3	320.44	5 178 383.0	350 905.5
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07-RR15	319.86	5 178 367.5	350 916.5
07-RR16	321.12	5 178 387.2	350 932.6
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07-RR18	321.12	5 178 392.5	350 946.4

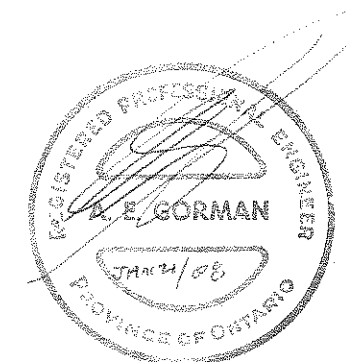
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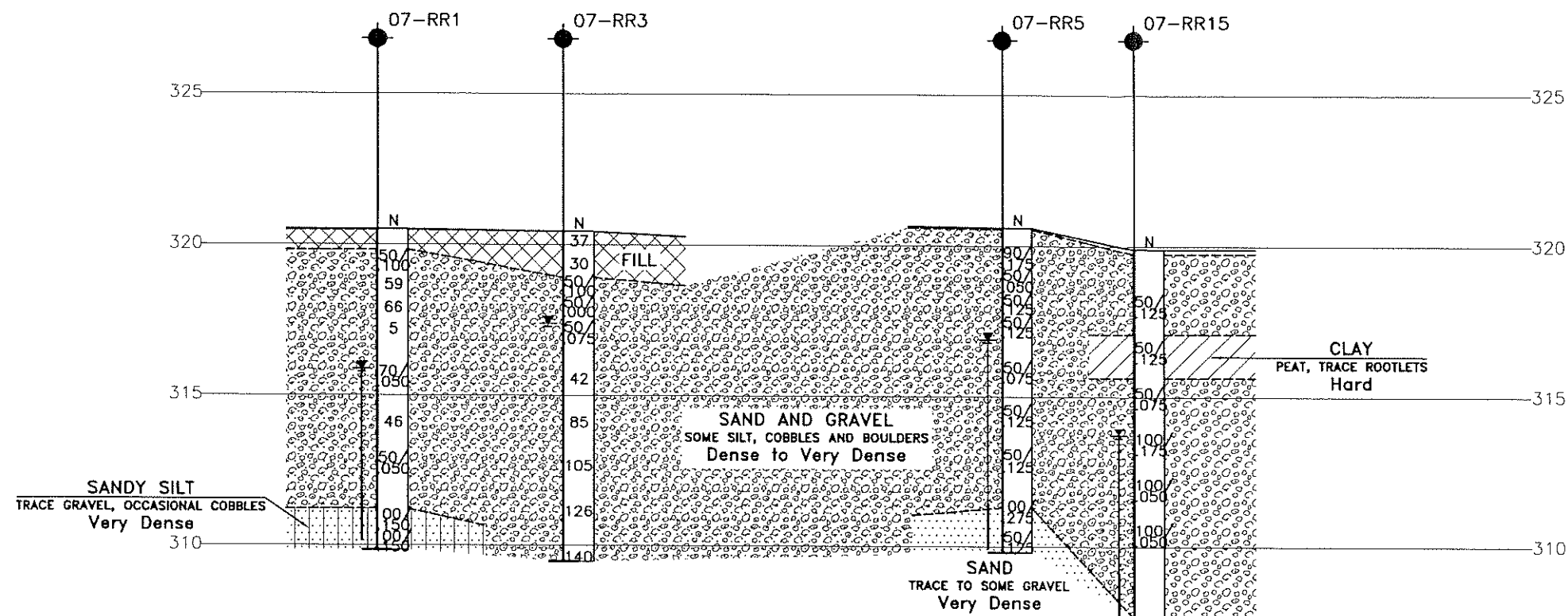
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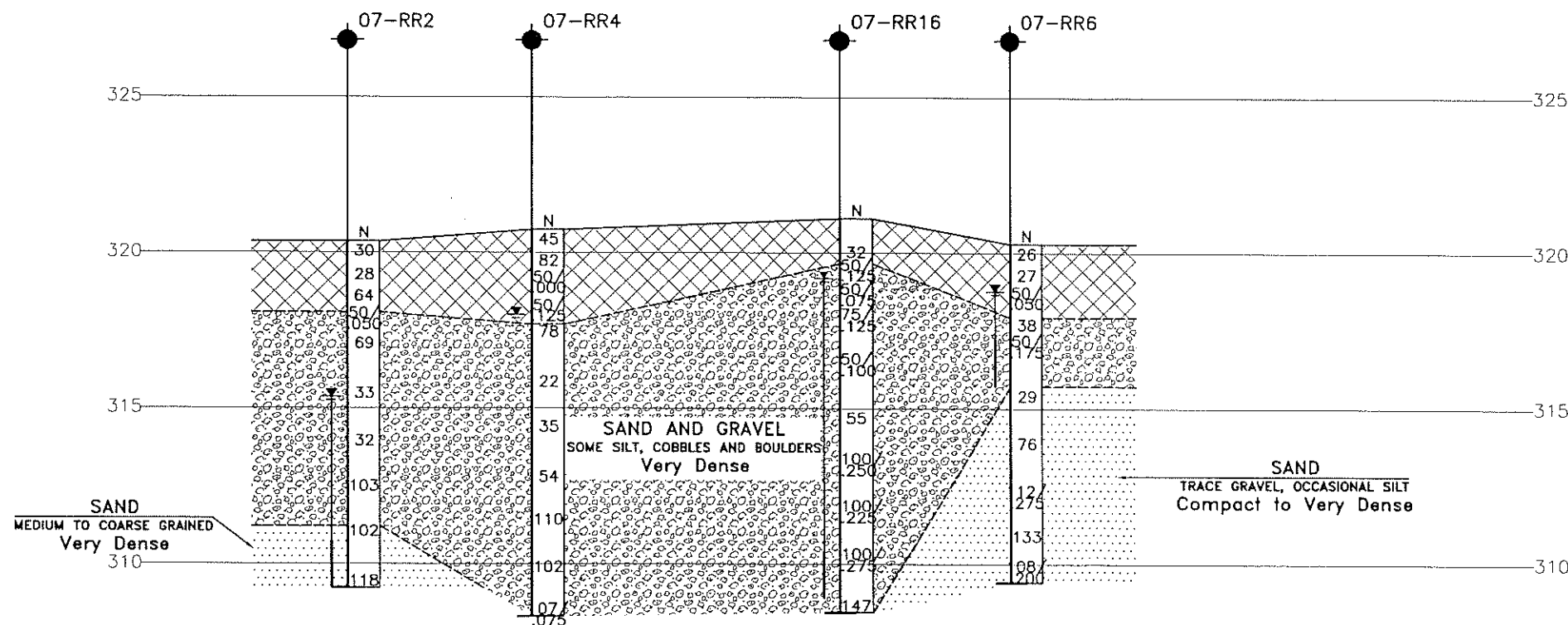
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SECTION D-D
1:200



SECTION E-E
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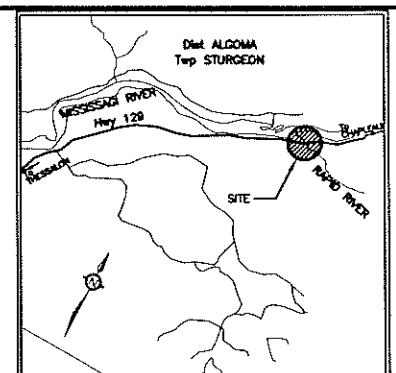
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No.5321-04-00



RAPID RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATION PLAN AND SOIL
STRATA

SHEET



KEYPLAN
LEGEND

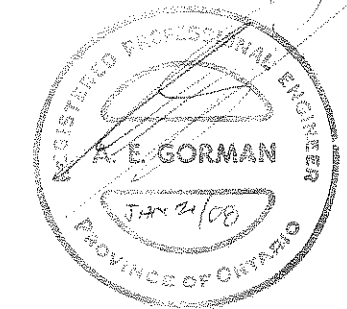
- BoreHole
- BoreHole and Cone
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GEOCREs No. 41J-74



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

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			DATE MAR 2007
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