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**Environmental
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Suite 200
2781 Lancaster Road
Ottawa ON
Canada K1B 1A7

Bus 613 738 0708
Fax 613 738 0721

www.jacqueswhitford.com



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FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 177-98-00

Highway 630
Amable du Fond River Bridge
Replacement – North Channel
Township of Calvin

McCormick Rankin Corporation

PROJECT NO. 1042746
SITE NO. 43-085
GEOCRES NO. 31L-125

PROJECT NO. 1042746

FOUNDATION INVESTIGATION AND DESIGN REPORT

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

ON Highway 630
Amable du Fond River Bridge
Replacement – North Channel
Site 43-085
Township of Calvin
GWP 177-98-00

August 2009

Jacques Whitford Stantec Limited
2781 Lancaster Road
Suite 200
Ottawa, Ontario
K1B 1A7

Phone: 613-738-0708
Fax: 613-738-0721
www.jacqueswhitford.com



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FOUNDATION INVESTIGATION REPORT

For

G.W.P 177-98-00

Highway 630 – Amable du Fond River Bridge Replacement
North Channel – Site 43-085
Township of Calvin

1.0 INTRODUCTION

This report was prepared as part of the Total Project Management (TPM) assignment for the Detailed Design for the replacement of the existing Amable du Fond River Bridges (Sites 43-085 and 43-086) located on Highway 630, approximately 1.3 km south of Highway 17. The work is being carried out under G.W.P. 177-98-00.

The work was carried out in general accordance with Jacques Whitford Proposal No. 1036590 dated March 2008. Authorization to proceed was provided by the Ministry of Transportation of Ontario (MTO) under Agreement Number 5007-E-0014 with McCormick Rankin Corporation (MRC), the Detailed Design Consultant for this project.

This report has been prepared specifically and solely for the replacement of the North Channel Bridge described herein. It contains factual information pertaining to the subsurface conditions which was obtained as part of this investigation.

2.0 SITE DESCRIPTION AND GEOLOGY

Site Location

The site location is shown on the Key Plan inset to Drawing No. 1, provided in Appendix A. It is noted that for project orientation purposes, Highway 630 will be assumed to run north-south at the Amable du Fond River, with chainage increasing from south to north.

General Site Description

Within the project limits Highway 630 is classified as a two-lane Rural Collector Undivided (RCU) highway that runs from Highway 17 south to the Town of Kiosk at the northern boundary of Algonquin Park. The highway narrows to a single lane at the bridge crossings.



At the bridge sites, the Amable du Fond River is split into two channels separated by a rocky island. Two separate bridge structures are used to cross the river: one to span the North Channel and one to span the South Channel.

Existing North Channel Bridge

The existing North Channel Bridge consists of a single lane bridge with two spans: one span consisting of a steel girder structure and the other span consisting of a rigid concrete frame (see Photo 3 and Photo 5 in Appendix A). It is understood that the original plans for the structure date back to 1910 and that the current abutments and pier are the originals. The superstructure is understood to have been replaced in 1958. The existing embankment side slopes are up to 4 m high and are no steeper than 2H:1V.

River Conditions

At the proposed North Channel structure site, the Amable du Fond River flows from west to east. The observed water level at the time of the detailed design (2008) field investigation was approximately 172.4 m (geodetic). The water is generally swift and turbulent and rapids are present immediately upstream (see Photo 1 and Photo 5 in Appendix A). The high water level (50-year storm) is identified in the Structural Planning Report as being elevation 174.1 m Geodetic.

Physiographic Description

The project site is located within the Physiographic Region known as the Algonquin Highlands. The soils within this physiographic region are described as follows:

- The Algonquin Highlands region is characterized by rough rounded knobs and ridges with frequent outcrops of bare rock. Much of the area is underlain by granite and other hard Precambrian rocks. The overburden soils are generally shallow; however, the depth to bedrock varies greatly over short distances. Many of the valleys are floored with outwash sand and gravel. There are frequent swamps and bogs (Chapman and Putnam 1984).

Replacement Alignment

The replacement structure is to be constructed on a new alignment approximately 10 m to the east of the existing bridge.

Exposed bedrock is evident along the south shore of the North Channel within the area of the proposed new alignment (see Photo 1 and Photo 2 in Appendix A). The top of the rock is approximately 2 m below the top of the Highway 630 pavement profile and 4 m above the observed water level in the river. Loose rock and boulders are visible along the shore adjacent to the existing south bridge abutment.

At the north shore within the proposed alignment, cobbles and boulders are present along the shore and the side slopes around the existing abutment. Beyond the toe of the existing highway embankment, the ground slopes gently up to the north and down to the east. The gently sloping ground is only marginally higher than the observed water level in the river.

Brush is present throughout the proposed new alignment.

3.0 METHOD OF INVESTIGATION

3.1 Previous Investigations

A preliminary foundation investigation for the proposed North Channel Bridge Replacement was carried out in 2006 by Peto MacCallum Ltd.

Nine (9) test holes from that investigation are within the area of the proposed work and have therefore been incorporated into this detailed design report.

The test holes carried out by Peto MacCallum as part of the preliminary design investigation were identified as A-3 through A-11 and consisted of test pits dug with an excavator where overburden soil was present or simply documentation of the top of bedrock elevation at bedrock outcrop locations.

3.2 Drilling Investigation

The field investigation for the detailed design of the North Channel Bridge replacement consisted of seventeen (17) boreholes. The boreholes were designated BH08-15 to BH08-21, BH08-21A, BH08-22 to BH08-26, BH08-26A, BH08-27 to BH08-29.

The location of the preliminary investigation test holes was taken into account when selecting the new borehole locations. The locations of the boreholes from both the preliminary and detailed design investigations are shown on the Borehole Location Plan, Drawing No.1 in Appendix A.

Prior to carrying out the investigation, Jacques Whitford contacted the public utility authorities to clear the borehole locations of both private and public utilities.

The field drilling program was carried out between November 4th to 5th, 2008, and December 5th to 10th, 2008.

The boreholes were advanced using portable drilling equipment which consisted of a tripod with a one-third weight hammer for advancing split spoon samplers and an electric core drill for advancing casing and for coring the bedrock. The drilling equipment was owned and operated by

OGS Drilling Inc. of Almonte, Ontario. The standard penetration test (SPT) N-values reported on the borehole records have been divided by three to account for the one-third weight hammer.

The subsurface stratigraphy encountered in each borehole was recorded in the field by Mr. Andy O'Keefe, P.Eng., an experienced Jacques Whitford field engineer. Split spoon samples were collected on a continuous basis (every 600 mm) where sufficient depth of overburden soil was encountered. It is noted that sample recovery from the split spoon sampler was poor due to the generally shallow bedrock and presence of large gravel and cobbles within the overburden. Bedrock was cored with NQ and/or EQ size coring equipment. All soil samples recovered were stored in moisture-proof bags. Bedrock core samples were labeled and placed in cardboard core boxes. All samples recovered were returned to our Ottawa laboratory for detailed classification and testing.

Standpipes were installed in Boreholes BH08-19, BH08-21A and BH08-26A to allow for the measurement of groundwater levels. Groundwater levels were measured on December 10, 2008. The water level readings are provided on the Borehole Records in Appendix B and in Section 4.2.

3.3 Survey

Borehole locations were established in the field by Jacques Whitford personnel relative to the centerline of the proposed alignment. The ground surface elevation at each borehole location was surveyed by Jacques Whitford personnel with reference to MTO Geodetic Benchmark 808183. The benchmark is located near the proposed south abutment line as shown on Drawing 1 in Appendix A. The Geodetic elevation of the benchmark used for this survey was 176.478 m.

3.4 Laboratory Testing

All samples were taken to our Ottawa laboratory where they were subjected to detailed visual examination by a geotechnical engineer. Selected bedrock samples were tested for Unconfined Compressive Strength. Selected soil samples underwent gradation, Atterberg Limit and moisture content testing.

Two soil samples were submitted to Paracel Laboratories in Ottawa, Ontario, for determination of pH, chloride content, soluble sulphate content and resistivity. Due to the limited soil recovery from the split spoon sampler, one of the samples consisted of a bulk sample collected with a hand shovel at Station 10+020, 6.25 m right of centerline during the pavement investigation for this project.

Samples remaining after testing will be placed in storage for a period of three months after issuance of this report. After the storage period, the samples will be discarded unless we are directed otherwise by McCormick Rankin Corporation.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided.

Borehole Records from the preliminary foundation investigation report for this project have been included in this report for completeness.

In general, the subsurface profile consists of a fill or a thin topsoil layer, overlying silty sand with gravel.

Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawings No. 1 and No. 2 in Appendix A.

4.1.1 Fill

Boreholes 08-18 and 08-26 were advanced through the side of the existing embankment slope on the northeast side of the existing bridge.

The thickness of the fill was 1.2 m and 0.9 m in Boreholes 08-18 and 08-26, respectively. The base of the fill was at elevation 174.2 m and 173.2 m in Boreholes 08-18 and 08-26, respectively.

The fill generally consisted of intermediate plasticity clay with occasional rock fragments. The clay fill was mottled with different shades of brown and was qualitatively described as firm to stiff. Cobbles and boulders were present at the surface of the fill and may be present within the fill.

The SPT 'N' values within the fill ranged from 3 to 10.

The moisture contents of the two samples of fill tested were 31% and 34%. The results of Atterberg limit testing on one sample indicated a liquid limit of 48 and a plasticity index of 25, which corresponds to a clay of intermediate plasticity (CI in the MTO Soil Classification System). A hydrometer analysis of the same clay fill sample indicated that it contained 7% sand, 33% silt and 60% clay sized particles. The gradation results are provided on Figure 2 in Appendix B and the Atterberg limit results are plotted on the plasticity chart on Figure 3 in Appendix B.

4.1.2 Topsoil/Rootmat

A layer of poor quality topsoil and/or rootmat was encountered at surface in about half of the boreholes where overburden soil was present. Topsoil/rootmat, 100 mm in thickness, was also observed beneath the fill in Borehole BH 08-26. Where encountered, the thickness of the topsoil/rootmat ranged from 100 to 300 mm with an average thickness of approximately 140 mm.

4.1.3 Silty Sand with Gravel

A thin deposit of silty sand with gravel was observed directly above the bedrock in eleven of the boreholes drilled as part of the detailed design investigation. Cobbles and boulders were observed at surface where the silty sand with gravel deposit was close to the shore of the Amable du Fond River. The thickness of the deposit, where observed, ranged from 0.2 m to 1.4 m with an average of 0.6 m. The base of the unit varied from elevation 171.1 m to 176.3 m (geodetic). SPT 'N' values ranged from 4 to 53, indicating that the deposit varies from a loose to dense state. Due to the limited thickness of the unit, SPT refusal on the underlying bedrock was frequently encountered.

The results of a grain size analyses indicate that the deposit contained 26% gravel, 52% sand and 22% fines. The gradation results are provided on Figure 1 in Appendix B. This material is an SM soil using the MTO Soil Classification System. The moisture content of the tested sample was 15%.

Thin deposits of granular material were also identified directly over the bedrock in two of the test pits excavated during the Preliminary Investigation. A 400 mm thick deposit of cobbles and boulders, some sand, trace silt was identified at Borehole A-3 and a 300 mm thick deposit of sand and gravel with boulders, trace silt was identified in Borehole A-4.

4.1.4 Bedrock

Four of the boreholes (two at each foundation unit) were advanced into the bedrock by coring. The rest of the boreholes were terminated at the bedrock surface as determined based on SPT refusal or based on visual observation of the bedrock surface. The depth to bedrock and bedrock elevation at the borehole locations is summarized in Table 4.1.

Table 4.1: Depth to Bedrock And Bedrock Elevation Summary

Borehole No.	Ground Surface Elevation (m)	Depth to Bedrock (m)	Bedrock Surface Elevation (m)	Comments
BH08-15	176.6	1.2	175.4	Split spoon refusal
BH08-16	176.0	0.4	175.6	Split spoon refusal
BH08-17	175.2	0.0	175.2	Rock Outcrop
BH08-18	175.4	1.2	174.2	Split spoon refusal
BH08-19	172.7	0.4	172.3	Proven by coring
BH08-20	172.5	1.4	171.1	Split spoon refusal
BH08-21	174.5	0.0	174.5	Rock Outcrop
BH08-21A	176.7	0.4	176.3	Proven by coring
BH08-23	175.3	0.3	175.0	Proven by coring
BH08-24	173.8	0.1	173.7	Split spoon Refusal
BH08-25	174.2	1.0	173.2	Split spoon refusal
BH08-26	174.1	1.4	172.7	Split spoon refusal
BH08-26A	173.1	0.4	172.7	Proven by coring
BH08-27	172.5	0.2	172.3	Split spoon refusal
BH08-28	172.7	0.8	171.9	Split spoon refusal
BH08-29	173.1	1.4	171.7	Split spoon refusal
A-3	172.3	0.4	171.9	Excavator Refusal
A-4	172.3	0.6	171.7	Excavator Refusal
A-5	175.5	0.0	175.5	Rock Outcrop
A-6	176.5	0.0	176.5	Rock Outcrop
A-7	176.2	0.0	176.2	Rock Outcrop
A-8	176.7	0.0	176.7	Rock Outcrop
A-9	177.2	0.0	177.2	Rock Outcrop
A-10	176.2	0.0	176.2	Rock Outcrop
A-11	177.6	0.0	177.6	Rock Outcrop

Boreholes 08-21A and 08-23 at the south foundation and 08-19 and 08-26A at the north foundation unit were advanced 1.8 m to 5.8 m into the bedrock by coring with NQ-size and EQ-size coring equipment. The core recovery was between 29% and 100 % (average = 89%). The rock quality designation (RQD) ranged from 0 % to 92% (average = 42%), indicating very poor to excellent rock mass quality. Voids were noted while coring the upper metre of bedrock in Borehole 08-26A (above elevation 171.87 m). Total core recovery within this zone was 71%. Voids were also identified within the upper 3.3 m (above elevation 173.0 m) in Borehole 08-21A. The total core recovery within this zone ranged from 29% to 100%.

The recovered rock core consisted of pinkish grey granite with grey/black gneiss partings. The rock ranged from slightly weathered to unweathered.

Joint spacing ranged from very close to moderate with dipping orientation typically ranging from 20 to 50 degrees from horizontal with the exception of the bedrock at Borehole 08-23 which had a flat orientation.

A detailed description of the rock cores is provided in the Field Core Logs in Appendix B. Selected photos of the recovered rock core are provided in Appendix C.

Unconfined compressive strength tests were carried out on four bedrock core samples taken from Borehole 08-19. Table 4.2 below summarizes the results of these tests.

Table 4.2: Unconfined Compressive Strength of Bedrock

Borehole No.	Ground Surface Elevation (m)	Test Elevation (m)	Unconfined Compressive Strength (MPa)
BH08-19	172.7	172.3	270
BH08-19	172.7	171.6	263
BH08-19	172.7	171.1	247
BH08-19	172.7	170.6	172

The average unconfined compressive strength for the four samples tested was 248 MPa. Based on the results of the unconfined compressive tests the rock strength of bedrock was determined to range between very strong and extremely strong.

4.2 Groundwater

Groundwater levels were measured in the standpipes installed during the investigation on December 10, 2008. The water levels ranged from 0.1 m to 3.8 m below ground surface (elevation 172.6 m to 173.0 m). Individual groundwater level readings are shown in Table 4.3 below.

Table 4.3: Summary of Groundwater Level Readings

Borehole No.	Location	Ground Surface Elevation (m)	Groundwater	
			Depth (m)	Elevation (m)
BH08-19	North Abutment	172.7	0.1	172.6
BH08-21A	South Abutment	176.7	3.8	172.9
BH08-26A	North Abutment	173.1	0.1	173.0

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

5.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Yours very truly,

JACQUES WHITFORD LIMITED



Paul Carnaffan, M.Eng., P.Eng.
Associate & Senior Geotechnical Engineer



Fred J. Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact



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FOUNDATION DESIGN REPORT

For

G.W.P 177-98-00

Highway 630 North Channel Bridge Crossing
of the Amable du Fond River

Site 43-085
Township of Calvin Ontario

6.0 DISCUSSION

6.1 Proposed Development

It is understood that the Ministry of Transportation of Ontario plans to replace the existing North Channel Bridge Crossing of the Amable du Fond River (Site 43-085).

The new structure will be constructed on a new alignment situated approximately 10 m east of, and parallel to the existing structure. The profile will be up to 1.0 m higher than the existing highway to provide the required navigational clearance under the structure and to improve the vertical alignment of the highway.

The preliminary general arrangement drawing indicates that the replacement structure will consist of a pre-cast concrete arch with a span of 28.65 m and rise of 3.66 m. It is proposed to support the arch on spread footings founded at approximately elevation 172.4 m geodetic.

A Retained Soil System (RSS) will be used to retain the soil between the top of the arch and the top of pavement. The top of pavement elevation is to be 177.900 m at the south end of the proposed structure and 178.046 m at the north end of the structure. The RSS will also extend back from the arch structure and tie-in to the highway embankment in place of wing walls.

The approach embankments will be 4 m and 5 m above the existing grades along the proposed realignment on the south and north sides of the structure respectively.

Due to property constraints on the east side of the proposed new alignment, embankment slopes steeper than 2H:1V may be required.

It is understood that the foundation loads for the proposed arch structure are approximately as follows:

Table 6.1: Foundation Loads for Arch Structures

Component	Horizontal Load (kN/m)	Vertical Load (kN/m)
Self Weight	337	174
Cover (600 mm)	732	576
Live Load	471	217

A typical arch structure will generate a portion of its load carrying resistance from passive earth pressure from the backfill soil. As indicated in Table 6.1, significant horizontal loads will be transmitted to the foundations. Foundation resistance to horizontal loads may be developed through sliding resistance, passive earth pressure, or by the addition of rock anchors/shear bolts.

6.2 Soil Summary

In general, the subsurface profile at this site consisted of shallow bedrock overlain by thin layers of topsoil/rootmat, clay fill and silty sand with gravel. The maximum thickness of overburden soil encountered in the twenty-six test holes was 1.4 m.

6.3 Foundation Options – Arch Structure

The following table compares the available foundation options considered for the structure on the new alignment:

Table 6.2: Foundation Comparison for Replacement Structure

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
Spread Footings Directly on Bedrock	<ul style="list-style-type: none">• moderate to high geotechnical resistance	<ul style="list-style-type: none">• clean/level bedrock base required	Low	<ul style="list-style-type: none">▪ excavation below waterline / dewatering required
Spread Footings on Concrete Pad	<ul style="list-style-type: none">• moderate to high geotechnical resistance• offers clean/level base to place forms and reinforcing steel	<ul style="list-style-type: none">• requires over-excavation of bedrock• requires additional excavation below water level	Low	<ul style="list-style-type: none">▪ excavation below waterline / do work in the wet

Bedrock is generally present at or above the proposed founding elevation. Due to the shallow bedrock conditions, deep foundations are not considered practical or cost effective. Spread footings directly on bedrock or on mass concrete over bedrock are recommended for the support of the proposed arch structure. The use of mass concrete is practical only where the bedrock surface is lower than the proposed founding elevation.

7.0 RECOMMENDATIONS

The design recommendations presented in the sections that follow have been developed in accordance with the requirements and methods described in the Canadian Highway Bridge Design Code, 2006 Edition (CHBDC).

7.1 Foundations

Shallow foundations should be supported on clean and level bedrock or mass concrete over clean bedrock. The bedrock elevations at the foundation locations are as follows:

South Foundation 174.5 m to 175.6 m

North Foundation 172.3 m to 173.2 m

Based on the proposed founding elevation of 172.4 m, 2 m to 3 m of rock excavation is anticipated at the south foundation. The requirements at the north foundation vary from needing 100 mm of mass concrete to build up the grades to requiring up to about 1 m of rock excavation. Since it is unlikely that a flat excavation base will be achieved due to the inclination of natural fractures in the bedrock, it is likely that some over-excavation will occur and need to be corrected with mass concrete.

Bearing Resistance

The design parameters in Table 7.1 may be used for shallow foundations bearing on clean level bedrock or mass concrete over clean bedrock.

Table 7.1: Geotechnical Resistance for Shallow Foundations on Rock

Founding Elevation	Footing Width	Factored Geotechnical Resistance at ULS ⁽¹⁾ (kPa)	Geotechnical Reaction at SLS ⁽²⁾ (kPa)
At or below 172.5 m	1.0 m to 3.0 m	3,000	N/A
<p>Notes:</p> <p>1) The factored geotechnical resistance at ULS provided above is for vertical loads and does not take into account the effects of inclined loads.</p> <p>2) N/A = Not Applicable. Negligible settlement is expected for footings founded on the bedrock. The rock mass is generally considered unyielding under the anticipated loads and therefore SLS does not apply.</p>			

The factored geotechnical bearing resistance at ultimate limit states (ULS) incorporates a resistance factor of 0.5 and takes into account the variability in the rock quality designation observed in the boreholes.

Where applicable, the effects of eccentric loading should be accounted for in accordance with the CHBDC Section 6.7.3 when proportioning the footing.

Sliding Resistance

The sliding resistance of poured concrete footings on clean bedrock may be calculated using an unfactored friction coefficient of 0.7.

The sliding resistance can be increased, if required, by providing vertical shear bolts or by providing pre-stressed rock anchors to increase the normal stress acting on the sliding surface. Rock anchors should be designed and constructed in accordance with SP No. 999S26.

The following parameters may be used for design purposes:

- Unfactored (ultimate) bond stress of 2,500 kPa between the bedrock and grout (to be confirmed with Test Anchors)
- A resistance factor of 0.4 as per CHBDC Table 6.1 (Static Analysis – Tension)
- A minimum bond length of 3 m

The anchors must be designed as permanent anchors with appropriate corrosion protection. Mechanical and resin cartridge anchors are not considered appropriate for this site and application.

The effects of shear on the anchors should be taken into consideration in the design.

7.2 Earth Pressure Design

The specific material to be used for backfill of the pre-cast concrete arch and RSS walls will depend on proprietary aspects of the system selected by the successful contractor, but will most likely consist of OPSS Granular A or Granular B. In addition, the earth pressure distribution acting on both the pre-cast arch structure and RSS walls will depend on proprietary design details, geometry and assumptions.

In general, computation of earth pressures should be in accordance with Section 6.9 of the CHBDC. For structures that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design.

For a structure with a vertical wall and horizontal backfill, the unfactored soil parameters provided in Table 7.2 may be used for design.

Table 7.2: Recommended Lateral Earth Pressure Parameters

Parameter	OPSS Granular A and Granular B Type II	OPSS Granular B, Type I and III
Total Unit Weight, γ (kN/m ³)	22.8	21.2
Effective Friction Angle	35°	32°
Coefficient of Active Earth Pressure (K_a)	0.27	0.31
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.47
Coefficient of Passive Earth Pressure (K_p)	3.69	3.3

The coefficients of earth pressure provided in Table 7.2 are not directly applicable to the pre-cast arch structure, as the vertical wall assumption is not valid; however, the total unit weight and effective friction angle of the backfill materials may be used in a soil structure interaction model.

The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6.6 of the CHBDC.

Compaction of the granular backfill near structures should be carried out using hand-operated equipment to prevent over-stressing the wall structures.

The earth pressure parameters in Table 7.2 may also be used to calculate horizontal resistance of the foundations.

7.3 Seismic Design Considerations

7.3.1 Zonal Acceleration Ratio

Table A3.1.1 of the CHBDC indicates that the Zonal Acceleration Ratio for Mattawa, which is approximately 10 km east of the site, is 0.15. Reference is made to Section C4.6.4 of the CHBDC for the calculation of seismic forces on abutments and retaining walls. A seismic hazard calculation for the site was obtained from Natural Resources Canada (copy provided in Appendix C). It indicates that for this site, the peak ground acceleration (PGA) value corresponding to a 10% probability of exceedance in 50 years is 0.115.

7.3.2 Soil Profile Type

It is recommended that Soil Profile 1 as defined in CHBDC Section 4.4.6 be used in the seismic design of this site.

7.3.3 Liquefaction of Foundation Soils

Liquefaction is not a design concern for the proposed North Channel crossing structure since the structure will be founded on bedrock and the embankment constructed as described herein.

7.3.4 Seismic Forces on Wall Structures

Earth retaining structures should be designed to resist the earth pressures produced under earthquake conditions. CHBDC Clause 4.6.4 recommends the use of the combined coefficients of static and seismic earth pressure, referred to as K_{AE} for active conditions and K_{PE} for passive conditions, for routine design purposes

The total active and passive thrusts can be calculated using the following equations:

- $P_{AE} = \frac{1}{2} K_{AE} \gamma H^2$
- $P_{PE} = \frac{1}{2} K_{PE} \gamma H^2$

where;

- K_{AE} = active earth pressure coefficient (combined static and seismic)
- K_{PE} = passive earth pressure coefficient (combined static and seismic)
- k_h = horizontal acceleration coefficient
- k_v = vertical acceleration coefficient

For this site, the following design parameters were used to develop the recommended K_{AE} and K_{PE} values.

- | | |
|--|-------|
| ▪ Zonal Acceleration Ratio, A | 0.115 |
| ▪ Horizontal Acceleration Coefficient, k_h | 0.058 |
| ▪ Vertical Acceleration Coefficient, k_v | 0.038 |
| ▪ Horizontal Backslope to retaining wall | |
| ▪ Vertical back of wall | |

The above k_h value corresponds to $\frac{1}{2}$ of the A value, and the k_v value corresponds to 0.67 of the k_h value. The angle of friction between the soil and the wall has been set at 0° to provide a conservative estimate.

Table 7.3: Combined Static and Seismic Coefficients of Earth Pressures Parameters

Parameter	OPSS Granular A or Granular B Type II	OPSS Granular B, Type I or III
Bulk Unit Weight, γ (kN/m ³)	22.8	21.2
Effective Friction Angle, ϕ'	35°	32°
Angle of Internal Friction between wall and backfill	0°	0°
Active Earth Pressure (K_{AE})	0.30	0.34
Height of Application of P_{AE} from base as a ratio of wall height (H)	0.353	0.351
Passive Earth Pressure (K_{PE})	3.69	3.25
Height of Application of P_{PE} from base as a ratio of wall height (H)	0.314	0.313

It is noted that the combined coefficients of static and seismic earth pressure presented in Table 7.3 deviate only slightly from the static coefficients presented in Table 7.2. This is due to the low zonal acceleration ratio at this site.

7.4 Retained Soil System (RSS)

A Retained Soil System (RSS) is proposed to contain the soil between the top of the pavement structure and the top of the concrete arch structure. The RSS will extend back into the approach embankments, effectively serving as wing walls.

Retained soils systems are available through the Ministry Designated Sources List. The Retained Soil System (RSS) should be tendered with the following attributes:

Application: Wall

Note: The MTO RSS Design Guidelines recommend specifying the False Abutment application for RSS adjacent to bridges (e.g. wing walls) due to better performance. Accordingly, the attributes for high performance and high appearance have been recommended below.

Geometry: Vertical (GV) 90°

Performance: High

Appearance: High

Site Specific Geotechnical Considerations

At the south end of the structure, bedrock is shallow and rock excavation will be required to construct the structure foundation and RSS at the elevations shown on the Preliminary General Arrangement drawing. It is anticipated that the RSS will be constructed on a leveling pad directly over bedrock. Therefore, settlement and global stability of the RSS at this location are not a concern. Some internal settlement of the RSS backfill should be expected but should occur during the construction period. Post construction settlement should be negligible. The factored bearing resistance at ULS for the RSS founded on bedrock or mass concrete over bedrock will be 3000 kPa.

At the north end of the structure, bedrock is shallow at the arch structure foundation and slopes up gradually to the north. The existing ground conditions beneath the RSS alignments include bedrock, silty sand with gravel and existing embankment fill. It is anticipated that the RSS will be constructed on concrete leveling pads on bedrock or structural fill. The structural fill may be underlain by thin deposits (<750 mm) of native silty sand with gravel near the outer ends where the RSS height is the least. It is anticipated that settlement of the soils beneath the RSS on the north side will range from 0 to 10 mm. It is anticipated that this settlement will occur quickly and will be virtually complete by the end of construction. Global stability and settlement of the RSS is not a concern due to the shallow bedrock conditions. The factored bearing resistance at ULS for the RSS founded on bedrock or mass concrete over bedrock will be 3,000 kPa. The factored bearing resistance at ULS for the RSS founded on structural fill over bedrock or structural fill over native silty sand with gravel will be at least 200 kPa, assuming a minimum width of 1.0 m and minimum embedment of 0.8 m. The actual bearing resistance will depend on the final design geometry.

It is understood that some problems with cracking of facing panels due to differential settlement have been experienced on past projects where RSS have been founded on a combination of rock and earth subgrades. This concern should be addressed by the specification of high performance and appearance, however, a conservative approach would be to found all RSS at this site on the bedrock or mass concrete over bedrock. This approach does not represent significant additional work or cost since the RSS only extends approximately 3 m back behind the foundations.

The minimum soil cover to the underside of the concrete leveling pad should be 800 mm.

The unit weight and effective friction angles provided in Section 7.2 may be used for design of the RSS.

7.5 Embankment Design

Although the current General Arrangement Drawing indicates 2H:1V embankment slopes, it is understood that steeper slopes may be desirable to address property constraint issues. The following embankment side slope geometries are feasible for slopes less than 6 m in height:

- No steeper than 1.25H:1V for rock fill embankments constructed above the high water line
- No steeper than 1.5H:1V for rock fill embankments that extend below the high water line
- No steeper than 2H:1V for embankments constructed of OPSS Granular A or Granular B, Type I, II or III.

Settlement of the underlying soil is expected to be less than 10 mm since the embankments will be constructed over bedrock or a thin layer of granular soil over bedrock. Due to the non-cohesive nature of these materials, it is anticipated that settlement will occur rapidly. Post construction settlements of the underlying soils will be less than 5 mm. Self settlement of the embankment fill of up to 15 mm will occur. This settlement will be complete at the completion of construction.

7.6 Excavation Unwatering

The proposed founding elevation corresponds with the water level observed in the Amable du Fond River adjacent to the proposed North Channel structure in October 2008 and is up to 600 mm below the water levels measured in the standpipes in December 2008.

Excavation unwatering may be required depending on the groundwater and river water levels at the time of construction. Ideally, foundation work should be scheduled to coincide with low water levels.

If river levels are higher than base of excavation level at the time of foundation construction, a cofferdam would be required to prevent river water from flooding the excavation. Even with a cofferdam in place, significant water inflow to the excavation would be expected due to the fractured nature of the bedrock. This would require placement of concrete in the wet using tremie techniques or grouting of the fractures in the rock mass to limit the amount of water inflow. An NSSP is recommended to red-flag the highly permeable nature of the fractured bedrock to the contractor.

Control of surface water that enters excavations due to precipitation or run-off can be controlled using conventional sump pumps.

7.7 Erosion Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. Rock protection should be provided on the embankment slopes to a minimum of 300 mm above the design flood elevation. This should provide adequate scour protection.

At other locations, normal slope vegetation should be established as soon as possible after completion of the embankment fills in order to control surficial erosion.

The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site.

7.8 Frost Protection

The design frost penetration depth at this site is 2.0 m. Foundations on soil should be provided with 2.0 m of earth cover or equivalent insulation for frost protection.

Frost protection for footings founded directly on unweathered bedrock need only be half of that recommended for footings on soils.

The minimum soil cover for RSS is typically 40% of the standard frost penetration depth or 800 mm, whichever is greater. In this case, both are equal to 800 mm. A greater soil cover requirement may be identified by individual RSS suppliers.

Where construction is undertaken during winter conditions, footing subgrades must be protected from freezing. In addition, extra diligence is required to ensure that fill materials do not include frozen material, snow or ice.

7.9 Other Construction Considerations

7.9.1 Site Grading and Preparation

The excavation and preparation of the subgrade surface beneath the arch structure foundations and RSS should be carried out in accordance with SP No. 902S01.

Due to the inclination of fractures and discontinuities in the bedrock, some over-excavation of the bedrock should be anticipated when attempting to create an excavation with a near horizontal base and near vertical walls. In addition, some large, displaced blocks of bedrock were evident along the shore of the South Channel and may be present (but partially obscured by

vegetation along the North Channel. All displaced rock blocks should be removed from beneath the foundations.

Portions of the RSS may be constructed over earth subgrades. In these areas, all organic soils, existing fill, boulders and other deleterious materials must be removed from beneath the RSS. Where deleterious materials are encountered, the material should be excavated and replaced. The lateral extent of such excavation should include all deleterious material within the influence zone of the RSS foundation. The influence zone includes all materials below an imaginary line drawn at an angle of 1 horizontal to 1 vertical downward and away from the vertical edges of the RSS.

Surficial vegetation, rootmat and topsoil should be removed beneath the approach embankments. Stripping of deleterious materials should be inspected by geotechnical personnel to ensure that all unsuitable materials are removed prior to placement of embankment fill. Embankment construction should be carried out in accordance with OPSS 206.

7.9.2 Excavation

Side slopes for open cut excavations should conform to the requirements of the Occupational Health and Safety Act and Regulations for Construction Projects (OHSA).

The overburden soil at this site should be considered as a Type 3 soil in accordance with the definitions in OHSA where they exist above the river water level. Above the river and ground water level, temporary cut slopes deeper than 1.2 m should be no steeper than 1 horizontal to 1 vertical from the base of the excavation. Under submerged conditions, the overburden is likely to behave as a Type 4 soil and excavation support of side slopes flatter than 3H:1V would be required to permit worker entry into the excavation.

Excavations in bedrock can be made with near vertical walls provided all loose rock in the wall of the excavation is removed prior to worker entry. Due to the inclination of natural fractures in the rock and the fractured nature of the upper bedrock, the excavation walls should be inspected to ensure that there are no unstable blocks of rock in the rock face.

The appropriate methods of rock excavation will depend on the planned excavation limits. The highly fractured rock could be excavated using line drilling and mechanical rock breakers, however, drilling and blasting will be required to excavate the relatively sound bedrock due to the very high strength of the intact rock.

Encroachment of excavations into the forward and side slopes of the existing structure will require special attention. Excavations are not expected to extend within the influence zone of the foundations for the

existing bridge structure which appears to be founded on bedrock. Excavations to allow for construction of the west side of the bridge foundations and RSS will encroach within the existing side slopes of the existing embankment based on the current General Arrangement plan. In these cases, excavations will require a Roadway Protection System meeting the requirements of Performance Level 2 as per OPSS 539 and should consider sloping backfill and traffic loading.

Installation of roadway protection systems may be challenging owing to the presence of cobbles and boulders, as well as the presence of shallow bedrock. Piles installed into rock sockets could be used in conjunction with timber lagging. Alternatively, the horizontal resistance could be achieved with an anchoring system.

7.10 Cement Type and Corrosion Potential

Two samples of the native soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The testing was completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The results of the analysis are summarized in the Table 7.4.

Table 7.4: Results of Chemical Analysis

Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
08-26 SS1	0.75	7.63	11	9	75
Bulk Sample 10+020 6.2 m Rt	0.15	4.61	<5	<5	450

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The soluble sulphate results ranged from less than 5 to 9 µg/g. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in the Table 8.4 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

8.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

This report has been prepared by Paul Carnaffan and reviewed by Fred Griffiths.

Respectfully submitted,

JACQUES WHITFORD LIMITED



Paul Carnaffan, M.Eng., P.Eng.
Associate & Senior Geotechnical Engineer



Fred J. Griffiths, Ph.D., P.Eng.
Designated Principal MTO Foundation Contact



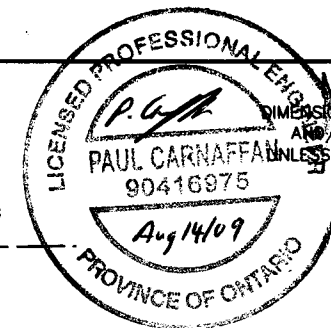
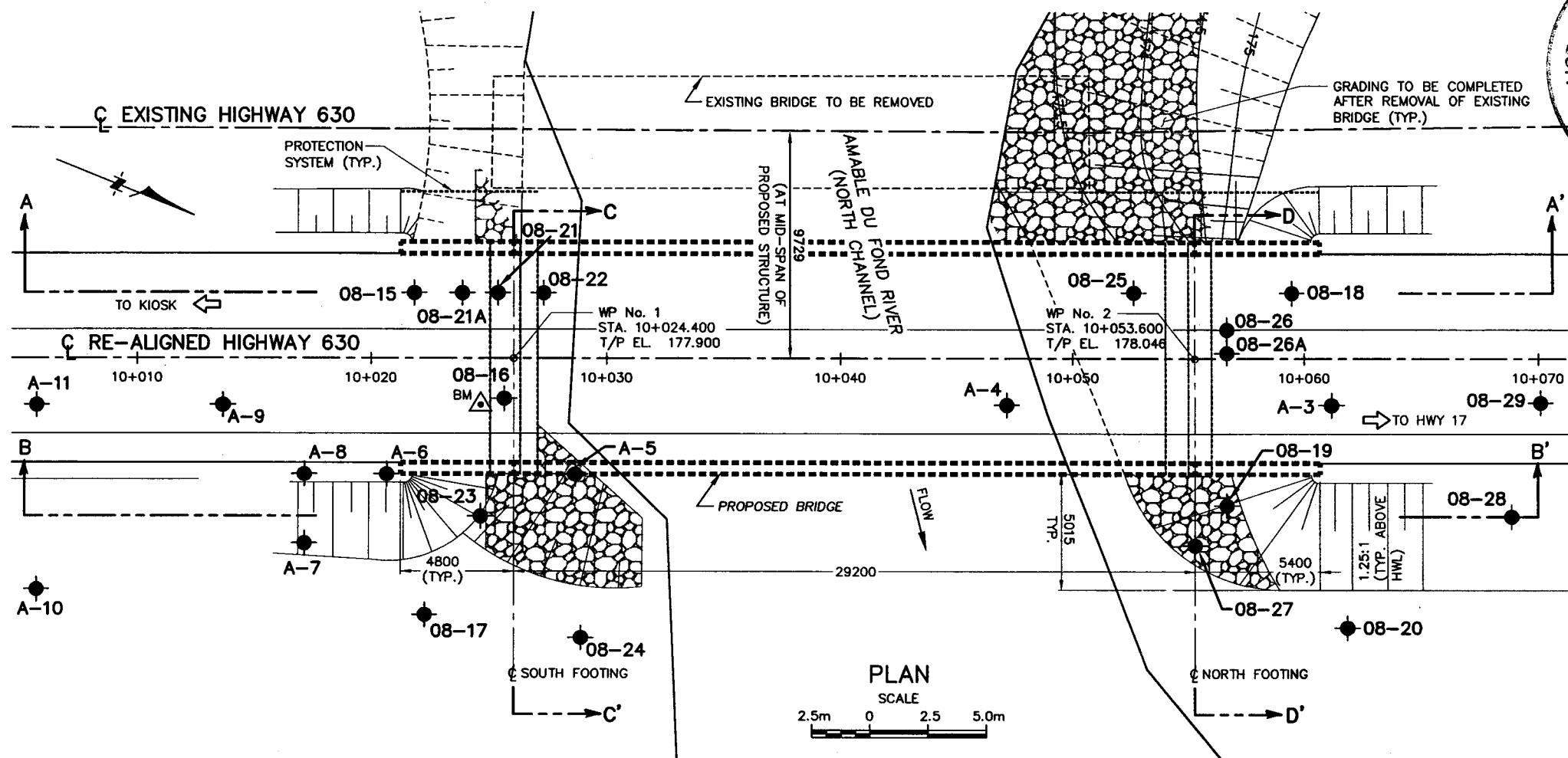
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APPENDIX A

Drawing No. 1 – Borehole Location Plan and Stratigraphic
Section

Drawing No. 2 – Stratigraphic Sections
Site Photographs

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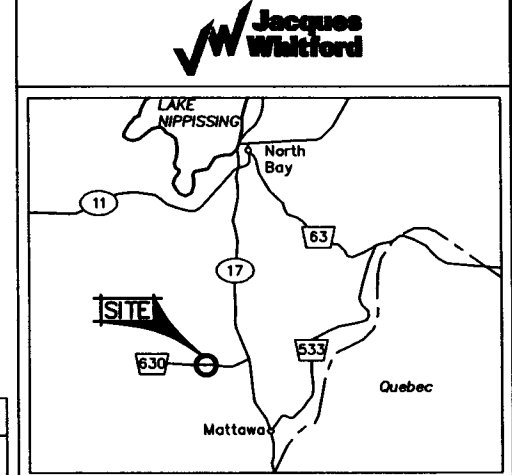
LEGEND	
●	Borehole
N	Blows/0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
↓	WL at time of investigation Oct 2008
⊥	WL in Piezometer
⊥	Piezometer
%	Rock Quality Designation (RQD)
(m SOUTH)	Offset from Cross-Section Line
BM	Benchmark #808183 Geodetic Elevation = 176.478 m

CONT No -
WP No 177-98-00

AMABLE DU FOND RIVER
HWY 630 NORTH CHANNEL

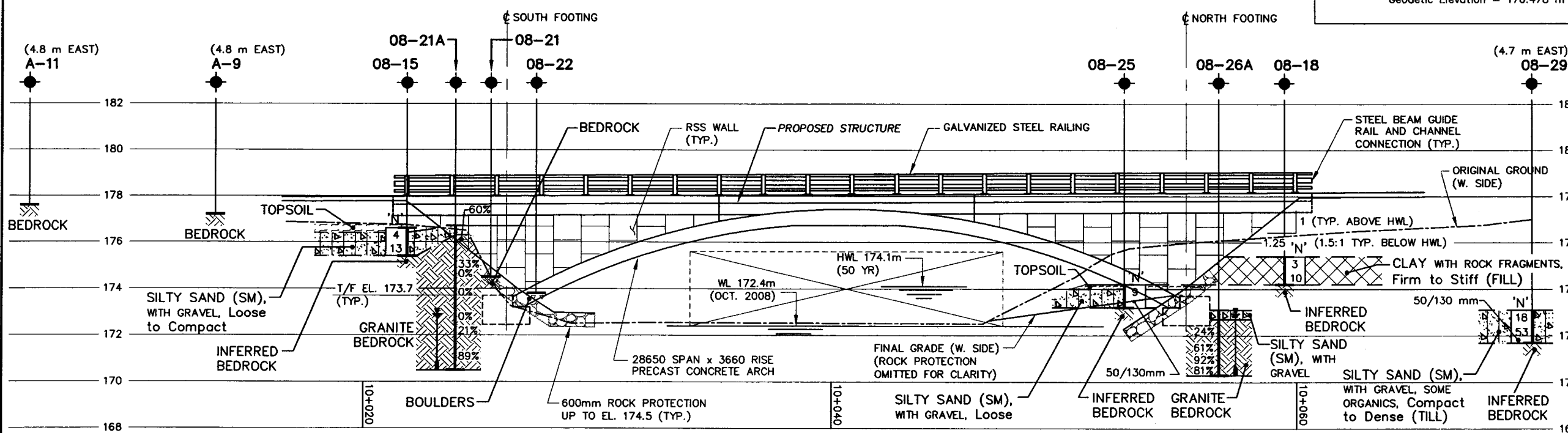
BOREHOLE LOCATIONS & SOIL STRATA

SHEET -

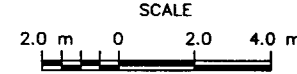


KEY PLAN
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No	ELEVATION	COORDINATES	
		NORTH	EAST
08-15	176.6	5 126 190.7	349 769.0
08-16	176.0	5 126 195.9	349 771.9
08-17	175.2	5 126 196.2	349 781.8
08-18	175.4	5 126 225.6	349 755.1
08-19	172.7	5 126 226.4	349 764.7
08-20	172.5	5 126 233.2	349 767.7
08-21	174.5	5 126 194.0	349 767.8
08-21A	176.7	5 126 192.6	349 768.3
08-22	173.8	5 126 195.7	349 767.0
08-23	175.3	5 126 196.9	349 777.0
08-24	173.8	5 126 202.7	349 780.3
08-25	174.2	5 126 219.2	349 757.6
08-26	174.1	5 126 223.6	349 757.6
08-26A	173.1	5 126 223.9	349 758.5
08-27	172.5	5 126 225.7	349 766.8
08-28	172.7	5 126 237.9	349 760.6
08-29	173.1	5 126 237.2	349 755.5
A-3	172.3	5 126 229.0	349 759.0
A-4	172.3	5 126 216.0	349 764.2
A-5	175.5	5 126 199.9	349 773.8
A-6	176.5	5 126 192.5	349 776.8
A-7	176.2	5 126 190.3	349 780.9
A-8	176.7	5 126 189.2	349 778.1
A-9	177.2	5 126 184.8	349 776.6
A-10	179.2	5 126 180.4	349 787.0
A-11	177.6	5 126 177.4	349 779.6



CROSS-SECTION A-A'



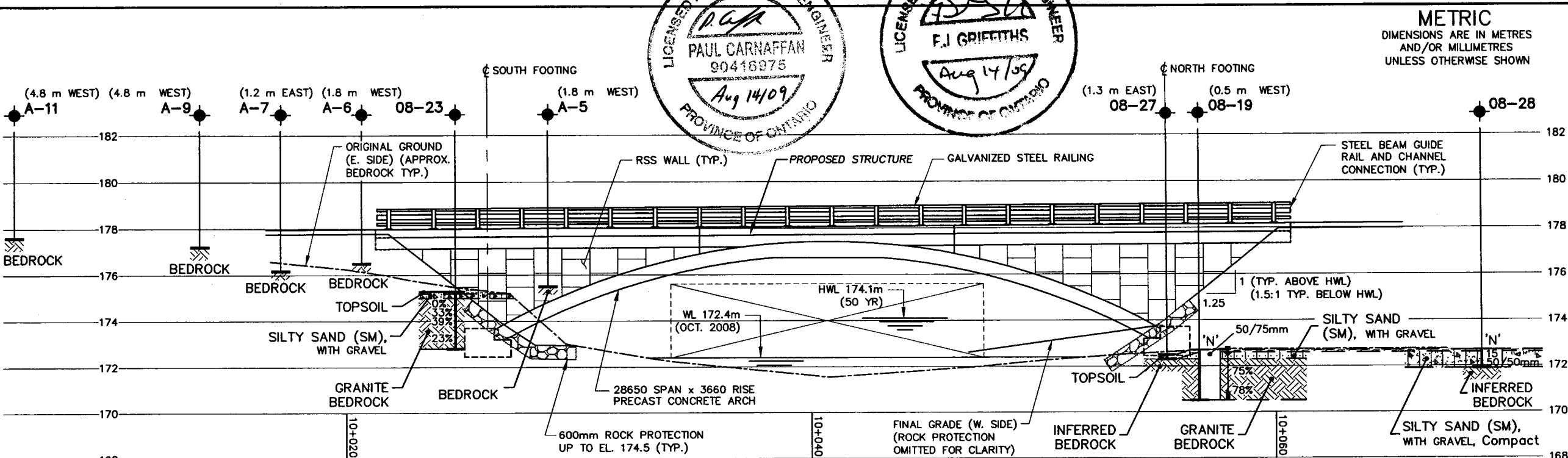
NOTE
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

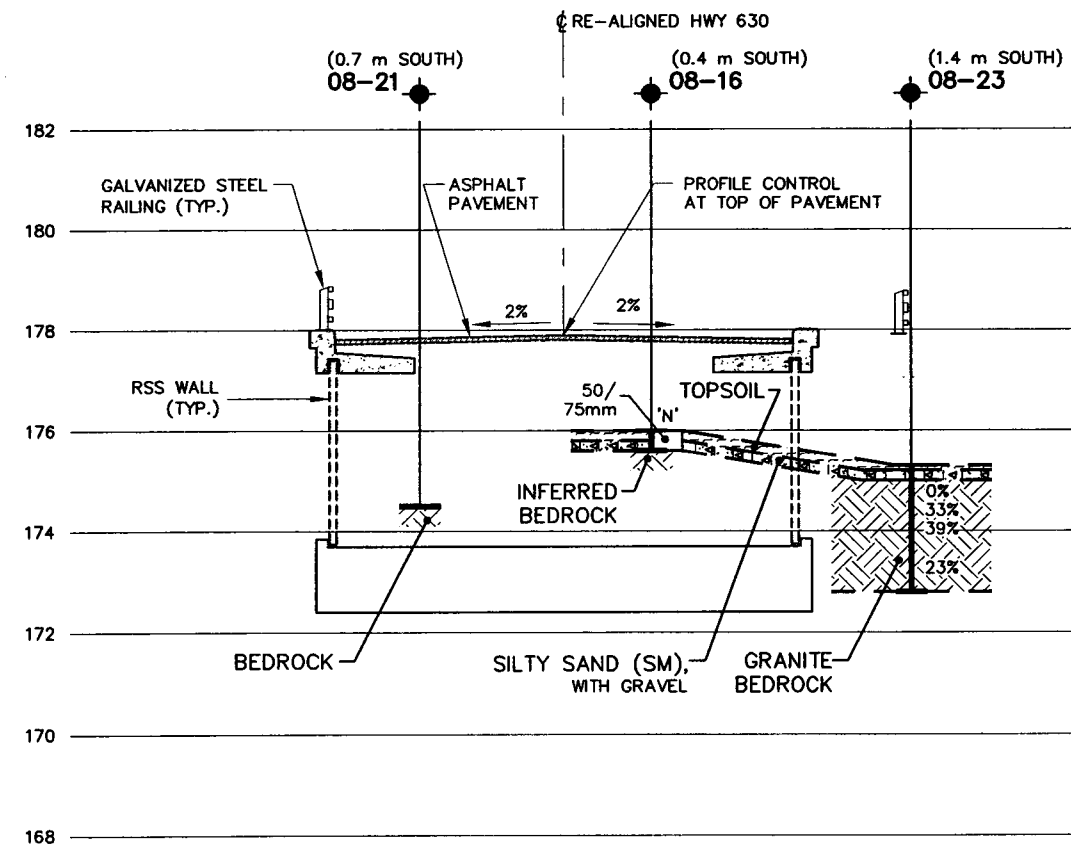
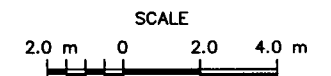
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DRAWN GBB	CHECKED	DATE 2009-08-13	CHECKED	SITE 43-085	DWG 1

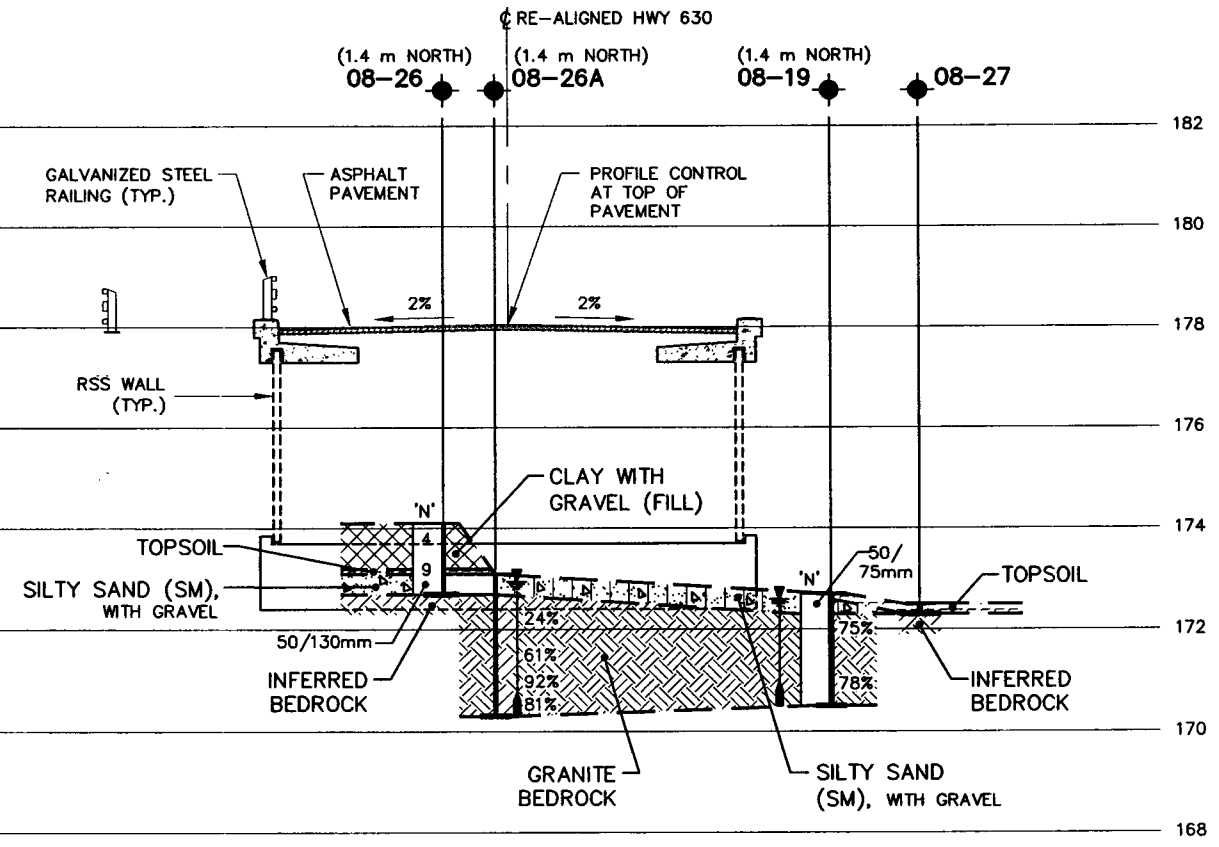
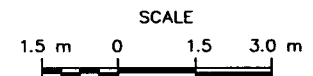
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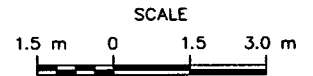
CROSS-SECTION B-B'



CROSS SECTION C-C'



CROSS SECTION D-D'



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CONT No -
WP No 177-98-00

AMABLE DU FOND RIVER
HWY 630 NORTH CHANNEL

BOREHOLE LOCATIONS & SOIL STRATA

Jacques Whitford

LEGEND

- Borehole
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- WL at time of investigation Oct 2008
- WL in Piezometer
- Piezometer
- % Rock Quality Designation (RQD)

(m SOUTH) Offset from Cross-Section Line

No	ELEVATION	COORDINATES	
		NORTH	EAST
08-15	176.6	5 126 190.7	349 769.0
08-16	176.0	5 126 195.9	349 771.9
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A-6	176.5	5 126 192.5	349 776.8
A-7	176.2	5 126 190.3	349 780.9
A-8	176.7	5 126 189.2	349 778.1
A-9	177.2	5 126 184.8	349 776.6
A-10	179.2	5 126 180.4	349 787.0
A-11	177.6	5 126 177.4	349 779.6

NOTE: The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 152-2 of Form 100.

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Photo 1: General view of south shore of North Channel.



Photo 2: Exposed bedrock at south shore of North Channel.



Photo 3: General view of north shore of North Channel.



Photo 4: Approximate location of new bridge foundation at north shore of North Channel.



Photo 5: North Channel – view upstream along north shore.

A vertical dashed line on the left side of the page, consisting of a series of short horizontal black bars separated by gaps.

APPENDIX B

Symbols and Terms Used on Borehole and Test Pit Records

Borehole Records

Field Core Log Records

Laboratory Test Results

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index). A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
<i>Very Soft</i>	<0.25	<12.5
<i>Soft</i>	0.25 - 0.5	12.5 - 25
<i>Firm</i>	0.5 - 1.0	25 - 50
<i>Stiff</i>	1.0 - 2.0	50 - 100
<i>Very Stiff</i>	2.0 - 4.0	100 - 200
<i>Hard</i>	>4.0	>200



ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	<i>Very Poor</i>
25-50	<i>Poor</i>
50-75	<i>Fair</i>
75-90	<i>Good</i>
90-100	<i>Excellent</i>

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	<i>Extremely Wide</i>	-
2000-6000	<i>Very Wide</i>	<i>Very Thick</i>
600-2000	<i>Wide</i>	<i>Thick</i>
200-600	<i>Moderate</i>	<i>Medium</i>
60-200	<i>Close</i>	<i>Thin</i>
20-60	<i>Very Close</i>	<i>Very Thin</i>
<20	<i>Extremely Close</i>	<i>Laminated</i>
<6	-	<i>Thinly Laminated</i>

Terminology describing rock strength:

Strength Classification	Unconfined Compressive Strength (MPa)
<i>Extremely Weak</i>	< 1
<i>Very Weak</i>	1 – 5
<i>Weak</i>	5 – 25
<i>Medium Strong</i>	25 – 50
<i>Strong</i>	50 – 100
<i>Very Strong</i>	100 – 250
<i>Extremely Strong</i>	> 250

Terminology describing rock weathering:

Term	Description
<i>Fresh</i>	No visible signs of rock weathering. Slight discolouration along major discontinuities
<i>Slightly Weathered</i>	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
<i>Moderately Weathered</i>	Less than half the rock is decomposed and/or disintegrated into soil.
<i>Highly Weathered</i>	More than half the rock is decomposed and/or disintegrated into soil.
<i>Completely Weathered</i>	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.



STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel



Sand



Silt



Clay



Organics



Asphalt



Concrete



Fill



Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



measured in standpipe, piezometer, or well



inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer



Stantec

RECORD OF BOREHOLE No BH 08-15

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126190.7 E349769.0 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC




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									
176.6	Grass																
0.0	Topsoil/Rootmat																
176.5																	
0.1	Silty sand with gravel (SM), loose to compact, brown		1	SS	4		176										
			2	SS	13												
175.4																	
1.2	End of Borehole																
	Splitspoon Refusal on Inferred Bedrock (50 blows/125 mm)																

RECORD OF BOREHOLE No BH 08-16

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126195.9 E349771.9 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

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									
176.0							20	40	60	80	100						
0.0	Topsoil/Rootmat					176											
175.9																	
0.2	Silty sand with gravel (SM), brown		1	SS	50/ 75mm												
175.7																	
0.4	End of Borehole Splitspoon Refusal on Inferred Bedrock																

RECORD OF BOREHOLE No BH 08-18

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126225.6 E349755.1 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

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						
175.4	Grass							20 40 60 80 100						
0.0	Clay (Cl) with rock fragments, firm to stiff, mottled brown (FILL)		1	SS	3		175	20 40 60 80 100				48		0 7 33 60
			2	SS	10									
174.2	End of Borehole													
1.2	Splitspoon Refusal on Inferred Bedrock (50 blows/100 mm)													

RECORD OF BOREHOLE No BH 08-19

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126226.4 E34976426 226 E: 349 765 ORIGINATED BY AO
DIST 54 HWY 630 BOREHOLE TYPE Splitspoons, NQ Coring Equipment COMPILED BY JF
DATUM Geodetic DATE 12.10.08 - 12.10.08 CHECKED BY PC

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									
							20	40	60	80	100						
172.7	Topsoil/Rootmat																
0.0 172.6	Silty sand with gravel (SM), brown		1	SS	50/75mm												
172.3	Pinkish grey granite BEDROCK with grey/black gneiss partings - good quality - unweathered - dipping orientation (20° to 50°) - close joint spacing - rough planar		2	NQ													
0.4																	
			3	NQ													
170.5	End of Borehole																
2.2	Standpipe Installed																

REC = 100%
RQD = 75%

REC = 100%
RQD = 78%

× 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 08-20

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126233.2 E349767.7 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

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									
172.5	Grass							20	40	60	80	100					
0.0	Topsoil/Rootmat																
172.3																	
0.2	Silty sand with gravel (SM), compact, brown		1	SS	24		172										
			2	SS	15												
171.1			3	SS	50/ 130mm												
1.4	End of Borehole Splitspoon Refusal on Inferred Bedrock																

× 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 08-21A

1 OF 2

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126192.6 E349768.3 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE NQ and EQ Coring Equipment COMPILED BY JF
 DATUM Geodetic DATE 12.8.08 - 12.10.08 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			20	40	60
176.7																	
0.0	Silty sand with gravel (SM), compact, brown																
176.3																	
0.4	Pinkish grey granite BEDROCK with grey/black gneiss partings - voids or soft areas noted to 3.7 m - fair to very poor quality - slightly weathered - dipping orientation (20° to 50°) - very close to close joint spacing - rough planar																
			1	NQ			176							REC = 95% RQD = 60%			
			2	NQ			175							REC = 100% RQD = 33%			
			3	NQ										REC = 70% RQD = 0%			
			4	NQ			174							REC = 29% RQD = 0%			
			5	EQ			173							REC = 94% RQD = 0%			
172.5																	
4.1	Pinkish grey granite BEDROCK with grey/black gneiss partings - very poor to good quality - unweathered - dipping orientation (20° to 50°) - moderate to close joint spacing - rough planar		6	EQ			172							REC = 89% RQD = 21%			

Continued Next Page

× 3, × 3

Numbers refer to
Sensitivity

○ 3%


STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 08-21A

2 OF 2

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126192.6 E349768.3 ORIGINATED BY AO
DIST 54 HWY 630 BOREHOLE TYPE NQ and EQ Coring Equipment COMPILED BY JF
DATUM Geodetic DATE 12.8.08 - 12.10.08 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L	kN/m ³	GR SA SI CL	
170.5	Pinkish grey granite BEDROCK with grey/black gneiss partings - very poor to good quality - unweathered - dipping orientation (20° to 50°) - moderate to close joint spacing - rough planar (continued)		7	EQ												REC = 98% ROD = 89%	
6.2	End of Borehole Standpipe Installed																

x³ x³ Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

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

 $\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 08-23

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126196.9 E349777.0 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE NQ Coring Equipment COMPILED BY JF
 DATUM Geodetic DATE 12.5.08 - 12.5.08 CHECKED BY PC

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									
175.3								20	40	60	80	100					
175.2	Topsoil/Rootmat		1	SS	150/ 75 mm												
0.1	Silty sand with gravel (SM), brown																
175.0							175										
0.3	Pinkish grey granite BEDROCK with grey/black gneiss partings - very poor to poor quality - unweathered - flat orientation - close joint spacing - rough planar		2	NQ													REC = 100% RQD = 0%
			3	NQ													REC = 83% RQD = 33%
			4	NQ			174										REC = 98% RQD = 39%
			5	NQ													REC = 98% RQD = 23%
							173										
172.8																	
2.5	End of Borehole																

RECORD OF BOREHOLE No BH 08-25

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126219.2 E349757.6 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

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									
174.2	Grass							20	40	60	80	100					
0.0	Topsoil/Rootmat																
174.1																	
0.2	Silty sand with gravel (SM), loose, brown		1	SS	9		174										
			2	SS	50/ 130mm												
173.2																	
1.0	End of Borehole Splitspoon Refusal on Inferred Bedrock																

RECORD OF BOREHOLE No BH 08-26

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126223.6 E349757.6 ORIGINATED BY AO
DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

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								
174.1	Grass							20	40	60	80	100				
0.0	Clay (CL) with gravel, brown (FILL)		1	SS	4		174									
173.2																
0.9	Topsoil/Rootmat		2	SS	9											
173.1																
1.0	Silty sand with gravel (SM), loose, brown						173									
172.7			3	SS	50/ 130mm											
1.4	End of Borehole															
	Splitspoon Refusal on Inferred Bedrock															

RECORD OF BOREHOLE No BH 08-26A

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126223.9 E349758.5 ORIGINATED BY AO
DIST 54 HWY 630 BOREHOLE TYPE NQ Coring Equipment COMPILED BY JF
DATUM Geodetic DATE 12.10.08 - 12.10.08 CHECKED BY PC

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							
173.1 0.0	Silty sand with gravel (SM), loose, brown						20	40	60	80	100				
172.7 0.4	Pinkish grey granite BEDROCK with grey/black gneiss partings - voids or soft areas noted to 1.3 m - very poor quality - slightly weathered - dipping orientation (20° to 50°) - very close to close joint spacing - rough planar		1	NQ											REC = 71% ROD = 24%
171.8 1.3	Pinkish grey granite BEDROCK with grey/black gneiss partings - fair to excellent quality - unweathered - dipping orientation (20° to 50°) - close joint spacing - rough planar		2	NQ											REC = 96% ROD = 61%
			3	NQ											REC = 100% ROD = 92%
			4	NQ											REC = 100% ROD = 81%
170.3 2.8	End of Borehole Standpipe Installed														

×³, ×³: Numbers refer to
Sensitivity


○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 08-27

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126225.7 E349766.8 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

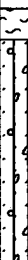
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED		× FIELD VANE							● QUICK TRIAXIAL × LAB VANE		
172.5	Grass						20	40	60	80	100								
0.0	Topsoil/Rootmat		1	SS	50/ .50mm														
172.3	End of Borehole																		
0.2	Splitspoon Refusal on Inferred Bedrock																		

RECORD OF BOREHOLE No BH 08-28

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126237.9 E349760.6 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splittingspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

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									
172.7	Grass																
0.0 172.6	Topsoil/Rootmat																
0.1	Silty sand with gravel (SM), compact, brown		1	SS	15												26 52 0(22)
171.9			2	SS	50/ 50mm		172										
0.8	End of Borehole Split spoon Refusal on Inferred Bedrock																

RECORD OF BOREHOLE No BH 08-29

1 OF 1

METRIC

W.P. 177-98-01 LOCATION Amable du Fond River - North Channel, N5126237.2 E349755.5 ORIGINATED BY AO
 DIST 54 HWY 630 BOREHOLE TYPE Portable Equipment, Splitspoons COMPILED BY JF
 DATUM Geodetic DATE 11.5.08 - 11.5.08 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
173.1	Moss/Grass							20 40 60 80 100		W _p W W _L				
0.0	Silty sand (SM) with gravel, some organics, compact to dense, brown (TILL)		1	SS	18		173							
			2	SS	53									
			3	SS	50/ 130mm		172							
171.8	End of Borehole													
1.4	Splitspoon Refusal on Inferred Bedrock													



Project No.: 1042746

Date: December 15, 2008

Borehole No.: BH08-19

Logger: Kenton C. Power

Page 1 of 1



Field Core Log

Client: Ministry of Transportation of Ontario
Project: Highway 630 Amable du Fond River Bridges
Contractor: OGS Drilling, Almonte, ON

Project No.: 1042746
Date: December 15, 2008
Borehole No.: BH08-21A
Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
0.4	1	95	60	0.63	Pinkish grey granite with grey/black gneiss partings		S	1	B	D	C	RP		T		
1.5	2	100	33	1.8	Pinkish grey granite with grey/black gneiss partings		U	1	B	D	M	RP		T		
1.8	3	70	0	2	Pinkish grey granite with grey/black gneiss partings		U	1	B	D	C	RP		T		
2	4	29	0	3.7	Pinkish grey granite with grey/black gneiss partings		S	1	B	D	C	RP		T		

STRENGTH (MPa)
 VH = Very High = >200
 H = High = 50-200
 M = Medium = 15-50
 L = Low = 4-15
 VL = Very Low = 1-4

WEATHERING
 U = Unweathered = No Signs
 S = Slightly = Oxidized
 M = Moderately = Discoloured
 H = Highly = Friable
 C = Completely = Soil-like

DISCONTINUITY TYPE
 B = Bedding Joint
 J = Cross Joint
 F = Fault
 S = Shear Plane

SPACING
 VW = Very Wide = >3m
 W = Wide = 1-3 m
 M = Moderate = 0.3-1 m
 C = Close = 5-30 cm
 VC = Very Close = <5 cm

ORIENTATION
 F = Flat = 0-20°
 D = Dipping = 20-50°
 V = n-Vertical = >50°

ROUGHNESS
 RU = Rough Undulating
 RP = Rough Planar
 SU = Smooth Undulating
 SP = Smooth Planar
 LU = Slickensided Undulating
 LP = Slickensided Planar

FILLING
 T = Tight, Hard
 O = Oxidized
 SA = Slightly Altered, Clay Free
 S = Sandy, Clay Free
 Si = Sandy, Silty, Minor Clay
 NC = Non-softening Clay
 SC = Swelling, Soft Clay



Field Core Log

Client: Ministry of Transportation of Ontario
 Project: Highway 630 Amable du Fond River Bridges
 Contractor: OGS Drilling, Almonte, ON

Project No.: 1042746
 Date: December 15, 2008
 Borehole No.: BH08-21A
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE			FILLING
3.7	5	94	0	4.1	Pinkish grey granite with grey/black gneiss partings		S	1	B	D	C	RP		T		
4.1	6	89	21	5	Pinkish grey granite with grey/black gneiss partings		U	1	B	D	C	RP		T		
5	7	98	89	6.2	Pinkish grey granite with grey/black gneiss partings		U	1	B	D	C	RP		T		

STRENGTH (MPa)

VH = Very High = >200
H = High = 50-200
M = Medium = 15-50
L = Low = 4-15
VL = Very Low = 1-4

WEATHERING

U = Unweathered = No Signs
S = Slightly = Oxidized
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B = Bedding Joint
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F = Fault
S = Shear Plane

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VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay



Field Core Log

Client: Ministry of Transportation of Ontario
 Project: Highway 630 Amable du Fond River Bridges
 Contractor: OGS Drilling, Almonte, ON

Project No.: 1042746
 Date: December 15, 2008
 Borehole No.: BH08-23
 Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE			FILLING
0.33	2	100	0	0.53	Pinkish grey granite with grey/black gneiss partings		S	1	B	F	C	RP		T		
0.53	3	83	33	0.91	Pinkish grey granite with grey/black gneiss partings		U	1	B	F	C	RP		T		
0.91	4	98	39	1.50	Pinkish grey granite with grey/black gneiss partings		U	1	B	F	C	RP		T		
1.50	5	98	23	2.54	Pinkish grey granite with grey/black gneiss partings		U	1	B	F	C	RP		T		
<div><div><div><div><div>STRENGTH (MPa)</div><div>VH = Very High = >200</div><div>H = High = 50-200</div><div>M = Medium = 15-50</div><div>L = Low = 4-15</div><div>VL = Very Low = 1-4</div></div><div><div>WEATHERING</div><div>U = Unweathered = No Signs</div><div>S = Slightly = Oxidized</div><div>M = Moderately = Discoloured</div><div>H = Highly = Friable</div><div>C = Completely = Soil-like</div></div></div><div><div><div>DISCONTINUITY TYPE</div><div>B = Bedding Joint</div><div>J = Cross Joint</div><div>F = Fault</div><div>S = Shear Plane</div></div><div><div>SPACING</div><div>VW = Very Wide = >3m</div><div>W = Wide = 1-3 m</div><div>M = Moderate = 0.3-1 m</div><div>C = Close = 5-30 cm</div><div>VC = Very Close = <5 cm</div></div></div><div><div><div>ORIENTATION</div><div>F = Flat = 0-20°</div><div>D = Dipping = 20-50°</div><div>V = n-Vertical = >50°</div></div><div><div>ROUGHNESS</div><div>RU = Rough Undulating</div><div>RP = Rough Planar</div><div>SU = Smooth Undulating</div><div>SP = Smooth Planar</div><div>LU = Slickensided Undulating</div><div>LP = Slickensided Planar</div></div></div><div><div><div>FILLING</div><div>T = Tight, Hard</div><div>O = Oxidized</div><div>SA = Slightly Altered, Clay Free</div><div>S = Sandy, Clay Free</div><div>Si = Sandy, Silty, Minor Clay</div><div>NC = Non-softening Clay</div><div>SC = Swelling, Soft Clay</div></div></div></div></div>																



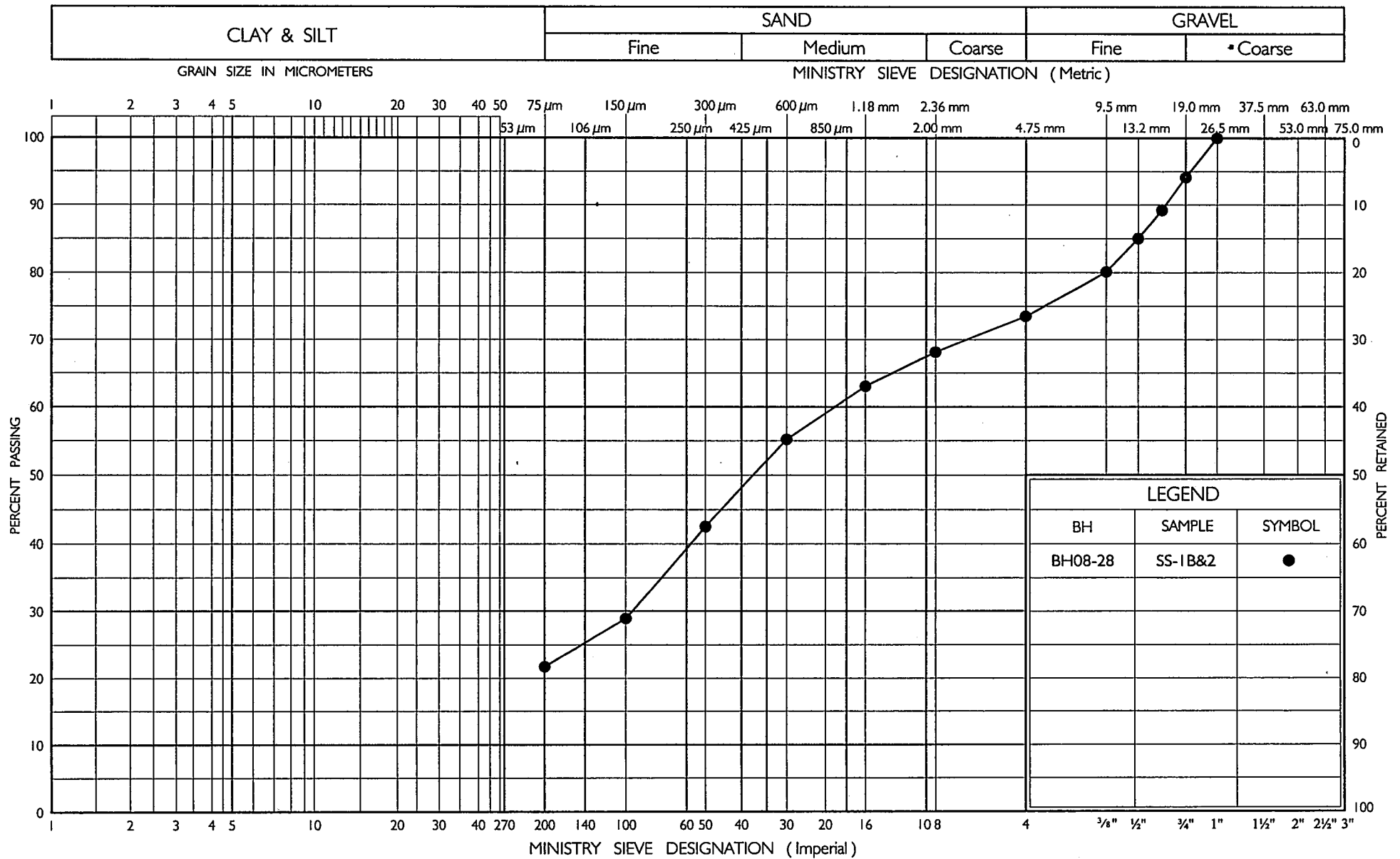
Field Core Log

Client: Ministry of Transportation of Ontario
Project: Highway 630 Amable du Fond River Bridges
Contractor: OGS Drilling, Almonte, ON

Project No.: 1042746
Date: December 15, 2008
Borehole No.: BH08-26A
Logger: Kenton C. Power

DEPTH FROM	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
0.38	1	71	24	1.30	Pinkish grey granite with grey/black gneiss partings		S	1	B	F	VC	RP		T		
1.30	2	96	61	1.88	Pinkish grey granite with grey/black gneiss partings		U	1	B	D	C	RP		T		
1.88	3	100	92	2.34	Pinkish grey granite with grey/black gneiss partings		U	1	B	D	C	RP		T		
2.34	4	100	81	2.77	Pinkish grey granite with grey/black gneiss partings		U	1	B	D	C	RP		T		
<div><div><div><div><div><u>STRENGTH (MPa)</u></div><div>VH = Very High = >200</div><div>H = High = 50-200</div><div>M = Medium = 15-50</div><div>L = Low = 4-15</div><div>VL = Very Low = 1-4</div></div><div><div><u>WEATHERING</u></div><div>U = Unweathered = No Signs</div><div>S = Slightly = Oxidized</div><div>M = Moderately = Discoloured</div><div>H = Highly = Friable</div><div>C = Completely = Soil-like</div></div></div><div><div><div><u>DISCONTINUITY TYPE</u></div><div>B = Bedding Joint</div><div>J = Cross Joint</div><div>F = Fault</div><div>S = Shear Plane</div></div><div><div><u>SPACING</u></div><div>VW = Very Wide = >3m</div><div>W = Wide = 1-3 m</div><div>M = Moderate = 0.3-1 m</div><div>C = Close = 5-30 cm</div><div>VC = Very Close = <5 cm</div></div></div><div><div><div><u>ORIENTATION</u></div><div>F = Flat = 0-20°</div><div>D = Dipping = 20-50°</div><div>V = n-Vertical = >50°</div></div><div><div><u>ROUGHNESS</u></div><div>RU = Rough Undulating</div><div>RP = Rough Planar</div><div>SU = Smooth Undulating</div><div>SP = Smooth Planar</div><div>LU = Slickensided Undulating</div><div>LP = Slickensided Planar</div></div></div><div><div><u>FILLING</u></div><div>T = Tight, Hard</div><div>O = Oxidized</div><div>SA = Slightly Altered, Clay Free</div><div>S = Sandy, Clay Free</div><div>Si = Sandy, Silty, Minor Clay</div><div>NC = Non-softening Clay</div><div>SC = Swelling, Soft Clay</div></div></div></div>																

UNIFIED SOIL CLASSIFICATION SYSTEM



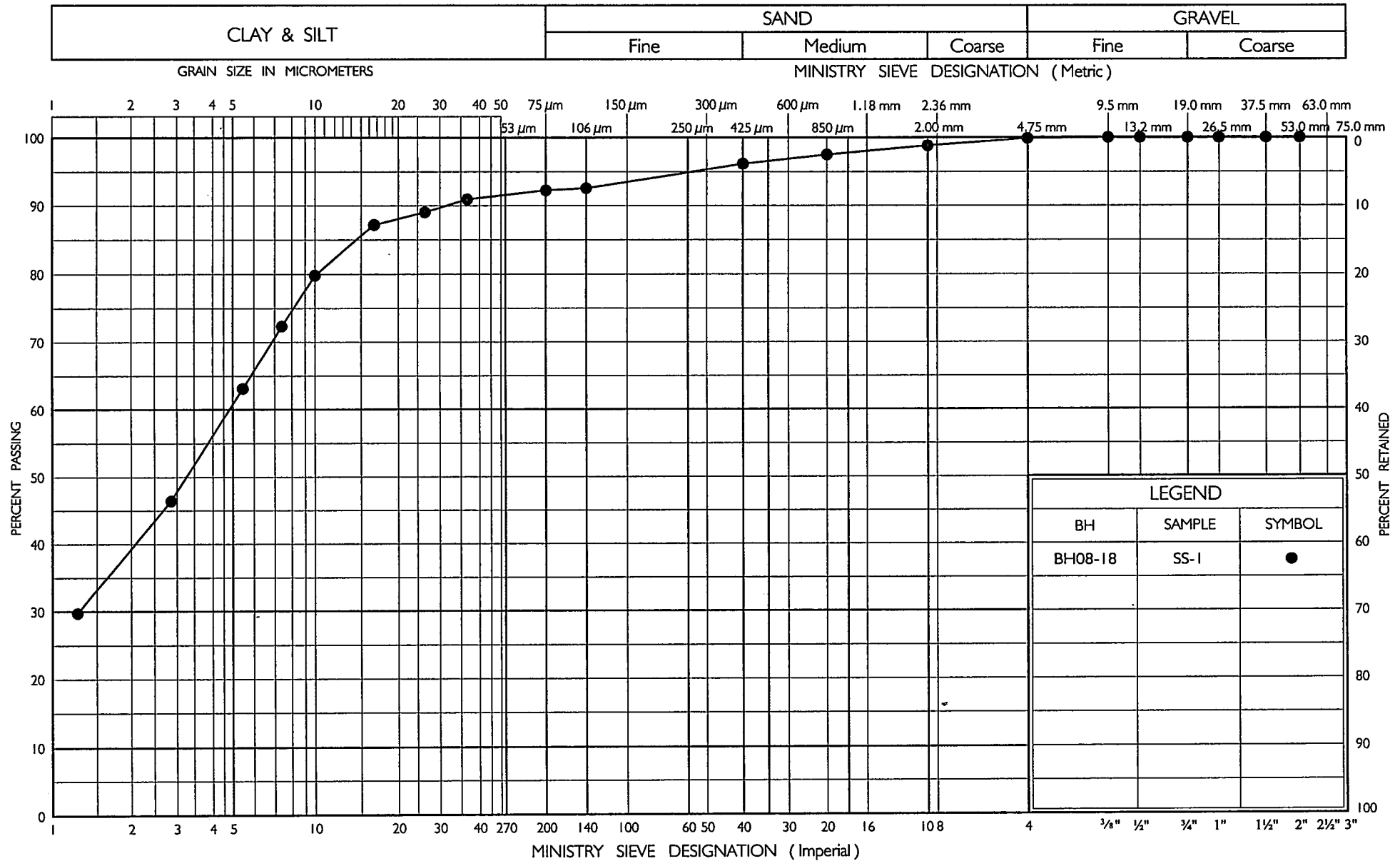
Ministry of
Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND WITH GRAVEL

FIG No 1

W P 177-98-00

UNIFIED SOIL CLASSIFICATION SYSTEM

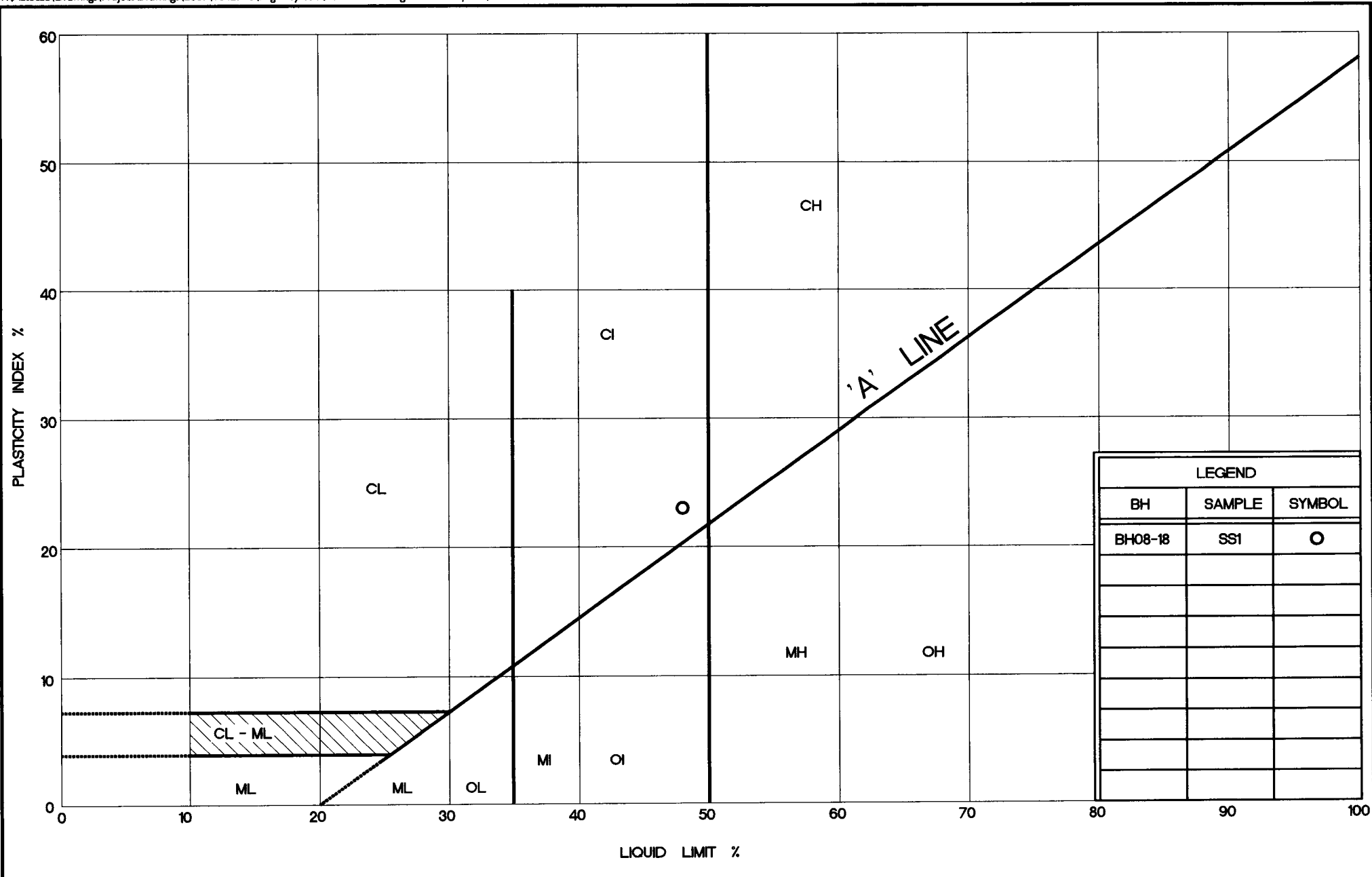


Ministry of
Transportation
Ontario

GRAIN SIZE DISTRIBUTION
FILL : CLAY (LOW PLASTICITY)

FIG No 2

W P 177-98-00



Ministry of
Transportation

PLASTICITY CHART
FILL : CLAY (INTERMEDIATE PLASTICITY)

FIG No 3

WP 177-98-00

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH T.W. ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM T.W. ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE
FV FIELD VANE	

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

m_v kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c %	COMPRESSION INDEX
C_s %	SWELLING INDEX
C_{α} %	RATE OF SECONDARY CONSOLIDATION
c_v m ² /s	COEFFICIENT OF CONSOLIDATION
H m	DRAINAGE PATH
t_v s	TIME FACTOR
U %	DEGREE OF CONSOLIDATION
σ'_{vo} kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p kPa	PRECONSOLIDATION PRESSURE
τ_f kPa	SHEAR STRENGTH
c' kPa	EFFECTIVE COHESION INTERCEPT
ϕ' °	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u kPa	APPARENT COHESION INTERCEPT
ϕ_u °	APPARENT ANGLE OF INTERNAL FRICTION
τ_r kPa	RESIDUAL SHEAR STRENGTH
τ_f kPa	REMOULDED SHEAR STRENGTH
S_t %	SENSITIVITY = $\frac{c_u}{\tau_f}$

PHYSICAL PROPERTIES OF SOIL

ρ_s kg/m ³	DENSITY OF SOLID PARTICLES	n %	POROSITY	e_{max} %	VOID RATIO IN LOOSEST STATE
γ_s kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w %	WATER CONTENT	e_{min} %	VOID RATIO IN DENSEST STATE
ρ_w kg/m ³	DENSITY OF WATER	S_r %	DEGREE OF SATURATION	I_D %	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w kN/m ³	UNIT WEIGHT OF WATER	w_L %	LIQUID LIMIT	D mm	GRAIN DIAMETER
ρ kg/m ³	DENSITY OF SOIL	w_p %	PLASTIC LIMIT	D_n mm	n PERCENT - DIAMETER
γ kN/m ³	UNIT WEIGHT OF SOIL	w_s %	SHRINKAGE LIMIT	C_u %	UNIFORMITY COEFFICIENT
ρ_d kg/m ³	DENSITY OF DRY SOIL	I_p %	PLASTICITY INDEX = $w_L - w_p$	h m	HYDRAULIC HEAD OR POTENTIAL
γ_d kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L %	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q m ³ /s	RATE OF DISCHARGE
ρ_{sat} kg/m ³	DENSITY OF SATURATED SOIL	I_C %	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v m/s	DISCHARGE VELOCITY
γ_{sat} kN/m ³	UNIT WEIGHT OF SATURATED SOIL			i %	HYDRAULIC GRADIENT
ρ' kg/m ³	DENSITY OF SUBMERGED SOIL	DTPL	DRYER THAN PLASTIC LIMIT	k m/s	HYDRAULIC CONDUCTIVITY
γ' kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	APL	ABOUT PLASTIC LIMIT	j kN/m ²	SEEPAGE FORCE
e %	VOID RATIO	WTPL	WETTER THAN PLASTIC LIMIT		

RECORD OF BOREHOLE No A-3

1 of 1

METRIC

G.W.P. 177-98-00 LOCATION Highway 630 (New) Sta.10+059.5 CL ORIGINATED BY M.R.
DIST 54 HWY 630 BOREHOLE TYPE Excavator COMPILED BY M.R.
DATUM Geodetic DATE December 14, 2006 CHECKED BY C.N.

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						
172.3	Ground surface													
0.0	Cobbles and boulders													
171.9	some sand, trace silt													
0.4	Dense Brown Wet													
	End of borehole													
	Refusal to excavate on bedrock or large boulders													
	NOTE: The relative density of the deposit was assessed by probing and visual methods.													
	* Borehole dry													

RECORD OF BOREHOLE No A-4										1 of 1		METRIC	
G.W.P. 177-96-00		LOCATION Highway 630 (New) Sta. 10+045.5 CL		ORIGINATED BY M.R									
DIST 54 HWY 630		BOREHOLE TYPE Excavator		COMPILED BY M.R									
DATUM Geodetic		DATE December 14, 2006		CHECKED BY C.N									
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					
172.3	Ground surface												
0.0	Topsoil												
0.3	Sand and gravel												
171.7	with boulders, trace silt												
0.6	Very Brown Moist dense												
	End of borehole												
	Refusal to excavate on bedrock or large boulders												
	NOTE: The relative density of the deposit was assessed by probing and visual methods.												
	* Borehole dry												



APPENDIX C

Rock Core Photographs

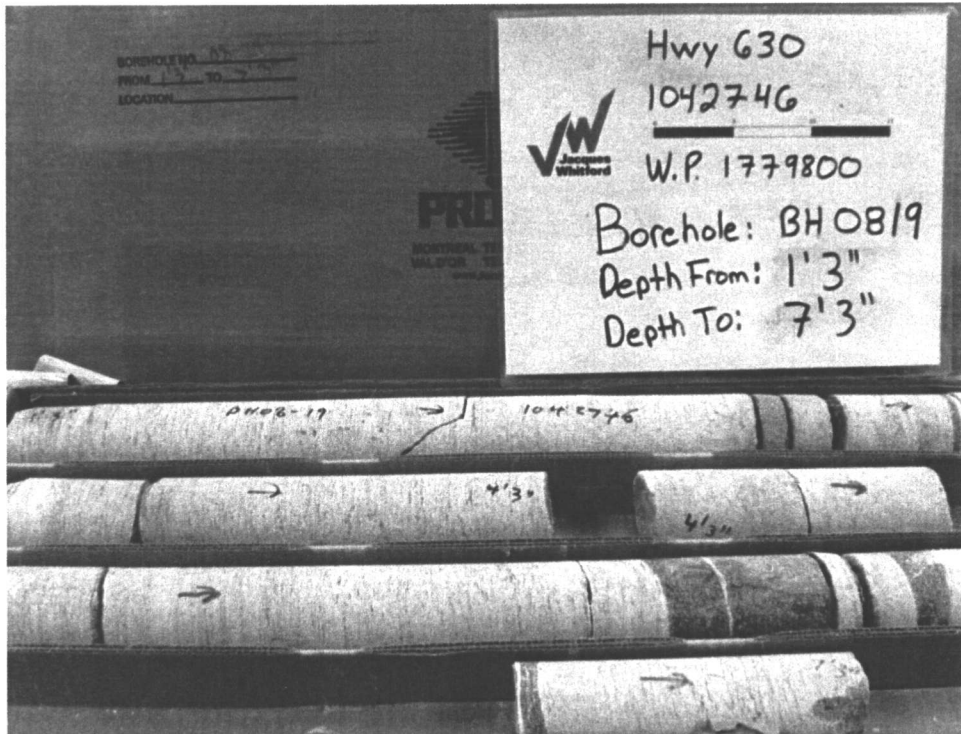


Photo 1: BH 08-19 Rock Core

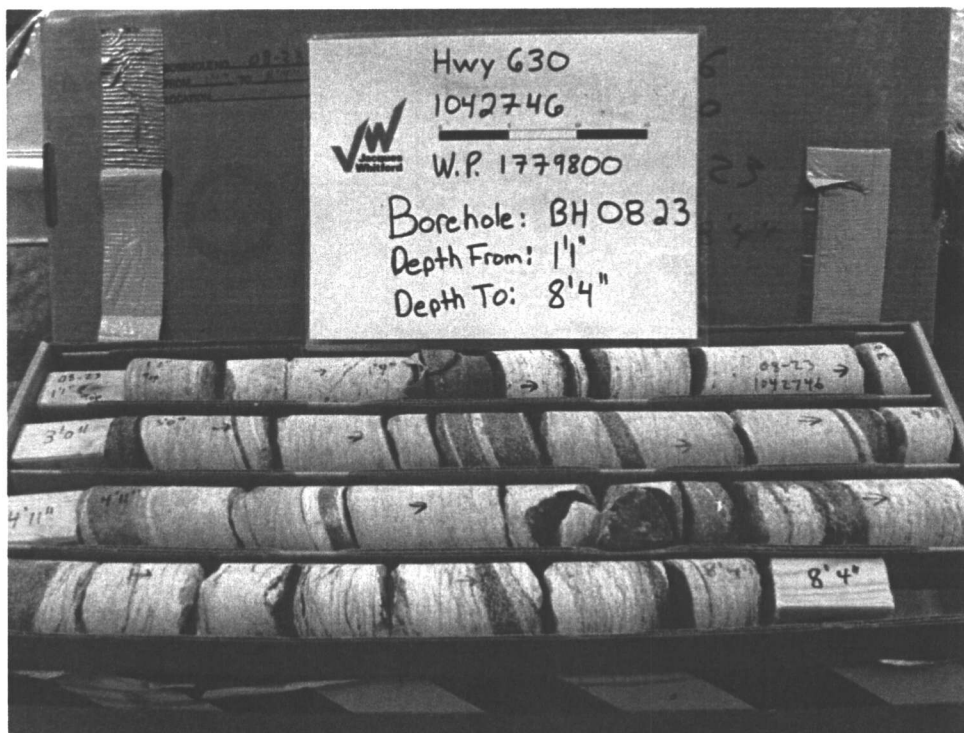


Photo 2: BH 08-23 Rock Core

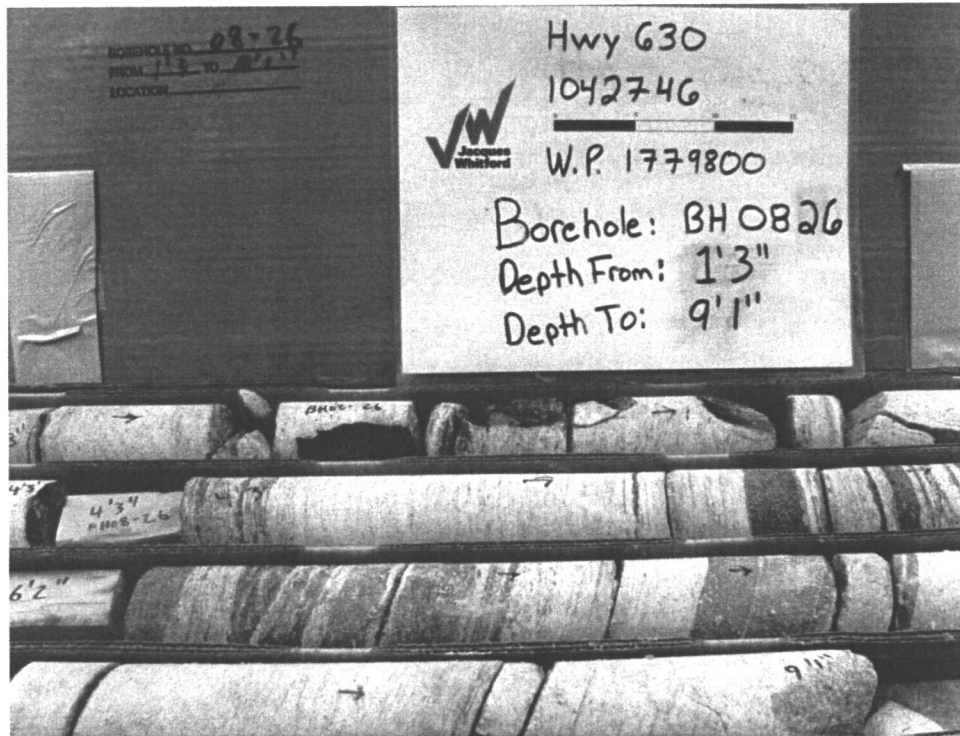


Photo 3: BH 08-26 Rock Core



APPENDIX D

Geological Survey of Canada Seismic Hazard Calculation

2005 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: Kenton C. Power, Jacques Whitford

January 09, 2009

Site Coordinates: 46.2738 North 78.9166 West

User File Reference: Amable du Fond River

National Building Code ground motions:

2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.399	0.193	0.083	0.028	0.263

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2005 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. *These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.*

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.061	0.163	0.247
Sa(0.5)	0.027	0.075	0.116
Sa(1.0)	0.010	0.032	0.050
Sa(2.0)	0.003	0.010	0.016
PGA	0.041	0.115	0.171

References

National Building Code of Canada 2005 NRCC no. 47666; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3

Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2005, Structural Commentaries NRCC no. 48192

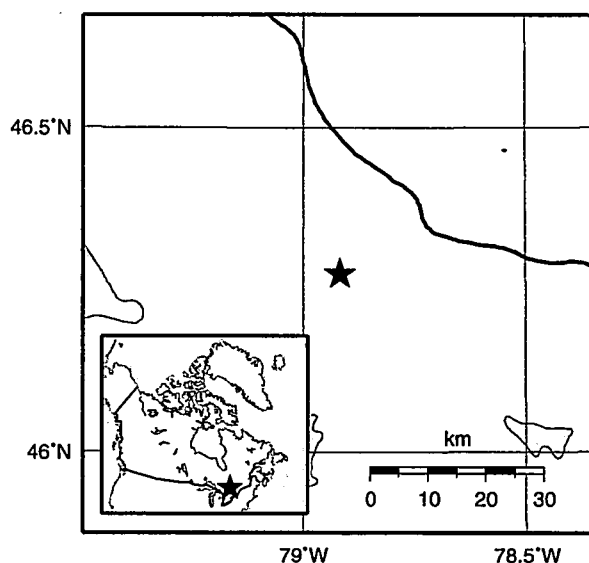
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx

Fourth generation seismic hazard maps of Canada: Grid values to be used with the 2005 National Building Code of Canada (in preparation)

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Aussi disponible en français



Natural Resources
Canada

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Canada

Canada

